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DEVELOPMENT AND MANAGEMENT OF AVIAN HABITAT ON DREDGED MATERIAL--ETC(U)
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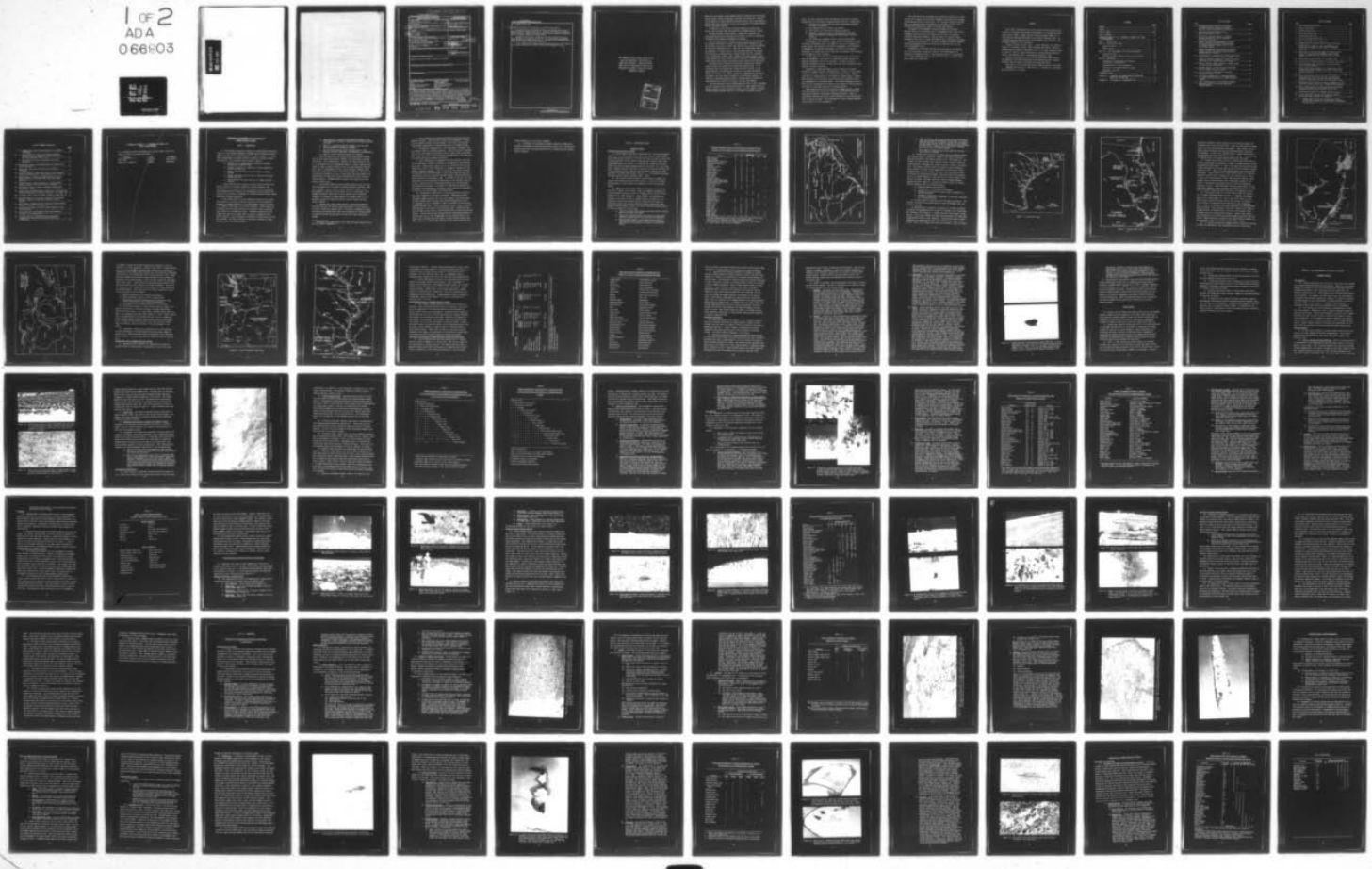

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Seven regional DMRP studies were conducted throughout Corps of Engineers-maintained waterways to determine dredged material island use by nesting waterbirds and the succession of vegetation on these islands as affected by bird use, to compare diked and undiked islands and natural and man-made islands and sites, and to study migratory and year-round use of dredged material islands. These data and pertinent management information are synthesized in this report. Recommendations and guidelines for management of existing dredged material

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islands and creation of new islands are set forth by the authors.

Five major factors determining selection for waterbird colony sites on dredged material islands are set forth: isolation from predators and humans, habitat diversity, nesting substrate stability, species behavioral characteristics, and species feeding and foraging habits.

Management for waterbird colonies has been proven feasible and may be accomplished by several important factors: (a) incorporation of management plans into routine dredging operations, (b) interagency and intraagency cooperation, and (c) public education and cooperation.

It was determined that dredged material islands are often crucial habitat for colonial waterbirds and should be maintained and managed as such.

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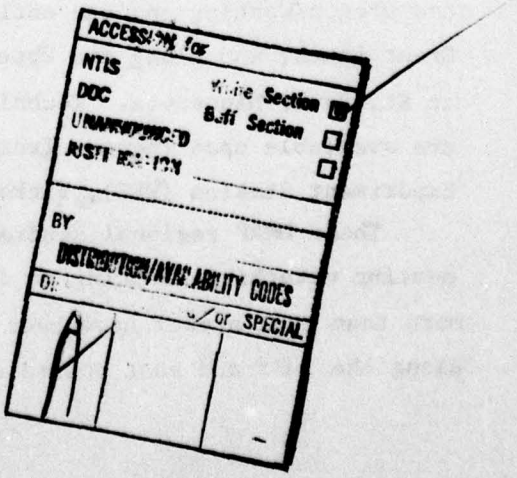

majority of the species using dredged material islands were tree nesting herons, egrets, ibises, cormorants, pelicans, and spoonbills. However, the populations of ground nesting waterbirds (gulls, terns, and skimmers) were so great that 59 percent of the total population on dredged material islands were ground nesters.

In addition to the colonial waterbird species, 56 other avian species (non-colonial) were found nesting on dredged material islands.

Breeding biology, nesting habitat, common nest predators, and nesting associations are discussed in the report, as well as vegetation requirements and vegetation management techniques.

The locational value of dredged material islands as nesting habitat for colonial waterbirds in various Corps-maintained waterways of the United States was found to range from critical (e.g., in North Carolina) to relatively unimportant (e.g., along the upper Mississippi River). The importance of these islands to nesting populations of the species found nesting on dredged material islands ranged from very important (e.g., gull-billed, common, least, Sandwich, and royal terns) to relatively unimportant (e.g., double-crested cormorants; anhingas; glaucous-winged, great black-backed, and western gulls; roseate and black terns).

Dredged material islands have become more important as nesting habitat as man has usurped their traditional nesting sites. It is anticipated that the islands will become even more valuable as the human population of North America continues to increase and heavier demands are placed on the timber resources in swamplands as well as on the barrier and other natural islands for recreational purposes. In addition to providing breeding habitat, dredged material islands are used extensively by birds for loafing, roosting, and feeding.

The most important factors determining the extent of use of dredged material islands by the colonial waterbirds in a given region were the species present and their population levels, and the number of suitable dredged material islands relative to the number of suitable natural

sites. The most important factors determining the extent of nesting waterbird use of a particular dredged material island in a region were:

a. The extent of isolation of the island from ground predators and human disturbance.

b. The habitat diversity found on the island.

c. The stability of the potential nesting substrate.

d. Behavioral characteristics of nesting species including social facilitation, interspecific interactions, and site tenacity.

e. The feeding and foraging habits of the nesting species.

A knowledge of the biology of target species is necessary in order to develop a management plan. The number of sites to be managed for a target species will depend on the need for management, the feasibility of management, its habitat requirements, the size of its breeding population, the number that can be supported by available food resources, and the number of sites available.

In many agencies it will not be known whether there is an actual need for management of the species of waterbirds present because the baseline information will not be available. In order to have an effective management program, studies will have to be initiated by these agencies to obtain these data.

Management of existing dredged material islands for breeding habitat is a highly desirable alternative use. Creation of new islands to provide nesting habitat is not desirable in many areas. However, creation of a limited number of new islands in certain areas is needed. When possible, the first option for providing nesting habitat should be the management of existing islands. The primary management practice that could be instigated by the Corps is the creation of nesting habitat diversity by controlled deposition of dredged material.

Eight habitat types used for nesting on dredged material islands have been identified. All of the types can be maintained with proper long-range planning of maintenance dredging operations. There is considerable regional variation in the availability of the nesting habitats on suitable islands. The development of certain nesting habitats may be sped up by plant propagation.

The construction of new islands and placement of additions to existing ones are feasible and productive management techniques for providing needed nesting habitat in some areas. Site location, timing of development, and physical design are important factors which should be considered when developing an island for nesting bird habitat.

Interagency and intraagency cooperation among the concerned agencies should be an important part of a management plan. Most of the management participation by the Corps would be a part of regularly scheduled maintenance dredging. However, there is a need for other management inputs such as protecting nesting birds from human disturbance.

Seeking the cooperation of the public through an education program explaining management objectives should be an important part of the overall management plan.

Management for waterbird colonies has been proven to be feasible, and is an economically acceptable concept in the development of a maintenance dredging operation. These man-made areas are crucial habitat for many waterbirds, and agencies should be able to provide habitat where needed for these birds.

PREFACE

This report synthesizes the results of seven research studies within Task 4F, entitled "Island Habitat Development," of the Habitat Development Project (HDP), Dredged Material Research Program (DMRP), U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss. An extensive state-of-the-art review and bibliography and a survey of other pertinent research is also presented.

Manager of Task 4F was Ms. Mary C. Landin, Biologist; Dr. Robert F. Soots, Jr., Ecologist, and Ms. Landin prepared this report. Work progressed under the general supervision of Dr. H. K. Smith, Manager of HDP, Dr. Roger T. Saucier, Special Assistant for Dredged Material Research, and Dr. John Harrison, Chief, Environmental Laboratory, WES.

Research synthesized in this study was performed by WES, private environmental firms and universities, other Federal agencies, private citizens, and the authors (published and unpublished data).

This report is also being published as Engineer Manual 1110-2-5015.

Commander and Director of WES was COL J. L. Cannon, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Continued)

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
cubic yards	0.7645549	cubic metres
miles (U. S. statute)	1.609344	kilometres

DEVELOPMENT AND MANAGEMENT OF AVIAN HABITAT ON DREDGED MATERIAL ISLANDS

PART I: INTRODUCTION

1. This document synthesizes research in Island Habitat Development (Task 4F) of the Corps of Engineer's Dredged Material Research Program (DMRP), and sets forth the principles and concepts necessary for development and management of dredged material islands for colonial nesting bird species. Five objectives were pursued in Task 4F.

a. Document use of dredged material islands by colonial nesting sea and wading birds.

b. Document succession of vegetation on these islands and relate it to bird use.

c. Compare vegetation and bird use of diked and undiked islands.

d. Compare vegetation and bird use of natural and man-made islands and sites.

e. Study migratory and year-round use of dredged material islands.

2. These objectives were pursued to provide Corps Districts with data on location of colonies, reasons for colony existence, life requirements of the specific species of colonial waterbirds primarily using dredged material islands, and recommendations and guidelines for creation of new islands or management of existing islands through routine maintenance dredging operations.

3. One hundred years of active dredging operations by the Corps, State agencies, and private industry has resulted in the creation by placement of dredged material of over 2000 man-made islands throughout U. S. coastal, Great Lakes, and riverine waterways. These islands are of varying sizes and characteristics and presently range in age from newly formed to an estimated 50 years. Although the majority of the islands were made by the Corps, many are owned or managed by other Federal agencies, State Governments, conservation organizations, or private citizens. The Corps continues to maintain an interest in these man-made islands for several reasons:

a. Responsibility is placed on the Corps by Congress to use environmentally acceptable dredged material disposal methods and sites.

b. There is a continuing need for disposal sites for maintenance dredging of navigable waterways.

c. The recreation potential these islands offer to bird-watchers, boaters, sportsmen, and fishermen is considerable.

d. There is a need to provide habitat for wildlife.

4. When the majority of the islands were formed during construction of the Intracoastal Waterway System in the 1930-1940's, wildlife use was not a real consideration. However, the rapid increase in the U. S. population and the corresponding demand on natural resources have helped to cause a gradual change in the use of the islands by wildlife and a need for reassessment of their role as habitats. Natural sites have been altered and occupied by man through industrial, housing, and recreational development to such a large extent that some areas of the United States no longer have coastal islands that are still suitable wildlife habitat. Dredged material islands have provided this vital habitat in many areas.

5. The primary wildlife species needing islands as part of their life requirements are the colonial nesting waterbirds: pelicans, cormorants, anhingas, herons, egrets, ibises, spoonbills, gulls, terns, and skimmers.* Several of these species are rare, threatened, or endangered throughout large parts of their ranges, and an estimated 2,000,000 are nesting on dredged material or man-made sites in U. S. waterways, especially along the Atlantic and Gulf coasts from Long Island to Mexico.

6. Islands offer these birds protection from ground predators, seclusion from man, and nesting substrates similar to those found in the birds' traditional nesting sites. The birds are especially vulnerable during the nesting season when they concentrate for several months in exposed colonies and must remain in them until their chicks have fledged.

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*Scientific and common names of all animal and plant species in the text are listed in Appendix A.

7. These waterbirds are protected by Federal laws since they are migratory species. These laws make destruction, harassment, or disruption of nesting colonies of birds illegal. State laws often back up these Federal regulations in offering protection to non-game species.

8. An important consideration is the uniqueness, the beauty, and the esthetic value of non-game waterbirds. This in turn gives consideration to the recreational and economic value of these birds to sportsmen and birdwatchers, many of whom contribute substantially to the monies of the tourist and sports equipment industries.

9. Since waterbirds are conspicuous in their habitats, their use in the educational training of students of biology gives them considerable value. These species, usually at the top of their food chain and usually fish eaters, are of importance as biological indicators of the health of aquatic ecosystem. Some of the species are greatly affected by pesticides and toxicants present in their food supply because their reproductive cycles are disrupted through egg-shell thinning which prevents incubation and hatching of eggs. An example of this was the total destruction of the brown pelican populations on the Louisiana coast due to toxic concentrations of insecticides washing into the Mississippi River estuary and marshes. In unhealthy or disturbed ecosystems, the scavengers of the waterbirds, the gulls, usually increase in population, as has been the case throughout the United States.

10. Historically, populations of colonial waterbirds covered in this report numbered in the tens of millions. Populations existed throughout swamps, marshes, lake and river systems, and coastal areas. In south Florida alone, declines from 2,500,000 waterbirds in 1870, to 1,500,000 in 1935, to 300,000 in 1960, to 150,000 in 1974 have been reported (Crowder 1974). Initial population declines resulted primarily from shooting of the birds for the millinery trade. Declines of the past 60 years are the result of man's destruction of feeding and nesting habitat. The decline has been slowing down and stabilizing somewhat in recent years, but is still progressing for some species and will continue to do so unless steps are taken to prevent further habitat loss. Adult population levels of these species in the United States are pre-

sently estimated at no more than 5,000,000.

11. In general, the correlation between increases in human populations and decreases in waterbird populations holds true. The only exceptions exist when alternate habitats such as dredged material islands become available.

PART II: AVIFAUNA AND FLORA

Regional Studies

Description and Scope of Studies

12. Seven regions selected as representative of various geographical sections of the United States were studied under Task 4F (Landin 1978a). These studies were conducted in 1974 and 1977 along the entire coastal and estuarine waterways of New Jersey, North Carolina, Florida, Texas, and Oregon/Washington; the entire U. S. shoreline and islands of the Great Lakes; and along the Upper Mississippi River from Alton, Ill. to St. Paul, Minn. Technical reports (TR D-78-1, TR D-78-8, TR D-78-9, TR D-78-10, TR D-78-13, TR D-78-14 {Vol I and II}, and TR D-78-17) generated by these studies are available upon request from the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss. 39180.

13. The colonial waterbird species found nesting on dredged material in the study areas are listed in Table 1. Some of the results and highlights of these studies are summarized in the following paragraphs.

14. Along the coast of North Carolina, 99 percent of the wading birds and 75 percent of the gulls, terns, and skimmers (totalling 25 colonial waterbird species) nested on dredged material islands in 1977 (Parnell et al. 1978) (Figure 1). Since diking of islands here and elsewhere to prevent free flow of dredged material depositions is a relatively recent Corps disposal method, comparisons of effects on vegetation and bird use between diked and undiked islands were made. Diking of islands seemed to affect the species nesting, feeding habitat, and plant succession in several ways:

a. Tree kills within diked islands destroyed potential nesting habitat for herons and egrets.

b. Borrow pits created by dike construction provided prime temporary feeding habitat for waterfowl and shorebirds.

c. Diked islands provided a more stable water supply by trapping fresh water, which resulted in more rapid and lush vegetation colonization, succession, and growth of plants.

Table 1

Colonial Waterbird Species found Nesting on Dredged Material Islands in Seven Regions of the Corps-Maintained Waterways[1]

Species	Regions[2]					
	TX	FL	NC	NJ	GL	PNW
White pelican	X					
Brown pelican	X	X	X			
Double-crested cormorant		X	X			
Olivaceous cormorant	X					
Anhinga		X				
Great blue heron	X	X	X	X		X
Green heron	X	X	X	X		
Little blue heron	X	X	X	X		
Cattle egret	X	X	X	X	X	
Reddish egret	X	X				
Great egret	X	X	X	X		
Snowy egret	X	X	X	X		
Louisana heron	X	X	X	X		
Black-crowned night heron	X	X	X	X	X	
Yellow-crowned night heron	X	X	X	X		
White-faced ibis	X					
Glossy ibis	X	X	X	X		
White ibis	X	X	X			
Roseate spoonbill	X	X				
Glaucous-winged gull						X
Great black-backed gull			X	X		
Herring gull			X	X	X	
Western gull					X	
Ring-billed gull					X	X
Laughing gull	X	X	X	X		
Gull-billed tern	X	X	X	X		
Forster's tern	X		X	X	X	
Common tern		X	X	X	X	X
Roseate tern		X	X	X		
Least tern	X	X	X	X		
Royal tern	X	X	X			
Sandwich tern	X	X	X			
Caspian tern	X	X	X		X	X
Black tern					X	X
Black skimmer	X	X	X	X		

[1] The Upper Mississippi River study is not listed since none of the nesting colonies found were located on dredged material.

[2] TX = Texas; FL = Florida; NC = North Carolina; NJ = New Jersey; GL = Great Lakes; PNW = Pacific Northwest.

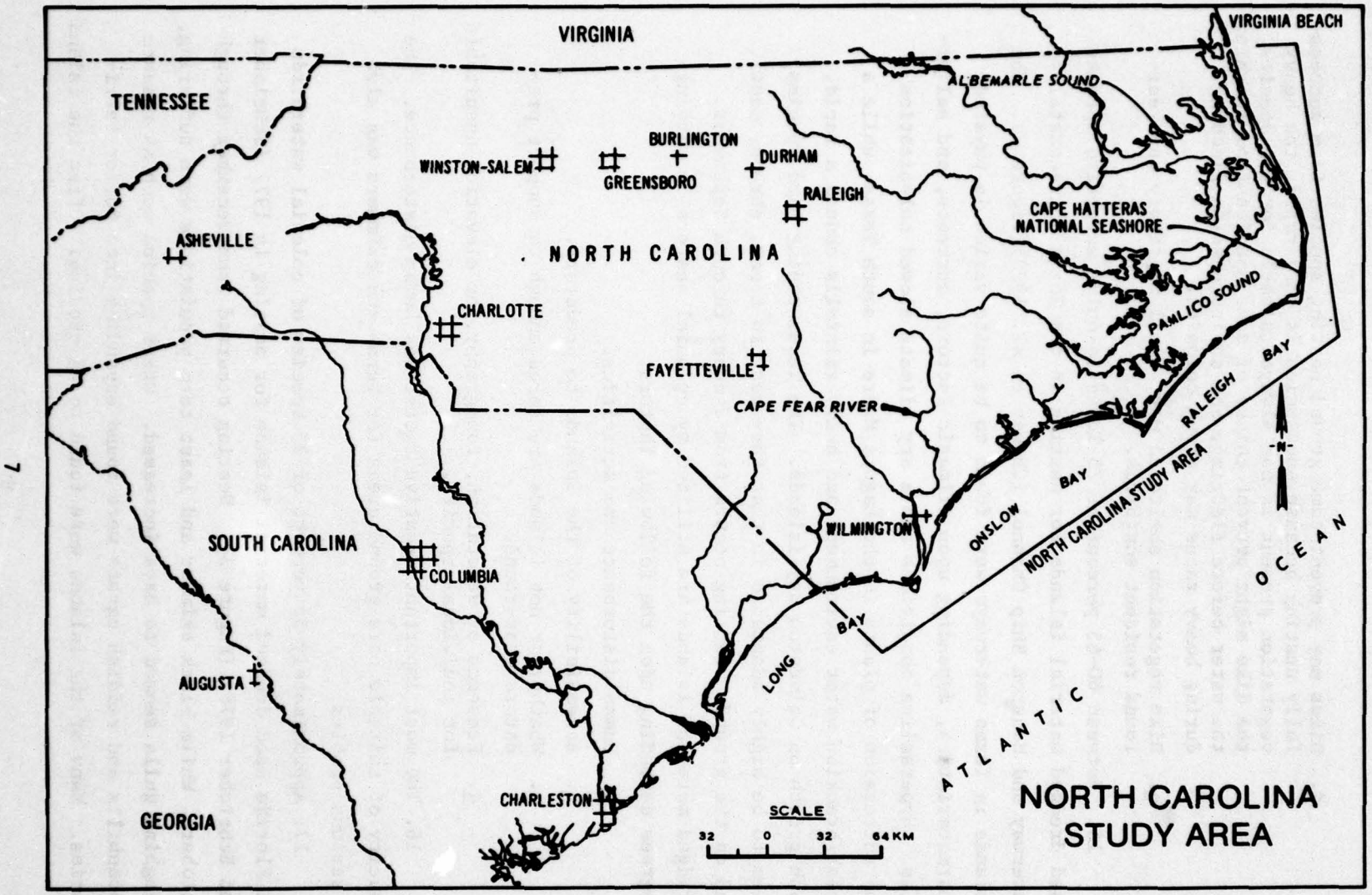


Figure 1. North Carolina Study Area

d. Dikes may prevent some ground nesting species from successfully nesting because succession is very rapid, the heavy vegetation present is not always suitable for the species, the dike might prevent chicks of some species from reaching the water before fledging, and an increase in flooding during heavy rains may drown colonies.

e. Dike vegetation sheltered many small migratory and year-round resident songbirds.

15. Between 60-65 percent of 25 Texas colonial waterbird species used dredged material islands for nesting in the Texas Intracoastal Waterway and Houston Ship Channel (Chaney et al. 1978)(Figure 2). The islands in Texas waterways were found to be quite varied in physical characteristics, depending upon climatic factors, currents, and salinities. Hypersaline conditions and a dry climate slowed colonization and succession of plants in the Laguna Madre in south Texas, while a fresh/brackish water environment and heavy rainfalls caused a rapid, lush growth on Galveston Bay islands. The Texas wading bird species seem to be highly adaptable in that they nest in trees, shrubs, cacti, and on the ground. Nesting occurs from January through September. Dredged material islands are utilized by colonial nesters in varying degrees depending upon the following factors:

a. Human disturbance and activities.

b. Accessibility of the islands to predators.

c. Whether or not islands are large enough to support predators year-round.

d. Presence of vegetation, topography, or elevation unsuitable for individual species.

16. The most important negative factor was human disturbance. The paucity of suitable bare ground areas for terns and skimmers was also a serious problem.

17. Approximately 55 percent of 25 species of colonial waterbirds in Florida used dredged material islands for nesting in 1977 (Schrieber and Schrieber 1978) (Figure 3). Nesting occurred from December through October. While black skimmer and least tern populations were suffering, laughing gulls seemed to have increased. Other species such as roseate spoonbills and reddish egrets were found expanding into former territories. Many of the islands were found to be eroding. Often the island

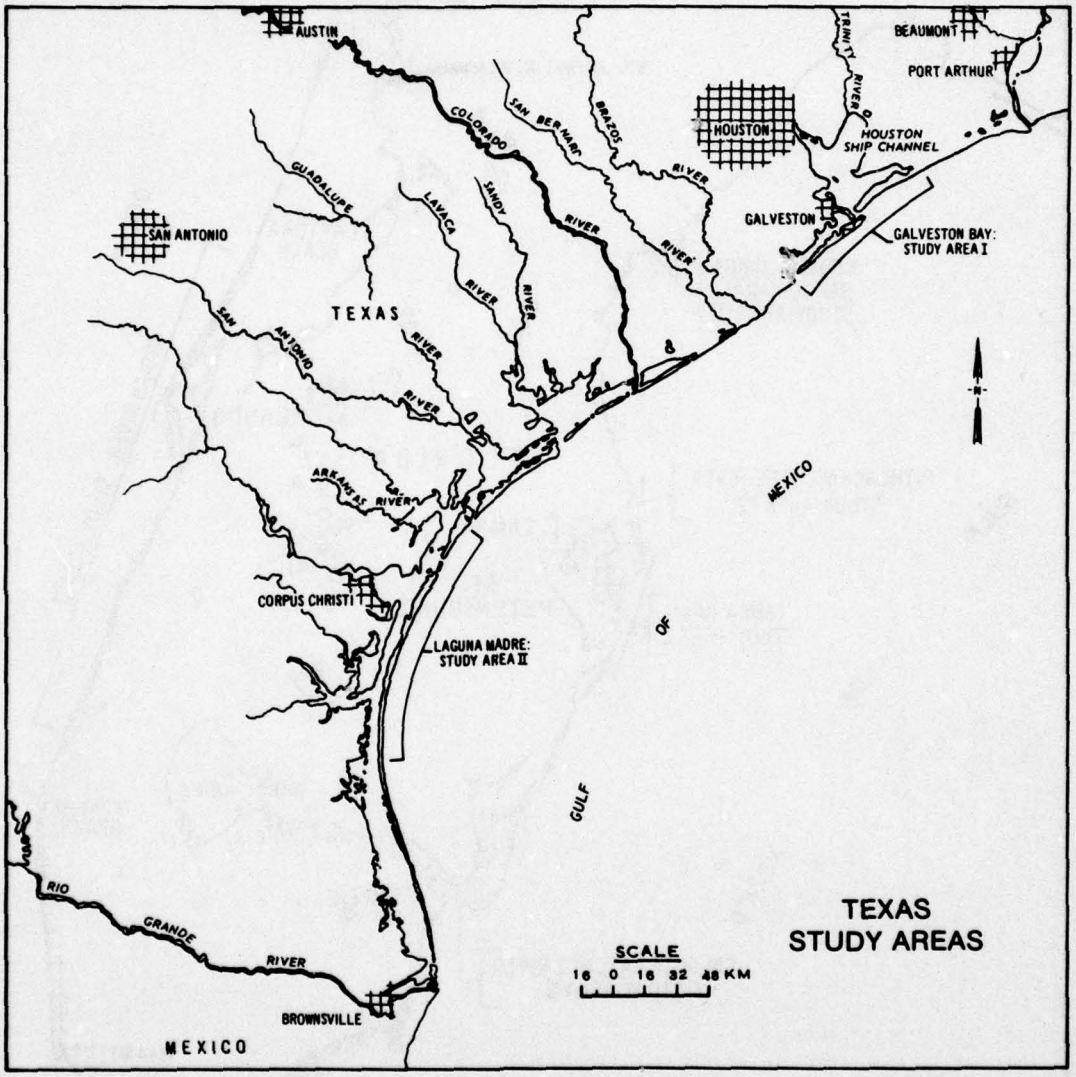


Figure 2. Texas Study Areas

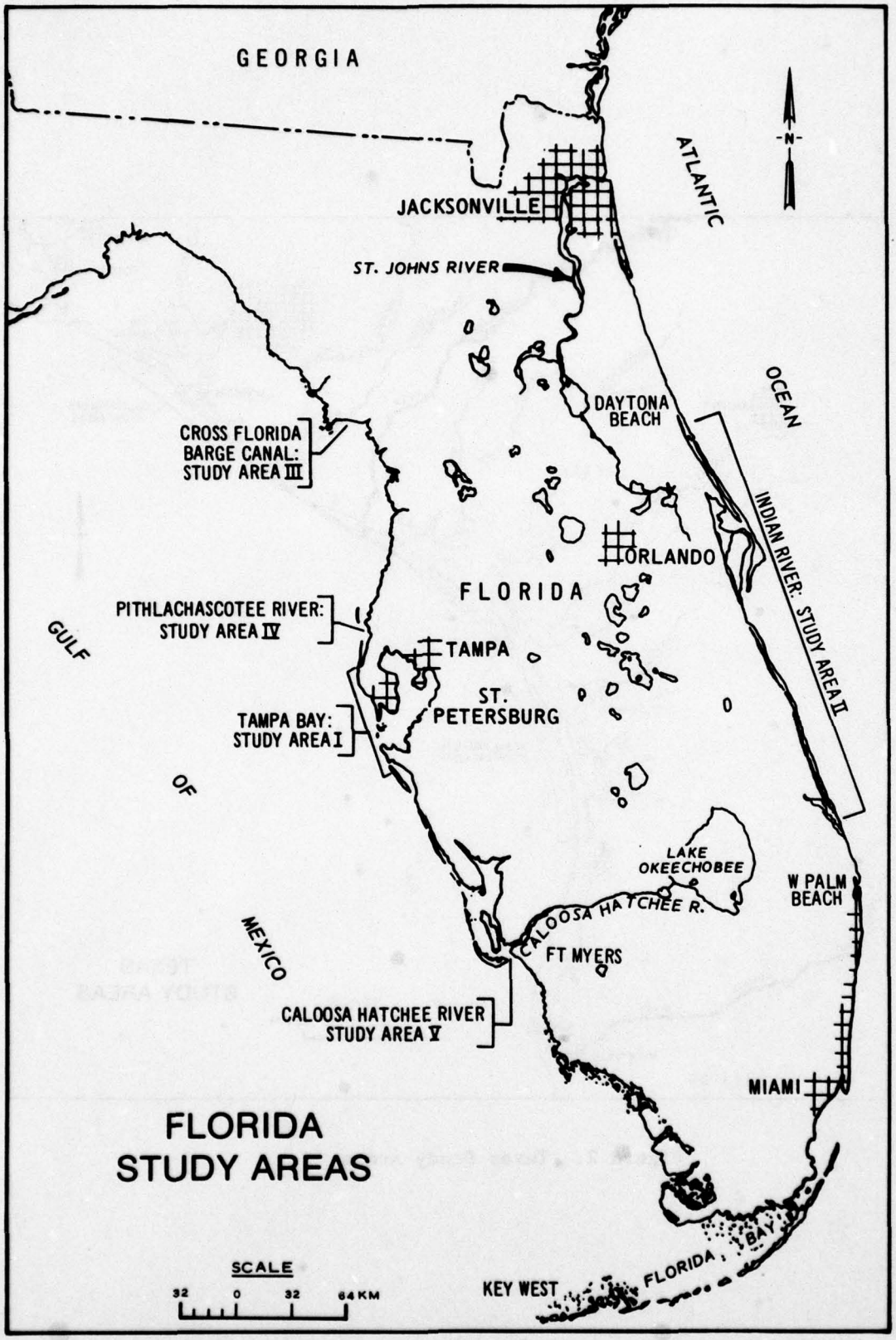


Figure 3. Florida Study Areas

vegetation consisted of exotic species such as Brazillian pepper and Australian pine (Lewis and Lewis 1978). These are often used by nesting birds as are the native mangroves and grasses. These islands are frequently used by migratory and over-wintering shorebirds, waterbirds, and songbirds, as well as by resident nesters. Human disturbance is the most important factor affecting nesting in Florida. A critical lack of suitable habitat for ground nesting species was also noted.

18. In New Jersey several species of colonial waterbirds were located on sites known or suspected to be made of dredged material (Buckley and McCaffrey 1978) (Figure 4). Most of the wading bird species and only a small percentage of the ground nesting species were nesting on dredged material in 1977. Most of the other ground nesters were in the adjoining marshes. Island habitat for colonial species seems to be severely restricted in New Jersey. Wading birds, which usually nest in shrubs or trees, were found nesting in giant reed, and black skimmers, which normally nest on elevated sandy sites, established colonies in salt marshes. Undisturbed bare ground areas for terns and skimmers are especially critical. Human disturbance was once again found to be the single most important factor governing the nesting success of the birds. Lack of suitable habitat was also identified as an important factor.

19. The two-year study in the Great Lakes located 267 colonies of 13 colonial waterbird species on the U. S. coastline and islands (Scharf 1977, 1978) (Figure 5). Due to lower water levels in 1977, newly exposed islands were being used by these birds, but whether or not an increase in population will result has not been determined. Habitat seems to be lacking in the lakes, especially for ground nesting terns and gulls. Only 22 percent of the 1977 colonies were located on dredged material or man-made sites, but close to 100 percent of all available sites were being used for nesting. Indeed, birds nest on new construction or fill sites and islands within months after they are formed. Human disturbance, predation, and limited suitable habitat all play important roles in the success of Great Lakes colonies.

20. Six colonial species used dredged material islands for nesting in Oregon and Washington. This represents relatively (10 percent)

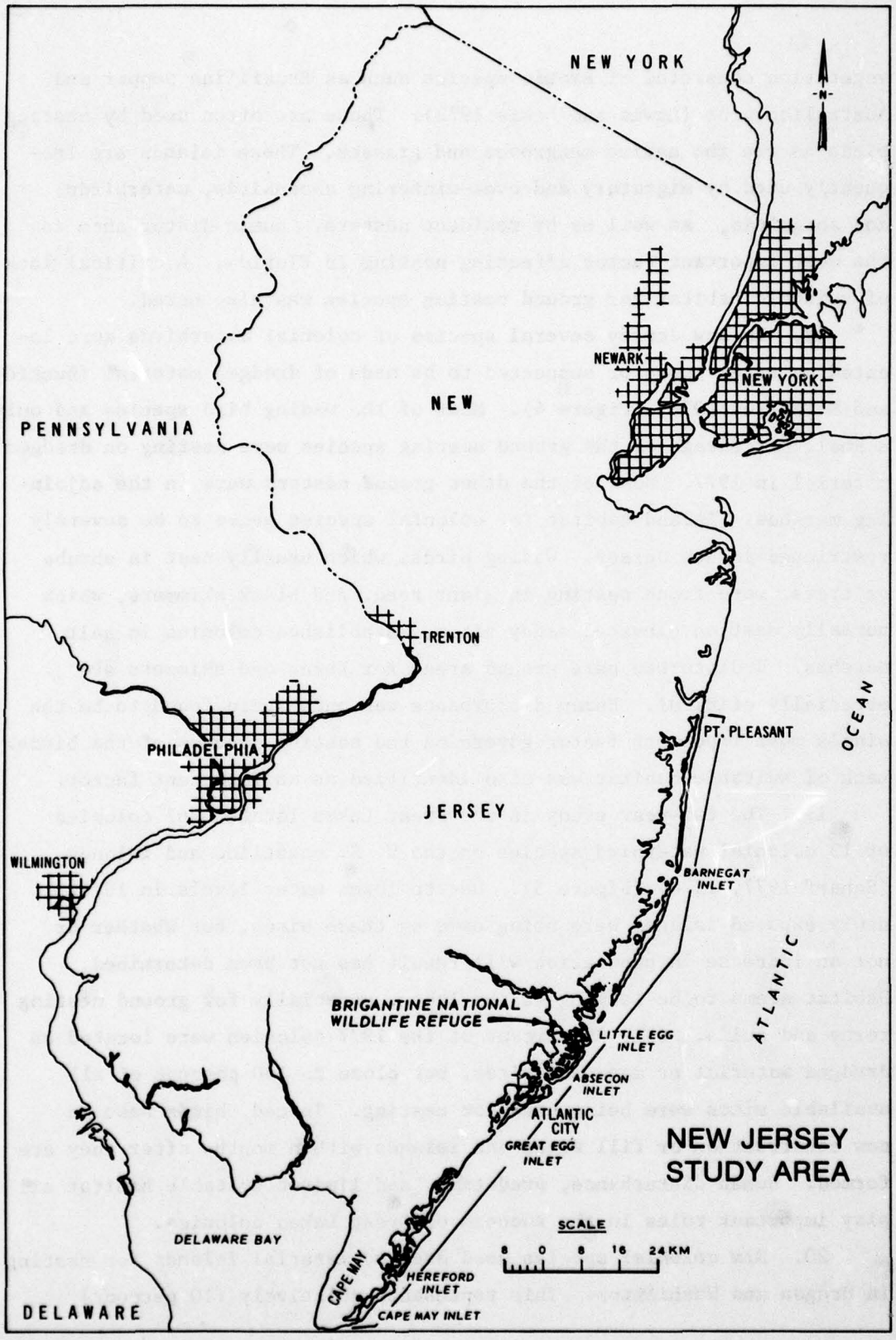


Figure 4. New Jersey Study Area

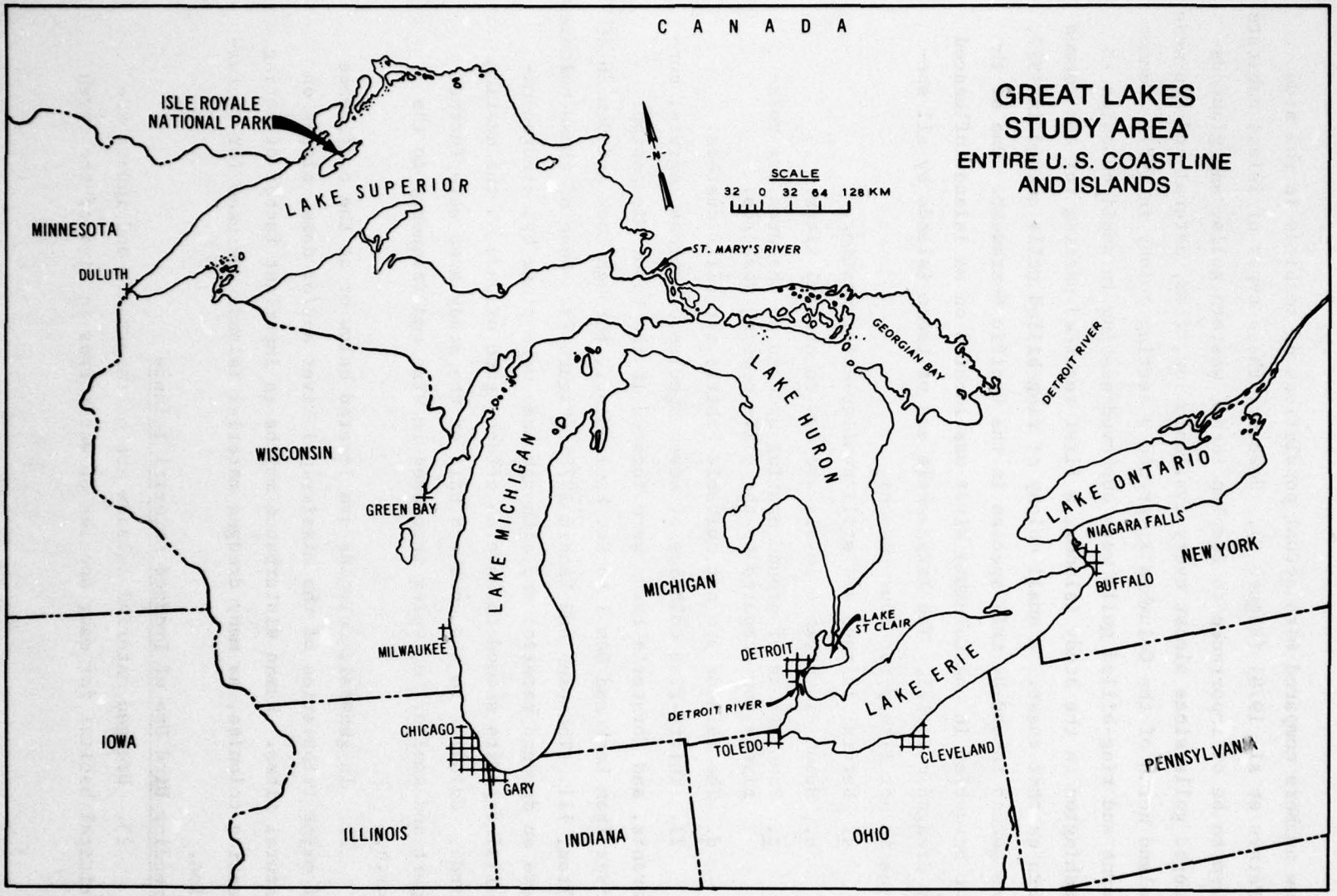


Figure 5. Great Lakes Study Area

low numbers compared with actual populations of seabirds in the area (Peters et al. 1978) (Figure 6). However, these types of island habitats seem to be of importance to Caspian terns, western gulls, and glaucous-winged gulls since almost every available low, flat, natural and man-made island north of the Columbia River had a nesting colony in 1977. Common terns and ring-billed gulls were observed nesting in small colonies in Washington on the study islands, a first recorded nesting for the common tern on that coast. A small colony of ring-billed gulls nested in 1977, the second record by this species in the Pacific Northwest. One of the two heronries in the Columbia River was located on an island influenced by dredged material. The large-scale use of these islands by all species is not likely for four reasons.

a. Natural islands are still available for nesting.

b. Human disturbance levels are low on natural sites.

c. Populations of ground nesting species in the area are relatively low compared to the cliff nesting seabirds.

d. The islands are not suitable habitat for cliff nesters.

21. Thirty-five colonies of seven species of herons, egrets, cormorants, and Forster's terns were located in the Upper Mississippi River from Lock and Dam 1 to St. Paul, Minn., through Lock and Dam 26 at Alton, Ill. (Thompson and Landin 1978) (Figure 7). None of these colonies were on dredged material and although some were close by, dredged material deposits seemed to have no effect, good or bad, on the nesting birds. Colonies in the southern half of the study area were further apart and smaller; colonies increased in size and frequency to the north.

22. In general, colonies are located below or at the confluence of major tributaries of the Mississippi River and/or dams, always on natural sites. Human disturbance may be an important factor affecting nesting colonies, as many dredged material islands are used for recreation.

Breeding Bird Use of Dredged Material Islands

23. Dredged material islands are of importance and indeed are critical habitat for many species of waterbirds in five of the seven

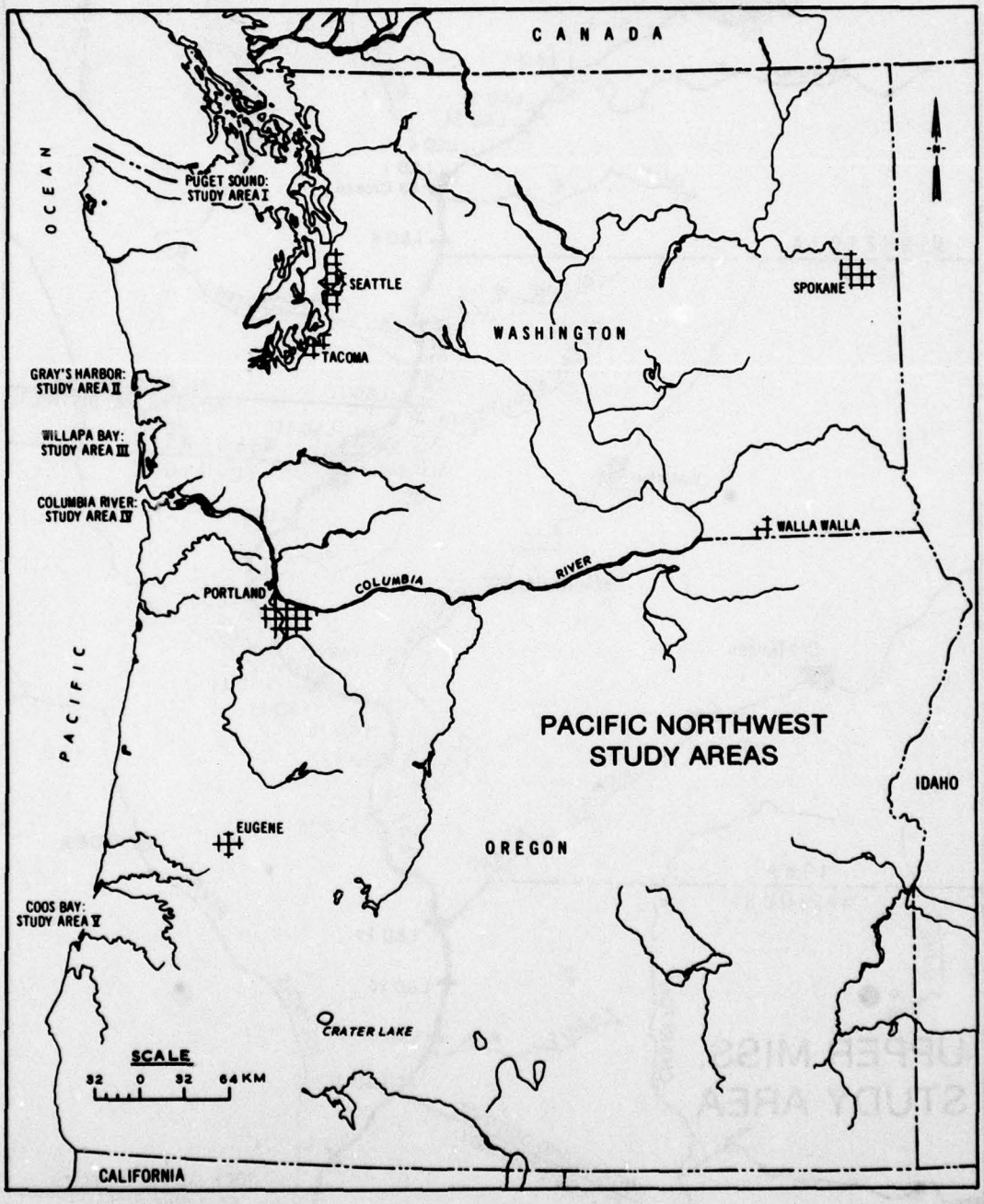


Figure 6. Pacific Northwest Study Areas

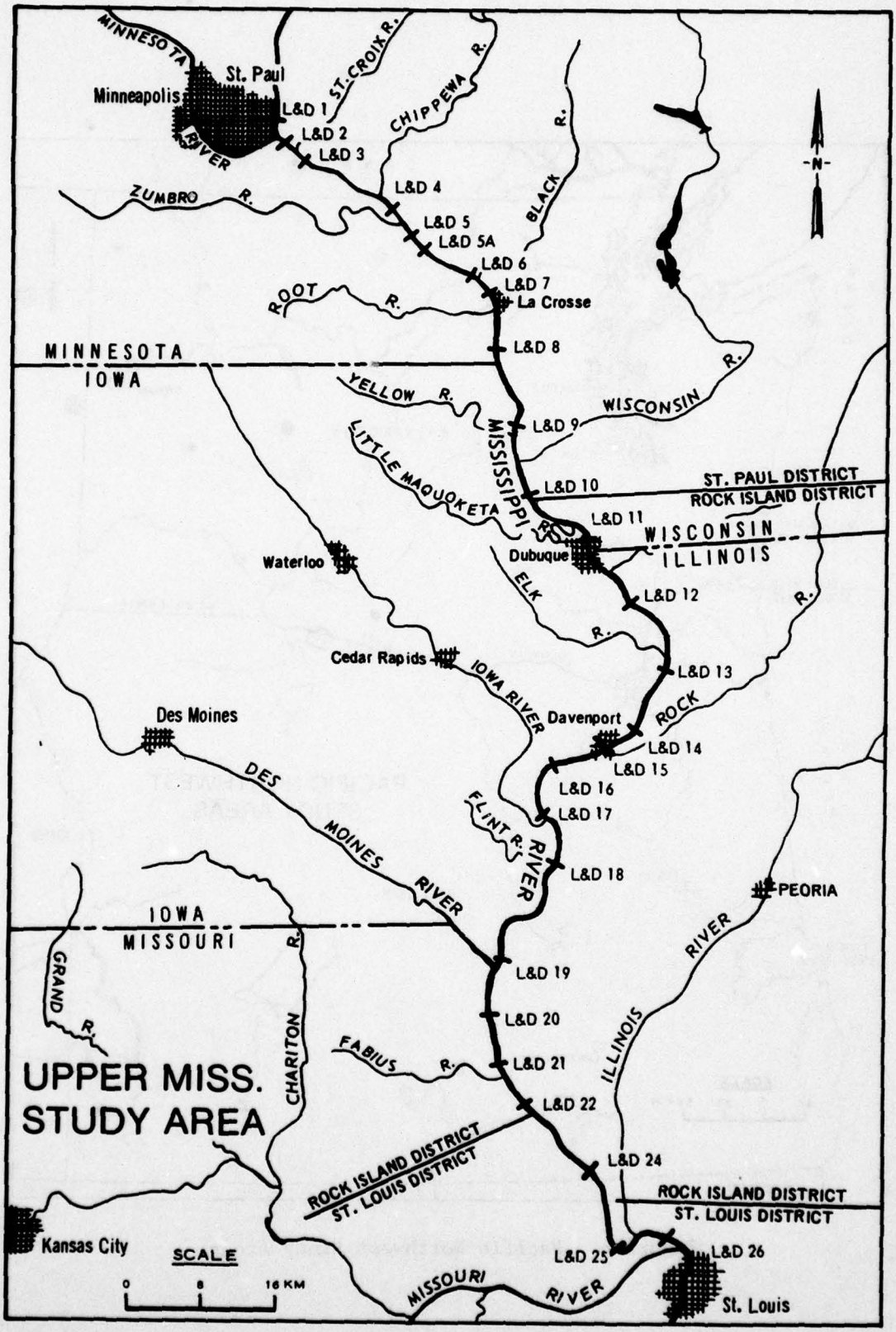


Figure 7. Upper Mississippi River Study Area

study regions (Table 2). Colonial ground nesting species (gulls, terns, and skimmers) use these islands or the adjacent marsh areas almost exclusively where no natural barrier island or other natural site is available. For the California least tern, an endangered species, dredged material islands often offer the only available nesting habitat.

24. This island habitat is used by the large wading birds in even greater percentages than for ground nesters. Rare, threatened, of special concern (Blue List), and endangered species which nest on these islands include the white pelican, brown pelican (endangered), double-crested cormorant, reddish egret, black-crowned night heron, roseate spoonbill, gull-billed tern, common tern, least tern (California race endangered), and the black tern. Dredged material islands are used to a considerable extent by non-colonial, or solitary, bird species for nesting as well (Table 3).

Non-breeding Bird Use of Dredged Material Islands

25. Even though a dredged material island may not be used for nesting, or may not provide suitable habitat for nesting, it may still be of real importance to colonial waterbirds and other species and satisfy other critical life requirements. Dredged material islands are used extensively not only by colonial waterbirds for loafing, roosting, and feeding, but by shorebirds, waterfowl, songbirds, and raptors as they migrate or over-winter. The southern coasts have numerous migratory species, and a few that over-winter, using the islands. Florida and Texas islands are used quite heavily by over-wintering species, and both areas serve as migratory "jump-off points" for birds flying to South Central America. These birds are known to feed heavily before attempting long flights, and apparently use shorelines of dredged material islands as well as natural shores for resting and feeding.

Comparison of Bird Use of Dredged Material Islands and Other Sites

26. Little difference has been found between use of a dredged material island as compared to a natural site. The critical factor is the availability of suitable habitat. That habitat may take years to develop through natural plant succession on a dredged material island after its formation or other additional deposition. Once an island

Table 2

Colonial Waterbirds Nesting in the Seven Study Areas in 1977[a]

STUDY AREA	GROUND NESTERS			TREE NESTERS		
	DREDGED MATERIAL	TOTAL	%	DREDGED MATERIAL	TOTAL	%
Texas	122,554	203,387	60	33,604	54,012	62
Florida	171,050	311,000[b]	59	80,438	241,000[b]	52
North Carolina	64,666	86,072	75	15,130	15,362	99
New Jersey	--[c]	93,246	--[c]	--[c]	11,164	--[c]
Great Lakes	65,088	272,166	25	32	5,062	0.2
Pacific Northwest	1,554	17,214	10	0	750	0
Upper Mississippi River	0	68	0	0	9,608	0
Totals	445,110	994,317		137,578	337,018	

a Totals only include actual breeding adults at colony sites. No estimates are included here of non-breeding adults, subadults, or immatures.

b Estimated total populations.

c Data not available.

Table 3

Non-Colonial Species Nesting on Dredged Material Islands in Corps of Engineers-maintained Waterways

Canada goose	Yellow-billed cuckoo
Mallard	Grove-billed ani
Black duck	Short-eared owl
Mottled duck	Common nighthawk
Gadwall	Scissor-tail flycatcher
Marsh hawk	Long-billed marsh wren
Osprey	Short-billed marsh wren
Kestrel	Fish crow
Bobwhite quail	Mockingbird
American bittern	Brown thrasher
Least bittern	Ruby-crowned kinglet
Sora	Loggerhead shrike
Black rail	Yellow warbler
Clapper rail	Chestnut-sided warbler
King rail	Prairie warbler
Common gallinule	Louisana waterthrush
American oystercatcher	Yellowthroat
American avocet	Eastern meadowlark
Black-necked stilt	Red-winged blackbird
Piping plover	Boat-tailed grackle
Snowy plover	Great-tailed grackle
Wilson's plover	Common grackle
Kildeer	Painted bunting
Spotted sandpiper	Savannah sparrow
Willet	Grasshopper sparrow
Sooty tern	Seaside sparrow
Mourning dove	Field sparrow
Ground dove	Song sparrow

that is isolated from ground predators has reached a successional stage attractive to a given species, it is likely to be used for nesting.

27. That many more colonial waterbirds are nesting on dredged material islands instead of natural islands in Atlantic and Gulf coast regions is a result of the destruction of suitable nesting habitat on natural sites. This decrease of natural habitat has occurred concurrently with a fortuitous increase in available habitat created by the Corps in their dredging operations. Where suitable natural sites are still available, as in the Pacific Northwest, Great Lakes, and Upper Mississippi River, the birds will continue to use them for nesting. However, in some cases natural islands are still available, but the birds are nesting on dredged material in preference to the natural sites. Since habitat requirements of these species are often quite rigid, this is a function of the dredged material site having preferred habitat over the natural site. An example would be a newly formed bare ground dredged material area used by terns in preference to barrier islands and beaches, where predation and human disturbance are more likely to occur. Many natural sites are subject to flooding and have plant communities unsuitable to those species requiring bare substrate or sparsely vegetated sites.

Ecological succession

28. Soots and Parnell (1975) showed in their definitive study of plant and avifaunal succession on dredged material islands in North Carolina that bird use of an island is directly related to the types of vegetation found on it. Task 4F research documented the floristic composition and rates and patterns of plant succession on selected islands. An overview will be presented in this report.

29. Structure and density of vegetation determined which species of birds would use an island, and rates and patterns of plant succession determined how long an island would be of use to certain bird species before becoming available to others. Bare ground nesters generally only have access to an island for 1-3 years before growth of vegetation causes them to abandon the site. Ground nesting species that prefer grass and herbaceous cover will use islands from two years of age and older,

depending on rates of plant colonization and succession. Under certain climatic or edaphic conditions an island will maintain indefinitely a community of low herbaceous plants that can be used by certain ground nesting species. Arboreal nesting species generally cannot use a dredged material island until the vegetation has reached the shrub or tree seral stage.

30. Rates of succession varied considerably from region to region, and even within regions. The rate of succession on a particular island in a region depended on the following factors:

a. Climatic. The weather is the primary factor controlling the floristic composition and rate of succession. Temperature, wind velocity and direction, and precipitation in combination strongly influenced the type of biotic community found on an island. For example, south Texas has a semi-arid climate, characterized by evaporation in excess of rainfall. The rate of plant succession is slow and the flora on dredged material islands in the Laguna Madre was composed mainly of xerophytes. Trees are very scarce on the islands. The Galveston Bay area has a humid climate. The rate of succession was found to be faster and tree species dominated the older islands. Rates of succession tended to be faster in the southern regions (eastern Gulf Coast, south Atlantic Coast) than in colder or more extreme conditions (Great Lakes, New Jersey, Pacific Northwest, northwestern Gulf Coast).

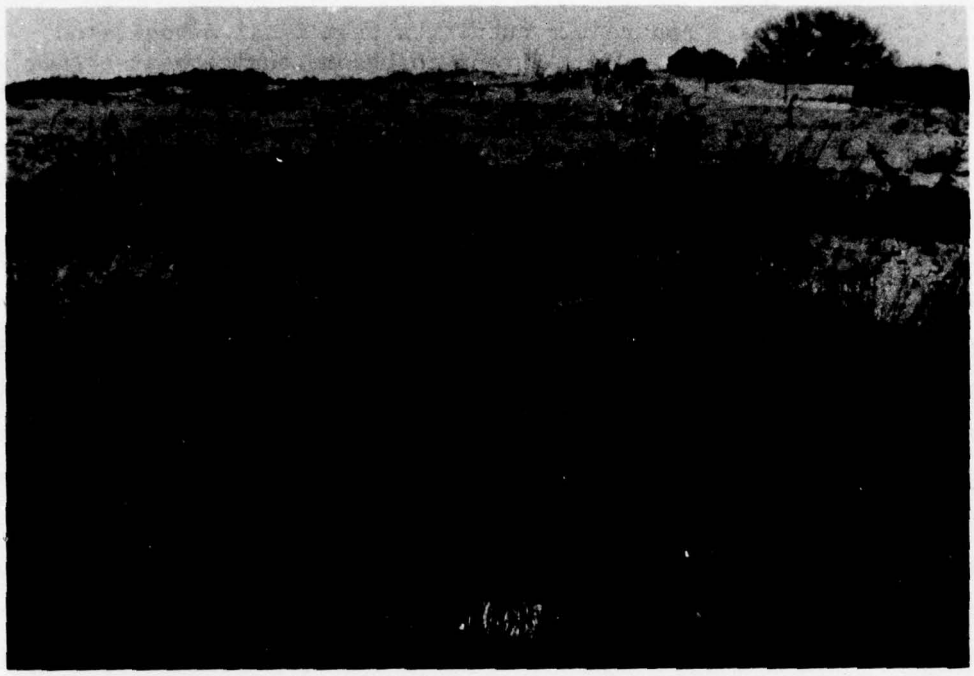
b. Edaphic. Variation in soil characteristics influences the types of community which may develop under a particular climatic regime. The Laguna Madre of south Texas is a hypersaline body of water. This causes the dredged material to be saltier than that found in other parts of the United States. Furthermore, the material remains salty over a longer period of time since the low rainfall results in a reduced rate of leaching. Consequently, plants with a high salt tolerence invade these deposits and tend to persist over a longer period of time. Given the same elevation and otherwise similar substrates, salt-tolerant species tended to extend higher onto islands in the Laguna Madre than in the other regions. On the dome-shaped islands found in other regions, the salt-tolerant species of plants only occurred as more or less narrow bands around perimeters. The texture of the surstrate was also an important edaphic factor. Pioneer plants became established more quickly on stabilized substrates. Fine materials more than coarse materials are affected by wind, rain, and wave erosion. This instability affected the rate of plant succession by retarding the establishment of pioneer plants. However, once the finer substrates became stabilized, a faster rate of succession was observed on them due to their greater water-holding capacity.

This phenomenon affected the rate of succession of bird communities since any particular nesting habitat for ground nesting species persisted over a longer period of time on the coarser substrates. Shrub and tree habitats necessary for arboreal species developed more quickly on finer substrates.

c. Topographic. Generally, in estuarine environments it was found that the rate of succession and species diversity of plants decreased as the elevation increased. A frequent pattern of vegetation observed on dome-shaped islands was the initial development of a concentric band of herbaceous pioneer plants around the perimeter (Figure 8a). As plant succession progressed, more xerophytic herbaceous plants invaded the slopes and domes as the concentric band of denser vegetation expanded toward the island interior (Figure 8b). In the absence of disruptive factors, the density of the herbaceous plants increased during succession. The herbaceous species were eventually replaced by shrubs except for a band of herbaceous marsh species which persisted around the perimeter of the island. As was the case for herbaceous plants, dominance by shrubs first occurred at lower elevations on undisturbed islands. Eventually, they spread to the interior. The shrub species were ultimately replaced by trees. A notable exception to the above pattern was observed in south Florida where mangroves were found around the perimeter in place of herbaceous marsh species.

d. Biotic. Several important factors affecting the rate of succession and species composition of the seral stages were identified. Succession occurred at a faster rate and the plant diversity was greater on islands closer to propagule sources. Pioneer plants were comprised of those species which produce seeds which are disseminated by either water or wind. The avifauna found on an island was partially determined by the types of plant communities present. The birds in turn had an impact on the plant communities. Seeds of many species found on the islands were transported there by birds. Some of the bird disseminated species were very important in bird colonies. Brazilian pepper and wax myrtle are two examples. Some species of upland songbirds were the most important transporters of seeds. Some of the colonial waterbird species affected plant communities by mechanically damaging plants by trampling or gathering nest material. Dense colonies also affected their nesting habitat by the deposition of feces. Royal and Sandwich terns appeared to actually extend the number of breeding seasons a particular site could be used. The excess accumulation of nutrients due to fecal deposition appeared to be toxic to the species of plants which would be expected to grow on the site. However, once nitrophilic species of plants invaded the sites, plant growth was more rapid than that observed on similar sites without bird colonies. On sites with fine substrates, dense concentrations of wading birds frequently caused mortality among some of the shrubs and trees used by them as nesting

a.



b.

Figure 8. Dredged material island in Myrtle Grove Sound, NC. a. Note vegetation during early spring of 1973 after dredged material deposition in January, 1971. b. The same island during the summer of 1974. Note the broader and denser band of vegetation around the island and the sparsely vegetated dome.

substrates. Apparently nutrients from fecal deposits on coarse substrates do not tend to become toxic because they leach from it more readily than on fine substrates. Most, if not all, of the conclusions regarding the effect of biotic factors on the rate of plant succession on dredged material islands must be considered tentative since very little research has been done on the subject.

31. Comparisons of succession of diked and undiked dredged material islands showed diked islands as not providing good nesting habitat compared to undiked islands (Parnell et al. 1978). Complete comparison of plant succession was not possible because no islands older than six years were available for study. Succession was found to be much more complex on diked islands in these early years due primarily to an increase in the number of topographic and edaphic features resulting from dike construction. Plant succession was found to be accelerated over that of undiked sites because plant propagules were usually readily availabe.

Other Studies

32. Several research studies and surveys located on or near dredged material islands have been completed by the Corps, other Federal and State agencies, National Audubon Society, and private citizens that are significant in documenting locations and populations of waterbird colonies in regions of the United States not studied under Task 4F.

33. Coastal Zone Resources Corporation (1977), in a study completed for the DMRP, documented use by populations of waterbirds of certain islands as a function of plant succession. Soots and Parnell, in a continuing eight-year study for the National Oceanic Atmospheric Administration (NOAA) Sea Grant Program, are studying plant and bird succession on dredged material islands in North Carolina estuaries (Soots and Parnell 1975; Parnell and Soots 1976).

34. Two U. S. Fish and Wildlife Service surveys of waterbird colonies were conducted in 1975 and 1976 by Custer and Osborn (1977) for tree nesters along the Atlantic coast, and in 1976 by Portnoy (1977) for the Gulf coast of Mississippi, Alabama, and Louisiana. Portnoy's

report noted 900,000 waterbirds (ground and tree nesters) in colonies in the three states, and that numerous colonies were located on dredged material sites.

35. The National Audubon Society has conducted surveys in Florida and Texas (Maxwell and Kale 1974; Paul 1977).

36. A continuing regional survey of importance has been the Texas Fish-eating Bird Survey conducted yearly by the Texas Parks and Wildlife Department to determine colony locations, species composition, and sizes of colonies in the State of Texas.

37. Robertson and Kushlan (1974) of the National Park Service surveyed all waterbirds of south Florida. Kushlan is continuing research in this part of Florida.

38. In addition to the research previously mentioned, numerous investigators have studied colonial waterbirds and their nesting, feeding, and other life requirements. An extensive bibliography of the most pertinent work is included in Landin (1978b). It compiles for the reader sources of information of specific waterbird species, situations, regional differences, and other factors.

PART III: LIFE REQUIREMENTS OF COLONIAL WATERBIRDS

Breeding Biology

Site Tenacity

39. Colonial waterbirds tend to return to sites where they successfully nested during the previous breeding season. They will even tolerate changes in the habitat of the site which would have prevented them from becoming established if those conditions had been present when they initially occupied the site. The manager can use this behavioral pattern in his planning. For example, the least tern, royal tern, and Sandwich tern prefer sites devoid of vegetation. However, all three will tolerate a limited amount of cover, which almost invariably develops on the site. There is a limit to the tolerance of changes in nesting habitat. A knowledge of these limits will be an invaluable tool in management.

40. Site tenacity may create problems in interpretation of what is the best habitat. Managers as well as research biologists should be aware of this problem. Colonies may frequently be found in plant communities which are near the limit of their tolerance with respect to structure of vegetation. If the manager attempted to duplicate this habitat on other sites in order to attract the birds to it, his attempt would be futile. Instead, habitat should be developed that approximates the features found at successful active sites during the early stages of use.

Colonial Behavior

41. In this report emphasis is placed on those species which tend to carry out their breeding activities in aggregations. The colonies formed by the aggregations are more likely than not to include other species as well.

42. Size of colonies and nest densities. There is a wide variation in the density of nests among species and even among colonies of the same species in some cases. Royal terns and Sandwich terns nest in the densest colonial aggregations of the species covered in this report (Figures 9 and 10). Nesting densities as great as $7.5/m^2$ have been reported for the royal tern (Buckley and Buckley 1972). The first author of this report has

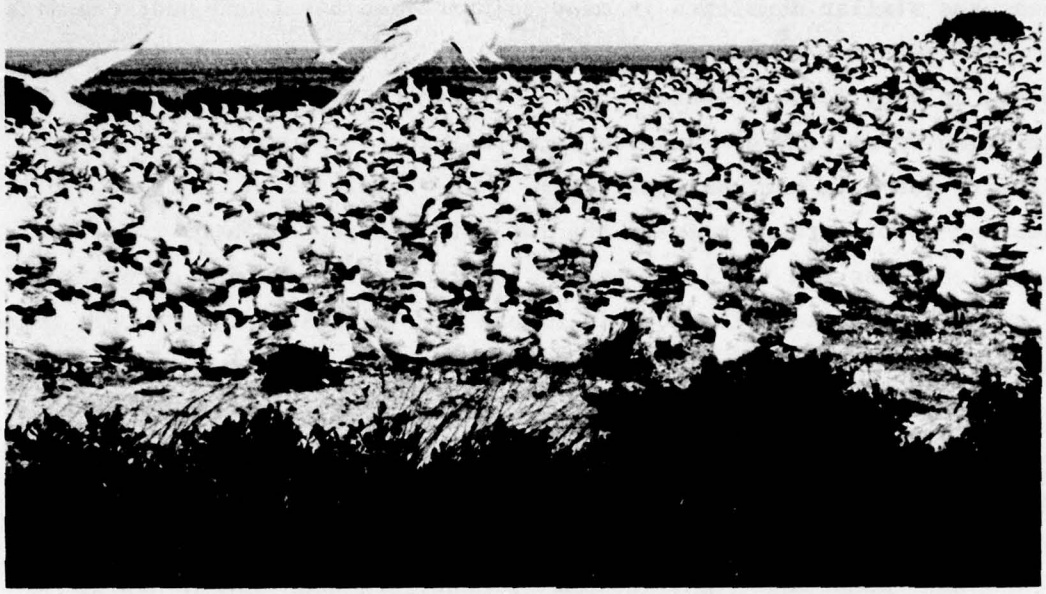


Figure 9. Mixed species colony of royal and Sandwich terns located on a dredged material island in Pamlico Sound, NC. The colony was comprised of 2988 royal tern nests and 897 Sandwich tern nests.

Figure 10. Close view of the nests and eggs of a mixed species colony of royal terns and Sandwich terns on Dump Island, a dredged material island located in Core Sound, NC.

measured similar densities in many colonies and has found nest densities greater than $8.0/m^2$ for the Sandwich tern. The least tern, in contrast, nests in very loose colonies with nests frequently widely scattered. Jernigan et al. (1978) measured densities in 18 colonies. The average density was only one nest per 213 m^2. The densities of other ground nesting species range between the two extremes shown by the royal and Sandwich terns and the least tern. The loose distribution of nests in a common tern colony is shown in Figure 11. Similar extremes were found among the tree nesters.

43. Colony size. The colonial waterbird species seldom nest in single colonies; rather, they tend to nest in large mixed colonies. For example, one colony comprised of 15 species and more than 35,000 individuals was located in Florida.

44. Management implications of density and number of nests. A knowledge of the potential nesting densities and sizes of colonies is needed in order to make decisions on the extent of nesting habitat required in the management program.

45. In general, the average area occupied by colonies tends to decrease as the density of the nests decreases. This is especially characteristic of the ground nesting species. In addition, those species which tend to space their nests more widely also form similar colonies and establish more colonies per unit area than do the species that form large colonies comprised of closely spaced nests. These nesting characteristics have strong management implications in the following ways:

a. Fewer sites would have to be managed for these species nesting in colonies with high nest densities than for those with lower nest densities.

b. Most of the ground nesters which nest in relatively small, loose colonies depend on cryptic coloration of their eggs and nest concealment as part of their defense against predation. Those species nesting in large, tight colonies do not depend on these factors and will have to be provided with varying amounts of plant cover depending on the species, while the latter require bare or sparsely vegetated sites.

Interspecific Associations

46. More colonies are comprised of mixed species than single species. Since those species nesting together have similar breeding habitat

Figure 11. Nests showing loose spacing of the common tern. Colony was located on New Dump Island, a dredged material island in Core Sound, NC.

requirements it is possible or even unavoidable to manage for two or more species simultaneously. The species of birds are listed by general nesting substrate in Tables 4 and 5.

47. Ground nesting species. Generally fewer species per colony are found among the ground nesting species than among arboreal nesting species. Interspecific nesting associations of ground nesting species are shown in Table 4, which reflects the most typical kind of associations the manager might expect to encounter on dredged material islands. Every species showing one or more positive associations may be found nesting in North America other than in royal tern colonies (Bent 1921, Buckley and Buckley 1972, Soots and Parnell 1975). The relationship appears to be obligatory for the Sandwich tern but not for the royal tern.

48. The Pacific Northwest regional study showed a strong association between glaucous-winged and western gulls. These gulls were not only nesting within the same colonies but were also found to be interbreeding. This fact plus the presence of many intergrades suggests that the two gulls are not separate species.

49. Gull-billed terns, common terns, and black skimmers frequently nest in interspecific colonies where their ranges overlap. However, there may be microhabitat differences in nest site selection among the three species (Soots and Parnell 1975). Management plans for mixed-species colonies may require the provision of habitat diversity. This topic will be developed further under management of specific habitats on islands.

50. Negative associations are also found among the ground nesting species. In general, those species that nest in dense colonies are not found among those in loose colonies and vice versa. Thus, glaucous-winged gulls and western gulls, ring-billed gulls, royal terns, and Sandwich terns are not generally found nesting among the other species which nest in looser colonies. There is also a lack of association among some members of the species nesting in loose colonies. Most can be explained by the variations in the breeding habitat requirements among the species. However, the least tern prefers to nest only with its own species regardless of the habitat.

51. Finally, the breeding ranges of many of the species do not

Table 4

Common Interspecific Associations of Ground Nesting Colonial Waterbirds Found Breeding on Dredged Material Islands in Six of the Seven Study Regions

White pelican															
0	Glaucous-winged gull														
0	0	Great black-backed gull													
0	0	+	Herring gull[a]												
0	+	0	0	Western gull											
0	0	0	+	0	Ring-billed gull										
-	0	-	+	0	0	Laughing gull									
-	0	-	-	0	0	-	Gull-billed tern								
-	0	-	-	0	+	-		Forster's tern							
-	0	-	-	0	-	-	+	-	Common tern						
0	0	-	-	0	0	-	-	-	+	Roseate tern					
-	0	-	-	0	0	-	-	-	-	-	Least tern[b]				
-	0	-	-	0	0	-	-	-	-	-	-	Royal tern			
-	0	-	-	0	0	-	-	-	-	-	-	+	Sandwich tern		
-	-	-	-	-	-	-	+	-	+	-	-	+	+	Caspian tern	
0	0	0	0	0		0	0		0	0	0	0	0	-	Black tern
-	0	-	-	0	0	-	+	-	+		-	-	-	+	0 Black skimmer

+ Found nesting together in mixed species colonies.

- Breeding ranges overlap but were not found in intermixed colonies.

0 Breeding ranges do not overlap in the study regions.

[a] Has been observed nesting in trees and on man-made structures.

[b] Has been observed nesting on flat, gravel-covered rooftops.

Table 5

Common Interspecific Associations of Arboreal Nesting Colonial Waterbirds Found Nesting on Dredged Material Islands

Brown pelican[a]															
+	Double-crested cormorant[a,b]														
0	0	Olivaceous cormorant[b]													
+	+	0	Anhinga												
-	+	+	+	Great blue heron[b,c]											
-	-	+	-	-	Green heron[c]										
-	-	?	+	-	-	Little blue heron									
-	-	+	+	-	-	+	Cattle egret								
-	-	-	+	-	-	+	+	Reddish egret[c]							
-	-	+	+	+	-	-	-	+	Great egret[b,c]						
-	-	+	+	-	-	+	+	+	+	Snowy egret					
-	-	-	+	-	-	+	+	+	+	+	Louisana heron[c]				
-	-	+	+	-	-	+	+	+	-	+	+	Black-crowned night heron[c]			
-	-	0	+	-	-	+	+	+	-	+	+	+	Yellow-crowned night heron		
-	0	0	0	+	-	+	+	+	-	+	+	-	0	White-faced ibis	
-	-	0	+	-	-	+	+	+	-	+	+	+	-	0	Glossy ibis[c]
-	-	?	+	-	-	+		+	-	-	-	-	-	+	+ White ibis[c]
-	-	+	+	-	-	+	+	+	-	+	+	+	+	0	+ + Roseate spoonbill

+ Close association.

- Nest on same island but not usually intermingled.

0 Were not found nesting on the same island together.

? Insufficient data to make an evaluation.

[a] Frequently nests on the ground.

[b] Nests on man-made structures.

[c] Occasionally nests on the ground.

overlap. Breeding ranges do change, however, so one should watch for new associations to develop when a species extends its range. The ranges of the great black-backed gull, herring gull, ring-billed gull, and common tern have all expanded during the past decade. Both negative and positive interspecific interactions involving these species may prove to be important to future management plans.

52. Arboreal nesting species. The interspecific associations among arboreal nesting species are shown in Table 5. The arboreal species generally nest together in mixed species colonies wherever their breeding ranges overlap. The following points about site selection should be considered when planning management of arboreal species:

a. Ground nesting. The brown pelican frequently nests successfully on the ground. Some other species nest on the ground when shrubs or trees are not available.

b. Vertical distribution. In contrast to ground nesting, species on the vertical as well as the horizontal distribution of nests must be considered. Brown pelicans, double-crested cormorants, olivaceous cormorants, anhingas, great blue herons, and great egrets usually nest in the highest stratum of a colony. The other species nest within the canopy and some of them may extend their nesting to the ground in colonies where there is keen competition for nesting space.

c. Horizontal distribution. Although many species may be found nesting within the same colony, some tend to form conspecific aggregations. The extent of intermixing is shown in Table 5. The degree of intermixing among the species is variable but the tables will allow the manager to predict which species he might expect to find nesting together in the same active colony in his area. The tables will be most useful to one who is knowledgeable of breeding ranges.

d. Geographical and local variation in nesting habitat. Members of the same species may nest in quite different habitats in different geographic regions while members of other species tend to be more uniform in their site selection. For example, the authors have observed great egrets and great blue herons nesting in swamps in the tallest cypress trees, in giant cordgrass thickets, and on coastal dredged material islands, in shrub thickets, and on the ground in North Carolina; in prickly pear cacti in Texas; and on man-made wire platforms in Louisiana. They have also been found nesting on channel

markers in the Columbia River (Henny and Kurtz 1978). Some variations in the breeding habits of great blue herons are shown in Figure 12. Examples of regional variation in nesting habits of other species may be found in the DMRP regional reports. The variations affect the types of interspecific associations to be found in an area.

e. Latitudinal and longitudinal variation in species composition. Eighteen species of arboreal nesting waterbirds were found using dredged material islands in the seven study regions. In general, the number of species decreased from south to north and from coastal habitats to inland habitats. Colonial waterbirds have not been found nesting on dredged material islands north of Long Island (Parnell and Soots 1978).

Life History

53. Management of individual bird colonies must eventually follow one of two courses of action or a combination of both. The courses of action include manipulation of the habitat and protection of the colony. A knowledge of some aspects of life history of the species using the management site will be essential regardless of whether one or both courses of action are taken.

54. Knowledge of life histories is important for the following reasons:

a. Human activity should be limited on colony sites during the breeding season.

b. If intrusion into a colony site is a necessary part of management, less damage will be done during some phase of the breeding season than others.

c. Onsite protective measures must coincide with the breeding season.

55. A knowledge of the following aspects of the species life history is essential to the development of a management program:

a. Onsite pre-nesting behavior. The utilization of the colony site prior to nest building, egg laying, and rearing of young is an essential part of the breeding period. Disruptions during this phase may lead to abandonment of the colony site more quickly than during latter phases. In the pelicans, cormorants, anhingas, herons, egrets, ibises, and spoonbills this time is essential to establishment of territories, pair formation, and strengthing of pair bond. Most gulls, terns, and skimmers probably form pairs prior to becoming established at the site. At least one species, the common tern, forms firm pair

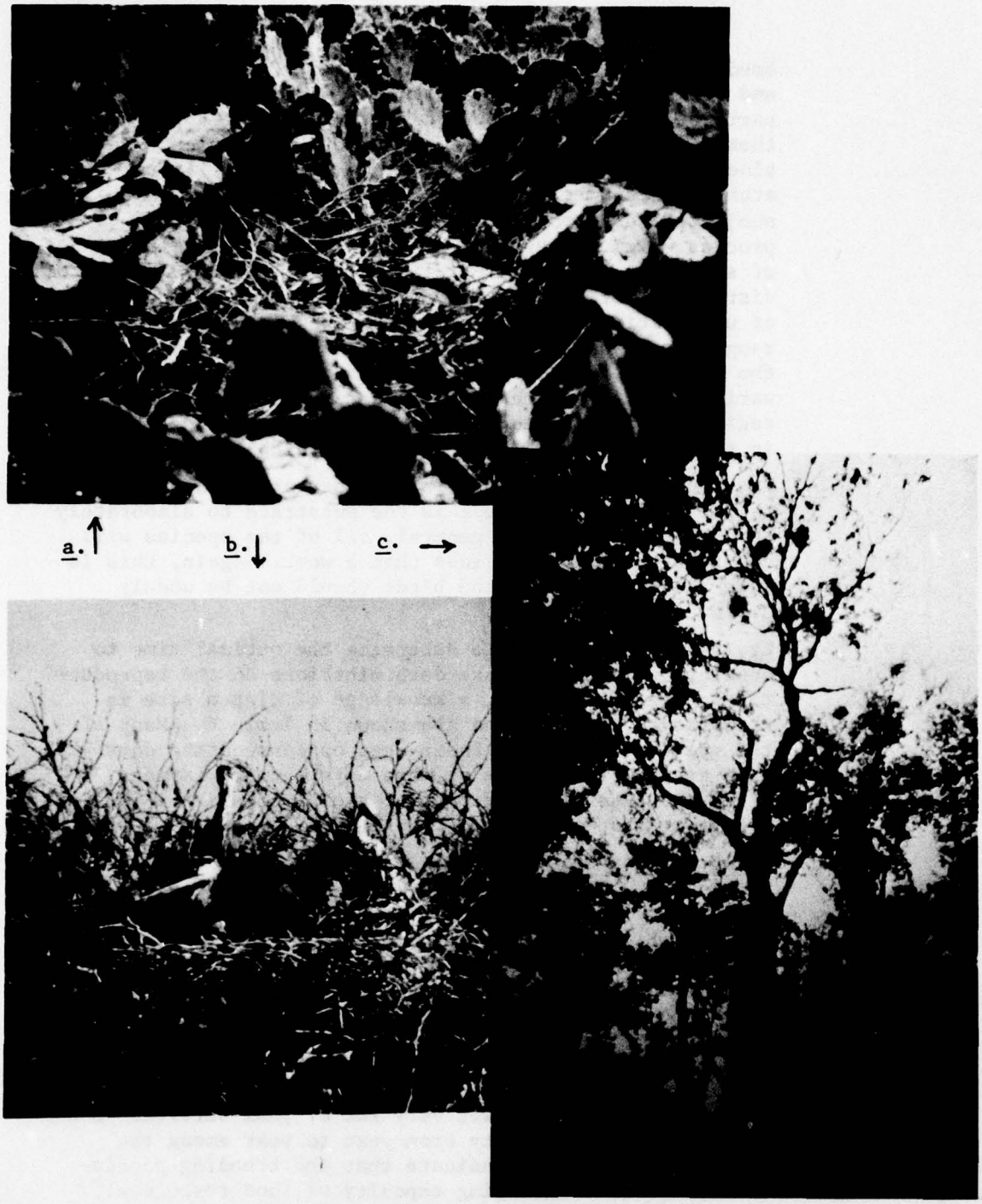


Figure 12. Variations in breeding habitat of the great blue heron. a. Nest located near the ground in prickly pear cactus on dredged material island in Texas. b. Nest located in huisache tree on dredged material island in Texas. c. Nests located 20 m high in elm tree in Upper Mississippi River.

bonds that last from season to season. The other gulls and terns may form such alliances. However, the other parts of the breeding period mentioned above apply to them as well. In addition, the activities which take place on a site allow the birds to determine if predators frequent it or whether or not the potential site is subjected to disruptions. Abandonment is a natural process which has evolved to increase the probability of selecting a site which will be relatively isolated from disruptive forces during the breeding season. The period of utilization of the sites for prenesting activities ranges from about two days to several weeks, depending on the species. Detailed information on the timing of the various phases of the breeding periods are given in the regional reports. Additional information may be found in the references listed in Landin (1978b).

b. Nest building. Nest building by the various species ranges from a bare scrape in the substrate to elaborately constructed nests. In general, all of the species will complete their nest in less than a week. Again, this is a sensitive phase and the birds should not be unduly disturbed.

c. Egg laying. In order to determine the optimal time to conduct censuses and make determinations on the reproductive stage of a colony, a knowledge of clutch size is necessary. Clutch sizes are shown in Table 6. Many of the species do not lay their eggs on consecutive days but have an interval of one or more days between laying. After the eggs are laid most of the species are less likely to abandon a site if disturbed.

d. Incubation of eggs. Incubation starts after the first egg is laid. Both sexes share the duties. Breeding periods are shown in Table 7. Hatching dates are staggered among those species which do not lay their eggs on consecutive days. This results in young of unequal sizes being present in nests of those species showing this type of egg laying behavior. The young hatching first have a competitive advantage over smaller siblings. Mortality is generally much higher among later hatching siblings. During years when food is scarce or the weather is unusually cold and wet very few of them survive. Consistently high mortality from year to year among the smaller siblings may indicate that the breeding population is near the carrying capacity of food resources. In such a case it would not be prudent to provide additional nesting habitat unless it was placed in an area where food resources are apparently available and nesting habitat is lacking.

Table 6

Clutch Sizes of the Species of Colonial Waterbirds Found Nesting on Dredged Material Islands

Species	Clutch Size Range*	Clutch Size Typical	Source
White pelican	1-3	2	Chaney et al. 1978
Brown pelican	2-5	2-3	Chaney et al. 1978
Double-crested cormorant	2-7	3-4	Palmer 1962
Olivaceous cormorant	3-5	4	Chaney et al. 1978
Anhinga	1-5	4	Palmer 1962
Great blue heron	3-7	3-5	Palmer 1962, Howell 1932
Green heron		4	Meyerriecks 1960, Byrd 1978
Little blue heron	2-5	4	Jenni 1969
Cattle egret	1-6	3	Jenni 1969
Reddish egret	2-7	3-4	Chaney et al. 1978
Great egret	1-5	3	Custer et al. 1975
Snowy egret	2-6	3-4	Jenni 1969
Louisana heron	2-7	3 4	Jenni 1969
Black-crowned night heron	1-8	3-4	Custer et al. 1975
Yellow-crowned night heron	3-6	4	Chaney et al. 1978
White-faced ibis	2-7	3-4	Chaney et al. 1978
Glossy ibis	1-4	3	Custer et al. 1975
White ibis	1-4	3	Custer et al. 1975
Roseate spoonbill	2-7	3-4	Chaney et al. 1978
Glaucous-winged gull	1-3	3	Vermeer 1963
Great black-backed gull	2-3	3	Chapman 1939
Herring gull	1-4	3	Haycock and Threlfall 1975
Western gull	1-6	3	Schreiber 1970
Ring-billed gull	1-5	3	Vermeer 1970
Laughing gull	2-5	3	Chaney et al. 1978
Gull-billed tern	1-4	2-3	Chaney et al. 1978
Forster's tern	2-6	3	Chaney et al. 1978
Common tern	1-6	3	Bent 1921
Roseate tern	1-4	2	LeCroy and Collins 1972
Least tern	1-4	2	Massey 1974
Royal tern	1-2	1	Buckley and Buckley 1972
Sandwich tern	1-3	2	Smith 1975
Caspian tern	1-4	2	Chaney et al. 1978
Black tern	1-4	3	Bergman et al. 1970
Black skimmer	3-7	4	Chaney et al. 1978

* The ranges in the clutch sizes shown do not show extreme examples of number of eggs rarely found in the nests of most of the species listed. It is generally believed that unusually large clutches result from more than one female laying eggs in the same nest.

Table 7

Length of Breeding Periods of Colonial

Waterbirds Found Nesting on Dredged Material Islands

Species	Breeding Periods*
White pelican	late April to August
Brown pelican	January to July (Florida: Nov to Sept)
Double-crested cormorant	January to August
Olivaceous cormorant	late January to late October
Anhinga	February to August
Great blue heron	January to September
Green heron	March to August
Little blue heron	March to August
Cattle egret	April to September
Reddish egret	February to August
Great egret	early March to late August
Snowy egret	late March to September
Louisiana heron	late March to August
Black-crowned night heron	early February to late July
Yellow-crowned night heron	early March to mid July
White-faced ibis	early April to late July
Glossy ibis	March to August
White ibis	March to September
Roseate spoonbill	April to July (Florida: Oct to May)
Glaucous-winged gull	late April to July
Great black-backed gull	April to July
Herring gull	April to July
Western gull	late April to July
Ring-billed gull	April to August
Laughing gull	March to August
Gull-billed tern	early April to mid August
Forster's tern	early April to mid July
Common tern	March to August
Roseate tern	April to August
Least tern	early April to early August
Royal tern	March to August
Sandwich tern	mid April to August
Caspian tern	mid March to mid July
Black tern	April to August
Black skimmer	mid March to early September

* Breeding periods may vary from region to region, especially in Florida and south Texas. A local ornithologist should be consulted to be assured of more exact nesting schedules.

e. Parental care of young. Parental care of the young primarily involves protecting them from adverse weather and predators and feeding them. All of the species brood their young during inclement weather and shade them during hot, sunny weather. This protection is critical to very young birds so disruption in colonies during unfavorable weather conditions may cause high mortality among very young birds. Defense of the eggs and young against predators varies among the species covered in this report from near passivity to agressive attacks. Awareness of the variations in defense of the eggs and young among the species is important to an investigator working in the colonies for the following reasons:

(1) Predators which normally take a relatively small number of eggs or young from unagressive species may cause considerable mortality when birds are flushed from their colony site.

(2) Members of very agressive species may attack and injure young of their own species if disruptions cause the young of other birds to enter their territory.

(3) Some species of terns become so aggressive toward intruders during late incubation and after hatching that even humans should be careful when entering their colony area.

The gulls, terns, and black skimmer are the only waterbirds considered in this report that have shown much aggression toward other species, including humans, which intrude upon their territory. The terns are much more aggressive than the gulls or skimmers. There is considerable variation even among the terns. The most aggressive species are the gull-billed tern, Forster's tern, common tern, roseate tern, least tern, and Caspian tern. Many investigators have had their heads cut by aerial attacks from terns, especially from the gull-billed and common terns. Practically all of the species of gulls and terns bombard an intruder with feces, making head gear necessary when working in colonies. The young of all the species depend on both parents for food at least until the time they fledge. The young of the species in this report can be placed into three categories depending on their degree of development at the time of hatching:

(1) Altricial young, which are naked, usually blind, and too weak to support themselves on their eggs. Nidicolous is another term used for young with these characteristics. The pelicans, cormorants, and anhinga are in this category.

(2) Semi-altricial young, which have down-covered bodies,

open eyes (usually), and are not able to leave their nest. The herons, egrets, ibises, and roseate spoonbills are in this category.

(3) Semi-precocial young with down-covered bodies, open eyes, and ability to leave the nest soon after hatching. However, the young of most species stay fairly close to the nesting territory unless severely disturbed by predators or humans. The gulls, terns, and black skimmers are in this category. The young of royal and Sandwich terns stay in their nests only two or three days.

A knowledge of the types of young is important for the following reasons:

(1) Altricial young are more vulnerable than other types, so greater care should be exercised during periods of inclement weather and when predators are present in the colony area.

(2) Semi-altricial young are not fed by the parents if they fall to the ground from arboreal nesting sites. Colony disruption causing them to fall will result in their death.

(3) Semi-precocial young readily seek hiding places when disturbed so care must be taken to avoid stepping on them or scattering them too far from their nesting territory.

f. Fledging. The interval between hatching and fledging of the young varies with species and involves ranges from 20 days in the least tern (Wilbur 1974) to about 60 days in the brown pelican and great blue heron (Meyerriecks 1960; Palmer 1962). Once young have fledged from an island, management operations or activities necessary for dredging operations may take place freely.

g. Sexual maturity. Most of the species do not reach sexual maturity until two or three years of age. Therefore, the effects of an unusually poor or unusually good reproductive season would not be reflected in the breeding population until two or three years later. This will have to be taken into account when evaluating the effects of management programs. New breeders entering the population tend to either join the perimeter of existing colonies or initiate new ones. In either case they are not as successful at rearing young as the older birds. It would be reasonable to predict that new colonies forming in a management area will be less successful than established colonies comprised of more experienced birds. It should not be concluded that a newly occupied site is not satisfactory simply because of a lower reproductive success

than found at older sites. The site should be evaluated during more than one season.

Predation

56. Consideration of predation must be a part of any management program dealing with the breeding habitat of colonial waterbirds. The most consistent characteristic found among the colonial waterbirds considered here is that all of them seek breeding sites which are relatively isolated from predators. Management of habitat which is freely accessible to predators, especially carnivorous animals, would generally be wasted effort.

57. Predators may be grouped into ground predators and aerial predators. The former consists mainly of various species of mammals but snakes may also take some eggs and young. Certain bird species of course comprise the aerial predators. Notable among the avian predators are some of the species of waterbirds included in this report. A list of some of the more common predators of the eggs, young, and adults of colonial waterbirds on some dredged material islands is shown in Table 8.

Feeding Habits and Foraging Behavior

58. This paper deals primarily with the management of nesting sites composed of dredged material. However, the feeding and foraging habits as well as the types of food eaten by the birds must be given consideration when developing a management plan. Some species feed in waters fairly close to their nests while others travel long distances as well as feeding close by when prey is available. For example, the royal tern feeds most frequently in open bays and may travel considerable distances from colony sites. The black skimmer feeds mostly in marshes and tidal pools relatively near their colony sites. The common tern is intermediate between the two in foraging behavior (Erwin 1977).

59. The foraging pattern has strong management implications. Those colonial species that tend to travel long distances to search for food resources with a clumped or patchy distribution form fewer, larger, and more dense nesting colonies. Just the opposite is true for those species which feed on more evenly distributed food resources near colony sites. This means that fewer sites would have to be managed for

Table 8

Some of the More Common Predators
of Eggs, Young, or Adult Colonial Waterbirds

Ground Predators	
Fire ants	Gray fox
Rattlesnakes	Coyote
Rat snakes	Dog (feral and domestic)
American alligator	Cat (feral and domestic)
Opossum	River otter
Raccoon	Mink
Red fox	Norway rat

Aerial Predators	
Black-crowned night heron	Great horned owl
Yellow-crowned night heron	Short eared owl
Common gallinule	Barred owl
Glaucous-winged gull	Burrowing owl
Great black-backed gull	Common crow
Western gull	Fish crow
Herring gull	Great-tailed grackle
California gull	Boat-tailed grackle
Ring-billed gull	
Laughing gull	

the royal tern than for the black skimmer. However, individual royal tern sites should receive more intense management since the destruction of one site may affect a large geographic region. For example, a large royal tern colony has nested on dredged material islands in the lower Cape Fear River of North Carolina for many years. The nearest colony along the Atlantic coast is 96 miles away. In 1976, 32,838 royal terns nested in eight colonies along the North Carolina coast while 3,198 black skimmers nested in 32 colonies. The average colony size of the two species was 4,105 and 74, respectively.

60. The wading birds (herons, egrets, ibises, spoonbills) require shallow water in which to feed. Large colonies will not occur where suitable wetlands are not located. Populations of wading birds along the Atlantic coast are correlated to abundance of coastal wetlands (Custer and Osborn 1977). Feeding habitats and foraging behavior are not the only factors affecting colony distribution. Social factors, site tenacity, disturbances by predators and humans, and site characteristics are also important.

Nesting Substrate Characteristics and Preferences

61. Vegetation (the types of plant communities or the lack of plants) on an island is one of the main factors which determines whether or not a species nests on it. The general nesting habitats range from bare substrate to forests. All of the species tolerate at least some vegetation in their colonies and many require it.

Vegetative habitats of nesting sites

62. Site characteristics found on dredged material islands may be categorized vegetatively as follows (Soots and Parnell 1975):

a. Bare substrate. Sites lacking plants (Figure 13).

b. Sparse herb. Less than 25 percent coverage of low non-woody plants (Figure 14).

c. Medium herb. Twenty-five to 75 percent coverage of low non-woody plants (Figure 15).

d. Dense herb. Greater than 75 percent coverage of low non-woody plants (Figure 16).

Figure 13. Bare substrate being utilized by a colony of royal terns in North Carolina.

Figure 14. Sparse herb habitat suitable for common terns, gull-billed terns, black skimmers, and certain other gulls and tern species.

Figure 15. Medium herb habitat being used by laughing gulls in Florida. This colony on Island I-49b had an estimated 50,000 nesting adults in 1977.

Figure 16. Dense herb habitat that may be used for nesting by laughing gulls, other gull species, and sometimes ground nesting herons, egrets, and white-faced ibises.

e. Herb-shrub. A mixture of low non-woody plants and relatively low, multiple stemmed, woody plants (Figure 17).

f. Shrub thicket. Canopy and understory comprised of dense woody plants (Figure 18).

g. Shrub-forest. Canopy comprised of densely packed crowns of woody plants. Understory relatively open (Figure 19).

h. Forest. Canopy dominated by trees (Figure 20).

The habitats utilized by each species are shown in Table 9.

Sites for ground nesting species

63. Ground nesting species may be found in habitats ranging from bare sites to herb-shrub. The critical amount of coverage of vegetation will be that which occurs on colony sites during the prenesting period. The density and size of plants may increase in some sites as the nesting season progresses. The vegetation may change to a stage which would have prevented occupation of the site if such conditions had been present during the prenesting period. The distribution and growth form of the plants comprising the ground coverage affects utilization of the plant communities. Some species prefer a more regular distribution of plants while others prefer to occupy sites with more clumped vegetation. Species which appear to favor more regularly distributed plant communities include the ring-billed gull, common tern (Figure 14), roseate tern, Caspian tern, and black skimmer. Species which reach greater nesting densities on a site dominated by clumps of vegetation include the glaucous-winged, great black-backed, herring, western, and laughing gulls (Figure 21). Features other than the form of vegetation may serve the same functions as the clumps. The clumps provide visual barriers between birds nesting in adjacent territories and provide cover for the young. Rocks, logs, drift material, or other structures may serve the same function (Figures 22 and 23).

64. Species nesting in dense herbs may require open areas interspersed within the site. Laughing gulls select such sites (Figure 21), and trails leading from their nests to open areas are a characteristic feature when open areas are not immediately adjacent to their nests (Figure 24).

Figure 17. Herb-shrub habitat being utilized by laughing gulls for nesting in North Carolina on a dredged material island.

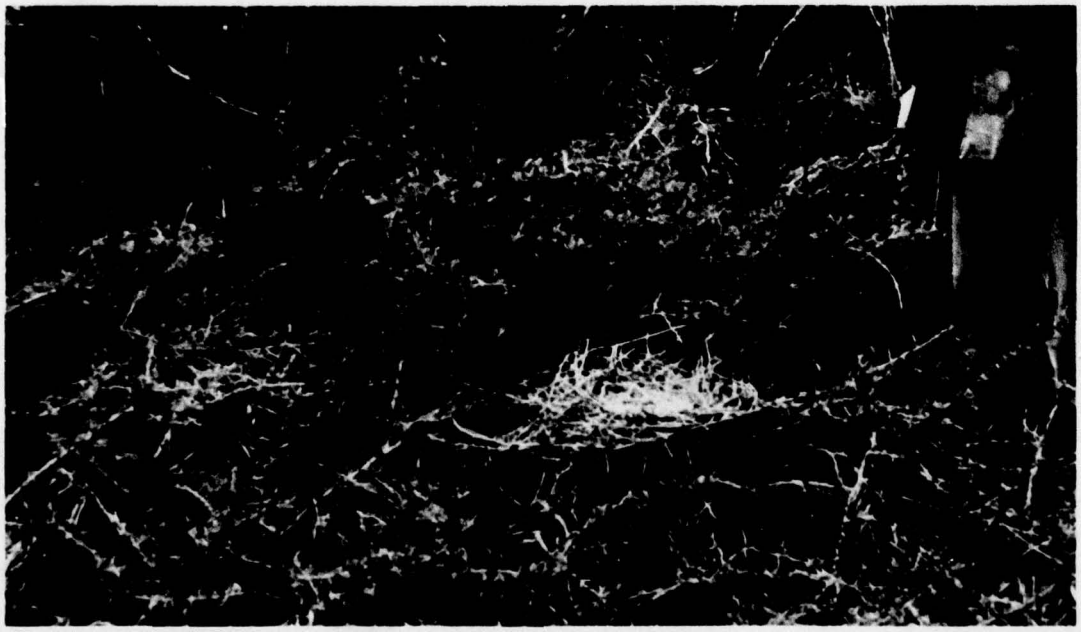


Figure 18. Shrub thicket habitat in Texas consisting of huisache trees, wild roses, and other dense shrubs that contained heron and egret nests.

Figure 19. Shrub-forest habitat on a dredged material island. Note the nests beneath the canopy layer.

Figure 20. Forest (maritime) habitat on an island in Florida, consisting almost entirely of mangroves. This site was used by a large mixed colony of brown pelicans, white ibises, and herons and egrets.

Table 9

Nesting Habitats in Which Colonial Waterbirds Nest On Dredged Material Islands

Species	Nesting Habitats[a]							
	BS	SH	MH	DH	HSh	ShT	ShF	F
White pelican	x	x			x		x[b]	x[b]
Brown pelican	x	x			x	x	x[b]	x[b]
Double-crested cormorant							x	x
Olivaceous cormorant								x
Anhinga							x[b]	x[b]
Great blue heron				x	x[b]	x	x	x
Green heron				x	x	x[b]	x[b]	x[b]
Little blue heron					x	x	x[b]	x[b]
Cattle egret					x	x[b]	x[b]	x
Reddish egret				x	x	x	x[b]	x[b]
Great egret				x	x	x[b]	x[b]	x
Snowy egret				x	x	x[b]	x[b]	x
Louisana heron				x	x	x[b]	x[b]	x[b]
Black-crowned night heron				x	x	x	x[b]	x[b]
Yellow-crowned night heron					x[b]	x	x	x
White-faced ibis				x	x	x		
Glossy ibis				x	x	x[b]	x[b]	x
White ibis						x	x[b]	x[b]
Roseate spoonbill						x	x	x
Glaucous-winged gull[c]		x	x[b]	x[b]	x			
Great black-backed gull		x	x[b]					
Herring gull[c]		x	x[b]	x[b]	x			
Western gull[c]		x[b]	x[b]	x	x			
Ring-billed gull	x	x	x	x[b]	x			
Laughing gull[c]			x	x[b]	x			
Gull-billed tern[c]	x	x[b]	x					
Forster's tern[d]	x	x[b]	x[b]	x[b]				
Common tern	x	x	x					
Roseate tern			x	x				
Least tern	x[b]	x						
Royal tern	x[b]	x						
Sandwich tern	x	x						
Caspian tern	x	x[b]	x[b]	x[b]				
Black tern[d]	x[b]	x[b]	x					
Black skimmer	x	x	x					

[a] Key to symbols: BS = bare substrate, SH = sparse herb, MH = medium herb, DH = dense herb, HSh = herb shrub, ShT = shrub thicket, ShF = shrub-forest, F = forest, x = species nests in the habitat.

[b] Most frequently used nesting habitats.

[c] Objects such as clumps of vegetation, logs, drift material, cobble, etc., readily accepted in nesting habitat.

[d] Primarily a marsh nesting species.

a.

b.

Figure 21. a. Laughing gull colony site in Tampa Bay, Florida (Island 49b), dominated by large clumps of broomsedge and dog fennel.
b. Laughing gull nest located adjacent to a clump of broomsedge.

a.

b.

Figure 22. a. Gull-billed tern colony site strewn with drift material deposited during a dredging operation on the lower Cape Fear River, NC. b. Gull-billed tern nest surrounded by the drift material.

Figure 23. Western gull colony located among logs on island in the Pacific Northwest.

Figure 24. Large royal tern colony on bare site in center of photograph. Surrounding the royal tern colony was a large laughing gull colony. An extensive trail system can be seen in the dense herbaceous nesting habitat caused by the laughing gulls.

Sites for arboreal nesting species

65. A species is considered arboreal if it places its nests above the ground in woody vegetation. The woody vegetation may range from low shrubs to the tallest trees occurring on dredged material islands. The habitats include herb-shrub, shrub thicket, shrub-forest, and forests. Nests are usually placed in the shrubs of the herb-shrub habitat. However, it is in this habitat type that ground nesting occurs among some mainly arboreal species. This nesting behavior probably results from the following factors:

a. Fewer arboreal nesting strata are available in the low shrubs compared to older plant communities which have tall shrubs or trees.

b. Birds may be strongly attracted to a site through social facilitation and may nest on the ground if suitable arboreal sites have already been filled by other birds.

Since arboreal species are not likely to be as successful while nesting on the ground, this behavior has management implications. The establishment of shrubs could be sped up by plantings, thus providing additional arboreal nesting sites.

66. Some species of woody plants were found to be very important to arboreal species in the study regions. When practical, plants to be propagated should be selected from those species. Detailed information on important species is given in the study reports and pages 80-85 in this report.

67. Ideally it would be best to maintain considerable diversity in the woody habitats of an island. While some species nest in all four of the arboreal habitats, there are definite preferences (Table 9). Furthermore, interspecific vertical and horizontal stratification may be found. Stratification is affected by the regional variation found in the growth form of the woody plants.

68. The Laguna Madre south of Corpus Cristi is the only hypersaline sound in the United States. The semi-arid climate and hypersalinity create a very stressed ecosystem. Terrestrial plants are dominated by xerophytes and halophytes. The woody species on dredged material islands are frequently those which have low growth forms, thus limiting vertical stratification of nests (Figure 18).

69. In Florida bird use decreases once an island passes the herb-shrub stage, and with few exceptions does not reoccur to a great extent unless a mangrove community develops (Lewis and Lewis 1978). Where they are present, mangroves are heavily utilized by arboreal nesting waterbirds (Figure 20). Florida arboreal nesting habitats are also characterized by several exotic species including Brazilian pepper and Australian pine. The latter may prove to be very important from a negative standpoint since it is not used by many species for nesting and may dominate the vegetation of an island. Selective cutting may be desirable.

70. The wax myrtle is by far the most important shrub species found in arboreal colonies in North Carolina. Around the perimeter of islands groundsel tree and marsh elder are very important. Marsh elder will also grow over an entire island when it is low in elevation and composed of brackish soil. A physiognomy frequently observed in colonies in North Carolina is a central shrub-forest dominated by wax myrtle and a perimeter band of shrub thicket dominated on the inside by groundsel trees and the outside by marsh elders (Figure 19). Where nesting space is unlimited, all of the wading birds nest in the canopy of the shrub forest. The great egret nests in the tops of the canopy while the smaller herons and egrets nest within the canopy. Where less nesting space is available in the canopy of the shrub-forest or forest, the smaller species, especially the snowy egret and Louisiana heron, will nest in the shrub thicket. This pattern also occurs on older islands where the forest replaces the shrub-forest. There is little difference in the physiognomy of these two plant communities on dredged material islands, even though the species composition changes. The forests are dominated by live oak, lobolly pine, yaupon, eastern red cedar, hackberry, and wax myrtle.

71. The physiognomy of the woody vegetation on dredged material islands in New Jersey is similar to that in North Carolina. However, giant reed is very important in the herb-shrub stage in New Jersey (McCaffrey and Buckley 1978) and less so in North Carolina. Bayberry replaces wax myrtle and it, along with the eastern red cedar, black cherry, groundsel tree, and winged sumac, were dominants in the shrub-

forest. The shrub-forest was the oldest stage reported in the New Jersey study. Marsh elder, groundsel tree, and bayberry formed shrub thickets around the perimeter similar to those observed in North Carolina.

72. The herons in New Jersey showed a preference for the grass, grass-shrub, shrub, and shrub-forest communities (Buckley and McCaffrey 1978). The giant reed, a very important grass on dredged material islands in New Jersey, was relatively unimportant on islands in the other areas except for some of those in the Cape Fear River estuary in North Carolina. The height of this tall grass may frequently exceed 2 m. In New Jersey it was used for nesting habitat by snowy egrets, black-crowned night herons, and glossy ibises. Nesting of wading birds in giant reed in New Jersey allowed them to be associated with an earlier successional stage here than in other study regions. However, the later seral stages should be considered the more preferred habitat.

73. The great blue heron was the only arboreal species found nesting on the study islands in the Pacific Northwest. The two colonies found were both located in the canopy of 25- to 32-m-tall black cottonwoods. Since no arboreal species were found nesting on dredged material islands, a comparison between the Pacific Northwest study region and the other regions cannot be made. It should be pointed out, however, that dredging does occur adjacent to the colony islands, and care should be taken to avoid any damage to the sites.

74. The two remaining study areas contrast sharply from the other studies in that both are remote from coastal areas and are dominated by fresh water ecosystems. The Upper Mississippi River study area was unique among the seven in that no colonial waterbirds, ground or arboreal, were found nesting on dredged material islands (Table 1). Arboreal species found there nested in the upper part of the canopy of tall trees located in mature riparian deciduous hardwood forests. Nests of the southernmost colonies found during the study were located in large American sycamores. The most commonly used tree in the north part of the study area was the silver maple. Other species commonly used were the American elm, eastern cottonwood, and green ash. Even though no colonies were found on dredged material, dredging operations have the

potential of damaging existing natural sites. Management plans should be developed to avoid such damage.

75. Arboreal sites on dredged material islands in the Great Lakes study area were scarce. Only three sites had developed woody vegetation suitable for arboreal species. The only habitat type found was shrub thicket, which supported small black-crowned night heron colonies. A small colony of cattle egrets also nested on one of the sites in 1976. All nests were found in shrub forms of peachleaf willow, sandbar willow, and eastern cottonwood. Thus, dredged material islands are presently relatively unimportant to arboreal nesting species in the Great Lakes. It is likely, however, that any site allowed to develop at least the shrub thicket habitat will be used for nesting if it becomes available.

PART IV: MANAGEMENT

Techniques for Evaluating the Breeding Populations of Waterbirds

Distribution and Habitat

76. Colonial waterbirds found nesting on dredged material islands have fairly narrow, well defined breeding distributions that are largely determined by two ecological requirements. First, most species feed primarily on aquatic or semiaquatic vertebrates and/or invertebrates. Second, all of the species require nesting habitat which is isolated and relatively free of predators. These nesting conditions were found mostly in large aquatic systems such as estuaries, lakes, and swamps, or major river systems.

77. The greatest concentrations of breeding birds associated with dredged material islands occur in those parts of the United States with large shallow sounds where navigable waterways are maintained by the Corps. Whether or not colonial waterbirds are nesting on dredged material islands in a particular area can be determined by one or more of the following:

a. Reported studies. The only comprehensive reports presently available which give detailed information on colony location and breeding bird populations on dredged material islands are the seven DMRP studies discussed in Part II of this report. The Portnoy (1977) and Custer and Osborn (1977) surveys of the Gulf coast and Atlantic coast are presently the only other surveys that cover a large region.

b. Knowledgeable persons. Only ornithologists experienced in the field study of colonial waterbirds should be contacted for assistance. The person contacted should be able to provide information on levels of breeding populations in the area, the status of the species present, and should be qualified to conduct censuses if needed.

c. Field censuses. In order for any wildlife management plan to be effective it is necessary to obtain population data on the species involved. Reliable data on populations, such as that found in the DMRP regional studies, must be updated periodically. Censuses of the total population in all habitats within the management area should be conducted at least every three years so that population trends can be followed. Less

intensive surveys within the area should be conducted to determine the status of colonies. Studies may show that some species do not need managing while others might require intensive management in order to maintain or increase population levels. In any case, rational management decisions cannot be made without monitoring the populations of the colonial waterbirds.

Census Techniques

78. Finding bird colonies, determining the species present, and estimating the number of breeding birds is not an easy task. To compound the problem there is not general agreement among biologists as to which techniques are best for censusing breeding populations of colonial waterbirds. Therefore, the recommendations in this section will be essentially those that the authors feel to be the best based on their experience.

79. Colony disruption. Great care should be taken to cause the least amount of disruption possible. Some disturbance is inevitable if a census is to be conducted; however, the effects of the disturbance can be minimized by adhering to the following guidelines:

a. Avoid disruptions during the courtship and egg laying period. The birds are more prone to abandon a site during the early part of the breeding period. In addition, surveys or censuses conducted too early in the breeding cycle will result in an underestimation of the breeding population since new birds may later join existing colonies or new colonies may subsequently form.

b. Avoid disruptions in heronries after the young are large enough to climb out of their nests, thus increasing the risk of falling to the ground. The parents will not feed the young if they fall beneath the canopy.

c. Avoid disruptions during the following weather conditions:

(1) Colder than normal weather
(2) Extremely hot weather or hottest part of day
(3) Rainy weather
(4) Very windy weather

Mortality will occur if the eggs or young become overchilled or overheated. Substrate surface temperatures above 60°C have been reported during the middle of the day (Modha and Coe 1969). Walton (1976) found that the temperature of one-day-old black skimmers rose from 39.3 to 41.3°C in five minutes when exposed to substrate temperatures of 40.8°C. Wind or rain worsen the effect of cold temperatures. Wind poses a further hazard to young in heronries in that they may be blown from their perches if chased from their nest

during very windy weather.

d. Drab clothing should be worn and slow deliberate movements should be made when entering a colony. Both bright clothing and fast or sudden movements cause a greater amount of disruption.

e. When censusing large areas, narrow transects are usually better than wide transects. Fewer birds are disrupted in any time period and these quickly return to their nests as the census takers move over to adjacent areas.

f. Discontinue any census which appears to be causing too much disruption in the colony.

g. Censuses should always be under the supervision of someone experienced in the field study of waterbirds.

80. Timing of censuses and surveys. Surveys should be conducted as close as possible to the peak of incubation period after most of the eggs have been laid and just prior to initiation of the census, since the function of the survey is to locate the colonies to be censused. However, enough time should be allowed between the survey and census to monitor selected colonies in order to determine breeding progress and to construct a census plan.

81. The following aspects of the breeding biology of colonial waterbirds must be considered when establishing census schedules:

a. All species do not overlap in timing of their breeding activities. Therefore, the number of censuses must be increased as the number of species to be censused increases.

b. In general, the number of species of colonial waterbirds and the length of breeding seasons in the contiguous 48 states decrease from southern to northern latitudes. As a consequence, censusing is more difficult in southern colony sites.

c. Prolonged cold, wet weather may delay the onset of nesting or cause nesting mortality and renesting. This complicates the interpretation of population data.

d. In some species new adults may join a colony, and eggs may be laid over an extended period of time. For example, in royal tern colonies new subcolonies may be added for a month. Young may be hatching in one part of a colony while eggs are being laid in another part (Figure 25). Similar problems are found in heronries. Great blue herons and great egrets generally nest earlier than the midsized herons. Cattle egrets usually join heronries after the other species are well into their breeding period.

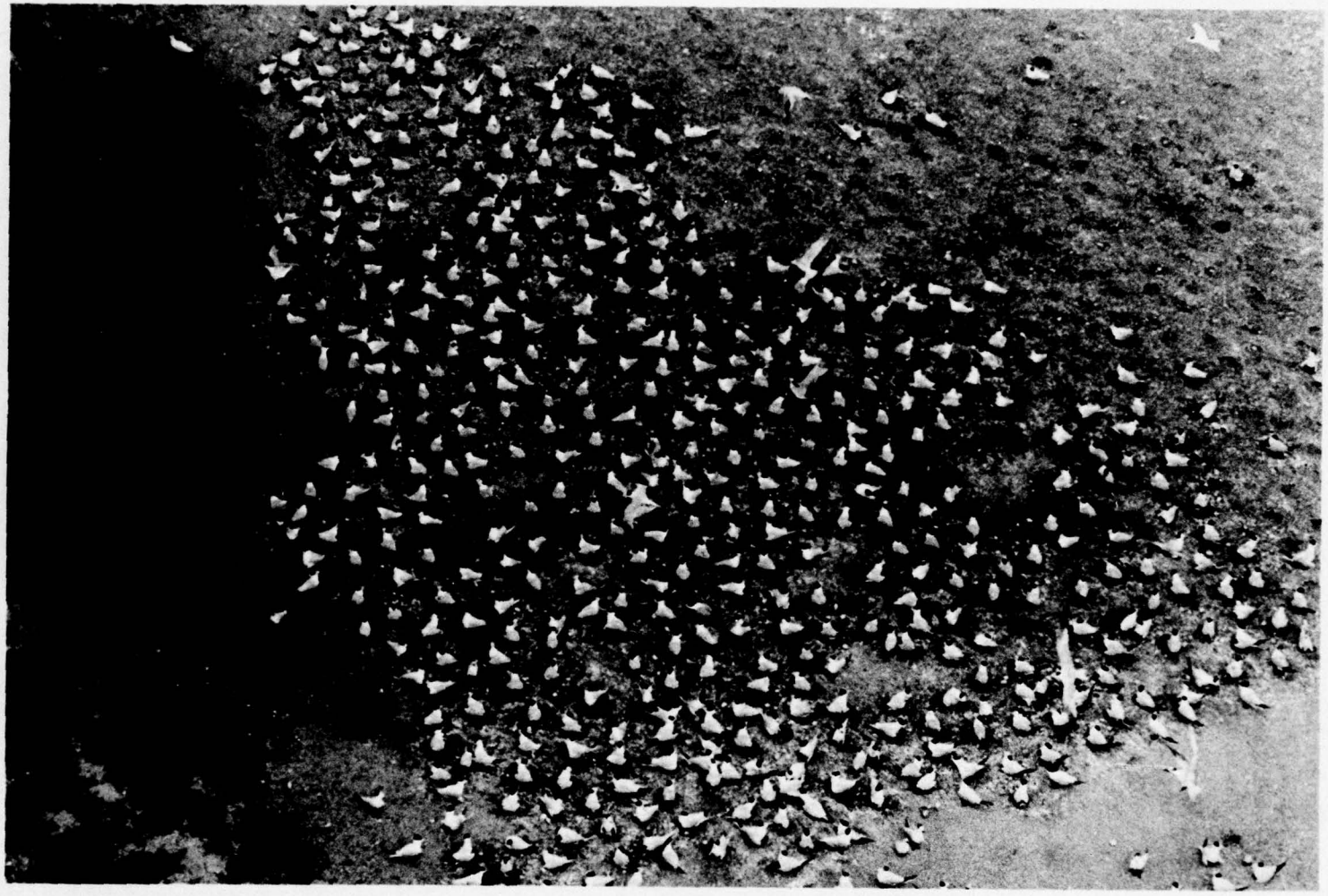


Figure 25. An aerial view of a royal tern colony in North Carolina, showing asynchronization of egg laying in the colony. Note the empty depression in the upper right hand corner where chicks have left the nests, while birds in the center are still incubating eggs.

82. One approach to determining if new nests and eggs have been added is to do a followup census after an interval of one incubation period. Only new nests containing eggs should be counted. However, notes on the condition of the colony should be recorded. If it appears that considerable mortality has occurred in the colony, the new nests may reflect renesting rather than the addition of new birds.

83. Surveys. The primary function of the survey is to determine the location of colonies. The following methods have been employed:

a. Aerial surveys. Either fixed-wing aircraft or helicopters may be used. Both have their advantages and disadvantages. Fixed-wing aircraft generally provide the following advantages over helicopters:

(1) Large areas can be surveyed in a shorter period of time.

(2) They do not cause as much disturbance in colonies.

(3) They do not require refueling as often. In remote areas where airports are not readily available considerable time may be spent traveling to an airport away from the census area in order to refuel a helicopter.

(4) They are generally more available for rental.

(5) The cost is much lower.

Helicopters offer the following advantages over fixed-wing aircraft:

(1) They are more maneuverable.

(2) Colonies may be observed at slower speeds.

(3) More accurate identification of species present in a colony can be made. Better estimates of the population are feasible.

(4) Landing near colonies to conduct ground censuses is possible.

When conducting aerial surveys two observers should be used, one for each side of the aircraft. One observer should be responsible for recording the location of colonies on maps while the other records data on the colony. Pilots experienced in aerial surveys contribute to a successful operation. Thorough coordination of preflight planning between the pilot and observers is essential.

b. Ground surveys. Ground surveys involve a search for

colonies by the use of boat or land vehicle. Unless the area to be searched is small, this method is not as efficient or productive as aerial surveys. Generally ground surveys should be used only to augment aerial surveys. Some species such as the least tern are not easily seen from the air unless the aircraft is flown at dangerously low altitudes (about 30 m). Ground surveys are more suitable for such species. A list of the species not easily seen from the air is given in Table 10. One of the problems involved in aerial surveys is illustrated in Figure 26. Note that only the white egrets are apparent in this photograph. However, 542 nests of Louisiana herons, glossy ibises, black-crowned night herons, and little blue herons were also present, mostly beneath the canopy. Furthermore, less than half of the white adults present can be seen in the photograph. There were 1289 nests of the white species present. Great egrets are the most conspicuous. The 693 cattle egrets nests and 450 snowy egrets nests were located beneath the canopy. Even though this photograph was taken during the peak of incubation period of the cattle egret and after the peak for the snowy egret, the white adults could not be easily seen sitting on the nest.

84. Censuses. The function of a census is to determine the breeding population on a management area. A combination of the following census techniques will usually have to be employed:

a. Total ground counts. Direct counting of all the nests or adults in a colony. This is the most accurate method for most species. Whether to use it or not depends on the following factors:

(1) The amount of time required to make the count.

(2) The size of the colony.

(3) The number of participants in the census. Under favorable weather conditions birds may be flushed from their nests for at least 30 minutes without causing significant mortality. A good general rule would be to use total counts as long as no nests will remain without protection for longer than 30 minutes. During hot or cold weather the time should be reduced to 15 minutes or less.

b. Total aerial counts. The breeding populations of most of the species covered in this report cannot be accurately censused from the air. This is due to the following factors:

(1) There may not be a one to one ratio of nests to adults.

(2) The nesting birds may not be readily seen from the air.

Table 10

List of Species of Waterbirds not Easily Detected by Aerial Surveys

Species	Reasons for Difficulty		
	Small Size	Cryptic Coloration	Nest beneath Canopy
Green heron	X	X	X
Black-crowned night heron[b]			X
Yellow-crowned night heron			X
Glossy ibis			X
Least tern	X	X	
Sandwich tern[a]			
Black tern	X	X	
Anhinga		X	X
Little blue heron[b]		X	X
Reddish egret[b]		X	X
Louisana heron		X	X
White-faced ibis		X	

[a]The Sandwich tern is difficult to identify from the air because it nests in large colonies of royal terns and can not be easily distinguished from them.

[b]Usually nests in mixed colonies containing white species, which facilitates verification of their presence.

Figure 26. Mixed species colonial waterbird colony located on Battery Island, in the lower Cape Fear River, North Carolina. Note highly visible white birds. Many dark species are not visible from the air and are impossible to census in an aerial survey.

(3) It might not be possible to determine whether birds observed are nesting or not.

Species which can be counted by the use of aerial photographs or direct counts include the white pelican, brown pelican, double-crested cormorant, great egret, glaucous-winged gull, great black-backed gull, herring gull, western gull, ring-billed gull, Forster's tern, royal tern, and Caspian tern.

c. Sampling. Sampling involves counting a part of a colony and extrapolating the results to the total population. The method used should give samples which are representative of the total population. Sampling should be used when the colony is too large for a total count to be practical or when total counts would cause too much disturbance in the colony. The following sampling units may be employed in censusing of colonial waterbirds:

(1) Quadrats.

(2) Strip transects.

(3) Plotless sampling.

There are no established criteria for selecting the technique to be employed or for the number of sampling units to be gathered once the technique has been selected. The units should be assigned so that each habitat type within the colony site is proportionally covered. Assume, for example, that a large gull colony includes two habitat types, one covering 60 percent of the area and the other 40 percent. Sixty percent of the sample units should be in the larger habitat type and 40 percent in the other. As many units as practical should be sampled without staying in the colony too long. Quadrats are probably better to use when a colony is large in both width and length (Figure 27). Transects are best in large colonies which are long but relatively narrow (Figure 28). Plotless sampling has not been adequately tested for use in colonies but future studies may find some of these methods to be useful. Use of plotless sampling requires that the nests be randomly distributed. The complexity and variation in the distribution of nests is such that the formulation of a mathematical model has not been possible. Therefore, it is recommended that only empirical methods be used.

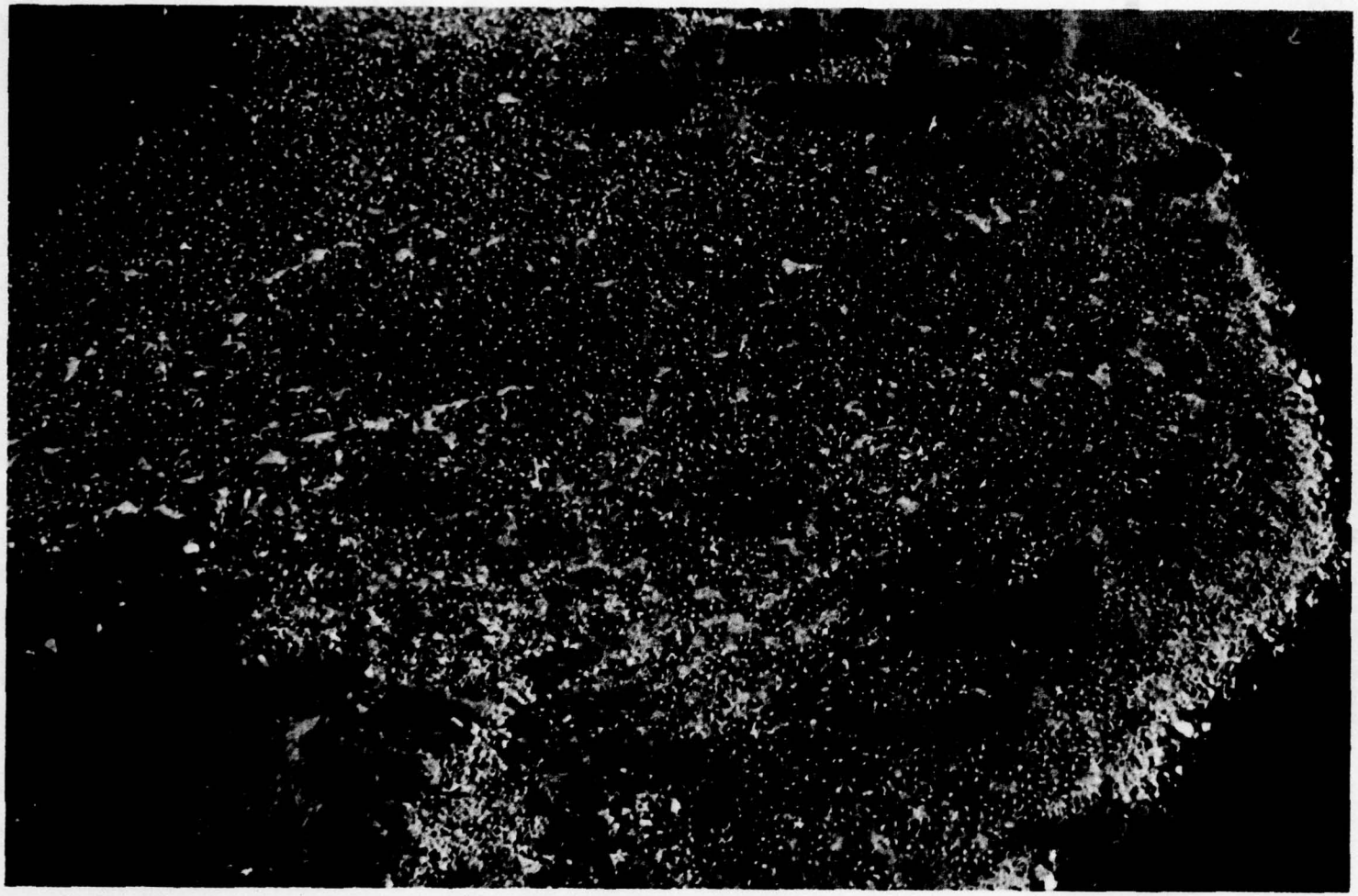


Figure 27. Ring-billed gull colony located on a 1.56-ha dredged material island in the Detroit River, Michigan. The site supported 5040 nests in 1976 and 5290 nests in 1977 (Scharf 1978).

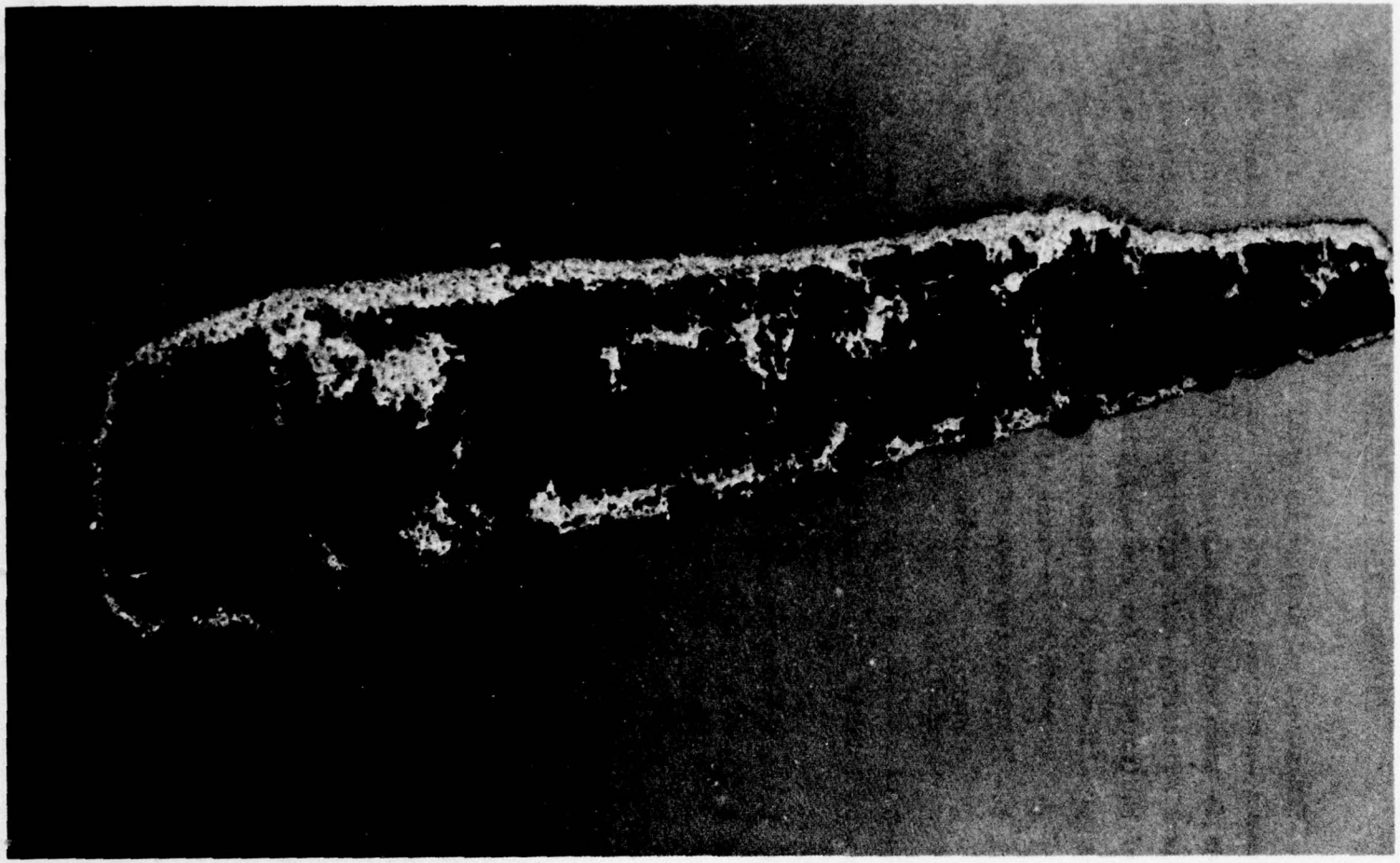


Figure 28. Herring gull colony located on Sandusky Turning Point in Lake Erie, Ohio. The site supported 983 nests in 1976 and 878 nests in 1977 (Scharf 1978).

Dredged Material Island Management

85. Management of dredged material islands covers a broad spectrum of management techniques. Basically, management of an island for colonial waterbirds is concerned with habitat manipulation, habitat establishment (both island substrates and vegetation), and habitat protection. Manipulation of habitats, by far the most likely technique to be used, includes proper placement of dredged material to:

a. Maintain or re-establish habitats.

b. Increase the size of existing islands or stabilize islands.

c. Change configuration, elevation, vegetation, and other island features for more desirable habitats.

Manipulation of habitats also includes control and management of existing vegetation on islands through various agronomic and horticultural techniques.

86. Establishment of new habitats is needed when:

a. Nesting habitat is lacking and new islands must be created, with the resulting need for vegetation establishment.

b. Nesting habitat is expanded by an addition to an existing island which must be established with vegetation.

c. Undesirable nesting habitats (vegetation) occurring on islands must be cleared out and desirable vegetation established in their place.

87. Protection of habitat may be accomplished by island posting or fencing for isolation. The waterbirds are already protected by law, but their habitats are not, except during the time they are occupied by the birds. Year-round protection to prevent destruction of habitat and seasonal protection to prevent nesting colony disruption by humans and predators are necessary.

88. Management of existing islands has been demonstrated to be an effective disposal technique and wildlife management practice. Considerable potential exists for the disposal of dredged material and the improvement of critical avian habitat. Management of existing dredged material islands is encouraged because the potential environmental impacts of disposing on an existing site are less than those of developing new islands.

Use of dredging operations on existing islands

89. The Corps has provided nesting habitat for colonial waterbirds since the agency first created dredged material islands. Subsequently, islands have been kept in various stages of plant succession through dredged material deposition from channel maintenance operations. These operations have had a significant positive impact on avian breeding populations (Tables 1, 2, and 3).

90. Through proper planning the positive impact of regular maintenance dredging could be increased. Past dredging operations have been carried out with little or no regard for nesting birds, and many areas do not have adequate diversity of nesting habitats. Some areas lack ground nesting habitats while others lack woody habitats. The investigators who submitted the DMRP regional reports expressed the following habitat needs:

a. Texas. Additional habitat is needed for ground nesters, especially in the northern study area. Nesting habitat for arboreal species is needed in the southern study area.

b. Florida. Bare substrate, sparse herb, and medium herb habitats are badly needed for ground nesting species.

c. North Carolina. Woody habitats for arboreal species are needed in the vicinity of river mouths and inlets. Bare, undiked sites for terns are needed in some localities.

d. New Jersey. Bare substrate or sparse herbs are needed for ground nesters, and habitat for arboreal species is needed.

e. Great Lakes. Sparse herb habitat is needed for common terns and herring gulls, and woody habitats are needed for arboreal species.

f. Upper Mississippi River. Bare isolated islands are needed to attempt to restore extirpated least tern populations.

91. Similar habitat needs may exist in other coastal areas, and need to be investigated to determine the habitat types needed. The rate at which various habitats appear on an island after receiving dredged material and an estimate of their longevity have been determined in the seven DMRP regional and other studies (Soots and Parnell 1975, Coastal Zone Resources Corporation 1977). Once these needs are known, nesting habitat management can easily become a part of the regular maintenance dredging process. To maintain target habitat diversity, islands would

have to be selected to receive periodic deposition. Restrictions against dredged material deposition on all or parts of some islands may be necessary in order to allow habitats for arboreal species to develop or to preserve existing habitats. The feasibility of these management recommendations has already been demonstrated by the Corps' Wilmington District. They have been practicing such management on a local, annual basis for several years and have developed a proposed long-range colonial waterbird management plan for the lower Cape Fear River estuary (Appendix B).

Constructing Islands

92. Construction of islands would be desirable under the following conditions:

a. It has been demonstrated that there is a need for nesting habitat in an area lacking suitable islands to fill the need.

b. The benefits to the nesting birds should exceed any negative effects construction of the island might have on the aquatic ecosystem. Islands can be placed on sites where there will be little negative effect on benthic organisms and on current flows.

c. Islands will not be placed in areas where they would be used for recreational purposes during the breeding season, thus eliminating their value as nesting sites.

93. Assessment of need. In most areas there is no need for more islands for colonial birds. Management of existing islands should be given first priority. There are areas, however, where additional nesting habitats would be beneficial to waterbirds and existing dredged material islands are not available to fulfill the need. Establishment of need should be determined by consultation with knowledgeable ornithologists or by field studies. Generally, construction of new islands for birds will not be feasible unless it can be demonstrated that the anticipated positive impacts on the target species will outweigh any negative impacts on the environment. However, it would be desirable to construct a limited number of new islands in various regions of the United States for study purposes. As more natural sites are usurped by man, strategic placement of new sites may become more valuable as a management tool. More baseline data are needed; the present knowledge of avian utilization

is based on empirical observations of existing islands.

94. Feasibility. In addition to establishment of need, the feasibility of new island construction will be dependent on the concerns of Federal and State agencies and the private sector. These concerns vary considerably among the Corps Districts. However, it has been demonstrated that construction of new islands for birds is feasible. The Wilmington District has constructed two islands in Core Sound, NC (Anonymous 1977). One of the islands (No. 17.07) is shown in Figure 29. The islands are unique in that they are the first constructed and placed in a manner to create habitat for colonial waterbirds and aquatic life, and they are retained by large nylon sand-filled bags. The sites are also designed so that during future maintenance dredging of the nearby navigation channel, materials may be added to them within the existing sandbag retainers, or more sandbags may be added to create higher retainment dikes. The kidney shape of the islands formed a small cove where it is expected that a marsh will develop and benthic organisms will thrive. The marsh has been given a boost by the grasses planted around the perimeter. The islands were placed in an area with adequate shallow water and food resources but with a scarcity of bare substrate habitat. Gull-billed terns, common terns, least terns, and black skimmers nested on the islands during the first breeding season after construction. It is also significant that two years earlier, dredged material was added to the end of a nearby island. Prior to the addition the only habitats existing on the island were medium and dense herbaceous plants and a small shrub thicket. A colony of laughing gulls nested in the herbaceous plants and a small colony of wading birds in the thicket. During 1977, 8638 royal terns and 956 Sandwich terns nested on the bare substrate habitat of the addition, while on the older part of the island, 3742 laughing gulls nested in the herbaceous habitats and 288 wading birds nested in the shrub thicket.

95. Lewis and Dunstan (1975) have proposed a design for artificial islands for Florida wading birds, and this design is being incorporated into the dredged material disposal plan for the Tampa Harbor Deepening

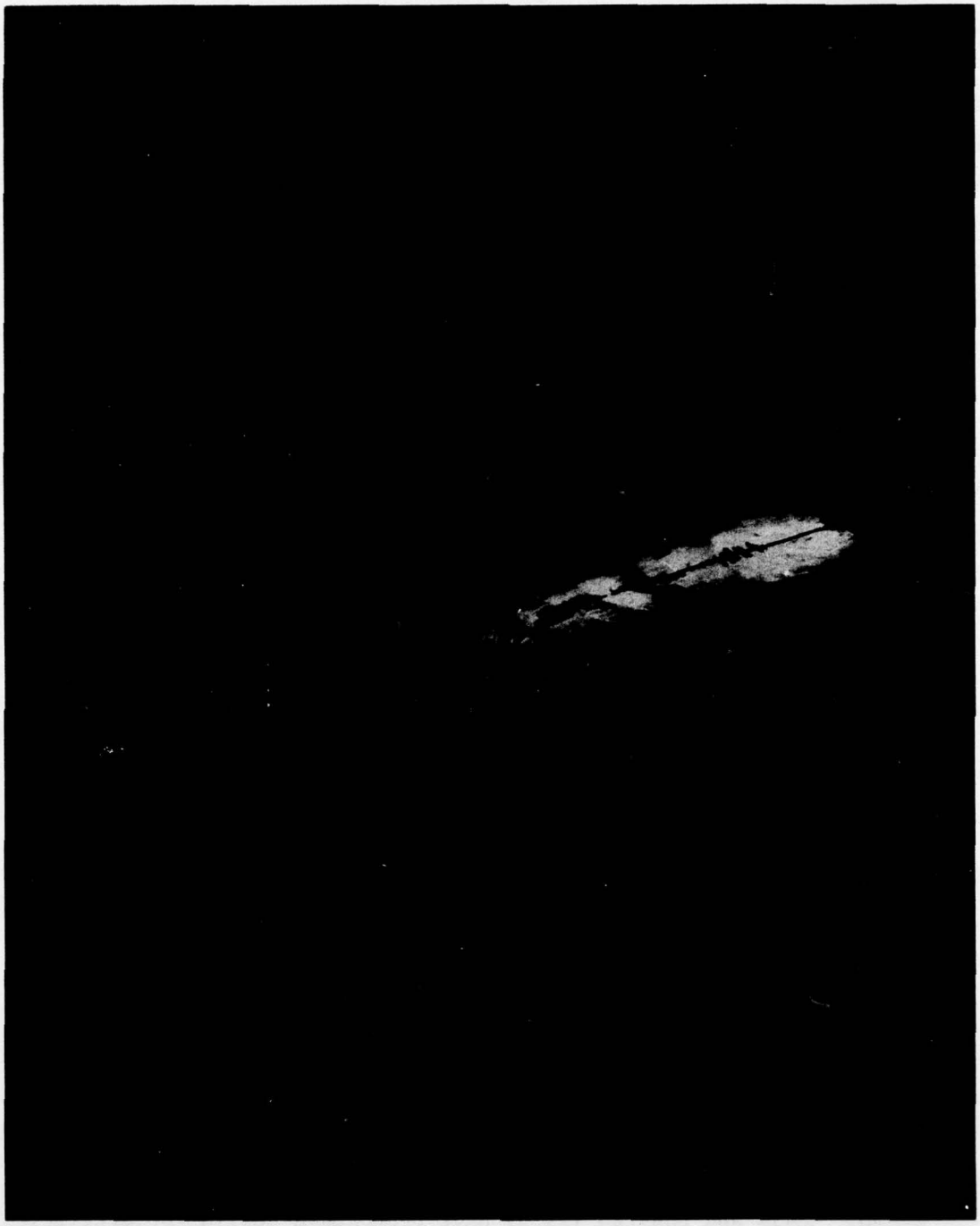


Figure 29. Aerial view of dredged material island (No. 17.07) built by Wilmington District for wildlife habitat in Core Sound, NC.

Project. Two islands will be created through the use of their design (Lewis 1977). A dredged material extension was added to Sunken Island, an Audubon sanctuary, in Tampa Bay in December 1977 (Figure 30). The site will probably be used during the first breeding season by royal terns, least terns, and black skimmers since bare sites are scarce in this area. Thus, new islands to be constructed in this area will probably receive heavy use by those species requiring bare substrate habitat.

96. Island development. Once the need and feasibility of development of a new island has been established, the next step will be development of the island. Three basic aspects have to be considered: site location, timing of development, and physical design.

a. Site location. Corps Districts should work with knowledgeable ornithologists and concerned agencies to establish the site within the area of their maintenance jurisdiction. Construction of an island in an area which does not conform to the specifications outlined in this report may fail to produce the desired nesting habitat. The islands must be placed in areas where the birds will be isolated from predators and human disturbances. However, greater flexibility in site location may be obtained if the colonies are to be subjected to protection. With protection, colonial waterbirds have successfully nested in harmony with man and have provided tourist attractions.

b. Timing of development. Ideally an island should be constructed during the fall or winter preceding the initiation of the next nesting season. The waterbirds generally do not use a site until after the initial sorting of fine materials by wind and water. Construction of the island several months or more in advance of the nesting season would allow time for sorting of the materials.

c. Physical design. Generally, islands have been utilized by nesting birds regardless of their design if they remain emergent at high water and relatively stable water. No research has been done to test bird usage of various designs. The following recommendations are based on empirical observations:

(1) Size. Ideally, new islands should be no smaller than 2 ha and no larger than 20 ha; however, birds have nested successfully on smaller and larger islands. Islands smaller than 2 ha are recommended only for least terns; however, they sometimes nest successfully on larger islands as well.

Figure 30. An aerial view of Bird and Sunken Islands in Tampa Bay, FL, showing an extension (upper center) onto Sunken Island made from dredged material in December 1977 by Jacksonville District. The site is already in use by royal and least terns and black skimmers as a resting site.

Islands larger than 20 ha would be very difficult to manage and would be more likely to support predator populations. Islands between the above extremes could be easily managed and considerable habitat diversity could be maintained. Generally, the greater the amount of habitat diversity to be maintained, the larger the island should be.

(2) Configuration. The configuration of an island will depend on the target species. Steep slopes such as those found on dikes should be avoided for all species. A slope no greater than a 1-m rise per 30 lin m has been recommended (Chaney et al. 1978). Substrate configurations for the ground nesting species are shown in Table 11. The least tern will be discussed to illustrate use of the table. The flat and slope columns under macrotopography are checked for this species as well as the ridge and lump columns under microtopography. This means that the least tern frequently nests on both flats and slopes, but prefers those which have ridges and/or lumps on them. The nests are usually placed on the ridges or lumps within the flats or slopes. The young of at least two species, the royal and Sandwich terns, require access to water by land and also appear to require a beach connected to the island (Figure 31). An island developed for these species should not be diked on all sides or, if it is diked, a travel lane should be broken through the dike after fine materials have settled out within it. Further information on the effect of diking on bird use may be found in the North Carolina DMRP regional study. There is some evidence that the formation of a bay (see Figure 30) or pond (Figure 32) makes an island especially attractive to nesting birds. In addition to the pond, Dump Island, NC (Figure 32) has practically every feature found on dredged material islands except a dike and a mature forest. Fifteen species of colonial waterbirds have been found nesting on it.

(3) Substrate. The general substrate of the species of nesting birds is shown in Tables 4 and 5. However, some substrates are preferred over others by particular species. Generally, coarser material, due to its greater stability, makes better nesting substrate than fine material, which is subject to wind and rain erosion. A mixture of sand and shell material makes good nesting substrate for most of the ground nesting species which nest in bare sub-

Table 11

Preferred Configuration of Nesting Substrates for Ground Nesting Species on Dredged Material Islands

Species	Substrate Configuration					
	Macrotopography			Microtopography		
	Flats	Slopes	Domes	Ridges	Lumps	Other
White pelican	✓		✓			
Brown pelican	✓		✓			
Glaucous-winged gull	✓	✓	✓			✓[a]
Great black-backed gull		✓	✓	✓		
Herring gull		✓	✓	✓		
Western gull	✓	✓	✓			✓[a]
Ring-billed gull	✓	✓	✓			
Laughing gull	✓	✓				✓[b]
Gull-billed tern	✓	✓	✓	✓	✓	✓[a]
Forster's tern	✓					✓[b]
Common tern	✓	✓	✓	✓	✓	✓[b]
Roseate tern	✓	✓	✓	✓	✓	
Least tern	✓	✓		✓	✓	
Royal tern		✓	✓			
Sandwich tern		✓	✓			
Caspian tern	✓		✓	✓		
Black tern	✓					✓[a]
Black skimmer	✓	✓		✓	✓	

a. Shows a preference for nesting on or adjacent to debris in the colony site (Figure 22).
b. Frequently nests on drift material left by lunar or wind tides.
✓ Denotes occurrence of preferred configuration for each species.

Figure 31. An aerial view of a royal *tern* colony site on a dredged material island in the Cape Fear estuary of North Carolina. Note the travel land (A) from the colony site (B). Growth of vegetation has been retarded in the lane and the colony

Figure 32. Dump Island, a dredged material island with great habitat diversity located in Core Sound, NC. All of the nesting habitats except a forest are found on the island.

strate or sparse herb habitats. This mixture is very similar to the beach overwash material found in former nesting sites as well as ones still existing on barrier islands. Fine, unstable dredged material may be stabilized to form suitable nesting substrate by adding coarse materials such as shells over its surface. This method has been successfully demonstrated. The Forster's tern shows a strong preference for nesting on drift material (Figure 33) located on the perimeter of dredged material islands or in marshes. The common tern and laughing gull also may utilize such substrate where higher terrestrial sites are not available. The gull-billed tern shows a preference for substrates strewn with debris such as clumps of wood (Figure 22) or large shell material (Figure 34). Obviously, the arboreal species prefer woody substrates and examination of the DMRP regional reports will show that some species of shrubs and trees appear to be used preferentially to others. If plant propagation is to be a part of a management scheme, these species should be given first consideration.

(4) Elevation. Elevations should be high enough to prevent flooding of the colony site, but not so high that the substrate will not become stabilized due to wind erosion. Generally the optimal elevation will be between one and three metres. The desirable elevation will depend on texture of the exposed dredged material, wind exposure, and the habitat objectives (or target species). Coarser materials may stabilize at higher elevations than finer materials. For example, Monks Island located adjacent to the AIWW in North Carolina had a maximum elevation of 3.8 m in 1977. It supported the largest least tern colony in the state. The terns were able to thrive here because the substrate was composed of sand and a high percentage of coarse shell material which provided stability even at this relatively high elevation. If islands are to be constructed and managed for ground nesting species requiring bare or sparse herb habitats, higher elevations within the acceptable range would be more desirable than lower ones because the higher the elevation the more slowly plants become established. Conversely, if an island is to be constructed for those species requiring dense herb through arboreal habitats, lower elevations would be more desirable. There is no evidence, given the proper substrates and vegetative habitats, that any of the species utilizing dredged material islands choose one elevation over another.

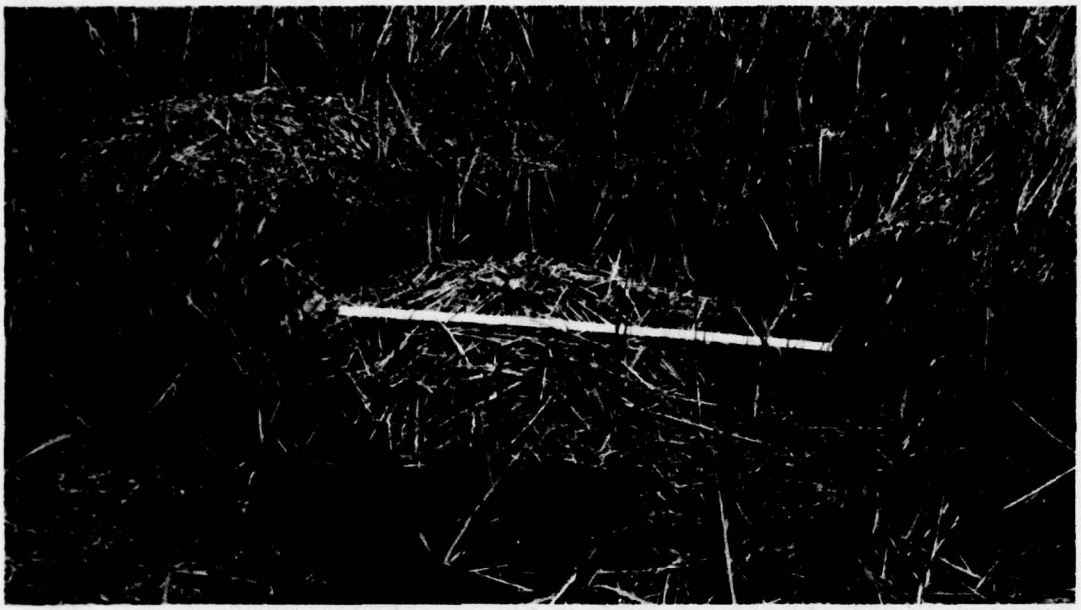


Figure 33. Forster's tern nests on drifted ridges composed of dead plant material.

Figure 34. Gull-billed tern nest showing coarse shell material utilized in its construction.

Vegetation for Dredged Material Islands

Management of vegetation

97. Selection of plants to be established on islands. There are a number of plant species that could be planted on new or existing dredged material islands that would increase the island's attractiveness to colonial waterbirds (Table 12). Little attention has been paid to this aspect of vegetating dredged material; rather, the purpose of planting has been to stabilize the substrate and prevent wave and wind erosion (Woodhouse et al. 1972, Lewis and Dunstan 1974a, 1974b). The DMRP's Habitat Development Project (HDP) has established plantings of herbaceous vegetation for wildfowl grazing (Crawford and Edwards 1978), and completed a study of available and feasible plant materials for use on upland dredged material disposal sites for stabilization and for general wildlife habitat (Coastal Zone Resources Division 1978). The reader is referred to that report and Hunt et al. (1978) and Landin (1978c) for detailed life requirements of pertinent plant species. Depending upon the bird species' specific nesting requirements, a variety of suitable plants could be incorporated into a management plan:

a. Ground nesting. The four habitat categories outlined previously that are used by ground nesting species all have potential for enhancement by plant management:

(1) Bare substrate. No plantings are necessary here; rather, the removal of excess plants is recommended where needed.

(2) Sparse herb. Plants that could be established on dredged material islands to benefit nesting in coastal areas are seaside paspalum, saltmeadow cordgrass, saltgrass, evening primrose, camphorweed, horseweed, and beach pea. These species can be propagated by seeds or transplants, will tolerate saline-stressed conditions, and occur over wide ranges. In Texas where hypersaline conditions exist, sea ox-eye and sea blite may be sprigged, as these plants will tolerate extreme conditions found there. In freshwater areas, upland sedges, rushes, smartweeds, fescues, prairie grasses, and knotweeds may be planted to increase nest cover and visual isolation for ground nesting colonies. It is important to remember when selecting species to plant that a low growth form (less than 1 m high), spaced widely, attracts certain nesting species.

Table 12

Plant Species that can be Planted on Dredged Material Islands for Colonial Waterbird Nesting Habitat

Species*	Occurrence Range**	Habitat Category***							
		BS	SH	MH	DH	HS	ST	SF	F
Saltmeadow cordgrass	6		x						
Seaside paspalum	2		x						
Saltgrass	6		x						
Evening primrose	5,6		x						
Camphorweed	2,5		x						
Horseweed	2,5		x						
Beach pea	2		x	x					
Sedge(s)	5,6		x	x					
Rush(es)	5,6		x	x					
Smartweed(s)	5,6		x	x					
Fescue(s)	5,6		x	x	x	x			
Knowtweed(s)	5,6		x						
Spurge(s)	5,6		x	x					
Sea ox-eye	2		x						
Sea blite	2		x						
Dog fennel	5,6			x	x	x			
Scotch broom	4,5			x	x	x			
Broomsedge	5,6			x	x	x			
American beachgrass	6			x	x	x			
Wild rye	5,6			x	x	x			
Sea oats	2			x	x	x			
Pepper grass	5,6		x	x	x	x			
Croton	5,6		x	x	x	x			
Purple top	5,6			x	x	x			
Beach panic grass	6			x	x	x			
Reed canary grass	5,6			x	x	x			
Goldenrod(s)	5,6				x	x			
Ragweed(s)	5,6				x	x			
Switchgrass	2,5				x	x			
Marsh elder	2					x	x	x	
Groundsel tree	2					x	x	x	
Wax myrtle	2					x	x	x	x
Bayberry	3					x	x	x	
Shrub verbena	2,5					x	x	x	
Wild indigo	2,5					x	x	x	
Yaupon	2					x	x	x	x

(Continued)

*Scientific names of all plant species in this report are listed in Appendix A.

**1=extreme southern United States (freeze intolerent), 2=mid-south(south of Virginia), 3=northern United States only, 4=western United States only, 5=freshwater conditions only, 6=entire United States.

***BS=bare substrate, SH=sparse herb, MH=medium herb, DH=dense herb, HS=herb-shrub, ST=shrub thicket, SF=shrub-forest, F=forest.

Table 12 (Concluded)

Species	Occurrence Range**	Habitat Category***							
		BS	SH	MH	DH	HS	ST	SF	F
Huisache tree	4,5					x	x	x	x
Brazilian pepper	1					x	x	x	x
White mangrove	1					x	x	x	x
Red mangrove	1					x	x	x	x
Black mangrove	1					x	x	x	x
Oleander	5,6					x	x	x	
Eastern red cedar	2,5					x	x	x	x
Live oak	2							x	x
Saltcedar	2,4						x	x	x
Sand pine	2							x	x
Loblolly Pine	2,5							x	x
Hackberry	5,6							x	x
Australian pine	1							x	x
Eastern cottonwood	5,6							x	x
Peachleaf willow	3,5					x	x	x	

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DEVELOPMENT AND MANAGEMENT OF AVIAN HABITAT ON DREDGED MATERIAL--ETC(U)
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Table 12 (Concluded)

Species	Occurrence Range**	Habitat Category***							
		BS	SH	MH	DH	HS	ST	SF	F
Huisache tree	4,5					x	x	x	x
Brazilian pepper	1					x	x	x	x
White mangrove	1					x	x	x	x
Red mangrove	1					x	x	x	x
Black mangrove	1					x	x	x	x
Oleander	5,6					x	x	x	
Eastern red cedar	2,5					x	x	x	x
Live oak	2							x	x
Saltcedar	2,4						x	x	x
Sand pine	2							x	x
Loblolly Pine	2,5							x	x
Hackberry	5,6							x	x
Australian pine	1							x	x
Eastern cottonwood	5,6							x	x
Peachleaf willow	3,5					x	x	x	

(3) Medium herb. Low to medium coverage by plants can be achieved with the plant species mentioned in a (2) simply by altering planting techniques or by selecting tolerant sites that will more readily allow a denser plant cover. In addition, somewhat taller herbaceous plants and grasses may be introduced, such as clumped species like dog fennel, Scotch broom, broomsedge, American beachgrass, wild rye, sea oats, and other tall grasses. These are all used as nesting habitat and may be readily introduced from numerous seed sources.

(4) Dense herb. There is an overlap of use by nesting species, with arboreal nesting occasionally taking place in this vegetation. Dense stands of giant reed, high marsh grasses, and dense grass mats categorize this habitat. Even though giant reed is occasionally used for nesting, it should not be introduced, as it quickly colonizes a site and excludes most other plants through competition. It seems to be used only when suitable shrub habitat is not available for arboreal nesters. In addition, its rapid growth prevents chicks' access to essential open areas. Control of giant reed with herbicides, burning, or mowing would allow room for other, more desirable species to colonize a site. Panic grasses, goldenrods, ragweeds, and similar plants are used for nesting in the study areas, and may be planted from native seed sources.

b. Arboreal nesting. Four arboreal habitats also have considerable vegetation management potential:

(1) Herb-shrub. Often an island with this habitat will support a colony of ground nesters and a colony of arboreal nesters, which may or may not be in overlapping areas. This habitat and the preceding one are used most often by gulls. They nest in the grasses and under the shrubs, and adapt to a variety of habitats. Plants suitable for planting here are listed in Table 12.

(2) Shrub thicket. This habitat usually requires several years from planting to actual use by arboreal nesting birds, and makes long-range planning as a management tool a necessity. An island targeted for deposition at any future time should not be planted with shrubs and trees. Existing islands with only herbaceous cover, and especially with much giant reed, could be mowed periodically just prior to and for some years after planting woody species to allow the plants to overcome competition by the giant reeds. Desirable shrubs that would eventually reach a size useful for nesting are shown in Table 12.

(3) Shrub-forest. This habitat is a later seral stage of b (2). Species that would be desirable in b (2) are also good in this habitat and in b (4). This habitat is even more heavily used than the shrub thicket.

(4) Forest. This habitat is a climax stage of b (2 and 3). Several species other than the aforementioned shrub-forest species are important. These are live oak, saltcedar, sand pine, hackberry, and eastern red cedar, all of which develop into large trees over a period of 50 years, and which are somewhat salt-tolerant.

98. General propagation and planting guidelines. The plant species listed in Table 12 are not difficult to grow; rather, the difficulty usually lies in obtaining a supply of viable seed, root stock, or seedlings. Planting techniques for most of these species are outlined in the plant materials report by Coastal Zone Resources Division (1978) and in Hunt et al.(1978). Only a general discussion will be provided here.

99. Establishment of plants on a site is often a costly operation. Therefore, careful planning should be carried out to insure success of the planting and post-propagation management of a site. Important considerations are selection of species, propagule type, time of planting, soil and moisture conditions, inclement weather and tidal conditions, elevation, salinity tolerance, growth habits of selected species, costs of obtaining propagules, costs of preparing and planting a site, and the length of time until desired results are obtained (5 to 17 months for ground nesting species; 3 to 10 years for arboreal nesting species). Plant spacing and numbers depend upon the density of cover desired. A good general rule of thumb for a 2-year ground cover (grasses and forbs) using vegetative propagules is one plant or clump/m^2. For 1-year cover, one plant or clump on 1/2-m centers is best. Seeding should be done at recommended agronomic rates for the desired species. A higher success rate is often obtained from vegetative propagules than from seeds, especially in high energy and saline situations. Costs increase greatly when seeding options are not available. Shrubs and trees should be spaced not less than 2 m apart to allow room for growth. A general-purpose fertilizer will benefit plants placed in sandy dredged material, with applications initially, and at intervals during the first two years for

ground covers, and first five years for woody plants.

100. Planting stock is available from few commercial sources. Soil Conservation Service Plant Materials Centers located throughout the United States and U. S. Forest Service nurseries are sources of plants of all types. Private firms such as Environmental Concern, Inc., St. Michael's, Maryland, and Wave Beach Grass Nursery, Florence, Oregon, are also good sources for marsh and dune plants, and some trees and shrubs. Collecting of seed and vegetative propagules by hand labor and transferring the plant materials to a site is the most frequent solution to the problem of plant material sources, but is accompanied by greatly increased costs.

101. Techniques for controlling vegetation. Any technique to be used by the Corps in the control of vegetation will have to be part of the regular maintenance dredging operations. Thus, the management role of the Corps should be mainly through manipulation of dredged material by careful site selection and timing of disposal. However, flattening of tall woody vegetation by bulldozing or other means prior to dredged material deposition would greatly increase the habitat value of the site for ground nesting species. Colonial ground nesting waterbirds will not use sites with standing dead shrubs and trees (Figure 35). When islands suitable for nesting except for lack of habitat diversity are present in an area which is not subjected to frequent dredging, interested agencies or organizations could employ other techniques to manipulate the vegetation. Feasible techniques include:

a. Mechanical removal. Small tractors or tillers could be used to retard herbaceous vegetation. Chain saws and axes could be used to remove undesirable woody plants from herbaceous habitats.

b. Control burning. With the proper permits this technique could be used to return a plant community to an earlier successional stage. However, control burning alone is not adequate to return a site to the bare substrate habitat. Herbaceous plants quickly become established on sites which have been burned over.

c. Herbicides. Herbicides could be effectively used to maintain a site in an early stage of succession. Proper safeguards and procedures should be followed. Unfortunately,

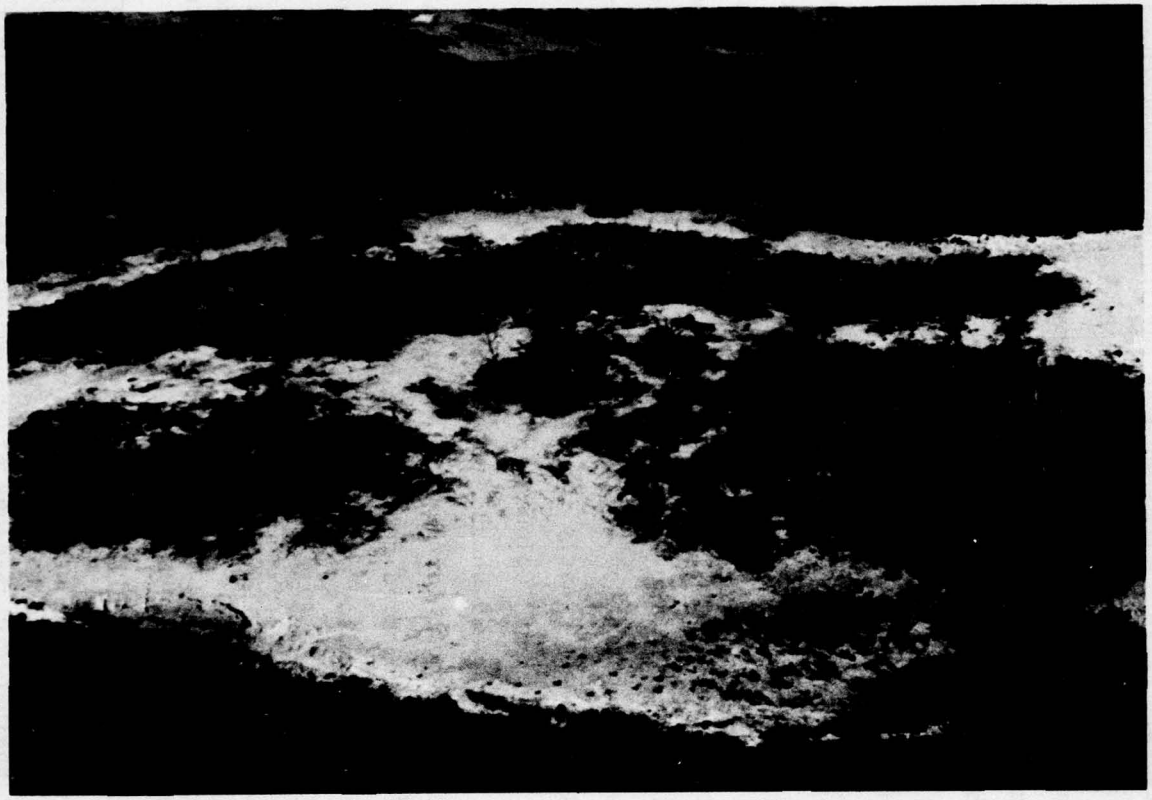

Figure 35. An aerial view of a dredged material island with standing dead shrubs and trees recently killed by a deposition. Flattening of these plants prior to the deposition of dredged material which would have covered them would have created habitat for ground nesting species.

research has been limited on use of herbicides on dredged material islands. The following herbicides have been found to be very effective on a wide variety of plants on North Carolina dredged material islands (Worsham et al. 1974):

(1) Bromacil (4 percent) + Diuron (6 percent) (Bo-rid)

(2) Techthiuron (Spike)

(3) Karbutilate (Tamdex)

The herbicides were found to be almost 100 percent effective at rates as low as 11 kg/ha (10 lbs/acre).

Additions to islands

102. Additions to islands may be a useful management tool in the following ways:

a. Frequently, valuable nesting sites are altered by erosion until eventually they are abandoned. Additions to such an island will prolong its usefulness as nesting habitat.

b. Additions to existing islands which are covered by vegetation will increase habitat diversity and provide nesting habitat for species requiring bare substrate or sparse herb habitats. In south Florida, additions may be done in a manner that encourages the growth of mangroves, which provide excellent nesting sites (Lewis and Lewis 1978).

The authors have observed colonization of additions to existing sites on many occasions, and several of the regional investigators recommended additions to specific existing islands in their study areas.

Protection of bird colonies

103. All of the colonial waterbirds nesting on dredged material islands are afforded protection under the U. S. Migratory Bird Treaty Act and its amendments. In addition, most states have laws and regulations designed to give protection by State conservation agencies. It has been shown that colonies that are given protection are generally very successful and unprotected colonies often are not. Every agency or individual has the responsibility to see that its actions are not in violation of Federal and State laws protecting birds nesting on dredged material islands used as disposal sites. To insure compliance with the law, maintenance operations should be conducted in a manner which will not disturb bird colonies. Management should include proper

care during deposition of dredged material, surveying, and dike construction. Detailed information is given in the DMRP regional reports on the time and duration of breeding seasons for the species in each study area as well as in Table 7.

104. Public education concerning the vulnerability of colonial nesting birds has the potential of being a valuable management tool. Through various public affairs channels the general public could be made aware of the value of dredged material islands to colonial birds and at the same time informed that the continued disposal of dredged material may be a viable management option.

105. Other protective measures which may be valuable management tools are discussed in the DMRP regional reports, in Appendix B, and in Landin (1978b). Some of the measures which have been recommended are posting of colonies, fencing, designation of certain colonies as sanctuaries, limiting of scientific study, and controlling of predators.

Management Problems

106. Many aspects of the development and management on dredged material islands were encountered during the DMRP. Some of these are seen as potential problems and discussed in the following paragraphs.

Interagency and intraagency cooperation

107. A key to success in the early planning stages is cooperation from Federal, State, and local agencies with regulatory authorities. Several potential problem areas may be anticipated:

a. Federal and State agencies whose primary responsibility is the protection of fisheries resources frequently express concern that island development could cover aquatic feeding and spawning areas. Such problems can be lessened or eliminated by:

(1) Developing an existing island without expanding its size.

(2) Locating the island or deposit away from productive aquatic areas such as marshes, mud flats, or seagrass beds.

(3) Using silt curtains to decrease turbidity or temporary retaining dikes to prevent flow of dredged material onto valuable water bottoms.

b. Agency concern for preservation of natural areas may prevent dredging in parks. When such dredging is a necessity, the placement of dredged material is often a major item of contention. Management of existing dredged material islands in such areas is possible and may be a satisfactory alternative disposal technique.

c. State game and fish agencies are concerned primarily with game animals because their source of revenue is usually derived from the sale of hunting and fishing licenses. The management of non-game animals has received low priority in many states, a situation that may hinder cooperation in island development and management.

d. Dredged material island management, like most aspects of dredged material disposal, may cause local public concern because of area-specific desires such as fisheries and recreation. Many problems associated with public concern can be anticipated and resolved through educational programs and public meetings.

e. Internal concerns of the developing agency regarding dredged material island management may arise because:

(1) It may make a project more costly.

(2) More detailed planning and scheduling is necessary.

(3) A lack of knowledge or available information regarding the habitat needs of colonial waterbirds exists.

(4) Habitat management is not considered an agency priority or concern.

Planning and engineering

108. The development of specifications for dredged material disposal to develop islands for waterbird habitat and simultaneously satisfy the need to dispose of a given amount of dredged material requires considerable care. Dredging contractors should be given specific instructions as to exact locations, time of disposal, size of deposit, elevation of deposit, and movement of disposal pipes. Onsite monitoring is highly desirable and necessary when the disposal is onto an island that has a bird colony.

109. Contract specifications such as use of temporary dikes may be required to limit the extent of the spread of dredged material. If

a dike is built on an existing island and filled, then the dike should be at least partially removed or breached to allow ground access to the water by young birds. This will generally require the return of earth-moving equipment to the site. Diking disrupts bird use, and it is recommended that dikes be constructed just prior to disposal and be removed or partially removed as soon as possible after filling.

110. Periodic post-disposal monitoring to determine the after-effects of disposal and succession of plant and bird life on the site and surrounding areas will provide useful information for future disposal operations within a given area.

Planning for future needs

111. Long-range plans, while highly desirable, are not often accurate. It is very difficult to accurately predict the cumulative impacts of such factors as industrial development, recreational use, erosion, changes in bird use patterns and populations, and climatic events such as hurricanes. Such plans may include consideration of long-term disposal needs, management of vegetation succession, monitoring of colony success, and target species management. All island management plans should be periodically reevaluated and revisions made to account for changes in habitat and waterbird populations.

Public awareness and cooperation

112. The private sector is seldom aware of waterbirds and their needs. The public does not know, for example, that fishing or swimming off an island with a colony will severely damage that colony. Education of the public can be achieved in several ways, and would be extremely beneficial. This can be accomplished by:

a. Posting large signs at colony islands to warn away recreationalists and intruders.

b. Mount an information campaign via local newspapers and radio and television public service announcements and programs. This will make people aware of the uniqueness of the birds and their requirements. This is also the time to inform people of laws concerning protection of non-game migratory birds.

c. Initiate an information program in local primary and secondary schools. Children have strong feelings about nature and can be quite effective in reaching their parents.

113. The public should be made to feel a part of management efforts and to realize that not only is dredging a necessity to maintain navigation channels, but that properly used dredged material can be very beneficial to these waterbirds and other wildlife. Reported observations from cooperating amateur birdwatchers can be quite valuable in areas where no professional ornithologist is maintaining current knowledge of waterbird movements and colonies. Positive public opinion regarding disposal operations may improve public acceptance and understanding of dredged material disposal operations.

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APPENDIX A:
SCIENTIFIC AND COMMON NAMES OF FLORA AND FAUNA USED IN THE TEXT

Each table is presented in alphabetical order. Sources for those names are the AOU checklist (1957, 1973), Britton and Brown (1970), Martin, Zim, and Nelson (1951), and Radford, Ahles, and Bell (1973).

Table A1

Common and Scientific Names of Birds in the Text

Common Name	Scientific Name
American avocet	*Recurvirostra americana*
American bittern	*Botauru lentiginosus*
American oystercatcher	*Haematopus palliatus*
Anhinga	*Anhinga anhinga*
Barred owl	*Strix varia*
Black-crowned night heron	*Nycticorax nycticorax*
Black duck	*Anas rubripes*
Black-necked stilt	*Himantopus mexicanus*
Black rail	*Laterallus jamaicensis*
Black skimmer	*Rynchops niger*
Black tern	*Chilidonias niger*
Bobwhite quail	*Colinus virginianus*
Brown pelican	*Pelecanus occidentalis*
Brown thrasher	*Toxostoma rufum*
Burrowing owl	*Speotyto cunicularia*
California gull	*Larus californicus*
Canada goose	*Branta canadensis*
Caspian tern	*Sterna caspia*
Cattle egret	*Bulbulcus ibis*
Chestnut-sided warbler	*Dendroica pensylvanica*
Clapper rail	*Rallus longirostris*
Common crow	*Corvus brachyrhynchos*
Common gallinule	*Gallinula chloropus*
Common grackle	*Quiscalus quiscula*
Common nighthawk	*Chordeiles minor*
Common tern	*Sterna hirundo*
Double-crested cormorant	*Phalacrocorax auritus*
Eastern meadowlark	*Sturnella magna*
Field sparrow	*Spizella pusilla*

(Continued)

Table A1 (Continued)

Common Name	Scientific Name
Fish crow	Corvus ossifragus
Forster's tern	Sterna forsteri
Gadwall	Anas strepera
Glaucous-winged gull	Larus glaucescens
Glossy ibis	Plegadis falcinellus
Grasshopper sparrow	Ammodramus savannarum
Great black-backed gull	Larus marinus
Great blue heron	Ardea herodias
Great egret	Casmerodius albus
Great-horned owl	Bubo virginianus
Great-tailed grackle	Cassidix mexicanus
Green heron	Butorides striatus
Ground dove	Columbigallina passerina
Grove-billed ani	Crotophaga sulcirostris
Gull-billed tern	Gelochelidon nitotica
Herring gull	Larus argentatus
Kestrel	Falco sparverius
Killdeer	Charadrius vociferus
King rail	Rallus elegans
Laughing gull	Larus atricilla
Least bittern	Ixobuychus exilis
Least tern	Sterna albifrons
Little blue heron	Florida caerulea
Loggerhead strike	Lanius ludovicanus
Long-billed marsh wren	Telmatodytes palustris
Louisana heron	Hydranassa violacea
Louisana waterthrush	Seiurus motacilla
Mallard	Anas platyrhynchos
Marsh hawk	Circus cyaneus
Mockingbird	Mimus polyglottos
Mottled duck	Anas fulvigula

(Continued)

Table A1 (Continued)

Common Name	Scientific Name
Mourning dove	Zenaidura macroura
Olivaceous cormorant	Phalacrocorax olivaceus
Osprey	Pandion haliaetus
Painted bunting	Passerina ciris
Piping plover	Charadrius melodus
Prarie warbler	Dendroica discolor
Red-winged blackbird	Agelaius phoenicus
Reddish egret	Dichromanassa rufescens
Ring-billed gull	Larus delewarensis
Roseate spoonbill	Ajaia ajaja
Roseate tern	Sterna dougallii
Royal tern	Sterna maxima
Ruby-crowned kinglet	Regulus calendula
Sandwich tern	Sterna sandivicensis
Savannah sparrow	Passerculus sandwichensis
Scissor-tail flycatcher	Muscivora forfic
Seaside sparrow	Ammospiza maritima
Short-billed marsh wren	Cistothorus platensis
Short-eared owl	Asio flammeus
Snowy egret	Egretta thula
Snowy plover	Charadrius alexandrinus
Song sparrow	Melospiza melodia
Sooty tern	Sterna fuscata
Spotted sandpiper	Actitis macularia
Sora	Porzana carolina
Western gull	Larus occidentalis
White-faced ibis	Plegadis chihi
White ibis	Eudocimus albus
White pelican	Pelecanus erythrorhynchos
Willet	Catophophorus semipalmatus
Wilson's plover	Charadrius wilsonia

(Continued)

Table A1 (Continued)

Common Name	Scientific Name
Yellow-billed cuckoo	*Coccyzus americanus*
Yellow-crowned night heron	*Nyctanassa violacea*
Yellowthroat	*Geothlypis trichas*
Yellow warbler	*Dendroica petechia*

Table A2

Common and Scientific Names of Plants in the Text

Common Name	Scientific Name
American beachgrass	Ammophila breviligulata
American sycamore	Platanus occidentalis
Australian pine	Casuarina equisitifolia
Bald cypress	Taxodium distichum
Bayberry	Myrica pennslyvanica
Beach panic grass	Panicum ararum
Beach pea	Strophostyles helvola
Black cherry	Prunus serotina
Black mangrove	Avicennia germinans
Brazilian pepper	Schinus terebinthifolius
Broomsedge	Andropogon virginicus
Camphorweed	Heterotheca subaxillaris
Croton	Croton punctatus
Dog fennel	*Eupatorium capillifolium*
Eastern cottonwood	Populus deltoides
Eastern red cedar	Juniperus virginiana
Evening primrose	Oenothera humifusa
Fescue(s)	Fescue spp.
Giant cordgrass	Spartina cynosuroides
Giant reed	Phragmites australis
Green ash	Fraxinus pennsylvanica
Groundsel tree	Baccharis halmifolia
Hackberry	Celtis occidentalis
Horseweed	Erigeron canadensis
Huisache tree	Acacia smallii
Knotweed(s)	Polygonum spp.
Live oak	Quercus virginiana
Loblolly pine	Pinus taeda
Marsh elder	Iva frutescens
Peachleaf willow	Salix amygdaloides

(Continued)

Table A2 (Concluded)

Common Name	Scientific Name
Peppergrass	*Lipidium virginicum*
Prickly pear cactus	*Opuntia lindbergii*
Reed canary grass	*Phalaris arundinacea*
Purple top	*Tripalsis purpurea*
Ragweed	*Ambrosia artemisiifolia*
Red mangrove	*Rhizophora mangle*
Rush(es)	*Scirpus* spp.
Saltcedar	*Tamarix gallica*
Saltgrass	*Distichlis spicata*
Saltmeadow cordgrass	*Spartina patens*
Sandbar willow	*Salix interior*
Sand pine	*Pinus clausa*
Scotch broom	*Cytisus scoparius*
Sea blite	*Suaeda maritima*
Sea oats	*Uniola paniculata*
Sea ox-eye	*Borrichia frutescens*
Seaside goldenrod	*Solidago sempervirens*
Seaside paspalum	*Paspalum virginatum*
Sedge(s)	*Carex* spp.
Sedge(s)	*Cyperus* spp.
Shrub verbena	*Lantana camara*
Silver maple	*Acer saccharinum*
Smartweed(s)	*Polygonum* spp.
Spurge	*Euphorbia polygonifolia*
Switchgrass	*Panicum virginatum*
Tupelo gum	*Nyssa aquatica*
Wax myrtle	*Myrica cerifera*
White mangrove	*Laguncularia racemosa*
Wild indigo	*Baptisia leucophaea*
Wild rose	*Rosa palustris*
Wild rye	*Elymus virginicus*
Winged sumac	*Rhus copillina*
Yaupon	*Ilex vomitoria*

Table A3

Common and Scientific Names of Other Animals in the Text

Common Name	Scientific Name
Cat (feral and domestic)	*Felis catus*
Coyote	*Canis latrans*
Dog (feral and domestic)	*Canis familiaris*
Fire ant	*Solenopsis invicta*
Gray fox	*Urocyon cinereoargenteus*
Mink	*Mustela vison*
Norway rat	*Rattus norvegicus*
Opposum	*Didelphis virginiana*
Raccoon	*Procyon lotor*
Rat snake	*Elaphe* spp.
Rattlesnake	*Crotalus atrox*
Red fox	*Vulpes fulva*
River otter	*Lutra canadensis*

APPENDIX B:

AN EXAMPLE OF A MANAGEMENT PLAN,

WILMINGTON HARBOR DREDGE ISLAND MANAGEMENT PLAN

U.S. ARMY ENGINEER DISTRICT

WILMINGTON, NORTH CAROLINA

FROM

ENVIRONMENTAL IMPACT STATEMENT:

MAINTENANCE OF WILMINGTON HARBOR

JULY 1976

WILMINGTON HARBOR DREDGE ISLAND MANAGEMENT PLAN

General

Objectives.

1. It is the objective of this plan to lay out the optimum course of action which could be carried out by the Wilmington District in response to the critical need for suitable nesting habitat for seabirds in the lower Cape Fear River. The plan is the result of a study of the bird's habitat needs and the ability of the Wilmington District to respond to them. As it presently stands, the plan is a proposal. As such, it is subject to change in response to the special interests of various agencies, including the Corps of Engineers. A review meeting will be held after the release of the Draft Environmental Statement and before the submittal of the Final Environmental Statement. Contact will be made with all known interested agencies or persons and a meeting time established. Interested agencies or persons not contacted are invited to contact the Corps to learn the meeting time and place.

Definition of Problem.

2. Due to the accelerated shoreline development and recreational use of beaches which have occurred in the recent past, beach nesting habitat for many species of seabirds has been destroyed or otherwise rendered unsuitable for such purposes. Coincidentally with this development, maintenance of the navigation project in the nearby Cape Fear River provided the seabirds alternative locations for nesting by the creation of dredged material disposal islands. Due to their seclusion and sandy substrates, these islands offer ideal nesting habitat safe from predation and development and have functioned as a refuge for nesting seabirds and other species that commonly over-winter in the area. The importance of dredged material islands in seabird reproductive biology is dramatically shown in Table B1.

3. Although they are initially little more than mounds of bare sand, these islands undergo the process of plant succession, ultimately developing a climax stand of vegetation consisting of trees and shrubs.

Table B1*

ESTIMATED NUMBER OF NESTS OF COLONIAL SEABIRDS OCCURRING IN NORTH CAROLINA DURING THE BREEDING SEASON OF 1973+

SPECIES	NESTS		TOTAL
	DREDGE	NATURAL	
BROWN PELICAN	30	0	30
HERRING GULL	94	5	99
LAUGHING GULL	7,137	6,257	13,394
GULL-BILLED TERN	399	121	520
FORSTER'S TERN	557	289	846
COMMON TERN	2,968	353	3,321
LEAST TERN	655	77	732
ROYAL TERN	32,760	2,574	35,334
SANDWICH TERN	251	3	254
BLACK SKIMMER	1,696	184	1,880
TOTALS	46,547	9,863	56,410
% OF TOTAL	82.52	17.48	

*This chart is taken from Proceedings of a Conference of Management of Dredge Islands in North Carolina Estuaries, UNC Sea Grant Pub. UNC-SG-75-01. (Parnell and Soots, editors 1975).
+These estimates should be considered minimal since most of them are based on one observation in May or June and do not include subsequent nesting.

Each early successional stage of vegetation is used by different species of nesting seabirds; therefore, to obtain maximum benefit through management, a series of islands in different stages of vegetational succession is highly desirable. Currently, there is no control over the vegetation of the existing riverine islands, and this has created a situation of random benefits.

4. In the past, dredging in the Cape Fear River was undertaken without adequate concern for the impacts which befell the resident seabird populations. More recently, frequent coordination and cooperation of the Wilmington District with authorities knowledgable in the field of seabird nesting has precluded much of the impact of each separate dredging event by programming dredging schedules to avoid disturbance of nesting seabirds. Although this method has met with relative success, it does not possess any degree of permanence in that, due to personnel changes or other unforseen developments, the process of coordination may, with time, be impaired.

Management Needs

5. In order for any management plan to be effective, it must address itself to the needs of the species to be managed. The lower Cape Fear River is used for nesting by both colonial and non-colonial bird species; however, for the purposes of this management plan, only colonial seabirds will be managed, as these birds are particularly vulnerable to maintenance dredging activities, and a significant contribution to their welfare can be readily realized. Of primary importance in management for colonial nesting seabirds is the maintenance of adequate nesting habitats. For seabirds, this consists of an area of sparse vegetation on sandy substrate away from all significant predators. These types of conditions can easily be met in the lower Cape Fear River.

6. Many other species of birds will use the river's dredged material disposal islands once the islands have reached a near climax stage of plant succession. Since, in the future, it is likely that many of the

existing dredged material disposal islands will be abandoned, there will be no management for species which nest on islands in advance stages of vegetative succession other than to avoid disrupting important nesting sites already in existence. Of particular importance at present is Battery Island, which currently hosts a very large rookery and is extremely important in the maintenance of stable heron, egret, and ibis populations in the area. It is anticipated that, in the future, as some dredged material islands are abandoned, they may ultimately achieve vegetative communities which will be favorable to these birds, and the islands may, in effect, serve as refuges.

Species to be Managed

7. The following list represents the species for which management is being undertaken and additional species that will be benefited as a result of management. It should be noted that other non-colonial nesting seabird species as well as species which commonly over-winter in the area will use managed islands and, therefore, will be benefited; however, due to their low-density nesting habitats or strictly wintertime use, management for these species in particular cannot be considered to be practical.

MANAGED SPECIES	ADDITIONAL BENEFITED SPECIES
Least tern - (Sterna albifrons)	Nesting
Common tern - (Sterna hirundo)	Willet - (Catoptrophorus semipalmatus)
Sandwich tern - (Sterna sandvicensis)	Wilson's plover-(Charadrius wilsonia)
Gull-billed tern - (Gelochelidon nilotica)	Oystercatcher - (Haematopus palliatus)
Royal tern - (Sterna macima)	Common nighthawk - (Chordeiles minor)
Caspian tern - (Sterna caspia)*	
Black skimmer (Rynchops niger)	Wintering
Laughing gull - (Larus atricilla)	Brown pelican - (Pelecanus occidentalis)

Double-crested cormorant - (Phalacrocorax auritus)

Herring gull - (Larus argentatus)

Ring-billed gull - (Larus delawarensis)

Forster's tern - (Sterna forsteri)

Bonapartes gull - (Larus philadelphia)

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*Species are nesting in the northeast part of the state and may extend their range.

Management Techniques

General.

8. Management of bird islands will be primarily by scheduled periodic deposition of dredged material in such a manner as to maintain a series of islands in various stages of plant succession. The relationship to the seabirds to be managed and the vegetational stages they associate with is quite clear. This is illustrated in Table B2.

9. In order to obtain the maximum benefit possible from each island managed, it is desirable to allow the natural process of plant succession to proceed from bare sand to a point where most species being managed are no longer being benefited. A small desposition can then be applied, starting another cycle of plant succession from its beginning.

Island Characteristics.

10. In addition to providing the sparsely vegetated sand substrate habitat which the seabirds require, there are other actions which are necessary or will be taken which further enhance the islands' value for nesting birds.

11. Island size. Maintaining an island of relatively small size is of primary importance to the success of the management plan. If an island were to become large enough, it would become capable of hosting predators as permanent residents, thereby seriously inhibiting any nesting attempts made by the seabirds. Soots and Parnell (1975) have found instances where entire colonies have abandoned otherwise suitable

Table B2*

Nesting Habitats and Earliest Year of Invasion by Common Nesting Birds of Dredged Material Islands and Span of Time Included in the Range of Habitat Usage

Earliest year of invasion	Species	Typical nesting habitat	Estimated use of a given site in years
1	American oystercatcher[1/]	Bare sand to sparse forbs	5
1	Black skimmer	Bare sand to moderate forbs	7
2	Wilson's plover[1/]	Bare shell and sand to sparse forbs	
2	Least tern	Bare sand and shell to sparse forbs	4
2	Royal tern	Bare sand to sparse forbs	4
2	Sandwich tern	Bare sand to sparse forbs	4
2	Gull-billed tern	Bare sand (with drift material or heavy shell) to moderate forbs	4
2	Common tern	Bare shell to moderate forbs	6
3	Forster's tern	On drift material surrounded by moderate to dense forbs	2
3	Eastern willet	Moderate to dense forbs	12
5	Herring gull	Sparse to dense forbs	5
5	Laughing gull	Moderate to dense forbs	10

[1/] Solitary nesters, all others colonial.

* Adapted from Ecological Succession of Breeding Birds in Relation to Plant Succession on Dredge Islands in North Carolina, UNC Sea Grant Pub. UNC-SG-75-27 (Soots and Parnell 1975).

islands due to the activities of predators.

12. A total of nine managed sites will be used on eight separate islands. Specific island locations can be seen in Figure B1, with each island having a site designation letter beside it. Sites A, B, D, and E will be used in conjunction with routine project maintenance; therefore, the flexibility in maintaining their vegetational stages is not as great as that for the other sites. Sites C, F, G, H, and I are residual lumps of sand from previous dredgings which will be enlarged by nylon sandbag diking.

13. Optimum island size ranges from 2.1 ha to 6.1 ha, although islands up to 10.1 ha may be suitable. Initially, the managed dredged material islands will be kept as small as possible; however, as regular deposition occurs, their size will, in time, increase. A maximum size limit of 6.1 ha has been placed on the islands to be created, and size reduction, if necessary, can take place by removing the sandbag diking and allowing erosive processes to decrease their size. No deposition would occur while diking is removed. It is expected that island sites A, B, D, and E will become unsuitable for management by dredged material deposition within the next 10 years due to their limited receiving capability. Size increase or decrease will not be feasible for these islands, as they are near the maximum feasible size, and erosion in this section of the river is not severe enough to be a useful tool. The island which contains sites D and E is larger than 10.1 ha but will be managed as a test site to see if data can be obtained by controlled deposition on large islands.

14. Specific island characteristics.

a. Islands A and B. Islands A and B are the northernmost islands to be managed and will probably receive the least use by birds of all the managed islands. Both islands are near the maximum of the ideal size limit, 6.1 ha and 4.9 ha, respectively. Both islands are diked and have a small marsh fringe encircling them. The dredged material received by these islands contains a high degree of fines which, in a diked state, are very slow to settle out. Attempts to remedy this situation will be made by mounding the dredged material at one end of the island and allowing the fines to settle to the lower end. Deposition will be every two years and will not allow any advanced

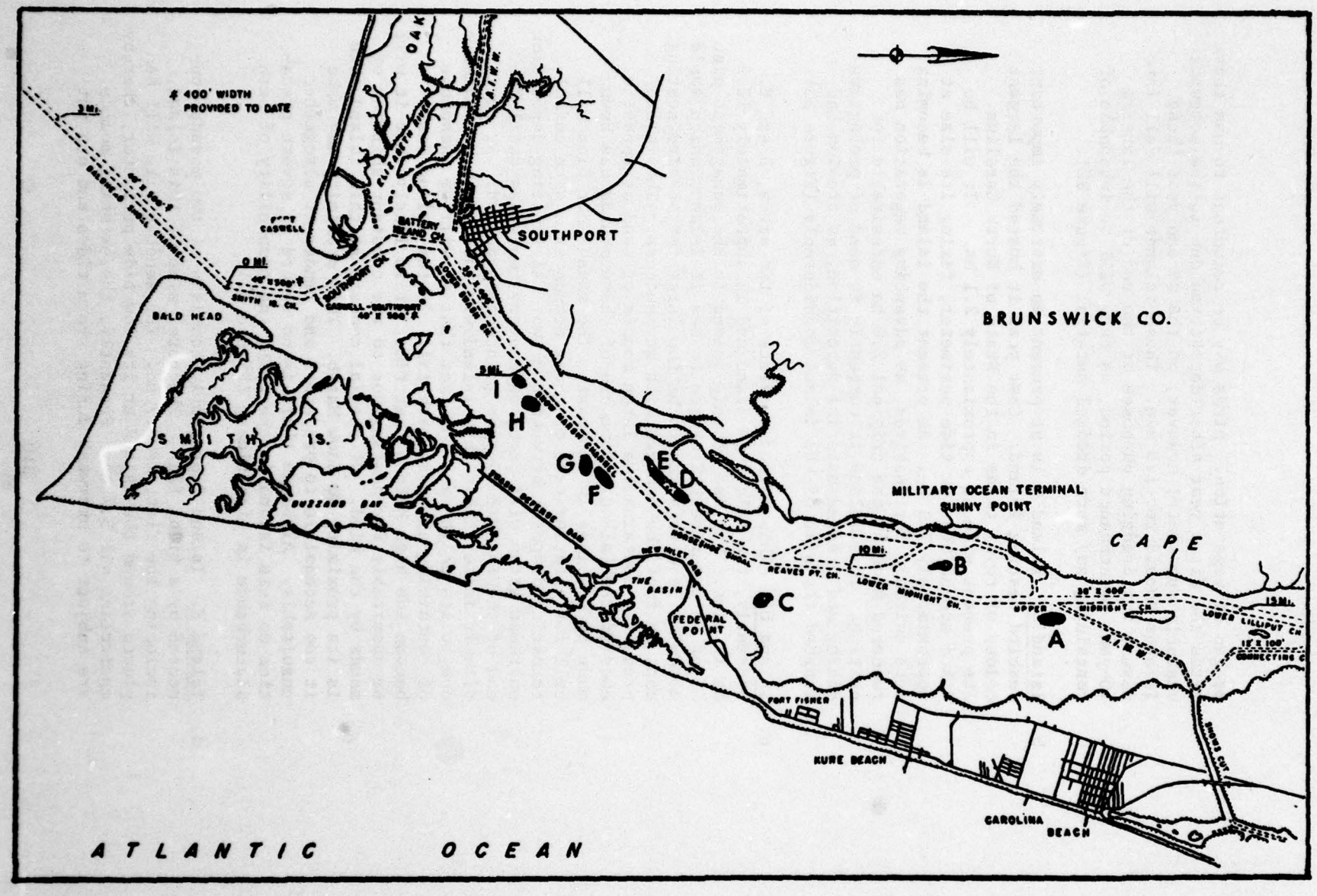

Figure B1. Island locations in Wilmington District management plan

stages of vegetation. Birds may be reluctant to use these sites the first year after deposition due to the somewhat unstable substrate; however, on the second year these islands should receive use. These islands will fall into disuse for dredging purposes at the end of the interim 10-year maintenance period, as they will be incapable of containing any more dredged material (Figure B2).

b. Island C. Island C is at present an extremely important seabird nesting island. Last year it hosted the largest colony of royal terns in the State of North Carolina. Its present size is approximately 2.1 ha. It will be diked around its low tide perimeter, fixing its size at approximately 3.3 ha. At present the island is becoming less suitable for seabirds, as advancing vegetation has rendered much of the original 2.0 ha undesirable for nesting. This island is currently in need of protective diking and dredged material deposition, as erosion has reduced the size of the island considerably (Figure B3).

c. Island DE. This island consists of two sites, D and E. Presently, the island is diked and is approximately 12.2 ha in size. The use of this island in the management plan is of an experimental nature to see if islands which would normally be considered to be too large for seabird nesting can, in fact, be managed with any success. The island presently contains two large mounds of sand at opposite ends of the island. Some use of these mounds has been made by seabirds in the past. The management plan will call for treating each of these mounds as a site and alternating disposal between the two. Alternating deposition on these sites will occur once every two years until the end of the interim 10-year maintenance period. At that time it is felt that this island will no longer be suitable due to its height and the fact that it will be incapable of containing any more material. If the island does become too high before that time, it is likely that it will be unsuitable for nesting due to the constant shifting of sands by the wind. Of special concern at this island site is its proximity to Snow Marsh. This proximity may make it too accessible to predators and render it altogether unsuitable. Although there is no record of severe predation on this island in the past, the possibility of such disturbance is significant (Figure B3).

d. Island F. Island F presently consists of two mounds connected by a tidal flat. The total size of this island, including the flat, is 3.7 ha. The sandbag dike will be placed around the island at its low tide perimeter, thereby encircling all 3.7 ha. Presently, the existing mounds are subject to overwash during storm tides and are not

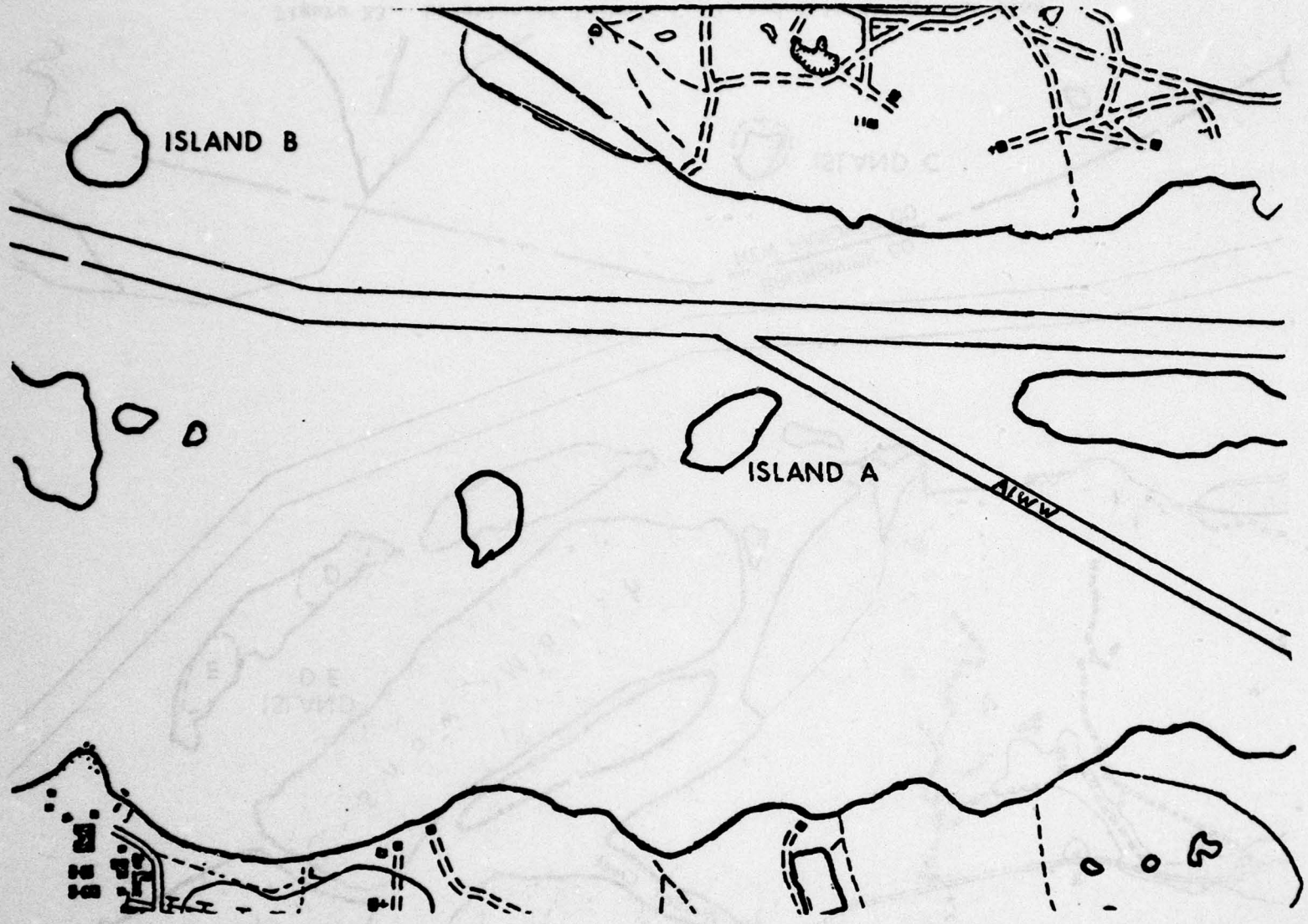

Figure B2. Location of Islands A and B in management plan

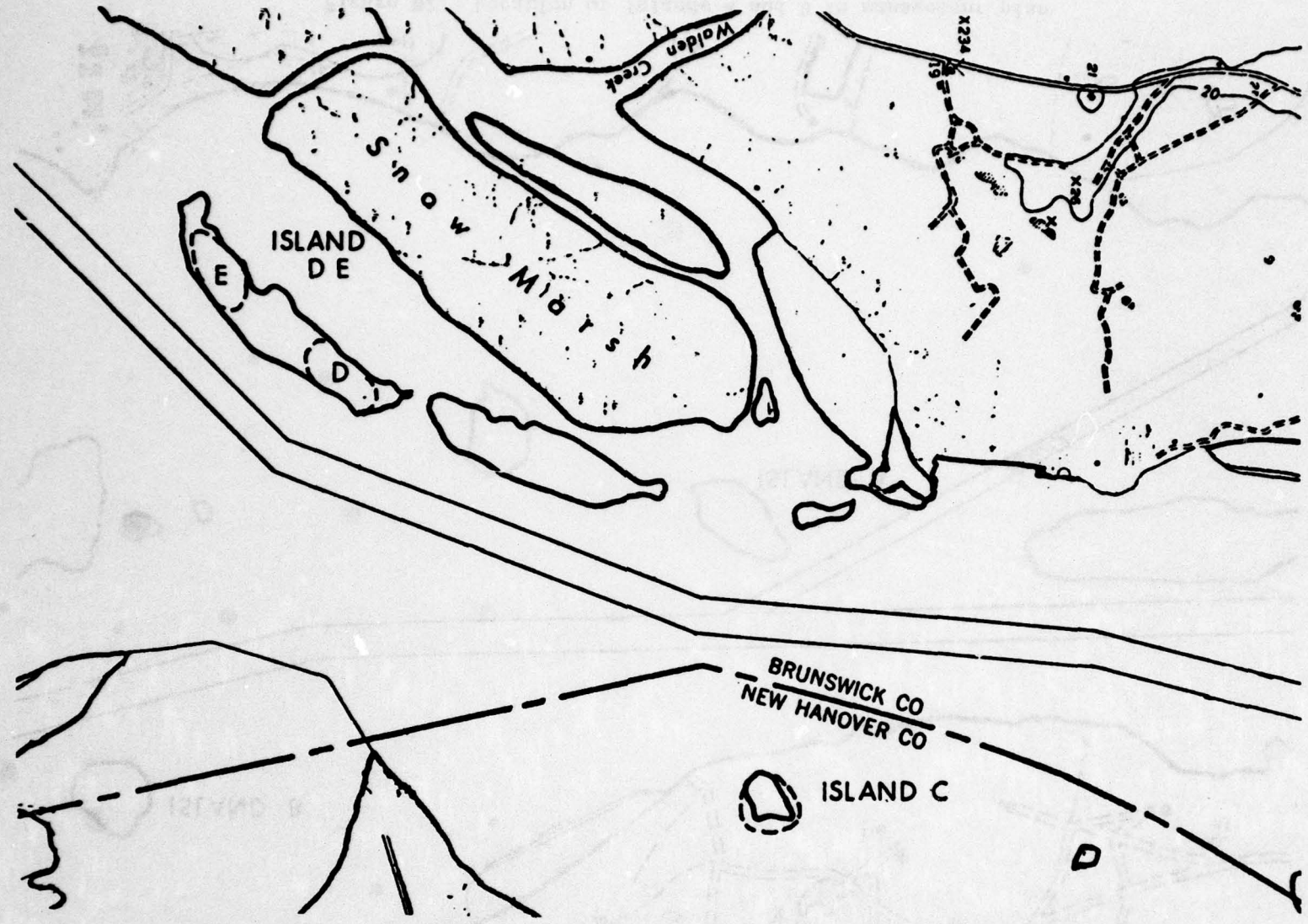

Figure B3. Location of Islands C, D, and E in management plan

used extensively by seabirds for nesting (Figure C4).

e. Island G. This island is a relatively small mound (0.9 ha) connected by a tidal flat to island F. A sandbag dike will encompass all of this island and approximately 1.2 ha of river bottom. This will bring the final island size to approximately 2.1 ha. The tidal flat will be left between this island and island F. Although this island could be connected to island F, it will be kept separate in order to obtain the benefits offered by a different vegetational stage. This island is subject to overwash and is not used for nesting by seabirds (Figure B4).

f. Island H. Island H will be comprised of the existing complex of tidal flats and the open water space which lies between them. Total size of the island will be approximately 6.1 ha. Of this 6.1 ha, 2.45 ha are exposed at low tide, leaving a balance of 3.7 ha of river bottom to be lost. This island complex is subject to overwash and is not used for nesting by seabirds (Figure B4).

g. Island I. Island I will be built up around 3 small islands currently separated by open water. Two of the islands are exposed at all times except during extreme high tides, and one is exposed only at low tide. By encircling these islands, one large island of approximately 3.5 ha will be created at a loss of approximately 2.6 ha of river bottom. Due to their small size and vulnerability to overwash, these islands are not currently used for nesting by seabirds (Figure B4).

Deposition Schedule.

15. Dredging normally occurs in the management area of the river once every two years, so it is upon this periodicity and the time frame of plant succession that the deposition schedules for the managed islands is based. Islands were scheduled to receive deposition so that islands in similar stages of plant succession are widely separated in the river. This circumvents some of the problems which could be encountered by clustering all of the birds in one segment of the river (Table B3).

16. As can be seen from the schedule, islands A and B will receive material at every dredging. Sites D and E will be used alternately, as they both occur on the same island. Sites A, B, D, and E will all fall from use under this plan at the end of the interim 10-year harbor maintenance period. The remaining sites will continue to be used under the

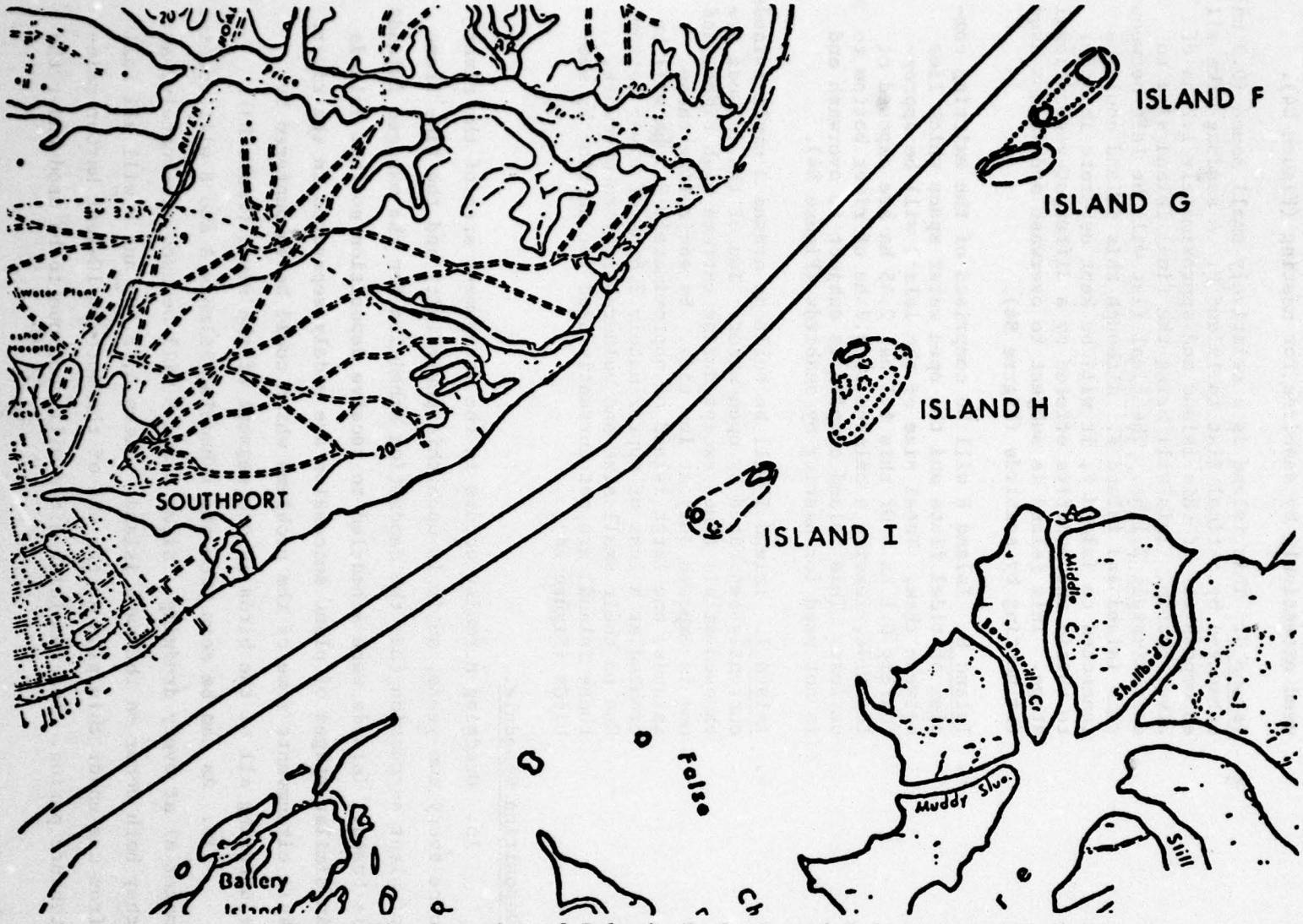

Figure B4. Location of Islands F, G, H, and I in management plan

Table B3

Dredging/Deposition Schedule

The deposition schedule is shown below. Years are from year zero when the first management dredgings take place. Letters opposite the year designate which islands are to receive dredged material at that time.

YEAR	ISLANDS TO RECEIVE MATERIAL
0	A, B, C*, D, F*, H*
2	A, B, E, G*, I*
4	A, B, D, H
6	A, B, E, F
8	A, B, C, D, I
10	A, B, E, G
12	H
14	F
16	I, C
18	G
20	H
22	F
24	I, C
26	G
28	H
30	F

*Denotes year of initial diking and construction.

long-range maintenance plan. Their scheduled deposition is on a cyclic basis, beginning at year 16.

17. The effect of sandbag diking on plant succession is an unknown factor at this time and is extremely important in determining the deposition schedule. If, as expected, the dikes inhibit plant succession, the dredging schedule for islands to be used under the long-range maintenance plant will be altered accordingly. This will have the desirable effect of decreasing the rate of the islands' growth in size. The present deposition schedule, of necessity, was based on the known time frame of plant succession.

Desposition of Dredged Material.

18. In the section of the river under consideration the dredged material will range from predominantly fines in the northern portion to coarse sand in the southern. (See Table B4). Because of this, as would be expected, the northern islands (A & B) will generally get less nesting use than the more sandy southern ones. Compensation will be made for this fact by alternating the normal method of deposition at the northern sites. Dredged material will be deposited on one end of the island, thereby creating a mound from which most of the fines will settle. This will leave a gently sloping mound, consisting primarily of sand, useful to the seabirds for nesting. During the subsequent dredging, deposition will be made at the opposite end of the island, leaving the first deposito continue through normal plant succession.

19. The sandy material of the southern reaches will be deposited in the form of gently sloping mounds into the sandbag dikes. Ultimately, these islands will receive material on an eight-year cycle. The amount of material deposited at each dredging will be the minimum required to destroy the existing vegetation. This amount is currently estimated to be about 5,000 cubic yards.

20. Initially, each of the four southernmost islands will receive approximately 26,000 cubic yards of dredged material. This will not fill the entire diked area of any island, but being placed in mounds will offer suitable nesting habitats which will be protected from wave action. Island C will initially receive approximately 14,500 cubic yards. This

TABLE B4

DREDGE ISLAND MANAGEMENT PLAN MATRIX

Island Designation		A	B	C	DE	F	G	H	I
Size (hectares)*	Present	6.1	4.9	2.1	13.4	3.7	0.9	2.4	0.8
	After Constr.	6.1	4.9	8	13.4	3.7	2.1	6.1	3.4
Max. Future Size		6.1	4.9	6.1	13.4	6.1	6.1	6.1	6.1
Total hectares river at initial constr.		0	0	1.2	0	0	1.2	3.7	2.6
Grain size of available material	% <.25 mm	6.66%	6.66%	95.08%	81.59%	81.59%	81.59%	81.59%	81.59%
	% >.25 mm	93.34%	93.34%	4.92%	4.92%	18.41%	18.41%	18.41%	18.41%
Initial Deposition (est)		-	-	14,500 cyds	-	26,000 cyds	26,000 cyds	26,000 cyds	26,000 cyds
Subsequent Deposition (est)		-	-	5,000 cyds	-	5,000 cyds	5,000 cyds	5,000 cyds	5,000 cyds
Max. holding capacity after initial constr.		-	-	77,500 cyds	-	87,000 cyds	48,500 cyds	145,000 cyds	82,000 cyds
Sandbagged		No	No	Yes	No	Yes	Yes	Yes	Yes
Erosion Rate		Insignificant	Insignificant	Severe	Moderate	Severe	Severe	Severe	Severe
Currently used by seabirds		Yes	Yes	Yes	Yes	No	No	No	No
Yrs. use at initial constr. size		-	-	100	-	95	35	190	90

*Hectare figures are approximate.

material will be placed on the existing sand mound.

Island Life Span

21. Island life span is the length of time which elapses between initial construction and the year in which the island is completely filled and incapable of containing any more dredged material. Once the island's life span has transpired, the island's size will have to be enlarged or, in the case of island H, decreased. If every new island were initially constructed at a size of 6.1 ha, the life span of each of the islands would be approximately 190 years. In effect, this means that if a maximum size limit of 6.1 ha is placed on any one island, it will be approximately 190 years before measures to decrease any island's size become necessary. As can be seen in Table B4, there are only three islands which will have to be increased in size within the next 50 years.

22. Island life span was computed by dividing the amount of material the island is capable of holding after the initial deposition by 5,000 (the amount of material to be deposited by each subsequent dredging) and multiplying the result by 8 (the number of years in a deposition cycle).

Unknowns and Concerns

23. Unknowns and concerns about the Dredge Island Management Plan as they have been realized to date are as follows:

a. Currently, there is little known of the effects of sandbag diking on plant succession. It is generally assumed that sandbag diking will have the effect of retarding the pioneer stages of plant succession, preventing the establishment of the normally occurring plant communities on the island's edge. If any difference in the rate of plant succession does occur, the deposition schedule will be altered accordingly.

b. The rate of erosion in the lower Cape Fear River has never been monitored. It is known that erosion in the area from Federal Point South is severe. Several islands that were created in the area in the late 1960's have completely

disappeared. The extent to which this erosion rate can be used as a future tool is uncertain.

c. The future growth of the Wilmington area may lead to increased recreational use of the lower Cape Fear River. If this does occur, human intrusion on or near the dredged material islands may have a severe impact.

d. Concern has been expressed over the loss of river bottom acreage due to the re-construction of existing islands. The long-term impact of such a loss is unknown, but it is certain to be adverse to aquatic resources.

In any undertaking such as this, there are always certain unknowns which must be coped with. At this point in time, professional judgment must be used and trade-offs made. It is the belief of the Wilmington District, after much thought and deliberation, that this plan represents acceptable trade-offs and is in the best public interest.

Coordination

24. A meeting was held on 19 December 1975 to determine the management needs and concerns in the lower Cape Fear River. Subsequent to the 19 December meeting, various aspects of the plan had been discussed with representatives of other agencies and experts in the field of seabird nesting. Conclusions drawn from these meetings indicated that management for seabirds was possible and desirable. It was generally considered that management for waterfowl (ducks) on Cape Fear River dredged material islands would be of little value in their reproductive biology.

25. The following agencies were represented in the 19 December meeting or were contacted subsequently: U.S. Fish and Wildlife Service, North Carolina Wildlife Resources Commission, and North Carolina Division of Marine Fisheries.

26. All contacts indicated an awareness of the problem and the desire to proceed with a project which would address the needs of the seabirds through a policy of wise resource management. This plan is an attempt to respond to those needs. The plan is a draft and, as such, is subject to changes in design or concept.

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Soots, Robert F
Development and management of avian habitat on dredged material islands / [by Robert F. Soots, Jr., Mary C. Landin]. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1978.
xi, 96, [27] p. : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; DS-78-18)
Prepared for Office, Chief of Engineers, U. S. Army, Washington, D. C.
Literature cited: p. 92-96.

1. Artificial islands. 2. Birds. 3. Dredged material disposal. 4. Habitat development. 5. Habitats. 6. Islands (Landforms). 7. Land management. 8. Vegetation establishment. 9. Waste disposal sites. 10. Waterfowl. 11. Wildlife habitats. I. Landin, Mary C., joint author. II. United States. Army. Corps of Engineers. III. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Technical report ; DS-78-18.
TA7.W34 no.DS-78-18