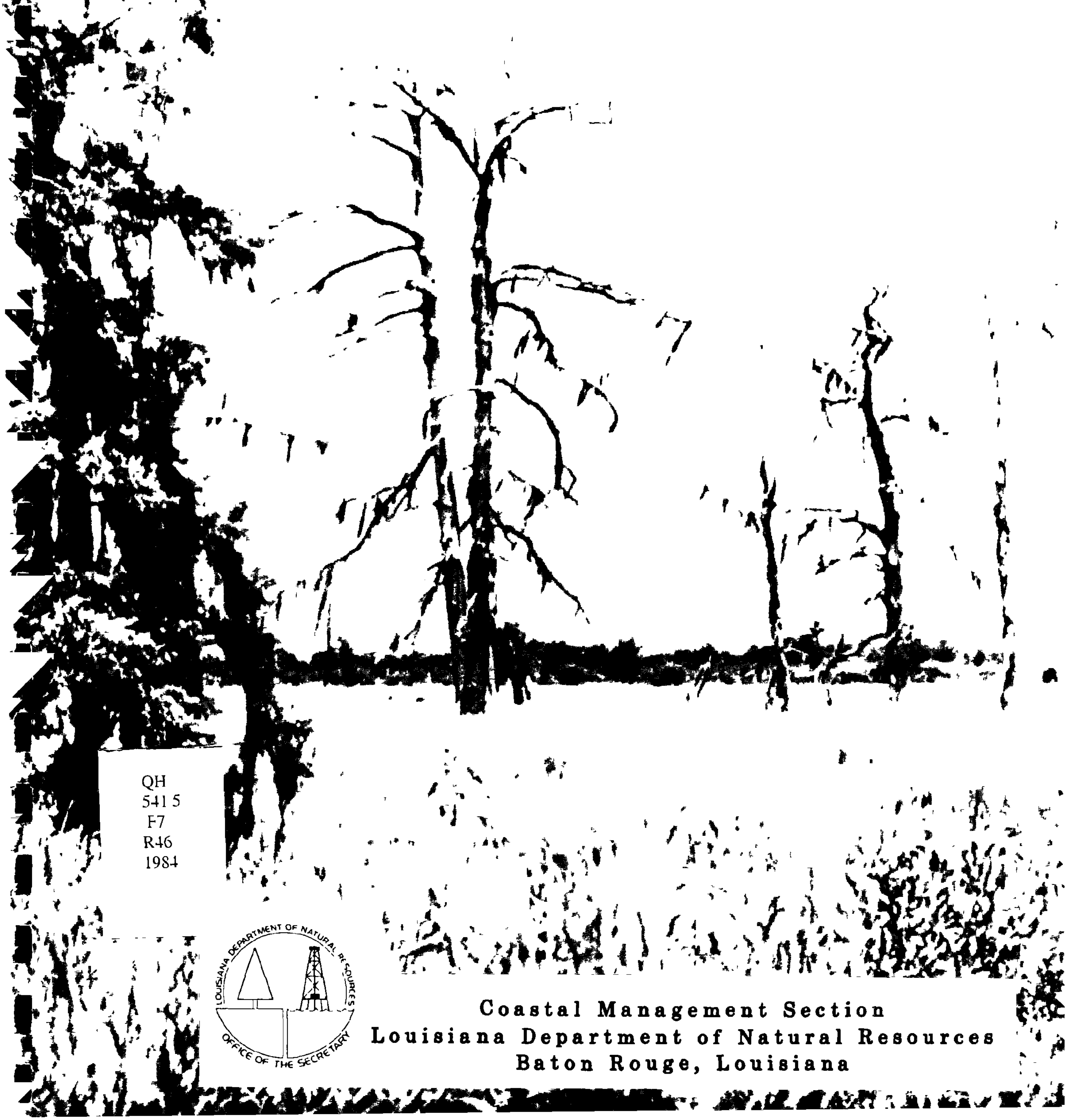
APPENDIX I

RECOMMENDATIONS FOR FRESHWATER DIVERSION TO BARATARIA BASIN, LOUISIANA



LOUISIANA DEPARTMENT OF NATURAL RESOURCES
OFFICE OF THE SECRETARY

Coastal Management Section
Louisiana Department of Natural Resources
Baton Rouge, Louisiana

RECOMMENDATIONS
FOR
FRESHWATER DIVERSION
TO
BARATARIA BASIN, LOUISIANA

COASTAL MANAGEMENT SECTION
LOUISIANA DEPARTMENT OF NATURAL RESOURCES
BATON ROUGE, LOUISIANA

This document was published at a cost of $ 1.73 per copy by the Louisiana Department of Natural Resources, P.O. Box 44396, Baton Rouge, Louisiana, for the purpose of carrying out the requirements of the Louisiana Coastal Zone Management Program under the authority of Act 361 of 1979. This material was printed in accordance with the standards for printing by state agencies established pursuant to R.S. 43:31 and was purchased in accordance with the provisions of Title 43 of the Louisiana Revised Statutes. This project was financed through a grant provided under the Coastal Management Act of 1972, as amended, which is administered by the U.S. Office of Coastal Zone Management, National Oceanic and Atmospheric Administration.

RECOMMENDATIONS
FOR
FRESHWATER DIVERSION
TO
BARATARIA BASIN, LOUISIANA

by

David W. Roberts
Donny J. Davis
Klaus J. Meyer-Arendt
Karen M. Wicker

Project Director: J. L. van Beek

COASTAL ENVIRONMENTS, INC.
BATON ROUGE, LOUISIANA

This study was funded by:

OFFICE OF COASTAL ZONE MANAGEMENT
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
DEPARTMENT OF COMMERCE

prepared for:

COASTAL MANAGEMENT SECTION
LOUISIANA DEPARTMENT OF NATURAL RESOURCES
BATON ROUGE, LOUISIANA

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

ACKNOWLEDGEMENTS

This study was funded by the Office of Coastal Zone Management, National Oceanic and Atmospheric Administration, U. S. Department of Commerce, through the Coastal Management Section, Louisiana Department of Natural Resources. We wish to thank Mr. Joel Lindsey, CMS Administrator, and Mr. David Chambers, CMS Project Officer, for their support in realizing this study.

The cooperation of a number of Federal and state agencies and officials was invaluable in obtaining hydrologic data. In this regard we wish to thank the New Orleans District Corps of Engineers; Mr. Harry E. Schafer and Mr. Ronald J. Dugas of the Seafood Division, Louisiana Department of Wildlife and Fisheries; and Mr. George Robichaux of the Louisiana Department of Health and Human Resources. Our thanks also to Dr. Robert H. Chabreck, School of Forestry and Wildlife Management, Louisiana State University, for insights into habitat changes, and to Greg Linscombe, Fur Division, Louisiana Department of Wildlife and Fisheries, for information on furbearer populations in the Barataria Basin. For 1983 data on the location and extent of private oyster leases in the study area, we are very grateful to Mr. Mike Meyers, Oyster and Water Bottoms Survey Division, Louisiana Department of Wildlife and Fisheries.

Within Coastal Environments, Inc. we wish to acknowledge the contributions of the staff in preparing this report. The cartography and drafting was done by Curtis Latiolais with the assistance of Debra Faiers. Linda Richard was responsible for editing and report production, and word processing was done by Ree Musso, Susan Crump, and Ludy Dyason. Finally, the authors wish to thank Dr. J. L. van Beek for his experienced advice, guidance, and support throughout the project.

CHAPTER 1: INTRODUCTION

The state of Louisiana has been blessed with the largest and most productive area of coastal wetlands in the United States. Concern over the continuing loss of the wetlands has prompted the state to seek ways of reducing the present rapid rate of deterioration of this valuable resource. In 1979, the Louisiana Legislature enacted an amendment to Section 213.10 of Title 49, adding subsection F, which directed preparation of a freshwater diversion plan under the State and Local Coastal Resources Management Act. As a result, the Coastal Management Section of the Louisiana Department of Natural Resources (LDNR) implemented the preparation of a freshwater diversion plan for the estuaries adjacent to the Mississippi River. Recommendations for diversion to the estuaries east of the Mississippi River were completed in June 1982. The present report constitutes Phase II of the freshwater diversion plan and presents recommendations for freshwater diversion from the Mississippi River westward into the Barataria Basin.

Scope of Work

The study area for this report includes the wetlands of Hydrologic Units III and IV of coastal Louisiana commonly called the Barataria Basin. The primary objective of the study is to make detailed recommendations as to the location, manner, and quantity of discharge diversion from the Mississippi River to the wetlands of the Barataria Basin. Concepts and information developed in previous work, especially the Phase I report (van Beek et al. 1982) and the Louisiana Coastal Areas Study Interim Report (U.S. Army Corps of Engineers [USACE] 1982), were fully utilized in realizing this objective. The recommendations contained in this report are based on the following major elements:

1. A thorough analysis of environmental baseline conditions within the basin, both historic and present, including salinity induced habitat changes and wetland loss.

2. Development of salinity goals that would perpetuate a balance of wetland habitat types for continued productivity of wildlife and fishery resources.

3. Generation of predictive statistical models that define the relationship between salinity and freshwater inflow in the estuary.

4. Analysis of feasible diversion sites in relation to freshwater needs including plans for delivery systems and outfall management.

5. Discussion of anticipated beneficial results and possible adverse impacts of freshwater diversion.

CHAPTER 2. DESCRIPTION OF THE STUDY AREA

Land Use

Land use in the Barataria Basin is mostly governed by two terrain types: upland and wetland. Within each category, several basic categories of land use occur, as shown in Plates 1 and 2. Delineation of these categories was made on the basis of 1:24,000 scale habitat maps (Wicker et al 1980), which were prepared from interpretation of 1978 color infrared photography of the same scale (National Aeronautics and Space Administration [NASA] 1978). Recent 1:250,000 land use/land cover maps (U.S. Geological Survey [USGS] 1978) were also consulted.

Uplands comprise primarily the natural levees of the Mississippi River, Bayou Lafourche, and many smaller distributary ridges. In addition, many backswamp and wetland areas have been reclaimed for agricultural, urban, or industrial expansion. These sites can be considered as functional uplands, as they are effectively separated from surrounding wetlands by levees and consequently not affected by water-level fluctuations. Within the upland category, major industrial and urban areas have been delineated. The bulk of the upland category contains agricultural land. For simplicity, small unincorporated urban areas and minor industrial areas are absorbed within the generalized upland category (Plates 1 and 2). The population of Barataria Basin between Bayou Lafourche and the Mississippi River has grown from 266,668 in 1970 to 337,912 in 1980 (U.S. Department of Commerce, Bureau of Census 1981). This increase of 26.7% is high when compared to the state's average growth rate of 15.3%. Most of the growth has been in that portion of Greater New Orleans south of the river, where 70% of the total population of the Barataria Basin resides. Bottomland hardwoods, a transitional zone between upland and wetland, are found toward the backswamp of the natural levees and on the smaller distributary ridges. While normally considered non-wetland, bottomland hardwoods are often affected by flooding, if only for a short period of the year. On the basis of inundation period, researchers have even delineated "transitional bottomland hardwoods" (LSU Division of Engineering Research 1976). These are included in the bottomland hardwood category on Plates 1 and 2.

New Orleans is the only major urban area in the Barataria Basin. Approximately 250,000 persons live on the West Bank of Greater New Orleans. While the City of New

Orleans proper has lost population during the last decade, adjacent Jefferson Parish has grown by 34.4%. Most of the parish's growth is occurring south of the Mississippi River, where the wards have experienced a 43.1% growth between 1970 and 1980 (Table 2-1). Numerous small communities are found along the natural levees of the Mississippi River and Bayou Lafourche, as well as on Grand Isle. Settlement along the natural levee ridges can, for the most part, be characterized as dense-rural, or containing 100 to 300 inhabitants per square mile of upland (Table 2-1).

Vegetation and Wildlife Resources

The Barataria Basin encompasses over 500,000 ac of wetland habitats, including wooded swamps and marshes of varying salinity regimes. The majority of the wooded swamps are located generally near the "top" of the basin west and northwest of Lake Boeuf and Lac des Allemands and flanking the natural levees of Bayou Lafourche and the Mississippi River (Plate 1). Bahr and Hebrard (1976) reported that the Barataria drainage system contained 242,048 ac of swamp forest, while Wicker et al. (1980) reported approximately 227,000 ac. Major species in the wooded swamps include baldcypress (Taxodium distichum), tupelo gum (Nyssa aquatica), swamp maple (Acer rubrum var. drummondii), and pumpkin ash (Fraxinus tomentosa) (Conner 1975, Conner et al. 1981). Salinities in swamp forests are generally quite low but may range up to near 2 ppt (parts per thousand) at the ecotone along the fresh marsh interface.

Fresh marsh occurs at slightly lower elevations and is subject to more frequent flooding than swamp forests (van Beek et al. 1982, Plates 1 and 2). Water salinities in the fresh marsh vegetative type in the Barataria Basin averaged 1.81 ppt over 24 sampling sites during August 1968 (Chabreck 1972) and ranged up to 4.51 ppt. Soil organic matter was usually high and averaged 67.35% (Chabreck 1972). Major plant species in fresh marsh in this basin include paille fine (Panicum hemitomon) with 41.35% composition; bulltongue (Sagittaria falcata), 17.42%; spikerush (Eleocharis sp.), 12.31%; and alligatorweed (Alternanthera philoxeroides), 3.43% (Chabreck 1972).

Marshes of intermediate salinities represent an ecotone or transition zone between fresh and non-fresh marshes and usually comprise a relatively small percentage of the total acreage of marsh in the basin (Plates 1 and 2). According to Chabreck (1972), water salinities in the intermediate marshes of the Barataria Basin averaged 5.42 ppt

Table 2-1. Demography, Barataria Basin

Parish (Wards)	POPULATION 1980	1970	change 1970 - 1980	density (per mi^2)*
Ascension (3, 4)	6,388	6,002	+6.4%	500
St. James (5, 6, 7)	8,896	8,167**	+8.9%	150
St. John (1, 2, 3)	5,042	4,647	+8.5%	200
St. Charles (1, 2, 4)	15,748	12,309	+27.9%	250
Jefferson (1-6, 11)	179,959	125,789	+43.1%	3,250
Orleans (15)	58,867	52,310	+12.5%	3,450
Plaquemines (3, 4, 5)	23,207	22,110	+5.0%	400
Assumption (1, 2)***	4,346	4,258	+2.1%	100
Lafourche (5-10)	35,459	31,076	+14.1%	275
TOTAL	**337,912**	**266,668**	**+26.7%**	**710**

Source: U.S. Dept. of Commerce (Bureau of Census) 1981

* per upland area only
** approximate
*** Wards 1-4 in 1970

and ranged from 2.67 to 8.04 ppt. However, these data were from only three sample sites. Soil organic matter was high and averaged near 65%. Important plant species in this marsh type include wiregrass (Spartina patens), comprising 41.99% by species composition; coastal waterhyssop (Bacopa monnieri), 16.79%; and fragrant flatsedge (Cyperus odoratus), 5.34% (Chabreck 1972).

Seaward of intermediate marsh, higher water salinities and increased tidal energy lead to establishment of brackish marsh (van Beek et al. 1982, Plate 2). Chabreck (1972) reported an extremely wide range of water salinities for this marsh type. Salinities averaged 9.68 ppt over 21 sample sites ranging from 3.28 to 28.08 ppt. Soil organic matter was somewhat lower in brackish marsh, as compared to fresh and intermediate types, and averaged 48.74%. Major plant species in Barataria brackish marshes include wiregrass, comprising 45.84%; saltgrass (Distichlis spicata), 28.96%; smooth cordgrass (Spartina alterniflora), 9.03%; and dwarf spikerush (Eleocharis parvula), 5.49% (Chabreck 1972).

Salt marsh occurs in areas of high tidal energy and water salinities above 15 ppt for much of the year (Plate 2). In the Barataria Basin, water salinities over 22 sampling sites averaged 15.84 ppt and ranged from 6.26 to 21.86 ppt in August 1968 (Chabreck 1972). Due to the increased mineral content of salt marsh soils, organic matter content is the lowest of any marsh type and averaged 25.48% in the Barataria Basin (Chabreck 1972). Plant diversity is generally reduced in saline environments since fewer species have adapted to the high salinities and greater tidal exchange here. Smooth cordgrass is dominant, comprising 62.79%, while other important species include black rush (Juncus roemerianus), comprising 14.90%; saltgrass, 10.05%; and wiregrass, 7.77% (Chabreck 1972).

Wildlife resources are diverse and abundant within the wetland habitats of Barataria Basin. The baldcypress swamps serve as important nesting, brood rearing, and wintering areas for the Wood Duck (Aix sponsa) (Bellrose 1976, Sincock et al. 1964). Other waterfowl, particularly Mallards (Anas platyrhynchos), also utilize swamp forest as overwintering sites. Other avian species utilizing swamp forests to a great degree include wading birds, such as herons, egrets, and ibises, that feed predominantly on small fish and crustacean populations in shallow water areas. Portnoy (1977) found over 30,000 wading birds nesting within wooded swamp habitat in the Barataria Basin.

These included Great Egrets (Casmerodius albus), Little Blue Herons (Egretta caerulea), Great Blue Herons (Ardea herodias), Louisiana Herons (Egretta tricolor), Snowy Egrets (Egretta thula), and Cattle Egrets (Bubulcus ibis). The swamp forests of Barataria also serve as prime nesting habitat for the Southern Bald Eagle (Haliaeetus leucocephalus). Dugoni (1980) reported seven active Bald Eagle nests within the Barataria Basin, including four in St. Charles Parish, two in Jefferson Parish, and one in St. John the Baptist Parish. Large baldcypress trees located near open water bodies are apparently important components of Bald Eagle nest sites (Dugoni 1980). Of the seven nest sites in Barataria, five are located in baldcypress trees and two in live oaks (Quercus virginiana). Every active nest in Louisiana as reported by Dugoni (1980) occurred in a baldcypress except the two live oak nests.

Other valuable wildlife species utilizing swamp forest habitat include furbearers such as raccoon (Procyon lotor) and mink (Mustela vison) and, to a lesser extent, nutria (Myocastor coypus). White-tailed deer (Odocoileus virginianus), squirrel (Sciurus sp.), and swamp rabbits (Sylvilagus aquaticus) are important game mammals in swamp habitats. Potential carrying capacities in swamp forest for these game species have been estimated at 1 deer per 30 ac, 1 squirrel per 4 ac, and 1 rabbit per 3 ac (Bahr and Hebrard 1976).

The high diversity of both plant species and low water salinities makes the fresh marsh vegetative type valuable wildlife habitat. The coastal marshes of Louisiana in some years may winter up to 4,000,000 ducks and 500,000 geese (Sanderson 1976, Bellrose 1976), both of which account for more than two-thirds of the migratory waterfowl population in the Mississippi Flyway. In southeastern Louisiana, fresh marsh may hold as much as 65% of the puddle duck wintering population (Palmisano 1973). In a survey of wading bird nesting colonies, Portnoy (1977) found over 64,000 wading birds in the Barataria Basin nesting within fresh marsh habitat. These colonies, comprised mostly of Little Blue Herons, Snowy Egrets, Cattle Egrets, and Louisiana Herons, were located predominantly in the vicinity of Lac des Allemands and Lake Boeuf in shrub outliers in the area of transition from swamp to fresh marsh.

The fresh marsh vegetative type is also important as commercial furbearer habitat. Although catch records are not necessarily indicative of population levels due to variations in trapping techniques and intensity of effort, fresh marsh evidently produces the highest mean and maximum harvests of nutria and mink, and the highest maximum harvests of raccoon (Palmisano 1973). Fresh marsh is also valuable alligator (Alligator mississippiensis) habitat. The fresh marshes of southeastern Louisiana contained 41% of the sub-delta marsh alligator population and 13.8% of the total coastwide population in 1977 (McNease and Joanen 1978).

Intermediate marsh represents an ecotone or transition zone between fresh and non-fresh marshes. This marsh type usually makes up only a small percentage of the total marsh acreage in any hydrologic unit. In the Barataria Basin, intermediate marsh comprised 20,084 ac out of 469,311 ac of natural marsh (Chabreck 1972) or 4.28%. Intermediate marshes in southeastern Louisiana can be valuable waterfowl habitat evaluated on a per unit area basis. Palmisano (1973) reported that intermediate marshes held 8.04% of the puddle ducks recorded, although this marsh type comprised only 7.59% of the habitat sampled. Furbearer production is also a valuable resource with relatively high yields of nutria, muskrat, and mink observed (Palmisano 1973). Intermediate marsh supported higher alligator population densities than either fresh or brackish marshes in the southeastern, sub-delta marshes (McNease and Joanen 1978).

Brackish marshes, lying seaward of intermediate marshes, historically have been the major producer of muskrat in Louisiana coastal marshes (O'Neil 1949). Three-cornered grass (Scirpus olneyi) marshes produce the highest densities of muskrat with as much as 80% of the harvest coming from these marshes in some years (O'Neil 1949). Management for three-cornered grass involves control of water levels and salinity (van Beek et al., 1982), but generally the lower salinity brackish marshes (5-10 ppt) with a decreased tidal energy regime are more favorable for its development. The lower salinity regime also favors alligator production, with population densities here slightly lower than fresh marsh densities (McNease and Joanen 1978). Waterfowl usage of brackish marshes is not as great as fresh or intermediate types on a per unit area basis but still is important in terms of the large expanse present (Palmisano 1973). The brackish marsh type has the greatest density of ponds and lakes (Chabreck 1972), which aids in its attractiveness for waterfowl. Widgeongrass (Ruppia maritima) is an important waterfowl food and is more prolific in conditions of low turbidity and stabilized water levels in shallow brackish-water ponds (Chabreck and Condrey 1979). Data from Portnoy (1977) indicate that brackish marshes are relatively unimportant as nesting habitat for wading birds and seabirds. However, this marsh type is used extensively as wintering and feeding sites by wading birds, seabirds, and shorebirds.

The saline marsh type, with greater tidal energy and salinities above 15 ppt much of the time, has low plant diversity and is generally poor habitat for furbearers (Palmisano 1973); waterfowl usage of this marsh type is low (Palmisano 1973). Because newly hatched alligators cannot tolerate the high salinity regime, saline marsh is not utilized by alligators (Joanen and McNease 1972). However, saline marsh in the Barataria Basin is important nesting habitat for wading birds and seabirds. Portnoy (1977) recorded nearly 85,000 wading birds and seabirds nesting within the saline marsh environment in the Barataria Basin. Nest sites were predominantly in black mangrove (Avicennia germinans) shrubs, particularly for wading birds. The most abundant species included the Louisiana Heron, Great Egret, Snowy Egret, White Ibis (Eudocimus albus), and Forster's Tern (Sterna forsteri). In addition, one of the few nesting colonies for the endangered Brown Pelican (Pelecanus occidentalis) is located on Queen Bess Island in Barataria Bay.

Salinity Induced Habitat Change and Land Loss

The coastal marshes of Louisiana were originally studied and classified by Penfound and Hathaway (1938), who identified four vegetative types: saline, brackish, slightly fresh (intermediate), and fresh. Chabreck (1970) made a more detailed study of the coastal marshes of the entire state using the same classification system in which species composition and area of each type were listed. In this study, vegetation transects were run along 39 parallel north-south lines equally spaced at 7.5 minutes of longitude along the coast (Chabreck 1972). In conjunction with this study, a vegetative type map was produced showing the extent and location of the coastal marsh types of Louisiana (Chabreck, Joanen, and Palmisano 1968). Ten years subsequent to this, these same transect lines were again flown to detect any movement or change in location of marsh types and another vegetative type map was published (Chabreck and Linscombe 1978). Overlays of these two type maps were compared to show changes of the boundaries of each marsh type in the Barataria Basin during the 10-year period (Figure 2-1).

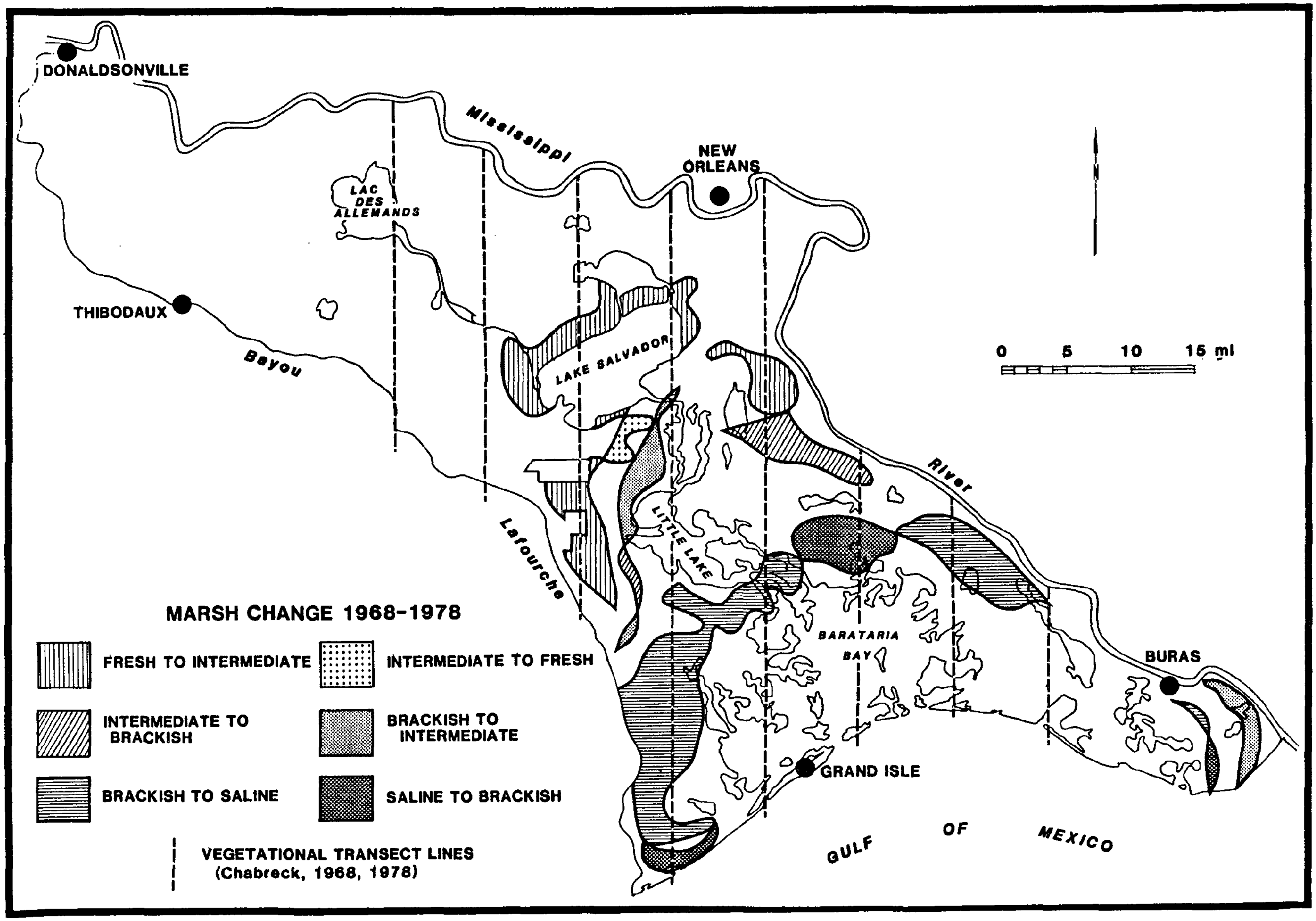


Figure 2-1. Marsh change in the Barataria Basin between 1968 and 1978 (Chabreck et al. 1968, Chabreck and Linscombe 1978).

In a similar exercise encompassing all the hydrologic units west of the Mississippi River, Chabreck and Linscombe (1982) noted that the Barataria Basin showed the greatest change in vegetative types of any hydrologic unit during the 10-year period. Vegetation changed to more saline types on 258.8 sq mi and changed to less saline types on 51.7 sq mi for a net change to more saline conditions on 207.1 sq mi in the Barataria Basin (Chabreck and Linscombe 1982). Canal dredging and stream channelization were mentioned as probable causes of the saline encroachment in this hydrologic unit.

On the whole, the Barataria Basin experienced increasing salinities during the interval of 1968-1978. This has manifested itself in the encroachment of saline marsh at the expense of brackish marsh in the lower estuary and in an increase in intermediate marsh at the expense of fresh marsh in the vicinity of Lake Salvador. The net result is a northward movement of marsh type boundaries with losses of fresh and brackish marsh habitats.

Changes in marsh vegetation types from 1968-1978 in the Barataria Basin are shown in Figure 2-1. It appears that the greatest change was a transition of brackish marsh to saline marsh in the lower part of the estuary bordering the Caminada-Barataria Bay system. In addition, the intermediate marsh type has advanced north of Lake Salvador at the expense of fresh marsh. To a much lesser extent, some intermediate marsh was replaced by brackish marsh, particularly on the east side of the basin. According to the maps, an area between Lake Salvador and Little Lake has changed to fresher vegetative types during the 10-year interval. However, in 1968 the vegetation was sampled only along the north-south transect lines and marsh type boundaries between these lines were delineated simply by interpolation. In 1978, numerous east-west lines were also flown between the established transects in order to more accurately map the vegetative marsh type (Chabreck 1982). It seems probable that the apparent changes to fresher marsh types between Lake Salvador and Little Lake do not represent actual changes but are simply a result of more accurate mapping of marsh type boundaries in 1978 (Chabreck 1982). Another area on the north side of Barataria Bay apparently changed from saline to brackish marsh. Since this area straddles an established transect line, this must represent an actual change to a fresher marsh type during the 10-year interval, although the cause is not apparent.

Based upon the recent study of habitat change within the Mississippi River deltaic plain (Wicker et al. 1980), land loss rates within the Barataria Basin were derived. Detailed areal measurements for each of the habitats as they existed in 1955 and 1978 were available for the institutional Louisiana Coastal Zone (approximately the lower two-thirds of the basin at that time). The individual habitat classifications were lumped into land and water categories. That portion of the basin not within the 1978 Coastal Zone was digitized on a quadrangle basis for the 1955 and 1978 periods and only the land and water categories were delineated.

The Barataria Basin, which contains a surface area of about 1,500,000 ac (2350 sq mi), shows a net loss of 110,000 ac (171 sq mi) of land between 1955 and 1978. In terms of annual loss rates, this translates to 4800 ac per year (7.5 sq mi per year).

Based upon the derived land loss values over the entire study period, a land loss isopleth (contour) map was generated (Figure 2-2). From this map, the geographic distribution of critically-deteriorating areas can be easily visualized. Land loss has been confined to wetland areas and marsh areas in particular. Highest rates of land loss occur in the saline and brackish marsh categories (Plates 1 and 2). Even within the fresh and intermediate marshes, however, between 1000 and 2000 ac of marsh per topographic quadrangle have disappeared between 1955 and 1978. While perhaps the bulk of the marsh loss can be attributed to widespread subsidence and an associated "accretion deficit" (Delaune et al. 1978) because of insufficient sedimentation, saltwater intrusion is an additional significant factor in the land loss process.

Fisheries Resources

The Barataria Basin contains in the neighborhood of 400,000 ac of water bodies in the form of ponds, lakes, and bays (Chabreck 1972). These aquatic environments, ranging from the highly saline waters near the Gulf of Mexico to totally fresh areas such as Lac des Allemands in the upper basin, provide nursery grounds, migration corridors, and resident habitat for a diverse sport and commercial fishery of tremendous magnitude, as shown by commercial harvest records of several species. Catfish and bullhead (Ictalurus sp.) harvest from the basin, principally from Lac des Allemands and Lake Salvador, averaged 1,227,300 pounds annually from 1963 through 1976 (USACE 1982). Harvest estimates for the estuarine dependent fish and shellfish, including

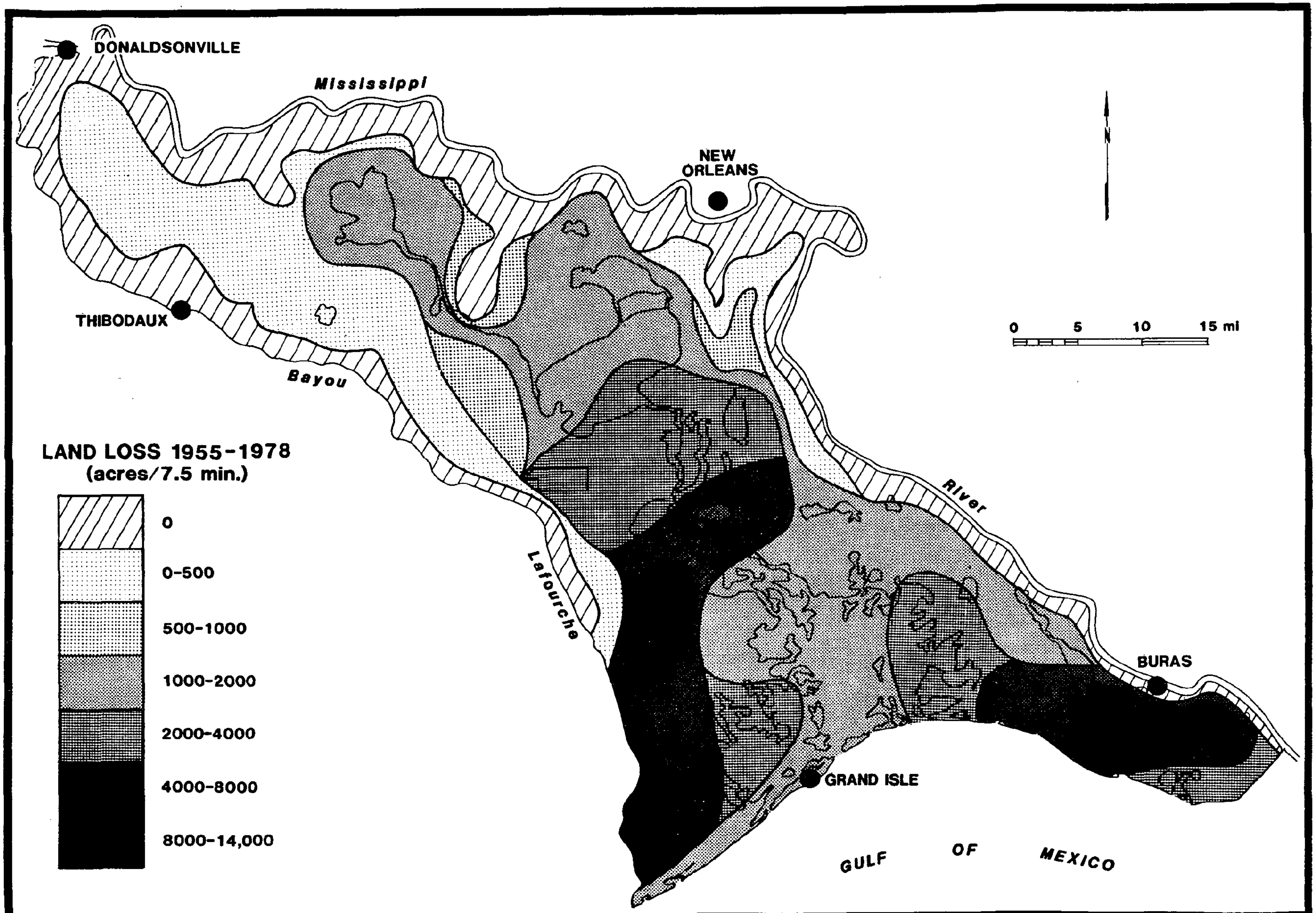


Figure 2-2. Land loss rates in the Barataria Basin between 1955 and 1978.

menhaden (Brevoortia patronus), shrimp (Penaeus sp.), American oyster (Crassostrea virginica), Atlantic croaker (Micropogon undulatus), blue crab (Callinectes sapidus), spotted trout (Cynoscion nebulosus), spot (Leiostomus xanthurus), and red drum (Sciaenops ocellata), are shown in Table 2-2 (USACE 1982). Although some of these species spend only part of their life history stages within the estuary, the total average annual harvest attributable to the Barataria Basin was over 300 million pounds valued in excess of 75 million 1981 dollars based on landing records from the years 1963-1978. Menhaden were harvested in greatest numbers at 225.8 million pounds, while shrimp held the greatest value at 45 million 1981 dollars (USACE 1982). The oyster harvest was the second most valuable fishery in Barataria, with an annual average value estimated at near $15 million based on average price for the years 1976-80 (Table 2-2).

Lac des Allemands is the most important area in the Barataria Basin for production of catfish. Rotenone samples taken in 1961 by Louisiana Department of Wildlife and Fisheries (LDWF) personnel revealed a standing crop of 213.5 pounds of fish per acre, of which 194.5 pounds were catfish. Lantz (1970) reported standing crops ranging from 78.0 to 211.7 pounds of fish per acre during three years of sampling. The increase in standing crop in the last year of sampling by Lantz (1970) was due in part to a movement of catfish into the lake from adjacent areas.

Evidently, as water salinities increased to brackish conditions in late spring and early summer, catfish tended to move out of the Lake Salvador area through Bayou des Allemands into the fresher Lac des Allemands, thereby increasing fish standing crops (Lantz 1970). In a study of the nekton communities of the upper Barataria Basin by Chambers (1980), the channel catfish (Ictalurus punctatus) comprised the largest percentage of total biomass sampled (29%) of either freshwater or estuarine species. It was second only to the bay anchovy in terms of number of individuals caught and occurred from the freshwaters of Lac des Allemands in the upper basin all the way to Bayou St. Denis south of Little Lake (Chambers 1980). Important freshwater sportfish in Lac des Allemands include yellow bass (Roccus mississippiensis) and black crappie (Pomoxis nigromaculatus); largemouth bass (Micropterus salmoides) and bluegill (Lepomis macrochirus) occur within canals in the adjacent fresh marsh (Lantz 1970).

Table 2-2. Average Annual Commercial Harvest [a] and Value of Major Estuarine-Dependent Fisheries (From USACE 1982)

SPECIES	BARATARIA BAY
Menhaden	
Harvest [c]	225.81
Value [d]	12.60
Shrimp	
Harvest	22.23
Adjusted Harvest [e]	42.26
Value	45.05
Oyster	
Harvest	4.05
Adjusted Harvest [f]	10.13
Value	14.79
Croaker [g]	
Harvest	15.25
Value	0.82
Blue Crab	
Harvest	3.56
Value	1.10
Seatrout [g]	
Harvest	2.70
Value	0.47
Spot [g]	
Harvest	2.88
Value	0.14
Red Drum	
Harvest	0.36
Value	0.16
TOTAL	
Harvest	277.84
Adjusted Harvest	302.95
Value	75.13

Source: U.S. Department of Commerce, National Marine Fisheries Service. General canvas catch by water body and species for the years 1963-1978.

a/ Harvest refers to total recorded commercial catch of a particular species from an area. The catch from offshore waters was assigned to inshore areas based on the relative abundance of estuarine marsh habitat.

Table 2-2 Concluded

b/ Catch from Chandeleur and Breton Sounds were disaggregated on the basis of estuarine marsh habitat and nursery grounds. A significant portion of that catch was landed in Mississippi, Alabama, and Florida.

c/ Millions of pounds.

d/ Millions of 1981 dollars. Value for all species except oysters represent a running average of 1974-1978 exvessel prices brought to 1981 price levels using the CPI Food Index. For oysters, due to atypical data for the year 1975, the average price was calculated for the period 1976-1980.

e/ Reflects 200% increase of period inshore only landings, based on surveys conducted by Louisiana Department of Wildlife and Fisheries (C. J. White, communication, letter dated 23 April 1979).

f/ Reflects 150% increase in reported landings, based on Mackin and Hopkins (1962) and Lindall et al. (1972).

g/ Includes food fish and industrial bottomfish. Quantities of croaker, spot, and seatrout calculated after Lindall et al. (1972).

The majority of the commercial fisheries in the Barataria Basin are centered around the estuarine dependent finfish and shellfish populations that use the wetland system as a nursery ground. Many of these species of important sport and commercial value spawn in the Gulf of Mexico, and their postlarval and juvenile stages enter the estuary through tidal passes. Sabins (1973) identified a cold water and a warm water assemblage of larval and juvenile fishes in the Caminada Pass area. The cold water fauna occurred primarily from November through April when mean water temperatures in the pass were below 20°C, while the warm water fauna occurred primarily from May through October when mean water temperatures were above 20°C. Members of the cold water fauna included spot, Atlantic croacker, and Gulf menhaden that spawn in the Gulf and occurred in peak abundance in Caminada Pass, in December, December, and April, respectively, as postlarvae (Sabins 1973). The bay anchovy (Anchoa mitchilli) and spotted sea trout were included in the warm water fauna and spawn in and near the passes. They occurred in peak abundance as postlarvae in June and August, respectively (Sabins 1973). The red drum was listed as an intermediate species that spawns in the shallow Gulf near the passes and occurs as postlarvae in peak abundance in October.

Brown shrimp (Penaeus aztecus) and white shrimp (Penaeus setiferus) spawn in the open Gulf and enter the estuary at the postlarval stage of development. Major peaks in abundance of postlarval brown shrimp in Barataria Bay occur between February and April in most years (Gaidry and White 1973), while peaks occur in June through August for white shrimp (Fish and Wildlife Service [FWS] 1980).

The postlarval forms of these finfish and shellfish species enter the estuary through the tidal passes with the movements of tides and shore currents. As growth and development proceeds with rising water temperatures, the juvenile and sub-adult forms ascend the estuary into the water bodies and marshes that serve as nursery grounds. Marshes and associated water bodies function as nursery grounds by providing essential food and cover requirements to promote rapid growth and enhance survival rates. The extent to which these juvenile forms ascend the Barataria Basin into the low salinity or freshwater areas seems to differ among species.

Simoneaux (1979) reported significant usage of the freshwater areas in the Barataria Basin as nursery grounds by menhaden. During sampling, menhaden were found at every station from Bayou St. Denis south of Little Lake to Lac des Allemands and were among the most abundant species found in the estuary (Chambers 1980). According to Simoneaux (1979), of 8900 menhaden taken during regular sampling trips, over 4100 were taken in freshwater areas that included stations in or near Lake Salvador, Lake Cataouatche, and Lac des Allemands. The Atlantic croaker also showed definite usage of the freshwater areas as nursery grounds, although not to the degree of menhaden (Chambers 1980). Spot and spotted seatrout were caught in much smaller numbers during sampling but tended to use water bodies associated with brackish and saline marshes as nursery areas (Chambers 1980).

Blue crabs tend to use the entire estuary during their life cycle. Peak abundance of juveniles has been associated with low salinity waters of less than 5 ppt (Lindall et al. 1972). After copulation in low salinity waters, females migrate back to open Gulf habitats for spawning (Lindall et al. 1972). Blue crab usage of freshwater areas in the Barataria Basin was documented by Chambers (1980), although the catch rate in the brackish-saline waters was higher than at the freshwater stations (Daud 1979). The brackish-saline waters were the major habitat for the juvenile crab stage, while samples from the fresher habitats tended to be comprised by somewhat larger, older individuals (Daud 1979).

Brown and white shrimp utilize a wide range of salinities in the nursery grounds. Although optimum salinities for nursery habitat for brown shrimp have traditionally been put in the range of 10-20 ppt (Barrett and Ralph 1976, Barrett and Gillespie 1973), Smith (1979) reported significant usage of low salinity waters in Barataria Basin by brown shrimp as well as white shrimp. In the study by Smith (1979), when water temperatures were above 20°C, brown shrimp distribution was not strongly controlled by salinity fluctuations in the low salinity to brackish zone. He concluded that the low salinity wetlands in Barataria provide important nursery grounds for both brown and white shrimp and that the penetration of low salinity waters is not always greater by postlarvae of white shrimp than postlarvae of brown shrimp (Smith 1979). As pointed out by Gaidry and White (1973), however, temperature may be an important factor in limiting shrimp distribution. Water temperatures present in the estuary after ingress of shrimp postlarvae in the spring can affect growth rate and possibly survival rates. In years in which temperatures remained below 20°C for weeks after ingress of shrimp postlarvae, subsequent shrimp harvest was low (Gaidry and White 1973). Thus, the number of days after the first week of April in which water temperatures remain below 20°C has been cited as an important criteria affecting growth and survival of postlarvae (Barrett and Gillespie 1973, Ford and St. Amant 1971, FWS 1980). A summary of pertinent information regarding environmental parameters affecting some important sport-commercial, estuarine dependent fish and shellfish has been compiled by FWS (1980) and is shown in Table 2-3 with associated references.

The Barataria Basin has been termed the most highly productive biological system in Louisiana (Lindall et al. 1972). It becomes obvious that the entire range of marsh types and salinity zones contribute to this high productivity by serving as important nursery grounds for the valuable commercial and sport fishery species. The freshwater wetlands, which have been shown to be preferred habitat for many wildlife species, also have been documented as important nursery habitat. Thus, the complete range of habitats, marsh types, and salinity zones must be maintained in order to insure the functional integrity of the Barataria wetland complex.

At an average of $15 million per year, production of oysters in the Barataria Basin is second only to shrimp in the value of the harvest. Because of the complexity of the oyster industry, a separate literature review and synthesis of available information is presented on the following pages.

Successful oyster production requires the enhancement of positive environmental conditions and the elimination of negative environmental conditions (Galtsoff 1964). Oysters are euryhaline organisms that can tolerate a wide range of water salinities, but specific salinities are favorable for various life stages. Adult oysters can tolerate salinity ranges of 5-30 ppt. Where average salinities are lower than 10 ppt, oyster mortalities are excessive if freshwater flooding is prolonged, especially during warm weather. Lower salinities also inhibit the reproductive capability of oysters. Where average salinities are high, reproduction is high, but oyster mortalities are often excessive due to higher incidences of predation and disease.

Oysters also tolerate a wide range of water temperatures (33° to 90° F) and are called "poikilothermic organisms." Temperature is a major factor in the oyster's environment in that it influences many of the oyster's activities, such as feeding, water transport, respiration, gonad development, and spawning (Galtsoff 1964).

Table 2-3. Pertinent Information Regarding Key Environmental Parameters Affecting Important Estuarine-Dependent Fishes and Shellfishes.

Species	Spawning Location	Peak Spawning Period	Period of Peak Juvenile Abundance	Optimum Salinity	Critical Salinity and/or Temperature Relationships
American Oyster	on oyster grounds (sessile)	May-September; peaks when temperature is 27°C	May-September	5-15 ppt for seed oysters; 10-25 ppt on bedding grounds; above 10 ppt for reproduction	exposure to salinity less than 5 ppt when temperature greater than 20°C causes mortality; Oysters subject to heavy predation by southern oyster drill at salinities above 18 ppt
Brown Shrimp	open Gulf	March-May	March-May	15-20 ppt best for for rapid growth of juveniles	salinities below 10 ppt and temperatures below 20°C occurring after first week of April lead to decreased growth and survival of post-larvae
White Shrimp	open Gulf	late spring-early summer, later fall early winter	main influx of post-larvae in June-August; smaller influx of over-wintering sub-adults in spring	0.5-10 ppt	growth of juveniles best at 20-35°C, growth negligible below 15°C
Blue Crab	copulate in low salinity waters; females migrate to waters greater than 21 ppt to spawn, usually in open Gulf or bays	June-August	January-March; June-July	peak juvenile catches below 5 ppt	inconclusive
Menhaden	Gulf	October-March	summer months	between 10 and 12 ppt	optimum catch in 23-25°C waters
Atlantic Croaker	offshore and deep passes	fall and winter	spring-summer	peak juvenile abundance less 5 ppt	inconclusive, greatest juvenile abundance 20-30°C
Spotted Seatrout	estuaries and lagoons	March-November peaks when water temperature between 22-25°C and where salinities are 34-36 ppt	data inconclusive; species in estuary entire year	5-20 ppt	abrupt decrease in salinity or temperature can cause mass movement to more saline areas
Red Drum	open ponds and along sandy beaches	September-January	data inconclusive species in estuary entire year	data limited; greatest catch in Louisiana is in 5-15 ppt range	extremes in temperature and salinity tolerated, sudden temperature drops (cold fronts) may cause mortality; greatest catch of juveniles in 5-15°C range

Source: FWS 1980

However, the exact cause-and-effect relationship between temperature and oyster behavior is complicated by other factors such as salinity, and temperature alone may not be the controlling factor.

The diet of oysters is composed of microscopic plants and animals (phytoplankton and zooplankton, respectively), bacteria, and organic detritus (van Sickle et al. 1976). Studies indicate that oysters require no more than 0.15 mg of utilizable organic matter per liter of water used (Jorgenson 1952) and that Louisiana waters contain sufficient food matter for existing populations (Owen 1955). Excessive rates of sedimentation inhibit oyster feeding and reduce the light supply, thereby inhibiting phytosynthesis and food production. It also makes surfaces unsuitable for veliger larvae attachment and can smother adult oysters.

Two of the most common pollution problems facing oyster production involve domestic sewage and industrial-trade wastes. The sludge from domestic sewage can smother oysters as well as reduce the dissolved oxygen supply, thereby impairing normal oyster functioning. The bacteria associated with domestic sewage can render oysters unfit for human consumption even though the oysters may not be impaired. Industrial and trade wastes can be immediately lethal due to their toxicity or can retard normal physiological functions.

Competition and commensalism from other organisms can have a negative impact on oysters through the competition for food and space. Organisms such as barnacles, mussels, and encrusting Bryozoans can affect market quality by reducing the oyster's fatness and making the encrusted shell bulky and the oyster difficult to shuck. Other organisms such as the boring clam, boring sponge, and mudworm weaken the shell structure, making the oyster susceptible to injury and lowering its market quality.

There are a number of diseases, both contagious and non-contagious, that either weaken or kill oysters. Contagious diseases traceable to pathogens and parasites can be destructive to oyster production. The most persistent pathogenic organism responsible for large numbers of mortalities in Gulf coast waters is the fungus parasite (Labyrinthomyxa marina, formerly named Dermocystidium marinum). The disease is lethal to oysters under conditions of high temperature, and the combination of high temperature and high salinity produce optimum conditions for the spread of the organism (Owen 1955).

The enormous array of animals that prey on oysters as a source of food include crustaceans, fish, molluscs, echinoderms, flatworms, birds, and mammals. Along the Gulf Coast, the most destructive predators, besides man, include the conches or oyster drills (Thais haemostoma haysae Clench), blue crabs (Callinectes sapidus Rathburn), stone crabs (Menippe mercenaria Say), and black drum (Pogonias cromis) (Hofstetter 1967). Of these, the drill is probably the most universally destructive and capable of exerting a large influence on the location of artificially cultivated oyster beds. Because of their great fecundity and the high survival rate of the larvae, this species multiplies rapidly in Gulf coastal waters. However, the drill is restricted to saline waters because a salinity as low as 10 ppt will immobilize it and exposures of 7 ppt for one or two weeks will kill it (Galtsoff 1964). Periodic flushing by freshwater during the year appears to be the only effective means to control this predator.

An analysis of the literature and maps of the distribution of oyster leases since the turn of the century indicates that the areal extent of water bottoms utilized for oyster production has increased in size and has expanded inland (LDWF 1982a, Tarver and Dugas 1973, van Sickle et al., 1976). In 1902, when the state assumed control of oyster leases, 223 people applied for leases covering 2,470 ac in coastal Louisiana (Figure 2-3). By 1982, 1,447 oyster producers had leased water bottoms totaling 236,331 ac (Plate 3). The average lease size expanded from 11 ac in 1902 to 163 ac in 1982. These statistics indicate that oyster production remains a profitable business in Louisiana but that oyster growers need more acreage to insure production success in any given year. It must be acknowledged that the expansion of lease acreage is made possible by technological advances in harvesting methods (motorized dredges, and transportation, i.e. hydrocarbon powered boats and trucks) to speed the catch to market.

It is interesting to note that despite the inland movement of salinity zones, which often devastates oyster production, leases nearer the coast have not been abandoned in favor of inland leases. The areas that were leased 80 years ago (Figure 2-3) are still leased today (Plate 3).

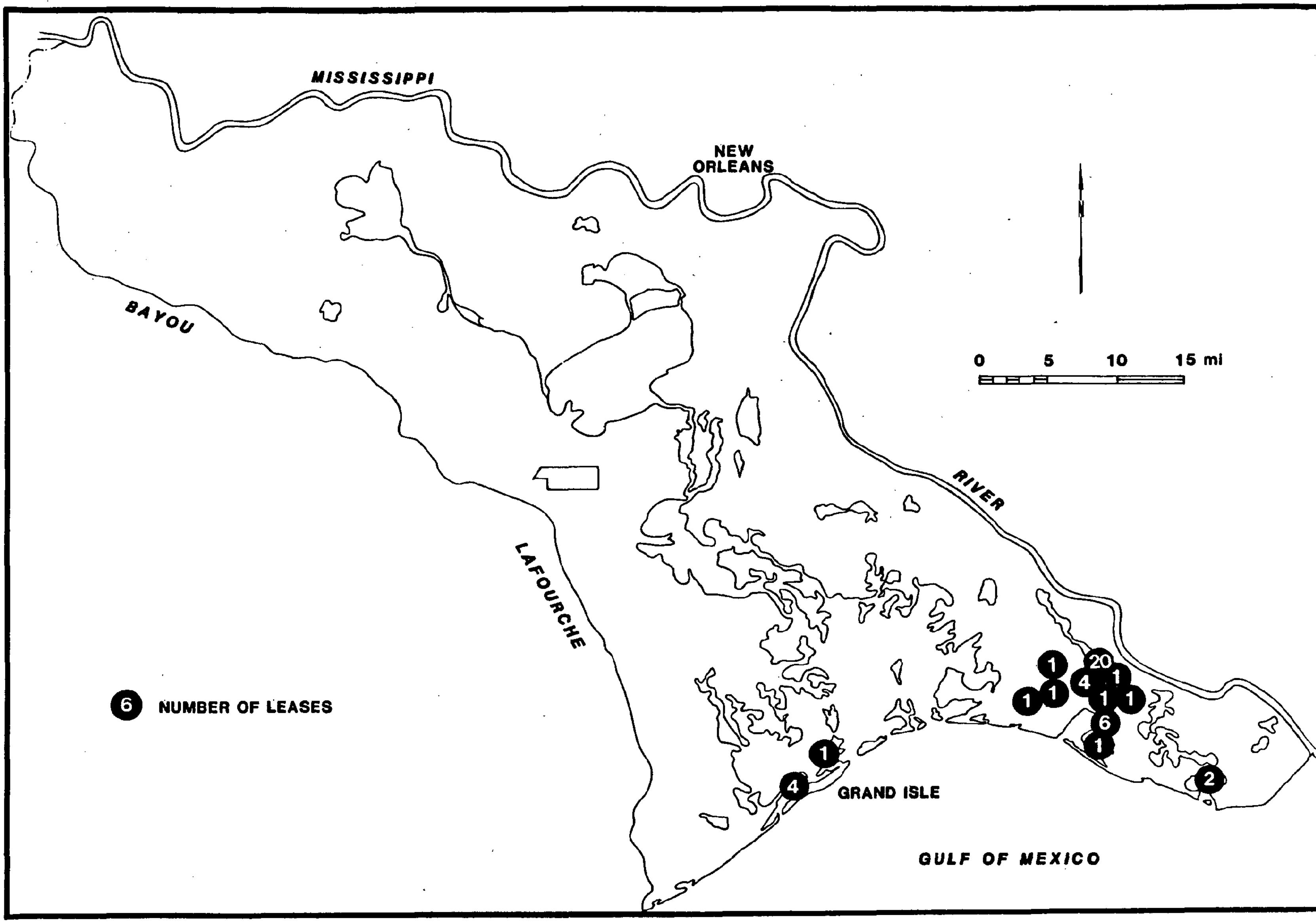


Figure 2-3. Leased oyster grounds in the Barataria Basin in 1902 (after Wicker 1979).

There were, and still are, several steps in the cultivation of oysters from seed. First the oysterman had to sail from his camp to public seed reefs where he could tong a boat load of small oysters. Upon returning to his private bedding grounds he would scatter the oysters evenly over the bottom. If the grounds were subject to predation by drum, they were often fenced to protect the newly planted seed. In 10 to 18 months the oysters were large enough to be retonged and culled for market. In the nineteenth century, oystermen would return to camp to cull their oysters (Vujnovich 1974). In the process of culling, dense clumps of oysters and shell were separated and placed in three or four piles according to size. The largest oysters were sold and the smaller ones were returned to the bedding grounds for further growth. The shells were saved for cultch, used to harden soft oyster growing bottoms, or deposited around the camp dwellings (Vujnovich 1974, McConnell and Kavanagh 1941, Waldo 1957, Zacharie 1897). Oysters that were to be sold as counter-stock underwent an additional step. They were placed in higher salinity areas a few weeks or months prior to marketing so that their meats would become firm and salty (Gates 1910). These oysters were usually served raw on the half shell in restaurants and oyster counters in New Orleans.

They were the highest grade of oyster grown in Louisiana and commanded the highest price. It was this quality of oyster that became well known in Louisiana and is closely associated with oyster cultivation by persons of Yugoslavic origins in the vicinity of Bayou Cook.

The southern portion of the Barataria Basin was not put into extensive oyster production as early as were the regions west of the Mississippi River near Bayou Cook-Adams Bay. While Moore (1898) noted several small productive reefs in the lower reaches of Barataria Bay at the turn of the century, Payne's later map (Figure 2-4) indicated only one area of highly productive oyster bottoms in Bayou St. Denis, by 1920. Overfishing and removal of shell substrate had rendered this formerly productive bay incapable of naturally replenishing oyster communities even though some spawn entered the area from the deeply scoured tidal channel communities that escaped harvesting (Moore 1898).

By 1920, saltwater intrusion into the lower, deteriorating Barataria Bay inter-levee basin had created unfavorable environmental conditions for natural reproduction and

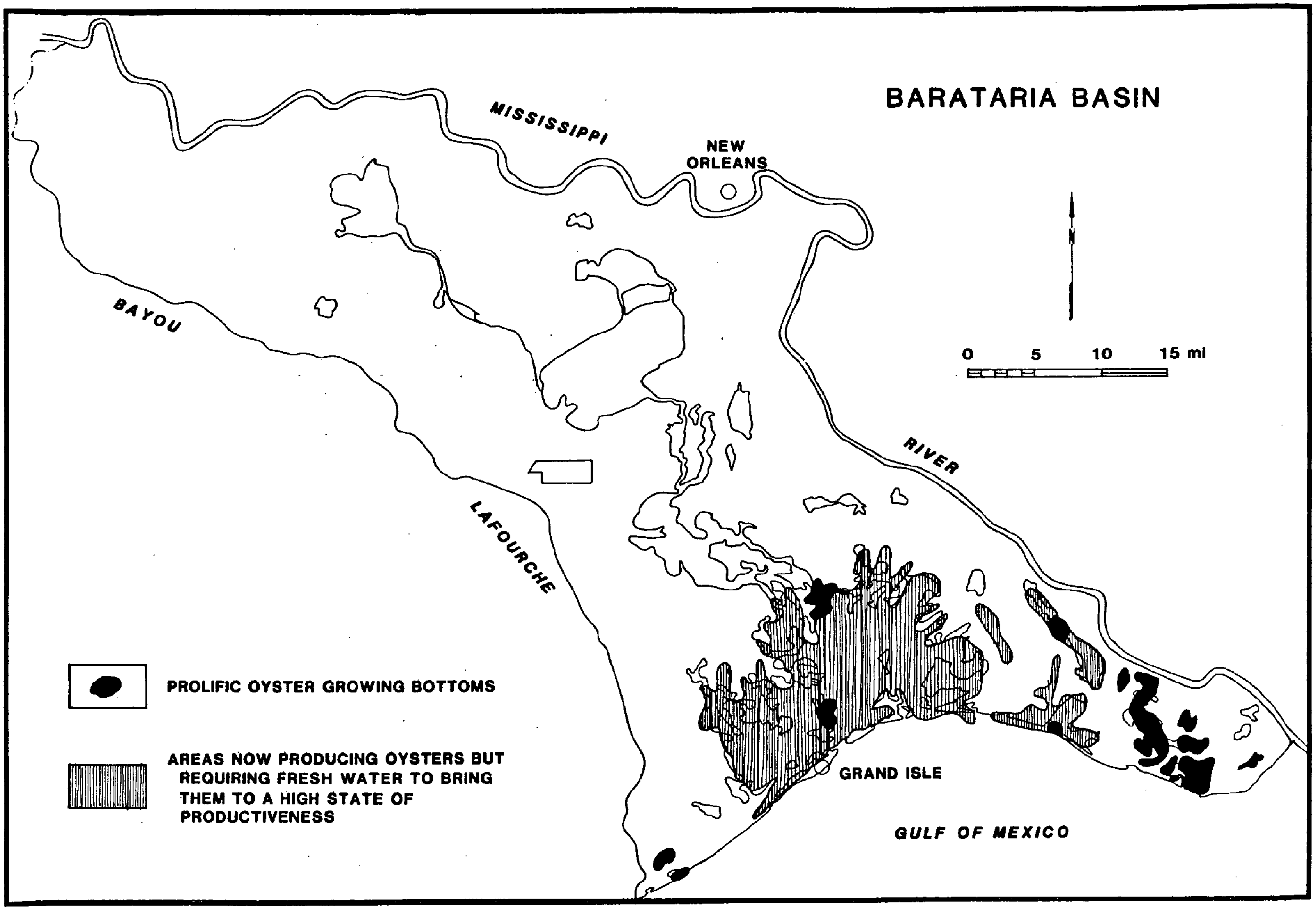


Figure 2-4. Condition of oyster producing areas in the Barataria Basin in 1920 (after Payne 1920).

growth. Payne (1920) indicated that the entire area could become highly productive once again if freshwater was introduced into the basin on a seasonal basis resembling that which occurred prior to artificial leveeing of the Mississippi River.

Earlier, experiments by Moore and Pope (1910) showed that salinity levels in the upper portions of the bay were favorable for creation of oyster communities, but the lack of naturally occurring, suitable substrate hindered establishment of these communities. Experiments in Bayou St. Denis indicated that in certain locations in the upper bay, oysters could strike successfully if given suitable cultch material and a sufficiently stable bottom. However, historically the upper bay was not a productive oyster growing region. It became so only after the 1910 Federally sponsored planting experiments showed that with cultivation techniques the area could produce large quantities of oysters. The lower bay, with its higher salinities, remained suitable for fattening and flavoring of nearly marketable sized oysters and continued to supply the raw shop and in some instances the counter trade.

A review of the oyster lease map for 1982 (Plate 3) indicates that the area of leased oyster bottoms in the Adams Bay-Bayou Cook region continues to expand into newly eroded, shallow water bodies despite the high salinities. However, major concessions must be made to the present environmental conditions. Instead of depositing cultch to catch spat, oystermen plant 1- to 3-in seed oysters that can be harvested in 3 to 5 months depending upon the buyer (i.e. whether he wants small oysters for canning or large oysters for the counter trade) (Dugas 1977). Seed oysters are usually gathered for replanting on private leases in the early fall and reharvested for sale in the late winter. If the oysters are left in higher salinity waters throughout the following summer, high mortalities are common due to oyster drill predation and fungus infection (Dugas 1977). This oyster harvesting scenario is common to virtually all oyster leases in the higher salinity zones (over 15 ppt) in coastal Louisiana.

According to personnel in the Survey Division of the Louisiana Wildlife and Fisheries Commission, oyster growers, if they can afford extensive leases, often locate their leases in environments with varying salinity conditions in order to minimize losses in any given year. For example, oysters on leases in lower salinity areas may be destroyed by freshwater flooding one year, while oysters on leases in high salinity areas may survive with little mortality from drills or disease because of the temporarily low salinities. Conversely, in drier years, oysters in low salinity areas will survive, while those in the normally higher salinity areas may be devastated by drills and disease. The more long-term, successful Louisiana oyster growers are probably those that recognize the dynamic nature of the oyster growing environments in Louisiana and protect their interest by responding to changes in the salinity regime on a seasonal and yearly basis. However, a major problem that all growers face when planting oysters in inland waters of lower salinity is that these areas are closer to residential and commercial development. As such, these grounds are subject to pollutants discharged from developed areas, and the grounds may be closed to commercial harvest.

Hydrology

The Barataria Basin, designated as Hydrologic Unit IV of coastal Louisiana, has been the subject of numerous hydrological studies in recent years. The results of some of these studies will be discussed here in a conceptual framework to describe the general hydrologic regime of the basin.

The basin resembles an inverted funnel that slopes seaward from a narrow upper end, gradually widening to the junction with the Gulf of Mexico. It can physiographically be divided into upper, middle, and lower sections by LA 90 and the Intracoastal Waterway, LA 45, respectively. The lower basin is further subdivided into eastern and western sections by the Barataria Waterway (Plates 1 and 2).

The upper basin is characterized by high natural levees that have mostly been cleared for agriculture and that surround a central area of wooded swamps. Extensive drainage canals have been built to increase the rate of runoff from the agricultural fields with concommitant increases in sediment and nutrient loading to receiving streams and Lac des Allemands (Kemp 1978). The response of the upper basin to rainfall is a rapid increase in discharge which returns to normal levels, usually within a week (Butler 1975). Spoil banks along the drainage canals tend to impound water in the swamp forest during times of low discharge and prevent overland flow during high discharge events. Hopkinson and Day (1980) found that in the Barataria Basin, overland flow through swamps is a significant route for runoff that is negated by construction of canals and spoil banks. Canalization of swamps may thus have decreased the rate of runoff from agricultural lands by containing it within channels while increasing the rate of eutrophication in Lac des Allemands and stressing the swamp forest. It has been calculated that the swamp forest is inundated 88.4% of the time (Bauman 1980, Conner et al. 1981). It is also possible that a combination of subsidence and impoundment is limiting the regeneration of seedlings that require dry conditions to germinate.

At present, freshwater surpluses generated in the upper basin flow down Bayou des Allemands into the middle basin. Because of the greater ratio of uplands to wetlands and open water, the upper basin acts as a source of freshwater flow that is stored in the large fresh marsh/open water area of the middle basin. Exchange of water between the middle basin and the lower basin is primarily related to meteorological events with astronomical tides being relatively unimportant. In Lake Salvador, the mean tidal range is essentially 0 (0.2 for 1971) due to a greater than 80% attenuation of tidal energy (Byrne et al. 1976). Mean monthly water levels for three stations in the middle basin show two peaks over the annual cycle (Byrne et al. 1976): a spring maximum and a fall maximum, which were attributed to freshets. Winter and summer minima were attributed to lowered Gulf of Mexico levels. A more plausible explanation is that the spring and fall peaks are primarily the result of water set-up due to strong southeast winds. This view is supported by the plot of mean monthly salinity at Lafitte (Figure 2-5), which shows the highest salinities of the year during the spring and fall. Especially during the fall, freshwater surpluses tend to be held back and stored in the fresh marshes of the middle basin. When there are small surpluses or deficits, brackish water intrudes because of the wind set-up. In the winter, predominant north winds cause the release of freshwater from the middle basin to the lower estuary, resulting in lower salinities at Lafitte (Figure 2-5). The pressure head created by heavy spring rains can often overcome the effect of wind set-up, resulting in freshwater release to the lower basin.

Within the lower basin, the influence of astronomical tides on water flux increases steadily from Lafitte to Grand Isle. Tidal dynamics in the Barataria Bay region have been discussed by Marmer (1948) and summarized by Byrne et al. (1976). It is important to note that the range of the tide is attenuated by 67% between Grand Isle and Lafitte, while the speed of the tidal signal progressing up the lower basin is reduced to one-third of the theoretical value (Byrne et al. 1976). Flushing power of

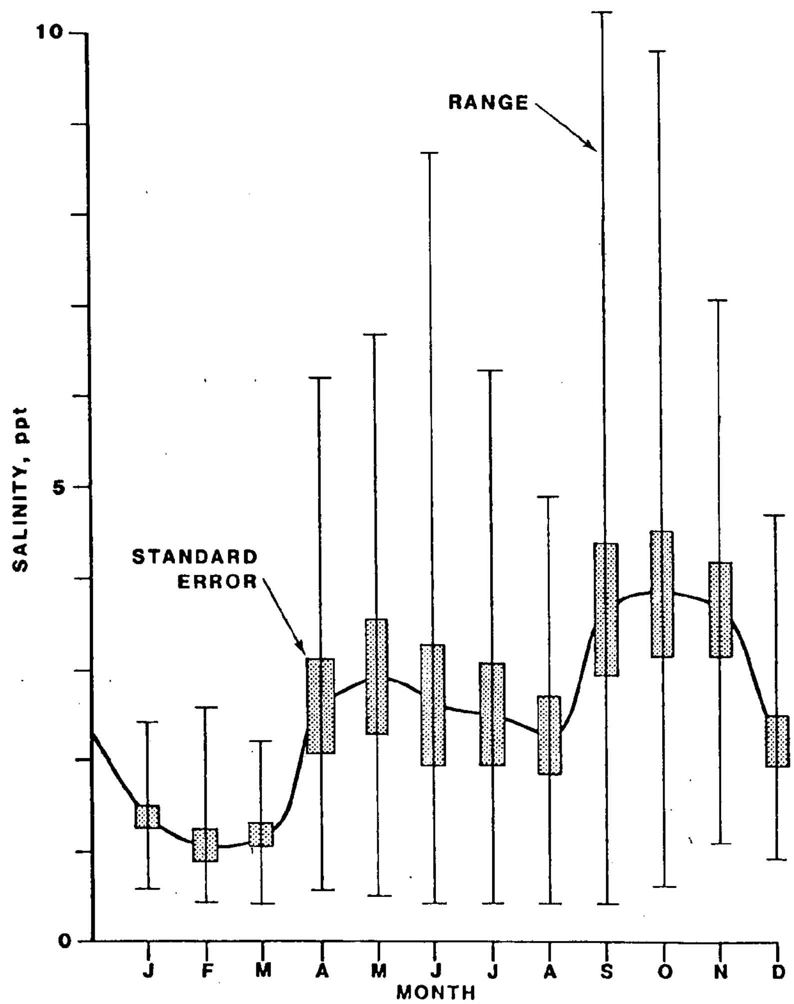


Figure 2-5. Mean monthly salinity, range, and standard error for Bayou Barataria at Lafitte, 1968-1979 (USACE 1982).

the tide is therefore progressively diminished within a short distance. Together with a larger freshwater surplus, this results in a much steeper salinity gradient than is found in Hydrologic Units I and II (van Beek et al. 1982).

The lower basin is segmented into western and eastern portions by the Barataria Waterway, an unnaturally deep navigation channel (Plate 2). Banas (1978) explains the effect of the channel on the salinity regime of the lower estuary as follows. Incoming saline waters from the passes should tend to move up the east side of Barataria Bay on a flood tide due to the Coriolis force, resulting in an east-west surface slope and a net flow of water from east to west over the tidal cycle. Data from release of drift bottles substantiates this phenomenon (Broussard 1982). The navigation channel, however, allows saline water to penetrate farther northward along the west side of the bay than occurred historically during a flood tide (Banas 1978). This would help to explain the large scale changes from brackish to saline marsh in the western half of the lower basin which are not paralleled by similar changes in the eastern half (Figure 2-1). Similarly, van Sickle et al. (1976) have reported a significant (0.108 ppt/yr) rise in salinity at the northern end of Barataria Bay.

The Coriolis force also appears to influence the path and distribution of freshwater flowing south from the middle basin. Discharge from Lake Salvador entering Bayous Barataria, Rigolettes, and Perot tends to be deflected to the west toward Little Lake, as evidenced by the large acreage of intermediate marsh extending far south on the western margin of the basin (Plate 2). The freshwater then flows through Grand Bayou and Bayou St. Denis and is intercepted by the navigation channel. Banas (1978) observed that the Barataria Waterway acts as a conduit for these southerly ebb flows.

The integration of these processes results in a very steep and seasonally variable salinity gradient between Barataria Bay and Little Lake on the western side of the lower basin with a flatter and less variable gradient on the eastern side. This difference can be seen in the plots of mean monthly salinity for St. Mary's Point (Figure 2-6) and Bay Batiste (Figure 2-7). Salinity at St. Mary's Point varies from a low of 10 ppt in May to a high of 18 ppt in November (Figure 2-6), while Bay Batiste salinity oscillates between 14 and 16 ppt throughout the year (Figure 2-7). The mean monthly ranges and standard errors are much wider for St. Mary's Point where large freshwater surpluses depress salinity and small freshwater surpluses allow saltwater intrusion.

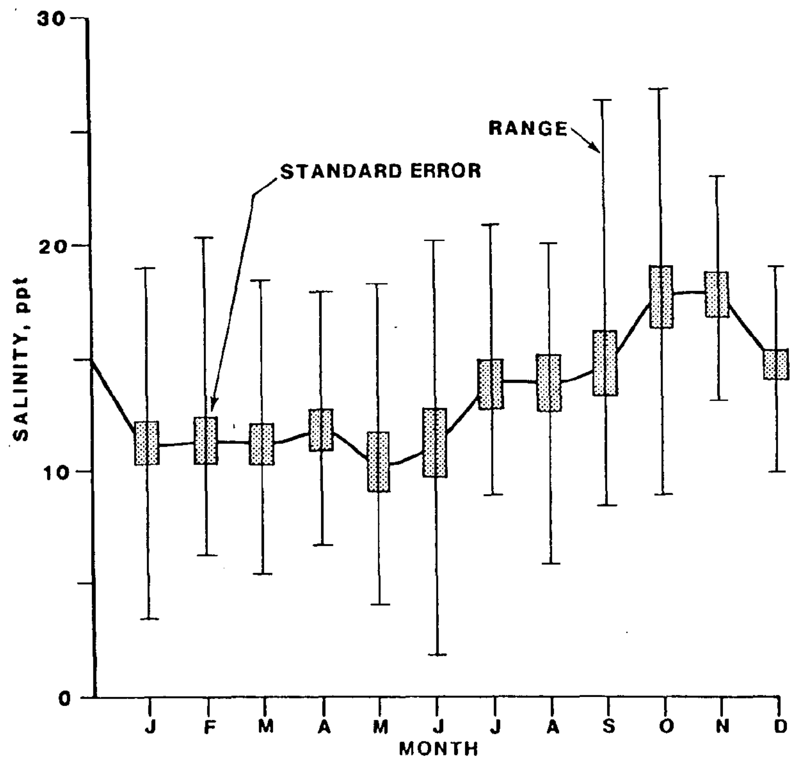


Figure 2-6. Mean monthly salinity, range, and standard error for St. Mary's Point, 1968-1979 (USACE 1982).

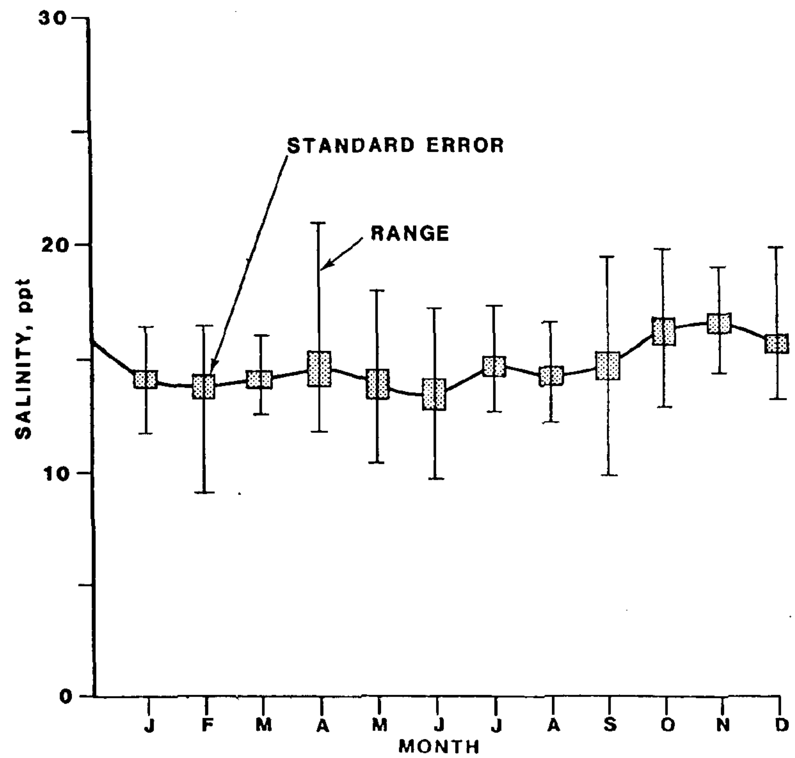


Figure 2-7. Mean monthly salinity, range, and standard error for Bay Batiste, 1968-1979 (LDWF, unpublished data).

CHAPTER 3: SALINITY GOALS FOR RESOURCE MANAGEMENT

During the last 25 years the Barataria Basin has experienced a trend of increasing salinity regimes within the marshes of this drainage basin. As a result of these increasing salinities, a net change to more saline marsh vegetation types occurred on 207.1 sq mi (17.2%) of the total marsh area in Barataria from 1968 to 1978 (Chabreck and Linscombe 1982). This was the greatest amount of change in terms of both square miles and percent of total marsh area of any hydrologic unit along coastal Louisiana during this 10-year period. Canal dredging, stream channelization, and a lack of inflow of freshwater were cited as the major causes of the saltwater intrusion and resulting vegetation changes. The major areas of change have been an increase in salt marsh at the expense of brackish marsh in the lower basin and a transition of fresh marsh to intermediàte marsh in the middle basin.

Upper Basin

The upper Barataria Basin has been delineated as that area lying above (i.e., generally northwest of) U.S. 90 and containing the majority of the baldcypress swamps in the basin, as well as fresh marsh in the Lac des Allemands and Lake Bouef area. The upper basin remains an essentially fresh wetland area without any evidence of salinity intrusion. With its large expanse of wooded swamps and fresh marshes, salinity goals here are to maintain these habitats as completely fresh and to allow them to act as a storage basin and filtering system for the runoff from adjacent uplands.

Middle Basin

The middle Barataria Basin has been delineated as that area lying between U.S. 90 and the Intracoastal Waterway below Lake Salvador. Most of this area has historically been fresh marsh habitat, but a substantial area around Lake Salvador has evidently changed to intermediate marsh since 1968 (Figure 2-1). Sampling during August of 1968 within the Barataria Basin revealed mean water salinity in the fresh marsh was 1.81 ppt with a range of 0.10 - 4.51 ppt (Chabreck 1972). Salinities in the intermediate marsh ranged from 2.67 ppt to 8.04 ppt with a mean of 5.42 ppt (Chabreck 1972), but only three samples were taken in this marsh type. These figures are somewhat higher than the normal ranges for fresh marsh (0-2 ppt) and intermediate marsh

(2-5 ppt) (Palmisano and Chabreck 1972). There are also indications that some of the baldcypress swamps adjacent to the fresh marshes, such as in the vicinity of Lake Cataouatche, are now showing signs of salinity stress. Salinity tolerance of baldcypress is not well understood, but there are indications that salinities exceeding 2 ppt in swamps for extended periods may eventually result in cypress mortality (Wicker et al. 1981).

Salinity goals for the middle basin are centered on reestablishing the fresh marsh around Lake Salvador where gradual transitions to intermediate marsh and higher salinity regimes have been noted. At the same time, the salinity regime should be such that the baldcypress swamps in the area are not in danger of stress from saltwater intrusion. Lake Salvador tends to act as a buffer between the higher salinity zones to the south and the fresh habitats to the north. In recent years salinities in Lake Salvador have at times crept into the brackish range, especially during low precipitation periods coupled with high tides and southeasterly winds. Salinity goals are to introduce freshwater so that salinities in Lake Salvador rarely if ever exceed 2 ppt for any extended period.

Lower Basin

The lower basin includes all of the Barataria Basin south of the Intracoastal Waterway, contains the greatest diversity of habitats, and exhibits the most complex hydrological and salinity conditions. Marsh types in the lower basin range from fresh to saline, with a variety of fish and wildlife resources inherent in each.

The greatest change in vegetation types in the lower basin between 1968 and 1978 was the transition of brackish marsh to saline marsh along the east and west margins of the basin flanking the Mississippi River and Bayou Lafourche, respectively (Figure 2-1). These major changes in marsh types in the lower estuary are symptoms of the general trend of marsh loss, saltwater intrusion, and encroachment of the Caminada-Barataria Bay system into areas formerly comprised of brackish marshes with lower salinities and less tidal energy. High rates of marsh loss have accompanied the transition from brackish to saline marsh, especially in the west (Figure 2-2), resulting in degradation of wildlife habitat, particularly furbearing mammals and waterfowl, over extensive areas. A major goal in the lower basin is to reestablish these brackish marshes to their former extent along the east and west margins of the basin. To accomplish this, the 15 ppt isohaline for the fall months must be moved gulfward to allow conversion to the brackish marsh type. This, however, may not take place unless the sediment input from the middle basin is enough to offset the marsh accretion deficit occuring due to subsidence (Baumann 1980).

The marshes surrounding Little Lake have historically shown a gradient of intermediate salinities on the north side (2-5 ppt) to high salinity brackish along the southern extremity (10-15 ppt). The recent salinity regime for a centrally located point in Little Lake is graphed in Figure 3-1. Although the monthly mean salinities are not excessive (1.5-6 ppt), the ranges are quite extreme for some months, including a maximum of 17 ppt for September. Such excessive salinity fluctuations make conditions extremely unfavorable for the establishment of important wildlife vegetative types. Usually those plants with wide salinity tolerances, such as wiregrass, are less valuable for wildlife. A goal for Little Lake is to moderate these extreme salinity fluctuations that decrease the value of this brackish marsh for wildlife and to move the 10 ppt isohaline seaward to produce conditions for low salinity brackish marsh (5-10 ppt).

The area just north of Bayou Perot and Bayou Rigolettes near Lafitte is at the present junction of the intermediate and brackish marsh with a trend of increasing salinities at Lafitte. Although monthly means are below 5 ppt for the entire year, maximums sometimes range in excess of 10 ppt (Figure 2-5). To insure that the intermediate marsh zone is not forced farther northward, mean monthly salinities should be held below 5 ppt at Lafitte and the extremes moderated.

As pointed out earlier, the estuarine fishery resources of the Barataria Basin are substantial and, taken as a whole, utilize the entire gradient of habitats from fresh marsh to saline marsh. Therefore, a primary goal of freshwater diversion is to preserve and maintain the complete range of habitats to insure the continued integrity of the system. The goals as outlined should insure that the diversity of nursery habitat required for all forms of estuarine fisheries organisms will be maintained. The oyster industry in the Barataria Basin, however, requires special salinity goals depending upon the season of the year and the particular area in question.

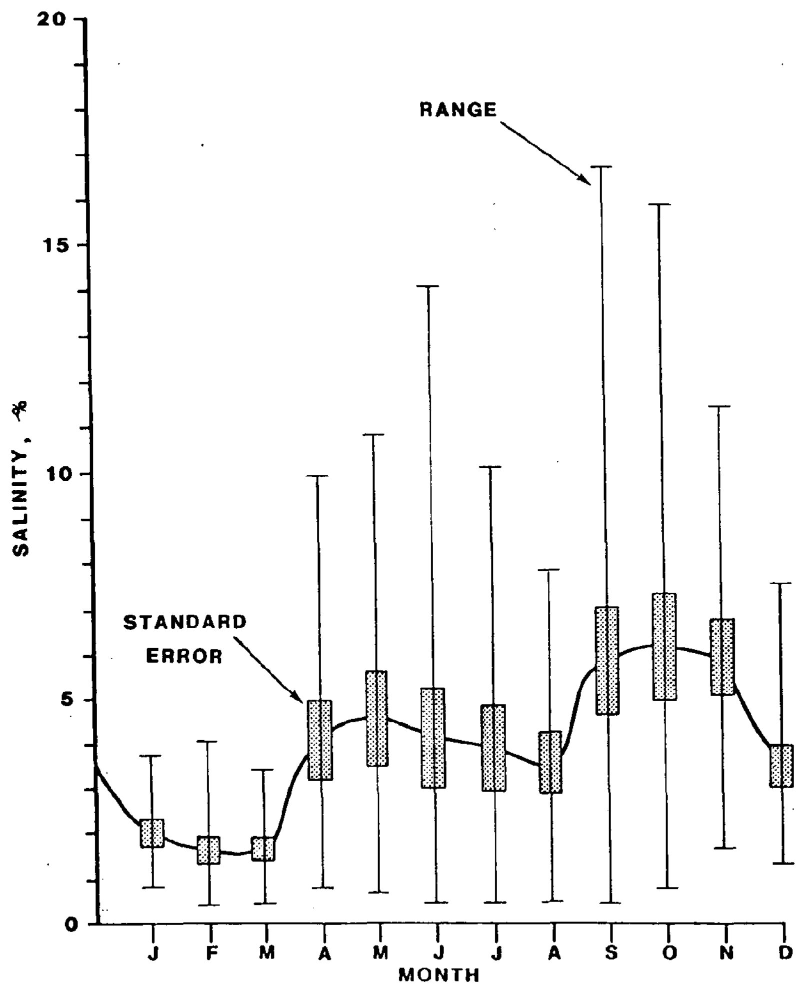


Figure 3-1. Mean monthly salinity, range, and standard error for Little Lake at Turtle Bay, 1968-1979 (LDHHR, unpublished data).

Commercial production of oysters depends to a large extent upon the successful establishment and growth of seed oysters 1 to 3 in long (see Chapter 2). In Breton Sound on the eastern side of the Mississippi River, a vast area of water bottoms is closed to private leasing and is maintained as public seed oyster grounds. This area produces 80% of the seed oysters in Louisiana. In the Barataria Basin, the only public seed grounds are located in Hackberry Bay (Plate 3). In addition, seed oyster production also takes place to a large extent on private leases where conditons are favorable. As discussed previously, an oysterman may lease water bottoms in different regions of the estuary to increase his chances of having ample seed for replanting from at least one of his leases or from the public grounds. Salinity goals for seed oyster production include a period of high salinity (greater than 15 ppt) and warm temperatures (greater than 27° C) in the summer and early fall for successful spawning, larval development, and spatfall (Table 3-1). After spat have become attached, it is desireable to lower salinities in the following spring to near 7 ppt for one or two weeks to kill the oyster drills that prey heavily on the spat. Figure 3-2 displays the annual salinity regime that has been recorded for good oyster years on the seed grounds in Breton Sound (LDWF 1982b). A worthwhile goal would be to mimic this salinity regime in Hackberry Bay and the surrounding smaller bays to establish a viable public seed oyster ground in the Barataria Basin.

Seed oysters that are transplanted to private leases are not usually as vulnerable to attack from oyster drills as spat and tend to have a more desirable flavor when the salinity is near 15 ppt or greater (Table 3-1). Salinity goals for the important commercial oyster grounds from St. Mary's Point eastward to Cyprian Bay would range from a low of 10 ppt in the spring to near 20 ppt in the late fall and early winter. Salinity below 15 ppt would reduce the incidence of disease and competition from fouling organisms, while allowing the salinity to approach 20 ppt near harvest time would ensure the desired flavor of the crop.

Table 3-1. Summary of Life History and Habitat Data for the American Oyster

Reproduction (spawning)	Larval Development	Larval Metamorphosis (Spatfall)
May - October Waters greater than 10 ppt and near 27°C	June - November Most favorable in waters of 25 ppt and 29°C; Growth inhibited below 12 ppt; No survival below 10 ppt	June - October Peak in late August in waters greater than 20 ppt and 29°C; No survival below 10 ppt
Seed Oysters* (1-3 in)	**Commercial Oysters* (greater than 3 in)**	**Adult Oysters***
All year Most favorable waters between 5-15 ppt	All year Most favorable waters between 10-25 ppt	All year General tolerance for waters between 5-30 ppt

* Oyster drill predation, incidence of disease, and competition of fouling organisms increase significantly for seed, commercial, and adult oysters when salinities exceed 15 ppt. Also, tolerance to salinities below 10 ppt is reduced when temperatures exceed 23°C.

Source: van Beek et al. 1982

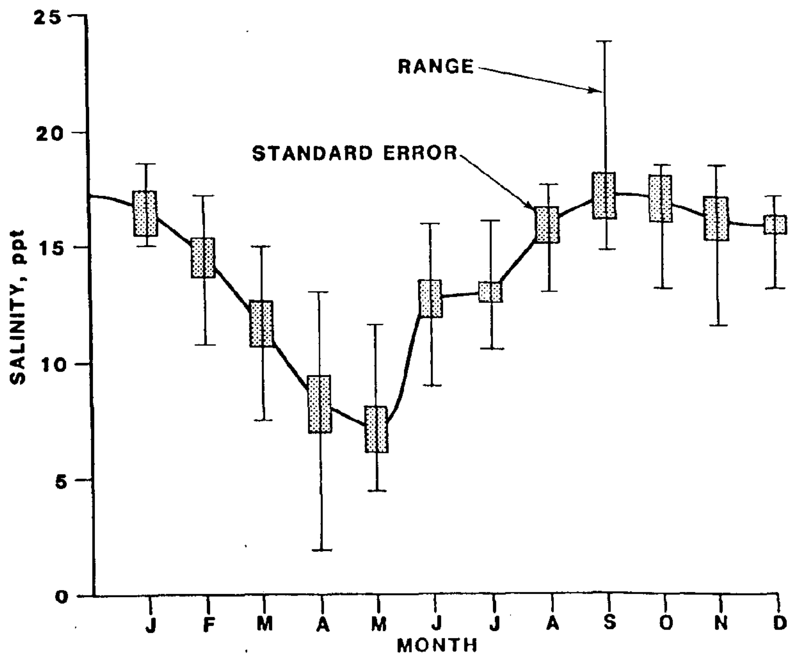


Figure 3-2. Mean monthly salinity, range, and standard error for good oyster years from stations on the public seed grounds in Breton Sound (LDWF 1982b).

CHAPTER 4: SUPPLEMENTAL FRESHWATER REQUIREMENTS

Methodology

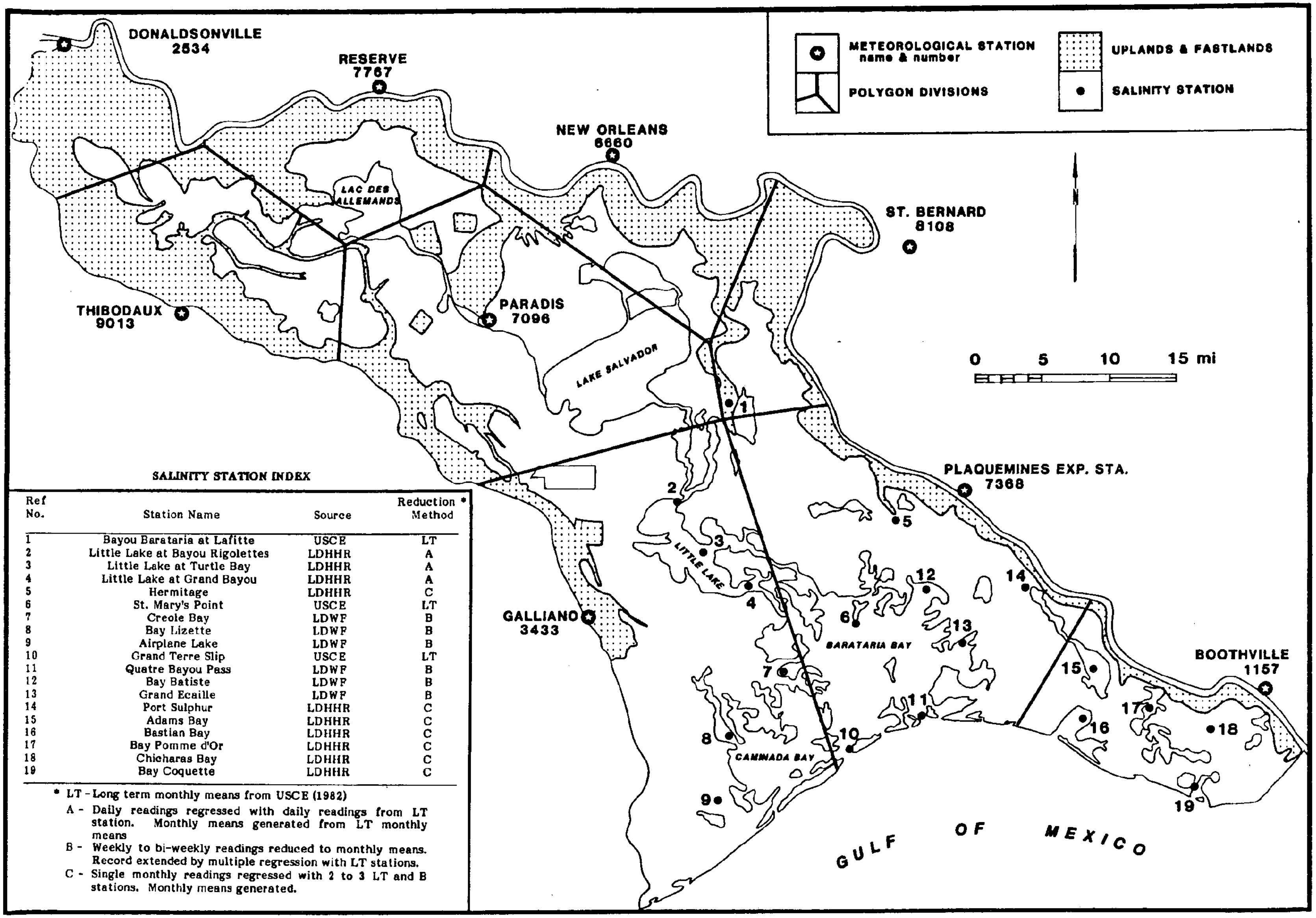
The methods used to estimate supplemental freshwater requirements for salinity control in Barataria Basin were essentially those employed in a previous, similar study of the Pontchartrain-Breton Sound estuaries (van Beek et al. 1982). Some minor modifications of the modeling process were made in the reduction of salinity data and the estimation of freshwater inflow.

Salinity Data

Salinity data were obtained primarily from three sources: USACE, New Orleans District; Louisiana Department of Wildlife and Fisheries (LDWF); and Louisiana Department of Health and Human Resources (LDHHR). Monthly mean salinities based on daily records were obtained from the Louisiana Coastal Areas Study (USACE 1982) for Bayou Barataria at Lafitte, St. Mary's Point, and Grand Terre Slip. Since these three stations had no missing data over the period of interest (1967 -1979), they were used to complete and extend salinity data for short-term and/or infrequently sampled stations.

Weekly to bi-weekly data were provided by the Seafood Division of LDWF for stations along the margins of Barataria and Caminada Bays. These data were reduced to monthly means, and missing data were generated through multiple linear regression from the long-term stations listed above (Figure 4-1).

Single monthly observations for a number of stations in the eastern portion of the study area were obtained from the Oyster Water Surveys of LDHHR. For most of these stations, multiple linear regression was applied using either long-term stations, LDWF stations, or both. Those stations that correlated poorly (R^2 less than .50) were eliminated. Monthly means were generated for stations that correlated well (R^2 greater than .50). The final salinity data set included mean monthly salinity values for 19 stations in the Barataria Basin extending from 1968 to 1979 (Figure 4-1).



SALINITY STATION INDEX

Ref No.	Station Name	Source	Reduction * Method
1	Bayou Barataria at Lafitte	USCE	LT
2	Little Lake at Bayou Rigolettes	LDHHR	A
3	Little Lake at Turtle Bay	LDHHR	A
4	Little Lake at Grand Bayou	LDHHR	A
5	Hermitage	LDHHR	C
6	St. Mary's Point	USCE	LT
7	Creole Bay	LDWF	B
8	Bay Lizette	LDWF	B
9	Airplane Lake	LDWF	B
10	Grand Terre Slip	USCE	LT
11	Quatre Bayou Pass	LDWF	B
12	Bay Batiste	LDWF	B
13	Grand Ecaille	LDWF	B
14	Port Sulphur	LDHHR	C
15	Adams Bay	LDHHR	C
16	Bastian Bay	LDHHR	C
17	Bay Pomme d'Or	LDHHR	C
18	Chicharas Bay	LDHHR	C
19	Bay Coquette	LDHHR	C

* LT - Long term monthly means from USCE (1982)

A - Daily readings regressed with daily readings from LT station. Monthly means generated from LT monthly means

B - Weekly to bi-weekly readings reduced to monthly means. Record extended by multiple regression with LT stations.

C - Single monthly readings regressed with 2 to 3 LT and B stations. Monthly means generated.

Figure 4-1. Meteorological and salinity stations used in the analysis of freshwater needs.

Freshwater Inflow Data

Mean monthly discharges of the Mississippi River were available from the previous Phase I study (van Beek et al. 1982) as was climatic data for stations throughout the basin (Figure 4-1). Since no discharge data was available for streams within the study area, freshwater inflow was estimated from a continuous daily water balance program described in the Phase I report. Because high ground within the basin is composed entirely of natural levee soils, a previously derived value of 6 in was used for total soil moisture capacity for each station. Monthly runoff and surplus totals were converted to freshwater volumes by multiplication with the area of uplands and wetlands, respectively, in each Thiessen polygon (Figure 4-1). Freshwater volumes were then converted to mean monthly discharge in cubic feet per second (cfs) for each polygon for the period 1968-1979.

The discharge estimates were not only summed to give one total basin discharge, but were also grouped according to distance from the Gulf of Mexico and other physical subdivisions within the basin in an attempt to improve the analytical value of the subsequent salinity models.

Generation of Salinity Models

The data for mean monthly salinity for 19 stations were merged with mean monthly discharge data by year and month for 1967-1979 to create a master data set. Initially, the basin discharge data were divided into upper, middle, and lower basin components. Mean monthly values of these three components as well as Mississippi River discharge were converted to logarithms. In addition, the discharge variables were lagged 0 to 6 months in the data set to test for the effects of water storage on salinities.

Linear regression analysis was performed on each of the three long-term salinity stations vs. each of the four groups of lagged discharge variables. The results indicated that the present and previous month discharges (0- and 1-month lags) were significantly correlated with salinity, while the 2- to 6-month lags of discharge were not significant. A multiple stepwise linear regression analysis was performed using the same 3 salinity stations and the 8 remaining discharge variables. The most influential variable for each station was the previous month discharge of the Mississippi River followed by present month Mississippi River discharge in some cases. Inconsistencies were found among the remaining variables. For example, salinity at Lafitte was correlated with the 1-month lag (lag 1) of middle basin discharge, with the lag 0 and lag 1 of upper basin discharge being eliminated from the model. For St. Mary's Point, the salinity was correlated with lag 1 of upper basin discharge and the middle basin variables were eliminated. These results were assumed to be artifacts of the division of discharge into upper, middle, and lower basin components.

Different combinations of the discharges (lag 0 and lag 1) for the four major hydrologic subdivisions in the basin (upper, middle, lower east, and lower west) were tried with the results being compared to a regression model using the intact total basin discharge (lag 0 and lag 1). The partitioning of discharge that gave the most significant correlation was the sum of upper, middle, and lower west basin discharges lagged 1 month and lower east basin discharge of the present month. These results agreed well with the literature cited in the conceptual discussion of general basin hydrology (see Chapter 2). The final forms of the freshwater discharge variables were, therefore, the logarithms of Mississippi River discharge lag 0 and lag 1 (MISSQ and MISSQ1, respectively), upper/middle/lower west basin discharge lag 1 (NORTHQ 1), and lower east basin discharge lag 0 (EASTQ).

From the Phase I report (van Beek et al., 1982), it was concluded that using the previous month salinity of the station as a variable improved the models by explaining the variability in salinity caused by antecedent conditions other than discharge. In attempting to repeat this procedure for the Barataria Basin, a correlation procedure was performed to detect co-linearity between salinity and the lagged and unlagged discharge variables. In the resulting matrix, a problem was identifed for one station. For Hermitage, both MISSQ and MISSQ1 were correlated with salinity. In order to include lagged salinity, MISSQ1 was eliminated from this model. No other co-linear variables were identified. EASTQ could not possibly affect salinity in the previous month, and since NORTHQ was eliminated from the models in stepwise regression, NORTHQ1 has an insignificant effect on the previous month salinity.

Models resulting from multiple linear regression on the four best variables are shown in Table 4-1. All of the models shown are significant at the 0.0001 level with R^2

Table 4-1. Statistical Models to Predict Mean Monthly Salinity in the Barataria Basin

STATION	R^2	LAG SALINITY A	MISSQ B	MISSQ1 C	NORTHQ1 D	EASTQ E	INTERCEPT F
Hermitage	.59	.457	5.067	0	1.476	2.040	45.74
Port Sulphur	.68	.498	0	5.766	1.226	1.570	50.64
Bay Batiste	.67	.487	0	3.205	1.289	1.075	34.25
Grand Ecaille	.67	.434	0	8.062	1.574	1.759	68.89
Adams Bay	.72	.479	0	7.565	1.443	1.590	62.26
Bastian Bay	.66	.430	0	9.468	1.659	2.065	77.11
Bay Pomme d'Or	.69	.484	0	8.664	1.218	1.639	66.30
Chicharas Bay	.67	.420	0	8.938	1.133	1.119	65.26
Lafitte	.62	.585	0	1.591	1.220	1.065	18.01
St. Mary's Point	.71	.473	0	7.521	2.498	4.064	72.72
Grand Terre Slip	.58	.414	0	8.591	1.725	1.226*	72.62
Bayou Rigolettes	.62	.585	0	1.551	1.190	1.039	17.79
Little Lake	.62	.585	0	2.603	1.996	1.743	29.39
Grand Bayou	.62	.585	0	3.977	3.049	2.662	44.92
Creole Bay	.52	.464	0	4.395	3.030	4.194	56.92
Bay Lizette	.62	.447	0	5.341	2.087	2.651	57.88
Airplane Lake	.57	.394	0	6.152	1.789	1.398	58.89

*not significant at .05 level

GENERAL FORM OF THE MODELS:

SALINITY = A (LAG SALINITY) - B(log MISSQ) -C (log MISSQ1) -D (log NORTHQ1) - E (log EASTQ) + F values ranging from 0.52 to 0.72. Models for Quatre Bayou Pass and Bay Coquette had R^2 values below 0.5 and were eliminated from the analysis at this point.

Estimating Freshwater Needs

Before the statistical models could be employed to estimate freshwater needs, it was necessary to determine monthly 50% and 80% exceedance values for the discharge variables. Values for the Mississippi River discharges were available from the Phase I report. Monthly 50% and 80% exceedance discharges for NORTHQ and EASTQ were obtained from the long-term water balance estimates using a Log-Pearson Type III distribution. These exceedance values are presented in Table 4-2. It was not assumed for this report that a whole year of 50% exceedance values constitutes an average discharge year. Each 50% monthly value is expected to be exceeded by a higher value one out of two years in that month. In order to generally determine the likelihood of having 12 consecutive months of 50% or 80% exceedance discharges, a percentile ranking of actual mean annual basin discharges for the period of record was constructed. Comparing the mean annual discharges from Table 4-2 with this ranking we found that a 50% exceedance year approximated the 70 percentile rank of the actual means (70% were higher) and the 80% exceedance year fell above the 99 percentile rank. Although these ranks do not equate to recurrence intervals, the test indicates that using consecutive months of 50% and 80% exceedance discharges in estimating freshwater needs tends to make the estimates liberal and provides a margin of safety with regard to maintaining desired salinities.

The model co-efficients for each station and the exceedance discharge values were entered into the computer and a program was written to execute the models in an iterative fashion whereby the resultant predicted salinity at a station was reentered as the lag salinity for the next monthly execution. Provision was made in the program to modify diversion discharge for each month within the constraints of Mississippi River stage. In this way the diversion discharge values could be increased until the salinity goals for a station were met.

Diversion discharges were entered into the program in the form of annual hydrographs based on Mississippi River stages for a particular exceedance criterion. The diversion

Table 4-2. 50% and 80% Exceedance Discharges in Cubic Feet Per Second for Variables Used in the Models

MONTH		MISSQ	NORTHQ	EASTQ
January	50%	437,979	4881	2280
	80%	272,734	3292	1538
February		521,614	5119	1847
		336,405	3362	1214
March		668,631	5156	2005
		493,048	3311	1288
April		734,914	4188	1936
		551,309	2338	1081
May		656,714	4899	1956
		495,012	3118	1244
June		471,647	3884	1474
		321,778	2389	907
July		357,094	5276	2002
		251,240	3938	1494
August		240,396	5099	2212
		177,952	3588	1556
September		189,274	4953	2313
		148,107	3169	1479
October		195,987	3384	1711
		136,173	1624	821
November		213,760	3897	2328
		144,931	2240	1337
December		300,209	5534	2235
		195,708	4023	1625

hydrographs are referenced in this report according to the maximum value in the hydrograph occurring under 50% exceedance discharge of the Mississippi River. The monthly variation in diversion discharge was obtained by applying a scaling factor to the diversion discharges for the Bonnet Carre site from the Phase I report (van Beek et al. 1982). Each of the diversion hydrographs were run for a minimum of 24 monthly iterations until the salinity values for the station stabilized to a recurring pattern. All 17 salinity stations were analyzed for both 50% and 80% exceedance conditions. The resulting predicted salinities for a particular station were first visually compared to the desired salinity range near the station until the general magnitude of diversion discharge was found. Then the mean spring and mean fall predicted salinities for each station were plotted on a map and isohalines constructed. A similar isohaline map was produced using predicted salinities for no-diversion conditions and for much larger diversions. These maps were analyzed to see if the goals had been met or if more freshwater was needed or warranted in view of obtained salinity reductions.

Results of Analysis

Critical salinity conditions for maintenance of marsh zones occur in the fall under 80% exceedance discharges. It is believed that much of the transition of the fresher marsh types to more saline types has occurred during times of infrequent, abnormally high salinities. Even though salinity regimes produced during 50% exceedance conditions will induce changes in marsh types to the fresher state, these would not be permanent. Conversely, for fisheries species that tend to produce an annual crop, the range between mean spring and mean fall salinities under 50% exceedance conditions is more important to recruitment and productivity.

Figure 4-2 displays the results of the models for the fall months under 80% exceedance discharges without diversion. Under these extremely dry conditions, the 5 ppt mean isohaline is at Lafitte and the 2 ppt isohaline extends northward beyond the coverage of the stations. Since these isohalines are means over a 3-month period, Lake Salvador would probably experience salinities greater than 5 ppt for short periods of time, leading to a change of intermediate marsh to brackish marsh. The same could be postulated for the 2 ppt isohaline and transition of fresh marsh north and west of Lake Salvador to intermediate marsh. The 15 ppt isohaline during this time extends from

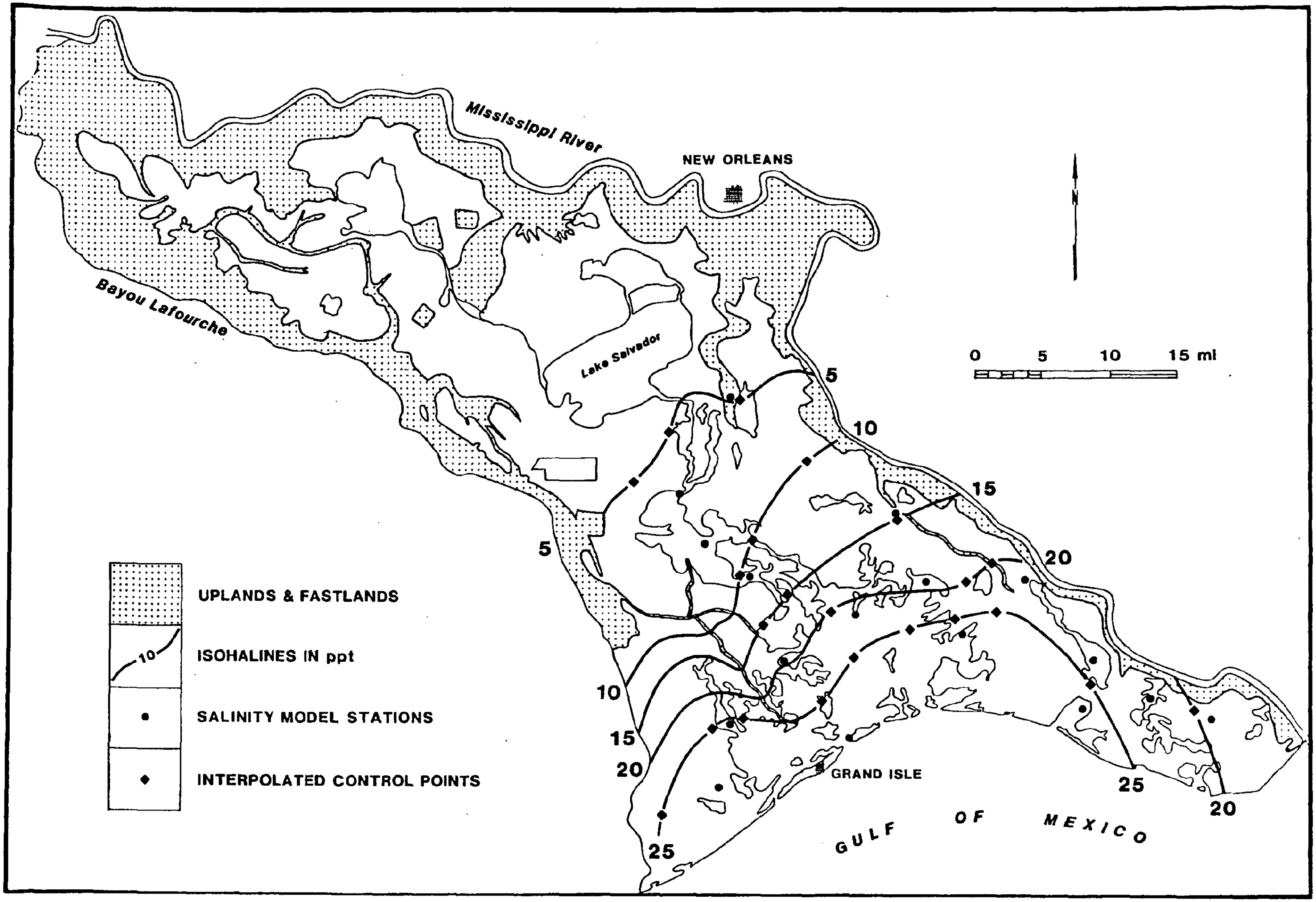


Figure 4-2. Predicted mean fall isohalines under 80% exceedance conditions with no freshwater diversion.

Hermitage (Lake Judge Perez) in the east through the central portions of Bayou St. Denis and Grand Bayou, tending to cause transition of brackish marsh to saline marsh in the vicinity of Roquette Bay and Upper Wilkinson Bay (Figure 4-2).

Predicted salinities for Lafitte and St. Mary's Point fell within the desired salinity ranges for attainment of the goals as the 50% exceedance diversion maximum reached 10,500 cfs. The mean fall predicted isohalines for 10,500 cfs diversion maximum and 80% exceedance conditions were plotted (Figure 4-3) for comparison with those in the absence of diversion (Figure 4-2). The 2 ppt isohaline associated with 10,500 cfs diversion conditions is located south of Lake Salvador, fulfilling the goal for protection and expansion of the fresh marshes fringing the lake. The 5 ppt isohaline lies south of Lafitte extending through the northern portion of Little Lake, meaning that the intermediate marsh north and west of Little Lake would be preserved and also that the brackish marsh encroaching along Bayous Perot and Rigolettes would revert to intermediate marsh. The 15 ppt isohaline was not displaced a great distance seaward with the 10,500 cfs diversion under these extremely dry conditions, as comparison of Figures 4-2 and 4-3 indicates. However, the isohaline does fall seaward of the demarcation between saline and brackish marsh on the west side of the estuary (Plate 2), which would translate into a change from saline marsh to brackish marsh in this area.

At this point, predicted salinities were generated for a 15,500 cfs maximum diversion. Mean fall isohalines for 80% exceedance conditions were plotted and projected onto the isohaline map for 10,500 cfs in Figure 4-3 to note the degree of improvement in salinity conditions. Additional seaward displacement of the 2 and 5 ppt isohalines was very minimal and did not exceed 0.5 mi at any point for the 48% increase in discharge. The displacement of the 15 ppt isohaline was even less. From these results it appeared that the 10,500 cfs diversion maximum approximated the point of greatest benefits per volume of freshwater diverted with regard to goals for marsh zones.

The predicted mean spring isohalines for 50% exceedance discharges without diversion were plotted to depict the existing low salinity spectrum of the basin expected to occur once in two years (Figure 4-4). It can be seen that the salinity regime is conducive to fisheries productivity for those motile species that utilize brackish and intermediate marsh as nursery grounds. At the same time, salinity along the northern

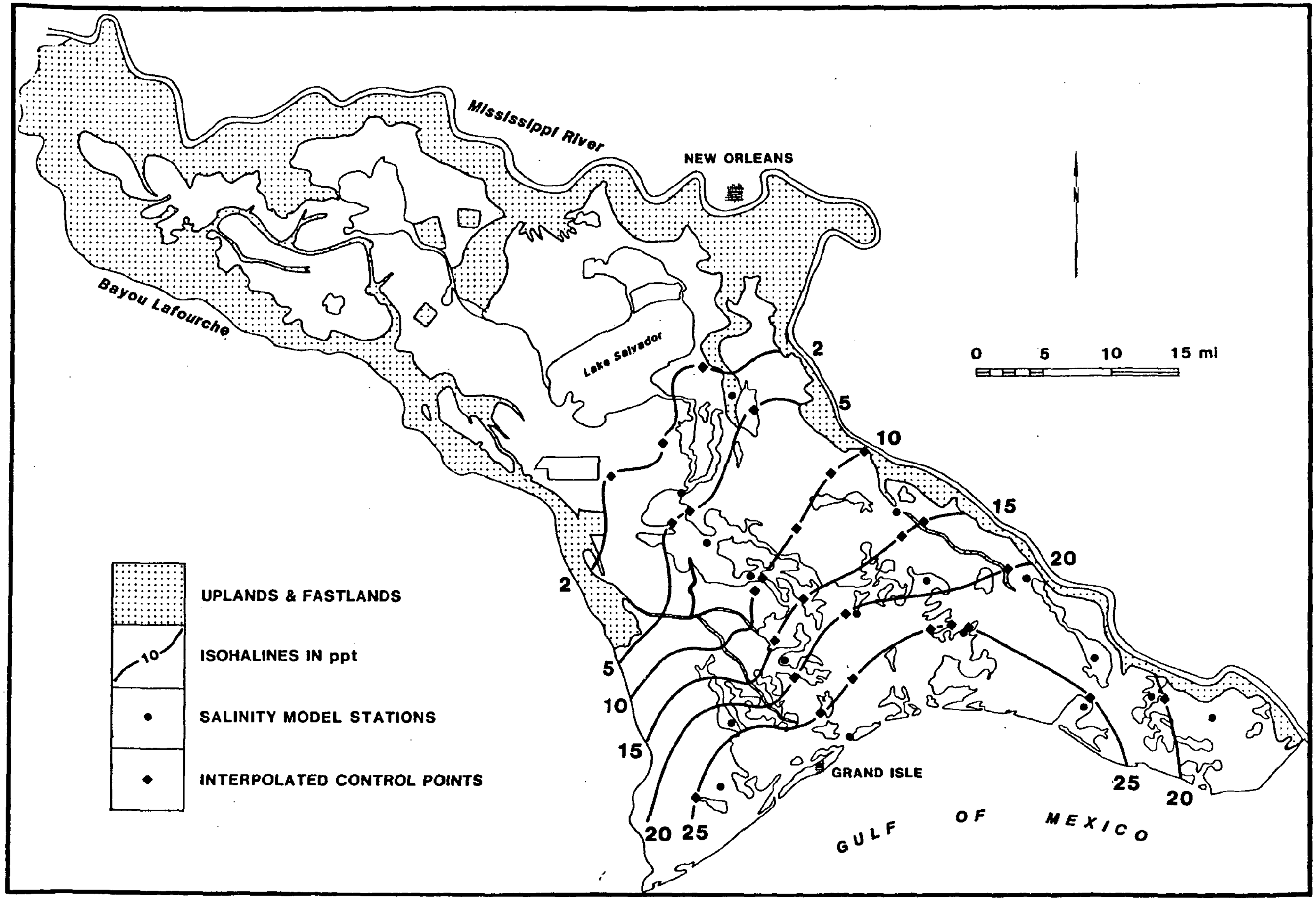


Figure 4-3. Predicted mean fall isohalines under 80% exceedance conditions with a 10,500 cfs maximum diversion.

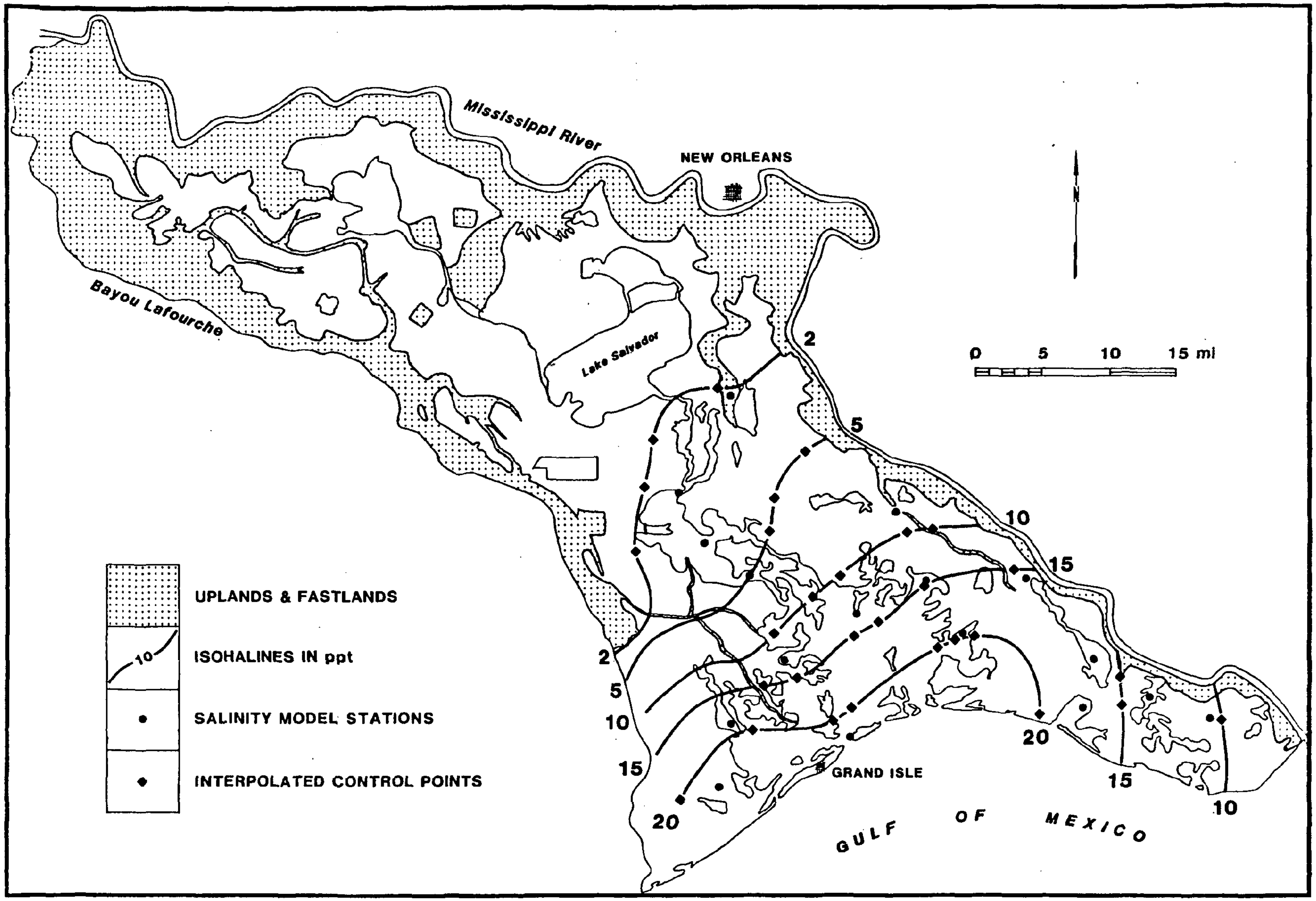


Figure 4-4. Predicted mean spring isohalines under 50% exceedance conditions with no freshwater diversion.

fringe of Barataria Bay is not low enough to diminish the population of the southern oyster drill, especially towards the east. Predation by the drills becomes a problem in years when there is not a period of low spring salinity to kill many of the reproductively mature individuals in the vicinity of the commercial oyster grounds.

Predicted mean spring and mean fall isohalines were mapped for 50% exceedance conditions and 10,500 cfs diversion (Plate 4). The mean spring 5 ppt isohaline is south of Little Lake and the 10 ppt isohaline runs along the northern fringe of Barataria Bay. Between these isohalines, drill populations would be eliminated or greatly reduced. This area includes the public oyster grounds in Hackberry Bay. Between the 10 and 15 ppt spring isohalines, the feeding activity and movement of the drills would be greatly diminished. These conditions would increase the production of seed oysters where the drills were eliminated and increase the survival rate of planted commercial oysters on the grounds in the eastern portion of the lower basin.

The results of all analyses indicate that a 10,500 cfs diversion maximum will satisfy the freshwater needs for the Barataria Basin. Table 4-3 lists the mean monthly discharges expected to occur during 50% and 80% exceedance discharges of the Mississippi River having a 10,500 cfs maximum diversion capacity.

Table 4-3. Freshwater Diversion Discharges from a 10,500 cfs Maximum Diversion for 50 and 80% Exceedance Conditions.

	50%	80%		50%	80%
January	9483	5879	July	7304	5040
February	9600	6432	August	5508	3360
March	9852	7980	September	3499	2519
April	10,500	8820	October	3651	2519
May	10,347	8484	November	6999	4199
June	9937	6856	December	8842	5040

CHAPTER 5: PROPOSED PLANS FOR FRESHWATER DIVERSION

The analysis of freshwater needs for the Barataria Basin in the preceding chapter suggests that a diversion structure capable of discharging 10,500 cfs during April under 50% exceedance flows in the Mississippi River could maintain an optimum salinity regime in the estuary. In the following section constraints will be analyzed to identify feasible sites for this size diversion. From these, the best site will be selected on the basis of positive ecological benefits to be provided other than reduction of salinities. A delivery system and outfall plan will then be formulated for the selected site.

Constraints for Freshwater Diversion

A variety of constraints preclude the emplacement of freshwater diversion structures at random sites along the west bank of the Mississippi River below Donaldsonville. Widths of natural levees, highly-populated urban areas, obstructions to overland flow and outfall, and inadequate canal infrastructure to funnel freshwater from the river to the wetlands are among the major constraints that must be considered.

Between Donaldsonville (river mile 175 Above Head of Passes [AHP]) and Luling (120 AHP), the limits of the upper Barataria Basin north of U.S. 90, most of the river stretches can be excluded from consideration for freshwater diversion (Plate 1). Between Donaldsonville and the Vacherie ridge (175 to 150 AHP), the width of the natural levee is about 2 mi. The wetlands behind the levee exhibit no saltwater intrusion problem. In fact, the removal of excess water from drainage of agricultural fields has been considered desirable in this area. Between 150 and 145 mi AHP, the dense urban buildup of the Vacherie area provides a constraint. Between 138 and 120 mi AHP (from Edgard to Luling), LA 3127, a four-lane, on-grade highway built along the edge of the backswamp, provides a constraint to diversion structure construction. The most feasible stretch is between 145 and 138 AHP. Rural settlement is fairly dense along the river road, but nonetheless a potential site has been identified by the USACE in this area. However, local opposition to this site and the fact that the upper basin is not presently experiencing increasing salinities makes this site less desirable.

Downriver of Luling, the urban area of New Orleans, poses constraints to freshwater diversion possibilities. Between about 115 and 118 AHP (just upriver of the St.

Charles/Jefferson Parish boundary), the natural levee is narrow and settlement is moderately dense, except in the vicinity of the Davis Crevasse of 1884. Diversion would be feasible here, especially since saltwater intrusion has affected marshes directly south of this point. Between miles 115 and 70 AHP, the urban and industrial build-up of greater New Orleans precludes diversion along this stretch.

South of New Orleans, the natural levee ridge becomes quite narrow. Back levees have been constructed along practically the entire length from New Orleans to Venice. In many areas, back levees have been extended further into the marsh for the purpose of reclamation and agricultural expansion. Wetland deterioration behind the back levees is characteristic of the entire length, particularly along the southernmost reaches below about 50 AHP (Plate 2).

Between about 70 and 64 AHP, the upland zone is relatively narrow. Hydrologic constraints, primarily spoil banks of oil and drainage canals, limit optimum diversion sites to the reach between 68 and 66 AHP. Between 64 and 49 AHP, the natural levee uplands have been widened by reclamation. Drainage canal spoil banks (outside of the back levees) offer hydrologic constraints, although several existing drainage canals, perpendicular to the river, could perhaps be modified and utilized for diversion of river water. Such canals are located at river miles 59, 52, and 49 AHP. However, utilizing the canal at Point Celeste (52 AHP) may have negative impacts on the recreational community of Hermitage (Lake Judge Perez).

Between Point a la Hache (49 AHP) and Port Sulphur (39 AHP), a number of feasible diversion sites exist. Several drainage canals could be utilized. Existing land use exhibits some constraints, such as between miles 45 and 43 where the fishing/trapping community of Grand Bayou and recreational settlement along Martins Canal would be impacted, but hydrologic factors may prove to be the deciding factor. Numerous rig cut canals may affect flow patterns, and the Bayou Grand Chenier ridge is a major obstacle to flow in a southwesterly direction.

Below 39 AHP, diverted freshwater would have little effect on the salinity regime of the remainder of the basin, although many feasible sites exist for smaller scale diversions such as siphons. Based on physiographic constraints, feasible sites for large-scale diversions are limited to the following river mile locations: 145 to 138, 118 to 115, 68 to 66, 59 (Plate 1), 52, and 49 (Plate 2).

Diversion Site Selection

Environmental elements, other than salinity, that will be affected by freshwater diversion include water temperature, suspended sediment concentration, dissolved mineral and nutrient loads, coliform bacteria populations, and levels of other polluting agents. Suspended sediments and dissolved minerals and nutrients can, in most cases, be considered as beneficial by-products of salinity reduction because of their contribution to the maintenance of wetland substrate elevation and enhancement of primary productivity. However, when these are introduced directly into open water areas, by-passing the marsh, siltation of navigation routes, smothering of oysters, and eutrophication can result. In addition, equilibration of water temperature and amelioration of pollutant concentrations is difficult to attain unless diverted waters are allowed to spread over a large expanse of wetlands prior to entry into estuarine open waters.

For these and other reasons, it is better to locate diversion sites toward the upper end of the estuary. In this way, the freshwater and its constituents come into contact with more wetland acreage before eventually entering the Gulf of Mexico. Steep salinity gradients and abrupt temperature changes are less likely to occur because the receiving waters in the upper estuary are normally of lower salinity and temperature. Freshwater input into the upper end of the estuary should therefore result in a more natural salinity gradient. Finally, diversion structures can be smaller and work for a longer period of the year if located upstream on the Mississippi River where stages are higher.

With this in mind, the feasible diversion sites downstream from New Orleans (below 70 AHP) become less desirable for a single diversion of this magnitude when compared to those upstream. Of the stretches of river upstream from New Orleans where diversion is feasible (145-138 and 118-115 AHP), the Davis Pond site at 118.5 AHP offers the greatest possibilities for constructive outfall management. As mentioned earlier, the Bayou Lasseigne site at approximately 141 AHP was initially considered by the USACE, New Orleans District, for freshwater diversion under the Louisiana Coastal Areas Study (USACE 1982). Aside from opposition from local commercial fishermen in Lac des Allemands, three additional elements combine to make the Davis Pond site a better choice than the Bayou Lasseigne site. First, the Bayou Lasseigne site would require a much longer delivery channel to carry the discharge across the natural levee. Second, drainage from the upper basin and diverted freshwater would have to be discharged under U.S. 90 at one point. To accomplish this, it is likely that Bayou des Allemands would have to be dredged to accommodate the additional flow. Finally, Lac des Allemands and vicinity is not presently experiencing salinity intrusion or severe land loss. The lake is experiencing eutrophication and gradual infilling. Sediment input from diverted water would tend to settle out in the lake, speeding the eutrophication process. More importantly, suspended sediment would not reach past Lake Salvador to the deteriorating marshes where it is needed the most. For these reasons, a freshwater diversion plan was formulated for the Davis Pond site.

Freshwater Delivery and Outfall Plan

The proposed plan for freshwater diversion is shown in Figure 5-1. This plan is very similar to the final plan adopted in the Louisiana Coastal Areas Study after abandonment of the Bayou Lasseigne site (USACE 1983). At river mile 118.5 AHP, a delivery channel extends from the diversion structure to U.S. 90 (6000 ft) with a containment levee on each side. Two bridges are shown where the channel crosses the Southern Pacific railroad and U.S. 90. South of the highway, the delivery channel extends 7400 ft, terminating in a large shallow lake formerly occupied by fresh marsh. The western segment of the containment levee continues southward from U.S. 90 to the southern edge of a natural ridge and thence westward to the Willowdale subdivision (Figure 5-1). From this point, the containment levee proceeds southward to the edge of the Bayou Cypriere Longue ridge and follows the ridge southeast to the Louisiana Cypress Lumber Canal. From U.S. 90, the eastern segment of the containment levee follows the south bank of a borrow canal before turning south along the Sellers Canal and Bayou Verret to Lake Cataouatche. The eastern and western sections of the containment levee are joined along the edge of the lake to enclose an outfall management area of about 9500 ac.

Location of the containment levees is dictated by foundation conditions and the need to minimize the impact of diversion on local drainage. East of the diversion structure, the natural levee will be drained by gravity flow to the borrow canal, Sellers Canal, and Bayou Verret. These waterways must be dredged to facilitate better drainage. West of the diversion structure, existing residential developments and lands slated for residential development are presently under forced drainage (Figure 5-1). The Corps of Engineers' plan calls for construction of a new, large capacity pumping station at

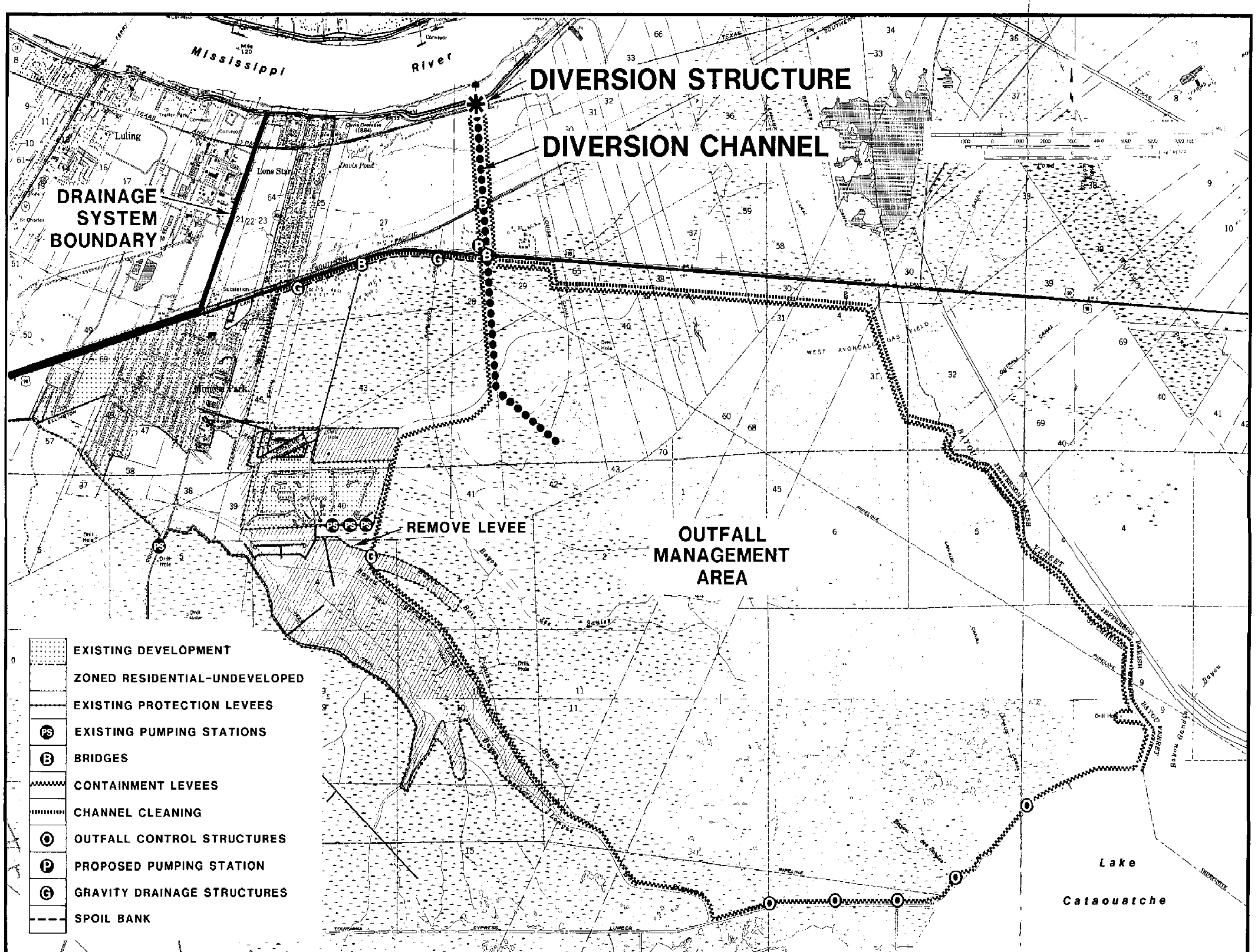


Figure 5-1. Proposed plan for a 10,500 cfs maximum diversion structure at the Davis Pond site, 118.5 AHP.

the intersection of the delivery channel and U.S. 90. In this plan, a pumping station is also proposed. However, the containment levee in this plan would exclude from the outfall area 1130 ac of bottomland hardwoods and swamp that would otherwise have either been immediately drained by the new pump or subjected to abnormally high water levels from the diversion structure. Instead, this area (which includes 75 ac of zoned residential land) would be isolated from the forced drainage system by a low spoil bank created by the dredging of the Peterson Canal and the U.S. 90 borrow canal (Figure 5-1). Gravity drainage control structures would be installed in the spoil bank at the King Canal and Garland Canal. During storm events, this wetland area could be used as a storage basin for runoff in excess of the pumping capacity. Whenever existing development is not in danger of flooding, the control structures could be opened to slowly remove excess water.

In this plan, the existing pumping station outfall from the Willowdale subdivision would be blocked by the containment levee. This would necessitate removal of the section of levee shown in Figure 5-1 to redirect this drainage toward the Cousin Canal pumping station, which will have a lessened load after construction of the new station. In addition, 39 ac of leveed ridge would be isolated by the containment levee. With a gravity drainage structure in place, this area could possibly serve as a park for the future residents, perhaps with launching facilities into the outfall area.

The 9500 ac outfall area is to be managed by constructing five 200-ft-long weirs at intervals along the southern reach of the containment levee (USACE 1983). The crest of the weirs should optimally be at 1 ft below the surrounding marsh level or lower to maintain the existing marsh while retaining sediments in the open water areas. However, any fixed weir height is destined to become lower relative to marsh level as sediments build up within the outfall area. This may have significant management implications. Channelization and natural levee formation will eventually occur in the area and be related to the location of the weirs. It may be advantageous to consider varying the height of the weirs to influence channelization in a preferred direction or to include provisions for stop-log bays or for weir crest additions in the future.

It is anticipated that water levels in the outfall area during maximum diversion (10,500 cfs) will vary from approximately 3 ft above marsh surface near the mouth of the delivery channel to +0.5 marsh level near the weirs. Fine sands and silts will be deposited near the mouth of the delivery channel, initially filling the large, shallow lake system that was formerly fresh marsh. Natural levees will tend to form quickly near the outfall and will slowly prograde along scour channels through the broken marsh. The existing natural ridges and channels will greatly affect channel and natural levee formation. The main channels are expected to form eastward toward the Lanaux Canal following the course of least resistance. It may be desirable to construct the easternmost outfall weirs, those bordering the lake, slightly higher to help distribute the discharge around the existing ridges and southward (Figure 5-1).

CHAPTER 6: PREDICTED RESULTS AND POSSIBLE IMPACTS

Vegetation and Wildlife

The diversion of freshwater from the Mississippi River into the Barataria Basin will modify seasonal salinity regimes so that substantial transformations will be likely to occur in marshes from one vegetative type to another. Marshes in the vicinity of Lake Salvador that had undergone transition from fresh to intermediate salinity types since 1968 will be restored to the fresh marsh type (Plate 5). Fresh marsh will extend below Lake Salvador south of the Delta Farms area. By maintaining salinities within Lake Salvador less than 2 ppt essentially at all times, the baldcypress swamps in the upper basin will be protected from salinity stress and the forested wetlands along the swamp-marsh ecotone should benefit from the fresher regime with a renewed health and vigor. The intermediate marsh type will be shifted somewhat to the south and will extend down to the northern edge of Little Lake (Plate 6) with no appreciable increase in acreage. South of Little Lake, the brackish marsh type will expand into extensive areas that are presently salt marsh but were formerly brackish and that have been subject to severe intrusion of saline waters (Plate 6). The projected shifts in marsh types as a result of freshwater diversion will to a degree, but not entirely, reverse or offset the trend of salinity encroachment and marsh type change as observed between 1968 and 1978 (Figure 2-1). The majority of the marsh transition is expected to occur within the western portion of the Barataria Basin (Plate 6) with little change expected to occur in marshes flanking the Mississippi River. Because of the Bayou des Familles ridge, which tended to hydrologically separate the eastern section of the basin; the Barataria Waterway that is a present hydrologic barrier; and the action of the Coriolis force, salinities have historically been fresher in the western portion of the lower basin. The net result of the diversion, then, will be a transition of marsh habitat to fresher vegetative types, particularly in the middle and lower basin.

There is indication that the input of waters from the Mississippi River, with its high nutrient content and load of fine, suspended sediments, will, to some extent, increase marsh primary productivity and generally improve health and vigor of the vascular plant communities (FWS 1980), although this has not been well substantiated. By increasing productivity and reducing salinity regimes, freshwater diversion should also retard land loss rates in the basin in which marshes are undergoing rapid transition to open water. However, because all coarse sediments will be allowed to settle in the outfall management area, little or no actual marsh building can be expected to occur. With ongoing subsidence and sea level rise, marsh loss will continue, but at a significantly reduced rate.

Wildlife resources within the Barataria Basin should benefit from the lowered salinity regime and transition of marsh to fresher types. Renewed plant vigor and increased productivity should generally result in greater wildlife productivity. Palmisano (1973) indicated that fresh marsh produced greater average harvests of many furbearers including nutria, mink, raccoon, and river otter. In brackish marshes, nutria and muskrat production is high when three-cornered grass is the dominant plant, but otherwise this marsh type is relatively poor for nutria and only fair for muskrat. Fur harvests are dependent upon a number of parameters of which salinity is only one and localized management techniques are possibly at least as important as any other factor. However, fur productivity in a general sense should be improved by the transition to fresher marsh types. Some areas of marsh in the Barataria Basin have experienced severe marsh breakup and land loss, particularly around Little Lake (Figure 2-2). Such marsh areas usually experience higher tidal regimes that may make it difficult to manage for plant communities preferred by wildlife and, therefore, may not be benefited as much from the lowered salinity regimes.

The increase in extent of fresh and intermediate marsh will benefit waterfowl resources. In southeastern Louisiana, these marsh types can winter over 80% of the dabbling duck population which may approach 2,000,000 (Palmisano 1973). The reduced land loss rate due to freshwater diversion will also benefit waterfowl populations including resident nesting species such as the Mottled Duck.

The Barataria Basin can also expect an increase in alligator populations. In the Deltaic Plain, densities in 1977 were estimated at 1 alligator per 4.6 hectares (ha) (11.4 ac) in fresh marsh, 1 per 2.7 ha (6.7 ac) in intermediate marsh, and 1 per 5.7 ha (14.1 ac) in brackish marshes of salinities less than 10 ppt, according to data from McNease and Joanen (1978). Alligators are not common in marshes with salinities greater than 10 ppt and, therefore, the area of potential alligator habitat should be increased substantially with freshwater diversion. Harvest of alligators average 10 animals per 1000 ac in fresh-intermediate marshes and 5.71 animals per 1000 ac in brackish marshes with a net monetary value of $982.50 and $561.00 per 1000 ac, respectively (FWS 1980). Thus, an increase in the potential economic value of marshes from fur and alligator harvest can be expected with diversion.

Fisheries Resources

The proposed freshwater diversion plan will have a net beneficial impact to fisheries resources in the Barataria Basin. Within the upper and middle basin, freshwater fish, especially the commercially important channel catfish, will be greatly benefited. Catfish harvests should increase tremendously in Lakes Cataouatche and Salvador where now the majority of the catch comes from Lac des Allemands. The blue crab fishery in Lakes Cataouatche and Salvador may be displaced somewhat to the southern portion of Lake Salvador with extension of optimum blue crab habitat into the northern end of Little Lake.

Low water temperature is not expected to pose problems to postlarval brown shrimp as a result of diversion. Based on general estimates of flow velocity, diverted water will have a residence time within Lake Salvador of one to two weeks under maximum flow. By that time, water temperature will have stabilized to the ambient level of the estuary. Estuarine organisms, including shrimp, menhaden, and sport/commercial fishes, will benefit indirectly from diversion through increased productivity of the wetlands and protection of nursery habitat from continued rapid loss. Again, there may be a redistribution of organisms within the estuary, especially the more mature, harvestable individuals. For example, if an abundance of desirable nursery habitat becomes available, postlarval shrimp may utilize a much larger area and have a higher survival rate. However, because of this dispersal, the mature shrimp may not be as easily harvested in the established fishing spots. Redistribution of estuarine organisms cannot be considered as an adverse impact to the basin as a whole.

Oyster resources in the lower basin will be benefited in the majority of presently occupied areas and will be able to expand in unoccupied areas within the constraints of substrate availability. Some impacts are anticipated for private oyster leases in the southern portion of Little Lake due to low salinity (Plate 6). However, as discussed in Chapter 2, the leasing of low salinity areas such as Little Lake are partly a response of oyster growers to unpredictable salinity conditions in the estuary. With freshwater diversion, the occasional years of high salinity and high mortality in the lower estuary will not occur, negating the need for an alternative site in a normally unproductive area.

Production of seed oysters will be enhanced on the public seed grounds in Hackberry Bay, the lower portions of Grand Bayou and Bayou St. Denis, and Wilkinson Bay (Plate 4). In Figure 6-1, the predicted salinity regime for Creole Bay is compared to the salinity goals for seed oyster production. Mean monthly salinities at Creole Bay are 3 ppt higher than optimum in the spring, but substantially lower than optimum in the summer and fall (with 50% exceedance rainfall and Mississippi River flow). Given the fact that the predicted freshwater needs are liberal (see Chapter 4), it will be possible to obtain the desired salinities each month by controlling the amount of water diverted in the summer, unless there is abnormally low rainfall in the late winter and spring.

Contamination of the oyster grounds with coliform bacteria derived from the diverted water will not occur. The USACE (1983) estimates that only 12% of the coliform bacteria in the diverted water will remain by the time it exits from the outfall management area. Velocity estimates indicate that it will then take two to three weeks for the diverted water to reach the oyster grounds below Little Lake. In that period of time, coliform bacteria will have virtually disappeared. This does not take into account the sometimes high coliform counts in the ambient estuarine waters. Possible impacts to the estuary from other pollutants that may exist in Mississippi River water are difficult to predict, especially on a long-term basis, for three major reasons. First, there is insufficient data on concentrations of various pollutants in the river. Data that are available show substantial variability at a station that could be the result of changing discharges of the river (which also affects suspended sediment concentration and travel time), changing rates of waste discharge, and accidental spills of contaminants. Second, not enough is known about the kinetics and interactions of various pollutants with other elements in the estuarine environment. It has been stated many times that the majority of pollutants are closely associated with suspended sediment particles and that deposition of these contaminated sediments within a wetland environment essentially removes them from the system. However, uptake by plants or erosion and resuspension of the sediments is also possible. Finally,

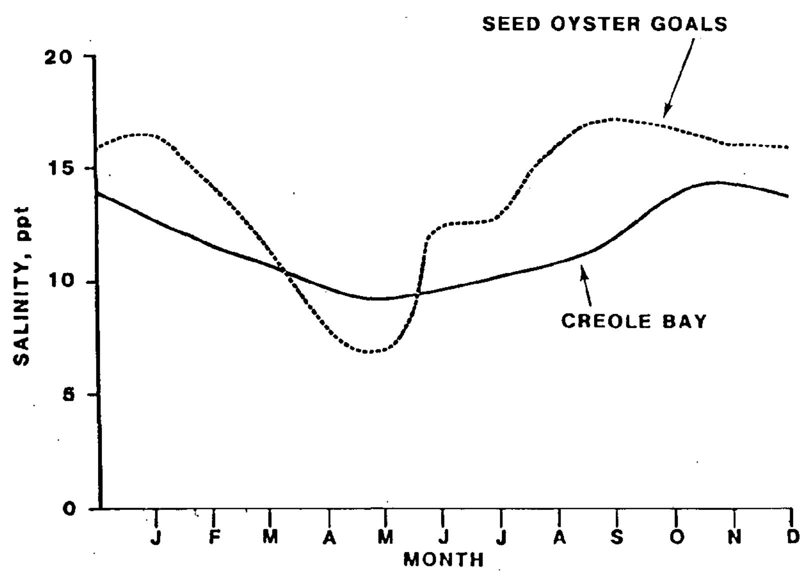


Figure 6-1. Comparison of predicted annual salinity regime at Creole Bay (50% exceedance) with the salinity regime for good oyster years in Breton Sound (see Figure 3-2).

even if it were possible to predict the degree of exposure of aquatic organisms to various pollutants, the ultimate impact of this exposure could not be ascertained with existing information on tolerance and bioaccumulation rates.

The answer to the problem of pollutant input lies in a well conceived monitoring program including the river, the outfall area, and the estuary. Monitoring results should be a key element in the decision-making network that will handle routine operation of the diversion structure. A separate facet of a monitoring program should include daily sampling of salinity and rainfall at key points to eventually allow for fine tuning of the salinity regime within the basin.

CHAPTER 7: SUMMARY AND CONCLUSIONS

In recent years, the Barataria Basin has experienced substantial changes in wetland habitats and wetland loss. The factors responsible include both man-induced changes such as flood control, wetland reclamation, oil and gas recovery, and navigation projects; and natural factors such as eustatic sea level rise, subsidence, and climatic variability. Interrelationships among these factors have led to a gradual increase in water salinities in the estuary as exemplified by transitions of brackish marsh to saline marsh and fresh marsh to intermediate marsh (Figure 2-1). Diversion of freshwater from the Mississippi River into the estuary is a means to control and manage salinity regimes, primarily by acting against climatic variability and, to a much lesser extent, subsidence and the effects of sea level rise.

Salinities in the Barataria Basin are presently controlled by water surpluses from rainfall acting from the upper end of the basin and Mississippi River flow acting on the nearshore waters of the Gulf of Mexico. Freshwater input from these two sources has a residual or lagged effect on salinity. Other factors such as wind-induced water movements also contribute to variability of salinity. Using multiple linear regression, predictive equations were derived for 17 stations where mean monthly salinity was related to water surpluses of the present and preceding month, Mississippi River discharges of the present and preceding month, and the mean salinity of the preceding month.

Using the equations, the existing salinity regimes were simulated for average and for very low rainfall and Mississippi River discharges without diversion. Diversion discharge was then added and gradually increased in subsequent simulations until the salinity regime of the estuary was considered optimum for attaining the previously determined goals for wildlife and fishery resources.

The results of this analysis indicated that a structure designed to deliver a maximum of 10,500 cfs under 50% exceedance flows of the Mississippi River would allow optimum salinities to be attained in the Barataria Basin. In an analysis of feasible sites for diversion, the Davis Pond site at river mile 118.5 AHP was chosen for implementation of this structure. A diversion plan for the site, which includes a 13,400-ft delivery channel and a 9500-ac outfall management area, was formulated.

Related elements include the cleaning of drainage channels and construction of a new pumping station to resolve conflicts with local drainage and adjacent urban development (Figure 5-1).

Predicted beneficial results and possible adverse impacts of the recommended freshwater diversion plan were discussed in Chapter 6. Intermediate salinity marshes along the northern shore of Lake Salvador are expected to revert to their former fresh marsh state. South and west of Little Lake, saline marsh will revert back to the brackish marsh type, but not to the extent that existed in 1968. Input of freshwater with nutrients and dissolved minerals is expected to improve the health and vigor of plant communities in all marsh types. Increased organic production along with increased suspended sediment input will help to retard subsidence-induced marsh loss in the basin.

Transition of marsh to fresher types will benefit wildlife resources, especially furbearers, waterfowl, and alligators. Increased marsh productivity and decreased marsh loss rates will benefit estuarine fisheries resources. Oyster production will be enhanced on the whole, although some private leases in Little Lake will not continue to produce oysters after diversion. Production of seed oysters is expected to increase on the public grounds in Hackberry Bay as well as in a broad band to the northeast.

The only other possible impact foreseen as a result of freshwater diversion involves input of unknown polluting agents from the Mississippi River and the unknown long-term effects of this on the estuary. To minimize the chance of impacts from this source, it is recommended that a thorough monitoring program be implemented to provide the additional information needed for prudent operation of the diversion structure.

REFERENCES

Bahr, L. M. and J. J. Hebrard
1976 Barataria Basin: Biological Characterization. Center for Wetland Resources, Louisiana State University, Baton Rouge, Sea Grant Publication LSU-T-76-005. 140 pp.

Banas, P. J.
1978 An Investigation of the Circulation Dynamics of a Louisiana Bar-Built Estuary. M.S. Thesis. Louisiana State University, Baton Rouge. 82 pp.

Barrett, B. B. and E. J. Ralph
1976 Environmental Conditions Relative to Shrimp Production in Coastal Louisiana. Louisiana Wildlife and Fisheries Commission, Technical Bulletin 21. 20 pp.

Barrett, B. B. and M. C. Gillespie
1973 Primary Factors which Influence Commercial Shrimp Production in Coastal Louisiana. Louisiana Wildlife and Fisheries Commission, Technical Bulletin 9. 28 pp.

Baumann, R. H.
1980 Mechanisms of Maintaining Marsh Elevation in a Subsiding Environment. M.S. Thesis, Louisiana State University, Baton Rouge. 92 pp.

Bellrose, F.C.
1976 Ducks, Geese, and Swans of North America. Stackpole Books, Harrisburg, Pennsylvania. 544 pp.

Broussard, W. A., Jr.
1982 Additions to the Drift Bottle Study of the Barataria system. In: Louisiana Department Wildlife and Fisheries Contributions of the Marine Research Laboratory - 1979. Technical Bulletin 35. pp. 83-85.

Butler, T.
1975 Aquatic Metabolism and Nutrient Flux in a South Louisiana Swamp and Lake System. M.S. Thesis, Louisiana State University, Baton Rouge. 58 pp.

Byrne, P., M. Borengasser, G. Drew, R. A. Muller, B. L. Sith, Jr., and C. Wax
1976 Barataria Basin: Hydrologic and Climatologic Processes. Louisiana State University, Center for Wetland Resources, Baton Rouge. 175 pp.

Chabreck, R. H.
1970 Marsh Zones and Vegetative Types in the Louisiana Coastal Marshes. Ph.D. Dissertation, Louisiana State University, Baton Rouge. 113 pp.

____
1972 Vegetation, Water and Soil Characteristics of the Louisiana Coastal Region. Louisiana State University Agricultural Experiment Station, Bulletin 664.

________ 1982 Personal communication regarding transition of marsh habitats, 1968-1978. August 11, 1982. Professor, School of Forestry and Wildlife Management, Louisiana State University, Baton Rouge.

Chabreck, R. H. and R. E. Condrey
1979 Common Vascular Plants of the Louisiana Marsh. Louisiana State University, Center for Wetland Resources, Sea Grant Publication LSU-T-79-003.

Chabreck, R. H. and R. G. Linscombe
1978 Vegetative Type Map of the Louisiana Coastal Marshes. Louisiana Wildlife and Fisheries Commission, Baton Rouge.

________ 1982 Changes in Vegetative Types in Louisiana Coastal Marshes Over a 10-Year Period. Proceedings of the Louisiana Academy of Science (In Press).

Chabreck, R. H., T. Joanen, and A. W. Palmisano
1968 Vegetative Type Map of the Louisiana Coastal Marshes. Louisiana Wildlife and Fisheries Commission, New Orleans.

Chambers, D. G.
1980 An Analysis of Nekton Communities in the Upper Barataria Basin, Louisiana. M.S. Thesis, Louisiana State University, Baton Rouge. 286 pp.

Conner, W. H.
1975 Productivity and Composition of a Freshwater Swamp in Louisiana. M.S. Thesis, Louisiana State University, Baton Rouge.

Conner, W. H., J. G. Gosselink, and R. T. Parrondo
1981 Comparison of the Vegetation of 3 Louisiana Swamp Sides with Different Flooding Regimes. American Journal of Botany 68(3):320-331.

Daud, N. M. B.
1979 Distribution and Recruitment of Juvenile Blue Crabs, Callinectes sapidus, in a Louisiana Estuarine System. M.S. Thesis, Louisiana State University, Baton Rouge. 83 pp.

Delaune, R. B., W. H. Patrick, Jr. and J. R. Buresh
1978 Sedimentation Rates Determined by ^{137}Cs Dating in a Rapidly Accreting Salt Marsh. Nature 275:532-533.

Dugas, R. J.
1977 Oyster Distribution and Density on the Productive Portion of the State Seed Grounds in Southeastern Louisiana. Louisiana Department of Wildlife and Fisheries, Technical Bulletin 23.

Dugoni, Joseph Andrew
1980 Habitat Utilization, Food Habits, and Productivity of Nesting Southern Bald Eagles in Louisiana. M.S. Thesis, Louisiana State University, Baton Rouge. 151 pp.

Fish and Wildlife Service (FWS)
1980 Mississippi and Louisiana Estuarine Areas Study: A Planning-Aid Report Submitted to the U.S. Army Corps of Engineers, New Orleans District. U.S. Fish and Wildlife Service, Division of Ecological Services. Lafayette, Louisiana. 86 pp.

Ford, T. B. and L. S. St. Amant
1971 Management Guidelines for Predicting Brown Shrimp, Penacus aztecus, Production in Louisiana. Proceedings of the Gulf and Caribbean Fisheries Institute 23:149-161.

Gaidry, W. J. and C. J. White
1973 Investigations of Commercially Important Panaeid Shrimp in Louisiana Estuaries. Louisiana Wildlife and Fisheries Commission, Oysters, Water Bottoms, and Seafoods Division, Technical Bulletin 8. 154 pp.

Galtsoff, P. S.
1964 The American Oyster, Crassostrea virginica Gmelin. U.S. Fish and Wildlife Service, Fishery Bulletin x 64.

Gates, W. H.
1910 A Few Notes on Oyster Culture in Louisiana. Gulf Biologic Station Bulletin 15. pp. 5-32.

Hofstetter, R. P.
1967 The Texas Oyster Fishery, Bulletin 40, Texas Parks and Wildlife Department, Austin, Texas. 38 pp.

Hopkinson, C. S. and J. W. Day, Jr.
1980 Modeling Hydrology and Eutrophication in a Louisiana Swamp Forest Ecosystem. Environmental Management 4(4):325-335.

Joanen, T. and L. McNease
1972 Population Distribution of Alligators with Special Reference to the Louisiana Coastal Marsh Zones. 1972 American Alligator Council Symposium, Lake Charles, Louisiana. 12 pp.

Jorgensen, C. B.
1952 On the Relationship Between Water Transport and Food Requirements of Some Marine Filter Feeding Invertebrates. Biology Bulletin 3(105): 447-489.

Kemp, G. P.
1978 Agricultural Runoff and Nutrient Dynamics a Swamp Forest in Louisiana. M.S. Thesis, Louisiana State University, Baton Rouge. 57 pp.

Lantz, K. E.
1970 An Ecological Survey of Factors Affecting Fish Production in a Louisiana Natural Lake and River. Louisiana Wildlife and Fisheries Commission Fishery Bulletin 6. 92 pp.

Lindall, W. Jr., J. Hall, J. Sykes and E. Arnold, Jr.
1972 Louisiana Coastal Zone: Analyses of Resource and Resource Development Needs in Connection with Estuarine Ecology. Sections 10 and 13 - Fishery Resources and Their Needs. Prepared for U.S. Army Corps of Engineers, New Orleans District. Contract No. 14-17-002-430. National Marine Fisheries Service, Biological Laboratory, St. Petersburg Beach, Florida. 323 pp.

Louisiana Department of Health and Human Resources
var. years Unpublished data from the Grand Terre Marina Lab files. Grand Isle, La.

Louisiana Department of Wildlife and Fisheries (LDWF)
1982a Oyster Lease Maps for Barataria Basin. Oyster, Water Bottoms and Seafoods Division. June 1982. New Orleans.

__________ var. years Unpublished data from the Grand Terre Marine Lab files. Grand Isle, La.

__________ 1982b Unpublished graph of salinity data compiled from stations routinely sampled on the public oyster seed grounds in Breton Sound for good oyster years.

LSU Division of Engineering Research
1976 Energy Related Activities and an Assessment of the Water Resource Management Alternatives in South Louisiana. Louisiana State University, Baton Rouge. 270 pp.

Mackin, J. G. and S. H. Hopkins
1962 Studies on Oyster Mortality in Relation to Natural Environments and Oil Fields in Louisiana. Publications of the Institute of Marine Science 7. pp. 3-131.

Marmer, H. A.
1948 The Currents in Barataria Bay. Texas A & M Foundation, Project A, College Station, Texas. 30 pp.

McConnell, J. M. and L. D. Kavanaugh
1941 The Louisiana Oyster. Department of Conservation Bulletin 1. New Orleans. pp. 1-47.

McNease, L. and T. Joanen
1978 Distribution and Relative Abundance of the Alligator in Louisiana Coastal Marshes. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 32:182-186.

Moore, H. F.
1898 Report of the Oyster Beds of Louisiana. U.S. Commissioners Report 1898, U.S. Government Printing Office, Washington, D.C. pp. 45-100.

Moore, H. F. and T. E. B. Pope
1910 Oyster Culture Experiments and Investigations in Louisiana. Department of Commerce and Labor, Bureau of Fisheries Document No. 731.

National Aeronautics and Space Administration (NASA)
1978 Flight request 0754, uncontrolled prints at 1:24,000, October 8, 9, 10, 15, 1978. Flights 78-143, 78-144, 78-145, 78-148. U.S. Environmental Protection Agency, Remote Sensing Division, Environmental Monitoring and Support Laboratory, Las Vegas.

O'Neil, T.
1949 The Muskrat in Louisiana. Louisiana Wildlife and Fisheries Commission, New Orleans. 159 pp.

Owen, H. M.
1955 The Oyster Industry of Louisiana, Louisiana Wildlife and Fisheries Commission, Division of Oysters, Water Bottoms, and Seafoods. New Orleans. Unpublished manuscript. 387 pp.

Palmisano, A. W.
1973 Habitat Preference of Waterfowl and Fur Animals in the Northern Gulf Coast marshes. Pages 163-190 in R. H. Chabreck (ed.), Proceedings of the Coastal Marsh and Estuary Management Symposium. Louisiana State University, Division of Continuing Education, Baton Rouge.

Palmisano, A. W. and R. H. Chabreck
1972 The Relationship of Plant Communities and Soils of the Louisiana Coastal Marshes. Proceedings of the Louisiana Association of Agronomists 13:72-101.

Payne, F. T.
1920 Report of the Division of Water Bottoms, Fourth Biennial Report, 1918-1920. New Orleans. pp. 131-153.

Penfound, W. T. and E. S. Hathaway
1938 Plant Communities in the Marshland of Southeastern Louisiana. Ecological Monographs 8:1-56.

Portnoy, J. W.
1977 Nesting Colonies of Seabirds and Wading Birds — Coastal Louisiana, Mississippi, and Alabama. Louisiana Cooperative Wildlife Research Unit. Louisiana State University, Baton Rouge. FWS/OBS-77/07.

Sabins, D. S.
1973 Diel Studies of Larval and Juvenile Fishes of the Caminada Pass Area, Louisiana. M.S. Thesis, Louisiana State University, Baton Rouge. 163 pp.

Sanderson, G. C.
1976 Conservation of Waterfowl. Pages 43-58 in F. C. Bellrose (ed.), Ducks, Geese, and Swans of North America. Stackpole Books, Harrisburg, Pennsylvania. 540 pp.

Simoneaux, L. F.
1979 The Distribution of Menhaden, Genus Brevoortia, with Respect to Salinity in the Upper Drainage Basin of Barataria Bay, Louisiana. M.S. Thesis, Louisiana State University, Baton Rouge. 96 pp.

Sincock, J. L., M. M. Smith, and J. J. Lynch
1964 Ducks in Dixie. Pages 99-106 in J. P. Linduska (ed.), Waterfowl Tomorrow. U.S. Government Printing Office, Washington, D.C.

Smith, D. A.
1979 Documentation of the Use of a Brackish-Water Estuarine Zone as a Nursery Ground by Penaeid Shrimp. M. S. Thesis, Louisiana State University, Baton Rouge. 91 pp.

Tarver, J. W. and R. J. Dugas
1973 Experimental Oyster Transplanting in Louisiana, Technical Bulletin 7, Louisiana Wildlife and Fisheries Commission, New Orleans. 6 pp.

U.S. Army Corps of Engineers (USACE)
1982 Louisiana Coastal Area Study, Interim Report on Freshwater Diversion to Barataria and Breton Sound Basins. USACE, New Orleans District.

____
1983 Personal communication at a public hearing on proposed plans for freshwater diversion for the Louisiana Estuarine Areas Study. Luling, Louisiana. January 20, 1983.

U.S. Department of Commerce (Bureau of Census)
1981 1980 Census of Population and Housing, Louisiana. U.S. Government Printing Office, Washington, D.C.

U.S. Geological Survey (USGS)
1978 Land Use and Land Cover Maps. Baton Rouge, Lousiana; Mississippi; Breton Sound, Louisiana; New Orleans. Scale of 1:250,000.

van Beek, J. L., D. Roberts, D. Davis, and D. Sabins
1982 Recommendations for Freshwater Diversion to Louisiana Estuaries East of the Mississippi River. Louisiana Department of Natural Resources, Coastal Management Section, Baton Rouge. 49 pp.

Van Sickle, V. R., B. B. Barrett, L. J. Golick, T. B. Ford
1976 Barataria Basin Salinity Changes and Oyster Distribution. Wildlife and Fisheries Technical Bulletin 20, Sea Grant Publication LSU-T-76-002, Louisiana State University, Baton Rouge. 22 pp.

Vujnovich, M. M.
1974 Yugoslavs in Louisiana. Pelican Press, Gretna, Louisiana. pp. 1-246.

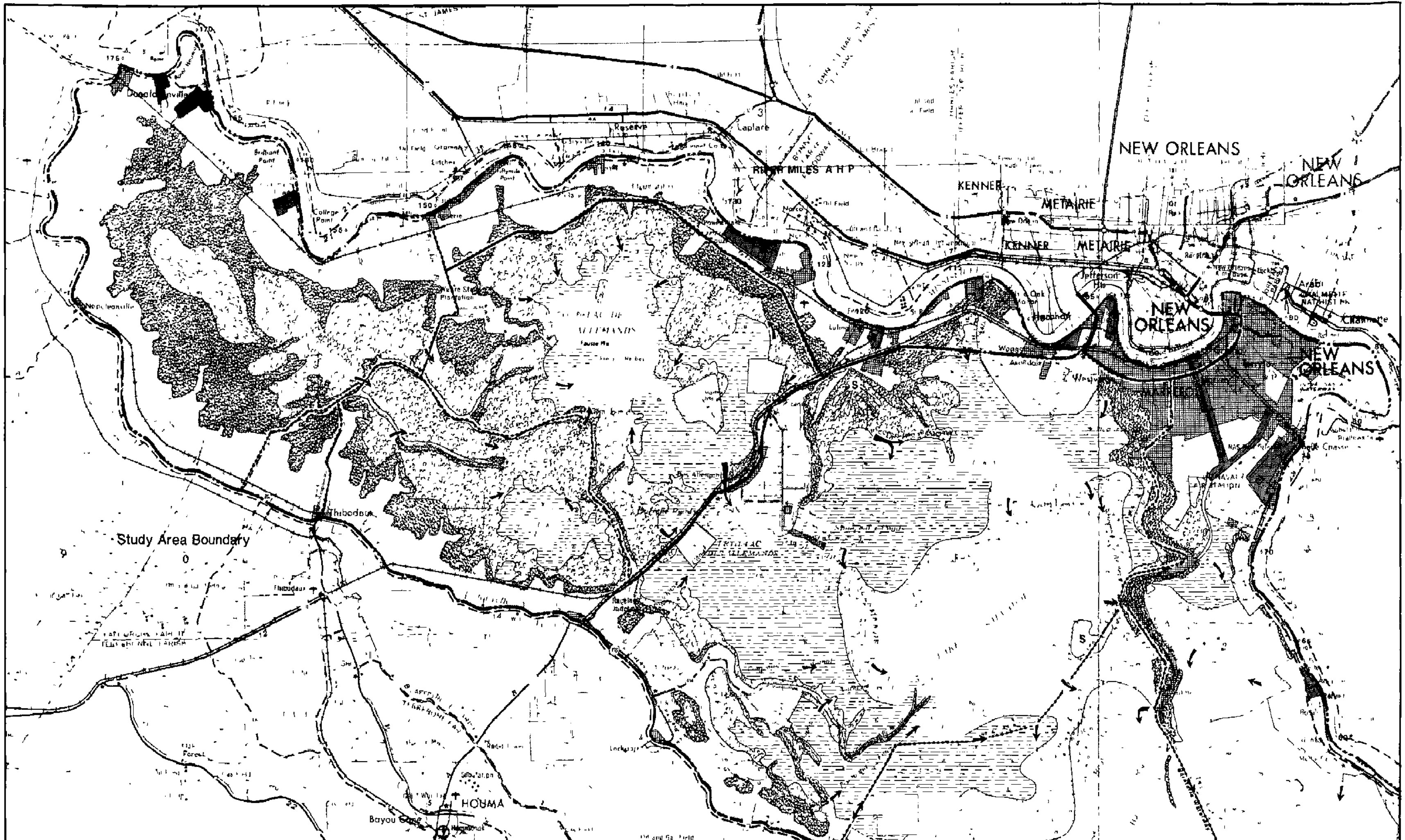
Waldo, E.
1957 The Louisiana Oyster Story, Louisiana Conservationist, November. New Orleans. pp. 1-11.

Wicker, K. M.
1979 The Development of the Louisiana Oyster Industry in the 19th Century. Louisiana State University, Baton Rouge. Ph.D. Dissertation, Unpublished. 214 pp.

Wicker, K. M., et al.
1980 The Mississippi Deltaic Plain Region Habitat Mapping Study. U.S. Fish and Wildlife Service, Office of Biological Services. FWS/OBS-79-07. 464 maps.

Wicker, K. W., D. Davis, M. DeRouen, and D. Roberts
1981 Assessment of the Extent and Impact of Saltwater Intrusion into the Wetlands of Tangipahoa Parish, Louisiana. Prepared for Tangipahoa Parish Police Jury by Coastal Environments, Inc. Baton Rouge. 59 pp.

Zacharie, F. C.
1897 The Louisiana Oyster Industry, House Documents, Vol. 71; No. 561, Fish Commission Bulletin, Vol. 17, U.S. Government Printing Office, Washington, D.C. pp. 297-304.



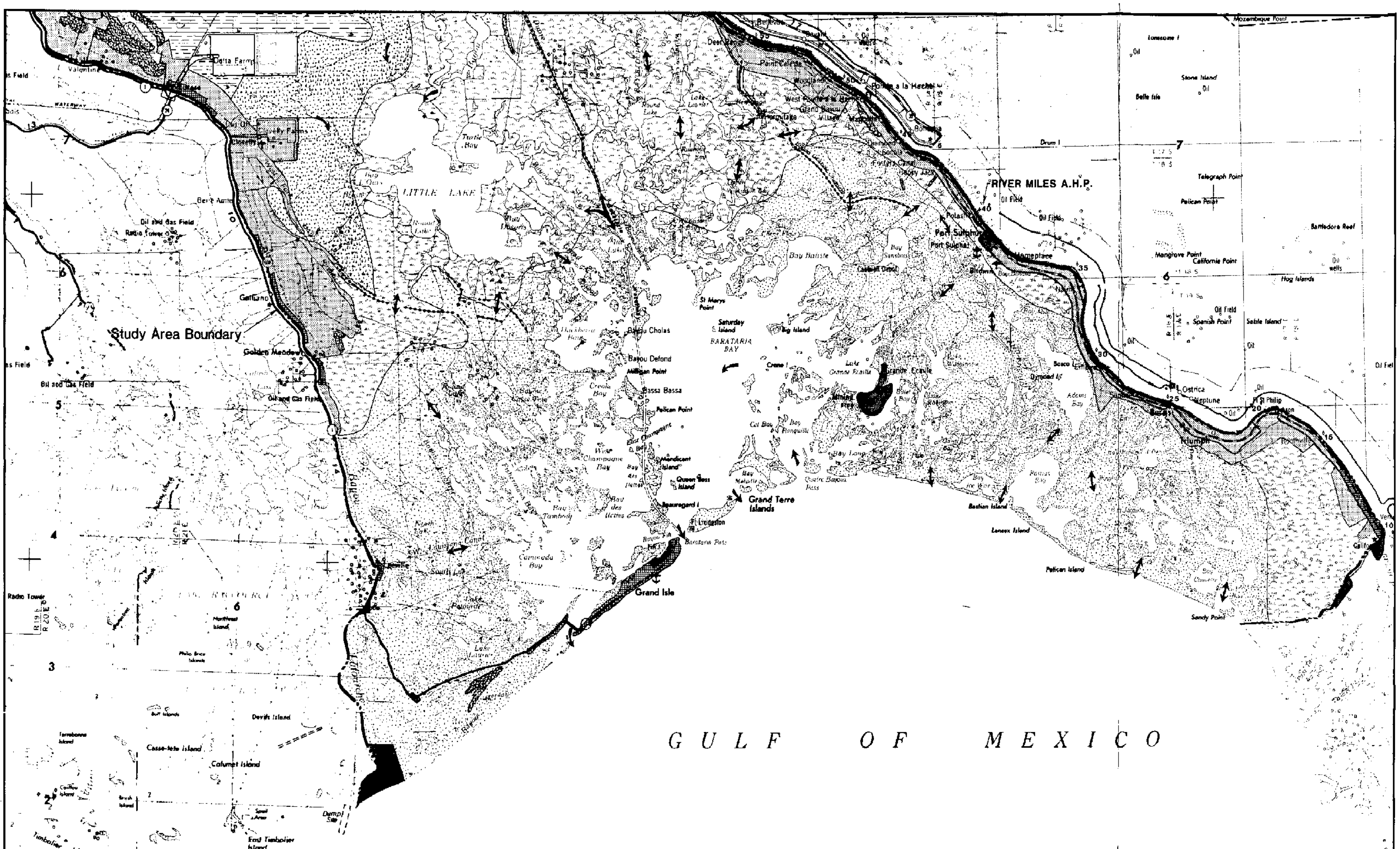
A FRESHWATER DIVERSION PLAN FOR THE LOUISIANA COASTAL ZONE
PHASE II –
HYDROLOGIC UNITS III AND IV

Des Allemands–Salvador

COASTAL ENVIRONMENTS INC

VEGETATION, LAND USE, AND WATER FLOW,
UPPER AND MIDDLE BASIN

Plate 1



A FRESHWATER DIVERSION PLAN FOR THE
LOUISIANA COASTAL ZONE
PHASE II -
HYDROLOGIC UNITS III AND IV

Barataria

COASTAL ENVIRONMENTS, INC.

legend

- DIRECTION OF WATER FLOW
- BARRIERS TO WATER FLOW
- INDUSTRIAL
- URBAN
- UPLANDS & FASTLANDS
- BOTTOMLAND HARDWOODS
- SWAMP

MARSHES

- FRESH
- INTERMEDIATE
- BRACKISH
- SALINE

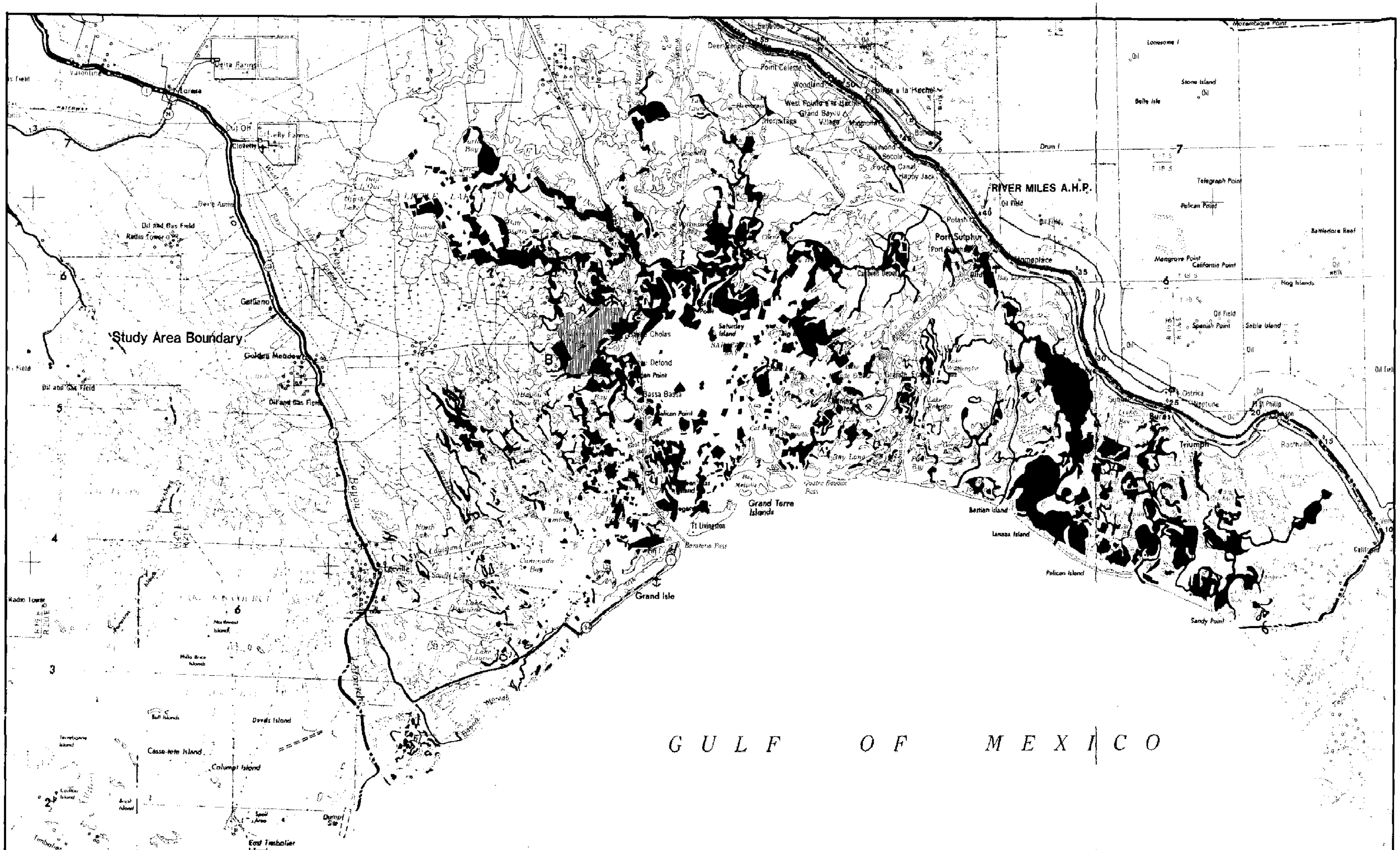
0 5 10 miles

0 5 10 kilometers

N

VEGETATION, LAND USE, AND WATER FLOW:
LOWER BASIN

plate 2



A FRESHWATER DIVERSION PLAN FOR THE
LOUISIANA COASTAL ZONE
PHASE II –
HYDROLOGIC UNITS III AND IV

Barataria

COASTAL ENVIRONMENTS, INC.

legend

OYSTER LEASES June, 1982

SHELL PLANT IN 1981

SHELL PLANT IN 1973

STATE OWNED SEED GROUNDS

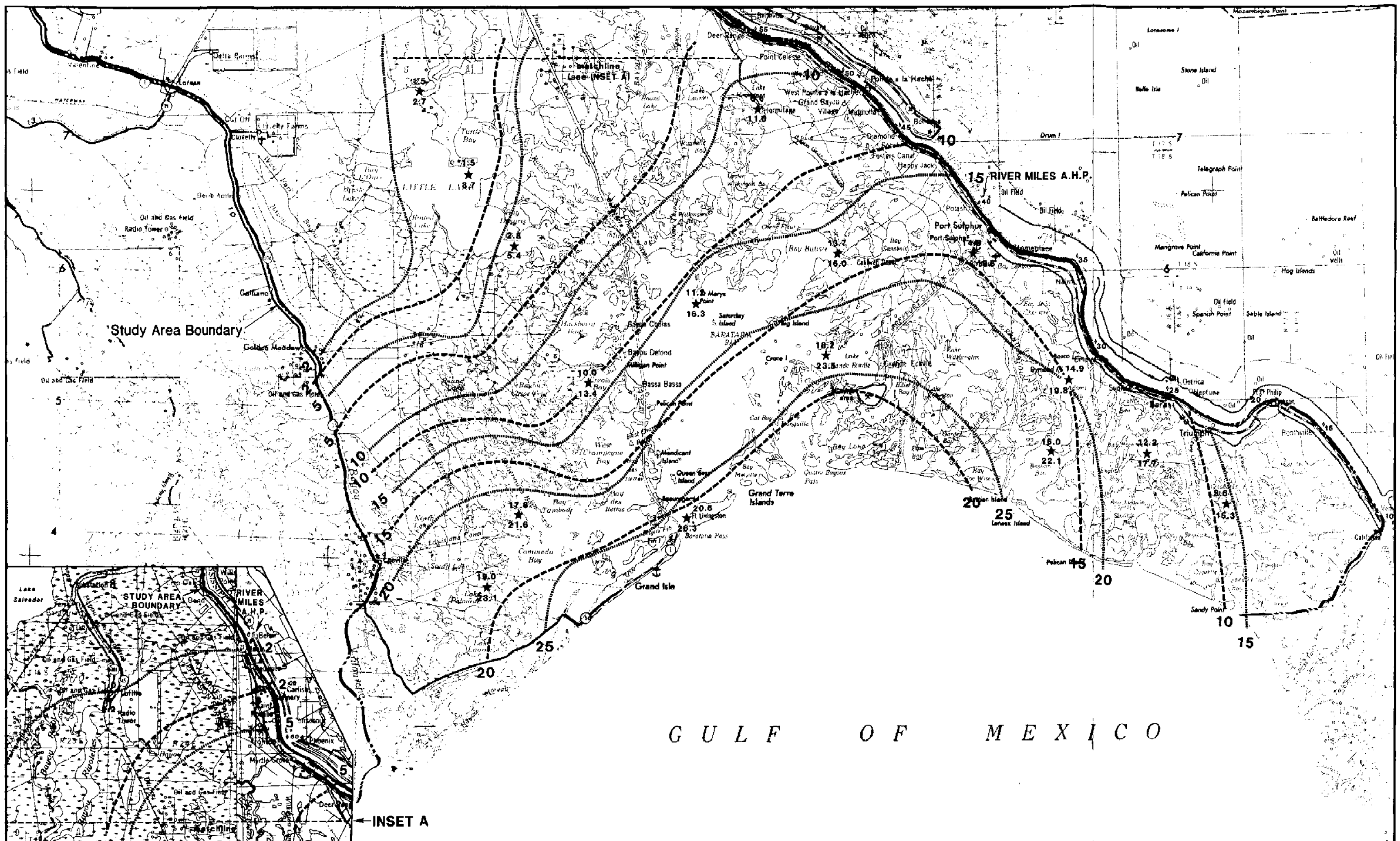
0 5 10 miles

0 5 10 kilometers

N

EXISTING OYSTER RESOURCES IN THE BARATARIA BASIN
(L.D.W.F., SURVEY DIVISION, 1982)

plate 3



A FRESHWATER DIVERSION PLAN FOR THE LOUISIANA COASTAL ZONE
PHASE II –
HYDROLOGIC UNITS III AND IV

Barataria

COASTAL ENVIRONMENTS, INC.

legend

PREDICTED ISOHALINES
(50% EXCEEDENCE - WITH 10,500 cfs DIVERSION)

SPRING ISOHALINE (ppt)

FALL ISOHALINE (ppt)

5.0 MEAN SALINITY FOR MARCH, APRIL, MAY

10.0 MEAN SALINITY FOR SEPT., OCT., NOV.

★ SALINITY STATION

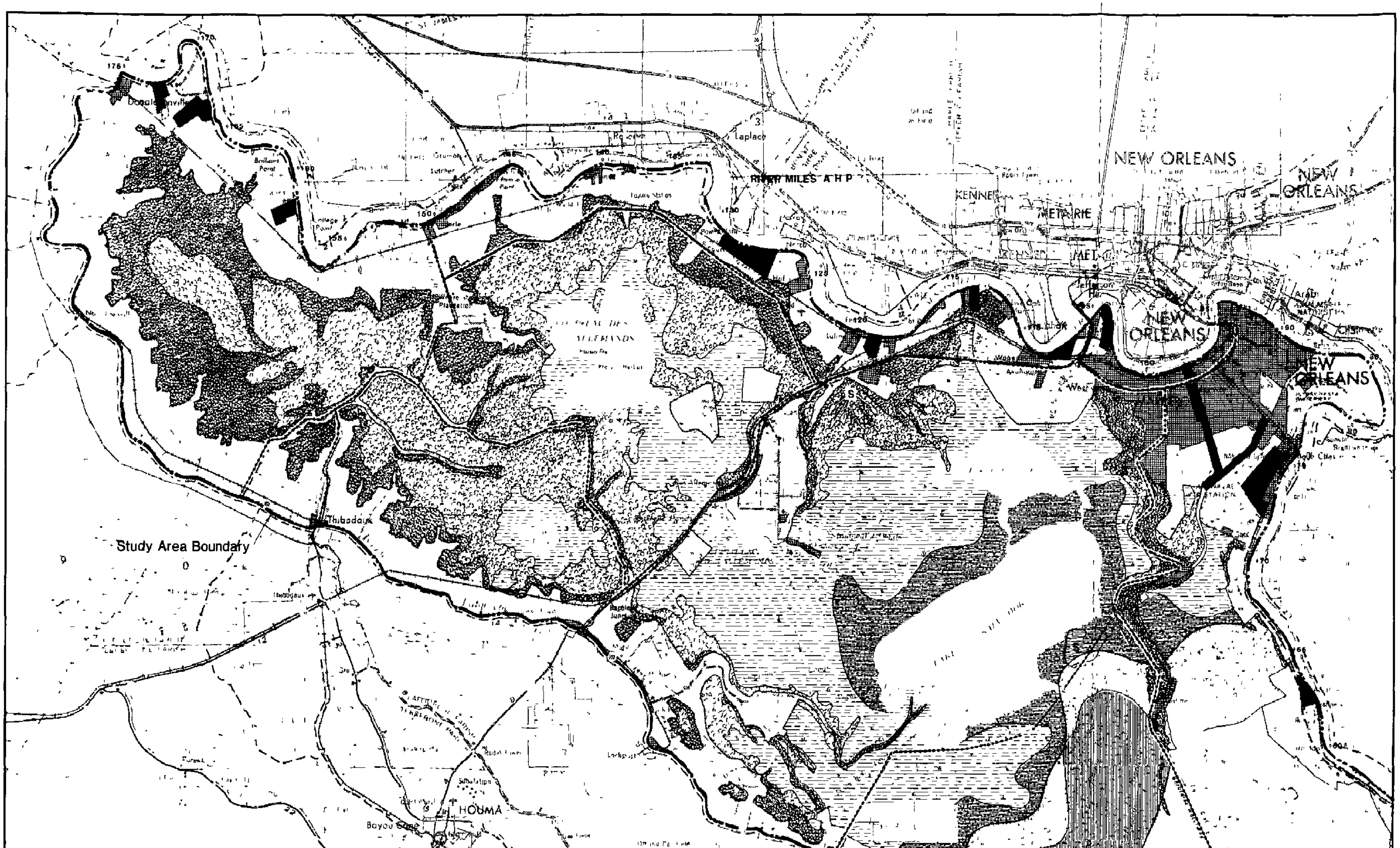
0 5 10 miles

0 5 10 kilometers

N

PREDICTED MEAN SPRING AND FALL ISOHALINES: 50% EXCEEDANCE

plate 4



A FRESHWATER DIVERSION PLAN FOR THE LOUISIANA COASTAL ZONE
PHASE II –
HYDROLOGIC UNITS III AND IV

Des Allemands-Salvador

COASTAL ENVIRONMENTS INC

legend

- BARRIERS TO WATER FLOW
- INDUSTRIAL
- URBAN
- UPLANDS & FASTLANDS
- BOTTOMLAND HARDWOODS
- SWAMP

S STRESSED SWAMP

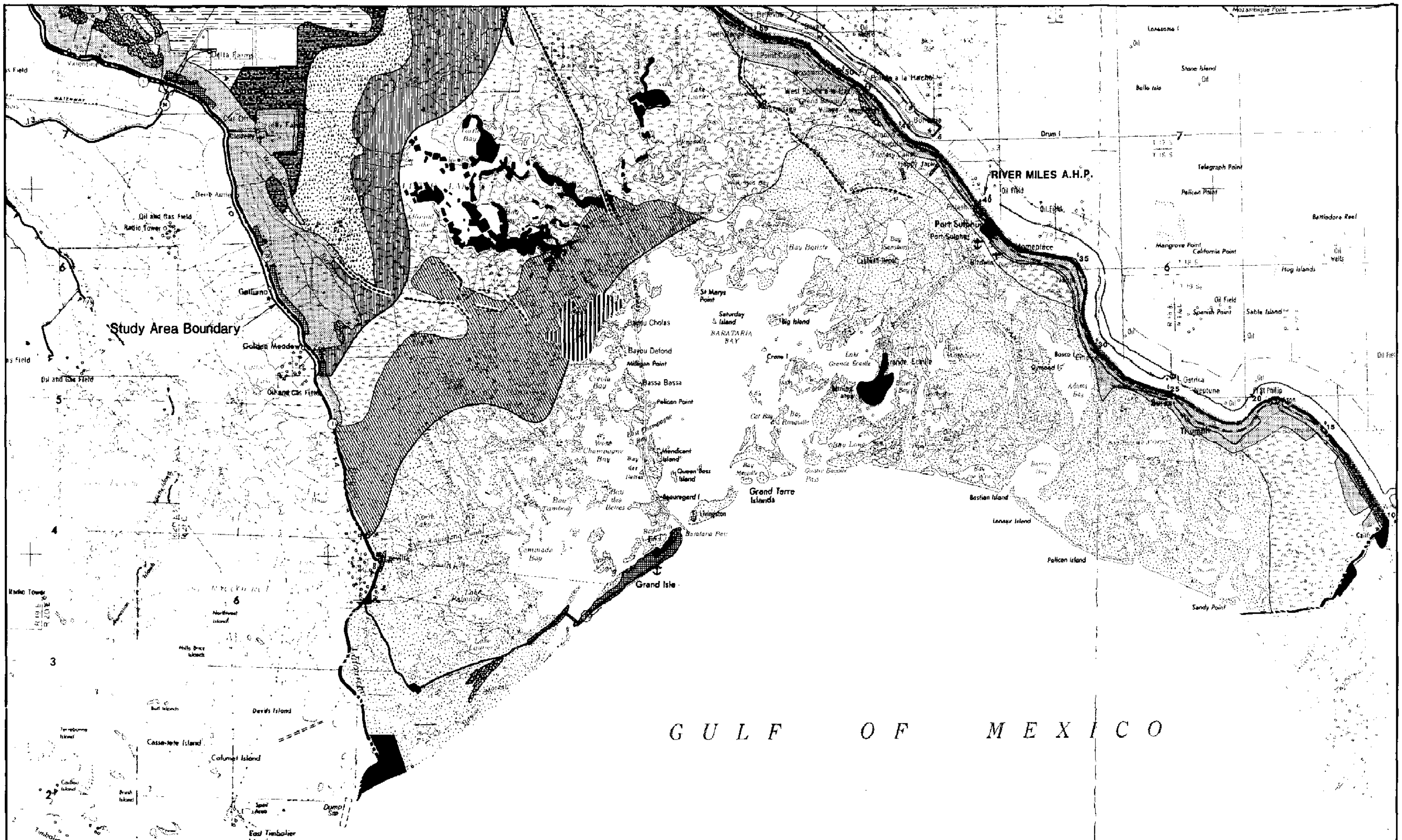
Existing	MARSH	Expansion
	FRESH	
	INTERMEDIATE	
	BRACKISH	

0 5 10 miles

0 5 10 kilometers

PREDICTED BENEFICIAL AND ADVERSE IMPACTS OF FRESHWATER DIVERSION: UPPER AND MIDDLE BASIN

Plate 5



A FRESHWATER DIVERSION PLAN FOR THE LOUISIANA COASTAL ZONE
PHASE II -
HYDROLOGIC UNITS III AND IV

Barataria

COASTAL ENVIRONMENTS, INC.

legend

- BARRIERS TO WATER FLOW
- INDUSTRIAL
- URBAN
- UPLANDS & FASTLANDS
- BOTTOMLAND HARDWOODS
- SWAMP

Existing	MARSH	Expansion
	FRESH	
	INTERMEDIATE	
	BRACKISH	
	SALINE	

- IMPACTS TO PRIVATE OYSTER LEASES
- IMPROVED SEED OYSTER PRODUCTION ON PUBLIC GROUNDS

0 5 10 miles

0 5 10 kilometers

PREDICTED BENEFICIAL AND ADVERSE IMPACTS OF FRESHWATER DIVERSION: LOWER BASIN

plate 6