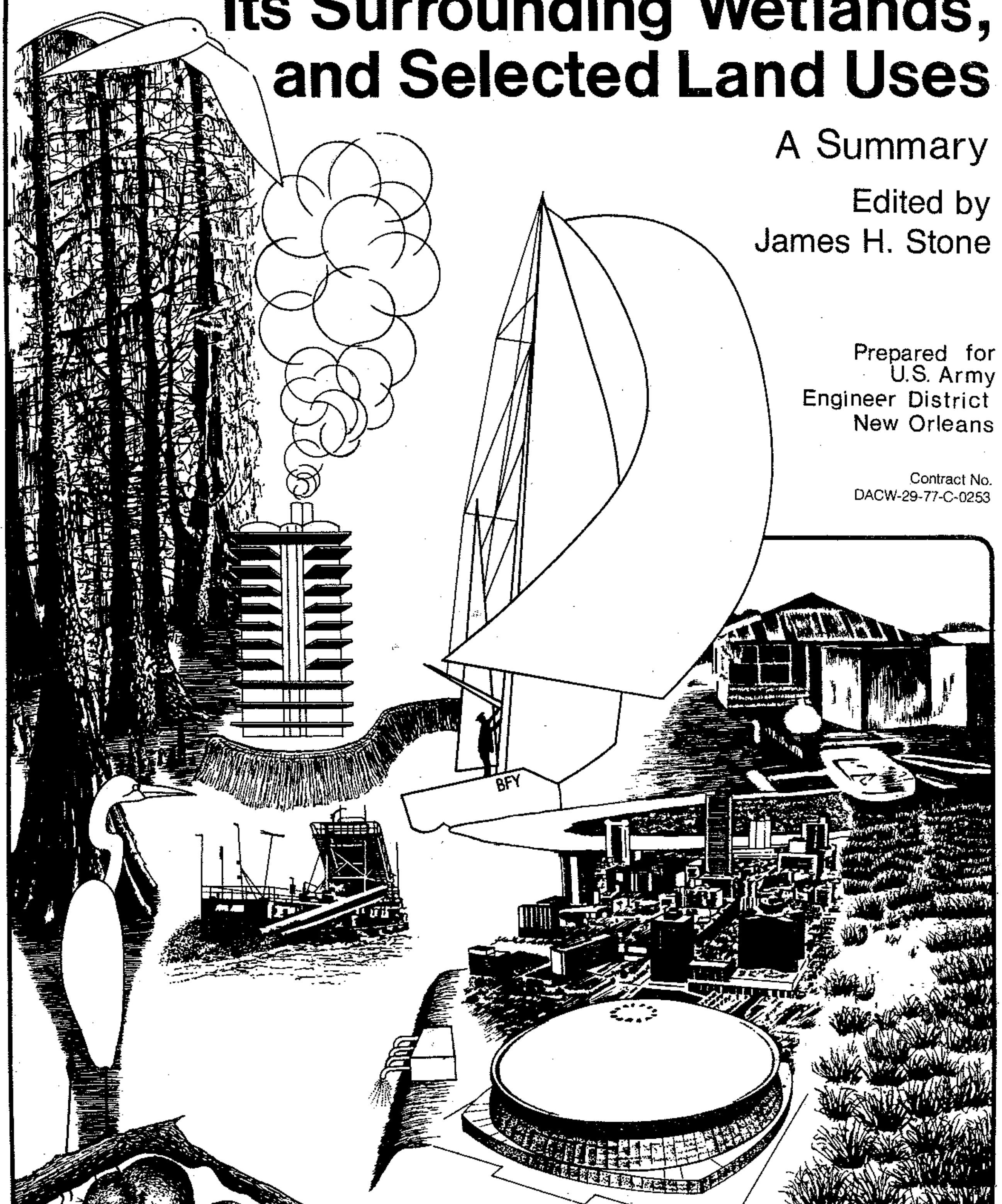
Environmental Analysis of Lake Pontchartrain, Louisiana, Its Surrounding Wetlands, and Selected Land Uses

A Summary

Edited by
James H. Stone



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New Orleans

Contract No.
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COASTAL ECOLOGY LABORATORY • CENTER FOR WETLAND RESOURCES • LOUISIANA STATE UNIVERSITY
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ENVIRONMENTAL ANALYSIS OF LAKE PONTCHARTRAIN, LOUISIANA, ITS SURROUNDING WETLANDS, AND SELECTED LAND USES

A SUMMARY

Edited by

James H. Stone
Coastal Ecology Laboratory
Center for Wetland Resources
Louisiana State University
Baton Rouge, Louisiana 70803

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Center for Wetland Resources
LOUISIANA STATE UNIVERSITY AND AGRICULTURAL AND MECHANICAL COLLEGE
BATON ROUGE • LOUISIANA • 70803
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504/388-1558

February 26, 1980

Col. Thomas A. Sands
District Engineer
U.S. Army Engineer District, New Orleans
P.O. Box 60267
New Orleans, LA 70160

Dear Colonel Sands:

I am pleased to submit this report documenting environmental studies of the Lake Pontchartrain, Louisiana area which were conducted during the period 1 September 1977 to 31 December 1979. The work was sponsored by the New Orleans District of the U.S. Army Corps of Engineers under Contract No. DACW 29-77-C-0253.

The investigations were directed by staff members of the Coastal Ecology Laboratory of the Center for Wetland Resources of Louisiana State University at Baton Rouge. Dr. James H. Stone served as project manager and principal investigator under the general supervision of Dr. Suzanne E. Bayley, Director, Coastal Ecology Laboratory. Associate project leaders were Drs. John W. Day, Leonard M. Bahr, Jr., and R. Eugene Turner.

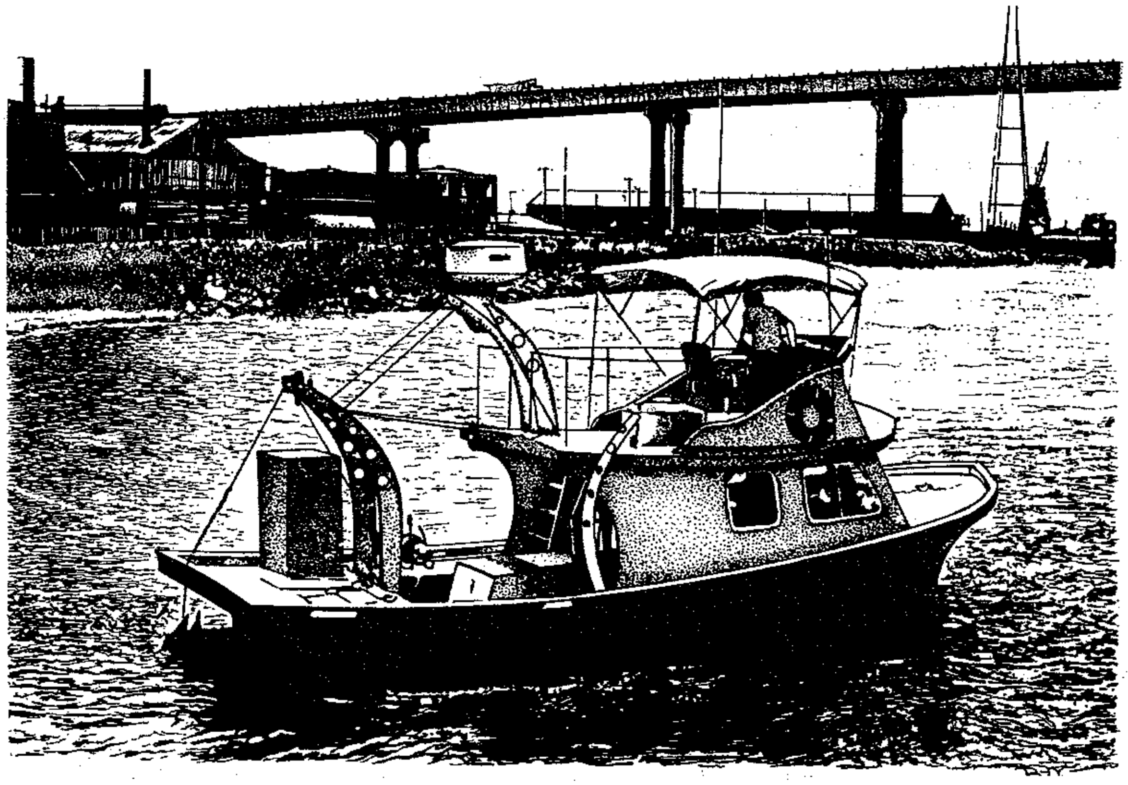
The report examines Lake Pontchartrain and its environs from the standpoint of selected ecological components and processes, useful ecologic models and simulations, and effects of natural and cultural events on environmental quality.

A primary objective of the LSU Center for Wetland Resources is effective utilization of university capabilities in addressing practical coastal and floodplain problems. As the New Orleans District Corps of Engineers plays a vital role in the conservation and development of Louisiana wetlands, it has been particularly appropriate and gratifying to work with your office in the conduct of this program.

Sincerely,

Jack R. Van Lopik
Dean
Center for Wetland Resources

jm
enc.



LSU work boat Wampus Cat

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PREFACE

Purpose

This project was conducted for the Planning Division, Department of the Army, New Orleans District, Corps of Engineers (COE), P. O. Box 60267, New Orleans, Louisiana 70160, under Contract No. DACW29-77-C-0253. The purpose of this research was to prepare an inventory and analysis of the environmental components in Lake Pontchartrain and the wetlands surrounding the lake in order to provide an information base and to indicate salient interactions, patterns, and environmental trends to facilitate future planning.

Chief of the Planning Division of the New Orleans COE District during the study was James F. Roy. Contracting Officer Representatives of the COE were William E. Shell, Jr., John C. Weber, Frank J. Cali, Sue R. Hawes, and Larry M. Hartzog.

Organization

Our research efforts were divided among various teams; each of these is given below with their members.

Team/Worker	Members
• Project Supervision	James H. Stone, John W. Day, Jr., Leonard M. Bahr, Jr., and R. Eugene Turner
• Hydrology	Erick M. Swenson
• Vegetation and Land Use Mapping	R. Eugene Turner, Rezneat M. Darnell, and Judith R. Bond

• Nutrient and Water Chemistry	Ronald K. Stoessell, Patricia A. Byrne, Annie M. Prior, and Judith R. Bond
• Primary Production and Structure	David D. Dow and R. Eugene Turner
• Plankton	Lawrence L. Cook, Edward C. Theriot, Nancy A. Drummond, Diane M. Lindstedt, and James H. Stone
• Benthos	Leonard M. Bahr, Jr., Jean P. Sikora, Walter B. Sikora, and Nan D. Walker
• Nekton	Bruce A. Thompson, Marion T. Fannaly, Steven J. Levine, J. Stephen Verret, Robert C. Cashner,* and Olivia House*
• Nekton Food Habits	Steven J. Levine, Bruce A. Thompson, Marion T. Fannaly, and J. Stephen Verret
• Macroplankton in Tidal Passes	Marion T. Fannaly, Bruce A. Thompson, Steven J. Levine, and J. Stephen Verret
• Anchovy	J. Stephen Verret, Bruce A. Thompson, Steven J. Levine, and Marion T. Fannaly
• Preliminary Survey of Higher Vertebrates	James J. Hebrard and James H. Stone
• Consultants	Rezneat M. Darnell,* Richard W. Heard,* Robert C. Cashner,* and Olivia House*
• Graduate Students — Modeling	Robert E. Hinchee and Linda A. Deegan
Grassbeds	Diane L. Steller and Richard L. Miller
Benthos	Glen W. Cramer
Plankton	Nancy A. Drummond
Food Web	Keith W. Higgins
• Modeling and Project Evaluation	James H. Stone, B. T. Gael, Linda A. Deegan, Robert E. Hinchee, John W. Day, Jr., Leonard M. Bahr, Jr., and R. E. Turner

*R. C. Cashner is affiliated with the Department of Biology, University of New Orleans; O. House is affiliated with the Department of Biology, St. Mary's Dominican College, New Orleans; R. M. Darnell is affiliated with the Department of Oceanography, Texas A&M University, College Station, Texas; R. W. Heard is affiliated with Richard W. Heard and Associates, Marine Environmental Consultants, Ocean Springs, Mississippi.

Support effort was provided by the following personnel:

- Logistical — Rodney D. Adams, Edwin M. Bishop, Paul Rabalais, Glen E. Ehrett, and J. Kenneth Kuzenski
- Boat — Michael J. Haight and Russell J. Wilson (Rental from Toula Enterprises, Inc.)
- Typing — Carolyn M. Lusk and Bonnie S. Grayson
- Cartography — Bobbie F. Young, Diane Baker, and Sarah Wells
- Cover — Bobbie F. Young
- Vignettes — Bobbie F. Young, Sarah Wells, and Larissa Rathburn
- Technical Editing — Joy D. Bagur

Disclaimer

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LIST OF CONTRIBUTORS*

Leonard M. Bahr, Jr., Associate Professor of Marine Sciences

Judy Bond, Research Associate II

Lawrence L. Cook, Research Associate II

Glenn A. Cramer, Research Associate III

Rezneat M. Darnell, Professor of Oceanography

John W. Day, Jr., Professor of Marine Sciences

Linda A. Deegan, Graduate Assistant

David D. Dow, Research Associate III

Nancy A. Drummond, Graduate Assistant

Marion Fannaly, Research Associate III

B. T. Gael, Research Associate III

James J. Hebrard, Post Doctoral Research Associate

Steven J. Levine, Research Associate III

Dianne M. Lindstedt, Research Associate III

Jean Pantell Sikora, Research Associate IV

Walter B. Sikora, Research Associate IV

Ronald K. Stoessell, Assistant Professor

James H. Stone, Professor of Marine Sciences

Erick M. Swenson, Research Associate III

Edward C. Theriot, Research Associate II

Bruce A. Thompson, Research Associate IV

R. Eugene Turner, Associate Professor of Marine Sciences

J. Stephen Verret, Research Associate III

Ann Seaton Witzig, Research Associate III

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*All contributors are staff members of the Center for Wetland Resources, Louisiana State University, Baton Rouge, LA 70803, with the exception of R. M. Darnell; Dr. Darnell is affiliated with Texas A&M University, College Station, Texas 77843.

EXECUTIVE SUMMARY: AN EMERGING VIEW OF THE LAKE PONTCHARTRAIN ECOSYSTEM

by

James H. Stone
John W. Day, Jr.
Leonard M. Bahr, Jr.
and
R. Eugene Turner

Lake Pontchartrain is a shallow, slightly brackish estuary that is located in the deltaic plain of the Mississippi River in southeastern Louisiana. The 1631 km^2 (629 mi^2) lake is fringed by 1603 km^2 (619 mi^2) of forest swamp and by 808 km^2 (312 mi^2) of fresh to brackish marsh. Greater New Orleans, with its approximately 1.2 million people, occupies about one half of the south shore. Lake Pontchartrain is an urban lake, and it is the focus of this report.

During 1978-1979, a year-long study was made by Louisiana State University of selected ecological components and processes of Lake Pontchartrain and its surrounding wetlands and of selected land uses in its drainage basin or watershed. This research was based on the premise that many of the important ecological events occurring within the lake are probably directly linked to actions happening elsewhere in the basin and hence outside the lake. Our data confirm this premise.

SALIENT FEATURES

The two most salient features of our studies are: (1) average turbidity (the amount of sediment suspended in the water) has increased by about 50 percent over the last 25 years; and (2) nutrients (phosphorus and nitrogen) are significantly higher in areas fringing and surrounding the lake such as in Lake Maurepas, in the marshes, and along the southeast shoreline just off New Orleans. We estimate that total phosphorus loading to Lake Pontchartrain has increased by about 70 percent since the 1950's.

An obvious question is: What are the effects of increased turbidity and nutrient loading on the Lake Pontchartrain ecosystem? We know part of the answer. For example, we know that turbidity reduces the amount of plant material produced in the water of the lake. This plant material is critical to the existence of many organisms, including some fish. For example, we estimate that fish production in Lake Pontchartrain has decreased by about six percent between 1953 and 1978 as a result of increased water turbidity.

In addition, we know that nutrients increase the amount of plant material in the water; our plankton data confirm that this has happened off Pass Manchac, in the surrounding marshes, and near the south shore next to New Orleans.

These two facts would appear to offset one another, but the interaction between suspended sediments and nutrients is definitely not that simple, and many details remain unknown at this time. We do know, however, that the excessive nutrients are producing large amounts of plant material, such as _Anabaena_ spp. and _Oscillatoria_ spp.; these forms are known to indicate eutrophication and to cause changes in the species composition of the food web. Also, we intuitively feel that the nutrients coming into the lake from Lake Maurepas, from New Orleans, and from the bayous and drainage canals in surrounding marshes are probably being taken up by the suspended material in the water column of the lake. Their ultimate fate is unknown but their probable impact is a reduction of plant material since, if absorbed by sediments, they would not be available for photosynthesis. In addition, as these sediments settle they can smother bottom forms, and this would in turn eventually reduce fish production and their commercial harvest.

Another obvious question is, What is causing the increased turbidity and nutrient concentrations in Lake Pontchartrain? Some of turbidity in the lake is caused by natural forces, i.e., the wind. We estimate that winds blowing over Lake Pontchartrain are sufficient to stir and mix bottom sediments throughout the water column about 15 percent of the time. But we also estimate that some of man's activities, such as shell dredging, can produce a significant amount of suspended materials in the water column that might affect up to one quarter of the lake at any one time. Nutrients are entering Lake Pontchartrain from several sources. Near Pass Manchac, the nutrients come mostly from the Amite-Comite drainage area (near and about the Baton Rouge area).

We believe that estuarine ecosystems such as Lake Pontchartrain are more fruitfully considered at the level of the coastal drainage basin or watershed (Fig. 1). Therefore, we consider the Lake Pontchartrain ecosystem to include bodies of open waters, associated wetlands, upland forests, agricultural lands, rivers, the associated natural processes, and human activities operating within its drainage basin and under its climatic influences. For simplification, it is possible to consider the Lake Pontchartrain estuarine basin as four linked components, each representing a different (but sometimes overlapping) aspect of structure and a different set of processes. The four components are shown in Figure 2: (A) "Hydrology" is water storage and flow throughout the basin; (B) "Natural Resources" deals with the structure and function of

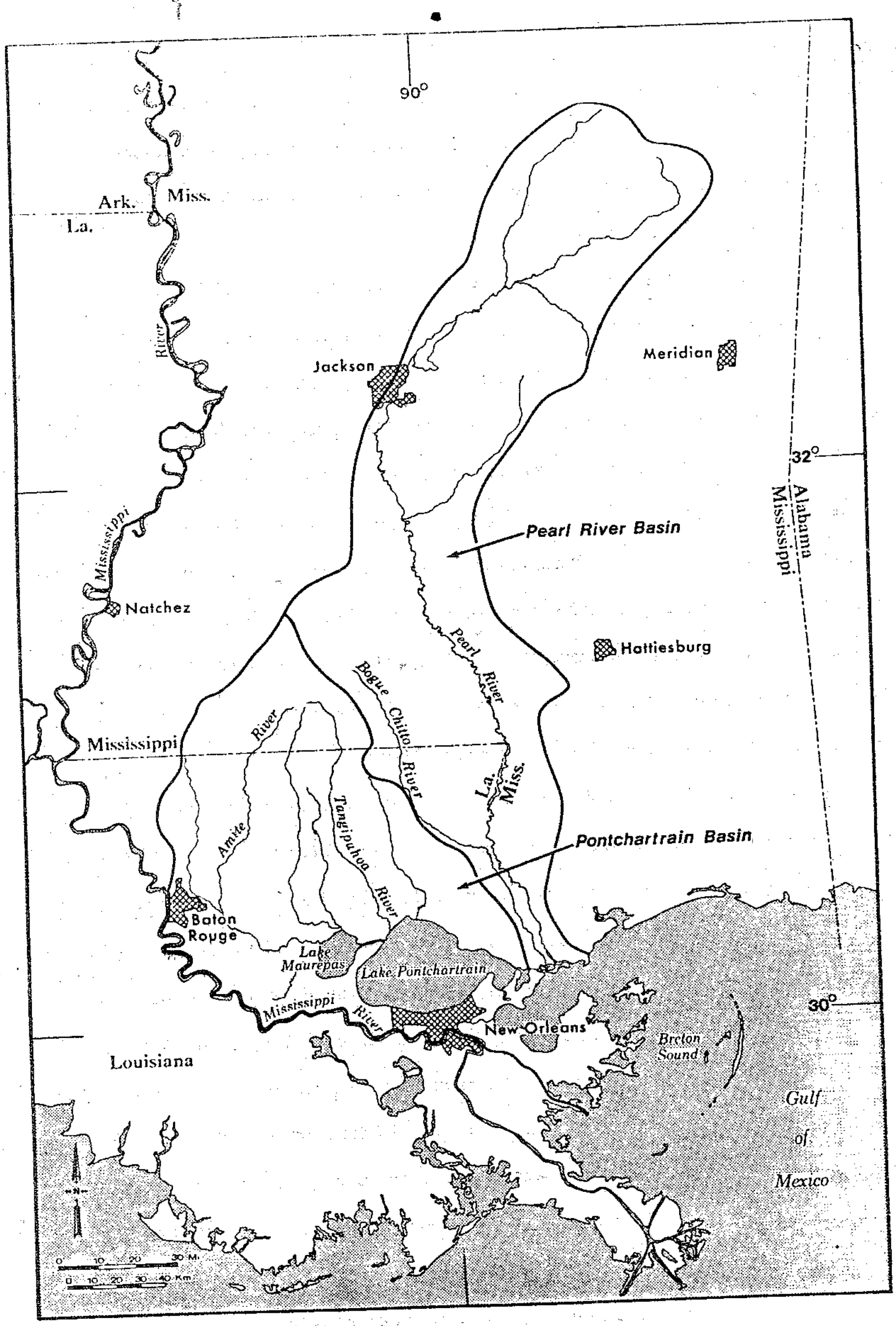


Figure 1. A general area map of the Lake Pontchartrain Basin showing the major rivers, cities, and the adjoining Pearl River Basin.

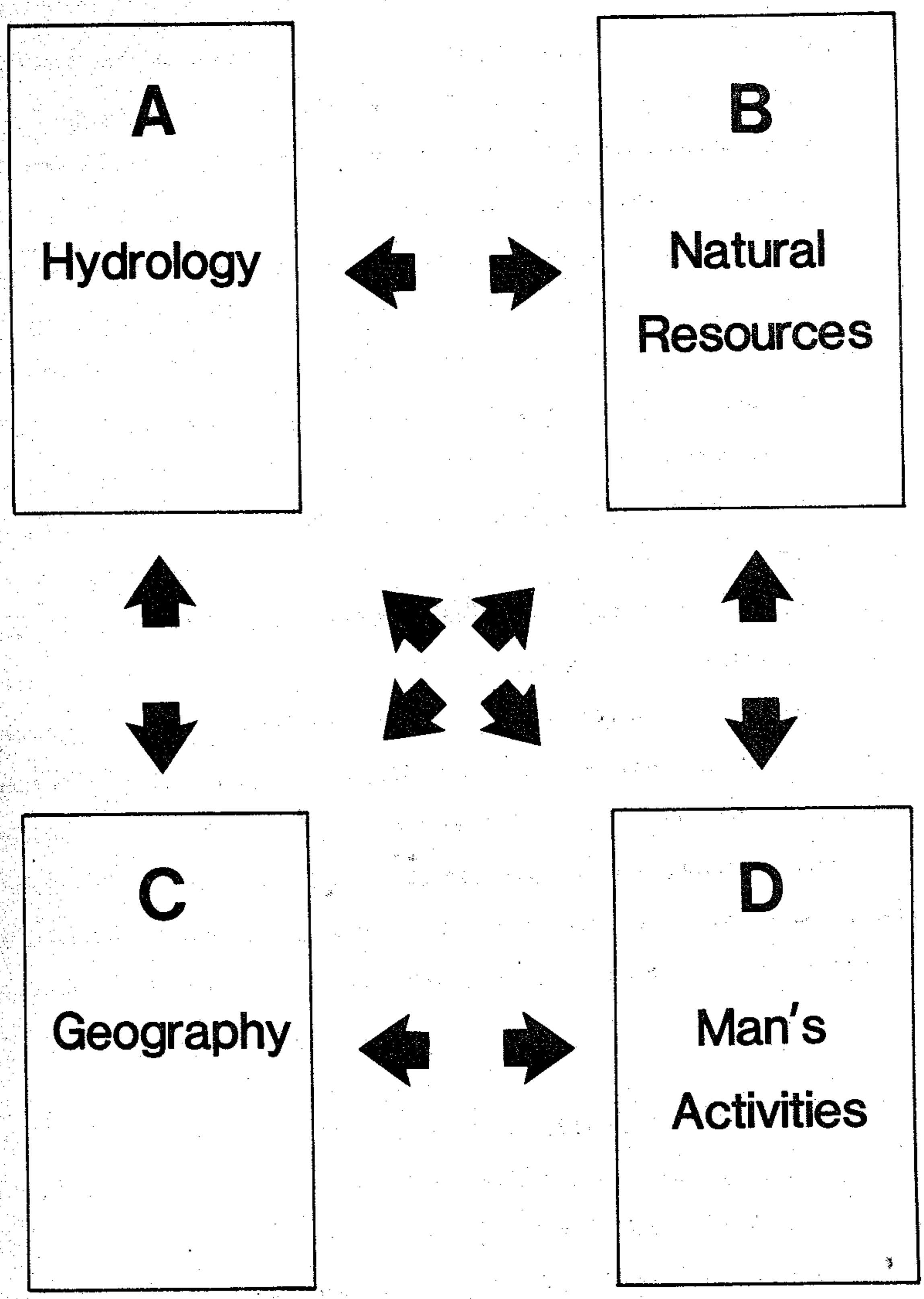


Figure 2. Conceptual view of the Lake Pontchartrain ecosystem (modified from Bahr in Stone et al. 1980). Chapters 3,4,5, and 19 deal with A. Hydrology. Chapters 7,8,9,10,11,12,13,14,15,16, and 17 deal with B. Natural Resources. Chapters 9,10, and 18 deal with Geography (C). Chapters 1,2, and 6 provide a context for the data of the other chapters.

the basin or its capacity to support all living forms (such as wildlife and fisheries) and to perform work services for man; (C) "Geography" or the physiography of the basin is the structure and accretion of natural lands such as forests, swamps, marshes, and grassbeds; and (D) "Man's Activities" operating within the basin.

Our 1978-1979 research efforts in Lake Pontchartrain concentrated on the (A) hydrology, (B) natural resources, and, to a lesser extent, on (C) geography. Component (D), man's activities, were not studied per se under this contract, but we have other ongoing efforts dealing with them; consequently, we repeatedly ask during our study what, how, when, and why man's activities affect each of the other three components or their subparts. Indeed, we believe that man's activities are one of the prime motivations for initiating this study.

Under each of the components of Figure 2 we have listed the chapters of our report that deal with selected parts and processes of that particular component. Chapters 1, 2, and 6 are more synthetic in that they provide a context and/or meaning for the data of the other chapters. Specific findings are summarized below under the three major compnents (i.e., A, B, and C), and followed by a general overview or a summary of chapters 1, 2, and 6.

A. Hydrology
(Chapters 3, 4, 5, and 19)

The circulation of Lake Pontchartrain is dominated by an easterly wind with either a north or south component, depending on the season. Wind speeds greater than 15 mph, which occur about 15 percent of the time, cause bottom sediments to become stirred and mixed throughout the water column and often impart a brownish color to the water. Tidal movements and water heights are amplified by the action of wind and rain in the Pontchartrain basin. For example, ebb tides in Pass Manchac and in each of the three tidal passes can continue unabated for several days. The lake is a well-mixed system; it shows little vertical stratification and a weak salinity gradient from a low of zero ppt in the west to a high of about nine ppt in the east during 1978. The general circulation pattern for both flood and ebb tides shows a littoral drift to the west along both the south and north shores and a return current by way of a broad band of water running approximately from the northwest to the southeast. Counter currents and eddies exist, however, in this area. Cells of waters, formed either by convergence or divergence, may persist near Pass Manchac and near the lakefront of New Orleans. These waters do not seem to mix as rapidly as those in other locales in the lake; they may persist for as long as 10 days. The discharge of waters through the Bonnet Carre Floodway markedly change the general circulation pattern. This water moves easterly near the south shore and mid lake and occupies one-half to two-thirds of the entire lake. Runoff from the Baton Rouge area also affects the hydrology of the basin and may increase the flushing time of Lake Maurepas by 30 percent, which in turn may affect between 2 to 10 percent of Lake Pontchartrain waters.

The Rigolets accounts for 44 percent of water transport in and out of the lake; Chef Menteur Pass, Inner Harbor Navigation Canal (IHNC), and Pass Manchac account for 32, 6, and 15 percent, respectively. Inflow of salt through the IHNC is twice as great as outflow, which suggests local accumulation for probably a short but unknown period of time. Annually, input by rivers account for about five percent of the total volume of the lake and most of the river volume (80%) is from the Amite-Comite and Tangipahoa Rivers.

B. Natural Resources
(Chapters 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, and 17)

Plankton numbers, biomass, and productivity were higher near the lakefront of New Orleans, especially off the Bonnabel Discharge Canal and the Inner Harbor Navigation Canal, near the outfalls of Pass Manchac and off the Tangipahoa and Tchefuncte Rivers. Phytoplankton were significantly more abundant (statistically) in the marshes fringing Lake Pontchartrain. Plankton kinds and number were also found to be about the same throughout the rest of the lake, which partially verifies that the lake is a well-mixed system. Plankton data corroborate the findings of the hydrologic and nutrient studies; phytoplankton were significantly more abundant in areas of higher concentration of nutrients but almost all species were found throughout the lake. Turbid waters caused by strong winds during late winter tend to inhibit photosynthesis. During spring and early summer, waters are less turbid, and the high plankton production is probably related to the concentration of phosphorous that was at a maximum then. During mid-summer conditions, plankton become less active, possibly because nitrogen was found to be at a minimum at that time. Plankton from Lake Pontchartrain are stimulated by substances in the waters of Lake Maurepas but are inhibited by substances in the waters of Lake Borgne.

Marsh grasses fringing Lake Pontchartrain are similar in structure and production to other brackish marshes in Louisiana. However, the impounded marsh in the New Orleans East area is shifting from brackish towards distinctly fresh marsh. The forest swamp in St. Charles Parish appears to be healthy and productive, but production and litterfall are significantly lower near Blind River. Causal factors appear to be continual flooding of this area and insect grazing. Forests in the Lake Pontchartrain Basin have been reduced by 40 percent, and the remaining forest is less dense; indeed, the forest swamps fringing the northwestern side of Lake Pontchartrain are almost devoid of trees and are becoming (functionally) marshes. This is particularly important to the higher vertebrates because the forest swamp is their principal habitat. The submerged grassbed habitat, which is located mostly along the north shore of Lake Pontchartrain, shows a 25 percent reduction over the last 25 years in the shoreline distribution of two of its dominant species, _Ruppia maritima_ and _Vallisneria americana_. This habitat is especially critical for many invertebrate and fish species; its area (about 2000 acres) and its general health should be monitored closely.

The macrobenthos of the lake is sparse in terms of numbers and species. However, initial biomass estimates of the total benthos (which include meiobenthos) are high and may suggest that the benthos are not suitable food for fishes or are not used by them. There are other possibilities, such as that the water transparency is insufficient to allow feeding on the benthos by the fish or that the bottom sediments are not stable enough to maintain a viable benthic community. These are critical questions that need to be answered because our studies on the food habits of the fishes of Lake Pontchartrain indicate that the fishes use two types of food webs: a benthic food web, and a planktonic food web.

Overall, the nekton of Lake Pontchartrain appear to be relatively healthy and seem to use Lake Pontchartrain environs primarily as a nursery. Preliminary data suggest that demersal fish catch per effort is considerably less than in the 1950's, which could indicate that there may be some problems in the transfer of energy between the benthos and the nekton. In addition, commercial fish harvest data suggest a slight reduction in the number of crabs, shrimp, and catfishes within Lake Pontchartrain.

C. Geography
(Chapters 9, 10, and 18)

Man's use of land within the Lake Pontchartrain Basin is increasing the rate and frequency of runoff waters and the amount of nutrients and sediments reaching the lake. They, in turn, may be causing a reduction in the lake's average salinity. The shoreline of Lake Pontchartrain is eroding at a rate of about 15 ha/yr (37.1 acres per year); the shoreline of Lake Maurepas is eroding at 0.5 ha/yr (1.2 acres per year). This difference in erosion rates may indicate that more of the basin's sediments are settling in Lake Maurepas than in Lake Pontchartrain, but Lake Pontchartrain is about five times larger than Lake Maurepas, and a direct comparison may not be possible.

D. Overview
(Chapters 1, 2, and 6)

Nutrients are significantly higher in the areas fringing Lake Pontchartrain than in the center of the lake. For example, nutrient loads are greater in the bayous and drainage canals of the marshes, off New Orleans, and near Pass Manchac. Trophic state analyses confirm these data. It appears that the nutrients are being taken up in part by the phytoplankton and, perhaps, in part by the suspended material in the lake proper.

Preliminary computer simulations of the Lake Pontchartrain ecosystem estimate that fish production has decreased by about 6% during the last 25 years because of an increase of turbidity. Wetland destruction since 1900 (about 67%), however, has probably had a greater adverse effect on the Lake Pontchartrain ecosystem.

The most important environmental trends in the Lake Pontchartrain ecosystem are: (1) a continuing loss of surrounding wetlands, (2) increasing nutrient loading into the lake, and (3) a progressive increase in the lake's turbidity.

Forest swamp in St. Charles Parish

Fort Macomb and boat marina

HIGHLIGHTS AND CONCLUSIONS

by

James H. Stone

CHAPTER 1. PRELIMINARY MODELING OF LAKE PONTCHARTRAIN ECOSYSTEM BY COMPUTER SIMULATIONS

- Lake Pontchartrain can be considered as a six compartment or trophic level model driven by sunlight and nutrients; the six levels are submerged grassbeds, phytoplankton, zooplankton, benthos, nekton, and detrital microbes. This simple model contains 22 types of interactions among the six compartments. (Simulation results are presented in the following four highlights.)
- Fish production in the Lake Pontchartrain ecosystem has been reduced by 49 percent since 1900 because of the loss of wetlands.
- If the grassbeds along the north shore of Lake Pontchartrain were eliminated, fish production within the basin would decline by an additional 26 percent.
- The nursery value of the grassbeds and marshes is three and four times, respectively, greater than their potential as a food source.
- An increase of turbidity between 1953 and 1978 caused a reduction in the production of phytoplankton, zooplankton, benthos, and fish by 38, 6, 5, and 6 percent, respectively.

CHAPTER 2. A TROPHIC STATE ANALYSIS OF LAKE PONTCHARTRAIN, LOUISIANA, AND SURROUNDING WETLAND TRIBUTARIES

- A Trophic State Index (TSI) developed for Coastal Louisiana is based on four variables: total organic nitrogen (TON), total phosphorus (TP), Secchi disc depth (SD), and chlorophyll _a_ (chloro _a_).
- Preliminary analyses suggest that Secchi disc depth (a measure of suspended material in the water or turbidity) and total phosphorus (a nutrient) are the most important variables for assessing the trophic state in Barataria Basin waterbodies.
- The marshes fringing Lake Pontchartrain are hypereutrophic, which means they have a high concentrations of nutrients and phytoplankton.
- Lake Pontchartrain is classified by the Louisiana TSI as meso-to-oligotrophic, which implies low productivity and low nutrient enrichment within the lake itself.
- High nutrient concentrations reaching the lake may be removed by means of both flocculation and saline waters.

CHAPTER 3. COMPUTATION OF DRIFT PATTERNS IN LAKE PONTCHARTRAIN, LOUISIANA

- Under normal conditions, wind is the most important cause of water motion in the lake; river and tidal inputs are not usually significant.
- During spring (April and May) there is a littoral drift toward the west along both the north and south shore, with a return current mid lake.
- Summer conditions, with gentle southeast winds, produce large gyrals in the center of the lake and a westerly or windward drift along both the north and south shores.

- Fall to winter conditions, with gentle northeast winds, produce gyrals in the center of the lake and a longshore drift toward the west.
- Extreme events, such as discharges from the Bonnet Carre Floodway or strong winds, can change the normal circulation markedly by suppressing the near shore and the wind-driven currents. The result is that most of the water moves directly through the center of the lake.
- Water discharges during summer along the lakefront of New Orleans probably tend to move very slowly to the west and do not disperse or purge themselves very quickly.

CHAPTER 4. GENERAL HYDROGRAPHY OF LAKE PONTCHARTRAIN, LOUISIANA

- Current speeds in the lake average 12 to 14 cm/sec. The lake does not show a strong two-layered (or stratified) system in terms of currents although two-layered flow is evident near the Inner Harbor Navigation Canal.
- Vertical profiles of conductivity (salinity) generally show a slight increase from lake surface to bottom of 1 to 2 mmhos/cm; water temperatures show a corresponding decrease of 1 to 2° C.
- Tides are diurnal, but winds can markedly change their cycle. The Lake appears to have a forced tidal oscillation, with the water level over the entire lake rising and falling as a unit.
- Water level in Lake Pontchartrain is controlled by tides and easterly winds. Wave heights are directly related to winds.
- During 1978, water temperatures during winter were lower than average, above average during spring and summer, and above average in the fall. Rainfall was slightly below average during all seasons,

but river flows were higher than normal during winter, somewhat low during spring, normal during summer, and below average during fall. Lake salinity. Lake salinity followed the normal pattern, with a minimum in the spring and a fall peak.

- The eastern half of the lake is influenced more by tidal factors than the western half; the western half shows more freshwater (or river input) effects. The "division" line runs approximately between Green Point and Walker Canal in the St. Charles marsh.
- Wind speeds of 15 to 38 mph and greater cause the bottom sediments to become mixed throughout the water column, and it is estimated that this mixing occurs about 15% of the time.
- The wetlands surrounding Lake Pontchartrain are generally flooded during spring (May) and fall (September), and flooding coincides with high water levels in the lake. Marshes are flooded about 50% of the time, primarily by storms.
- Water discharges from the Bonnet Carre Floodway move easterly close to the south shore and do not seem to affect the north shore. This water can affect up to one-half to two-thirds of the lake's total volume. Over a 60-day period, these water discharges can replace the total volume of the lake, which is six times faster than average total streamflow would replace the total volume.

CHAPTER 5. GENERAL HYDROGRAPHY OF THE TIDAL PASSES OF LAKE PONTCHARTRAIN, LOUISIANA

- The lengths of The Rigolets, Chef Menteur Pass, and Inner Harbor Navigation Canal tidal passes are 14.5, 11.3, and 30 km, respectively. Their respective cross-sectional areas are 7500, 2422, and 1125 m^2.

- The vertical structures of currents are similar in each of the three tidal passes; they are usually homogeneous and not two layered, except at times in the Inner Harbor Navigation Canal. There is no pronounced vertical stratification in The Rigolets and the Chef Menteur passes; however, a salt wedge is often present in the Inner Harbor Navigation Canal.
- Wind in the tidal passes can significantly extend a flood or ebb tide.
- Transport of biological and chemical species should be more homogeneous in The Rigolets and the Chef Menteur Pass and more constrained to the bottom or salt wedge in the Inner Harbor Navigation Canal.
- Water transported in and out of Lake Pontchartrain is mainly via The Rigolets ($\sim$44 percent) and the Chef Menteur Pass (32 percent); the Inner Harvor Navigation Canal and Pass Manchac account for lesser amounts, i.e., 6 and 15 percent, respectively.
- It takes about 100 days for all the water of Lake Pontchartrain to flush out into the Gulf of Mexico.
- The tidal passes are about four times more important than rivers in determining salt and water content of Lake Pontchartrain. Rivers supply about 5 percent of the total volume of the lake, and the Amite-Comite and Tangipahoa Rivers supply 80 percent of this.
- The Rigolets and Chef Menteur Pass each supply about 40 percent of the salt transported into the lake; the Inner Harbor Navigation Canal accounts for about 20 percent.
- Tidal energy through The Rigolets is about equal to the energy flow through the Chef Menteur Pass and, in turn, the tidal energy through the Inner Harbor Navigational Canal is negligible because of the small volume flow through it.

- Tides predominate in Lake Pontchartrain when winds range in speed between 1 to 2 m/sec; they are about equal when winds range between 3 to 4 m/sec; and winds predominate when greater than 4 m/sec.
- Currents within the tidal passes correlate well with a change in electric potential as measured by electrodes. The electrode technique offers a relatively inexpensive way to monitor currents continuously.

CHAPTER 6. NUTRIENT AND CARBON GEOCHEMISTRY IN LAKE PONTCHARTRAIN, LOUISIANA

- Nutrient and carbon concentrations show seasonal trends within Lake Pontchartrain.
- PO_4^{3-}, dissolved P, and Si concentrations were usually high in spring, low in summer, and they increased in the fall.
- $NH_3 + NH_4^+$ and $NO_2^- + NO_3^-$ levels were usually high in spring, low in summer, and they remained low in the fall.
- Organic N fractions and undissolved P content did not show consistent lake-wide trends.
- The highest values of PO_4^{3-} and dissolved P usually occurred doing the south side of the lake.
- Inorganic C concentrations increased from west to east and southeast across Lake Pontchartrain.
- Dissolved organic C levels were high in the spring, low in the summer, and increased in the fall.
- Undissolved organic C levels were high in spring and nearly non-detectable in the summer and fall.
- Nutrient concentrations in Lake Pontchartrain rank between high values of Barataria Bay estuary and average (nutrient depleted) sea water.

CHAPTER 7. STRUCTURE AND FUNCTION OF THE PHYTOPLANKTON COMMUNITY IN IN LAKE PONTCHARTRAIN, LOUISIANA

- Water transparency is generally lower (the water is more turbid) during winter and spring than during summer and fall.
- Near Pass Manchac the waters are usually more turbid than at other lake locations.
- Water turbidity in Lake Pontchartrain may be caused by weather fronts and their wind systems.
- Fluorescence, chlorophyll a, and primary production are usually highest near the southeast shoreline near New Orleans and its suburbs.
- Water plumes near the New Orleans shoreline appear to move predominately toward the east.
- High plankton biomass was often found just off the entrances of the Tchefuncte and Tangipahoa Rivers. These blooms were often dominated by the blue-green alga *Anabaena* spp. In addition, dense blue-green algal blooms were also found off Pass Manchac and in Lake Maurepas.
- The most active (physiologically) phytoplankton populations were often off Pass Manchac.
- The waters of the western half of Lake Pontchartrain are generally more turbid but contain more active phytoplankters.
- Phytoplankton populations of Lake Pontchartrain appear to be light-limited during winter, nitrogen-limited during mid-summer, and phosphorus-limited during spring and early summer.
- Spatial and temporal variations of phytoplankton population in Lake Pontchartrain are often pronounced. These variations may be artifacts of sampling or indications of well-mixed waters.

- Inorganic nitrogen in Lake Pontchartrain comes primarily from Lake Maurepas. Lake Maurepas receives its nitrogen from the Amite and Comite Rivers. Other nitrogen sources for Lake Pontchartrain are the drainage canals of Metropolitan New Orleans.
- Inorganic nitrogen in Lake Pontchartrain does not exhibit the fluctuations or high concentrations found in Lake Maureaps. Lake sediments or biota may dampen these effects.
- Phytoplankton taken from outside of Lake Pontchartrain are stimulated by being mixed with water from the lake. Organisms from Lake Pontchartrain are inhibited by being mixed with water from outside the lake.
- Nitrogen appears to be the major growth-limiting nutrient for phytoplankton of Lake Pontchartrain.
- Inorganic nitrogen for Lake Pontchartrain appears to come mainly by way of Pass Manchac, Lake Maurepas, the Amite River, and the drainage canals of Metropolitan New Orleans.
- Inorganic nitrogen concentrations in Lake Maurepas show other fluctations than those of Pass Manchac (and thus Lake Pontchartrain), which suggests something is damping the fluctuations of nitrogen in Lake Pontchartrain.

CHAPTER 8. THE DISTRIBUTION AND ABUNDANCE OF PLANKTON OF LAKE PONTCHARTRAIN, LOUISIANA, 1978

- Phytoplankters are significantly more abundant in the marshes surrounding Lake Pontchartrain than in the lake itself.
- Two recurrent groups or associations of phytoplankton taxa prevail in the Lake Pontchartrain area. Both groups are characterized by freshwater and euryhaline members.

- Group I is made up of eight taxa and one associate. It occurred only during the summer and fall months and was found more in the lake (48%) than in the marshes (30%).
- Recurrent Group II is made up of three taxa and two associates. It occurred during all months of the year and was found more in the marshes (53%) than in the lake (28%).
- Phytoplankters are taxonomically more diverse in the marshes than in the lake during spring and summer. During fall and winter, the number of taxa are almost the same in the two areas.
- Microzooplankton are taxonomically more diverse in the marshes than in the Lake Pontchartrain proper.
- Four recurrent groups or associations of microzooplankton taxa prevail in the environs of Lake Pontchartrain.
- Group I is made up of seven taxa and was found mainly (91% of the time) during summer months and at lake stations (51%). It is a fresh to brackish water association.
- Groups II and III are each made up of two taxa. Group II was found during all months of the year and equally in the lake and in the marshes. Group III was found only during winter and early spring and equally in the lake and in the marshes. Both groups are fresh to brackish water associations.
- Group IV is made up of two taxa. It was found only rarely, and the taxa are freshwater associations.
- Three recurrent groups or associations of macrozooplankton prevail in the environs of Lake Pontchartrain.
- Group I, Argulus sp. and Crab Zoea (mud crab), occurred predominately during summer and mostly (56%) within the lake proper. It is a brackish water association.

- Group II, *Acartia tonsa* (adults and juveniles) and Copepoda nauplii, occurred during all months of the year and mostly at lake stations. Both are brackish water associations.
- Group III, Cladocera and *Mesocyclops edax*, occurred mostly during spring and summer at marsh stations. It is a freshwater association.

CHAPTER 9. PRODUCTIVITY OF THE SWAMPS AND MARSHES SURROUNDING LAKE PONTCHARTRAIN, LOUISIANA

- Detritus formation in the impounded marsh of New Orleans East is higher than in Goose Point marsh or Irish Bayou marsh; it is about the same as in the Walker Canal marsh.
- Live and dead marsh grass (*Spartina patens*) is less dense in the impounded marsh of New Orleans East than in other marsh areas surrounding Lake Pontchartrain.
- Net production of marsh grass is generally higher in Walker Canal than in other marsh areas surrounding Lake Pontchartrain.
- *Spartina patens* is the dominant macrophyte in the brackish marshes surrounding Lake Pontchartrain (namely, in Tchefuncte, Green Point, Cane Bayou, Goose Point, and Bayou Bonfouca marshes). Fresher marshes (such as Tchefuncte Canal and Bayou Powell) are dominated by *Sagittaria lancifolia*. Big Point marsh is dominated by *S. patens* and *Scirpus olneyi*. Brackish marshes exhibited a higher biomass and lower species diversity than freshwater marshes.
- Nutrient levels are generally higher in the water of the impounded marsh of New Orleans East and in the St. Charles marsh (near Walker Canal) than in other marsh areas surrounding Lake Pontchartrain.

- Swamp forests of St. Charles marsh are dominated by baldcypress and Drummond red maple. Swamp forests of Blind River are dominated by water tupelo, Drummond red maple, ash, and baldcypress.
- The swamp forest of the St. Charles marsh is relatively healthy and productive (1097 g dry $wt \cdot m^{-2} \cdot yr^{-1}$) compared to the swamp forest in the Blind River (621 g dry $wt \cdot m^{-2} \cdot yr^{-1}$). This difference could be caused by earlier intensive logging, heavy insect grazing, and perhaps more importantly by continual flooding.
- The New Orleans East marsh is changing from its original brackish character into a fresh marsh as a result of its impoundment.
- Litter-fall in the swamp forest of Blind River is probably being significantly reduced because of insect grazing.

CHAPTER 10. CHANGES IN THE SUBMERGED MACROPHYTES OF LAKE PONTCHARTRAIN (LOUISIANA): 1954-1973

- Two species of submerged grasses dominate the grassbeds of the north and south shores of Lake Pontchartrain: *Ruppia maritima* and *Vallisneria americana*. *Najas guadalupensis* is now present in areas where it was not found in 1954. *Potamogeton perfoliatus* was abundant in 1973 but was not found in 1954.
- Urban areas have increased three times and eight times on the south and north shore, respectively, between 1954 to 1974, especially along those shore areas where the submerged grassbeds have declined. Causal factors may be eutrophication (from agricultural and urban discharges), saltwater intrusion (via the Inner Harbor Navigation Canal), and selected toxins (via chlorination of discharge water).
- There was approximately a 25 percent decline in the shoreline distribution of *R. maritima* and *V. americana* between 1954 and 1973.

- Most of the decline of these two macrophytes occurred near New Orleans (along the south shore) and near The Rigolets. Rising salinities may have caused this decline because salinities were higher during 1973 than in 1954.
- Other factors that could possibly reduce the macrophytes include urban development and discharges and increased turbidity, particularly since a similar decline of macrophytes has also occurred near Madisonville and Mandeville.

CHAPTER 11. MACROBENTHIC SURVEY OF LAKE PONTCHARTRAIN, LOUISIANA, 1978

- Water column salinities in Lake Pontchartrain suggest a western low salinity zone and an eastern higher salinity zone; the former comprises 60 percent and the latter, 40 percent of the lake area.
- Sediment analyses reveal at least seven sediment types in the lake but silty clay dominates the other types.
- Organic carbon in the sediments of Lake Pontchartrain are somewhat lower (∿ 1% carbon by weight) than other estuaries, such as in South Carolina and Georgia.
- The macrobenthos of Lake Pontchartrain is relatively depauperate in terms of both species and density. Mean species per sample was 9 and mean density was 286 organisms per sample.
- The six dominant macrobenthic species were *Vioscalba louisianae*, *Mulinia pontchartrainensis*, *Rangia cuneata*, *Texadina sphinctosoma*, *Hypaniola florida*, chironomids; these comprise 93 percent of the total abundances. Average dry weight was 3.3 gm/m^2.

- Large <u>Rangia cuneata</u> ($\geq$ 30 mm) were found restricted to shallow waters, especially along the north shore; smaller individuals ($\leq$ 10 mm) were common in the open lake.
- Through the use of a cluster analysis of the macrobenthos, seven groups of stations were identified. Each group was characteristic of locales within the lake. For example, one group was predominantely a low salinity group and was found in the western sections; another group preferred higher salinity in the eastern sections; one group seemed characteristic of sediments subject to urban influences; and finally, one group was characteristic of dredged areas..

CHAPTER 12. NEKTON OF LAKE PONTCHARTRAIN, LOUISIANA, AND ITS SURROUNDING WETLANDS

- During 1978, 85 fish species (77 percent of its known fish fauna) were identified in the environs of the lake. Four species dominate the fish population: anchovy, croaker, menhaden, and silverside. These four species comprise 80 percent of the fish population.
- The fish community of Lake Pontchartrain is considered a transient fauna. It is composed of 55 lake species, 22 marsh species, and 8 species resident to both areas.
- Eight of the most abundant species are primarily marsh dwellers. They are: sheepshead minnow, rainwater killifish, sailfish molly, mosquitofish, spotted sunfish, bluegill, redear sunfish, and least killifish.
- The seasonal faunal similarity pattern in the lake is very much like that of the marsh, with 26 and 27 species found during all four seasons.

- Fish species found only in the marsh are primarily freshwater and euryhaline in character. These are the bowfin, carp, yellow bullhead, saltmarsh killifish, freshwater silverside, white bass, flier, longear sunfish, black crappie, and green goby.
- The numbers of fish increase during spring, peak during July, and then gradually decrease during late summer and fall. This is a typical pattern of estuarine recruitment.
- Of the 20 most abundant fish species, 9 are primarily lake in habitants and 11 use the marsh.
- The anchovy is the most ubiquitous species in the Lake Pontchartrain area. It is found almost year-round in both the lake and the marsh.
- Young croaker are abundant in most open water areas of the lake from spring through fall. They seem to avoid areas of heavy vegetation and marsh habitats.
- Juvenile menhaden use inshore beach and marsh areas as their primary habitat, but as they become larger, they move to the open waters of the lake.
- Young spot use the shore grassbeds as their primary habitat between June and September, but when they become larger, they use the open waters of the lake.

CHAPTER 13. ASPECTS OF THE LIFE HISTORY OF ANCHOA MITCHILLI CUVIER AND VALENCIENNES IN LAKE PONTCHARTRAIN, LOUISIANA, JANUARY THROUGH DECEMBER 1978

- Anchovies are one of the dominant fishes of Lake Pontchartrain and comprise about 29% of the LSU total nekton catch in terms of number.

- Anchovies generally increase in number from winter through fall.
- Anchovies occurred at all stations--open lake, shoreline, and marsh--but seem to be more abundant in the open waters of the lake.
- Anchovy spawning may start in March and cease in October or November.
- Anchovies were most abundant in waters having temperatures between 20° to 30° C and salinities between 2°/₀₀ to 4°/₀₀.
- Growth of anchovies is greatest during spring (March and April) and averages about 12 mm/month.

CHAPTER 14. GUT CONTENTS OF FORTY-FOUR LAKE PONTCHARTRAIN, LOUISIANA, FISH SPECIES

- Fishes of Lake Pontchartrain feed primarily within a benthic or a planktonic-nektonic food web. Detritus probably input to nekton via numerous invertebrate detritivores that are used as food by fishes. Relatively few Lake Pontchartrain fishes seem to derive nourishment directly from detritus; however, mullet and menhaden are detritus consumers.
- The benthic food web of Lake Pontchartrain is composed primarily of worms, mollusks, crabs, insect larvae, amphipods, and isopods. Each of these forms is fed upon by at least 10 fish species.
- The plankton-nekton food web of Lake Pontchartrain is composed primarily of mysids, copepods, decapods, and fishes. Each of these forms is fed upon by at least seven fish species.
- Fish species like the sheepshead and pinfish, which have a generalized diet and the ability to feed effectively on hard surfaces, might have advantages in future years over other fish species in Lake Pontchartrain.

- The grassbeds and those areas with high concentrations of bivalves and snails are critical fish habitats. Turbid or muddy waters could endanger these habitats.
- Most fishes of Lake Pontchartrain tend to be generalists or facultative in their feeding habits.
- Similar fish species, like the blue and channel catfish and the sand seatrout and spotted seatrout, "avoid" competition for food by using different locations of the lake such as shoreline areas as opposed to mid lake.

CHAPTER 15. MACROPLANKTON MOVEMENT THROUGH THE TIDAL PASSES OF LAKE PONTCHARTRAIN

- Salinities were significantly different among the three tidal passes. The Inner Harbor Navigation Canal (IHNC) had the most saline waters, followed by the Chef Menteur Pass, and then The Rigolets.
- Water temperatures were significantly different among the three tidal passes. The IHNC had the highest temperature, followed by The Rigolets and the Chef Menteur Pass.
- Anchovies were the dominant macroplankters collected in the tidal pass, and were followed by menhaden, blue crab, croaker, gobies, grass shrimp, and brown shrimp. These were followed by 41 less common species.
- There were no significant numerical differences in the monthly movements of macroplankton through the three tidal passes of Lake Pontchartrain.
- Macroplankton were not significantly more abundant in any of the three tidal passes although the mean catch per sample was highest in the IHNC.

- Most of the species collected moved through the tidal passes at the mid-depth and bottom levels.
- More organisms move through the three tidal passes at night than during the day and on a flood rather than ebb tide. The tide apparently acts differently in each pass because of their different physical configurations, and tidal action affects the movement of macroplankton.
- Selected species differences were found in terms of monthly collections, tidal passes, depth, light, and tidal cycle.

CHAPTER 16. SELECTED COMMERCIAL FISH AND SHELLFISH DATA FROM LAKE PONTCHARTRAIN, LOUISIANA, DURING 1963-1975, SOME INFLUENCING FACTORS, AND POSSIBLE TRENDS

- Blue crab dominates the commercial fishery of Lake Pontchartrain and comprises two-thirds of the total value and about four-fifths of the total volume.
- Shrimp and fishes account for about 19% and 14%, respectively, of the total catch value and about 10% each of the total catch volume.
- The shrimp catch is composed mainly of two species, i.e., brown shrimp (*Penaeus aztecus*) and white shrimp (*P. setiferus*).
- Commercial fish species are mainly catfishes and sea trout.
- Many factors probably influence commercial fish harvest in Lake Pontchartrain, including: natural envirionmental factors such as rainfall, salinity, temperature, turbidity, and substrate; natural biological factors, such as competition and predation; and man-induced factors, such as, the Mississippi River Gulf Outlet, the Bonnet Carre Floodway, dredging, shore alterations, loss of grassbeds, industrial and urban discharges, and various economic factors.

- Harvest data of blue crab, shrimp, and catfish from Lake Pontchartrain suggest a downward trend for all species. This condition is probably occurring each year by insignificant increments, which makes discussion and evaluaton difficult.

CHAPTER 17. PRELIMINARY SURVEY OF HIGHER VERTEBRATES OF LAKE PONTCHARTRAIN, LOUISIANA

- There are three macrohabitats for higher vertebrates in the Lake Pontchartrain drainage basin: the forested wetlands, the marshes, and the lake itself.
- Summer and winter conditions in all three habitats probably show the greatest differences of the vertebrate species composition and feeding habits.
- Preliminary food web analysis was done by means of the following index:

$$\% \text{ connection} = \frac{\text{observed connections}}{\text{possible connections}} \times 100$$

  This index expresses the amount of connectivity between the predator and its food; for example, the connectivities among vertebrates and their food in the take are 27% and 36%, respectively, during summer and winter.
- Respective connectivities in the marshes are 40% and 38%, respective connectivities in the forested wetlands are 36% and 40%.

CHAPTER 18. RECENT LAND USE CHANGES IN THE LAKE PONTCHARTRAIN WATERSHED

- The surface area of Lake Pontchartrain is increasing by 15 ha/yr compared to 0.5 ha/yr for Lake Maurepas.

- Within part of the Lake Pontchartrain watershed (about 16,000 km^2 or 6,200 mi^2), urban areas occupy 6% of the total surface area; agricultural lands, 22%; upland forested land, about 40%; and wetland, about 16%.
- Forty percent of the Lake Pontchartrain watershed is deforested, and the remaining 60% has less vegetation per acre than in 1700. This may have increased fresh water flow to Lake Pontchartrain. Secondary effects of this may be sedimentation and increased nutrient concentrations in Lake Maurepas. Also, there may be a decline in soil fertility in the upper part of the watershed.
- Man-made features, canals and navigational channels, have especially increased in the Lake Pontchartrain watershed near the Mississippi River and near New Orleans.
- About 60% of the original vegetation of Lake Pontchartrain watershed remains, and its species composition is being changed to softwoods. The original forest swamps near Lakes Maurepas and Pontchartrain now have few trees that they may now be functionally marshes.
- Agricultural land between Baton Rouge and New Orleans has increased threefold between 1954 and 1972; agriculture has also increased in the rest of Lake Pontchartrain watershed.
- Land use changes with Lake Pontchartrain watershed probably affects Lake Pontchartrain by increasing water runoff and decreasing salinity and by increasing nutrient and sediment loading.

CHAPTER 19. URBANIZATION, PEAK STREAMFLOW, AND ESTUARINE HYDROLOGY (LOUISIANA)

- Vegetation cover in the northwestern part (Baton Rouge) of Lake Pontchartrain has not changed significantly over the last 30 years, but its urban population increased tenfold along with more drainage culverts, street pavements, levees, ditches, and stream channelization.
- Peak flood discharge and flood frequency on the Comite River at Comite, Louisiana, increased 23% and 50%, respectively, between 1951 and 1970 as a result of changing land uses near Baton Rouge, Louisiana. Potential peak flood discharges have increased on the Amite River by 29% and on the Comite River by 37%.
- The amount of water runoff has not changed. However, peak discharge during storms has increased.
- These changes in streamflow also influence erosion rates, downstream nutrient concentrations, and the biology of wetlands downstream.
- Nutrient concentrations and phytoplankton distributions and abundances in Lake Maurepas are probably being changed, and this in turn would affect Lake Pontchartrain.
- Instantaneous flushing rates of Lake Maurepas during storm events have increased about 30% since the 1950's as a result of increased peak flood discharge.

SELECTED ENVIRONMENTAL TRENDS

by

James H. Stone

I believe that there are three major environmental trends within and surrounding Lake Pontchartrain. First, and probably the most important, is the continuing loss of wetlands. Second, there is the increase of nutrients coming into the lake and its surrounding wetlands. Third, there is the decrease in water clarity (increase in the turbidity) of the lake's water. Each of these is briefly discussed below with selected data.

1. Loss of Wetlands

The wetlands surrounding Lake Pontchartrain are important because they provide much of the energy needed to run the Lake Pontchartrain ecosystem but also because they act as a nursery or habitat for important commercial species. There is, however, a downward trend in the total wetland area within the Lake Pontchartrain basin or drainage area (Fig. 1). Since 1900, almost one half of it has been destroyed, and most of this loss has occurred since 1950.

2. Increase in Nutrients

Nutrients coming into Lake Pontchartrain are increasing (Fig. 2). Since 1900, the loading rate of phosphorus has almost doubled, and projections indicate a continual increase unless remedial actions are taken.

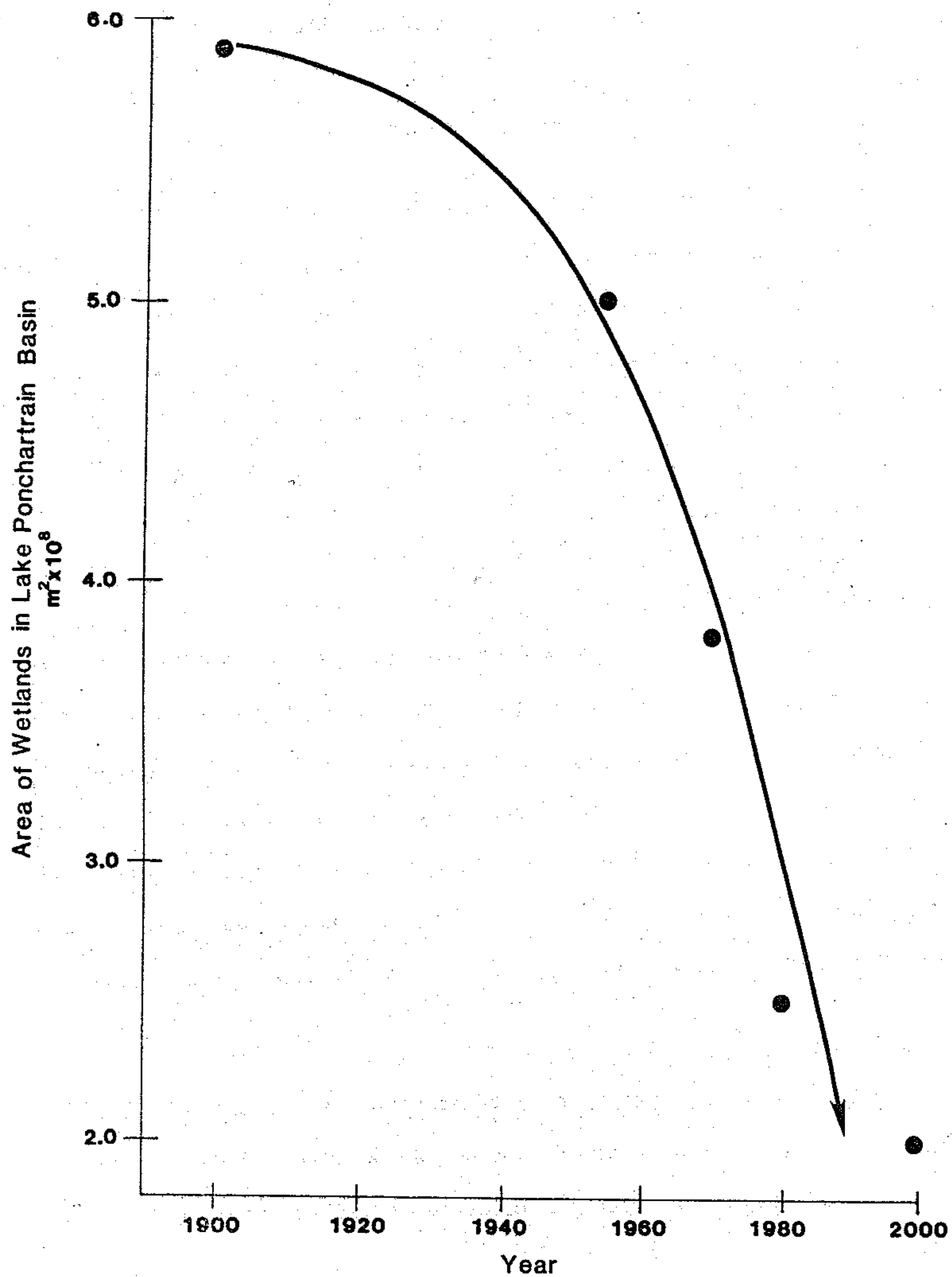


Figure 1. Amounts of wetlands in Lake Pontchartrain Basin as a function of time (R. E. Hinchee, 1977, M.S. thesis, Louisiana State University, Baton Rouge, LA 70803).

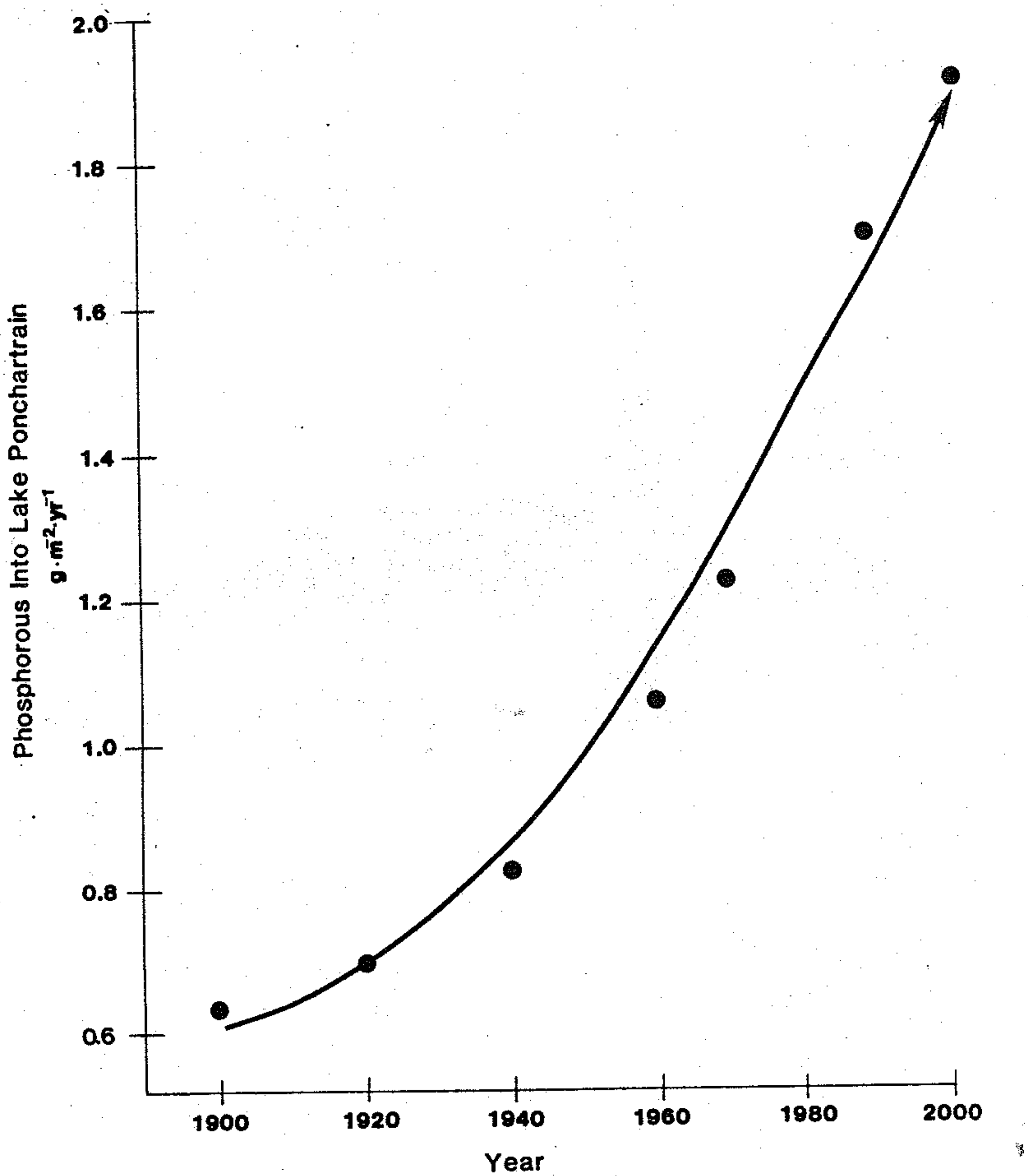
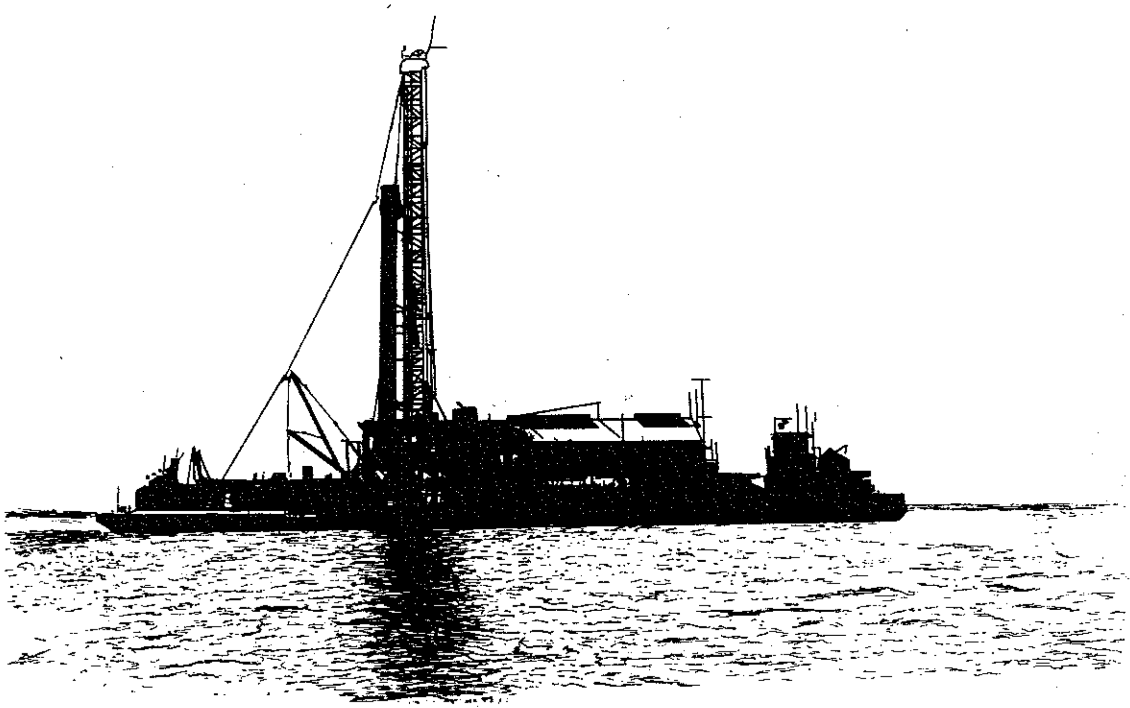


Figure 2. Phosphorous loading into Lake Pontchartrain, LA, as a function of time (from P. Kemp, 1977, in Cumulative impact studies in the Louisiana coastal zone: eutrophication and land loss. Final report to Louisiana Department of Transportation and Development by the Center for Wetland Resources, Louisiana State University, Baton Rouge, LA 70803).

3. Decrease in Water Clarity

Water transparency or clarity is decreasing in Lake Pontchartrain. Since 1953, it has decreased by about 50 percent (Fig. 3).



Petroleum drilling rig and support

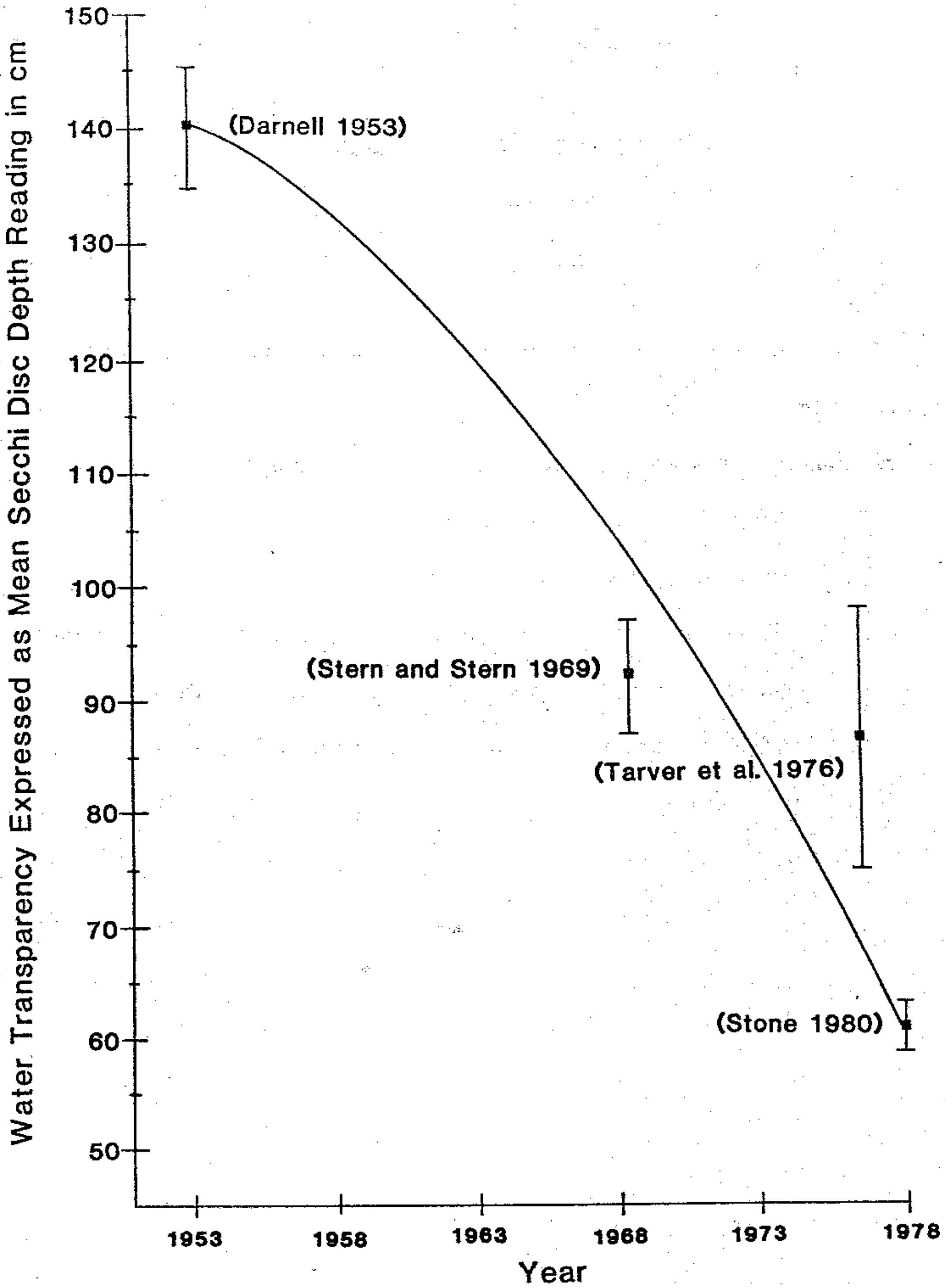


Figure 3. Water transparency expressed as mean Secchi disc reading in cm as a function of time. Standard error of mean is expressed as vertical ars. (Source: R. M. Darnell, 1979. Hydrography of Lake Pontchartrain, Louisiana, during 1953-1955. Unpublished M.S., Coastal Ecology Laboratory, Center for Wetland Resources, Louisiana State University, Baton Rouge, LA 70803; Stern, D. H., M. S. Stern, 1969. Physical, chemical, bacterial, and plankton dynamics of Water Resources Research Institute. Louisiana State University, Baton Rouge, LA 70803; Tarver, J. W. and L. B. Savoie, 1976. An inventory and study of Lake Pontchartrain-Lake Maurepas estuarine complex. Section II. Zooplankton distribution and abundance. pp. 57 to 144. Technical Bulletin No. 19. Louisiana Wildlife and Fisheries Commission, Oysters, Water Bottoms and Seafoods Division).

RECOMMENDATIONS FOR RESEARCH

by

James H. Stone

Our data from the Lake Pontchartrain ecosystem suggest a variety of courses for future research.

We recommend research be initiated on the following:

1. The fate of nutrients entering the lake.
2. The extent and role of toxins in the lake.
3. The extent and general health of the submerged grassbeds.
4. The environmental quality of all existing wetlands.
5. Selected studies on interactions between the benthos and the nekton.