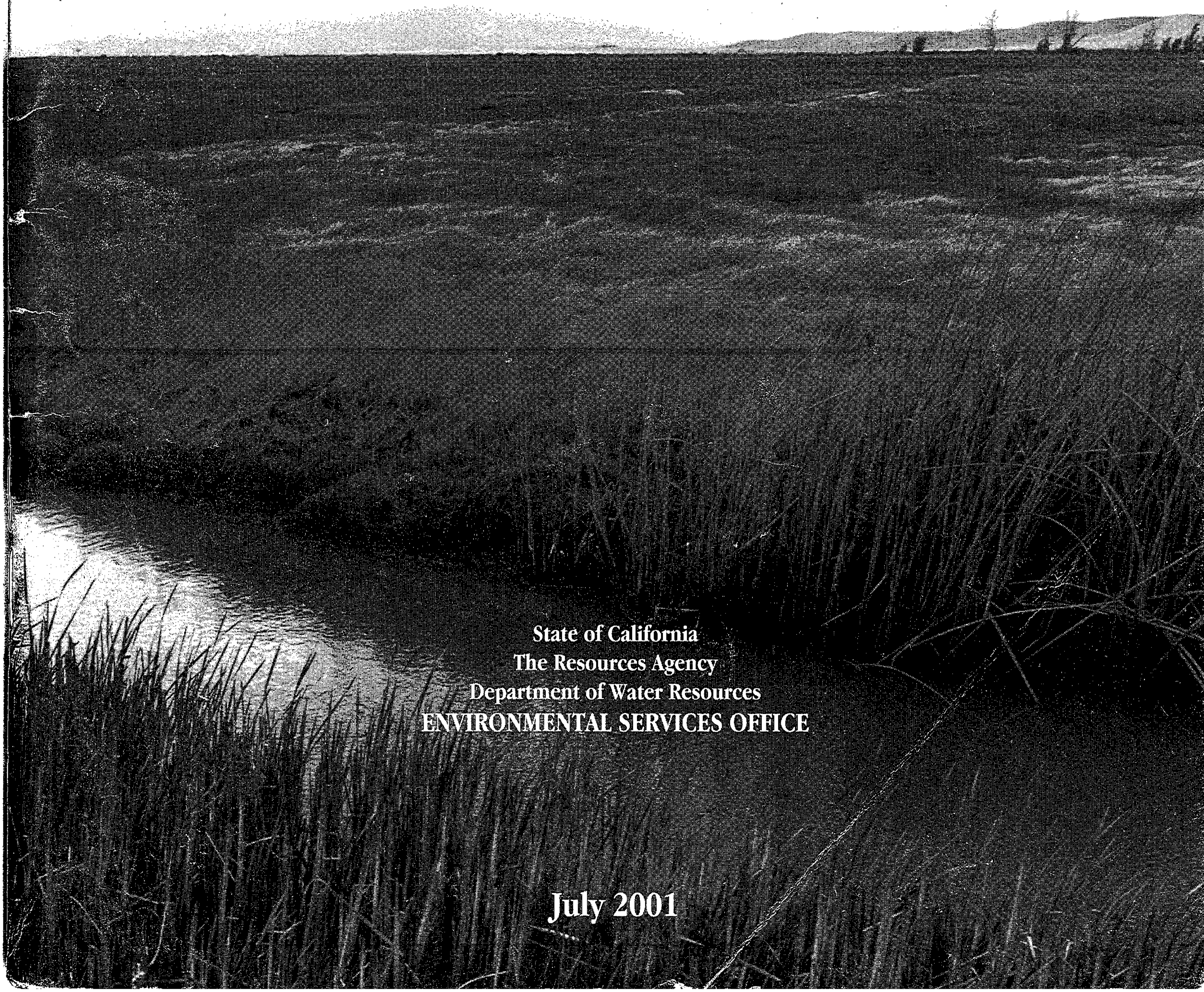
Water Quality Conditions in the Sacramento-San Joaquin Delta During 1996

A Report to the State Water Resources Control Board in Accordance with Water Right Decision 1485, Order 4(f)



State of California
The Resources Agency
Department of Water Resources
ENVIRONMENTAL SERVICES OFFICE

July 2001

DWR cover photo of typical waterway for wildlife, Suisun Marsh, April 1994.

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Foreword

The California State Water Project (SWP) is a multipurpose project. The SWP has a primary role in providing a supply of water statewide and a secondary role in providing flood control, power and recreation. SWP operators must consider water quality needs and have an understanding of the relationship between project operations and the potential impacts on the aquatic environment.

As a condition for operating the SWP, the State Water Resources Control Board (SWRCB) issued a series of water right decisions to the Department of Water Resources. Past decisions include Water Right Decision 1379 (D-1389) of July 1971 and Water Right Decision 1485 (D-1485) of August 1978. D-1485 was amended by the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Estuary (the Bay-Delta Plan) of May 1995. Finally, the Bay-Delta Plan and D-1485 were superceded by Water Right Decision 1641 (D-1641) of December 1999.

The previous decisions, the Bay-Delta Plan and D-1641 have established water quality standards to protect the beneficial uses of water supplies in the Sacramento-San Joaquin Delta (delta) and Suisun Marsh. Staff of DWR, the U.S. Bureau of Reclamation (USBR) and the Department of Fish and Game (DFG) conducted water quality monitoring in 1996 to ensure compliance with the standards contained in D-1485 as amended by the Bay-Delta Plan. The monitoring also identified changes potentially related to SWP and Central Valley Project (CVP) operations, and assessed the effectiveness of the Bay-Delta Plan in preserving the water quality of the delta and Suisun Marsh.

The monitoring program and associated special studies conducted to comply with the water right decisions in effect over the years have provided SWP operators with information that has enabled them to obtain a more complete understanding of the effects of operating the SWP on the ecology of the delta. The program has also provided information that will be used to help determine future operating criteria to protect the waters of the delta and San Francisco Bay.

D-1485 and the Bay-Delta Plan were in effect throughout 1996 and require that a detailed report on monitoring results be prepared and submitted to the SWRCB. The compliance monitoring data base is also available electronically to serve as a source of information for agencies, organizations and individuals involved in delta study programs.

Barbara McDonnell

Barbara McDonnell, Chief
Environmental Services Office

Contents

Contents *(continued)*

Contents *(continued)*

Acknowledgments

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Chapter 1—Introduction

To protect beneficial uses of water in the delta and Suisun Bay, the SWRCB sets water quality standards. The present standards were established in Water Right Decision 1485, issued in August 1978. These standards can affect State Water Project (SWP) and Central Valley Project (CVP) operations because the operations modify flow and water quality variables such as salinity and water temperature. The SWP and CVP are operated to meet these standards and contractual water quality objectives at all points of delivery.

Decision 1485 also requires the Department of Water Resources (DWR) and U.S. Bureau of Reclamation (USBR) to monitor compliance with the water quality standards and report the results annually to the SWRCB. This report summarizes the 1996 water quality monitoring results, compares water quality patterns with those of previous years and meets the reporting requirement of Term 4(f) of Decision 1485.

Summary—Water year 1996 was classified as a wet year with an average streamflow similar or somewhat above that in 1993. As in many recent years, snowpack water content was below average and precipitation was high early in the spring. Dilution associated with the high streamflow produced low nutrient and specific conductance, and high dissolved oxygen concentration compared with drier years—especially the recent drought years 1987-1992. However, the pattern of highest nutrient concentration in the winter among seasons and in the south delta among regions persisted. Water quality conditions in 1996 were also characterized by comparatively higher Secchi disk depth than in the early 1970s. Further, even though 1996 was a wet year, the dissolved oxygen concentration in the Stockton Ship Channel was below the U.S. Environmental Protection Agency (USEPA) water quality standard of 5 mg/L in August and Regional Water Quality Control Board (RWQCB) water quality standard of 6 mg/L in September and October.

Continuous data generally agreed with the discrete water quality data, but demonstrated wide diel variation. For example, average dissolved oxygen was consistently above 7 mg/L in the southern delta, but the daily range was as high as 4 mg/L in the Stockton Ship Channel. As a result, dissolved oxygen concentration was frequently below 5 mg/L. Discrete monitoring done during the daytime consistently missed these daily minima because they often occurred early in the morning, just before daybreak.

High streamflow may have partially affected the low biological production in 1996. Monthly average chlorophyll *a* concentration was less than 8 $\mu g/L$ throughout the estuary and was consistent with the low chlorophyll *a* and organic matter concentrations that have characterized the estuary since the early 1980s. These low chlorophyll *a* concentrations were probably partially a function of the high streamflow in 1996 that would have reduced total production by washout. Low chlorophyll *a* concentration (< 3 $\mu g/L$) was also measured in Suisun Bay in the spring and early summer. Low chlorophyll *a* concentration (< 4 $\mu g/L$) has been measured in Suisun Bay since 1987, when clam grazing increased due to the establishment of the clam *Potamocorbula amurensis*. The somewhat higher average chlorophyll *a* concentration (4 - 8 mg/L) in Suisun Bay in July through September suggested production in the Bay was influenced by high streamflow in 1996. High streamflow deposits upstream phytoplankton production into Suisun Bay and moves clams downstream.

The relatively low chlorophyll *a* concentration and organic carbon concentration was accompanied by low zooplankton abundance. Cladocera, rotifer and native copepod abundance was lower in 1996 than in the 1970s and early 1980s. In addition, the long-term decline in abundance of the native *Neomysis mercedis* continued. However, the relationship between the phytoplankton chlorophyll *a* concentration and zooplankton abundance was unclear because seasonal peaks did not coincide.

Like the zooplankton community, the benthic community in 1996 demonstrated many differences compared with previous years. In 1996, alone, ten new benthic species were identified. Despite these new species, the community was primarily comprised of three taxa: annelida, arthropoda and mollusca. Together, these taxa comprised

92 percent of the benthic fauna in 1996. Among regions, annelid abundance was most stable, although abundance was higher upstream than downstream. Among seasons, high abundance usually occurred in the spring for annelids and in the summer and fall for molluscs.

Chapter 2—Hydrologic Conditions

Water year 1996 (October 1, 1995 to September 30, 1996) was classified as a wet year and is the second consecutive wet year since 1994. The wet year classification was based on the new Sacramento Valley 40-30-30 Water Year Hydrological Classification Index (Figure 2-1) and the San Joaquin Valley 60-20-20 Water Year Hydrological Index (Figure 2-2) that have been used operationally since 1995. These indexes classify a water year as wet if the index value is above 9.2 or 3.8 respectively.

Water year 1996 was also classified as a wet year by the Sacramento River and San Joaquin River Unimpaired Runoff indexes that were used to classify years prior to 1995. Unimpaired Runoff (during water year 1996) exceeded 22 million acre-feet in the Sacramento River Basin (Figure 2-3) and 7 million acre-feet in the San Joaquin River Basin (Figure 2-4).

Precipitation, runoff and reservoir storage were above average and snowpack water content was slightly below average during water year 1996. Rainfall was below normal during the fall, but increased to above normal during the winter. On May 1, statewide precipitation was 130 percent of average, snowpack water content was 95 percent of average, seasonal runoff was at 125 percent of average and reservoir storage was 120 percent of average.

High winter rainfall and good carry over storage in major reservoirs caused the high streamflow in the Sacramento and San Joaquin rivers. Average monthly streamflow between January and May ranged from 1 million cfs to 2.2 million cfs in the Sacramento River and 80,000 cfs to 300,000 cfs in the San Joaquin River (Figure 2-5). This combined streamflow produced a maximum Net Delta Outflow Index (Figure 2-6) in February of 125,000 cfs that decreased to less than 40,000 cfs by June.

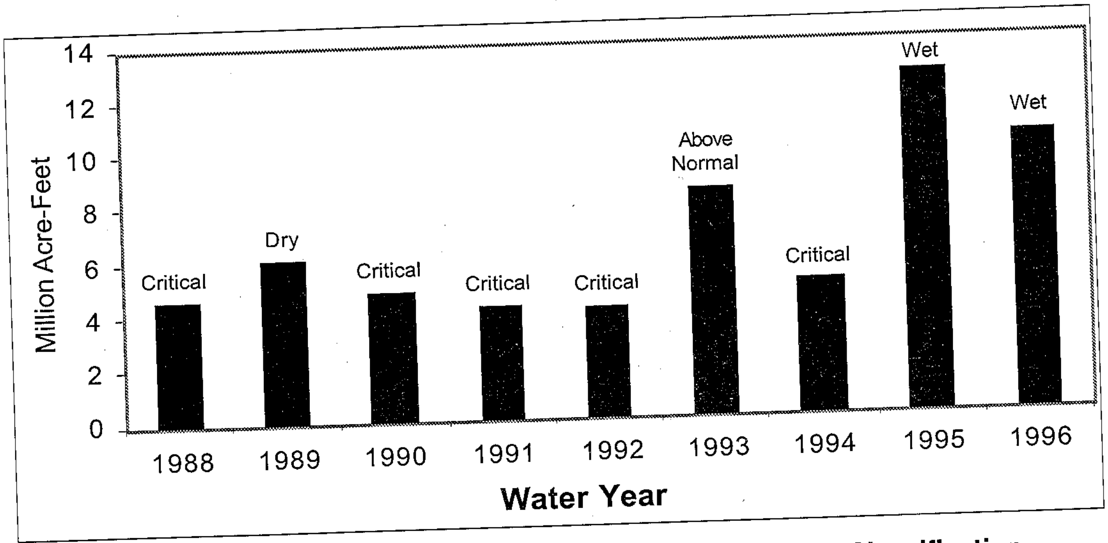

Figure 2-1—Sacramento Valley 40-30-30 Water Year Hydrological Classification Index, 1988-1996

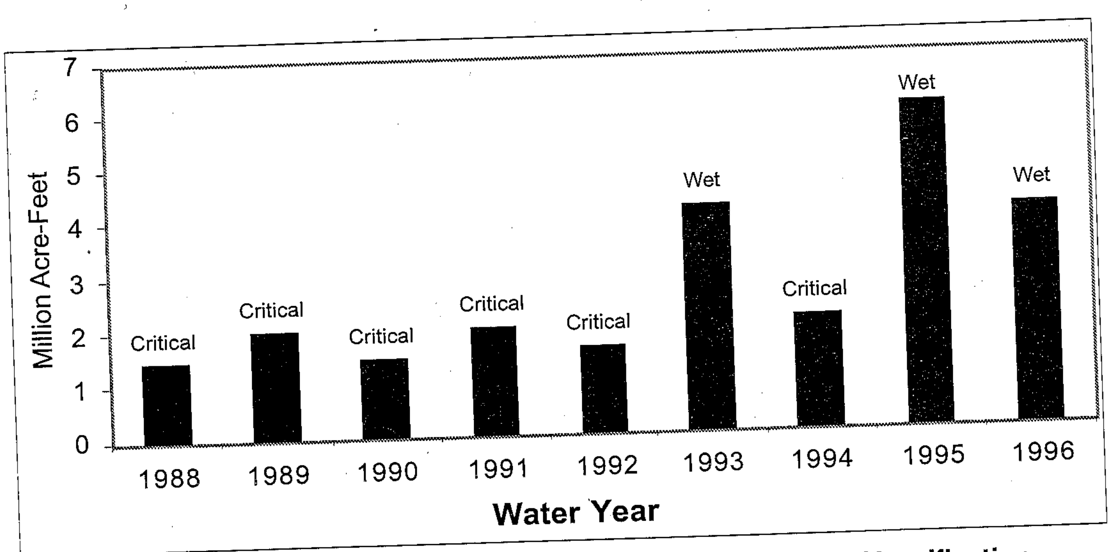

Figure 2-2—San Joaquin Valley 60-20-20 Water Year Hydrological Classification Index, 1988-1996

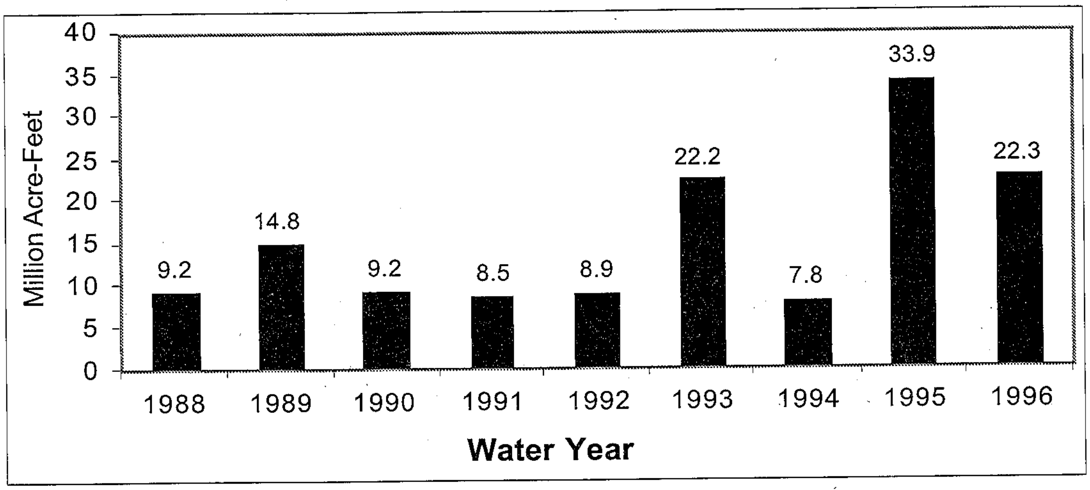

Figure 2-3—Sacramento River Unimpaired Runoff, 1988-1996

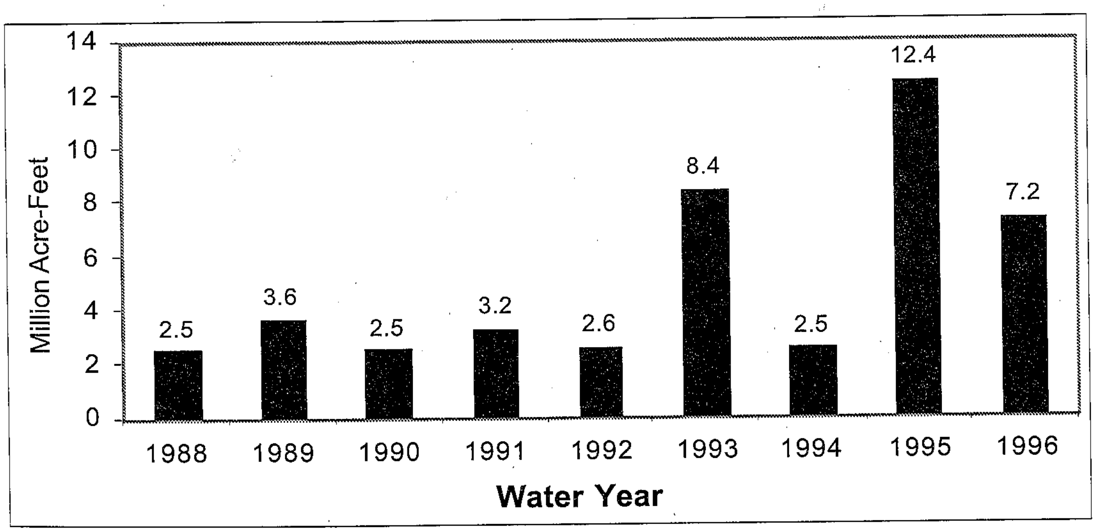

Figure 2-4—San Joaquin River Unimpaired Runoff, 1988-1996

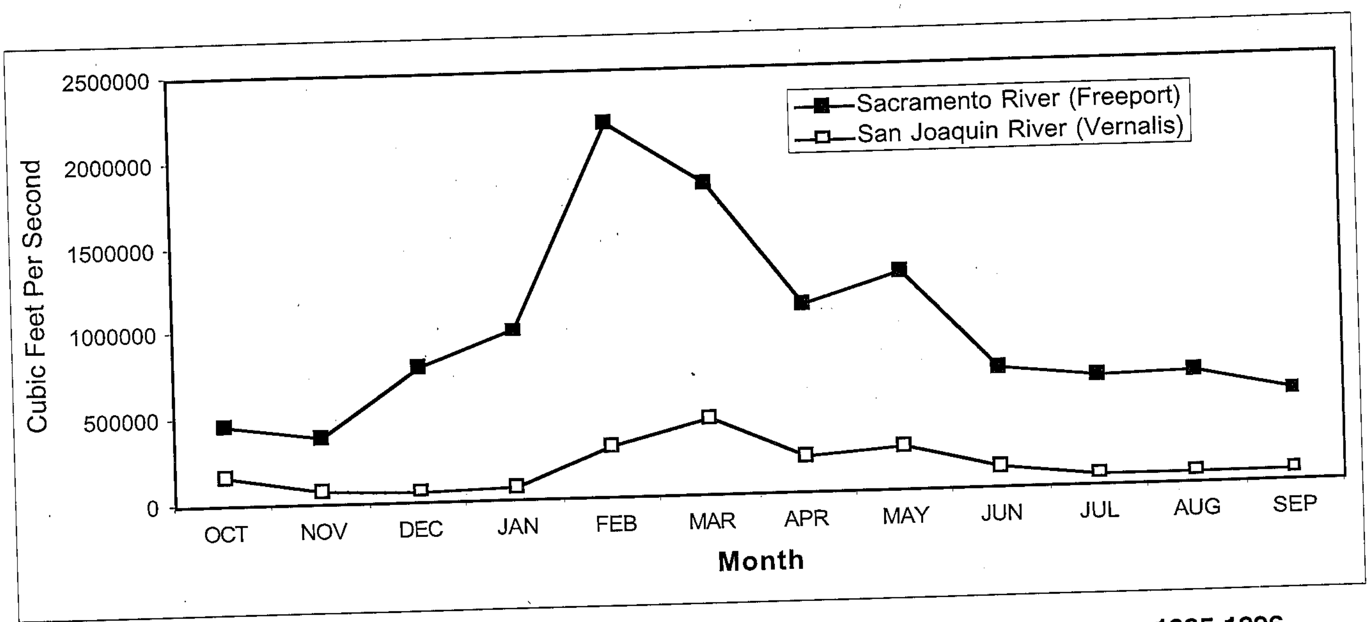

Figure 2-5—Average monthly flow in the Sacramento and San Joaquin rivers, water year 1995-1996

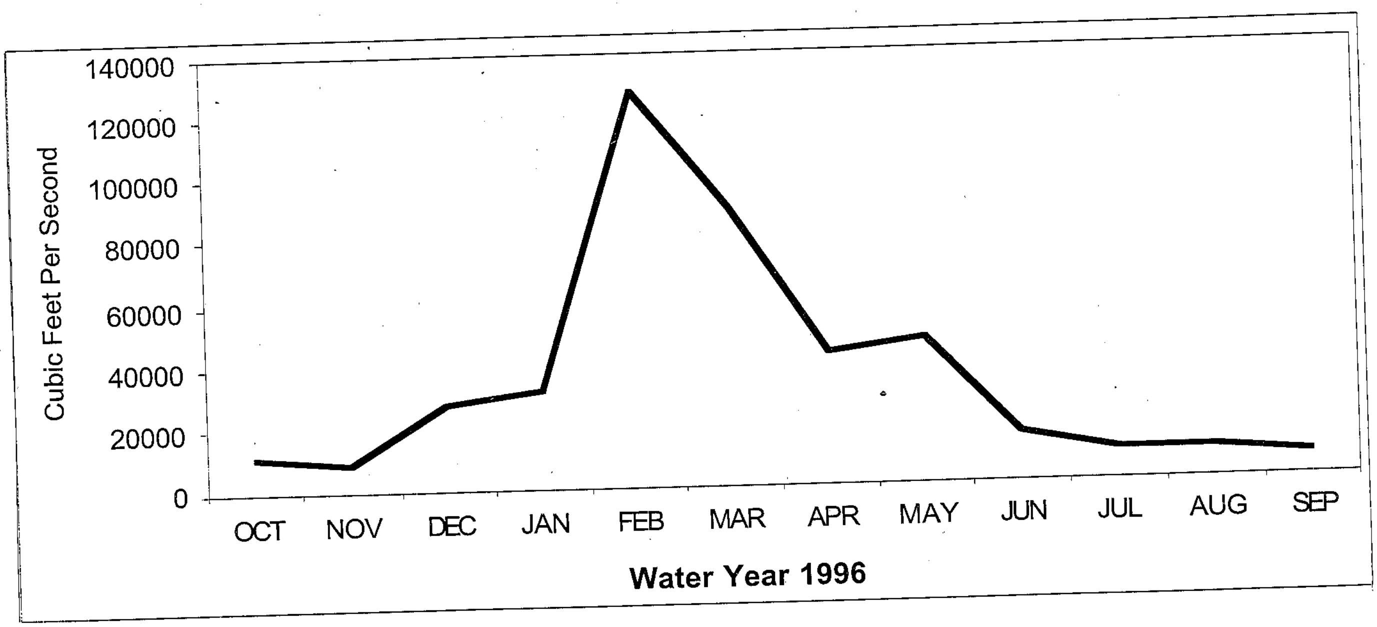

Figure 2-6—Net Delta Outflow Index

Chapter 3—Physical and Chemical Discrete Monitoring Results

This chapter describes physical and chemical discrete monitoring results. Revisions to DWR's water quality program were implemented in 1996, decreasing the number of discrete water quality sampling sites from 26 to 11. Discrete measurements of physical and chemical variables were obtained at 11 stations at 1 m depth on a monthly basis (Figure 3-1). Measurements were made within 1 hour of high slack tide and the time of each sample was recorded to the nearest 5 minutes using Pacific Standard Time. Data were grouped together into regions based on hierarchical cluster analysis for the summary analyses in this report (Lehman 1996 b). Details of the physical and chemical analyses are described in Lehman (1996 b).

Water quality parameters such as nutrients, dissolved oxygen and salinity showed patterns that are comparable to other wet years. In general, seasonal patterns in nutrient concentrations remain comparable to other years although overall concentration levels were lower than in dry or critical years due to higher diluting streamflows. Dissolved oxygen seasonal patterns were comparable as well, but showed higher concentration levels due to the higher streamflow. In addition, 1996 water temperature and water transparency continue to be higher than those measured before the late 1970s (Lehman 1996 b).

Physical Variables

Secchi disk depth—Secchi disk depth, a measure of water transparency, averaged 0.58 m in the delta and Suisun and San Pablo bays. The regional averages ranged from 0.34 m in Suisun Bay to 0.92 m in the central delta (Figure 3-2). These Secchi disk depths were high compared to those before 1980 and continue a trend of increasing water clarity since the late 1970s (Lehman 1996 b). Seasonally, Secchi disk depth varied little in Suisun and San Pablo bays, the lower Sacramento River and southern delta. Peak Secchi disk depth occurred in the fall for the northern, eastern, and central delta and the lower San Joaquin River, probably due to reduced suspended matter produced by low inflow and high residence time in the fall. Secchi disk values were more variable in upstream (eastern, central and northern delta and lower San Joaquin River) than downstream regions (Suisun and San Pablo bays).

Water Temperature—Average annual water temperature in the delta and Suisun and San Pablo bays was 17°C. The regional averages ranged from 15.6°C in the northern delta to 18.6°C in the eastern delta. Seasonally, water temperatures were high during June, July and August and low during December and January throughout the estuary (Figure 3-3). The high summertime water temperature in the delta was probably due to both long residence time and high air temperature. The lowest summertime water temperature occurred in the Bay regions where the ocean influence was strong and in the northern delta where there was an inflow of cool Sacramento River water.

Nutrients and Organic Matter

Silica—Most of the silica enters the estuary via the Sacramento and San Joaquin rivers. Average annual silica concentration was 14.2 mg/L. Regional averages ranged from 8.5 mg/L in San Pablo Bay to 16.6 mg/L in the northern delta. Seasonal variation differed for upstream and downstream regions (Figure 3-4). Downstream regions had high winter concentrations due to high downstream transport and low summer and fall concentrations when phytoplankton uptake is high and downstream transport is low. Silica concentration was low upstream during the spring when phytoplankton uptake and dilution are high. Upstream and downstream silica concentrations were lower in 1996 than the drought years of the late 1980s (Lehman 1996 b).

Orthophosphate—Average annual orthophosphate concentration was 0.08 mg/L. Regional averages ranged from 0.04 mg/L in the northern delta and lower Sacramento River to 0.13 mg/L in the southern delta. Maximum orthophosphate concentration occurred in the eastern and southern delta and were up to 12.6 times higher than downstream regions (Figure 3-5). High concentrations in the southern and eastern delta may be a result of the nutrient-rich San Joaquin River and agricultural runoff within these delta regions. Downstream, maximum concentration occurred during the summer and fall. Upstream, high concentration occurred during the winter from runoff. In general, orthophosphate concentrations in the 1996 wet year were lower than those during drought years of the late 1980s (Lehman 1996 b).

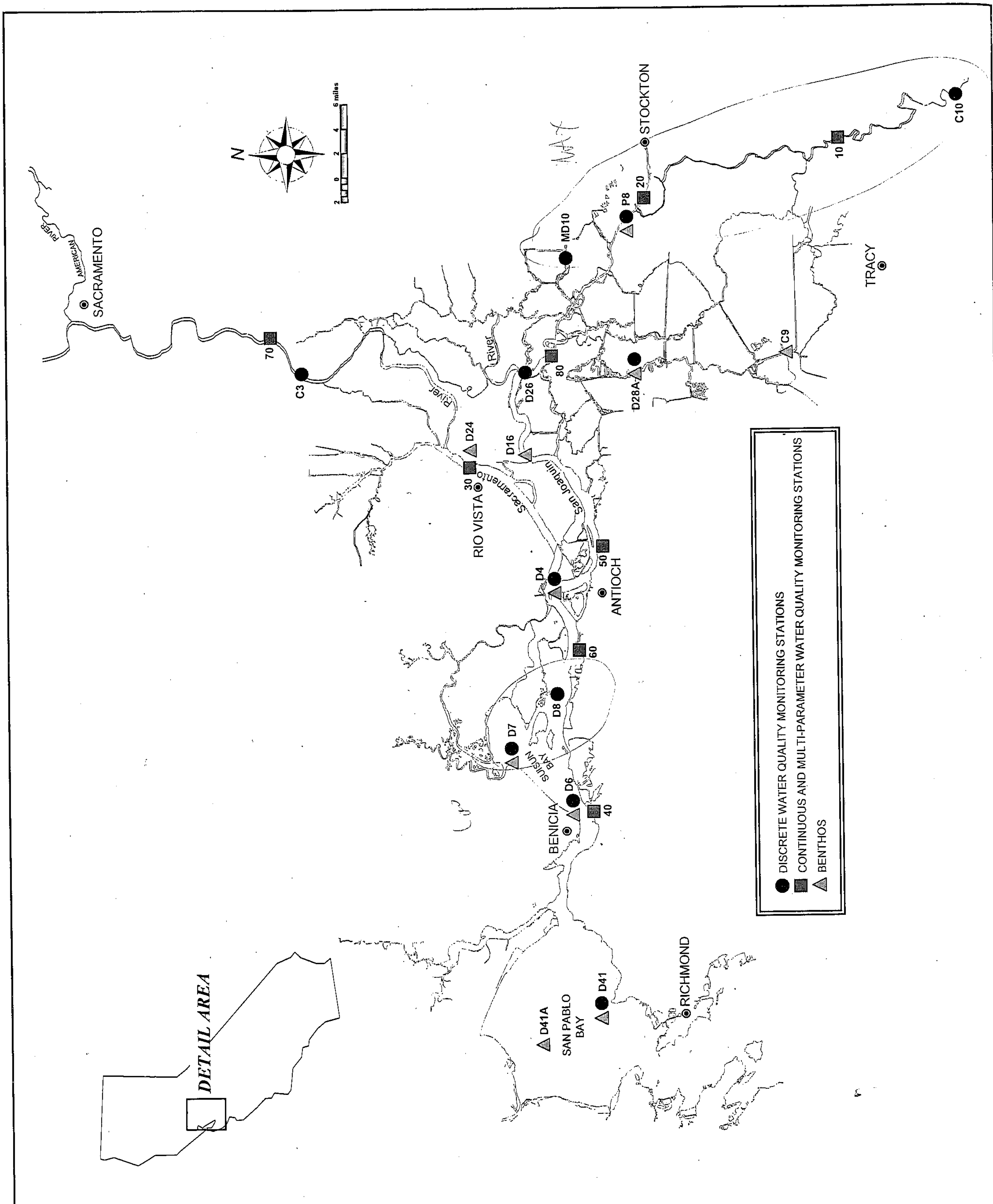

Figure 3-1—Water quality compliance and baseline monitoring stations

Dissolved inorganic nitrogen—Dissolved inorganic nitrogen concentration is the sum of dissolved nitrate, nitrite and ammonia concentration. Average annual dissolved inorganic nitrogen concentration in 1996 was 0.61 mg/L. Regional averages ranged from 0.29 mg/L in the northern delta to 1.45 mg/L in the southern delta. For most regions, concentrations were highest during winter and spring due to nutrient laden runoff from high flows. Low concentration during summer and fall was due to reduced inflow and increased uptake by phytoplankton and higher aquatic plants. In contrast, concentrations were highest in the southern delta during summer and early fall, due to agricultural and municipal discharge. The San Pablo and Suisun bay regions varied little seasonally, but nitrogen concentrations were slightly higher in summer and fall (Figure 3-6). Dissolved inorganic nitrogen concentrations in 1996 were lower than those during the drought years of the late 1980s (Lehman 1996 b) because high flows in 1996 apparently diluted nutrient concentrations.

Volatile suspended solids—Volatile suspended solids (the amount of suspended material that is volatilized at 550° C) represents an estimate of organic matter. The annual average concentration of volatile suspended solids in 1996 was 3.62 mg/L. Regional averages ranged from 1.58 mg/L in the lower San Joaquin River to 5.33 mg/L in the southern delta. Organic matter concentrations varied seasonally (Figure 3-7). High concentrations in the summer were probably produced by phytoplankton. High concentrations in the winter were probably produced by organic matter washed downstream with precipitation. The annual average for the period 1971-1993 was 4.29 mg/L. The 3.62 mg/L annual average in 1996 is lower than averages in the 1980s and early 1990s (Lehman 1996).

Chemical

Specific conductance—The yearly average specific conductance was 5,025 µS/cm in the delta. Regional averages ranged from 133 µS/cm in the northern delta to 28,384 µS/cm in San Pablo Bay. Specific conductance varied seasonally with maximum values in the late summer and fall when river flows into the delta were low (Figure 3-8). However, there was little seasonal variation in the northern delta, eastern delta and lower San Joaquin River. Seasonal and regional salinity patterns in 1996 are comparable to other previous wet years (Lehman 1996 b).

Dissolved oxygen—High stream inflows in 1996 kept dissolved oxygen concentrations above 7.0 mg/L throughout much of the year in the bay-delta (Figure 3-9). The average annual dissolved oxygen concentration in 1996 was 8.5 mg/L. Regional averages ranged from 7.7 mg/L in the eastern delta to 9.2 mg/L in the northern delta. Seasonally, dissolved oxygen concentration was low during the summer due to high water temperatures, phytoplankton respiration and long water residence time. Dissolved oxygen concentration was high during winter when water temperature was low, residence time short and phytoplankton biomass low. Low concentrations occur each fall in the Stockton Ship Channel when dissolved oxygen commonly decreases to below 5.0 mg/L. Little variation occurred in most regions except in the southern and eastern delta where algal blooms produced a wide range of concentrations. The 1996 dissolved oxygen concentrations were comparable to those in other wet years (Lehman 1996 b).

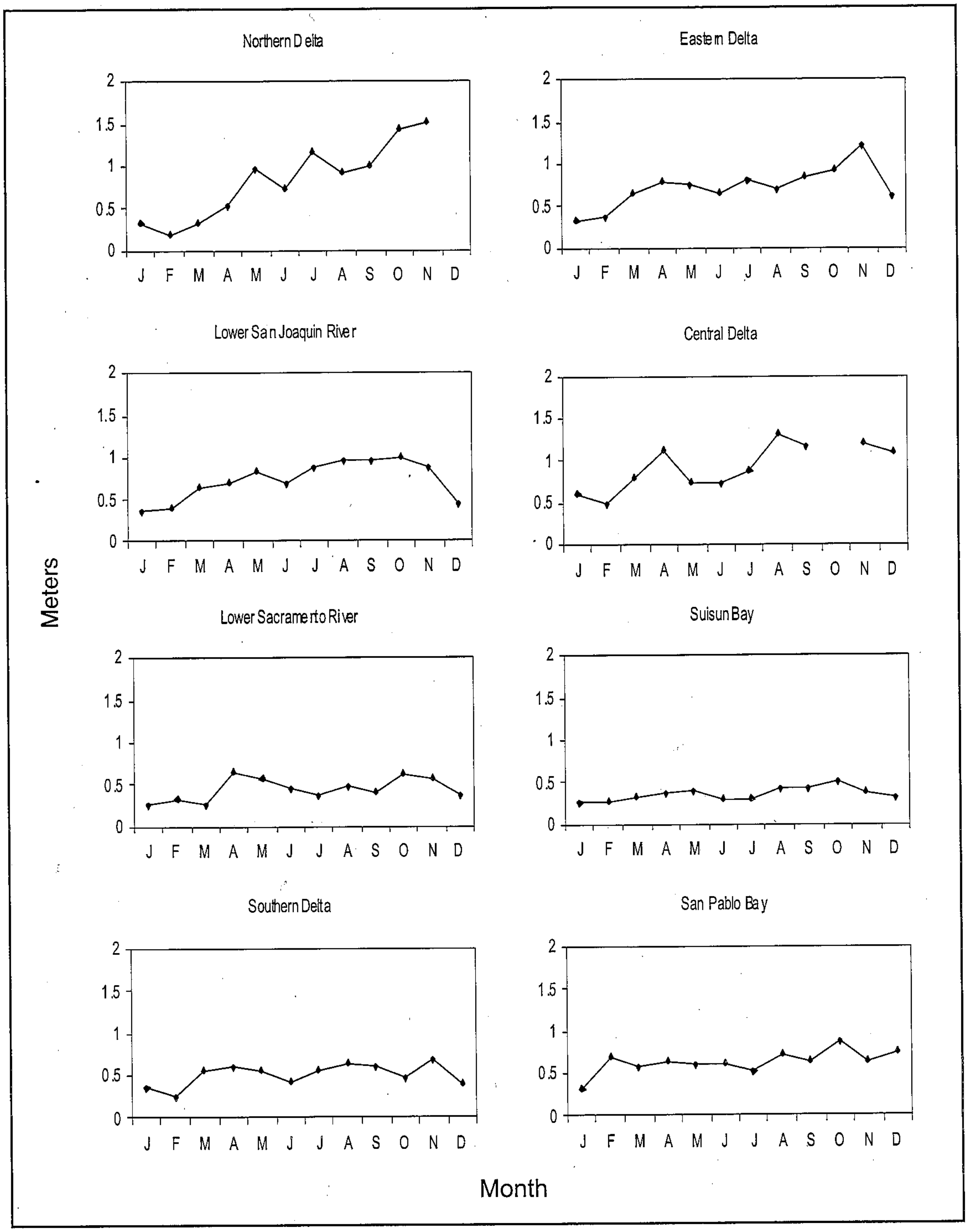

Figure 3-2—Secchi disk depth (meters) by region and month

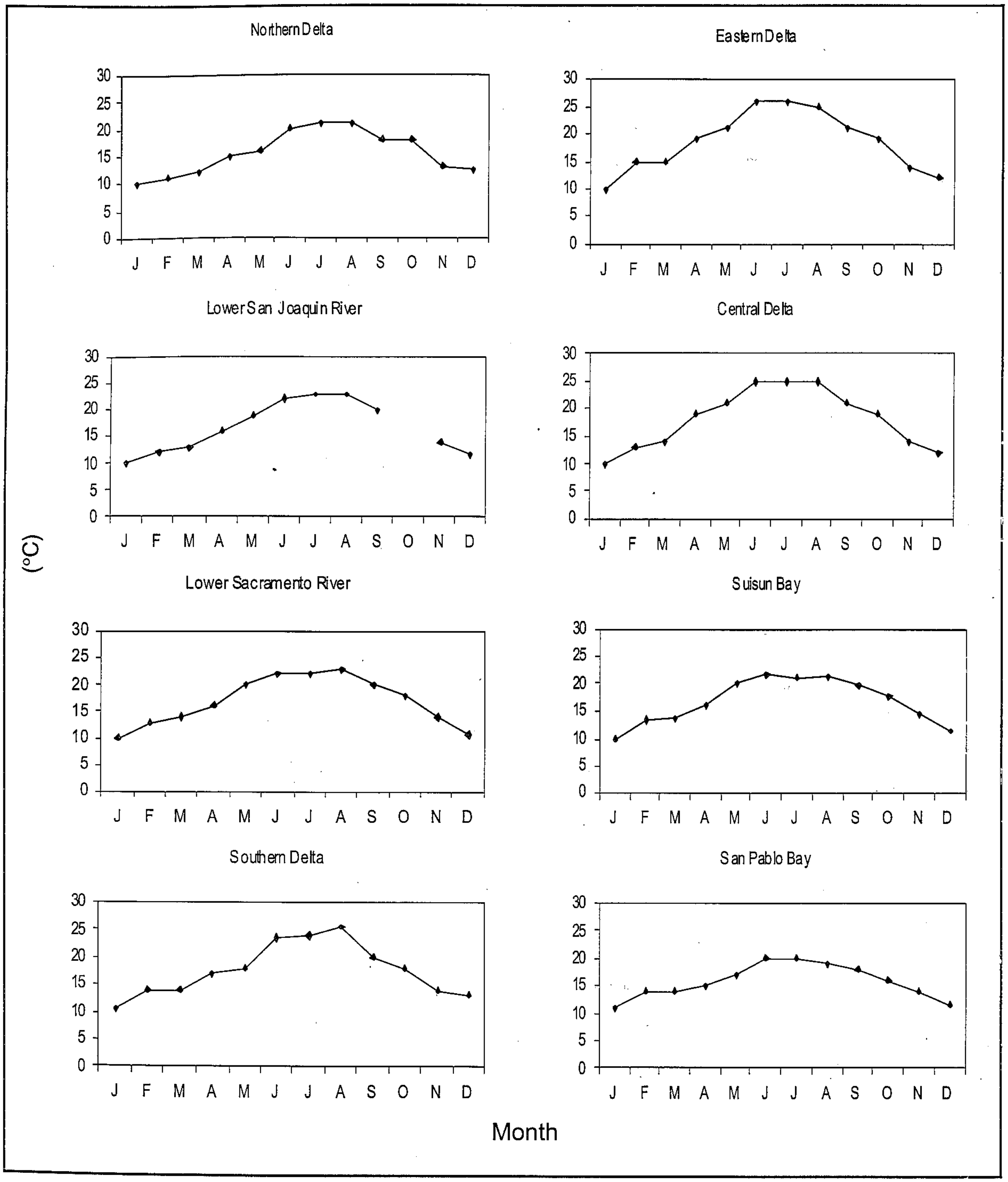

Figure 3-3—Water temperature (°C) by region and month

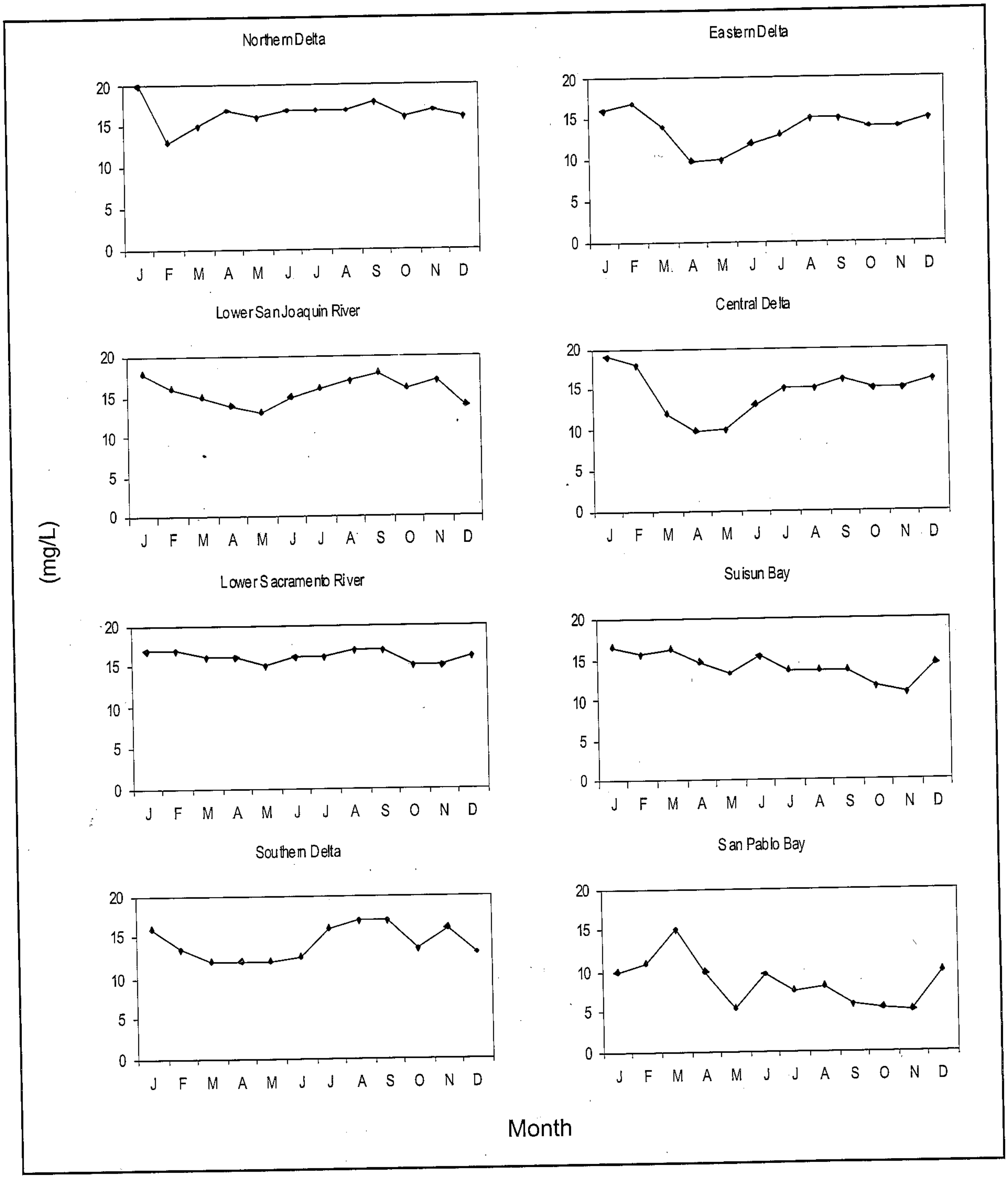

Figure 3-4—Silica concentration (mg/L) by region and month

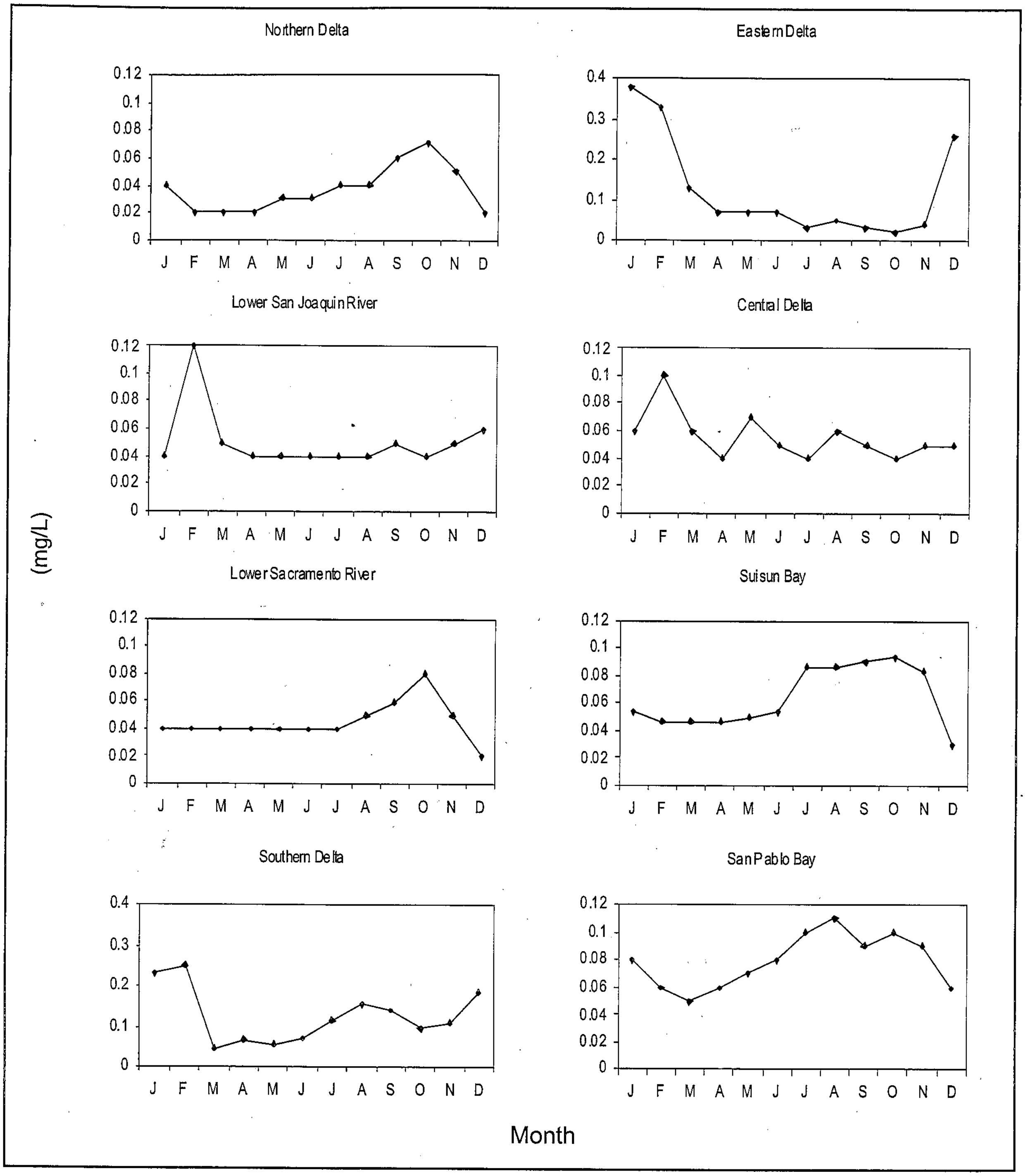

Figure 3-5—Orthophosphate concentration (mg/L) by region and month ***(note difference in Y-axis scale)***

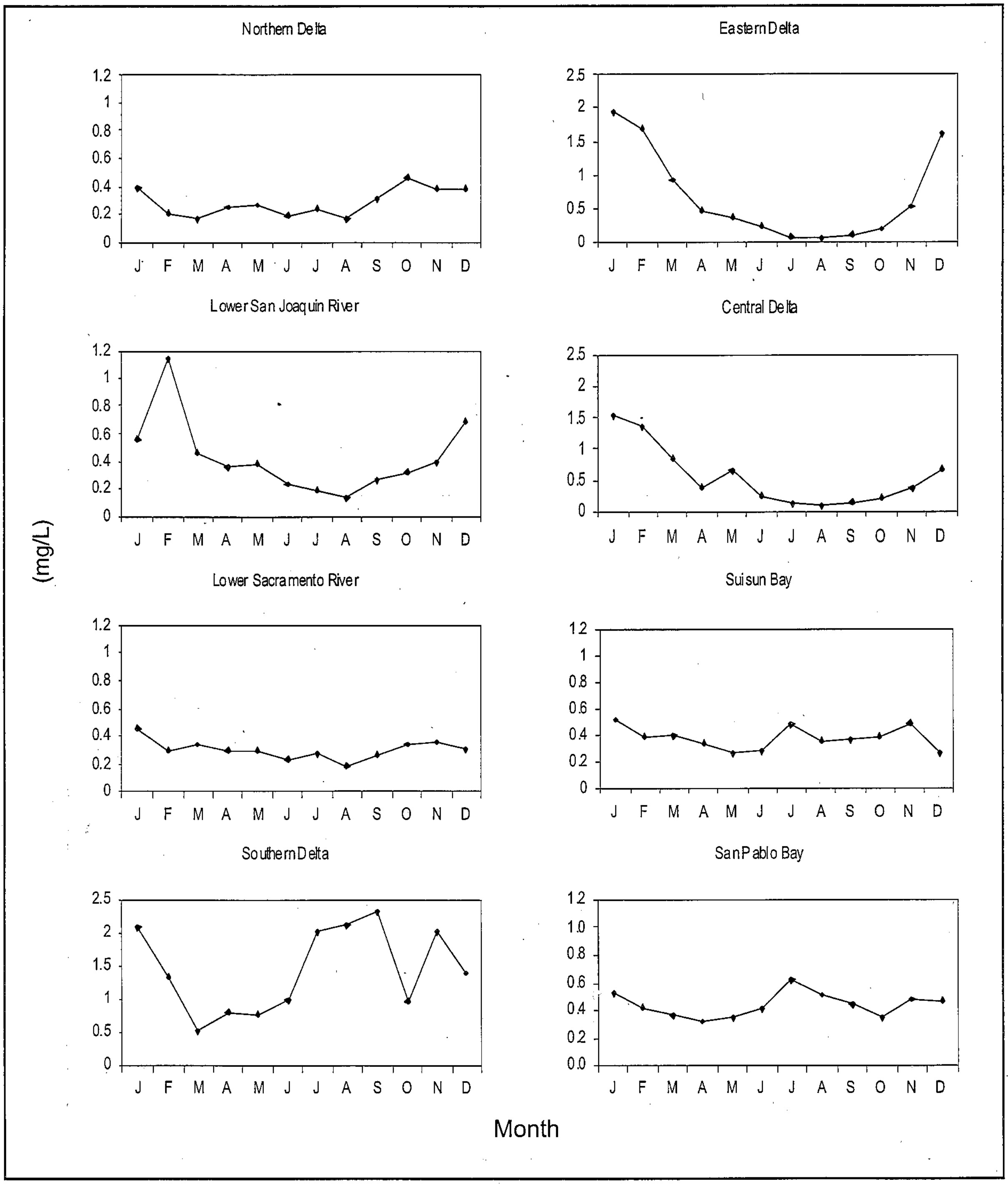

Figure 3-6—Dissolved inorganic nitrogen concentration (mg/L) by region and month ***(note scale change on Y-axis)***

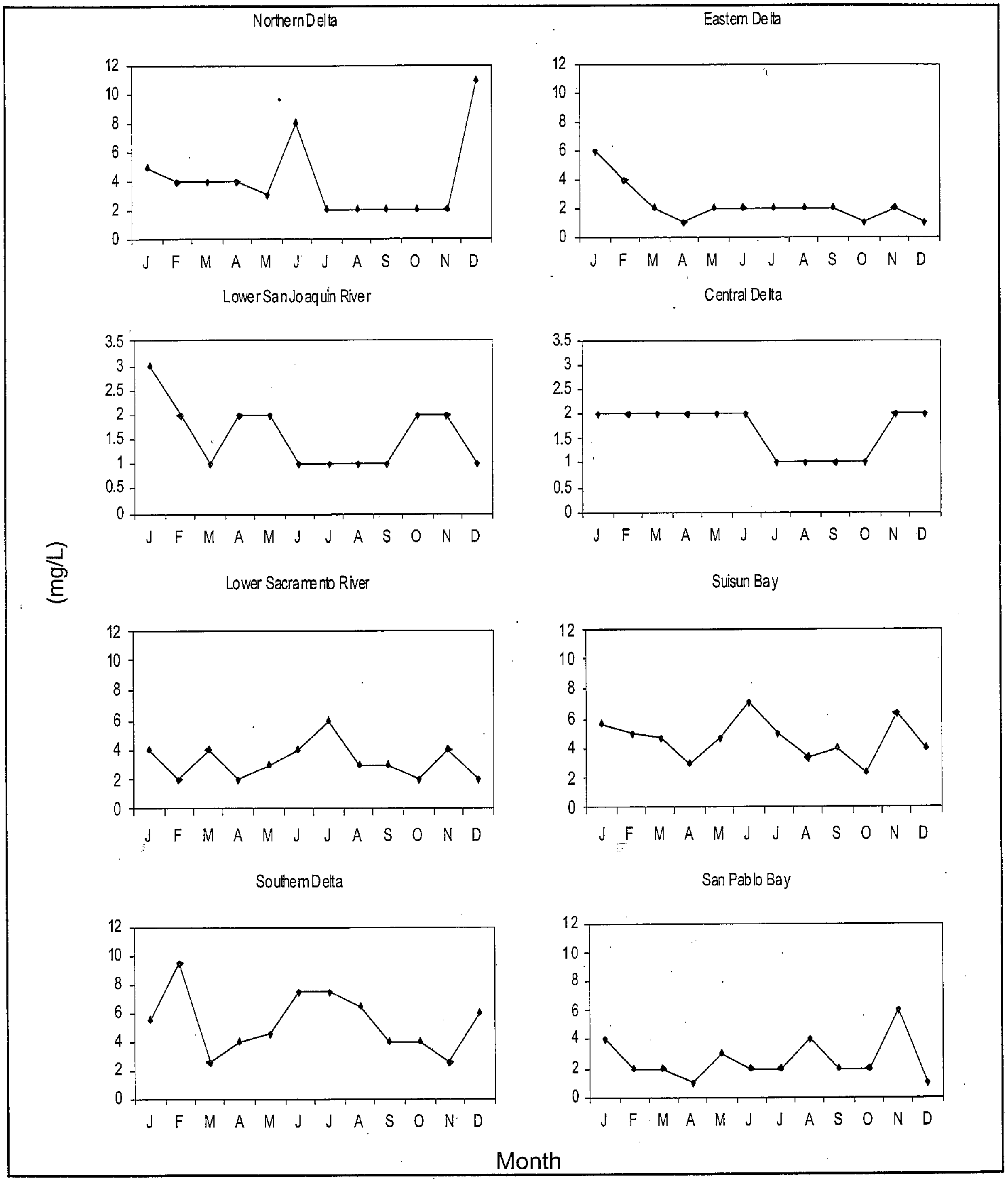

Figure 3-7—Volatile suspended solids concentration (mg/L) by region and month *(note scale change on Y-axis)*

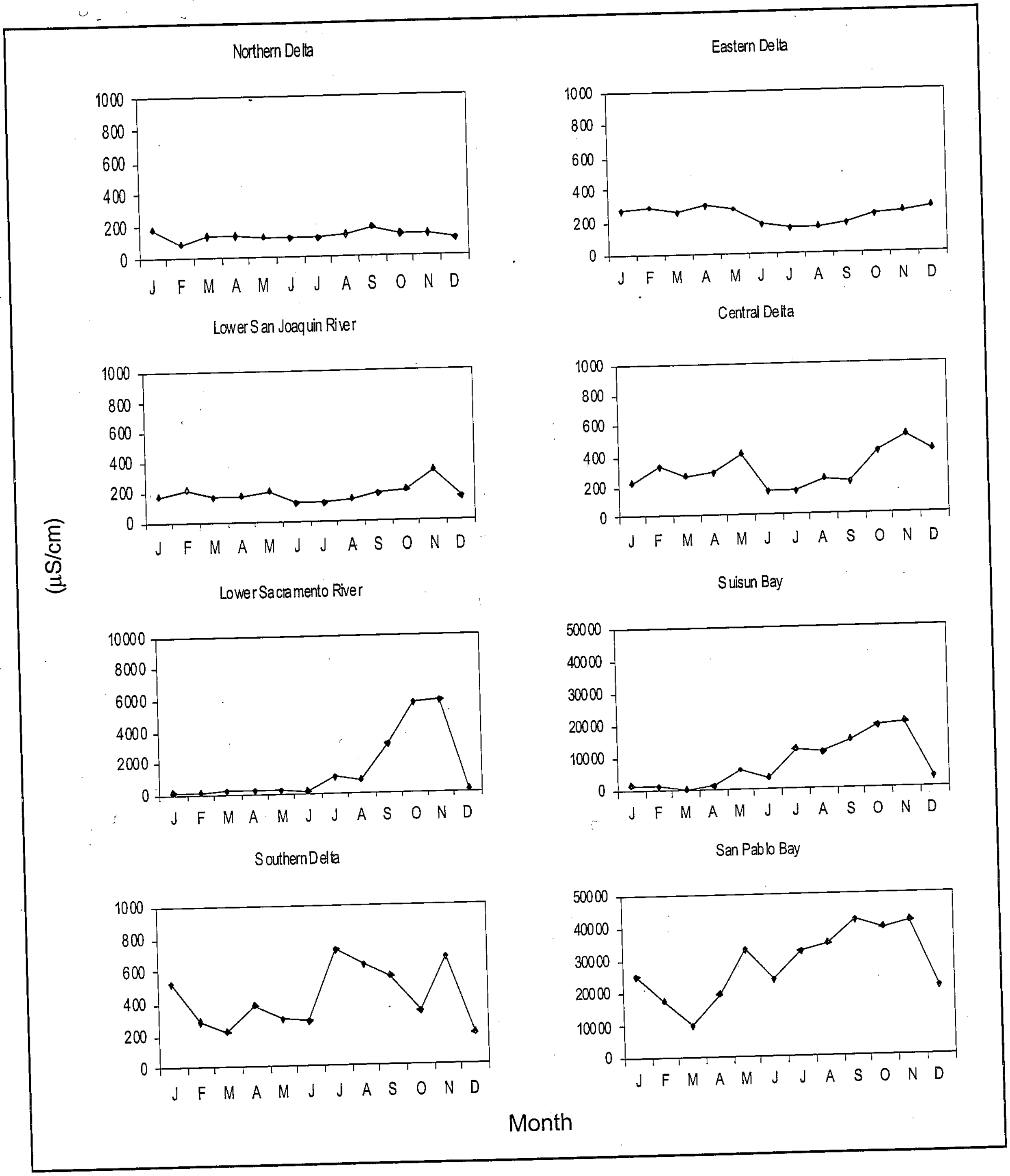

Figure 3-8—Specific conductance (µS/cm) by region and month
(note change in Y-axis scale)

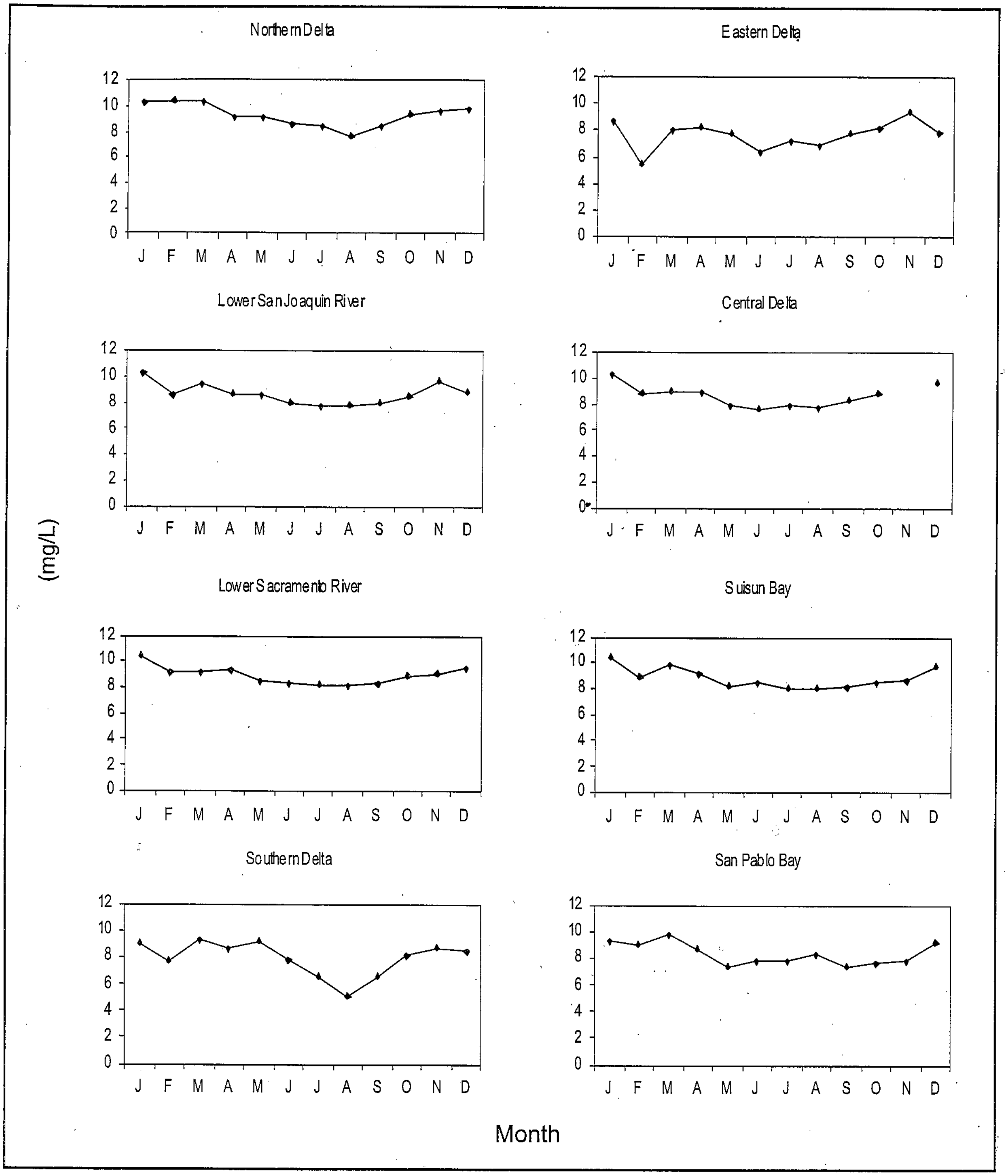

Figure 3-9—Dissolved oxygen concentration (mg/L) by region and month

Chapter 4—Dissolved Oxygen Concentration in the Stockton Ship Channel

Dissolved oxygen concentration in the Stockton Ship Channel is monitored in the late summer and fall each year because levels often drop below 5.0 mg/L. Dissolved oxygen concentration below the Central Valley Regional Water Quality Control Board (CVRWQCB) basin standard of 6 mg/L and the USEPA national standard of 5 mg/L can cause physiological stress to aquatic organisms and may block upstream migration of fall run Chinook salmon (Central Valley Basin Plan for the Sacramento and San Joaquin River Basin). Low dissolved oxygen concentration is probably produced by a combination of long residence time, warm water temperature and high biochemical oxygen demand.

As part of a 1969 Memorandum of Understanding between DWR, USBR, the U.S. Fish and Wildlife Service and DFG, DWR usually closes the head of Old River with a temporary rock barrier (the Old River Closure) during periods of low flow in the fall. The Closure increases net flow down the San Joaquin River past Stockton. In 1996, the Closure was installed on October 3 when flows in the San Joaquin River dropped to less than 2,000 cfs and was in place until November 19.

Dissolved oxygen concentration was measured at fourteen stations between Prisoner's Point Station 1 to the Stockton Turning Basin Station 14 (Figure 4-1). Dissolved oxygen concentration and water temperature were measured at the top and bottom of the water column on ebb slack tide at each station. Dissolved oxygen was determined using the Winkler Method and a Hydrolab multiparameter surveyor model OS-3.

Dissolved oxygen concentration below 5 mg/L was first measured in August between Light 28 to Light 43 (Figure 4-2). These low dissolved oxygen levels were accompanied by high water temperatures of 25-27° C and high residence time. The net flow past Stockton was -197 cfs to +194 cfs. Dissolved oxygen concentration below 5 mg/L persisted in the eastern Channel from Light 28 to Light 43 in September and was accompanied by warm water temperature of 21-24° C and low net flows of -117 to +469 cfs at Stockton.

The Old River Closure was installed in early October to improve flow conditions in the San Joaquin River and the eastern Stockton Ship Channel. By mid-October, average daily streamflow past Vernalis increased to 4,000 cfs and reverse net flows were eliminated. However, a dissolved oxygen depression in the eastern Channel was measured on October 11 (Figure 4-2). Dissolved oxygen concentrations less than 5 mg/L persisted from Light 19 to Light 40. Relatively low San Joaquin River flow past Vernalis of 2,500 cfs or less, high water temperatures of 21-23° C and reverse net flows past Stockton in early October probably contributed to the persistence of low dissolved oxygen concentration in the eastern Channel.

By October 25, dissolved oxygen conditions at the surface and bottom depths increased to above 7.8 mg/L (Figure 4-2). Water temperatures of 14-16° C accompanied these higher dissolved oxygen concentrations. The final run on November 21 showed dissolved oxygen concentration was higher than 7.5 mg/L throughout the Channel. The Old River Closure was removed on November 19 because of acceptable oxygen levels within the Channel and anticipated increases in San Joaquin River flows from precipitation.

Exceptionally high surface and low bottom dissolved oxygen levels were periodically measured in the Stockton Turning Basin during the study period (Figure 4-2). The Turning Basin is the dead end terminus of the Stockton Ship Channel, where water circulation is low and residence time is high. Algal blooms composed of crytomonads, diatoms, flagellates and blue green and green algae are common. The strong dissolved oxygen gradient in the Turning Basin was probably produced by high algal biomass near the surface and decomposed algae near the bottom.

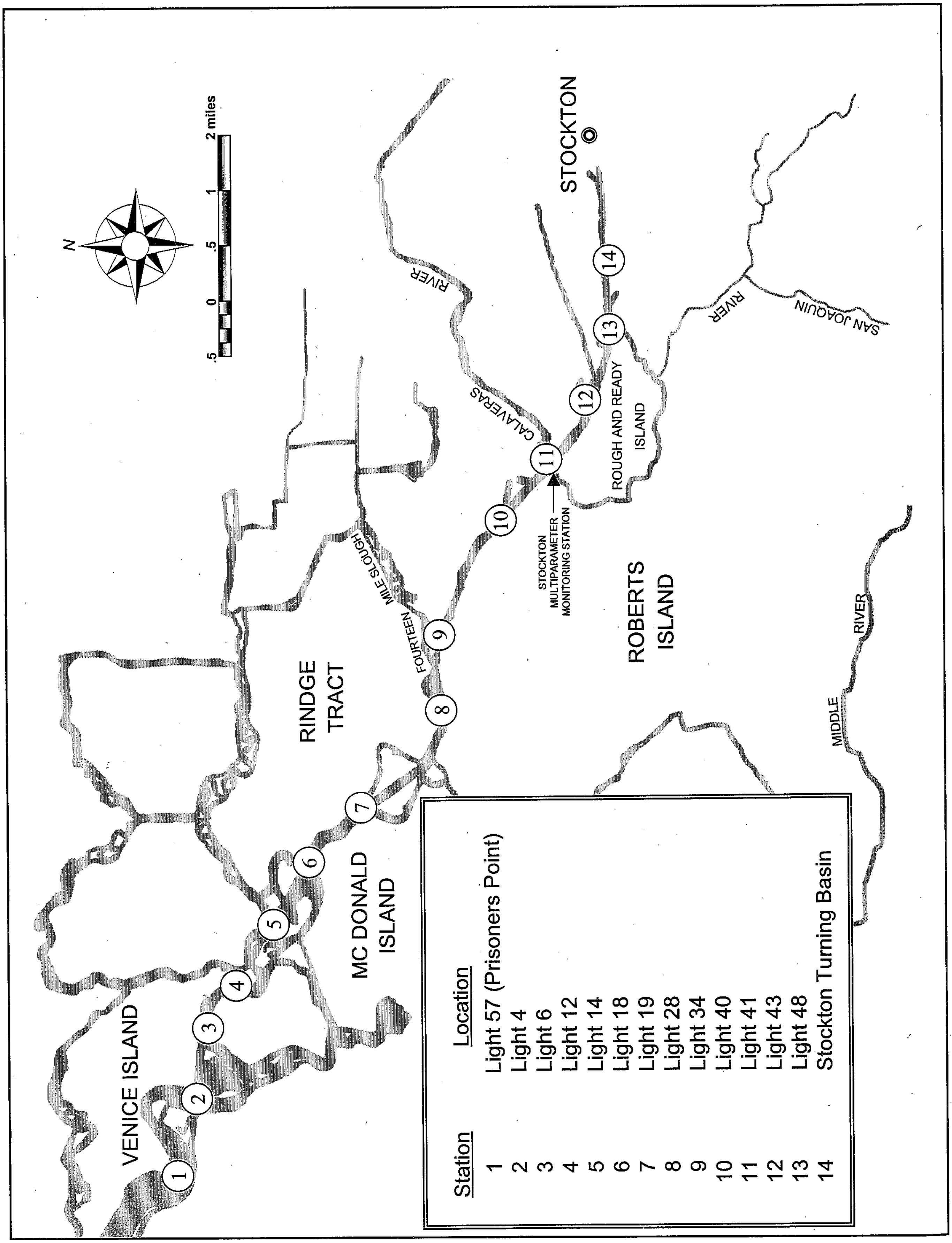

Figure 4-1—Monitoring stations in the Stockton Ship Channel

This is the raw data and graphics for the 1996 dissolved oxygen runs. The values were obtained through the Winkler method (except for 9/26/96).

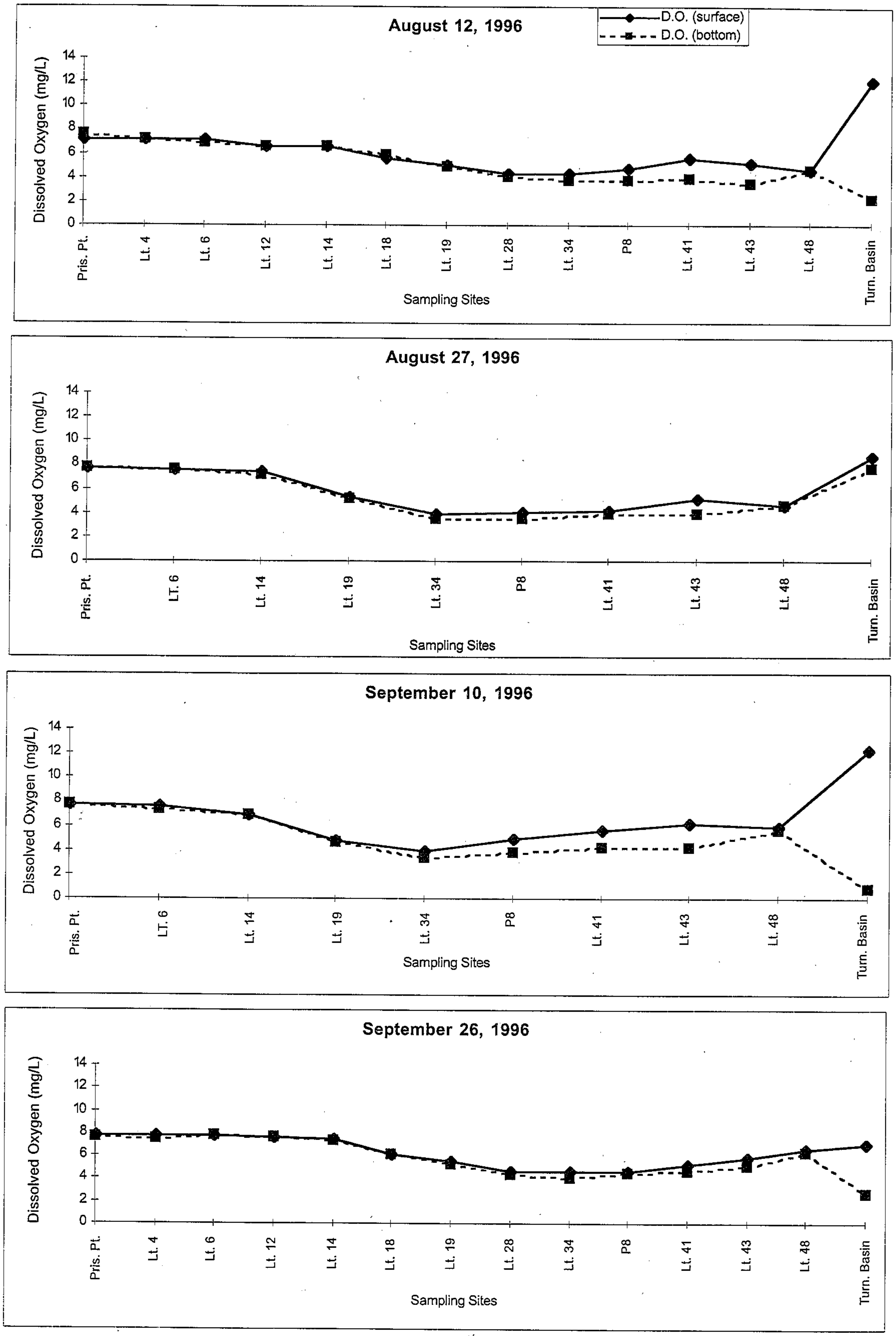

Figure 4-2—Dissolved oxygen concentration in the Stockton Ship Channel

This is the raw data and graphics for the 1996 dissolved oxygen runs. The values were obtained through the Winkler method (except for 9/26/96).

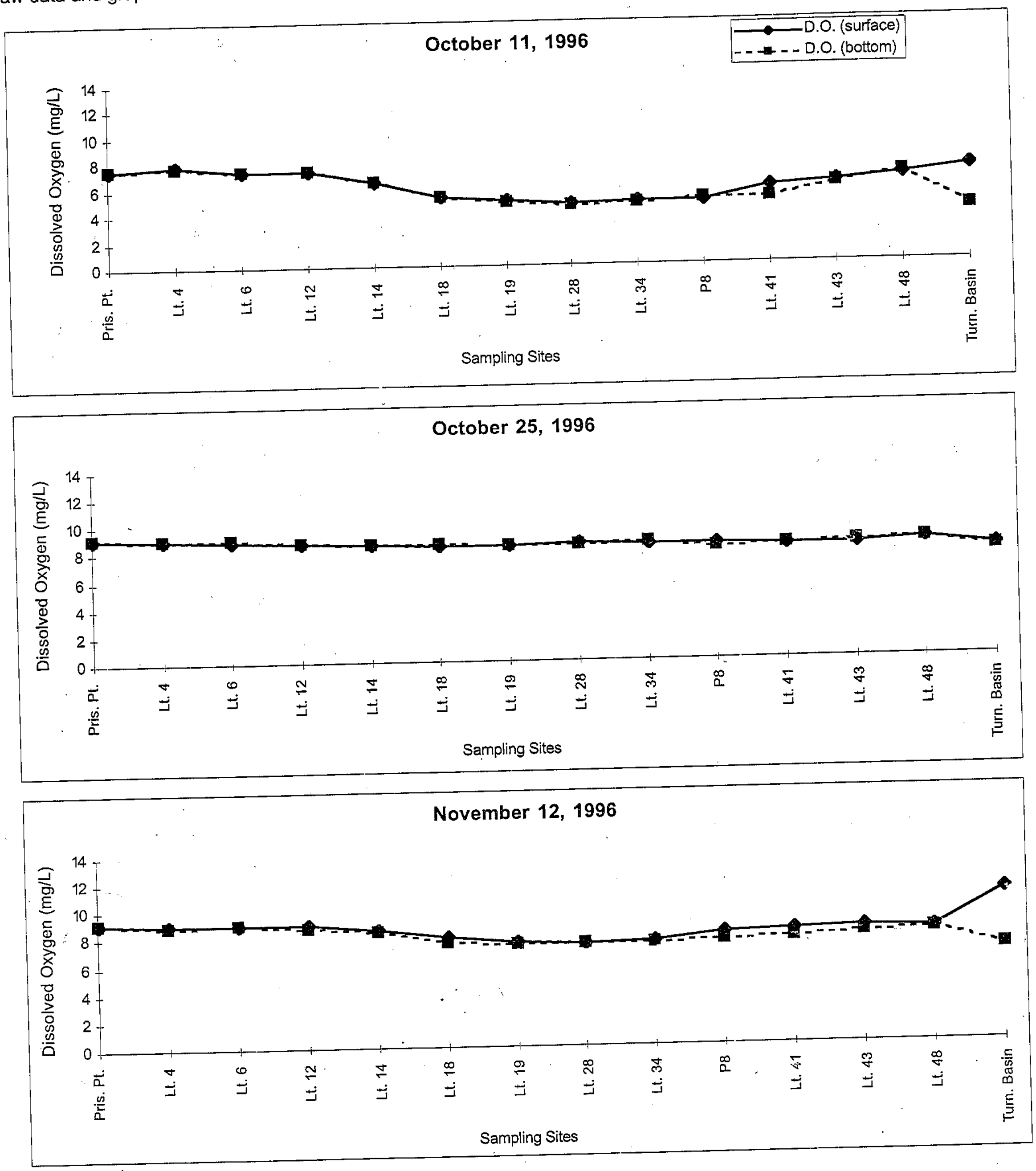

Figure 4-2—Dissolved oxygen concentration in the Stockton Ship Channel (continued)

Chapter 5—Continuous Monitoring

The continuous monitoring element supplements the monthly D-1485 Compliance Monitoring Program by providing real-time water quality data from six automated sampling stations located in the bay-delta (Figure 3-1, page 8).

Water temperature, pH, dissolved oxygen, specific conductance, air temperature, wind speed, wind direction and solar irradiance are measured at each site; chlorophyll fluorescence is measured at Mallard Island, Antioch and Rio Vista. The values on the sensors are scanned three times per second and data recorders store hourly averages. Continuous data have been collected since 1983. In the early 1990s additional sensors were installed five feet from the channel bottom at the Antioch, Mallard Island and Martinez stations to measure bottom specific conductance and tidal stage needed to determine compliance with the 2.64 µS/cm bottom salinity standard (also known as X2) mandated by the USEPA in the 1995 delta smelt biological opinion.

Figures 5-1 through 5-6 show the daily minimum, maximum and average water temperature, air temperature, dissolved oxygen, specific conductance and pH at surface and specific conductance at bottom stations in 1996. Gaps in the data result from periods when monitoring equipment was inoperable or unavailable. A brief summary for each constituent is provided below.

Water Temperature—The diel variation in water temperature was small at most stations and varied closely with air temperature (Figure 5-1). The greatest variation occurred at Martinez. Daily water temperature peaked in July and August with minimum daily values below 10°C at most stations in winter and maximum daily values above 27°C at the Stockton and Mossdale stations.

Air Temperature—The diel variation in air temperature was often 10-15° C, particularly during the summer and fall (Figure 5-2). Seasonally, air temperatures were highest in the summer, with maximum temperatures exceeding 30°C, and lowest in the winter with maximum temperatures generally below 15°C.

Dissolved Oxygen—The diel variation in dissolved oxygen concentration varied little around the daily average at most stations (Figure 5-3). In contrast, the daily minimum and maximum concentration at the Stockton and Mossdale stations varied by as much as 4 mg/L around the daily average, particularly during the summer and fall. The lowest concentrations were measured at Stockton in September. All stations except Stockton had dissolved oxygen levels above the USEPA standard of 5.0 mg/L.

Specific Conductance—The highest daily average specific conductance occurred at Martinez and the lowest at Rio Vista. The diel variation in specific conductance varied widely among stations and was lowest at Stockton and Mossdale, but highest at Antioch (Figure 5-4). The diel variation was highest during the late summer and fall at the three stations near the confluence and downstream—Antioch, Mallard and Martinez. This daily variation probably reflected the strong influence of tidal variation in the summer and fall when streamflow is low. The high daily variation at Antioch probably reflects both tidal variation and water management in the summer for agriculture. In contrast, a wide diel variation in the winter and late fall at Rio Vista may reflect the influence of seasonal precipitation on upstream streamflow.

Bottom specific conductance (Figure 5-5) at Antioch, Mallard and Martinez exhibited a seasonal pattern similar to the surface, with higher values and diel variation during summer and fall than the spring. High spring outflow probably decreased the diel variation produced by tide during the spring months.

Bottom specific conductance ranged from 0 to approximately 1000 µS/cm at the Antioch and Mallard Island monitoring stations. Average specific conductance was 387 µS/cm for Antioch and 374 µS/cm for Mallard Island. At Martinez, the furthest station downstream, specific conductance was generally much higher (consistently above 200 µS/cm). The average bottom conductance in this region was 18,295 µS/cm with recorded daily minimum and maximum specific conductance values of 180 µS/cm and 38,000 µS/cm, respectively.

pH—The diel variation in pH was small at all six stations (Figure 5-6). Seasonally, pH values varied little at all the stations and were generally above 7. High pH in spring at the Stockton station and in early spring and summer at the Mossdale station were probably due to phytoplankton blooms.

Chlorophyll—Chlorophyll *a* fluorescence was measured at Mallard Island, Antioch and Rio Vista from February to October, 1996. Chlorophyll fluorescence was converted to chlorophyll *a* concentration with the following equation:

$$\text{chlorophyll concentration } (\mu g/L) = .46 \text{ (chlorophyll fluorescence [voltage])} - 1.97$$

Chlorophyll *a* concentration was low and generally consistent with the values measured in the discrete monitoring program (Figure 5-7). The seasonal range was highest at Rio Vista, 6.25 μg/L to 0.65 μg/L. Peak concentrations occurred in early summer and fall at Mallard Island and Antioch and in early and midsummer at Rio Vista.

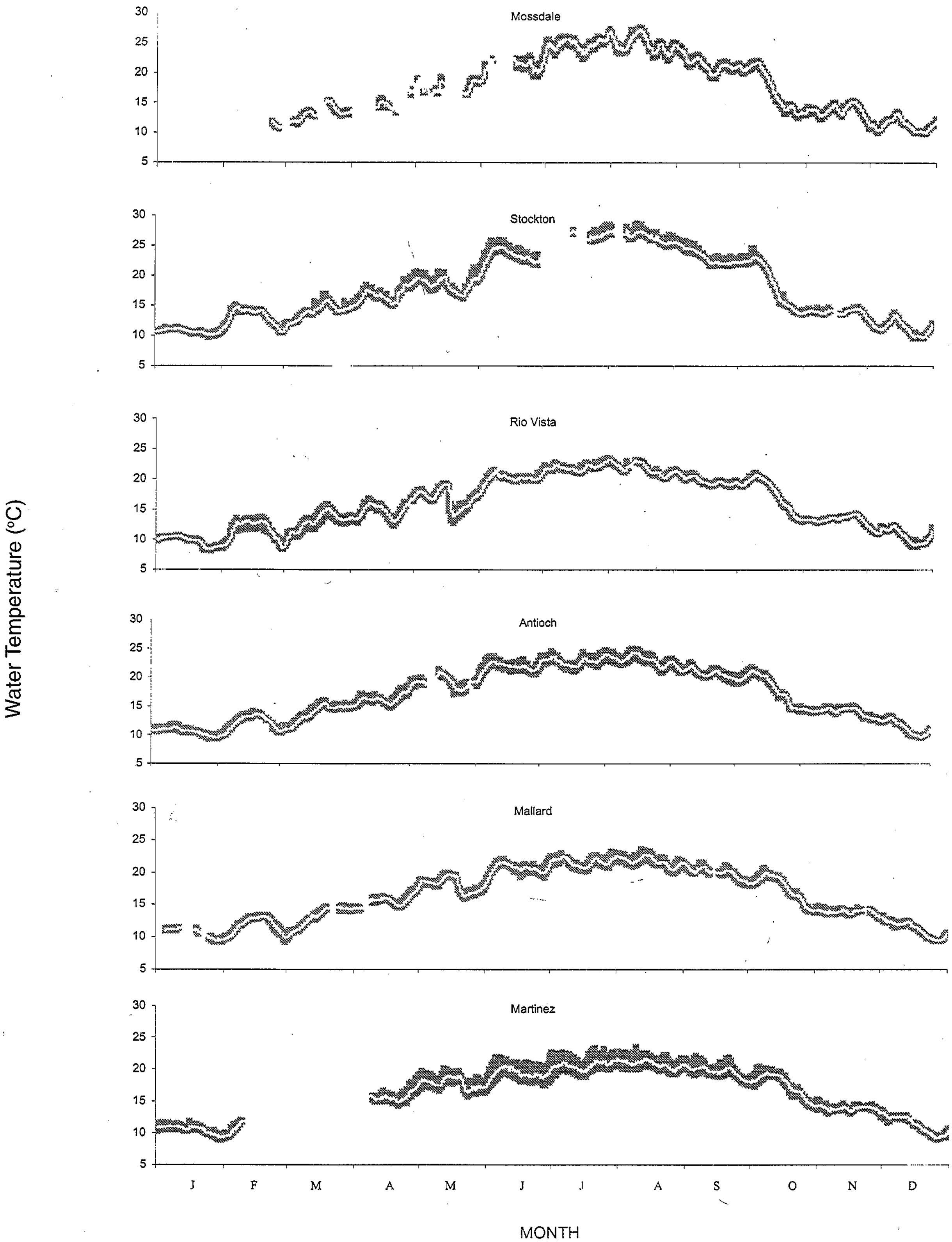

Figure 5-1—Water temperature (°C) at the continuous monitoring stations
(The shaded areas indicate maximum and minimum values and the white line represents the mean.)

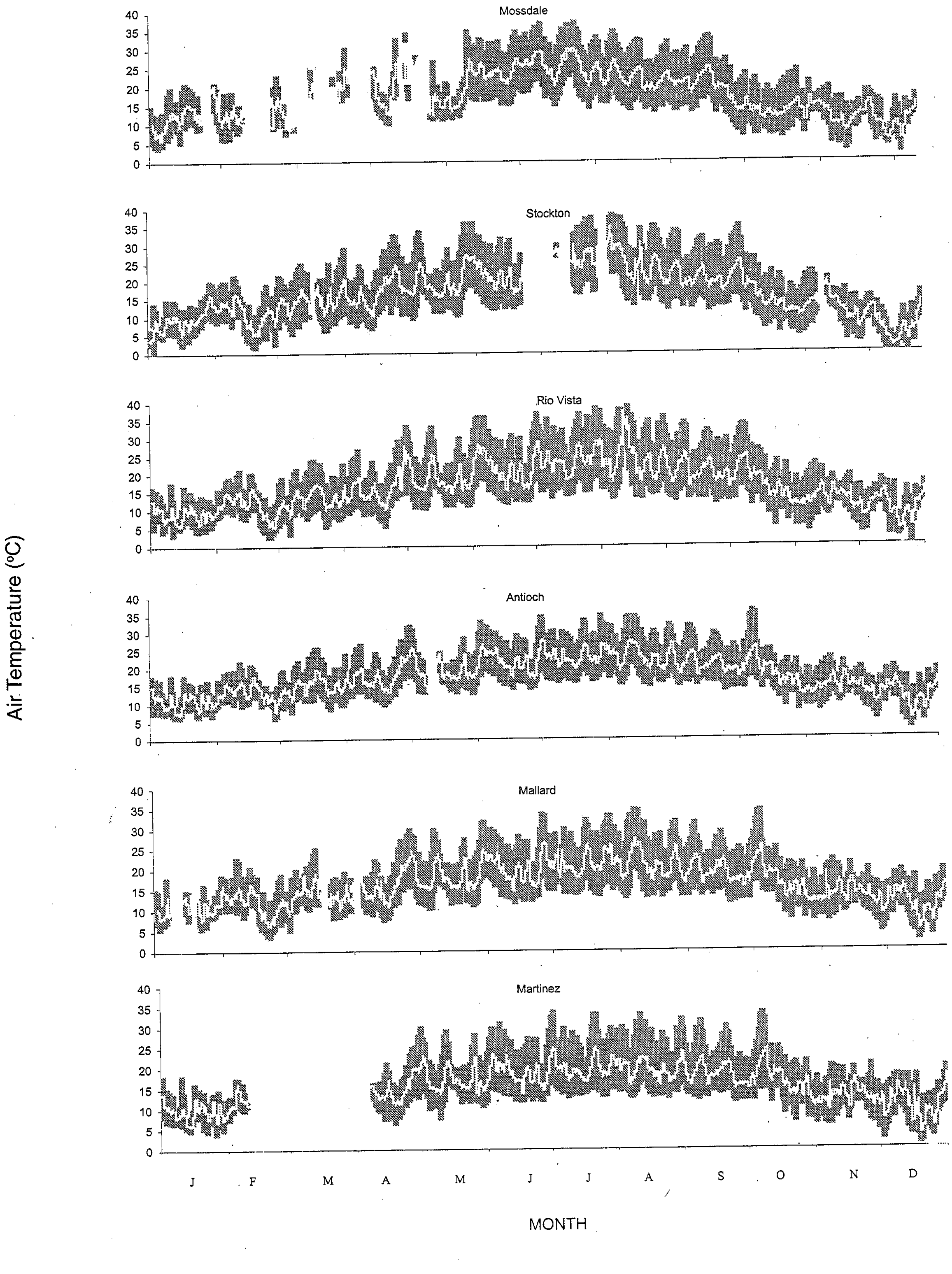

Figure 5-2—Air temperature (°C) at the continuous monitoring stations
(The shaded areas indicate maximum and minimum values and the white line represents the mean.)

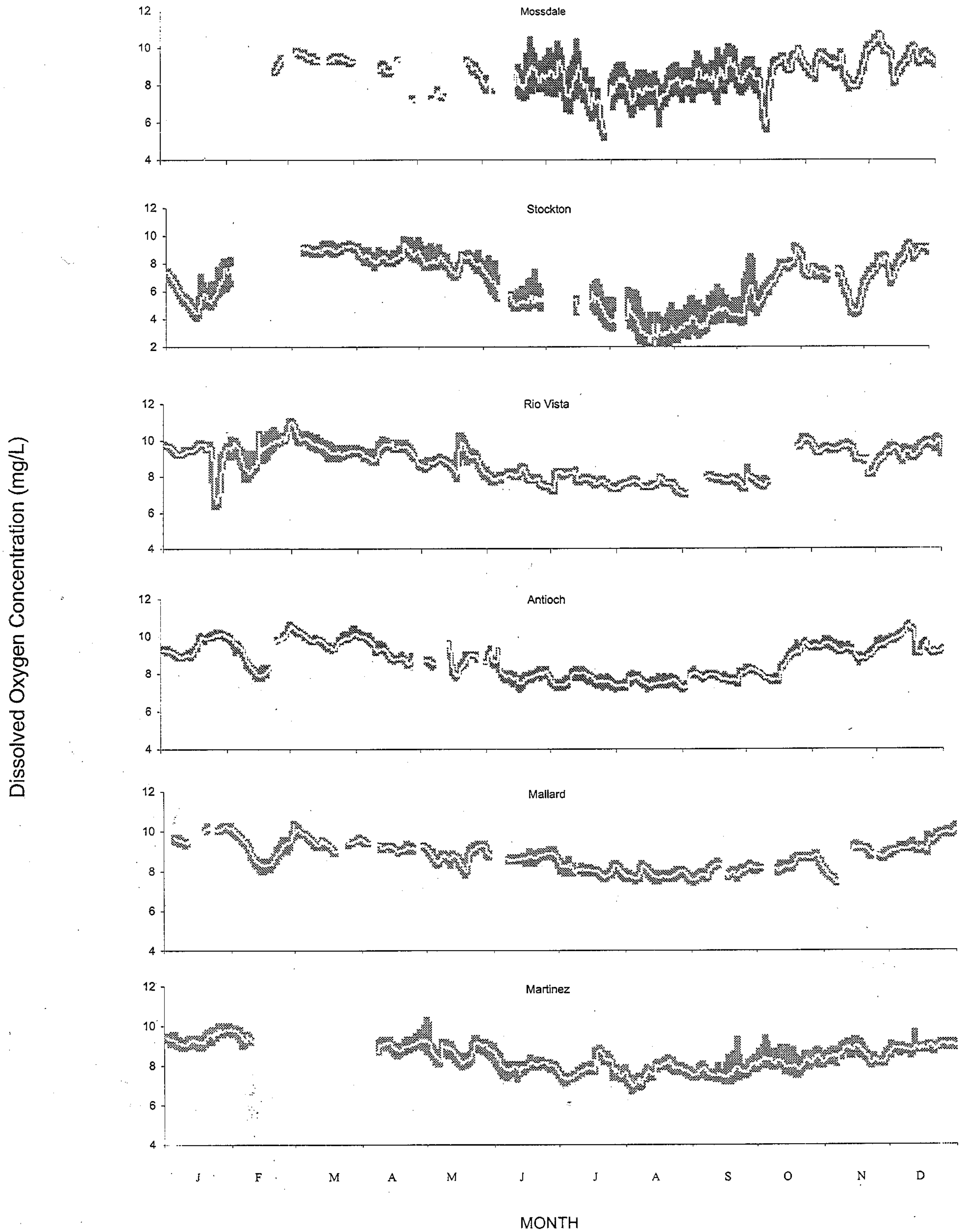

Figure 5-3—Dissolved oxygen (mg/L) at the continuous monitoring stations
(The shaded areas indicate maximum and minimum values and the white line represents the mean.)

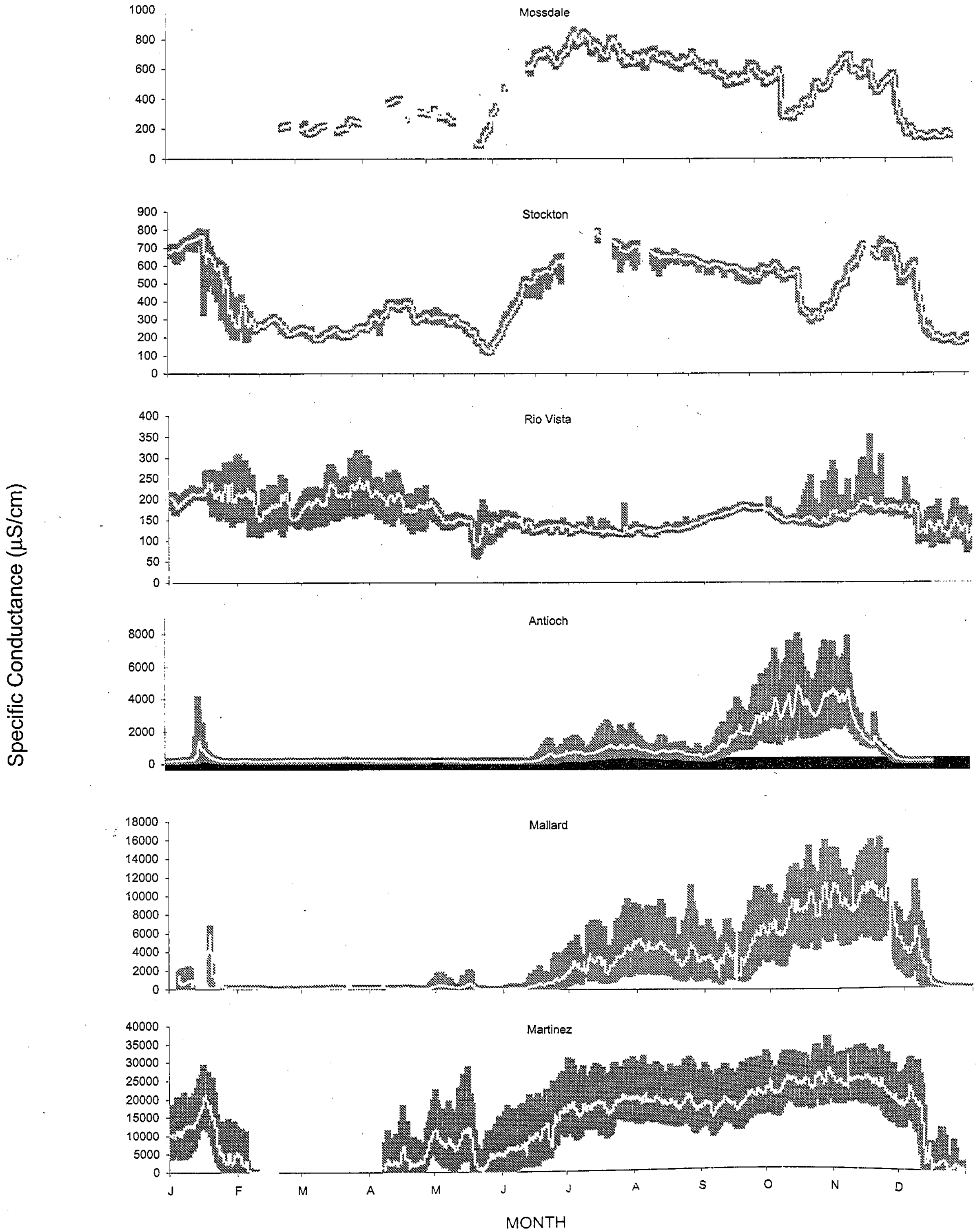

Figure 5-4—Specific conductance (µS/cm) at the continuous monitoring stations—note scale change on Y-axis
(The shaded areas indicate maximum and minimum values and the white line represents the mean.)

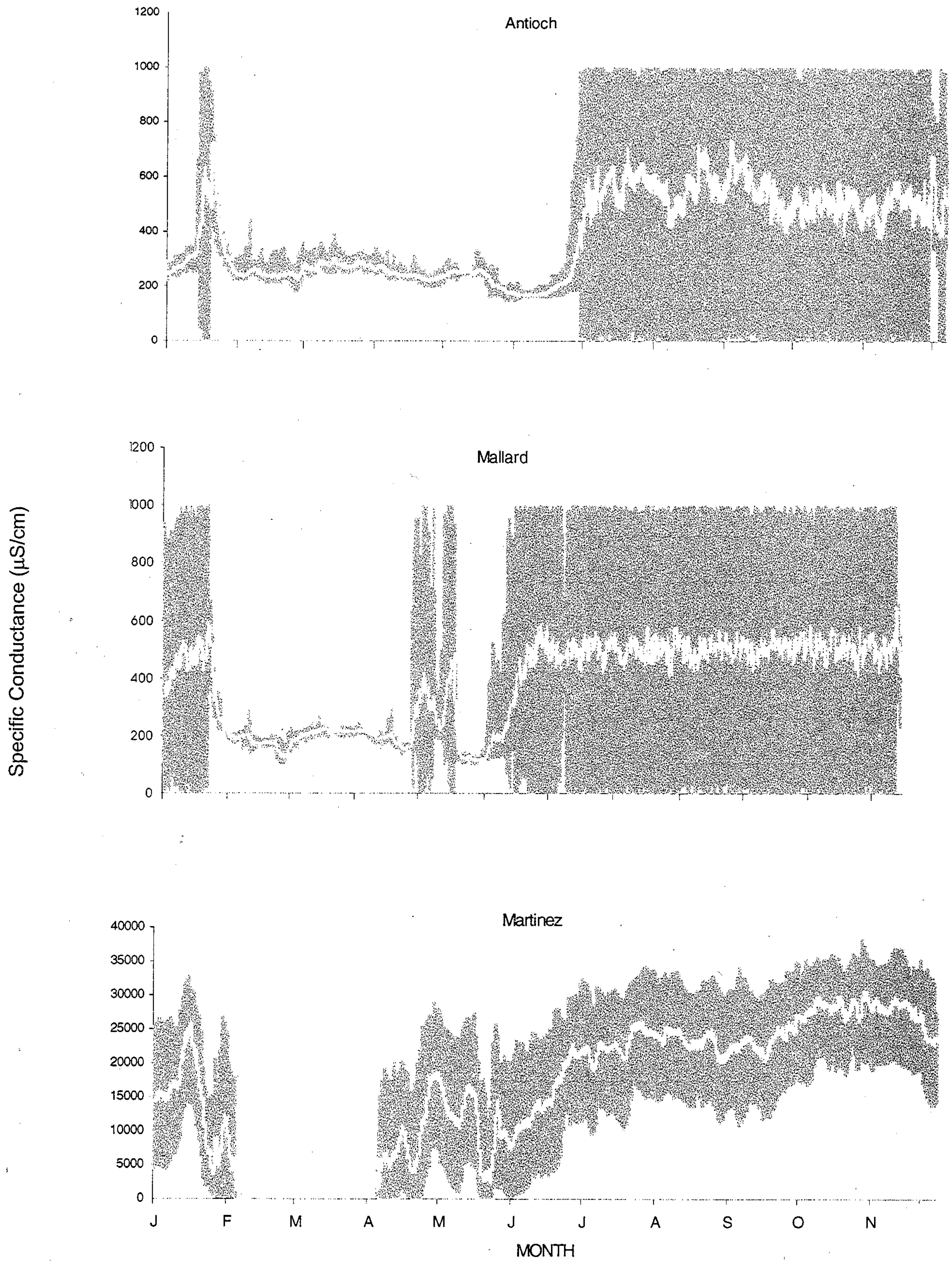

Figure 5-5—Specific conductance (µS/cm) five feet from channel bottom at the Antioch, Mallard Island and Martinez continuous monitoring stations—note scale change on Y-axis
(The shaded areas indicate maximum and minimum values and the white line represents the mean.)

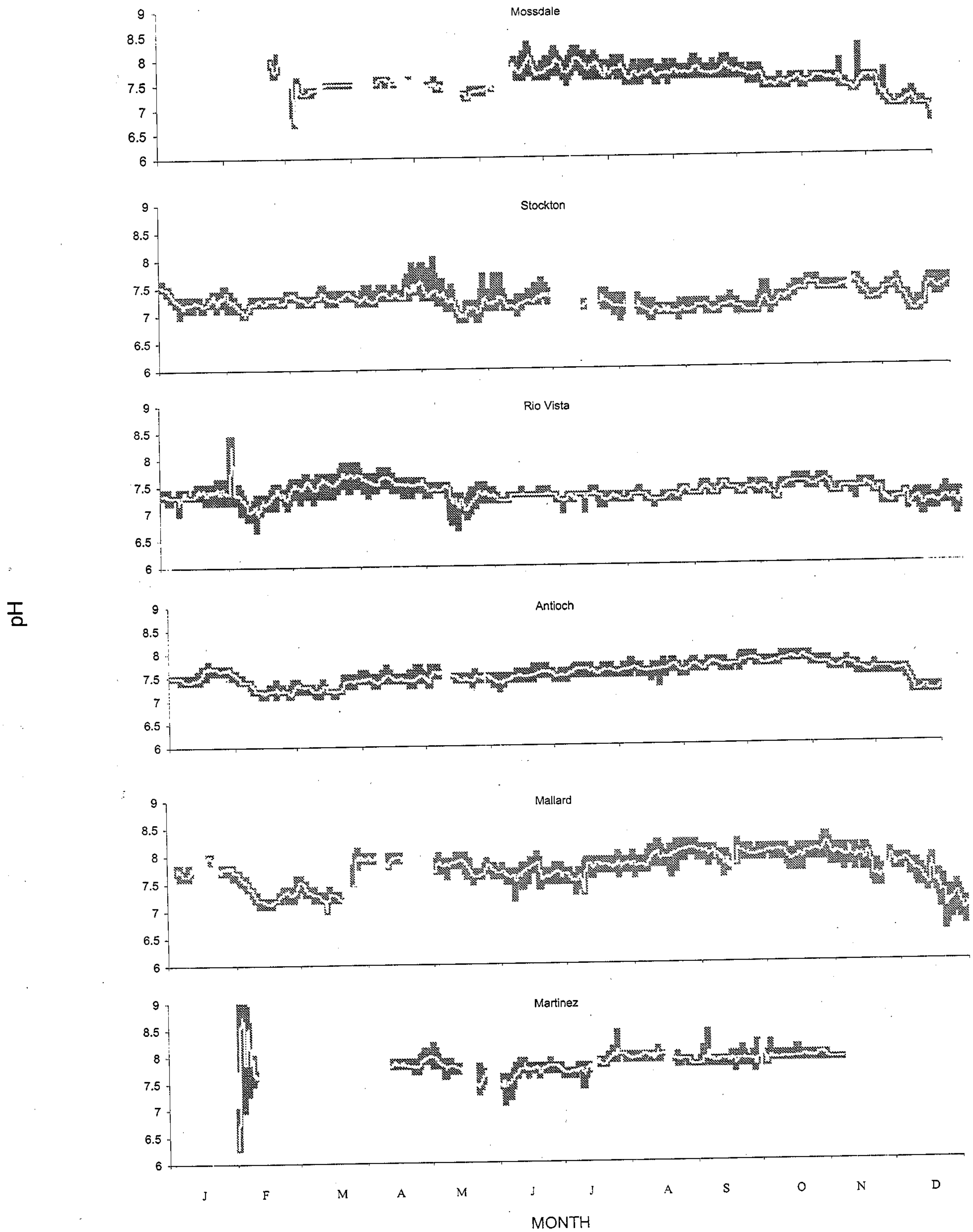

Figure 5-6—pH at the continuous monitoring stations
(The shaded areas indicate maximum and minimum values and the white line represents the mean.)

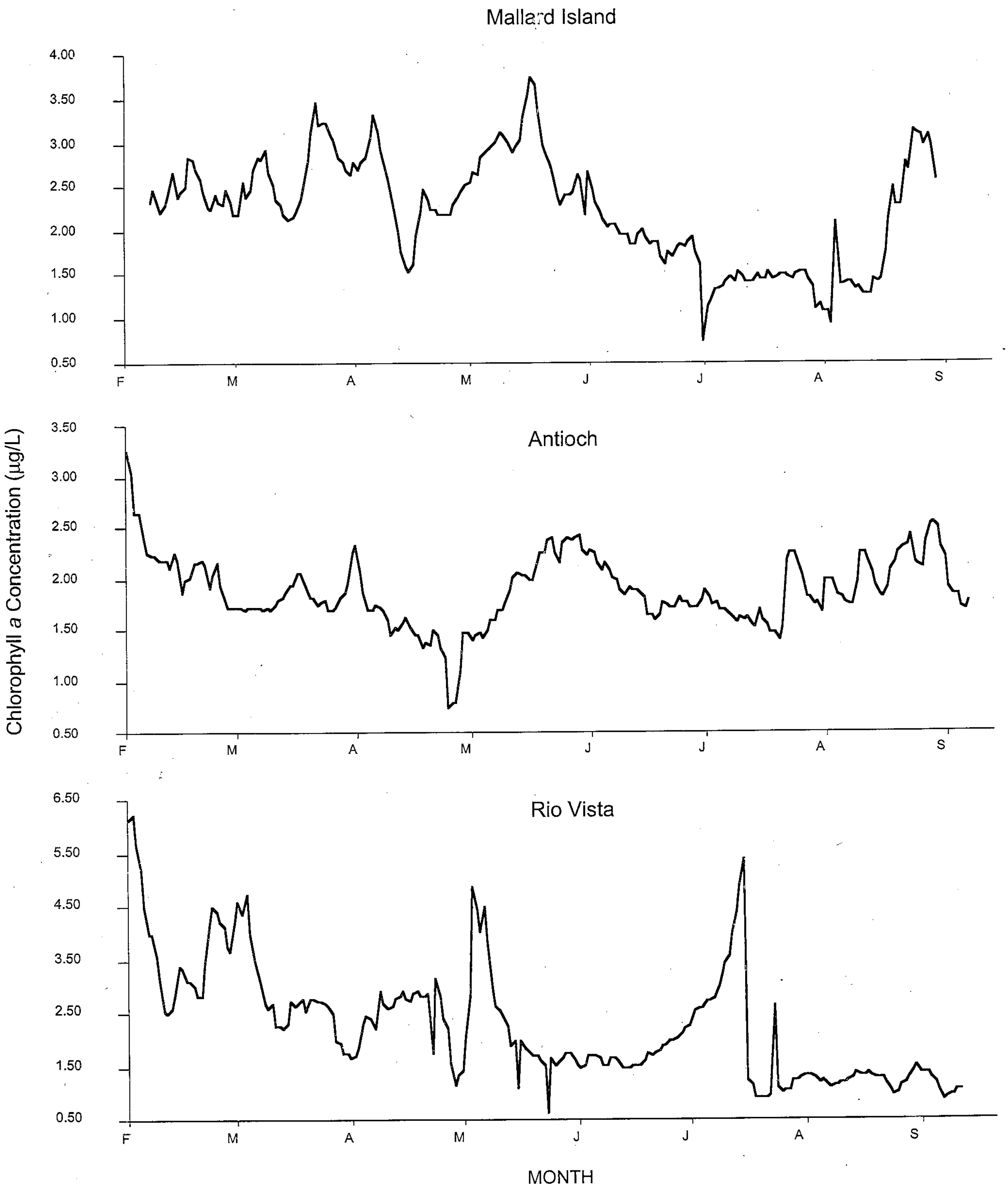

Figure 5-7—Daily average chlorophyll *a* concentration from the Mallard Island, Antioch and Rio Vista continuous monitoring stations, February 29, 1996-October 10, 1996

Chapter 6—Chlorophyll *a* Concentration and Phytoplankton Community Composition

This chapter describes chlorophyll *a* concentration (an estimate of phytoplankton biomass) and phytoplankton community composition in 1996 in the delta and Suisun and San Pablo bays. As required by Decision 1485, DWR and USBR collect phytoplankton samples at stations throughout the upper estuary. In 1996 official revisions to the water quality program were implemented that decreased the number of stations from 26 to 15 for chlorophyll *a* and from 16 to 11 sites for phytoplankton sampling (Figure 3-1, page 8). For this summary, stations were grouped into regions based on hierarchical cluster analysis (Lehman 1996 a). Chlorophyll *a* concentration was measured according to Standard Methods (APHA 1998)

Chlorophyll *a* concentration was below 7 µg/L for most of the regions of the delta during 1996, except the southern delta and San Pablo Bay (Figure 6-1). Maximum chlorophyll *a* concentration occurred between March and June in the northern delta, lower Sacramento River, Suisun Bay and lower San Joaquin River. In contrast, chlorophyll *a* maxima occurred between July and September in the central, western, eastern and southern delta regions. San Pablo Bay had chlorophyll *a* maxima in both May and July.

Maximum chlorophyll *a* concentration in the delta commonly occurs in the spring and summer maxima in 1996 may have been due to high winter and spring rainfall that delayed development of a phytoplankton bloom (Figure 6-1). However, peak concentrations in 1996 (like those of 1995) were lower than those measured in similar wet years before 1987.

Phytoplankton species composition differed between the spring and summer. Diatoms comprised the spring chlorophyll *a* maxima in the northern delta and the lower Sacramento River. Flagellates and the chain-forming diatom *Thalassiosira eccentrica* were abundant in the lower San Joaquin River. Chlorophyll *a* maxima consisted of miscellaneous flagellates and the cryptophyte *Cryptomonas ovatas* in Suisun Bay and miscellaneous flagellates and the dinoflagellate *Peridinium* sp. in San Pablo Bay.

Summer chlorophyll *a* maxima were comprised of the cryptophytes *Cryptomonas ovatas* and *Rhodomonas lacustris* in the central delta, and by the diatoms *Achnanthes lanceolata*, *Thalassiosira eccentrica* and the blue-green algae *Anacystis* sp. in the eastern delta. A mixed phytoplankton assemblage composed of greens, diatoms, crytomonads, flagellates and dinoflagellates characterized the summer chlorophyll *a* maxima in the southern delta, lower San Joaquin River and San Pablo Bay regions.

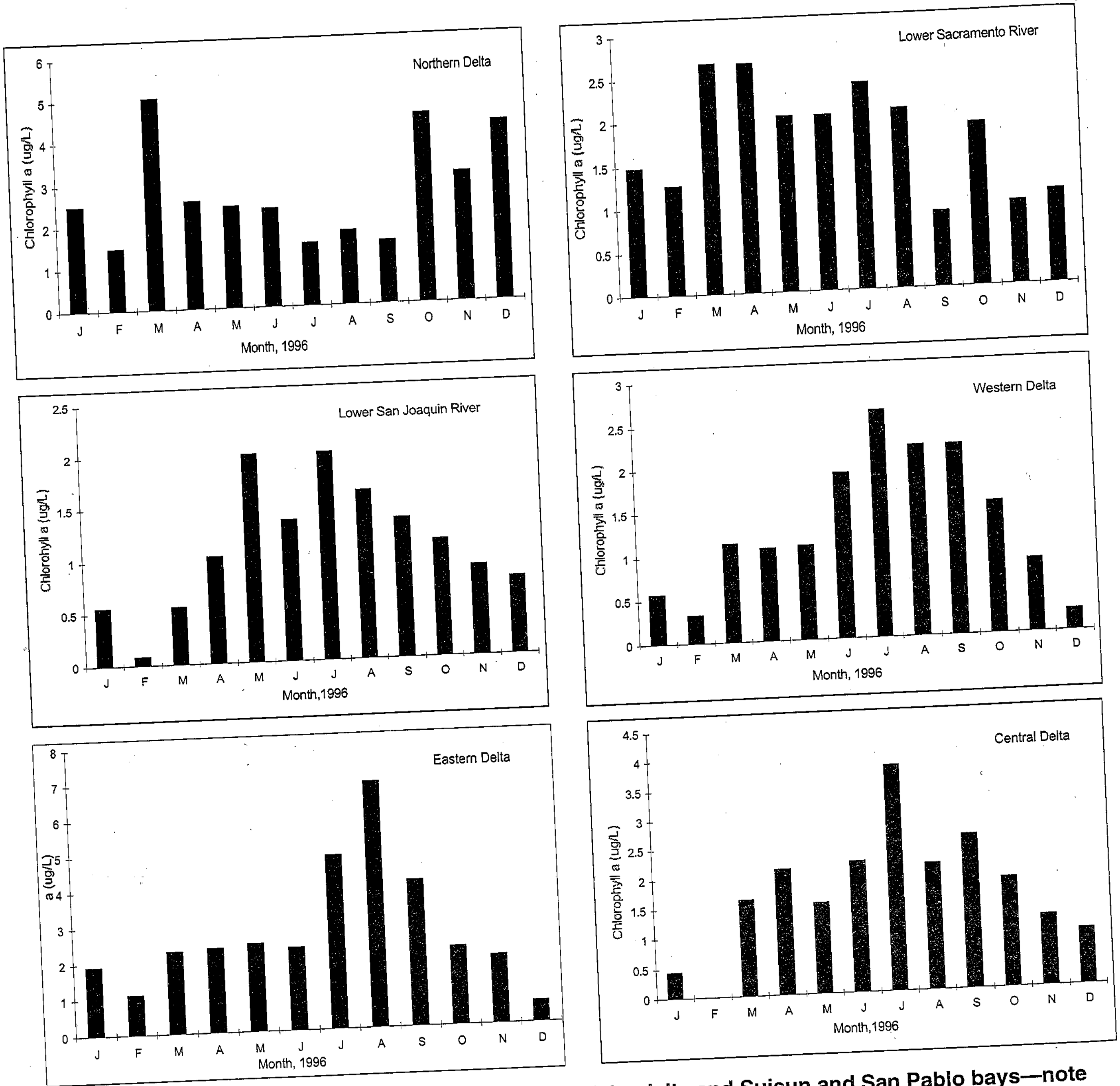

Figure 6-1—Chlorophyll *a* concentration in regions of the delta and Suisun and San Pablo bays—note scale change on Y-axis

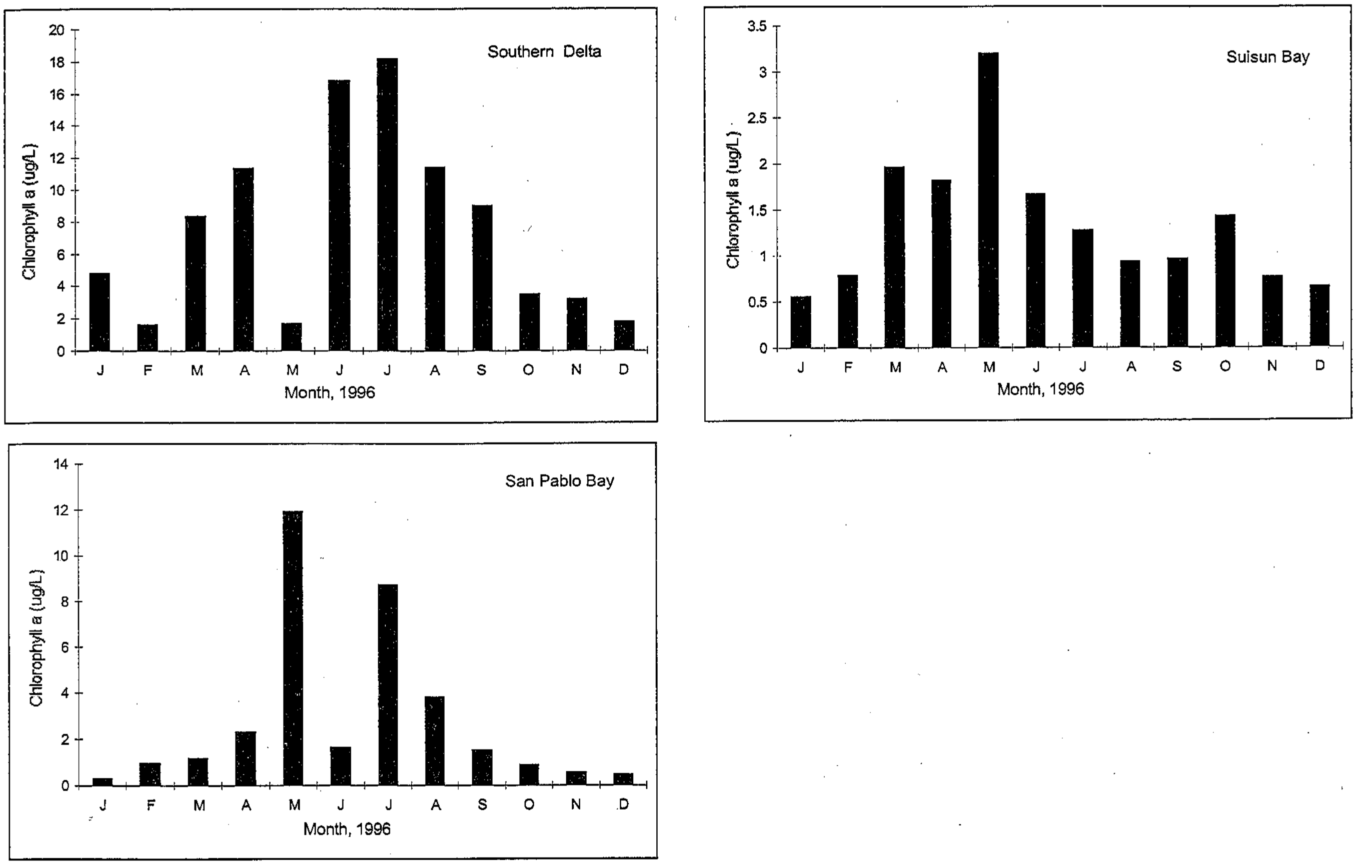

Figure 6-1—Chlorophyll *a* concentration in regions of the delta and Suisun and San Pablo bays—note scale change on Y-axis

Chapter 7—Zooplankton and Mysid Shrimp

Mysids and zooplankton are important food organisms for larval, juvenile and small fish such as delta smelt, juvenile salmon, striped bass and splittail. The *Neomysis*/Zooplankton study seeks to determine the annual population size of *Neomysis mercedis*, other mysids and various zooplankton species or genera to assess the size of the food resource for fish. The study also seeks to detect the presence of exotic species introduced in ship ballast water, monitor the distribution and abundance of these exotics and determine their impacts on native species.

Methods—Zooplankton and mysid shrimp were sampled monthly at 16 stations in the delta and Suisun Bay (Figure 7-1). Fourteen of these stations were fixed and two were "floating" stations located at bottom specific conductance of 2 and 6 mS/cm. Zooplankton were sampled with a Clarke-Bumpus net, mesh size 154 um. Zooplankton small enough to pass through this mesh (mostly copepod nauplii, rotifers and *Limnoithona* species) were sampled with a 15-liter/minute capacity pump. Mysid shrimp were captured with a large net 1.48 m long and 29 cm in mouth diameter, mesh size 0.505 um, with a General Oceanics net meter at its mouth. Both the Clarke-Bumpus and the neomysid nets were attached to a towing frame made of steel tubing. The Clarke-Bumpus net was mounted above the neomysids net. At each station, the net frame was lowered to the bottom and retrieved diagonally in several steps over a 10-minute towing period. At the end of each tow the pump inlet was lowered to the bottom and raised slowly to the surface. The pumped water entered a 20-liter carboy. The carboy was shaken and 1.5 liters were decanted into a jug. All samples were preserved in buffered 10 percent formalin and returned to the laboratory for identification. Surface temperature and specific conductance were measured at the beginning and surface conductance was measured at the end of each tow. Bottom specific conductance was also measured where the specific conductance at the surface was >1 mS/cm.

The monthly abundance (organisms/m^3) of each taxon was calculated and the total abundance divided by the number of stations sampled. Although no species was present at all stations in every month, averaging by the total number of stations sampled provided a common and consistent base for all species.

Results—Two mysid species, the native *Neomysis mercedis* and the introduced *Acanthomysis bowmani*, were caught in 1996. *Acanthomysis bowmani* was the most abundant mysid and peak abundance occurred in June and October (Figure 7-2). *Neomysis mercedis* was abundant in June and was absent in catches after June.

Three calanoid copepods, the possibly native *Eurytemora affinis* and the introduced *Pseudodiaptomus forbesi* and *Acartiella sinensis*, shared the low-salinity zone (Figure 7-3). Of these, *E. affinis* was the least abundant and was only abundant in April and May. *Pseudodiaptomus forbesi* and *A. sinensis* were most abundant in May and October. The fall *A. sinensis* peak density of 5,000 animals/m^3 was much higher than the *P. forbesi* peak density of 3,000 animals/m^3.

The native *Cyclops* spp. and *Diaptomus* spp. and the introduced *Sinocalanus doerrii* are freshwater calanoid copepods that were all an order of magnitude less abundant than *P. forbesi* and *A. sinensis* in 1996. *Cyclops* spp. was the most abundant of the three and peaked in June (Figure 7-4), followed by *Sinocalanus doerrii* in May. *Diaptomus* spp. was found at low densities between February and June.

Cyclopoid abundance was higher than calanoid abundance in all months except May and June. The most abundant cyclopoid copepod was *Limnoithona tetraspina* which occurred in the low-salinity zone. It peaked in August at 13,213 animals/m^3 and was abundant from July to October (Figure 7-5). Cyclopoid and calanoid copepods differ anatomically. In addition, calanoids tend to be more planktonic and herbivorous and cyclopoids are more littoral and carnivorous.

Bosmina was the most abundant freshwater cladoceran and was abundant in May and August (Figure 7-6). *Daphnia* abundance was unimodal and peaked in May. Other cladocerans had a summer peak.

Rotifers could be divided into two groups, the low-salinity *Synchaeta bicornis* and freshwater species. *Synchaeta bicornis* was not present until July, peaked in August and was absent by November (Figure 7-7). Other freshwater rotifers were most abundant in March.

Abundance of cladocerans, rotifers and native copepods (including *Eurytemora*) did not recover to the levels seen in the 1970s and early 1980s. Abundance of introduced calanoid copepods (*S. doerrii, P. forbesi, A. sinensis* and *L. sinensis*) was within the range that occurred during the early 1990s. *Neomysis mercedis* remained at the extremely low levels first seen in 1994, following the 1993 introduction of *A. bowmani*, which peaked in 1994 and declined in the next two years.

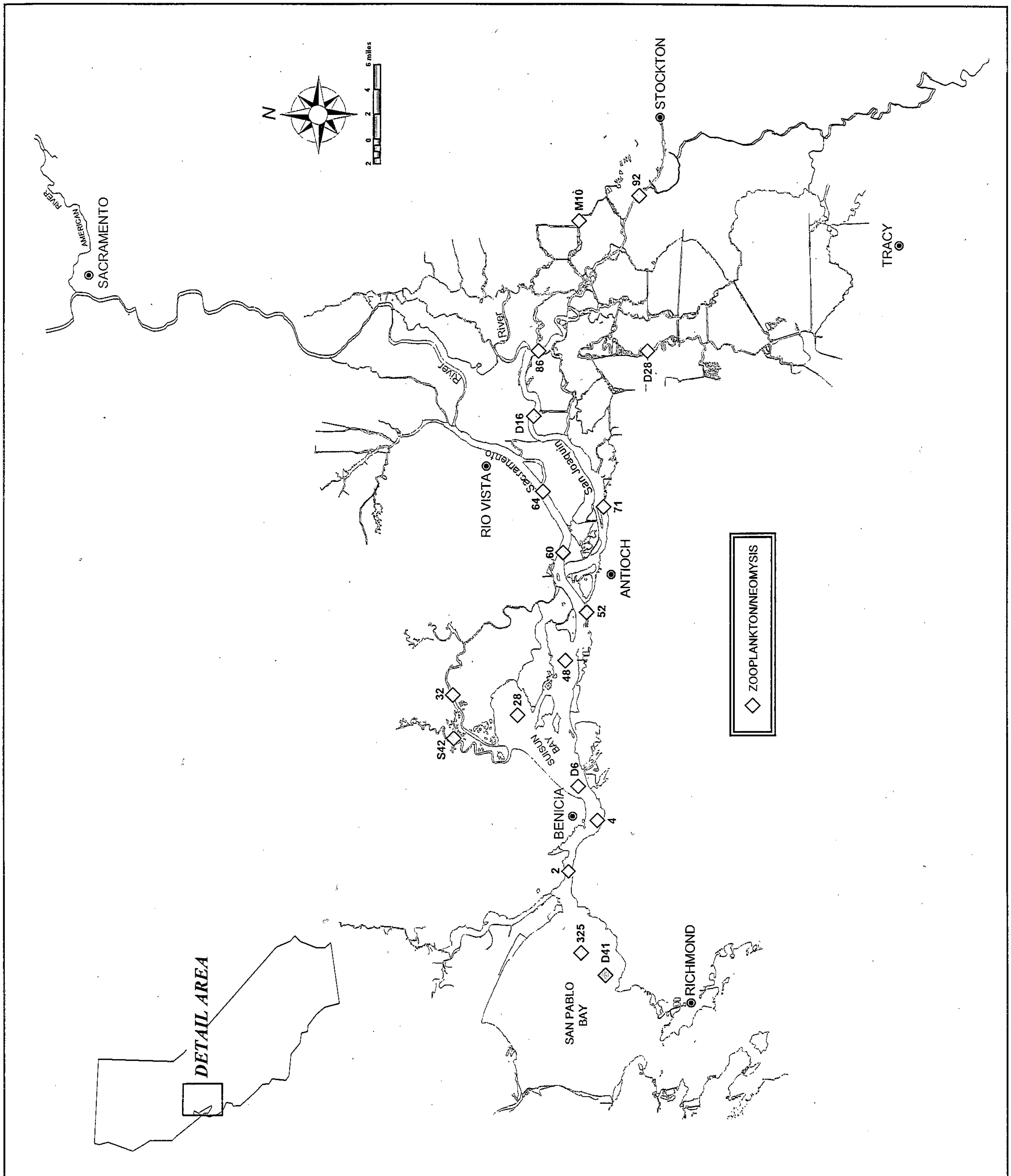

Figure 7-1—Mysid and zooplankton sampling stations

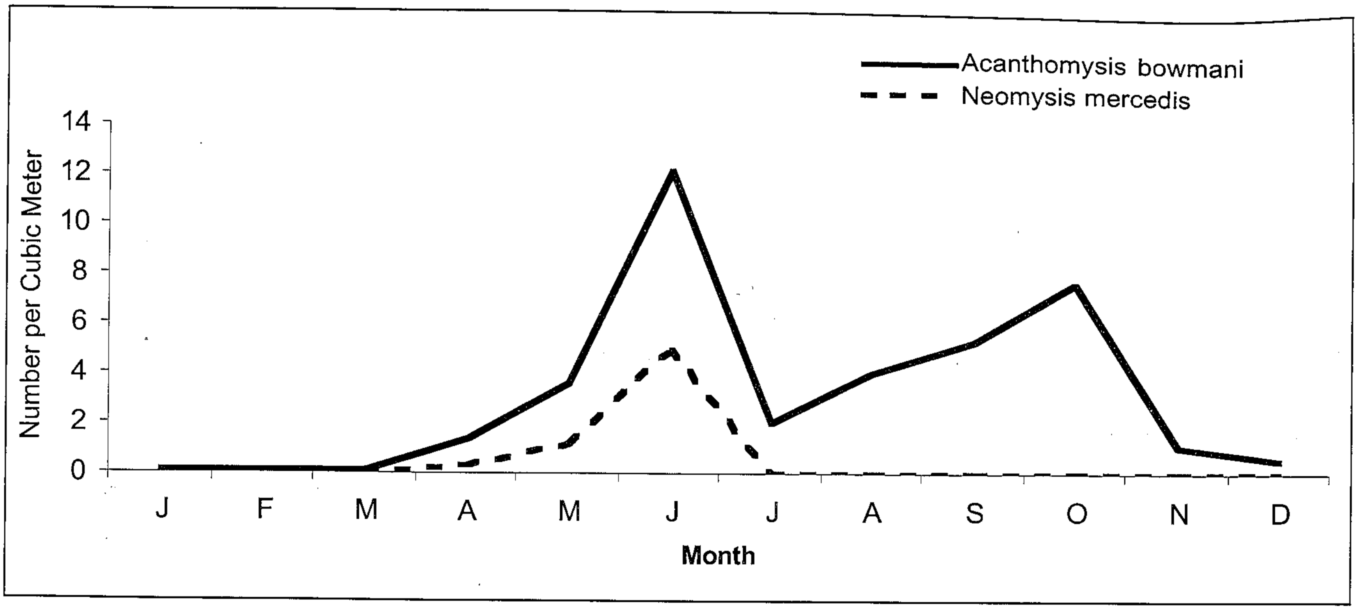

Figure 7-2—Monthly abundance of *Acanthomysis bowmani* and *Neomysis mercedis* in 1996

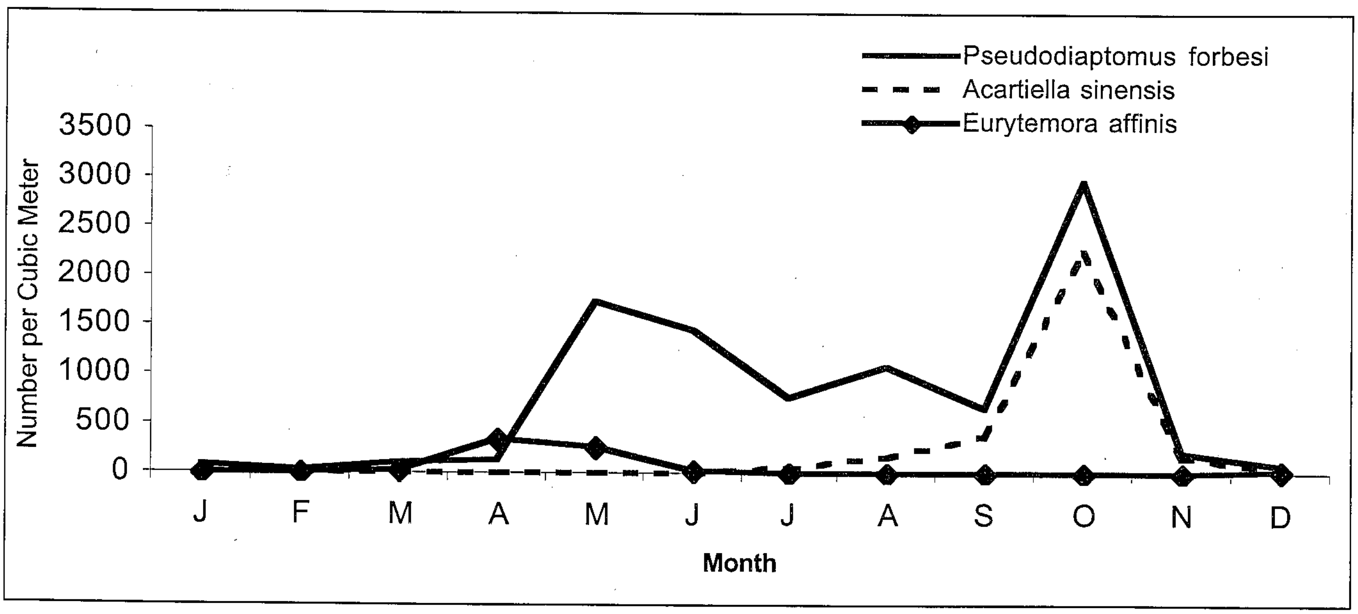

Figure 7-3—Monthly abundance of *Pseudodiaptomus forbesi, Acartiella sinensis* and *Eurytemora affinis* in 1996

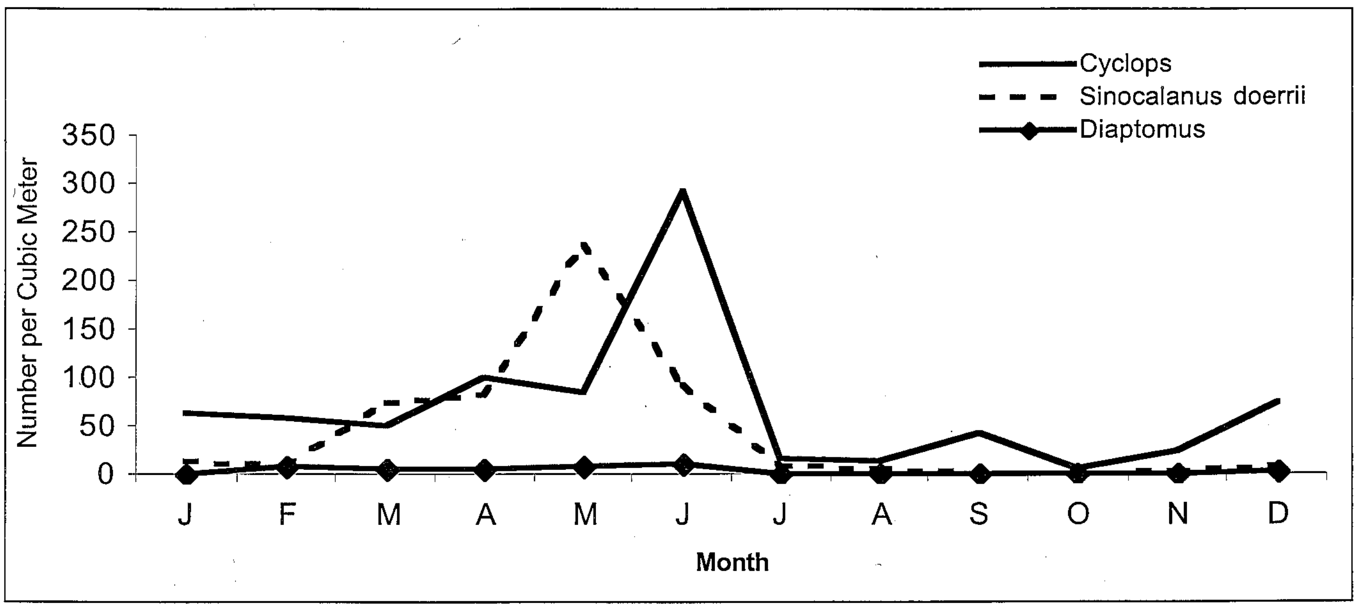

Figure 7-4—Monthly abundance of Cyclops, Diaptomus and *Sinocalanus doerrii* in 1996

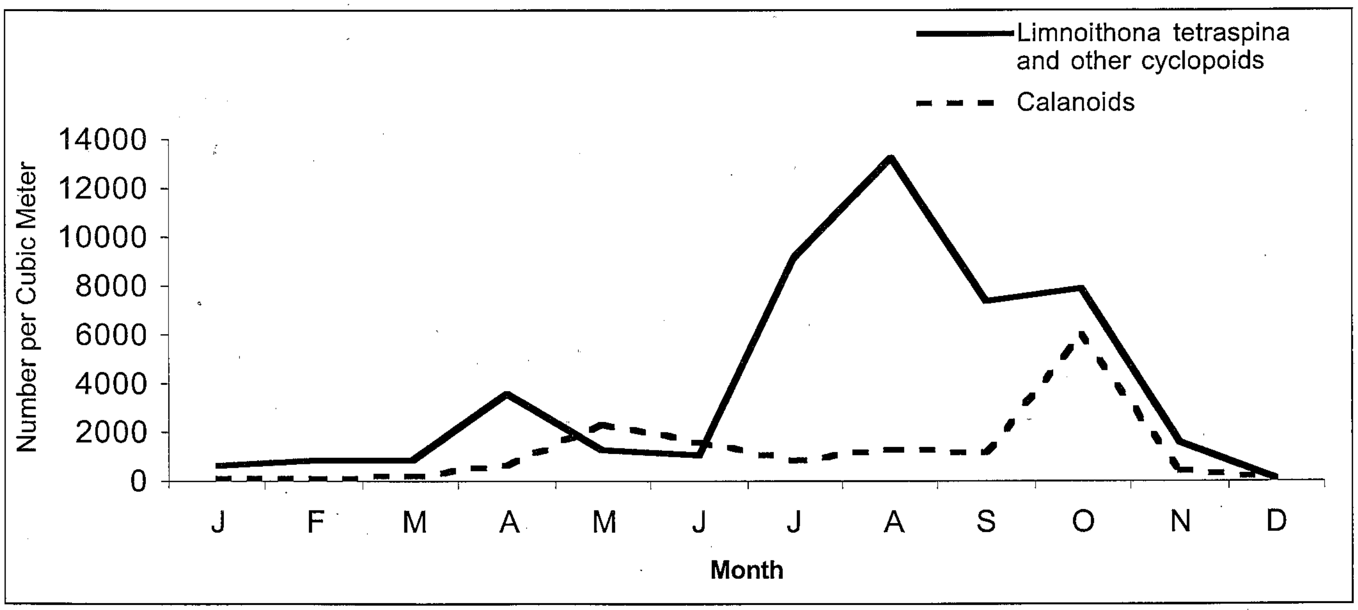

Figure 7-5—Monthly abundance of *Limnoithona tetraspina* and other cyclopoids compared to calanoids in 1996

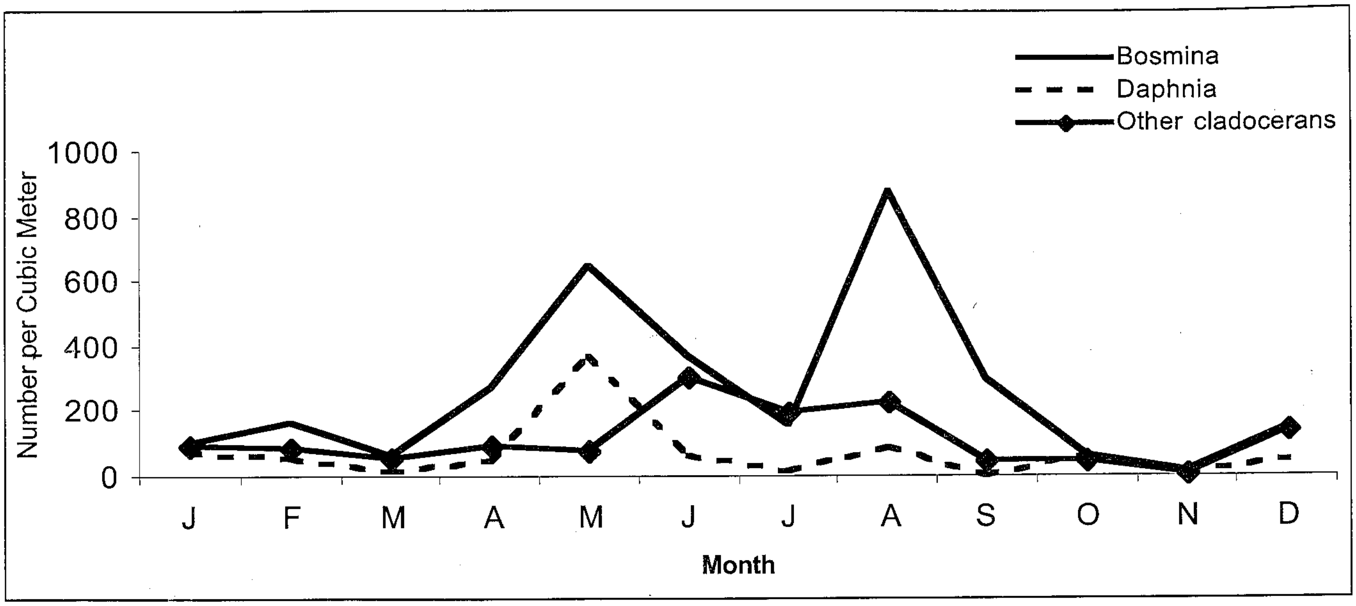

Figure 7-6—Monthly abundance of Bosmina, Daphnia and other cladocerans in 1996

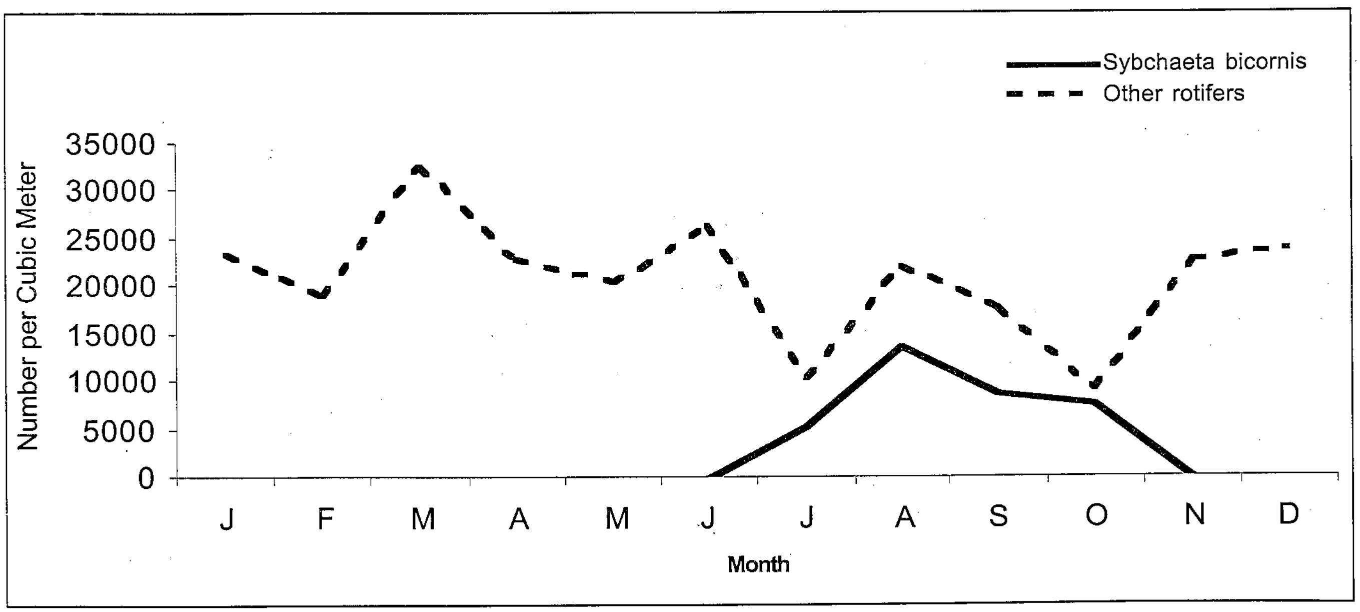

Figure 7-7—Monthly abundance of *Sybchaeta bicornis* and other rotifers in 1996

Chapter 8—Benthic Monitoring

The Benthic Monitoring Program is designed to document the distribution, diversity and abundance of benthic (bottom dwelling) organisms and substrate composition in the Sacramento/San Joaquin Delta and Suisun and San Pablo bays. The benthic community of the delta and bays is a diverse assemblage of organisms which includes fungi, ciliates, worms, crustaceans, insects and molluscs. This program monitors benthic invertebrate macrofauna (larger than 0.5 mm). Substrate composition is monitored to evaluate changes in benthic fauna in relation to benthic substrate.

In 1996 the number of benthic monitoring stations was increased from six to ten (Figure 8-1) to sample more of the environmental diversity within the delta and bays. For this summary, stations were grouped together into six regions based on geographic location. The six regions are the eastern delta, southern delta, lower Sacramento River, lower San Joaquin River, Suisun Bay and San Pablo Bay. Five bottom grab samples are taken at each station using a Ponar dredge having an area of $0.053 m^2$. Density of organisms/m^2 in the dredge sample are calculated by multiplying the count in each sample by 18.9. Four of the samples are taken for benthic macrofauna analysis and the fifth sample is taken for substrate analysis.

A private laboratory identifies and enumerates organisms in the macrofaunal samples. Inorganic and organic content analyses, as well as particulate size analyses of substrate samples, are conducted by the DWR Soils and Concrete Laboratory.

Methods—Fluctuations in the total abundance of benthic organisms and species composition were used to investigate trends in the benthic community (Figures 8-2 through 8-13). Data from all stations within a region are averaged together to obtain regional abundance.

Substrate was analyzed for particle size according to the American Society of Testing and Materials protocol D 422. Particles were sorted into the following categories: > 2350 µm, >1180 µm, >600 µm, > 300 µm, >100 µm and >75 µm. Substrate composition is reported as: gravel (> 2350 µm), sand (100 µm to 2350 µm) and fines (<100 µm). No substrate samples for 1996 contained gravel (Figure 8-14).

Organic content of the sediment was determined using American Society of Testing and Materials protocol D 2974, method C. For this method, organic material is based on difference in weight between sediment samples before and after combustion at 440° C.

Results—A total of 248 species were collected in 1996. All animals collected fell into one of nine phyla:

- Cnidaria (hydras, sea anemones)
- Platyhelminthes (flatworms)
- Nemertea (ribbon worms)
- Nematoda (roundworms)
- Annelida (segmented worms, such as oligochaetes and polychaetes)
- Arthropoda (aquatic insects, amphipods, isopods, shrimp, crabs, mites, etc.)
- Mollusca (clams, snails)
- Chordata (tunicates)
- Echinodermata (seastars)

Of these phyla, Annelida, Arthropoda and Mollusca made up 92 percent of all organisms collected.

Eastern Delta—The eastern region consists of station P8, which is the easternmost station in the program and is located in the San Joaquin River near Buckley Cove (Figure 8-1). Total abundance was high in the spring and declined throughout the rest of the year (Figure 8-2). Total abundance peaked in March at 8,459 organisms/m^2 and was primarily composed of the annelids *Ilyodrilus frantzi capillatus*, *Limnodrilus hoffmeisteri* and *Varichaetadrilus angustipenis*. Arthropods comprised 50, 46 and 58 percent of the animals in April, May and June, respectively (Figure 8-3) and included the amphipods *Corophium stimpsoni* and *Gammarus daiberi*. The density of molluscs rose in July and stayed high through November due to an increased catch of the Asian clam *Corbicula fluminea*.

Sediment composition for the eastern region averaged 60 percent sand, 37 percent fine silt and 3 percent organic (Figure 8-14).

Southern Delta—The southern region consists of stations D28A and C9 (Figure 8-1). Total abundance was high in the spring and declined throughout the rest of the year (Figure 8-4). Peak abundance occurred in April at 17,073 organisms/m^2. This region had the highest benthic abundance in the delta and was primarily composed of the annelids *Aulodrilus limnobius*, *Limnodrilus hoffmeisteri*, *Varichaetadrilus angustipenis*, *Manayunkia speciosa* and *Ilyodrilus frantzi capillatus* (Figure 8-5). Annelids were the most numerous organisms collected in this region comprising 63 percent of the total collection for 1996.

Sediment composition for the southern region varied greatly between the two sites (Figure 8-14). Fines comprised 73 percent of the sediment composition at D28A. Sand comprised 93 percent of the sediment at C9 for the year.

Lower Sacramento River—This region consists of stations D4 and D24, both of which are on the lower stretch of the Sacramento River (Figure 8-1). Benthic macroinvertebrate abundance for most of the year stayed between 1,761 and 3,683 organisms/m^2 (Figure 8-6). In May a large peak in abundance occurred at 9,053 organisms/m^2 due to an increase in the number of arthropods collected. Arthropods accounted for 75 percent of the species collected followed by molluscs at 16 percent and annelids at 7 percent. The four species of arthropods primarily responsible for the peak in May were the amphipods, *Corophium stimpsoni*, *Corophium spinicorne* and *Gammarus daiberi*, and a chironomid, *Paratendipes* sp. Percentages for the top three phyla (Annelids, Arthropods and Molluscs) were more evenly distributed over the year for this area than other regions. The yearly average percentages for annelids, arthropods and molluscs were 26, 33 and 36 percent, respectively (Figure 8-7).

Sediment composition for the two stations varied with D4 having an average of 73 percent fine silts in the sediment and D24 consisting of 80 percent sand (Figure 8-14).

Lower San Joaquin River—The lower San Joaquin River region consists of station D16 which is located in the San Joaquin River near Twitchell Island (Figure 8-1). Total abundance of macrofauna was usually low, under 1,000 organisms/m^2, and increased somewhat in May to 4,669 organisms/m^2 and in November to 8,688 organisms/m^2 (Figure 8-8). Arthropods comprised up to 91 percent of the organisms collected during the November peak, with the amphipod *Gammarus daiberi* comprising the majority (Figure 8-9). During the months of March and September, the density of molluscs increased with the Asian clam, *Corbicula fluminea*, making up 78 percent of the species collected during this time. Annelid density was very low within this region and averaged around 12 percent of the total species collected for the year.

Sediment composition for station D16 averaged 74 percent sand, 24 percent fine silt and 2 percent organic materials (Figure 8-14). During the months of May, September and December sediment composition changed with fine silt comprising 81, 58 and 85 percent of the sediment, respectively.

Suisun Bay—The Suisun Bay region consists of stations D6 and D7 with D6 located at Bulls Head near the city of Martinez and D7 located in Grizzly Bay (Figure 8-1). Peak abundance of benthic organisms occurred in May at 3,048 organisms/m^2 (Figure 8-10), with 49 percent of this peak consisting of the tubificid oligochaete worm, *Tubificoides heterochaetus,* and the spionid polychaete worm, *Marenzelleria viridis*. *Potamocorbula amurensis* comprised 34 percent of the remaining organisms collected during peak abundance. This region had the lowest total abundance among the six regions. *Potamocorbula amurensis* dominated the species found in this region and made up 44 percent of all animals (Figure 8-11).

Sediment composition varied between the two stations in this region (Figure 8-14). Station D6 consisted of 49 percent sand and 46 percent fines. Sand deposits for this station were dominant from January through August and again in November and fines were more prevalent in September, October and December. Sediment composition for station D7 averaged 86 percent fines, 7 percent organic materials and 7 percent sand (Figure 8-14).

San Pablo Bay—The San Pablo Bay region consists of stations D41 and D41A, with D41 located near Point Pinole and D41A located near the mouth of the Petaluma River (Figure 8-1). Monthly average total abundance of benthic organisms for this region exceeded 3,285 organisms/m^2 (Figure 8-12). Peak abundance occurred in December at

9,710 organisms/m^2 with 64 percent of this peak comprised of the amphipod *Ampelisca abdita*. Molluscs were the second most abundant group of organisms detected during the December peak (33 percent) with *Potamocorbula amurensis* dominating this group. Molluscs were the most abundant organisms collected in this region (54 percent); *P. amurensis* comprised 48 percent of all species (Figure 8-13).

Sediment composition was consistent between the two individual stations with fines accounting for the majority of the substrate throughout the year. Fine silt made up 87 and 91 percent of the sediment at D41 and D41A, respectively (Figure 8-14).

Species of Interest—For 1996, ten new species were added to the list of organisms collected at the six regions. These species included:

- two unidentified microturbellarian flatworms;
- two tubificid worms (*Limnodrilus claparedianus* and *Tubificoides wasselli*);
- three chironomid species (*Microtendipes* sp., *Hydrobaenus* sp. and *Cryptotendipes* sp.);
- one unidentified amphiurid species and two gastropod species;
- an unidentified nudibranch species later identified as *Okenia plana*; and
- an unidentified cephalaspidean species later identified as *Philine* sp.

Average abundance (organisms per squared meter) for *Corbicula fluminea* and *Potamocorbula amurensis* was calculated for benthic monitoring sites sampled in 1994 through 1996 (Figures 15 and 16). Due to a revision of the monitoring program in 1995, the total number of monitoring sites increased in 1996 (Figure 8-1). For this comparison, only sites sampled in 1994,1995 and retained in 1996 were used. For *C. fluminea* these sites include, D28A, D4, and D7. For *P. amurensis* these sites include, D4, D41A, and D7.

P. amurensis abundance was high in 1994 and 1995. In 1994, clam numbers peaked in October at 1828 clams/ m^2. Numbers were also high in February (1729 clams/ m^2) and July (1761 clams/ m^2) of this year (Figure 15). In 1995, clam density peaked in August at 2286 clams/ m^2, May (2134 clams/ m^2), and January (2217 clams/ m^2) (Figure 15). In 1996, clam density is lower than the previous year. *P. amurensis* numbers peak in August at 1726 clams/ m^2, in July (1381 clams/m^2), and September (1327 clams/m^2). The remaining months have densities at or below 1000 clams/ m^2 (Figure 15). Data for June of this year is not included in this analysis because of an incomplete data set due to vessel complications. Though 1995 is classified as a "wet" year, the density of *P. amurensis*, a species requiring saline conditions, is higher overall than in 1994 (a "critically dry" year).

C. fluminea abundance was generally low in 1994 and 1995. In 1994, a critically dry water year, clam density peaked in July at an average of 836 clams/m^2 (Figure 16). In 1995, classified as a wet water year, clam density continued to remain low and peaked in July at 418 clams/m^2 (Figure 16). Clam numbers appear to rebound in 1996, classified as a wet water year, with a peak of 1280 clams/m^2 in May. Numbers remain high (greater than 500 clams/m^2) for most of 1996 (Figure 16). Data for June of this year is not included in this analysis because of an incomplete data set due to vessel complications.

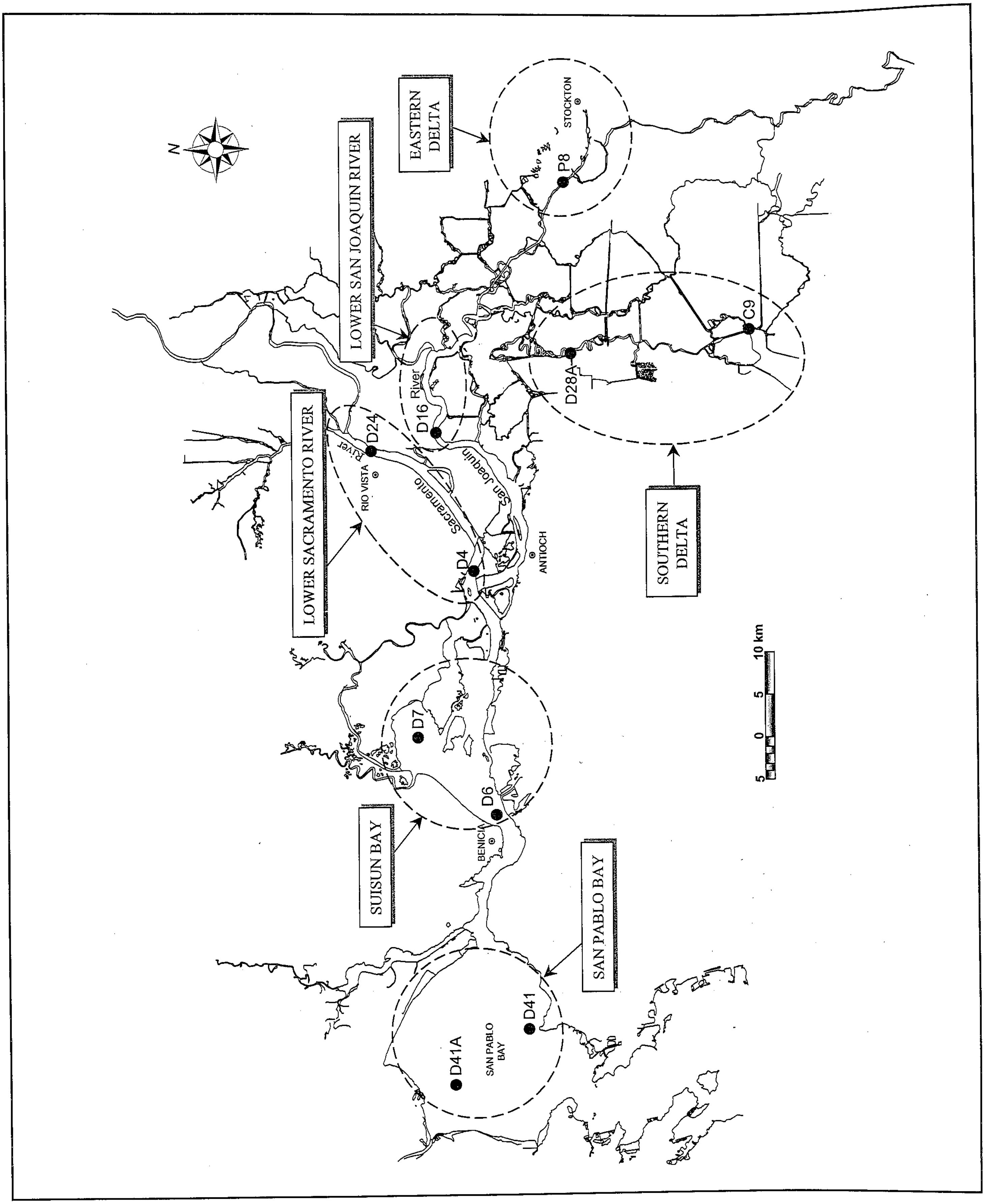

Figure 8-1—Benthic monitoring stations by region

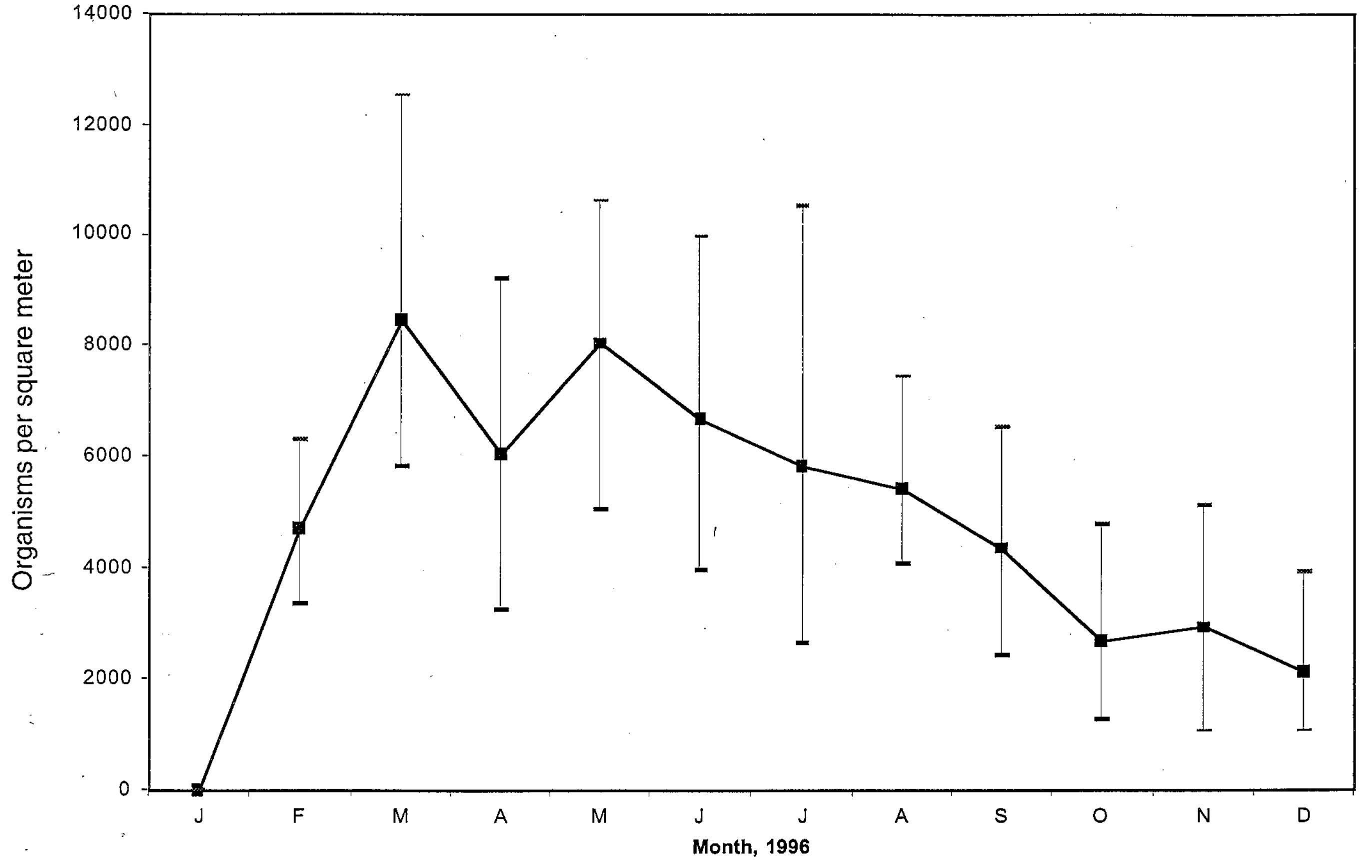

Figure 8-2—Total abundance of organisms in the eastern delta

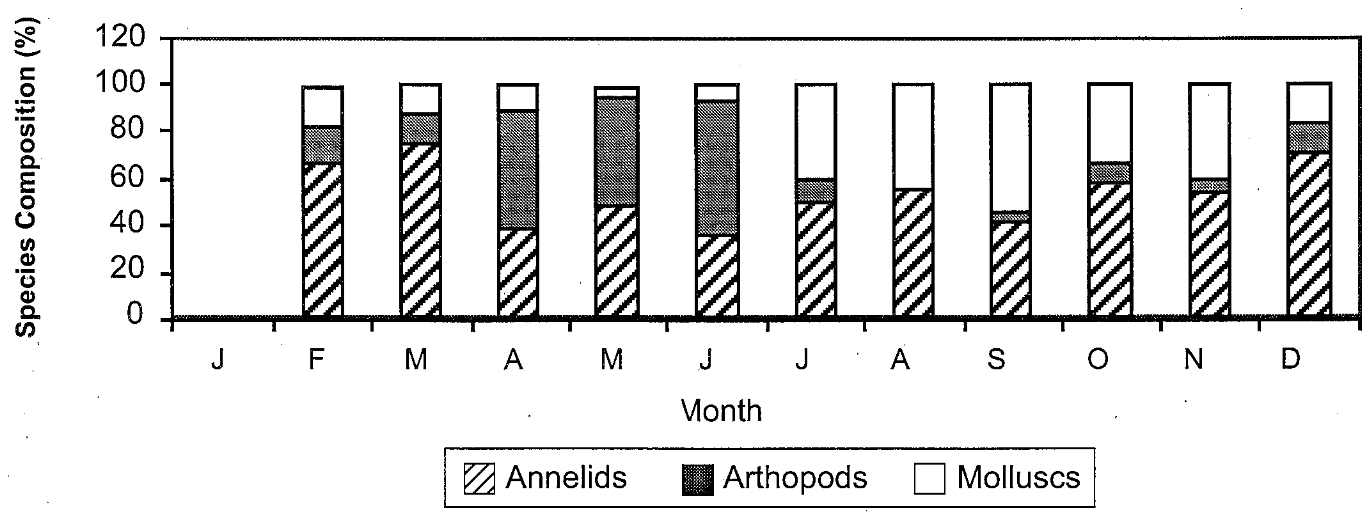

Figure 8-3—Species composition by percent of the three most abundant phyla in the eastern delta

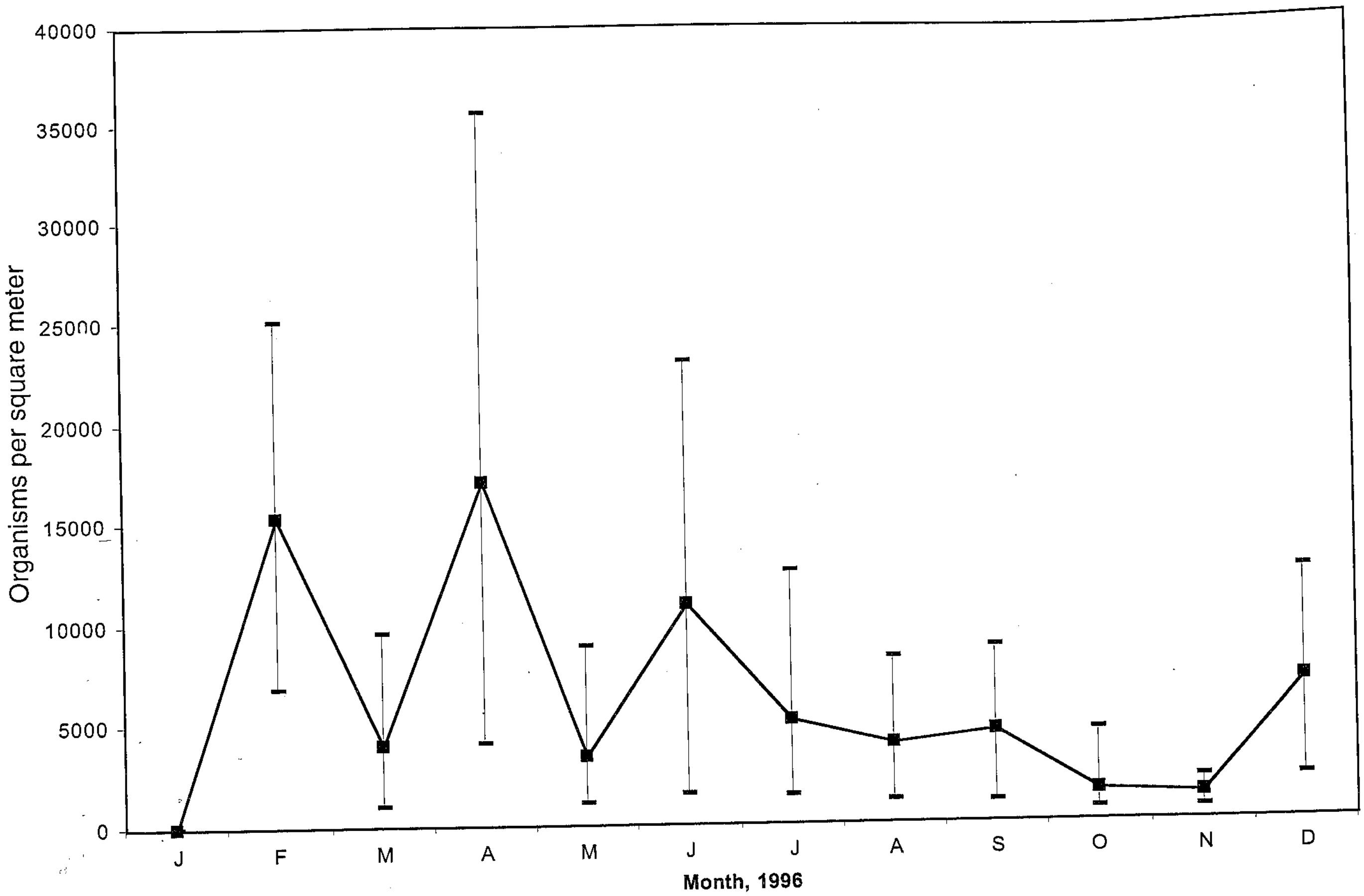

Figure 8-4—Total abundance of organisms in the southern delta

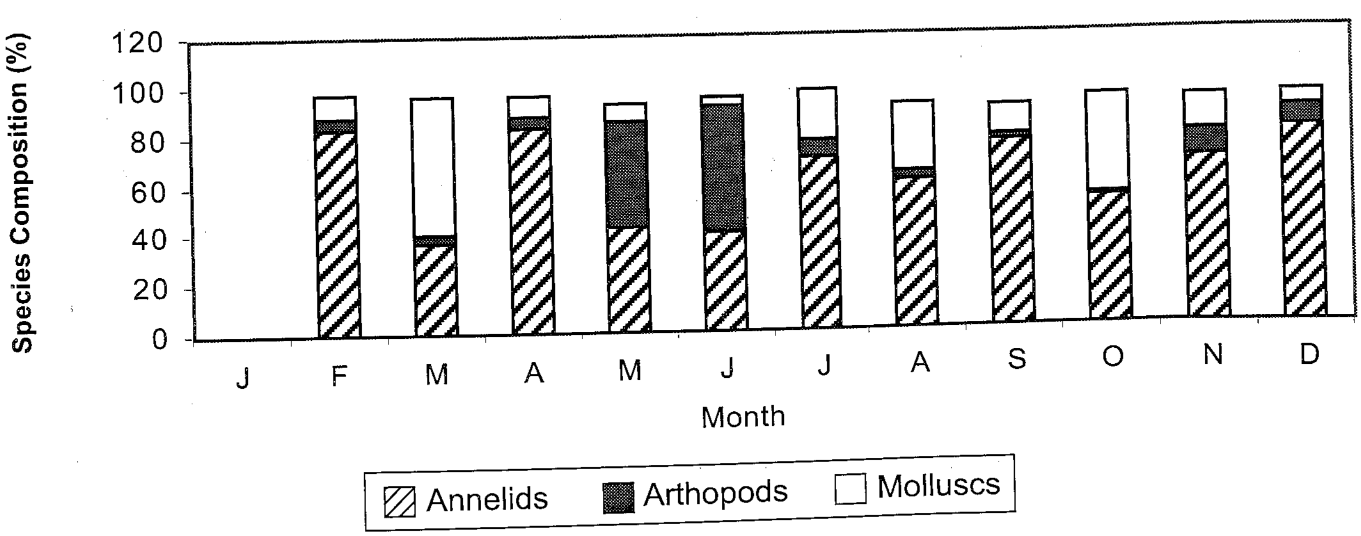

Figure 8-5—Species composition by percent of the three most abundant phyla in the southern delta

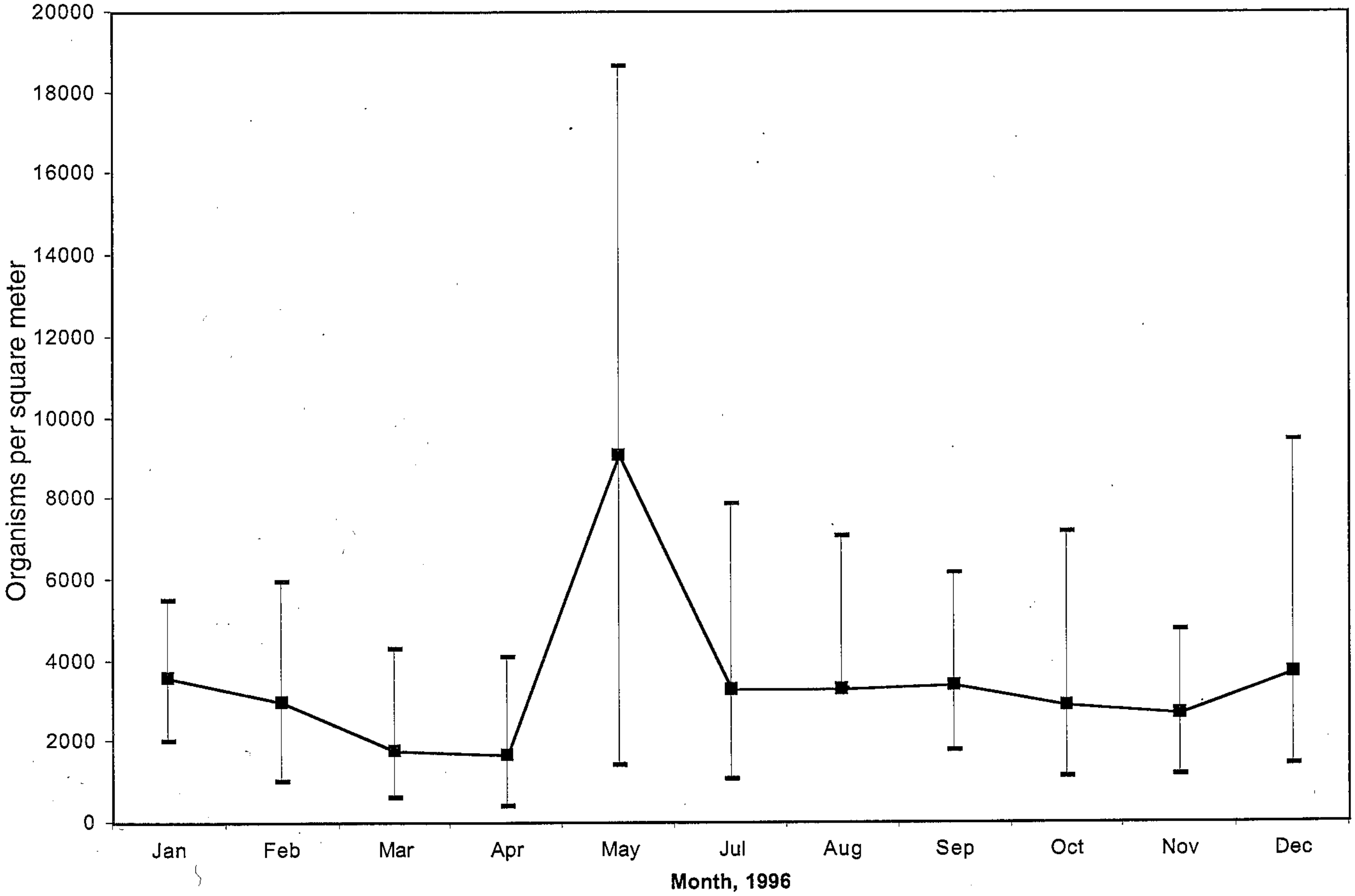

Figure 8-6—Total abundance of organisms in the lower Sacramento River

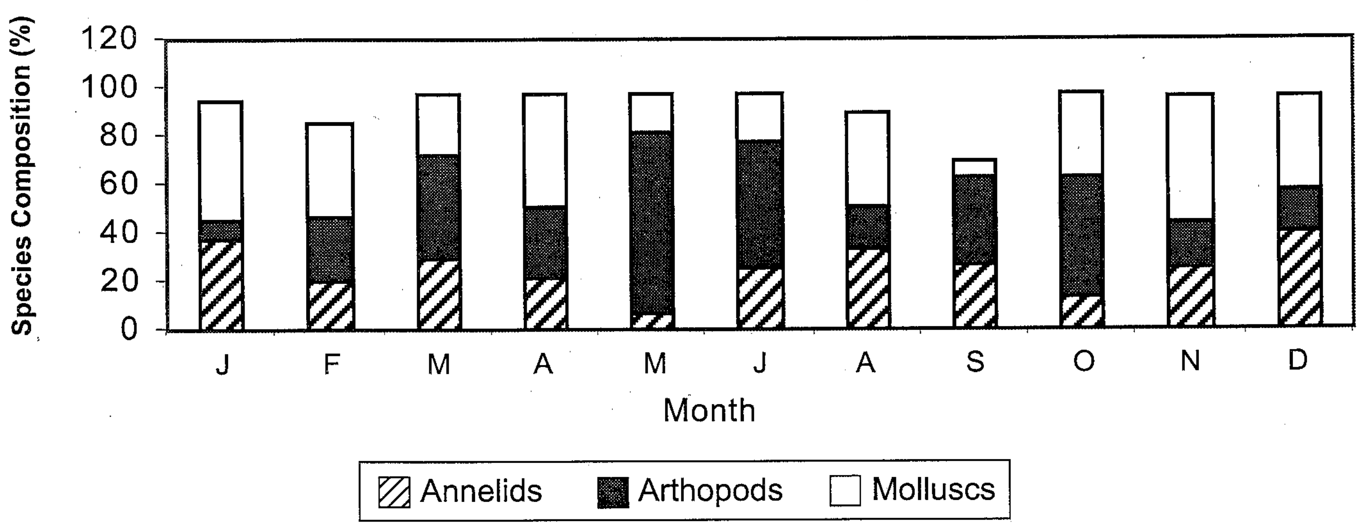

Figure 8-7—Species composition by percent of the three most abundant phyla in the lower Sacramento River

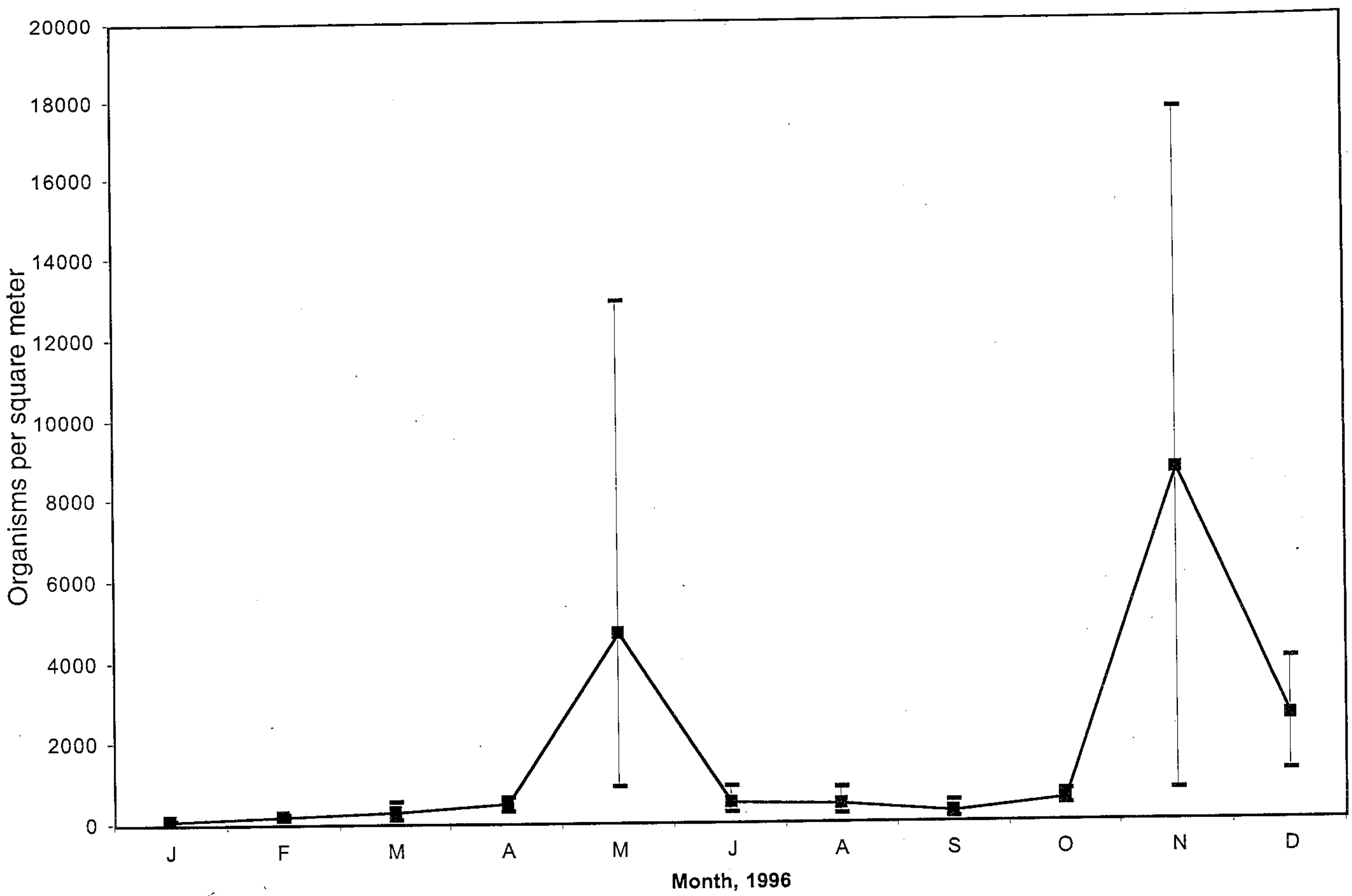

Figure 8-8—Total abundance of organisms in the lower San Joaquin River

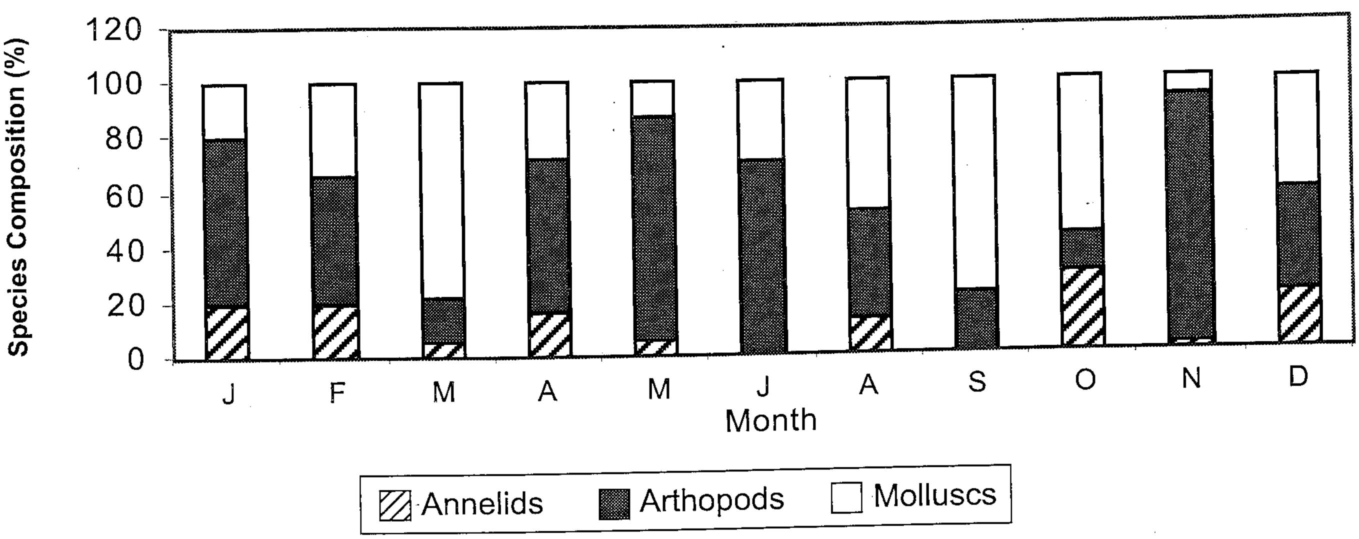

Figure 8-9—Species composition by percent of the three most abundant phyla in the lower San Jo..quin River

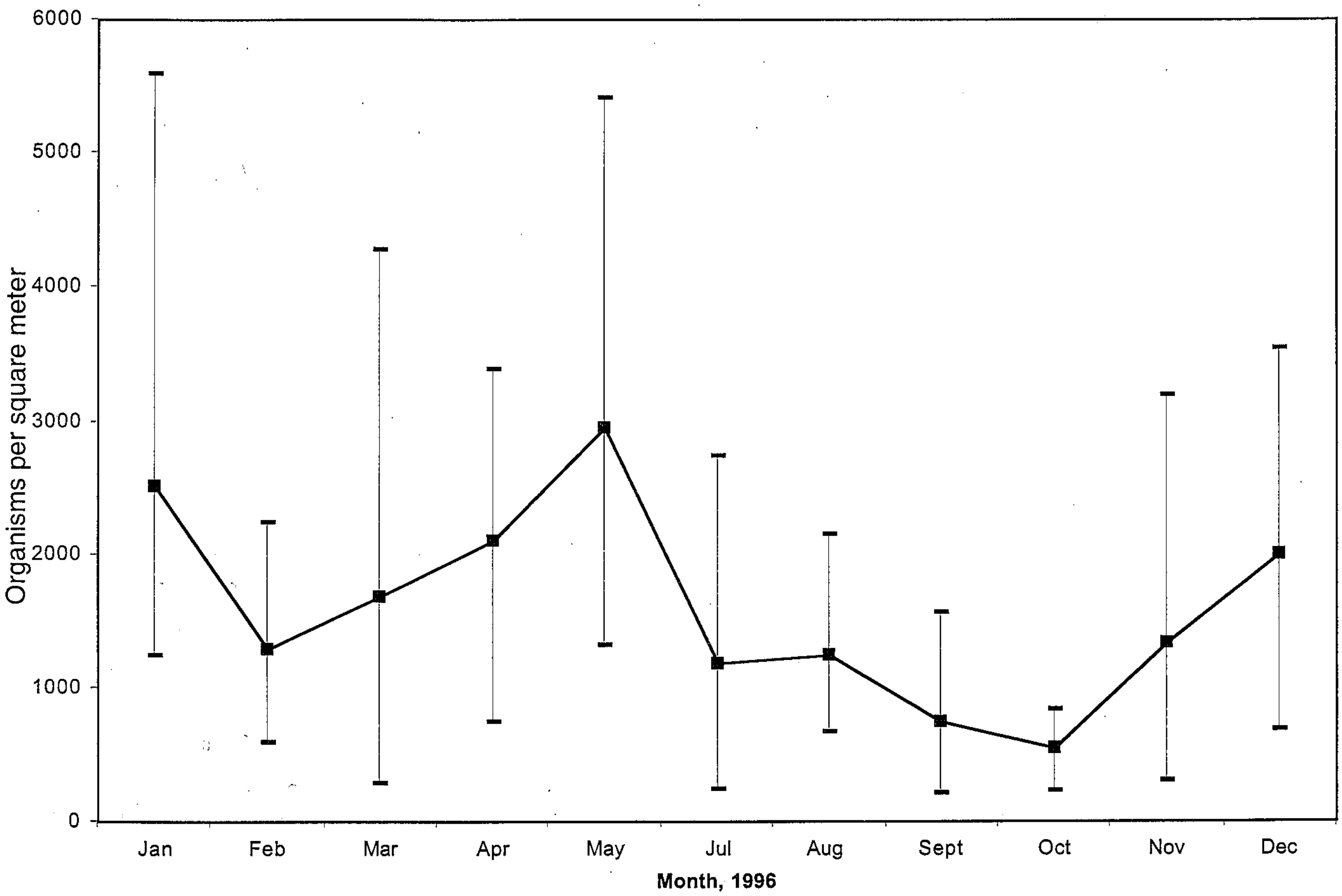

Figure 8-10—Total abundance of organisms in Suisun Bay

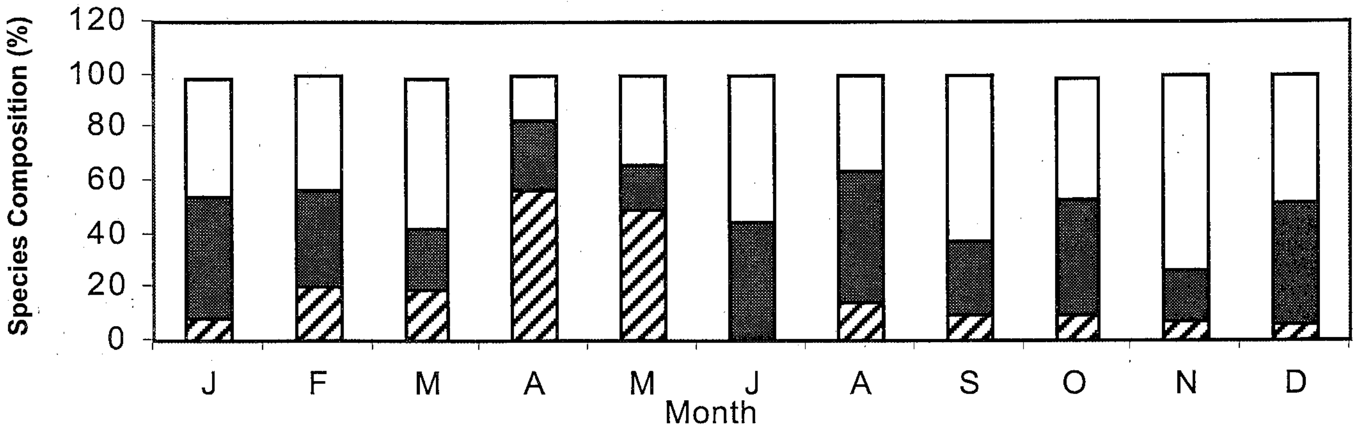

Figure 8-11—Species composition by percent of the three most abundant phyla in Suisun Bay

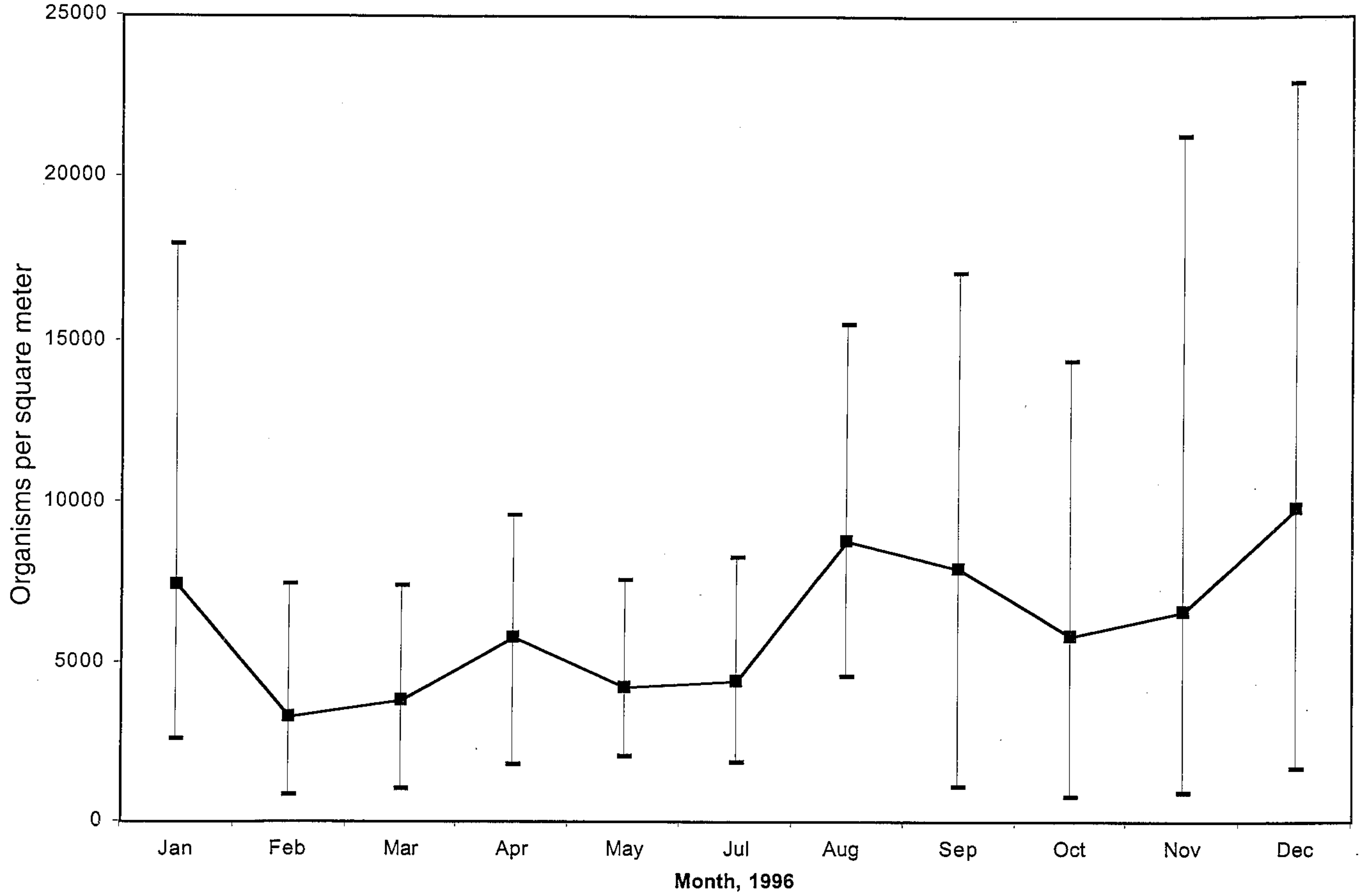

Figure 8-12—Total abundance of organisms in San Pablo Bay

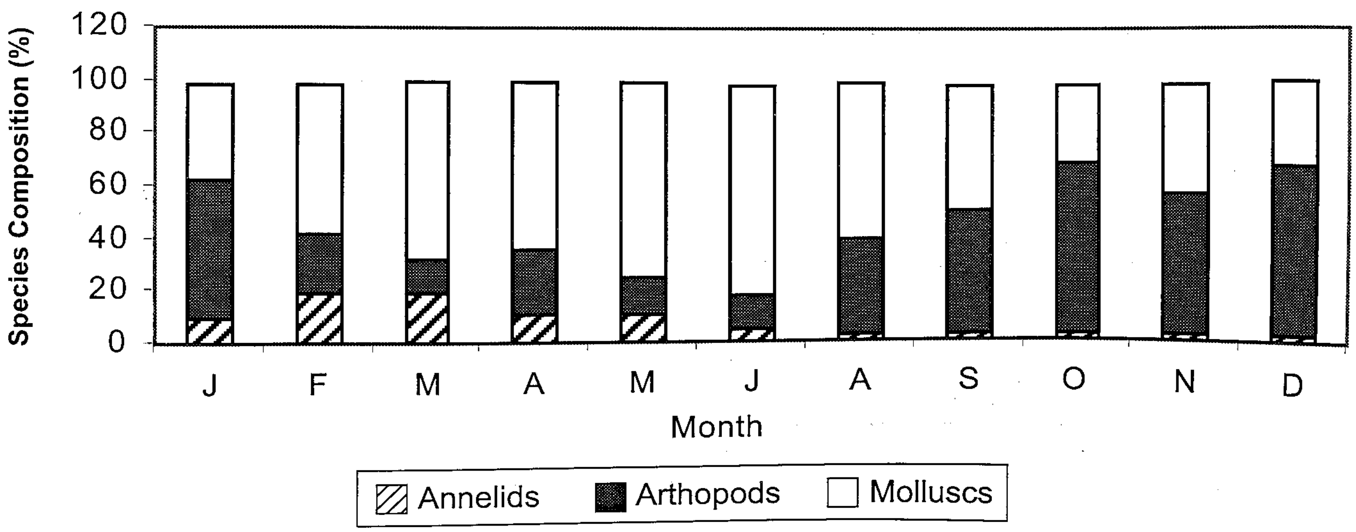

Figure 8-13—Species composition by percent of the three most abundant phyla in San Pablo Bay

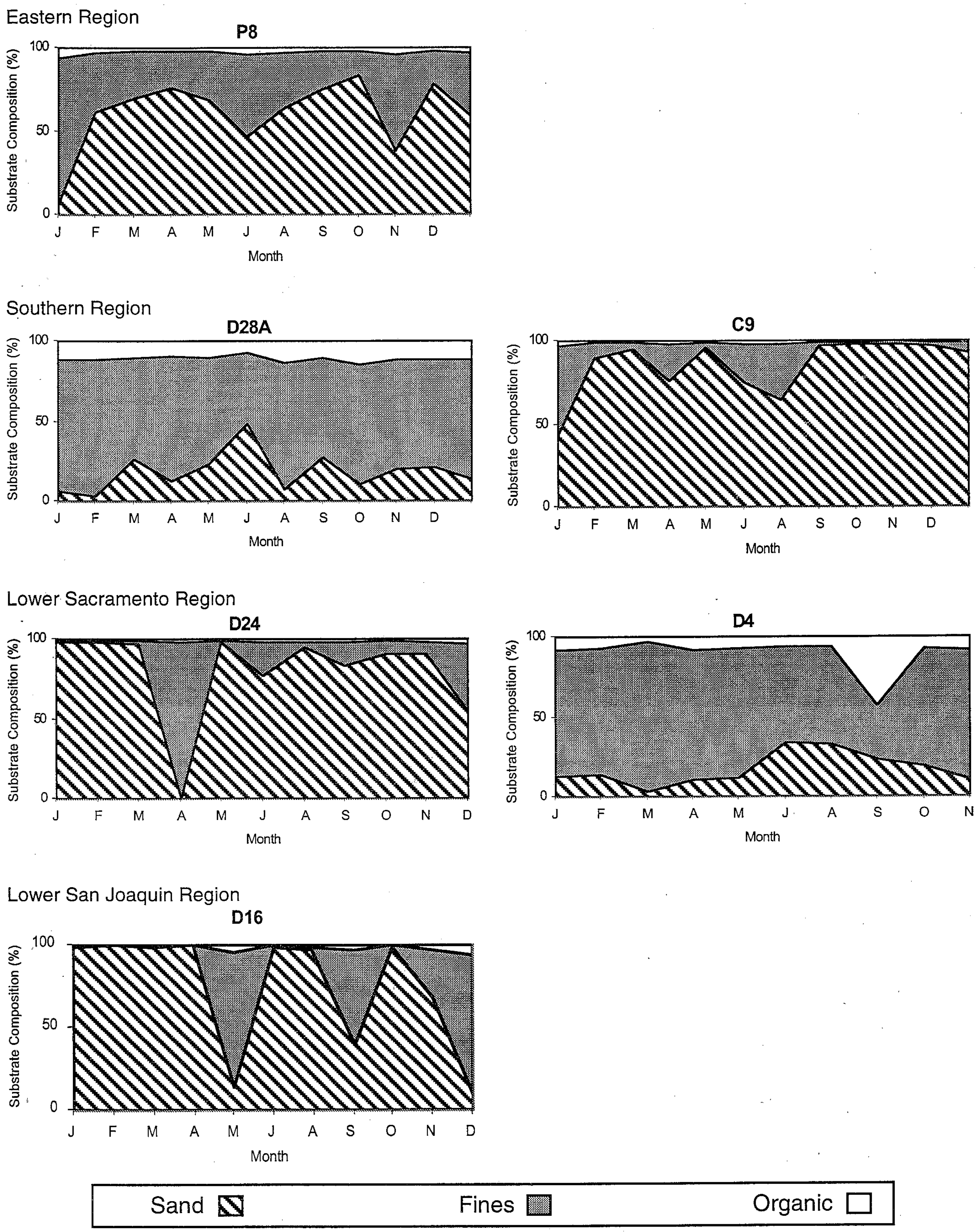

Figure 8-14—Sustrate composition by percent for individual sites

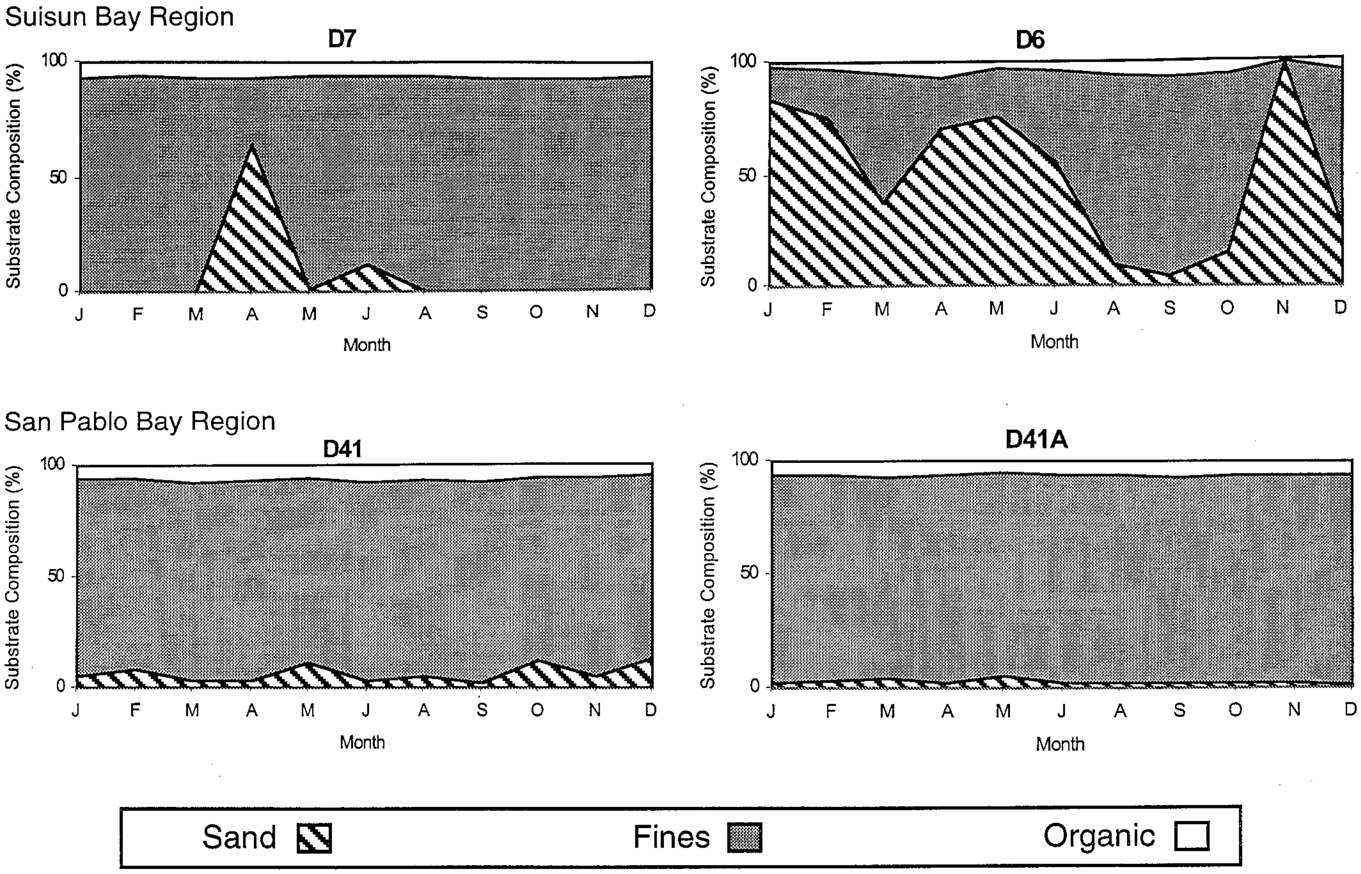

Figure 8-14—Sustrate composition by percent for individual sites *(continued)*

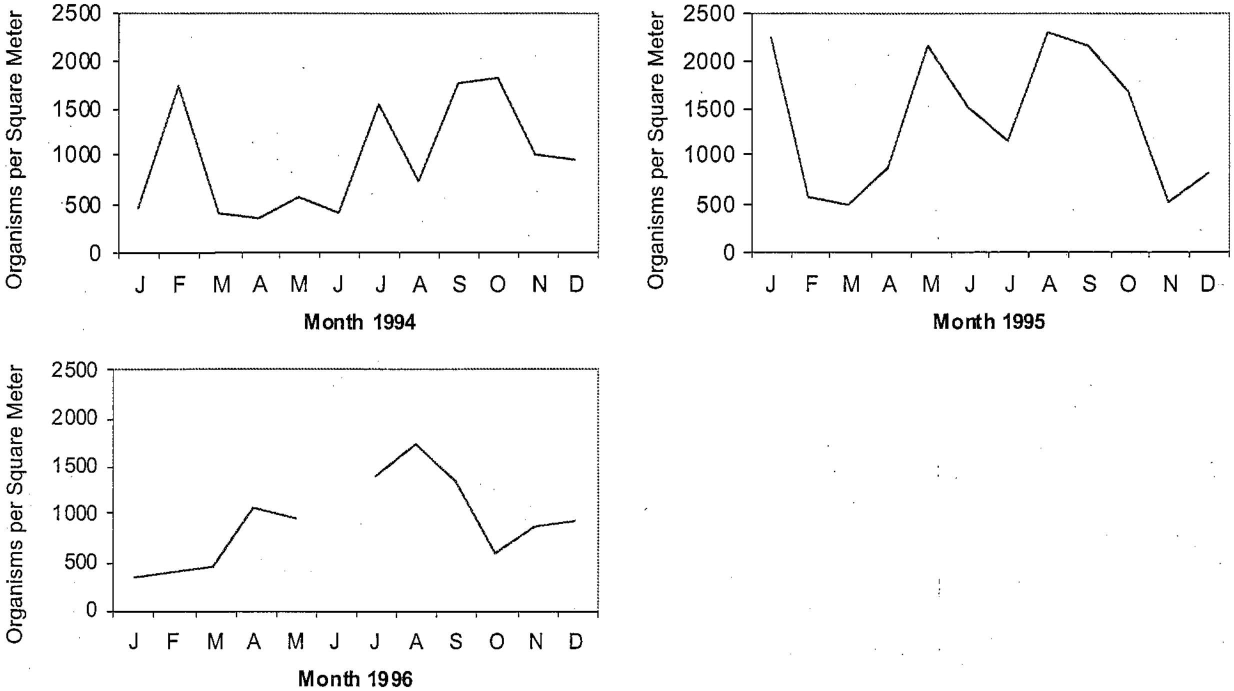

Figure 8-15—Average abundance of *Potamocorbula amurensis* at D4-C, D41A-C and D7-C, 1994-1996

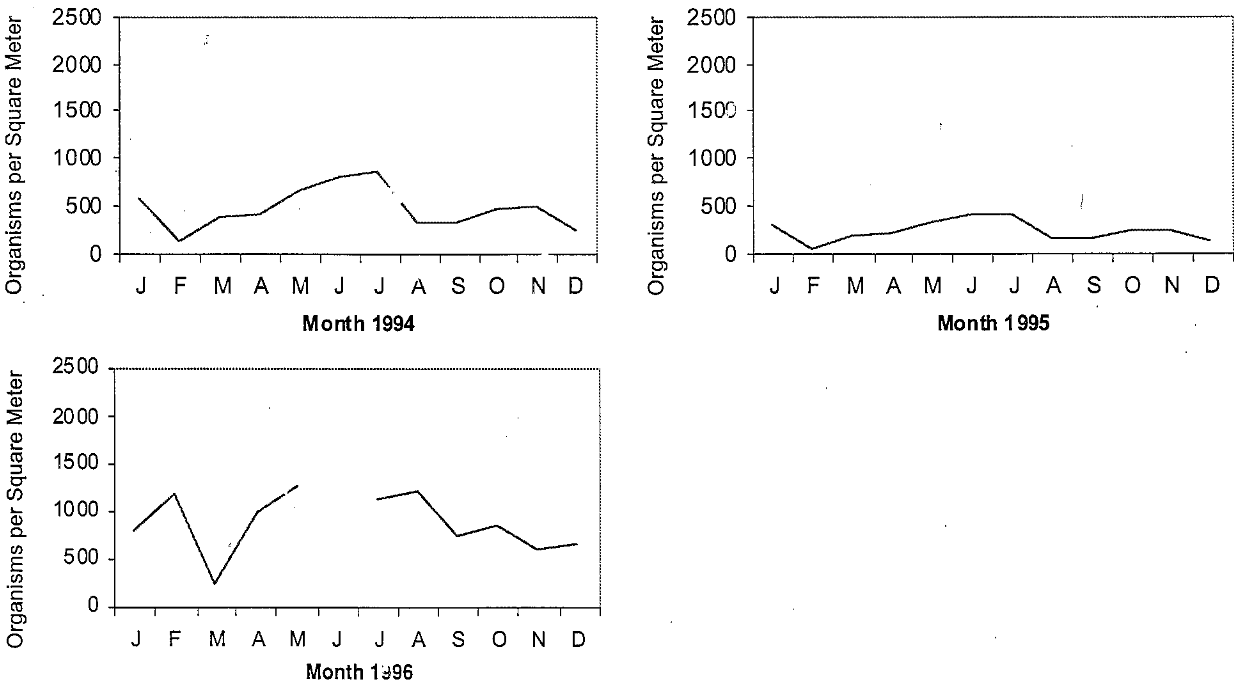

Figure 8-16—Average Abundance of *Corbicula fluminea* at D28A-L, D4-L and D7-C, 1994-1996

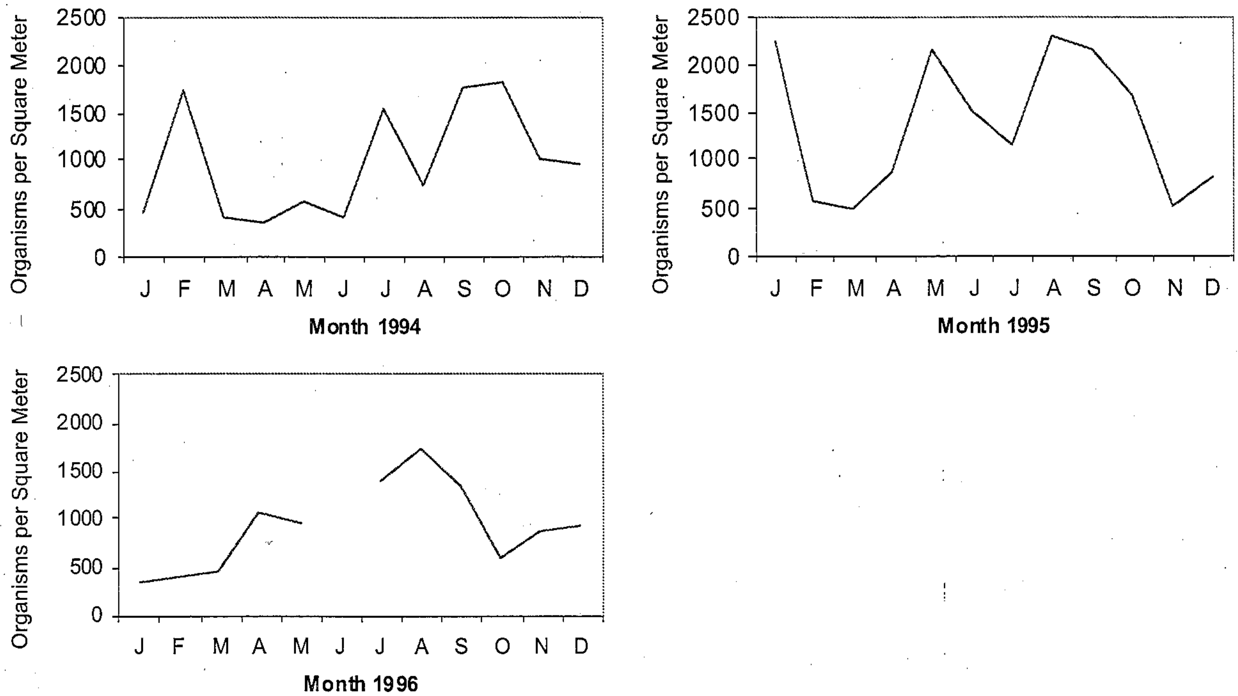

Figure 8-15—Average abundance of *Potamocorbula amurensis* at D4-C, D41A-C and D7-C, 1994-1996

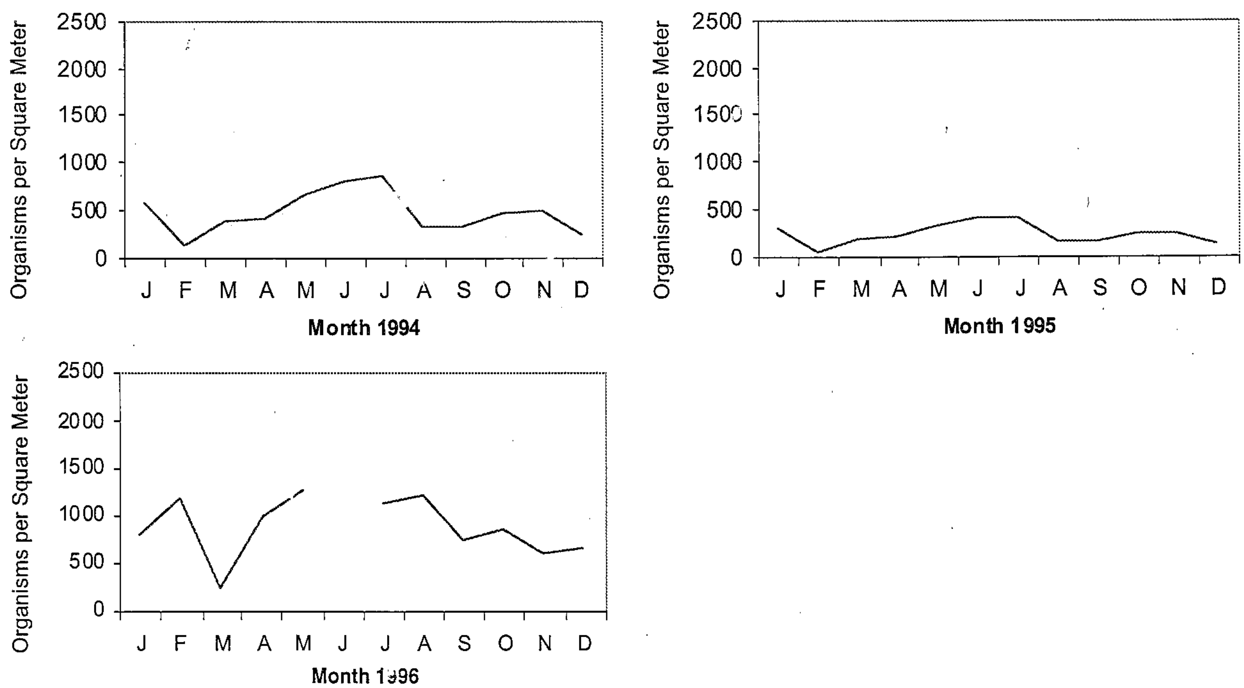

Figure 8-16—Average Abundance of *Corbicula fluminea* at D28A-L, D4-L and D7-C, 1994-1996

Chapter 9—Data Management and Availability

DWR's Compliance Monitoring and Analysis Branch maintains over 25 years of compliance monitoring data collected in the San Francisco Estuary. This data falls into three collection categories:

- discrete monthly data collected by vessel;
- continuous horizontal profile water quality data collected with Seabird electronic equipment by vessel; and
- continuous water quality data collected by automated land-based sampling stations.

These data have been stored and managed in a variety of data management systems over the years. A new system is currently under development using Microsoft Access. The goal is to provide agency staff and the public easier access to needed data. Ultimately, the public will be able to query the entire data set using station, sample dates and constituent type criteria to download desired data from an Internet Web site. In the interim, the public can access the existing Interagency Ecological Program (IEP) Web site and download text files organized by year and type of data (phytoplankton, benthic and water quality).

Discrete compliance monitoring data (water quality, phytoplankton and benthic) have been collected from up to 46 stations located between eastern San Pablo Bay and the delta since 1970. Discrete monitoring data from 1975 to 1995 are available on the IEP Web site in ASCII file format at **www.iep.water.ca.gov/wqdata**. Data from 1996 through the present are in Access database files stored locally within the Monitoring and Analysis Branch and can be requested directly from Branch staff (contact Steve Hayes at **shayes@water.ca.gov**) until these data become available on the IEP Web site.

New turbidity, fluorescence and water quality sampling instrumentation was installed in 1996 on board the IEP monitoring vessels. In 1996, continuous horizontal profiles of turbidity, dissolved oxygen, water temperature, salinity and chlorophyll fluorescence were collected in eastern San Pablo Bay and the delta using this new equipment. Vertical profiles of dissolved oxygen, water temperature and salinity are also collected at each discrete compliance monitoring station. Data from 1996 to late 1997 is available on the IEP Web site at **www.iep.water.ca.gov/wqdata/seabird/data.html**. More recent data awaits development of a new data processing application that will convert the data into a usable format that can then be posted on the IEP Web site. In the interim, this data is available by request (contact Steve Hayes at **shayes@water.ca.gov**).

Continuous multiparameter station data for air temperature, water temperature, pH, dissolved oxygen and salinity is collected at six permanent stations (Mossdale, Stockton, Martinez, Antioch, Rio Vista and Mallard Island). These data are available in ASCII file format from 1983 to the present on the IEP Web site at **www.iep.water.ca.gov/dss**. These data are uploaded to the IEP Web site monthly. Continuous fluorescence data is collected at three of the multiparameter stations (Rio Vista, Mallard Island and Antioch). This data is not yet available on the Web site, but can be requested from Branch staff (contact Mike Dempsey at **mdempsey@water.ca.gov**).

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