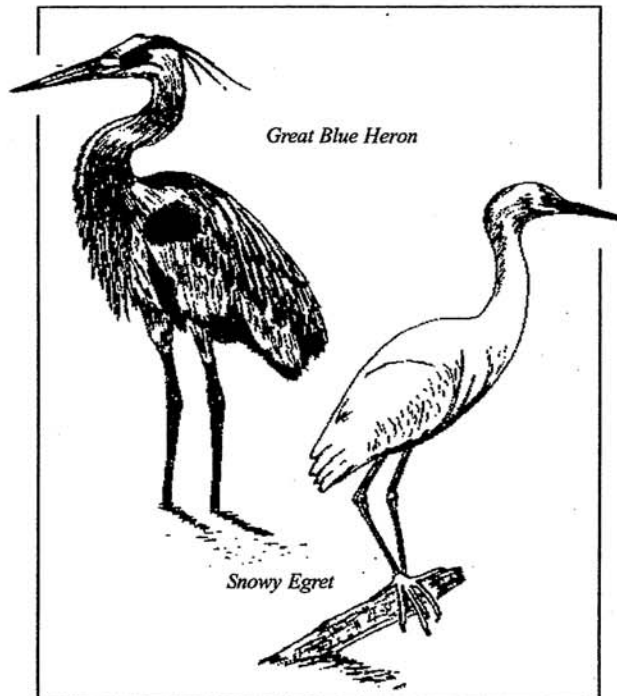


COLONIAL WADING BIRDS

Dave Jenkins
New Jersey Department of Environmental
Protection
Division of Fish, Game & Wildlife
Endangered & Nongame Species Program
P.O. Box 236
Tuckahoe, NJ 08250
and
Lisa A. Gelvin-Innvaer
Delaware Division of Fish and Wildlife
Department of Natural Resources and
Environmental Control
Nongame & Endangered Species Program
Smyrna, DE 19977



ABSTRACT

Ten species of colonial nesting wading birds inhabit the Delaware Estuary and surrounding wetland habitats. This assemblage of birds includes the great blue heron (*Ardea herodias*), little blue heron (*Egretta caerulea*), tri-colored heron (*Egretta tricolor*), green-backed heron (*Butorides striatus*), black-crowned night heron (*Nycticorax nycticorax*), yellow-crowned night heron (*Nycticorax violaceus*), snowy egret (*Egretta thula*), great egret (*Casmerodius albus*), cattle egret (*Bubulcus ibis*), and the glossy ibis (*Plegadis falcinellus*). Although numerically abundant within nesting colonies, the cattle egret forages primarily in upland terrestrial habitats and has been excluded from this chapter. The green-backed heron will also not be discussed; while this species is colonial in some locations, it is primarily a solitary nester in the Delaware Estuary and does not typically co-occur in the large nesting colonies of other colonial waders there.

These birds tend to feed and nest in groups called foraging aggregations and colonies, respectively. These typically mixed-species assemblages may enhance foraging success and perhaps reduce the risk of predation. They require different habitats for feeding, nesting, and roosting that are not widely separated, to conserve the birds' energy. In the estuary, nearly all the species prefer saline or brackish habitats.

Toxic water contaminants, predation, and wetland loss are among the problems facing these birds. Among the management schemes for their protection and enhancement are creation of dredged-material islands that provide isolated habitat, and control of ecotourism in areas that would disturb the colonial nesters.

INTRODUCTION

Eight of the 10 species of colonial nesting birds that occur in the estuary are considered in this chapter: the great blue heron (*Ardea herodias*), little blue heron (*Egretta caerulea*), tri-colored heron (*Egretta tricolor*), black-crowned night heron (*Nycticorax nycticorax*), yellow-crowned night heron (*Nycticorax violaceus*), snowy egret (*Egretta thula*), great egret (*Casmerodius albus*), and the glossy ibis (*Plegadis falcinellus*). (The cattle egret [*Bubulcus ibis*] is numerically abundant within nesting colonies, but was excluded because it forages primarily in upland terrestrial habitats. The green-backed heron [*Butorides striatus*] is colonial in some locations, but will not be discussed further because it is a solitary nester in the Delaware Estuary and does not typically co-occur in the large nesting colonies of other colonial waders there.)

Large wading birds are long-lived, high-level predators that serve as valuable indicators of environmental quality, including resource abundance and health, levels of toxic substances such as organic contaminants and heavy metals, and degrees of human disturbance (Kneib 1982; Parsons and Burger 1982; Shear 1984; Niethammer, Baskett, and White 1984; Hoffman et al. 1986; Harris 1988; Erwin 1989; Custer et al. 1990; Davis and Parsons 1991; Burger et al. 1992).

Estuarine ecosystems are, in turn, extremely important to wading birds. They supply the primary, and in some cases, the only, feeding habitats for several wading-bird species in the mid-Atlantic region. Estuarine islands also provide important nesting habitat. Pea Patch Island, located in the upper Delaware Bay just west of Fort Mott State Park, supports the largest wading bird nesting colony of mixed species on the Atlantic Coast north of Florida (Erwin and Korschgen 1979).

GEOGRAPHIC RANGE

Hérons and egrets are found throughout the world in tropical and temperate regions. Of the eight species under consideration here, all except the black-crowned night heron and the glossy ibis are found only in the New World. In North America, wading birds are most abundant in southern regions. However, the range of the black-crowned night heron and the great blue heron extends northward to the northern Great Lakes and southern Canada and along the Atlantic Coast to Quebec and Nova Scotia. A few species occur in relatively limited ranges; these include the glossy ibis and the tri-colored heron, which inhabit the immediate Gulf and Atlantic coastal fringe from southern Texas to southern New England. Others, such as the great blue heron and black-crowned night heron, range over virtually the entire United States except for high mountain and desert areas.

Most wading birds within the Delaware Estuary are migratory. They occur there during the spring, summer, and early fall, migrating to southern coastal areas for the winter. The exceptions include the large number of great blue herons that remain through the winter and the smaller number of black-crowned night herons that behave similarly.

Pea Patch Island is the most northern nesting site within the estuary for all colonial species, with the exception of the great blue heron. At least three additional nesting colonies of mixed species are scattered along the eastern (Delaware) shore of the bay. No nesting colonies are known to exist along the western (New Jersey) shore of the bay. Great blue heron nesting colonies are scattered along the river and bay, and inland throughout the lower Delaware drainage in Pennsylvania, New Jersey, and Delaware. All eight species can be found feeding throughout the estuary in wetlands and

**Most wading birds
within the Delaware
Estuary are migratory.**

nearby shallow-water and wetland habitats, from the head of tide near Trenton to the mouth of the bay. Except for the great blue heron, however, all species are more abundant in the mid- to lower estuary, that is, southward from the Delaware Memorial Bridge. This is particularly true for tricolored herons and glossy ibises, which are strongly tied to brackish marshes, and is also the case for black-crowned night herons and great egrets, which regularly occur in Tinicum Marsh near Philadelphia and even up to the Trenton Marshes.

STATUS AND TRENDS

Overall, the numbers of wading birds in the eastern United States have recovered dramatically from the plume-hunting era that occurred around the turn of the century (Terres 1980; Ehrlich, Dobkin, and Wheye 1988). During the last three to four decades, wading birds have expanded to inhabit virtually all areas they occupied prior to being decimated by hunting (Ogden 1978, Niemeyer and Reigner 1993), and several species have expanded beyond their historically known ranges. There is insufficient information, however, for comparison of contemporary population numbers with pre-hunting populations. Geographically, Florida presents a significant exception to these observations. There, loss of coastal and inland feeding and breeding habitat has significantly depressed state populations of virtually all waders (Ogden 1978, Erwin 1979). Among individual species, there is some evidence that numbers of little blue herons along the Atlantic Coast may have declined during the previous two to three decades (Ogden 1978, Erwin 1979).

Data on population trends within the Delaware Estuary are relatively limited. The Delaware Division of Fish and Wildlife (DEDFW) performs

statewide counts of nesting colonies infrequently, although counts of the Pea Patch Island colony have been performed more regularly (Parsons 1993). The New Jersey Division of Fish, Game and Wildlife (NJDFGW) conducts periodic aerial surveys of colonies along the Atlantic Coast covering all wading bird species except great blue heron. Because no colonies are known to exist along the New Jersey side of Delaware Bay, no surveys are conducted there. A ground-based statewide survey of great blue heron colonies was last conducted in 1985 in New Jersey and as recently as 1991 in Pennsylvania. Survey figures and trends for wading bird colonies in Cape May County, New Jersey, are shown in Table 1.

Some wading birds from Atlantic Coast colonies in Cape May County feed and roost within the lower Delaware Estuary (Crans, Caccamise, and McNelly 1991). Insufficient data are available to examine trends in numbers of great blue herons. Circumstantial evidence, including an apparent increase in the number of nesting colonies, suggests that the great blue heron populations may be increasing in New Jersey (Sciascia 1994), while their numbers are relatively stable in Pennsylvania (Brauning 1994). The most recent information indicates that there are approximately a dozen known great blue heron nesting colonies in the vicinity of the Delaware Estuary, containing a total of at least 250 nesting pairs.

The states bordering the Delaware Estuary classify a total of four colonial wading bird species as threatened or endangered (see Table 2), although none are listed as threatened or endangered by the U.S. Fish and Wildlife Service.

LIFE HISTORY

Except for those individuals that overwinter, wading birds arrive in the Delaware Estuary from mid-March to early May (Bent 1963, Stone 1965, Erwin 1979). Early in the breeding season, both sexes develop ornate breeding plumage and changes in coloration as males begin occupying and defending nest sites. Waders engage in elaborate displays involving their specialized breeding plumage. Both sexes typically participate in nest building, with the males collecting small branches and large twigs while the female forms the rudimentary platform nest.

Eggs are laid in the large stick nests from late March to mid-June. Clutches range from three to seven eggs that are pale blue to blue-green in color. Both sexes share incubation duties for the 23-28 days before the first-laid egg begins to hatch.

Both parents are also involved in feeding the ungainly altricial nestlings that remain in the nest for four (in the case of the smaller species) to eight weeks (the latter being the great blue heron). The young continue to depend on their parents for food for a short period following fledging.

Table 1 1989 Survey Results for Wading Birds in Cape May County; Trends Based on Six Surveys Conducted between 1977 and 1989

| | TCH | LBH | GE | SE | BCNH | YCNH | GI |
|----------------------------|------------|-------|-------|-------|-------------|-------|-------|
| 1989 survey results | 127 | 131 | 208 | 1991 | 98 | 25 | 810 |
| (# adults) | | | | | | | |
| 1977-1989 trend | sli. incr. | stab. | stab. | stab. | large decr. | decr. | decr. |

Key: TCH = tri-colored heron, LBH = little blue heron, GE = great egret, SE = snowy egret, BCNH = black-crowned night heron, YCNH = yellow-crowned night heron, GI = glossy ibis

Table 2 Endangered (E) and Threatened (T) Wading Birds of the Delaware Estuary

| Species | Delaware | New Jersey | Pennsylvania |
|----------------------------|----------|------------|--------------|
| Great blue heron | - | T* | - |
| Little blue heron | - | T | - |
| Great egret | - | - | T |
| Yellow-crowned night heron | - | T | T |

• Breeding only

One of the most conspicuous aspects of wading-bird ecology involves their tendency to feed and nest in groups. Feeding groups (foraging aggregations) and nesting groups (colonies) may be comprised of single species, but are more typically mixed-species assemblages (Krebs 1978, Burger 1981). Feeding aggregations range from a few birds to dozens while mixed-species nesting colonies can include several thousand birds.

Researchers have offered several hypotheses to explain the occurrence of foraging and nesting aggregations (see review in Krebs 1974, 1978; Kushlan 1978; Burger 1981). These explanations fall into one of two groups: those that stress that aggregations reduce the risk of predation for individuals, and those that focus on aggregations as a means to enhance foraging success. There is little evidence that wading-bird assemblages have a primary role of reducing predation pressures. Consequently, most scientists tend to attribute a primary role to foraging enhancement without totally discounting the role of predation (Krebs 1974, 1978; Willard 1977; Custer and Osborn 1978; Kushlan 1978; Erwin 1983; Waltz 1983).

Nesting colonies established by herons and egrets range from very large mixed-species colonies to colonies of two to three nests of a single species. For example, Pea Patch Island contains nine species and 10,000 to 12,000 pairs of birds, yet yellow-crowned night herons often nest here in small groups of only a few nests. Great blue herons and black-crowned night herons also commonly nest in smaller single-species colonies of 10 to 200 pairs, although larger colonies are not uncommon.

Large wading birds typically build their large stick nests in trees and shrubs, but other substrates, such as tall, dense *Phragmites* (*Phragmites australis*) may also be used. The position of nests within

mixed-species colonies is dictated by the interaction of such factors as substrate availability, bird size, timing of arrival on nesting areas, and aggressive interactions (Burger 1978).

Hérons and egrets primarily feed on fish and crustaceans, but will also choose a variety of aquatic animals, including worms, insects, frogs, and tadpoles (Kushlan 1978). Some species, such as the yellow-crowned night heron, specialize and feed almost entirely on small crabs. Others, such as the black-crowned night heron, are generalists, and may include such items as the eggs and young of birds in their diet.

Wading birds employ a wide variety of behavior in their quest for food, partially dictated by the target food and the feeding habitat (see Kushlan 1976, 1978, for a review). Techniques range from the very active such as running, lunging, and diving, to a more sedentary "standing and waiting," or "walking slowly and probing" behavior.

ECOLOGICAL/ECONOMIC ROLE

Large wading birds represent prominent members and important predators of the estuarine ecosystem, feeding near the top of the food chain on a wide variety of forage fish, and on marine invertebrates such as small crabs and molluscs.

The presence of colonies of wading birds in the estuary generates an economic return for the area because of their recreational and aesthetic value to ecotourists.

HABITAT REQUIREMENTS

Wading birds require specific but different habitats for feeding, nesting, and roosting. Suitable nesting and roosting habitats must be located close enough

to good feeding habitat to ensure the distance to be flown is energy efficient for the bird. Erwin et al. (1993) conservatively estimate that most birds feed within 10 kilometers (6.2 miles) of nesting colonies or roosts, but note that some may feed at a greater distance. Parsons (1993) found that a substantial number of waders nesting on Pea Patch Island forage in New Jersey in apparent preference to marshes available in Delaware.

A variety of quiet shallow-water areas provide the primary feeding habitat used by wading birds, including tidal and non-tidal rivers and creeks, saltmarsh panes, ponds, impoundments, and brackish and freshwater marshes. None of the species covered here feed exclusively in either freshwater or saltwater habitats, although in the estuary, all except the great blue heron appear to prefer saline or brackish habitats (Kushlan 1976, Kushlan 1978, Custer 1978, Erwin 1983).

Human development
of barrier islands
has severely reduced
these preferred
habitats.

Water quality may affect habitat suitability indirectly by influencing the availability of prey species. Turbidity may affect the ability of birds to find and capture prey and may also influence the growth of submerged aquatic vegetation that provide habitat for prey species.

Historically, the primary nesting habitat used by coastal wading birds in Cape May County consisted primarily of maritime dune shrub and forest vegetation. Human development of barrier islands has severely reduced these preferred habitats. A large number of nesting colonies are now found on old dredge-disposal islands where succession has provided woody vegetation similar to historic habitats. Erwin (1983) and Erwin et al. (1993) note that the largest, most persistent colonies are generally located on isolated sites where predator and human access are limited. This does not preclude the use of sites amidst human develop-

ment so long as access is restricted. For nearly 30 years, the Stone Harbor bird sanctuary, located in a two-block area of a barrier island, comprised the largest mixed-species heronry in New Jersey. Although housing and other development surrounded this site, it was entirely fenced and posted to prevent entry. It should be noted that this colony abandoned the site in 1991 and the resident birds began nesting on two more isolated sites located nearby (Jenkins 1992-1994). The role of human disturbance in this abandonment is not known.

Nesting sites of great blue herons in this region are nearly all single-species colonies located in inland woodland swamps. These herons seem to prefer relatively large trees (greater than 10 meters [33 feet] tall), and will use either deciduous or evergreen trees as well as dead snag trees.

SPECIAL PROBLEMS

Contaminants. At present, scientists suspect environmental contaminants have exerted a minor influence on recent waterbird populations in the Chesapeake Bay (Ohlendorf 1981, Heinz and Wiemeyer 1991), although contaminants and their effects remain a significant concern in the Delaware Estuary. Studies indicate that contaminants such as PCBs, DDT metabolites, and other chlorinated hydrocarbons are present and are moving through trophic levels within the Delaware Estuary. Contaminant levels may be higher toward the upper portion of the Delaware River where the heronry is located (Greene and Miller 1994; Steidl, Griffin, and Niles 1991a, 1991b). Among sensitive avian species, PCBs disrupt normal patterns of growth, reproduction, metabolism, and behavior. In general, PCB accumulation in these species is rapid and depuration is lengthy. Diet is an important route of PCB accumulation; fish-eating birds integrate ecotoxicological characteristics of the

wetlands they use. Avian feeding ranges often include a significant portion of an entire estuary and its contributing watersheds. Wading birds can provide a cost-effective management tool for marsh systems, serving as an "early warning" of threshold levels of lipophilic toxicants present in the marsh that can bioaccumulate (Parsons 1993).

Oil and chemical spills not only allow bioaccumulation of contaminants but also have more direct effects on feathers and on the digestive and respiratory functions of the birds. Nesting areas containing high densities of nests (e.g., Pea Patch Island) are particularly vulnerable. Emergency-response plans must be in place to reduce or prevent impacts to sensitive habitats. Ford et al. (1993) provide recommendations to help reduce threats from oil spills.

Predation. A number of species on Pea Patch Island suffered reproductive failure apparently as a result of localized predation. Parsons (1993) reported many potential predators were within the immediate vicinity of the Pea Patch heronry, including American and fish crows (*Corvus brachyrhynchos*, *C. ossifragus*), great horned owls (*Bubo virginianus*), and raccoons (*Procyon lotor*). Tracks believed to be those of the red fox (*Vulpes vulpes*) and domestic dog (*Canis familiaris*) were found also. Effects of ground predators were more common in *Phragmites* marshes whereas avian predators were active in the upland areas. Egg loss occurred during the egg-laying and incubation periods and afflicted the majority of study nests for all species. However, predation was not a significant factor for glossy ibis or snowy egret. Their reproductive success was notably influenced by high egg inviability (ibis) and consistent lack of food (egret).

Wetland Loss. Between the mid-1950s and the early 1980s, Delaware lost approximately 57 per-

cent of its wetlands (Tiner 1985); figures for New Jersey and Pennsylvania are similar. Loss of feeding and nesting habitat is certainly critical to wading birds. Indirectly, this habitat loss may also reduce available food resources for the birds because estuarine wetlands also serve as nursery habitat for many of the fish on which herons and egrets feed.

MANAGEMENT CONSIDERATIONS AND RECOMMENDATIONS

General Strategies. Measures to protect land or water for waterbirds must include several different spatial scales, ranging from colony site, to a marsh or tributary, to an entire watershed (Erwin et al. 1993). Management efforts on a given site should consider also the function of that site in the context of the larger landscape.

Regulatory Protection of Habitats. Regulatory protection of wading-bird habitat is complicated because it involves federal, state, county, and local jurisdictions. Significant gaps exist in the land-use regulations of all three states bordering the Delaware Estuary. For example, Delaware currently has no laws protecting non-tidal wetlands. Torok et al. (1993) have reviewed laws that pertain to the coastal areas of the Delaware Bay. Erwin et al. (1993) stressed that wetlands adjacent to nesting sites of wading birds need additional protection under special designations and that riparian areas should receive the highest protection status.

Dredge Disposal and Site Creation. When managed properly, dredged-material islands (DMIs) can provide a crucial substitute for wading bird habitats that have degraded or are being lost to erosion. These DMIs provide habitat for reproduction, loafing, roosting, and feeding (Soots and Landin 1978). Minimal plans for DMIs should consider the potential species composition, impacts,

location, timing, quality of dredged material, and island size and structure. Constructing or maintaining DMIs in the fall avoids disturbance during critical breeding and brood-rearing periods.

DMIs created for wading birds should be 2-20 hectares (5-50 acres) in size and 1-3 meters (3.3 to 9.9 feet) above high water so that the island is low enough to prevent significant wind erosion, but high enough to prevent flooding from all but the most severe storms (Smith 1978, Soots and Landin 1978). Slopes should be 1:30 or less. Deposition of dredged spoil onto existing islands is encouraged by some authors who cite more severe environmental impacts when new islands are created (Soots and Landin 1978). However, care must be taken not to deposit new material that will cover thickets associated with river mouths, inlets, or existing nesting areas of wading birds, all highly valuable to wading birds. The quality of dredged material influences island stability and vegetative succession. Bioaccumulation of environmental contaminants contained in dredged materials is also a concern.

Many species of wading birds depend upon shrubs and trees for nesting. Shrub thickets are characterized by a canopy and an understory of dense woody vegetation. Woody structure may be lost through factors such as senescence, wind, weather, erosion, human intervention, and the phytotoxic effect of heavy guano deposition (Wiese 1979). This might be countered through plantings, but replacement usually requires time for vegetative succession. Re-establishing suitable shrubs may require three to 10 years and growing trees will require many more years (Soots and Landin 1978).

Vegetation Management. Controlling undesirable plant species frequently involves application of herbicides, followed by prescribed burning to remove dead material and encourage natural

succession. Glyphosate compounds have been approved for wetland use and are typically used to control *Phragmites*, an aggressive plant that frequently outcompetes other species and dominates many coastal marshes (Jones and Lehman 1987). However, *Phragmites* should not be controlled automatically without proper evaluation. In 1993, approximately 82 percent ($n = 12,251$) of the wading birds nesting on Pea Patch Island were located in the *Phragmites* marsh adjacent to the wooded upland area historically used. These included little blue heron, cattle egret, snowy egret, glossy ibis, tri-colored heron, and black-crowned night heron. Hence, the *Phragmites* marsh provided a critical nesting substrate and for some species may have contributed to higher reproductive success. Currently, helicopter application of glyphosate permits selective control of *Phragmites* not being used by nesting waders (Parsons 1993). Special care will be required to protect nesting areas during subsequent burning of treated areas.

Foraging Habitat. Erwin et al. (1993) recommended conservation of remaining brackish marshes, especially near riparian areas and establishment of feeding sanctuaries. Parsons (1993) observed that a majority of birds on Pea Patch Island flew to New Jersey to feed. Based on this observation, she speculated that broad-scale efforts to control water levels via impoundments in Delaware's coastal wetlands may have created habitat unsuitable for wader foraging. However, integrated management of impoundments can accommodate multiple feeding guilds over time and space. Managing a wetland complex to create different habitat types by drawdowns, flooding, and vegetative and bottom-contour manipulation increases food diversity and availability. With care, these efforts can benefit a wide variety of waterbirds (including waders) while still being compatible with mosquito control, fish manage-

ment, and other resource objectives. Helmers (1992) provides examples and guidelines that must be fine-tuned for managing a specific area.

Open Marsh Water Management (OMWM) is a mosquito-control technique characterized by selective pond and ditch excavation in saltmarsh habitats. In a Delaware study, no significant difference was detected in the species composition or densities of herons or egrets in areas using grid-ditch marshes compared to those where OMWM was practiced (Meredith and Saveikis 1987). Erwin et al. (1991) also found no significant effect related to the OMWM treatment. They also reported a strong correlation between waterbird abundance and the pond area within a marsh site, although densities may not be higher in larger ponds.

Disturbance. Disturbance may be the result of attention directed specifically towards wading birds. Ecotourism (also called ecological, nature-based, or natural-history tourism) is discussed in Jacobson and Lopez (1994). Generally, it entails travel to natural areas to enjoy and study the scenery and the wildlife (Boo 1990). To many, ecotourism represents a low-consumption use of natural resources that may generate substantial economic return, thereby fostering sustainable management of resources. Ecotourism destinations, however, often involve fragile ecosystems and wildlife that is threatened, endangered, or otherwise sensitive. Without care, ecotourists may potentially be more damaging to wildlife than other types of tourists because they actively seek and approach wildlife. Careful management is necessary to ensure that natural tourist attractions do not become "non-renewable resources," the fate, described by Butler (1980), of many tourist areas where environmental and social costs eventually exceeded benefits.

Colonially nesting birds are highly sensitive to the presence of humans (Parsons and Burger 1982, Davis and Parsons 1991). DeMauro (1993) found that a buffer of 229 meters (756 feet) was a conservative and effective buffer to protect an Illinois heronry during public viewing from an observation platform. An initial orientation for visitors and educational programs at the observation station made the public more sympathetic to the birds and may have minimized visitor-related disturbances. Short-term, infrequent disturbances (e.g., low-flying planes) seemed to have less impact on the heronry than noisy activities of longer duration (e.g., a day-long auction on adjacent property).

Disturbance-free zones become an important habitat consideration as shoreline development and commercial and recreational boating activities increase. Erwin et al. (1993) recommended limiting the approach of boaters to islands and open-water feeding areas by posting restrictions. Erosion also may be reduced by these actions.

Colonial waterbirds may show less response to human disturbance after they have laid eggs than earlier when sites are first being selected or when courtship and nest building are taking place (Conover and Miller 1979). Early-season prospecting for suitable colony sites may be adversely affected if disturbance by pedestrians, pets, or vehicles occurs anywhere in the vicinity.

REFERENCES CITED

- Bent, A.C. [1926] 1963. Life Histories of North American Marsh Birds. U.S. Natl. Mus. Bull., No. 135. Reprint. Dover Publ., New York. 385 pp.
- Boo, E. 1990. Volume One: Ecotourism: The Potentials and Pitfalls. World Wildl. Fund Publ., Baltimore, MD. 73 pp.
- Brauning, D. 1994. Personal communication.

- Burger, J. 1978. The patterns and mechanisms of nesting in mixed species heronries. Pages 45-58 in A. Sprunt, IV, J.C. Ogden, and S. Winckler, eds. *Wading Birds*. Nat. Aud. Soc. Res. Rep. No. 7.
- Burger, J., K. Parsons, T. Benson, T. Shulka, D. Rothstein, and M. Gochfeld. 1992. Heavy metal and selenium levels in young cattle egrets from nesting colonies in the northeastern United States, Puerto Rico and Egypt. *Arch. Environ. Contam. Toxicol.* 23:435-439.
- Butler, R.W. 1980. The concept of the tourist cycle of evolution: implications for management of resources. *Cal. Geogr.* 24:5-12.
- Conover, M.R., and D.E. Miller. 1979. Reaction of ring-billed gulls to predators and human disturbances at their breeding colonies. *Proc. 1978 Conf. Col. Waterbird Group* 2:41-47.
- Crans, W.J., D.F. Caccamise, and J.R. McNelly. 1991. Evidence suggesting a role for glossy ibis (*Plegadis falcinellus*) in the epidemiology of eastern equine encephalitis. *Proc. 78th Ann. Meeting of N.J. Mosq. Control Assoc.* 78:82-85.
- Custer, T.W., and R.G. Osborn. 1978. Feeding habitat use by colonially breeding herons, egrets, and ibises in North Carolina. *Auk* 95:733-743.
- Custer, T.W., B.A. Rattner, H.M. Ohlendorf, and M.J. Malancon. 1990. Herons and egrets as proposed indicators of estuarine contamination in the United States. *Acta XX Congressus Internationalis Ornithologici*: 2474-2479.
- Davis, W.E., and K.C. Parsons. 1991. Effects of investigator disturbance on the survival of snowy egret nestlings. *J. Field Ornithol.* 62:432-435.
- DeMauro, M.M. 1993. Colonial nesting bird responses to visitor use at Lake Renwick Heron Rookery, Illinois. *Natural Areas J.* 13:4-9.
- Ehrlich, P.R., D.S. Dobkin, and D. Wheye. 1988. *The Birders Handbook: A Field Guide to the Natural History of North American Birds*. Simon and Schuster, New York.
- Erwin, R.M. 1979. Coastal waterbird colonies: Cape Elizabeth, Maine to Virginia. U.S. Fish and Wildl. Serv., Off. Biol. Serv. FWS/OBS-79/08.
- Erwin, R.M. 1983. Feeding habitats of nesting wading birds: spatial use and social influences. *Auk* 100:960-970.
- Erwin, R.M. 1989. Responses to human intruders by birds nesting in colonies: experimental results and management guidelines. *Colonial Waterbirds* 12:104-108.
- Erwin, R.M., D.K. Dawson, D.B. Stotts, L.S. McAllister, and P.H. Geissler. 1991. Open marsh water management in the Mid-Atlantic region: aerial surveys of waterbird use. *Wetlands* 11:209-228.
- Erwin, R.M., G.M. Haramis, D.G. Krementz, and S.L. Funderburk. 1993. Resource protection for waterbirds in Chesapeake Bay. *Environ. Manage.* 17:613-619.
- Erwin, R.M., and C.E. Korschgen. 1979. Coastal waterbird colonies: Cape Elizabeth, Maine to Virginia, 1977: an atlas showing colony locations and species composition. U.S. Fish and Wildl. Serv., Off. Biol. Serv. FWS/OBS-79/08.
- Ford, R.G., D. Heinemann, M.L. Bonnell, and J.L. Casey. 1993. Computer based planning for protection of sensitive Delaware Bayshore habitats from oil spill impacts. *Proc. of N.J. Div. of Fish, Game and Wildl. Delaware Bay Shorebird Workshop*, May 24-26, 1993, Stone Harbor, NJ. Unpublished.
- Greene, R.W., and R.W. Miller. 1994. Summary and assessment of polychlorinated biphenyls and selected pesticides in striped bass from the Delaware Estuary. Final report. Del. Dept. Nat. Resour. and Environ. Cont. (March 1994).
- Harris, H.J. 1988. Persistent toxic substances and birds and mammals in the Great Lakes. Pages 557-570 in M.S. Evans. *Toxic Contaminants and Ecosystem Health: A Great Lakes Focus*. John Wiley & Sons, New York.
- Heinz, G., and S. Wiemeyer. 1991. Effects of contaminants on birds. Pages 23.1-23.9 in S. Funderburk, S. Jordan, J. Mihursky, and D. Riley, eds. *Habitat Requirements for Chesapeake Bay Living Resources*, 2nd ed. Living Resources Subcommittee, Chesapeake Bay Program.
- Helmers, D.L. 1992. Shorebird management manual. Western Hemisphere Shorebird Reserve Network, Manomet, MA. 58 pp.
- Hoffman, D.J., B.A. Rattnes, C.M. Bunck, A. Krynsky, H.M. Ohlendorf, and R.W. Lowe. 1986. Association between PCBs and lower embryonic weight in black-crowned night-herons in San Francisco Bay. *J. Toxicol. and Environ. Health* 19:383-391.
- Jacobson, S.K., and A.F. Lopez. 1994. Biological impacts of ecotourism: tourists and nesting turtles in Tortuguero National Park, Costa Rica. *Wildl. Soc. Bull.* 22:414-419.
- Jenkins, D. 1992-1994. Personal observations.
- Jones, W.L., and W. C. Lehman. 1987. Phragmites control and revegetation following aerial application of glyphosate in Delaware. Pages 184-199 in W. R. Whitman, and W. H. Meredith, eds. *Waterfowl and Wetlands Symposium: Proceedings of Symposium on Waterfowl and Wetlands Management in the Coastal Zone of the Atlantic Flyway*. Delaware Coastal Management Prog., DE Dept. Nat. Resour. and Environ. Cont., Dover, DE. 522 pp.
- Kneib, R.T. 1982. The effects of predation by wading birds (Ardeidae) and blue crabs (*Callinectes sapidus*) on the population size structure of the common mummichog, *Fundulus heteroclitus*. *Estuarine, Coastal and Shelf Sci.* 14:159-165.
- Krebs, J.R. 1974. Colonial nesting and social feeding as strategies for exploiting food resources in the great blue heron (*Ardea herodias*). *Behaviour* 51:99-134.
- Krebs, J.R. 1978. Colonial nesting in birds, with special reference to the Ciconiiformes. Pages 290-311 in A. Sprunt, IV, J.C. Ogden, and S. Winckler, eds. *Wading Birds*. Nat. Aud. Soc. Res. Rep. No. 7.

- Kushlan, J.A. 1976. Feeding behavior of North American herons. *Auk* 93:86-94.
- Kushlan, J.A. 1978. Feeding ecology of wading birds. Pages 249-297 in A. Sprunt, IV, J.C. Ogden, and S. Winckler, eds. *Wading Birds*. Nat. Aud. Soc. Res. Rep. No. 7.
- Meredith, W.H., and D.E. Saveikis. 1987. Effects of open marsh water management (OMWM) on bird populations of a Delaware tidal marsh, and OMWM's use in waterbird habitat restoration and enhancement. Pages 299-321 in W. R. Whitman, and W. H. Meredith, eds. *Waterfowl and Wetlands Symposium: Proceedings of Symposium on Waterfowl and Wetlands Management in the Coastal Zone of the Atlantic Flyway*. Delaware Coastal Management Prog., Del. Dept. Nat. Resour. and Environ. Control., Dover, DE. 522 pp.
- Niemeyer, L., and M. Reigner. 1993. Long Legged Wading Birds of the North American Wetlands. Photography by Lucian Niemeyer; text by Mark Reigner. 1st ed. Stackpole Books, Hong Kong. 207 pp.
- Niethammer, K.R., T.S. Baskett, and D.H. White. 1984. Organochlorine residues in three heron species as related to diet and age. *Bull. Environ. Contam. Toxicol.* 33:491-498.
- Ogden, J.C. 1978. Recent population trends of colonial wading birds on the Atlantic and Gulf Coast plains. Pages 137-145 in A. Sprunt, IV, J.C. Ogden, and S. Winckler, eds. *Wading Birds*. Nat. Aud. Soc. Res. Rep. No. 7.
- Ohlendorf, H.M. 1981. The Chesapeake Bay's birds and organochlorine pollutants. *Trans. N. Am. Wildl. and Nat. Resour. Conf.* 46:259-270.
- Parsons, K.C. 1993. The Pea Patch Island wader colony: a proactive plan for natural resource protection and management. Progress Rep. submitted to Del. Dep. Nat. Resour. and Environ. Control, Dover, DE. 37 pp.
- Parsons, K.C., and J. Burger. 1982. Human disturbance and nestling behavior in black-crowned night-herons. *Condor* 84:184-187.
- Sciascia, J. 1994. Personal communication.
- Shear, H. 1984. Contaminants research and surveillance - a biological approach. Pages 31-52 in J.O. Nriago and M.S. Simmons. *Toxic Contaminants in the Great Lakes*. John Wiley & Sons, New York.
- Smith, H.K. 1978. An introduction to habitat development on dredged material. U.S. Army Eng. Waterways Exper. Stn. Tech. Rep. DS-78-19. Vicksburg, MS. 40 pp.
- Soots, R.F., and M.C. Landin. 1978. Development and management of avian habitat on dredged material islands. U.S. Army Corps of Eng. Waterways Exper. Stn. Tech. Rep. DS-78-18. Vicksburg, MS. 123 pp.
- Steidl, R.J., C.R. Griffin, and L.J. Niles. 1991a. Differential reproductive success of ospreys in New Jersey. *J. Wildl. Manage.* 55:266-272.
- Steidl, R.J., C.R. Griffin, and L.J. Niles. 1991b. Contaminant levels of ospreys eggs and prey reflect regional differences in reproductive success. *J. Wildl. Manage.* 55:601-608.
- Stone, W. [1937] 1965. *Bird Studies at Old Cape May*. Vol. 1. Delaware Valley Ornith. Club. Reprint. Dover Publications, Inc., New York. 484 pp.
- Terres, J.K. 1980. *The Audubon Society Encyclopedia of North American Birds*. Wings Books, New York.
- Tiner, R.W., Jr. 1985. *Wetlands of Delaware*. U.S. Fish and Wildl. Serv., National Wetlands Inventory, Newton Corner, MA, and Del. Dept. Nat. Resour. and Environ. Control, Wetlands Section, Dover, DE. Coop. Publ. 77 pp.
- Torok, L.S., A.T. Wendolowski, L.A. Gelvin-Innvaer, and D.M. Peters. 1993. Shorebird management and protection: regulatory protection of habitats. *Proceedings of N.J. Div. of Fish, Game and Wildl. Delaware Bay Shorebird Workshop, May 24-26, 1993*, Stone Harbor, NJ. Unpublished.
- Waltz, E.C. 1983. On tolerating followers in information-centers, with comments on testing the adaptive significance of coloniality. *Colonial Waterbirds* 6:31-36.
- Wiese, J.H. 1979. A study of the reproductive biology of herons, egrets, and ibis nesting on Pea Patch Island, Delaware. Final Interpretive Rep. for Delmarva Power and Light. 255 pp.
- Willard, D.E. 1977. The feeding ecology and behavior of five species of herons in southeastern New Jersey. *Condor* 79:462-470.