

THE AVIFAUNA OF BISCAYNE BAY

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ABSTRACT

Ecological studies of the avifaunas of subtropical estuaries such as Biscayne Bay are much needed. Broad ecological surveys are not possible until basic natural history of estuarine species is appreciated. Outline is herein presented of foraging habitats and feeding strategies of birds of Biscayne Bay. Inventory of species important from population sizes or special ecological considerations is given. References are made to completed and ongoing research with these taxa. This information is basic to future work. Recommendations for needed research are made.

INTRODUCTION

Inventory of birds of a subtropical estuary, such as Biscayne Bay, emphasizes a surprisingly diverse spectrum of species. Far more than typically aquatic birds must be considered. Birds of the forest canopy breed in the mangroves; these too are supported by the Bay's productivity. At times the mangroves are filled with landbirds, migrants pausing to rest before or after long over-water passages. Raptors hunt over both the Bay and its fringing habitats. Colonial land birds gather to nest and/or roost at the Bay and, having foraged inland, add productivity, via their excrement, to the Bay. Many of the Bay's birds are represented there by more than one population; southern Florida wading birds, for example, are joined at the Bay in winter by members of their species from a large area of North America. Through local movements of birds and from long distance migrants, seasonal turnovers of the Bay's avian populations become complex indeed.

The ecological importance of the Bay's avifauna is obviously significant. Yet, ecological studies of this Bay, and of similar situations, are rarely directed to birds. Odum (1971), for example, "conducted no investigations of the diet of carnivorous birds", although he described them as important components of the top trophic level. One searches the texts of may seemingly widely inclusive titles of estuarine research -- for example, "An ecological survey of the subtropical inshore waters adjacent to Miami" (Smith et al., 1950) -- without finding mention of birds. Thus, while birds are acknowledged as important components of the subtropical estuary's fauna, surprisingly little actual information backgrounds the acknowledgement.

There are patent explanations for this lack of information. Birds are shy and volant. Their populations are not necessarily static. Censusing an avian population is not easy. Cragg (1967:83) summarized the general situation regarding our knowledge of bird populations nicely (albeit with British ones): "except for a very few species no attempt has been made to assess population numbers ... of 200 or so breeding birds ... estimates ... have only been made for 15 species ... in only four have estimates been made in three or more years" Another basic lack of information arises from the lack of autecological studies of birds within subtropical estuaries or comparable habitats. With but few exceptions (e.g., Allen, 1942 and Kushlan, 1974) such studies are lacking. Significant strides have now been made in bioenergetic studies of birds (e.g., Paynter, 1974). But to study energy flows involving an avifauna, one must have estimates of the populations involved, appreciate the components of the diets of the species, and know a great deal more about factors which affect energy budgets. It can be misleading indeed to apply data of these sorts, gathered in ecological communities and in geographical areas not comfortably comparable with the subtropical estuary to Biscayne Bay.

One fact is clear. Estuarine birds are in large part consumers at upper trophic levels. Volant, they emphasize the open nature of the estuarine ecosystem to greater degree than most animals. Probably no animals express productivity of the Bay at more remote portions of the continent (in some cases continents) than do birds.

Better knowledge of the Bay's avifauna is important. The birds constitute an enormous biomass, a biomass varying seasonally both qualitatively and quantitatively. Its place in an overview of the ecology of the Bay cannot be ignored. Changes in the avifauna will reflect themselves importantly in the entire ecosystem. Ultimate consumers at apices of many of the food chains, birds' roles, if understood could serve as convenient indicators of many aspects of Bay ecology. Tabb et al. (1962: 73) showed this nicely re disappearance of certain birds from areas of changing salinity in Coot Bay. The time to gain our knowledge, however, is passing. There have been profound changes in the Bay's avifauna. These changes are ongoing. The time is uncomfortably late at which to be seeking basic information regarding a major segment of the megafauna.

Knowledge of the Bay's avifauna is critical to more than the estuarine ecologist. Biologists, wildlife managers, and conservationists remote from Florida are concerned with the species which have migrated to their areas after wintering in or passing through subtropical estuaries. Florida's conservationists, county planning boards, and lawmakers need the ecologist's information so that they may effect realistic planning for the ecosystem. Finally, and not of least importance, is the naturalist. Knowledge enhances esthetic appreciation and, as Davis (1943) aptly expressed it, the bird life is "one of the most attractive features of south Florida."

PLAN OF THIS WORK

The initial step in consideration of an avifauna is an inventory of the major taxa and at least its most significant species. For Biscayne Bay this is fairly routine. The inventory can be compiled from Howell (1932) and from Sprunt (1954 and 1963). Along with this one needs knowledge of the status of the species in southern Florida and of their population movements or migrations. The former can, in general,

be found in the above references. Infra-peninsular population movements of many species are by no means well understood. Broad patterns of movement (migrations) have been summarized (A.O.U. 1957).

The next step is summarization of pertinent aspects of the natural history. What types of residents are the species at the Bay -- permanent, winter, summer, migratory, etc.,? What is known of local population movements? Have censuses been made of Bay populations? For a number of years December (Christmas) birdcensuses have been made in the northern portion of the Bay. these are published in American Birds as the "Dade County Count". Do the birds breed at the Bay?, roost at the Bay?, feed at the Bay? What are the feeding strategies? What is the general diet? Have analyses of the diet been made in Biscayne Bay or at another subtropical estuary? What pertinent research has been achieved with the species and what is the nature of ongoing research?

It is with such basic information that this contribution is largely concerned. It is information basic to future work with ornithology or general ecology. The information will clearly indicate avenues for meaningful future investigation.

Birds of Biscayne Bay

Foraging strategies

Before inventory and discussion, it will be useful to categorize the taxa in terms of usage of the ecosystem, specifically the foraging opportunities presented by the Bay and its ecologically dependent surroundings. From this the diversity of the avifauna adapted to utilize the Bay's productivity is nicely apparent. The outline can also be utilized in construction of models for a variety of studies of the avifauna .

The Bay's birds forage within:

- A. Open water of the Bay. Here are found:
 1. Birds that swimming submerged forage for:
 - a. fish (birds such as cormorants and mergansers),
 - b. invertebrates (cormorants and diving ducks),
 - c. plants (coots, some diving ducks),
 - d. animals and plants (coots and some diving ducks).
 2. Birds that plunge to the surface from flight and secure prey from upper inches of surface water. These forage chiefly for:
 - a. fish (pelicans, ospreys, terns, kingfishers),
 3. Birds that "skim" the surface and forage for:
 - a. fish and macroplanktonic invertebrates (skimmers).
 4. Birds that either pick up food from the air or land and swim to the food. These forage chiefly for:
 - a. fish (eagles, gulls and frigatebirds),
 - b. dead animals and animal refuse (gulls).
 5. Birds that forage from swimming positions at the surface and reach down to feed on objects at the substrate of shallow water. These forage upon:
 - a. invertebrates ("dabbling" ducks and coots),
 - b. plants (dabbling" ducks and coots).
- B. Shallow perimeters of the Bay and its islands. Here are found:
 1. Birds with long legs, long necks, and long mandibles. These forage for:
 - a. aquatic vertebrates (herons, spoonbills, etc.),
 - b. invertebrates (herons, ibises, oystercatchers).
- C. Shores and exposed tidal flats. Here forage:
 1. Birds that pick or probe for:
 - a. invertebrates (plovers and sandpipers),
 - b. dead organisms and refuse (vultures, gulls, grackles).
- D. The forest floor beneath the mangroves. Foraged in by:
 1. Birds that walk (sometimes wade) for:
 - a. invertebrates (rails and night-herons).
- E. The mangrove forests (usually not the forest floor). These are foraged in by:
 1. Birds that glean the bark or penetrate twigs and trunks to feed upon:
 - a. insects (woodpeckers, vireos, some warblers, etc.)
 - b. sap (Yellow-bellied Sapsucker).
 2. Birds that forage within the canopy for:
 - a. insects (cuckoos, vireos, warblers).

3. Birds that fly up from the canopy to "flycatch" above it. These forage for:
 - a. insects (kingbirds and other flycatchers).
 4. Birds that forage while in flight above the canopy. These forage for:
 - a. insects (swallows).
- F. All of the area within the Bay ecosystem. Such foragers are:
1. Predatory birds which forage upon:
 - a. assemblages of birds or other animals (falcons, hawks, and owls),
 - b. eggs and young at rookeries as well as food being carried to young by adults (frigatebirds).
 2. Scavengers upon:
 - a. dead animals, refuse, etc. (vultures and gulls).

Inventory of taxa

The species enumerated below do not constitute a complete inventory of the Bay's avifauna. Discussed are largely those now represented by sizable populations during some period of the year. Also included are species the occurrence of which can be regarded as ecologically significant aside from abundance: rare, threatened and endangered species I include in this category -- these categories were assigned by the Florida Committee on Rare and Endangered Plants and Animals (1974). General information important to an ecologist's approach is included as are comments regarding needed information.

Gaviiformes: Gaviidae
 Common Loon
Gavia immer

A winter resident of Florida's coastal waters, this piscivore is present in Biscayne Bay in small numbers. Large "kills" of the birds have occurred in Florida in recent years (e.g., Stevenson, 1971: 567). Causes of many of these remain unsolved. Fresh carcasses of loons and of other aquatic birds of the Bay should be transmitted to pollution control authorities; information of significance can be obtained from them.

Podicipediformes: Podicipedidae
 Pied-billed Grebe
Podilymbus podiceps

Fresh-water areas of southern Florida are habitat of a breeding population of this grebe which nests when water levels are high (they build floating nests). Large numbers migrate into southern Florida in winter and grebes then become distributed in coastal waters as well as fresh. Thus on 22 December, 1974, 41 were observed (American Birds, 1975) about the Bay's north-central portion. Throughout the entire Bay many more were undoubtedly present.

Food of the grebes, which forage while submerged, in fresh-water consists of small fishes, crayfish, and insects (Howell, 1932). Stomach analyses from birds in marine habitats of Florida are needed. To what extent do the birds move between marine and fresh-water habitats? Whether post-breeding birds of south Florida's population move into estuarine habitats is not known.

Pelecaniformes: Pelecanidae
 Brown Pelican
Pelecanus occidentalis

Since 1950 the breeding range of the eastern race (P. o. carolinensis) has contracted into peninsular Florida (Schreiber and Risebrough, 1972) and the subspecies is designated "endangered." The birds now do not apparently breed in Biscayne Bay (Williams and Martin, 1970). They are common however, throughout the Bay; 285 were counted in a portion of the Bay on 21 December, 1974 (American Birds, 1975). Any number is obviously important re the total population (estimated by Schreiber et al., 1973) now remaining in the state. Every effort should be made to determine the seasonal fluctuations and composition (adults: immatures) of the Bay's population. Areas important to roosting should be determined. Status of the birds at the Arsenicker Keys, where they once may have nested, should be monitored. Dependence upon man's activities (i.e., fish refuse for feeding and man-made structures for roosting should be determined). Levels of organochlorines, apparently responsible for the population's decline should be determined from fresh carcasses which may be found.

Pelecaniformes: Phalacrocoracidae
 Double-crested Cormorant
Phalacrocorax auritus

This is one of the abundant piscivorous birds of the Bay where it is common virtually everywhere. The population is large throughout the year but it appears to increase in winter when migrants of the northeastern subspecies (P. a. auritus) join the local populations (P. a. floridanus). A specimen in

the University of Miami Reference Collections (UMRC 6151) found unable to fly in Biscayne Bay in April 1970 had been banded as a nestling in June 1969 at Port Clyde, Maine. A December count of birds in the north-central portion of the bay totaled 779 birds (American Birds 1975); several times this number were undoubtedly present in the entire bay at this time.

Cormorants forage while submerged. Owre (1967) listed Opsanus beta, Bagre marina, Myrichthys acuminatus, and Sparisoma sp. from cormorants taken near Biscayne Bay; Scattergood (1950) listed Scomber scombrus and Mugil cephalus from stomachs of cormorants taken near Pensacola. These lists imply that the cormorants pursue some fish and forage at the bottom for others. The numbers of the birds in Biscayne Bay, if the diet here were known, could be used as indicators of the fish populations present.

Cormorants nest in the mangroves of West Arsenicker Key. Pierce (1962) described a rookery (he did not specify nesting) at Black Point in 1885 and another at the Arsenickers.

The hundreds of cormorants perched upon pilings and other dock-side structures are attractive sights. Along with the pelicans they are an important part of the picturesque fauna of the bay.

Pelecaniformes: Fregatidae
Magnificent Frigatebird
Fregata magnificens

In 1885 Pierce (1962) observed frigatebirds in north Biscayne Bay and found them roosting near the Arsenicker Keys. These portions of the bay are still frequented by the birds, particularly in spring and summer. At these times herons and ibises are nesting at the Arsenickers. I counted more than 100 frigatebirds about this rookery in early summer 1975. The frigatebirds, which roost in mangroves of the coastal fringe and nearby islets, are attracted by opportunities to rob adult herons of food they are carrying to their young; eggs and small nestlings may be taken as well. Frigatebirds also seize flying-fish and pick up other marine organisms from the water's surface (Bent 1922).

Their long, forked tails, seven-foot wing-spans, and peerless aerial maneouwerings place these birds among the most picturesque of any avifauna and the bird-watching tourist in southern Florida has such pan-tropical birds high on the list of species to see.

Regarded as a "threatened" species, much needs to be learned about birds of the local population. Careful inventory should be made of the bay's birds.

Ciconiiformes: Ardeidae
Herons and Egrets

Ten species (there are two color morphs of two of these) are of importance about the bay:

Great Blue Heron (Ardea herodias) The white morph or color phase of this species is known as the "Great White Heron" and was until recently accorded specific distinction as Ardea occidentalis (See A.O.U. 1973).

Green Heron (Butorides virescens)

Little Blue Heron (Florida caerulea)

Cattle Egret (Bubulcus ibis)

Reddish Egret (Dichromanassa rufescens) Reddish and white morphs or color phases are found.

Great Egret (Casmerodius albus)

Snowy Egret (Egretta thula)

Louisiana Heron (Hydranassa tricolor)

Black-crowned Night Heron (Nycticorax nycticorax)

Yellow-crowned Night Heron (Nyctanassa violacea)

Only two of these are essentially non-piscivorous. The Cattle Egret, which has colonized Florida since 1950, is probably the most abundant ardeid in the world. It now breeds in large numbers at West Arsenicker Key (several thousand nests in 1975) and on mangrove islets in Greynolds Park (these mangroves are a part of the bay ecosystem). Largely insectivorous, the egrets fly inland to fields and open areas to feed. This species has reversed the usual pattern of ciconiiforms removing estuarine productivity

through distributing excreta away from the bay. Browder (1973) analysed stomachs of more than 100 Cattle Egrets from southern Florida.

Yellow-crowned Night Herons, a species of "special concern", are at the bay essentially birds of the mangroves where they feed to a large extent upon crustaceans and molluscs. They probably nest solitarily in the bay's mangroves; they join the mixed species assemblage of ardeids nesting at the Arsenicker Keys.

Black-crowned Night Herons are less abundant about the bay than the preceding species and, at least inland, their diet includes fish to a considerable extent (Howell 1932). They may breed sparingly about the bay.

The remaining herons are largely piscivorous and occur at the bay in varying abundance. Robertson and Kushlan (1974: 427) summarized the seasonal movements of the species in southern Florida. Migrations from outside the state and intra-peninsular population shifts are noteworthy. The species employ different strategies in foraging (Kushlan 1976) and the spectrum of prey taken is great. Foraging is virtually throughout the bay ecosystem: shallow shorelines, within as well as bayward of the mangroves; along canals penetrating the bay's perimeters; along tidal creeks; at the shorelines of causeways; and about the extensive tidal flats. Important feeding areas exist in the landward swamps which receive fresh-water runoff from the interior (see Wanless 1974: 191). Where the coastal mangrove swamp gives way to dwarf red mangrove swamp and/or fresh-water swamp, ciconiiforms gather to feed. Robertson identified the light between Old Rhodes and Totten Key as an important feeding area of some ciconiiforms.

Although Heald et al. (1974: 184,185) commented on the volume of mangrove productivity wading birds consume, there are no actual figures for such that I am aware of and in making their estimates a non-ardeid, the Wood Stork (Mycteria americana) was used as a base-line. Data used for this bird were gathered at inland fresh-water situations.

At this time we are not certain of the main feeding areas of the ardeids from the Greynolds Park breeding rookery of Little Blue Herons, Snowy Egrets, Cattle Egrets, and others (J. King pers. comm.). Nor do we know the main feeding areas of the Arsenicker Key breeding birds. Flights of these birds should be tracked to and from their rookeries. Special consideration or "immunity" from development should be accorded prime feeding areas.

Two herons merit special comment. The Reddish Egret and the white morph ("Great White Heron") of the Great Blue Heron are "threatened" and "rare" respectively. The most northerly breeding locality on the Atlantic Coast of the latter is at the Arsenickers (Robertson 1964). The species increases in abundance southward along the Florida Keys. The former probably breeds at the Arsenickers (adults flushed from the breeding colony in summer 1975) and probably (Robertson 1964) at Islandia. Rich Paul (pers. comm.), under auspices of the National Audubon Society, is currently studying the species in Florida and elsewhere. Important information can usually be gained from study of species at the periphery of their ranges which in these cases are, in part, in Biscayne Bay.

Ciconiiformes: Ciconiidae
Wood Stork
Mycteria americana

The Wood Stork an "endangered" species, enters the bay at times. The ecology of the species has been investigated by Kahl (1964) and others are conducting ongoing studies of this stork which nests in mangrove areas elsewhere in southern Florida and at inland points. In recent years only small numbers of the birds have fed seasonally in the bay.

Ciconiiformes: Threskiornithidae
White Ibis
Eudocimus albus

There are coastal breeding colonies of this species and some birds from the much larger inland breeding colonies apparently move to the coast after breeding (Kushlan 1974). West Arsenicker Key, by my counts, contained well more than 1,000 ibises in the spring of 1975, most of them nesting. On certain days out-flights of ibises from the rookery proceeded north along the west side of the bay to at least Fender and Black Points before being lost to view. Thus the bay appears to afford this breeding colony foraging areas. The birds also breed at Greynolds Park; it is not clear where these forage.

Kushlan (loc. cit.) found that at coastal areas quite different food was taken than at inland habitats. His estimates of the energy requirements of the birds provide information pertinent to birds of south Florida estuaries. Major feeding areas of breeding birds of the bay and of those entering the bay at other times of the year need to be determined. Population censuses within the bay are needed.

Ciconiiformes: Threskiornithidae
Roseate Spoonbill
Ajaia ajaja

This "threatened" species occurs with some regularity about the bay. There are apparently no recent records of nesting anywhere within the bay's perimeters. Allen's (1942) extensive study of the species provides information important to any considerations of the ecology of mangrove swamps. Ongoing study of the birds in Florida Bay is being conducted by J. Ogden of the National Audubon Society.

Anseriformes: Anatidae
Ducks

Species of waterfowl visiting the bay seasonally, chiefly in winter, are too numerous to enumerate. These are largely migrants from northern states and Canada, although the Mottled Duck, Anas fulvigula, which breeds in largely fresh water of southern Florida, enters the bay at times. Numbers of ducks in the bay today are much reduced, as are duck populations throughout the continent. Pertinent to reductions of species wintering in Biscayne Bay are, presumably, those factors enumerated by Lindall (1973) as threatening fish resources of southern Florida: reduction of fresh-water runoff into the estuaries, pollution, pesticides, thermal addition, and dredging and filling activities. Human traffic in and about the bay must also be a deterrent.

That the Lesser Scaup (Aythya affinis) was formerly "the most abundant species of duck in winter and spring" is indicated by Howell's (1932: 149) quoted account from 1910 of flocks in the upper end of Biscayne Bay "sometimes two or three miles long" numbering "tens of thousands." In 1973 and 1974 censuses in roughly the same area recorded, respectively, 182 and 12 individuals (American Birds 1974, 1975). Lesser Scaups consume plant and animal food in about equal quantity (Kortright 1942). They dive when foraging, securing food while beneath the surface.

The Red-breasted Merganser (Mergus serrator), a piscivore foraging while submerged, is seldom hunted. It frequents shallow bays and estuaries of Florida in winter. Probably never abundant as the Lesser Scaup was, the birds are a noticeable part of the bay's avifauna. In December 1974, 160 were tallied within a portion of the north-central part of the bay (American Birds 1975).

Falconiformes: Cathartidae
Turkey Vulture
Cathartes aura

Concentrations of these vultures about the bay have increased as the city has grown. In 1973 a December census of birds within a circle 15 miles in diameter, including both urban areas and the bay, tallied 1,200 Turkey Vultures (American Birds 1974). This is probably only a portion of the total present at that time. The concentrations are largely seasonal. Numbers increase in fall and winter, presumably from birds migrating to the city from north of the state and possibly from intra-peninsular populations. The vultures forage at garbage dumps, sewage disposal areas, and incinerators. They also search the bay's shorelines where they glean refuse, animal wastes, etc. Along with gulls and some additional scavengers, these birds are subsidized by man and their concentrations have grown in correlation with man's activities. They are a conspicuous sight about the bay, roosting on the ground or in trees wherever suitable areas are found; until Burlingame Island, at the mouth of the Miami River, was "improved" hundreds of the birds roosted there. Their actual importance, in terms of the bay's productivity, seems largely incidental.

Falconiformes: Accipitridae
Bald Eagle
Haliaetus leucocephalus

To considerable extent piscivorous, the Bald Eagle is an apex of the organochlorine, heavy metal residue-concentrating food chain of aquatic animals (Krantz *et al.* 1970). This, along with habitat change and illegal shooting, has resulted in substantial reductions of the eagle's populations in eastern United States (Braun *et al.* 1975). Numbers still breed in peninsular Florida and Florida Bay. An eyrie existed in Biscayne Bay near Bear Cut in 1959-1960 (W.B. Robertson, Jr., *pers. comm.*), another south of Tahiti Beach in the fifties and early sixties, and in 1974-1975 breeding was attempted near Cutler. Eagles continue to frequent the bay. These are, presumably, birds from nearby areas in Florida; some may be migrants from elsewhere. The unhappy status of our national emblem was well described by Zimmerman (1976). Every effort should be undertaken to protect the bay's eagles from molestation and to insure suitable habitat for foraging, roosting, and possible future nesting.

Falconiformes: Pandionidae
Osprey
Pandion haliaetus

A fish-eating raptor, the Osprey has also been severely reduced in numbers over much of the United

States and is now "endangered". The population in southern Florida, however, has remained relatively stable (Henny and Ogden 1970). Ospreys still nest at points within Islandia (Robertson 1964) and elsewhere about the bay. The population apparently increases in winter as migrants arrive.

As with the eagles, every effort is needed to preserve suitable habitat for the birds. Protected zones should be maintained about nests, nesting success should be determined and populations of the birds about the bay should be carefully monitored.

Falconiformes: Accipitridae, Falconidae
Hawks and falcons

Mangrove forests attract a variety of hawks and falcons. Attention is well directed to some of these.

The Red-shouldered Hawk (Buteo lineatus), a permanent resident, is ubiquitous in southern Florida. More characteristic of inland habitats, it nevertheless ranges into the mangroves where it forages, roosts, and may nest. In the mangroves it preys upon a variety of reptiles, mammals, birds, etc. which are part of the ecosystem's food web.

The Short-tailed Hawk (Buteo brachyurus), an extremely rare bird in Florida, hunts and sometimes nests in mangrove forests. It preys largely upon small birds, foraging along forest edges (Ogden 1974: 97). In southern Florida the species becomes more numerous in winter, its population apparently contracting southward in the peninsula (Ogden op. cit.). I have seen individuals in mangroves at the southern end of the bay and Robertson (1964) suggested that it might nest in Islandia.

Merlins (Falco columbarius) migrate through southern Florida and some winter here. Individuals frequent the mangroves where they hunt small birds and insects. In spring, merlins perch atop mangroves where they intercept small birds in migration making their way in from the ocean towards landfall.

Gruiformes: Rallidae
Clapper Rail
Rallus longirostris

This rail is restricted to salt marshes or marine swamp-forests. Three subspecies have been described from Florida's coastline. R. l. scotti is distributed from Pensacola along the southern tip of the peninsula (excepting the Florida Keys) and northward through Biscayne Bay (Howell 1932). The loud, harsh calls of this secretive bird are frequently the only evidence of its presence within the mangrove forests. Arthropods and molluscs are among the food items it takes from about the mangrove roots. Little is known about its niche within this habitat. Because of the ongoing destruction and alteration of mangrove habitats, there is concern for the population.

Gruiformes: Rallidae
American Coot
Fulica americana

Coots, largely winter residents in southern Florida, congregate in fresh, brackish, or sheltered marine waters. They often become abundant locally and flocks exceeding 1,000 are not unusual. During the December 1974 census about portions of the northern one-half of the bay, 1,401 were counted (American Birds 1975). Omnivorous, coots forage along shorelines while afoot, dabble for food while swimming at the surface, and dive to procure food and will move distances while submerged. A variety of plants and animals is consumed. Large concentrations of the birds effect considerable impact on an aquatic ecosystem. Information, which could be easily gained, since the birds are tractable in captivity, as to their bioenergetics in a subtropical estuary is apparently lacking.

Charadriiformes: Charadriidae
Plovers

Short-legged, running birds, plovers range the tidal flats and beaches of the bay. With relatively short, stout bills, they pick up food from the substrate, securing a great variety of littoral invertebrates.

Common within the bay are: the Semipalmated Plover (Charadrius semipalmatus) found on mud flats and along shorelines as a migrant and wintering bird; Wilson's Plover (Charadrius wilsonia), is present at all seasons and breeds sparingly; its nest is a "scrape" in the sand above high tide lines; the Black-bellied Plover (Pluvialis squatarola), a conspicuous bird along shorelines and tidal flats, migrates to breed on the arctic tundra.

Charadriiformes: Scolopacidae
Sandpipers, yellowlegs,
turnstones, sanderlings, etc.

More than 20 species of this much diversified family of littoral-inhabiting birds may be looked for

within the bay. These range in total length from about 140 mm in the smallest species to more than 500 mm in the largest. Bills of the smallest are about 16 mm in length, of the largest as much as 180 mm. The species can, therefore, reach into varying depths of water and substrate, many of them probing for food. The birds exhibit a variety of feeding techniques (Baker and Baker 1973) which further define their species-specific niches. The scolopacids, along with other charadriiform taxa, exploit a wide littoral environment (see, e.g. Hall 1960). Enumeration of some of the species at the bay will emphasize this.

Willetts Catoptrophorus semipalmatus inhabit coastwise marshes and protected shallow water. They winter in some numbers within the bay; some breed in coastal areas elsewhere in southern Florida on certain keys in Florida Bay. Medium-sized (about 380 mm in length and with bills 50 mm long) willetts wade while feeding and take a variety of crabs (Uca, Sesarma), other arthropods, molluscs, small fish, etc.

Ruddy Turnstones (Arenaria interpres) are abundant, except in summer, along the bay's intertidal areas. Flocks of the birds, moving along the shorelines, glean marine invertebrates and their eggs and larvae, from beneath stones, shells, seaweed, etc., which the birds overturn with their bills.

The Sanderling (Crocethia alba), its nesting in the arctic completed, migrates southward over littoral areas of the world. Compact flocks hurry along the beaches and exposed flats of Biscayne Bay gleaning invertebrates exposed by receding waves.

Dowitchers (Limnodromus spp.) winter in southern Florida. Their long bills (bills about 75 mm, bodies about 285 mm in total length) enable them to probe deeply for a variety of invertebrates.

Charadriiformes: Laridae: Larinae
Gulls

The Laughing Gull (Larus atricilla) breeds locally and occurs in large numbers in Biscayne Bay in winter. In portions of the upper one-half of the bay, 6,384 were tallied on 21 December 1974 (American Birds 1975). In winter the Ring-billed Gull (Larus delawarensis) migrates south into Florida and its numbers in the bay become considerable (from the same count as above, 4,972). Small numbers of Herring Gulls (Larus argentatus) and Bonaparte's Gulls (Larus philadelphia) also winter about the bay.

It is chiefly the Laughing and Ring-billed gulls that form the very large wintering assemblages of gulls in and about Biscayne Bay. In January 1973 I estimated that no fewer than 70,000 gulls were present. These roost at night on mud flats and spoil islands (where they are immune from approach by terrestrial predators). The birds feed throughout the bay as well as its urban surroundings. The sizes of the flocks of these birds at their inflighting and outflighting over the bay while en route to and from their roosts cause no little comment. The gull "traffic" over the area, especially at Miami International Airport and in its vicinity and the presence of the birds at the airport where they come to scavenge and rest and sun in the open areas of the field, create serious problems for aircraft operation.

Wintering gull populations can be controlled to some extent by elimination or alteration of spoil islands and other man-made areas where the birds roost. Relocating garbage and refuse dumps where the birds gather to feed or employing different methods of disposal of this refuse will also be effective. These are the primary attractions for the birds.

It is obvious that the bay's productivity is not the important factor attracting this large segment of its associated fauna. Scavengers, the gulls have discovered superabundant food supplies. Their adaptations to aquatic environments, in particular their roosting requirements, and the proximity of food, albeit of non-aquatic origin, have concentrated their population at the bay. The guano deposited at the bay by this extremely large number of roosting birds must be considerable indeed. As with the Cattle Egrets, the usual process of birds distributing their excreta inland, the bay thus losing a part of its productivity, has been reversed here.

Charadriiformes: Laridae: Sterninae
Terns

Terns, primarily piscivorous and plunging to the surface for prey, are represented at the bay by at least 7 species (some of them in categories of concern), that appear, at least seasonally, in numbers. Two are considered here.

The Least Tern (Sterna albifrons) migrates from South America and breeds within littoral areas along coastlines and riverine systems of the United States. Colonial in nesting, the birds seek open areas of high beach for their scrapes. Increasingly in south Florida freshly bulldozed sandy areas, land fills, spoil islands, etc. present the only habitat for nesting. At one time the birds nested abundantly along the dredged up right-of-way of Biscayne and other causeways and on the increasing areas of land fills. Growing human populations have seriously interfered with Least Tern colonies. The species is now considered "threatened".

Unusual nesting sites of these terns were first reported about 15 years ago. At the present time

"roof-nesting" is well-established and numbers of locations of such within the urban surroundings of Biscayne Bay are known (Fisk 1975). These birds continue to forage in bay habitats. There has been, thus, the unusual situation of a species maintaining its dependence upon the bay's productivity for food, but shifting its nesting habitat away from the marine littoral.

The Royal Tern (Thalasseus maximus), now a species of "special concern", no longer breeds in Florida (Kushlan and Robertson 1974); it remains, however, common about the marine littoral and is variously abundant in Biscayne Bay throughout the year. Foraging carries many well beyond the bay to the ocean littoral. Many roost on spoil islands, flats, and exposed areas within the bay. Those birds which return to the bay from the ocean are, through their excrement, enriching the bay from the ocean itself. They are, of course, not the only species to do so. A great many of the fish-eating and invertebrate-devouring species forage to some extent along or offshore the coast and seek protected sites within the bay for roosting.

Charadriiformes: Rynchopidae
Skimmers

The Black Skimmer (Rynchops nigra), a species of "special concern", exploits the bay's productivity in winter when its numbers may reach several hundred, possibly 1,000 or more. It forages from flight with its lower mandible partly immersed, the bill snapping shut on contact with fish and invertebrate prey. Largely crepuscular and nocturnal, the skimmers roost by day on spoil islands, tidal flats, and other open spaces.

Cuckoos, nighthawks,
kingfishers, and woodpeckers

These species, of diverse taxa, exploit the mangroves or their immediate vicinity.

The Mangrove Cuckoo (CUCULIFORMES: CUCULIDAE: Coccyzus minor) is as certain other birds to be discussed, a species evidently in current colonization of southern Florida. Its range is still largely that of the mangrove forest (to an increasing extent inland of this) where it is present all year. Its diet, as with most cuckoos, probably emphasizes caterpillars. Close study of its diet would be of interest with respect to the mangrove food chains involving insects.

The Common Nighthawk (Chordeiles minor) winters in South America, returning to breed in this continent. Crepuscular and nocturnal, the birds forage awing. During the nesting season much foraging is accomplished about the mangroves where flying insects, which are abundant at this time of year, are taken.

The Belted Kingfisher (CORACIIFORMES: ALCEDINIDAE: Megaceryle alcyon), solitary when not breeding, defends stretches of tree and shrub-bordered marine and fresh-water habitats. From its perches, or from hovering flight nearby, the birds plunge to the surface for fish.

Two of the several species of south Florida's woodpeckers utilize the mangrove forests. The Red-bellied Woodpecker (PICIFORMES: PICIDAE: Centurus carolinus) is widespread in Florida. About Biscayne Bay it is commonly seen in the mangroves both of the coastlines and on nearby islets. It forages, in part at least, for tree-frequenting invertebrates found on bark and within the wood of trunks and twigs. At least two species of termites, Prorhinotermes simplex and Kalotermes jouteli, occur commonly in the mangroves (Banks and Snyder 1920) and are no doubt among food sought by these woodpeckers. The Yellow-bellied Sapsucker (Sphyrapicus varius) is a winter resident in southern Florida. The birds drill rows of small holes in the bark of twigs and trunks and visit these sap "wells" regularly to drink the accumulated sap. While sapsuckers are most frequent in upland situations, that they also forage in mangroves is indicated by the numerous trees which bear "scars" of the bird's activities. This is an unusual ramification of the mangrove food chain.

Passeriformes
Passerine birds

To most people these are the familiar birds of the landscape, the songbirds of city parks and yards. Where urban areas extend to the bay, these birds become bayside dwellers and are, to an extent, subject to certain influences of the bay. The Passeriformes to be emphasized in this discussion are those which under natural conditions are obvious parts of the food web of the bay. They are, with a few exceptions, conveniently discussed as groups and in very general manner.

The migrants which in spring and fall pass along the peninsula often rest and feed in extraordinarily large numbers in the mangroves and other coastwise vegetation. Anyone in spring who has witnessed the flocks of warblers (PARULIDAE) flying landward from the open sea appreciates the importance of coastal forests in affording both shelter and food to migrating birds. Such birds inhabit, at different seasons, different land masses and continents of the hemisphere. A portion of the bay's productivity, then, supports population movements of insectivorous birds, as well as those dependent upon fish and aquatic invertebrates, to and from Florida. In addition to warblers, vireos (VIREONIDAE), tanagers (THRAUPIDAE),

finches (FRINGILLIDAE), and species of additional families may enter or depart southern Florida via the mangroves. Swallows (HIRUNDINIDAE) fly Florida's peninsular route to and from South America in large numbers. They forage awing across the air space above the bay and the mangrove forests, feeding while passing, upon flying insects.

Certain passerines are resident seasonally within the mangroves fringing the bay. Small numbers of some parulid warblers may winter here. Other passerines breed within the forests fringing the bay. The Red-winged Blackbird (ICTERIDAE: Agelaius phoeniceus), flocks of which forage about the mangroves as well as inland of them in winter, breeds in considerable numbers in marshes and dwarf red mangrove areas adjacent to the bay-fringing trees. Breeding is apparently geared to the spring-summer "blooms" of insect life about the coastal mangrove areas. A subspecies of the Prairie Warbler (Dendroica discolor paludicola) is one of the characteristic birds of mangrove areas of southern Florida, its song being heard wherever there are extensive stands of mangroves about Biscayne Bay.

Some passerines, all of which in Florida are more or less restricted to the mangroves, are regarded as relatively recent colonizers of southern Florida from West Indian areas. These are of more than ordinary interest to the ornithologist. Because their habitat is a restricted one that is being rapidly modified, the birds are of concern. The Gray Kingbird (TYRANNIDAE: Tyrannus dominicensis), a summer resident, is as the following species probably a recent colonizer (Robertson and Kushlan 1974: 443). The species is extending its range inland, particularly into ecologically "disturbed" areas. It feeds largely upon flying insects it detects and flies for from perches about the coastal mangroves. The Black-whiskered Vireo (Vireo altiloquus) is moving northward coastwise in Florida. A summer resident, it too is found nesting in mangroves. Little is known of the invertebrates it forages for within the canopy. The West Indian subspecies of the Yellow Warbler (Dendroica petechia gundlachi) was first observed more than 30 years ago (Greene 1946: 255) in mangroves of the lower Florida Keys. Its northward spread has brought it to the mangroves of the Arsenicker Keys and the mainland of Card Sound where I encountered singing birds in spring 1975. A canopy-feeder of small invertebrates, it can be expected to breed in mangrove areas northward along Biscayne Bay.

SUGGESTIONS FOR RESEARCH WITH THE BISCAYNE BAY AVIFAUNA

Suggestions fall into a number of easily outlined categories: First, a year-long monthly census by overflight of the bay with respect to a.) the megavifauna and b.) the locations of feeding, roosting, and breeding concentrations of these megavifauna should be undertaken.

Second, a study should be implemented to locate the feeding areas of the Ciconiiformes from the breeding rookeries at Greynolds Park and the Arsenicker Keys.

Third, a year long census of the Charadriiformes (Charadrii) should be undertaken on a monthly basis. This can be carried out by visiting concentrations of these populations by foot, car and/or boat. While it would be impossible to achieve a complete census of these birds, enough could be sampled to allow meaningful estimates of the total populations.

Fourth, a judicious sampling on a monthly basis should be undertaken of populations of certain abundant species of the bay. If ten samples per month were taken of species such as cormorants, coots, and a medium-sized heron, the following analysis should be made: a.) stomach contents; b.) pesticide levels; c.) subspecies they represent if there are more than one subspecies of this bird in the bay; d.) breeding condition and fat deposit. The specimens should then be wet preserved and deposited in a recognized institutional collection for future reference.

Fifth, life history work should be undertaken with one or more of the passerine species that breed in the mangroves.

Sixth, bioenergetic studies of one or more of the estuarine species should be undertaken. Double-crested Cormorants are easily kept in laboratory conditions (DeLaRonde et al. 1972) and certain base-line data have already been gathered for these birds (Dunn 1975). Coots would, presumably, be appropriate birds for such study. Additional species which might be selected should represent taxa with widely different feeding strategies and diet.

DISCUSSION

Little has been presented here with respect to Biscayne Bay's avifauna as it must have been before Dade County's urban communities grew up about it. Obviously, drastic changes in the water and general flora and fauna of the bay, destruction of much of the fringing mangrove forests, and drainage of the peninsula's interior wetlands - from which populations of aquatic birds moved back and forth to coastal

waters - have resulted in enormous changes in the bay's bird populations. The numbers of endangered, threatened, and rare species of birds cited in the preceding inventory attest to these changes. The ecologist can address himself to the changes by gaining information adequate to 1) acquiring knowledge basic to understanding the requirements of rare as well as more abundant species, and 2) being in a position to recommend planning which may encourage a response by the species.

It is patent that many of the endangered and threatened species are primarily piscivores (Brown Pelican, Bald Eagle, Osprey). At the same time other piscivores of the bay (Double-crested Cormorant, Red-breasted Merganser, etc.) have not declined drastically. Careful monitoring of these populations and study of the species' diets will be worthwhile.

It is noteworthy that not all the birds at the bay are decreasing in population. Populations of some wintering gulls have probably increased significantly. At least one species now present, the Cattle Egret, was not a part of the avifauna of even thirty years ago. These bring a new dimension to the avifauna one, as would be expected, intimately associated with human activity. It will be of interest to estimate what addition to the bay's productivity excrement of the large populations of the species may have brought about.

We can now certainly foresee a threshold in management of some of the bay's bird populations. Areas where species held to undesirable congregate to roost and feed can be altered. Conditions required for successful breeding - such as with the threatened Least Tern - can, if we so determine, be created and protected.

High on the list of priorities is action re: the shrinking mangrove fringes of the bay. These (as for that matter the whole bay) lie virtually within the metropolitan area and, conveniently reached, can be a laboratory of meaningful research for the many biologists of nearby institutions.

From an ornithologist's point of view, we face, in a sense, a dilemma circular in nature. We lack a tremendous amount of basic ecological information about Biscayne Bay's birds. Much of this information we can never gain unless the ongoing degradation of the bay is somehow deaccelerated. But until we have our basic information it is hard to make recommendations regarding planning for the bay. Preventing as little alteration of the bay as possible, will, for the moment, buy some time in which to get on with our ecological studies.

ACKNOWLEDGEMENTS

W.B. Robertson, Jr. and James Kushlan kindly supplied me with certain information. I acknowledge Sea Grant for making possible publication of the volume of which this is a part.

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