Technical Paper No. 29

CHOCTAWHATCHEE BAY:

ANALYSIS AND INTERPRETATION OF BASELINE ENVIRONMENTAL DATA

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FLORIDA SEA GRANT COLLEGE

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By

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FOREWORD

Choctawhatchee Bay, with its 86,295 acres of surface area and 1,321,106 acre-feet of water, comprises the third largest estuarine system on the Gulf Coast of Florida. As human activities encroach on the natural ecology of the Bay, its natural equilibrium will be altered. We can have a positive influence on these changes through a greater understanding of the dynamics of the ecosystem of the Bay. The future use and exploitation of the Bay must be carefully planned, and effective planning can result only from detailed knowledge of the biology, water chemistry, physiography, sediments and the general health of the ecosystem.

PREFACE

The final objective of any environmental study of this scope is to provide the insight that natural resource managers require to develop an appropriate management program. A comprehensive resource management program should precede all future decisions which affect Choctawhatchee Bay and point the direction to initiation of further studies. Delineation of guidelines, within a resource management program, requires a comprehensive data base and report concerning the dynamics of the Bay ecosystem and the components of the current and previous state of the Bay. Initial objectives in this process are to provide a concise summary of historical technical data and information which exist concerning Choctawhatchee Bay. This report attempts to integrate both historical and current environmental knowledge to provide a basic understanding of Choctawhatchee Bay to planners involved with implementing a much needed Bay management strategy.

Among the bays and estuaries of the Florida Panhandle Region, Choctawhatchee Bay is one of the most sparsely documented in terms of dynamics and ecology. In a first effort toward gaining insight on the nature of the Bay, all available technical and historical information and data sources were compiled. Presently, all of the sources of information concerning Choctawhatchee Bay are maintained at the Northwest Florida Water Management District. Reduction of the literature to pertinent information sources was greatly facilitated by a comprehensive summary of all known literature concerning the environment of Choctawhatchee Bay (Northwest Florida Water

Management District, 1980). The pertinent literature was reviewed and information concerning each environmental character represented in these historical and technical documents are presented and discussed. Of primary concern are temporal and spacial differences in the Bay as well as the quality and accuracy of the source.

The second phase of this report is concerned with the presentation of data gathered during the 1975 Florida Sea Grant sponsored project R/EM-5 (Collard, 1976). This grant was carried on through the University of West Florida, Department of Biology under the direction of Sneed B. Collard. It was primarily concerned with a biophysical environmental inventory of Choctawhatchee Bay over both seasonal and quarterly diurnal time frames. After the data were computerized they were visually checked for accuracy and summarized over time and space using tabular output and graphics including maps, contours, time plots and profiles. In order to grasp the interrelationships, and in turn the dynamics of the Bay, a host of statistical techniques including correlations, regressions, non-parametrics and cluster analyses were employed. Finally, the data were stored as a computerized data base at the Northeastern Regional Data Center (NERDC) in Gainesville, Florida, for future use by concerned groups desiring to study Choctawhatchee Bay (Blaylock, 1982).

ABSTRACT

This report characterizes the environmental conditions and mechanisms present in Choctawhatchee Bay. Existing environmental conditions documented in literature are summarized and discussed. Biological, physical and chemical data collected by the University of West Florida in 1975, through Florida Sea Grant Funding are analyzed and presented. Finally, the summarized literature and the 1975, University of West Florida study are assimilated into a detailed characterization of the ecosystem of Choctawhatchee Bay.

Intensive literature surveys were conducted for documents concerning both historical and current information on environmental conditions in Choctawhatchee Bay. Much of the survey was done by the Northwest Florida Water Management District, who also maintains a complete library of literature concerning Choctawhatchee Bay. The information in these documents was reviewed, condensed and discussed as an introductory characterization.

The University of West Florida conducted an intensive monthly survey of environmental conditions in Choctawhatchee Bay for thirty-one stations during the year 1975. Also, diurnal 48 hour studies were conducted at eight stations for each of the four seasons. Data collected includes phytoplankton, zooplankton, coliform bacteria, benthos, fish, nutrients and physical information. This information was computerized and reviewed using graphic and statistical techniques.

Finally, information from both documented sources and the University of West Florida data analysis were integrated and general conclusions describing the conditions of the Bay were presented.

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APPENDICES

Unattached Supplemental Appendices

Unattached Supplemental Appendices (continued)

Unattached Supplemental Appendices (continued)

Acknowledgment

The author is grateful to many individuals who contributed to the development of this comprehensive report on the ecology of Choctawhatchee Bay. Sneed B. Collard was instrumental in initiation of the project and must also be thanked for allowing the use of the data collected in Choctawhatchee Bay in 1975 by the Department of Biology, University of West Florida. Charles T. Gaetz assisted with computerized data presentation and graphics. The staff at the Northwest Florida Water Management District provided constructive editorial comments throughout the project. Anne Howick provided typing and editorial assistance for the final report.

1 - INTRODUCTION

Choctawhatchee Bay is located in the Panhandle Region of Northwest Florida with the longitudinal axis in an east-west orientation (Figure 1-2). The primary tributary to the Bay is the Choctawhatchee River at the eastern end of the Bay, while East Pass is the only direct outlet to the Gulf of Mexico, and is located near the west end of the Bay at Destin, Florida (Figure 1-1). Santa Rosa Sound opens into Choctawhatchee Bay in the vicinity of Fort Walton Beach and is an indirect passage to the Gulf of Mexico through Pensacola Bay approximately 40 miles to the west (Figure 1-2). The largest municipality, Fort Walton Beach, is located around Santa Rosa Sound and the deeper bayous at the western end of the Bay. From 1954 to 1974 Fort Walton Beach and nearby municipalities experienced a 700 percent increase in population (Nix, 1976) and the rate is expected to continue, since large amounts of land around the Bay have been purchased for residential development. This will add to the sewage and storm water input to the Bay, particularly around the many adjacent bayous where most of the development is centered. Some of these bayous are already sites of degradation problems, and continued increases to the nutrient loading to these bayous through point source, and nonpoint source input only exacerbate the problems in these specific bayous (Ross, Anderson and Jenkins, 1974).

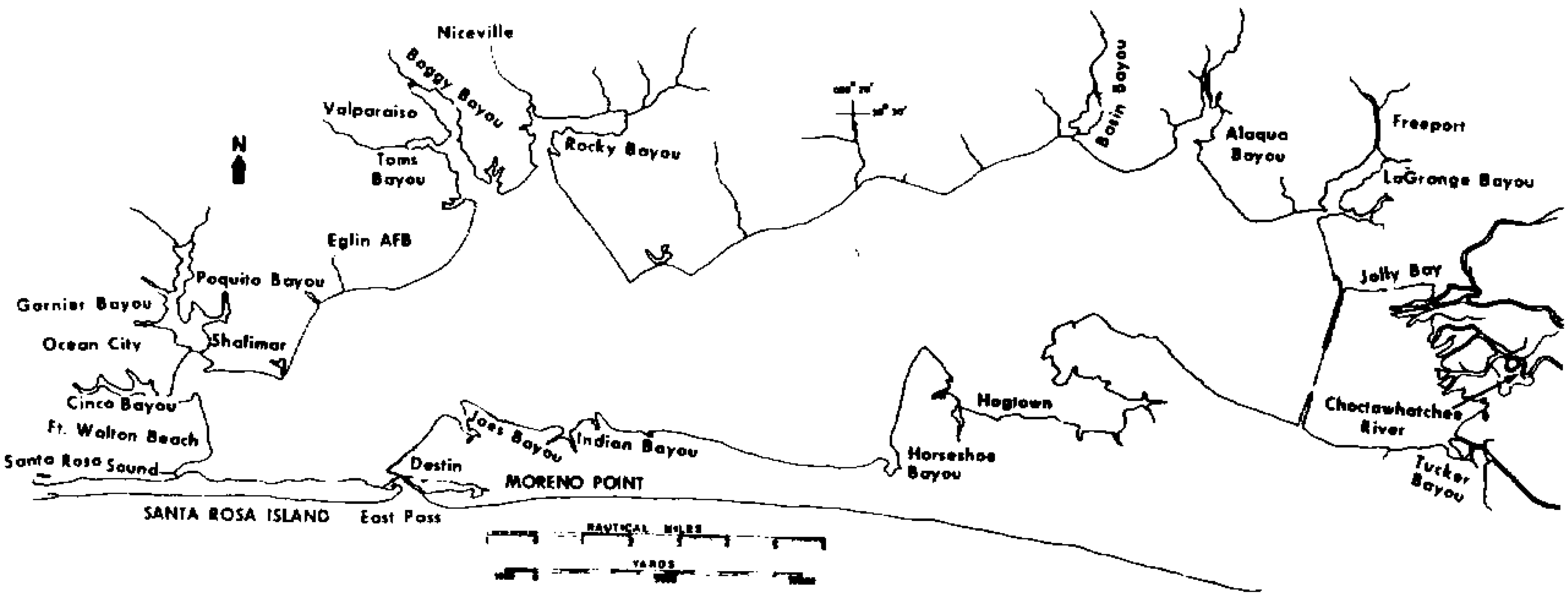

Figure 1-1: Map of Choctawhatchee Bay.

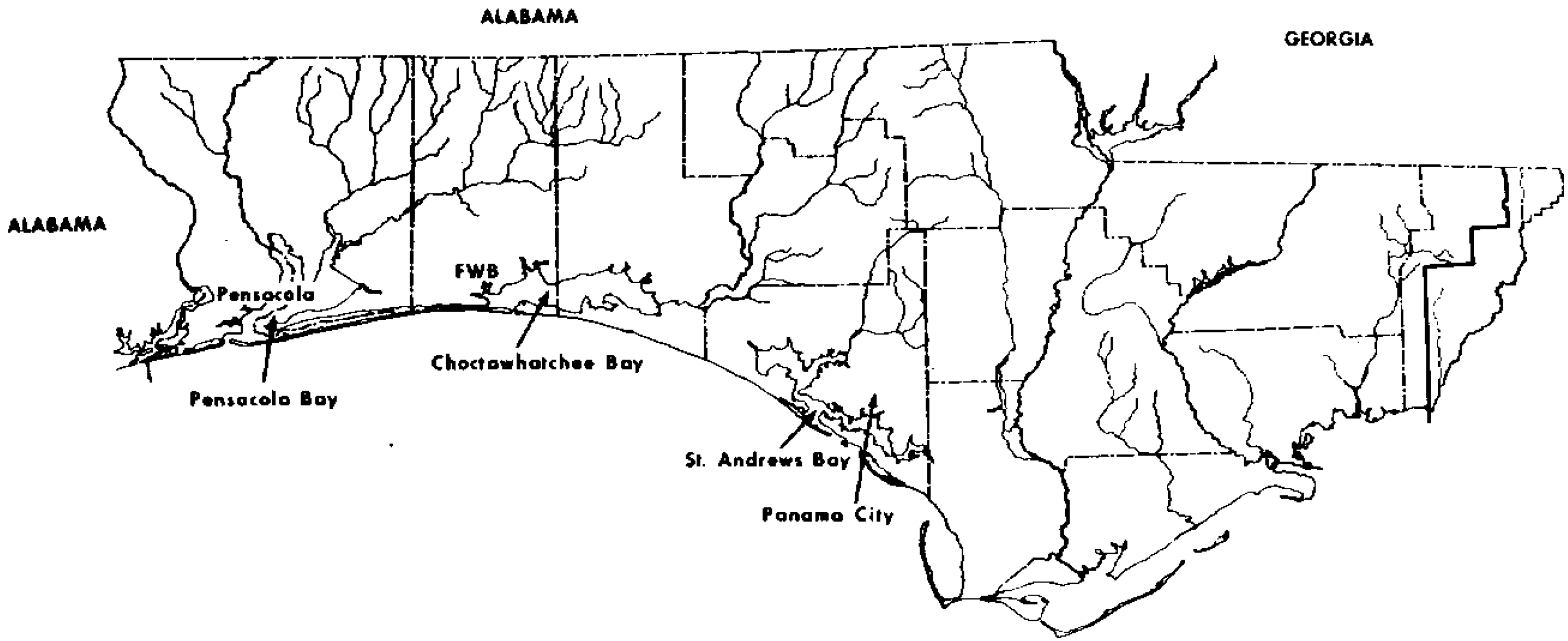

Figure 1-2: Map of the Northwest Florida Panhandle.

PHYSICAL CHARACTERISTICS

Choctawhatchee Bay has a surface area of 86,295 acres and is the third largest estuarine system on the Gulf Coast of Florida. Only Tampa Bay and Charlotte Harbor are larger (McNulty, Lindall and Sykes, 1972). The Bay is approximately 29.2 miles from east to west and about 3 miles wide at its widest point. A maximum depth of 43 feet may be found in the Bay just north of East Pass. Tidal range inside Choctawhatchee Bay varies from .6 feet in the eastern bay to 1.4 feet in Santa Rosa Sound (U.S. Army Corps of Engineers, 1976). Outside East Pass, the tidal range averages 1.5 feet (U.S. Army Corps of Engineers, 1976). The low tidal range in eastern Choctawhatchee Bay as compared to the western end of the Bay and other bays in Northwest Florida, including St. Andrews Bay and Escambia Bay with tidal ranges of 1.5 feet, may be attributed to many factors. These include the size of Choctawhatchee Bay, the shallowness of East Pass, the inflow volume and proximity of Choctawhatchee River, and Santa Rosa Sound, an indirect outlet to the Gulf of Mexico.

The entrainment of Choctawhatchee Bay occurred at approximately 3000 B.P., when a sea level change formed Moreno Point (Goldsmith, 1966, Pastula, 1967). This formation eventually led to the creation of a bay of brackish nature, which supported estuarine shellfish including oysters, which occurred in archeological digs in large numbers between the ages of 3135 B.P. to about 800 B.P. (Fairbanks, 1960). Choctawhatchee Bay, in the early 1900's was an inland, slightly brackish, body of water with minimal saltwater intrusion and mixing (Okaloosa Economic Development Council (OEDP), 1978. During flood conditions the freshwater inflow often exceeded the drainage rate through the former pass which was part of Destin's Old Pass Lagoon. In the late twenties, during flood conditions, a trench was dug at the site of East Pass and the rapid flow of water from the Bay to the Gulf of Mexico rapidly washed out a wide pass (OEDP, 1978). The Corps of Engineers periodically dredged that pass to prevent natural shoaling (U.S. Army Corps of Engineers, 1975).

Choctawhatchee Bay is fed through 13 major inflow points with the Choctawhatchee River accounting for more than 95% of the flow. Choctawhatchee River is the fourth largest river in Florida, draining about 4,000 square miles in lower Alabama and the Florida Panhandle. The main tributaries are Pea River in Alabama and Holmes Creek in Florida. The annual flow rates in Choctawhatchee River average from 5,500 cfsd in late summer to a maximum of 28,000 cfsd in early spring. The effect of the tributaries on the Bay can be determined by measuring the loading rates of nutrients, sediments and toxics. This rate is the total volume of a particular item contained in the inflow being deposited into the reaches of the Bay. The minor tributaries to Choctawhatchee Bay flow into the fringing bayous, and these bayous receive initial loading of nutrients and runoff wastes from these tributaries. For this reason, long term effects on the Bay due to a given set of circumstances may be observed more rapidly within the bayous. In order to measure effects within the bayous, their physiography must be studied to assess the final effects on the Bay. In the Choctawhatchee River drainage basin, the eastern bayous are generally shallow and must be dredged to allow moderate boat traffic (U.S. Army Corps of Engineers, 1973). The western bayous, including those located west of Niceville (Figure, 1-1), are deep and may act as sediment traps for their respective tributaries. Garnier Bayou in Shalimar, Florida, was suspected to once have have been a river channel.

ECONOMIC CONSIDERATIONS

Historically, Choctawhatchee Bay has been widely recognized for its recreational, transportational and commercial fishing importance. The Bay also serves as an important nursery and/or breeding ground to commercial and sport fishing species.

The recreational potential of the Bay has stimulated localized growth and promoted tourism. The quiet bayous of the Bay are used extensively for swimming, water-skiing, sailing and fishing, while the open waters of the main Bay are suited for large pleasure craft. Sportfishing interests in the Bay include trolling for spanish mackerel and bluefish, shrimping, cast fishing for seatrout, croaker and other sport fish and oystering. These recreational interests, as well as aesthetic appeal, have led to a boom in residential and commercial development around the Bay (Hennington, Durham and Richardson, 1976; West Florida Regional Planning Council, 1976). In 1975, the growth of the three western counties adjacent to Choctawhatchee Bay was second in Florida only to the Tampa-St. Petersburg area. Secondly, and possibly of greater importance to the economy, is the support the Bay lends in promotion of tourism. Tourism contributes significantly to retail sales which is second only to military spending as a revenue source for Okaloosa County (Post, Buckley, Schuh and Jernigan, 1977).

A portion of the U.S. Intercoastal Waterway passes through the length of Choctawhatchee Bay connecting it with Pensacola Bay in the west through Santa

Rosa Sound, and to West Bay in the east. An average of 4,381,234 tons of shipping passed between these points from 1970 to 1974 (Table 1-1). Maintenance dredging is performed by the Corps of Engineers to prevent shoaling of the Intracoastal Canal channel through deposition of sediments from Choctawhatchee River. In Walton County a minor seaport is maintained at Freeport, Florida, by the Corps of Engineers on LaGrange Bayou. The average annual tonnage of shipping moving through LaGrange Bayou from 1970 to 1974 was 202,764 tons. Gasoline was the principal import, while agricultural products, fertilizers, sand and gravel were the primary exports. Tables 1-1, 1-2 and 1-3 represent vessel trips, passengers and shipping tonnages for East Pass, LaGrange Bayou, and the Intracoastal waterway from Pensacola to Panama City, Florida.

Choctawhatchee Bay and adjacent Gulf of Mexico waters are widely recognized for both recreational and commercial fishing importance. Sport fishing in Choctawhatchee Bay accounts for 19.5 percent of the local sport fishing effort, while commercial Bay fishermen are responsible for only 12.7 percent of the total local commercial harvest (Irby, 1974). Irby, 1974, reports some 41,971 sport fishermen spending 104,004 man-hours of effort in the Bay, accounting for 16.4 percent of the total sport fishing harvest over a 13.5 month period. A federal fishery management program for striped bass (Morone saxatilis) was established in 1968, but was discontinued due to lack of funding (Northwest Florida Water Management District, 1980). A number of commercial oystering interests have been developed in Choctawhatchee Bay as described by Ritchie, 1961. But, as he points out, any further development should follow a detailed seasonal study of hydrographic conditions.

Table 1-1: Waterborn Commerce through the Gulf Intracoastal Waterway from Panama City, Florida to Pensacola, Florida (110 miles).

Year	Tons Shipping	Number of Vessel Trips
1970	4193132	7978
1971	4630497	7861
1972	4469075	7839
1973	4427047	7787
1974	4186422	7371

Source: Waterborn Commerce of the United States, 1970-1974.

Table 1-2: Waterborn Commerce through LaGrange Bayou

Year	Tons Shipping	Number of Vessel Trips
1970	164565	461
1971	234348	255
1972	197828	279
1973	236696	316
1974	1803852	252

Source: Waterborn Commerce of the United States, 1970-1974.

Table 1-3: Waterborn Commerce through the East Pass

Year	Tons Shipping	Passengers	Number of Vessel Trips
1970	3324	61392	4742
1971	332	79962	5616
1972	486	100464	8184
1973	2473	91104	7288

Source: Waterborn Commerce of the United States, 1970-1974.

Table 1-4: The Amount and Value of Commercial Marine Invertebrates Taken from Choctawhatchee Bay, Florida (Source: National Marine Fisheries Service, New Orleans)

	1966		1967		1968		1969		1970	
	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars
Blue Crab	4,300	1,200	50,400	2,671	220,300	14,914	233,400	17,822	15,200	1,396
Shrimp	158,500	83,761	122,600	63,247	106,200	60,261	41,500	21,156	72,900	32,084
Spring Oysters	4,300	400	5,200	2,260	4,600	1,967	9,700	4,203	10,900	5,298
Fall Oysters	400	153	1,400	609	2,700	1,155	3,800	1,646	1,300	631
Squid	2,500	193	2,400	175	3,700	441	700	64	1,500	99

Table 1-5: Average Annual Seafood Catch for Choctawhatchee Bay

	Catch Per Acre (pounds)		
Area (acres)	Finfish	Shellfish	Total
86,295	5.4	2.8	8.2

Source: National Marine Fisheries Service, Monthly Reports.

2 - READERS GUIDE

The document culminates much time and effort by students and faculty of the University of West Florida. It is hoped that it will be useful in decisions made concerning Choctawhatchee Bay. I hope that the decisions are made with the thought that environmental changes in most cases occur very slowly and that it takes many years to correct mistakes.

Section Four is a complete literature review with detailed discussions of the processes and properties which affect the ecology of an estuary. This section is most useful for persons interested in a detailed history of the ecological studies in Choctawhatchee Bay. It covers each aspect of the estuary as well as a discussion of information necessary to explain the results of this study. Section Seven contains the results of this study along with explanations of the processes in the Bay. As in Section Four the parameters are discussed individually. In addition to the Appendices shown here a complete supplemental Appendix of all results is available. *

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*NOTE: The Supplemental Appendices (p.xx) contain 965 pages, and are not included with this document. Also not included is an additional Supplemental Appendix, "Key to the Fishes of Choctawhatchee Bay and Other Northern Gulf of Mexico Estuaries." Single copies of the Supplemental Appendices and the additional Supplemental Appendix are on file at the Northwest Florida Water Management District Headquarters in Havana, the Florida State University Marine Laboratory, and the Florida Sea Grant office at the University of Florida.

3 - CONCLUSIONS

Prior to 1975, environmental information concerning Choctawhatchee Bay was sparce and incomplete. This study documents that information and provides much of the environmental information required to assess current conditions in the Bay. Future studies should be undertaken to determine changes in Choctawhatchee Bay due to either natural or cultural influences.

Choctawhatchee Bay is an estuarine embayment dominated by freshwater inflow. Salinities in the Bay are controlled by the volume of freshwater inflow due to topography of the Bay and the proximity and depth of East Pass. Since East Pass is much shallower than the central Bay the heavier, higher salinity water from the Gulf of Mexico becomes trapped below the freshwater from the tributaries. This process causes Choctawhatchee Bay to become highly stratified except during climatic disturbances such as Hurricane Eloise in 1975. Temperature was found to regulate dissolved oxygen concentrations in Choctawhatchee Bay with increasing temperatures depleting concentrations of dissolved oxygen. The mechanism of cause is thought to be both physical gas laws and biological activity. During summer months, the high temperatures and stratification cause extremely low dissolved oxygen concentrations in benthic waters. In bayous around the Bay and near the mouth of Choctawhatchee River the low freshwater flow in the spring and summer months causes surface waters to become oxygen depleted.

Productivity in Choctawhatchee Bay is limited by low concentrations of dissolved phosphorus. This is characteristic of other Northwest Florida Panhandle estuaries. Although tributary input of phosphorous is low it is relatively constant. Primary producers rapidly deplete dissolved phosphorous near the mouths of the tributaries to the Bay. These primary producers and higher levels of the food chain slowly die and settle to the bottom of the Bay. Here an equilibrium is established at the sediment water interface where phosphorous dissolved back into the water. The phosphorous recirculates back into surface waters at the turbidity maximum zone or zone of maximum mixing of surface and bottom waters. The location of this zone is controlled by the volume of freshwater discharge and in the high flow year of 1975 was found near stations 17 and 18 in the central Bay. The highest concentrations of chlorophyll were found at these stations suggesting high productivity and/or large numbers of senescent phytoplankton.

Nitrate, nitrite, ammonia, and organic nitrogen all enter the Bay through fluvial loading. However, the principal nitrogen compound leaving the Bay via East Pass is organic nitrogen. This indicates that nitrate, nitrite and ammonia are deposited in the sediments of the Bay through physical and biological processes. These compounds follow a similar trend to phosphorous where they become remineralized in the sediments and are released back into the water column.

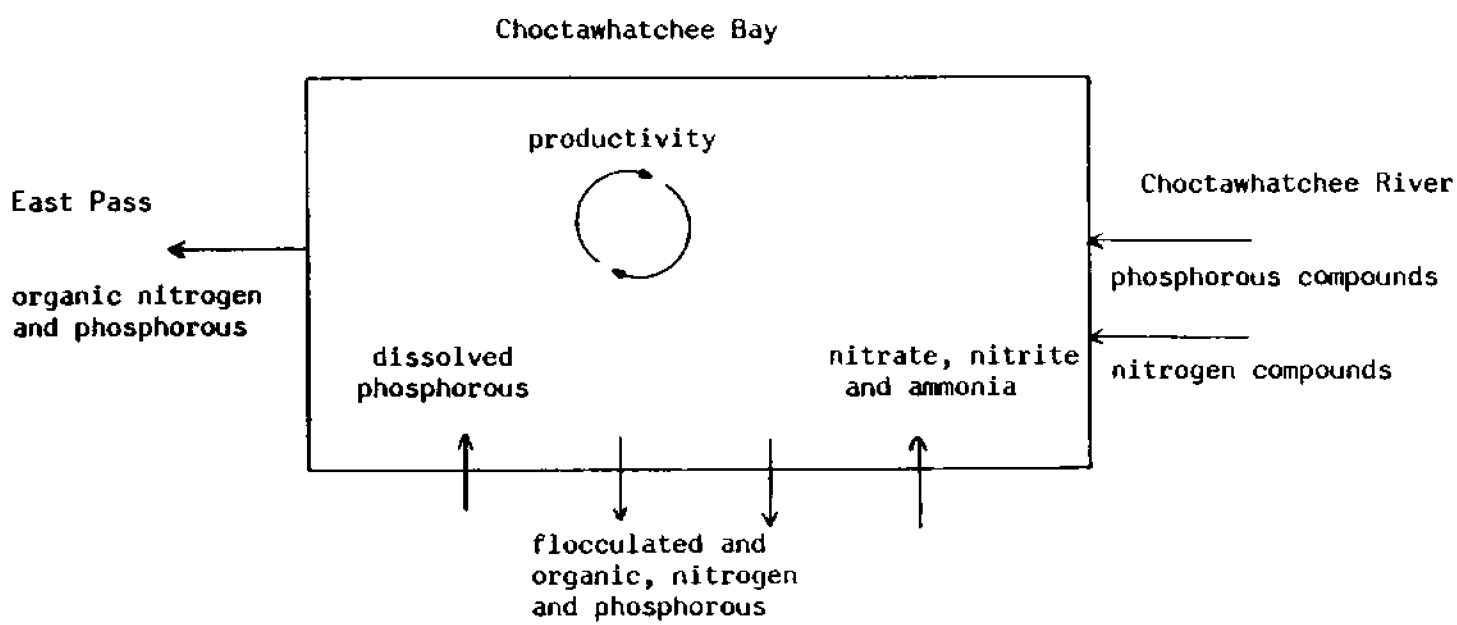


Figure 3-1: Box Model Depicting Nutrient Flux in Choctawhatchee Bay.

4 - LITERATURE SYNOPSIS

PHYSICIAL CHARACTERISTICS

Climatology

Choctawhatchee Bay, in the Northwest Florida Panhandle, is geographically located in the semi-tropical region of the northern hemisphere. This region is characterized by annual temperatures of about 68°F and 50 inches average annual rainfall. Storm fronts for the Florida Panhandle generaly move in a southeasterly direction, while winter winds originate predominately from the north (Taylor Biological Co., 1977). Goldsmith, 1966, reported the prevailing winds to be northerly from September to February and southerly from March to August, showing a distinct temporal pattern. The temporal variation of temperature precipitation, wind speed and wind direction play an important role in the nature of the Bay.

Daily weather conditions were obtained from the Department of the Air Force at Eglin Air Force Base, Florida, which is located on the northern shore of Choctawhatchee Bay. Air temperature in 1975, as depicted in Figure 4-1, exhibits a seasonal pattern, while short term variation is the result of storm events and local disturbances. Temperature patterns for the five years previous to and incuding 1975 are shown in Figure 4-2. The average annual temperature for 1975 was 67.4°F, slightly below that of the five previous years, but very close to the regional long term mean. This slight depression in the

FIGURE 4-1 : DAILY AIR TEMPERATURE DURING 1975 AT EGLIN AIR FORCE BASE, FLORIDA.

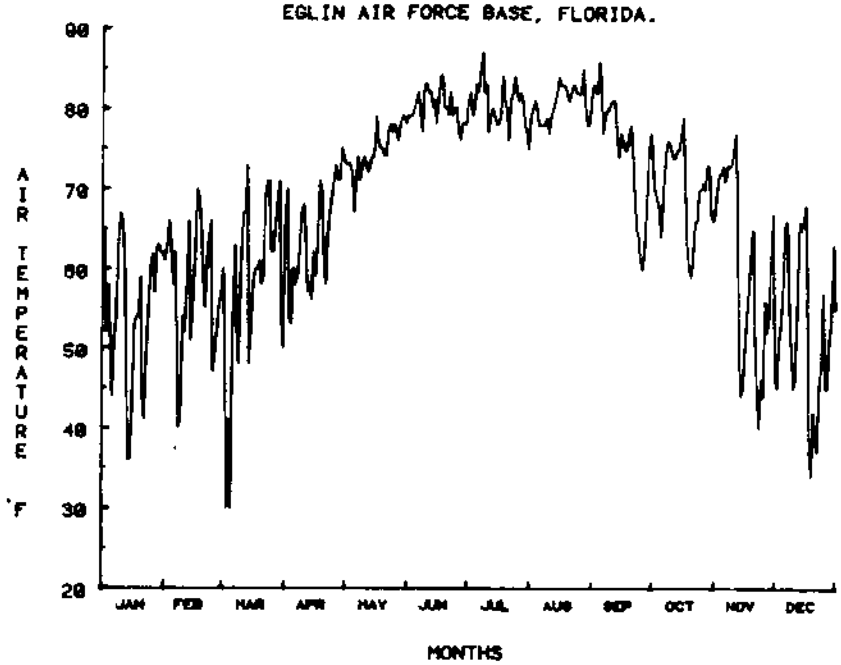
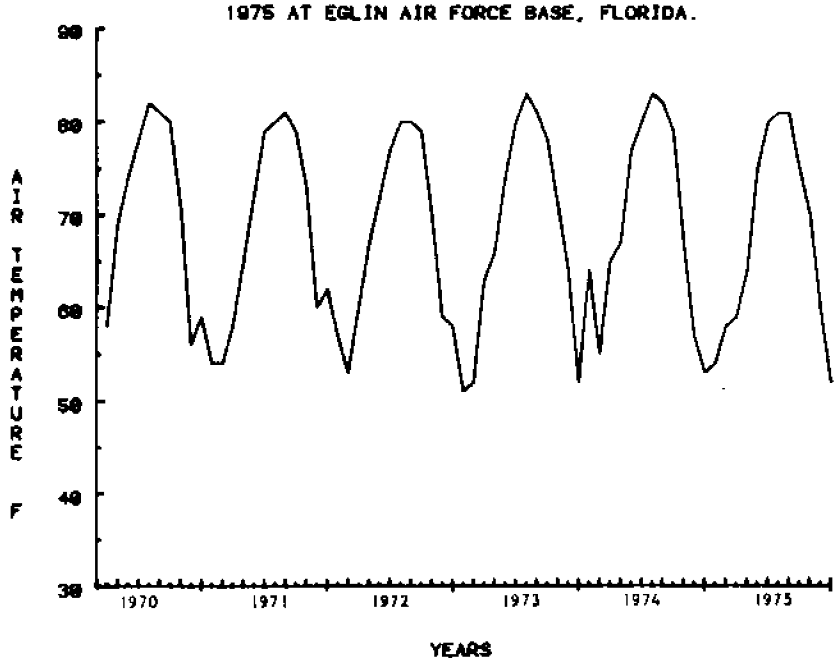


FIGURE 4-2 : AVERAGE MONTHLY AIR TEMPERATURES FROM 1970 TO 1975 AT EGLIN AIR FORCE BASE, FLORIDA.



annual average temperature appears to be the result of a longer winter season than in the previous five years. Figure 4-1 shows temperature fluctuations in 1975 to be sporadic in the winter and smoother, steady state in the summer. A sharp decrease in temperature occurred midway through October and below average temperatures occurred in early March.

The amount of rainfall within a region will control both surfaces and ground water discharge. This directly affects flow rates in the tributaries, and thus in turn, circulation and salinity within the Bay. Five years of monthly rainfall data from 1970 to 1975 show a departure in normal rainfall patterns for the year 1975 (Figure 4-4). The annual total precipitation for 1975 was 97.27 inches, almost double the mean of the preceeding four years (Figure 4-5). The regional average annual amount of rainfall is 62.3 inches/year (U.S. Department of Commerce). The departure from the mean may be attributed to extremely high rainfall in late July, 1975, and Hurricane Eloise in September, 1975, (Figure 4-3). These high precipitation periods generally depress salinity and increase suspended sediments in the Bay.

Figure 4-6 depicts cloud cover percentiles for the year 1975. In 1975, weather data from Eglin Air Force Base, Florida, show clear days to account for only 28.5 percent of the year.

Wind speed and wind direction aid in mixing of surface and bottom waters. Wind mixing facilitates increased gas transport and oxygenation of surface waters. Wind mixing in shallow depths of the Bay causes resuspension of sediments which reintroduces metals and toxics into the water as well as causing an increase in chemical and biological oxygen demand in the water column. Strong winds, acting on a large embayment of water such as Choctawhatchee Bay, can also affect circulation patterns by causing a temporary pile up of water at

FIGURE 4-3 : DAILY PRECIPITATION DURING 1975 AT EGLIN AIR FORCE BASE, FLORIDA.

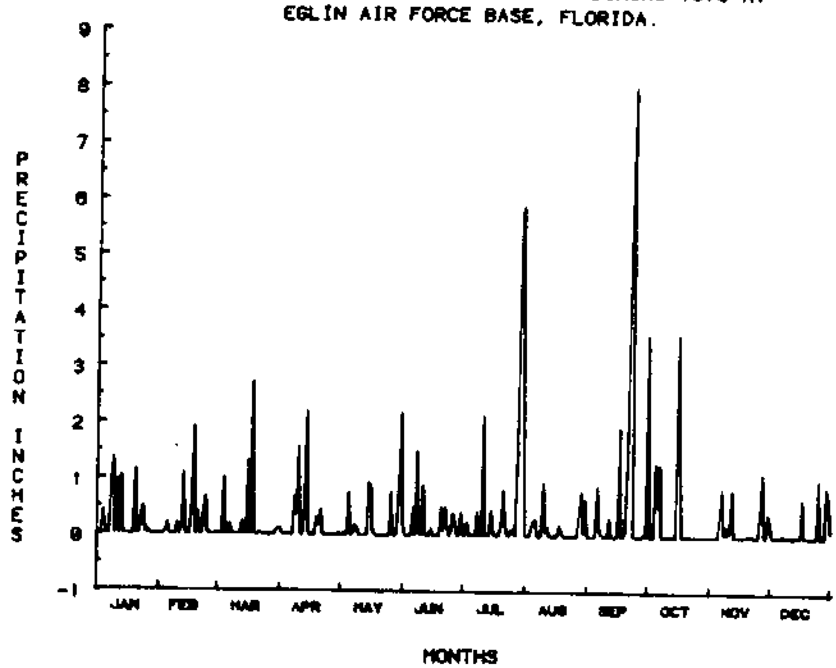


FIGURE 4-4 : AVERAGE MONTHLY PRECIPITATION FROM 1970 TO 1975 AT EGLIN AIR FORCE BASE, FLORIDA.

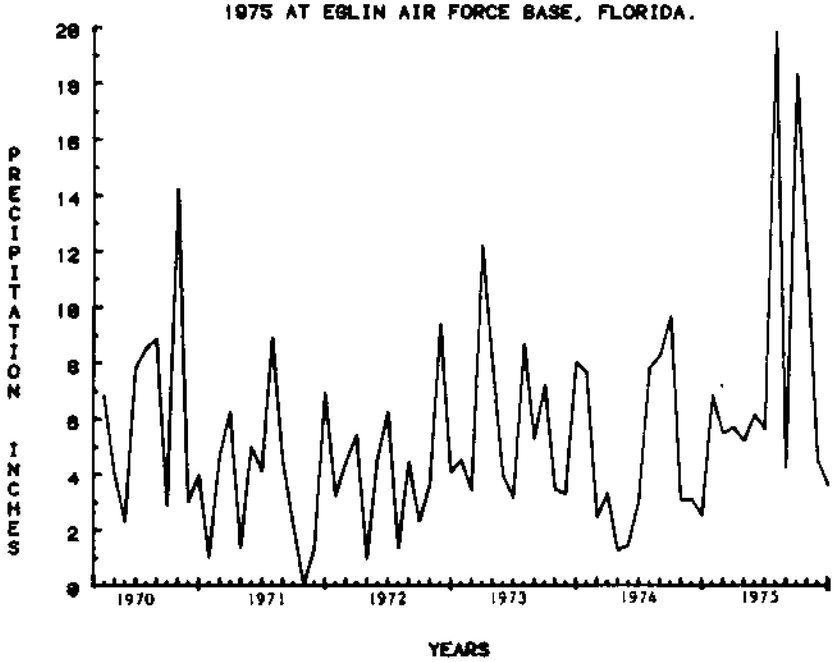


FIGURE 4-5 : ANNUAL PRECIPATION FROM 1971 TO 1975
AT EGLIN AIR FORCE BASE, FLORIDA.

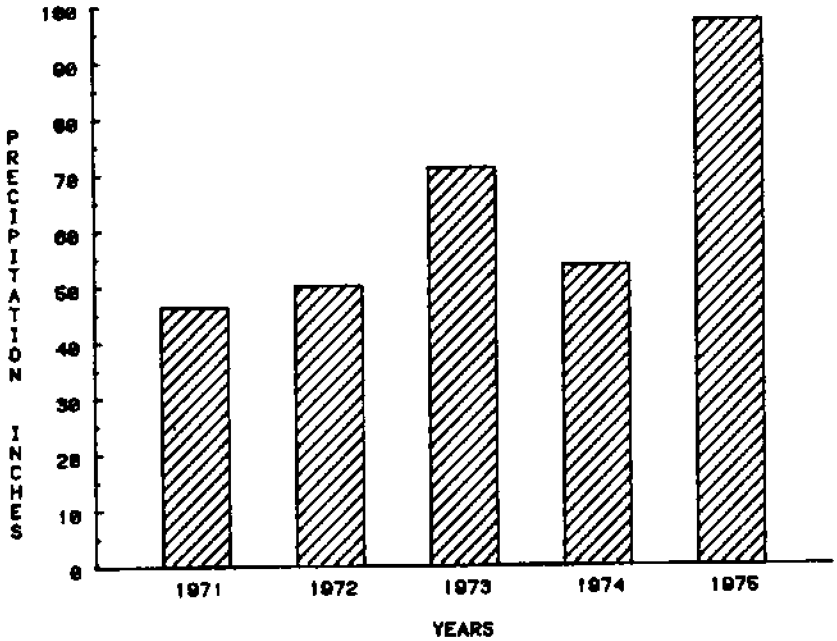
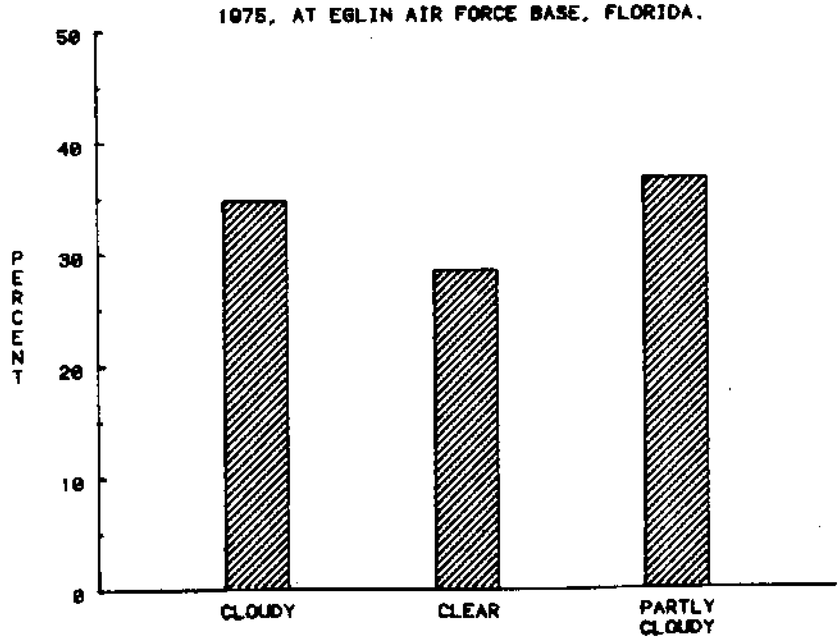


FIGURE 4-6 : CLOUD COVER PERCENTAGES FOR THE YEAR
1975, AT EGLIN AIR FORCE BASE, FLORIDA.



one end of the Bay. Figure 4-7 shows the largest percent of wind to originate from the north with southerly and southeasterly wind directions accounting for a combined 24.29 percent of the prevailing winds directions. This is in agreement with figures from the Escambia Bay Recovery Study (U.S. Environmental Protection Agency, 1975). EPA, 1975, also shows average wind velocity to be lower in the summer months than in winter months.

Hydrodynamics

Circulation within Choctawhatchee Bay can be described as two layered flow with entrainment of the bottom, higher salinity water underneath the freshwater, surface layers (Dyer, 1973). The two layered flow pattern is fosthered by the bathymetry of the Bay, and the proximity of both East Pass and Choctawhatchee River to the Bay. The effect which Santa Rosa Sound exhibits on the circulation of the Bay is not described and remains unexplained here.

The depth in Choctawhatchee Bay decreases from east to west, with a maximum depth of 43 feet located about one mile northeast of East Pass (Figure 4-9). This gentle slope allows benthic tidal water to move slowly into the eastern reaches of the Bay, but generally it does not cause strong mixing by upward currents of higher salinity tidal water with the overflowing freshwater from the tributaries. In the Bay west of Niceville, increased mixing of tidal water and freshwater are probably due to this area's proximity to East Pass, as well as the greater inclination of the bottom in near shore regions. As incoming tidal water reaches these steeper inclines, the water is forced upward mixing it with the overlying freshwater layer. The gradual slope toward the eastern end of the Bay allows the tidal water to disperse more

FIGURE 4-7 : WIND DIRECTION PERCENTAGES FOR THE YEAR 1975, AT EGLIN AIR FORCE BASE, FLORIDA.

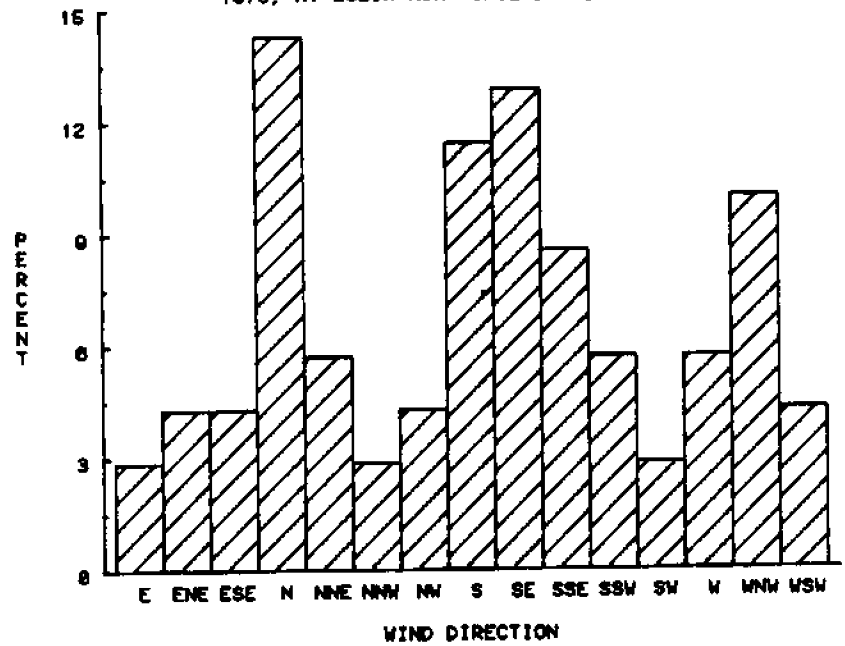
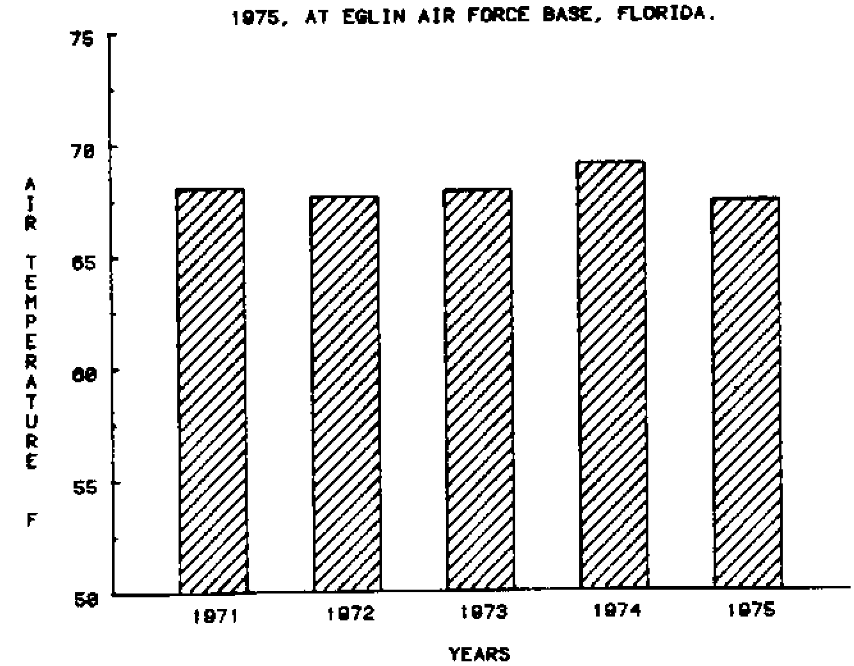


FIGURE 4-8 : ANNUAL AVERAGE AIR TEMPERATURE FOR THE YEAR 1975, AT EGLIN AIR FORCE BASE, FLORIDA.



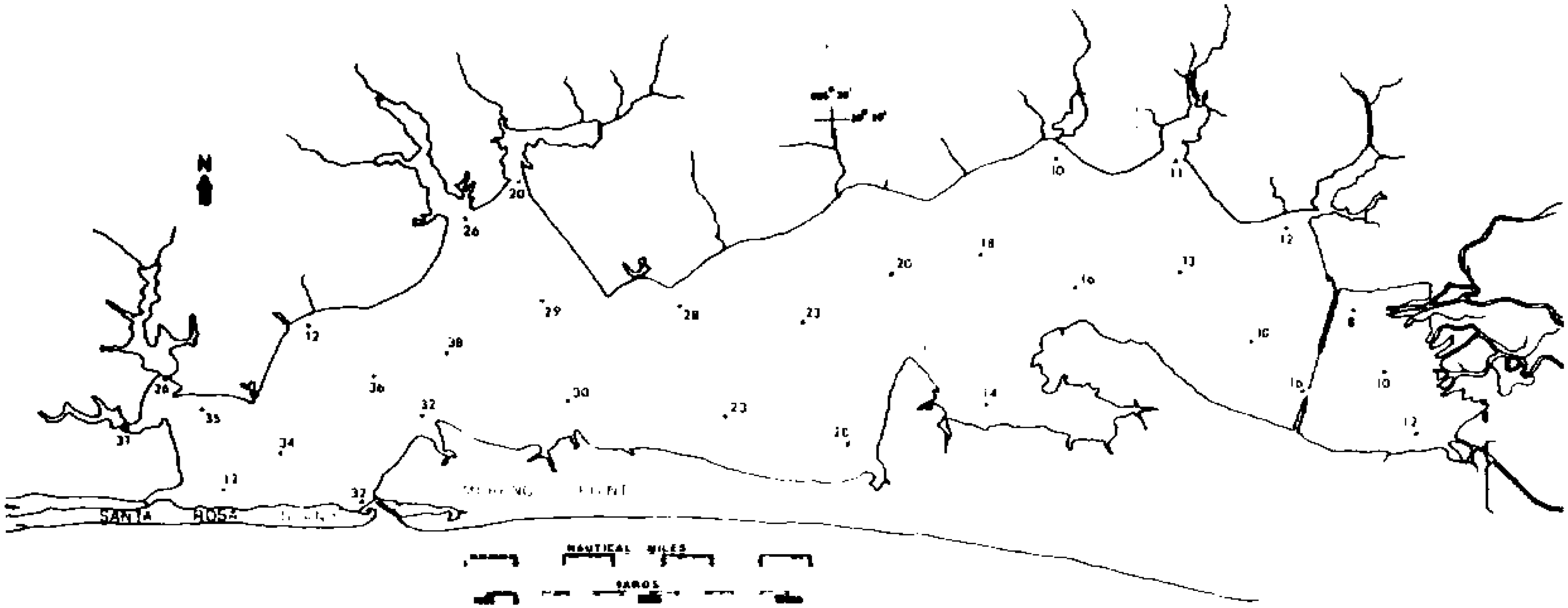


Figure 4-9: Station Depths in Choctawhatchee Bay

slowly along the bottom toward the east, creating the two layered flow system.

The major cause of bottom water entrainment in Choctawhatchee Bay is the shallow depth at East Pass which is maintained at 12 feet by the U.S. Corps of Engineers, 1975. This greatly inhibits tidal flushing of bottom waters as tidal amplitude ranges greater than one foot outside East Pass, about 0.8 feet in East Pass and less than 0.5 feet at the State Highway 331 bridge crossing the eastern end of the Bay. The low tidal ranges are characteristic of the diurnal tides of the northern Gulf of Mexico, and they are very low energy tides when compared to most other United States coastlines. As a result, tides play a much smaller role in the circulation and net flushing of Choctawhatchee Bay than does freshwater discharge.

Due to the minor role of tides in the Bay, freshwater discharge and runoff usually govern circulation, nutrient loadings, salinity and sedimentation rates. Discharge from the Choctawhatchee River ranges from 3,400 cubic feet/second/day (cfsd) to a high of 28,000 cfsd. Higher discharge rates normally occur in mid-summer. Within Choctawhatchee Bay, Goldsmith, 1966, found surface velocity rates at East Pass to be 1.0 knots, while all other flow velocities throughout the Bay were less than 0.5 knots. The U.S. Fish and Wildlife Service, 1969, found both bottom and surface flow velocities in the Bay to be about 0.5 knots and East Pass flow velocities to average 1.0 knots. Also surface waters were found to have a gentle westerly drift and tidal waters on the bottom were found to move at least as far east as the State Highway 331 bridge. Movement of bottom waters in the Bay has been traced through foraminiferal test deposition in the sediments (Pastula, 1967). Deposits of foraminiferal tests in the sediments indicate historical zones of freshwater and sea water interfaces where the calcified tests settle to the bottom in the lower density freshwater (Figure 4-10). The presence of these foraminifern tests are indicative that the Bay was once a higher salinity Bay with greater topographical variation causing upwelling of tidal water into overlying freshwater and deposition of foraminiferan tests.

Surface water flow in the eastern end of the Bay is depicted in reproduced NASA photographs of flood water sediments in the Bay (Figure 4-11). This interpretation of the photograph shows a water mass moving westward with eddies of the main stream of flow moving into the shallow bayous along with southern shores of the Bay.

Through the above documentation and suggestions of the frequent presence of a strong salinity gradient, it may be concluded that little mixing of salt water and freshwater occurs in Choctawhatchee Bay. As freshwater flows to East Pass, the underlying bottom waters are slowly removed by outgoing tides. Ross, Anderson and Jenkins, 1974, suggest that the salt water exchange rate in Choctawhatchee Bay is only 14% during each tidal cycle. The major portion, i.e. 86 percent of the incoming tide, is comprised of both freshwater and tidal water exchanged through previous tidal cycles. For this reason Ross, Anderson and Jenkins, 1974, predicted the overall flushing rate of the Bay to exceed one year. As mentioned previously, the reasons for this are probably the location of East Pass and Choctawhatchee River, as well as the depth of East Pass. These characteristics foster low tidal amplitude at 1.0 feet compared to 1.5 feet for nearby Pensacola Bay and St. Andrews Bay, and causes a 2 to 2.5 hour lag in tides from East Pass to the State Highway 331 bridge.

In 1975, freshwater discharge from Choctawhatchee River peaked in April

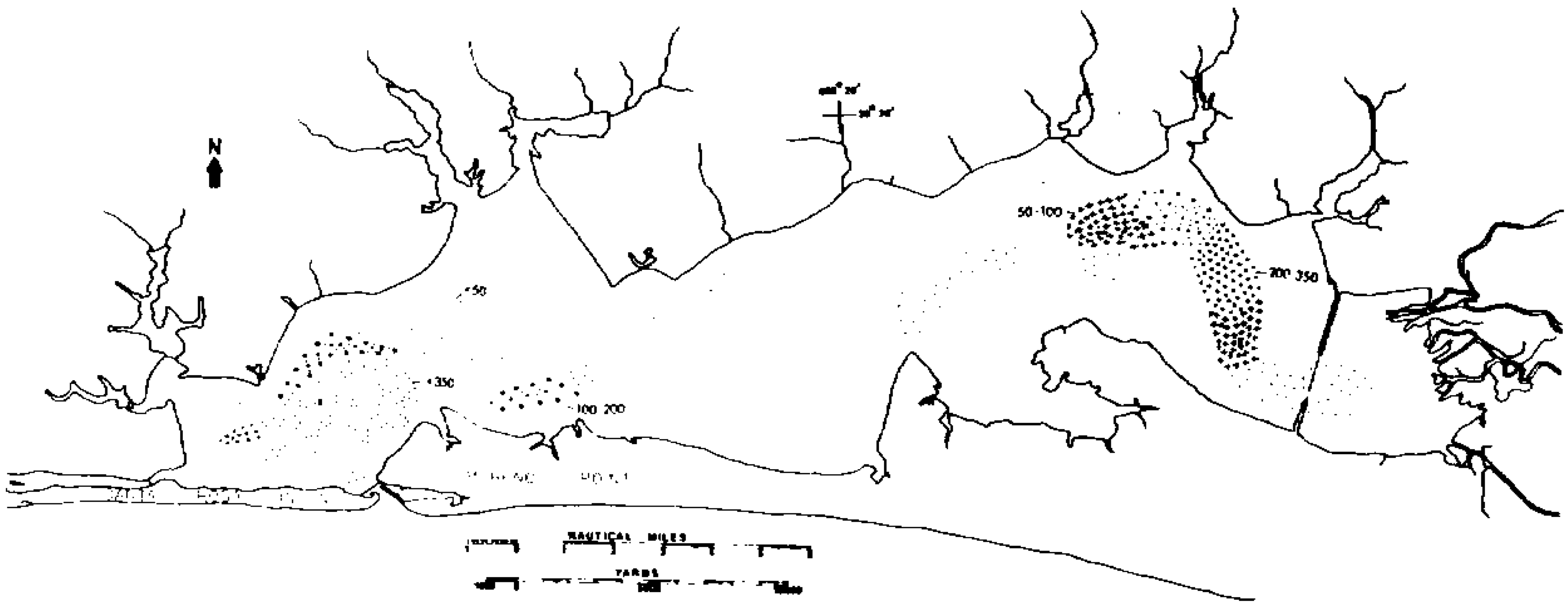


Figure 4-10: Foraminiferal distribution in Choctawhatchee Bay sediments (from Pastula, 1967).

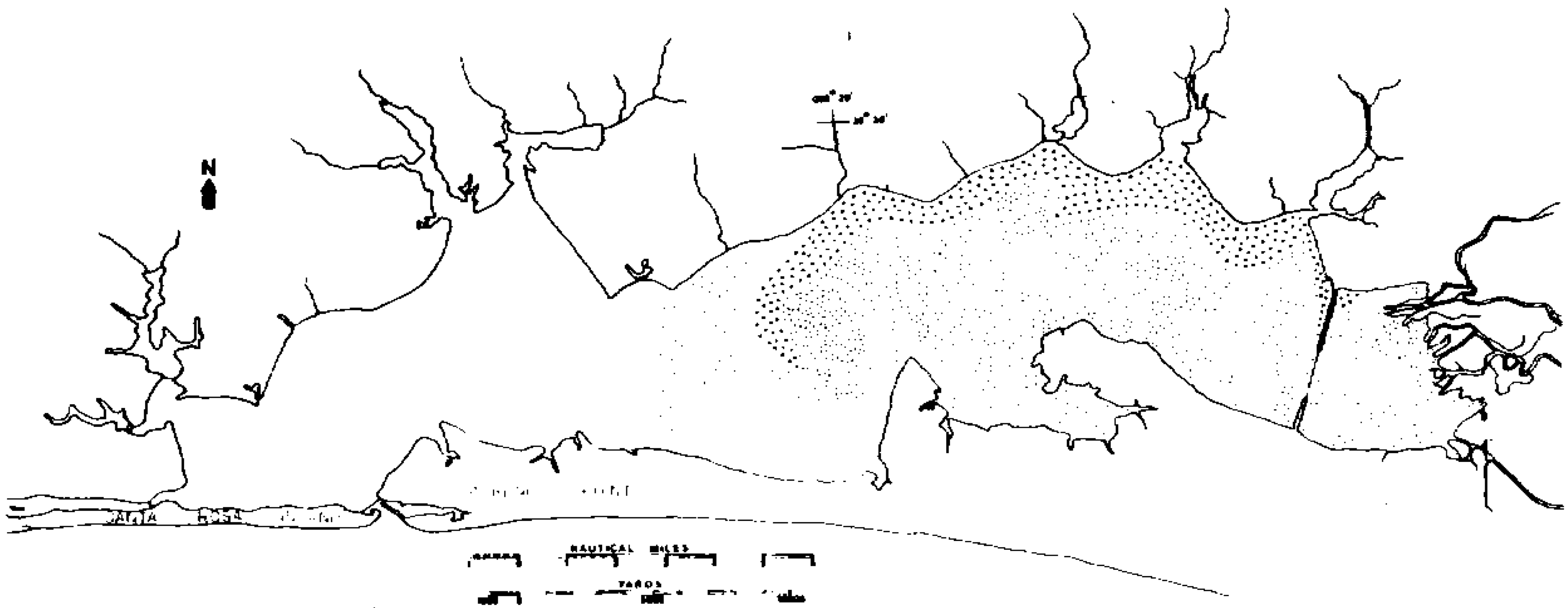


Figure 4-11 : Silt laden freshwater entering Choctawhatchee Bay during a March, 1975 storm (from NASA ERTS photograph).

with minor peaks occurring in August and October (Figure 4-16). The unseasonal high discharge rates in August and October are due to high precipitation in late July and Hurricane Eloise in late September. These unseasonal events are represented strongly in several smaller tributaries to the Bay (Figures 4-17, 4-18, 4-19). Figures 4-12, 4-13, 4-14 and 4-15 show annual discharge trends from 1968 to 1978. All stations, excluding Juniper Creek near Niceville, had the highest discharge occurring in 1975.

Water Temperature

Water temperature exhibits seasonal trends based on air temperature and solar insolation. Water temperature is also an important limiting factor for the biotic communities within an estuary. Alteration of the temperature regimes in an estuary will often drastically alter productivity and food-web dynamics (O'Connor and McErlean, 1975). Increasing temperatures, fresh-water discharge and increasing nutrient loadings have been suggested to be the controlling factors in spring blooms in other Northwest Florida estuaries (Estabroda, 1973; Myers and Iverson, 1977). Increasing summer water temperature is thought to be the cause of increased biological oxygen demand and chemical oxygen command (U.S. Environmental Protection Agency, 1975), particularly in the sediments. As shown by Ferguson and Murdock, 1975, higher temperatures increase the standing crop of heterotrophic microbes which will deplete both dissolved oxygen and benthic detrital concentrations. Therefore, with the slow tidal exchange in Choctawhatchee Bay, temperatures play an important role in causing depressed dissolved oxygen levels in bottom waters. Ritchie, 1965, found only slight differences in water temperature in the surface and bottom waters. Similar results were found by U.S. Fish and Wildlife

FIGURE 4-12: AVERAGE ANNUAL DISCHARGE FROM JUNIPER CREEK NEAR STATE ROAD 85, NICEVILLE, FLORIDA FROM 1968 TO 1978.

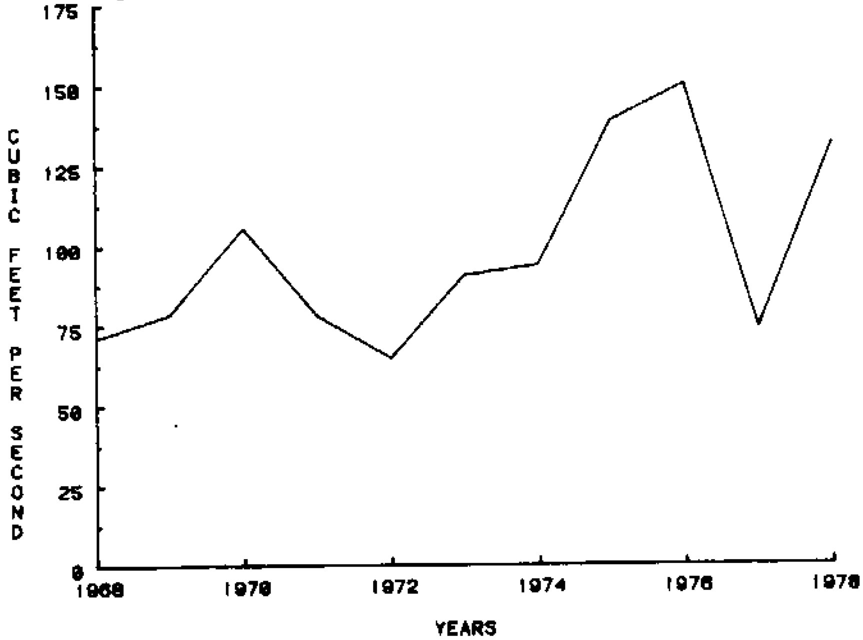


FIGURE 4-13: AVERAGE ANNUAL DISCHARGE FROM ALAQUA CREEK NEAR DEFUNIAK SPRINGS, FLORIDA FROM 1968 TO 1978.

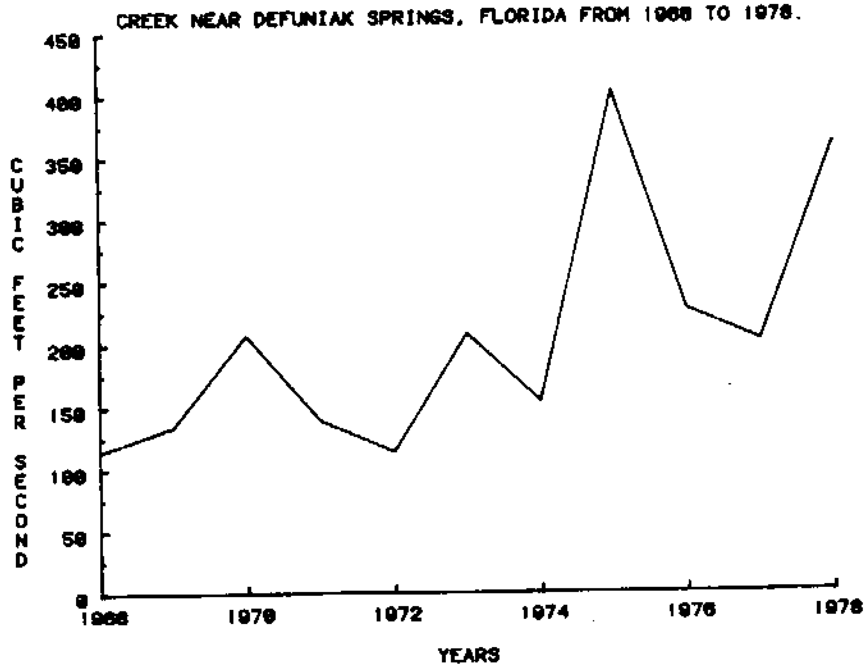


FIGURE 4-14: AVERAGE ANNUAL DISCHARGE FROM MAGNOLIA CREEK NEAR FREEPORT, FLORIDA FROM 1968 TO 1978.

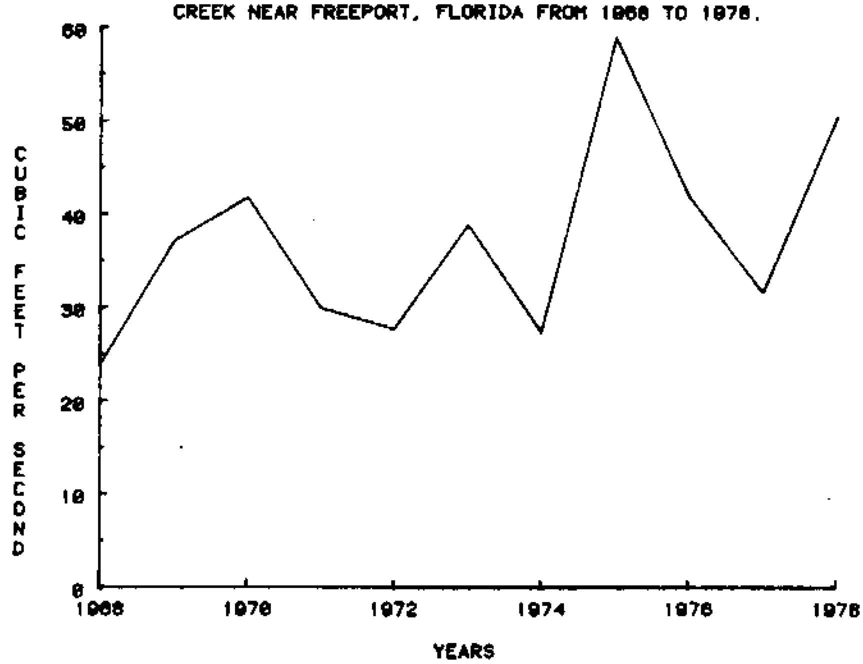


FIGURE 4-15: AVERAGE ANNUAL DISCHARGE FROM CHOCTAWHATCHEE RIVER NEAR BRUCE, FLORIDA FROM 1968 TO 1978.

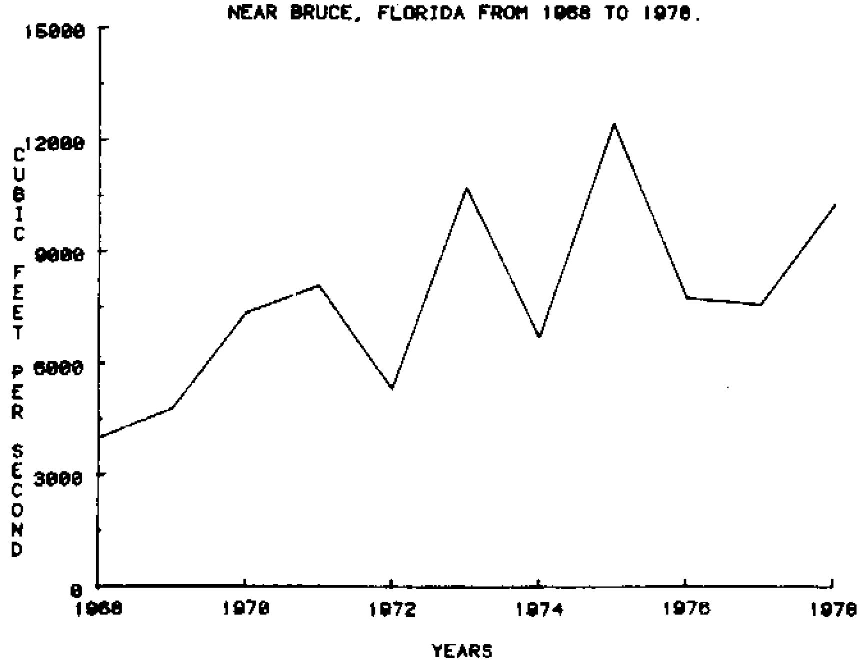


FIGURE 4-16: MEAN MONTHLY DISCHARGE FROM CHOCTAWHATCHEE RIVER NEAR BRUCE, FLORIDA IN THE YEAR 1975.

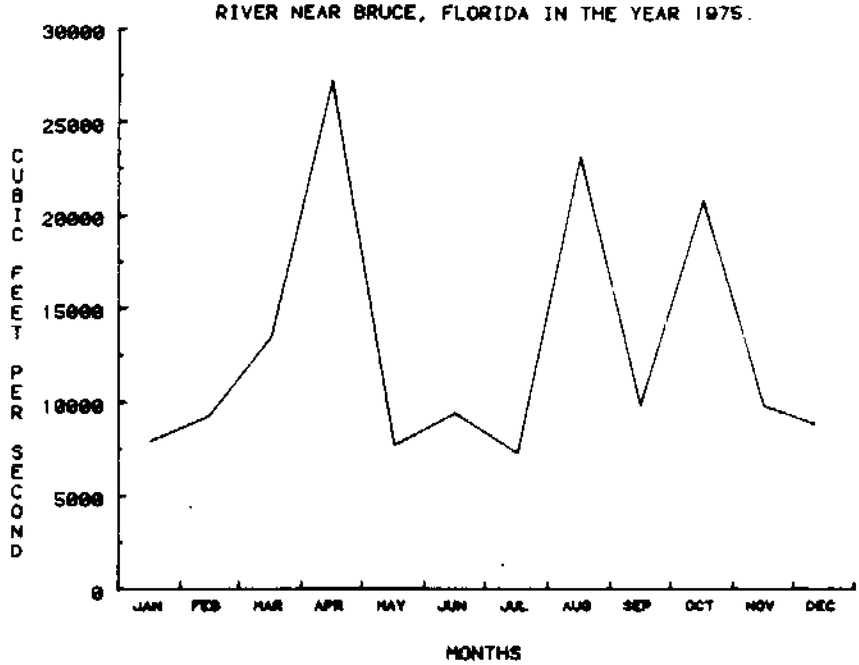


FIGURE 4-17: MEAN MONTHLY DISCHARGE FROM MAGNOLIA CREEK NEAR FREEPORT, FLORIDA FOR THE YEAR 1975.

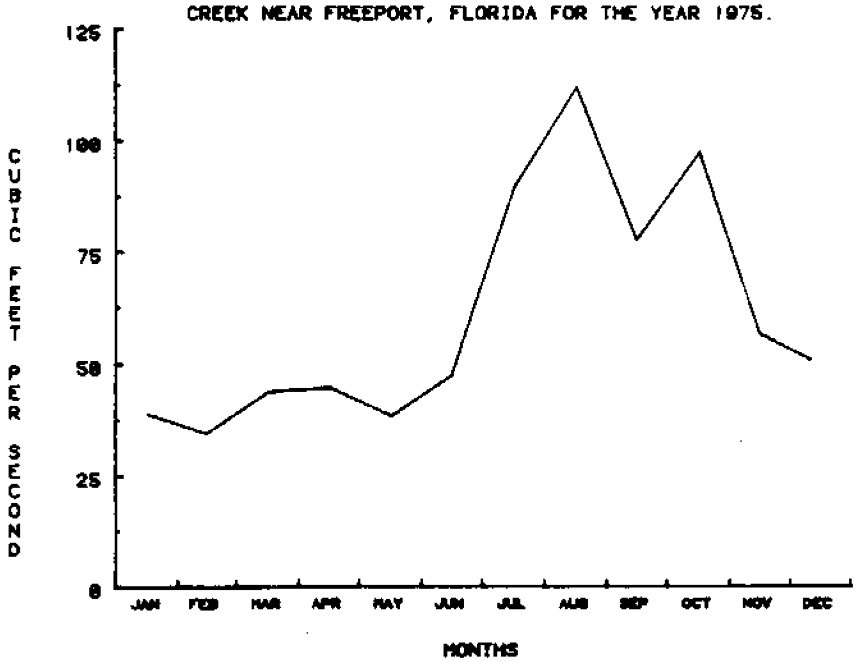


FIGURE 4-18: MEAN MONTHLY DISCHARGE FROM ALAQUA CREEK NEAR DEFUNIAK SPRINGS, FLORIDA IN THE YEAR 1975.

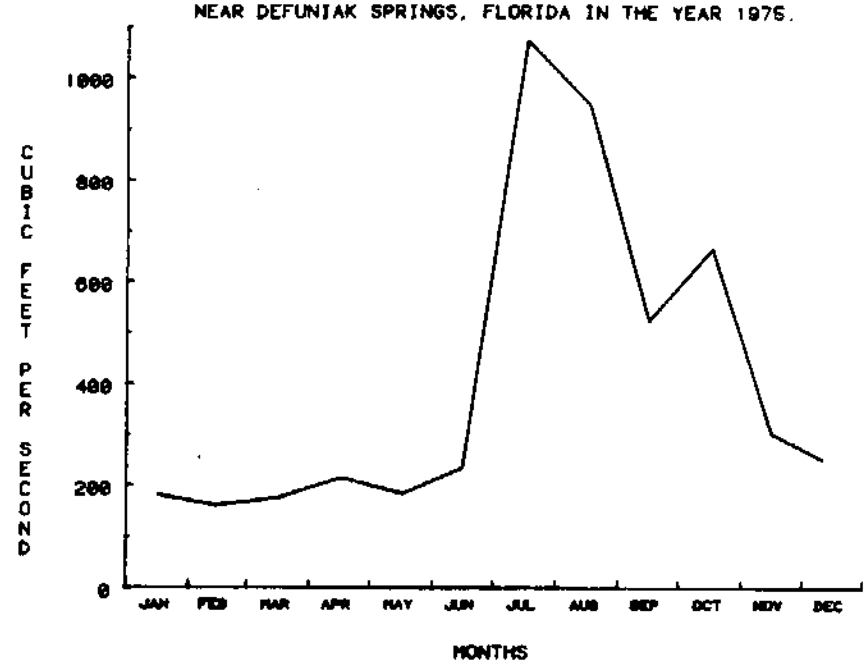
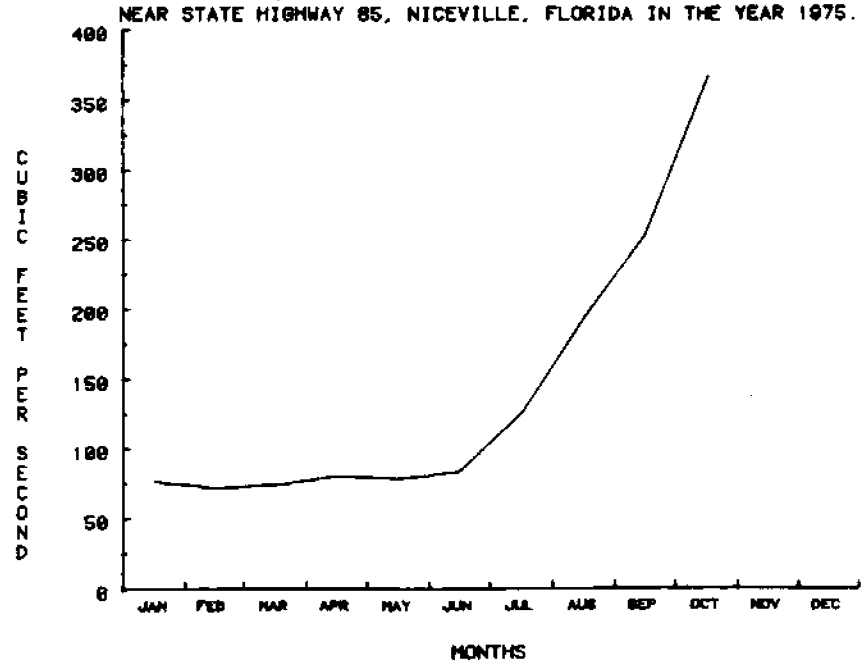


FIGURE 4-19: MEAN MONTHLY DISCHARGE FROM JUNIPER CREEK NEAR STATE HIGHWAY 85, NICEVILLE, FLORIDA IN THE YEAR 1975.



Service, 1968, while spatially, temperatures in the Bay ranged from 19.8 degrees centrigrade to a low of 13.7 degrees centigrade in the middle of March.

pH

Tributaries to Choctawhatchee Bay, excluding Choctawhatchee River, are slightly acidic with a pH as low as about 5.0 to 6.50 (U.S. Geological Society, 1980). The source waters of Choctawhatchee River arise in regions which are characterized by the Northwest Florida Water Management District as having a chemical type consisting of calcium and magnesium bicarbonates (Northwest Florida Water Management District, 1978). This could lead to a fluvial input of slightly alkaline pH waters in the eastern end of the Bay. This hypothesis is supported by Battelle Columbus Lab, 1977, in a baywide survey of pH. Battelle-Columbus Lab., 1977, found pH to be higher in surface fresh waters and decreasing slightly with increasing depth. The ranges in the main Bay were from 7.0 to 8.1 while in the more freshwater dominated intercoastal canal the pH ranged from 7.4 to 8.0.

Salinity

The characteristic feature of an estuarine habitat is the brackish water, or water of a reduced salinity when compared to oceanic realms. The actual measured salinity depends on the degree of mixing between inflowing fresh water with resident tidal salt water. Some forces in control of the mixing of fresh and salt water include the water density of both sources, volume of river inflow and tidal transport, tidal resurgency, meteorological conditions and the bathymetry of the estuarine system. Since chlorides in sea water are conservative elements, they may be used as tracers of the aforementioned characteristics depicting the circulation of an estuary. Secondly, the salinity is often the item of primary importance in determining the distribution of marine organisms in a tidal estuary. Estuarine organisms, for the most part, have wide salinity ranges, but are limited as salinities approach that of either freshwater or oceanic waters.

Choctawhatchee Bay has been characterized as having two layer flow with vertical mixing in the east and two layer flow with entrainment of the bottom water in the middle and western regions (U.S. Environmental Protection Agency, 1975). The freshwater flow moves from Choctawhatchee River to East Pass as surface flow while the denser high salinity bottom waters move slowly with the tides. The deep, gentle sloping bottom and shallow outlet to the Gulf of Mexico helps entrain the bottom waters except in the eastern reaches where the Bay is shallow. Bowden, 1967, shows a positive relationship between slope of the bottom and increased tidal mixing rates which would indicate strong mixing in western bayous and moderate mixing throughout the central and eastern Bay. The U.S. Army Corps of Engineers report increased tidal exchange through the mouth of East Pass with every periodic dredging, but no harm occurs to the Bay ecosystem (U.S. Army Corps of Engineers, 1975). The U.S. Environmental Protection Agency, 1975, reports constant surface salinities and bottom salinities which decrease slightly with decreasing bottom depth toward the east. During periods of low freshwater inflow from Choctawhatchee River, greater tidal salt water exchange results forcing the movement of the dense, higher salinity bottom water in the Bay toward the mouth of the River. This bottom water moves along both natural and maintained channels from which the higher salinity bottom water overflows and mixes with overlying freshwater (U.S. Army Corps of Engineers, 1973). Sea water and freshwater mixing is also reported to occur in the western bayous and around the shallow perimeter of the Bay, though it is not as important as toward the center of the middle and eastern end of the Bay (U.S. Fish and Wildlife Service, 1975).

The strong halocline commonly found in Choctawhatchee Bay (Ritchie, 1961; U.S. Department of the Interior, 1968; Collard, 1976) is the result of reduced tidal mixing, not an arrested salt wedge. The degree of mixing increases with increasing tidal energy and is reduced in a low tidal energy system such as Choctawhatchee Bay. In Choctawhatchee Bay the salt wedge penetrates at times well into the eastern end of the Bay and also up the deep water bayous in the western end of the Bay. For this reason, the western bayous have greater flushing rates than those in the eastern Bay, and can handle higher loading rates of nutrients and organics (Ross, Anderson and Jenkins, 1974). Ross, Anderson and Jenkins, 1974, also contend that the flushing rate for Choctawhatchee Bay is less than 14 percent of new Gulf of Mexico oceanic water for each tidal cycle. At this rate, the estimated transport rate of nutrients entering the Bay from Choctawhatchee River and leaving via East Pass will slightly exceed one year. Attributing to the long residence of nutrients in Choctawhatchee Bay is the reduced tidal exchange and velocity within the Bay.

In Choctawhatchee Bay, a strong halocline exists between the lighter surface fresh waters and the denser bottom waters with as much as a 14 ppt difference within two feet of water (Collard, 1976). The strong demarkation of salinity probably results from the velocity of the surface waters and the bathymetry of the Bay. The submarine topography in the Bay support three pockets where high salinity water is concentrated (Goldsmith, 1967). These salt water sinks are not strongly demarked and they remain well connected by central channels in the Bay through tidal movement. Tidal movement is slight and the resulting sluggish flow rates and the strong halocline lead to other problems which have been documented for the main Bay. Bottom waters in Choctawhatchee Bay are often depleted of dissolved oxygen. This, along with sedimentation in the central and eastern Bay, often lead to anaerobic conditions resulting in a biologically barren deep water region (Taylor Biological Co., 1978).

Dissolved Oxygen

Dissolved oxygen content is a strong indicator of current environmental conditions within an estuary. When dissolved oxygen is low, metabolic processes will be reduced accordingly in the estuarine community. Many factors regulate the dissolved oxygen content in an estuary. In an estuary such as Choctawhatchee Bay where tributary inflow dominates circulation, the dissolved oxygen content from the river will be the major factor in determining dissolved oxygen in the Bay. During normal and above average discharge conditions from Choctawhatchee River, the incoming freshwater will increase dissolved oxygen content in the Bay. However, during low river discharge periods the river water will consist of drainage from low marshy regions and underground seepage, both of which are generally oxygen depleted. The biochemical oxygen demand (BOD), during certain conditions, can also severely deplete dissolved oxygen levels. When dissolved and sestonic organic carbon and temperatures are high, as in the summer, the BOD will increase, thus reducing dissolved oxygen in the Bay. The greatest BOD in the water column will be in the halocline, which in Choctawhatchee Bay also seems to be the same region as the turbidity maxima. Here sediments and clays tend to flocculate (Postma, 1967) and negatively charged dissolved organics precipitate and are adsorbed onto flocculated sediments (Darnell, 1967). These processes are initiated upon contact with magnesium and calcium ions found in seawater (Postma, 1967). This region of the turbidity maxima is also where heterotrophic microbes concentrate, particularly in warmer months when favorable growing conditions for the microbes exist.

Dissolved oxygen fluctuates largely over a diurnal cycle. This fluctuation increases in regions which are nutrient enriched. The nutrient enrichment precludes high photosynthetic rates increasing dissolved oxygen during the day and high respiration rates at night depleting the oxygen supplies. Temperature affects dissolved oxygen, not only through regulation of metabolic processes, but also physically through gas constants. As temperature increases, gas solubility decreases and diffusion rates increase. Thus, during the warmer summer months, the dissolved oxygen content saturation is lower and dissolved oxygen input from the tributaries is reduced. Also affecting dissolved oxygen concentrations in the Bay are gas transport rates. Theoretically, oxygen should be distributed evenly throughout the water column; however, dissolved gases, including oxygen, are inversely proportional to salinity. In Choctawhatchee Bay diffusion rates of oxygen to bottom waters would be disrupted at the halocline causing a reduction in dissolved oxygen transport to the tidal waters on the bottom. The above conditions create a zone in Choctawhatchee Bay known as the compensation level, defined as the level where respiration and decomposition consume oxygen in equal amounts to that produced or input in a twenty-four hour period (Reid and Wood, 1976). Contributing to the location of the compensation level is the turbidity of the water. Increasing turbidity will reduce light penetration of the water column thereby limiting primary productivity and oxygen production to surface waters.

Many studies have found depleted oxygen levels in Choctawhatchee Bay (Battelle-Columbus Laboratories, 1973; U.S. Environmental Protection Agency, 1975; Ross, Anderson and Jenkins, 1974). In particular, the benthic dissolved oxygen levels have been cited as problematic (U.S. Environmental Protection Agency (EPA), 1975). EPA, 1975, found in comparative samples during the summer of 1974, that nine of twenty-one bottom stations do not meet the Florida standard (Florida Administrative Code, 1973), for Class II and Class III waters. The minimum levels are 4.0 mg/1, except in natural dystrophic estuaries. Lowest dissolved oxygen levels occurred in deeper waters of the Bay. In surface waters EPA, 1975, found dissolved oxygen concentrations to be at 70 percent of the saturation concentration at the mouth of Choctawhatchee River, increasing to 100 percent saturation in the middle of the Bay. This is indicative of acceptable environmental conditions in surface waters of the Bay. Ross, Anderson and Jenkins, 1974, and the U.S. Fish and Wildlife Service, 1968, both suggest that lowest dissolved oxygen levels occur in bottom waters during periods of high inflow during the late spring and summer, since benthic dissolved oxygen remains unreplenished due to the strong halocline.

While analyzing Florida Department of Pollution Control data, Ross, Anderson and Jenkins, 1974, found BOD rates to range up to 5.4 mg/1 in the mouth of several minor tributaries. The U.S. Environmental Protection Agency, 1975, found surface BOD ranging from 5.2 mg/1 to 6.2 mg/1 and bottom water BOD raning from 1.8 mg/1 at East Pass to 13.6 mg/1 in the central Bay above Hogtown Bayou. These data show a potential problem in the deeper waters of central Choctawhatchee Bay during September, 1975. Aside from being a natural occurrence in Choctawhatchee Bay, one possible cause of the high BOD rate could be increased organics from seasonal demise of phytoplankton populations. Florida Department of Environmental Regulation, 1979, suggests potential degradation problems in the western Bay resulting from increased urbanization. Santa Rosa Sound was found to be relatively healthy in terms of BOD and benthic diversity.

WATER QUALITY

Phosphorous

In estuarine environments, most phosphorous exists primarily in an insoluble form; however, primary producers require it in a soluble form. The soluble form commonly found in estuaries is composed of orthophosphate, polyphosphate and organic phosphate. The insoluble forms predominate in the estuary because of high bacterial utilization, primary productivity, adsorption onto insoluble residues and formation of insoluble precipitates. The basic pH conditions of estuaries enhance these processes. Principal allochthonous sources of phosphorous are precipitation and gas transport from the air, and in some estuaries, from human derived sources. Phosphorous is a conservative nutrient in estuaries. The precipitated insoluble phosphorous remains in equilibrium with soluble phosphorous in the water and the ratio of the two is indirectly mediated by dissolved oxygen concentrations (Webb, 1981).

Northwestern Gulf of Mexico estuaries are characteristically limited in terms of productivity by phosphorous. Any major input of phosphorous to these estuaries could lend to excessive phytoplankton blooms and eutrophication (Meyers and Iverson, 1981). Choctawhatchee Bay is similar in respect to phosphorous to many other Northeastern Gulf of Mexico estuaries (U.S. Environmental Protection Agency, 1975). EPA, 1975, found mean total phosphorous to be 0.03 mg/1 and the mean dissolved phosphorous to be 0.013 mg/1 in Choctawhatchee Bay. The eastern region and tributaries seemed to have higher phosphorous values than the central Bay. The phosphorous levels found during the Escambia Bay Recovery Study, (EPA, 1975), never exceeded criteria for total phosphorous of .05 mg/1 established in 1972 (Water Quality Criteria, 1972). Ross, Anderson and Jenkins, 1974, studied phosphorous input to Choctawhatchee Bay from fluvial sources, point sources and non-point sources. These studies indicated that the major source of phosphorous to Choctawhatchee Bay was from Choctawhatchee River. Toms Bayou and other bayous in the western Bay and Santa Rosa Sound were also found to have significantly higher concentrations of phosphorous than found in the main Bay. This was thought to be the result of urbanization around the western end of the Bay.

The principal nutrient index used to characterize phytoplankton blooms is the phosphorous-nitrogen ratio (P:N ratio). Optimal conditions are suggested to be as high as 1:20 (Ross, Anderson and Jenkins, 1974), with lower ranges of 1:5 and 1:10 (Webb, 1981). Preliminary observations of data from Choctawhatchee Bay found P:N ratios as high as 1:50 (Ross, Anderson and Jenkins, 1974), thereby suggesting a high degree of phosphorous limitation in terms of productivity.

Nitrogen

In estuaries nitrogen is essential to primary productivity; however, excessive nitrogen, under certain conditions, can contribute to eutrophication. Nitrogen compounds in an estuary can come from many allochthonous sources.

Seemingly insignificant sources in Choctawhatchee Bay are precipitation and surface nitrogen fixation by certain algal groups. Gaseous nitrogen stays at equilibrium at the surface air water interface; however, this elemental form of nitrogen is relatively unimportant to nitrogen cycling within the estuary (Webb, 1981). Fluvial loading of nitrogen from tributaries includes input from both natural and human sources. Theses sources include surface land runoff, groundwater seepage and discharge of municipal and industrual waste products into waters above the falline or the head of tide. Increased culturally derived nitrogen input into an estuary through fluvial loading, runoff and point source discharge often causes eutrophication problems within an estuary (Jaworski, 1981).

Autochthounous nitrogen sources in the estuary are from the death and decomposition of biotic components of the Bay and from sediment nitrogen release. These nitrogen cycles within the estuary are well documented (Webb, 1981). Nitrogen compounds in an estuary occur in inorganic and organic fractions. Nitrogen compounds or species most readily used by primary producers include nitrate, nitrite and ammonia. Total nitrogen is computed as the sum of nitrate, nitrite and total kjeldahls nitrogen (TKN). TKN is computed as the sum of ammonia nitrogen and organic nitrogen. Water Quality Criteria, 1972, suggests a maximum concentration of 0.36 mg/1 of total nitrogen for coastal oceanic water, however, this value may not be appropriate for estuaries which may be dominated by high natural sources of nitrogen compounds. There are no Florida State criteria for nitrogen levels in estuarine waters.

The U.S. Environmental Protection Agency, 1975, found mean levels of total nitrogen to average 0.25 mg/1 in Choctawhatchee Bay, well below levels in Escamia Bay to the west and suggested U.S. Environmental Protection Agency levels (Water Quality Criteria, 1972). In the same study organic nitrogen was found to compose an average 74.2 percent of the total nitrogen levels. Ross, Anderson and Jenkins, 1974, found the range of total nitrogen to be from 0.3 to 0.4 mg/1, with concentration increasing toward the eastern end of the Bay. This suggests high fluvial loading rates of total nitrogen from Choctawhatchee River. High total nitrogen levels were found in LaGrange Bayou, Lafayette Creek, Santa Rosa Sound, Cinco Bayou, Garnier Bayou and Boggy Bayou (Ross, Anderson and Jenkins, 1974). These high levels were probably the result of municipal input.

Carbon

Organic carbon represent the concentration of both living and non-living carbon compounds available to heterotrophic activity and contributing to microbial biomass. Biggs and Flemer, 1972, suggest in upper estuaries the concentration of organic carbon to be dominated by fluvial discharge of allochthonous organics while in lower estuaries the primary organic carbon sources are through primary productivity. Most of the particulate organic carbon and flocculated dissolved organic carbons from the river end up in the sediment where they either become buried or used in heterotrophic activity. Organic carbon is lost in significant amounts from the estuary through respiration and tidal circulation in nearly equivalent amounts (Biggs and Flemer, 1972).

In 1975, the U.S. Environmental Protection Agency found the mean total organic carbon (TOC) concentration in Choctawhatchee Bay to be 3.4 mg/1. Generally, the TOC was higher toward Choctawhatchee River and decreasing toward East Pass. Ross, Anderson and Jenkins, 1974, found many tributaries to have a high influx of carbon and suggested that this would increase the biological oxygen demand in the bayous and eastern Bay. Water Quality Criteria, 1972, suggests a water column concentration of total organic carbon in coastal waters exceeding 2.0 mg/1 to be sufficient to depress dissolved oxygen concentrations. The U.S. Environmental Protection Agency, 1975, found Choctawhatchee Bay to have the highest average total carbon content in the sediments of five Northwest Florida bays. EPA, 1975, also found a general trend in Northwest Florida estuaries for increasing depths to have increased volatile organics in the sediments.

Total and Fecal Coliform Bacteria

Coliform bacteria are used as indicators of water quality in terms of health hazards in the State of Florida. The numbers of coliform bacteria indicate the degree of fecal pollution in a body of water. The fecal coliform bacteria represent the percent of the total coliform bacteria which are truly from fecal origin. In the State of Florida, the median coliform number or Most Probable Number (MPN) of Class II shellfish harvesting waters, cannot exceed seventy per one hundred milliliters of water in natural conditions and no more than two hundred thirty per one hundred milliliters of water in ten percent of the samples during extreme hydrological conditions. For Class III waters, which are for recreation, propagation and management of fish and wildlife, the fecal coliforms should not exceed a monthly average of 200/100 milliliters, and no more than 400 total coliforms per 100 milliliters of water in ten percent of the samples. Also, the fecal coliforms should not exceed 800/100 milliliters of water on any given day, nor 2,400 total coliforms per 100 milliliters of water on a given day. For total coliforms, the monthly average should be less than 1000/100 milliliters in 20 percent of the samples within a month. Monthly averages for the above are expresses as a geometric mean based on a minimum of 100 samples taken over a 30 day period.

Significant coliform bacteria numbers in the water column are usually indicative of untreated sewage input into an estuary through both point source and non-point source discharge. In Choctawhatchee Bay most of the waste load in 1975 was due to stream discharge while the lowest loading was from urban runoff (Ross, Anderson and Jenkins, 1974). Ross, Anderson and Jenkins, 1975, found high coliform levels in Santa Rosa Sound. The high number of municipality point source dischargers in the urbanized western end of the Bay may have contributed to declining water quality (Figure 4-20). Another problem associated with urbanization which possibly could contribute to declining water quality in the western Bay, is the drainage of private septic tanks for which loadings are not estimable (Ross, Anderson and Jenkins, 1974).

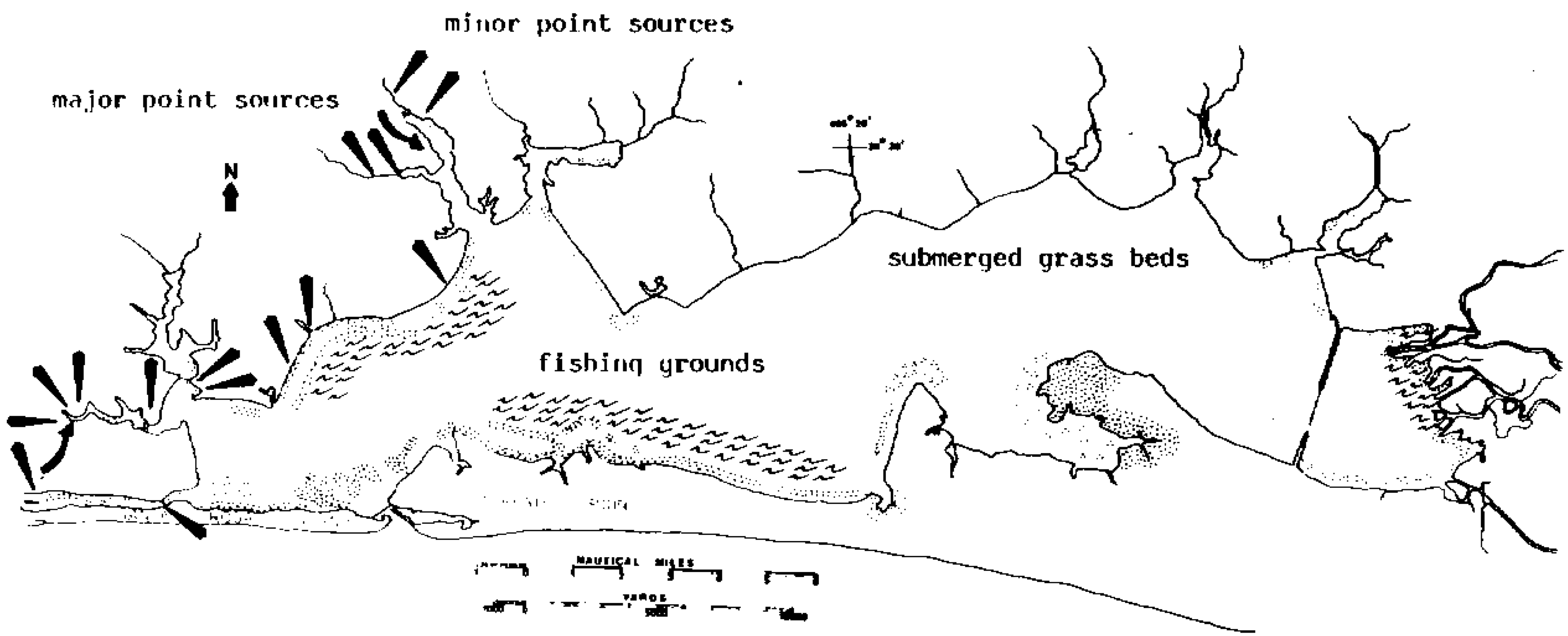


Figure 4-20: Point Source Inputs, Submerged Grass Beds, and Major Fishing Grounds In Choctawhatchee Bay. (in part from McNulty)

SEDIMENTS

Sediment Characterization

Choctawhatchee Bay is fringed with fine to medium sized, well washed quartz sand. The sand extends from the mean high water level to the six to eight foot contour where the bottom drops sharply into a transition zone of sand and silt. From Battelle-Columbus Laboratories, 1973, for Grayton Beach and eastern Choctawhatchee Bay and Goldsmith, 1966, for the entire Bay, this sand marginal shelf grades into a deep water zone composed of clay and silt. The sedimentology study conducted by Goldsmith, 1966, further indicates a different bottom composition in the far western end of the Bay where the bottom is primarily composed of relict quartz sand. The western Bay lacks the large clay deposits found in the eastern and central portions of the Bay. The difference may be due to the erosion of existing shorelines on the northern and northeastern shores.

The topology of Choctawhatchee Bay lends itself to the formation of an expansive sediment trap, due to the shallow pass to the Gulf of Mexico relative to the depth of the Bay. The clay deposits in the Bay are suspected to have originated in sediment loading from Choctawhatchee River (Goldsmith, 1966). The clay and silts from the river discharge tend to flocculate and settle as the freshwater carrying them encounters increasingly greater salinity gradients. Previous studies found salinity and pH to increase in waters moving from the mouth of Choctawhatchee River toward East Pass (Goldsmith, 1966; Ritchie, 1961), and the combination of these two factors cause increasingly greater sedimentation (Postma, 1967). In addition, the salinity density gradient should cause a gradient of large particle size sediments to finer sediments from Choctawhatchee River to the deep water region above East Pass. Flocculation of sediments is greatest at the salinity gradients found at minor upwelling sites in Choctawhatchee Bay. Goldsmith, 1966, found this to be evident with increased clay deposits at suspected upwelling sites north of Hogtown Bayou and northeast of East Pass (Figure 4-21). An examination of Figure 4-9 depicting bottom depth confirms these sites as sites of potential upwelling.

A review of sediment data from the U.S. Environmental Protection Agency, 1975, the U.S. Corps of Engineers, 1975, and the U.S. Corps of Engineers, 1976, suggests increasingly greater organic constituents with finer silts and clay in the sediment. In Choctawhatchee Bay this results in increasingly greater organic component concentrations in the deeper sediments and in turn increased reduction/oxidation (redox) from the east to the central region of the Bay. In support, Goldsmith, 1966, found the redox potential to increase with increasing depth. The high redox potential facilitates and prompts low alkalinity and low dissolved oxygen concentration. This both enhances the growth of sulfate bacteria and restricts the benthic fauna. Low pH values from the freshwater inflow causes calcium carbonate to go into solution (Goldsmith, 1966; Postula, 1967). Calcium carbonate concentrations are higher in Choctawhatchee Bay than in other bays along the Florida Panhandle with high

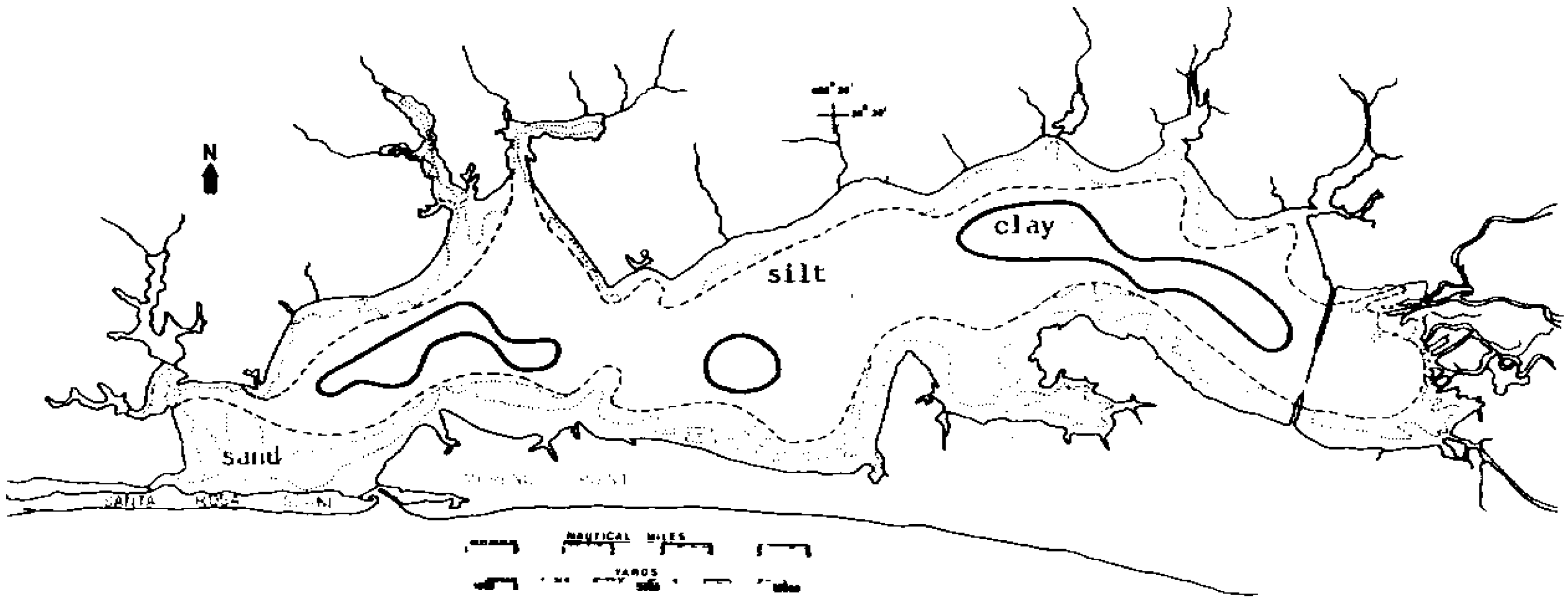


Figure 4-21: Bottom Types in Choctawhatchee Bay.

percentages of clay in the sediments. However, in areas of greater silt and sand composition the trend is reversed. Foraminiferal deposits (Figure 4-10) found by Pastula, 1967, are in regions where higher saline water tongues can buffer the pH, thus decreasing the dissolution of calcium carbonate. The pockets of calcium carbonate in bottom sediments correspond directly to saline pockets of water and large deposits of clay in the sediment (Goldsmith, 1966). Other deposits of calcium carbonate in the form of oyster shells have been located and dredged by Radcliff, Inc. (Taylor Biological Co., 1978). Taylor Biological Co., 1978, found extensive beds of oyster shell lying 4 to 6 feet beneath fine sediments and sand about 0.5 miles off the northern shores of the central bay. These deposits indicate a previous change of nature of the character of Choctawhatchee Bay possibly due to the formation of Morino Point about 3000 B.P. Morino Point is thought to have been formed by a westward longshore drift in the Gulf of Mexico blocking easy exchange of salt water and fresh water in the Bay.

Sediment Chemistry

Choctawhatchee Bay was found to have higher organic nitrogen and carbon in the sediment than many other Northwest Florida bays (Table 4-1). Sediment phosphorous concentrations ranged from lows of 13.0 mg/kg to 78.75 mg/kg (U.S. Army Corps of Engineers, 1976) to a mean for the central Bay of 350.7 mg/kg (U.S. Environmental Protection Agency (EPA), 1975). Phosphorous concentrations were greatest in the eastern portion of the Bay. Excluding Alagua Bayou with residual sawdust sediments and the mouth of Choctawhatchee River stations, EPA, 1975, found organic nitrogen and carbon to correlate well with depth.

Table 4-1: Total phosphorous, organic nitrogen, and organic carbon in mud sediments samples from five northwest Florida bays.

Location	Number of Samples	Mean Total Phosphorous (mg/g)	Mean Organic Nitrogen (mg/g)	Mean Organic Carbon (mg/g)
Escambia Bay	19	248.8	0.57	31.4
East Bay	5	195.6	0.59	33.7
Panama City Bay	9	468.9	1.18	58.6
Choctawhatchee Bay	6	350.7	1.60	59.0
Pensacola Bay	1	468.0	0.71	35.4

Source: U.S. Environmental Protection Agency, 1975.

The U.S. Army Corps of Engineers, 1976, found stations in Santa Rosa Sound near the Ft. Walton Beach sewage treatment plant (STP) and near the Intercoastal Waterway Canal mouth in eastern Choctawhatchee Bay to exceed recommended standards of 1,000 mg/kg of nitrogen in the sediment by 150 to 300 percent.

Volatile organic compounds in the sediments of Choctawhatchee Bay were sampled by the U.S Environmental Protection Agency (EPA), 1975, and the U.S. Army Corps of Engineers, 1976. EPA, 1975, found deep water sediments to contain from 8.42 to 24.52 percent volatile organics. The U.S. Army Corps of Engineers, 1976, found percent volatile organics to range from 0.35 t 1.2 percent in sandy locations, 3.83 percent in clay sediments and from 17.04 to 23.37 percent in silty sediments. Percent volatile organics in silty sediments exceeded the criteria of 6 percent maximum volatile organics (Water Quality Criteria, 1972), in all cases. The U.S. Army Corps of Engineers, 1976, also found high biological oxygen demand and chemical oxygen demand (COD) at silty sediments stations near the mouth of Choctawhatchee Bay. In 1974, in eastern Choctawhatchee Bay, along with Intracoastal Waterway, the COD exceeded recommended levels of 50 mg/kg $*10^3$ (Water Quality Criteria, 1972), for coastal waters. Clay sediments had a COD of 27.35 mg/kg$*$ 10^3, while sandy bottom stations had a COD ranging from 2.09 to 6.21 mg/kg $*10^3$. Sediment biological oxygen demand was found to be much higher in central Choctawhatchee Bay than in other Northwest Florida Bays (U.S. Environmental Protection Agency, 1975).

Table 4-2: Percent of mud in sediments (top 15 cm.) from central basins of northwest Florida bays.*

Bay	Number of Stations	Mean Depth (m)	Percent Mud (%)	Percent Clay (%)
Escambia	17.	3.3	91.36	50.63
East Bay	4.	4.2	88.34	64.69
Pensacola Bay	1. **	8.4	97.47	60.05
Choctawhatchee Bay	6.	5.2	98.00	73.93
Bays at Panama City	7.	6.3	91.43	62.19
Blackwater Bay	1.	2.6	94.78	70.30

* Data generated from samples that have either greater than 80% mud or greater than 50% clay.

** Station near a recent channel dredging project and probably this station dredged in the past year.

Source: U.S. Environmental Protection Agency, 1975.

Metals and Pesticides

Toxic metals and pesticides in the environment, often termed toxics, are accumulated in fine grain sediments and may be resuspended through natural disturbances or human activities such as dredging (U.S. Army Corps of Engineers, 1976; Taylor Biological Co., 1978). Toxics in the sediments of Choctawhatchee Bay have been sampled by the Corps of Engineers in 1975 and 1976, the Florida Department of Environmental Regulation, 1975, and the U.S. Environmental Protection Agency, 1975. Although the above studies rather sparsely cover the Bay, comparison with similar studies in other Northwest Florida Bays suggest that Choctawhatchee Bay potentially has problems in the sediments of the eastern Bay which receives the greatest fluvial loading from the Choctawhatchee River Basin. The U.S. Army Corps of Engineers studied East Pass and the western Bay around the mouth of Santa Rosa Sound, but no seriously high concentrations of toxics were found.

Toxics are generally associated with sediment movement and deposition. Due to its hydrography, Choctawhatchee Bay had been described as a sediment trap accumulating most of the sediments entering the Bay. As sediments accumulate, so do many toxic metals and toxic chemicals. Mollusks have a tendancy to bio-accumulate many toxic compounds, and often are most sensitive to metals. Documentation of present toxic compound distributions and changes from normal distributions in an estuary are important to the assessment of toxic effects in an estuary. Toxicity of many metals are inversely correlated with salinity, i.e., the higher the salinity, the less toxic a metal may be. Thus, in Choctawhatchee Bay the most biologically damaging high metal concentrations will be near the mouth of the tributaries, including

Choctawhatchee River. Many metals are most detrimental to larval stages of estuarine organisms. Both cadmium and mercury are deleterious to crustacean larvae and seasonal spawning of crustaceans may be strongly affected by sediment disturbances.

The U.S. Environmental Protection Ageny (EPA), 1975, found metal concentrations in Northwest Florida estuaries to be much higher in deep water sediments than in sandier shallow water sediments. This may be attributed to sediment accumulation of metals. The U.S. Army Corps of Engineers, 1976, found zinc concentrations exceeding standards of 50 mg/kg (U.S. Environmental Protection Agency, 1971) in four of seven stations sampled with a maximum of 419.9 mg/kg. In centrally located stations zinc was below recommended standards (U.S. Environmental Protection Agency, 1975). Mercury at 0.91 mg/kg, just west of the Highway 331 bridge, was just below the recommended standard of 1.0 mg/kg (U.S. Army Corps of Engineers, 1976). The U.S. Environmental Protection Agency, 1975, during the Excambia Bay Recovery Study, found the mean for many metals in Choctawhatchee Bay sediments including lead, chromium, cadmium, manganese, nickel, aluminum, iron, cobalt and vandium to be generally higher than in many other Northwest Florida estuaries (Table 4-3). However, the sample locations and sizes may have biased these means. Iron and aluminum were naturally high due to the large amounts of clay in Choctawhatchee Bay sediments.

Pesticides in an estuary are both biologically and geologically accumulated (Odum, 1976). Pesticides cause the most problems in estuaries by physiologically disrupting components of the food web in estuaries (Odum, 1976). The U.S. Army Corps of Engineers found chlorodane (41.024 mg/kg), DDE (0.334

Table 4-3: Mean concentration of metals in surface sediments of selected bays in Northwest Florida.

	Escambia	Pensacola	East	Blackwater	Choctawhatchee	Panama City	Mobile
Lead	18.5	39.8	16.2	13.0	26.1	23.2	28.4
Zinc	43.2	140.3	28.8	19.7	45.8	37.9	90.3
Chromium	39.7	55.7	38.4	13.1	71.2	55.1	-
Cadmium	1.0	1.0	1.0	1.0	1.0	1.0	1.2
Copper	8.7	19.3	4.4	2.5	11.3	11.6	-
Manganese	188.8	318.5	188.2	105.6	654.2	129.8	-
Nickel	8.8	15.7	8.7	2.8	15.6	11.1	-
Aluminum	17778	14565	10554	4684	21050	13433	-
Iron	29298	32740	23836	11520	47967	20522	-
Cobalt	12.2	9.8	8.6	4.8	12.0	4.9	-
Vanadium	73.6	47.3	37.4	23.4	99.5	34.6	-
Titanium	70.2	33.0	55.0	47.6	40.2	64.0	-

Source: U.S. Environmental Protection Agency, 1975.

mg/kg), Diazinon (1.38 mg/kg) and PCB AR-1254 (14.679 mg/kg) in Choctawhatchee Bay just east of Santa Rosa Sound in 1975. Diazinon was also found in the Intracoastal Waterway just east of the State Highway 331 bridge at 7.172 mg/kg. The U.S. Army Corps of Engineers, 1976, also tested for the pesticides aldrin, dieldrin, DDD, DDT, endrin, heptachlor, heptachlor epoxide, lindane, methoxchlor, mirex, toxaphene, guthion, malathion, methlparathion, parathion, PCB AR-1242 and PCB AR-1260, but did not find these in significant amounts. EPA, 1975, found 0.95 mg/kg of mirex at the mouth of Choctawhatchee River. Also found were DDE up to 17.0 mg/kg and one station with 2.5 mg/kg DDD and DDT ranging from 1.2 mg/kg to 2.8 mg/kg in central Choctawhatchee Bay.

BIOTIC COMMUNITIES AND NATURAL RESOURCES

Plankton

Studies of planktonic communities in Choctawhatchee Bay are scarce. Battelle-Columbus Lab., 1973, assessed plankton numbers at several stations in the eastern end of the Bay in a single sampling period. The principal component of the zooplankton proved to be copepod nauplii, probably the species *Acartia tonsa*, the dominant zooplankter in Northwest Florida estuaries (U.S. Environmental Protection Agency, 1975). Battelle-Columbus Lab., 1973, concludes there is a functional relationship between temperature and zooplankton. However, this hypothesis would be difficult to explain based on one day of sampling at only a few stations. Studies in Santa Rosa Sound near Pensacola Bay (Moshiri, et al., 1978) and in the St. Andrews Bay system (Hopkins, 1966), both found large numbers of rotiferans near freshwater tributaries and cirripedia nauplii, polychaete larvae and ctenophores occurring seasonally. The dominant species in both studies throughout the year was the calanoid copepod *Acartia tonsa*.

Battelle-Columbua Lab., 1973, found the dominant phytoplankton phyla to be the Chrysphyta, more specifically, the Bacillariophyceae or diatoms. Numbers of phytoplankton from stations nearer the tributaries are distinctly greater than those from the more centrally located stations in eastern Choctawhatchee

Bay (Battelle-Columbus Lab, 1973). This possibly is the result of high nutrient input from the tributaries which are immediately utilized by the phytoplankton. General phytoplankton trends in Santa Rosa Sound near Pensacola Bay are for large numbers of dinoflagellates to occur in late winter and early spring (Moshiri, et al., 1980; Moshiri, et al., 1978). These give way to large numbers of single celled algae of many classes in the late spring followed by high numbers of Bacillariophycae in the late summer, remaining prevalent until midwinter. Cell counts in the Choctawhatchee Bay have been recorded as high as 230,000 cells/milliliters (U.S. Environmental Protection Agency, 1975). Ross, Anderson and Jenkins, 1975, speculated that the phytoplankton growth in the eastern end of Choctawhatchee Bay would be greater than in the western and central bay based on nutrient input from Choctawhatchee River.

A better estimate of productivity than phytoplankton numbers is the volume of chlorophyll pigment retained in the water column. Active growing phytoplankton populations will have a greater chlorophyll content than phytoplankton populations on the demise. Chlorophyll content represents the physiological state of phytoplankton cells and thus, in turn, the productivity potential. The U.S. Environmental Protection Agency, 1975, made a comparative study of uncorrected chlorophyll in Choctawhatchee Bay. Chlorophyll in the water column showed a decrease from Choctawhatchee River to the mouth of the Bay at East Pass with a range from 8.0 mg/l to 0.0 mg/l. The study also found chlorophyll to decrease from the central Bay to the peripheral Bayous and Santa Rosa Sound. The average for the entire Bay for 20 stations was 4.2 mg/l.

This supports the hypothesis of high utilization of nutrients near inflow points and potential nutrient limitations in the central region of the Bay.

Benthos

Choctawhatchee Bay has several distinct types of benthic habitats which support varied communities of macroinvertebrates. Benthic faunal surveys in Escambia Bay to the west of Choctawhatchee Bay (U.S. Environmental Protection Agency, 1975) revealed three major benthic habitat descriptions which would apply to habitats in Choctawhatchee Bay. Marginally, Choctawhatchee Bay is fringed with a shallow sand shelf. This blends into deeper regions with varying mixtures of sand and mud comprising the transitional zone. Lastly, there is a broad central deepwater mud plain. Other smaller habitats, possibly of more importance, are the grass beds and oyster beds. The grass beds and oyster beds provide substrate for attachment, shelter, feeding and reproduction of macroinvertebrates. Also, these areas should have a greater species diversity than found in the three major habitats of the Bay.

Studies of the benthic macroinvertebrate communities in Choctawhatchee Bay have been made by the Corps of Engineers in 1974 and 1976, Taylor Biological Co., 1978*, Battelle-Columbus Lab., 1973, and Ross and Jones, 1979. Ross and Jones, 1979, found sixty four species at eighteen stations in six primary

*Radcliff Company, Mobile, Alabama, removed eight million cubic yards of oyster shell from the sediments of Choctawhatchee Bay from 1946 to 1970. In an effort to extend this dredging activity, Taylor Biological Company, 1978, performed a study to assess dredging activities in the Bay.

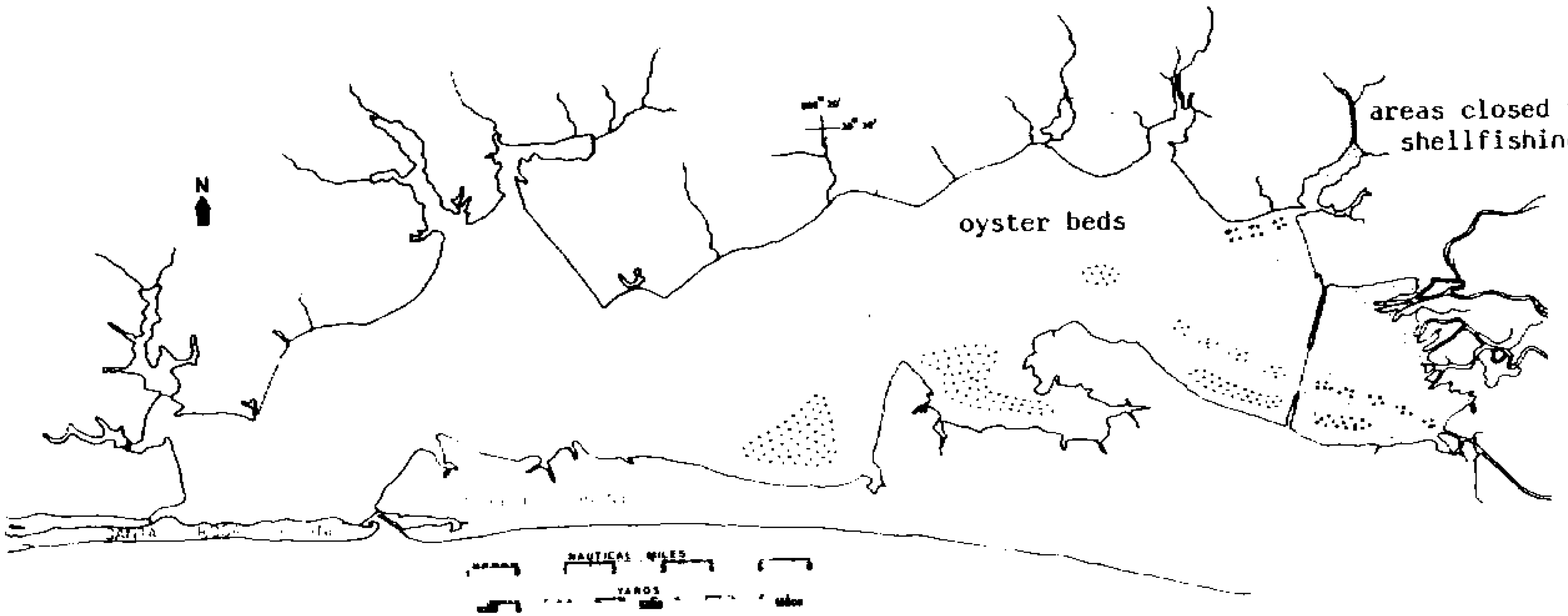


Figure 4-22: Map Depicting Oyster Beds and Areas Closed to Shellfishing in 1970.

habitats including shallow and deep water sand and mud communities, as well as grass beds and a deep water red algae community. The Florida Department of Regulation (unpublished data) has periodically sampled the benthos above Piney Point and found 110 species of benthic invertebrates thus far. Collard, 1976, and Pastula, 1968, both suggested that benthic invertebrates were least abundant toward the eastern end of the Bay. Pastula, 1967, attributes the decrease to reductions of both salinity and dissolved oxygen toward the eastern end of Choctawhatchee Bay. Most of the information concerning the benthos is centered in deeper waters of the Bay. Further studies should investigate grass beds, oyster reefs and the near shore shelf around the Bay.

In studies of deep water stations, both Taylor Biological Co., 1978, and Battelle-Columbus Lab., 1978, found polychaete worms to be the most common organisms in both numbers and species diversity. All previous investigations concerning the benthos in Choctawhatchee Bay have noted a general paucity of benthic invertebrates. This paucity has been blamed on the extreme environmental stress at deep water stations in the Bay, resulting from salinity changes, long term low dissolved oxygen concentrations and high sedimentation rates. This stress is particularly evident in the summer and early fall. In LaGrange Bayou, the U.S. Corps of Engineers, 1973, found freshwater bivalves and crustacea to comprise the dominant fauna.

Fisheries

The general concensus concerning sport and commerical fishing in Choctawhatchee Bay is that it has been on the decline since the late 1960's. Prior to the late 1920's, the Bay existed as a limited access embayment with only slight tidal exchange resulting in slightly brackish water (Okaloosa Economic Development Council, 1978). In the years prior to the formation of East Pass, Santa Rosa Sound should have played a much more important role in the flushing of Choctawhatchee Bay than it does at present. With increased salt water intrusion into the Bay due to the opening of East Pass, and the subsequent maintenance of the Pass (U.S. Army Corps of Engineers, 1975), the species of fish in the Bay, particulary in the western Bay, should have tended toward more marine species. In the late 1960's, bridge fishermen from Okaloosa County reported catching red snapper in Cinco Bayou and Garnier Bayou. However, since then many local fishermen feel that both numbers of fish caught have declined and that some species such as red snapper are completely absent where they were once common. Barret, Daffin and Carlin, 1979, make similar connotations.

Irby, 1974, discusses sea trout (Cynosion nebulosus) populations in Choctawhatchee Bay. Many Bay sports fishermen attribute declining catches of sea trout to over-fishing by commerical fishermen (Irby, 1974) and more recently, declining grass beds (personal communication). However, Irby, 1974, concludes that without earlier baseline data such reductions cannot be found and that survey results do not indicate exploitation by commercial fishermen.

Fish kills occurring in both Garnier Bayou and Rocky Bayou from 1972 to 1975, are the result of low flushing rates, high temperatures and low dissolved oxygen concentrations. The Fish and Wildlife service initiated a striped bass (Morone saxtilis) stocking program and a basin wide species survey in 1968 (U.S. Fish and Wildlife Service, 1973). An associated environmental study suggested that heavy sedimentation from Choctawhatchee River could be detrimental to fisheries in the Bay (U.S. Fish and Wildlife Service, 1973). The striped bass stocking program was discontinued in 1975 due to budget cuts (Northwest Florida Water Management District, 1980); however, the stocking program was showing signs of success with striped bass found to be spawning in Choctawhatchee River in the spring of 1975 (U.S. Fish and Wildlife Service, 1975).

Submerged Aquatic Vegetation

Submerged aquatic vegetation is an important component of estuaries. This vegetation provides food and shelter to many estuarine organisms, as well as spawning and nursery grounds for both resident and non-resident species. Chemically, the grass beds in an estuary aid in oxygenation of the water and act as buffers to nutrients and toxic metals. Submerged aquatic vegetation can also play an important role in nutrient cycling within an estuary.

Many local residents have suggested that grass beds in Choctawhatchee Bay are declining in acreage. Suggestions as to reasons include increased turbidity, adverse weather conditions, increased activity by commercial net fisherman and testing of the herbicide, agent orange on the northern shores of Choctawhatchee Bay. Without good documentation of the historical and existing grass beds, no conclusions can be made as to the actual demise, if any, of the grass beds in Choctawhatchee Bay. Figure 4-20 depicts grass beds in Choctawhatchee Bay. These beds are composed from both McNulty, Lindall and Sykes, 1971, and drawings from 1973 aerial photographs covering the shoreline of Choctawhatchee Bay. The prevalent estuarine seagrass in Choctawhatchee Bay is *Ruppia maritina*. McNulty, Lindall and Sykes, 1971, found Choctawhatchee

Bay to contain 3,092 acres of submerged aquatic vegetation and 2,816 acres of tidal marsh grasses (Figure 4-20).

The decline of existing grass beds within many of the estuaries in the Gulf of Mexico and on the Atlantic Coast is well documented (U.S. Environmental Protection Agency, 1975; EPA, 1981). The demise has been due to both natural causes and cultural disturbances. Turbidity caused by weather disturbances, increased fluvial sediment loads, increased boat traffic and dredging operations is thought to severly limit the resources required for productive grass beds (EPA, 1981). EPA, 1975, found dredge and fill operations to destroy existing grass beds by excessive siltation. Other factors thought to cause the decline of sumberged aquatic vegetation include natural diseases, temperature and salinity trend changes, excessive nutrients, herbicides and excessive petrochemicals (U.S. Fish and Wildlife Service, 1978). The author has also observed significant damage to seagrass beds due to careless operation of gill nets.

5 - MATERIALS, METHODS AND EXPERIMENTAL PROCEDURES

General

Understanding the environmental processes affecting the quality of Choctawhatchee Bay necessitated a sampling regime which covered both spatial and temporal ranges of ecological parameters affecting the Bay. The sampling regime was designed to cover both monthly fluctuations and seasonal diurnal fluctuations over geographical boundaries including major currents and inflow/outflow points. Annual trends were assessed by comparing current information and historical information that is available in the literature. The sampling regime excludes the periphery of the Bay. Monthly sampling stations were selected after reviewing the bathymetry of the Bay, as well as knowledge concerning dredge channels, bayou and discharge inputs, suspected currents and major inflow/outflow locations (Collard, 1976). Diurnal studies were completed in each of the four seasons to determine daily fluctuations along the central axis of the Bay (Collard, 1976).

Monthly Sampling

Monthly sampling includes physical/chemical data collection and collection of the various components of the planktonic communities. Thirty-one monthly water quality stations (Figure 5-1) were designated and sampled on the times in Table 5-1. The entire sampling circuit was 105 statute miles and usually

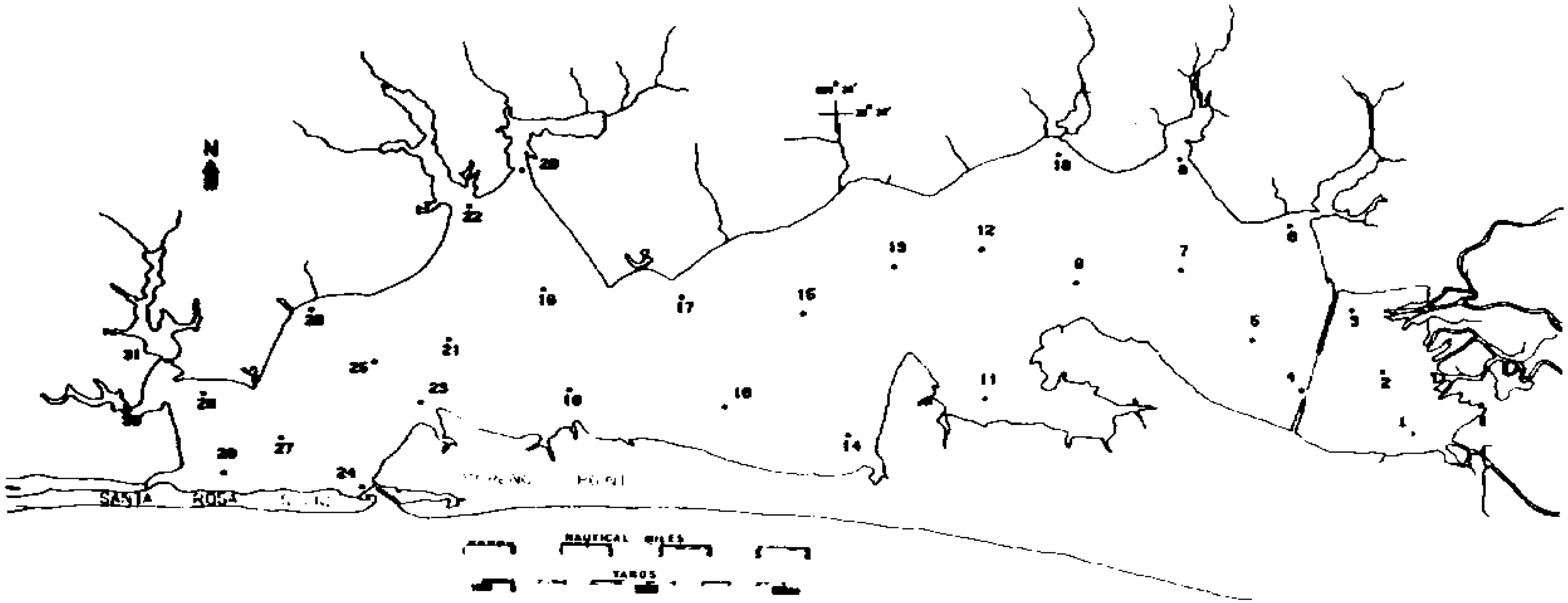


Figure 5-1: Monthly sampling stations in Choctawhatchee Bay, 1975.

Table 5-1: Sampling Time Frame for the Sea Grant sponsored University of West Florida Study of Choctawhatchee Bay, Florida. Monthly sampling schedules.

MONTHLY (31 Stations)
28-29 JAN. 1975
19-20 MAR. 1975
21-22 APR. 1975
20-21 MAY 1975
21-22 JUN. 1975
19-23 JUL. 1975
25-26 SEP. 1975
29-30 OCT. 1975
15 DEC. 1975

required two days each month to complete. Samples in February and August were not collected due to scheduling and weather difficulties. Weather conditions for five days prior to each sampling period are depicted in Table 5-2. Chemical and physical parameters were sampled at each of the thirty-one water quality stations and consisted of a surface sample one foot below the surface, a middle depth (mid-depth) sample at the approximate mid-depth and a bottom sample one foot off the bottom in the water column. The parameters sampled are depicted in Table 5-3. The biotic components of the Bay sampled on a monthly basis include total and fecal bacteria at ten stations from the surface and bottom of the water column, phytoplankton at fourteen stations from the surface only, and icthyoplankton and zooplankton from nine stations in surface waters only (Figure 5-2, Table 5-3). Productivity was measured in surface waters through determination of chlorophylls A, B, and C at each of the thirty-one water quality stations.

Physical Parameters (from Collard, 1976)

Salinity and temperature were determined using a Beckman RS5-3 Electrodeless Induction Salinometer (Beckman Instruments). Dissolved oxygen for January through May was measured with a Delta Scientific Model 85 Dissolved Oxygen Meter (Delta Instruments). A YSI Model 51A Dissolved Oxygen Meter (Yellow Springs Instruments) was used for dissolved oxygen measurements for June through December. The two probes, with cables, were bound together along with a nylon water hose and calibrated in one-foot units. Water depths were determined using a Raytheon fathometer and the probes were lowered to the proper depth.

Table 5-2: Weather Conditions for the Five Days Previous to Each Sampling Period.

Monthly Sampling

Sample Date	Mean Air Temperature (°C)	Max. Air Temperature (°C)	Min. Air Temperature (°C)	Total Precipitation (Inches)	Wind Speed (Knots)
1/28/75	61	72	50	0.10	1.2 - 11.4
3/30/75	64	75	46	0.20	2.8 - 14.8
4/22/75	65	76	50	0.93	1.6 - 11.4
5/20/75	75.8	84	63	0.91	0.8 - 10.2
6/21/75	81.4	92	70	0.58	1.4 - 10.6*
7/19/75	80	89	71	0.56	0.8 - 9.6
7/23/75	80	89	74	1.31	0.8 - 8.4
9/25/75	6.4	77	49	14.90**	2.4 - 18.2**
10/29/75	71.4	84	61	0.00	1.0 - 9.4
11/24/75	49.2	76	34	0.08	0.8 - 12.2
12/15/75	59.6	75	32	0.00	1.0 - 8.8

* 6/21/75 Max. wind speed was 20 mph.

** 9/23/75 Max. wind speed was 40 mph, precipitation was 40 inches due to Hurricane Camille.

Table 5-3: Physical, chemical and biological parameters sampled monthly in Choctawhatchee Bay, 1975.

Parameter	Units
Salinity	ppt
Water Temperature	degrees Celsius
Dissolved Oxygen	mg/1
Dissolved Ammonia	mg/1-n
Dissolved Nitrate	mg/1-n
Total Organic Nitrogen	mg/1-n
Dissolved Orthophosphate	mg/1-n
Total Phosphate	mg/1-n
Total Carbon	mg/1-C
Total Organic Carbon	mg/1-C
Chlorophyll A	mg/1
Chlorophyll B	mg/1
Chlorophyll C	mg/1
Total Coliform Bacteria	MPN
Fecal Coliform Bacteria	MPN
Phytoplankton	cells/liter
Zooplankton	numbers/liter
Icthyoplankton	numbers/liter

C - coliforms
P - phytoplankton
Z - zooplankton

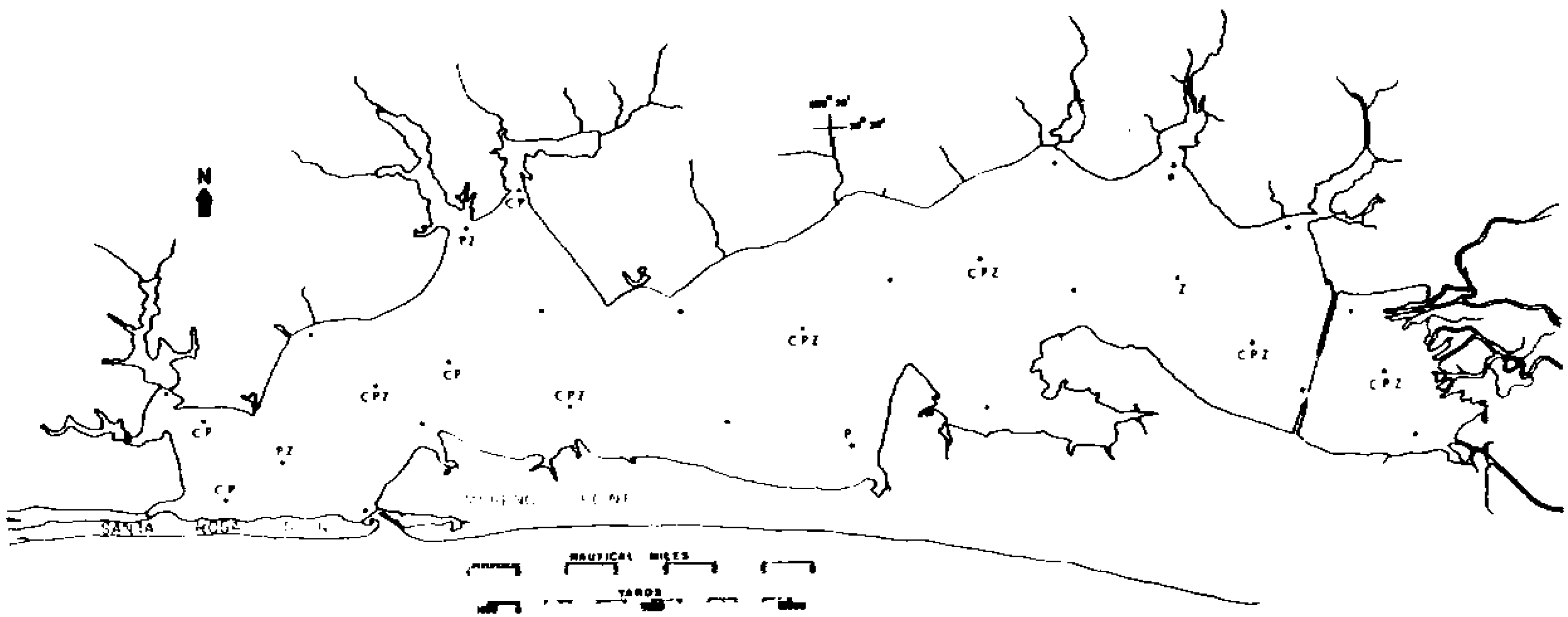


Figure 5-2: Location of Biotic Sampling Stations in Choctawhatchee Bay, 1975.

Water Chemistry Parameters

Water samples of chemical analyses were collected using a nylon hose connected to a brass pump (Jabsco). This system was considered chemically nonreactive with the parameters being measured. Water samples were placed in plastic bottles and stored at 4°C until anlaysis. Analyses were completed withn 48 hours.

All methods for water chemistry analyses are those currently used by the Environmental Protection Agency (U.S. Environmental Protection Agency, 1974). The parameters and methods used are:

a) Dissolved Ammonia	Automated Colorimetric Phenolate
b) Dissolved Orthophosphate	Automated Colorimetric Ascorbic Acid Reduction
c) Dissolved Nitrate/Nitrite	Automated Cadium Reduction
d) Total Organic Nitrogen	Automated Phenolate
e) Total Phosphorous	Automated Colorimetric Ascorbic Acid Reduction
f) Total Carbon	Beckman Carbon Analyzer (Model 915)
g) Total Organic Carbon	Beckman Carbon Analyzer (Model 915)

Biological Parameters

Five hundred milliliter aliquots of surface water from each of the thirty-one stations was filtered through 0.45 micron filters. The residue on each filter was analyzed for chlorophylls A, B, and C, using the Trichomatic Methods of Weber, 1973. Chlorophyll concentrations were calculated using SCOR/UNESCO equations (Strickland and Parsons, 1972).

Coliform bacterial levels were determined from water samples collected by pump. Samples were collected in sterile glass bottles with ground glass stoppers and placed on ice until anaysis. A maximum of twelve hours elapsed between collection and analysis. For analysis, the samples were allowed to warm to room temperature and analyzed using the Most Probable Number (MPN) multiple dilution tube germentation test as described by the American Public Health Association, 1971. For the presumtive tests, lauryl tryptose broth was used in dilutions of 10°, 10^{-1}, and 10^{-2}. Positive tubes were indicated by the presence of gas after 24 or 48 hours at 35°C. Positive tubes were used to innoculate brilliant green bile broth and EC medium. If gas was produced after either 24 or 48 hours at 35°C in the brilliant green bile broth the presence confirmed total coliform numbers. Fecal coliforms were determined by growth and gas production in 24 hours at 44.5°C in EC medium.

Phytoplankton investigations included the classification and enumeration of all genera of algae found in Choctawhatchee Bay. Samples were collected in 100 ml bottles, then preserved and stained with 1 ml of Lugols iodine solution. Classification and enumeration was accomplished using 10 milliliter settling chambers viewed on an inverted microscope. One 10 milliliter water sample was taken from each 100 ml sample bottle. An overall scan was taken through the middle of each settling chamber at 10x. Only the larger species of algae, in particular diatoms and dinoflagellates, were counted in the scan. In addition, 20 random field counts were viewed at 20x for enumeration of the smaller species of algae, including members of Chlorophyta and Cyanophyta and smaller members of Chrysophyta.

Zooplankton and icthyoplankton were collected using standard half meter Nitex plankton nets equipped with a General Oceanics quart plastic codend. The net was towed with the top of the net approximately at the surface of the water and at an average speed of 1.3 meters per second (varying between two and three knots) for ten minute intervals. Since sampling was done from many vessels whose speeds and rpm indicators varied, it was impossible to assess volumetric differences in the numbers of individuals per unit volume. Flow meters were not used at the onset of this study and consequently no quantitative estimate of the amount of water filtered can be made. Also, an estimate of net clogging is impossible. Zooplankters were collected in a 165 micron mesh net, while icthyoplankters were collected in a 505 micron net. At the conclusion of each tow the net was washed with the aid of an electric pump and plastic hose; the codend was removed and the sample transferred to a quart jar and preserved in three to five percent solution of sodium borate buffered formalin in sea water. The samples were returned to the lab for identification and quantification.

In the laboratory, each sample was filtered through a mesh sieve, then rinsed carefully and placed in 70% ethanol solution. The fish eggs were counted and the fish larvae were counted and identified to the lowest possible taxa with the aid of a binocular microscope. The standard lengths of the fish larvae were measured.

Quarterly Diurnal Studies (from Collard, 1976)

In order to complement the monthly sampling schedule, four quarterly studies were conducted to measure 48 hour diurnal changes in salinity, temperature, dissolved oxygen and pH (Table 5-4). Eight stations were established along the midlength of Choctawhatchee Bay (Figure 5-3). Each station was sampled approximately every six hours and measurements were taken at three foot inter-

Table 5-4: Sampling Time Frame for the Sea Grant sponsored University of West Florida Study of Choctawhatchee Bay, Florida. Quarterly sampling schedule.

QUARTERLY (8 Stations)
25-28 FEB. 1975
27-30 MAY 1975
25-29 AUG. 1975
10-14 NOV. 1975

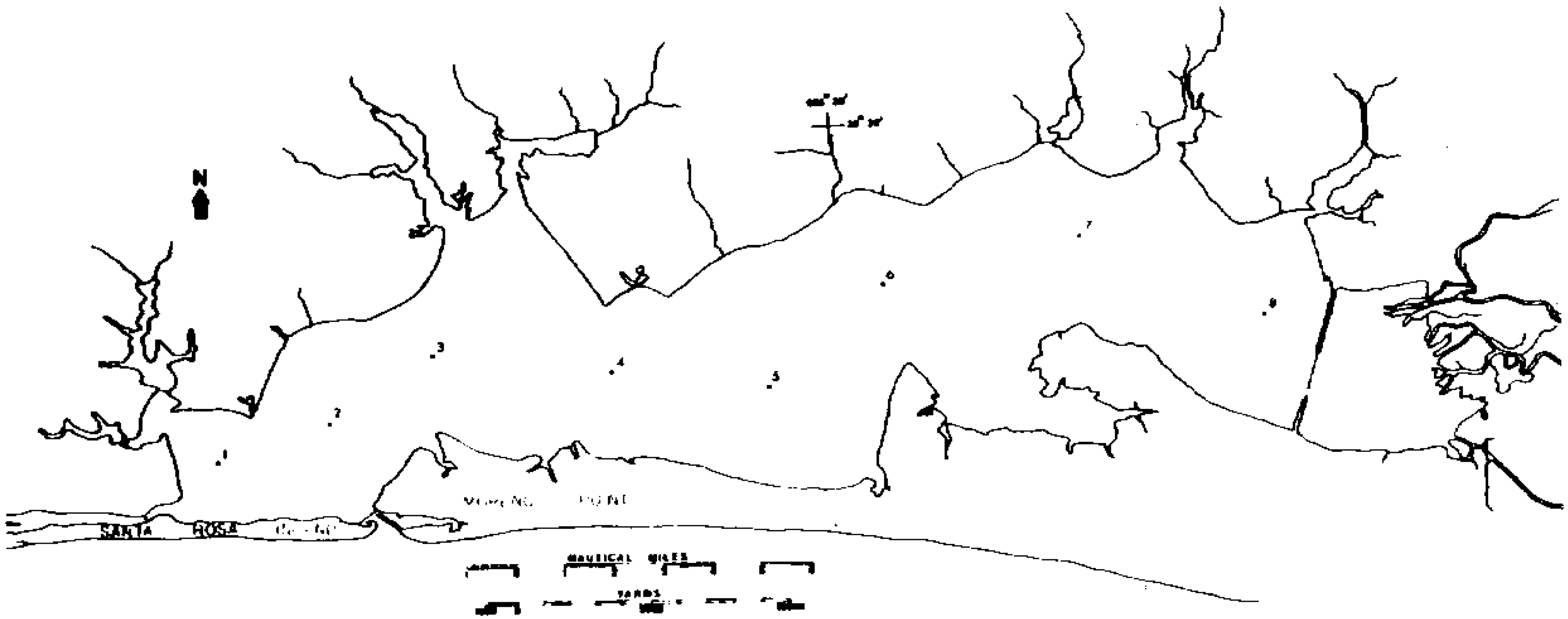


Figure 5-3: Locations of the Eight Stations Sampled During the Quarterly Diurnal Studies in Choctawhatchee Bay, 1975.

vals from the surface to the bottom. Salinity, temperature and dissolved oxygen were determined using the instruments defined previously in Physical Parameters. Water samples were collected from each depth by pump, and pH was determined using a Corning Model 7 Laboratory pH Meter. In addition to water sampling, hourly observations of air temperature, wind speed and direction, sea condition, cloud cover and barometric pressure were recorded (Table 5-5).

Following the 48-hour study, eight benthic grabs, using a 0.05 m^3 Ponar dredge, were collected from each station. Each grab sample was washed through a 1.0 mm standard sieve. The resulting sample of benthic invertebrates was preserved in 10% formalin prior to sorting, enumeration and identification of individuals.

The final phase of each quarterly study was the collection of fishes and macroinvertebrates within Choctawhatchee Bay. A 30 foot otter trawl was towed at random locations of 30 minute intervals. Both daytime and nighttime trawls were made. Fishes were identified and preserved in 10% formalin. Macroinvertebrates were stored in 70% ethanol and later identified. Results of this is published as a species key by Sneed Collard and John Wright as a supplemental Appendix.

Sediment Analysis (from Collard, 1976)

Sediment samples were collected once during the year from each of the thirty-one water quality stations. One sample, using a 0.05 m^3 Ponar grab, was collected and analyzed for total Kjeldahl nitrogen and total phosphorous, using EPA methods (U.S. Environmental Protection Agency, 1974). Percent organics of sediments was determined by weight loss after combustion of a dried

Table 5-5: Mean weather conditions for the Five Days Prior to Each Quarterly Sampling Period.

Quarterly Sampling

Sample Data	Mean Air Temperature (°C)	Max. Air Temperature (°C)	Min. Air Temperature (°C)	Total Precipitation (Inches)	Wind Speed (Knots)
2/25/75	57.4	73	38	1.05	2.2 - 13.2
5/27/75	77.2	90	65	.77	0.6 - 8.8
7/26/75	82.4	92	72	0.0	0.8 - 10.6
11/11/75	74.2	79	69	1.25	1.4 - 11.2

sample at 550°C for 24 hours. Particle size distribution of each sediment was determined by the methods of Folk, 1968.

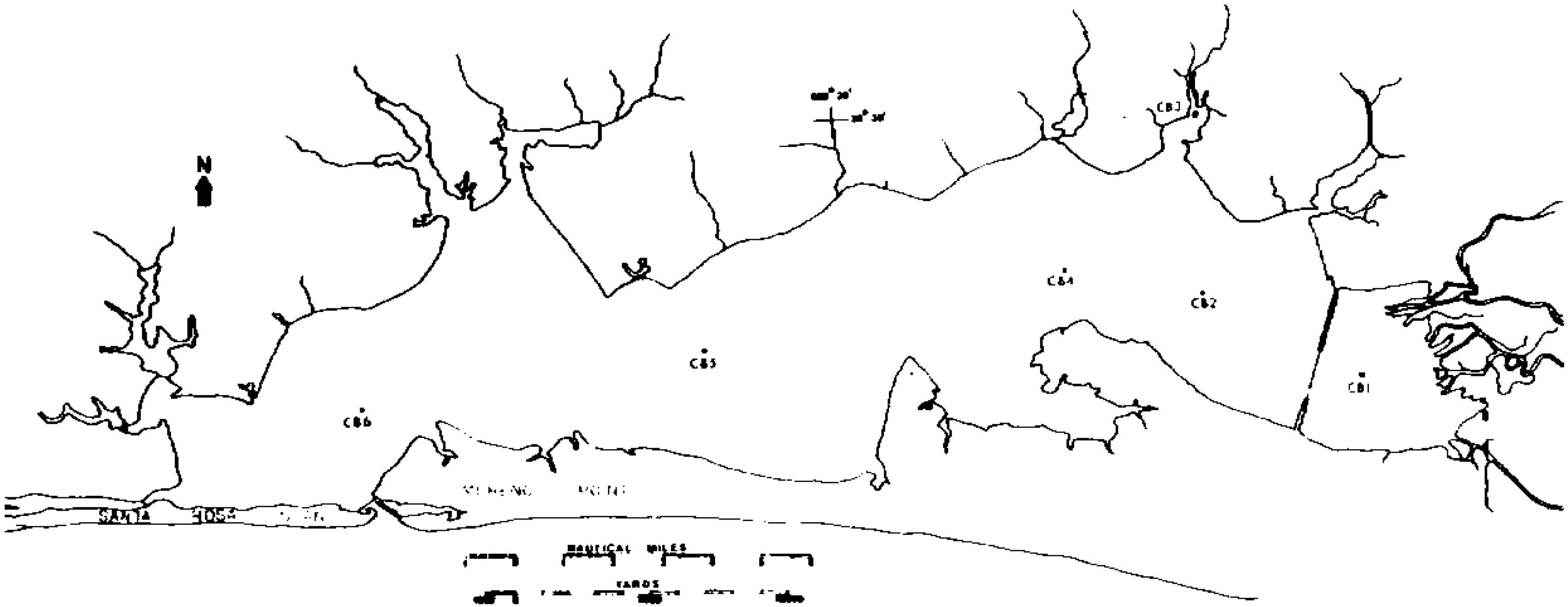


Figure 5-4: Location of Sediment Samples Collected in Choctawhatchee Bay in 1974 by the U. S. Environmental Protection Agency, 1975.

Table 5-6: U.S. Geological Society Flow Gages on Tributaries to Choctawhatchee Bay.

Gauge Station	Drainage Area (sq. mi.)	Period of Record	Aug* Discharge
1. Choctawhatchee River near Bruce, Fl. (02366500)	4384	10/30-12/81	7,056
2. Magnolia Creek near Freeport, Fl. (02366900)	11.2	9/68-12/81	36.4
3. Alaqua Creek near Defuniak Springs, Fl. (02356000)	65.2	4/51-12/81	164
4. Juniper Creek near S.R. 85, Niceville, Fl. (02367310)	29.5	3/66-9/75	83.8

Source: U.S. Geological Society, 1980

6 - DATA MANAGEMENT AND ANALYSIS

In addition to a thorough presentation of both the biophysical inventory of data and selected analyses of the data, a permanent computerized data base for Choctawhatchee Bay has been compiled. This permanent data base will include physical/chemical and biological information and will be available publicly through the Northeastern Regional Data Center (NERDC) at Gainesville, Florida. The software package through which the data may be accessed is the Statistical Analysis System (SAS). Copies of the data files will be sent on computer tape to Florida Seagrant, Gainesville, Florida, Northwest Florida Water Management District, Tallahassee, Florida, and the Institute for Statistical and Mathematical Modeling at the University of West Florida, Pensacola, Florida. Blaylock, 1982, discusses user availability and access to the data. For reporting purposes the data are presented as an inventory in both tabular and graphic formats (Supplemental Appendices A-DD).

The raw data were tabulated and keypunched on cards using an outdated input format of STORET, the U.S. Environmental Protection Agency's environmental data storage and retrieval software system. In 1980 the data were sent to the U.S. Environmental Protection Agency (EPA) Laboratory in Athens, Georgia for reformating and computerization. Due to the outdated STORET formats the cards could not be read, so they were returned. At this time the author designed input/output facilities using SAS to create computerized data sets.

The SAS data sets were maintained on IBM System 3350 disk pacs at NERDC for graphic and statistical analyses.

Data analyses using statistical, graphic and inferential methods proceeded with a thorough review of the data for quality control. The data were first checked using visual data scans to detect gross abnormalities. Secondarily, the data were described utilizing summaries statistics of means and minimum/ maximum ranges by station, depth and time. These summary statistics were compared with acceptable ranges from previous literature. Abnormalities in the data were checked with raw data sheets and corrected where necessary.

The biological data were initially presented as tabular output and the physical/chemical data were presented graphically. The monthly physical/ chemical data were reduced and displayed on maps by time and sample depth. Also mapped were the benthic sediment parameters. The second phase of monthly graphic display involved production of linear plots of each parameter for each depth over the period of sampling to depict any changes throughout the year. Quarterly diel study data was depicted as comparative profiles from which one can determine vertical depth variation as well as variation across the diel study period. This data allows conclusions to be made concerning tidal cycles as well as diurnal changes in the photoperiod. The physical/chemical data are also summarized in tabular format displaying simple statistics across the bay for the year, at each station for the year, across the bay at each depth for the yar and for each month during the year. Quarterly data are summarized in tabular format with sample statistics for each station and across the entire bay. Phytoplankton, zooplankton and the benthos are summarized in tables depicting numbers found at each station at each sampling period. Maps were prepared for the more common species collected in the benthos. Other assorted maps and tables were prepared in conjunction with descriptions of the various conditions in the Bay and affecting the Bay.

Statistically, the monthly physical/chemical data were correlated over time to suggest any relationships. These parameters were also correlated with phytoplankton and zooplankton numbers at each station. Benthic species were correlated with the sediment physical chemical measurements to determine if there was a spatial relationship in the benthos. Stepwise regressions were made using fecal coliforms, total coliforms, total chlorophyll and chlorophyll A as dependent variables. These parameters were tested with dissolved oxygen, temperature, total organic carbon, nitrate, total phosphorous and ammonia to see if they could be modeled statistically through simple regressions. Temporal studies were made with plots of phytoplankton and zooplankton numers over the period of sampling.

All graphic display was done on a Tektronix graphic system comprised of a 4052 intelligent terminal, paired 4907 file manager diskette drives, and a 4663 flatbed plotter. The software was designed for all graphics on the 4052 terminal. Graphic programs included X/Y plot routines, multiple profile plot routines, bar charts and digitizing/mapping routines. To facilitate data transferal to the Tektronix, a communcations program was written and supplemented with data transformation files. All statistical analyses as well as much of the data analyses were made using Statistical Analyses Systems (SAS) software on the University of Florida computer facility, at NERDC.

7 - RESULTS AND DISCUSSION

PHYSICAL CHARACTERISTICS

Temperature

Water temperature in Choctawhatchee Bay is relatively constant spacially. Water temperature, as expected, does vary seasonally with seasonal changes in the ambient air temperature. The mean annual water temperature was 21.12 degrees Celsius across the entire Bay (Table 7-1). Spatially the temperature was 2 to 3 degrees higher in the western and central reaches of the Bay due to freshwater inflow depressing the temperature of surface water in the east. The mean annual temperature at stations nearer the mouth of the bayous around the Bay tended to be 1 to 2 degress Celsius higher than those in the central Bay. The central Bay bottom stations did not show strong seasonal variation when compared to surface and mid-depth waters (Figures 7-1 and 7-2). These central Bay stations exhibited benthic temperatures with close to a one month lag behind surface water temperatures with mid-depth temperatures falling between the two. The seasonal spring increase in temperature occurred between April and May while fall decreases occurred between October and November (Figure 7-3). Water temperature in September was slightly lower than in October due to the passing of Hurricane Eloise. During the fourth quarterly sampling period in November the surface temperatures appeared to decrease with increasing freshwater inflow (Figures 7-5 through 7-12).

Table 7-1: Annual means of physical parameters for Choctawhatchee Bay and for each individual sampling depth during 1975.

	Temperature (C°)	Salinity (ppt)	Dissolved Oxygen (mg/1)
Grand Means	21.21	13.36	5.74
Surface Depth Means	21.20	7.23	7.20
Mid-Depth Means	21.01	11.93	6.25
Bottom Depth Means	21.16	20.96	3.76
Station 1	19.97	4.91	6.15
2	20.07	4.45	5.81
3	20.05	3.33	5.92
4	20.38	6.87	5.99
5	20.83	7.59	6.25
6	21.49	9.04	5.14
7	20.83	9.77	5.94
8	21.47	9.21	5.83
9	20.78	10.42	6.37
10	21.67	9.26	5.89
11	20.27	11.40	6.47
12	21.13	12.72	5.74
13	22.01	14.41	4.71
14	21.28	13.37	5.51
15	21.46	15.40	5.44
16	21.11	14.50	6.23
17	21.34	19.01	4.77
18	21.30	19.00	5.07
19	21.34	16.22	5.64
20	21.88	14.70	5.20
21	21.36	18.96	5.82
22	22.01	17.94	4.30
23	21.25	17.96	5.28
24	21.15	20.89	6.84
25	21.35	20.44	5.24
26	21.32	10.54	7.31
27	21.16	19.97	5.65
28	20.36	13.23	7.15
29	21.17	19.19	5.70
30	21.62	15.61	6.33
31	21.56	18.21	5.51

Figure 7-1: Water temperature (Celsius) at Station Seventeen in Choctawhatchee Bay during the year 1975.

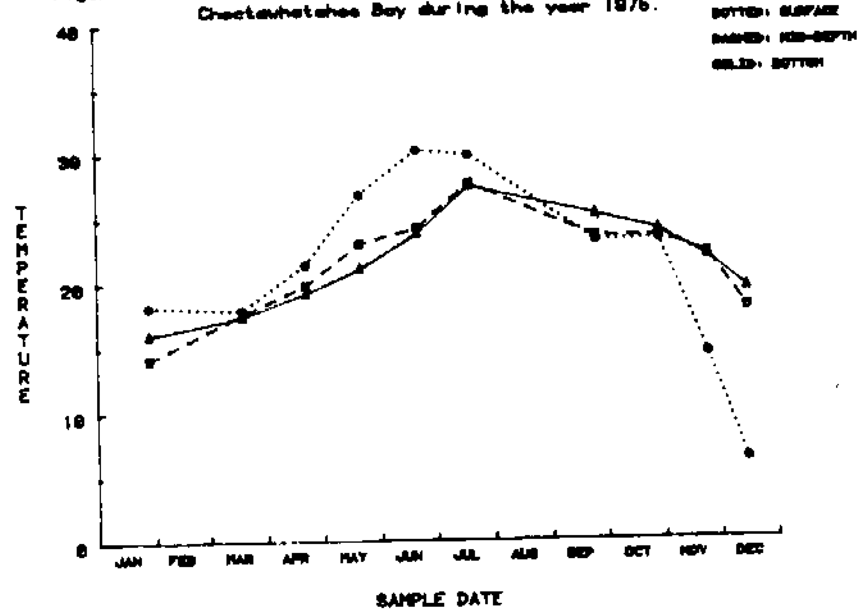


Figure 7-2: Water temperature (Celsius) at Station Twenty-three in Choctawhatchee Bay during the year 1975.

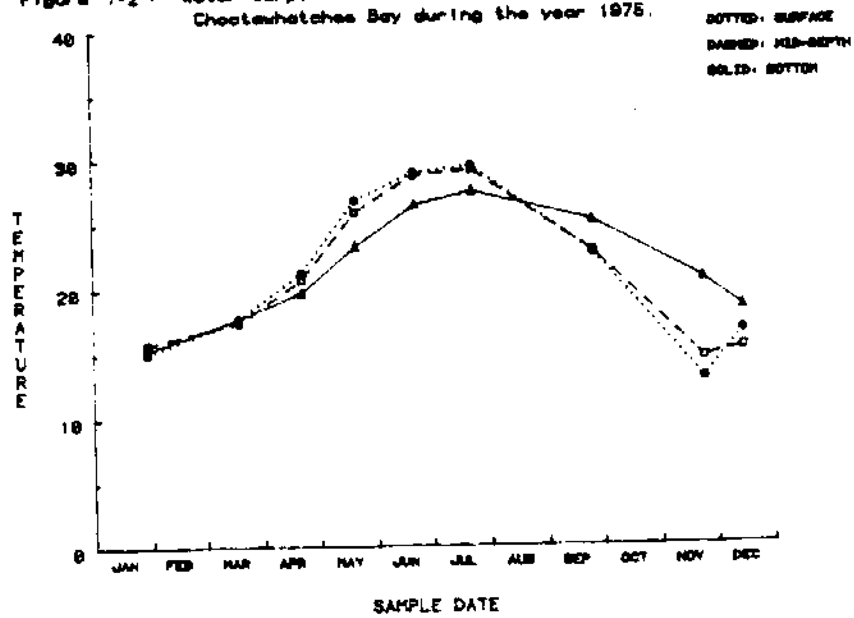


Figure 7-3: Average Monthly Water Temperature for Choctawhatchee Bay during the year 1975.

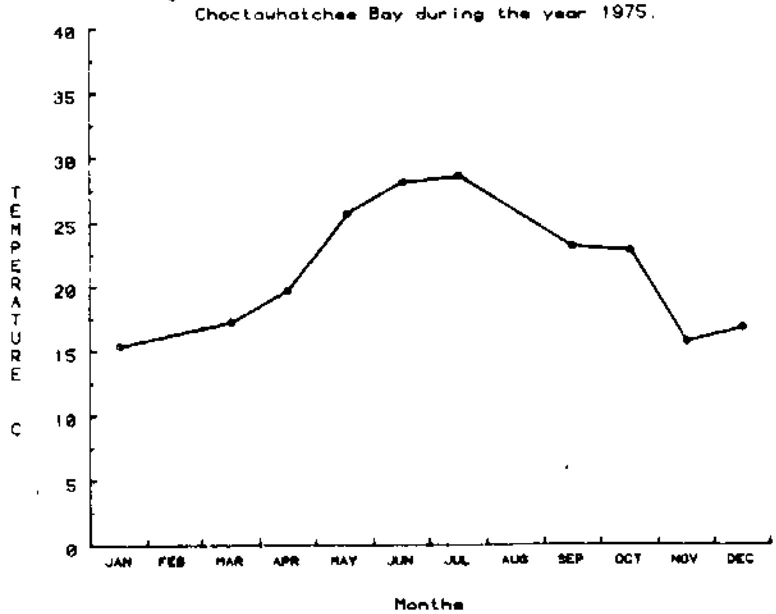


Figure 7-4: Average Monthly Surface Water Temperature for Choctawhatchee Bay during the year 1975.

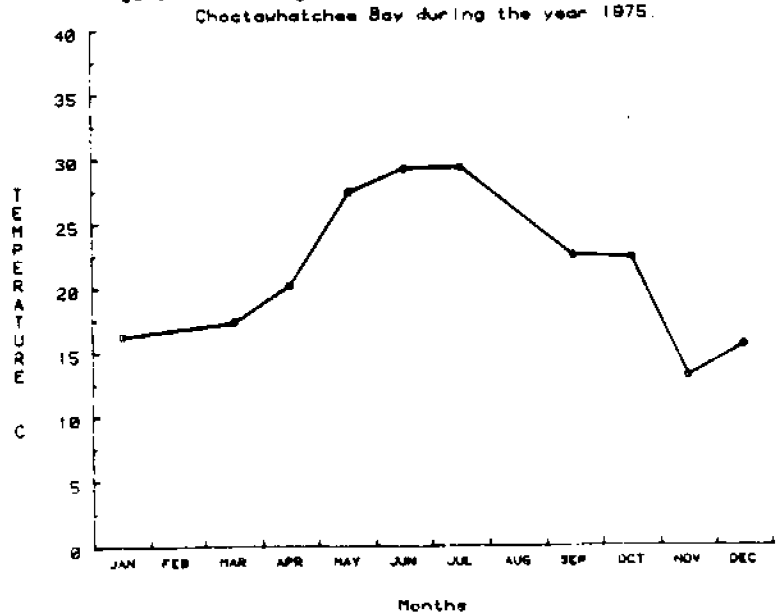


Figure 7-5: Profiles of temperature, salinity, pH and dissolved oxygen at Station 1 on May 28, 1975.

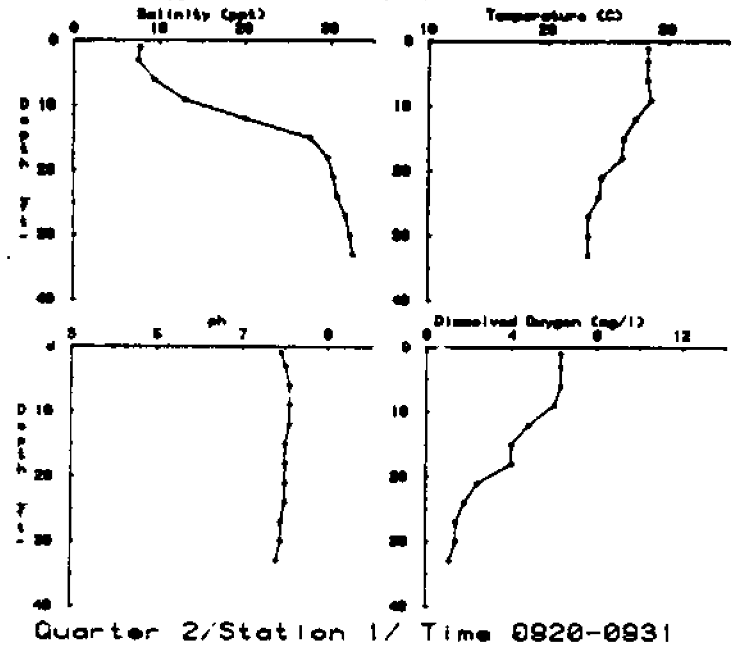


Figure 7-6: Profiles of temperature, salinity, pH and dissolved oxygen at Station 2 on May 28, 1975.

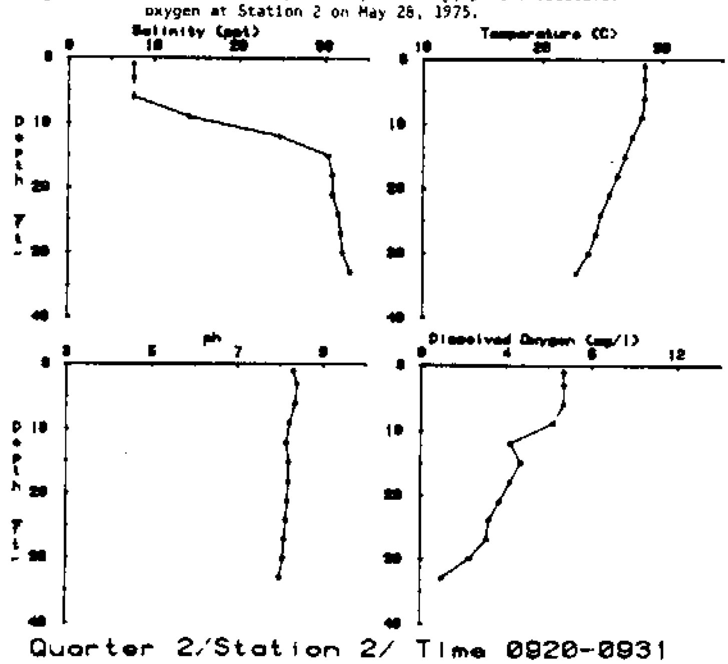


Figure 7-7: Profiles of temperature, salinity, pH and dissolved oxygen at Station 3 on May 28, 1975.

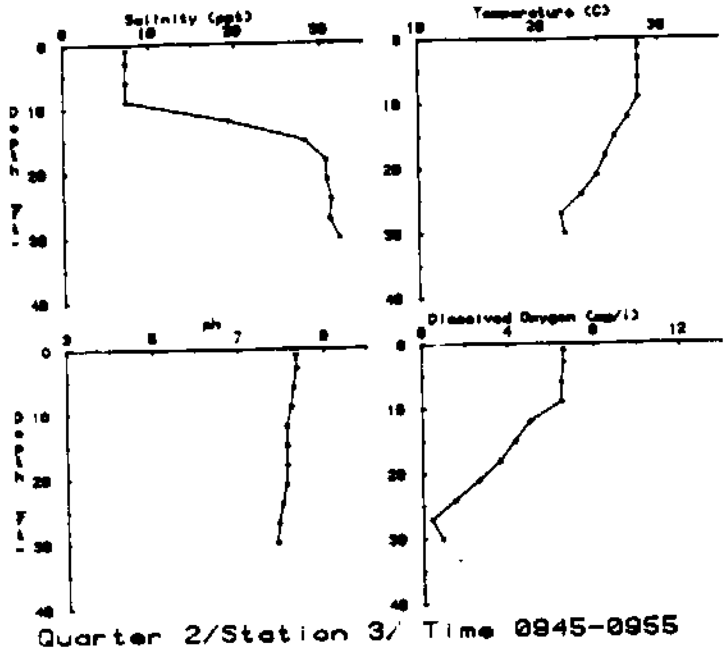


Figure 7-8: Profiles of temperature, salinity, pH and dissolved oxygen at Station 4 on May 28, 1975.

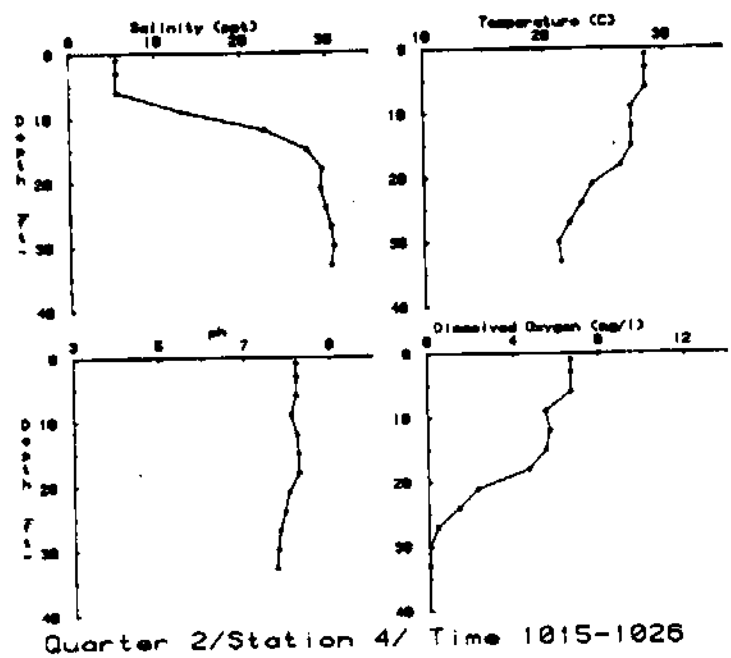


Figure 7-9: Profiles of temperature, salinity, pH and dissolved oxygen at Station 5 on May 28, 1975.

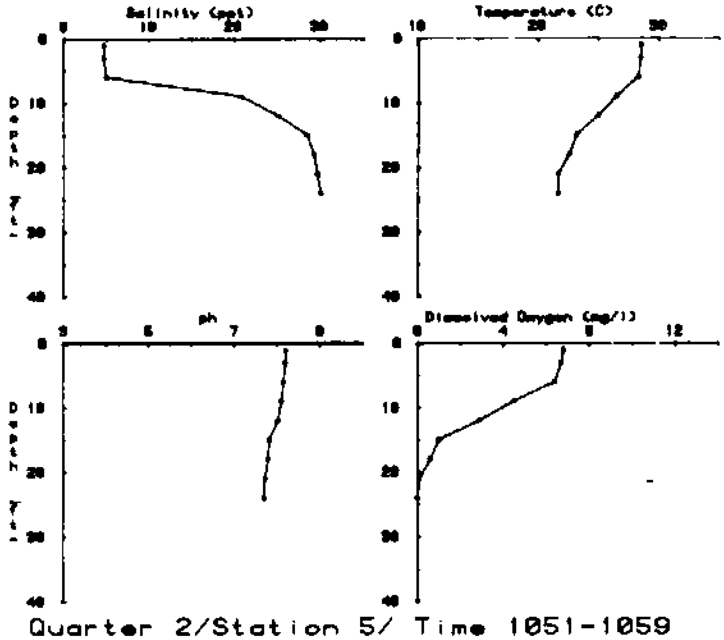


Figure 7-10: Profiles of temperature, salinity, pH and dissolved oxygen at Station 6 on May 28, 1975.

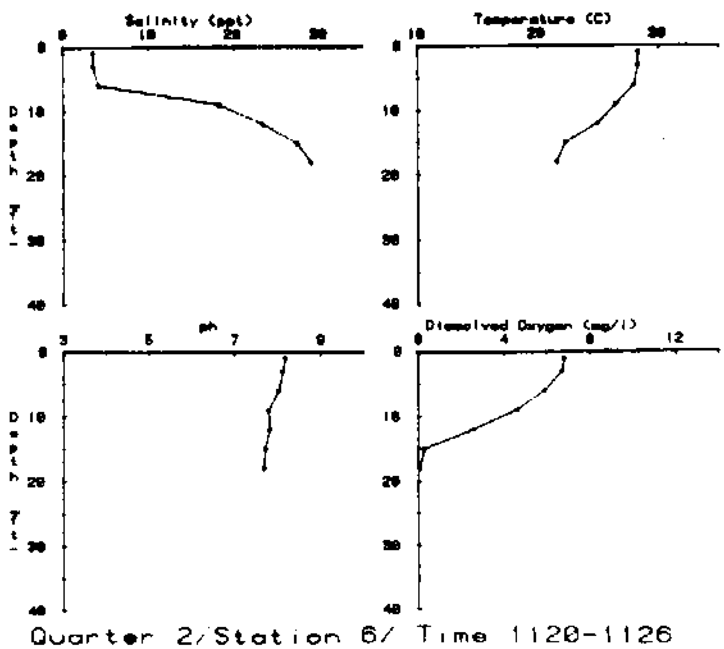


Figure 7-11: Profiles of temperature, salinity, pH and dissolved oxygen at Station 7 on May 28, 1975.

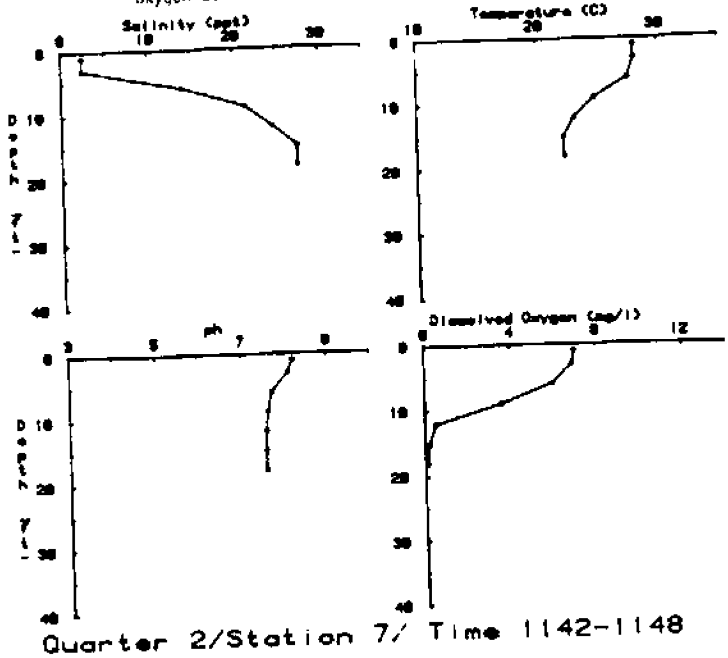
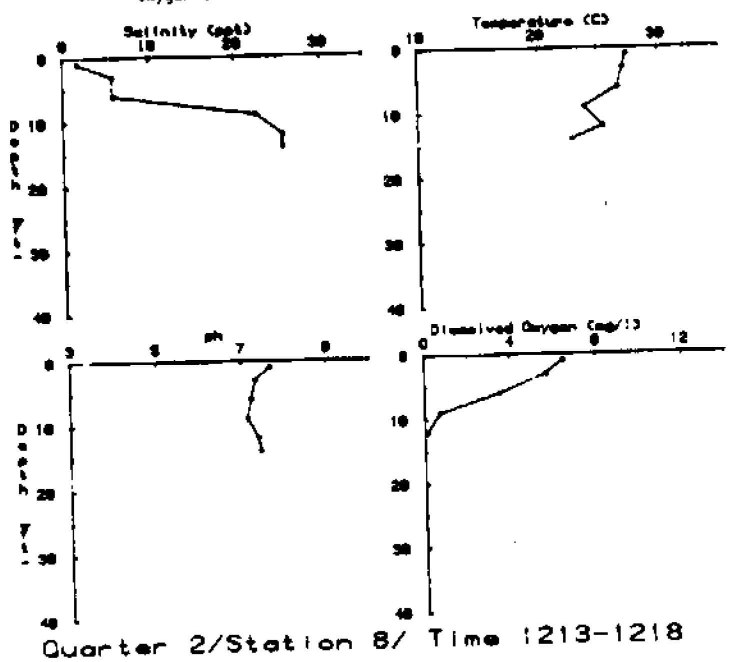


Figure 7-12: Profiles of temperature, salinity, pH and dissolved oxygen at Station 8 on May 28, 1975.



Water temperature was found to be statistically significant in stepwise regression models predicting fecal and/or total coliform bacteria numbers at monthly stations 18, 21, 28 and 29 for benthic waters and for prediction of total coliform bacteria numbers at stations 18 and 29 for surface waters (Tables 7-2, 7-3). This significance may result from increased non-point source discharge from residential districts near those stations. Statistically significant inverse correlations occurred baywide between ambient water temperature and dissolved oxygen (Table 7-4). This is in accordance with physical gas transport laws and increasing biological activity as expected with increasing temperatures. In surface and mid-depth waters a statistically significant correlation exists between temperature and ammonia nitrogen and the P:N ratio (ratio phosphorous : total nitrogen). Also, temperature was found to correlate strongly with total nitrate at all sample stations between station 5 and station 22 and stations 25 and 27 (Appendix E). This may be a function of both phytoplankton activity and water column microbial activity. The surface samples also showed a correlation between nitrate and temperature except in western Choctawhatchee Bay (Table 7-4). The absence of statistically significant correlations between temperature and nitrate may be due to the increased number of municipal discharges in the western Bay.

pH

In Choctawhatchee Bay pH was measured only during the four quarterly diurnal sampling periods at the eight central quarterly stations. Spatially, during each quarter, pH gradually increased 0.5 pH units from the eastern Bay to the western Bay. The lowest Baywide average pH occurred in February, while

Table 7-2: Parameters for which significant (a = 0.10) models for bottom water column coliform bactera were found using a maximum R-square stepwise regression technique.

	Station	Parameter	R-square
Total Coliform Bacteria	18	Temperature	0.446
	20	Total Organic Carbon	0.816
	21	Total Organic Carbon and Dissolved Oxygen	0.840
	28	Temperature	0.4688
	29	Temperature	0.493
Fecal Coliform	18	Temperature	0.469
	21	Total Organic Carbon and Temperature	0.669
	28	Total Organic Carbon and Temperature	0.696
	29	Temperature	0.493

Table 7-3: Parameters for which significant (a = 0.10) models for surface water column coliform bactera were found using a maximum R-square stepwise regression technique.

	Station	Parameter	R-square
Total Coliform Bacteria	18	Temperature	0.646
	21	Dissolved Oxygen and Temperature	0.805
	29	Temperature	0.723
Fecal Coliform Bacteria	29	Dissolved Oxygen	0.731

Table 7-4: Significant correlations between temperature and other water quality parameters across the Bay and for each depth across the Bay.

	Parameter	R-square	PROB > F
Entire Bay	Dissolved Oxygen	-0.8787	0.0008
Bottom	Dissolved Oxygen	-0.8022	0.0052
Mid-depth	Dissolved Oxygen	-0.8438	0.0021
	Ammonia	-0.7406	0.0143
	Phosphorous/ Nitrogen Ratio	-0.7443	0.0214
Surface	Dissolved Oxygen	-0.9293	0.0001
	Ammonia	-0.6376	0.0473
	Nitrate	-0.7458	0.0133
	Phosphorous/ Nitrogen Ratio	-0.5826	0.0997

much higher pH levels occurred in May and July (Table 7-5). In individual profiles, the pH was relatively constant from surface to bottom except at the stations nearest the Choctawhatchee River (Figures 7-3 through 7-12). Here the surface pH was slightly lower than on the bottom. The pH change was in the halocline indicatng that the freshwater discharge was slightly more acidic than resident tidal waters. Also interesting to note were pH fluctuations occurring in the turbidity maximum or zone of maximum mixing of overlying freshwater and bottom waters. This was unusual in that pH levels in the surface and bottom waters were nearly the same.

Salinity

In 1975 the average salinity in Choctawhatchee Bay was 13.363 parts per thousand (ppt) with a range from 0 ppt to 36.9 ppt (Table 7-1). Average salinities in the eastern Bay and in the bayous around the Bay range from 2 ppt to 5 ppt lower than salinities in the mainbay. This can be attributed to a decrease in tidal infiltration and increased mixing with surface waters as suggested by lower than average benthic salinities and higher than average surface and mid-depth salinities in both the eastern bay and the mouths of the bayous. The increased mixing can be attributed to decreasing depths in these areas. Western surface waters also have higher than average surface salinities when compared to other mainbay stations indicating either increased tidal mixing of surface waters on low flow rates in western tributaries. The topography of the Bay creates localized turbidity maxima zones near the mouths of bayous and along the central axis of the Bay toward the east. These turbidity maxima zones are created where freshwater and salt water mix, floculating

Table 7-5: Quarterly diurnal pH averages and overall averages in Choctawhatchee Bay, 1975.

	February	May	July	November	Annual
Station 1	5.87	7.98	6.75	7.84	7.14
Station 2	5.83	8.05	6.60	7.93	7.10
Station 3	5.77	7.95	6.78	7.89	7.10
Station 4	5.77	7.85	6.90	7.77	7.07
Station 5	5.76	7.76	6.54	7.71	6.94
Station 6	5.74	7.62	6.69	7.65	6.93
Station 7	5.64	7.54	6.46	7.51	6.79
Station 8	5.31	7.31	6.34	7.49	6.61
Baywide	5.71	7.76	6.63	7.74	(6.96)

sediments and concentrating these and other particulates forming a high turbidity zone. The turbidity maxima is a function of tides, freshwater inflow and the bottom topography.

Choctawhatchee Bay salinities are dominated by freshwater inflow. Salinity is inversely correlated with flow across the entire Bay (Table 7-6). Mid-depth and surface salinity are affected the most while benthic salinities are buffered from freshwater inflow effects through tidal influx of seawater. The domination of salinity by flow is also evident through the uniformity of surface salinity as opposed to the salinity in the benthic zone except at East Pass (Figures 7-5 through 7-12). The depth of the halocline is also controlled by flow except during low flow periods when tides influence the location of the halocline. Salinity differences in the surface and benthic waters of the Bay in quarterly stations 3 to 8 were as great as 28 ppt during the quarterly samples, however, the average difference for all eight was near 17 ppt. This definitely confirms earlier conclusions which showed Choctawhatchee Bay to be a stratified system during specific sample periods. The stratification resulting from the halocline breaks down only infrequently and then only in stations inside the Highway 331 Causeway in the eastern end of the Bay during extremely high flow periods.

Tidal inflow into Choctawhatchee Bay moves as depicted in Figure 7-14. As the saline waters come into the Bay, they are soon forced below the residual freshwater into the deep water central basin north of East Pass. Interchange of Choctawhatchee Bay and fresh Gulf of Mexico waters is depicted in mean salinities at East Pass (Station 24) which average higher than the rest of the Bay for bottom, mid-depth and surface salinities (Table 7-1). The lack of

Table 7-6: Statistically significant correlations of freshwater discharge into Choctawhatchee Bay with salinity and dissolved oxygen, 1975.

R-square

Station	Dissolved Oxygen	Salinity	Station	Dissolved Oxygen	Salinity
1	.575		19	.6633	-.8562
3	.7327		20		-.9277
4	.5585		21		-.8415
5		-.5504	22		-.8042
6	.6257		23		-.8049
7	.5865	-.5888	24		-.6432
8		-.5665	25		-.8615
9	.5959	-.6639	26		-.8121
10	.6039	-.6623	27		-.7285
11	.6838	-.7274	28	.6334	-.7123
12	.6633	-.7886	29		-.8095
13		-.7555	30		-.7554
14		-.8539	31		-.7697
15		-.8159	Surface		-.7875
16		-.5667	Mid-depth	.5898	-.8278
17		-.7702	Benthos		-.5584
18		-.7471	Baywide		-.8193

Figure 7-13: Zone of Maximum Turbidity. Arrows indicate where mixing occurs and sediments are trapped.

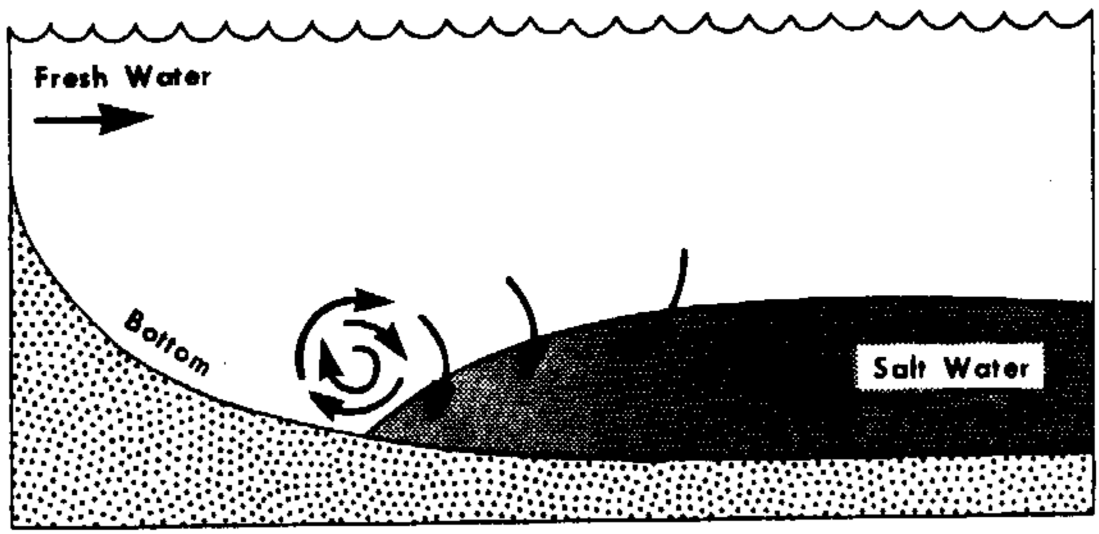
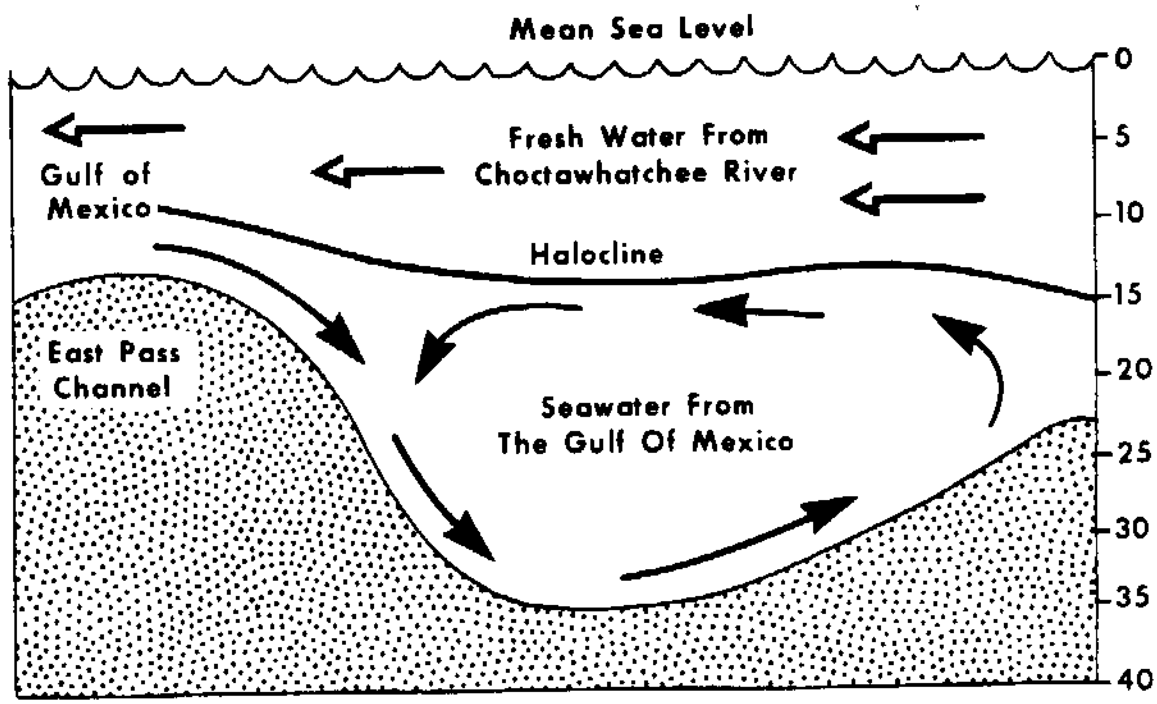


Figure 7-14: Tidal Inflow into Choctawhatchee Bay.



similar trends at both stations 23 and 25 indicate submergence of the heavier incoming tidal waters into the central basin (Table 7-7). The waters then move both east and west into the Bay with an intensity which is limited by surface freshwater flow rates.

In the western Bay, waters move toward the northwest, possibly along an old channel which leads into Garnier Bayou. Outflow from the west is predominantly along the southern shore parallel to Santa Rosa Island into Santa Rosa Sound. This movement is probably the reason for below average salinities near the mouth of Santa Rosa Sound at station 28. Low salinities at station 26 are probably the result of tidal movement during incoming tides, forcing residual freshwater to concentrate along the shallow north shore between Shalimar and Valparaiso.

Tidal movement toward the eastern Bay is stronger along the central bottom channel following the bottom topography. This movement is closer to the northern shore since freshwater outflow is stronger along the southern shore as indicated by mean salinities in the central Bay (Table 7-7). The strength of the outflow as previously noted will control the tidal movement. The location of the mainbay turbidity maxima where the bottom and surface waters are forced to mix through current and tidal pressure will vary in the central Bay between stations 21 and 15 depending upon the hydrological conditions. During the period of study, the turbidity maxima was located most often at station 17 and occasionally at station 18 where the mean mid-depth salinities exceeded that of all other stations (Table 7-8). Statistically significant correlations of salinity with phytoplankton pigments and total phosphorous at stations 17 and 19 substantiates indications of a turbidity maxima since this

Table 7-7: Mean Salinities at the Surface, Mid-depth and Bottom for sections 23, 24 and 25.

	Station		
	23	24	25
Grand Mean	17.76	20.89	20.44
Surface	10.84	18.50	11.61
Mid-depth	13.60	21.49	18.87
Bottom	29.44	22.69	30.83

Table 7-8: Mean salinities at the Surface, Mid-depth and Bottom for stations 15, 16, 17, 18, 19, 20, 21 and 22.

Station	Grand Mean	Surface	Mid-depth	Bottom
15	15.40	7.53	11.47	27.2
16	14.50	8.71	11.49	24.28
17	19.01	7.42	21.56	28.04
18	18.99	9.28	19.62	28.07
19	16.22	8.52	11.51	28.63
20	14.70	6.85	12.56	24.70
21	18.96	8.37	19.48	28.07
22	11.94	7.99	17.76	29.44

nutrient rich zone enhances phytoplankton growth (Table 7-9; Appendix E).

During low discharge periods from Choctawhatchee River, high salinity pockets are formed in central Choctawhatchee Bay as described by Goldsmith, 1966, and Pastula, 1967. These pockets are the result of reduced tidal movements within the benthic waters since tidal flux is constrained to mid-depth and surface waters. Since 1975 was considered a high flow year, this trend is evident only in the location of station 13 during the month of December (Figure 7-15).

Freshwater inflow dominated the system in March, April, May, August and September in terms of salinity with extremes occurring in August, and September during Hurricane Eloise. The highest salinities across the Bay occurred in January, July and December, corresponding to low flow periods. In all months the difference in surface and bottom salinities increased as expected from the mouth of the Choctawhatchee River to the East Pass at the mouth of the Bay. Greatest mixing of the waters of the Bay occurred in March and September where on time plots there was the least difference between surface and bottom water salinities (Figures 7-5 through 7-12). These low difference periods were during months of increased flow and wind turbulence (Figure 4-16; Table 5-2).

Salinity exhibits a positive relationship with total carbon at four stations around the mouth of the Bay along with the southern shore including stations 18, 23, 25 and 27 (Appendix E). Stations 24 and 25 were inversely correlated with dissolved oxygen suggesting that often the high salinity waters at these stations are also oxygen depleted as has been previously noted (Ross, Anderson and Jenkins, 1974). Across the benthic regions for the entire

Table 7-9: Statistically significant (a = 0.10) step-wise regressions depicting the relationship between nutrients and total chlorophyll.

Station	Nutrient	R-square	PROB > 1
17	Dissolved Phosphorous	0.9300	0.0001
18	Dissolved Phosphorous, Nitrate	0.9220	0.0017
19	Nitrate	0.4366	0.0527
20	Dissolved Phosphorous	0.7481	0.0026
21	Dissolved Phosphorous	0.9619	0.0001

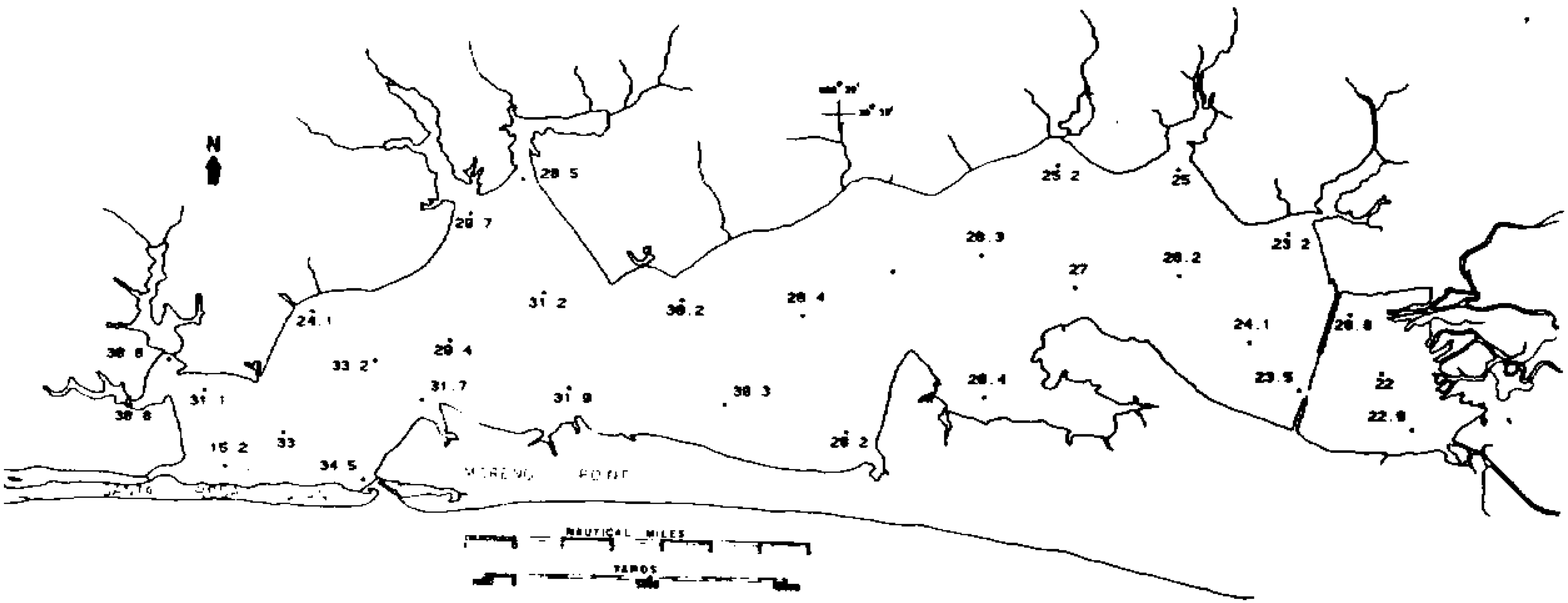


Figure 7-15. Salinity (ppt) in bottom waters of Choctawhatchee Bay on December 15, 1975.

Bay, salinity is significantly correlated with dissolved phosphorous indicating a potentially strong sediment/water column exchange of phosphorous as salinity increases. Surface water salinities are inversely correlated to dissolved phosphorous showing tributary loadings of phosphorous to be rapidly depleted from surface waters in the Bay. This also indicates that Choctawhatchee Bay is nutrient limited with dissolved phosphorous being the limiting nutrient.

Dissolved Oxygen

Except during infrequent times when strong winds, tides and currents exist in Choctawhatchee Bay, the Bay exhibits a strong dissolved oxygen stratification. The average dissolved oxygen content in the Bay during 1975 was 5.7 mg/l with 7.2 mg/l on the surface, 6.2 mg/l at mid-depth and 3.8 mg/l on the bottom (Table 7-1). The lowest annual average dissolved oxygen concentration occurred in the mouth of Rocky Bayou (station 20), where several fish kills occurred from 1972 to 1975 (Taylor Biological Co., 1978). Statistically significant correlations of dissolved oxygen with water temperature indicate a strong influence of seasonal temperature changes on dissolved oxygen concentrations (Table 7-4). The highest correlation significance probabilities between water temperature and dissolved oxygen occurred in surface waters, however, temperature was still statistically significantly correlated with dissolved oxygen at mid-depth and on the bottom. The significant inverse relationship between water temperature and dissolved oxygen are explained by gas solubility rates and increasing biological activity (Oppenheier, 1970). It is commonly understood that the oxygen saturation coefficient is much greater in cooler water. Increasing temperatures also stimulate biological activity in micro and macro organisms. This increasing activity results in liberation of nutrients and the utilization of oxygen. These situations contribute to dissolved oxygen deficits during middle and late summer as is evident in Choctawhatchee Bay in bottom waters throughout the summer. Other low dissolved oxygen locations in Choctawhatchee Bay include several bayous during certain time periods (Table 7-1). Low concentrations in these bayous are thought to be the result of increased organic load and poor flushing rates. High dissolved oxygen areas are characterized by high flow and strong mixing rates such as are found in East Pass at Destin (Station 24) and at the mouth of the Choctawhatchee River (Stations 1 and 2). This is evidenced by significant correlations of dissolved oxygen with flow stations 1, 3, 4, 6, 7, 9, 10, 11, and 12 (Appendix D) and inversely with salinity at stations 24 and 25 (Appendix E). Dissolved oxygen concentrations during the high flow periods in April and September were higher than average. Increased discharge rates from Choctawhatchee River broke down the dissolved oxygen stratification at eastern stations resulting in homogenous dissolved oxygen concentrations from surface to bottom in the eastern Bay (Figures 7-5, 7-6). Flow controlled dissolved oxygen levels at mid-depth where a statistically significant correlation existed between flow and dissolved oxygen (Appendix D). This is also evident in quarterly dissolved oxygen profiles which show maximum variation in mid-depths where friction between underlying saline water and faster moving upper freshwater mixes the two layers (Figures 7-5 through 7-12). It is in this layer that most of the aforementioned heterotrophic activity occurs, due to the accumulation of suspended particulates and floculated organics, further reducing dissolved oxygen levels. Quarterly profiles reveal strong differences down the mainbay between surface and bottom dissolved oxygen. The depressed benthic dissolved oxygen level is thought to be a result of high biological and chemical activity in the sediments while surface variation is a combination of the solubility constant, flow rate and photosynthesis. Diurnal fluctuation in dissolved oxygen remained totally inconsistent throughout diurnal cycles, as often the lowest dissolved oxygen level in the diurnal cycle occurred in mid and late afternoon. A plausible explanation is the activity of tides and flow creating mixing convection currents which are low in dissolved oxygen.

Seasonally dissolved oxygen should follow trends of ambient air temperature due to its strong correlation with water temperature. There is a strong summer benthic dissolved oxygen deficit due to temperatures, decreased mixing and increased biological activity (Figures 7-16 through 7-19). A strong relation exists in surface waters between dissolved oxygen and nitrate (Appendix E). This significant correlation is also found at stations 3, 9, 14, 18, 19, 20, 21, 22, 26 and 27. It is not known whether this relation is seasonal, as is flow, or if it is a result of high primary productivity with the increased productivity aiding in the saturation of surface waters with dissolved oxygen. Similar positive correlations exists between dissolved oxygen and kjedahl nitrogen at stations 1, 3, 12, 13, 27 and 30 and ammonia at stations 5, 11, 13 and 14. The increased productivity is not supported by similar correlations between dissolved oxygen and chlorophylls. Statistically significant inverse correlations with dissolved oxygen exists with chlorophyll A at stations 8, 9 and 15 and with total carbon at stations 8 and 12.

Figure 7-16: Dissolved oxygen (mg/l) at Station Thirteen in Choctawhatchee Bay during the year 1975.

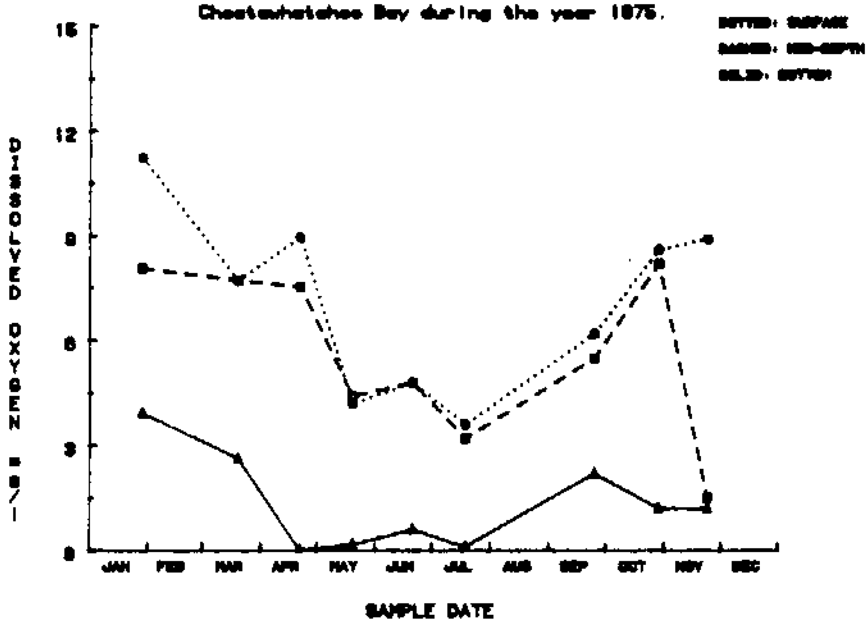


Figure 7-17: Dissolved oxygen (mg/l) at Station Seventeen in Choctawhatchee Bay during the year 1975.

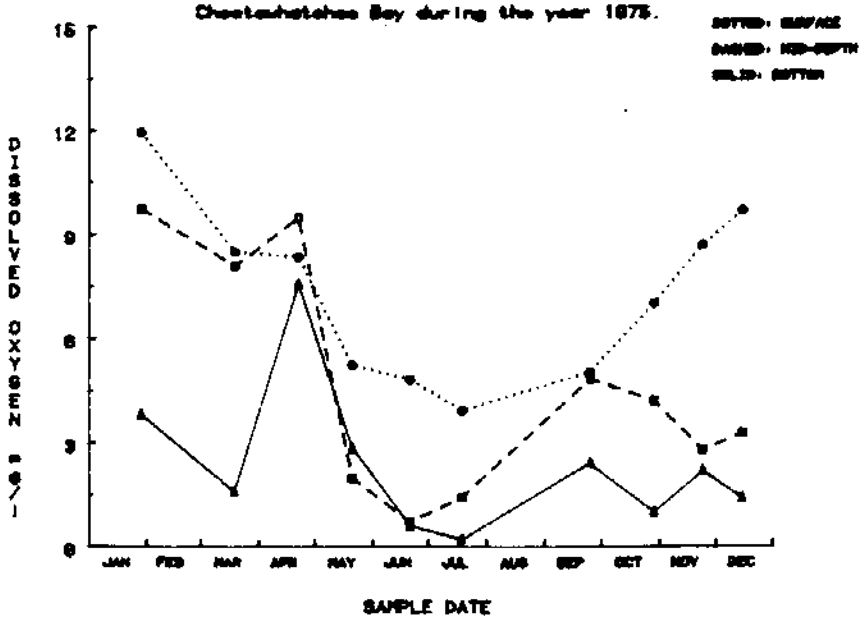


Figure 7-18: Dissolved oxygen (mg/l) at Station Eighteen in Choctawhatchee Bay during the year 1975.

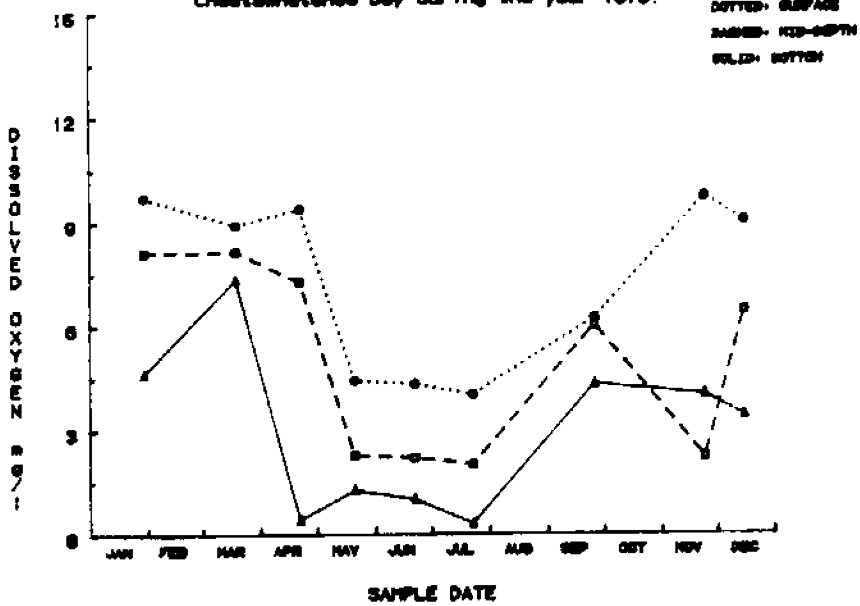
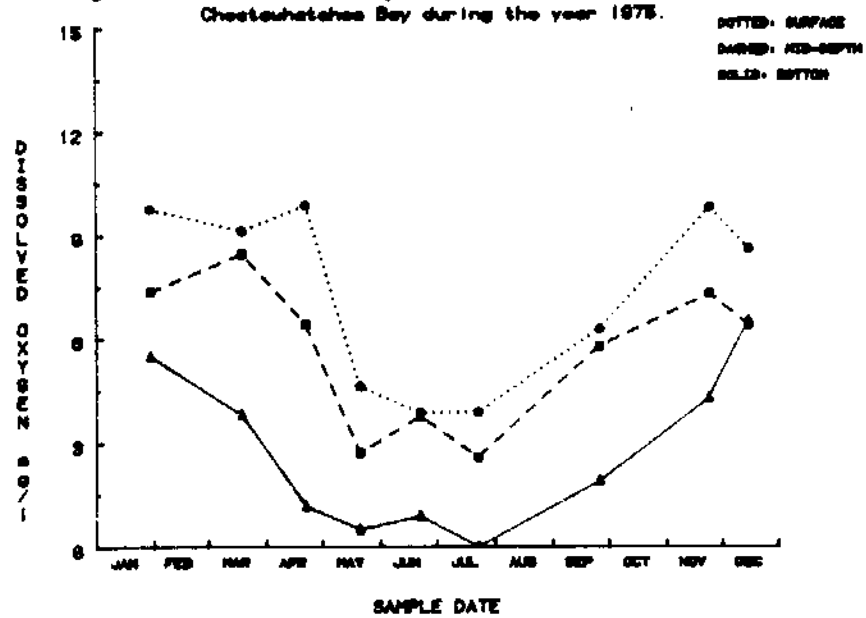


Figure 7-19: Dissolved oxygen (mg/l) at Station Twenty-five in Choctawhatchee Bay during the year 1975.



WATER QUALITY

Phosphorous

Phosphorous has been suggested to be a limiting factor in phytoplankton productivity in Northwest Florida estuaries (U.S. Environmental Protection Agency, 1975; Myers and Iverson, 1981). This is opposite to the supposition that estuaries are characteristically limited in productivity by nitrogen (Nixon, 1981). Choctawhatchee Bay follows trends found in both Escambia Bay and Apalachicola Bay. Total nitrogen to total phosphorous ratios in nitrogen limited estuaries are generally below 16:1 and phosphorous limited estuaries are above 16:1. The total mean N:P ratio in Choctawhatchee Bay is 15:1; however, this figure may be misleading. Recent studies have shown that only soluble reactive nitrogen and phosphorous compounds should be used when calculating the N:P ratio. Soluble reactive nitrogen includes ammonia, urea, nitrate and nitrite; while soluble reactive phosphorous includes orthophosphate, polyphosphate and organic phosphate. N:P ratios in Choctawhatchee Bay for only the soluble reactive fractions of nitrogen and phosphorous are well above the 16:1 figure indicating strong limitations on primary productivity through the absence of soluble reactive phosphorous.

Total phosphorous in Choctawhatchee Bay averages .0465 mg/l with surface averages of .0432 mg/l, mid-depth at .0391 mg/l and benthic averages at .0571 mg/l (Table 7-10). Spatial analyses suggest very irregular patterns in

Table 7-10: Annual means of water quality parameters including dissolved phosphorous, total phosphorous, total carbon and total organic carbon for Choctawhatchee Bay and for each sampling depth during 1975.

	Dissolved Phosphorous (mg/l)	Total Phosphorous (mg/l)	Total Carbon (mg/l)	Total Organic Carbon (mg/l)
Overall Means	.0036	.0465	43.86	29.09
Surface Depth Means	.0031	.0432	43.28	32.46
Mid-Depth Means	.0036	.0391	41.28	27.36
Bottom Depth Means	.0042	.0572	47.02	27.47
Station 1	.0003	.0481	52.71	42.86
2	.0017	.0350	47.25	36.64
3	.0027	.0307	63.92	54.48
4	.0167	.0739	58.22	46.35
5	.0137	.0233	49.04	37.39
6	.0027	.0286	35.03	21.95
7	.0060	.0197	34.52	21.16
8	.0003	.0225	48.05	35.29
9	.0003	.1309	81.30	67.42
10	.0007	.0906	46.38	33.66
11	.0000	.0382	49.37	36.52
12	.0011	.0468	46.72	31.39
13	.0013	.0568	76.65	60.70
14	.0000	.0148	77.94	63.16
15	.0024	.0337	51.40	36.03
16	.0007	.0464	42.73	27.37
17	.0045	.0696	36.64	18.03
18	.0031	.0513	43.26	25.40
19	.0028	.0775	36.29	19.64
20	.0136	.0511	49.27	34.73
21	.0045	.0205	39.22	20.12
22	.0022	.0675	32.57	16.41
23	.0031	.0606	28.23	10.19
24	.0004	.0394	29.28	11.90
25	.0036	.0475	25.10	6.86
26	.0068	.0663	23.34	11.72
27	.0075	.0215	33.92	15.84
28	.0009	.0120	22.07	8.52
29	.0032	.0649	34.16	16.24
30	.0015	.0185	28.20	12.69
31	.0030	.0206	23.18	5.91

distribution. Total phosphorous is significantly correlated with chlorophyll across the entire Bay and in surface samples (Table 7-11). Significant correlations with chlorophyll were strongest in central stations 16 and 25 (Table 7-9). High total and dissolved phosphate concentrations were found at stations 17 and 18 where a turbidity maxima zone was found in the year 1975 (Table 7-10). Total phosphorous correlated with nitrate and ammonia at 3 of the 31 sampling stations (Appendix E). Seasonally, total phosphorous was lowest January through March, increasing toward the summer with irregular distributions throughout the rest of the year. The irregularity may have been induced through sediment disturbance created by Hurricane Eloise. Exceedingly high phosphorous concentrations relative to the entire year were found in September after the hurricane (Figure 7-20).

Dissolved phosphorous was highest at stations 4 and 5 (.016 mg/l and .015 mg/l, respectively) and at the mouth of Rocky Bayou (.013 mg/l). The baywide average was .0036 mg/l with .0031 mg/l, .0036 mg/l and .0042 mg/l at the surface, mid-depth and bottom (Table 7-10). Seasonally dissolved phosphorous was higher at the eastern stations during high flow periods. This is supported by strong correlations with flow at both stations 4 and 5 (Appendix D). Dissolved phosphorous was found in higher concentrations in the central Bay in benthic waters from mid-summer through the end of the year. Summer increases can be attributed to decreasing dissolved oxygen on the bottom. The low dissolved oxygen sediments are preclusive to remineralization of phosphorous from the sediments. Other studies have suggested in nitrogen limited estuaries that as much as 20% of the phosphorous input into an estuarine system may be due to remineralization (Nixon, 1981). In a phosphorous limited estuary, this rate of release of phosphorous into the water

Table 7-11: Significant correlation (a < 0.10) of water quality with total phosphorous across Choctawhatchee Bay at surface, mid-depth and bottom.

	Parameter	R-square	PRO
Surface	Chlorophyll A	0.7797	0.0
	Chlorophyll B	0.8942	0.0C
	Chlorophyll C	0.8968	0.00
	Total Chlorophyll	0.8937	0.001
Mid-depth	-	-	-
Bottom	-	-	-

Figure 7-20: Annual Trend of Total Phosphorous for Choctawhatchee Bay during the year 1975.

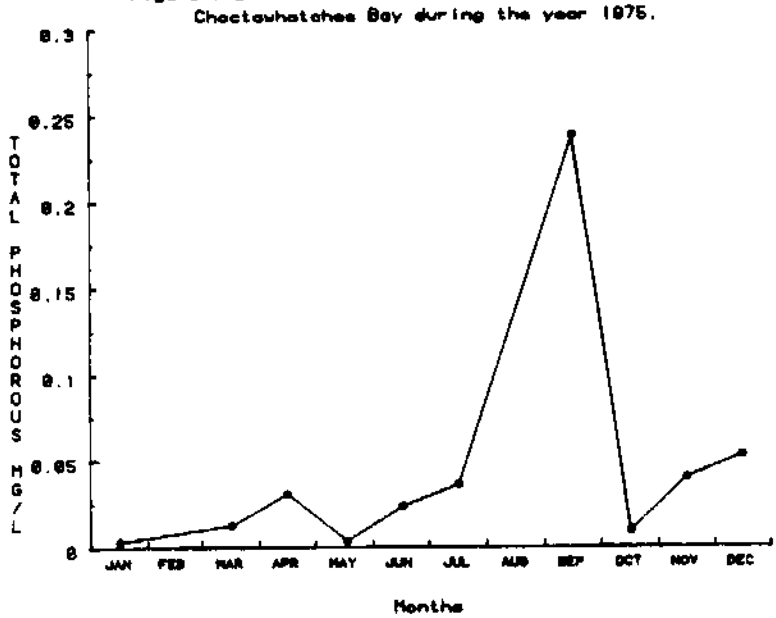
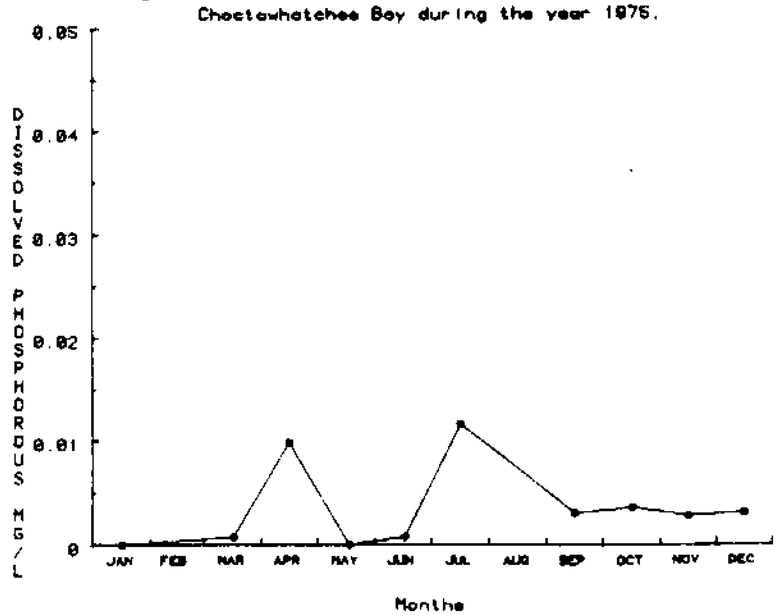


Figure 7-21: Annual Trend of Dissolved Phosphorous for Choctawhatchee Bay during the year 1975.



column may be increased significantly. Also interesting is the correlation of dissolved phosphorous to salinity in benthic waters and inversely to salinity in surface waters (Table 7-11). This further supports conclusions of benthic remineralization since salinity in Choctawhatchee Bay tends to increase in deeper waters where the dissolved oxygen supply is limited in deeper waters. The data also suggest that all the input of dissolved phosphorous from fresh-water inflow is being rapidly utilized in surface waters accounting for high chlorophyll concentrations in the eastern reaches of Choctawhatchee Bay. Chlorophyll is found to correlate significantly with dissolved phosphorous at station 4 (Appendix E). In the mid-bay, from stations 16 to 21, dissolved phosphorous correlates significantly with chlorophyll. The significance is supported by significant inverse correlations between dissolved phosphorous and ammonia and mid-depth where the turbidity maxima is most often sampled (Table 7-12). After mixing of the dissolved phosphorous from the bottom waters into the turbidity maxima zone, ammonia is utilized strongly with increased phytoplankton productivity and increased chlorophyll production. The source of phosphorous to the sediments is from the settling of senescent phytoplankton, fluvial loadings of particulate phosphates and settling of sediments to which total phosphates have absorbed.

Nitrogen

In Choctawhatchee Bay, as in other Northwest Florida estuaries, nitrogen is not the primary limiting factor to processes of primary productivity. Levels of nitrogen nutrients such as ammonia and nitrate suggest that eutrophication problems could exist at some locations in Choctawhatchee Bay with an influx of soluble phosphates. Water column organic nitrogen, which is

Table 7-12: Significant correlations (a < 0.10) of water quality parameters with dissolved phosphorous across Choctawhatchee Bay at the surface, mid-depth and bottom.

	Parameter	R-square	PROB > F
Surface	Freshwater Discharge	0.9362	0.0001
	Salinity	-0.7439	0.0136
Mid-depth	Ammonia	-0.5726	0.0837
Bottom	Salinity	0.5503	0.0993

not utilized in primary productivity, seems to have reached an equilibrium state with organic nitrogen compounds resident in the sediments.

Kjedahls nitrogen in the water column in Choctawhatchee Bay averages .332 mg/l with .284 mg/l, .318 mg/l and .393 mg/l at the surface, mid-depth and bottom respectively (Table 7-13). Highest concentrations in the Bay are found seasonally in Garniers Bayou in the western end of the Bay indicating a potential source of organic nitrogen. The highest input of kjedahls nitrogen occurs during winter months from eastern bayous and the Choctawhatchee River. Exceptionally high inputs are noted at station 6 in the mouth of LaGrange Bayou. In surface waters the kjedahls nitrogen dropped and remained low throughout the spring and summer except at station 5 and station 24 located in East Pass. High concentrations of kjedahls nitrogen throughout the year at East Pass are indicative of either high exchange rates with benthic waters of organic nitrogen or an organic nitrogen source from the Gulf of Mexico. The latter is unlikely with the pristine nature of the waters in the Gulf of Mexico off the west coast of Florida. The high concentrations of kjedahls nitrogen in the sediments are indicative of an equilibrium state in which dissolved organics are exchanged between the water column and sediments. Throughout the central stations from north of Hogton Bayou across to station 27, kjedahl nitrogen concentrations were significantly higher than in surrounding stations at mid-depth and benthic waters. This was also true for surface samples during the warmer months. The high concentrations are thought to be due to benthic nitrogen cycles. Nitrogen nutrients are transformed into organic nitrogen through productivity. These living organics are released to the water column through cellular and organismic excretions and death. Large numbers of the biotic community will settle to the benthos where they are recycled to nutrient nitrogen and released back into the water column to begin the cycle again. Excepting seasonal highs in Garnier and Rocky Bayou, the western and northern bayous have lower concentrations than in the central Bay. At mid-depths the eastern reaches of Choctawhatchee Bay had zero concentrations during warmer months showing that mainbay concentrations are due strictly to biotic cycles and remineralization. Remineralization is the release of nutrient nitrogen to the water column.

Ammonia is the principle source of nitrogen nutrient to primary productivity (Nixon, 1981). Within an estuary, nitrogen is cycled through the primary producers emerging as dissolved and particulate organic nitrogen which then can be hydrolysed back through both biotic and physical processes to ammonia. The average ammonia concentration in Choctawhatchee Bay is .0722 mg/l with .039 mg/l, .061 mg/l and .117 mg/l at the surface, mid-depth and bottom respectively (Table 7-13). The lowest ammonia concentrations are found in East Pass (Station 24) and at the mouth of Santa Rosa Sound (Station 28). This indicates that there is little net output of ammonia from Choctawhatchee Bay to the Gulf of Mexico through tidal outflow. The most constant concentrations of ammonia, temporally, are those found at stations near the mouth of the Choctawhatchee River with slight decreases occurring in the summer (Figures 7-22, 7-23). Highest ammonia concentrations occur in the mouths of peripheral bayous and at station 13, particularly at mid-depth. Seasonally ammonia concentrations are significantly lower in the warmer months corresponding to the months when productivity should be higher (Figure 7-24). At benthic stations the total ammonia is considerably higher as evidenced by the baywide means (Table 7-13). High benthic concentrations are due to remineralization in the sediments. This causes concentrations of ammonia to

Table 7-13: Annual means of water quality parameters including ammonia, nitrate and kjedahl nitrogen for Choctawhatchee Bay and for each sampling depth during 1975.

	Ammonia (mg/1)	Nitrate (mg/1)	Kjedahls Nitrogen (mg/1)
Overall Means	.072	.077	.332
Surface Depth Means	.040	.065	.294
Mid-Depth Means	.061	.071	.318
Bottom Depth Means	.117	.094	.393
Station 1	.087	.110	.269
2	.080	.104	.311
3	.060	.103	.313
4	.049	.110	.387
5	.064	.097	.274
6	.095	.163	.348
7	.079	.095	.282
8	.101	.078	.378
9	.079	.087	.247
10	.064	.075	.206
11	.041	.069	.232
12	.076	.082	.278
13	.116	.084	.353
14	.067	.057	.260
15	.079	.074	.522
16	.053	.062	.367
17	.083	.093	.376
18	.072	.074	.374
19	.085	.072	.298
20	.077	.068	.358
21	.082	.081	.335
22	.081	.087	.336
23	.058	.054	.387
24	.042	.032	.343
25	.066	.050	.329
26	.059	.047	.323
27	.077	.048	.333
28	.031	.039	.297
29	.078	.041	.419
30	.073	.046	.266
31	.083	.064	.467

Figure 7-22: Ammonia concentration (mg/l-N) at Station Three in Choctawhatchee Bay during the year 1976.

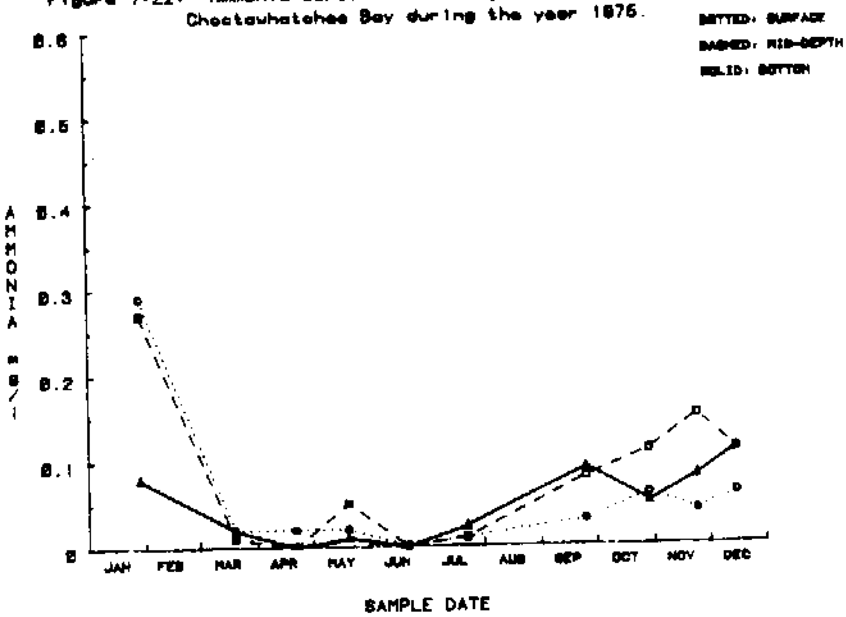
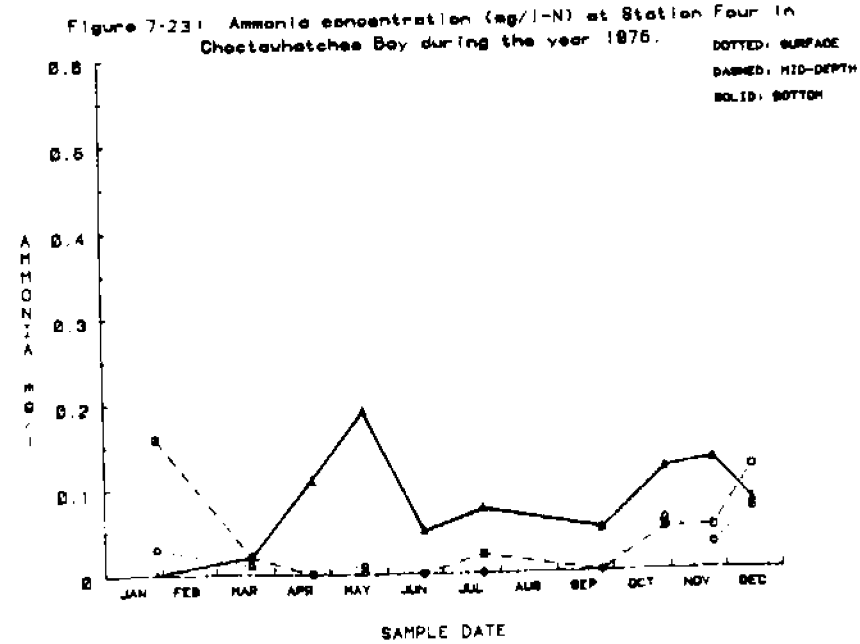


Figure 7-23: Ammonia concentration (mg/l-N) at Station Four in Choctawhatchee Bay during the year 1976.



increase at mid-depth stations where mixing is strong such as at bayou mouths and some central bay stations (Figures 7-24 through 7-26). Highest concentrations of ammonia on the bottom occurred in the October to November period and to a lesser degree in April and May (Figure 7-28). Generally, the ammonia concentration is Choctawhatchee Bay was stable throughout the winter with slight increases in the spring. This was followed by lowest ammonia concentrations in summer months increasing in the late fall. Stability of this cycle is most evident in surface stations with benthic stations showing the highest variability.

Nitrate-nitrite nitrogens are used secondarily to ammonia and urea in primary productivity. Previous studies have suggested nitrogen enrichment problems in the western bayous; however, samples in this study from the mouths of these bayous suggest no problems are evident. The baywide average is .077 mg/l with .065 mg/l, .071 mg/l and .093 mg/l at the surface, mid-depth and bottom, respectively (Table 7-13). Station means suggest higher nitrate-nitrite concentrations in the eastern end of Choctawhatchee Bay, decreasing towards the west. Lowest concentrations are at East Pass (Station 24), indicating evidence of negligible nitrate-nitrite loss to tidal flux, and slow flushing rates of nitrogen in the Bay. High nitrate-nitrite concentrations in the east are due to freshwater discharge with a potential problem source at LaGrange Bayou (Station 6). In mid-depths, both freshwater input and mixing affect nitrate-nitrite concentrations. Western bayous show evidence of cultural nitrate input into mid-depth and benthic waters. Strong mixing of surface and bottom water at stations 17, 18, 19, 20, 21, 22 and 23 is evident since mid-depth temporal trends of nitrate-nitrite follow similar trends on the bottom (Figures 7-29 and 7-30). Other stations in the Bay show this

Figure 7-24. Ammonia concentration (mg/l-N) at Station Seventeen in Choctawhatchee Bay during the year 1975.

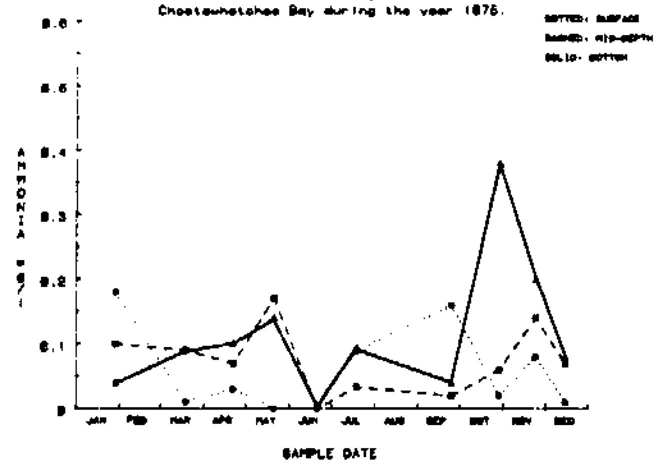


Figure 7-25. Ammonia concentration (mg/l-N) at Station Twenty in Choctawhatchee Bay during the year 1975.

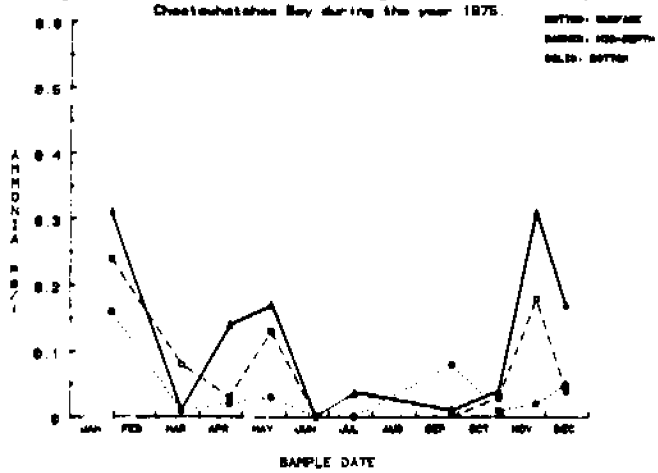


Figure 7-26. Ammonia concentration (mg/l-N) at Station Twenty-one in Choctawhatchee Bay during the year 1975.

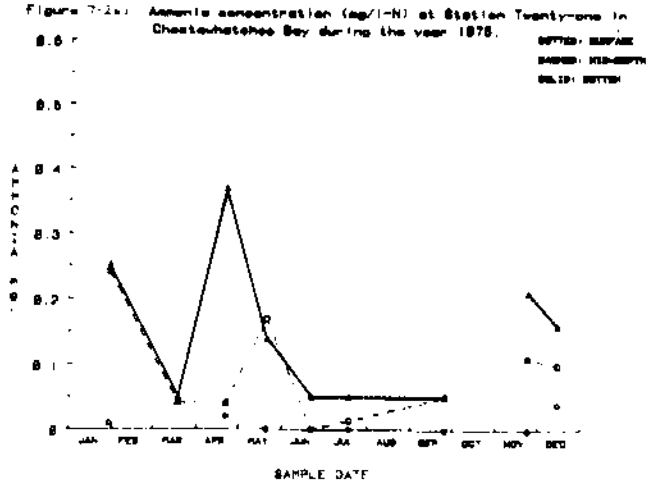


Figure 7-27: Annual Trend of Ammonia for
Choctawhatchee Bay during the year 1975.

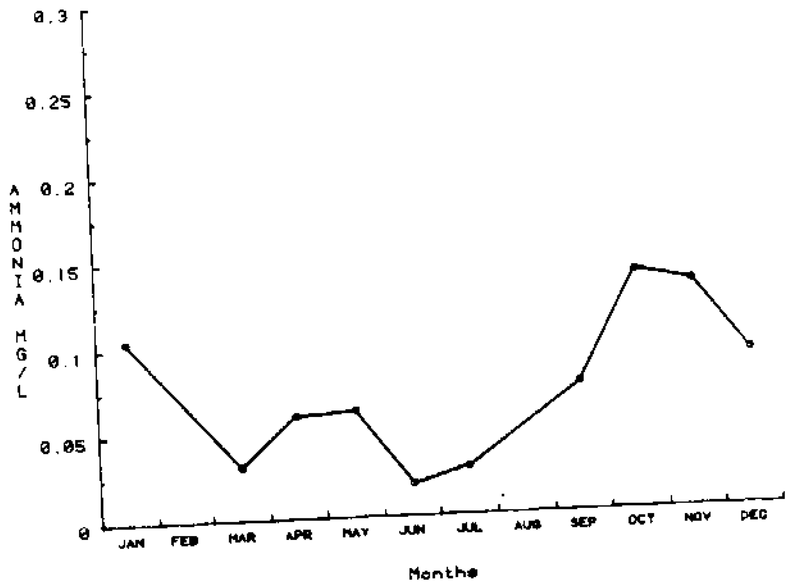


Figure 7-28: Annual Trend of Ammonia in Bottom Waters for
Choctawhatchee Bay during the year 1975.

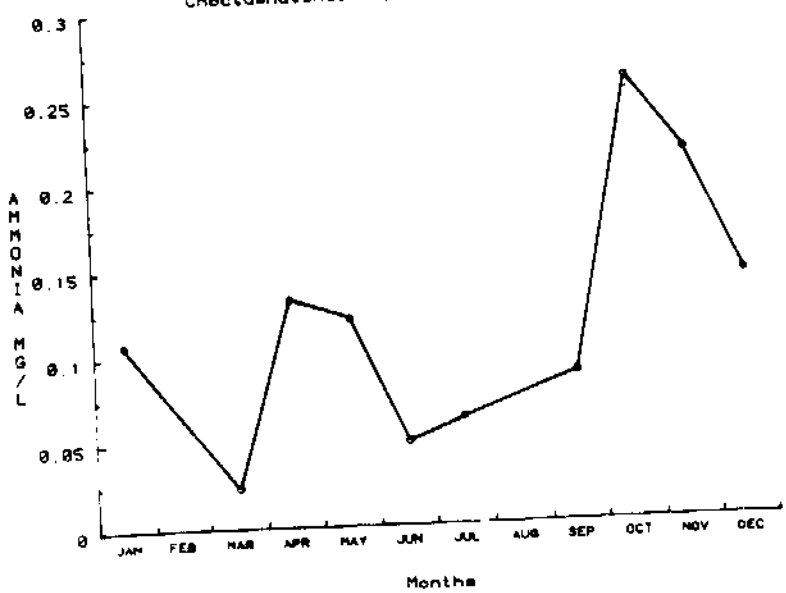


Figure 7-29: Nitrate-nitrite (mg/l-N) at Station Seventeen in Choctawhatchee Bay during the year 1975.

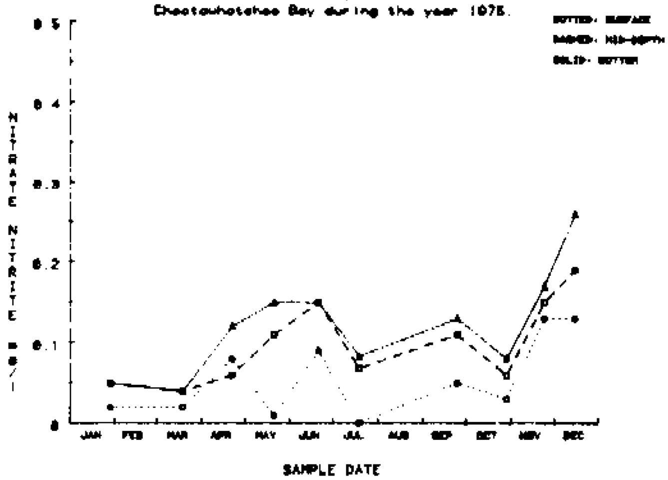


Figure 7-30: Nitrate-nitrite (mg/l-N) at Station Twenty-two in Choctawhatchee Bay during the year 1975.

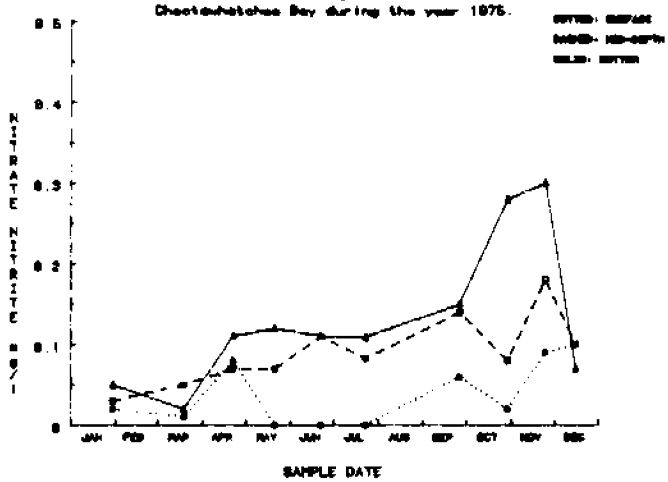
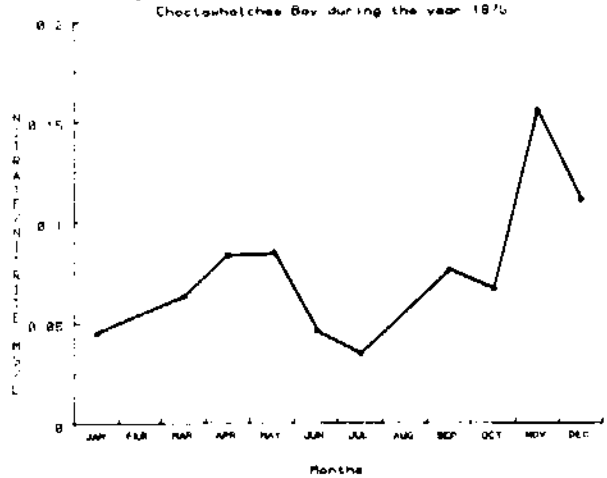


Figure 7-31: Annual Trend of Nitrate-Nitrite for Choctawhatchee Bay during the year 1975



affect seasonally during periods of strong mixing (Example: Hurricane Eloise). Seasonally, the nitrate-nitrite concentration in the Bay is moderate in the late winter, increasing in the spring, decreasing to annual lows in the summer with high productivity and then increasing into late fall and early winter with high inflow rates (Figure 7-31). The western bayous did not show nearly as strong an increase in the fall as did the eastern stations. Benthic stations showed nitratenitrite concentrations which were much more variable and higher in concentration than that of surface water. Primary sources of nitrate-nitrite to benthic waters were probably through nutrifying bacteria. Summer lows were a result of low oxygen in those deeper water stations.

In the benthic waters, ammonia and nitrate-nitrite concentrations are significantly correlated (Table 7-14). This indicates that remineralization rates of both from the sediments are roughly equivalent. In addition, both are inversely correlated with temperature in surface waters, and also at mid-depth for ammonia (Tables 7-14 and 7-15). This significant correlation with temperature holds across most of the stations in the Bay and is augmented by inverse correlations with chlorophylls and correlations with dissolved oxygen (Appendix E), showing a relationship of nutrients with primary production, and also with increasing oxygen concentrations. There is a lag effect of nutrient mixing through increased winds and currents and primary production resulting in the inverse relation with chlorophyll. Strangely, there is an inverse correlation between dissolved phosphate and nitrate-nitrite in mid-depth waters. Organic nitrogen correlates with dissolved oxygen at six of the thirty-one stations sampled and ammonia at some of the main bay stations (Appendix E).

Table 7-14: Significant correlations (a < 0.10) between ammonia and water quality parameters across Choctawhatchee Bay at the surface, mid-depth and bottom.

	Parameter	R-square	Prob > F
Surface	Temperature	-0.6376	0.0473
Mid-depth	Temperature	-0.7406	0.0143
	Dissolved Phosphorous	-0.5726	0.0837
Bottom	Nitrate-Nitrite	0.7762	0.0081

Table 7-15: Significnt correlations (a < 0.10) between nitrate-nitrite and water quality parameters across Choctawhatchee Bay at the surface, mid-depth and bottom.

	Parameter	R-square	Prob > F
Surface	Temperature	-0.7458	0.0133
	Dissolved Oxygen	0.6160	0.0579
Mid-depth			
Bottom	Ammonia	0.7762	0.0081

Carbon

The Baywide average in Choctawhatchee Bay for total carbon was 43.85 mg/l with 43.27 mg/l in surface waters, 41.285 mg/l at mid-depths, and 47.022 mg/l on the bottom (Table 7-10). The high concentrations are the result of large fluvial inputs from Choctawhatchee River as the concentrations at eastern Bay stations are much higher than toward the west. Stations 9, 13 and 14 has the highest average total carbon concentrations along with station 20 near the mouth of Rocky Bayou. One would expect the surface water, total carbon concentration to be slightly lower than mid-depth total concentrations. However, the surface total carbon concentrations are influenced by high concentrations of total organic carbon relative to the mid-depth and bottom total organic carbon concentrations. The Baywide average total organic carbon concentration was 29.09 mg/l with 32.457 mg/l, 27.362 mg/l and 27.474 mg/l at the surface, mid-depth and bottom, respectively (Table 7-10). It might be noted that station 20, near the mouth of Rocky Bayou, and stations 9, 13 and 14 had the highest total organic concentrations which would influence total carbon concentrations. Total carbon concentrations were greatest in bottom waters. This high concentration is influenced by the lack of productivity in benthic waters, as well as increased heterotrophic activity in the sediments releasing carbon dioxide to the water column. The higher total organic carbon concentrations in the surface water are the result of both fluvial loading of organics and increased productivity in surface waters. Rocky Bayou (Station 20) might be expected to have potential eutrophication problems since total organic carbon concentrations there exceeded concentrations throughout the western Bay, particularly in July. In benthic waters both total carbon and total organic concentrations were high throughout the year in Jolly Bay, Alagua Bayou and Horseshoe Bayou.

Total concentrations were highest in the eastern Bay in the spring and summer (Figure 7-32). In September total carbon was noticeably higher at western stations, possibly due to the disturbances created by Hurricane Eloise. The lowest annual concentrations of total carbon throughout the Bay was in October. Total organic carbon was highest in the spring in the eastern Bay. This probably is the result of increased fluvial discharge rates. Toward middle summer the central mainbay exhibited the highest total organic carbon concentrations.

Throughout the Bay total carbon and total organic carbon were statistically significantly correlated (Appendix E). This is expected due to the relationship of carbon dioxide to the production of organic carbon by phytoplankton through productivity. The relationship does not exist at mid-depths where heterotrophic activity utilized organic carbon and releases carbon dioxide (Table 7-16). The significant relation between total organic carbon and total carbon on the bottom is unexplained. Flow is significantly correlated with total organic carbon at stations 18, 20, 22, 23, 24, 26, 27, 29 and 30 (Appendix O). At these stations, western municipal discharge influences the carbon cycle in the Bay.

Total and Fecal Coliform Bacteria

Both total and fecal coliform bacteria in Choctawhatchee Bay in 1975 were higher in surface waters than in bottom waters (Table 7-17). This is attributed to the association of the bacteria with cultural sources and freshwater discharge. In benthic waters the greatest concentration of fecal and

Table 7-16: Significant correlations (a < 0.10) between total carbon and total organic carbon across Choctawhatchee Bay at the Surface, mid-depth and bottom.

	R-square	Prob < F
Surface	0.9967	0.0001
Mid-depth	-	-
Bottom	0.9945	0.0001

Figure 7-32. Annual Trend of Total Carbon for Choctawhatchee Bay during the year 1975.

Figure 7-33. Annual Trend of Total Organic Carbon for Choctawhatchee Bay during the year 1975.

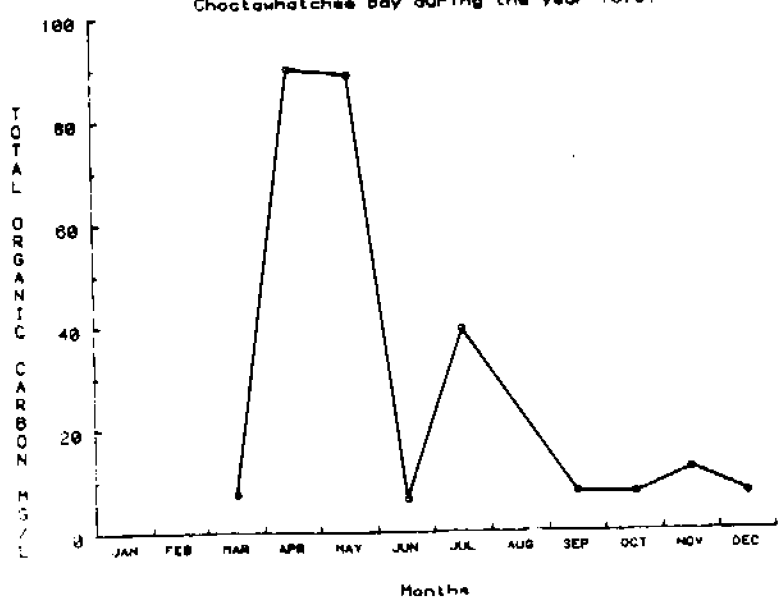


Table 7-17: Annual Means of Total and Fecal Coliform Bacteria for Choctawhatchee Bay and for each sampling depth during 1975.

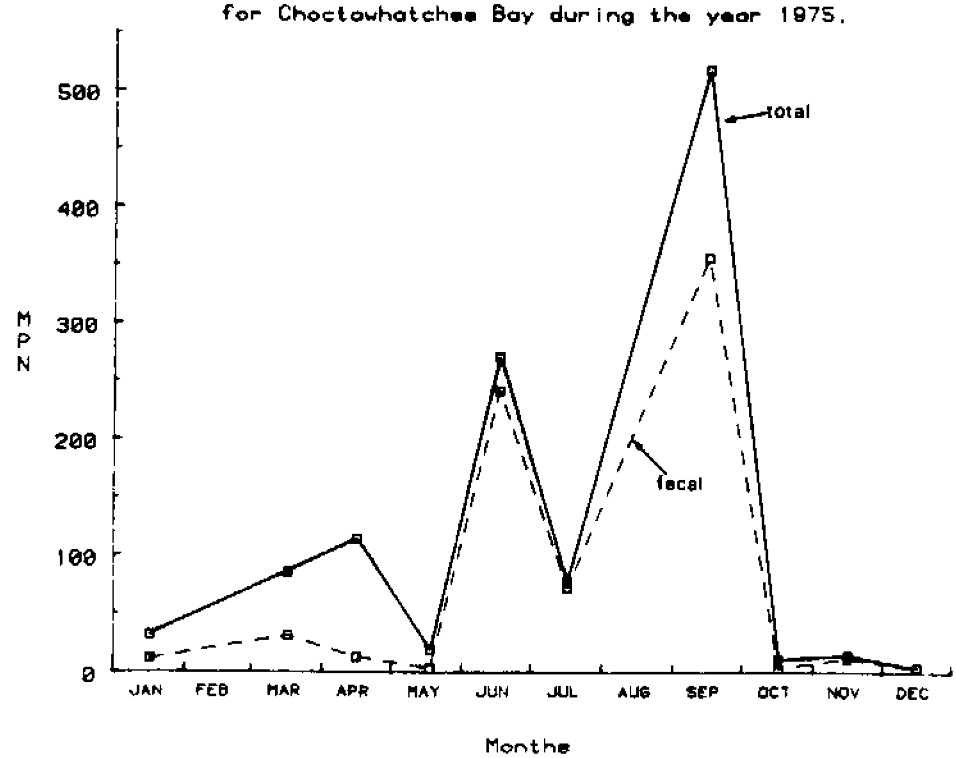
	Total Coliforms (MPN)	Fecal Coliforms (MPN)
Overall Mean	122.427	80.114
Surface Mean	152.914	104.688
Bottom Mean	91.609	55.272
Station 2	228.842	129.684
5	234.474	246.632
12	85.650	50.000
15	93.300	89.000
18	25.050	19.300
20	151.800	71.450
21	46.278	29.222
25	34.667	16.667
28	219.250	34.125
29	103.833	97.444

total coliforms were in the east where freshwater flow dominates the water column much of the year. Rocky Bayou (Station 10) and Garnier Bayou (Station 25), as well as the eastern Bay, showed the highest surface concentrations of fecal coliform bacteria; however, the most signficant source in surface waters of total coliform bacteria to the Bay appears to be Santa Rosa Sound (Station 28).

Seasonally both total and fecal coliform bacteria occurred in the highest concentrations during June and September (Figure 7-34). The large numbers in September are the result of disturbances created by Hurricane Eloise with high concentrations resulting from both seasonal temperatures and climatological effects.

In bottom waters the total coliform bacteria are statistically significantly correlated with temperature at stations 18, 28 and 29 and with total organic carbon at stations 20, 21 and 28 (Table 7-2). Both temperature and total orgnaic carbon are important to the heterotrophic activity of coliform bacteria. Fecal coliform bacteria in bottom waters show significant correlations with temperature at stations 18, 21, and 29 and with total organic carbon at stations 21 and 28. In surface waters total coliform bacteria are correlated with temperature at stations 18, 21 and 29 (Table 7-3).

Figure 7-34: Annual Trend of Total and Fecal Coliform Bacteria for Choctawhatchee Bay during the year 1975.



SEDIMENTS

Sediment Characterization

In Choctawhatchee Bay the majority of the bottom is composed of fine particle sediments, clays and silts, all of which are less than 50 microns in diameter. Choctawhatchee Bay is fringed with fine to medium grain size sand. This sand shelf extends from the mean low water mark to approximately the six to eight foot contour, where the bottom drops sharply into a transition zone. All stations in the fringing shelf, or near the shelf, including stations 3, 8, 11, 14, 16, 26, and 28 are relatively clean sand low in particulates (Figure 7-35).

Goldsmith, 1966, reports that clay entering the Bay from Choctawhatchee River discharge, tends to floculate and settle out of suspension when the freshwater encounters the sharp salinity gradients in the Bay. As river water flows westward in the Bay, the first area for clay floculation is north of Hogtown Bayou near station 12 (Figure 7-36). Textural data for Choctawhatchee Bay do not show any pure clay deposits; however, the highest percentages of clay in benthic sediments occur near stations 10 and 12 above Hogtown Bayou and between stations 25 and 27 northwest of East Pass. The paucity of shell material in sediment samples may be explained by the pH range along the bottom of Choctawhatchee Bay. Goldsmith, 1966, reports that pH values lower than 7.8 would cause the calcium carbonate composing invertebrate shells and tests to

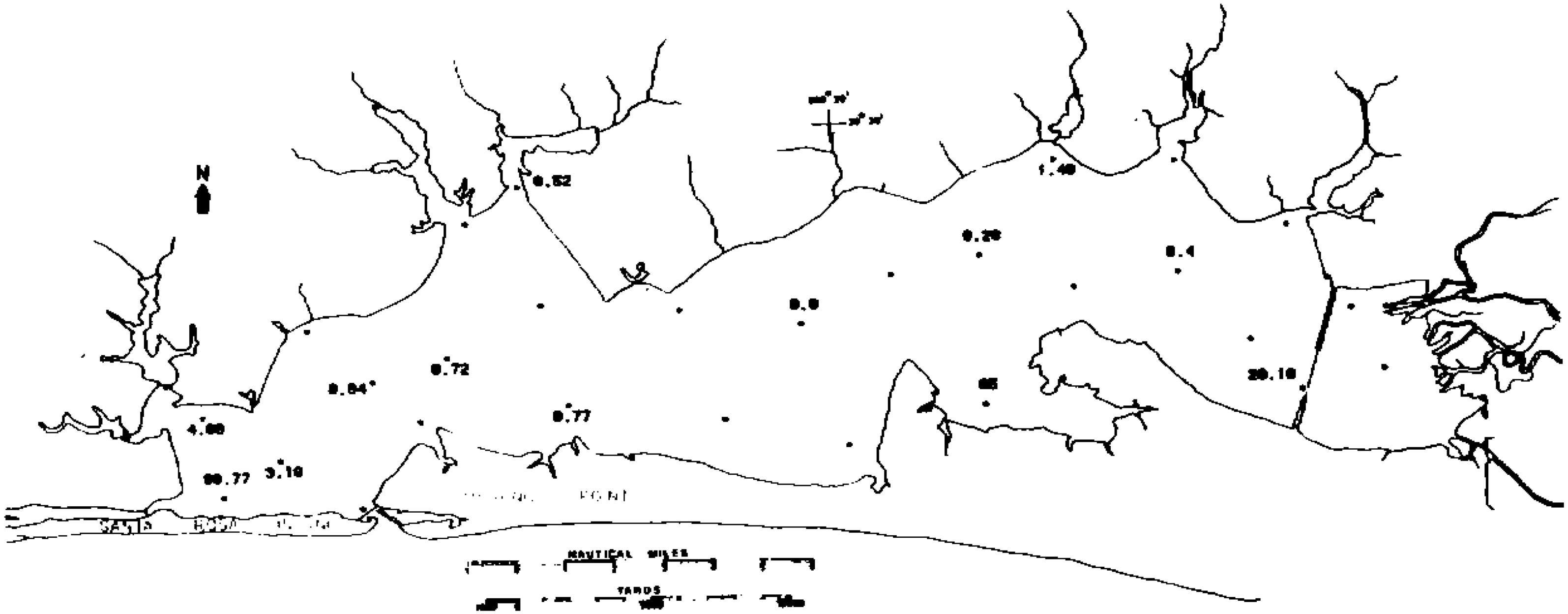


Figure 7-35: The percent sand in the sediments in Choctawhatchee Bay, November 25, 1975.

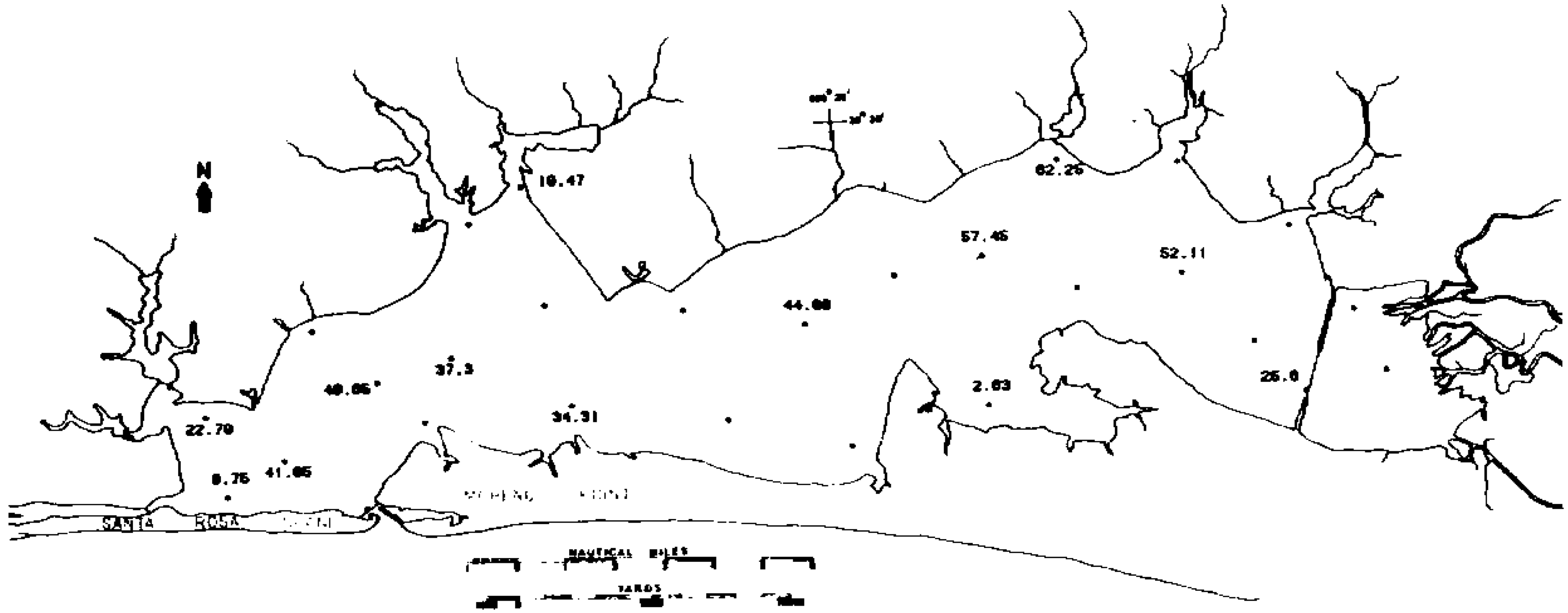


Figure 7-36: The percent of clay in the sediments in Choctawhatchee Bay, November 25, 1975.

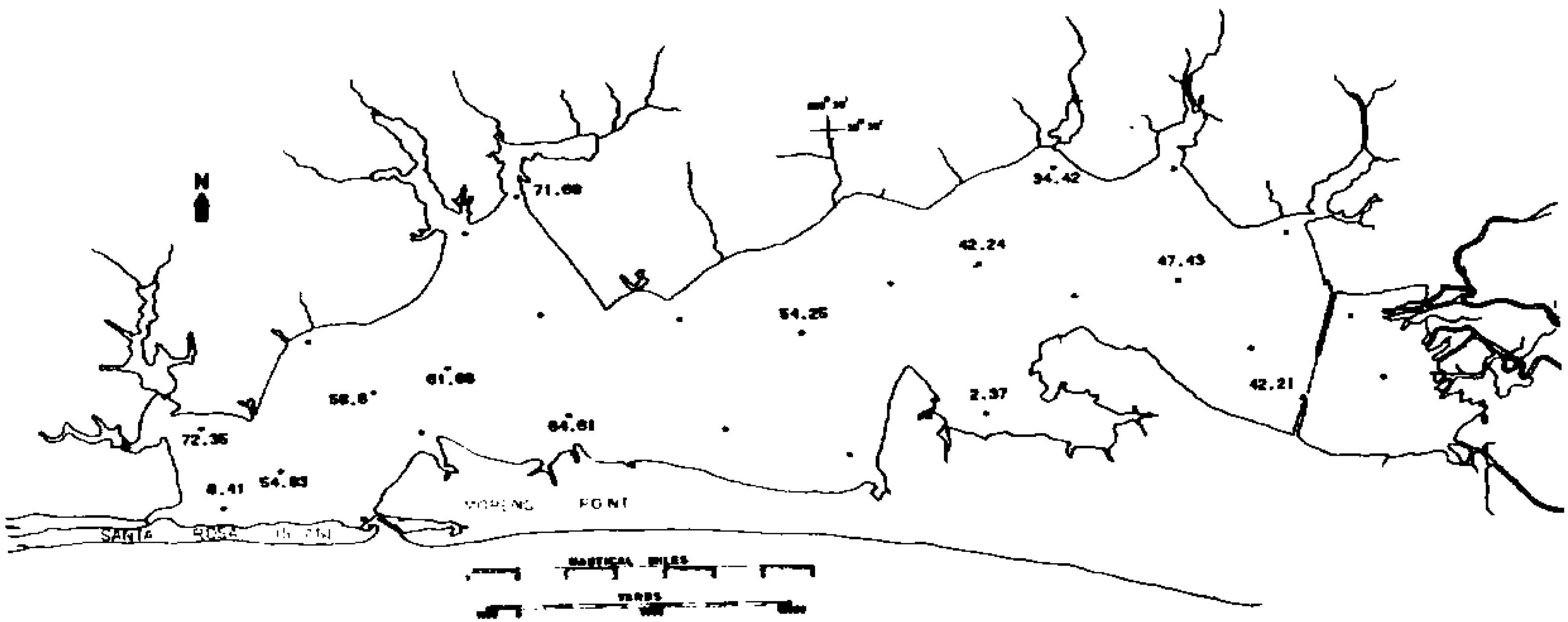


Figure 7-37: The percent of silt in the sediments in Choctawhatchee Bay, November 25, 1975.

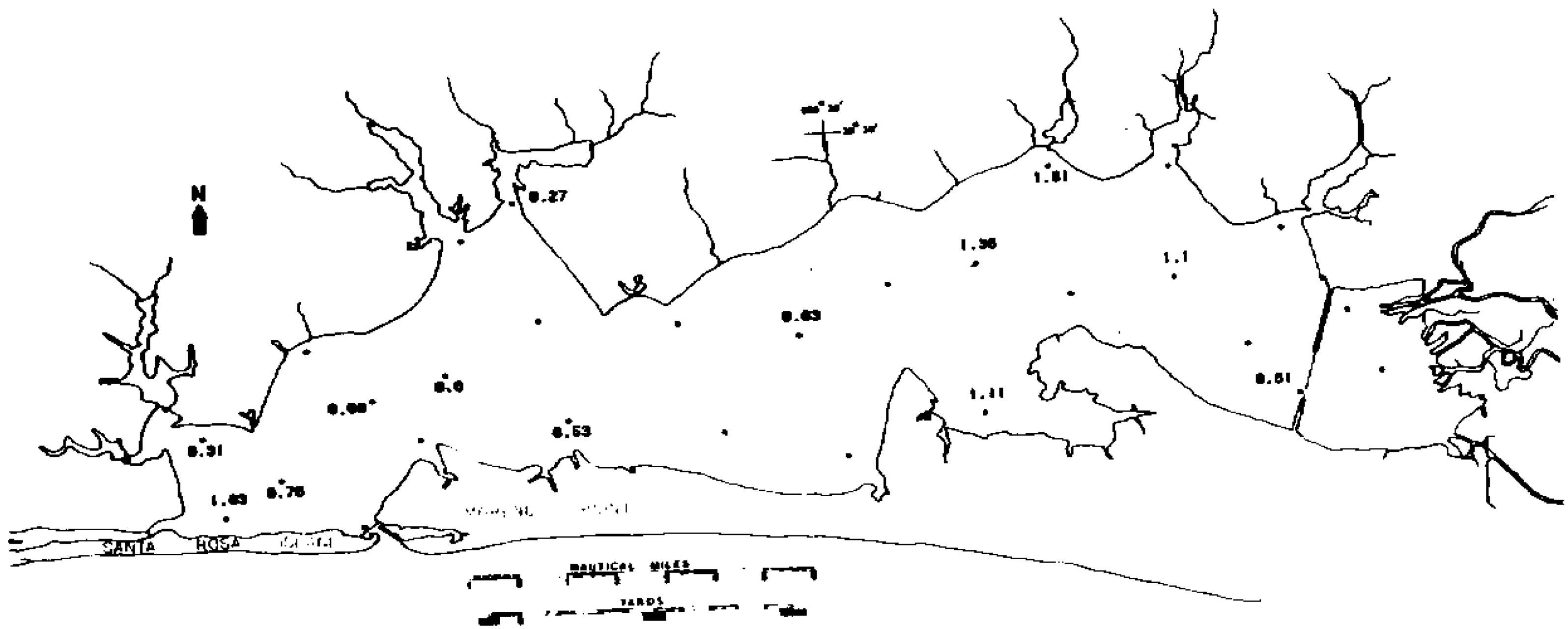


Figure 7-38: The clay/silt ratio in the sediment in Choctawhatchee Bay, November 25, 1975.

go into solution relatively quickly. Since the mean pH levels in Choctawhatchee Bay are usually lower than 7.8, particularly away from the River, one would expect little shell material in benthic sediment samples. In Choctawhatchee Bay samples, the little shell material present showed evidence of abrasion and decay.

Sediment Chemistry

Generally, any station in Choctawhatchee Bay with less than 5 percent organic composition, is in water shallower than 15 feet (Figure 7-39). Exceptions to this are stations 17 and 23 with well washed sand on the bottom. The high sandy bluffs along the northern shore of central Choctawhatchee Bay probably supply the sand to these stations through erosion. The deeper stations in Choctawhatchee Bay are higher in organic composition, total Kjeldahl nitrogen and total phosphorous (Figures 7-39, 7-40, 7-41). The principal source of these nutrients to the bottom are through settling of sediments and particulate nutrients. The sediment nutrient concentrations are highly important in the nutrient cycles of the Bay through remineralization. Nutrient concentrations and percent organics are much higher in Choctawhatchee Bay than in other Northwest Florida estuaries (U.S. Environmental Protection Agency, 195). As discussed in Chapter 4, this is the result of the bathymetry and hydrography in Choctawhatchee Bay. The percent organics in the sediments across the Bay is significantly correlated with Kjeldahls nitrogen. This indicates that much of the nitrogen nutrients remain bound in the sediments with the organics while total phosphorous concentrations in the sediments are under other constraints.

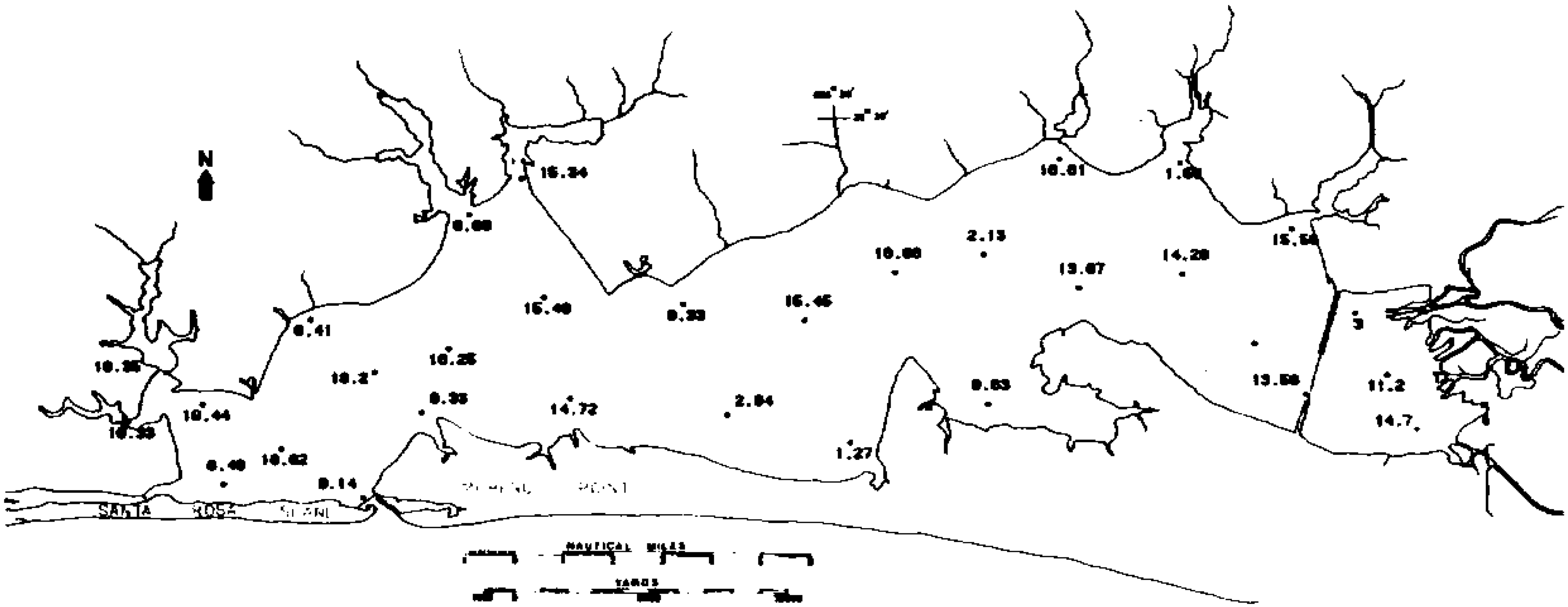


Figure 7-31: The percent organics in the sediments in Choctawhatchee Bay, February 11, 1976.

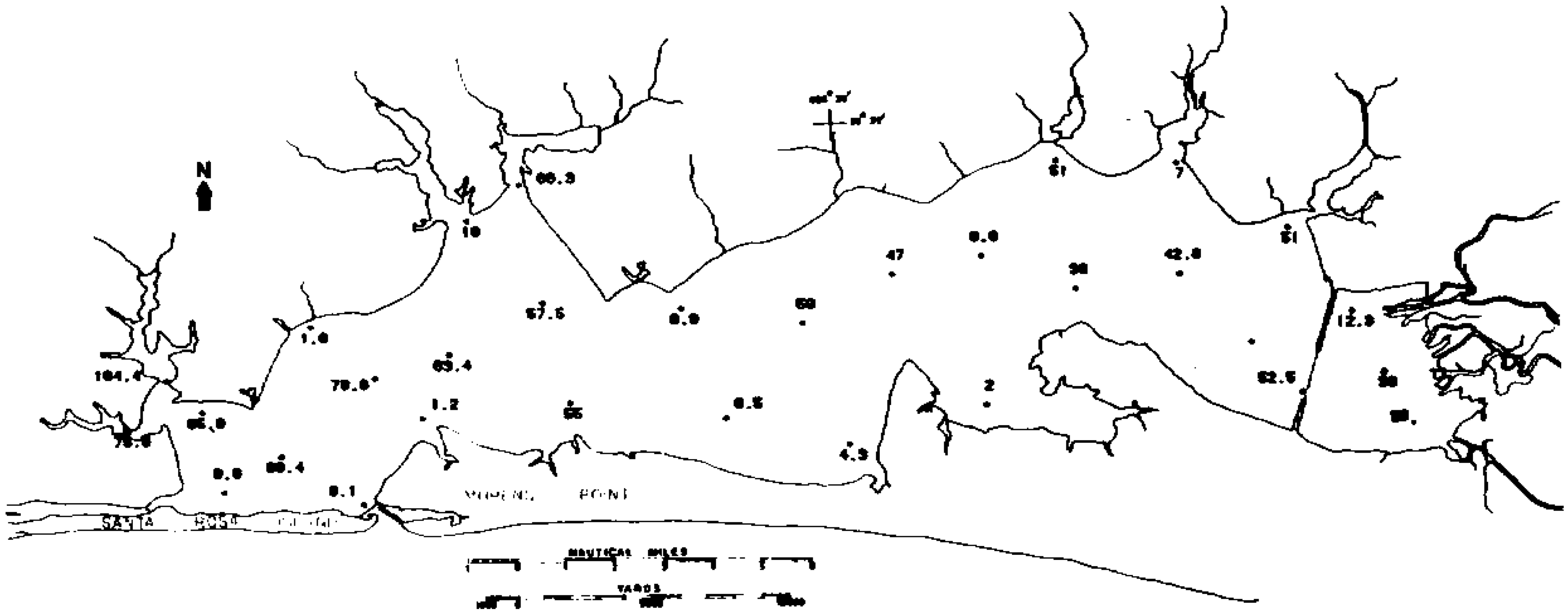


Figure 7-40: Total Kjeldahls nitrogen in the sediment in Choctawhatchee Bay, November 24, 1975.

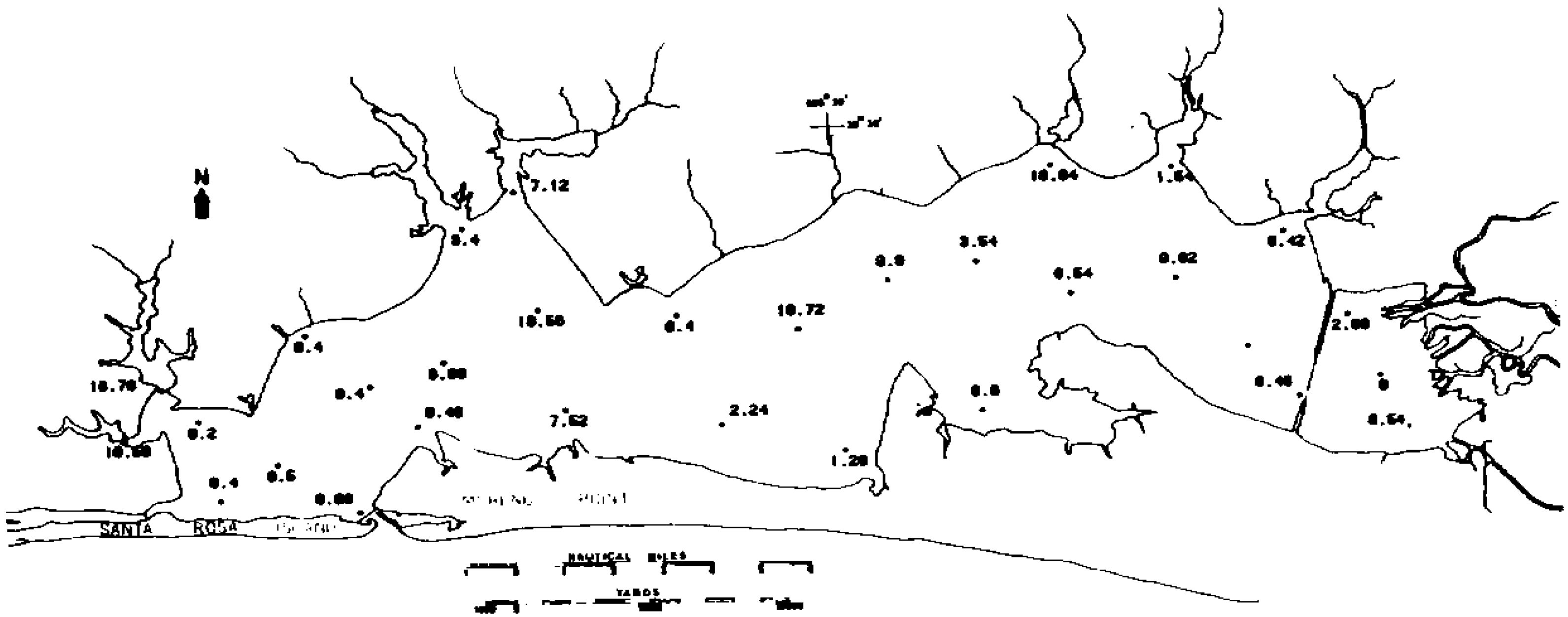


Figure 7-41: Total phosphorous in the sediment in Choctawhatchee Bay, November 25, 1975.

BIOLOGICAL COMPONENTS

Phytoplankton

Fluctuation of phytoplankton numbers and biomass in estuaries is regulated by many parameters. In Florida west coast estuaries salinity, temperature, nutrients, light, trace metals, grazing, external metabolites, currents, river discharge rates, and biological rhythms are all suggested to influence phytoplankton populations (Steidinger, 1973). For this reason, both spatial and seasonal variability of phytoplankton can be expected. In Choctawhatchee Bay the system is dominated by freshwater inflow, thus phytoplankton trends in the Bay should also strongly correlate with discharge rates from Choctawhatchee River (Figure 4-16). This may be seen in examination of monthly total chlorophyll baywide averages in Choctawhatchee Bay in 1975 (Figure 7-42). Seasonally the total chlorophyll was highest in April with spring flow and after Hurricane Eloise in September (Figure 7-42). Hurricane Eloise caused a resuspension of total phosphorous in September, significantly altering normal nutrient cycles in the Bay.

The baywide average of total chlorophyll was 0.021 mg/l and was principally composed of chlorophyll C (Table 7-18). This would be expected in an estuarine system dominated by diatoms and dinoflagellates (Prescott, 1968). Chlorophyll A concentrations (.0041 mg/l) in Choctawhatchee Bay were slightly higher than chlorophyll B concentrations (.0039 mg/l) and very close to con-

Figure 7-42: Annual Trend of Total Chlorophyll for Choctawhatchee Bay during the year 1975.

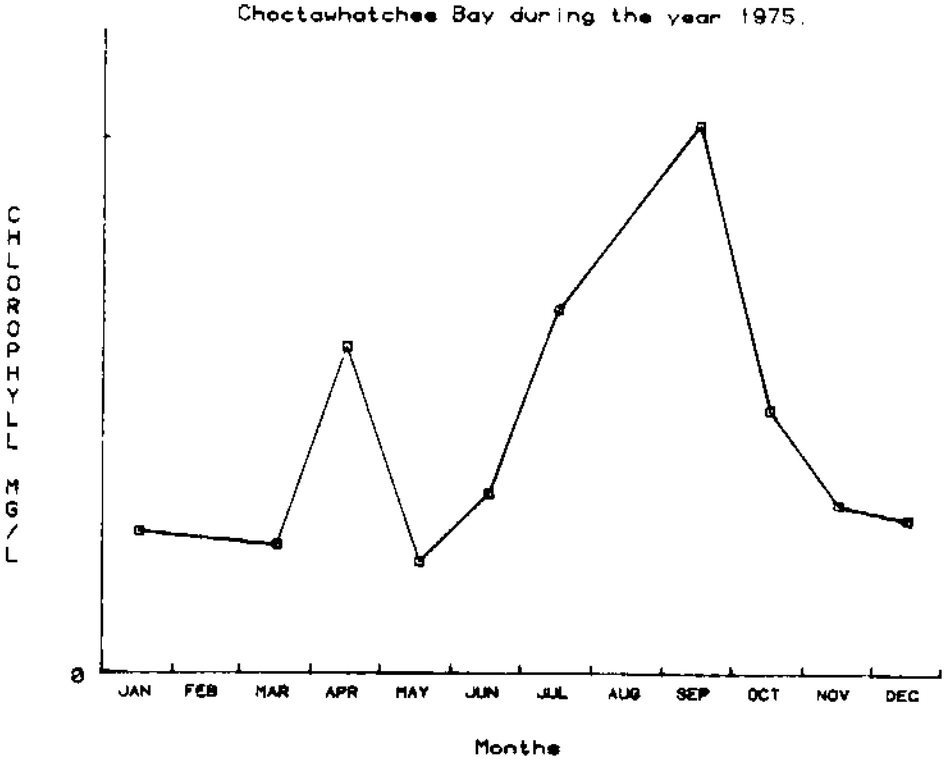


Table 7-18: Annual Means of Total Chlorophyll, Chlorophyll A, Chlorophyll B, and Chlorophyll C for Choctawhatchee Bay and at each Station during 1975.

	Total Chlorophyll	Chlorophyll A	Chlorophyll B	Chlorophyll C
Mainbay-Surface	0.02120	0.00412	0.00397	0.01311
Station 1	0.02514	0.00376	0.00474	0.01664
2	0.02099	0.00341	0.00396	0.01362
3	0.01788	0.00363	0.00326	0.01099
4	0.01486	0.00183	0.00366	0.00937
5	0.01953	0.00337	0.00376	0.01241
6	0.01717	0.00427	0.00323	0.00967
7	0.02726	0.00446	0.00540	0.01740
8	0.01753	0.00379	0.00317	0.01058
9	0.02311	0.00415	0.00427	0.01470
10	0.02068	0.00461	0.00354	0.01252
11	0.02919	0.00579	0.00538	0.01802
12	0.02694	0.00461	0.00564	0.01669
13	0.02379	0.00454	0.00459	0.01468
14	0.01869	0.00352	0.00334	0.01182
15	0.01787	0.00354	0.00330	0.01102
16	0.02096	0.00434	0.00380	0.01281
17	0.02161	0.00367	0.00436	0.01359
18	0.02587	0.00479	0.00487	0.01621
19	0.02444	0.00459	0.00411	0.01544
20	0.02216	0.00486	0.00387	0.01343
21	0.02065	0.00435	0.00369	0.01261
22	0.01913	0.00384	0.00351	0.01178
23	0.02648	0.00495	0.00488	0.01665
24	0.01546	0.00280	0.00289	0.00976
25	0.02024	0.00366	0.00369	0.01289
26	0.01886	0.00423	0.00353	0.01111
27	0.02229	0.00411	0.00426	0.01391
28	0.02017	0.00383	0.00391	0.01243
29	0.01715	0.00400	0.00305	0.01010
30	0.02333	0.00576	0.00410	0.01346
31	0.01845	0.00471	0.00314	0.01060

centrations in the Bay found by the U.S. Environmental Protection Agency, 1975 (.0042 mng/l). Average chlorophyll concentrations in the Bay are lower east of Hogtown Bayou, along the northern shores, than in the central Bay. Stations 7, 9, 12 and 13 along the central axis have higher than average total chlorophyll concentrations while centrally located stations in the western central Bay are consistant with the baywide mean. The lowest concentrations occur in channels and near the mouths of bayous except at station 23 above Joes Bayou and in the mouth of Cinco Bayou at station 30. East Pass (Station 24) and station 4 at the Highway 331 causeway in the east have the two lowest average total chlorophyll concentrations in the Bay (Table 7-18).

As in many estuaries, the micro-flagellates, chlorophytes and blue green algae were numerically dominant in Choctawhatchee Bay except during June in the central Bay when diatoms occurred in greater numbers. In terms of biomass, the diatoms and dinoflagellates dominated in the Bay during various time periods and at various stations (Appendix G). Generally, the diatoms were more predominant from early spring through to mid summer, at which time the dinoflagellates began to dominate the phytoplankton population in terms of biomass (Figure 7-44). Toward late fall and early winter the phytoplankton biomass was evenly distributed between dinoflagellates, diatoms and micro algae, including the chlorophyta, micro-flagellates and blue green algae. Seasonally, the phytoplankton biomass was highest in May and June during late spring, and early summer, diatom and dinoflagellate blooms (Figure 7-43). These trends are not followed well in stations near the periphery of the Bay (Appendix G). This may be due to the influence of the minor tributaries and circulation within the bayous around the Bay. Stations 28 and 29 in the western Bay had the greatest phytoplankton biomass in December.

Figure 7-43: Annual Trend of Total Numbers and Total Biomass in Choctawhatchee Bay during the year 1975.

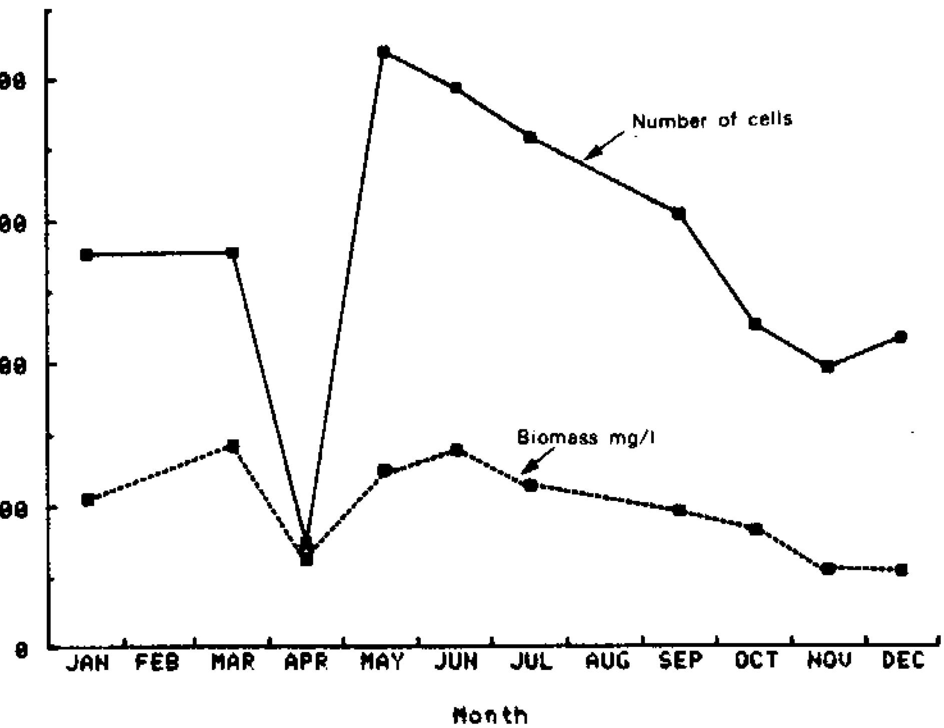
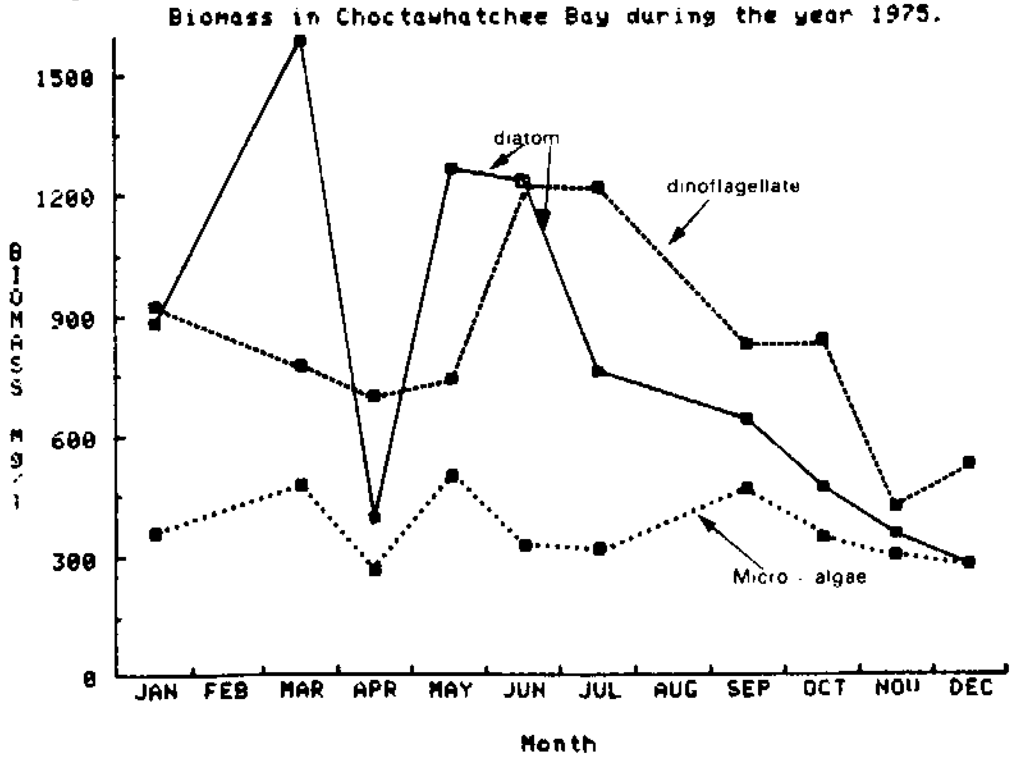


Figure 7-44: Annual Trend of Diatom, Dinoflagellate and Micro-algae Biomass in Choctawhatchee Bay during the year 1975.



Contrary to suggestions made by Steidinger, 1973, concerning estuaries on the Florida western coastline, Choctawhatchee Bay shows a slight increase in phytoplankton cell number and biomass from Choctawhatchee River to Destin Pass (Appendix G). Phytoplankton numbers from stations 2 and 5 increase strongly toward the central Bay and then more gradually into the western Bay. At stations 7 and 21 in the mainbay from March through September, a strong decline in numbers of dinoflagellates is evident while diatoms are increasing slightly. Interestingly, in the fall and winter the mainbay appears to support more diatoms, while dinoflagellates prefer peripheral stations near the bayous. However, this trend is reversed in the same months at stations west of station 25.

In Choctawhatchee Bay the smaller flagellates dominated the samples in terms of cell concentrations. Some of the more important genera include Platymonas sp., Pyramimonas sp., Dunaliella sp., Rhodomanas sp., Cryptomonas sp. and Eutreptia sp. These micro-flagellates were relatively constant throughout the Bay; however, individually, they varied widely in generic composition and numbers across the Bay. Predominate diatoms were Nitzchia sp., Navicula sp., Thalassiosira sp. and Chaetoceros sp. The absence of large numbers of the estuarine diatom Shelotonema costatum is indicative of the high flows occuring through the year 1975. Both Gymnodinium sp. and Exuviella sp. (dinoflagellates) occurred throughout the Bay in significant numbers, while Gonyaulax sp. was present in the central Bay only in late summer and fall. Appendix A lists the genera of phytoplankton collected from Choctawhatchee Bay in 1975.

Icthyoplankton

Estuaries serve as both spawning and nursery grounds for many species of fish. Often the critical phase of the juvenile life cycle of many species of fish is spent in estuarine habitats where both food and shelter are available to the young fish. Although many species of fish spawn offshore, their larvae move into the estuary from January to March and then back out with increasing temperatures from October to November (U.S. Environmental Protection Agency, 1975).

From icthyoplankton samples in Choctawhatchee Bay in 1975, it was determined that anchovies (Anchoa sp.) and silversides (Menidia beryllina) comprise 67.34 and 30.75 of the pelagic fish larvae in Choctawhatchee Bay (Table 7-19). Sheridan and Livingston, 1979, suggest that Anchoa sp. in North Florida estuaries spawns most often in October and November. Results from Choctawhatchee Bay do not confirm these suggestions, as fish eggs were more abundant in July and September and to a lesser degree in May and June (Figure 7-45). The fish eggs were most abundant in the mainbay stations 15, 17 and 25, less abundant at stations 18 and 22, and virtually absent from stations in the eastern Bay (Figure 7-46).

Table 7-20 depicts occurence of the fish larvae at all the stations sampled in Choctawhatchee Bay in 1975. The majority of the fish larvae were caught during May, with others caught in April, June and September (Figure 7-47). Anchoa sp. represented most of the May and June catches while Menidia sp. represented catches from April, May and September. As with fish eggs, the fish larvae are primarily from mainbay stations 18 to 27 except for large numbers of Anchoa sp. larvae at station 12 (Figure 7-48).

Table 7-19: Relative Abundance of the Fish Larvae found in Choctawhatchee Bay in 1975.

	Total Numbers	Percent	
Engraulidae			
Anchoa spp.	1064	67.34	
Atherinidae			
Menidia beryllina	486	30.75	98.09
Gobiidae	10	0.63	
Sciaenidae			
Menticirrhus	8	0.51	
Carangidae			
Oligoplites saurus	5	0.32	
Blenniidae	4	0.25	
Syngnathidae			
Syngnathus floridae	2	0.13	
Syngnathus louisianae	1	0.06	1.91

Figure 7-45: Annual Trend of Fish Eggs Found in Choctawhatchee Bay during the year 1975.

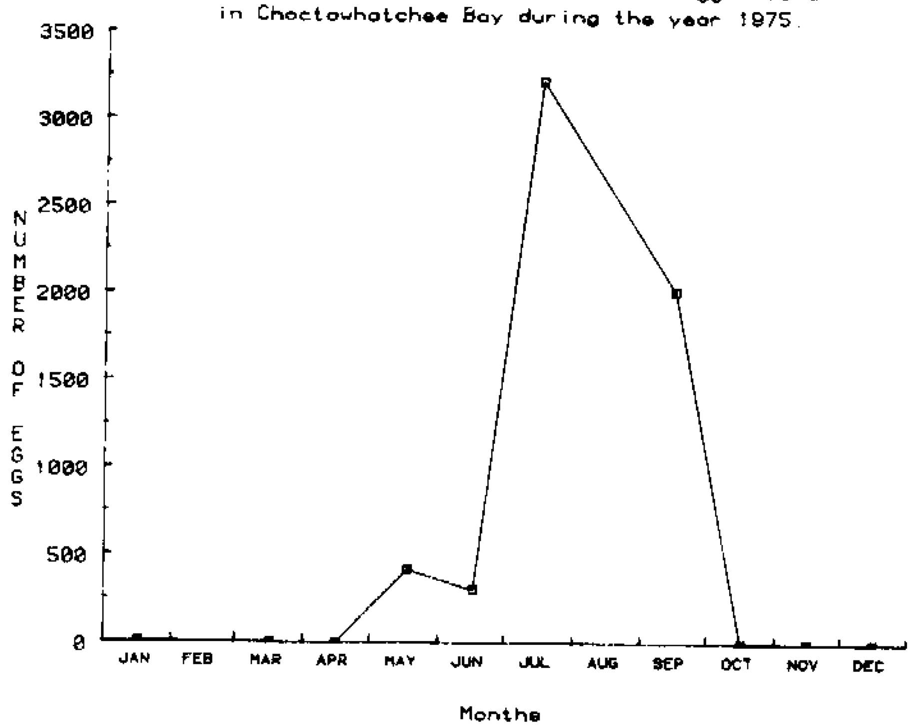


Figure 7-46: Annual Abundance of Fish Eggs from Choctawhatchee Bay Sampling Stations in 1975.

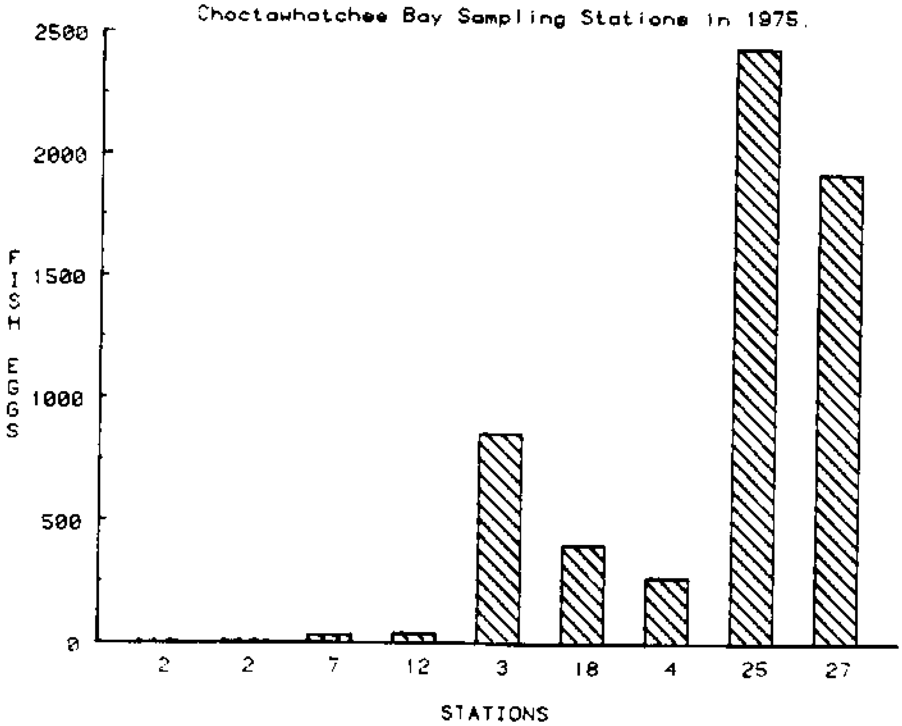


Table 7-20: Species Checklist of Fish Larvae found in Choctawhatchee Bay in 1975.

	Stations								
	2	5	7	12	15	18	22	25	27
Engraulidae (anchovies)									
Anchoa hepsetus		+							
Anchoa mitchilli						+			
Anchoa spp.	+	+	+	+	+	+	+	+	+
Atherinidae (silversides)									
Menidia beryllina	+	+	+	+	+	+	+	+	+
Sciaenidae (pipefishes)									
Syngnathus floridae		+			+				
Syngnathus louisianae							+		
Carangidae (jacks)									
Oligoplites saurus							+	+	
Syngnathidae (drums)									
Menticirrhus spp.			+	+			+	+	+
Blenniidae (blennies)					+	+	+	+	
Gobiidae (gobies)			+			+	+	+	

Figure 7-47: Annual Trends of Fish Larvae, Menidia sp. Larvae, and Anchoa sp. Larvae in Choctawhatchee Bay in 1975.

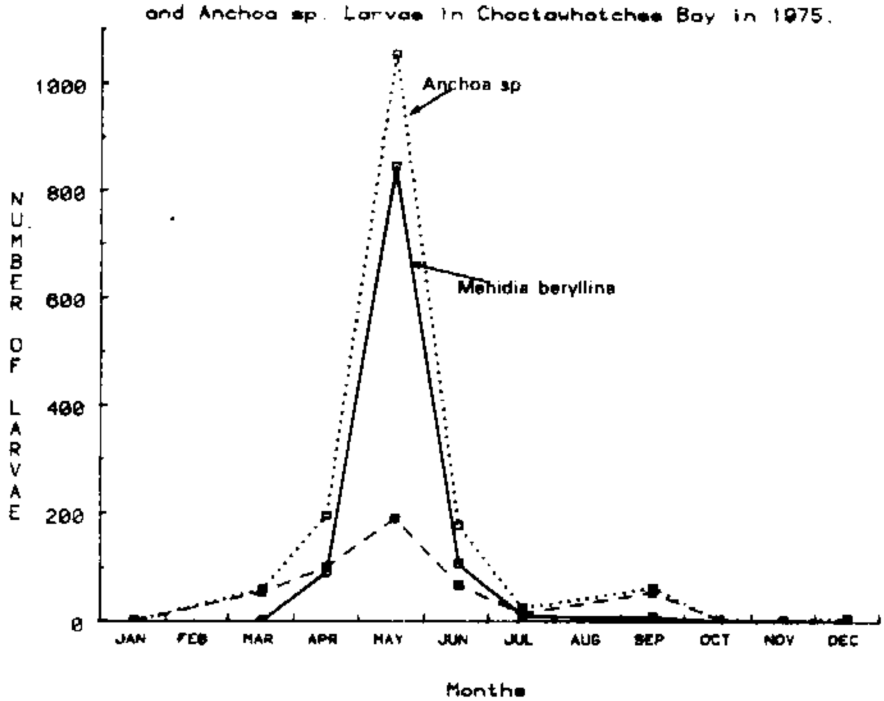
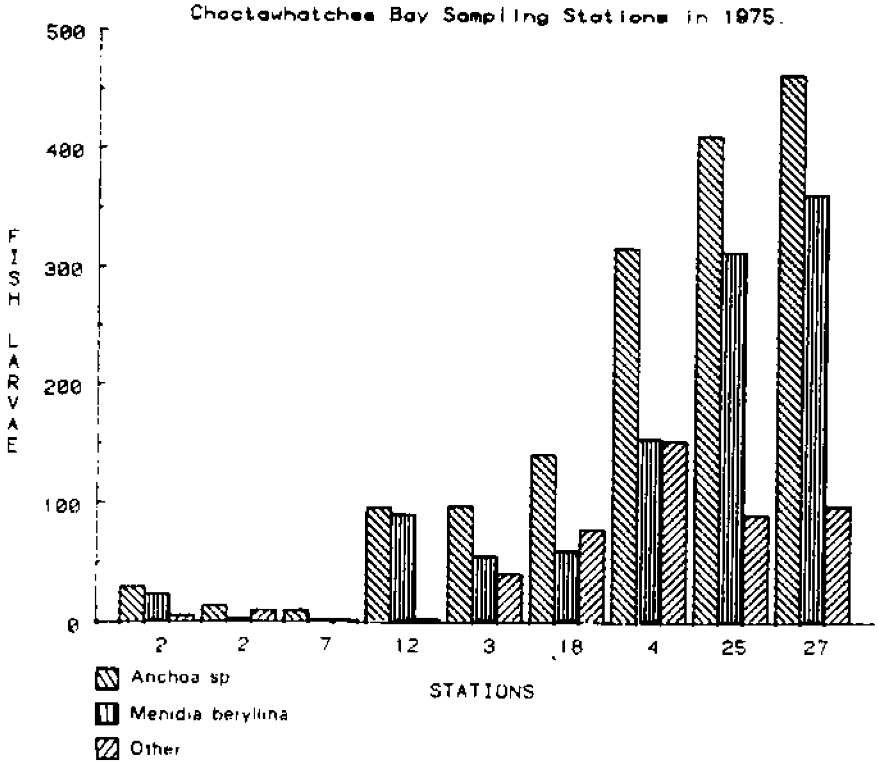


Figure 7-48: Annual Abundance of Fish Larvae from Choctawhatchee Bay Sampling Stations in 1975.



Zooplankton

Northwest Florida estuaries are characterized as having increasingly more diverse zooplankton populations toward the mouth of the estuary where salinity is higher. Zooplankton numbers are also generally higher in the late spring and summer months (Hopkins, 1973). Hopkins, 1966, found seasonal maxima in St. Andrews Bay to occur in June and September, and seasonal minima in February, April and December. In Choctawhatchee Bay, in 1975, spring zooplankton maxima were composed of the calanoid copepod *Acartia tonsa*, harpacticoid copepods, cladocerans, the rotifer, Brachionus sp., veliger larvae, larvaceans and ctenophores. A listing of zooplankton found in Choctawhatchee Bay in 1975 may be found in Apprendix B.

In Choctawhatchee Bay the dominant zooplankter was the calanoid copepod, *Acartia tonsa*. Except at station 2 near the mouth of Choctawhatchee River and in the months of January and October, *Acartia tonsa* accounted for the greatest percentage of the zooplankton samples (Tables 7-21 and 7-22). Other Northwest Florida estuaries, including Escambia Bay to the west and St. Andrews Bay to the east, are also dominated in terms of zooplankton numbers by *Acartia tonsa* (U.S. Environmental Protection Agency, 1975; Hopkins, 1966). Excluding *Acartia tonsa*, in Choctawhatchee Bay in 1975, harpacticoid and calanoid copepods were most common (Tables 7-23 and 7-24). Harpacticoids were most common in the spring and summer, while calanoid copepods, excluding *Acartia tonsa*, were common only in the central and western Bay from December to April. The cyclopoid copepod, Oncaea sp., was common at station 2 and throughout the Bay in December. Copepod nauplii occurred in bloom conditions in both May and

Table 7-21: Annual Average Numbers of the Major Species of Zooplankton collected at each station in Choctawhatchee Bay in the year 1975.

Station	*Oncaea* sp.	*Acartia tonsa*	*Microsetella* sp.	*Brachionaus* sp.	*Oikiopleura* sp.	*Mnemiopsis* sp.
2	2152	22554	120	1289	61	0
5	48200	883243	57	6208	450	50
7	0	484986	0	433	100	217
12	2100	662257	0	3200	400	158
15	4800	1364198	0	12678	700	150
18	1625	527238	0	15083	214	196
22	800	1399480	100	19900	1000	513
25	0	421613	0	39625	1375	375
27	125	397092	0	150491	8042	134

Table 7-22: Monthly Average Numbers of the Major Species of Zooplankton collected at each station in Choctawhatchee Bay in the year 1975.

Month	Species					
	Oncaea sp.	*Acartia tonsa*	Microsetella sp.	Brachionaus sp.	Oikiopleura sp.	Mnemiopsis sp.
Jan	0	167746	191	1437	190	16
Mar	8	709052	0	556	0	292
Apr	0	102552	111	309	0	37
May	167	1964361	0	15167	1333	611
Jun	0	795593	0	137926	1278	259
Jul	1482	468259	0	49802	8580	620
Sep	0	350146	0	0	0	0
Oct	46	489083	9	315	65	0
Nov	0	102523	0	4	0	0
Dec	64370	1623704	0	25556	148	0

Table 7-23: Annual Average Numbers of the Major Groups of Zooplankton collected at each station in Choctawhatchee Bay in the year 1975.

Station	Calanoid Copepods	Harpacticoid Copepods	Cyclopoid Copepods	Cladocerans	Ostracods	Rotifers
	Group					
2	23087	1747	2152	6581	1115	1289
5	884293	8107	48200	1176	121	6208
7	503189	1000	0	26157	429	433
12	671490	4900	2100	800	21	3200
15	1365098	19061	4800	77951	33	12678
18	536117	9583	1625	50521	83	15083
22	1405835	17333	800	48791	617	20300
25	425952	8917	0	89399	1464	39625
27	424545	35741	125	253524	292	150491

Table 7-24: Monthly Average Numbers of the Major Groups of Zooplankton collected at each station in Choctawhatchee Bay in the year 1975.

Month	Group					
	Calanoid Copepods	Harpacticoid Copepods	Cyclopoid Copepods	Cladocerans	Ostracods	Rotifers
Jan	168131	397	0	165857	857	1437
Mar	710532	4373	8	150173	667	556
Apr	102590	1160	0	6145	583	309
May	1967417	36056	167	1528	0	15167
Jun	819407	7982	0	1648	0	137926
Jul	472926	47228	1482	202494	296	50247
Sep	352000	4563	0	292	83	0
Oct	489083	3287	46	2019	741	315
Nov	102523	3489	0	370	1143	4
Dec	1665074	0	64370	37	370	25556

December throughout the Bay.

Hopkins, 1966, suggests that the meroplankton, including invertebrate larvae, veliger larvae and polychaete larvae, comprises twenty percent of the annual zooplankton biomass in St. Andrews Bay. These temporary zooplankton were not as prevelant in Choctawhatchee Bay (Tables 7-15 and 7-26). Crustacean zoea larvae were common only in July. Barnacle nauplii were common only at stations 5, 7, 25 and 27 from December to May. Polychaete larvae were common only in December and molluscan veliger larvae were common from May to July.

The second most numerous zooplankton group in Choctawhatchee Bay, 1975, was the Cladocerans (Tables 7-23 and 7-24). The most common cladoceran was Podon sp., which was more common in the central and western Bay during the mid-winter and early spring (Tables 7-27 and 7-28). The other cladocerans, including Penilla sp., Evadne sp., Alona sp., Chydoris sp., Ceriodophnia sp., and Bosmia sp. were more common in the eastern Bay in January, March, April and October. Ostrocods were common in the spring and fall but were unpredictable spatially.

In many North Florida estuaries, the ctenophores and jellyfish are common in the winter (Hopkins, 1973). However, in Choctawhatchee Bay, these secondary grazers in the plankton were more common from May to June following the seasonal increases of the micro zooplankton in the spring (Table 7-21 and 7-22). Of these macro zooplankton, both Oikiopleura sp. and Mnemiopsis sp. were identified.

Table 7-25: Annual Average Numbers of the Larval Zooplankton collected at each station in Choctawhatchee Bay in the year 1975.

Station	Larval Form					
	Copepod Nauplii	Zoea Larvae	Barncle Nauplii	Polychaete Larvae	Veliger Larvae	Echinoderm Larvae
2	1164	322	18.7	72	61	78
5	11135	0	284	1025	450	0
7	15142	0	131	400	100	0
12	2867	300	452	0	400	0
15	8696	0	111	300	700	0
18	10688	0	0	0	214	63
22	5538	0	370	300	1000	0
25	3423	0	1048	0	1375	0
27	2973	125	3389	42	8042	0

Table 7-26: Monthly Average Numbers of the Larval Zooplankton collected at each station in Choctawhatchee Bay in the year 1975.

Month	Larval Form					
	Copepod Nauplii	Zoea Larvae	Barncle Nauplii	Polychaete Larvae	Veliger Larvae	Echinoderm Larvae
Jan	460	0	182	0	190	0
Mar	5883	0	1121	0	0	0
Apr	3204	0	550	0	0	0
May	15268	333	1700	0	1333	0
Jun	57	37	300	0	1278	37
Jul	2593	321	0	12	8580	12
Sep	625	0	0	250	0	104
Oct	2167	167	0	227	65	0
Nov	4667	0	20	0	0	0
Dec	31574	0	1317	1981	148	0

Table 7-27: Annual Average Numbers of Cladoceran genera collected at each station in Choctawhatchee Bay in the year 1975.

Station	Species							
	Penilla sp.	Evadne sp.	Podon sp.	Scapholeberis sp.	Alona sp.	Chydoris sp.	Ceriodaphnia sp.	Bosmina sp.
2	1042	31	582	760	710	2428	28	1000
5	185	50	86	0	207	324	0	324
7	350	0	25486	0	7	157	0	157
12	14	0	686	100	0	0	0	0
15	300	11700	65340	44	56	256	0	256
18	0	1396	48896	208	21	0	0	0
22	88	0	48604	100	0	0	0	0
25	18	14821	74060	0	0	250	0	250
27	0	184792	68545	0	63	63	0	63

Table 7-28: Monthly Average Numbers of Cladoceran genera collected at each station in Choctawhatchee Bay in the year 1975.

Month	Species							
	Penilla sp.	Evadne sp.	Podon sp.	Scapholeberis sp.	Alona sp.	Chydoris sp.	Ceriodaphnia sp.	Bosmina sp.
Jan	175	63	162048	24	262	2111	0	524
Mar	566	16	148004	48	95	722	0	722
Apr	83	0	3596	373	414	840	0	840
May	667	0	667	0	194	0	0	0
Jun	204	1407	0	37	0	0	0	0
Jul	235	190000	12222	0	37	0	0	0
Sep	0	292	0	0	0	0	0	0
Oct	269	0	167	1167	157	106	46	106
Nov	116	0	0	54	71	64	0	64
Dec	19	19	0	0	0	0	0	0

Benthos

Major abiotic factors which affect the distribution and composition of benthic macro fauna in Choctawhatchee Bay include temperature, salinity, turbidity and substrate type. The most important single factor in estuaries is substrate type (Collard and D'Asaro, 1973). Lauff, 1967, reports that the estuary is an ecotone between the freshwater and marine communities. In an ecotone the gradients should allow for abundant, diverse communities. However, other studies report in estuaries that four-fifths of benthic fauna inhabit hard substrate. Thus, the deep water mud plains in Choctawhatchee Bay are limited not only by water column characteristics as discussed earlier, but also by the nature of the substrate itself. Appendix C lists the species found in 1975, in Choctawhatchee Bay. The species found were quite dissimilar to species listed by Taylor Biological Co., 1978, and Ross and Jones, 1979. Appendix C has only four common genera with Taylor Biological Co., 1978, and 12 genera in common with those in Ross and Jones, 1979. Of the 12 common genera from Ross and Jones, 1979, six were pelecypods.

The three major groups of benthic macro fauna, including gastropods, pelecyods and polychaets were all statistically significantly related to salinity (Table 7-29). This confirms the similarity of Choctawhatchee Bay to other North Florida estuaries where benthic invertebrate abundances increase with increasing salinity. Polychaetes were also significantly correlated to total organic nitrogen and the percent organics in the sediments. This might be expected after considering the feeding habits of polychaetes. Table 7-29 also shows individual significant relationships existing in Choctawhatchee Bay between benthic species and sediment characteristics.

Table 7-29: Significant Correlations of Benthic Macroinvertebrate Numbers with Benthic Sediment Parameters across the Quarterly Choctawhatchee Bay Sampling Stations in 1975.

	Kjedahls Nitrogen	Percent Organics	Total Phosphorous	Benthic Salinity
Gastropods	-	-	-	0.8430**
Acteocina canaliculata	0.8746*	0.7618*	-	0.8378*
Cyclostremiscus pentagonus	-	-	-	0.7695**
Pelecypods	-	-	-	0.7598**
Abra aequalis	-	-	0.9137*	-
Anomalocardia auberiana	-	-	0.7219*	-
Anadara sp. (juvenile)	-	-	-	0.8892*
Mercenaria campechiensis	0.7990*	-	-	0.9353**
Malinia lateralis	0.9017**	0.8153*	-	-
Macoma sp. (juvenile)	-	-	-	0.9243**
Naculana acuta	-	-	-	0.9243**
Tellina versicolor	0.8287*	-	-	-
Polychaetes	0.8768**	0.8979**	-	0.8943**
Glycera dibranchiata	-	-	-	0.8621**
Medionastus californiensis	-	-	-	0.8412**
Notomatus latericus	0.8604*	0.8247*	-	-
Noris sp.	-	-	-	0.9047**
Prionspio pinnato	-	-	-	0.9496**

Table 7-30 shows the combined annual numbers of more common benthic invertebrates at the eight quarterly sampling stations in Choctawhatchee Bay, in 1975. Gastropods comprise the most commonly found species, followed by pelecypods and then polychaetes. The two most common species appear to be *Nuculana acuta*, a bivalve with greater numbers in the central, western Bay and the gastropod *Acteocina canaliculata* which is most common in the central eastern Bay. Other commonly found species include *Cyclostremiscus pentagonus*, *Haminoea succinea*, *Mulinia lateralis*, *Nuculana actus*, *Odostamoa* sp. and the polychaete *Prionospio pinnata*.

Table 7-30: Combined annual numbers of benthic invertebrates found at the eight quarterly sampling stations in Choctawhatchee Bay, 1975.

SPECIES	STATION NUMBER 1	2	3	4	5	6	7	8
Abra aqualis	0	2	0	3	5	4	1	0
Anomalocardia auberiana	5	4	8	5	4	5	5	1
Anachis avara	1	2	4	10	4	2	0	0
Acteocina canaliculata	166	145	333	251	825	648	608	155
Anadara ovalis	1	2	7	5	1	2	1	0
Anomia simplex	0	1	0	2	1	6	0	1
Agriopoma texasana	2	5	6	3	0	0	0	0
Ampelisca vandorum	12	1	0	0	0	2	0	0
Anachis juvenile	1	2	5	3	0	0	1	0
Anadara juvenile	1	1	0	3	2	44	0	0
Anodontia juvenile	1	1	4	3	6	19	1	1
Crassatella lunulata	0	0	0	0	1	157	4	1
Cyclostremiscus pentagonus	61	117	99	82	47	36	5	1
Corbella swiftiana	17	37	15	16	3	7	5	0
Crepidula sp.	2	0	1	1	3	9	0	2
Creseis sp.	11	92	38	113	33	20	2	0
Dinocardium juvenile	2	1	1	3	2	1	0	0
Glycera dibranchiata	96	113	71	59	57	52	64	7
Godiva rubralineata	1	0	0	0	0	0	11	0
Haminoea succinea	90	50	104	39	212	59	65	24
Littorinidina	1	0	3	3	0	5	2	4
Medionastus californiensis	3	1	4	5	4	5	7	17

Table 7-30: Combined annual numbers of benthic invertebrates found at the eight quarterly sampling stations in Choctawhatchee Bay, 1975.

SPECIES	STATION NUMBER							
	1	2	3	4	5	6	7	8
Mercenaria campechiensis	3	6	9	11	13	19	12	5
Mulina lateralis	12	20	51	169	197	161	194	129
Macoma mitchelle	15	19	15	18	8	11	5	38
Macoma pusilla	2	1	0	8	0	0	0	1
Macoma juvenile	7	6	0	1	2	2	1	0
Nuculana acuta	193	505	641	813	473	257	203	36
Nuculana acutus	15	18	55	116	234	169	91	71
Notomatus latericus	146	136	41	15	39	59	71	25
Nassarius vibex	2	0	34	0	0	1	2	1
Nereis sp.	61	36	84	42	76	44	26	1
Odostomia seminuda	2	6	9	2	2	9	0	0
Odostomia sp.	22	41	104	54	203	136	114	34
Podarke obscura	3	0	1	1	1	3	1	0
Prionospio pinnata	147	122	174	149	140	164	118	68
Paramphinome pulchella	0	4	1	1	0	0	0	0
Polychaete fragment	21	26	17	3	5	4	7	11
Pryramidella	1	0	0	1	5	3	0	1
Rissonia catesbyana	0	0	0	1	0	0	1	0
Semele juvenile	3	2	0	12	0	1	0	0
Spionidae A Unknown	2	7	3	3	0	2	4	2
Tellina versicolor	8	3	4	1	2	1	0	0
Turbinella sp.	3	1	0	0	0	5	1	0

REFERENCES

American Public Health Association. Standard Methods for the Examination of Water and Wastewater, 13 ed. American Public Health Association, Inc., New York. 1971.

Barrett, Daffin and Carlan, Inc. Comprehensive Plan for Walton County and Participating Cities of Freeport and Paxton. 1980. 126 pp.

Battelle-Columbua Laboratories. A Study of Selected Coastal Zone Ecosystems in the Gulf of Mexico in Relation to Gas Pipeling Activities. 1973. 48 pp.

Biggs, R. B. and D. A. Flemer. "The Flux of Particulate Carbon in an Estuary". Marine Biology. Volume 12, Number 1. January, 1972. pp 11-17.

Bowden, K. F. "Circulation and Diffusion". In Estuaries. Ed. George H. Lauff. American Association for the Advancement of Science. Publ. No. 83. 1967. pp. 15-36.

Collard, Sneed B. Biological, Chemical, Geological and Physical Parameters Essential to Estuarine Management in Choctawhatchee Bay. (Annual Progress Reports). Sea Grant Project R/EM-e. 1976. 15 pp.

Darnell, Rezneat M. "Organic Detritus in Relation to the Estuarine Ecosystem". In Estuaries. Ed. George H. Lauff. American Association for the Advancement of Science. Public No. 83. 1967. pp. 376-382.

Dyer, Keith R. Estuaries: A Physical Introduction. John Wiley and Sons. 1973. 140 p.

Estabrook, R. H. Phytoplankton Ecology and Hydrography of Apalachicola Bay. M. S. Thesis. Florida State University, Tallahassee. 1973. 166 pp.

Fairbanks, Charles H. "Excavations at the Fort Walton Temple Mound, 1960" in Florida Anthropologist 18 (4): 239-264.

Ferguson, Randolph L. and Marianne B. Murdoch. "Microbial ATP and Organic Carbon in Sediments of the Newport River Estuary, North Carolina". In Estuarine Research. Ed. L. Eugene Cronin. 1975. pp. 229-250.

Florida Administrative Code. Pollution of Waters, Rules of the Department of Pollution Control. Chap. 17-3. 1973. pp. 7-12A.

Folk, R. L. 1968. Petrology of Sedimentary Rocks. Geol. Publication of the University of Texas. 170 pp.

Goldsmith, Victor. The Accent Sedimentary Environment of Choctawhatchee Bay, Florida. Unpublished Master's Thesis, Florida State University. 1966. 75 pp.

Henningson, Durham and Richardson. Bluewater Bay Development Company - Development of Regional Impact. 1976.

Hopkins, T. L. "Plankton of the St. Andrew Bay System of Florida". Bull. Inst. Mar. Sci. University of Texas, 11:12-64. 1966.

Hopkins, Thomas L. "Zooplankton". In A Summary of Knowledge of the Eastern Gulf of Mexico. Ed. J. Jones, R. Ring, M. Rinkel and R. Smith, State University System of Florida, Institute of Oceanography. pp. IIIF 1-10.

Irby, Edwin W., Jr. A Fishing Survey of Choctawhatchee Bay and Adjacent Gulf of Mexico Waters. Florida Department of Natural Resources. 1974. 26 pp.

Jaworski, Norbert A. "Sources of Nutrients and the Scale of Eutrophication Problems in Estuaries". In Estuaries and Nutrients. Edited by Bruce J. Neilson and L. Eugene Cronin. Humana Press. 1981. pp. 83-110.

Jeffrey, S. W. "Algal Pigment Systems". In Primary Productivity in the Sea. Ed. Paul Falkowski. Plenum Press. 1980. pp. 33-58.

McNulty, K., W. Lindall and J. Sykes. Cooperative Gulf of Mexico Estuarine Inventory and Study, Florida: Phase I, Area Description. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Meyers, Vernon B. and Richard I. Iverson. "Phosphorous and Nitrogen Limited Phytoplankton Productivity in Northeastern Gulf of Mexico Coastal Estuaries". In Estuaries and Nutrients. Edited by Bruce J. Neilson and L. Eugene Cronin. Humana Press. 1981. pp. 569-582.

Moshiri, G. A., W. G. Crumpton, and D. A. Blaylock. "Algal Metabolies and Fish Kills in a Bayou Estuary: An Alternative Explanation to the Low Dissolved Oxygen Controversy". Journal of the Water Pollution Control Federation. Vol. 50:2042:2046. 1978.

Myers, R. H. Phytoplankton Ecology and Hydrography of Apalachicola Bay. M.S. Thesis, Florida State University, Tallahassee. 1973. 166 pp.

Nix, Robert. Land Use Plan for the West Florida Region. West Florida Regional Planning Council. 1976.

Nixon, Scott W. "Remineralization and Nutrient Cycling in Coastal Marine Ecosystems". In Estuaries and Nutrients. Editor, B. J. Neilson and L. Eugene Cronin. Humana Press. 1981. pp. 111-138.

Northwest Florida Water Management District. Initial Investigation Toward the Development of a Management Program for Choctawhatchee Bay, Florida. 1980. 75 pp.

Northwest Florida Water Management District. Water Resources Management Plan. Volume 1: The Regional Setting. 1978. 196 pp.

O'Connor, S. G. and A. J. McErlean. "The Effects of Power Plants on the Productivity of Nekton" in Estuarine Research, Volume I. Ed. L. Eugene Cronin. Academic Press, Inc. 1975. pp. 494-517.

Okaloosa Economic Development Council. Minutes of OEDP Economic/Environmental Symposium. November 15-17, 1978.

Oppenheimer, C. H. "Temperature: Bacteria, Fungi and Blue-green Algae" in Marine Ecology. Volume I. Part I. Editor Otto Kinne. Wiley Inter-Science, 1970. pp. 347-362.

Pastula, Edward John, Jr. The Ecology and Distribution of Recent Foraminifers of Choctawhatchee Bay, Flörida. Unpublished Master's Thesis. Florida State University. 1967. 104 pp.

Post, Buckley, Schuh and Jernigan, Inc. Existing and Projected Population, Economic and Social Activity (Escambia, Santa Rosa and Okaloosa Counties). West Florida Regional Planning Council. 1977.

Postma, H. "Sediment Transport and Sedimentation in the Estuarine Environment". In Estuaries. Ed. George H. Lauff. American Association for the Advancement of Science. Publ. No. 83. 1967. pp. 158-179.

Prescott, G. W. The Algae: A Review. Houghton Mifflin Company. 1968. 436 pp.

Ritchie, Theodore P. Preliminary Report on the Hydrography and Oyster Growing Conditions in Choctawhatchee Bay. July 11-13, 1961. Florida Board of Conservation. 1961. 5 pp.

Ross, Bernard E., Melvin Anderson, and Paul Jenkins. A Waste Load Allocation Study of Choctawhatchee Bay, Florida. Hydrosystems Associates, Inc. 1974. 140 pp.

Ross, Landon T., and Douglas A. Jones, ed. Biological Aspects of Water Quality in Florida. Part 1: Escambia-Perdido, Choctawhatchee-Apalachicola, Aucilla-Ochlockonee-St. Marks, and Suwanee Drainage Basins. Florida Department of Environmental Regulation. 1979. 516 pp.

Sheridan, Peter F. and Robert J. Livingston. "Cyclic Trophic Relationships of Fishes in an Unpolluted River Dominated Estuary in North Florida." In Ecological Proceedings in Coastal and Marine Systems. Ed. Robert J. Livingston. Plenum Press. 1979. pp. 143-162.

Steidinger, Karen A. "Phytoplankton". In A Summary of Knowledge of the Eastern Gulf of Mexico. Ed. J. Jones, R. Ring, M. Rinkel and R. Smith. State University System of Florida, Institute of Oceanography pp. III E 1-9.

Strickland, J. D. H. and T. R. Parsons. A Practical Handbook of Seawater Analysis. Fisheries Research Board of Canada. 1972. Bulletin 167. 310 pp.

Taylor Biological Company. Environmental Summary and Benthic Investigation- Choctawhatchee Bay, Florida. Lynn Haven, Florida. 1978. 55 pp. and 4 appendices.

U.S. Army Corps of Engineers, Mobile District. Draft Environmental Impact Statement. LaGrange Bayou (Maintenance Dredging). Walton County, Florida. 1973. 39 pp.

U.S. Corps of Engineers, Mobile District. Final Environmental Impact Statement East Pass Channel. (Maintenance Dredging). Okaloosa County, Florida. 1975. 69 pp.

U.S. Army Corps of Engineers, Mobile District. Maintenance Dredging of the Gulf Intracoastal Waterway from Pearl River, Louisiana-Mississippi to Apalachee Bay, Florida. 1976. 238 pp.

U.S. Army Corps of Engineers. Waterborne Commerce of the United States, Calendar Year 1970 through Calendar Year 1974. 1974.

U.S. Geological Society, Department of the Interior. Hydrologic Data for Okaloosa, Walton, and Southeastern Santa Rosa Counties, Florida. 1980. 227 pp.

U.S. Fish and Wildlife Service, Department of the Interior. Summary of Available Information on Chesapeake Bay Submerge Vegetation. FWS/OBS 78/66. 1978.

U.S. Fish and Wildlife Service, Department of the Interior. Fishery Management Program. Choctawhatchee Striped Bass Study. Northwest Florida Striped Bass Project. Annual Project Report. 1972.

U.S. Fish and Wildlife Service, Department of the Interior. Northwest Florida Striped Bass Investigation. Choctawhatchee Bay Study. Final Report. 1975.

U.S. Fish and Wildlife Service, Department of the Interior. Special Report: Cooperative Environmental Study: Choctawhatchee River System. 1968. 34 pp.

U.S. Environmental Protection Agency. Methods for Chemical Analysis of Water and Wastes. Methods Development and Quality Assurance Research Laboratory. Cincinnati, Ohio. 1975. 297 pp.

U.S. Environmental Protection Agency. "Proposed Criteria for Water Quality". Volume One. 1973.

U.S. Environmental Protection Agency. Water Quality Considerations for Construction and Dredging Operations. Revised April, 1971.

U.S. Environmental Protection Agency. Environmental and Recovery Studies of Escambia Bay and the Pensacola Bay System, Florida. Region IV, Athens, Georgia. 1975.

Water Quality Criteria, 1972. National Academy of Science - National Academy of Engineering.

Webb, Kenneth L. "Conceptual Models and Processes of Nutrient Cycling in Estuaries". In Estuaries and Nutrients. Edited by Bruce J. Neilson and L. Eugene Cronin. Humana Press. 1981. pp. 25-46.

Weber, C. 1973. Biological Field and laboratory methods for measuring the quality of surface waters and effluents. Ofc. Res. and Development, U.S. EPA, Cincinnati, Ohio. p. 14-16.

West Florida Regional Planning Council. Development of Regional Impact Assessment for Raintree. 1976.

Appendix A: Phytoplankton species from Choctawhatchee Bay during the year 1975.

PHYLUM CHRYSOPHTA

Subphylum DIATOMACEAE

Order Pennales

Nitzschia sp.
Synedra sp.
Meridion sp.
Navicula sp.
Gyrosigma sp.
Opephora sp.
Amphiprora sp.
Cymbella sp.
Frustulia sp.
Cocconeis sp.
Diploneis sp.
Diatomella sp.
Epithemia sp.
Achnanthes sp.
Pinnularia sp.
Fragilaria sp.
Diatoma sp.
Tabellaria sp.
Gomphonema sp.
Synedra sp.
Asterionella sp.
Bacillaria sp.

Order

Thallasiosira sp.
Hemiaulus sp.
Bacteriastrum sp.
Skeletonema Costatum
Chaetoceros sp.
Rhizosolenia sp.
Cyclotella sp.
Biddulphia sp.
Coscinodiscus sp.

Subphylum CHRYSOPHYCEAE

Order Ochromonadales

Ochromonas sp.
Dinobryan sp.
Mallomonas sp.

Order Chromulinales

Chromilina sp.

Order Rhizochrysidales

Diceras sp.

Subphylum CHRYSOPHYCEAE

Order Isochrysidales

Isochrysis sp.

Subphylum XANTHOPHYCEAE

Order Mischococcales

Centritractus sp.

PHYLUM CHLOROPHYTA

Subphylum Chlorophyceae

Order Volvocales

Haematococcus sp.
Platymonas sp.
Pyraminonas sp.
Carteria sp.
Dunaliella sp.

Order Chlorococcales

Scenedesmus sp.
Ankistrodesmus sp.
Actinastrum sp.

PHYLUM EUGLENOPHYTA

Order Euglinales

Eutreptia sp.
Euglena Sanguines

PHYLUM CRYTOPHYTA

Family Cryptomonadaceae

Crytomonas sp.

Family Cryptochrysidaceae sp.

Rhodomonas sp.
Chroomonas sp.

PHYLUM CYANOPHYTA

Order Nostacales

Anabaena sp.

Order Chroococcales

Merismopedium sp.

PHYLUM PYRRHOPYTA

Class Dinophyceae

Gymnodinium sp.
Ceratium sp.
Gonyaulax sp.
Glenodinium sp.
Peridinium sp.
Dinophysis sp.

Class Desmokontae

Prorocentrum sp.
Exuviella sp.

Appendix B: Zooplankton found in Choctawhatchee Bay during the year 1975.

PHYLUM ARTHROPODA

Class Insects

Subclass Pterygota

Superorder Megopteroidea

Order Diptera

Larvae, unidentified

Class Crustacea

Subclass Copepods

Nauplius, unidentified

Order Cyclopoida

Oncaea sp.

Order Calonoida

Acartia _tonsa_

Order Harpacticoida

Microsetella sp.

Subclass Brachyura

Zoea, unidentified

Subclass Cladocera

Penilla sp.
Evadne sp.
Podon sp.
Scapholeberis sp.
Alona sp.
Chydoris sp.
Ceriodaphnia sp.
Bosmina sp.

Subclass Ostracoda

Subclass Cirripedia

Balanus sp. nauplii

Subclass Malacostraca

Order Eucarida

Suborder Decapoda

Family Sergestidae

Lucifer faxoni

Subphylum Chelicerata

Class Arachnida

Order Acarina

Mites, unidentified

PHYLUM ROTIFERA

Brachionus sp.

PHYLUM ANNELIDA

Class Polychaeta

PHYLUM MOLLUSCA

Veligers, unidentified

PHYLUM ECHINODERMATA

Larvae, unidentified

PHYLUM CHORDATA

Class Larvacea

Oikipleura sp.

PHYLUM CTENOPHORA

Mnemiopsis sp.

Appendix C: Benthic Macrofauna found in Choctawhatchee Bay in 1975.

PHYLUM ARTHROPODA

Class Crustacea

Order Cumacea

Cyclaspis Sp.

Order Mysidacea

Mysis Sp.

Order Amphipoda

Ampelisca vandorum
Listriella barnardi
Listriella sp.

PHYLUM MOLLUSCA

Class Gastropoda

Cyclostremiscus pentagonus
Aceteocina canaliculata
Nassarius acutus
Nassarius uibex
Haminoea succinea
Odostomia sp.
Neritina reclivata
Crepidula sp.
Cantharus tinctus
Creseis sp.
Cavolina sp.
Anachis avara
Anachis sp. juvenile
Natica pusilla
Mitrella pusilla
Seila adamsi
Lithorinidina sp.
Pyramidella sp.
Rissonina catesbyana
Acteon punctostraitus
Odostomia seminuda
Triphora sp.
Epitonium sp.
Godiva rubralineata
Turbinella sp.

Class Pelecypoda (Bivalvia)

Solen sp.
Cyrtopleura costata
Tellina alternata
Tellina versicolor
Nuculana acuta
Corbula swiftiana
Mercenaria campechiensis
Agriopoma texasiana
Mulinia lateralis
Mytilopsis leucophaeta
Crassostrea virginica
Laevicardium laevigatum
Laavicardium mortoni
Anadara ovalis
Anadara sp. juvenile
Anodara floridana
Anodontia alba
Glycymeris pectinata
Anomalocardia auberiana
Anomia simplex
Semele proficua
Semele sp. juvenile
Rangia cuneata
Dinocardium sp. juvenile
Linda amiantus
Macoma sp. juvenile
Anodontia sp. juvenile
Abra aequalis
Chione cancelleta
Macoma mitchelli
Crassatella lunulata

PHYLUM ANNELIDA

Class Polychaeta

Notomastus latericus
Glycera dibranchiata
Nereis sp.
Branchiomma nigromaculata
Paramphinome pulchella
Medionastus californiensis
Armandia agilis
Prionospio pinnata
Podarke obscura
Family Spionidae
Family Syllidae

PHYLUM ECHINODERMATA

Class Stelleroidea

Ophiura sp.

PHYLUM SIPUNCULA

PHYLUM NEMATODA

PHYLUM CHORDATA

Class Ascidiacea

Molgula manhattensis

PHYLUM BRYOZOA

Class Gymnolaemata

Bugula sp.

PHYLUM CNIDARIA

Class Anthozoa

Oculina sp.

Appendix D: Significant Correlations (a < 0.10) of Monthly Water Quality Parameters with the Net Discharge of Freshwater from the Tributaries to Choctawhatchee Bay at each of the thirty-one water quality stations in 1975.

Parameter	Station	R-square	PROB > F
Salinity	5	-0.5504	0.0992
	7	-0.5888	0.0733
	8	-0.5665	0.0878
	9	-0.6639	0.0363
	10	-0.6623	0.0369
	11	-0.7274	0.0171
	12	-0.7886	0.0067
	13	-0.7555	0.0186
	14	-0.8539	0.0017
	15	-0.8159	0.0040
	16	-0.5667	0.0876
	17	-0.7702	0.0091
	18	-0.7471	0.0130
	19	-0.8562	0.0016
	20	-0.9277	0.0001
	21	-0.8415	0.0045
	22	-0.8042	0.0050
	23	-0.8409	0.0045

Parameter	Station	R-square	PROB > F
Salinity	24	-0.6432	0.0616
	25	-0.8615	0.0028
	26	-0.8121	0.0078
	27	-0.7285	0.0260
	28	-0.7123	0.0474
	29	-0.8095	0.0082
	30	-0.7554	0.0186
	31	-0.7697	0.0153
Dissolved Oxygen	1	0.5753	0.0818
	3	0.7727	0.0088
	4	0.5585	0.0933
	6	0.6257	0.0530
	7	0.5865	0.0747
	9	0.5959	0.0691
	10	0.6039	0.0645
	11	0.6838	0.0292
	12	0.6633	0.0365
	19	0.6633	0.0365
	28	0.6334	0.0918
Dissolved Phosphorous	4	0.7627	0.0103
	5	0.7663	0.0097
	26	0.7238	0.0275
Kjedahls Nitrogen	10	0.6895	0.0399
Ammonia	12	0.5619	0.0909

Parameter	Station	R-square	PROB > F
Total Carbon	2	0.5910	0.0938
	18	0.7399	0.0226
	22	0.7460	0.0210
	23	0.9405	0.0005
	24	0.9401	0.0005
	27	0.9615	0.0001
	28	-0.7495	0.0524
	29	0.6723	0.0677
	31	-0.7640	0.0273
Total Organic Carbon	2	0.6155	0.0776
	18	0.7527	0.0192
	20	0.5936	0.0920
	22	0.7641	0.0165
	23	0.9368	0.0006
	24	0.0333	0.0007
	26	0.7105	0.0483
	27	0.9574	0.0002
	29	0.7468	0.0333
	30	0.6557	0.0775
Chlorophyll A	4	0.7855	0.0121
	13	0.6727	0.0675
	20	0.6353	0.0660
Chlorophyll B	13	0.7102	0.0484
Chlorophyll C	3	0.6168	0.0768
	13	0.6621	0.0736
Total Chlorophyll	13	0.6788	0.0642

Appendix E: Significant Correlations (a < 0.10) of water quality parameters with each other at each of the Thirty-one water quality stations in Choctawhatchee Bay, 1975.

1. Temperature correlated with:

Station	Parameter	R-square	PROB > F
1	Dissolved Oxygen	-0.9094	0.0003
2	Dissolved Oxygen	-0.9083	0.0003
3	Dissolved Oxygen	-0.9135	0.0002
	Kjedahls Nitrogen	-0.6067	0.0832
4	Dissolved Oxygen	-0.8940	0.0005
5	Dissolved Oxygen	-0.8950	0.0005
	Nitrate/Nitrite	-0.5563	0.0949
6	Dissolved Oxygen	-0.6148	0.0585
	Nitrate/Nitrite	-0.5786	0.0797
	Ammonia	-0.5600	0.0922
7	Dissolved Oxygen	-0.9582	0.0001
	Nitrate/Nitrite	-0.6310	0.0504
8	Dissolved Oxygen	-0.8627	0.0013
	Nitrate/Nitrite	-0.8172	0.0039
9	Dissolved Oxygen	-0.9504	0.0001
	Nitrate/Nitrogen	-0.8571	0.0015
10	Dissolved Oxygen	-0.8368	0.0025
	Nitrate/Nitrite	-0.7791	0.0079
	Total Carbon	0.6046	0.0846
	Total Organic Carbon	0.5922	0.0930

1. Temperature correlated with:

Station	Parameter	R-square	PROB > F
11	Dissolved Oxygen	-0.8875	0.0006
	Nitrate/Nitrite	-0.7761	0.0098
	Ammonia	-0.8269	0.0032
12	Dissolved Oxygen	-0.88907	0.0005
	Nitrate/Nitrite	-0.5727	0.0836
	Ammonia	-0.6656	0.0357
	Total Carbon	0.8520	0.0035
13	Dissolved Oxygen	-0.8895	0.0013
	Nitrate/Nitrite	-0.5965	0.0900
	Ammonia	-0.6796	0.0440
14	Dissolved Oxygen	-0.8457	0.0020
	Nitrate/Nitrite	-0.7532	0.0119
	Ammonia	-0.6386	0.0469
15	Dissolved Oxygen	-0.8703	0.0011
16	Dissolved Oxygen	-0.8794	0.0008
	Nitrate/Nitrite	-0.6636	0.0364
17	Dissolved Oxygen	-0.7761	0.0083
	Nitrate/Nitrite	-0.5857	0.0752
18	Dissolved Oxygen	-0.9362	0.0002
	Nitrate/Nitrate	-0.6472	0.0431
19	Dissolved Oxygen	-0.8867	0.0006
	Nitrate/Nitrite	-0.6333	0.0493
20	Dissolved Oxygen	-0.8251	0.0033
	Nitrate/Nitrite	-0.6206	0.0555
21	Dissolved Oxygen	-0.8985	0.0010
	Nitrate/Nitrite	-0.7164	0.0299

1. Temperature correlated with:

Station	Parameter	R-square	PROB > F
22	Dissolved Oxygen	-0.9412	0.0001
	Nitrate/Nitrite	-0.6403	0.0461
	Total Organic Carbon	-0.6081	0.0823
23	Dissolved Oxygen	-0.9066	0.0007
	Ammonia	-0.6645	0.0509
24	Dissolved Oxygen	-0.8919	0.0012
25	Dissolved Oxygen	-0.9179	0.0005
	Nitrate/Nitrite	-0.6079	0.0824
	Ammonia	-0.6619	0.0521
26	Dissolved Oxygen	-0.8550	0.0033
	Ammonia	-0.6022	0.0861
27	Dissolved Oxygen	-0.9528	0.0001
	Nitrate/Nitrite	-0.6439	0.0613
	Kjedahls Nitrogen	-0.7767	0.0266
28	Dissolved Oxygen	-0.9422	0.0005
29	Dissolved Oxygen	-0.9423	0.0001
30	Dissolved Oxygen	-0.9347	0.0002
	Kjedahls Nitrogen	-0.9269	0.0003
31	Dissolved Oxygen	-0.9735	0.0001
	Total Phosphorous	-0.6244	0.0723

2. Salinity correlated with:

Station	Parameter	R-square	PROB > F
7	Ammonia	-0.5537	0.0968
8	Total Carbon	0.7733	0.0244
12	Kjedahls Nitrogen	-0.7586	0.0178

2. Salinity correlated with:

Station	Parameter	R-square	PROB > F
14	Total Phosphorous	-0.5800	0.0788
	Total Organic Carbon	-0.5833	0.0988
17	Dissolved Phosphorous	0.6636	0.0364
	Total Phosphorous	0.6646	0.0360
18	Total Organic Carbon	-0.5845	0.0984
19	Total Phosphorous	0.6919	0.0266
21	Dissolved Phosphorous	0.7725	0.0147
23	Total Organic Carbon	-0.7904	0.0196
24	Dissolved Oxygen	-0.6484	0.0589
	Nitrate/Nitrite	-0.5881	0.0958
25	Dissolved Oxygen	-0.6276	0.0704
	Total Carbon	0.7825	0.0217
27	Total Carbon	0.6692	0.0695

3. Dissolved Oxygen* correlated with:

Station	Parameter	R-square	PROB > F
1	Kjedahls Nitrogen	0.6128	0.0793
3	Kjedahls Nitrogen	0.7104	0.0320
5	Ammonia	0.6017	0.0657
8	Nitrate/Nitrite	0.6102	0.0610
	Total Carbon	-0.6518	0.0799
9	Nitrate/Nitrite	0.7159	0.0199
11	Ammonia	0.7953	0.0059
12	Kjedahls Nitrogen	0.7583	0.0179
	Total Carbon	-0.9069	0.0007

*Note: For complete listing see also previous parameters in Appendix E.

3. Dissolved Oxygen* correlated with:

Station	Parameter	R-square	PROB > F
13	Ammonia	0.7984	0.0099
	Kjedahls Nitrogen	0.8764	0.0043
14	Ammonia	0.5538	0.0967
	Nitrate/Nitrite	0.6253	0.0532
18	Nitrate/Nitrite	0.6542	0.0559
19	Nitrate/Nitrite	0.5596	0.0925
20	Nitrate/Nitrite	0.5924	0.0712
21	Nitrate/Nitrite	0.7316	0.0251
22	Nitrate/Nitrite	0.5585	0.0733
24	Total Organic Carbon	0.6276	0.0957
26	Nitrate/Nitrite	0.6205	0.0746
27	Nitrate/Nitrite	0.7243	0.0273
	Kjedahls Nitrogen	0.6569	0.0546
30	Kjedahls Nitrogen	0.9085	0.0007

4. Ammonia correlated with:

Station	Parameter	R-square	PROB > F
1	Total Carbon	-0.6514	0.0573
	Total Organic Carbon	-0.6617	0.0522
3	Kjedahls Nitrogen	0.7374	0.0234
7	Kjedahls Nitrogen	0.7019	0.0351
9	Kjedahls Nitrogen	0.7361	0.0237
10	Dissolved Phosphorous	0.9084	0.0003
11	Total Phosphorous	0.5645	0.0891
12	Total Carbon	-0.6302	0.0689

*Note: For complete listing see also previous parameters in Appendix F.

4. Ammonia* correlated with:

Station	Parameter	R-square	PROB > F
13	Kjedahls Nitrogen	0.8639	0.0057
17	Kjedahls Nitrogen	0.6983	0.0247
18	Dissolved Phosphorous	0.7109	0.0212
	Total Phosphorous	0.7082	0.0219
22	Nitrate/Nitrite	0.0275	0.0521
	Total Carbon	0.6025	0.0860
25	Nitrate/Nitrite	0.7551	0.0186
27	Nitrate/Nitrite	0.5859	0.0973
29	Total Phosphorous	0.7040	0.0343
	Total Carbon	0.6495	0.0813
	Total Organic Carbon	0.7679	0.0261
30	Total Carbon	0.6926	0.0569
	Total Organic Carbon	0.6265	0.0965
31	Total Phosphorous	0.9329	0.0002

5. Nitrate/Nitrite* correlated with:

Station	Parameter	R-square	PROB > F
1	Total Phosphorous	0.8551	0.0016
3	Kjedahls Nitrogen	-0.7109	0.0318
11	Total Phosphorous	0.5524	0.0977
26	Dissolved Phosphorous	0.6300	0.0690
	Total Organic Carbon	0.6366	0.0896
27	Total Phosphorous	0.8376	0.0048
31	Total Organic Carbon	0.6454	0.0839

*Note: For complete listing see also previous parameters in Appendix E.

6. Dissolved Phosphorous* correlated with:

Station	Parameter	R-square	PROB > F
4	Total Carbon	0.6537	0.0562
	Total Organic Carbon	0.6682	0.0492
17	Total Phosphorous	0.9982	0.0001
18	Total Phosphorous	0.9987	0.001
21	Kjedahls Nitrogen	-0.7103	0.0320
27	Total Organic Carbon	0.6579	0.0762

7. Total Phosphorous* correlated with:

Station	Parameter	R-square	PROB > F
15	Kjedahls Nitrogen	-0.6145	0.0783
25	Total Carbon	0.7785	0.0229

8. Kjedahls Nitrogen* correlated with:

Station	Parameter	R-square	PROB > F
27	Total Carbon	0.6679	0.0703

9. Total Carbon* correlated with:

Station	Parameter	R-square	PROB > F
1	Total Organic Carbon	0.9995	0.0001
2	Total Organic Carbon	0.9998	0.0001
3	Total Organic Carbon	0.9989	0.0001
5	Total Organic Carbon	0.9996	0.0001
6	Total Organic Carbon	0.8644	0.0026
7	Total Organic Carbon	0.9966	0.0001
8	Total Organic Carbon	0.7967	0.0179

*Note: For complete listing see also previous parameters in Appendix E.

9. Total Carbon* correlated with:

Station	Parameter	R-square	PROB > F
9	Total Organic Carbon	0.9991	0.0001
10	Total Organic Carbon	0.9986	0.0001
11	Total Organic Carbon	0.9994	0.0001
12	Total Organic Carbon	0.1331	0.0246
13	Total Organic Carbon	0.9982	0.0001
14	Total Organic Carbon	0.9997	0.0001
15	Total Organic Carbon	0.9986	0.0001
17	Total Organic Carbon	0.9978	0.0001
18	Total Organic Carbon	0.9984	0.0001
19	Total Organic Carbon	0.9912	0.0001
20	Total Organic Carbon	0.9997	0.0001
21	Total Organic Carbon	0.9972	0.0001
22	Total Organic Carbon	0.7920	0.0110
23	Total Organic Carbon	0.9915	0.0001
25	Total Organic Carbon	0.6221	0.0995
26	Total Organic Carbon	0.9887	0.0001
28	Total Organic Carbon	0.7446	0.0549
29	Total Organic Carbon	0.6823	0.0623
30	Total Organic Carbon	0.9183	0.0013

*Note: For complete listing see also previous parameters in Appendix E.

Appendix F: Correlations of Chlorophylls with water quality parameters of each of the Thirty-one water quality sampling stations in Choctawhatchee Bay, 1975.

1. Chlorophyll A correlated with:

Station	Parameter	R-square	PROB > F
2	Ammonia	-0.6951	0.0376
4	Dissolved Phosphorous	0.8169	0.0072
5	Salinity	-0.7664	0.0160
6	Temperature	0.6154	0.0777
7	Nitrate/Nitrite	-0.7240	0.0423
8	Dissolved Oxygen	-0.6896	0.0398
	Total Organic Carbon	-0.7147	0.0711
9	Dissolved Oxygen	-0.7041	0.0512
10	Temperature	0.8885	0.0014
	Nitrate/Nitrite	-0.7078	0.0329
13	Total Phosphorous	0.7138	0.0329
15	Dissolved Oxygen	-0.6404	0.0633
17	Salinity	0.7387	0.0230
	Dissolved Phosphorous	0.9492	0.0001
	Total Phosphorous	0.9492	0.0001
18	Ammonia	0.8013	0.0094
19	Total Phosphorous	0.6362	0.0654
21	Salinity	0.6436	0.0851
	Dissolved Phosphorous	0.8259	0.0115

1. Chlorophyll A correlates with:

Station	Parameter	R-square	PROB > F
22	Kjedahls Nitrogen	0.7007	0.0355
24	Dissolved Phosphorous	-0.6455	0.0839
25	Total Phosphorous	0.8887	0.0032
	Total Carbon	0.7264	0.0645
	Total Organic Carbon	0.7485	0.0529
29	Total Phosphorous	0.7039	0.0514
30	Total Carbon	0.7698	0.0430
	Total Organic Carbon	0.7244	0.0655

2. Chlorophyll B correlated with:

Station	Parameter	R-square	PROB > F
2	Ammonia	-0.6028	0.0858
	Total Carbon	0.8488	0.0157
	Total Organic Carbon	0.8443	0.0169
5	Salinity	-0.7855	0.0121
	Total Phosphorous	0.6338	0.0668
6	Nitrate/Nitrite	-0.7187	0.0291
7	Total Carbon	-0.8697	0.0110
10	Ammonia	0.9073	0.0007
	Total Phosphorous	0.7672	0.0158
13	Total Phosphorous	0.6304	0.0938
15	Kjedahls Nitrogen	0.6465	0.0832
16	Total Phosphorous	0.9468	0.0001

2. Chlorophyll B correlated with:

Station	Parameter	R-square	PROB > F
17	Salinity	0.6312	0.0683
	Dissolved Phosphorous	0.9547	0.0001
	Total Phosphorous	0.9590	0.0001
18	Ammonia	0.8079	0.0084
	Dissolved Phosphorous	0.6452	0.0606
	Total Phosphorous	0.6473	0.0595
	Nitrate/Nitrite	0.6171	0.0767
19	Total Phosphorous	0.7806	0.0130
	Nitrate/Nitrite	0.6732	0.0469
20	Dissolved Phosphorous	0.8900	0.0013
21	Salinity	0.7697	0.0255
	Dissolved Phosphorous	0.9744	0.0001
22	Ammonia	0.7724	0.0145
24	Ammonia	0.6608	0.0744
25	Total Phosphorous	0.9589	0.0002
	Total Carbon	0.7114	0.0731
	Total Organic Carbon	0.8371	0.0188
29	Total Phosphorous	0.8579	0.0064
30	Total Carbon	0.7903	0.0344

3. Chlorophyll C correlated with:

Station	Parameter	R-square	PROB > F
2	Ammonia	-0.5968	0.0897
	Total Carbon	0.8403	0.0179
	Total Organic Carbon	0.8365	0.0189

3. Chlorophyll C correlated with:

Station	Parameter	R-square	PROB > F
5	Salinity	-0.7781	0.0135
	Total Phosphorous	0.6287	0.0697
6	Nitrate/Nitrite	-0.6051	0.0843
7	Total Carbon	-0.8169	0.0249
10	Ammonia	0.8967	0.0010
	Total Phosphorous	0.7942	0.0106
15	Kjedahls Nitrogen	0.6562	0.0771
16	Total Phosphorous	0.9441	0.0001
17	Salinity	0.6313	0.0683
	Dissolved Phosphorous	0.9610	0.0001
	Total Phosphorous	0.9658	0.0001
18	Ammonia	0.7362	0.0237
	Dissolved Phosphorous	0.6396	0.0636
	Total Phosphorous	0.6441	0.0612
	Nitrate/Nitrite	0.6854	0.0416
19	Total Phosphorous	0.7426	0.0219
	Nitrate/Nitrite	0.6597	0.0532
20	Dissolved Phosphorous	0.9067	0.0007
21	Salinity	0.7335	0.0384
	Dissolved Phosphorous	0.9799	0.0001
22	Ammonia	0.7763	0.0139
24	Ammonia	0.6532	0.0790
25	Kjedahls Nitrogen	0.6234	0.0986
	Total Phosphorous	0.9547	0.0002
	Total Organic Carbon	0.7899	0.0346

3. Chlorophyll C correlated with:

Station	Parameter	R-square	PROB > F
29	Total Phosphorous	0.8678	0.0052
30	Total Carbon	0.8203	0.0238
	Total Organic Carbon	0.6802	0.0927

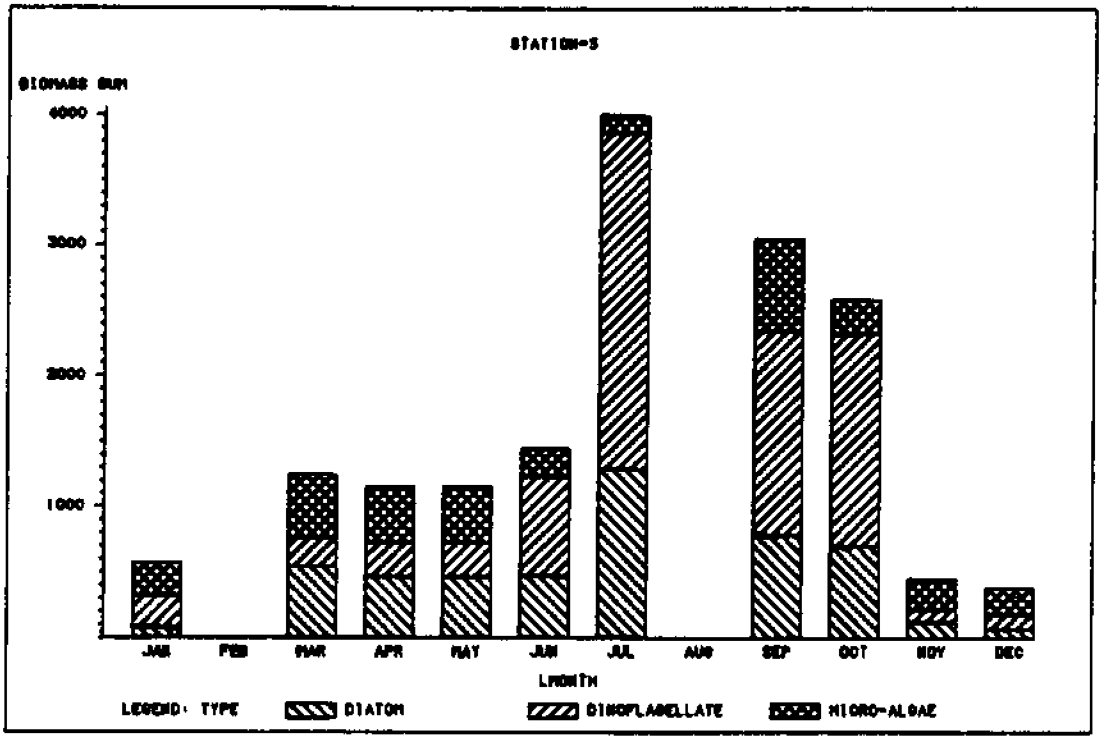
4. Total Chlorophyll correlated with:

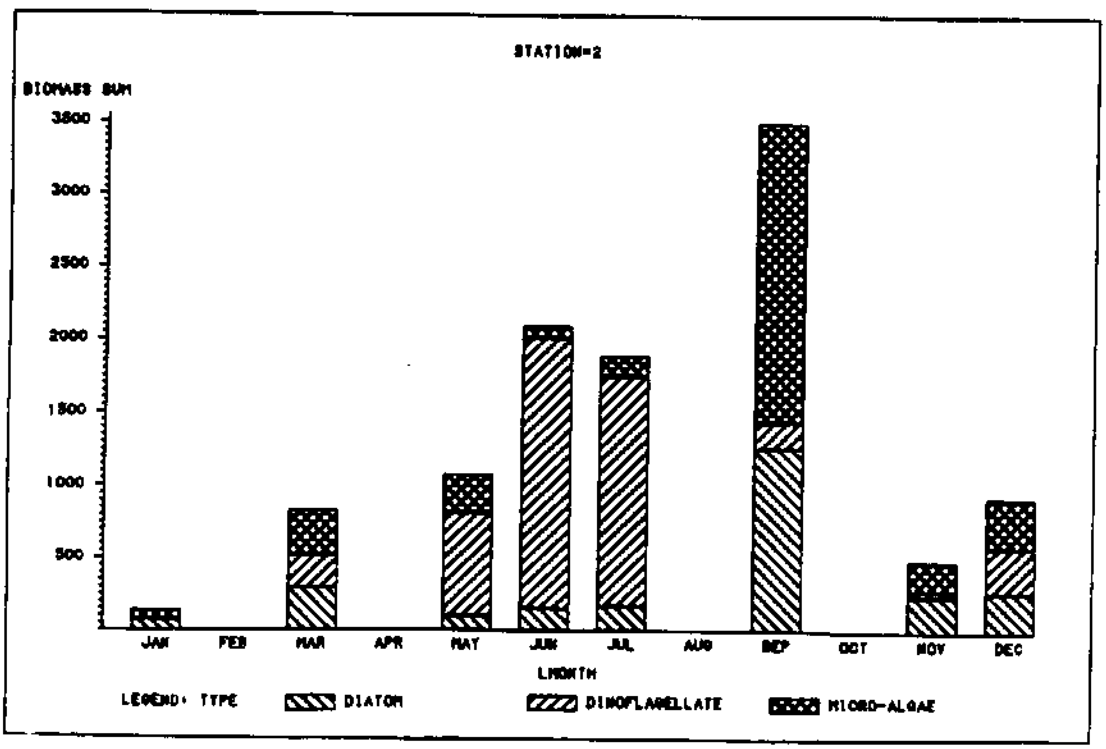
Station	Parameter	R-square	PROB > F
2	Ammonia	-0.6326	0.0675
	Total Carbon	0.7904	0.0344
	Total Organic Carbon	0.7866	0.0359
4	Dissolved Phosphorous	0.6607	0.0527
5	Salinity	-0.7928	0.0108
	Total Phosphorous	0.6295	0.0693
6	Nitrate/Nitrite	-0.6777	0.0447
7	Total Carbon	-0.8250	0.0223
10	Ammonia	0.8867	0.0014
	Total Phosphorous	0.7933	0.0107
13	Total Phosphorous	0.6289	0.0948
15	Kjedahls Nitrogen	0.6586	0.0757
16	Total Phosphorous	0.9350	0.0002
17	Salinity	0.6455	0.0604
	Dissolved Phosphorous	0.9643	0.0001
	Total Phosphorous	0.9685	0.0001
18	Ammonia	0.7700	0.0152
	Nitrate/Nitrite	0.6509	0.0576
	Dissolved Phosphorous	0.6305	0.0687
	Total Phosphorous	0.6344	0.0665

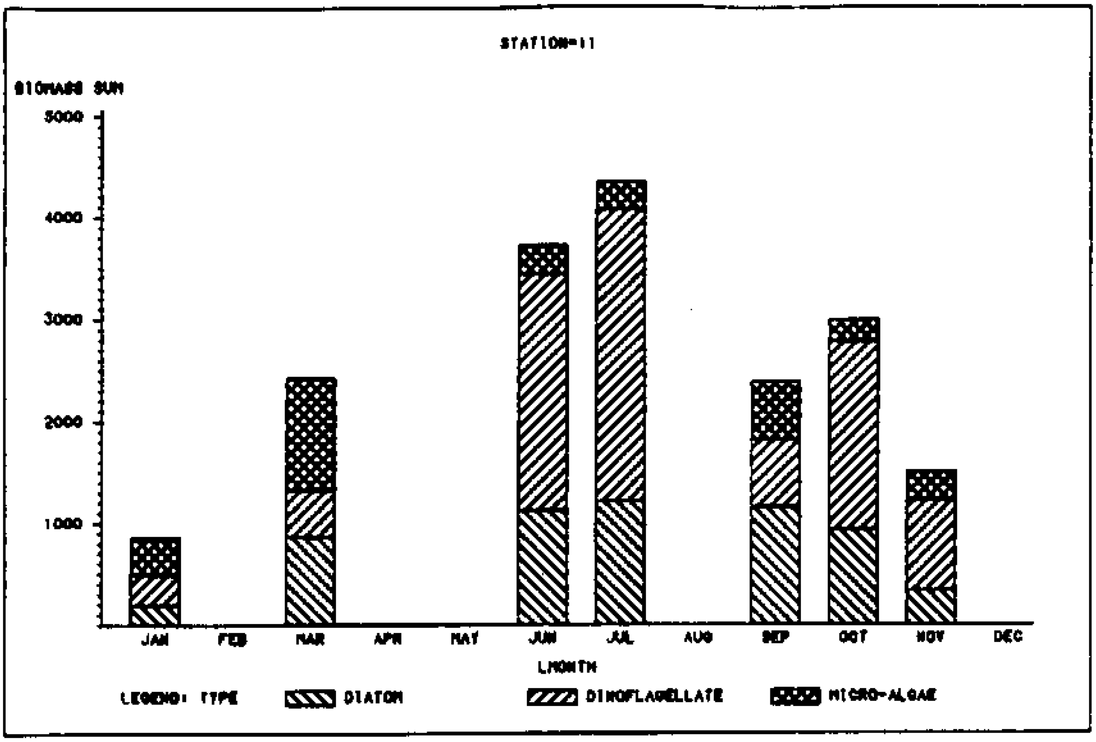
4. Total Chlorophyll correlated with:

Station	Parameter	R-square	PROB > F
19	Nitrate/Nitrite	0.6608	0.0527
	Total Phosphorous	0.7476	0.0206
20	Dissolved Phosphorous	0.8649	0.0026
21	Salinity	0.7456	0.0337
	Dissolved Phosphorous	0.9808	0.0001
22	Ammonia	0.7631	0.0168
24	Ammonia	0.6492	0.0815
25	Kjedahls Nitrogen	0.6308	0.0936
	Total Phosphorous	0.9559	0.0002
	Total Organic Carbon	0.7991	0.0311
29	Total Phosphorous	0.8557	0.0067
30	Total Carbon	0.8105	0.0270
	Total Organic Carbon	0.6874	0.0879

APPENDIX G: Spacial and Monthly Distributions of Phytoplankton in Choctawhatchee Bay, 1975



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1000
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MAR
APR
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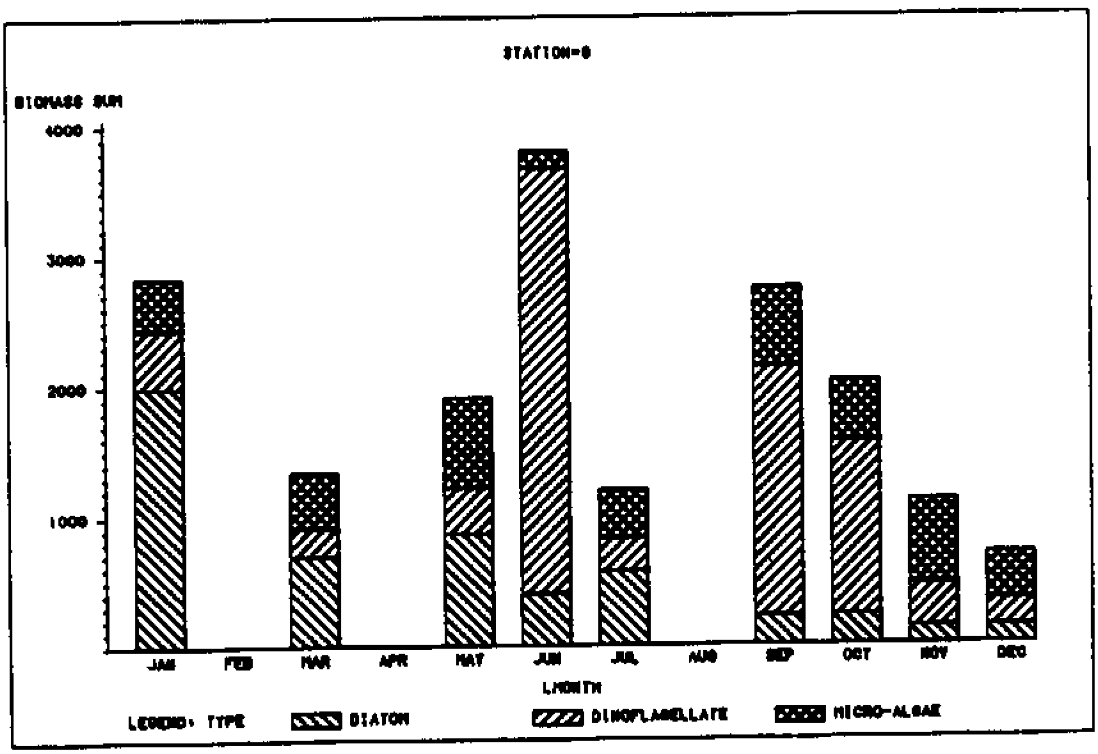
AUG
SEP
OCT
NOV
DEC
LMONTH
LEGEND: TYPE
DIATOM
DINOFLAGELLATE
MICRO-ALGAE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MAR
APR
MAY
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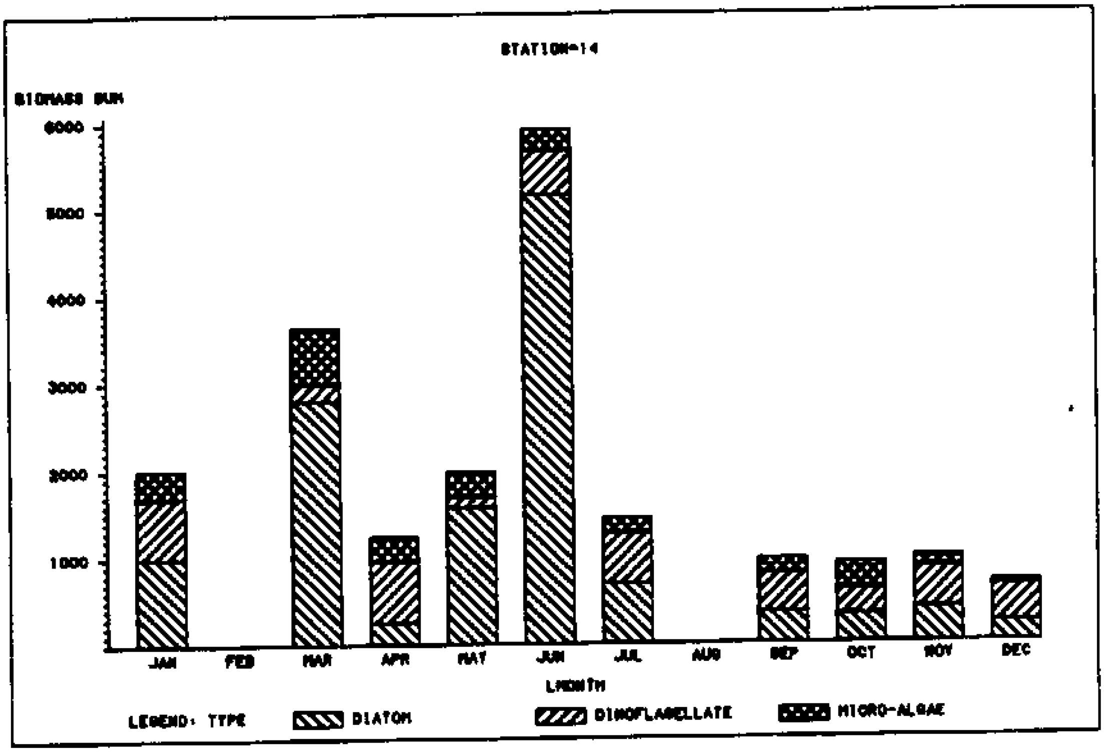
AUG
SEP
OCT
NOV
DEC
LMONTH
LEGEND: TYPE
DIATOM
DINOFLAGELLATE
MICRO-ALGAE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JAN
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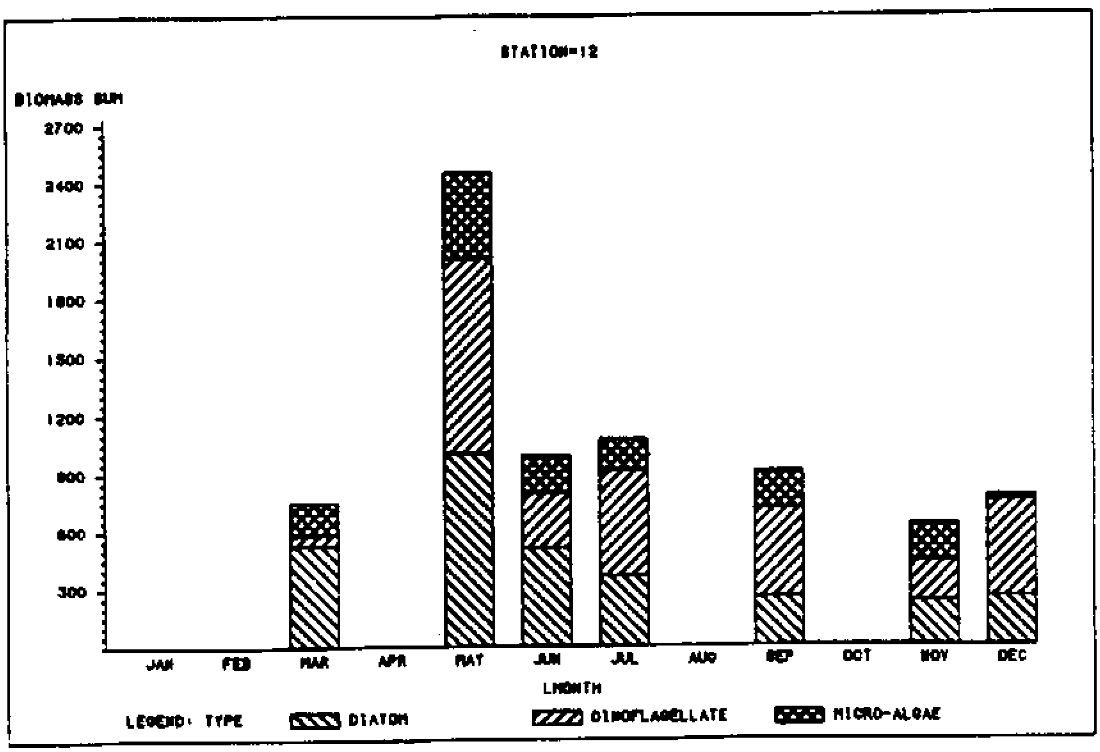
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
LMONTH
LEGEND: TYPE
DIATOM
DINOFLAGELLATE
MICRO-ALGAE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APR
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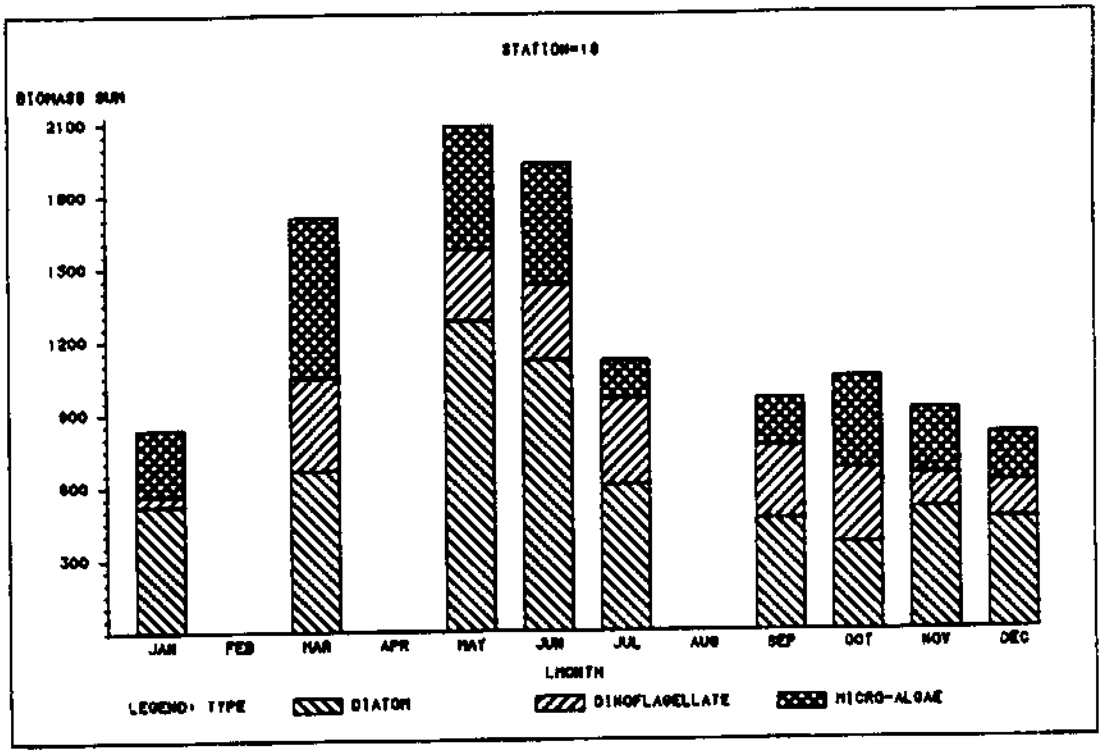
SEP
OCT
NOV
DEC
LMONTH
LEGEND: TYPE
DIATOM
DINOFLAGELLATE
MICRO-ALGAE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FEB
MAR
APR
MAY
JUN
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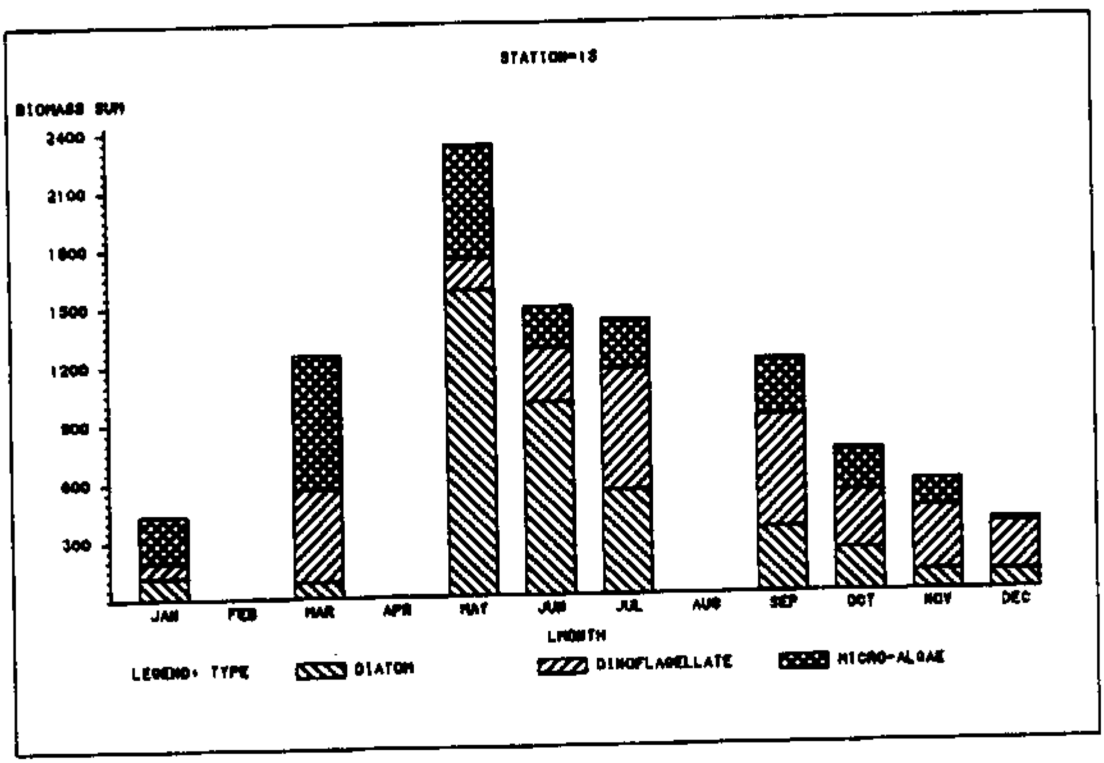
AUG
SEP
OCT
NOV
DEC
LMONTH
LEGEND: TYPE
DIATOM
DINOFLAGELLATE
MICRO-ALGAE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MAR
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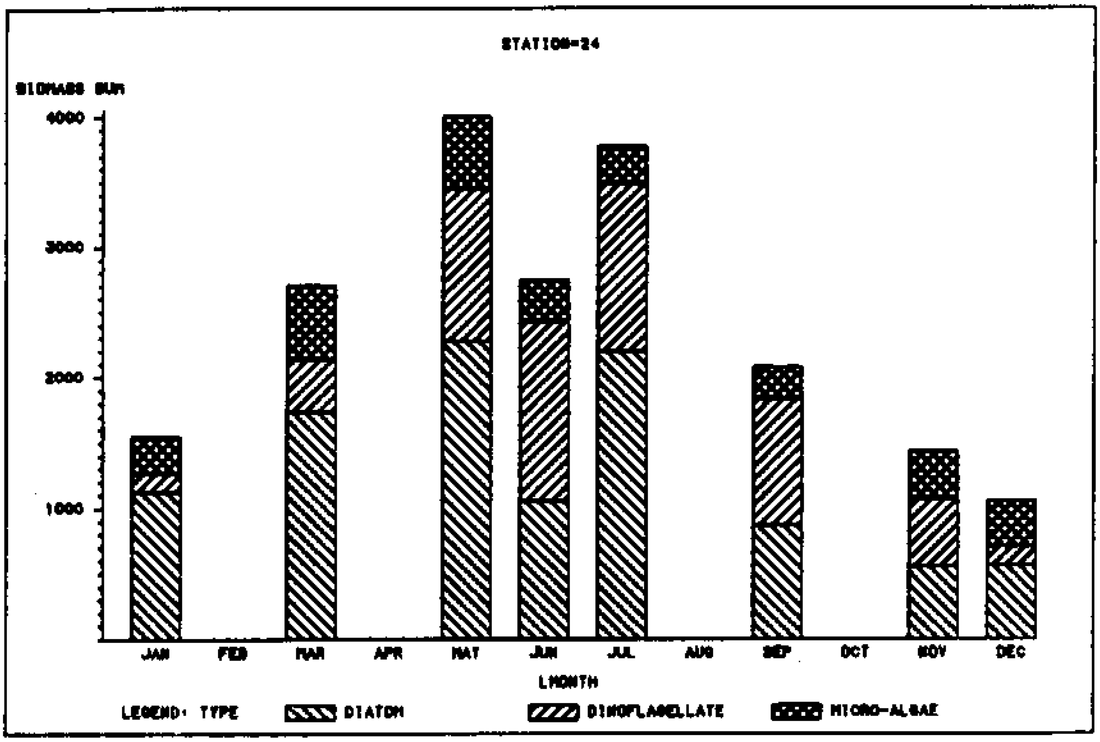
SEP
OCT
NOV
DEC
LMONTH
LEGEND: TYPE
DIATOM
DINOFLAGELLATE
MICRO-ALGAE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MAR
APR
MAY
JUN
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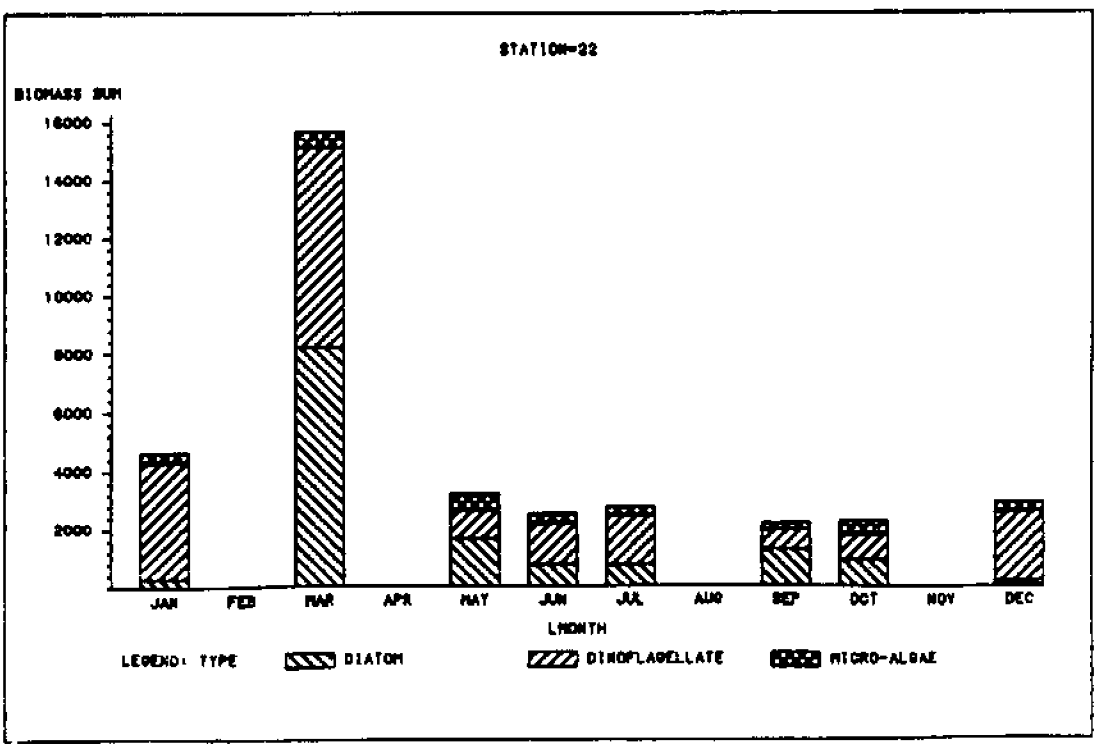
AUG
SEP
OCT
NOV
DEC
LMONTH
LEGEND: TYPE
DIATOM
DINOFLAGELLATE
MICRO-ALGAE


STATION=22
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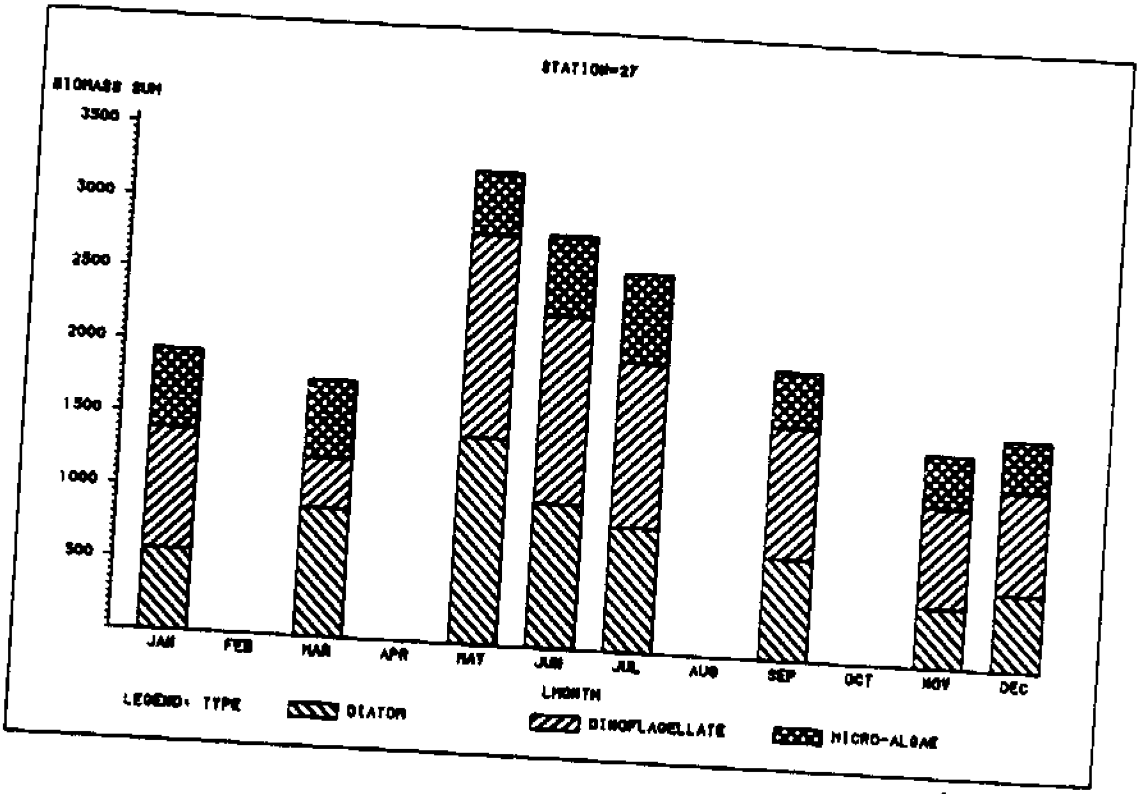
12000
10000
8000
6000
4000
2000
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
LMONTH
LEGEND: TYPE
DIATOM
DINOFLAGELLATE
MICRO-ALGAE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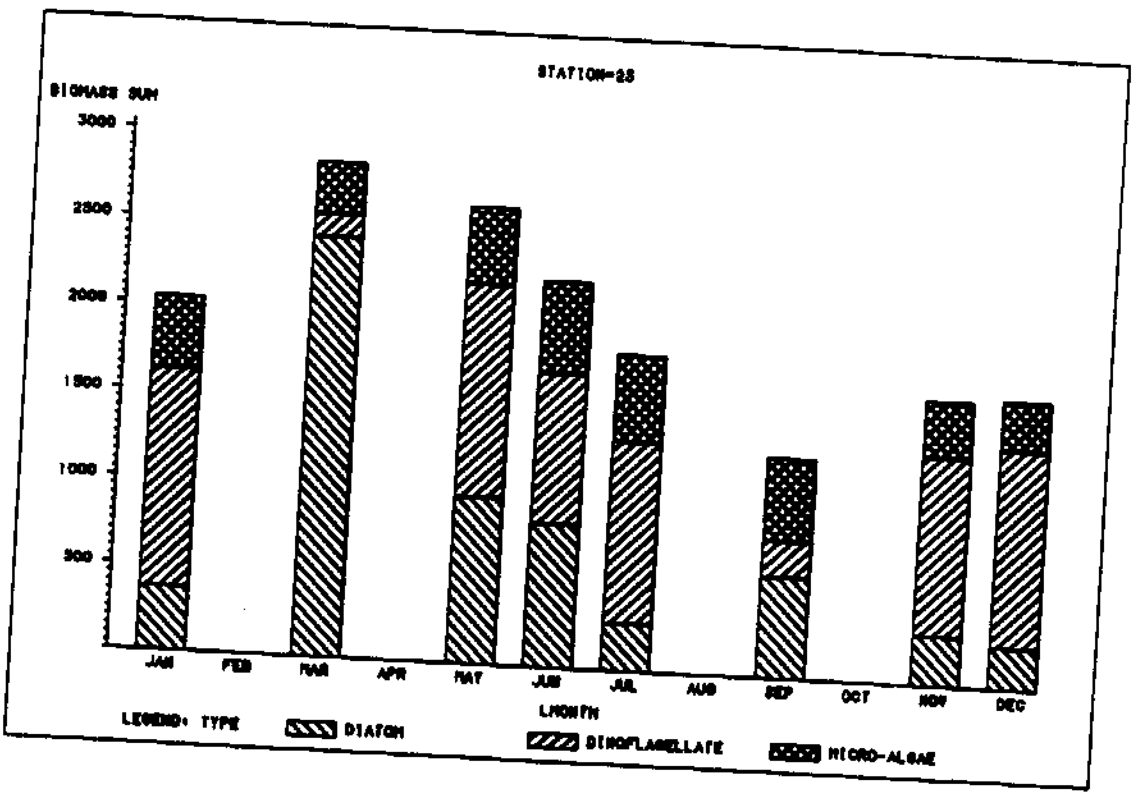
AUG
SEP
OCT
NOV
DEC
LMONTH
LEGEND: TYPE
DIATOM
DINOFLAGELLATE
MICRO-ALGAE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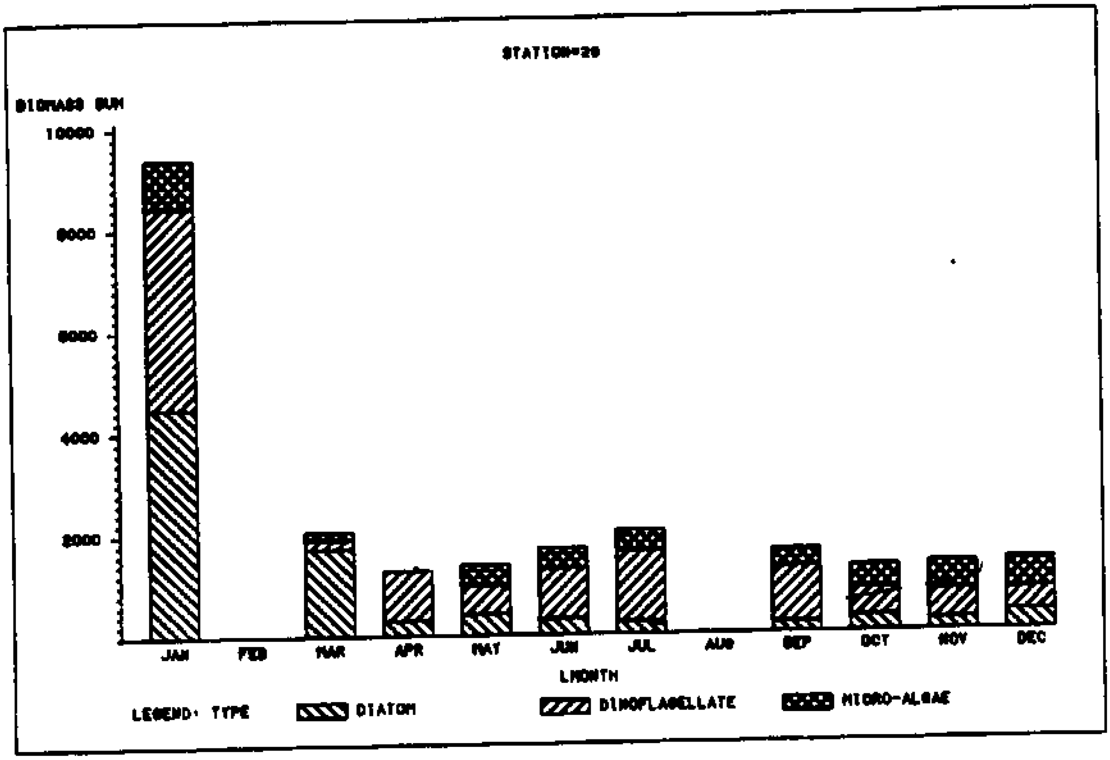
AUG
SEP
OCT
NOV
DEC
LMONTH
LEGEND: TYPE
DIATOM
DINOFLAGELLATE
MICRO-ALGAE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BIOMASS SUM
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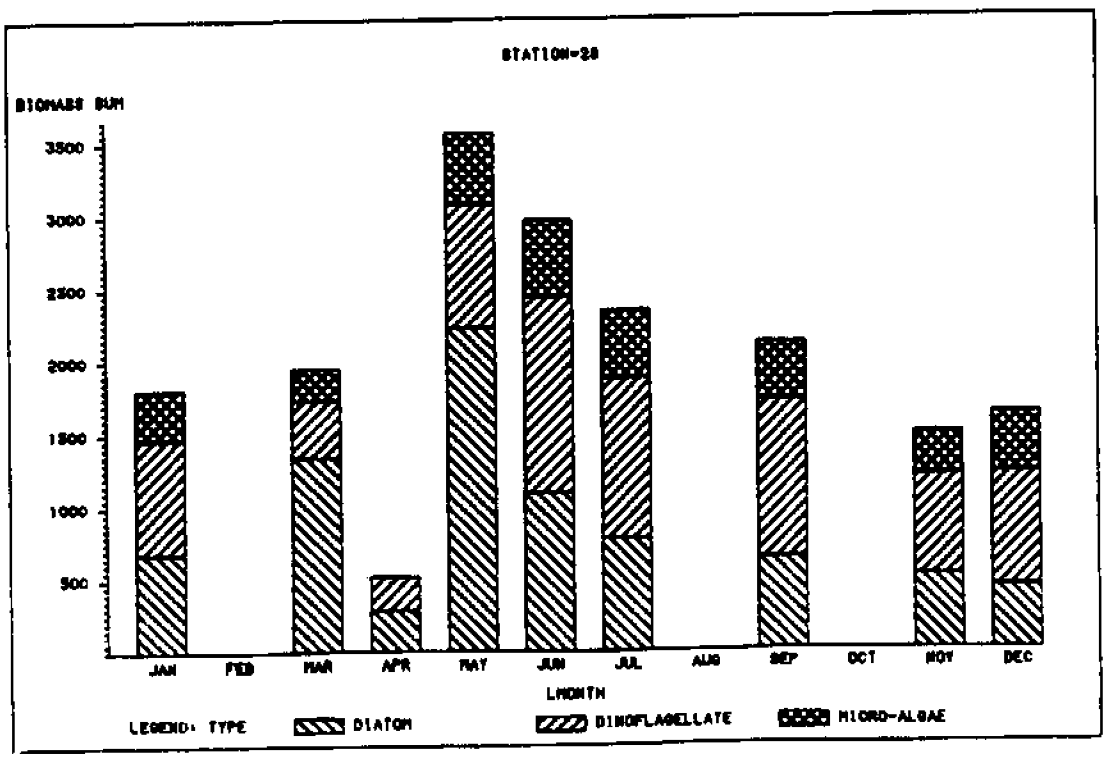
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
LMONTH
LEGEND: TYPE
DIATOM
DINOFLAGELLATE
MICRO-ALGAE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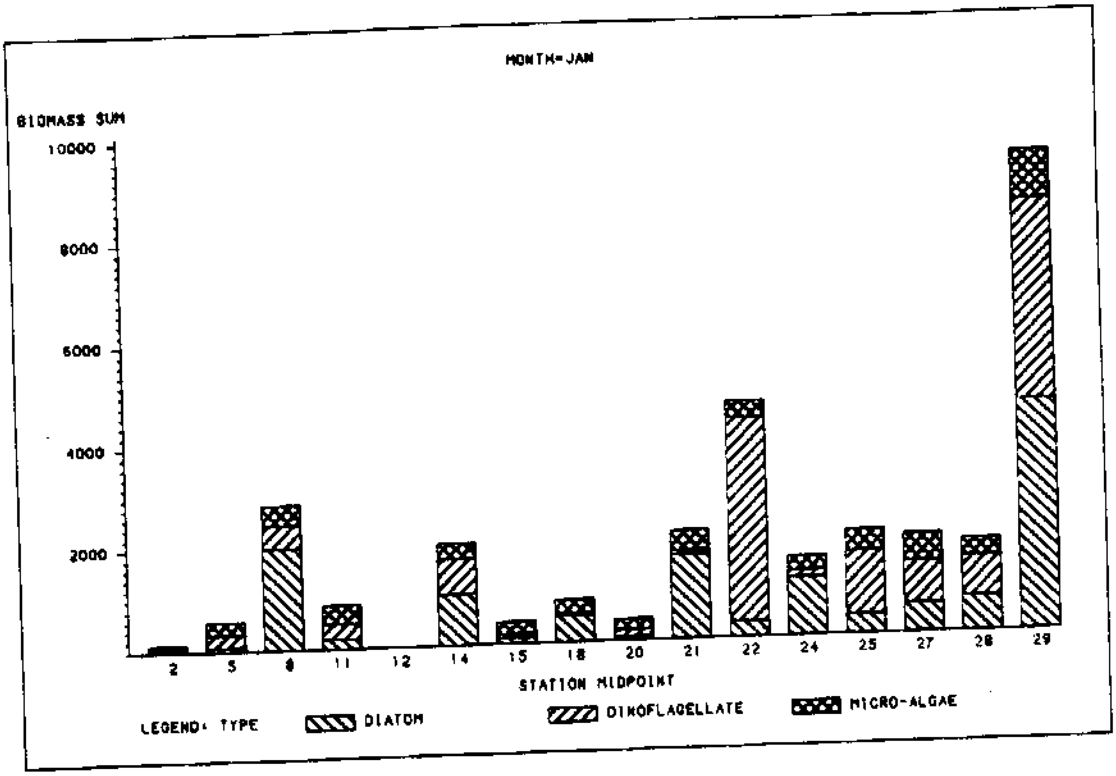
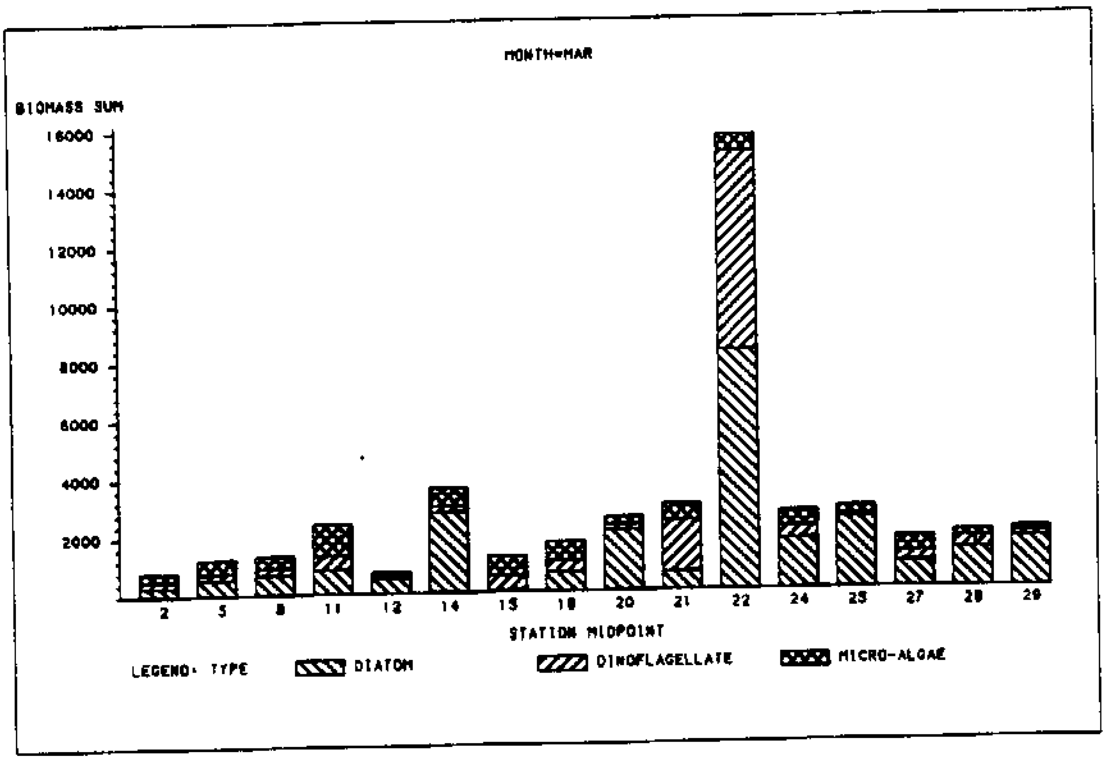
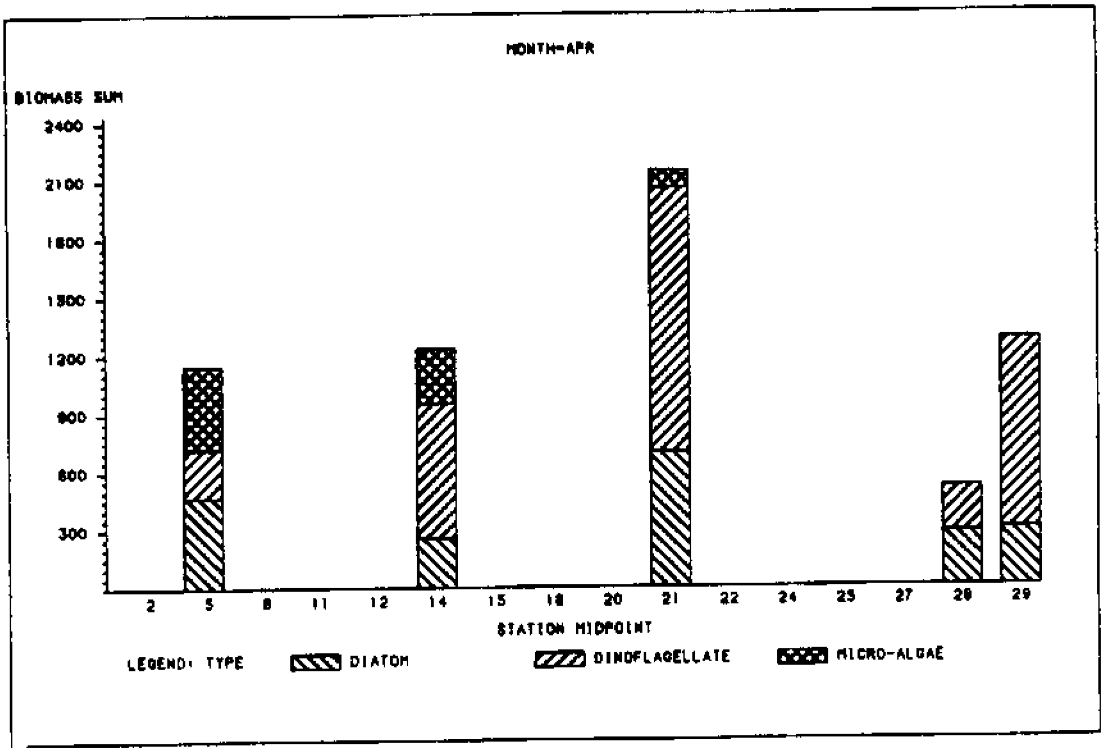
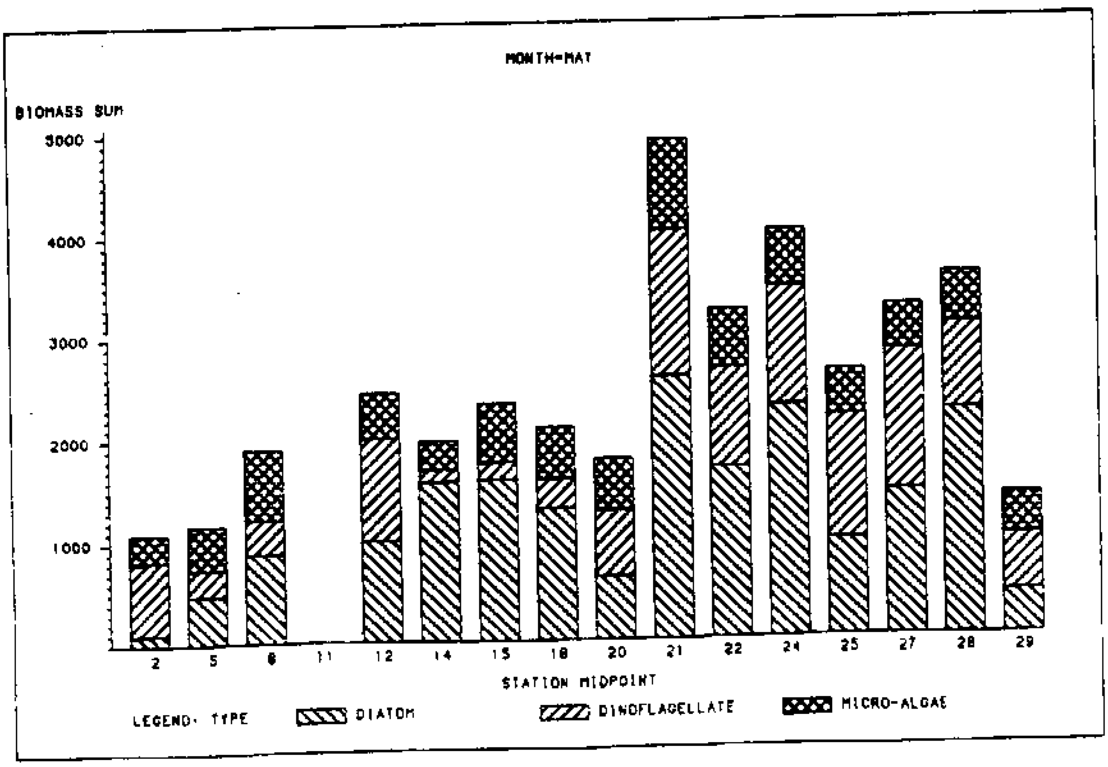
2500
2000
1500
1000
500
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
LMONTH
LEGEND: TYPE
DIATOM
DINOFLAGELLATE
MICRO-ALGAE


MONTH=JAN
BIOMASS SUM
10000
8000
6000
4000
2000
2
5
8
11
12
14
15
18
20
21
22
24
25
27
28
29
STATION MIDPOINT
LEGEND: TYPE
DIATOM
DINOFLAGELLATE
MICRO-ALGAE


MONTH=MAR
BIOMASS SUM
16000
14000
12000
10000
8000
6000
4000
2000
2
5
8
11
12
14
15
18
20
21
22
24
25
27
28
29
STATION MIDPOINT
LEGEND: TYPE
DIATOM
DINOFLAGELLATE
MICRO-ALGAE


MONTH=APR
BIOMASS SUM
2400
2100
1800
1500
1200
900
600
300
2 5 8 11 12 14 15 18 20 21 22 24 25 27 28 29
STATION MIDPOINT
LEGEND: TYPE
DIATOM
DINOFLAGELLATE
MICRO-ALGAE


MONTH=MAY
BIOMASS SUM
5000
4000
3000
2000
1000
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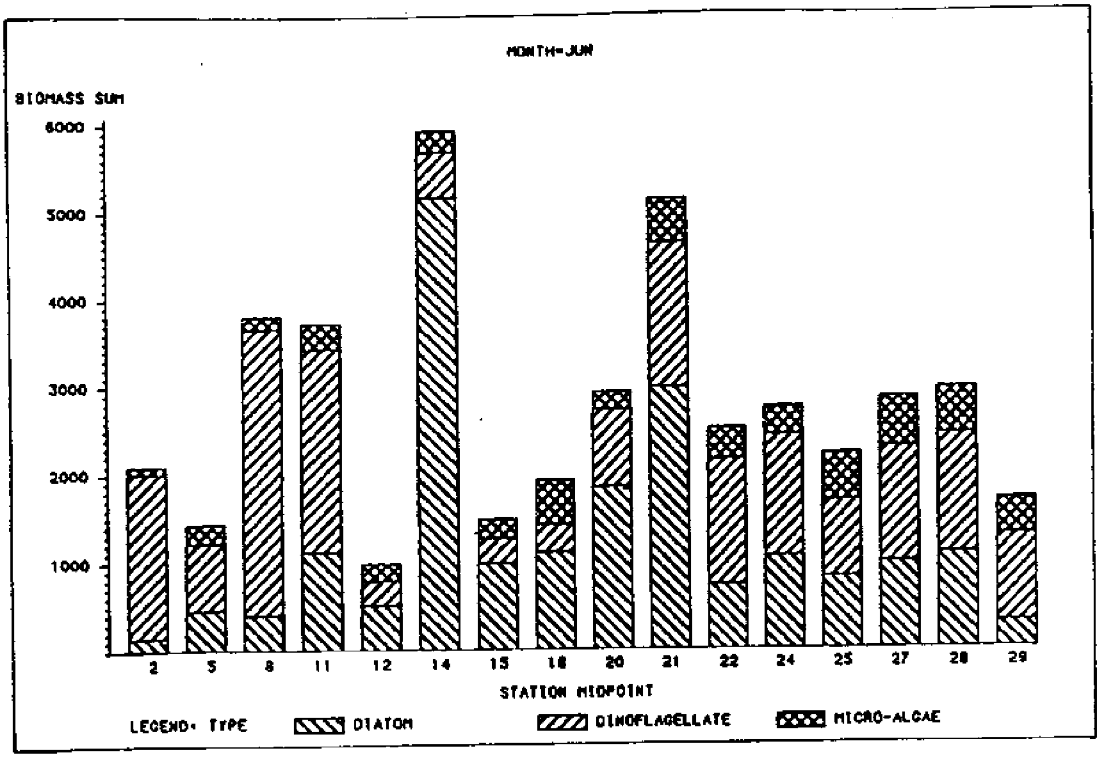
STATION MIDPOINT
LEGEND: TYPE
DIATOM
DINOFLAGELLATE
MICRO-ALGAE


MONTH=JUN
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5000
4000
3000
2000
1000
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STATION MIDPOINT
LEGEND: TYPE
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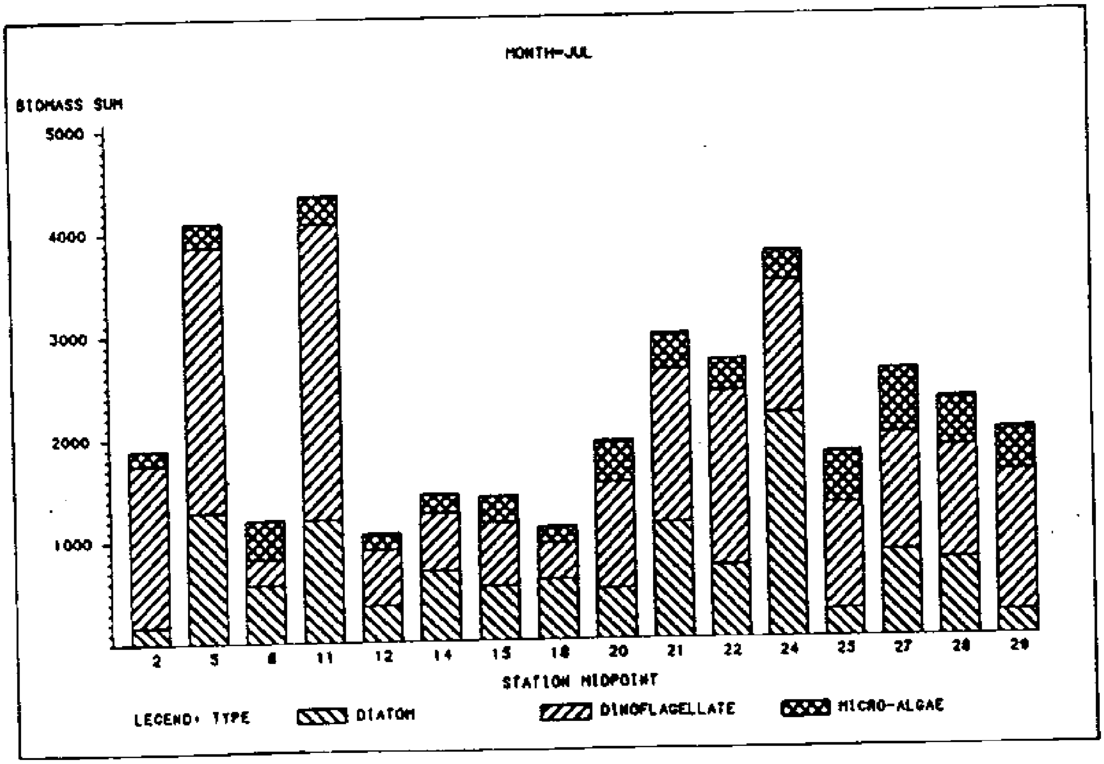
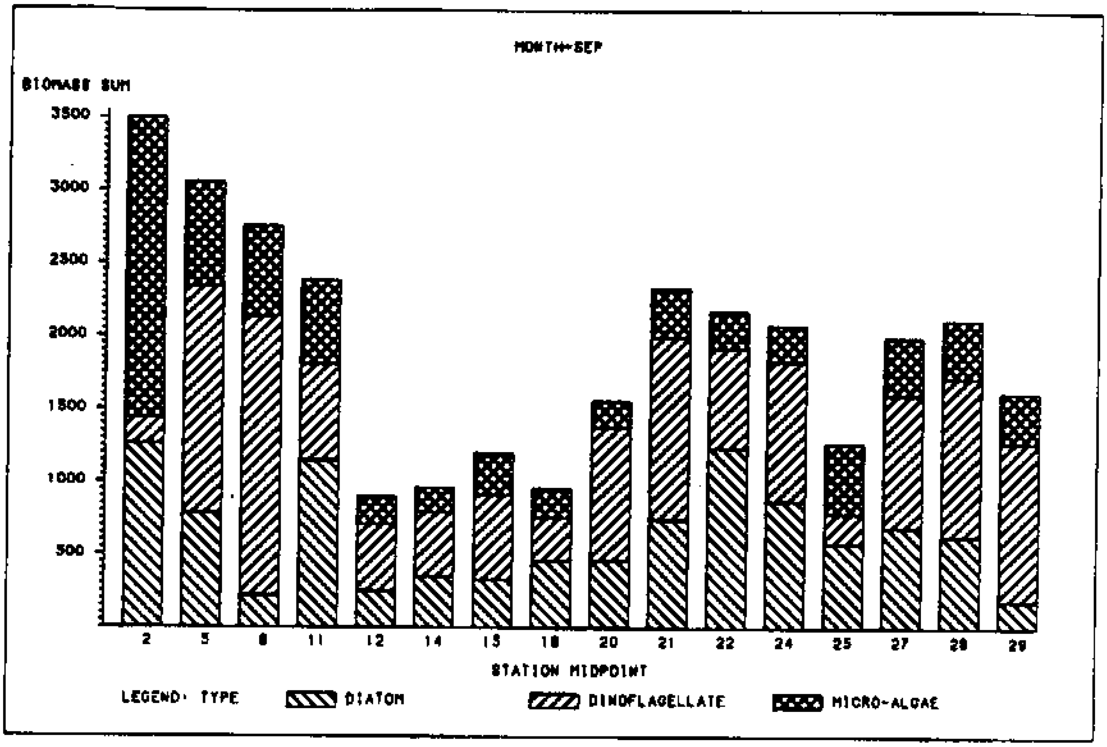
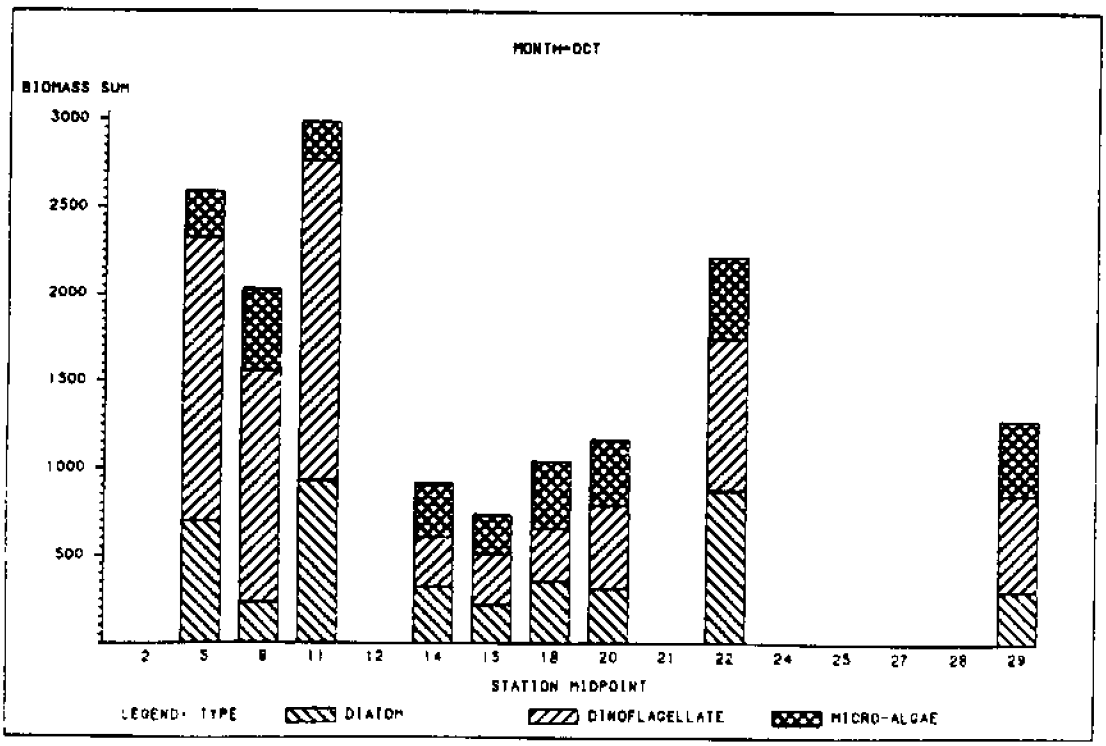
DINOFLAGELLATE
MICRO-ALGAE


MONTH=JUL
BIOMASS SUM
5000
4000
3000
2000
1000
2 5 8 11 12 14 15 18 20 21 22 24 25 27 28 29
STATION MIDPOINT
LEGEND: TYPE
DIATOM
DINOFLAGELLATE
MICRO-ALGAE


MONTH=SEP
BIOMASS SUM
3500
3000
2500
2000
1500
1000
500
2
5
8
11
12
14
15
18
20
21
22
24
25
27
28
29
STATION MIDPOINT
LEGEND: TYPE
DIATOM
DINOFLAGELLATE
MICRO-ALGAE


MONTH=OCT
BIOMASS SUM
3000
2500
2000
1500
1000
500
2
5
8
11
12
14
15
18
20
21
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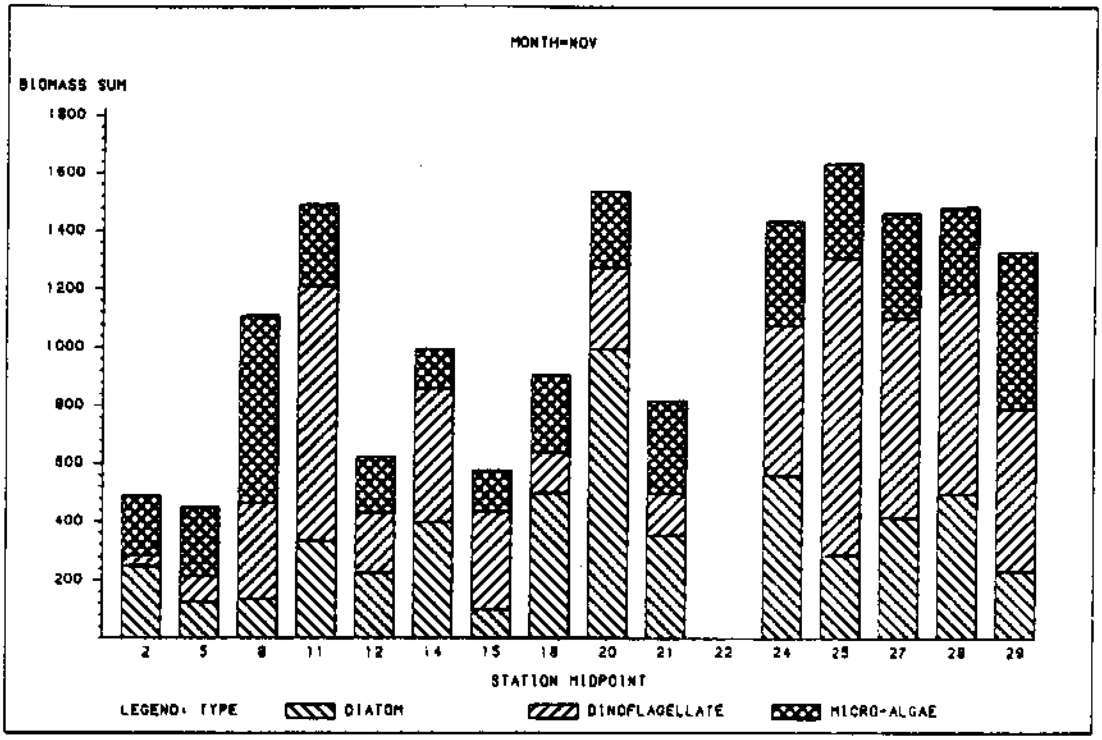
24
25
27
28
29
STATION MIDPOINT
LEGEND: TYPE
DIATOM
DINOFLAGELLATE
MICRO-ALGAE


MONTH=NOV
BIOMASS SUM
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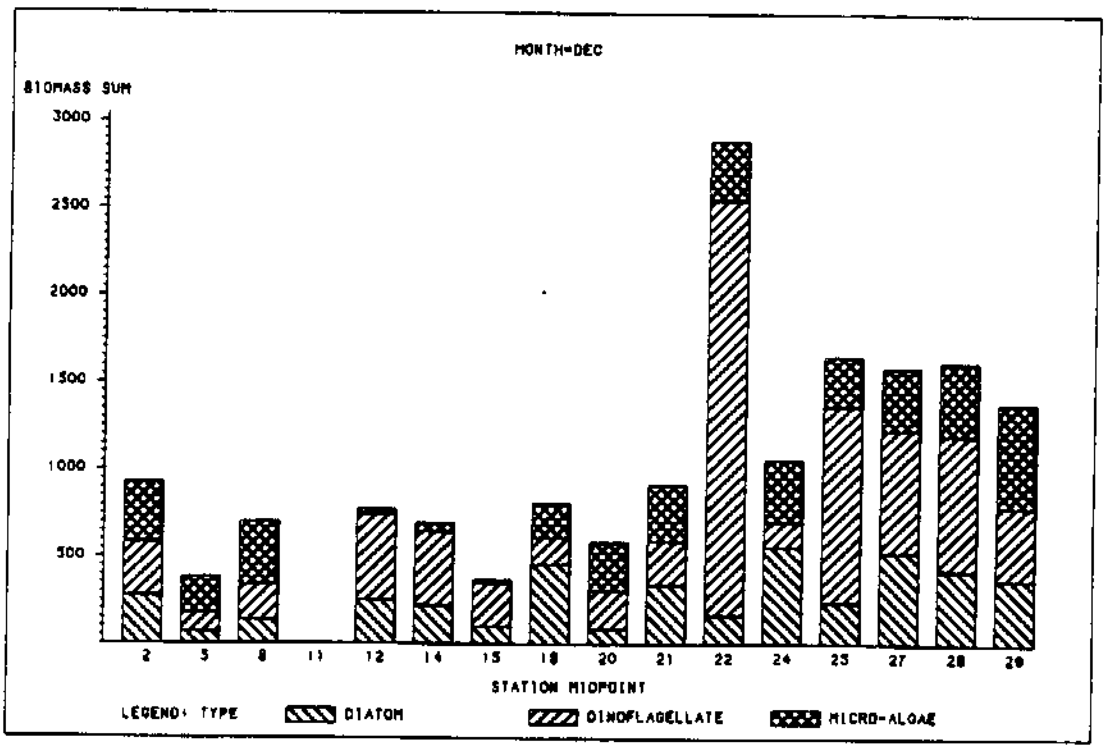
1600
1400
1200
1000
800
600
400
200
2 5 8 11 12 14 15 18 20 21 22 24 25 27 28 29
STATION MIDPOINT
LEGEND: TYPE
DIATOM
DINOFLAGELLATE
MICRO-ALGAE


MONTH=DEC
BIOMASS SUM
3000
2500
2000
1500
1000
500
2 5 8 11 12 14 15 18 20 21 22 24 25 27 28 29
STATION MIDPOINT
LEGEND: TYPE
DIATOM
DINOFLAGELLATE
MICRO-ALGAE

Appendix H: Spacial and Monthly Distributions of Icthyoplankton in Choctawhatchee Bay, 1975.

Month	Number of Fish Larvae									
	Station									
	2	5	7	12	15	18	22	25	27	Total
Jan	0	0	0	0	1	0	0	0	0	1
Mar	0	0	1	2	0	16	10	3	27	59
Apr	23	5	3	0	0	24	81	21	38	197
May	6	0	4	7	55	82	208	375	317	1054
Jun	1	4	1	88	33	10	7	6	27	177
Jul	0	0	0	0	11	0	2	0	12	25
Sep	0	2	1	0	0	10	8	8	34	63
Oct	0	3	0	0	0	0	0	0	0	3
Nov	0	0	1	0	0	0	0	0	0	1
Dec	0	0	0	0	0	0	0	0	0	0

Number of Fish Eggs

Month	Station 2	5	7	12	15	18	22	25	27	Total
Jan	2	1	3	0	1	1	0	0	0	8
Mar	0	0	0	0	1	0	2	0	0	3
Apr	0	0	0	0	0	0	0	0	0	0
May	0	0	0	0	0	15	137	233	37	422
Jun	0	0	0	2	0	51	1	242	11	307
Jul	0	0	1	5	789	93	25	981	1328	3222
Sep	1	0	25	33	68	241	106	985	557	2018
Oct	0	0	0	0	0	0	0	0	0	0
Nov	0	0	0	0	0	0	0	0	0	0
Dec	0	0	0	0	0	0	0	0	0	0

Total *Menidia beryllina* Larvae

Month	Station 2	5	7	12	15	18	22	25	27	Total
Jan	0	0	0	0	0	0	0	0	0	0
Mar	0	0	0	0	0	16	10	3	25	54
Apr	0	4	1	0	0	10	61	10	12	101
May	6	0	0	1	14	34	70	66	0	191
Jun	0	2	0	2	16	9	7	5	27	68
Jul	0	0	0	0	11	0	1	0	3	15
Sep	0	1	1	0	0	10	1	8	33	54
Oct	0	3	0	0	0	0	0	-	-	3
Nov	0	0	0	0	0	-	0	0	-	0
Dec	0	0	0	0	0	0	0	0	0	0

Total Anchoa Larvae

Month	Station									
	2	5	7	12	15	18	22	25	27	Total
Jan	0	0	0	0	0	0	0	0	0	0
Mar	0	0	0	0	0	0	0	0	1	1
Apr	23	0	1	2	0	14	16	9	26	91
May	0	0	0	6	40	46	131	306	317	846
Jun	1	2	0	86	17	1	0	0	0	107
Jul	0	0	0	0	0	0	1	0	9	10
Sep	0	0	0	0	0	0	7	0	1	8
Oct	0	0	0	0	0	0	0	-	-	0
Nov	0	0	1	0	0	-	0	0	-	1
Dec	0	0	0	0	0	0	0	0	0	0

Appendix I: Numbers of Zooplankton/Liter Found During Each Month at Each Station During 1975.

January

Zooplankton Group	Station								
	2	5	7	12	15	18	22	25	27
Insects	0	143	0	0	0	71	143	0	0
Dipteran Larvae	143	0	0	0	0	0	0	0	0
Copepod Nauplii	0	429	429	0	286	0	0	1714	1286
Calanoid Copepods	0	0	36	0	0	0	429	2714	286
Acartia tonsa	9000	26929	22357	06071	211429	226071	289714	544571	53571
Harpacticoid Copepods	929	0	0	0	0	0	0	0	929
Microsetella sp.	1143	571	0	0	0	0	0	0	0
Penilla sp.	929	357	0	143	0	0	0	143	0
Evadne sp.	0	0	0	0	0	0	0	571	0
Podon sp.	1071	571	857	3357	1286	388000	301286	554143	20785
Scapholeberis sp.	214	0	0	0	0	0	0	0	0
Alona sp.	214	2071	71	0	0	0	0	0	0
Chydoris sp.	17143	1286	517	0	0	0	0	0	0
Bosmina sp.	2857	1286	571	0	0	0	0	0	0
Ostrocods	4286	1214	286	214	0	0	0	1714	0
Barnacle Naupli	0	143	679	71	0	0	0	429	500
Acarina sp.	143	214	0	0	0	0	0	0	0
Brachionus sp.	0	0	0	0	0	0	0	0	12929
Veliger Larvae	0	0	0	0	0	1714	0	0	0
Oihipleura sp.	0	0	0	0	0	1714	0	0	0
Mnemiopsis sp.	0	0	0	0	0	71	0	0	71

Appendix I: Numbers of Zooplankton/Liter Found During Each Month at Each Station During 1975.

January

Species	Station 2	5	7	12	15	18	22	25	27
Insecta	0	143	0	0	0	71	143	0	0
Dipteran larvae	143	0	0	0	0	0	0	0	0
Copepoda nauplii	0	429	429	0	286	0	0	1714	1286
Oncaea	0	0	0	0	0	0	0	0	0
Calanoida	0	0	36	0	0	0	429	2714	286
Acartia tonsa	9000	26929	22357	106071	231429	226071	289714	544571	53571
Harpacticoida	929	0	0	0	0	0	0	0	929
Microsetella	1143	571	0	0	0	0	0	0	0
Zoea	0	0	0	0	0	0	0	0	0
Penilla	929	357	0	143	0	0	0	143	0
Evadne	0	0	0	0	0	0	0	571	0
Podon	1071	571	857	3357	1286	388000	301286	554143	207857
Scapholeberis	214	0	0	0	0	0	0	0	0
Alona	214	2071	71	0	0	0	0	0	0
Chydoris	17143	1286	517	0	0	0	0	0	0
Ceriodaphnia	0	0	0	0	0	0	0	0	0
Bosmina	2857	1286	571	0	0	0	0	0	0
Ostracoda	4286	1214	286	214	0	0	0	1714	0
Balanus nauplii	0	143	679	71	0	0	0	429	500
Lucifer faxoni	0	0	0	0	0	0	0	0	0
Acarina	143	214	0	0	0	0	0	0	0
Rotifera	0	0	0	0	0	0	0	0	0
Brachionus	0	0	0	0	0	0	0	0	12929
Polychaeta	0	0	0	0	0	0	0	0	0
Veligers	0	0	0	0	0	1714	0	0	0
Echinodermata	0	0	0	0	0	0	0	0	0
Oikipleura	0	0	0	0	0	1714	0	0	0
Mnemiopsis	0	0	0	0	0	71	0	0	71

Appendix I: Numbers of Zooplankton/Liter Found During Each Month at Each Station During 1975.

March

Species	Station 2	5	7	12	15	18	22	25	27
Insecta	214	143	0	0	0	0	125	1000	0
Dipteran larvae	1429	0	0	0	0	0	0	0	0
Copepoda nauplii	143	429	8000	0	36000	1000	375	4000	3000
Oncaea	71	0	0	0	0	0	0	0	0
Calanoida	0	0	9000	0	0	200	2125	0	2000
Acartia tonsa	9643	51071	1344000	89000	3008000	21000	918750	465000	475000
Harpacticoida	857	0	0	0	0	1000	1500	5000	31000
Microsetella	0	0	0	0	0	0	0	0	0
Zoea	0	0	0	0	0	0	0	0	0
Penilia	214	0	1000	0	3000	0	875	0	0
Evadne	143	0	0	0	0	0	0	0	0
Podon	500	286	253000	3500	646000	1000	64750	36000	327000
Scapholeberis	429	0	0	0	0	0	0	0	0
Alona	857	0	0	0	0	0	0	0	0
Chydoris	4500	0	0	0	0	0	0	2000	9000
Ceriodaphnia	0	0	0	0	0	0	0	0	0
Bosmina	4500	0	0	0	0	0	0	2000	0
Ostracoda	4000	0	1500	0	0	0	500	0	0
Balanus nauplii	0	214	0	0	0	0	0	2000	9000
Lucifer faxoni	0	0	0	0	0	0	0	0	0
Acarina	143	0	0	0	0	200	0	0	0
Rotifera	0	0	0	0	0	0	0	0	0
Brachionus	0	0	0	0	0	0	0	0	5000
Polychaeta	0	0	0	0	0	0	0	0	0
Veligers	0	0	0	0	0	0	0	0	0
Echinodermata	0	0	0	0	0	0	0	0	0
Oikipleura	0	0	0	0	0	0	0	0	0
Mnemiopsis	0	0	500	0	1000	0	125	1000	0

Appendix I: Numbers of Zooplankton/Liter Found During Each Month at Each Station During 1975.

April

Species	Station 3	4	5	12	15	18	22	25	27
Insecta	0	0	500	0	111	167	0	0	0
Dipteran larvae	0	500	0	0	0	1667	0	333	0
Copepoda nauplii	0	0	0	667	0	0	24000	1667	2500
Oncaea	0	0	0	0	0	0	0	0	0
Calanoida	0	0	0	333	0	0	0	0	0
Acartia tonsa	2250	5500	9500	27000	39556	14333	581000	210333	33500
Harpacticoida	1500	1000	1500	1000	778	1333	1000	1333	0
Microsetella	0	0	0	0	0	0	1000	0	0
Zoea	0	0	0	0	0	0	0	0	0
Penilia	250	0	150	0	0	0	0	0	0
Evadne	0	0	0	0	0	0	0	0	0
Podon	4250	0	0	0	111	2167	100000	2333	13500
Scapholeberis	250	0	0	0	444	1667	1000	0	0
Alona	2500	0	0	0	556	167	0	0	500
Chydoris	2000	1500	1000	0	2556	0	0	0	500
Ceriodaphnia	0	0	0	0	0	0	0	0	0
Bosmina	2000	1500	1000	0	2556	0	0	0	500
Ostracoda	750	0	1500	0	333	667	2000	0	0
Balanus nauplii	0	2000	500	0	0	0	3000	0	0
Lucifer faxoni	0	0	0	0	0	0	0	0	0
Acarina	0	500	0	0	222	0	0	0	0
Rotifera	0	0	0	0	0	0	0	0	0
Brachionus	250	750	0	0	1778	0	0	0	0
Polychaeta	0	0	0	0	0	0	0	0	0
Veligers	0	0	0	0	0	0	0	0	0
Echinodermata	0	0	0	0	0	0	0	0	0
Oikipleura	0	0	0	0	0	0	0	0	0
Mnemiopsis	0	0	0	333	0	0	0	0	0

Appendix I: Numbers of Zooplankton/Liter Found During Each Month at Each Station During 1975.

May

Species	Station 2	5	7	12	15	18	22	25	27
Insecta	0	0	0	0	0	0	0	0	0
Dipteran larvae	1500	0	0	0	0	0	0	0	0
Copepoda nauplii	5000	42000	24000	19000	32000	4500	2000	6000	3000
Oncaea	1500	0	0	0	0	0	0	0	0
Calanoida	0	0	3000	18000	0	1500	0	5000	0
Acartia tonsa	5250	3426000	1654000	2840000	7250000	179000	893000	1146000	286000
Harpacticoida	5000	72000	0	15000	164000	4000	0	13000	51000
Microsetella	0	0	0	0	0	0	0	0	0
Zoea	0	0	0	2000	0	0	0	0	1000
Penilia	5000	0	1000	0	0	0	0	0	0
Evadne	0	0	0	0	0	0	0	0	0
Podon	0	0	0	0	6000	0	0	0	0
Scapholeberis	0	0	0	0	0	0	0	0	0
Alona	1750	0	0	0	0	0	0	0	0
Chydoris	0	0	0	0	0	0	0	0	0
Ceriodaphnia	0	0	0	0	0	0	0	0	0
Bosmina	0	0	0	0	0	0	0	0	0
Ostracoda	0	0	0	0	0	0	0	0	0
Balanus nauplii	0	0	0	3000	0	0	0	2000	12000
Lucifer faxoni	0	0	0	0	0	0	0	0	0
Acarina	0	0	0	0	0	0	0	0	0
Rotifera	0	0	0	0	0	0	0	0	0
Brachionus	500	0	0	4000	62000	2000	3000	41000	24000
Polychaeta	0	0	0	0	0	0	0	0	0
Veligers	0	2000	0	2000	0	0	0	8000	0
Echinodermata	0	0	0	0	0	0	0	0	0
Oikipleura	0	2000	0	2000	0	0	0	8000	0
Mnemiopsis	0	0	1000	1000	0	500	1000	1000	1000

Appendix I: Numbers of Zooplankton/Liter Found During Each Month at Each Station During 1975.

June

Species	Station								
	2	5	7	12	15	18	22	25	27
Insecta	0	0	0	0	0	0	0	0	0
Dipteran larvae	0	167	0	0	0	0	0	0	0
Copepoda nauplii	0	500	0	0	0	0	0	0	0
Oncaea	0	0	0	0	0	0	0	0	0
Calanoida	0	0	0	6000	0	333	0	0	208000
Acartia tonsa	41000	31333	81000	880000	85000	73000	5900000	60000	9000
Harpacticoida	1000	1000	0	1000	1500	5333	36000	26000	0
Microsetella	0	0	0	0	0	0	0	0	0
Zoea	333	0	0	0	0	0	0	0	0
Penilla	333	1500	0	0	0	0	0	0	0
Evadne	0	0	0	0	0	9667	0	3000	0
Podon	0	0	0	0	0	0	0	0	0
Scapholeberis	333	0	0	0	0	0	0	0	0
Alona	0	0	0	0	0	0	0	0	0
Chydoris	0	0	0	0	0	0	0	0	0
Ceriodaphnia	0	0	0	0	0	0	0	0	0
Bosmina	0	0	0	0	0	0	0	0	0
Ostracoda	0	0	0	0	0	0	0	0	0
Balanus nauplii	0	0	0	1000	1000	0	0	0	1000
Lucifer faxoni	0	0	0	0	500	0	0	0	0
Acarina	0	0	0	0	0	0	0	1000	0
Rotifera	0	0	0	0	0	0	0	0	0
Brachionus	3000	2333	333	23000	13000	1667	132000	274000	792000
Polychaeta	0	0	0	0	0	0	0	0	0
Veligers	0	1000	0	2000	4500	0	2000	2000	0
Echinodermata	333	0	0	0	0	0	0	0	0
Oikipleura	0	1000	0	2000	4500	0	2000	2000	0
Mnemiopsis	0	0	333	0	0	0	2000	0	0

Appendix I: Numbers of Zooplankton/Liter Found During Each Month at Each Station During 1975.

July

Species	Station 2	5	7	12	15	18	22	25	27
Insecta	0	0	0	0	0	0	0	0	0
Dipteran larvae	667	0	0	0	0	0	0	0	0
Copepoda nauplii	2333	9000	2000	0	0	0	10000	0	0
Oncaea	333	0	0	0	0	13000	0	0	0
Calanoida	0	0	0	0	0	0	0	0	0
Acartia tonsa	3333	106000	31000	17000	51000	504000	1370000	122000	2010000
Harpacticoida	2556	2000	1000	5500	8000	65000	118000	23000	200000
Microsetella	0	0	0	0	0	0	0	0	0
Zoea	2889	0	0	0	0	0	0	0	0
Penilia	2111	0	0	0	0	0	0	0	0
Evadne	0	0	0	0	117000	0	0	115000	1478000
Podon	0	0	0	0	0	0	110000	0	0
Scapholeberis	0	0	0	0	0	0	0	0	0
Alona	333	0	0	0	0	0	0	0	0
Chydoris	0	0	0	0	0	0	0	0	0
Ceriodaphnia	0	0	0	0	0	0	0	0	0
Bosmina	0	0	0	0	0	0	0	0	0
Ostracoda	667	0	0	0	0	0	0	0	2000
Balanus nauplii	0	0	0	0	0	0	0	0	0
Lucifer faxoni	0	0	0	0	0	0	0	0	0
Acarina	444	0	0	0	0	0	0	0	0
Rotifera	0	0	0	0	0	0	4000	0	0
Brachionus	222	1000	4000	0	20000	41000	10000	2000	370000
Polychaeta	111	0	0	0	0	0	0	0	0
Veligers	222	1500	1000	0	2500	0	8000	0	64000
Echinodermata	111	0	0	0	0	0	0	0	0
Oikipleura	222	1500	1000	0	2500	0	9000	0	64000
Mnemiopsis	0	500	333	250	500	1000	2000	1000	0

Appendix I: Numbers of Zooplankton/Liter Found During Each Month at Each Station During 1975.

September

Species	Station								
	2	5	7	12	15	18	22	25	27
Insecta	333	500	0	0	0	500	0	0	667
Dipteran larvae	0	0	0	0	0	0	0	0	0
Copepoda nauplii	0	0	1000	0	4000	0	0	0	0
Oncaea	0	0	0	0	0	0	0	0	0
Calanoida	0	0	0	0	0	0	0	0	0
Acartia tonsa	67667	196000	144000	1081000	1021000	82500	78333	0	130667
Harpacticoida	1667	4500	3000	18000	6000	0	333	0	3000
Microsetella	0	0	0	0	0	0	0	0	0
Zoea	0	0	0	0	0	0	0	0	0
Penilla	0	0	0	0	0	0	0	0	0
Evadne	0	500	0	0	0	1500	0	0	333
Podon	0	0	0	0	0	0	0	0	0
Scapholeberis	0	0	0	0	0	0	0	0	0
Alona	0	0	0	0	0	0	0	0	0
Chydoris	0	0	0	0	0	0	0	0	0
Ceriodaphnia	0	0	0	0	0	0	0	0	0
Bosmina	0	0	0	0	0	0	0	0	0
Ostracoda	0	0	0	0	0	0	667	0	0
Balanus nauplii	0	0	0	0	0	0	333	0	0
Lucifer faxoni	0	0	0	0	0	0	0	0	0
Acarina	0	0	0	0	0	0	0	0	0
Rotifera	0	0	0	0	0	0	0	0	0
Brachionus	0	0	0	0	0	0	0	0	0
Polychaeta	0	0	1000	0	0	0	1000	0	0
Veligers	0	0	0	0	0	0	0	0	0
Echinodermata	333	0	0	0	0	500	0	0	0
Oikipleura	0	0	0	0	0	0	0	0	0
Mnemiopsis	0	0	0	0	0	0	0	0	0

Appendix I: Numbers of Zooplankton/Liter Found During Each Month at Each Station During 1975.

October

Species	Station 2	5	7	12	15	18	22	25	27
Insecta	0	0	0	0	0	0	0	0	0
Dipteran larvae	0	0	0	0	0	0	0	0	0
Copepoda nauplii	0	1000	8000	0	4000	0	0	0	0
Oncaea	278	0	0	0	0	0	0	0	0
Calanoida	0	0	0	0	0	0	0	0	0
Acartia tonsa	0	54000	391000	333500	1021000	0	1135000	0	0
Harpacticoida	2167	0	0	500	6000	0	11000	0	0
Microsetella	56	0	0	0	0	0	0	0	0
Zoea	0	0	0	1000	0	0	0	0	0
Penilia	611	0	1000	0	0	0	0	0	0
Evadne	0	0	0	0	0	0	0	0	0
Podon	0	0	1000	0	0	0	0	0	0
Scapholeberis	6000	0	0	1000	0	0	0	0	0
Alona	944	0	0	0	0	0	0	0	0
Chydoris	389	250	0	0	0	0	0	0	0
Ceriodaphnia	278	0	0	0	0	0	0	0	0
Bosmina	389	250	0	0	0	0	0	0	0
Ostracoda	444	0	1000	0	0	0	3000	0	0
Balanus nauplii	0	0	0	0	0	0	0	0	0
Lucifer faxoni	0	0	0	0	0	0	0	0	0
Acarina	0	0	0	0	0	0	0	0	0
Rotifera	0	0	0	0	0	0	0	0	0
Brachionus	1889	0	0	0	0	0	0	0	0
Polychaeta	111	250	1000	0	0	0	0	0	0
Veligers	389	0	0	0	0	0	0	0	0
Echinodermata	0	0	0	0	0	0	0	0	0
Oikipleura	389	0	0	0	0	0	0	0	0
Mnemiopsis	0	0	0	0	0	0	0	0	0

Appendix I: Numbers of Zooplankton/Liter Found During Each Month at Each Station During 1975.

November

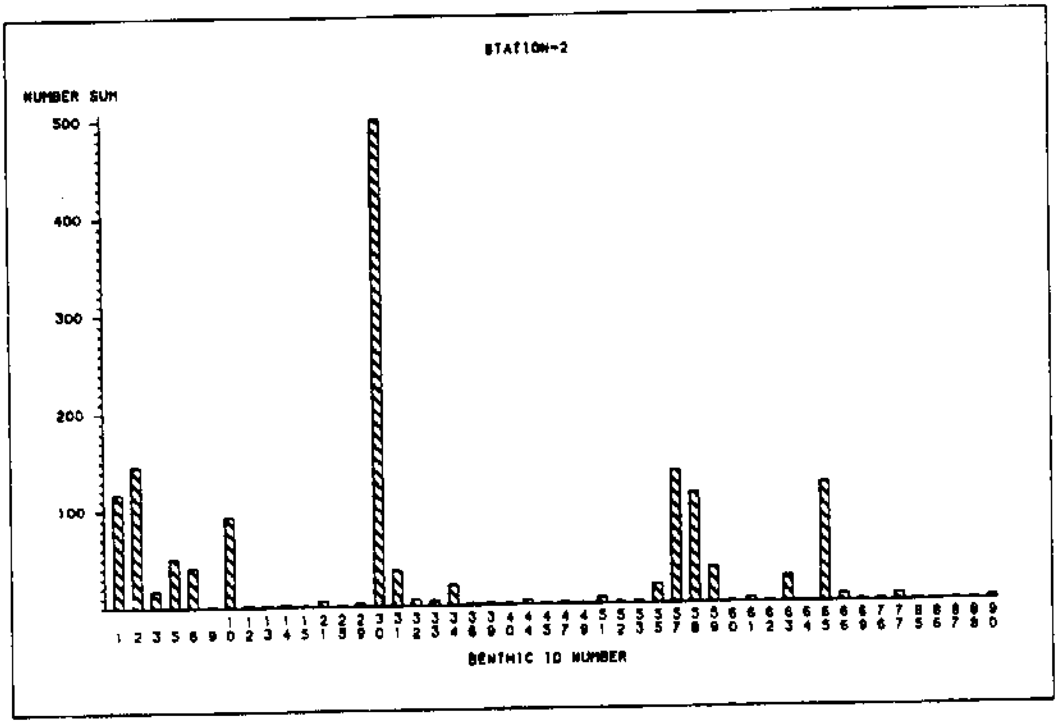
Species	Station 2	5	7	12	15	18	22	25	27
Insecta	0	0	0	0	0	0	0	0	0
Dipteran larvae	0	0	0	0	0	0	0	0	0
Copepoda nauplii	0	0	4000	4000	3667	0	9000	12000	0
Oncaea	0	0	0	0	0	0	0	0	0
Calanoida	0	0	0	0	0	0	0	0	0
Acartia tonsa	63	53600	75000	78000	44000	0	171000	296000	0
Harpacticoida	94	0	4500	8000	4333	0	4500	3000	0
Microsetella	0	0	0	0	0	0	0	0	0
Zoea	0	0	0	0	0	0	0	0	0
Penilla	813	0	0	0	0	0	0	0	0
Evadne	0	0	0	0	0	0	0	0	0
Podon	0	0	0	0	0	0	0	0	0
Scapholeberis	0	0	0	0	0	0	0	0	0
Alona	0	0	0	0	0	0	0	0	0
Chydoris	0	0	0	0	0	0	0	0	0
Ceriodaphnia	0	0	0	0	0	0	0	0	0
Bosmina	0	0	0	0	0	0	0	0	0
Ostracoda	0	0	0	0	0	0	667	0	0
Balanus nauplii	0	200	0	0	0	0	0	0	0
Lucifer faxoni	0	0	0	0	0	0	0	0	0
Acarina	0	0	0	0	0	0	0	0	0
Rotifera	0	0	0	0	0	0	0	0	0
Brachionus	31	0	0	0	0	0	0	0	0
Polychaeta	0	0	0	0	0	0	0	0	0
Veligers	0	0	0	0	0	0	0	0	0
Echinodermata	0	0	0	0	0	0	0	0	0
Oikipleura	0	0	0	0	0	0	0	0	0
Mnemiopsis	0	0	0	0	0	0	0	0	0

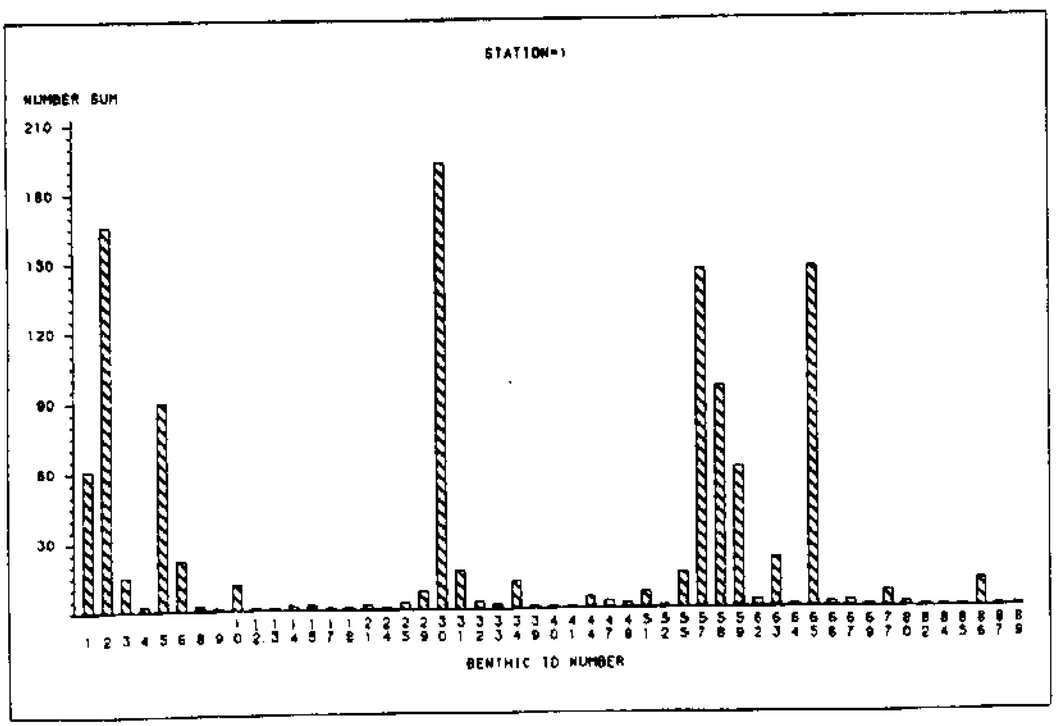
Appendix I: Numbers of Zooplankton/Liter Found During Each Month at Each Station During 1975.

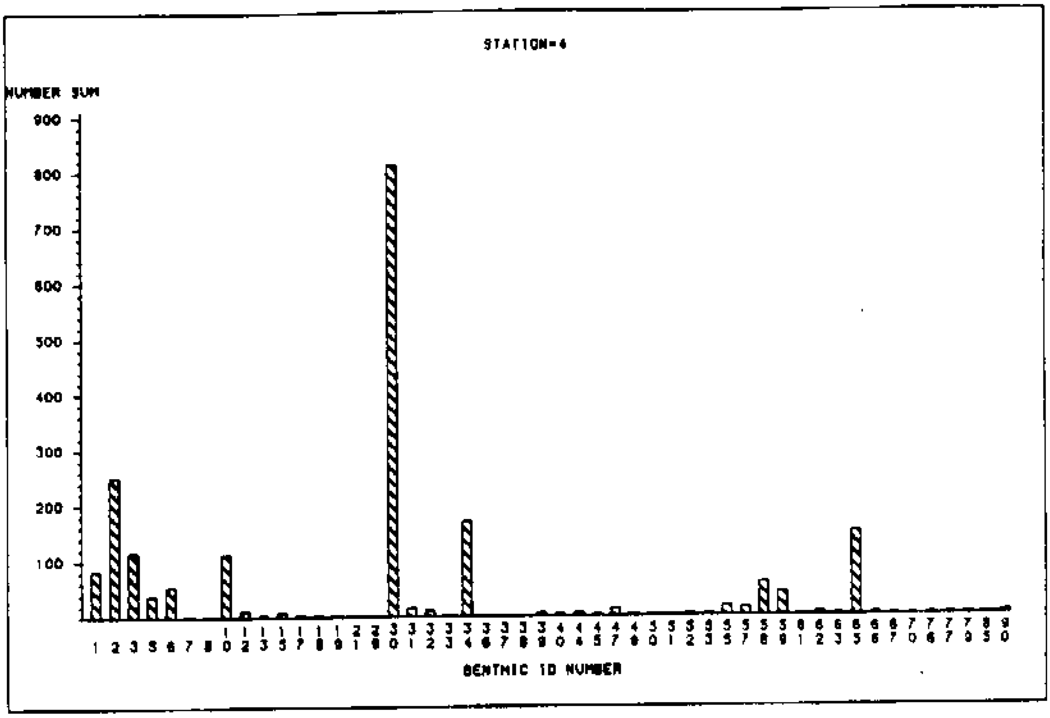
December

Species	2	5	7	12	15	18	22	25	27
Insecta	0	0	0	0	0	0	6000	0	0
Dipteran larvae	167	0	0	0	0	0	0	0	0
Copepoda nauplii	4167	58000	104000	5000	7000	80000	10000	2000	14000
Oncaea	19333	482000	21000	48000	0	8000	0	1000	
Calanoida	5333	4000	17000	61000	8000	60000	38000	21000	5000
Acartia tonsa	87333	4882000	1098000	1171000	891000	3118000	2658000	529000	179000
Harpacticoida	0	0	0	0	0	0	0	0	0
Microsetella	0	0	0	0	0	0	0	0	0
Zoea	0	0	0	0	0	0	0	0	0
Penilia	167	0	0	0	0	0	0	0	0
Evadne	167	0	0	0	0	0	0	0	0
Podon	0	0	0	0	0	0	0	0	0
Scapholeberis	0	0	0	0	0	0	0	0	0
Alona	0	0	0	0	0	0	0	0	0
Chydoris	0	0	0	0	0	0	0	0	0
Ceriodaphnia	0	0	0	0	0	0	0	0	0
Bosmina	0	0	0	0	0	0	0	0	0
Ostracoda	1000	0	0	0	0	0	0	2000	333
Balanus nauplii	167	0	0	0	0	0	0	5000	8000
Lucifer faxoni	0	0	0	0	0	0	0	0	0
Acarina	0	0	0	0	0	0	0	0	0
Rotifera	0	0	0	0	0	0	0	0	0
Brachionus	7000	58000	0	5000	30000	76000	54000	0	0
Polychaeta	500	10000	2000	0	3000	0	2000	0	333
Veligers	0	0	0	0	0	0	0	1000	333
Echinodermata	0	0	0	0	0	0	0	0	0
Oikipleura	0	0	0	0	0	0	0	1000	333
Mnemiopsis	0	0	0	0	0	0	0	0	0

APPENDIX J: Spacial and Monthly Distributions of Benthic Macro Invertebrates in Choctawhatchee Bay in 1975



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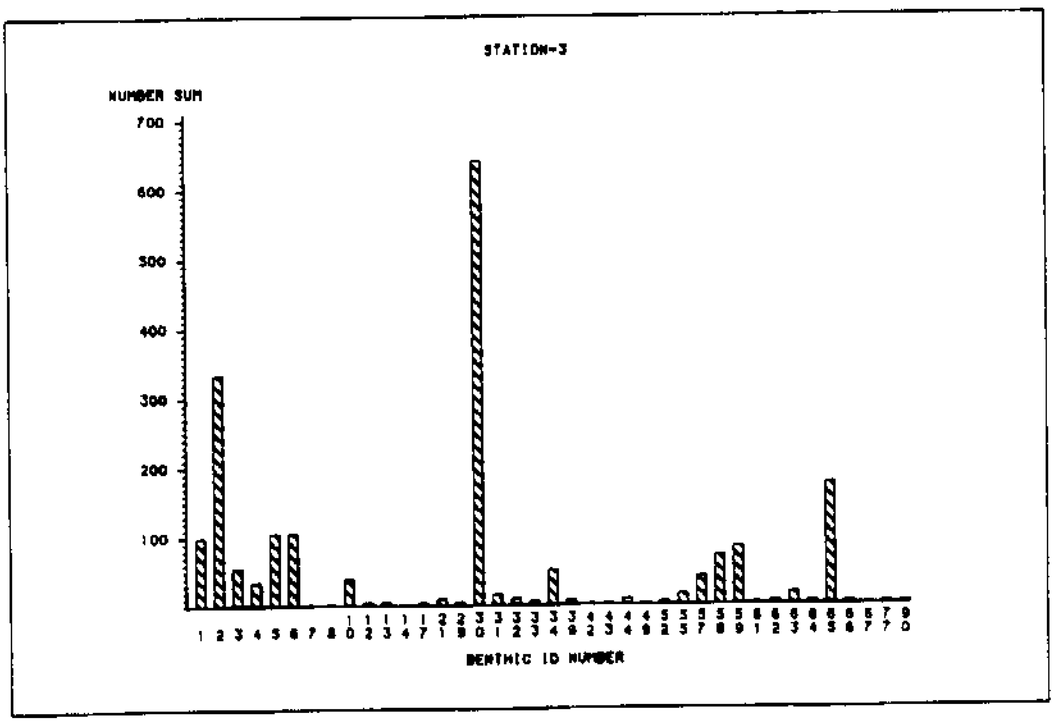
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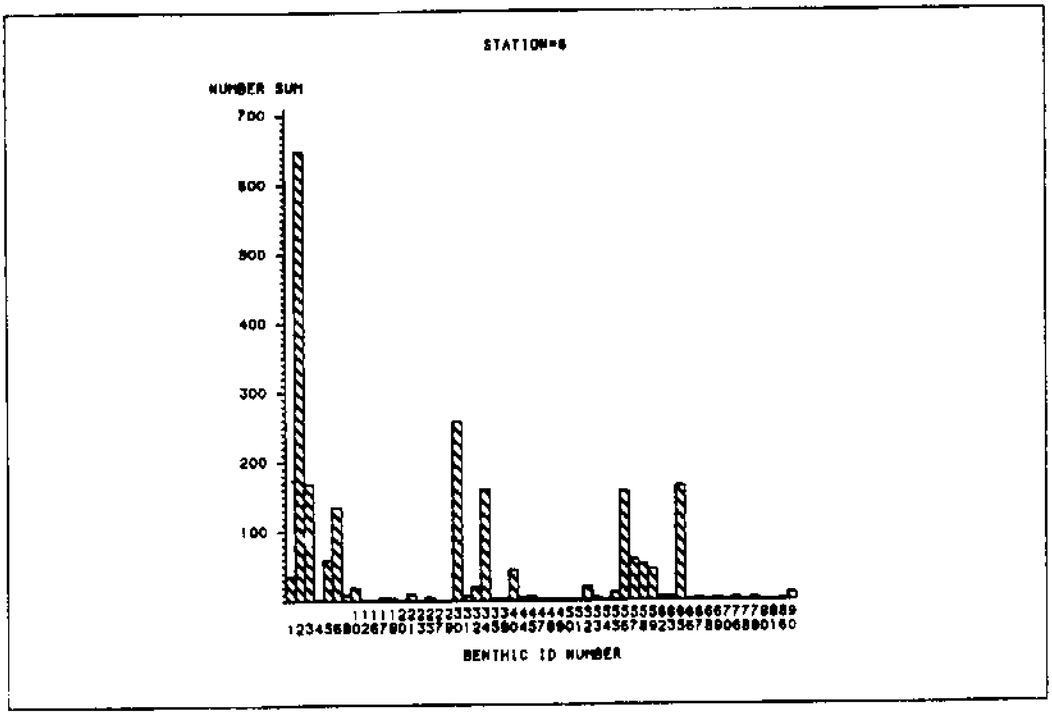
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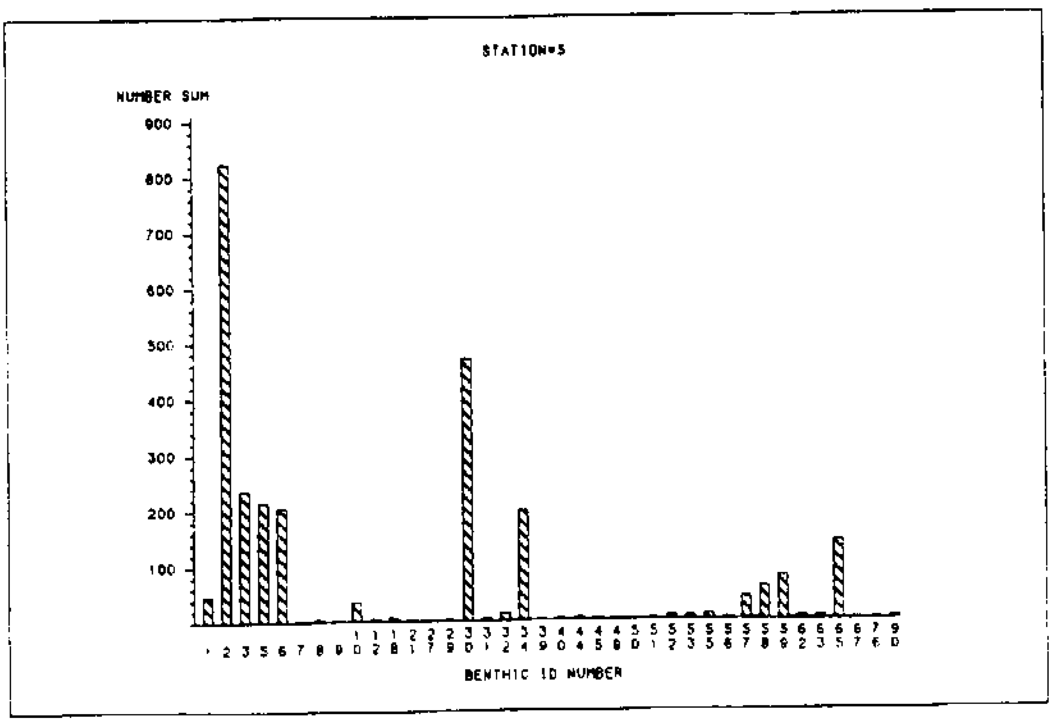
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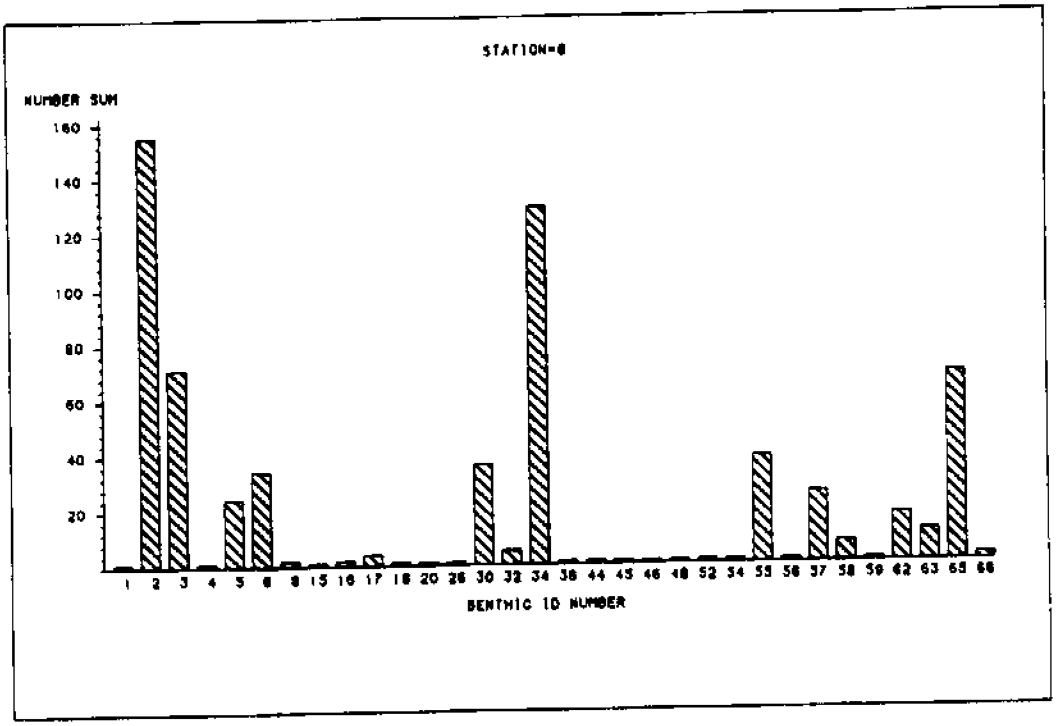
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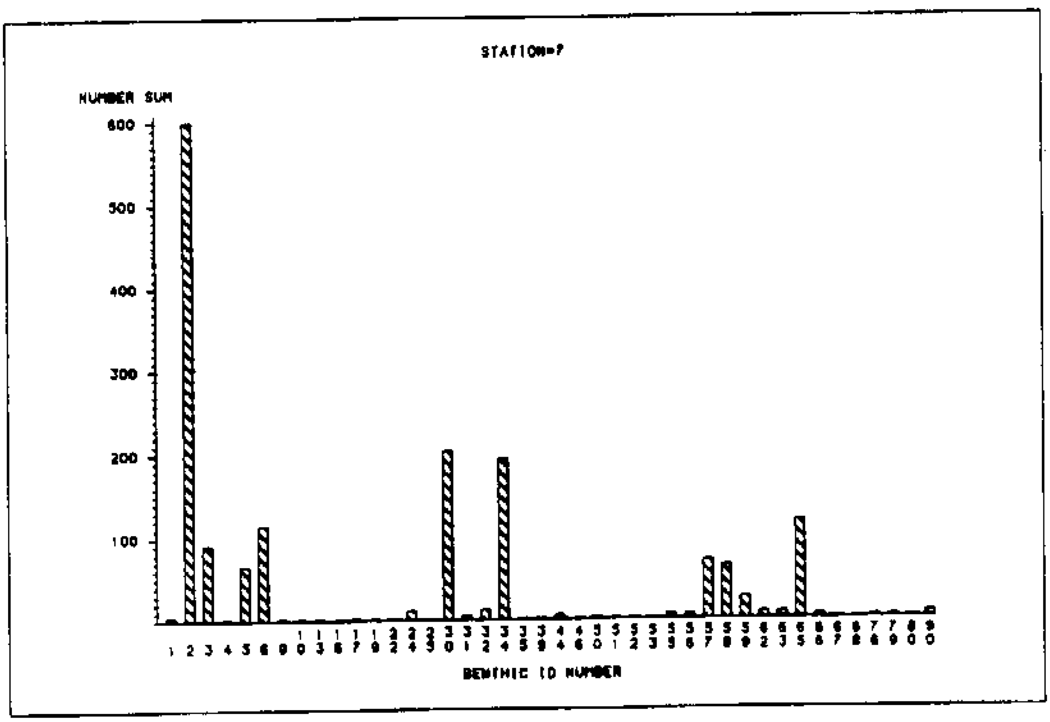
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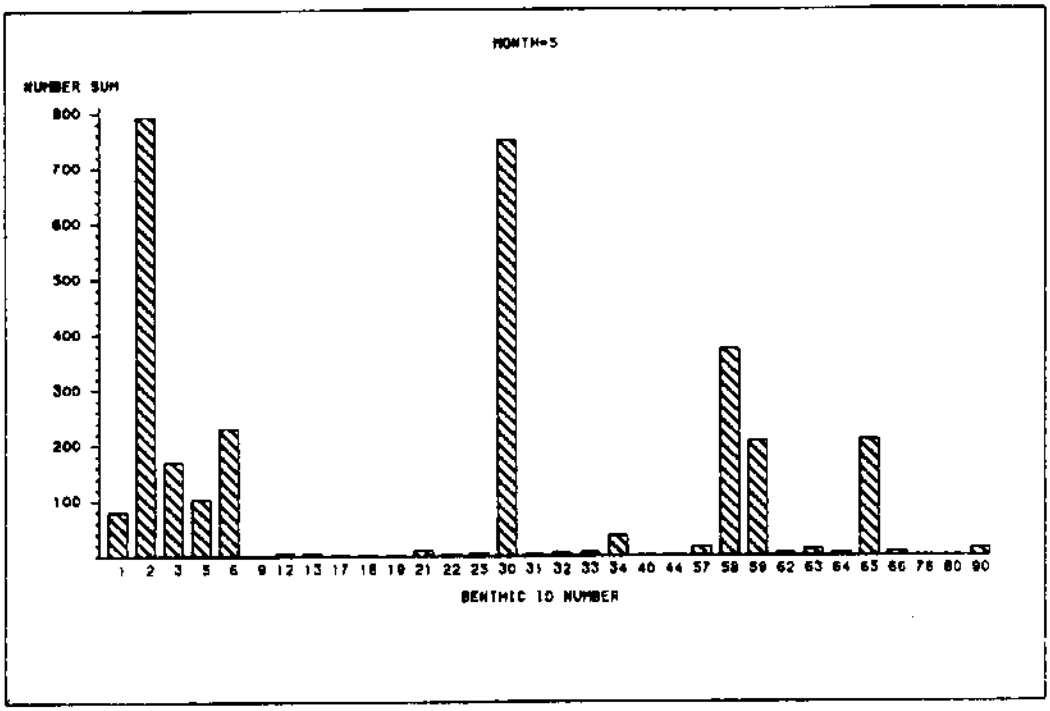
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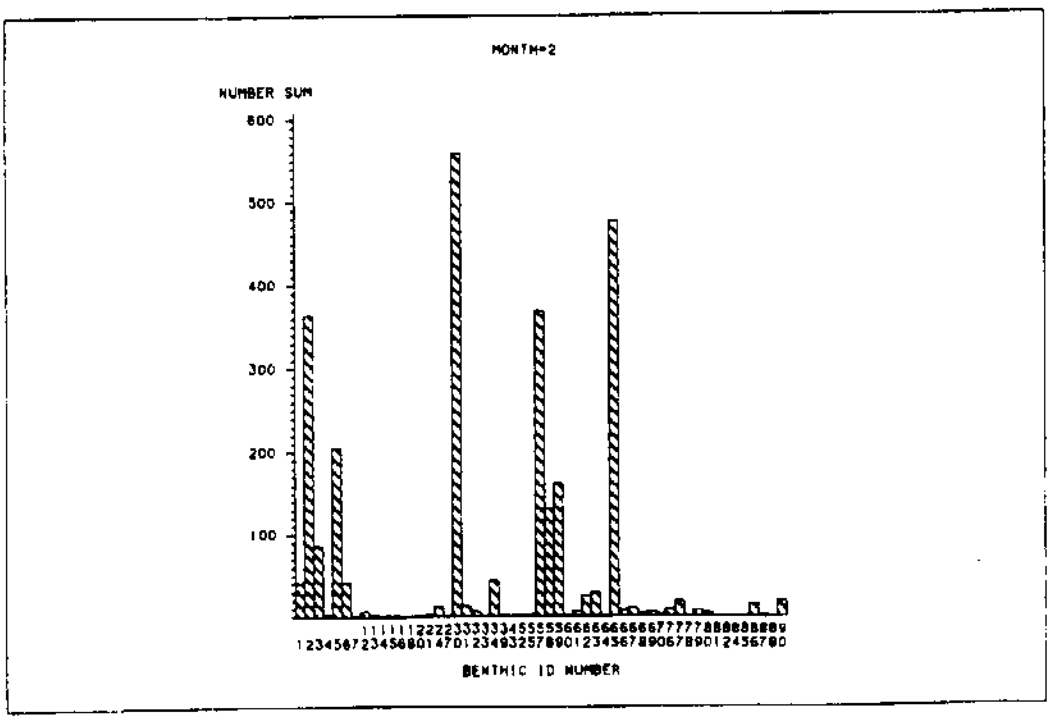
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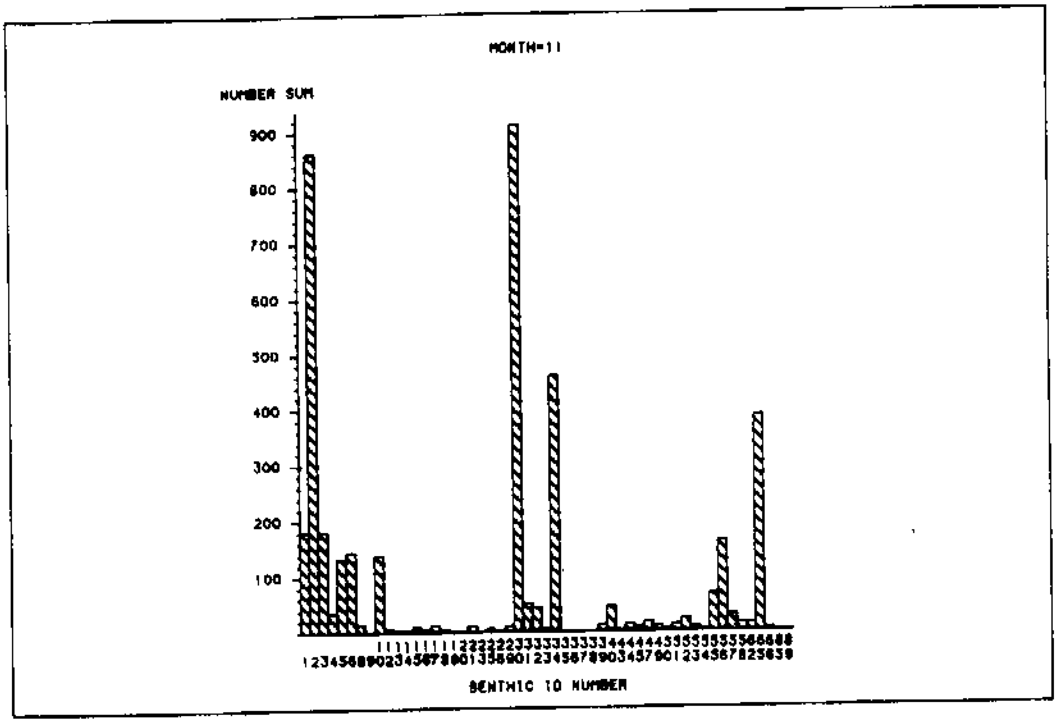
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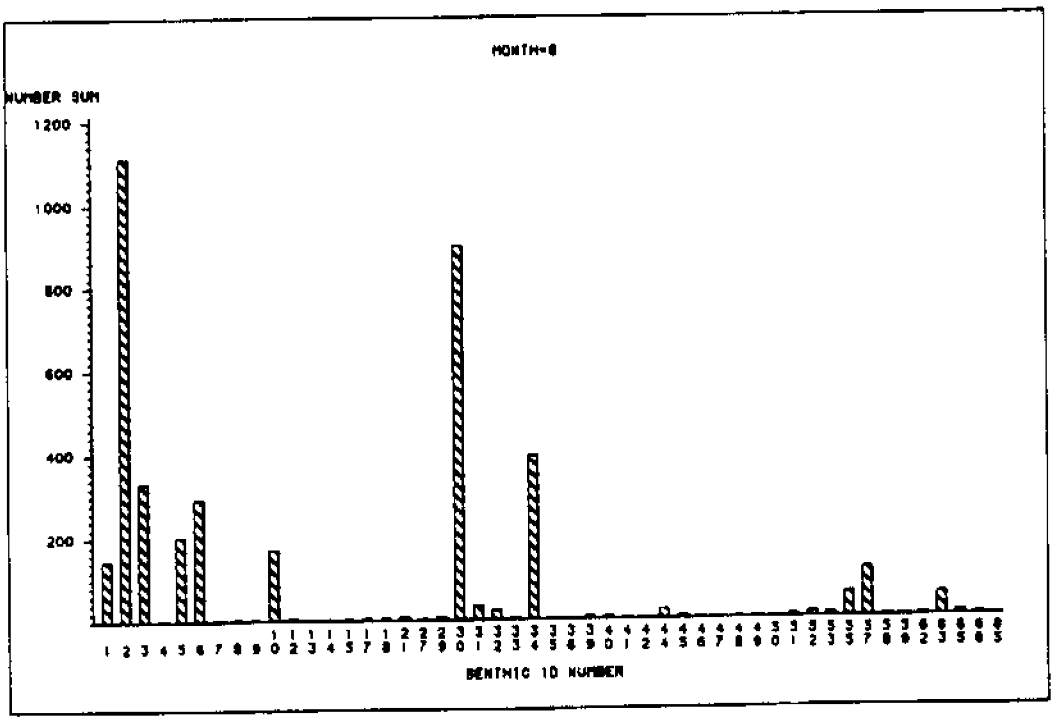
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