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Colonial Waterbird Management in North America*

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Abstract.—Colonial waterbirds are an important natural resource highly valued by many people in Canada and the United States. The habit of nesting often in large groups makes these birds especially susceptible to problems, such as human disturbance, predation, severe weather events, and competition for nesting habitat. They, like all birds, also face threats from habitat degradation, loss and contamination of their environments, and changes in food webs.

Management strategies to deal with these problems include habitat preservation and restoration, the elimination of toxic chemicals from the environment, reduction of predation, competition, and disturbance at nesting sites, reintroduction of species to nesting sites from which they have been eliminated, and fisheries management from a multispecies ecosystem perspective. Techniques are discussed and examples provided. A few colonial waterbird species have increased greatly in numbers and now pose problems for other bird species or are in conflict with people. Management is also involved in the control of such problem birds. Strategies include habitat modifications and scaring or killing problem birds.

There is a continuing need for information and research to allow appropriate management to be applied. Regular surveys and inventories are necessary on a regional basis to detect trends in population status and to minimize and mitigate conflicts with human activities. Studies of population demography are needed for species declining in numbers, and research into species ecology is often necessary before appropriate management can be applied. Additional techniques to reduce conflicts between birds and humans are also needed. Human activities are likely a major limiting factor for some species, and, conversely, humans are largely responsible for the increases of several species that have become problems.

Continued education of the public and of conservation management agencies to the role and importance of colonial waterbirds is important. Many species are likely to continue to suffer from gradual incremental loss and degradation of habitats, and a conservation strategy for the protection of these birds throughout North America is recommended.

Key words.—Alcids, colonial waterbirds, colony, cormorants, conservation, contaminants, egrets, gulls, terns, herons, ibises, natural resources management, pelicans, petrels, storks, seabirds, wildlife.

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Colonial waterbirds are distinctive members of wetland and shoreline ecosystems. To millions of North Americans, gulls symbolize the ocean and lakefront; and, to many, the egret is a recognized symbol of wetland conservation. Colonial waterbird populations have long been a focus for conservation action, particularly for efforts to preserve the wetlands on which they depend. They are worthy of

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such attention not only for their symbolic value but as useful indicators of the ecological health of these ecosystems.

PHILOSOPHY OF MANAGEMENT

Conservation of these species long has been a matter of public concern. Conservation measures in the past generally focused on preventing the killing of birds and the taking of eggs. These are no longer adequate in the face of new problems, and new solutions are necessary to maintain populations of the native colonial waterbirds of North America. The need for active management at the population, habitat, and food web levels have only recently been widely appreciated (Buckley and Buckley 1976, Buckley and Buckley 1977, U.S. Dept. Commerce 1978, Parnell and Soots 1978, Dusi 1983, Kushlan 1983, Brown and Nettleship 1984), and management is required to stem the relentless loss of feeding and nesting habitat, to reverse local population decreases that have led to species being placed on endangered lists, and to alleviate the converse problem of rapid population growth of a few other species that have become pests.

Our primary goal here is to focus issues relating to the conservation and management of colonial waterbirds. More specifically, we review the many problems facing colonial waterbirds, review management techniques, discuss implementation of management programs, and indicate needs for research and education.

Our intended readership consists primarily of land managers, policy makers, developers, and conservation officers. We hope that this report will also be of use to interested lay persons, students, and professional ornithologists.

THE COLONIAL BIRD RESOURCE

Colonial birds are those that come together into groups to nest at locations called colony sites (Fig. 1). Assemblies of birds breeding at such sites are called colonies (Kushlan 1986a). Technically it would take only two pairs nesting at a site to make a colony, but most range from hundreds to thousands of birds. The spatial limits of specific colony sites are sometimes hard to define precisely (Buckley and Buckley 1980). For the species dealt with here, the habit of nesting socially is well established, but the degree of coloniality varies. Some species, such as the Herring Gull usually nest in colonies but also may nest as single pairs. Other species, such as the Least Bittern, usually nest singly but occasionally breed in small groups, and are considered semi-colonial (Hancock and Kushlan 1984). Typical colony sites include marshes, swamps, precipitous headlands, or islands, ranging from rocky coastal islands to patches of trees in the middle of a marsh, and at least one colony of Ivory Gulls has been reported on a floating iceberg (MacDonald and Macpherson 1962). Most species feed in deep water or wetland habitats such as marshes, lakes, rivers and associated riparian ecosystems, swamps, coastal lagoons and bays, and the open ocean.

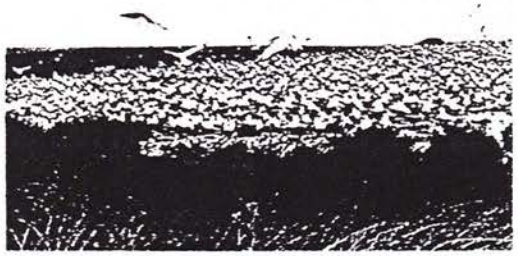

Figure 1. Colony of Royal Terns. This colony is nesting on material deposited by channel dredging activities. Photograph by James F. Parnell.

The birds that are the subject of this report belong to several taxonomic orders, including tubenoses (Procellariiformes), pelicans and allies (Pelicaniiformes), waterfowl (Anseriformes), waders (Ciconiiformes) (Fig. 2), and gulls, terns (Fig. 3), auks, and allies (Charadriiformes). Within some of these taxa are species that nest solitarily or are not aquatic, and within other generally non-colonial taxa are species that could reasonably be classified as colonial waterbirds: i.e. some geese and ducks (Anseriformes), kites (Falconiformes), Osprey (*Pandion haliaetus*), and some passerines (Passeriformes) especially blackbirds (Icteridae) (Maehr and Rodgers 1985). In this paper we treat those nesting on or near

Figure 2. White Ibis and chick, nesting on Dressing Point Island, East Matagorda Bay, Texas. Photograph by Kirke A. King.

Figure 3. Sandwich Tern and chick, nesting on Sundown Island, Matagorda Bay, Texas. Photograph by Kirke A. King.

the mainland of North America north of Mexico (Appendix 1).

HISTORY AND STATUS OF MANAGEMENT

Active management of colonial waterbirds may have been initiated in North American in 1892 when E. A. McIlhenny dammed a small creek and built a holding cage over the resulting pond on Avery Island, Louisiana (McIlhenny 1934). He then introduced eight fledgling Snowy Egrets taken from nests in nearby swamps. All were released in late summer and left the area as winter approached. Six returned the next spring, and two pairs nested in the vicinity of the holding pen. By 1905 the colony had grown to over 1000 pairs of five species. Management continued with the enlarging of the pond, the building of nesting platforms, and the supplying of nesting materials. Over 20,000 nests were counted in 1922 (McIlhenny 1934). In 1909, McIlhenny shipped over 3,000 Snowy Egrets to Miami, Florida to be placed in a large flying cage and subsequently released. The Avery Island colony was still active in 1987.

Although a few individuals were devising ways to increase wading bird numbers in the late 1800s, fashions of the day were resulting in losses among several species. Egrets and terns bore the brunt of the feather trade, and at the same time the eating of eggs and chicks of many species was a regular practice. This combination of factors resulted in reductions in numbers of many herons, egrets, gulls, terns, and alcids (Dutcher 1901, Doughty 1971, Graham 1978).

Efforts to manage colonial waterbirds at the national level began in the United States in the late 1800s with the organization of several state Audubon Societies. These units coalesced into the National Association of Audubon Societies in 1905 and provided leadership to stop the killing of colonial waterbirds.

Early efforts involved the protection of birds and their eggs. The Lacey Act of 1900, which prohibited the interstate transport of animals killed illegally, was the first U. S. federal law to address bird protection. It was followed by a series of migratory bird laws leading, in 1916, to the Migratory Bird Treaty between the United

States and Canada (Leopold 1933, Phillips 1934).

The early 1900s also saw the first widespread efforts, promoted by the National Audubon Society, to protect nesting sites. The first wildlife sanctuary in the United States was dedicated by the state of California in 1870, primarily as a waterfowl refuge (Gabrielson 1943). Many refuges created during the early 1900s were, however, designed to protect breeding sites of colonial waterbirds. The first National Wildlife Refuge in the United States, Pelican Island in Florida, was designated in 1903 to protect a nesting colony of Brown Pelicans (Graham 1978). Public interest in Canada paralleled that in the United States, and Canada set aside its first bird refuge, at Last Mountain Lake, Saskatchewan in 1887. This was followed by designation of Bonaventure Island, Perce Rock, and Bird Rock in Quebec as sanctuaries in 1919 (Foster 1978). The National Audubon Society began a sanctuary system designed specifically to protect nesting habitat in 1900. In the early years, sanctuaries were often on private property. That system now contains over 80 units in 19 states. The National Wildlife Refuge system maintained by the U. S. Fish and Wildlife Service now has over 437 units in 49 states and includes 88,337,015 acres of land. There are also 150 waterfowl production areas with conservation easements (1,737,061 acres) and 58 cooperative areas totaling 419,001 acres (U. S. Department of the Interior 1986).

States, Provinces, other public entities, and private organizations such as Ducks Unlimited and the Nature Conservancy, and private individuals also have established refuges that either protect colonial waterbird habitat or provide such habitat coincidental to other purposes. Since the 1920s most National Wildlife Refuges have been set aside to provide habitat for waterfowl or other game species. In some instances, colonial waterbirds have benefited greatly since many species utilize the same kinds of wetland habitats important to waterfowl. This "management-by-association" has been an important factor in providing both breeding and feeding habitat for many species.

The result of laws and refuges is that most colonial waterbird species are protected against the taking of birds or eggs (exceptions relate to rights of native peoples to take birds and eggs for food) and have many of their colony sites and some feeding areas protected. The existence of laws, however, does not mean that all are automatically enforced. The latter requires public education and support.

In the case of many species, especially those of coastal, marine areas, the conservation of a viable prey base is a particularly difficult problem because no land ownership is involved. Fisheries managers, however, are becoming educated to the need for a multi-species perspective in fishery management plans. For instance, the Anchovy Management Plan for the Pacific West Coast contains provisions directed toward the prey needs of Brown Pelicans (U. S. Dept. Commerce 1978). Thus far, this plan is unique.

Several other developments have recently benefited colonial waterbirds. The most significant has been the emerging worldwide interest in wetlands protection (Kushlan 1986b). This has resulted in a slowing of wetland destruction in North America and provides hope for the maintenance of adequate feeding habitat for many species. Also, the great load of persistent environmental contaminants introduced into the North American environment during the past 50 years is diminishing somewhat (Schmitt et al. 1985), as demonstrated in part from studies of colonial waterbirds (e.g. Mineau et al. 1984, Weseloh et al. 1979, Noble and Elliott 1986). Another significant but incidental form of management is the provision of breeding sites by deposition of material dredged during waterway construction and maintenance (Saucier et al. 1978, Soots and Landin 1978).

Many of the management actions discussed above are considered passive in that they do not involve manipulation of birds or their habitats. The diking of wetlands, the deposition of dredged material, and the management of vegetation are examples of active management. Until recently, however, little effort has been made to directly manage populations in the manner of McIlhenny in the late 1800s.

A significant increase in our knowledge of colonial waterbirds resulted from a series of regional surveys which began in

the 1970s. Surveys had been conducted since the 1930s in Florida and Texas (by the National Audubon Society) and later in Texas by the Texas Colonial Waterbird Survey, and in the Canadian prairies by the Canadian Wildlife Service in the 1970s.

Regional surveys sponsored by the U. S. Fish and Wildlife Service and Minerals Management Service along the Atlantic, Gulf, Pacific, and Arctic coasts of the United States and Canada in 1975-1977 (Custer and Osborn 1977, Osborn and Custer 1978, Sowls et al. 1978, 1980, Erwin and Korschgen 1979, Brown 1986) provided the first opportunity for broad regional comparisons and involved many students and researchers in colonial waterbird work for the first time. This coordinated effort by many people and organizations was a part of the impetus for the formation of the Pacific Seabird Group in 1973 and the Colonial Waterbird Group in 1976, which have provided much of the interchange of ideas leading to the current high level of interest in colonial waterbirds and their management in North America.

A second side to the concept of managing colonial waterbirds is that certain species at certain times and places have been considered nuisances, dangers to public health, or competitors with humans for resources. Cormorants, for example, are thought to compete for fishery resources and have at times been controlled (Craven and Lev 1987). Cattle Egrets and gulls, especially species such as Ring-billed, Herring, and Glacous-winged gulls whose populations have grown rapidly in recent years, can prove to be nuisances, and perhaps health hazards (Blokpoel and Tessier 1986, Telfair and Thompson 1986, Vermeer et al. 1988a) or hazards to aircraft (Blokpoel 1984). They may also compete at nesting sites with other species whose populations have declined (Blokpoel 1984).

PROBLEMS

Birds that gather in groups to nest are particularly susceptible to predation, catastrophic natural events such as storms and disturbance. Colonial nesting, however, also facilitates management.

Most of the species that are declining have been persecuted by man. Many were able to rebound following legislative protection because the growing human population had not usurped or degraded habitats required for reproduction and other requirements. Today an expanding, modernized human population is placing a renewed threat on this group of birds.

Habitat Degradation and Loss

The greatest threat to colonial waterbird species is the reduction in habitat quantity and quality that is occurring today. Worldwide demands for agricultural land, forest products, coastal recreational areas, home sites, and other activities that result in environmental degradation all contribute to the loss. As a consequence, the number of colony sites and amount of feeding habitat is declining, which in turn further limits the number of birds that can be sustained within breeding ranges. In addition, the remaining segments of populations are becoming more concentrated, placing them in greater jeopardy, because a single event could destroy a significant portion of the survivors in a number of cases.

Although each species has specific habitat requirements, there are sufficient factors common to closely related forms that single threats will often limit populations of clusters of species.

Tree Nesting and Tree Roosting Species.—A variety of forest types, from mature upland hardwoods to coastal mangroves, are used by pelicans, frigate birds, herons, egrets, storks, ibises, and murrelets for nesting and roosting. The greatest threat to many species results when wetlands and forests are converted to other uses. Clearing can result in environments inhospitable to colonial waterbirds, and coastal forests are being cleared at an alarming rate (Wolf 1985). Many coastal wetlands have been drained and filled which eliminates any chance of the impacted land reverting back to natural communities in the future. Lesser developments may be equally devastating since the remaining habitat is avoided by waterbirds. For example, stands of timber are being fragmented by housing developments, lumbering, highway construction and agriculture. Managing for younger stands of timber with increased biomass or

stumpage for woodchip operations also is generally not compatible with colonial waterbird use of a forest.

Breaking up larger tracts reduces the buffer against human disturbance. Avoidance of such areas reduces the regional avian population and further compacts birds in the remaining suitable habitat. Some individuals may acclimate to such modified nesting environments, if foraging opportunities exist.

Grazing by livestock and fire also may reduce the attractiveness of a woodland to colonial waterbirds. Fire and heavy grazing eliminates the understory and creates a park-like setting. The result is loss of a buffer effect, increased disturbance, and the absence of replacement trees developing in the understory. Fires during the nesting season can result in direct mortality or site abandonment.

Ground Nesting Species.—A variety of factors affect habitat availability and quality for island-and-beach-nesting gulls, terns, and skimmers. Development of barrier islands and other coastal areas represent one of the most serious threats (Erwin 1980b, Vermeer and Rankin 1984). Coastal communities further impact the birds by attracting increasing numbers of people to the shoreline for recreation. Swimmers, picnickers, anglers, all-terrain-vehicle operators and other beach enthusiasts displace birds from areas essential for reproduction (Fisk 1975, Buckley and Buckley 1980, Downing 1980, Vermeer and Rankin 1984) and diminish the reproductive success of remaining nesters (Warriner et al. 1986).

Dredging operations and the associated diking and spoil deposition in coastal areas and along major rivers can be detrimental. The timing of deposition of dredged material is of major importance since nests may be destroyed and nesting activities may be disrupted when deposition occurs during the breeding season (Hutchinson et al. 1987). The deposition of dredged material may also alter substrates by covering existing plant cover or by changing substrate texture, thus rendering sites unsuitable or less suitable to some species (Soots and Parnell 1975, Parnell et al. 1978, Soots and Landin 1978, Thompson and Slack 1982).

Natural changes in habitat quality also may be detrimental to some species, although beneficial to others. Plant succession may render a site unsuitable for ground nesting species that prefer open expanses on islands or coastal shorelines. Portions of island habitats are eventually invaded by woody shrubs and perhaps trees (Soots and Parnell 1975). Species such as gulls and terns that have nested at such sites for many years may continue to do so even when conditions are becoming suboptimal. They eventually abandon the site, which may now become suited for herons, egrets, pelicans or other tree-nesting forms (Soots and Parnell 1975). Such natural changes in habitat availability do not jeopardize the displaced species when alternate sites are available. A problem today is that there are progressively fewer suitable sites that may be colonized by birds forced to relocate.

All of these types of problems are exacerbated by the increased restriction of colonial waterbirds to fewer and smaller suitable sites as human development progresses. Planned and coordinated dredged material deposition could play an important role in some regions in creating alternate nesting sites for birds displaced by such activities.

Wetland Nesters.—Nesting habitat essential to birds such as Forster's and Black terns, requiring palustrine, riverine, lacustrine or coastal wetlands, continues to disappear in North America. Wetlands are also important feeding sites for both ground and tree nesters. A significant portion of the wetlands in the United States have disappeared as a result of draining, filling, damming and flood control projects (Frayer et al. 1983, Burger and Shisler 1978). In other cases, competition for water by the growing human population dictates water distribution, and often this results in too much in some habitats and too little in others. The situation is becoming desperate in some states as development chips away at remaining wetlands.

The loss of wetland function owing to water diversion and flood control practices has as great an impact as drainage. Colonial waterbirds that feed in wetlands are attuned to seasonal patterns of hydrologi-

cal fluctuations (Kushlan in press). Disruption of these patterns can lead to lowered nesting success and population decreases. Thus, protection of wetland habitat is only the first step in colonial waterbird conservation; such wetlands must also be managed to provide appropriate feeding and nesting conditions (Kushlan 1986b, 1987).

Environmental Contamination

Colonial waterbirds generally are high in food webs. Many contaminants biomagnify, leading to high contaminant residue levels in birds (Vermeer and Peakall 1977, Ohlendorf et al. 1978a, Gochfeld and Burger 1982). At this time there are no North American colonial waterbird species known to be at risk of extinction because of contaminants. There are, however, individuals and in some cases populations that are being seriously affected either through direct mortality, decreased reproductive success, or degradation of feeding habitat. Four major groups of environmental contaminants are known to affect North American colonial waterbirds. They include petroleum, organochlorine compounds, organophosphorus pesticides, and metals.

Petroleum.—The effect of petroleum contamination in the estuarine zone is summarized by Ohlendorf et al. (1978a) and Albers (1982). Most oil contamination in the marine environment arises from transport and refining operations. Only three percent of oil in the marine environment is estimated to come from catastrophic spills (Farrington 1977). Chronic low-level pollution could also be potentially more dangerous to estuarine or marine ecosystems than isolated catastrophic spills (Stenzel et al. 1988). Gauging the direct mortality of such pollution, or even of isolated spills is a complex and major undertaking (Carter and Page 1988).

Direct effects of oil include mortality due to plumage oiling, mortality of eggs as a result of the transfer of oil from adults (Vermeer and Vermeer 1975, Ainley et al. 1981, Parnell et al. 1984), and reduced reproduction due to ingestion of oil (Hartung 1965, Albers 1982). Indirect effects can occur by decreasing the prey available.

Millions of barrels of produced water (brine) contaminated with water soluble fractions of oil, as well as small droplets of oil, are discharged daily into bays and bayous in Texas and Louisiana. Sediments in the receiving areas are usually heavily contaminated with aliphatic and aromatic hydrocarbons (Armstrong et al. 1979) resulting in a severely depressed aquatic fauna (Heffernan 1972). Dikes adjacent to evaporation pits used to dispose of oil-field brine attract some nesting terns and plovers. Young and adults become oiled when they enter the pit water to escape disturbances.

The biggest gap in our knowledge is the long-term effect of chronic oil contamination. Areas of concern include large shipping ports, heavily used shipping lanes, offshore drilling sites, and onshore drilling sites with brine discharge (e.g. Ainley and Lewis 1974).

Organochlorines.—Organochlorine contaminants do not appear to pose a continent-wide threat to colonial waterbirds. However, there are several hotspots where survival and reproduction of local colonial waterbird populations are being adversely affected (Ohlendorf et al. 1978a, Nisbet 1980).

Data from the Pesticide Monitoring Program 1980-1981 (Schmitt et al. 1985) indicate that, with a few exceptions, significant declines in total DDT are occurring in fish throughout the United States; the process, however, is slow. Residues of total DDT near former DDT manufacturing sites in Alabama and Arkansas remain substantial. A significant downward trend in polychlorinated biphenyls also is occurring in the United States. Dieldrin concentrations showed no trends and remained highest in the Great Lakes and Hawaii. Toxaphene concentrations have reached a plateau after a steady increase through the 1970s. Chlordane concentrations have decreased slightly. Other organochlorines were found at relatively few stations or were characterized by relatively low concentrations.

Data from waterbirds indicate that organochlorine poisoning is continuing. Although endrin, DDT, and dieldrin were banned in 1964, 1972, and 1975, respectively, these chemicals have caused mortal-

ity years later (Ohlendorf et al. 1981, Boellstorff et al. 1985). DDT is still in the environment, and existing residues have been shown to affect avian reproduction (i.e., Custer et al. 1983, Henny et al. 1984). Great Blue Herons and Black-crowned Night-Herons have been diagnosed as dying from dieldrin or DDE poisoning, while endrin was shown to be a factor in the death of American White Pelicans. Residues of DDE in eggs of colonial waterbirds seem to be picked up at breeding areas along the Atlantic (Ohlendorf et al. 1978b, Custer et al. 1985, Nisbet and Reynolds 1984) and Gulf coasts (White et al. 1984) and in the Canadian Great Lakes (Mineau et al. 1984). In contrast, DDE residues in eggs from the Intermountain West seem to have been picked up on the wintering areas (Henny et al. 1984, Henny and Blus 1986, Henny et al. 1986).

Current environmental levels of PCBs do not seem to pose a threat to survival or reproduction (Eisler 1986a). In contrast, PCBs in Black-crowned Night-Heron embryos from San Francisco Bay were associated with reduced embryo size or development (Hoffman et al. 1986). Dioxins have been associated with low reproduction of herring gulls in Lake Ontario (Stolzenburg and Sullivan 1983, Eisler 1986b).

Organophosphorus Pesticides.—Organophosphorus compounds have replaced many organochlorines and are now the most widely used pesticides in North America (Grue et al. 1983). Reports of unintentional poisoning by organophosphorus pesticides include Great Blue Herons, Great, and Snowy egrets (Zinkl et al. 1981), Laughing (White et al. 1976), Ring-billed (Hill and Fleming 1982), Black-headed (Koeman 1979), and Franklin's gulls (White and Kolbe 1985). Sublethal exposure can affect physiological and behavioral characteristics necessary for survival and reproduction (White et al. 1983a). Indirect effects on wildlife can occur through reduction in the prey base. Toxicity varies with the chemical, level of exposure, animal species, sex, and physical condition. If an animal survives organophosphate exposure, it may return to "normal" within about a month. Persistence of most organophosphorus pesticides varies from a few hours to several weeks. Although these pesticides may affect local populations (White et al. 1983b), we have no indications that organophosphorus pesticides have had a major effect on any wading bird species.

Exposure routes of organophosphorus pesticides include: agricultural fields sprayed with pesticides and used as feeding areas; agricultural drains used by colonial waterbirds; and estuarine areas used by colonial waterbirds and located at the mouths of agricultural drains (Mitchell and White 1982, White et al. 1983b).

Metals and Related Elements.—Most metals and related elements do not reach environmental concentrations shown to effect survival or reproduction in the laboratory. Notable exceptions include mercury, lead, arsenic, and selenium. Aquatic birds accumulate mercury in their tissues (Vermeer and Peakall 1977, Ohlendorf et al. 1978a, Goede 1985, King and Cromartie 1986). High mercury concentrations in aquatic organisms are often related to discharges from chlor-alkali plants, pulp mills, and other industrial plants that use mercury. Studies of penned birds indicate effects of mercury on reproduction (i.e., Heinz 1979). Fimreite (1974) reported reduced fledging success of Common Terns in a mercury-contaminated area.

Lead contamination is recognized as a problem for marine birds and waterfowl and the predators that eat waterfowl (Fimreite et al. 1971, Munoz et al. 1976, Ohlendorf et al. 1978a, Goede 1985). The primary cause of lead poisoning in North American birds is lead shot used by hunters. Lead contamination also may be a problem for colonial waterbirds. An estimated 25% of White-faced Ibis along the upper Texas coast had lead pellets in their gizzard (Hall and Fisher 1985). The effects of lead contamination on this species and other colonial waterbirds are unknown.

Arsenic compounds have been widely used in agriculture as insecticides and herbicides, have been associated with fish kills (Sandhu 1977), and aquatic birds feeding in areas of high arsenic use accumulate arsenic in the tissues (Goede 1985). We know of no field studies linking arsenic to impaired reproduction or lowered survival of aquatic birds. A potential secondary effect of arsenic is on the prey base through reduction in aquatic vegetation.

The effects of selenium on wildlife was discussed by Eisler 1985, Goede 1985, and Ohlendorf in press). Ohlendorf et al. (1986) reported severe reproductive effects on aquatic birds nesting at irrigation drainwater ponds in the San Joaquin Valley, California. It was concluded that selenium was the probable cause of poor reproduction. Just how widespread selenium contamination is in North America and how much of a threat it is to colonial waterbirds is unknown.

Other Contaminants.—Other contaminants that may affect colonial waterbirds include industrial waste products such as organic solvents, chlorinated phenols, phthalate esters, antifouling compounds (i.e., tributyltin), and intermediate chemicals used in synthesis of herbicides and plastic compounds. Several types of environmental contaminants were not discussed in this review because there is no evidence of direct toxic effects of these contaminants on colonial waterbirds. Some of the contaminants not listed include herbicides, pyrethroid insecticides, polychlorinated styrenes, polychlorinated diphenyl ethers, and plastic particles (Ohlendorf et al. 1978a, Fry et al. 1987). Although these chemicals may not directly influence mortality or reproductive success, indirect effects on the food resource may be substantial. Ingestion of plastic, however, has been linked recently to the distress of seabirds, although not at the population level (Day et al. 1985, Ryan 1987, 1988a & b). The threat of deterioriation of wetland ecosystems from acid precipitation is also a serious concern.

Alteration of Food Webs

Many coastal marine birds feed at the same trophic level as humans, sometime taking the same prey (Brown and Nettleship 1984, Furness and Ainley 1984). Well-known examples of overharvesting of certain fish stocks, which led to major reductions of bird populations, exist for Peru and South Africa (Schaefer 1970, Crawford and Shelton 1978). In California, the disappearance of sardines (*Sardinops caerulea*) led to declines, or prevented recovery, in bird populations (MacCall 1984), but the extent to which the large (but now extinct) commercial fishery was involved is not clear.

Brown and Nettleship (1984) propose that overfishing of capelin (*Mallotus villosus*) off Newfoundland may be responsible for reduced nesting success by Atlantic Puffins during recent years; puffins have similarly been affected by a fishery in Norway (Barrett et al. 1987). Springer and Roseneau (1985) have proposed that overfishing of walleye pollock (*Theragra chalcogramma*) in the southeastern Bering Sea may be responsible for reduced nesting success of Black-legged Kittiwakes in that region. Changes in prey availability in this same fishery may have resulted in reduced survival of subadult murres (Murphy et al. 1986).

Fishery-caused changes in food webs have also benefited some seabird populations. In Britain, exploitation of certain predatory fishes has resulted in an increase in the availability of prey for competitors, including birds; in response, populations of some seabirds have increased (Furness 1982). Similarly, in the Bering Sea, where pollock, which feed on zooplankton, have been reduced in numbers, more food may now be available for other planktivores (i.e. auklets), which could explain recent population increases (Springer and Roseneau 1985).

Diseases and Parasites

The gregarious habits of colonial waterbirds provide opportunity for rapid spread of contagious diseases. Diseases and parasites have caused substantial mortality in various species. Avian cholera, caused by the bacterium *Pasteurella multocida*, has been reported or suspected in gulls, herons, and terns (Rosen and Bischoff 1949, Korschgen et al. 1978, Montgomery et al. 1979). Nesting Common Eiders have been especially hard hit by this disease, with as many as 1000 adult females affected in the St. Lawrence estuary in 1964 (Reed and Cousineau 1967).

Avian botulism, a paralytic disease caused by the ingestion of toxin produced by the bacterium *Clostridium botulinum*, also has been known to kill colonial waterbirds. Several types of this disease are known. Type C or E are known to have killed Brown Pelicans, White Pelicans, Northern Gannets, Common Murres and several species of gulls and terns (Reilly and

Boroff 1967, Rosen 1971, Jensen and Price 1987, Brand et al. 1988).

Chlamydiosis, an infectious disease caused by a rickettsia-like intracellular parasite, *Chlamydia psittaci*, occurs frequently in herons, egrets, and ibises and occasionally in gulls and terns (Locke 1987, Burkhart and Page 1971). It is of particular interest because it can be transmitted to humans (Wobeser and Brand 1982).

Verminous peritonitis, caused by the nematode *Eustrongylides* sp. has been reported in herons and egrets (Locke 1961, Cooper et al. 1978, Windingstad and Swineford 1981). Mortality in these species was attributed to this organism in Delaware in 1976 (Weise et al. 1977) and Louisiana in 1985 (Roffe 1988).

Although the factors discussed above are known to occasionally cause mortality among colonial waterbirds, their impact on populations is unknown. Numerous other parasites have been found in waterbirds, but their significance, in terms of mortality, is also very poorly understood.

Disturbances at Colony Sites

Disturbances at breeding, feeding and roosting sites have been recognized for a long time and have been well documented during the past 10 to 15 years. These problems range from factors having minimal effects to those that compromise breeding activities and that may result in complete site abandonment. Such disturbances generally result from the effects of weather, human activities, research, predation, and noise from aircraft and other machines.

Human activities are a major factor in the disturbance of breeding and foraging by birds (Hunt 1972, Ainley and Lewis 1974, Gillet et al. 1975, Roberts and Ralph 1975, Johnson and Sloan 1976, Werschkul et al. 1976, Ellison and Cleary 1978, Manuwal 1978, Campbell 1979, Duffy 1979, Shugart et al. 1979, Tremblay and Ellison 1979, Anderson and Keith 1980, Cairns 1980, Hand 1980, Parker 1980, Burger 1981a, Burger 1981b, Bunnell et al. 1981, Desgranges and Reed 1981, Rodgers and Burger 1981, Parsons and Burger 1982, Safina and Burger 1982, Fetteroff and Blokpoel 1983, Vermeer and Rankin 1984, Jackson and Jackson 1985, Kushlan and Frohring 1985, Vos et al. 1985, and Hill 1986).

When disturbed, adult birds fly away from their nests. Some species, e.g. the Green-backed Heron, go a short distance, alight and watch their nests (Ensor, pers. comm.). Other birds such as herons, gulls, terns, and murres may circle overhead or fly some distance away. Cormorants depart for the water where they remain until the cause of their fright is gone. If the disturbance is minor, just a few birds react (usually those not incubating); if major or prolonged, the whole colony may react by temporarily deserting the site (Mueller and Glass 1988). Short disturbances (automobiles, aircraft) permit the birds to return to their nests rapidly. Lengthy disturbances (humans on foot) may keep them from their nests for a longer period; both adults leave eggs or young nestlings, thus, exposing them to avian predators such as crows (Shields and Parnell 1986), to cold, or on a hot summer day to a lethally hot temperature (Kury and Gochfeld 1975). Birds may not abandon a site because of frequent human disturbance, but reproduction may be impaired.

Birds may become habituated to disturbances such as sounds of passing airplanes or boats, and may feed at the edge of a busy highway or airport taxiway and pay no attention to the noises. Heron colonies are even established near houses, within cities (Dusi 1985a). The herons tolerate and perhaps derive benefit from human presence at the periphery of the colony site, but when people enter the site, the disturbance they cause may be disruptive to nesting. When herons are establishing nests, egg laying, or incubating, a disturbance may cause nest and colony site abandonment, but after eggs are hatched, even great and frequent disturbances may not cause desertion (Dusi 1983).

Disturbance of beach colonies of gulls, terns, or shorebirds depends upon the ease of access to the beach (Buckley and Buckley 1976, Taylor et al. 1982). In highly populated areas, unprotected colonies often are vandalized or driven through by off-road-vehicles or horseback riders. They may be affected also by spraying for mosquito control. Isolated beaches are usually safe in comparison (Buckley and Buckley 1976).

Often people can easily enter upland colonies. Herons may even be shot for "sport" (Dusi 1958) or for food if protection is lax (Dusi pers. obs.). Swamp colonies are not as easily disturbed by people, especially if the vegetation is thick enough to keep boats out, and disturbance is usually peripheral.

Heron colonies on islands are somewhat protected by the water barrier. If the island is well above water and the surrounding water deep, boats can easily approach and disturbances may result (Vermeer 1970, Pullin 1983). If the island is low and marshy or the water too shallow for most boats, e.g., Cat Island, Alabama, then people can not easily disturb the colony (King pers. comm.).

Gulls, terns, shorebirds, pelicans, or murres occupying insular colonies are disturbed also by people if, like heron colonies, they are elevated well above water level and easily approached by boat. Sites with sandy beaches are especially desirable to boaters seeking isolated beaches (J. F. Parnell pers. obs.). Least Terns on some heavily developed Mississippi beaches, however, appear to have benefited from a lack of natural predators usually associated with beaches (Jackson and Jackson 1985).

Gull and tern colonies in urban/industrial areas are highly vulnerable to disturbance by people and their pets, yet many sites (dredged-material deposits, breakwaters, dump sites) appear attractive to these birds. Disturbances by people and off-road-vehicles are difficult to control at unprotected sites (Blokpoel and Tessier 1986), but such colonies may persist with protection (Jackson and Jackson 1985).

Domestic animals, such as unleashed dogs may flush birds that are nesting, feeding, or roosting and disrupt nests and eat nestlings and eggs. Feral cats are sometimes serious problems on beaches and adjacent marshlands. Cats kill ground nesting species and occasionally young herons in upland colonies, even climbing trees to nests (McKitrick 1975). They are not found generally in swamps or on isolated islands. The night-time presence of domestic animals may cause great disturbance to ground nesting birds. Cattle and horses pay little attention to ground-nesting birds, but may accidentally trample nests or disturb colonies during feeding activities (J. F. Parnell pers. obs.). Hogs may destroy nests and eat eggs and nestlings. Mammals such as the introduced nutria (*Myocaster coypus*) also may cause disturbance and even colony abandonment when nocturnal foraging takes them into colonies of ground nesters such as Laughing Gulls (J. F. Parnell, pers. obs.).

Research activities, especially trapping and handling, may interfere with normal breeding activities and reduce productivity (Southern 1972, Blokpoel 1981, Brubeck et al. 1981, Gochfeld 1981, Nisbet 1981, and Southern and Southern 1983). Experimental egg removal also has been shown to influence production (Feare 1976), and some marking techniques alter reproductive behavior (Southern and Southern 1985). As these factors received greater recognition in the 1970s and 1980s, interest was directed at mitigating the effect of researcher presence (Kress 1983, Cairns et al. 1987, Ainley and Boekelheide in press).

Competition and Predation at Colony Sites

A dynamic equilibrium exists among species that compete for a shared resource such as nesting habitat. However, when one species greatly increases in numbers, it may encroach upon the nesting space of other species and eventually take over an entire site as is happening in the Great Lakes where Ring-billed Gulls are usurping nesting areas of Common Terns and, to a lesser extent, Caspian Terns (Blokpoel and Tessier 1986). Increasing murre and cormorant populations on the Farallon Islands displace Western Gulls (Ainley and Boekelheide in press).

Herons may compete for nesting sites and materials with others of their species and with other species nesting at the same colony site, but sites and materials are seldom limiting. Cattle Egrets have been observed pecking Little Blue Heron nestlings until forced from their nests, then taking over the nests (McKitrick 1975, Dusi 1966); they have taken over heron nests containing eggs (Dusi and Dusi 1970).

Predation is a natural occurrence and becomes of management importance when it adversely affects declining species or when it affects a large portion of a colony. A variety of avian predators have been

identified (McNicholl 1973, Emlen et al. 1966, Nisbet 1975, Andersson 1976, Kruuk 1976, Montevecchi 1977, Conover and Miller 1979, Southern and Southern 1979, Southern et al. 1982, Vermeer et al. 1984, Kilham 1985, and Shields and Parnell 1986), but perhaps most unusual is the eating of Common Tern eggs by the Canada Goose (*Branta canadensis*) (Courtney and Blokpoel 1980).

The colonial habit makes birds especially susceptible to predation during the breeding season, because once a colony is located predation may continue for many days and may result in the complete failure of the colony. Great Horned Owls (*Bubo virginianus*) were implicated in a colony failure of Common Terns in southern Manitoba (Hebert 1985), and in losses of California Gull chicks in a California colony (Jehl and Chase 1987). Coyote (*Canis latrans*) predation caused site abandonment by California Gulls at Mono Lake, California, when decreasing lake levels allowed coyote access to the colony (Winkler 1981). Grey fox predation resulted in the abandonment of a small heronry in North Carolina (J. F. Parnell pers. obs.), and intense red fox (*Vulpes vulpes*) predation reduced reproductive success of a Ring-billed Gull colony significantly over a nine-year period (Southern et al. 1985). Bald Eagles were seen feeding repeatedly on Royal Tern and Brown Pelican chicks in North Carolina colonies, however, without colony abandonment (J. F. Parnell pers. obs.).

Gull predation is especially damaging to eggs and nestlings of many species on the East Coast (Johnson 1938, Hatch 1970, Southern and Southern 1984). Increases in Herring and Great Black-backed Gull populations in New England resulted in increased predation by gulls on chicks of Common and Arctic terns, and thus contributed to a 40-year decline in Maine tern populations (Kress 1983). Gulls also affected reproductive success through competitive interactions (Burger 1979). Under unaltered conditions, gulls may benefit other species nesting nearby by mobbing predators such as foxes and crows (see review in Poysa 1988).

Crows are known predators on the eggs and chicks of many species. Shields and Parnell (1986) documented Fish Crows (*Corvus ossifragus*) taking nearly 50% of the eggs from marked nests in a White Ibis colony in southeastern North Carolina. Black-crowned and Yellow-crowned Night-Herons also eat other nestlings in colonies (Bent 1926, Palmer 1902, Hunter and Morris 1976).

Mammals including opossums (*Didelphis virginiana*), raccoons (*Procyon lotor*), bobcats (*Felis rufus*), foxes, (Kadlec 1971, Shugart 1977, Patton and Southern 1978, Patton 1979, Lensink 1984, Moors and Atkinson 1984, Southern et al. 1985), river otters (*Lutra canadensis*) (Vermeer et al. 1988a), and rats, have been identified as predators on colonial waterbirds, and on nestlings (McKitrick 1975). A few mammals, e.g., mink (*Mustela vison*) prey on nestling herons in swamp colonies (Summerour 1971) and terns in marsh colonies (McNicholl 1982). Norway rats (*Rattus norvegicus*) prey on ground-nesting gulls, terns, and alcids (Austin 1948, Campbell 1968). The striped skunk (*Mephitis mephitis*)is an acknowledged predator of eggs and young of ground-nesting birds (Godin 1982). Domestic mammals, especially feral, or free-ranging dogs, and cats also eat gulls, terns, and nestling herons fallen from nests in upland colonies (McKitrick 1975).

Mammalian predation often occurs at night (Southern et al. 1982), and under these circumstances it is compounded by severe disturbance; colony abandonment appears much more likely than under similar levels of diurnal predation (Southern et al. 1985).

Snakes, especially rat snakes (*Elaphe obsoleta*), eat heron eggs and young (Dusi and Dusi 1987), and garter snakes (*Thamnophis sp.*) are also known to eat gull (Campbell 1969, Fetterolf 1979) and Common Tern chicks (Southern et. al. 1985).

Weather and Climate

Climatic events may alter a colony site so greatly that it is temporarily or perhaps permanently unsuitable for use. Local flooding and changes in water levels in lakes, rivers, or bays may inundate nesting sites. Such conditions may displace ground nesting species during a particular breeding season or may permanently eliminate a site (Houston 1962, Scharf 1981,

McNicholl 1985). High water levels also tend to increase erosion rates from currents and wave action. The loss of islands through erosion may be more serious today than in the past as suitable sites are declining in some areas (Parnell et al. 1984). Sites lost may be protected ones, and displaced birds may be faced with attempting to nest at less optimal alternate sites where disturbance or other problems are more likely.

Flooding by rain or high tides may cause ground-nesting birds to abandon a site, and eggs and nestlings may be destroyed (Erwin and Smith 1985). Flooding of large rivers may inundate nesting sites in floodplains and estuaries. If flooding occurs soon after colony establishment, the birds may seek another nesting site but not always (Frederick 1987) . Flooding later in the season may result in failure to reproduce for a season. This frequently happens to colonies along the Atlantic Coast and along rivers such as the lower Alabama-Tombigbee River system (J. L. Dusi pers. obs.). Gulls in Florida (Frohring and Kushlan 1986) and terns nesting on natural beaches in North Carolina (J. F. Parnell pers. obs.) are very susceptible to nest destruction caused by flooding by tide surges during "northeasterly" storms and by flooding during heavy rains associated with summer thunder storms. The entire reproductive effort of Least Terns on North Carolina beaches was lost in 1975 due to frequent storm events (J. F. Parnell pers. obs.). On the Maine coast, earlier nesting by Herring and Great Black-backed gulls have displaced Common Terns from many higher nesting islands causing them to nest on low islands and ledges where they are more vulnerable to flooding (Kress 1983). Species that nest on river bars and beaches have evolved life-history strategies to cope with occasional inundation of sites. This usually involves the ability to relocate and renest quickly (Hardy 1957). They encounter difficulty, however, if alternate sites are not available.

Weather has many direct and indirect effects on breeding, feeding, and roosting birds, but reproductive strategies of long-lived species, such as colonial waterbirds, are able to compensate for the occasional loss of a season's reproductive effort (Ainley and Boekelheide in press). Human disturbances, however, may exacerbate the effects of weather, particularly at critical periods such as the peak of hatching (W. E. Southern, pers. obs.). The effects of inclement weather, although unquestionably a natural factor, can be especially severe when birds are breeding in large concentrations, particularly threatening those sensitive species that have reduced numbers and are nesting at only one or a few locations (White et al. 1976, Thompson 1978, Quay 1963, Burger 1982, and McNicholl 1982). Quay (1963) described the complete destruction of a heron colony in southeastern North Carolina in early June by a hail storm, but noted that a strong renesting effort partly offset losses for that season. Hurricanes can be devastating to waterbird colonies. Tern colonies along Gulf of Mexico beaches have suffered heavy losses during such storms (White et al. 1976, Jackson and Jackson 1985), and a hurricane removed nesting and roosting herons from Cat Island, Mobile County, Alabama (J. Dindo pers. comm.). Near-passage of a water spout caused abandonment of a Brown Pelican colony (Kushlan and Frohring 1985). Through its influence on food supply, weather patterns can affect water birds over large regions (Ainley et al. in press, Ainley and Boekelheide in press).

Human-Caused Mortality

Accidents and other kinds of direct mortality may take a high toll among a local population (Avery 1978, Spear et al. 1987), and if mortality is human-caused (such as an obstacle like a power line installed near or over a waterbird colony) there would be good justification for alleviation of the problem.

Bird entanglements are frequent human-caused accidents. In some cases only a few individuals are entangled, as when birds become entangled in discarded fishing line. Drowning of diving birds such as loons, auks, and cormorants entangled in the nets of fishermen may, however, have a serious impact on bird populations and warrants the serious concern of wildlife managers (Nettleship 1977, Atkins and Heneman 1987, Craven and Lev 1987).

Shooting, trapping and egging are normally illegal under U.S. (federal and state)

and Canadian (federal and provincial) law although it is still fairly widespread in Latin America during the boreal winter. Special permits are required in cases where birds cause serious damage to human interests. When Newfoundland joined the Canadian Confederation in 1956, the traditional murre hunt was allowed to continue (Phillips 1934). Newfoundlanders can hunt murres without permits or bag limits, but not for sale. The Canadian Wildlife Service is considering regulations to prevent overhunting (R. D. Elliot, pers. comm.).

Pests

In a few cases problems arise due to colonial waterbirds becoming overabundant in certain areas. When numbers quickly increase, the birds may cause conflicts with human interests or conflicts with other bird species. Impacts may range from trivial to fatal. We discern three categories of problem birds including nuisance birds (causing minor annoyance or inconvenience), pest birds (causing economic damage) and hazardous birds (posing threats to human health and safety).

Nuisances caused by colonial waterbirds range from occasional or repeated defecations on wharfs, boats, or cars, to aggressive gulls begging for food in parks and beaches, and to the noise and smell emanating from colonies near areas of human settlements.

Colonial waterbirds have caused crop depredation (e.g., Ring-billed Gulls feeding on tomatoes, Blokpoel and Tessier 1986), predation in fish ponds (e.g., cormorants feeding on fish stock, F. Boyd pers. comm.), damage to woodlots (e.g. a heronry located in a woodlot may reduce the value of the timber, Dusi 1983), damage to roofs (gulls loafing on roofs may tear out insulation material and their shed feathers may block drainage screens Vermeer et al. 1988), and miscellaneous damages, such as gulls taking feed at turkey farms and zoos.

Hazzards caused by birds include both safety and health concerns. Gulls are a hazard at airports world-wide because of their relatively large size, slow flight, soaring behavior and gregarious nature (Blokpoel 1976, 1980, 1984, Solman 1978, and Burger 1985). Public health may be a concern in situations where bird feces contain human pathogens or when accumulated fecal deposits create an appropriate environment for human pathogens. Gulls roosting in large numbers on a water storage reservoir near Glasgow, UK, contributed substantial bacterial pollution to the reservoir (Benton et al. 1983). Recently a few cases of histoplasmosis associated with a Ring-billed Gull colony were reported (Southern 1986). The fungus *Histoplasma capsulatum* grows well in accumulations of droppings of birds, bats, and livestock. People can contract the disease histoplasmosis by inhaling the spores of the fungus.

SOLUTIONS

Habitat Improvement

Both nesting and feeding habitats can sometimes be managed for the benefit of colonial waterbirds (Buckley and Buckley 1976, Soots and Landin 1978, Kushlan 1987). The most effective management involves site protection and structural manipulation. Where limited, colony sites can be established by creating islands (Fig. 4). Many birds use dredged-material islands that resulted from maintenance of shipping channels both along coastal and inland waterways. A nationwide research effort in the United States on dredged-material resources conducted by the U. S. Army Engineer Waterways Experiment Station produced a series of regional reports documenting the use of dredged-material sites by colonial waterbirds (Soots and Par-

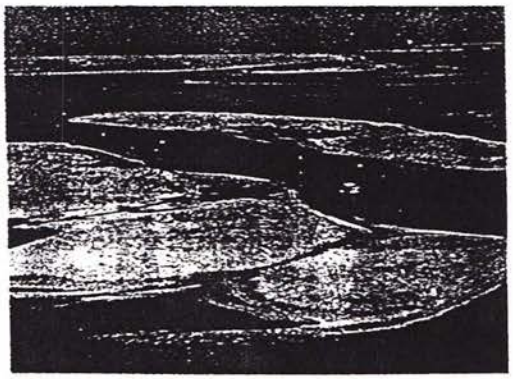

Figure 4. Hydraulic dredge working a channel in southeastern North Carolina, creating a new island. Photograph by James F. Parnell.

nell 1975, Portnoy 1977, Buckley and McCaffrey 1978, Chaney et al. 1978, Lewis and Lewis 1978, Peters et al. 1978, Scharf 1978, Schreiber and Schreiber 1978, Thompson and Landin 1978). In North Carolina, use of dredged-material sites is very high, with nearly 80 percent of all coastal colonial waterbirds nesting on these man-made sites in 1983 (Parnell et al. 1986). Dredging and the deposition of material in the United States is generally under the control of the U. S. Army Corps of Engineers, and the deposition of such material in wetland or aquatic environments is subject to review by fisheries and wildlife agencies. It is generally not legally possible for the Corps of Engineers to construct islands explicitly for birds, but it is sometimes possible to place dredged material where it is needed in local colonial waterbird management plans provided it is also cost effective and serves the needs of waterway maintenance. Close coordination between concerned agencies is necessary to assure that channel maintenance, avian management, and protection of other natural resources are congruent.

Normal plant succession on dredged-material islands often results in a series of sites usable by both ground and arboreal nesting species (Soots and Parnell 1975, Lewis and Lewis 1978, Schreiber and Schreiber 1978). Management can alter normal community succession by removing vegetation to maintain conditions suitable for pioneer ground nesting species (Worsham et al. 1974) (Fig. 5), and plantings can speed succession toward woody vegetation for arboreal nesters (Jackson and Jackson 1985).

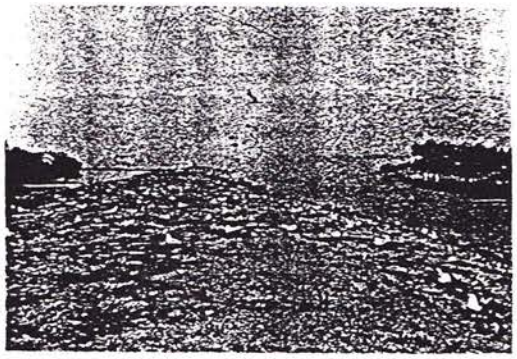

Figure 5. Common Terns nesting at a site from which vegetation had been manually removed to create appropriate habitat. Photograph by Hans Blokpoel.

There are techniques for attracting target species to islands once appropriate habitat is available. Decoys have been successfully used to attract Least Terns (Massey 1981, Kotliar and Burger 1984), Common and Arctic terns (Kress 1983) and wading birds (Dusi 1985b) to potential colony sites, and artificial nest sites, such as boards and old tires, were used to attract terns (Spendelow 1982).

Feeding habitat can also be manipulated. At the extreme, feeding ponds can be provisioned and presented to birds at appropriate times, as McIlhenny (1934) did in the early 1900s and as is proving successful for Wood Storks in northern Georgia (McIlhenny 1934, Coulter et al. 1987). Shallow impoundments managed for waterfowl also provide attractive habitat for other birds (DeVoe et al. 1986) and offer potential for management. Natural habitats can also be managed by manipulating water levels to enhance food availability (Kushlan 1987).

Environmental Improvements

Alternative methods of disposal of oilfield brine in coastal areas are needed. Evaporation pits, especially, should be eliminated and graded to the natural contour of the area. Similarly, organochlorine contamination today is mostly due to residual compounds in soil or sediment that may be transported during rainfall or relocated during dredging operations. Areas that are known to be organochlorine hotspots should be managed in a way that allows runoff to collect in detention ponds or basins. Detention areas can then be drained after the runoff event in a manner that retains the sediment. Drying and removal of sediment and disposal in accordance with local hazardous waste disposal laws would eliminate movement of contaminants into estuaries.

Reduction of organophosphates in the environment can best be accomplished by managing their application. Many organophosphates are short-lived, and colonial birds could be dispersed from contaminated areas until the compound has degraded to a safe level. An effort should be aimed at coastal mosquito control agencies to reduce routine or "insurance" spraying in coastal wetlands. Retention of

water that has received an organophosphate pesticide for a period of time equal to the half life of the compound would further reduce the hazard to waterbirds in nearby wetlands.

Toxic heavy metals are usually limited to habitats that receive runoff from industrial or large urban areas. Arsenic and selenium contamination, however, may be found in areas receiving subsurface agricultural drainage water. Metals are usually bound to fine sediment particles and accumulate in the substrate. Dredging of waterways and disposal of the dredged material in open water may re-suspend these metals. Environmental improvement to reduce exposure of waterbirds to toxic heavy metals should include upland disposal of contaminated dredged-material in places where the sediments can be dried and planted with vegetation (Saucier et al. 1978). Such practice would reduce erosion and subsequent transport of contaminants back into the wetlands.

Reductions of the levels of various other contaminants in sensitive environments will require alerting regulatory agencies to the presence of these chemicals, their un-metered release, and the danger to birds. A review of draft permits issued by the U. S. Environmental Protection Agency indicates that many of these chemicals are released to aquatic systems via discharge of processed wastewater from industries. The wastewater is monitored for such parameters as chemical oxygen demand (COD), or total organic carbon (TOC), without regard to the chemical compounds that make up these two parameters in the discharge. Improvement to this system should include mandatory acute toxicity bioassays before wastewater release.

Control of Disturbances

People control is a foremost aspect of colonial waterbird management. Visitors come to colonies for many reasons: bird watching, curiosity, scientific studies, and even vandalism. The distance at which disturbance occurs will vary greatly depending on species and stage of nesting. The length of time minimal disturbance can occur without damaging colony members, through exposure of eggs and nestlings to weather and predators, also varies with environmental conditions and other factors; and visits to colony sites must be carefully controlled in terms of time of day, proximity to nesting birds, and duration of visit.

Disturbance is especially critical to nesting success at certain stages of the breeding cycle. In most colonies this is the period from colony formation until nestlings hatch and achieve thermoregulation. Adult herons will seldom desert nests after chicks hatch (Dusi 1979, 1983). Nestlings will fall from nests if people pass too close, and colonies in shrub thickets where fallen chicks can not climb back into nests are vulnerable during the first two to three weeks after hatching.

During the critical disturbance period, visitors should be kept out of colonies. Scientists, working in colonies, should include a consideration and mitigation of the effects of disturbances in their study plans. Visitation should occur only during noncritical stages of breeding, unless studies concern these critical stages. All disturbances should be minimized by restricting visitation to short periods under appropriate weather conditions. Many studies can be done from hides, or blinds, and these can be entered during darkness or through tunnels (Shugart and Fitch 1981, Cairns et. al 1987) to minimize disturbance. Management and permitting agencies should require that these considerations be made explicit before permission is given for work in waterbird colonies.

All sand and tree colonies susceptible to disturbance should be posted and when possible fenced. Such posting should be educational and should keep both foot and off-road-vehicle travel clear of the colony site. Signs should be removed as soon as nesting is completed. Posting is most effective where backed up with regular patrol by uniformed authorities or concerned citizens. Although posting may draw attention to a colony, without it, visitors have no information to instruct their actions.

Personnel at the Cape Hatteras National Seashore, North Carolina, have been successful with a program of posting tern colonies on beaches. They wait until the colony is established, place signs around the entire site, and string a line between signs effectively fencing the colony. This, coupled with regular visits by

park personnel, has allowed colonies to be successful on sites near intense travel by off-road-vehicles (J. F. Parnell pers. obs.).

Reduction of Natural Interactions

There is normally a natural level of competition and predation between different bird species, but, as a result of human activities, these may become excessive and result in severe reduction or elimination of a nesting species at a colony site. If the impacted species is endangered, threatened, or of special concern for some other reason, it may be justified for wildlife managers to intervene in order to maintain or restore species diversity.

The methods that can be used to eliminate problem birds in interspecies conflicts involve habitat manipulation, scaring, and killing. The application of these methods is more complicated, however, when dealing with interspecific conflicts.

Habitat manipulations.—It is sometimes possible to modify habitat so that it becomes less suitable for the undesired species without also making it less attractive to the desired species. One successful example involved the installation of monofilament lines over former nesting habitat of Common Terns that had been taken over by Ring-billed Gulls (Fig. 6). After the installation of parallel lines 60 cm apart and about 60 cm above the ground the gulls gave up the site. Tern decoys below the wires were then used to attract Common Terns which re-occupied their former nesting area. As tern nesting progressed, lines were removed and the terns were able to hold on to the site, probably because the gulls had already relocated elsewhere (Blokpoel unpubl. data, M. Richmond pers. comm.).

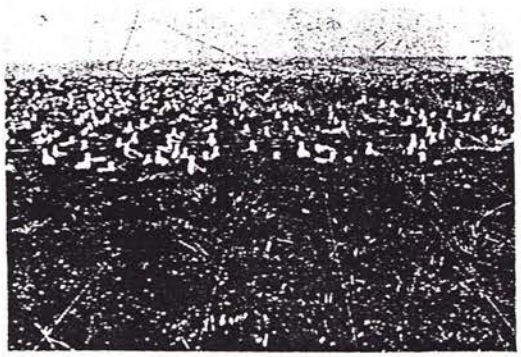

Figure 6. Gulls were prevented from nesting in the foreground by the installation of monfilament lines. Photograph by Hans Blokpoel.

Scaring of problem birds.—Although scaring an undesired species will usually also scare the desired one, asynchronous arrival of species may allow scaring of problem birds prior to arrival of desired species (H. Hayes, pers. comm.). In one case, tethered birds of prey resulted in Ring-billed Gulls abandoning traditional colony sites at the Eastern Headland of the Toronto Outer Harbour, after which Common Terns occupied the site and nested successfully within view of tethered raptors (Waterman 1985).

Killing problem animals.—In some cases, killing may be the only method that will reduce excessive competition or predation. An example of vigarous long-term gull control occurred during the reintroduction of Atlantic Puffins and Arctic Terns at Eastern Egg Rock, Maine (Kress 1983). The program involved shooting and poisoning adult Herring and Great Black-backed gulls and destruction of their eggs and chicks over a nine-year period, during which time the terns became reestablished. At colonies in Ontario, gull nests were destroyed to reduce competition between Ring-billed Gulls and Common and Caspian terns (H. Blokpoel, unpubl. data).

Some predators can be captured by using traps or nets, and others may be excluded by fences. Native predator species should be released where they cannot return to the colony site. Feral cats and dogs are best eliminated directly. Shooting is the only way to remove some predators. It should be unobtrusive and with proper permits. Carcasses of predators should be provided to museums when possible (Wood 1976).

It should also be noted that there may be dramatic differences in level of predation and in the final effect of the predator. Shields and Parnell (1986) reported the loss of nearly 50 percent of marked White Ibis eggs in a study in a southern North Carolina colony. In spite of this apparent heavy level of predation, replacement clutches allowed the number of young White Ibis fledged per nest to be about the same as found in other studies, and more importantly the colony is growing steadily.

Killing problem birds and predators is usually a proximate strategy that ignores the ultimate problem, often human intrusion into otherwise natural systems. Decisions to kill birds should be joined with critical review of ways that the problem's human dimension can be minimized. Elimination of predators or competitors should always involve specific permits requiring detailed justification and an analysis of effects on regional populations of all species involved.

Multispecies Fishery Management

May et al. (1979) point out the needs and problems of multispecies fishery management, and further insights are provided by Furness (1984) and MacCall (1984). The management plan for the northern anchovy (*Eagrautis mordax*) contains provisions for preserving a prey base for the Brown Pelican (U. S. Dept. Commerce 1978), which at the time of drafting was considered an Endangered Species. That fishery plan, however, is unique in containing such a provision. Solution to the growing problem of alteration of marine food webs by fishing is one of education of the public and of fishery and wildlife managers. Progress is being made. The recently instituted Convention for the Conservation of Antarctic Marine Living Resources, to which the United States is a signatory, contains provisions for ecosystem management and the use of predators, including sea birds, to monitor ecosystem state. This kind of cooperative effort is needed on a much broader scale if bird populations are to be considered in the management of marine ecosystems.

Pest Control

Methods for controlling birds in conflict with humans are the same as for controlling predators. The control technique used should depend on the seriousness, extent and urgency of the problem, the rarity of the problem species, the locale of the problem, the humaneness, effectiveness, and side effects of the technique, and the availability of funds and personnel. The more serious the problem, the more likely that effective but unpleasant and controversial methods will be appropriate.

Habitat manipulations.—It is sometimes desirable to reduce the attractiveness of a site to the pest species. Habitat modification (maintaining long grass or undesirable crops) has been done at airports around the world in efforts to prevent collisions between birds and aircraft (Blokpoel 1976).

Control of birds using water can be accomplished by draining, filling, levelling or pumping but this is inappropriate in natural habitats. Stainless steel wires or monofilament lines installed in parallel rows over the water are effective in keeping gulls and herons out of natural ponds, fish ponds, hatcheries, and reservoirs (McAtee and Piper 1936, Blokpoel 1976, Amling 1980, Ostergaard 1981). The parallel lines of wire form a psychological ceiling through which gulls are unwilling to pass. Advantages are almost total effectiveness, long-term success, because the gulls do not appear to become habituated, and low cost of materials. Disadvantages are that installation and maintenance of the wires can be labor-intensive, wires and lines may break, accidents or vandalism may occur, and gulls become occasionally entangled (Blokpoel and Tessier 1983, 1984).

A control of gulls visiting public parks to scavenge for food (hand-outs, picnic remains, etc.) is to make the habitat less attractive and to introduce and enforce rules that prohibit people from feeding gulls or littering. Overhead lines have been used successfully to prevent gulls from landing on the tables of outdoor restaurants (Blokpoel and Tessier 1984).

Ways to make garbage dumps less attractive include making the garbage unavailable to the birds by dumping at night, covering dumped material with a layer of soil or dirt, enclosing the dump site in a large cage-like structure, and installing overhead wires. A mobile "tent", 10 m high × 36 m × 36 m, suspended between tall wooden masts mounted on moveable trolleys, allowed garbage trucks to dump without attracting gulls. The contraption resulted in an almost total reduction of gulls visiting the site (Ferns and Johnson 1982). Overhead wires have been installed on an experimental basis at sanitary landfills in Niagara Falls, New York, and near Jedburg, South Carolina. Properly spaced

overhead wires did deter birds, but species and seasonal differences in effectiveness were reported (McLaren et al. 1984, Forsythe and Austin 1984).

Scaring of problem birds.—There are no simple, cheap, effective ways to frighten problem birds from areas that are very attractive. On the other hand, even the most tenacious birds will leave an area if they are thoroughly and persistently harassed. The most common problem encountered in scaring birds is habituation, requiring the use of a variety of frightening devices in an imaginative, non-routine way (Risley and Blokpoel 1984, Southern and Southern 1984). Gulls on dump sites have been scared away successfully by persistent patrol operations, including the use of fire crackers (W. E. Southern and L. K. Southern 1984), or a combination of several devices (Risley and Blokpoel 1984).

Destruction of problem birds.—Destroying problem birds may involve direct killing or the prevention of reproduction by egg destruction (Thomas 1972). Problem birds are killed most easily at colony sites, but results are often short-lived as newcomers arrive and replace those killed. Other drawbacks are public opposition and the need for expert assistance to prevent undesired side effects, such as the shooting or poisoning of nontarget species.

Continued occupancy by gulls despite control efforts that continued over a 20-year period at a colony of Southern Black-backed Gulls (*L. dominicanus*) in New Zealand, shows that killing may not be an effective way to eliminate a problem (Caithness 1984). Multiple techniques such as egg collecting, scaring devices, and daily mowing of lawns may be needed, and it will often take years before an appreciable reduction of gull numbers can be expected as immigration of naive newcomers occurs.

It is obvious that control efforts are complex, costly, and usually of long duration. Such efforts should be considered only after careful study, and should always involve input from knowledgable scientists and all appropriate wildlife management and conservation agencies.

Reintroductions and Establishment of Colony Sites

Following E. A. McIlhenny's creation of a heronry at Avery Island, Louisiana, in 1892 (McIlhenny 1934), there has been surprisingly little subsequent effort to actively establish waterbird colonies in North America. Even where species such as Double-crested Cormorants and egrets were known to have former nesting areas, management efforts have generally been restricted to protecting existing colonies and associated habitats. This trend, however, has changed in recent years, with a variety of active management programs intended to re-introduce populations to former parts of their range or to restore bird communities at specific sites. Active restoration programs usually rely on one or more of the following techniques.

Use of Captive Parent Stock.—Free-flying, wild adults may be stimulated to breed near captive adults, thereby establishing a colony. This has been accomplished with Brown Pelicans and Great Blue Herons at the Suncoast Seabird Sanctuary in St. Petersburg, Florida, (R. Heath pers. comm.) and with Black-crowned Night-Herons at the "ornamental" wading bird flight cage at the National Zoological Park in Washington, D. C. (Peterson and Fisher 1955, Armistead 1987).

Artificial Social Attractants.—Artificial attractants, such as decoys and tape recordings, can help to stimulate colony formation. At Eastern Egg Rock, Maine, tern decoys and non aggressive courtship calls were used in 1978-1981 to establish a colony of over 1000 pairs of Common, Arctic and Roseate terns (Kress 1983). Other programs have employed decoys (with or without tape recordings) to attract terns, skimmers, and herons to former nesting habitat. These include projects with Common Terns at Ottawa National Wildlife Refuge on Lake Erie (Case 1987), Jamaica Bay National Wildlife Refuge (B. Norton pers. comm.), Muskegat Island, Massachusetts (R. Forster pers. comm.), and Duluth-Superior Harbor on Lake Superior (Matteson 1986), with Sandwich Terns in Ireland (Nairn 1987), with Least Terns on many sites including Chincoteague Island, Virginia (Britton 1982), southern California beaches (Rigney and Emery 1980, Anderson 1981), RSPB reserves in eastern England (M. Everett pers. comm.), Griswold Point, Connecticut (Zickefoose 1984), and New Jersey beaches

(Kotliar and Burger 1984); and with Black Skimmers in Texas (Slaydon 1981), herons in Alabama (Dusi 1985b), and Laysan Albatross in Hawaii (Podolsky 1985). Tape recordings and artificial burrows without decoys were used to stimulate colony formation in Leach's Storm-Petrels (Kress 1987).

The importance of decoys and tape recordings for colony restoration programs is often difficult to assess, since most efforts to attract birds also employ concurrent predator removal (Kress 1983) or habitat improvements (Atwood et al. 1977, Slaydon 1981, Podolsky 1985). The success of such programs also depends on time lapsed since the last breeding. Programs are likely to achieve quick success if there are still many birds alive with a memory of breeding on the restored site. For example, a tern colony was re-established in only one breeding season when gulls were removed from Petit Manan National Wildlife Refuge in Maine (Drennan et al. 1987). Likewise, Common Terns were re-established at Stratton Island, Maine, when gulls were removed in conjunction with the use of decoys and tape recordings (Kress 1987).

Chick Transplants.—Transplanting young birds and then rearing them for release at fledging age is certainly the most difficult and expensive approach to starting bird colonies. For these reasons it is seldom tried, but two recent programs demonstrate the potential of the technique.

In a program similar to McIlhenny's 1892 transplant of fledgling Snowy Egrets, the Tennessee Valley Authority began in 1985 a program of moving fledgling Great and Snowy egrets to the Guntersville reservoir in northeast Alabama (Pullin 1988). Fledgling-age herons were placed in pens containing artificial nests and a feeding trough, in a procedure similar to that used for hacking birds of prey. As many as 30 egrets were observed at Guntersville Reservoir in 1987. Although it is too early to know if this program will lead to the creation of a new egret colony, the technique shows promise.

The transplant technique has also been successfully used to restore Atlantic Puffins to Eastern Egg Rock, a former nesting island off mid-coast Maine (Fig. 7). A program sponsored by the National Audubon Society and Canadian Wildlife Service has

Figure 7. Artificial puffin burrows under construction at Egg Rock, Maine. Photograph by Stephen W. Kress.

demonstrated that puffin chicks ranging in age from three to 33 days old could be successfully transplanted approximately 1429 km from their natal colony. After the transplant, the chicks were reared in individual sod burrows and hand-fed thawed fish with vitamin supplements (Kress 1978). To date, 21 percent of 774 transplanted chicks released at Eastern Egg Rock between 1973 and 1981 have been re-sighted at puffin colonies in the Gulf of Maine. This program demonstrates the need to continue transplants over many years. Although fledging success averaged 97 percent between years, returns of chicks from any one transplant cohort varied from five to 55 percent (Kress and Nettleship 1988).

Transplanted young birds were used to establish a breeding population of Common Eiders at Penikese Island, Massachusetts. Approximately 175 young eiders were released at Penikese Island between 1973 and 1975. Eggs within one to two weeks of hatching were collected from nests in Maine and hatched in a poultry incubator. The young were then captive-reared until they were approximately one month old, at which time they were transferred to a fenced enclosure at Penikese Island. They were fed within the enclosure until about seven weeks old at which time they were released (Stanton 1977). The released eiders began breeding in 1975 on Penikese and have since colonized at least three nearby islands. By 1987, this population had increased to between 200 and 300 pairs (P. Stanton pers. comm.)

MECHANISMS FOR MANAGEMENT

Legal Basis for Management

Canada.—Historically, birds and other wildlife were sources of food. The first law to protect game species was passed in Ontario in 1821 (Dagg 1974), presumably to curb population declines. In 1856 the law was applied only to Upper Canada establishing the concept that game regulation is under provincial authority (Dagg 1974), a view supported by subsequent jurisprudence (Boyd 1984). The British North America Act (1867) although not dealing directly with wildlife, established that international treaties are under jurisdiction of the Federal Government.

Canada and the United States signed the Migratory Birds Convention in 1916, and in 1917 Canada passed the Migratory Birds Convention Act, which covered migratory non-game birds such as auks, fulmars, gannets, herons, ibises, gulls and terns, but not cormorants and pelicans, although most Provinces later passed acts to protect them.

Migratory birds, when alive, are the property of the Province in which they reside, and at the same time they come under federal jurisdiction; when dead, game birds belong to the person who legally killed them (Dagg 1974). Because of this complicated legal situation, management of game birds requires intensive federal-provincial consultation (Bossenmaier 1984), and over the years a tacit understanding has evolved that "while the Canadian Wildlife Service gives its first attention to preserving the stock of birds, the Provinces give priority to maintaining hunting opportunities for their hunters" (Boyd 1984).

Bird species that have established themselves without the deliberate help of man are protected by the Migratory Birds Convention. Colonial waterbirds such as the Cattle Egret and the Little Gull fall in this category.

The *raison d'etre* for the Migratory Birds Convention, as stated in the Migratory Bird Convention Act, was the desire to insure the preservation of those migratory birds either useful to man or considered harmless. The Canadian Wildlife Service has the mandate to administer the Act which provides the legal framework to realize the goals of the Convention. Thus, the Canadian Wildlife Service clearly has the responsibility to prevent deliberate destruction of non-game birds, but it is much less clear to what extent the Service is responsible for enhancing population levels of non-game species in general. The North American Waterfowl Management Plan (Anonymous 1986) has target populations for the various game bird species, but there is no similar plan for colonial waterbirds.

In 1973, The Canada Wildlife Act was passed primarily to help deal with wildlife habitat preservation (Boyd 1984). It was hoped that this enabling legislation would result in Federal-Provincial initiatives to

preserve habitat, but for financial and political reasons such joint actions have been limited (Boyd 1984).

The Committee on the Status of Endangered Wildlife in Canada classifies species at various risk levels. While unofficial, their work assists agencies, developers, etc. in the preparation of environmental assessments (Keith 1984).

The United States.—In response to the devastating market hunting and millinery trade of the late 1800s, all states enacted wildlife laws and most employed game wardens by 1880 (Chandler 1986). However, early bird protection laws varied greatly among states, and only a few provided protection for colonial waterbirds. There was practically no provision for enforcement (Graham 1978). To provide more rigorous conformity for state legislation, the American Ornithologists' Union, Bird Protection Committee wrote its "Model Law" for non-game bird protection (published in Science, 26 February 1886). In the decade following publication, 34 states passed legislation containing its provisions, and by 1916, three-fourths of the states prohibited sale of heron plumes (Palmer 1902). Even in states with strong laws, constant vigilance was necessary to prevent repeals or local exemptions (Doughty 1975).

From inconsistent and poorly enforced state legislation, it became apparent that interstate commerce in bird feathers could best be controlled by federal laws. The Lacey Act (1900) strengthened state laws by giving the Bureau of Biological Survey, predecessor of the U. S. Fish and Wildlife Service, authority to prohibit interstate traffic in birds killed in violation of state laws (Cart 1973).

The Migratory Bird Act of 1913 was the first federal law enacted to conserve and manage wild bird populations (Chandler 1986). While this legislation was being examined by the Supreme court, the Migratory Bird Convention with Great Britain, on behalf of Canada, provided legal protection for most colonial waterbirds including herons, cranes, gulls, terns and alcids (Bean 1986). The Migratory Bird Treaty Act (1918) provided authority to implement the 1916 Convention (Chandler 1985a). The Migratory Bird Conservation Act of 1929 established a commission to approve potential habitats for acquisition as a publicly financed bird refuge system. It also provided authority for the Secretary of the Interior to cooperate with local wildlife authorities to conduct research and publish documents about American birds (Senner 1986).

In 1920, the Supreme Court upheld the migratory bird treaty and in so doing dismissed state's rights for solely managing migratory birds (Chandler 1985a). With well-established rights to manage migratory birds, the federal government proceeded to sign treaties with Mexico (1936), Japan (1972), and the Soviet Union (1976) (Bean 1986) giving the Department of the Interior the authority to protect and manage most birds (Senner 1986).

The federal role in bird protection was further extended in 1940 when President Franklin D. Roosevelt signed the Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere, legislation designed to identify migratory species and their habitats and to implement measures to prevent migratory birds from becoming endangered or threatened (Senner 1986). The United States Fish and Wildlife Service was created in 1940 and has primary responsibility for management of migratory birds (Chandler 1985b). Congress passed the Migratory Bird Conservation Act of 1929 initiating the National Wildlife Refuge System and providing protection to important wetland habitat. The Migratory Bird Hunting Stamp Act of 1934 (Duck Stamp Act) provides funds exclusively for acquisition of Refuge System lands. Additional funds for refuge acquisition are also available from the U.S. Treasury through the Wetlands Loan Act of 1961. Habitats for colonial waterbirds benefit from the Fish and Wildlife Coordination Act of 1934 (revised in 1946, 1956, and 1958) which mandates that water projects of federal agencies (i.e., Army Corps of Engineers and Bureau of Reclamation) consider impact on wildlife in planning and implementation as long as these concerns do not conflict with the primary interest of the project.

The federal endangered species program, starting with passage of the Endangered Species Act of 1973, sustains endangered species programs in many states and territories and supports the Conven-

tion on International Trade in Endangered Species of Wild Fauna and Flora. Several colonial waterbirds including Wood Stork, Brown Pelican, Hawaiian Dark-rumped Petrel, California and Interior Least Terns, and Roseate Tern are presently listed as endangered or threatened and receive special protection under the Act. The southeast population of the Brown Pelican was removed from the list in 1985. Absence from the list does not, however, imply healthy populations.

Agency Activities

Agency Roles in Canada.—The Canadian Wildlife Service has no national program specifically aimed at colonial waterbirds; however the Service is involved in various management activities such as law enforcement, public education, surveys, research and habitat management.

Habitat acquisition, which originally was mainly directed at waterfowl, was made easier by the passing of the Canada Wildlife Act in 1973, although in recent years funds for acquisition have been limited. By 1986, the Canadian Wildlife Service managed 44 National Wildlife Areas and 99 Migratory Bird Sanctuaries. Many of these provide nesting, resting or feeding habitat for colonial waterbirds. The Canadian Wildlife Service also has been instrumental in designating 28 Ramsar wetland sites of international importance totaling more than 100,000 km2 (Poston and Hyslop 1987). In 1984 the Canadian Parks Service operated 31 National Parks, covering some 135,000 km², many of which contain important habitat for colonial waterbirds (Taschereau 1985).

Provinces and Territories have their own wildlife legislation and wildlife programs. Hundreds of sites of different sizes receive different levels of protection depending on their designated status. Although these programs are usually aimed at game birds, colonial waterbirds benefit in many instances. Many Provincial Parks also provide protected habitat that supports colonial waterbirds. In Ontario, for example, there were, in 1984, 191 provincial parks with a combined area of some 5,618,000 ha (Taschereau 1985).

At the municipal level, wildlife management is usually modest in scope and frequently concerned with control of nuisance wildlife rather than enhancing wildlife populations.

Several non-government organizations in Canada are involved in one or more aspects of wildlife management. Ducks Unlimited Canada is particularly active in acquiring and managing waterfowl habitat. By the end of 1984, a total 1,430,000 ha of wetland and essential upland had been reserved. Almost 750,000 ha and almost 24,000 km of shoreline had been developed as waterfowl habitat (Anonymous 1986). The Canadian Wildlife Federation, with more than 500,000 members, supports wildlife research, wildlife education, and lobbying. The goals of the Canadian Nature Federation are to develop a public appreciation of Canada's wildlife and wilderness heritage through publication, education and lobbying. The role of the Nature Conservancy of Canada is mainly to acquire and manage wildlife habitat. World Wildlife Fund Canada funds research, education and action projects and advises decision makers. Naturalist clubs are mainly local organizations, sometimes organized provincially as in the Federation of Ontario Naturalists. Most clubs are affiliated with the Canadian Nature Federation which acts as an umbrella organization.

The efforts of these government and non-governmental agencies provide a wide array of benefits including some for colonial waterbirds. Despite these efforts, wildlife habitat (especially wetland areas) is steadily dwindling, and in 1984 a new agency, Wildlife Habitat Canada, was founded to promote wildlife habitat by working in cooperation with land-owners, associations, governments and concerned citizens. A recent review of the status of wildlife habitat in Canada points out the need for "a cohesive and comprehensive land-use strategy which will unite scattered conservation efforts and turn land-use policies, competing resource programs, and conflicting goals to the advantage of habitat management and conservation of our renewable wildlife resources" (Wildlife Habitat Canada 1986).

Agency Roles in the United States.—The U.S. Fish and Wildlife Service, placed within the Department of the Interior, has primary responsibility for management of

816 migratory birds which include 162 game and 654 nongame species. Since 103 game species are no longer hunted, the effective number of nongame species is 757, 93% of all federally protected species. Attention is placed on migratory birds of special emphasis which include 34 waterfowl species or populations, 4 upland game species, and 7 nongame species (Chandler 1985a). In 1986, for example, waterfowl related reseach received nearly 3 times as much funding as all other bird research, including contaminant and endangered species research. This emphasis results in part from agencies responsibilities, which include the establishing of hunting regulations for migratory game birds. The U.S. Fish and Wildlife Service now spends about one million dollars annually on nongame bird research, excluding contaminant or endangered species research (Senner 1986).

Although they are not usually targeted for management, colonial waterbirds benefit greatly from the protection of wetland habitat for game species. Recent initiatives by the U.S. Fish and Wildlife Service to manage Herring Gulls and Great Black-backed Gulls in New England to benefit terns are indication of increased interest in managing non-game species at specific sites such as Monomoy Island, Massachusetts (Larsen 1980), Eastern Egg Rock, Maine (Kress 1983) and Petit Manan Island, Maine (Drennan et al. 1987). The Service recently invoked the Migratory Bird Treaty Act in California to alter fishery practices that were negatively affecting seabirds (Atkins and Heneman 1987), another example of non-game management.

States have the constitutionally established right to manage wildlife for the public benefit. States have the power to regulate wildlife populations, except where the federal government has exercised paramount constitutional powers (Chandler 1986). Migratory waterbirds are managed by a cooperative partnership between the U. S. Fish and Wildlife Service and state wildlife agencies. State fish and wildlife agencies have recognized four flyway councils (Atlantic, Mississippi, Central and Pacific), and all work closely with the U.S. Fish and Wildlife Service in management of waterfowl within these regions. State wildlife agencies also conduct waterbird censuses, research, and banding programs, acquire and manage waterfowl refuges, and assist in the enforcement of federal hunting and bird-protection laws. The Pittman-Robertson Act provides funds to state wildlife agencies from the sale of firearms, ammunition, and some archery equipment, but most of these funds are used for managing game species. Colonial waterbirds, like most nongame species, have been largely ignored by most state wildlife agencies until very recently. With increasing public interest in nongame species and management of wildlife habitats, many states have recently devised ways to add nongame activities to their programs. By 1985, 48 states provided some kind of funding for nongame or endangered species research and management programs. Five states spent over $1 million each and 23 spent $100,000-500,000. California alone spent $9.3 million on nongame species (Cerulean and Fosburgh 1986, Thompson 1987).

Several private conservation organizations are also involved in protecting important wetland habitats in the United States. More than 1200 Ducks Unlimited chapters provide funds to lease and manage habitat for migratory waterfowl, traditionally in Canada, but with some emphasis shifting to the United States in recent years. The Nature Conservancy buys wetlands and either holds or transfers these to local institutions for management and protection. The National Audubon Society maintains a series of sanctuaries (many of which protect important colonial waterbird nesting sites). It also has an "Adopt-a-Refuge" program with its 550 chapters to encourage volunteer assistance for management programs on National Wildlife Refuges. The Laboratory of Ornithology at Cornell University maintains a database of information on colonial waterbird colonies. Many other private organizations hold wetland habitats and provide protection and sometimes management for bird life.

RESEARCH, EDUCATION, AND ENFORCEMENT

Long-term protection of populations of many species of colonial waterbirds will likely require active management. As dis-

cussed earlier, active management consists of such activities as habitat acquisition and manipulation, food web management, and reduction of chemical pollution, disturbances, predation, competition, and man-induced mortality. It also includes active colony creation and restoration programs. To arouse and maintain public, and thus political, support for management there is an ongoing need to inform the public, political, and government leaders. This section reviews the needs for further information, law enforcement, and education relative to the management of colonial waterbirds.

Research

Major research needs include determining population trends with sufficient precision to be able to detect changes of importance, understanding the reasons for populations changes in order to permit management, and developing new and innovative management techniques.

Much colonial waterbird management involves that portion of the annual cycle when the birds are gathered at breeding sites, and the most basic information needed to initiate management involves knowing where the birds are nesting. It is also very valuable to know nesting numbers and the level of production.

Concern for the status of colonial waterbirds is usually expressed at one of several levels: regional (e.g. the Great Lakes watershed), a political area (i.e. a state or province), an entire species such as the endangered Wood Stork, or for composite groups such as "wading birds" or "sand nesters."

Although it is important to be concerned with preservation of individual colony sites, and all such sites need to be protected and managed as described previously, it should be recognized that for many species, colony-site use is rather ephemeral and sites may have life spans of only a few years (McNicholl 1975, Soots and Parnell 1975, Erwin et. al 1981, McCrimmon and Parnell 1983). Furthermore, it is likely that few colonies are truly independent of a larger more regional population with which they exchange birds, and colonies, being sites of offspring production, may have little relationship to factors that affect recruitment rates of subadults into the breeding population. Thus, the local colony site is often too small a unit for appropriate management of a regional population.

Colonial waterbirds found in North America tend to be widespread, and usually an entire species does not become endangered. However, the criteria for declaration of "endangered species" do not require threat to the entire species. The Wood Stork was declared endangered primarily because of its population decreases in southern Florida (Kushlan and Frohring 1986), despite large extant populations in South and Central America (Kushlan 1987). Thus the biological species is often too large a unit for appropriate management.

The appropriate management unit would often appear to be the regional population of each species (Kushlan 1983) or the combined regional populations of small groups of species having similar ecological requirements. Such units would seldom correspond to political boundaries nor would they necessarily be the same for taxonomically related species. Population units should ideally be based on an understanding of patterns of interchange among colony sites, as determined from banding programs and possibly electrophoretic studies, and should aim to reflect genetic and ecological subdivisions of the species. Such a perspective has been employed in the management of fisheries for decades.

Colony monitoring.—Basic to most management is knowledge of the distribution of colony sites, the numbers of breeding pairs, and the reproductive success of the population to be managed (Erwin et al. 1984). The location of breeding sites is often accomplished by aerial surveys. Such surveys, usually conducted from small fixed or rotary-winged aircraft, flying at low altitudes can provide information on colony location, species composition, activity status, and habitats occupied. There are severe limitations to such surveys in that some species and some colony types are not readily observable from the air. The value of such surveys increases with the area covered, and wide-ranging and consistently conducted surveys such as those sponsored by the U. S. Fish and Wildlife Service in the mid-1970s (Custer and

Osborn 1977) are most useful in providing a regional perspective on the distribution of species and colony sites. Annual surveys serve an important but indirect benefit by providing periodic awareness of conditions prevailing at specific sites or nesting areas in general. Such surveys may be important by providing information about location to a variety of agencies. The planning of dredging operations by the U. S. Army Corps of Engineers, for example, often occurs many months prior to the actual dredging, perhaps at seasons when colony sites are not occupied. Accurate current knowledge about colony site locations may prevent serious conflicts when colonies are on actively used dredged-material islands.

Censuses of the numbers of breeding birds at colonies should follow standards accepted for wildlife censuses in general, including quantitative evaluation of accuracy and precision. Complete direct counts, ground-visual estimates, controlled photography for two dimensional colonies and ground techniques such as transects may be appropriate census techniques at various colony sites (Nettleship 1976, Hutchinson 1979, Erwin 1980a).

Care should be taken to distinguish surveys from censuses. Censuses designed to provide estimates of populations of nesting birds generally require precision not attainable from the air except in the case of large distinct species nesting in open habitats or in the tops of vegetative canopies (e.g. McCrimmon 1982).

Censuses designed to provide information on numbers of birds comprising nesting populations generally must be obtained by visits to colony sites. In such cases, many factors complicate achieving adequate population estimates. Populations that are well synchronized in initiating the nesting cycle may be censused adequately with a single visit, while species less well synchronized, or multispecies colonies where different species begin at different times, may require several visits, and this may result in unacceptable losses due to the degree of disturbance necessary to conduct the censuses. Censusing some species, as in mixed species wading bird colonies in tall arboreal vegetation, may be impossible due to the difficulty of access and to lack of visibility by census takers. The point to be made is that censuses are often difficult and the levels of accuracy and precision possible under actual field conditions may be low. What is sufficient precision? If managers are to understand population trends, it is important to know the precision of individual estimates and of trend lines. To evaluate this requirement it is useful first to consider deficiencies in presently available census data and then to determine appropriate standards to be met in the future. Most available data on colonial-nesting birds are actually surveys rather than censuses, in that the reliable information supplied is on the location and activity status of colonies but not on colony size and composition. Most of this work is conducted by aerial survey, which if done in a statistically appropriate way, using total coverage or known percentage coverage, can provide an estimate of the number of colony sites with known precision and the exact location of those actually observed. However, evidence has become increasingly strong that it is inappropriate to use such aerial surveys for estimating nesting population sizes and composition because of large and usually unknown errors in both species identification and numbers (see Kadlec and Drury 1968, Hutchinson 1980, Kushlan 1979). Only if statistically valid correction factors are calculated for each application and the precision is found to be appropriate to management needs are visual aerial censuses likely to provide data comparable to that obtained on ground visits (see e.g. Buckley 1978, Erwin 1979) although they may provide "indices" for some species. It is very difficult to extrapolate such results between areas or observers (Erwin 1980a). Hutchinson (1980) summed up the situation by stating that unless basic standards of reliability and duplicatability were met, the validity for conducting such censuses in the first place is open for question. It is therefore important to standardize for time of year, time of day, observers, and techniques.

Thus, research is needed to develop monitoring programs having known error sufficiently small to detect changes of a magnitude of concern to management. For a population not known to be decreasing, we suggest that researchers should strive for censuses accurate to within 20% of

the total number of adults and precise enough to detect a single-year deviation of 20%. For certain species in certain areas research may suggest that higher or lower figures might be accepted. What is important is that detection goals be set a priori and that census techniques used be sufficiently sensitive to meet the agreed upon goals.

Population dynamics.–One of the first steps in evaluating trends is to assess reproductive success. To estimate reproductive success in a population one would ideally like to determine the number of young fledged per nesting female. However, this is often difficult because the adults are not usually marked, the colony is not visited frequently enough, and the investigator is seldom able to monitor all young until they fledge. To overcome some of these problems statistical approaches have been developed (Erwin and Custer 1982) but many difficulties remain, and new innovative research is needed to obtain information on the reproductive output per adult bird and information on recruitment as well as the number of adult birds in the population of interest.

Ecological studies.—Research also is needed to provide information on the reproductive strategies and environmental factors affecting reproductive success and survivorship. The recent history of colonial waterbird populations has provided variables that are worthy of monitoring in case of subsequent population decreases, including environmental contaminants in adults, young, and food sources, migration patterns of ringed birds, sources of disturbance and direct mortality, foraging habitat use by nesting and wintering birds with respect to both habitat preservation and nuisance abatement, and, potentially, genetic similarity among and within populations.

Management techniques.—There is a strong need for research relative to ecosystem management. This relates primarily to increasing our knowledge of the relationships between colonial waterbirds and their environments, especially with respect to the availability of adequate and appropriate food supplies. Recent studies have demonstrated strong relationships between many colonial waterbirds and seasonal hydrologic regimes (e.g. Kahl 1964, Springer et al. 1984, Kushlan 1986b, Brush et al. 1987, Duffield 1987, Erwin et al. 1987, Powell 1987). Studies of shallow impoundments in South Carolina, managed for wintering waterfowl, indicated heavy summer use by waders (DeVoe et al. 1986). It is likely that such impoundments could be made more valuable to waders without detracting from use by waterfowl and that such impoundments may be managed to provide superior feeding habitat for waders. Work at the Silver Bluff Audubon Sanctuary in South Carolina (Coulter et al. 1987) has explored the creation and stocking of ponds for endangered Wood Storks. Similarly, management of fisheries without regard to ecological relationships can strongly affect predators including birds (Brown and Nettleship 1984). It appears that further research into ecosystem management may be important for a future North America with even more people and greater disturbance of natural ecosystems.

There is a strong need for further research on control of problem birds. While the use of elevated wire "ceilings" has shown promise as a non-lethal control method, much bird control still involves killing of birds. Also lethal methods are often costly, require long periods to achieve results or fail to achieve satisfactory results, and are controversial, especially when killing large numbers of individuals is required. Further research leading toward non-lethal, long term solutions to the problems of pest birds is necessary if we are to deal with them in a manner acceptable to modern society.

Education

Management of colonial waterbirds is and will continue to be largely dependent on the demand for management from the public. The level and kinds of management carried out will depend on needs as determined by scientists and managers and as funded by public and private sources. Funding depends on an interested citizenry and ultimately on how well educated they are to the needs of the species involved.

There has been a rather strong effort for many years in North America to educate the public to the values of birds, and

colonial waterbirds have often been at the center of this effort. Recent interest in wetland protection throughout the world has emphasized relationships between colonial waterbirds and wetlands, and the public is generally aware and sympathetic to the needs of colonial waterbirds. U. S. and Canadian public and private conservation agencies and organizations are presently presenting strong cases for the protection of wetlands and their wildlife through films, television programs, and written materials. What we need to do is to see that this material is translated from the general to the specific.

There is also a need to educate the wildlife management profession to the concepts and validity of a philosophy of managing nongame non-endangered animals (Thompson 1987). This change is clearly in progress as evidenced, for example, by subject matter in the 1987 volume of The Journal of Wildlife Management. There is still a strong need, however, to work with managers, wildlife protectors, and other professionals relative to the newly emerging concepts that all wildlife is worthy of and often in need of assistance. Professionals trained to work only with game species need to be provided opportunities to expand their expertise. Short courses, seminars, and opportunities for association with scientists working with colonial waterbirds can all help to bridge the knowledge and interest gap and can provide extremely important management of colonial waterbird species by simply engaging the active participation of professionals already in place within the wildlife management structure.

Zoological exhibits also provide viewers an opportunity to learn much about colonial waterbirds, their habitats, and habits. Viewers can be introduced to the complexities of colony structure and life within a colony. Such exhibits can provide a strong management message by conveying ideas about disturbance, vandalism, predators (especially domesticated ones), damage by off-road-vehicles, and other thoughtless kinds of destruction that often accompany human visits to colony sites. Such messages can often be presented in such a way that a lasting impression will be made on the viewer. Care must be taken, however, not to stimulate viewers to attempt unsupervised visits to colony sites.

Enforcement

There are adequate laws to protect most colonial waterbirds against direct exploitation. Laws are not adequate, however, to protect habitats of many species or to minimize human disturbance during critical reproductive periods. Wetland nesters get some protection from wetland protection statutes, but there is often no protection provided to upland nesting sites during that period of the year when birds are absent, and protection is often tenuous when they are nesting. The best protection for such sites is through public or private ownership. Other mechanisms including leases, conservation easements, and dedication are being actively explored by such agencies as the National Audubon Society, the Nature Conservancy, state Natural Heritage programs, and similar Canadian organizations. Such protection will become more critical as the human population of North America continues to expand and as utilization of natural resources increases.

Lack of enforcement of laws may be more serious than a lack of statutes. Where colonies occur on sanctuaries or refuges, protection against human disturbance is likely adequate. The same can not be said, however, for colonies outside such protected areas. In Canada and the United States, wildlife protection officers are trained to deal with concerns relative to game species, and in many cases non-game animals do not receive the same level of concern as those that are hunted. Thus, colony sites may not be regularly monitored and laws may not be actively enforced.

Another problem is enforcement of statutes designed to protect wildlife during parts of their annual cycle when they are not on refuges. A case in point is the difficulty with the high mortality of seabirds due to entanglements in gill nets in California. The Migratory Bird Treaty Act was applicable but was not enforced until the public became educated about the problem (Atkins and Heneman 1987).

CONCLUSIONS AND RECOMMENDATIONS

Public interest in colonial waterbirds varies among species groups depending on aesthetics and economic perceptions. In

general, large, colorful birds are more conspicuous and attract greater attention than smaller birds, explaining their greater presence in art motifs and popularity among the wildlife viewing public. Pelicans, for example, are large easily observed birds that share many beaches with tourists and provide a strong point of interaction between people and birds. Generally this interest is positive, so there is strong sentiment for the preservation of these birds. Rare species also have added appeal, perhaps explaining how the recovery of a rare species such as the Whooping Crane (*Grus americana*), has captured the attention of the general public and media.

Large aggregations of colonial waterbirds also have broad appeal, as evidenced by the 80,000 visitors who observed waterbirds in National Audubon Society Sanctuaries in 1985 (Anderson and Dunstan 1985). This is further evidenced by the 1980 National Survey of Fishing, Hunting, and Wildlife Associated Recreation (1982) which found that 28.8 million Americans (17 percent of the U.S. population) took trips primarily to observe, photograph and feed wildlife. Sixteen percent of these non-consumptive wildlife users visited National Wildlife Refuges and 22 percent took trips to observe wildlife on other federal lands.

Special interest groups, particularly fisherman, may develop negative attitudes about certain fish-eating colonial waterbirds. Double-crested Cormorants are one of the best examples. Even though there have been no studies demonstrating wide negative impact on public water fisheries, depredation permits for cormorant control are frequently issued. Without successful public education campaigns, the conspicuous cormorants are likely to continue taking abuse as scapegoats for fisheries depletion even though reductions are only substantiated for relatively confined fish populations such as hatcheries and aquaculture facilities.

Colonial waterbirds, thus, perhaps because of their large size and tendency to gather in large conspicuous groups, have attracted more interest from the public than have many other groups of animals. They also generally feed high in food webs at a similar level to that of humans. Strong public interest and strong associations with the well being of wetland and aquatic ecosystems make these birds excellent barometers of environmental health (Kushlan 1983). It is therefore crucial that strong efforts be made at all levels to maintain and monitor populations and understand the factors that affect population fluctuations, both for the sake of the birds and for our own well being. The coloniality of these birds at breeding time makes the job of monitoring populations somewhat easier than with species that scatter over wide areas to nest as isolated pairs. It also makes management somewhat easier, and more critical, in that an important part of the effort can be concentrated in both time and space. The other side of this coin is, of course, the fact that the crowding together of many birds to nest more or less simultaneously in a small area makes them more vulnerable to perturbations of all sorts. We must also not lose sight of the fact that the gathering of birds into dense, highly visible concentrations at breeding time may tend to make us overlook problems that occur when they are scattered. Adequate feeding habitat, a clean environment, undisturbed roosting areas and many other facets of the lives of these birds may be as likely to become limiting as are factors associated with the breeding process.

It is clear that most wetland types are declining in North America despite a surge of interest in wetlands preservation (Tiner 1984). The success of protection and all other forms of management are directly tied to the availability of adequate appropriate habitat. All of our efforts will fail unless the diverse wetlands and coastal waters required by many species are maintained in healthy condition. It seems clear to us, however, that even with adequate amounts of healthy habitats, a more active continent-wide management effort will be necessary to assure the continued success of these birds. This relates to the fact that many species of so-called waterbirds nest in upland environments or feed in oceanic waters, near wetlands but often in areas not protected by wetland protection laws, and because even protected wetlands are often being used and polluted very heavily by people.

The continued well being of this large group of ecologically and aesthetically important birds is going to require that resource managers at all levels begin to pro-

vide the kind of attention that has been provided to such game species as waterfowl, not to produce birds for the taking, but to maintain healthy populations to enjoy and to continue to serve to warn us of impending dangers to ourselves.

In recent years conservation strategies were developed for North America's waterfowl and shorebirds. The North American Waterfowl Management Plan, recently approved by the United States and Canada, aims at maintaining North American waterfowl species at certain desirable levels, describes needed actions, and makes recommendations regarding implementation (Anonymous 1986). A conservation strategy has been developed recently for shorebirds. It is designed primarily to protect especially important staging and wintering areas that are critical for the survival of many species, which nest widely scattered across arctic habitats but which often become concentrated during migration and winter. A unique consortium of public and private organizations are collaborating in an international effort to protect these sites as part of the Western Hemisphere Shorebird Reserve Network. As of 1987, the U. S. Fish and Wildlife Service, the Canadian Wildlife Service, the Peruvian national forestry and wildlife agency, and 23 state and provincial wildlife agencies have committed relevant lands under their administration to the reserve network, as have the Nature Conservancy and National Audubon Society (Myers et al. 1987).

Colonial waterbirds have several characteristics that make them candidates for such a continent-wide conservation strategy. During the breeding season many adults are vulnerable, and the reproductive success of all colony members can be affected by a single factor. For several species there is an increasing scarcity of high-quality nesting habitat, and for some with specialized diets or feeding strategies feeding habitats may be scarce both during and after breeding. For others, direct interactions with man are proving serious.

We, therefore, recommend that efforts begin to evaluate the possibility of a conservation strategy for North American colonial waterbirds. Such an effort should evaluate conservation needs for individual species by region, amalgamate regional needs into a national or continental perspective, and determine the need for and feasibility of a continental strategy. Such an effort is outside the scope of this report, but the problems outlined herein indicate the magnitude of difficulties facing these wide-ranging birds, and an organized effort at the continent-wide level appears appropriate.

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APPENDIX I.

Colonial Waterbirds nesting in Canada and the United States

Procellariiformes, Procellaridae: Northern Fulmar (*Fulmarus glacialis*). Hydrobatidae: Leach's Storm-Petrel (*Oceanodroma leucorhoa*); Ashy Storm-Petrel (*Oceanodroma homochroa*); Fork-tailed Storm-Petrel (*Oceanodroma furcata*). Procellariidae: Bermuda Petrel (*Pterodroma cahow*); Manx Shearwater (*Puffinus puffinus*).

Pelicaniformes, Fregatidae: Magnificent Frigatebird (*Fregata magnificens*). Pelecanidae: White Pelican (*Pelecanus erythrorhynchos*); Brown Pelican (*Pelecanus occidentalis*). Sulidae: Masked Booby (*Sula dactylatra); Northern Gannet (Sula bassanus*). Anhingidae: Anhinga (*Anhinga anhinga*). Phalacrocoracidae: Olivaceous Cormorant (*Phalacrocorax olivaceus*); Great Cormorant (*Phalacrocorax carbo*); Double-crested Cormorant (*Phalacrocorax auritus*); Red-faced Cormorant (*Phalacrocorax urile*); Brandt's Cormorant (*Phalacrocorax penicillatus*); Pelagic Cormorant (*Phalacrocorax oelagicus*).

Anseriformes, Anatidae: Common Eider (Somateria mollissima).

Ciconiiformes, Ardeidae: Black-crowned Night-Heron (*Nycticorax nycticorax*); Yellow-crowned Night-Heron (*Nycticorax violaceus*); Green-backed Heron (*Butorides striatus*); Tricolored Heron (*Egretta tricolor*); Little Blue Heron (*Egretta caerulea*); Reddish Egret (*Egretta rufescens*); Snowy Egret (*Egretta thula*); Great Egret (*Casmerodius albus*); Cattle Egret (*Bubulcus ibis*); Great Blue Heron (*Ardea herodias*). Ciconiidae: Wood Stork (*Mycteria americana*). Threskiornithidae: Glossy Ibis (*Plegadis falcinellus*); White-faced Ibis (*Pledagis chihi*); White Ibis (*Eudocimus albus*); Roseate Spoonbill (*Ajaia ajaja*).

Charadriiformes, Laridae: Ivory Gull (*Pagophila eburnea*); Franklin's Gull (*Laru pipixcan*); Laughing Gull (*Larus atricilla*); Bonaparte's Gull (*Larus philadelphia*); Common Black-headed Gull (*Larus ridibundus*); Little Gull (*Larus minutus*); Ring-billed Gull (*Larus delawarensis*); Mew Gull (*Larus canus*); Heerman's Gull (*Larus heermanni*); Herring Gull (*Larus argentatus*); California Gull (*Larus californicus*); Glaucous Gull (*Larus hyperboreus*); Iceland Gull (*Larus glaucoides*); Thayer's Gull (*Larus thayeri*); Lesser Black-backed Gull (*Larus fuscus*); Great Black-backed Gull (*Larus marinus*); Western Gull (*Larus occidentalis*); Glaucous-winged Gull (*Larus glaucescens*); Ross' Gull (*Rhodostethia rosea*); Black-legged Kittiwake (*Rissa tridactyla*); Red-legged Kittiwake (*Rissa brevirostris*); Sabine's Gull (*Xema sabini*); Common Tern (*Sterna hirundo*); Arctic Tern (*Sterna paradisaea*); Aleutian Tern (*Sterna aleutica*); Roseate Tern (*Sterna dougallii*); Forster's Tern (*Sterna forsteri*); Gull-billed Tern (*Sterna nilotica*); Least Tern (*Sterna antillarum*); Sandwich Tern (*Sterna sandvicensis*); Royal Tern (*Sterna maxima*); Caspian Tern (*Sterna caspia*); Elegant Tern (*Sterna elegans*); Black Tern (*Chlidonias niger*); Sooty Tern (*Sterna fuscata*); Black Skimmer (*Rhynchops niger*).

Alcidae: Razorbill (*Alca torda*); Common Murre (*Uria aalge*); Thick-billed Murre (*Uria lomvia*);

Dovekie (*Alle alle*); Black Guillemot (*Cepphus grylle*); Pigeon Guillemot (*Cepphus columba*); Marbled Murrelet (*Brachyramphus marmoratus*); Kittlitz's Murrelet (*Brachyramphus brevirostris*); Xantus' Murrelet (*Synthliboramphus hypoleucus*); Ancient Murrelet (*Synthliboramphus antiquus*); Cassin's Auklet (*Ptychoramphus aleuticus*); Rhinoceros Auklet (*Cerorhinca monocerata*); Atlantic Puffin (*Fratercula arctica*); Horned Puffin (*Fratercula corniculata*); Tufted Puffin (*Fratercula cirrhata*).