Monitoring and Assessment of the 1997 Bonnet Carre' Spillway Opening in Mississippi Sound, MS

by

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and
Gulf Coast Research Laboratory

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BONOYS.dbf - oyster length data
CHLOPHYL.dbf - chlorophyl-a data
COLIFORM.dbf - coliform data
OYSMORT.dbf - oyster mortality data
SPECCODE.dbf - species codes for use with oyster and trawl data files

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INTRODUCTION

The U.S. Army Corps of Engineers announced on March 12, 1997 that the Bonnet Carre' Spillway would open on Monday, March 17, 1997 for only the seventh time since 1937. The spillway, which is located 28 miles north of New Orleans, Louisiana, was opened due to large amounts of rain in the Ohio Valley that subsequently entered the river system. To protect the city of New Orleans from flooding, the spillway diverts Mississippi River floodwaters through Lake Pontchartrain, the Rigolets, the Mississippi Sound, and eventually into the Gulf of Mexico. Peak flow (Figure 1) through the spillway occurred in late March and early April.

Previous spillway openings in conjunction with freshwater inflow from the Pearl River have had short-term detrimental impacts on oyster reefs in the western Mississippi Sound (Deegen, et al., 1980 and Deegen and Van Devender, 1984). Other than effects on oysters, little information has been obtained on other impacts to biota due to freshwater intrusion from the Bonnet Carre' into the Mississippi Sound.

The purpose of this study was to provide biological and hydrological data on the effects of the 1997 Bonnet Carre' Spillway opening in western Mississippi Sound. These data were compared to historical information to assess any short-term impacts. The study was subdivided into three segments: (1) oyster assessment (2) finfish and invertebrate assessment and (3) hydrology and water quality assessment.

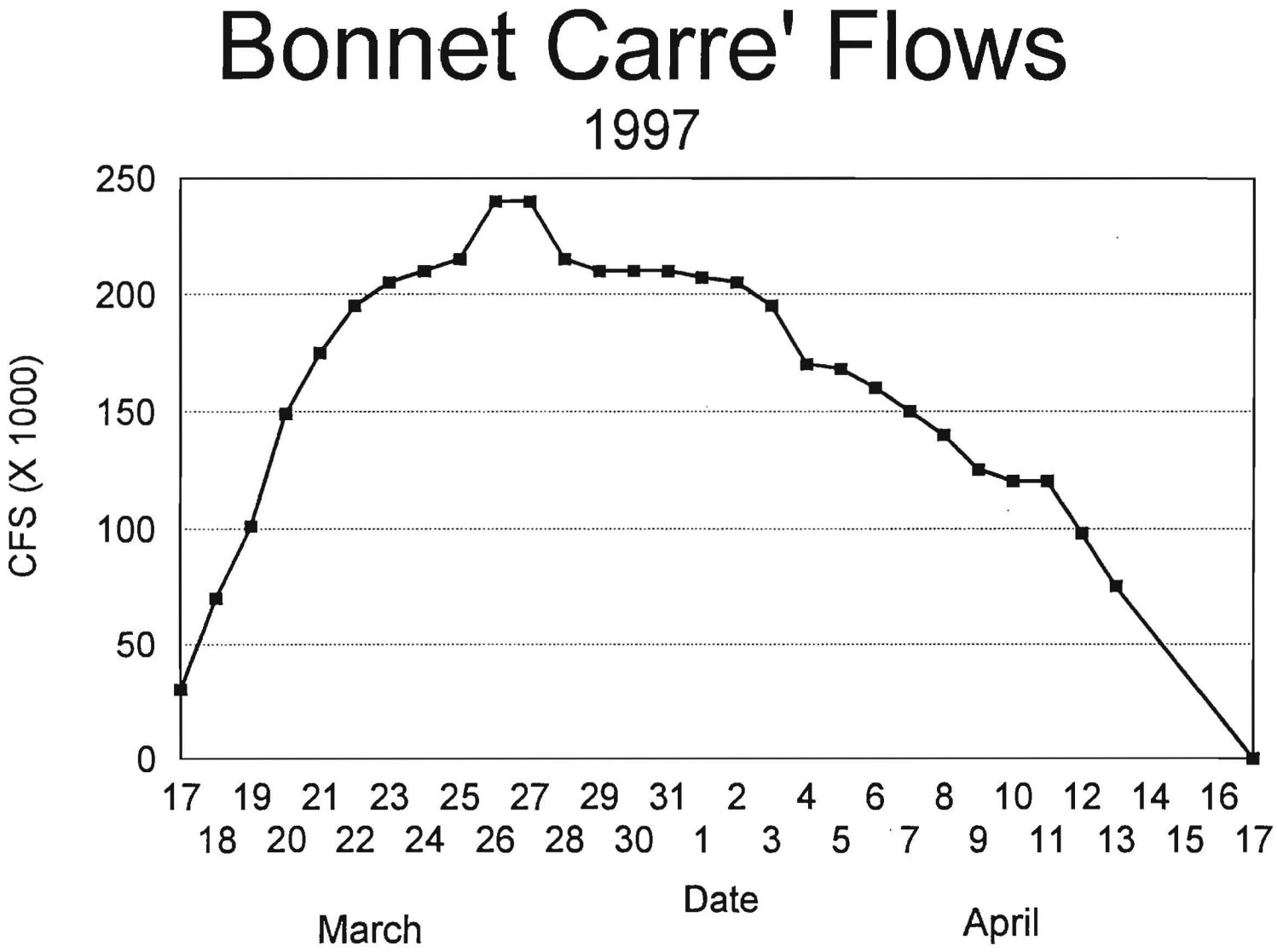

Figure 1. Bonnet Carre' flow rates for March and April, 1997. (data provided by U.S. Army Corps of Engineers, New Orleans District)

SEGMENT 1 - OYSTERS

INTRODUCTION

Almost all Mississippi oyster, *Crassostrea virginica*, production is produced from reefs located in western Mississippi Sound. Past flood events have been shown to be deleterious to oyster populations in Mississippi. Reports of oyster mortalities ranged from 50 to 100 percent after spillway openings in 1979 and 1983 (Deegen, et al., 1980 and Deegen and Van Devender, 1984). Similar mortalities were noted in Louisiana in 1983 (Chatry and Millard, 1986).

The objective of this study segment was to determine impacts to oyster populations and qualitatively assess oyster health on the major reefs in western Mississippi Sound relative to the opening of the spillway.

METHODS AND MATERIALS

Public reefs were sampled once a month with a 22-inch, 9-tooth hand dredge. This dredge was towed by boat for one minute at constant speed at seven selected sampling stations (Figure 2). Latitude and longitude coordinates for the seven oyster sampling stations are given in Table 1. Oyster samples were returned to the Gulf Coast Research Laboratory where the oysters were counted and measured (bill to hinge) to the nearest millimeter. Mortality was calculated as the number of dead oysters (either fresh dead or new "boxes" divided by the total number of oysters (live and dead).

Five oysters were randomly chosen from each sample to be used to assess the condition of the oysters at each station. The five oysters were opened and evaluated for the color of the digestive diverticula, color of the crystalline style (if present), and the texture of the oyster meat. Oyster condition was considered poor when the digestive diverticula was light in color (i.e., pale green or yellow) and oyster meats were soft and easily damaged through normal handling. The presence or absence and color of the crystalline style was noted, indicating whether or not the oyster was actively feeding.

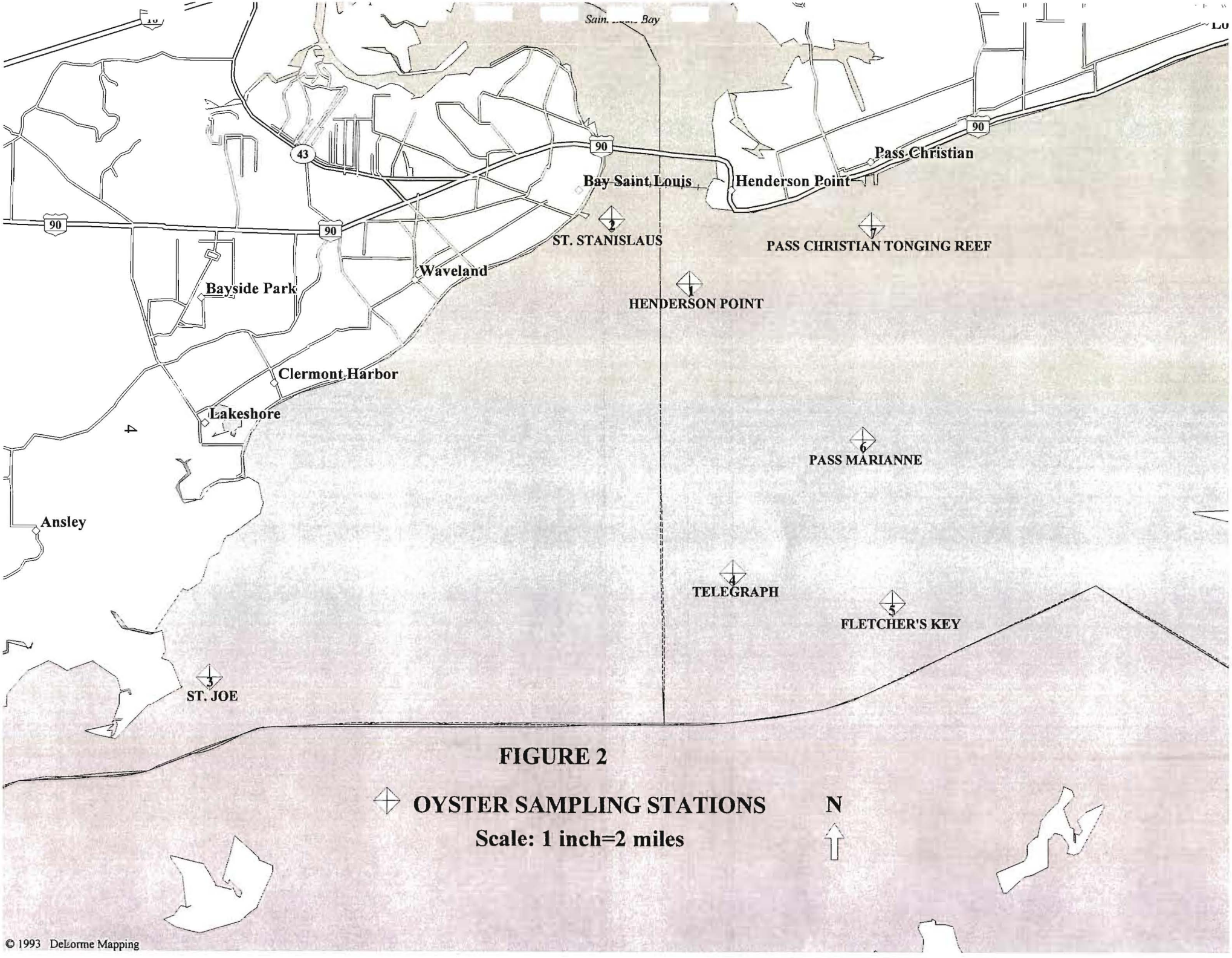
Bay
43
90
90
90
90
Pass Christian
Bay Saint Louis
Henderson Point
ST. STANISLAUS
PASS CHRISTIAN TONGING REEF
Waveland
Bayside Park
HENDERSON POINT
Clermont Harbor
Lakeshore
PASS MARIANNE
Ansley
TELEGRAPH
FLETCHER'S KEY
ST. JOE
OYSTER SAMPLING STATIONS
N
Scale: 1 inch=2 miles
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FIGURE 2

Table 1. Latitude and longitude coordinates for Bonnet Carre' oyster sampling stations.

STATION #	OYSTER STATIONS
1	Henderson Point
	30° 17.020" \ 89° 18.250"
2	St. Stanislaus
	30° 18.156" \ 89° 19.288"
3	St. Joe
	30° 11.091" \ 89° 25.525"
4	Telegraph
	30° 13.778" \ 89° 17.053"
5	Fletchers Key
	30° 12.899" \ 89° 13.994"
6	Pass Marianne
	30° 14.205" \ 89° 15.749"
7	Pass Christian Tonging Reef
	30° 18.092" \ 89° 14.938"

RESULTS AND DISCUSSION

Mortality rates observed during the study were highly variable from month to month ranging from 0 to 10 percent over the eight-month sampling period. Mortalities (<7%) observed during the first two months of sampling may have been attributable to exposure to lowered salinities for a short time. An unexpected result of our data monitoring was that oyster mortality was lowest at Station 3, St. Joseph Reef (Figure 2). Station 3 is geographically closer to the influence of fresh water from the Pearl River system and the Bonnet Carre' Spillway, where salinities were generally lowest. The oysters in this area may be more acclimated to withstand longer periods of lower salinities than oysters living in higher salinity regimes, since they are located near the mouth of the Pearl River and experience low salinity conditions on a more frequent basis. Mortalities observed in the later months may have been due to oyster drill, *Thais haemastoma*, predation as salinities increased to a level that would have allowed this predator access to the reefs (Figure 3). Based on subjective observations of oyster meat quality, an overall degradation was noted (i.e., soft meat and light colored diverticula) through the middle of April. After April, oyster meat quality improved as the salinities began to increase.

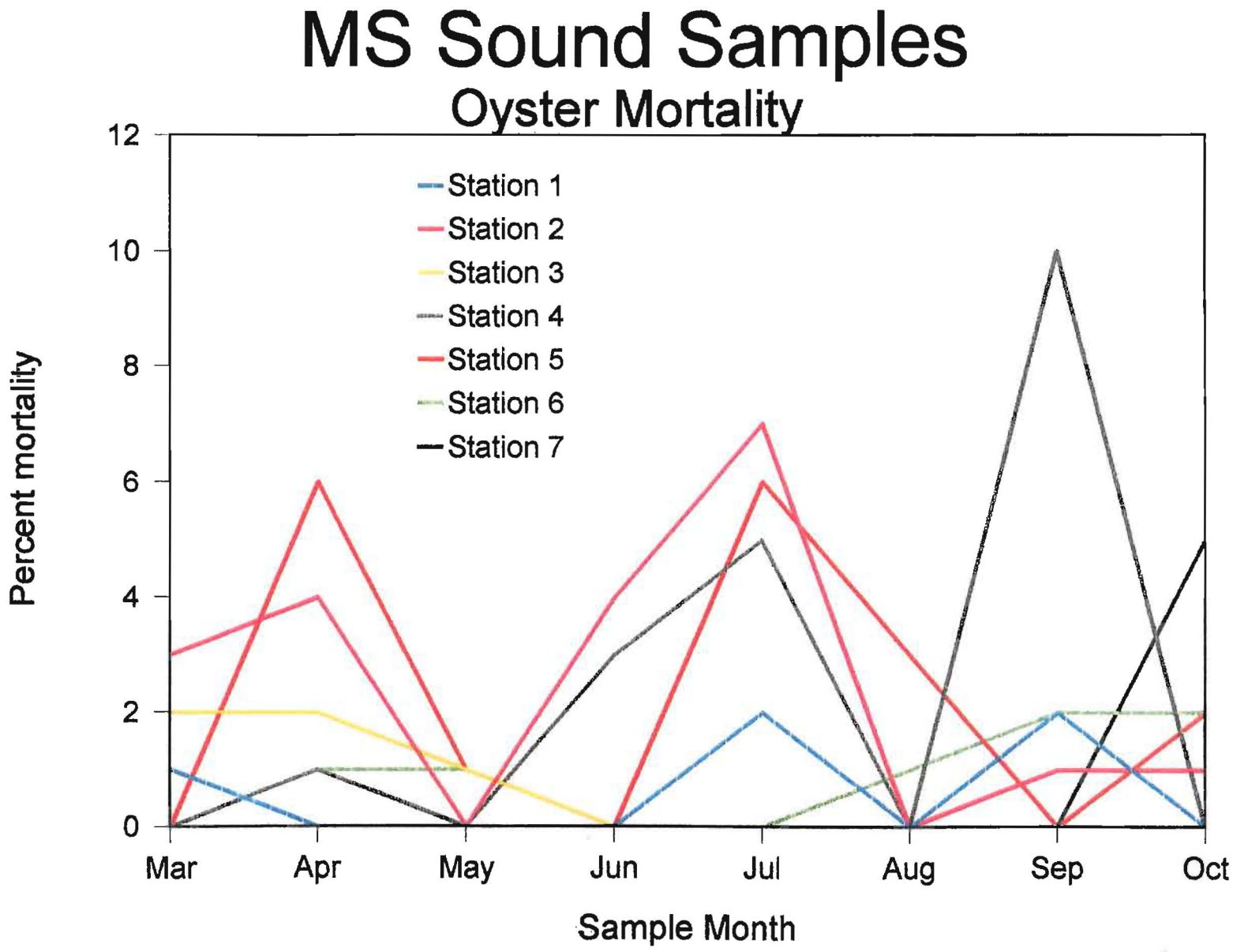

Figure 3. Percentage of oyster mortality for Bonnet Carre' stations 1-7 by sample month

SEGMENT 2 - FINFISH AND INVERTEBRATES

INTRODUCTION

Much of the biological information collected on the impact of freshwater intrusion has been focused on oysters. Not only are oysters economically important, they are sedentary which makes them vulnerable to freshwater intrusion, which can cause high mortalities with sufficient exposure. Other species of marine organisms can be adversely affected if salinities are suppressed by freshwater intrusion. Some species can be affected by being displaced into less desirable habitat which could increase mortality. Salinity of habitat (i.e. marsh grasses or seagrass beds) normally utilized by larvae and/or postlarvae as they recruit into Mississippi Sound from offshore waters could be suppressed to levels that would impact survival. The objective of this study segment was to evaluate finfish and invertebrate abundance in western Mississippi Sound during and after the Bonnet Carre' Spillway opening.

METHODS AND MATERIALS

Trawl samples were taken using a 16-foot standard ¾-inch bar mesh otter trawl with ¼-inch bar liner in the cod end at seven selected sampling stations (Figure 4). Latitude and longitude coordinates for the seven trawl stations sampled during this study and Station 60 of a historical Fisheries Monitoring and Assessment (FMA) program in Mississippi are presented in Table 2. Trawling tow time was 10 minutes per sample at a constant speed of 2.5 knots. Each station was sampled weekly for the first four months of the study and semi-monthly thereafter. Triplicate trawl samples were obtained once per month at each of the stations for one of the sampling weeks.

Finfish and invertebrates were placed in labeled plastic bags and transported to the laboratory. Animals were identified to the lowest possible taxon, counted and up to 50 of each species were measured to the nearest millimeter in each sample.

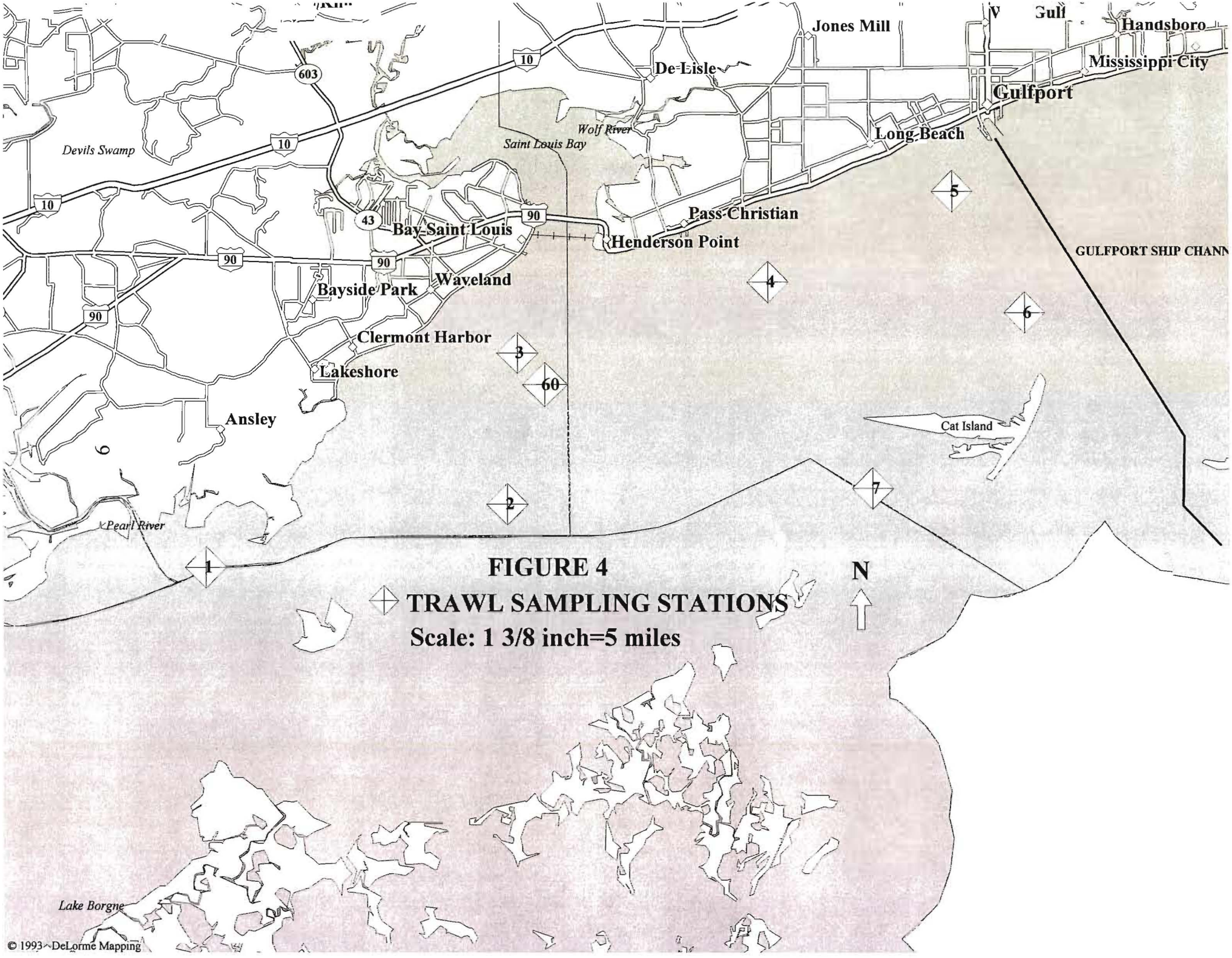

FIGURE 4

TRAWL SAMPLING STATIONS

Scale: 1 3/8 inch=5 miles

Table 2. Latitude and longitude coordinates for Bonnet Carre' trawl sampling stations.

STATION #	TRAWL STATIONS
1	30° 10.277"
	89° 28.474"
2	30° 10.540"
	89° 22.050"
3	30° 17.560"
	89° 18.650"
4	30° 17.150"
	89° 10.590"
5	30° 19.050"
	89° 04.060"
6	30° 17.147"
	89° 03.910"
7	30° 13.371"
	89° 09.625"
HISTORICAL STATION #60	30° 15.616"
	89° 19.116"

RESULTS AND DISCUSSION

Monthly numbers by station for the bay anchovy, *Anchoa mitchilli*, spot, *Leiostomus xanthurus*, Atlantic croaker, *Micropogonias undulatus*, sand seatrout, *Cynoscion arenarius*, blue crab, *Callinectes sapidus*, and brown shrimp, *Penaeus aztecus*, are presented in Figures 5-10. White shrimp, *Penaeus setiferus*, were excluded from the analysis because very few were captured in the trawl samples. These species were chosen because of their relative abundance and/or commercial and recreational importance. Monthly numbers were variable for each species and can be affected by environmental conditions, recruitment patterns, and manmade perturbations (i.e., June 17 shrimp season opening). For data analysis, the number of animals by species for each station was averaged on days when triplicate trawl samples were obtained.

The number of bay anchovies began to generally increase at most stations in early April through the end of May, then decreased during June and part of July. The peak catch was recorded in early August at Stations 3 and 5. Numbers of spot increased slightly from April through the end of June when the numbers dropped dramatically. This species was relatively abundant during May and June at most sampling stations. Atlantic croaker were most abundant during late April through May. Numbers dropped at all stations after the first part of June. An unusual peak was observed for Station 1 during mid-May. Numbers of sand seatrout began to increase in early May, reached highest levels during June and fell off during July for most sampling stations. Blue crab numbers were relatively high at most stations during the first sampling week. The numbers of blue crabs decreased to a level maintained through mid-July. Peaks were observed for Station 4 during early April and for Station 1 during mid-June. Brown shrimp were nearly absent from samples until mid-May. From mid-May, numbers increased through early June and declined afterward. By early July through the end of the sampling period brown shrimp were virtually absent from samples.

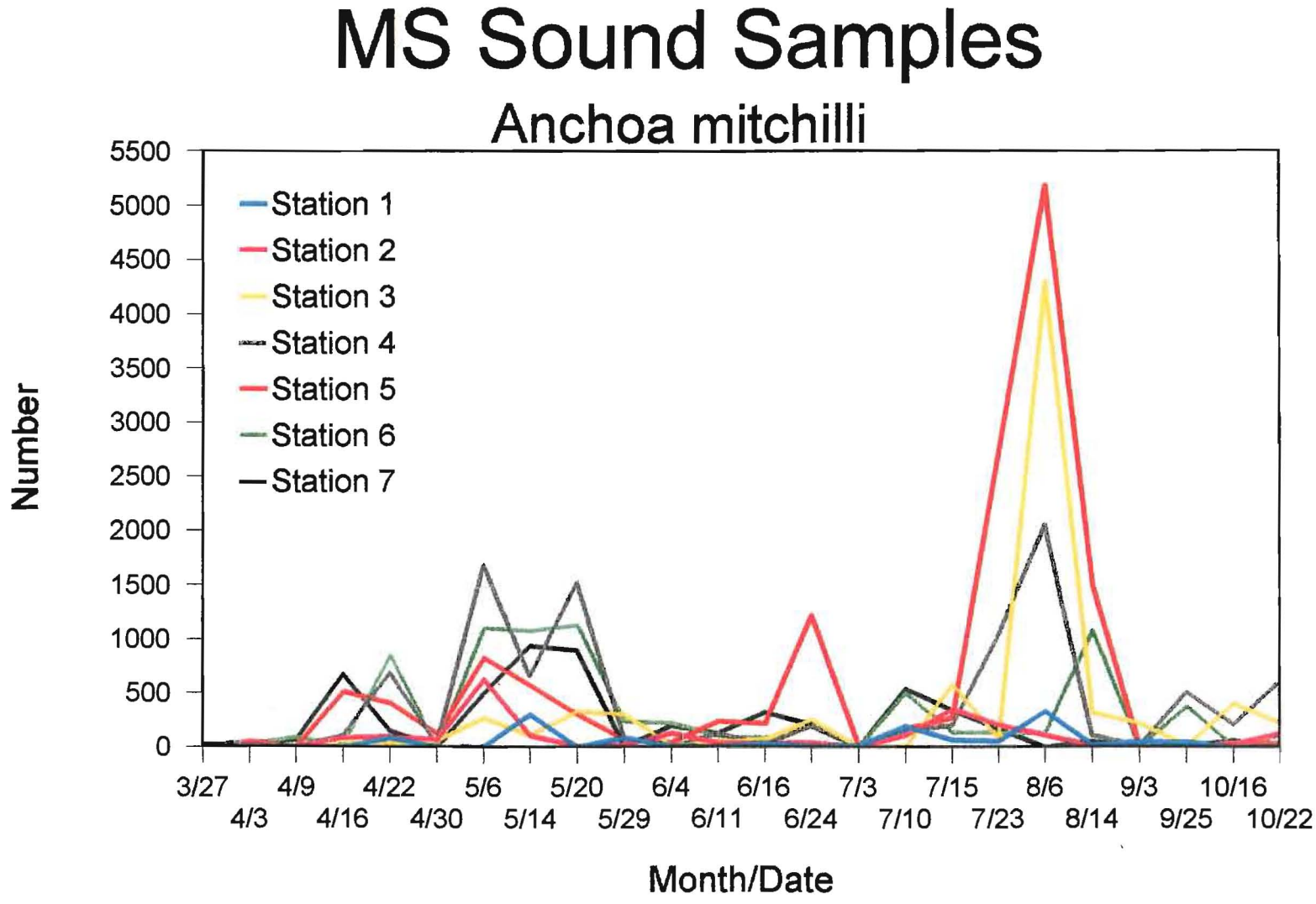

Figure 5. Numbers of Bay anchovy, *Anchoa mitchilli*, for Bonnet Carre' stations 1-7 by sample date.

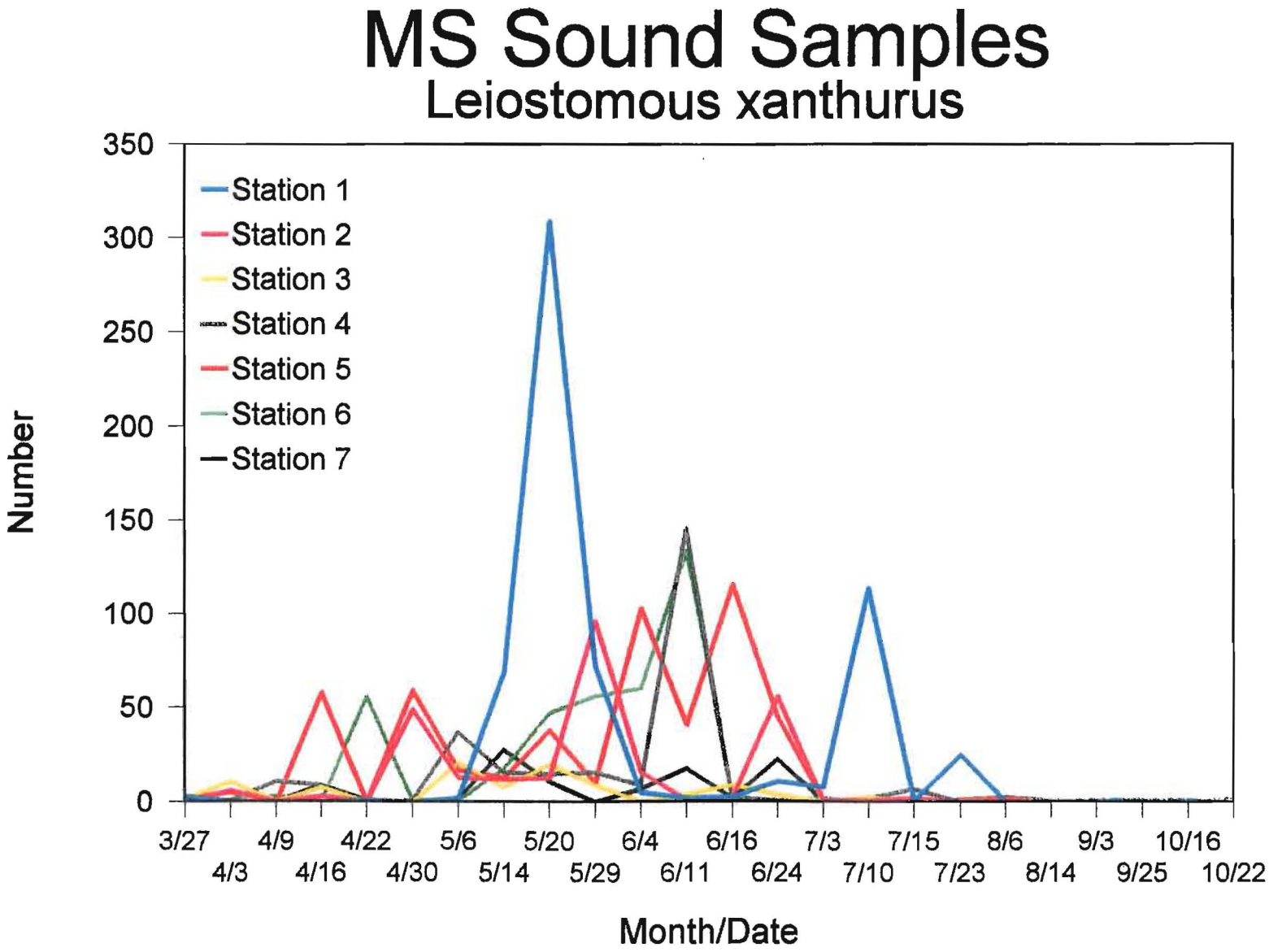

Figure 6. Numbers of Spot, *Leiostomus xanthurus*, for Bonnet Carre' stations 1-7 by sample date.

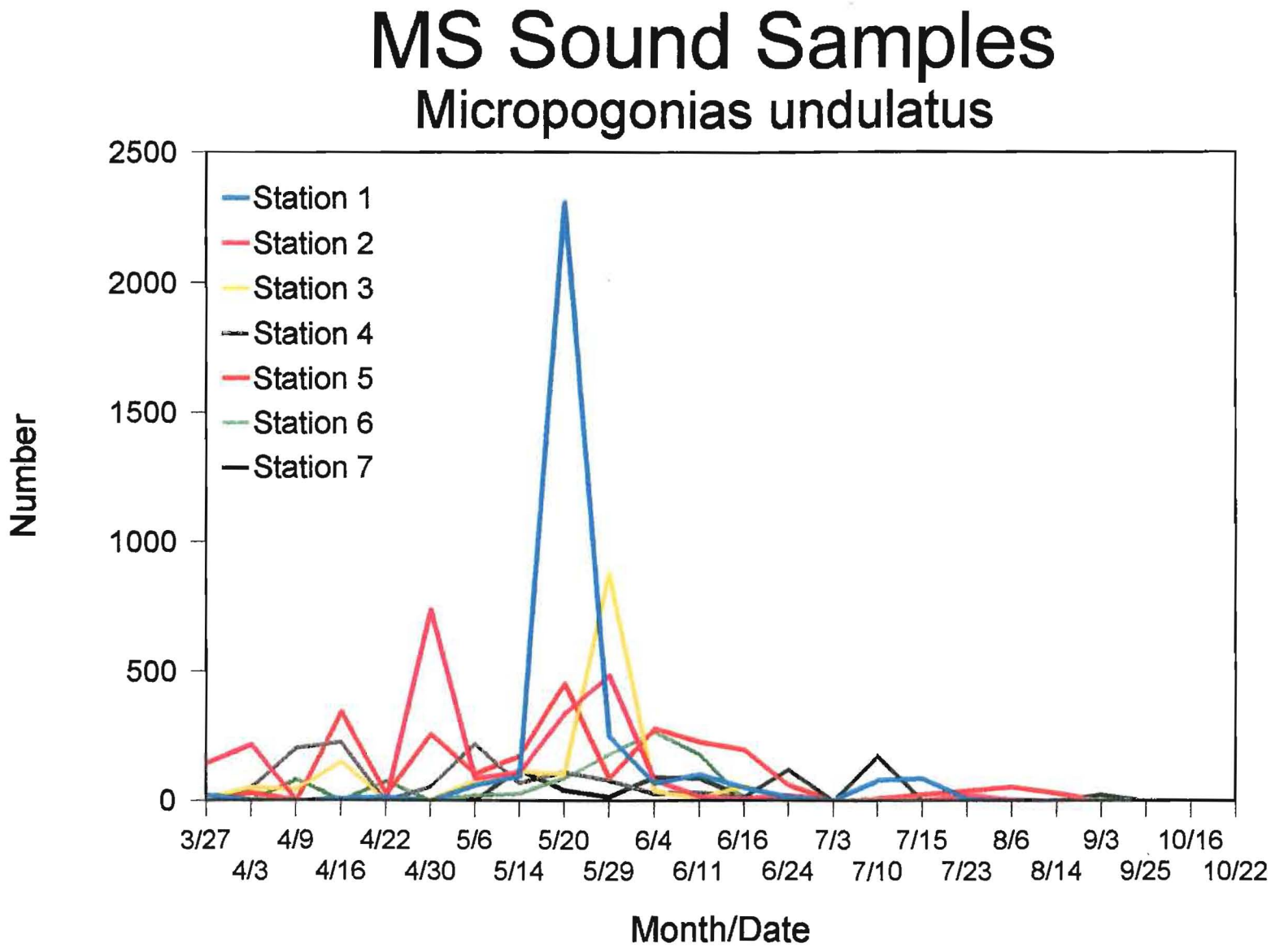

Figure 7. Numbers of Atlantic croaker, *Micropogonias undulatus*, for Bonnet Carre' stations 1-7 by sample date.

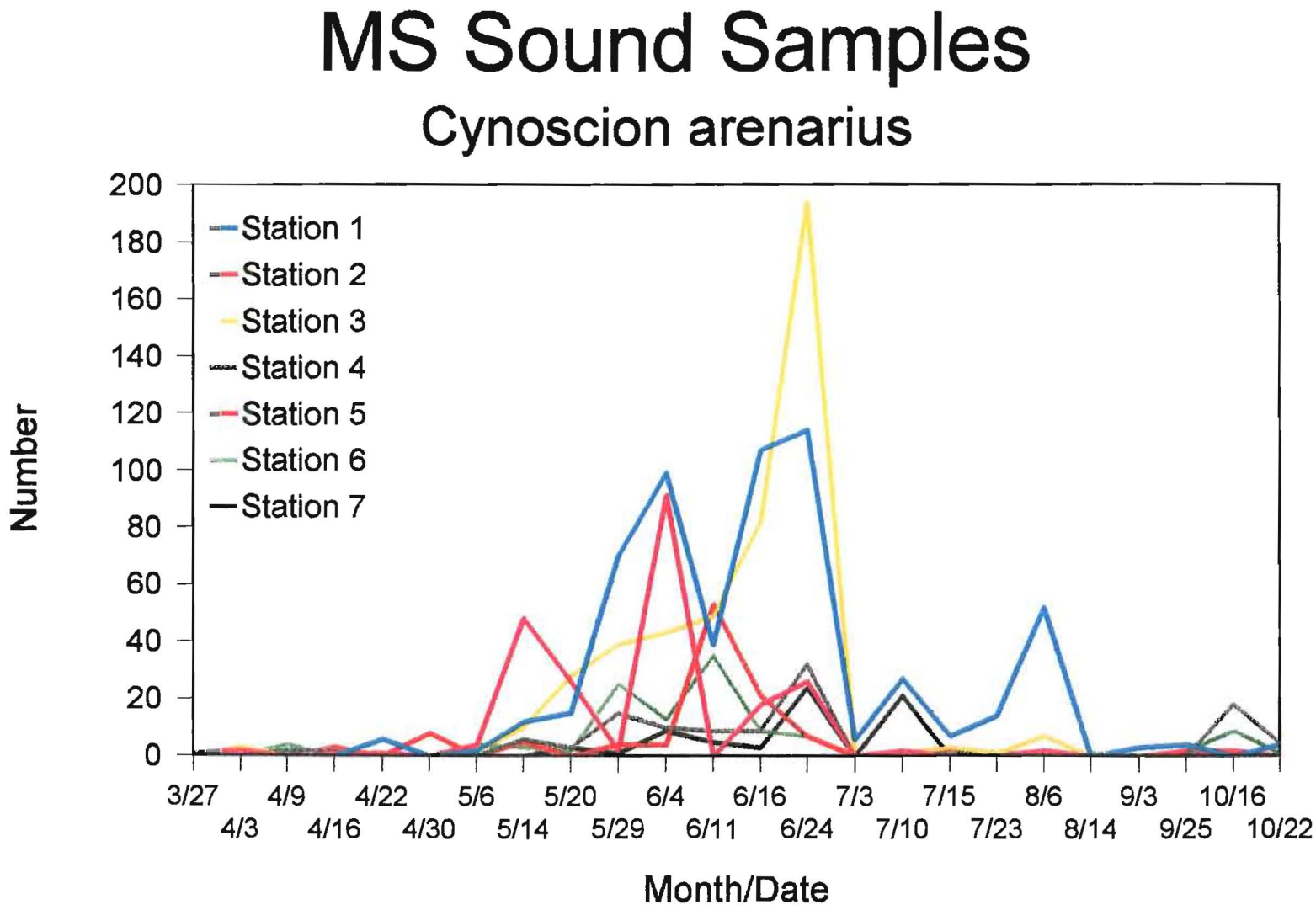

Figure 8. Numbers of Sand seatrout, *Cynoscion arenarius*, for Bonnet Carre' stations 1-7 by sample date.

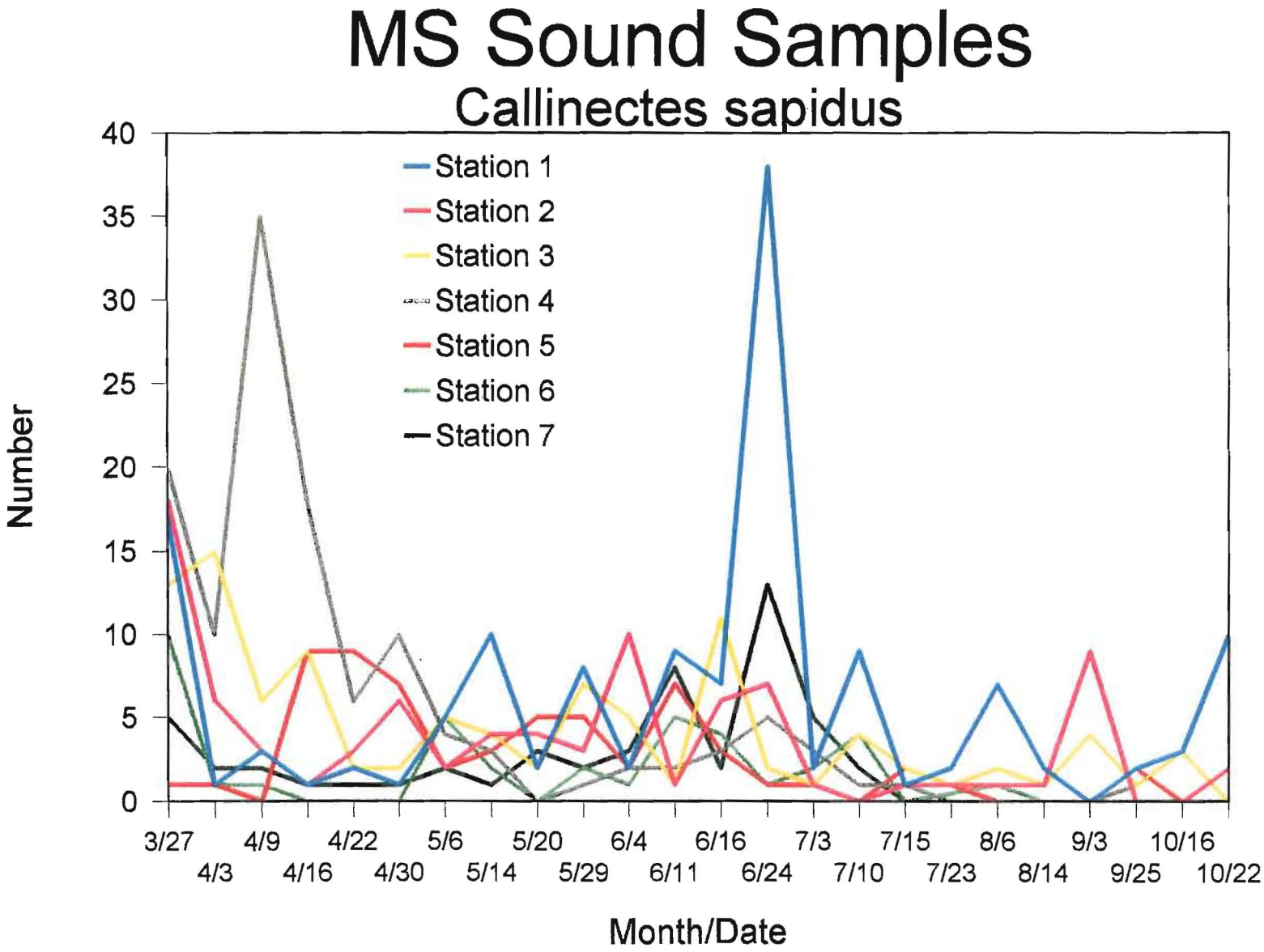

Figure 9. Numbers of Blue crab, *Callinectes sapidus*, for Bonnet Carre' stations 1-7 by sample date.

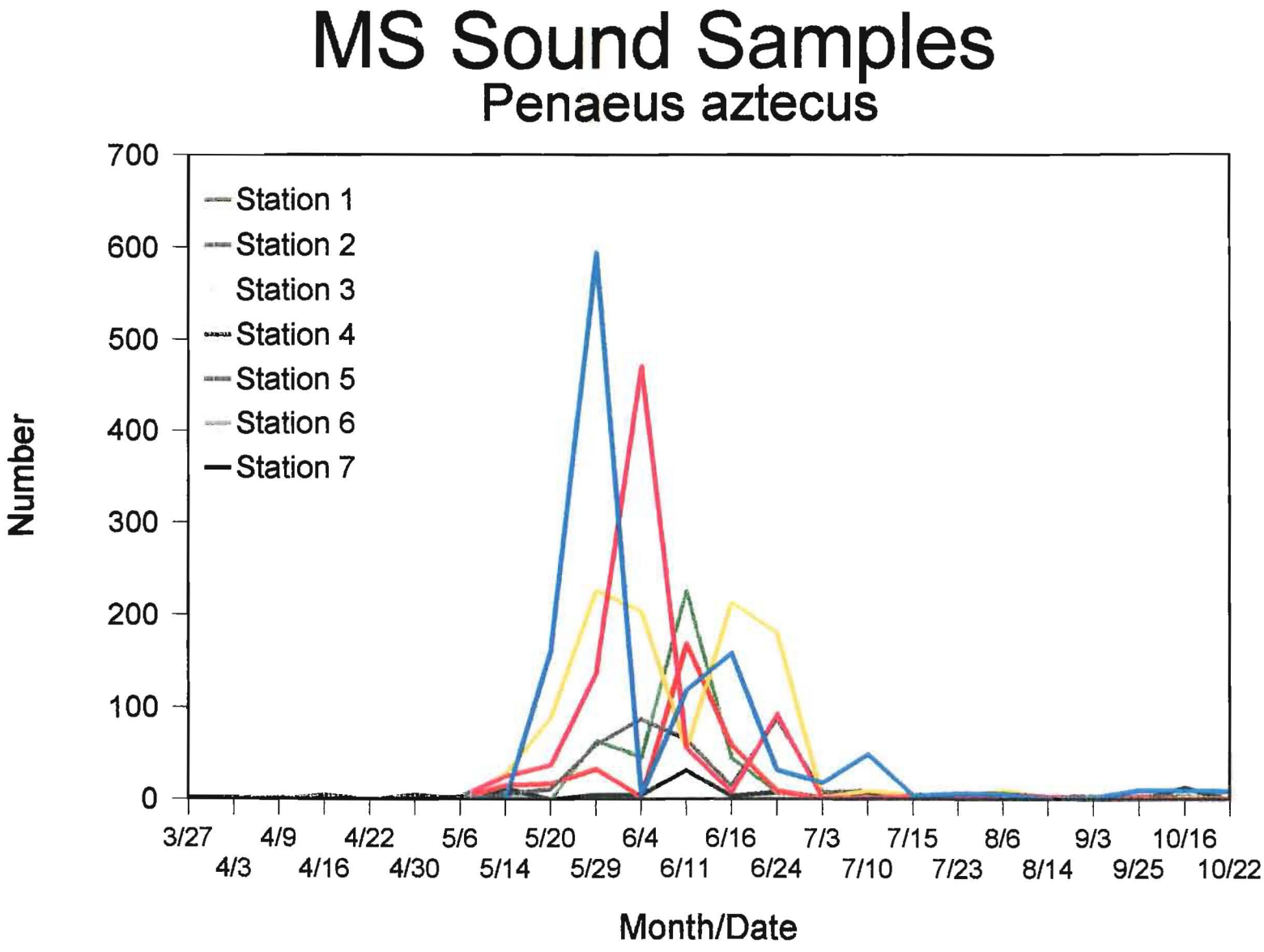

Figure 10. Numbers of Brown shrimp, *Penaeus aztecus*, for Bonnet Carre' stations 1-7 by sample date.

SEGMENT 3 - HYDROLOGY/WATER QUALITY

INTRODUCTION

Hydrological factors such as salinity, temperature, and dissolved oxygen affect the distribution, movement patterns, and recruitment survival of many species. One of the objectives of this segment was to monitor changes in salinity, temperature, and dissolved oxygen during and after the 1997 Bonnet Carre' Spillway opening. Another objective of this segment was to determine the concentration of fecal coliform bacteria at selected stations in western Mississippi Sound to evaluate any possible effects from the increased fresh water flow by opening the spillway. Fecal coliform bacteria levels are used in classifying waters approved for oyster harvest in Mississippi. Chlorophyll-a can be used to indicate levels of primary productivity and as a third objective, concentrations of this compound were measured in water taken at selected sample stations in western Mississippi Sound.

METHODS AND MATERIALS

Salinity, temperature, and dissolved oxygen values for surface and bottom water were measured concurrently with trawl samples (Figure 4, Table 2). Salinity was measured with a Reichert-Jung refractometer. Temperature and dissolved oxygen values were measured with a YSI Model 54 oxygen meter. Chlorophyll-a and fecal coliform water samples were collected in 250-milliliter sterile, plastic bottles at eight stations (Figure 11). Latitude and longitude coordinates for these stations are provided in Table 3.

Beginning in May chlorophyll-a samples were collected once per week for the first two months of the study and then once per month until the study was completed. Fecal coliform samples were collected once per week beginning in April for the first two months of the study and once a month for the duration of the study. Previously collected samples in March of 1997 were included in the analysis. Chlorophyll-a samples were protected

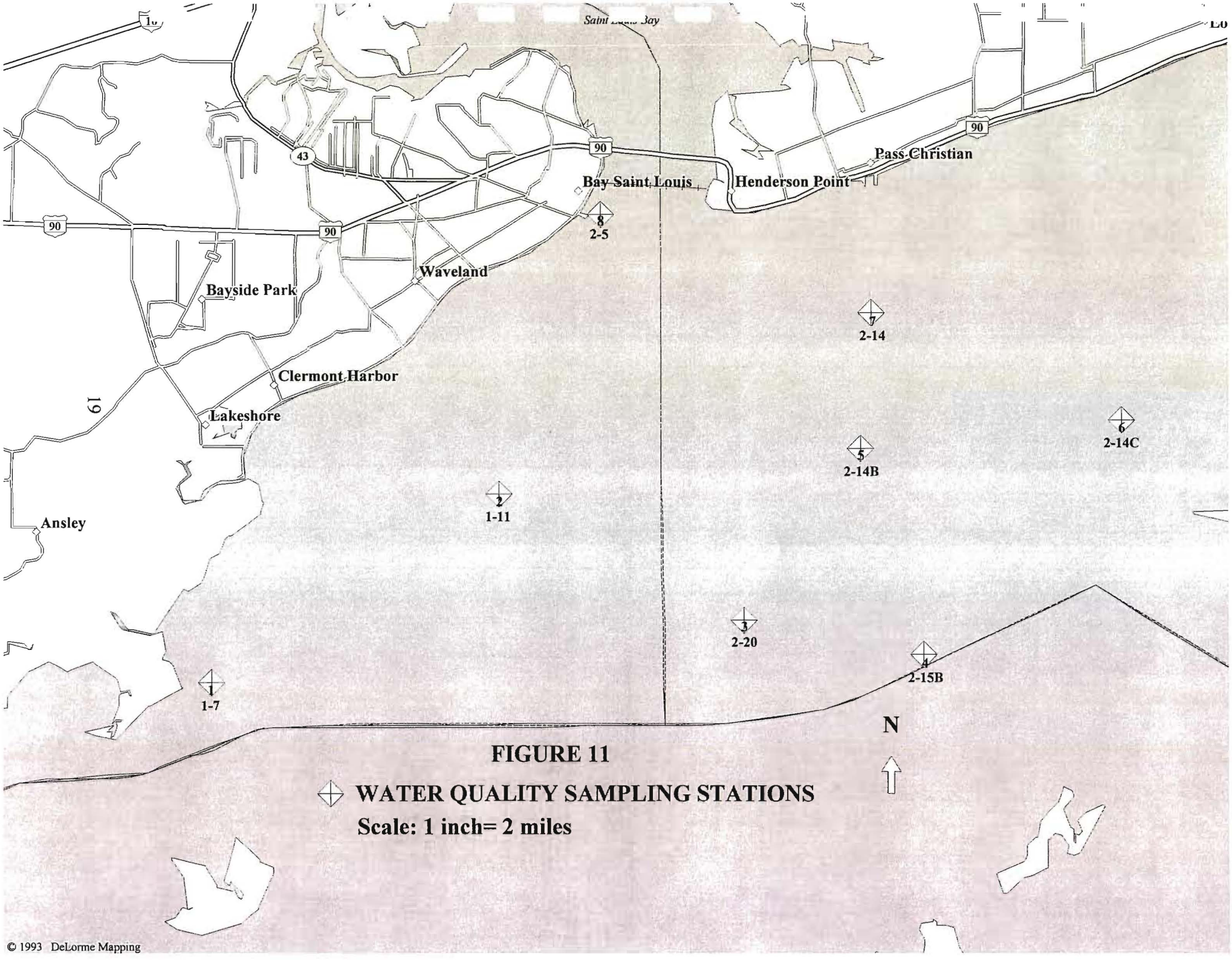

FIGURE 11

WATER QUALITY SAMPLING STATIONS

Scale: 1 inch= 2 miles

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Table 3. Latitude and longitude coordinates for Bonnet Carre' hydrology/water sampling stations.

STATION #	HYDROLOGY/WATER QUALITY STATIONS
1	30° 11.055"
	89° 25.538"
2	30° 13.275"
	89° 22.508"
3	30° 13.275"
	89° 16.475"
4	30° 11.786"
	89° 13.516"
5	30° 14.540"
	89° 14.981"
6	30° 15.212"
	89° 10.851"
7	30° 17.097"
	89° 14.228"
8	30° 18.083"
	89° 19.545"

from the sun and fecal coliform samples were iced before transport to the laboratory for analysis. Chlorophyll-a samples were analyzed with methods from Strickland and Parsons (1968) Practical Handbook of Seawater Analysis and are reported in micrograms/liter. Fecal coliform concentrations were determined in accordance with methods found in the American Public Health Association publication Laboratory Procedures for the Examination of Seawater and Shellfish (Roberts, 1985) and are reported as the most probable number (MPN) of fecal coliform bacteria per 100 milliliters of water.

RESULTS AND DISCUSSION

Surface salinities at the western-most stations were 0.0 parts per thousand (ppt) in March and all stations decreased to 0.0 ppt by the week of April 16th (Figure 12). After April 16th salinities generally increased through the sampling period at all stations with the lowest salinities being recorded for Station 1. Bottom salinities followed the same general trend, however, not all bottom salinities reached 0.0 ppt (Figure 13). Surface and bottom temperatures decreased through the middle of April and thereafter continued to rise (Figures 14 and 15). Dissolved oxygen levels generally increased through the middle of April and then gradually decreased as water temperatures rose (Figures 16 and 17).

Chlorophyll-a samples were obtained from May through October. Somewhat higher values of chlorophyll-a concentration were recorded during the early portion of the sampling period with values decreasing during mid-June and increasing somewhat during the latter months (Figure 18).

The Bonnet Carre' Spillway opening introduced river waters of relatively high fecal coliform levels (up to 210 CFU/100 ml) into Lake Pontchartrain. However, a concurrent study of water quality in Lake Pontchartrain by the U.S. Army Corps of Engineers showed that floodwaters at mid-lake (at the Causeway) remained low in fecal coliform counts (<10 CFU/100 ml) throughout the duration of the spillway opening (Baird, personal communication). This indicates that die-off of bacteria was occurring long before the floodwaters reached Mississippi. Any increases in coliform concentrations in western Mississippi Sound would thus more likely be related to other direct sources of fecal coliform bacteria. The Bonnet Carre' Spillway opening could possibly influence fecal

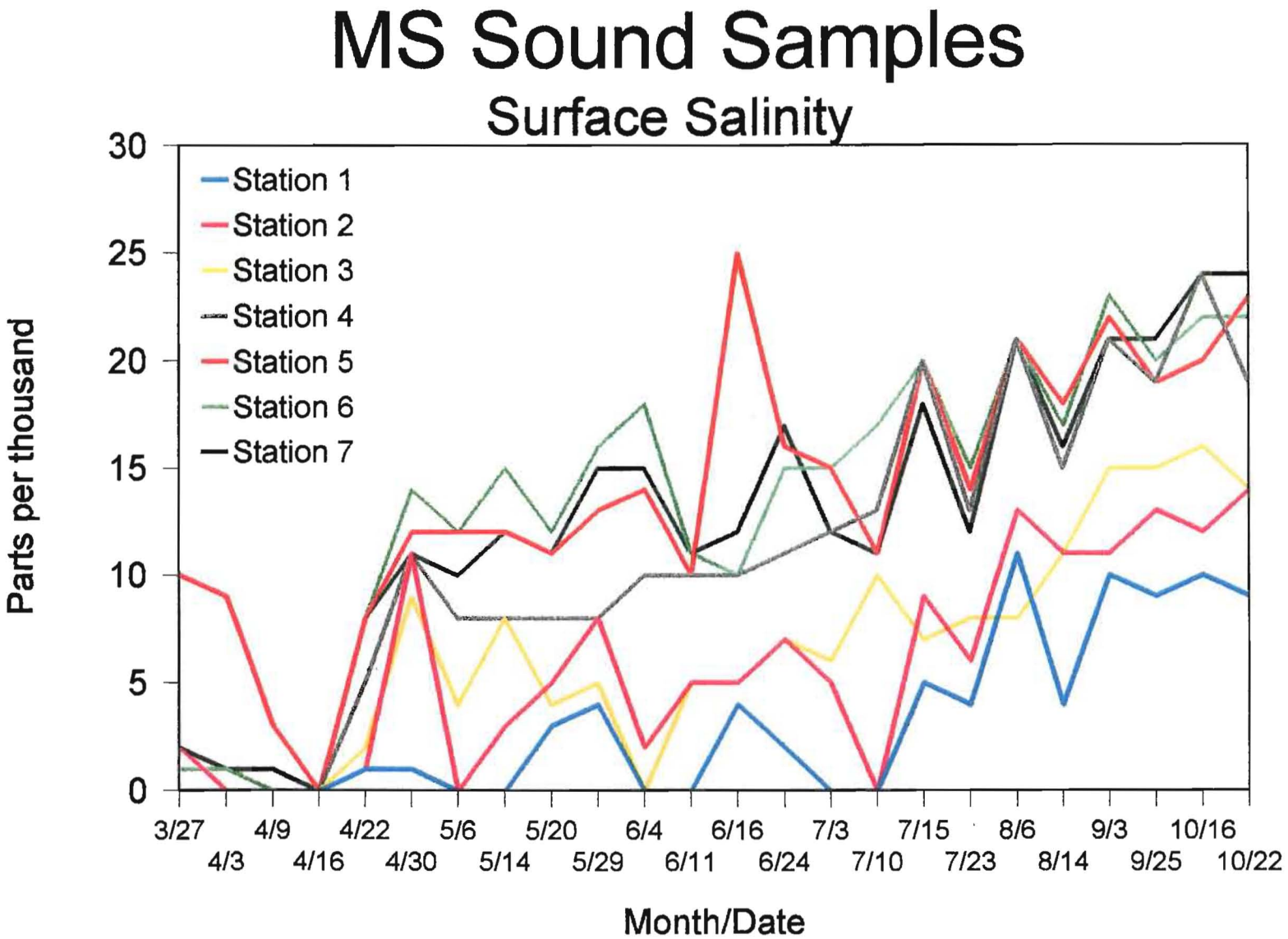

Figure 12. Surface salinity (ppt) for Bonnet Carre' stations 1-7 by sample date.

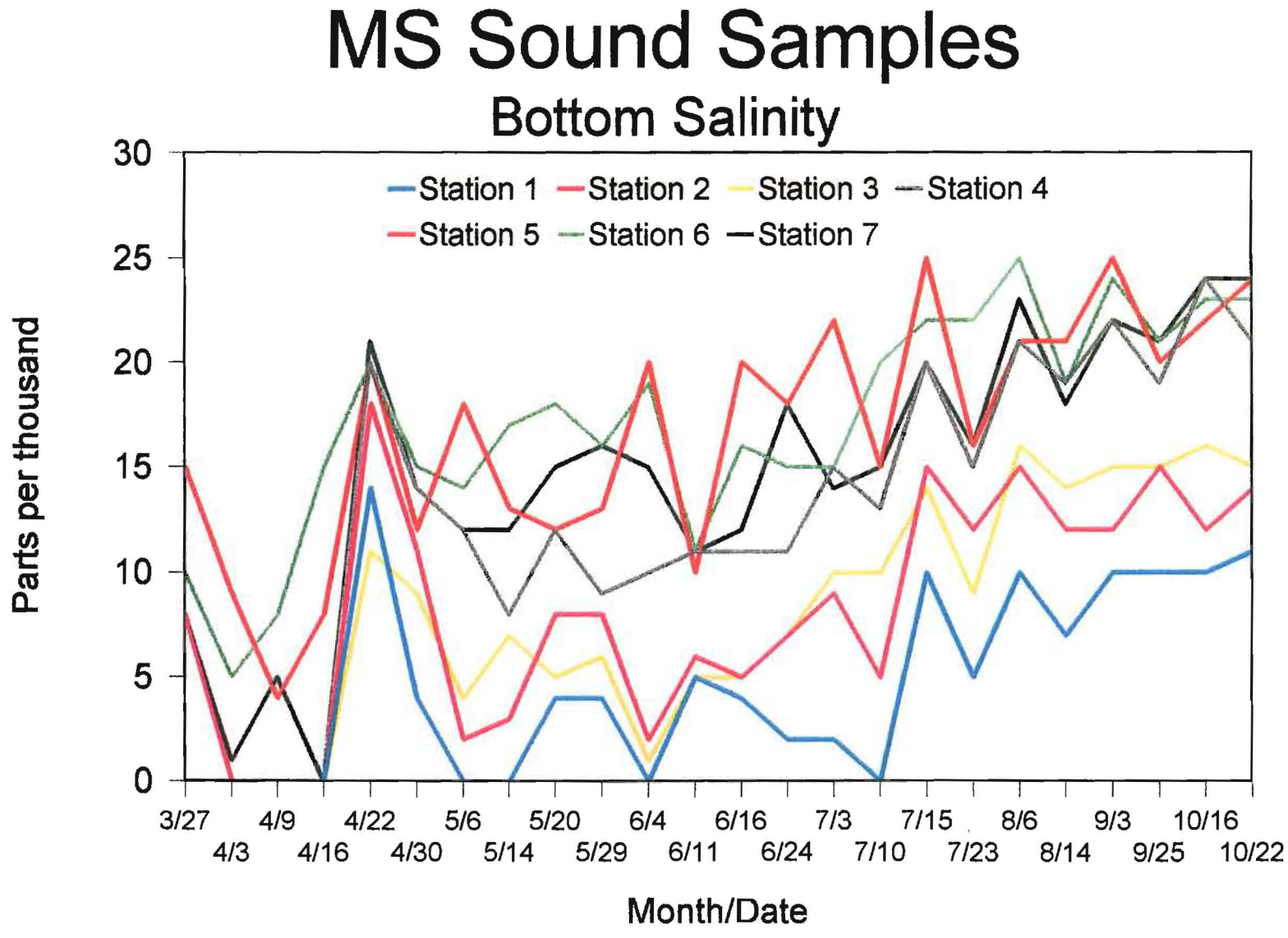

Figure 13. Bottom salinity (ppt) for Bonnet Carre' stations 1-7 by sample date.

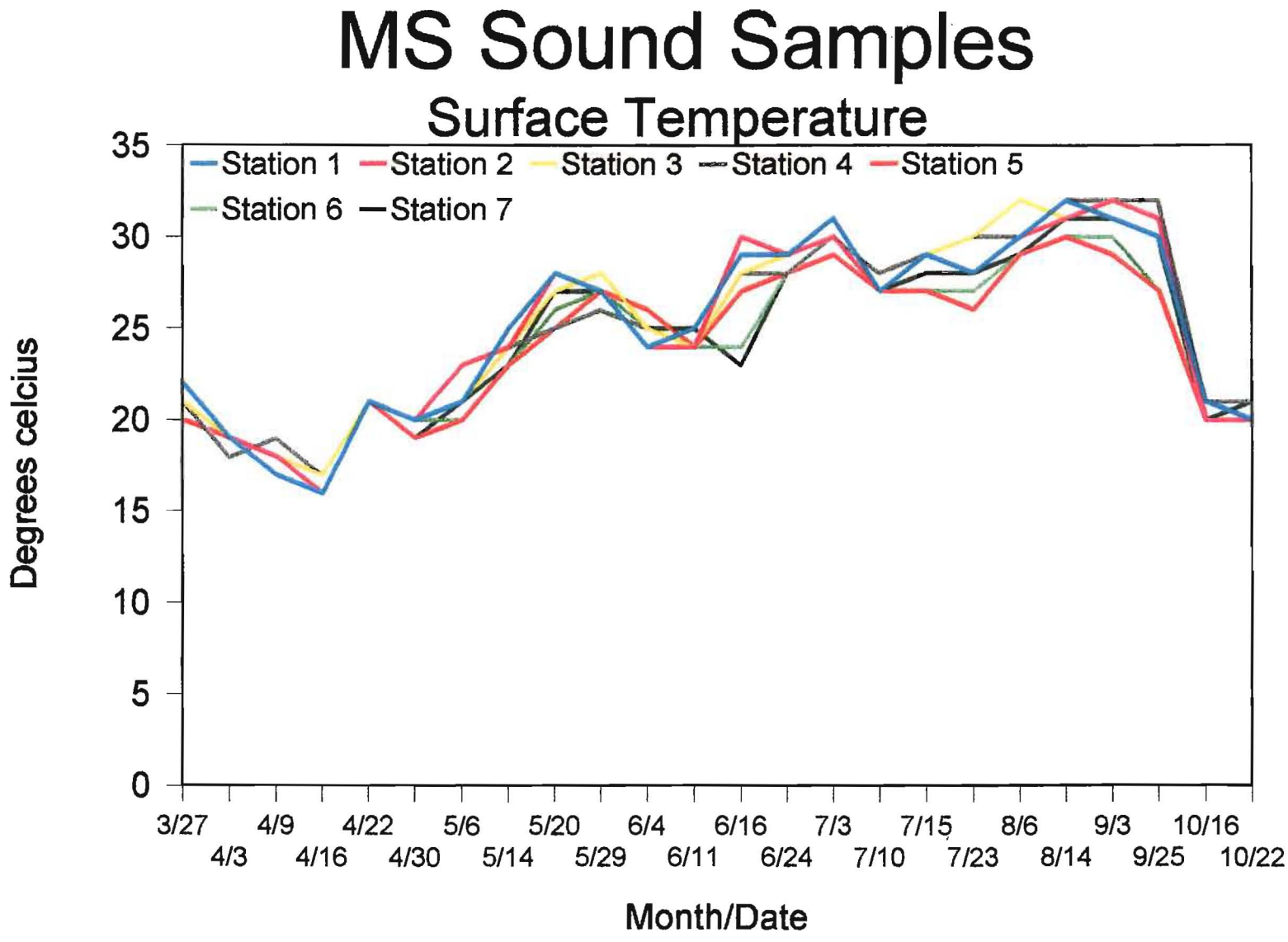

Figure 14. Surface temperature (°C) for Bonnet Carre' stations 1-7 by sample date.

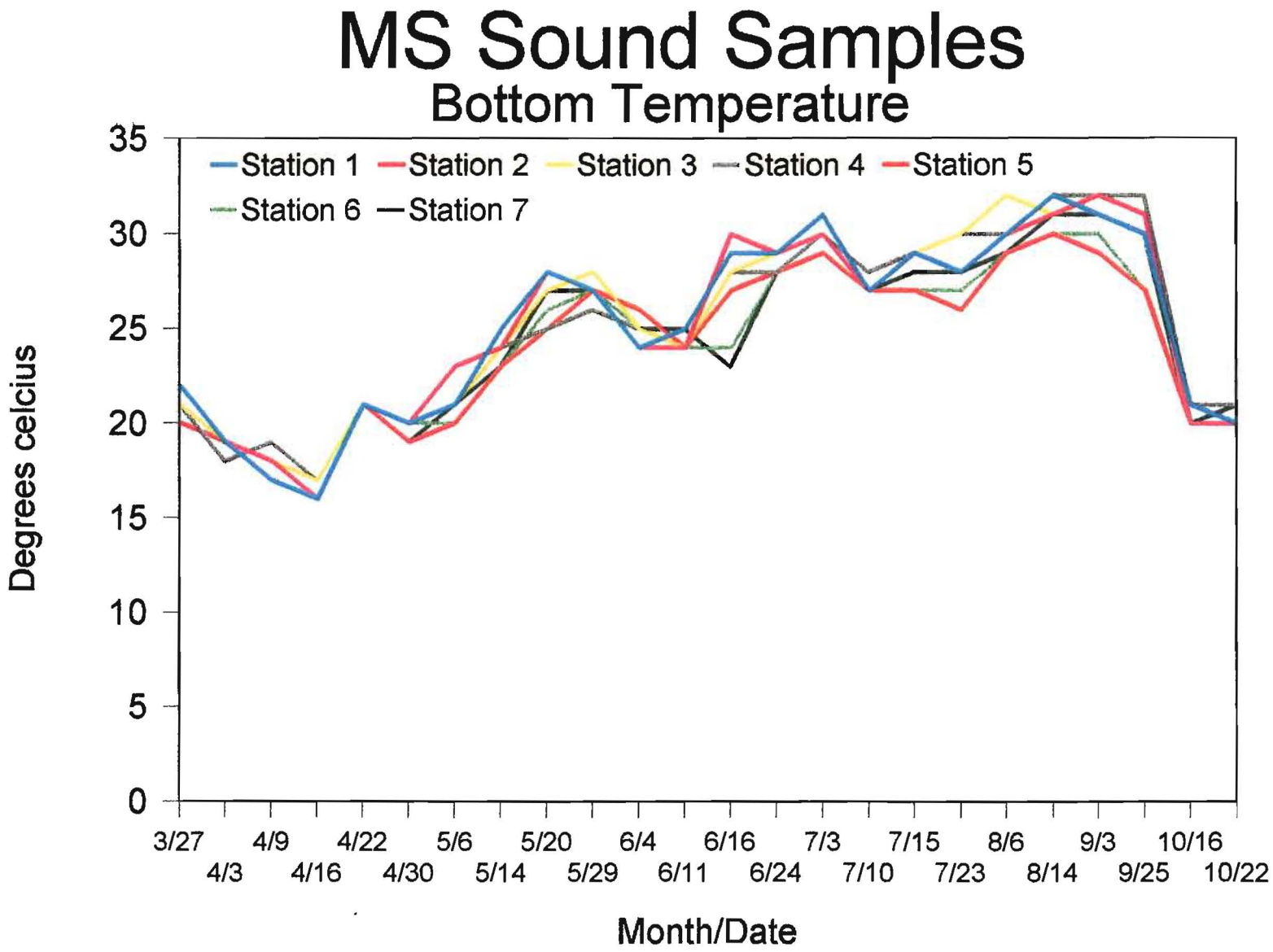

Figure 15. Bottom temperature (°C) for Bonnet Carre' stations 1-7 by sample date.

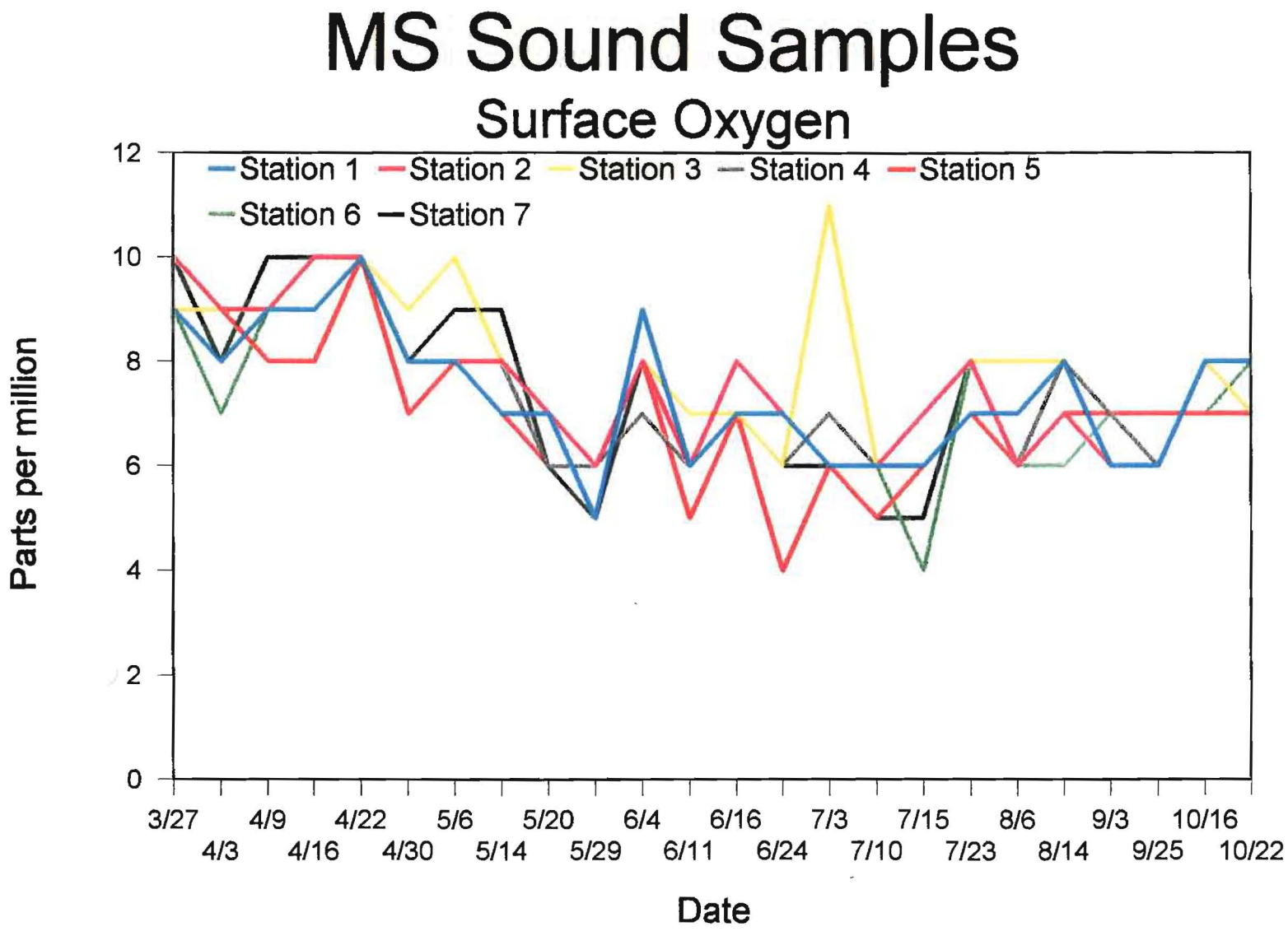

Figure 16. Surface oxygen (ppm) for Bonnet Carre' stations 1-7 by sample date.

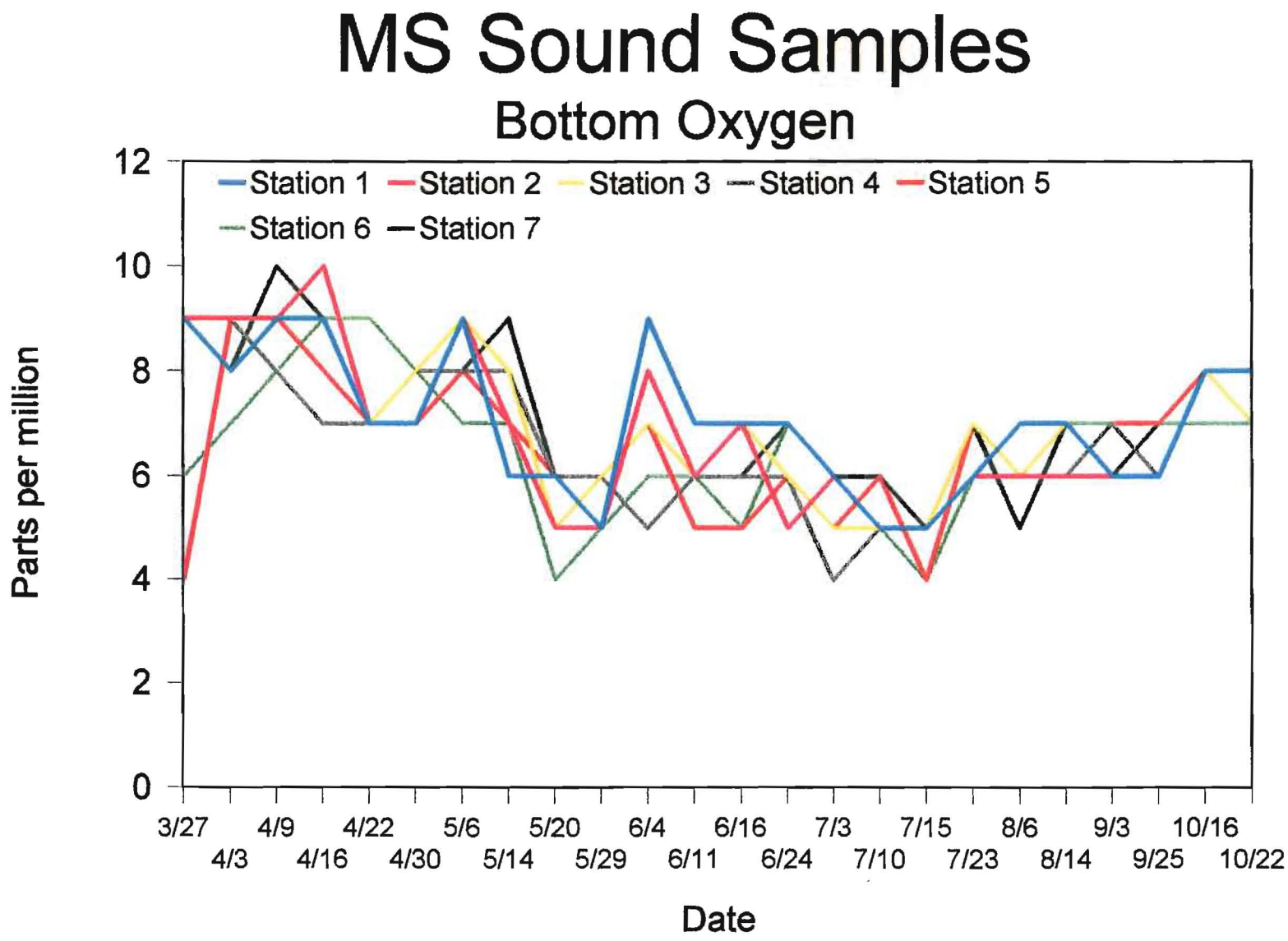

Figure 17. Bottom oxygen (ppm) for Bonnet Carre' stations 1-7 by sample date.

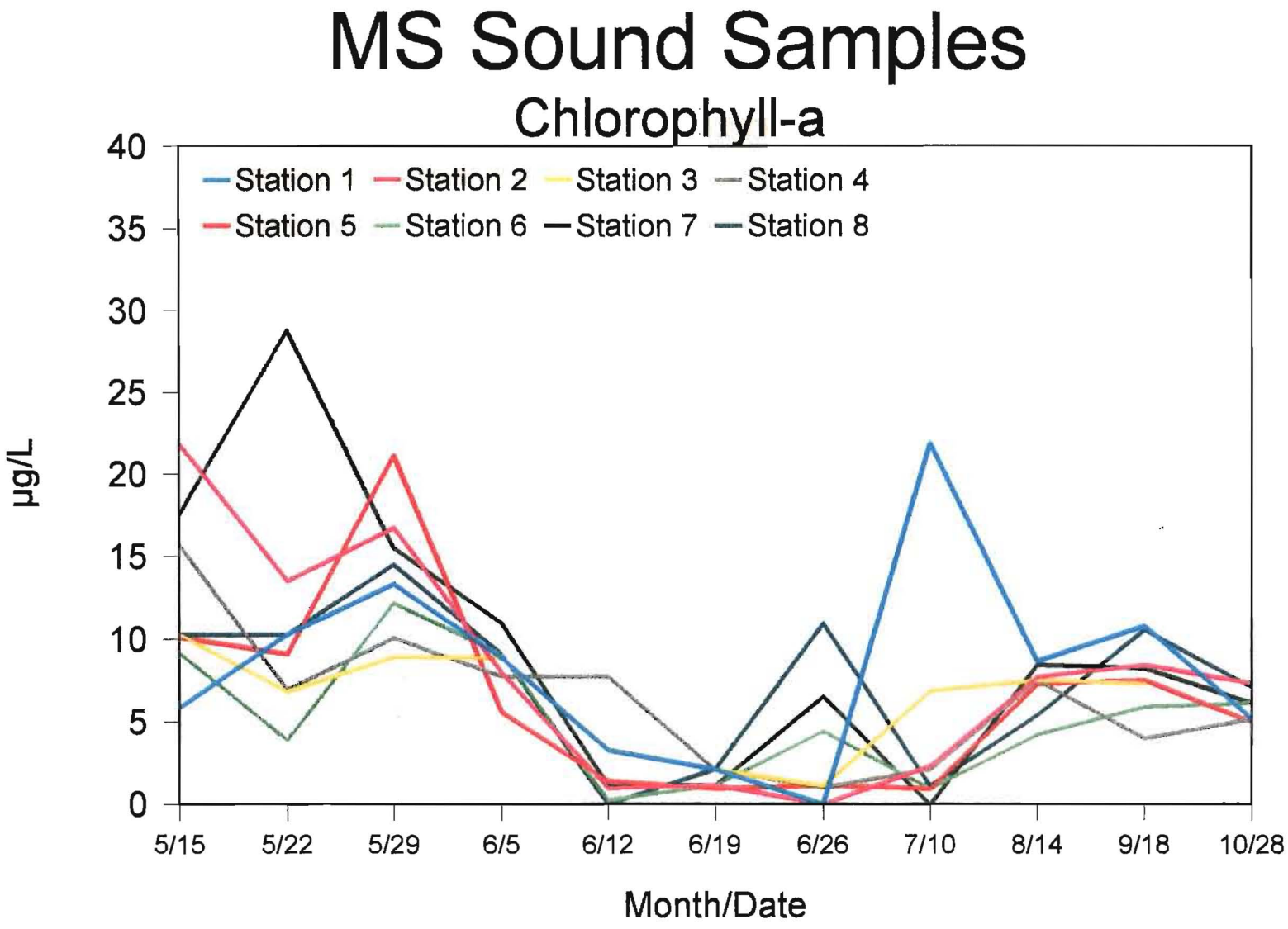

Figure 18. Chlorophyll-a (µg/L) for Bonnet Carre' stations 1-8 by sample date.

coliform levels at the stations sampled if the increased freshwater flow displaced or transported water containing higher levels of fecal coliform bacteria into the Mississippi Sound.

Factors that can affect coliform concentration levels are water temperature (Anderson et. al., 1983), salinity and/or terrestrial runoff from rainfall. Salinity and temperature in western Mississippi Sound are influenced by the intrusion of freshwater. Fecal coliform concentrations (Figure 19) were higher in early March at a time when the Pearl River was at one of the highest stages during the study period. In late March another peak of coliform concentration was observed and coincided with another rise of the Pearl River. As water temperatures began to rise, the coliform concentrations began to decrease.

Peak Bonnet Carre' floodwaters occurred in the Mississippi Sound during the week of April 16th when the surface salinities dropped to 0.0 ppt at all stations. This finding is consistent with salinity data collected by USACE, USGS, LDNR, and satellite imagery available during the time period. Fecal coliform concentration did not increase during the time that peak Bonnet Carre' Spillway floodwaters flowed through the western Mississippi Sound (Figure 19). Fecal coliform concentrations did rise at Station 1 on May 15th, however, this was attributed to floodwaters from the Pearl River (Figure 20).

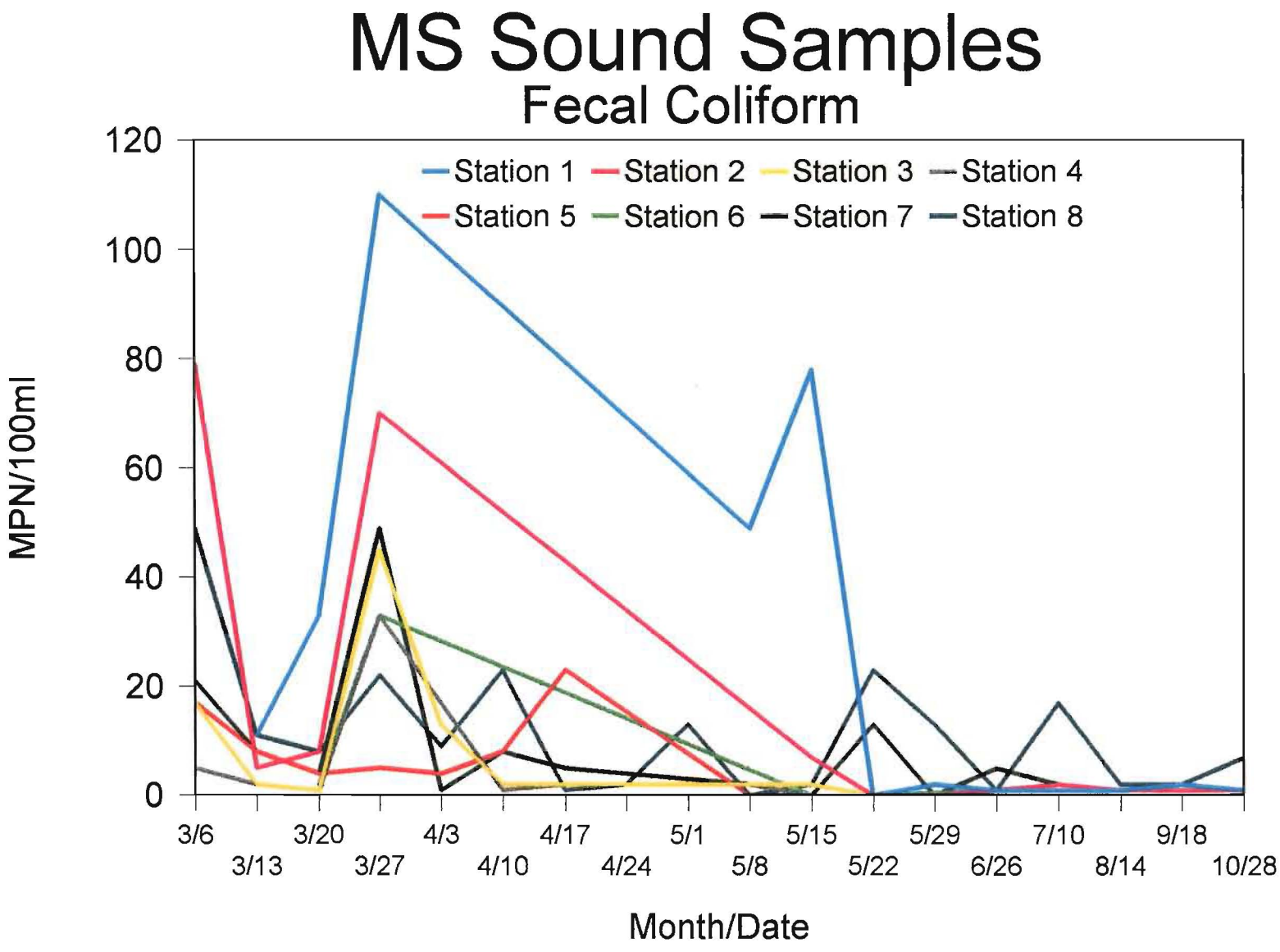

Figure 19. Fecal coliform (MPN/100ml) for Bonnet Carre' stations 1-8 by sample date.

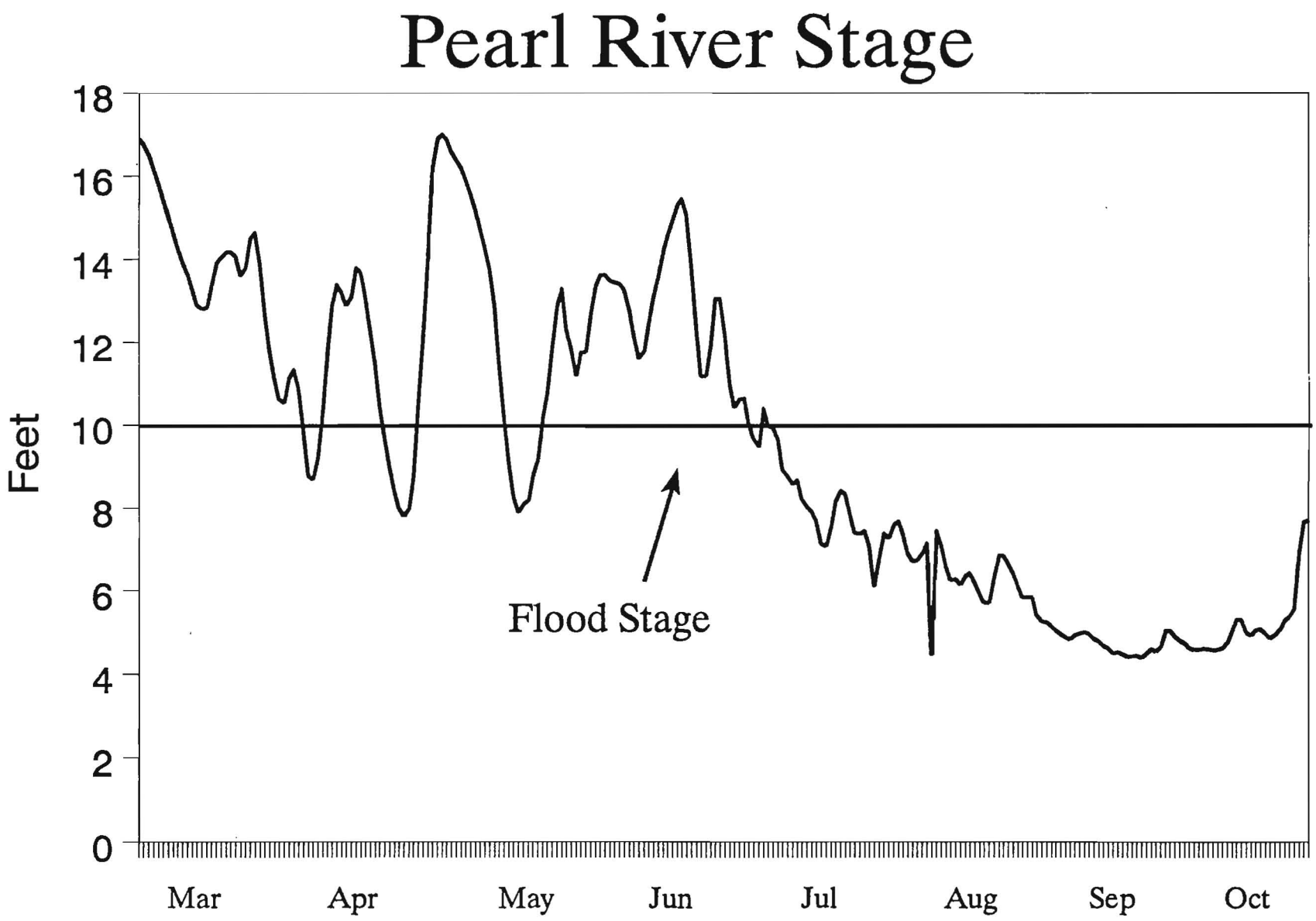

Figure 20.Pearl River stages (ft.) for March - October, 1997.

IMPACT OF THE 1997 BONNET CARRE' SPILLWAY OPENING

During the time of the Bonnet Carre' Spillway opening on March 17, 1997, the Pearl River was above flood stage (10 feet at the Pearl River, LA gauge, Figure 20) and remained high with some fluctuations through June 1997. High river flow by the Pearl River during this time period contributed to the freshwater influence on the western Mississippi Sound's hydrology, water quality, and species distribution. Separation of the influences between the Bonnet Carre' and Pearl River is practically impossible. To assess impacts by these fresh water intrusions comparisons were made of oyster mortalities from this study and historical oyster mortality data collected by the Gulf Coast Research Laboratory under the Fishery Monitoring and Assessment (FMA) program during 1992-96. Hydrology and trawl catch data comparisons are made with the available historical data collected by the Gulf Coast Research Laboratory under the FMA program during 1974-81 exclusive of 1975 and 1979 Bonnet Carre' Spillway openings.

Average monthly oyster mortalities pooled over all stations were compared with historical data collected from the same area over the past five years (Figure 21). While mortality was slightly higher in April 1997, and might be attributed to freshwater inflow, the magnitude of that mortality was not great. Oyster mortalities are within the range of the historical oyster mortalities that occurred without a Bonnet Carre' Spillway opening and are well below the extremely high mortalities (50 to 100%) Mississippi experienced during the 1979 and 1983 Bonnet Carre' openings. These data suggest that only a short-term impact may have occurred to oyster populations in Mississippi Sound relative to the 1997 Bonnet Carre' Spillway opening. The extremely high mortality (45%) observed in June 1995 historical data was a result of flood conditions that occurred in western Mississippi from large amounts of coastal rainfall. An earlier spillway opening, March 17, 1997 as compared to April 18, 1979 and May 20, 1983, and a cool Spring kept water temperatures low and may have helped reduce oyster mortalities.

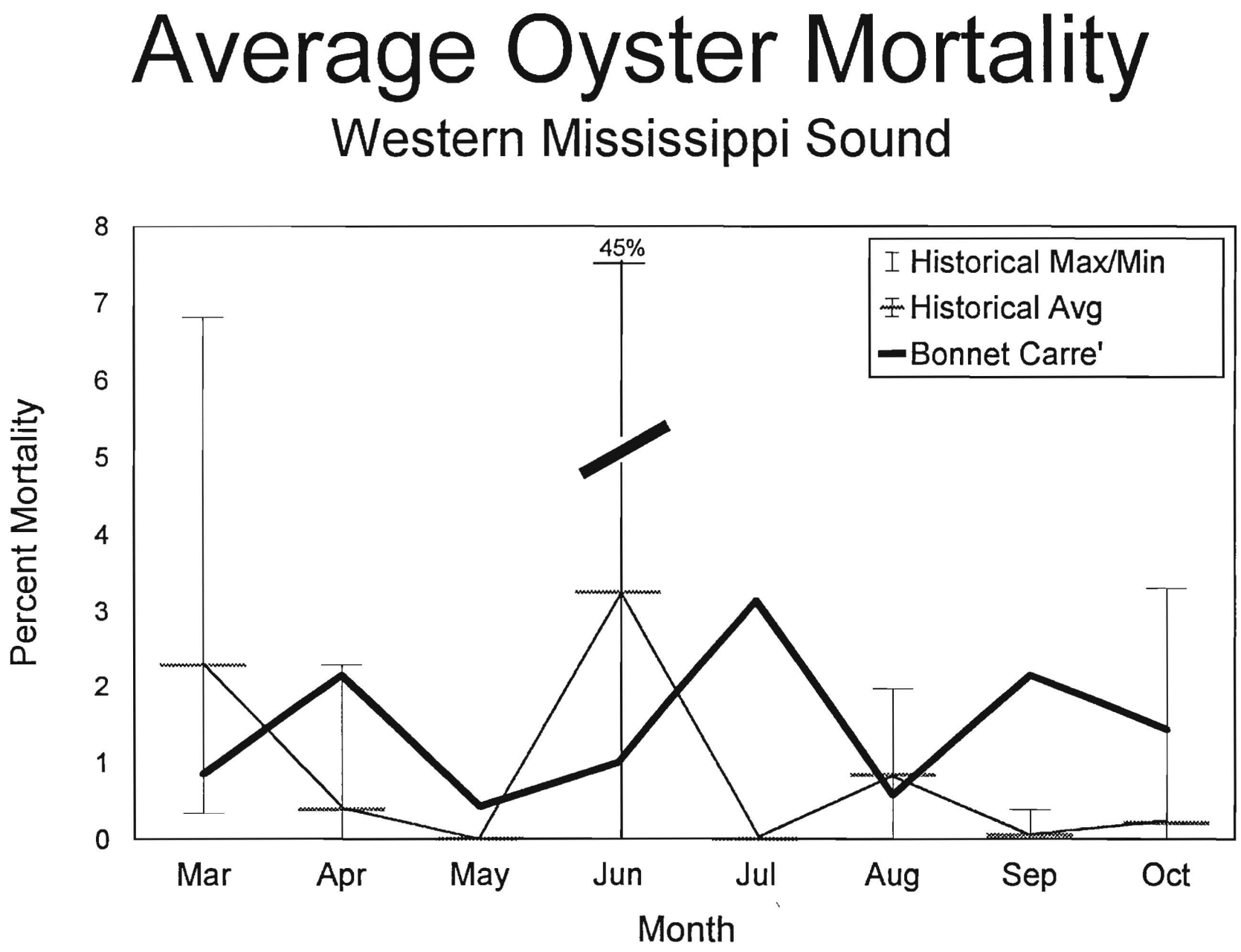

Figure 21. Average monthly oyster mortalities pooled for Bonnet Carre' and historical oyster data.

Freshwater intrusion into western Mississippi Sound during April could be seen to have a definite impact by lowering salinities at all of the stations. Surface salinities at all the stations (Figure 12) were 0.0 ppt on April 16th even though the Pearl River level was dropping. The drop to 0.0 ppt was probably directly associated with the arrival of the floodwaters from the Bonnet Carre' opening. Similarly, bottom salinities (Figure 13) at most stations dropped to zero at this time. The influence was short term as salinities began to rise the following week.

Historical hydrological parameters taken at a station (FMA, Station 60) closest in proximity to sampling Stations 2 and 3 in this study were used to compare hydrological impacts of freshwater intrusion into western Mississippi Sound between the 1997 Bonnet Carre' opening and years when no opening occurred. Monthly averages of historical surface and bottom salinities, temperatures, and dissolved oxygen values for March through October 1974-1981, excluding the years of Bonnet Carre' Spillway openings (1975 and 1979), were compared to monthly averages of salinities, temperatures and dissolved oxygen pooled for trawl Stations 2 and 3 in this study (Figures 22-27). The 1997 average monthly surface and bottom salinities were consistently below the historical average for all months, however, many of the 1997 average values were within the range observed for historical samples. Bottom and surface salinity was below the historical range during March 1997, the month of the Bonnet Carre' opening. Little difference was seen between current and historical surface and bottom temperature and dissolved oxygen values.

Average monthly catch for selected finfish and shellfish from current and historical data from Station 60 of the FMA program are presented in Figures 28-33. The relative average numbers for the bay anchovy and Atlantic croaker were lower in most months in this study than the historical average level. Sand seatrout abundance in current sampling efforts showed higher catches in May and June when compared to historical trends. Average spot and blue crab catches did not deviate appreciably from historical data. Comparisons between 1997 brown shrimp catches and historical catch data for brown shrimp indicate a similar trend in abundance over the same time period with an exception that brown shrimp

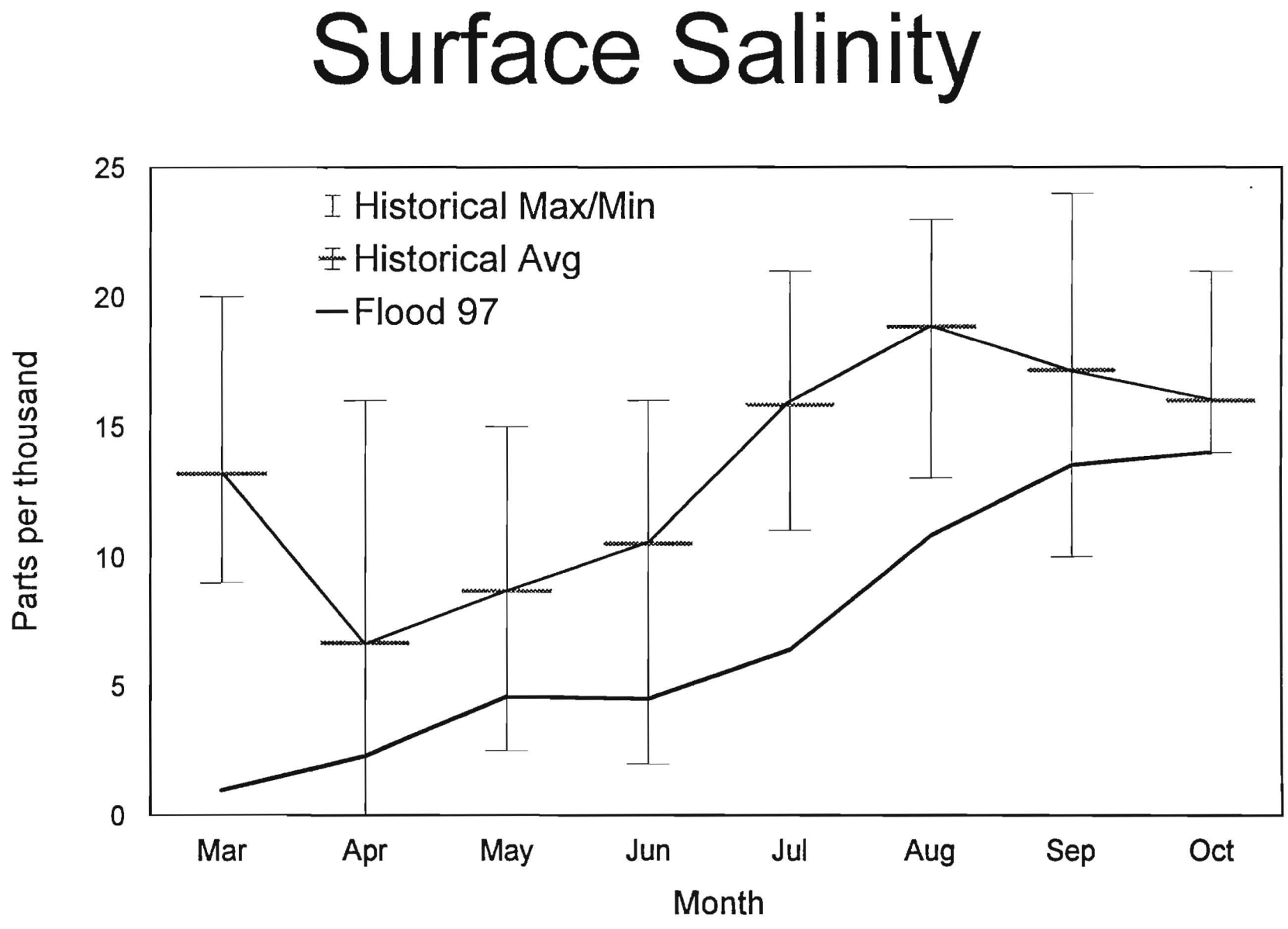

Figure 22. Average monthly surface salinity (ppt) pooled for Bonnet Carre' and historical hydrology data.

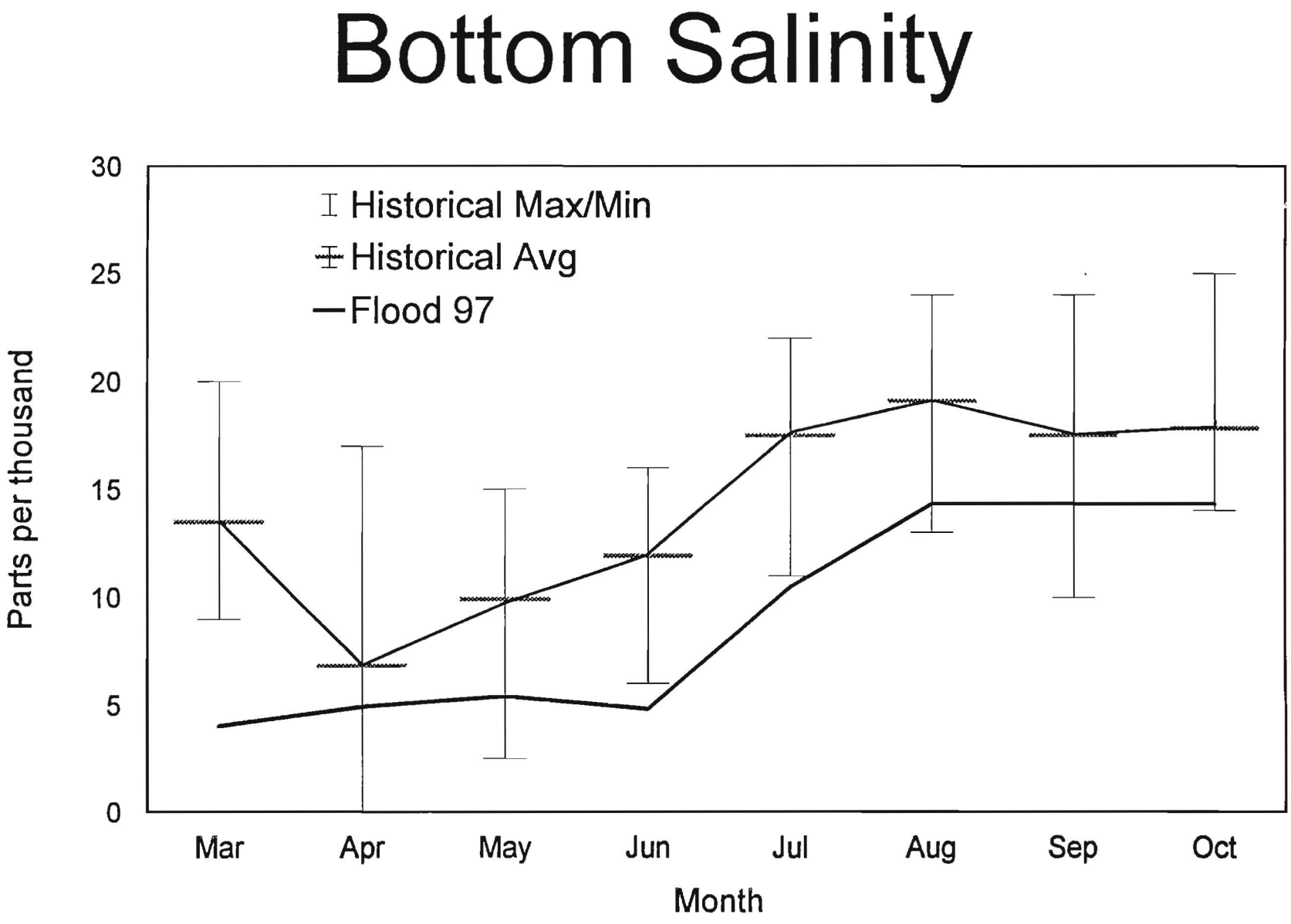

Figure 23. Average monthly bottom salinity (ppt) pooled for Bonnet Carre' and historical hydrology data.

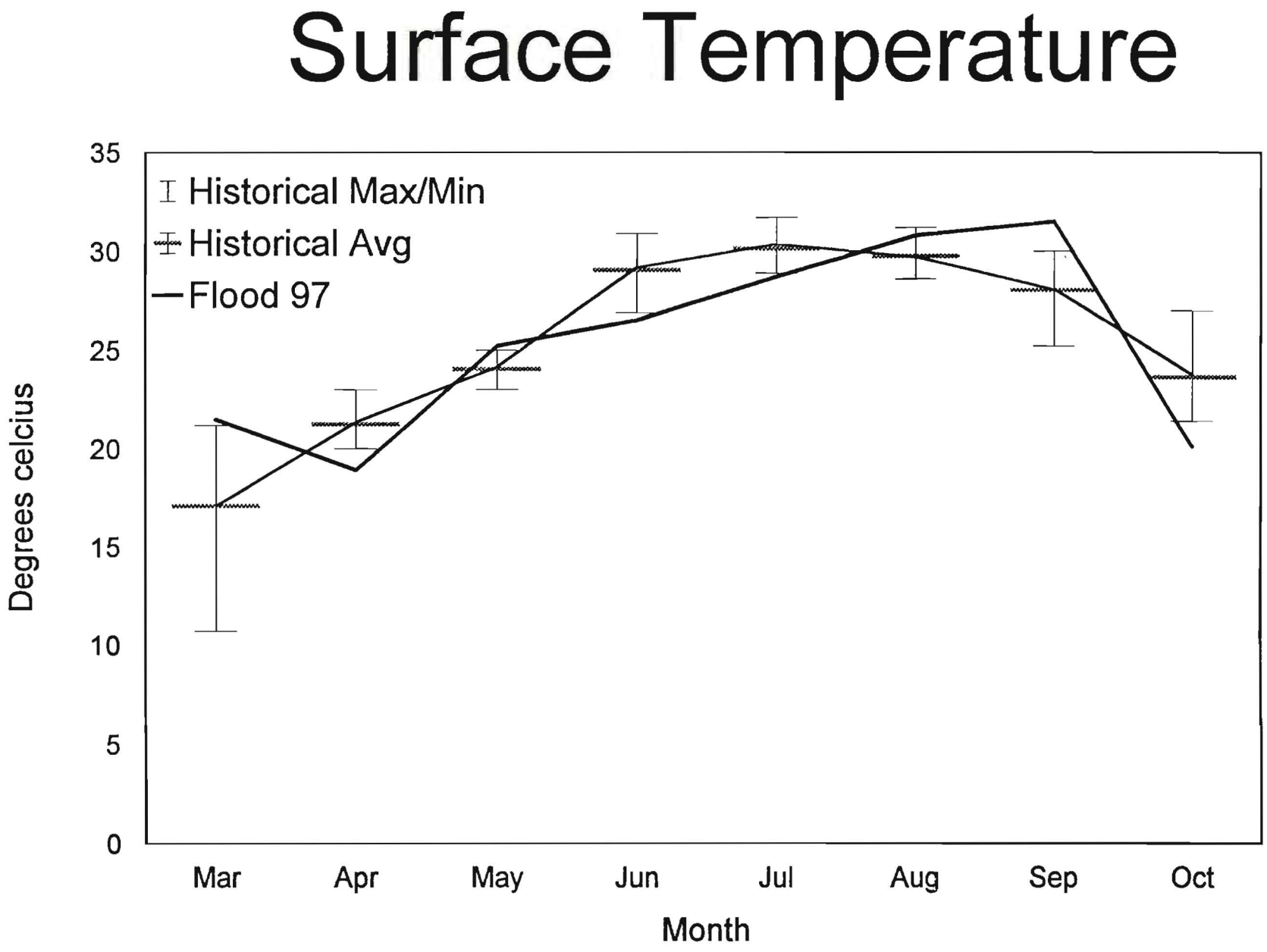

Figure 24. Average monthly surface temperature (°C) pooled for Bonnet Carre' and historical hydrology data.

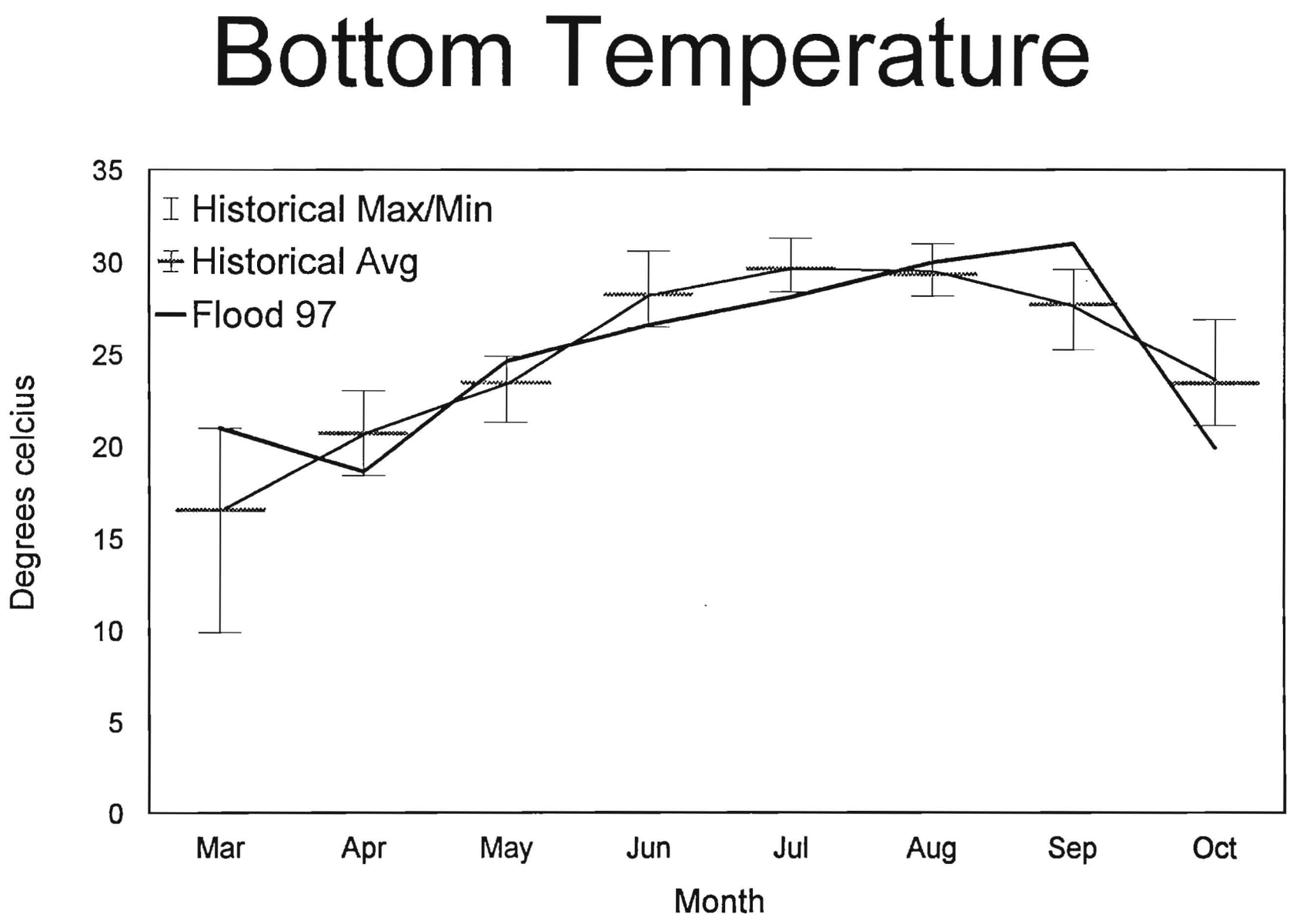

Figure 25. Average monthly bottom temperature (°C) pooled for Bonnet Carre' and historical hydrology data.

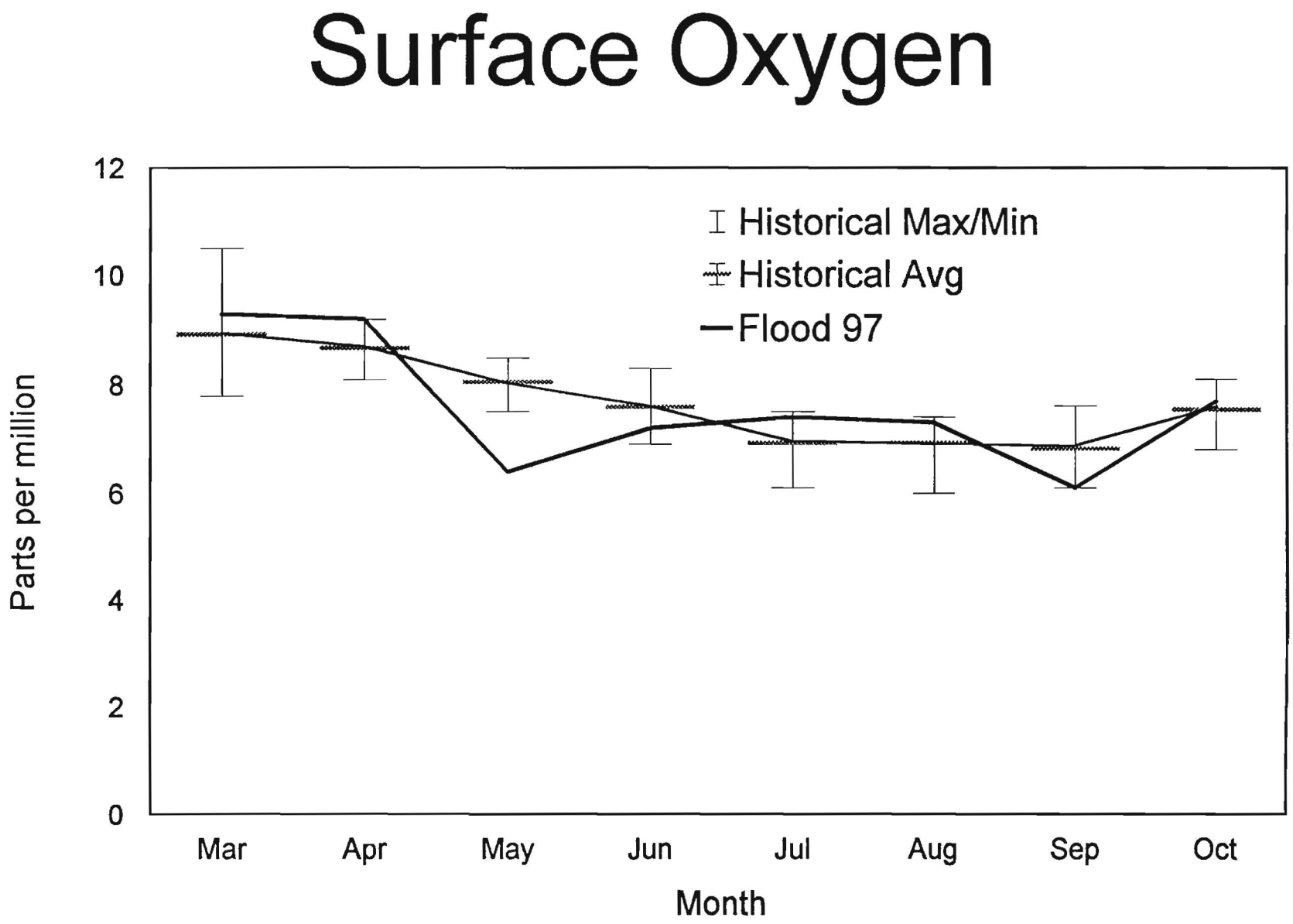

Figure 26. Average monthly surface oxygen (ppm) pooled for Bonnet Carre' and historical hydrology data.

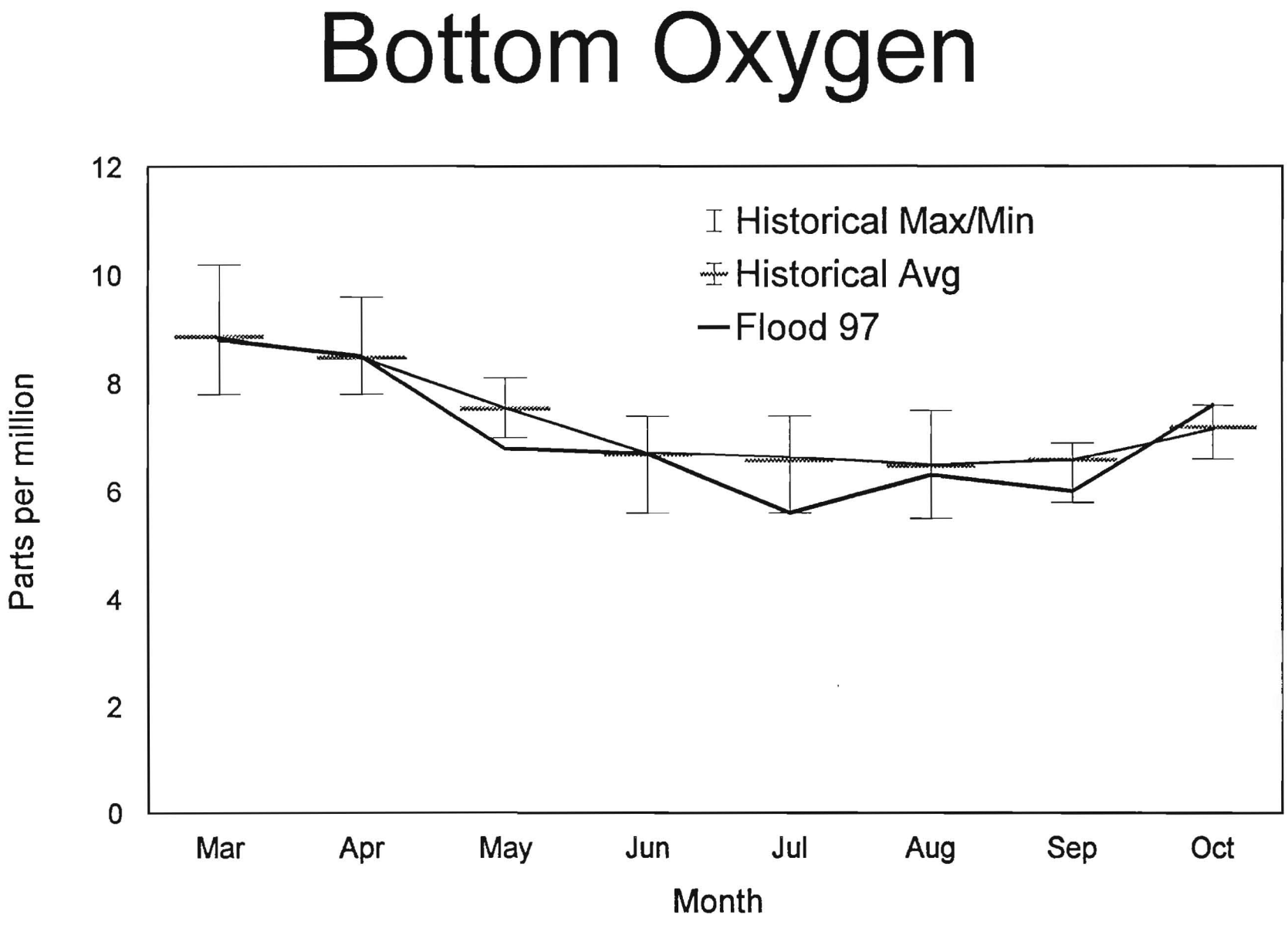

Figure 27. Average monthly bottom oxygen (ppm) pooled for Bonnet Carre' and historical hydrology data.

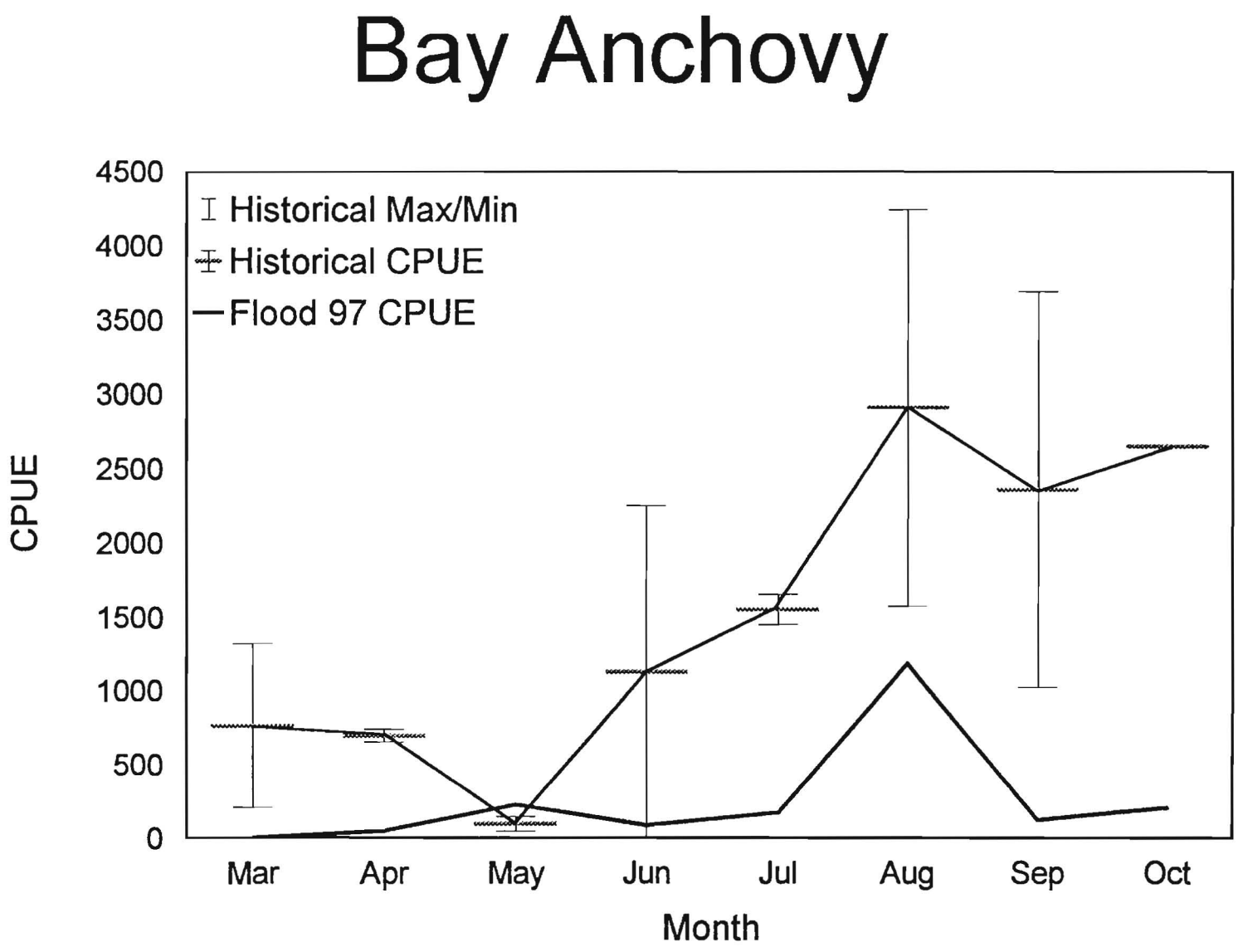

Figure 28. Average monthly catch for the bay anchovy, *Anchoa mitchilli*, pooled for Bonnet Carre' and historical trawl catch data.

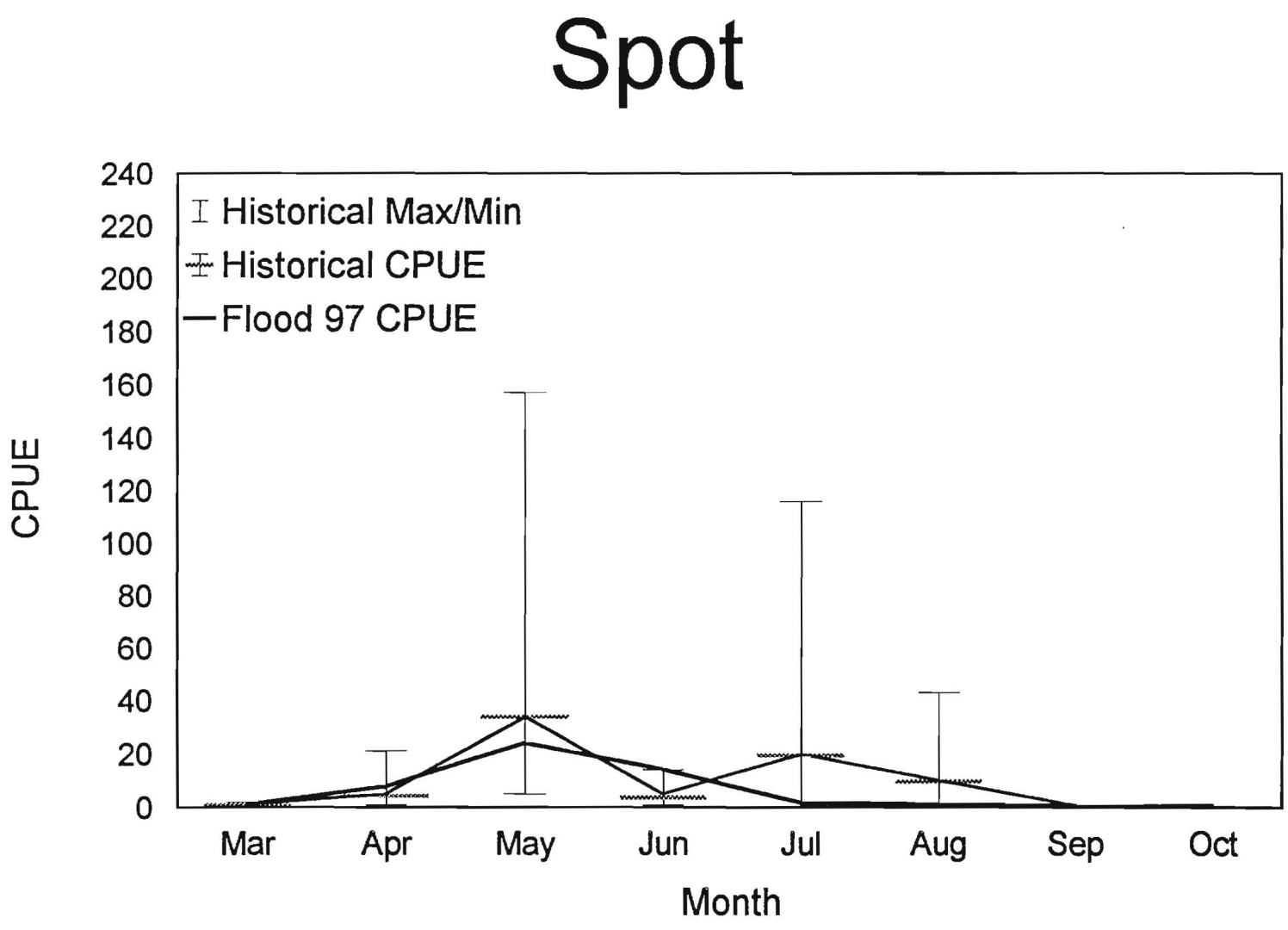

Figure 29. Average monthly catch for spot, *Leiostomus xanthurus*, pooled for Bonnet Carre' and historical trawl catch data.

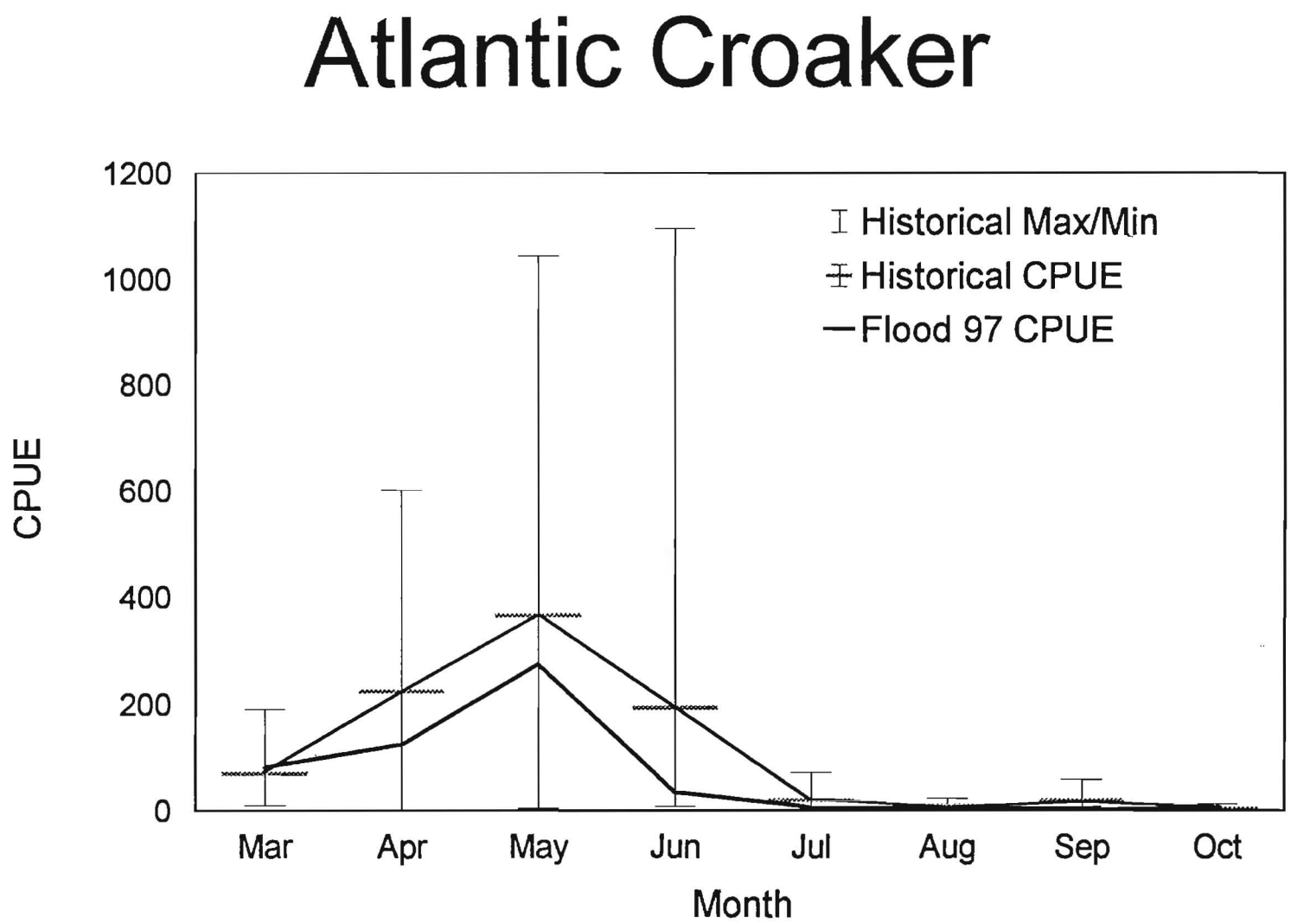

Figure 30. Average monthly catch for atlantic croaker, *Micropogonias undulatus*, pooled for Bonnet Carre' and historical trawl catch data.

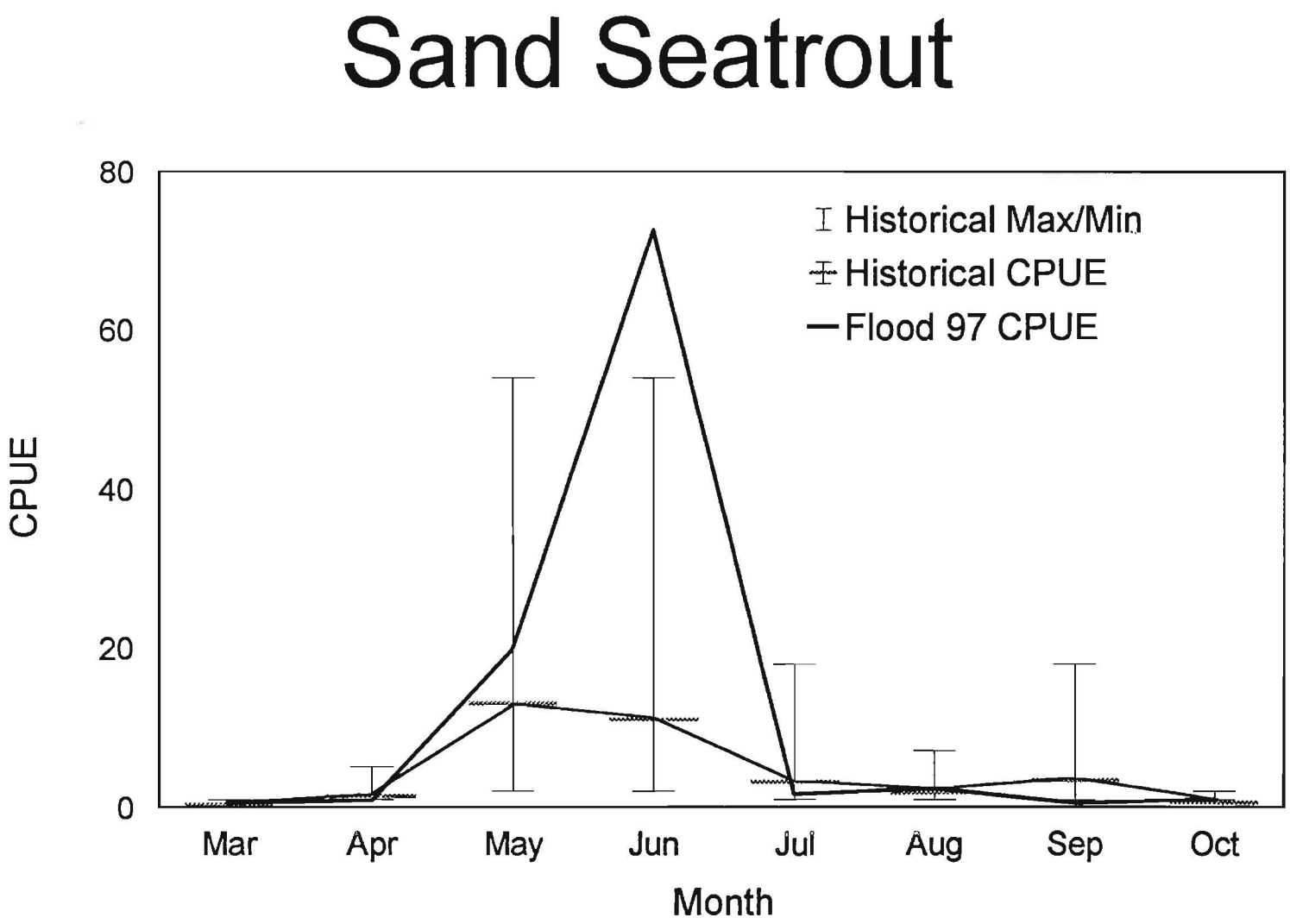

Figure 31. Average monthly catch for the sand seatrout, *Cynoscion arenarius*, pooled for Bonnet Carre' and historical trawl catch data.

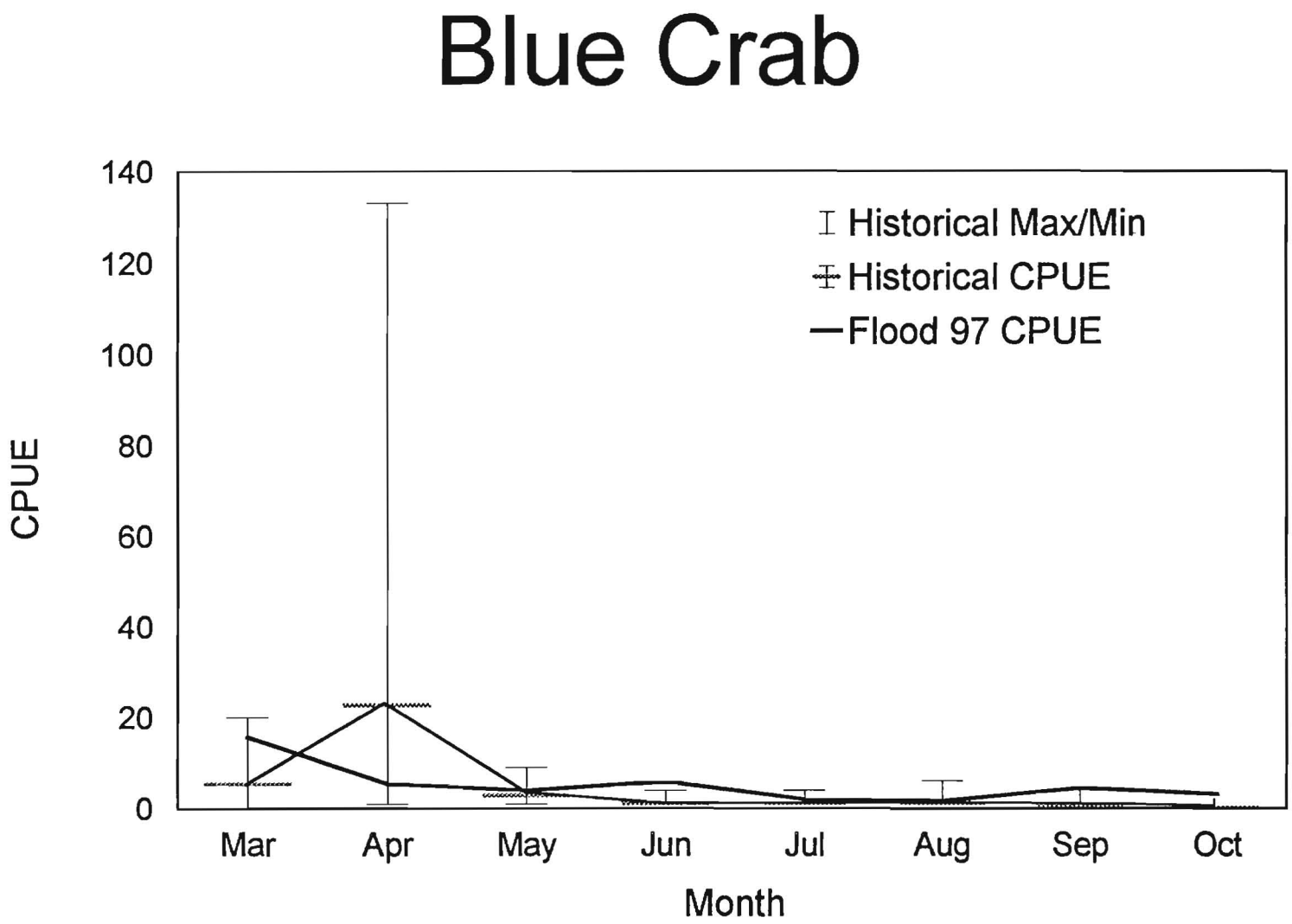

Figure 32. Average monthly catch for blue crab, *Callinectes sapidus*, pooled for Bonnet Carre' and historical trawl catch data.

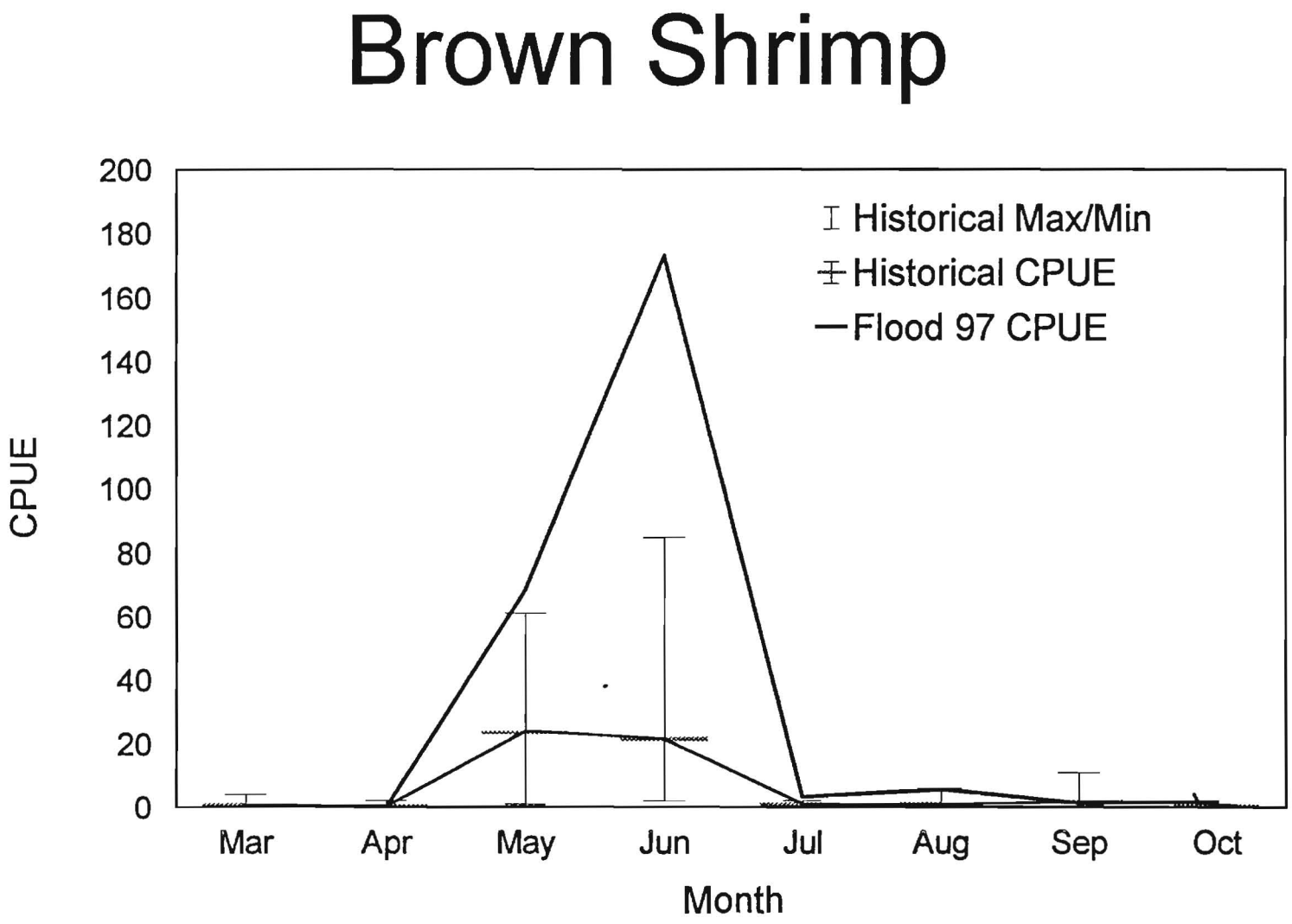

Figure 33. Average monthly catch for brown shrimp, *Penaeus aztecus*, pooled for Bonnet Carre' and historical trawl catch data.

catch was lower in April, followed by an increase in May and June for both 1997 and historical data, however, the relative numbers observed in May and June 1997 were considerably higher than average numbers observed in the historical data and even higher than the historical maximum. Monthly catch dropped dramatically during July through October when numbers of brown shrimp were comparable to historical levels.

Even though the monthly magnitude of catch data was different for most species, the patterns of monthly relative abundance between the current study and historical data were generally similar for all species analyzed. These similar trends seem to indicate that for the species selected the hydrological conditions found in western Mississippi Sound during this limited study did not appreciably effect monthly trends in number taken by trawling gear.

PROJECT CONCLUSION

During the 1997 Bonnet Carre' Spillway opening the Pearl River was consistently above flood stage. Surface salinities in western Mississippi Sound were low during March and dropped to zero in April. The Pearl River stage was at one of its highest points during the study in March but generally dropped through mid-April and was still above 10 feet for most weeks. Peak floodwaters from the Bonnet Carre' opening entered western Mississippi Sound by mid-April, as indicated by the zero surface salinities observed at all stations on April 16th. Salinities increased by the next week and continued to rise throughout the study period, even though the Pearl River stayed above flood stage through June. These data indicate that the opening of the spillway lowered salinities in western Mississippi Sound for a short period, however, water temperature and oxygen levels were similar to historical levels and were not appreciably affected.

Even though the condition of oysters degraded through April, no significant oyster mortality was noted on the major reefs in Mississippi and the mortalities observed were generally similar to years when the spillway did not open.

Finfish and invertebrate patterns of abundance (16 ft. trawl samples) were similar to the historic patterns during non-spillway opening years. Some species showed lower abundance during the study period when compared to historical data. However, two important recreational and commercial species, sand seatrout and brown shrimp catches showed higher numbers during the study period when compared to historical trends (except during April). Commercial annual preliminary landings show no appreciable decline when compared to historical production (Figure 34). The information from this study indicates that any impacts from the 1997 Bonnet Carre' opening were of short-term duration.

Since the results of this study may have been impacted by the flow levels from the Pearl River (i.e. above flood stage from March thru June), it is important to have long term baseline biological and hydrological data for this area. Strong consideration should be given to placing constant recording instruments that continuously monitor salinity, temperature, etc., in these areas and for the implementation of a continuous biological monitoring program for oysters, finfish, and invertebrates, including non-flood years.

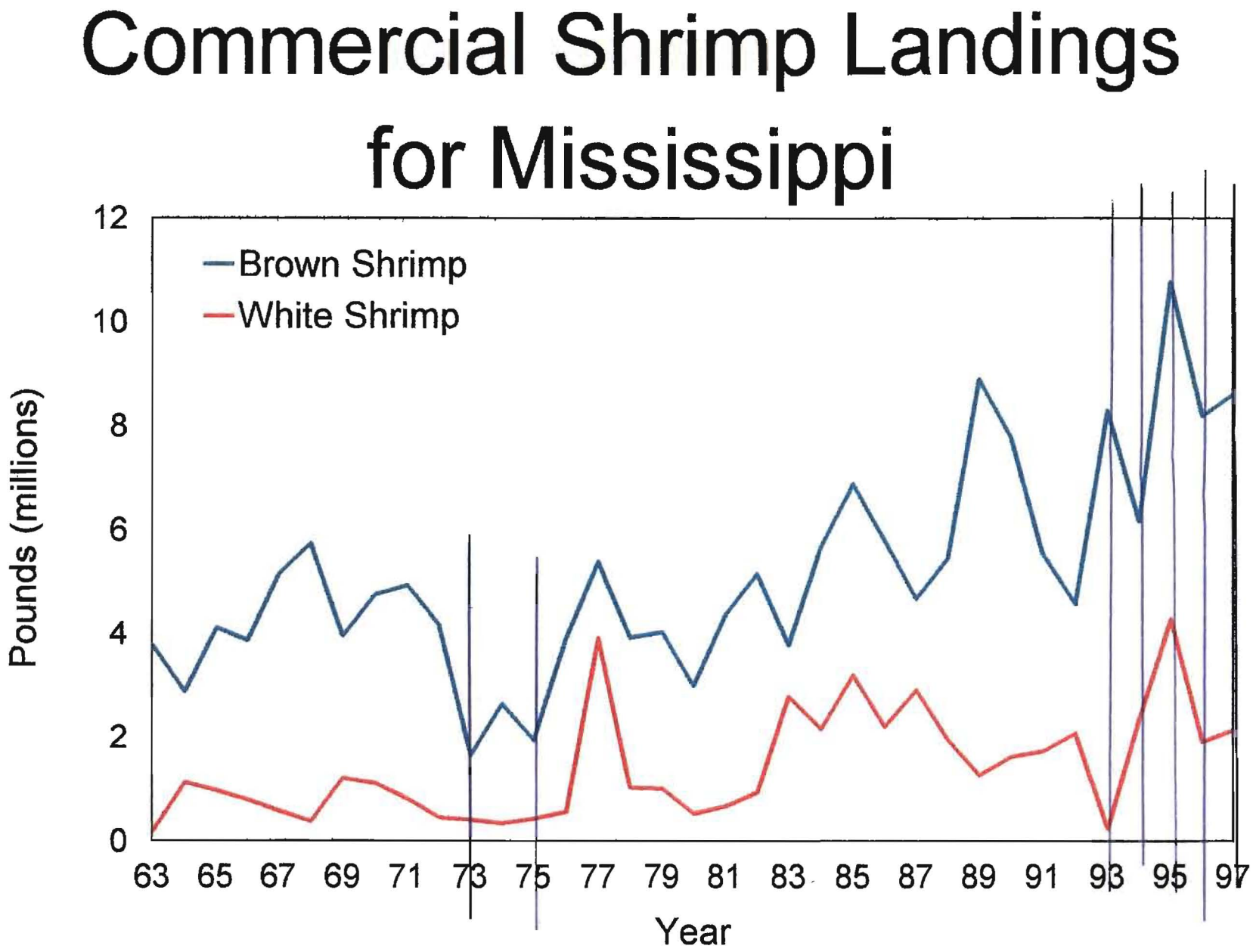

Figure 34. Commercial shrimp landings for brown and white shrimp in Mississippi, 1963-1997.

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