FINAL REPORT

STUDIES OF FRESHWATER INFLOW EFFECTS ON THE LAVACA RIVER DELTA AND LAVACA BAY, TEXAS

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EXECUTIVE SUMMARY

The Texas Water Development Board (TWDB) is concerned with management of surface freshwater resources. They must plan on water use by urban populations, industry, and agriculture. In addition they must also consider the needs of Texas bays and estuaries that have evolved to receive freshwater input. In order to better understand these needs, the TWDB has been conducting and sponsoring research on the freshwater requirements of bays and estuaries in both impounded and non-impounded drainage basins.

The TWDB contracted with the University of Texas at Austin's Marine Science Institute (UTMSI) for one such project. Officials from TWDB and UTMSI met and worked out the components of a two year, multidisciplinary study on selected sites in the upper Lavaca-Tres Palacios Estuary and parts of Matagorda Bay. Data were collected on 14 sampling trips between November 1984 and August 1986. The primary goals were to obtain an environmental assessment of the upper Lavaca Bay after completion of the Palmetto Bend reservoir project on the Navidad River (dam closed in 1980, forming Lake Texana); and to document the use of the lower river delta as a nursery area for finfish and shellfish. The study had several components that are reported as separate chapters within this report.

The broad objective of this and similar studies is addressed by three questions. What happens when freshwater is introduced into the estuary? What happens when freshwater is withheld from the estuary? How much freshwater must be introduced to forestall the negative effects of withholding it? These questions have little meaning unless there is a clear understanding of what processes are being studied and what temporal and spatial scales are being considered. There is a crucial relationship between the scales of physical forcing and biological response that is dependent on the generation times and mobilities of the organisms in question (Haury *et al.* 1979; Lewis and Platt 1982). Because the diverse biological components of an estuarine ecosystem have vastly different lifespans and capacity for movement, the answers to the three questions above would depend in large part on ecological perspective.

A reasonable approach would be to look at the temporal scale of a year and the spatial scale encompassing the drainage basin. Appropriate biological components for study would include larger organisms that integrate their environment and may have some economic importance: finfish, shrimp, and benthic macrofauna. Unfortunately, many of the effects of physical forcing (i.e. freshwater input) on higher trophic levels are likely to be indirectly expressed through influences on the productivity and taxonomic composition of food resources. So, to answer our three questions in the appropriate context for management (relatively long term, large scale, higher trophic levels), it is necessary to answer the same questions for lower trophic levels on appropriate scales for each biological component. In addition, the nature of biological coupling between producers and consumers must be determined. For example, what is the relationship between primary production and fish production? The problem assumes immense proportions.

Ideally, a study of the freshwater requirements of an estuary would look at statistical relationships between state variables (e.g. salinity, chlorophyll, zooplankton abundance, fisheries yield) and also the dynamic processes linking the variables (e.g. light-limitation of primary production, feeding habits of juvenile fish, etc.). This two-year study with approximately bimonthly sampling was by necessity constrained. Systematic sampling provided good records of a large number of variables over limited temporal and spatial scales but process-oriented studies were beyond the scope of the contract. Many process-oriented questions are now being addressed in a project recently initiated in San Antonio Bay.

Individual components are summarized below. A general assessment completes this summary.

Nutrients, Hydrographic Parameters and Phytoplankton:

This component of the study was designed to observe spatial and temporal patterns of nutrients and phytoplankton in the Lavaca Bay estuary and to interpret the observations with respect to the influence of freshwater input on primary production. Strong patterns were found, and these were often related to the influence of freshwater. Sampling was inadequate to examine properly some relationships such as interannual correlations of nutrients and salinity. Also, the statistical relationships that are documented cannot be interpreted as demonstrations of causality.

Year 1 (1984-1985) was relatively wet and Year 2 (1985-1986) was relatively dry. A salinity gradient, associated with proximity to freshwater input, was evident throughout the study period. Nitrate concentration seemed to reflect the importance of freshwater input to nutrient dynamics. High concentrations were associated with low salinities and concentrations were very low in the dry year. Nitrite and phosphate were also substantially higher in the wet year. Pigment concentrations were significantly higher in the first year, consistent with, but not demonstrating higher primary production. Total phosphorus was also higher in fresh water. Total Kjeldahl nitrogen (TKN)

concentrations were higher in the dry second year. Nitrate and nitrite are not measured by the Kjeldahl method. Total nitrogen, here defined as TKN + nitrate + nitrite, was not significantly different between years.

It is concluded that the Lavaca Bay estuary was indeed influenced by freshwater. High nutrient concentrations were associated with freshwater input and biological utilization of the nutrients was indicated by nutrient depletion away from the input and in the dry year as compared to the wet year. The flushing action of freshwater inflow was evident during sampling periods when nutrients were high and chlorophyll was relatively low in low-salinity water. During other sampling periods, chlorophyll was high in the freshwater upstream, apparently as a result of biological utilization of nutrient input associated with freshwater. These results are consistent with the notion that as flow subsides, nutrients are utilized and phototrophic biomass increases in the fresher water. Thus, there is no reason to expect stable relationships between salinity, nutrients, and phytoplankton in an estuarine system subject to episodic perturbations, at least on the time scale of those perturbations. Over months or years, though, freshwater input, nutrients and primary production are likely to be related. The differences between a wet year and a dry year at Lavaca Bay are consistent with the proposition that freshwater input has a strong influence on primary production. The relationship has by no means been proven, however.

Enhanced flushing associated with freshwater input increases turbidity due to sediment resuspension and transport. A model of photosynthesis suggests that under a wide range of conditions in Lavaca Bay, increased turbidity is likely to reduce water-column photosynthesis (normalized to chlorophyll). Nutrients associated with the same freshwater input should stimulate

productivity by supporting net growth of phytoplankton. It is thus possible for primary productivity to be sensitive to both light and nutrients.

The importance of very small phytoplankton in the Lavaca Bay estuary was demonstrated. Because epifluorescence microscopy was not employed in this study and in previous studies of Texas bays, the phytoplankton assemblages have not been fully described. Cell counts and biovolume estimates from this study are considered to be relatively poor indicators of phytoplankton biomass. The counts do contain substantial amounts of information on the relative abundance of identifiable taxa and do show that small forms, especially cyanobacteria, were quite abundant.

Freshwater introduced to a rather salty bay system formed a lens over the river in June 1986, restricting vertical mixing and promoting anoxia below the surface at two river stations. This phenomenon should be considered when assessing the impact of intermittent freshwater input to a high-salinity estuary.

Experience with sampling variability suggested that wind-induced mixing and sediment resuspension can have pronounced influence on observations. For example, measurements of pigments made on successive days (windy vs calm) at the upper bay station varied by a factor of nearly 10, presumably due to suspension of microphytobenthos. The biomass of microphytobenthos was found to be substantial and distributed well below the upper millimeter of sediment where net photosynthesis is possible. The amount of pigment in the upper 5 mm of sediment is on the same order as that in the overlying water column.

The ratio of phosphorus to nitrogen in the water column declined as a function of salinity and it appears that phosphorus declined more sharply than would be predicted from mixing of different water types (i.e. P was removed from the water column) whereas there was no indication of a net demand for nitrogen. Even though inorganic nitrogen levels were often very low and the potential for phytoplankton growth may have been limited by the supply of nitrogen, it is possible that the supply of phosphorus could ultimately exert an important control on productivity of the system. More study on nitrogen-phosphorus relationships is clearly warranted.

Benthic Respiration Rate and Ammonium Flux:

Two methods were used to assess benthic respiration and nutrient regeneration. An experimental approach was employed to measure the changes of oxygen and ammonium concentration in natural water enclosed in a chamber over the sediment. These measurements were time consuming and technically challenging. They were performed during each sampling period at only one station (85). The flux of ammonium from the sediment was also estimated indirectly by calculating diffusion out of the sediments based on vertical profiles of pore-water ammonium concentration and assumptions about diffusivity in the sediments and boundary conditions at the sediment-water interface. Ammonium in the pore-waters was determined at most stations.

Through the seasons, dissolved oxygen concentration was higher in relatively wet Year 1 as compared to the dryer Year 2. The percent oxygen saturation also followed a similar pattern.

Benthic respiration was monitored during chamber experiments. Benthic respiration rate was not significantly related to temperature or to salinity during the two year period.

Results from benthic chamber experiments showed that ammonium flux from the sediments for Year 2 was greater than Year 1 for all months except March 1985 when a very large peak of 2000 mg-at N m^{-2} h^{-1} was measured.

Ammonium flux was found to be from the water column into sediments rather than from sediments to the water column or was not significantly different from zero on three sampling trips in Year 1. Rough calculations show that the demand for the regenerated nitrogen in the water column is on the same order of magnitude as the benthic flux typically measured in the chambers.

The vertical pattern of porewater ammonium was unusual in the wet Year 1: maximum concentration was often in the upper 1 cm, not at depth as has been regularly observed during similar studies. This unusual pattern of ammonium in the sediments may have been related to nutrient loading, resultant production, and deposition of nitrogen. During Year 2, when freshwater input was less and nutrient and chlorophyll concentrations were lower than in Year 1, the reservoir of ammonium in the upper few cm of sediment declined and pore water ammonium concentrations generally increased with sediment depth. The reservoir of ammonium in the sediments was thus much greater during year 1, when freshwater input was greater. Because other forms of dissolved nitrogen were not measured and transformations of nitrogen species were not assessed, it is difficult to draw firm conclusions from the data on porewater ammonium. Even though the pool size of total nitrogen in surface sediments and the main processes related to ammonium remineralization are unknown, we can state that the ammonium pool in surface sediments seemed to be responsive to freshwater inflow.

A substantial discrepancy existed between calculated and measured ammonium flux. This discrepancy was due to excessively high calculated fluxes resulting from the arbitrary assumption made when ammonium concentration was maximal in top sediment section. Therefore, ammonium flux measured from the chamber experiment is a more reliable estimate than calculated (theoretical) flux in this study.

Although neither measured nor calculated flux show a significant relationship to temperature, and measured flux was not significantly related to salinity, calculated flux did decrease as salinity increased at station 85. Higher ammonium concentration of top sediment pore waters in Year 1 (wet year) relative to those in Year 2 (dry year) seems to be responsible for such a relationship.

Zooplankton:

Zooplankton occurrence and abundance in upper and lower Lavaca Bay were affected by freshwater events and seasonality. Flood events in the estuary resulted in the physical displacement of estuarine zooplankton with a population of freshwater species. In most cases it seemed that the displacement was transient and salinity increases allowed estuarine species to recolonize quickly.

Although freshwater inflows were higher in Year 1 than Year 2, there was no difference in the standing crop between the two years. Seasonal cycles in the upper bay are difficult to discern because of sporadic freshwater input and displacement of populations. The seasonal highs of standing crop occurred during one of the summer months in each year.

Zooplankton dry weight biomass generally followed zooplankton standing crop measurements. Biomass measurements in Year 2 indicated that the estuary was organized into zones grading from low salinity areas, with low zooplankton biomass and presumably low productivity, to a zone of higher salinity and a higher biomass of marine species. There was an intermediate zone where estuarine species predominated. This was also the zone of highest zooplankton standing crops. This middle-bay region, which moved some with periodic freshwater events, had relatively stable salinities and represented a buffer between the low salinity regime and the marine zone. The extent to which marine species range into the middle and upper bay is dependent on the salinity gradient established by freshwater inflow. It is concluded that the distributions of freshwater, estuarine and marine zooplankton species were quite responsive to physical forcing associated with freshwater input.

The body length of the dominant estuarine zooplankter, *Acartia tonsa*, was measured systematically. There was a significant positive correlation between body length and salinity. Two distinctly different populations of this species may occur in the same estuary or else the size variations are due to other environmental factors. Secondary productivity was not assessed during this study.

Benthos:

Very little change was seen in the concentrations of benthic organisms between Years 1 and 2. The vertical distribution of infauna in the sediment was typical for this type of estuary. Highest concentrations of organisms were found in the upper 3 cm. Numbers declined with depth to the lowest concentrations at 10-20 cm.

Although abundances changed little between years, benthic biomass did show a pattern, with an overall increase in biomass for Year 2. Biomass, unlike individual abundance, increased with depth. The largest biomass measurements were in the 10-20 cm stratum. The molluscs, *Mulinia lateralis* and *Macoma mitchelli*, had an overwhelming effect on these patterns of benthic biomass.

Any relationship between freshwater input and benthic biomass will depend on the nature of the effect (e.g. enhanced survival and growth, or perhaps restricted recruitment) and the generation times of the benthic organisms. Influences of freshwater input on recruitment might show up months later in the biomass of a cohort whereas effects of freshwater inflow on growth or survival should reflect average conditions over an extended period, possibly offset by a lag. Simple correlations between infaunal biomass and short-term stream flow are not to be expected, except in special cases. The only species which were affected by inflow on a short term were the aquatic chironomid larva which had a lagged response to inflow and the polychaete, *Hobsonia florida.*

Finfish and Shellfish:

The purpose of this component was to provide data on the utilization of the Lavaca River delta as a nursery habitat for finfish and selected macro-invertebrates.

As is typical of fish populations, a small number of species comprised the bulk of the population. The seven most abundant species accounted for 75% of the total number of individuals collected. Cluster analysis yielded a significant temporal grouping of three "seasons". These seasonal distribution patterns were relatively consistent between the two years despite significant differences in salinity. Spatial patterns were a minor factor in groupings shown by cluster analysis.

It is concluded that the primary factor influencing changes in fish species composition in the Lavaca River delta is the sequential arrival and departure of postlarval and juvenile fishes and invertebrate species. Salinity effects were seen only as a minor perturbation within these major temporal patterns.

The data show that the Lavaca River delta is utilized extensively as a nursery area by most estuarine dependent species which are of commercial or recreational importance in the Gulf of Mexico. There are also numerous other species utilizing the delta as a nursery area, many of which are important components in the food web leading to commercial or recreational species.

The seasonal pattern is, therefore, a reflection of spawning times of these species utilizing the delta as a nursery. In general, the "seasons" include the juveniles of winter spawners in March-June and the spring and early summer spawners in July-October. The low number of species spawning in late summer are reflected in the relatively low diversity of the November-February period.

Stable Isotopes:

The objective of the stable isotope studies was to determine the extent of utilization of river-transported organic matter by the biota of the system. This was to be accomplished by applying a mixing model to infer carbon sources based on different $\delta^{13}C$ characteristics of organic carbon from marine and terrestrial sources. The model indicated that substantial river-transported C_3-higher plant organic carbon is being taken up and assimilated by organisms in the Lavaca Bay ecosystem. Strong correlations between $\delta^{13}C$ and distance of collecting station from the river were shown by sedimentary total organic matter, total infauna, total bivalves and net zooplankton; moderate correlations were shown by total fish, total shrimp and *Acartia tonsa*; weak correlations were shown by dissolved and particulate organic matter.

As might be expected, samples from Matagorda Bay always showed less higher plant influence than did Lavaca Bay samples. This difference is probably a good measure of the importance of river transported organic matter. Fish as a group seemed to be related to phytoplankton in both bays while shrimp showed a definite river/higher plant signal. *Acartia tonsa*, an estuarine copepod, reflected a higher plant based food-web, possibly based on a detrital-microbial pathway.

While $\delta^{13}C$ data provides no information on the number of animals utilizing a given source of carbon, when combined with abundance and distribution data from other studies, it permits an assessment of the relative importance of organic carbon from different sources. The study area was found to have diverse food-webs with animals utilizing both the river and bay as sources of nutrition.

Comments and Conclusions

This was not a process-oriented study but many insights into processes were obtained. The results of the study have stimulated many suggestions for future research. Some have been incorporated into a follow-up program in San Antonio Bay.

A few topics deserve mention. Primary productivity (including photosynthesis as a function of light) should be measured regularly. A special effort should be made to assess any physiological differences associated with salinity and perhaps nutrient input. Primary production by the microphytobenthos should be assessed as well as the effects of resuspension.

Almost nothing is known of the proximate fate of primary productivity nor the relative importance of different paths of nutrient regeneration, even though very close coupling of growth and grazing of phytoplankton is indicated. Filter feeding by benthic macrofauna, including patchily-distributed oysters, might be very important. Further work should be done on methods to measure fluxes at the sediment-water interface. Rates of nutrient transformations should be measured as well as pools and fluxes of dissolved organic nitrogen. Secondary production should be estimated and related to freshwater input via primary production. Growth rates of fish should be estimated to evalute the estuary as a nursery. Stable isotope studies should use two tracers to reduce analytical ambiguity.

While keeping in mind the large quantity of useful information that was obtained during this study, it is useful to examine some of the limitations, too. The sampling scheme that was chosen for this study determined the types of relationships that could be effectively observed. The temporal scale (1-2 months between samplings) was too coarse to observe the dynamic relationships between nutrient injections and uptake by phytoplankton. Also, it was not possible to quantify the importance of sediment resuspension in redistributing the autotrophic community. Analytical problems plagued measurements of benthic nutrient regeneration to the extent that modification of sampling frequency is not a priority. The sampling schedule seemed to be appropriate for documenting the influence of freshwater, especially flood events, on the distributions of zooplankton. However, measurements of standing crops of zooplankton do not convey a compreshensive description of secondary productivity. Relatively slow-growing benthic infauna were sampled fairly well (with notable exception of oysters), but the length of the record (2 years) was too short to document many possible relationships between freshwater input and the benthic community. Because mechanisms of freshwater influence are not specified, it is difficult to know what correlations and what lag periods should be expected. The sampling frequency was adequate to document the seasonal utilization of the river delta by fish and it was shown that the distribution of fish was not very sensitive to changes in salinity. The importance of freshwater to the estuary as a nursery was not assessed comprehensively, however, because growth rates and survival were not determined. Stable isotope studies are inherently immune from some problems of sampling scales, because the organisms integrate their own environment on scales appropriate to them. Highly mobile organisms might frustrate some analyses, because their movements prior to sampling cannot be specified.

One approach to assessing the influence of freshwater on an estuary would be to obtain a very long time series (20 or more years) of finfish and shellfish abundance and correlate the data with freshwater inflow and other pertinent parameters. Analysis might not be straightforward because of unnatural external influences. Also, the influences of physical forcing would not be described mechanistically. The data set would be of great value nonetheless.

Despite some inherent limitations, this study was successful in describing many responses of an estuarine system to freshwater input. Directions for further study were clearly indicated.

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CHAPTER I

INTRODUCTION

A two year study to monitor the effects of freshwater inflow on selected sites in the upper portion of the Lavaca-Tres Palacios Estuary and parts of Matagorda Bay was conducted from November 1984 through August 1986. Increasing freshwater demands for industry, municipalities, agriculture, and recreation have made provision of sufficient freshwater inflow to maintain maximum production in Texas bays and estuaries a major concern. One means of allocating freshwater among competing users is the construction of dams on the rivers which supply Texas estuaries; e.g. the Navidad River which was dammed in May 1980 to form Lake Texana. This reservoir was constructed to supply water for industrial and municipal use and was not intended for flood control. Major floods are allowed to pass through the flood gates and inundate the marsh system associated with the Lavaca-Navidad River delta.

The upper Lavaca Bay and Matagorda Bay (Fig. 1.1), located at latitude 28°40' North and longitude 96°36' West, is part of one of the seven major estuaries along the Texas coast. Lavaca Bay is a shallow estuary with a maximum natural depth of about 2.4 m and a surface area of about 16,576 ha. The perimeters of the upper bay shorelines are lined with patchy *Spartina* and the surrounding low salinity marshes are vegetated mainly with *Juncus* downriver and *Phragmites* upriver. The majority of freshwater inflow into upper Lavaca Bay comes from the Lavaca and Navidad Rivers, while lesser contributions come from Venada, Garcitas and Placedo creeks. Circulation between the upper and lower bay is modified by the presence of state highway

35 causeway, the remains of the old causeway, and the presence of Chickenfoot Reef which extends from the west side of the bay parallel with the causeway. Marine influence enters through Pass Cavallo and the Matagorda Ship Channel.

Two small tertiary bays or lakes are associated with the Lavaca River. Redfish Lake (Station 603) is approximately 4.8 km (3 miles) and Swan Lake (Station 613) is approximately 1.6 km (1 mile) north of Lavaca Bay (Fig. 1.1). Redfish Lake is about 194 ha (0.75 miles^2) and Swan Lake is about 259 ha (1 mile^2). Both lakes are shallow with a maximum depth of about 1.2 m. The salinity of Redfish Lake is usually similar to the river's while the salinity in Swan Lake is more estuarine due to its proximity to and its connection to Lavaca Bay via Catfish Bayou. Parts of the study area description were derived from previous work by Gilmore *et al.*, 1976.

Historically, upper Lavaca Bay has been mainly supplied with freshwater from the Lavaca and Navidad Rivers. The forty-five year daily flow average for the Lavaca River is 334 cubic feet/second and the forty year daily flow average for the Navidad River is 572 cubic feet/second (U.S. Geological Survey Water Data Report). Daily mean stream flow into Lavaca Bay from 1975 through 1986 is illustrated in Figure 1.2. Freshwater inflow rates from gauge 08164000 on the Lavaca River near Edna, Texas indicates that the average daily flow rate for Year 1 of this study was 357 cubic feet/second, 50% higher than the daily average of 177 during Year 2. Since the closing of the dam on the Navidad River in May, 1980 the freshwater inflow pattern has been altered, although it has not deviated much from the historic flow rate of 572 cubic feet/second. The average stream flow from January 1983 through 1986 demonstrates cyclic inflow from year to year (Fig. 1.3). A wet cycle occurred in 1983 followed by a dry year in 1984 prior to Year 1 of this study which was another wet year. Initial filling of Lake Texana from May 1980 through December 1982 resulted in negligible input from the Navidad. Freshwater releases beginning in December 1982 through December 1983 on a monthly basis resulted in a daily mean flow of approximately 1,250 cubic feet/second, which is above average. January 1984 through December 1985 was a drier period with sporadic discharges in January, May, and October 1984 averaging 340 cubic feet/second/day. From January 1985 through December 1985 increased inflow was noted with releases occurring every month except May, August and September 1985. The daily average flow rate for this period was 662 cubic feet/second. Flow rates were down from January 1986 through December 1986 with releases only in May, June, and September, 1986, resulting in a daily average of 282 cubic feet/second. Lavaca River streamflow was averaged for 14 and 28 days prior to and including the first sampling day of each trip and correlated with mean salinity data using Pearson Correlation Coefficients. The 14 day $\bar{x}$ flow was significantly correlated with salinity (r = -0.55474*) while the 28 day $\bar{x}$ flow was not significant; therefore the 14 day $\bar{x}$ flow was used to calculate freshwater inflow effects on the benthos in Chapter 5. An example of the $\bar{x}$ 14 day inflow and its relation to $\bar{x}$ salinity is shown in Figure 1.4 for November 1984 through August, 1986.

The objectives of this study were to examine the environmental effects of altered freshwater inflow into upper Lavaca Bay resulting from the Palmetto Bend Project on the Navidad River and to document the use of the Lower River Delta as a nursery area for finfish and shellfish. The study had several components: (1) primary producers and nutrient dynamics, (2) benthic nutrient regeneration, (3) zooplankton, (4) benthos, (5) finfish and shellfish and (6) natural isotopic studies of organic input in Lavaca Bay.

Fourteen sampling trips were conducted which included the following months: November 1984, January, March, April, May, June, July, August, October and December 1985, and February, March, June and August 1986. Year 1 of the study was from November 1984 through August 1985 and Year 2 was from October 1985 through August 1986. Each sampling trip involved two days in Lavaca Bay. The first day's sampling included zooplankton, ichthyoplankton, trawls, chemistry, nutrients, hydrographic parameters, and phytoplankton. Benthic respiration chambers and primary production experiments aboard the R/V KATY, benthic cores, seine and sled samples were collected on the second day. Stations in the lower bay were sampled on the return trip to Port Aransas aboard the R/V KATY.

The first eight trips focussed mainly on stations located in the upper part of the bay north of state highway 35. The sampling sites in Figure 1.1 included stations 45 and 65 (river sites), 603, 613, 623 (lake sites), 85 (river delta) and 633 (upper bay). Two additional stations, 1505 and 1905 were sampled for nutrients, hydrography, and phytoplankton. Benthic respiration chambers were deployed only at station 85.

During the last 8 trips stations 1, 2, 3, 1505, 1905 and 35-36 south of highway 35 were added for zooplankton. Stations 65, 613 and 623 for isotope analyses were discontinued and stations 1505, 1905 and 35-36 in the lower bay were added to increase coverage over a greater salinity range.

Support vessels included the R/V KATY, a 58' fiberglass trawler which was anchored at station 85 for laboratory space and berthing, a 21' Skip Jack, and a 16' Boston Whaler.

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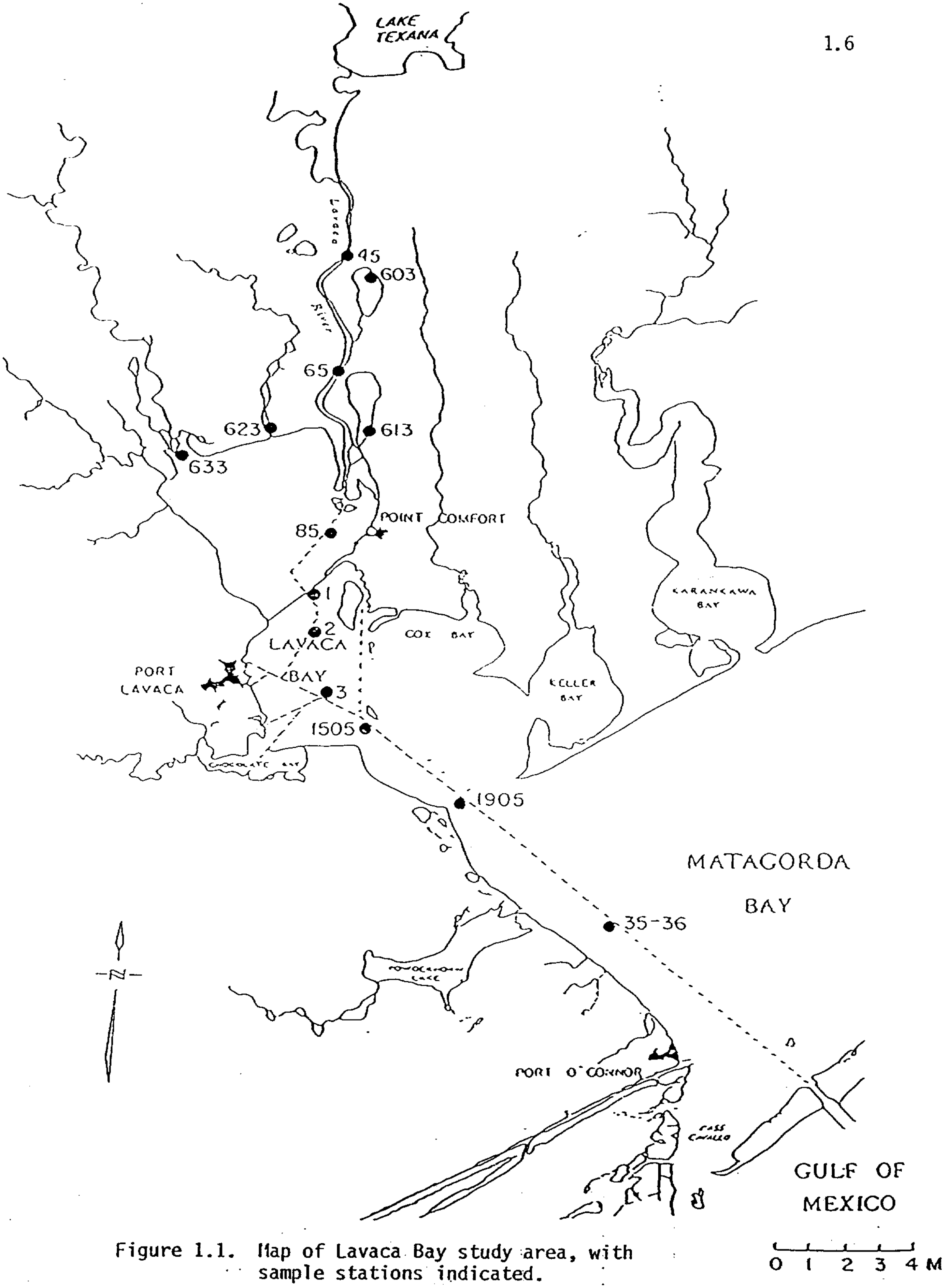

Figure 1.1. Map of Lavaca Bay study area, with sample stations indicated.

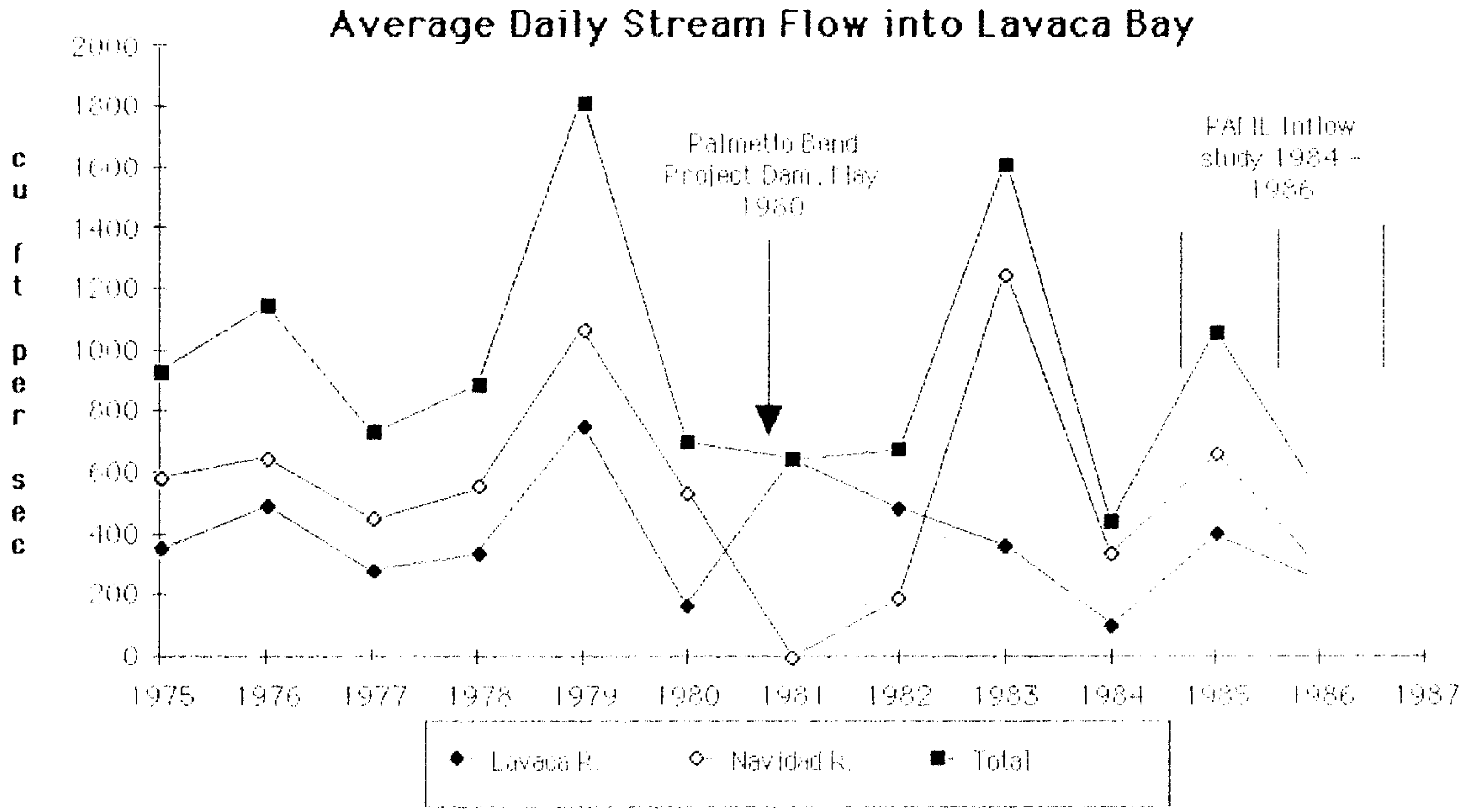

Fig. 1.2. Average daily Lavaca-Navidad River flow into Lavaca Bay by year from 1975 through 1986.

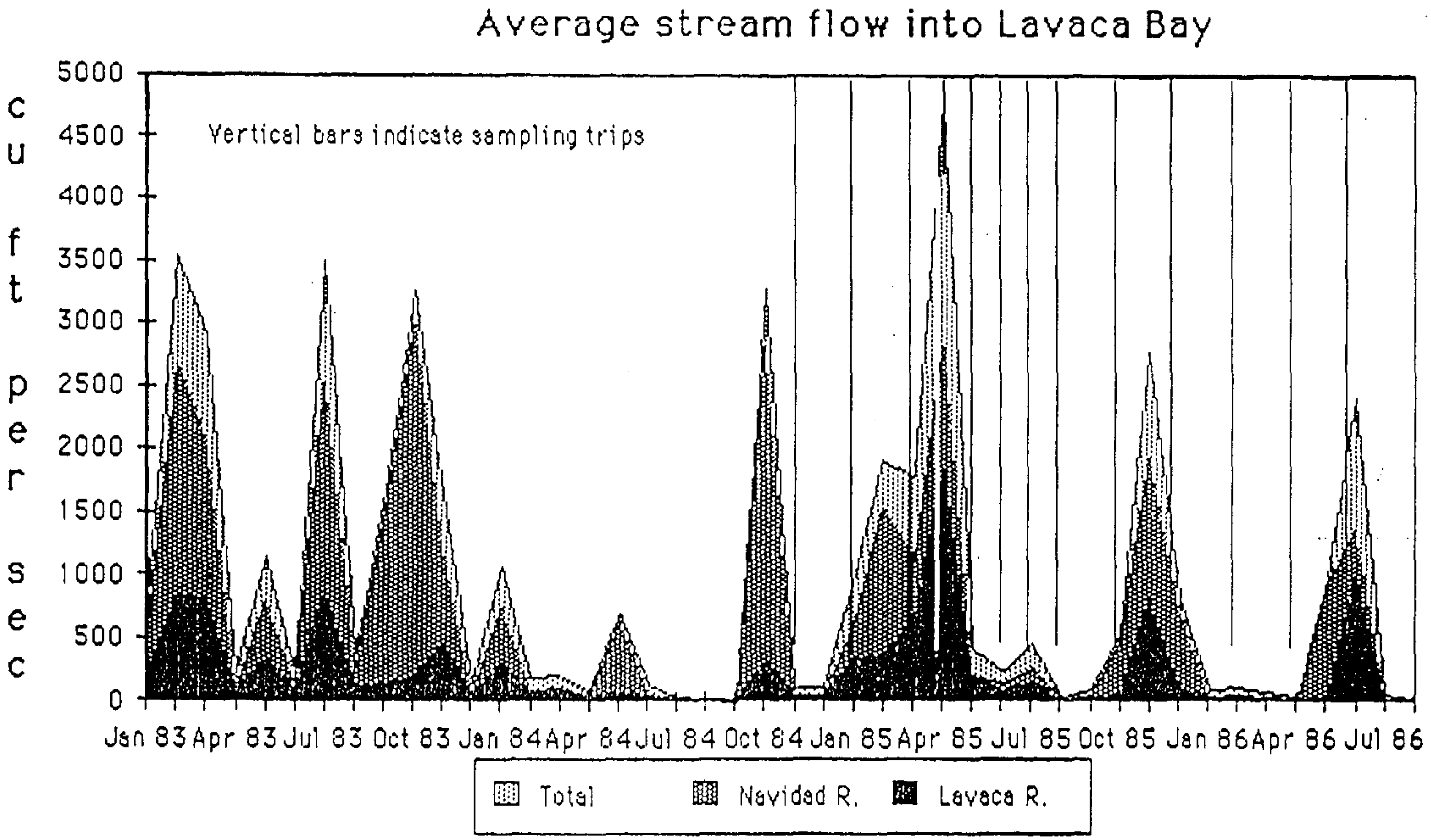

Figure 1.3. Average daily Lavaca-Navidad River flow into Lavaca Bay by month from January 1983 through August 1986.

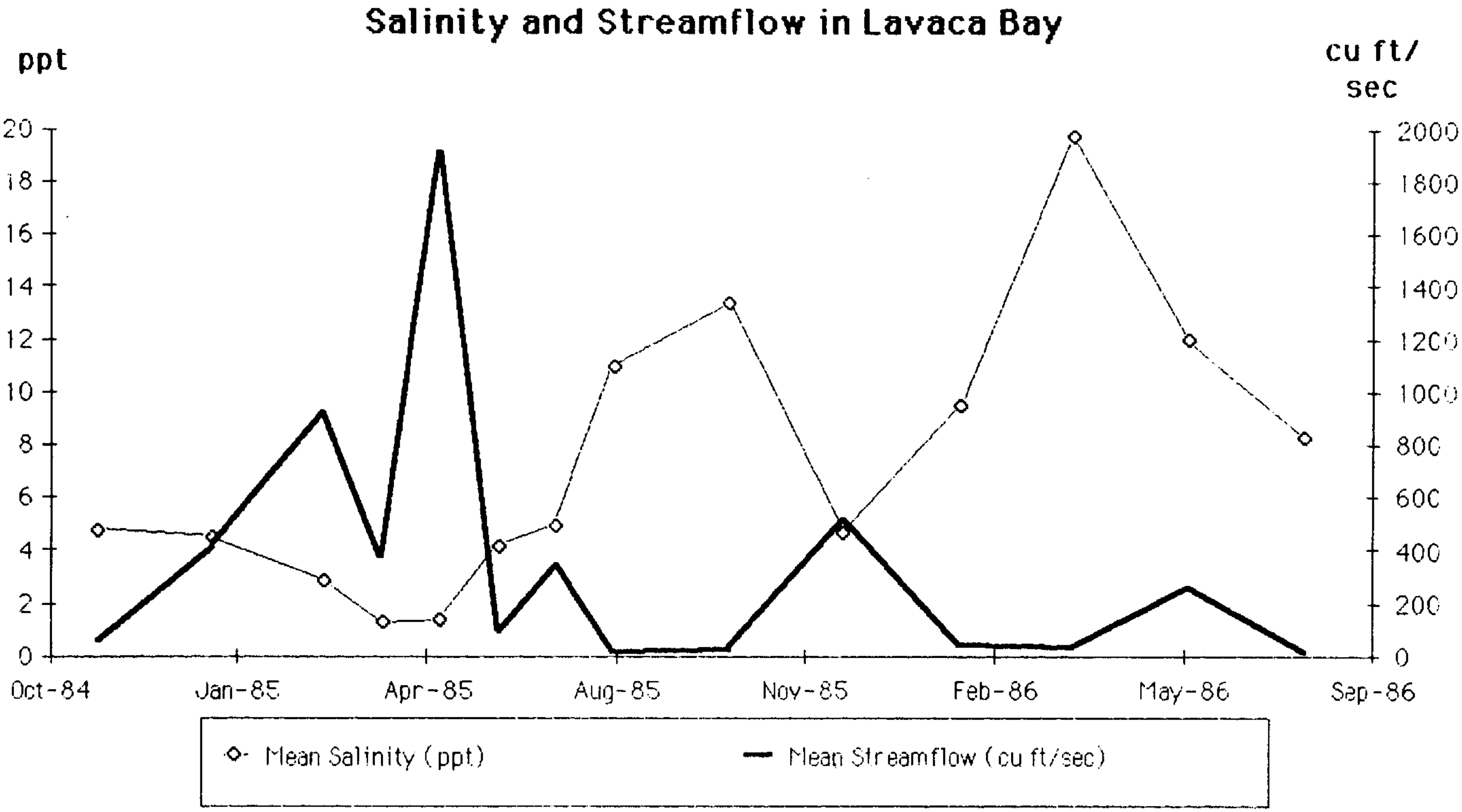

Figure 1.4. Lavaca River streamflow 14 day average prior to each sampling trip and its relation to average salinity for all stations by month from November 1984 through August 1986. The 14 day average streamflows corresponding with each sampling trip starting in October 1984 are as follows: 63, 424, 926, 377, 1913, 97, 349, 19, 33, 521, 43, 32, 258, and 15 cu ft/sec.

CHAPTER 2

NUTRIENTS, HYDROGRAPHIC PARAMETERS AND PHYTOPLANKTON

1984 - 1986

INTRODUCTION

This component of the study was designed to observe spatial and temporal patterns of nutrients and phytoplankton in the Lavaca Bay estuary and to interpret the observations with respect to the influence of freshwater input on primary production. Strong patterns were found, and these could often be related to the influence of freshwater. Sampling was inadequate to examine properly some relationships such as interannual correlations of nutrients and salinity. Also, the statistical relationships that are documented cannot be interpreted as demonstrations of causality. It is thus inappropriate to make generalizations about some patterns which seem obvious. Nonetheless, the data allow instructive comparisons between a wet year and a dry year and between sites along a salinity gradient.

METHODS

Sampling sites and schedules are described in the introduction. Data described below were obtained concurrent with zooplankton and nekton sampling. Upon occupation of the station, air temperature, wind, and cloud cover were recorded, followed by determination of Secchi depth. A Hydrolab sonde (Hydrolab, Austin, TX) was used to measure pH, conductivity, temperature, and dissolved oxygen at the surface. The same measurements were often made at one or more depths below the surface. A water sample of about 2 liters was taken by submerging a clean, rinsed polycarbonate bottle just below the surface. This sample was used for the measurements of nutrients, organic material, pigments and phytoplankton. Duplicate samples were taken at each site, separated by about 20 minutes.

During the 1984-1985 sampling year, salinity was calculated from conductivity on the basis of laboratory calibrations of the Hydrolab sensor. A dilution series of seawater was prepared and salinity was determined on a Beckman oceanographic salinometer (A. Amos, Pers. comm.) and compared statistically to conductivity as measured by the sensor. The empirical formulas (Table 2.3) are sensor-specific and not intended for general application. During the 1985-1986 sampling year, salinity was calculated from temperature-compensated conductivity using the practical salinity scale (UNESCO, 1978). Note that measurements of salinity below 2-3 ppt in an estuarine environment may be neither accurate nor particularly meaningful (Mangelsdorf, 1967) and that salinity should be reported in dimensionless units, not ppt as we have done in this report. The determination of salinity is discussed in a TWDB interoffice memorandum (G. Powell, March 3, 1986).

Dissolved nutrients were measured on filtered and frozen samples. Immediately after sampling, water was filtered through a 47mm glass-fiber filter and, after appropriate rinsing of the containers with filtrate, poured into a carefully cleaned 265 ml polycarbonate bottle for storage on dry ice and then in a freezer. Ammonium (phenol-hypochlorite method, in duplicate), phosphate, nitrate (cadmium reduction) and nitrite were determined as in Parsons et al. (1984). Filtration and freezing of samples is preferable to transporting whole water to the laboratory. The tenfold-higher concentrations of ammonium found in a prior study of the region (Gilmore et al., 1976) are thus possibly attributed to artifact. Our method of filtering and freezing prior to analysis is better than those used previously but they are not optimal: it is generally held that ammonium measurements on frozen samples are unreliable and that only fresh samples can be used for critical measurements of ammonium concentration. Uncertainty associated with freezing may be on the order of .5 ug-at/l (.007 mg/l N/l), not much of a problem in the context of this study.

Total Kjeldahl Nitrogen was determined by W. M. Pulich, Jr. on whole-water samples poisoned with $HgCl_2$ and stored at $2^{o}C$. Total phosphate (persulfate digestion in an autoclave) was measured, usually in triplicate, on whole-water samples stored at $2^{o}C$. For unknown reasons our measurements of total phosphate tend to be about twice as high as those reported by Gilmore *et al.* (1976) for the Lavaca Bay region in 1973-1975.

Samples were collected on Whatman GF/F filters (0.7um nominal retention) and extracted in 90% acetone for duplicate fluorometric determinations of chlorophyll a and pheopigment (Parsons et al., 1984). Values for chlorophyll and pheopigment from the progress report for 1984-85 have been corrected for a calibration error. Pheopigments are reported in $\mu g \cdot l^{-1}$ chlorophyll equivalents. Because of interference from pigments such as chlorophyll b (Lorenzen and Jeffreys, 1980) and problems associated with incomplete extraction of some taxonomic forms in acetone (Holm-Hansen and Riemann 1978), pigment data should be viewed with some caution. When comparing these pigment data with other studies, pore size of filters should be noted, as significant proportions of phytoplankton biomass can pass filters of 1 um pore size and larger.

Samples for phytoplankton enumeration were preserved with Lugol's solution and settled for observation with an inverted microscope at 100x and 400x magnification. Representative cell dimensions for each common form was recorded and biovolume calculated by geometrical approximation. Cell counts reported here are higher than what might be found in earlier studies because the abundant and very small (<5um) forms were counted. There is a systematic difference between the counts for Year 1 and Year 2 attributable to differences in the counts for extremely small phytoplankton. This is because the two operators had different "thresholds" for counting the smallest cells. Therefore the two years cannot be legitimately compared for total cell counts or biovolume. Although many small phytoplankton can be discerned with the inverted microscope, a technique such as epifluorescence microscopy is needed for accurate assessment of autotrophs in the 0.5um-2um range (Johnson and Sieburth 1979). Methods used in this study have probably yielded underestimates of the smallest phytoplankton in Year 2 as well as in Year 1, even though some heterotrophic bacteria may have unavoidably been confused with cyanobacteria in the counts from Year 2.

The data were subjected to a variety of statistical analyses, including linear regression, one- and two-way analysis of variance (parametric and nonparametric), nonparametric correlation, Tukey's HSD test, and the Mann-Whitney U test. Missing values and violations of the assumptions of parametric statistics plagued the analysis, and thus the statistical presentation is limited. The results presented here were generated by SYSTAT for the Macintosh (Wilkinson, 1986), except the regressions, which were generated by Cricket Graph.

Field sampling was performed by Amy G. Whitney, Hugh MacIntyre, and Sung R. Yang. Ancillary experimental work was carried out by Zhu Mingyuan and Richard Davis. Don Pierson and Zhu Mingyuan supervised analytical work early in the study. Enumeration of phytoplankton was done by Amy Whitney in Year 1 and Barbara Cullen in Year 2.

RESULTS

Annual Pattern

A graphic presentation of the data demonstrates very clearly the dominant patterns during the study. Year 1 (1984-1985) was relatively wet and Year 2 (1985-1986) was relatively dry. A salinity gradient, associated with proximity to freshwater input, was evident throughout the study period (Fig. 2.2). Nitrate concentration (Fig. 2.8) seemed to reflect the importance of freshwater input to nutrient dynamics. High concentrations were associated with low salinities and concentrations were very low in the dry year, and at the bay stations as compared to the upriver stations. The general picture is one of freshwater input having a very important influence on nutrient concentrations. A more detailed examination of the data provides additional insight and some information on biological utilization of the nutrients associated with freshwater input.

To examine the relationships between freshwater input, nutrient dynamics and primary production on a scale appropriate to fisheries, it would be useful to compile a long record and correlate annual averages of salinity, nutrient concentrations and biological responses. We only have two years to work with, one wet and one dry, we cannot confidently ascribe statistically significant differences between years to freshwater influence. It is useful to compare the two years nonetheless.

Stations 1505 and 1905 were least influenced by freshwater and most afflicted with missing values, they were excluded from the statistical comparison of Year 1 vs Year 2 (Mann-Whitney U test, Table 2.1). Comparison of the parameters from the remaining stations (Table 2.1) showed substantial differences between years that are in most cases evident in graphical presentation (Figs. 2.1-2.13). The water was indeed fresher in Year 1 ($p<.001$) and the concentrations of dissolved nutrients, excluding ammonium, were substantially higher in the wet year ($p<.001$), as was total phosphate. Pigment concentrations were significantly higher in the first year, consistent with, but not demonstrating, higher primary production. Total Kjeldahl nitrogen (TKN) did not behave the same as other measures of nutrient loading: concentrations were higher in the second year. Nitrate and nitrite are not measured by the Kjeldahl method. Total nitrogen, here defined as TKN + nitrate + nitrite, was not significantly different between years. Nitrogen and phosphorus dynamics are discussed below.

It is reasonable to expect that enhanced flushing associated with freshwater input would increase turbidity due to sediment resuspension and transport. The relationship was obvious to the sampling party and is represented by the differences in Secchi depth between Year 1 and Year 2 (Fig. 2.5). If phytoplankton biomass is held steady or is flushed away, increased turbidity from freshwater input will reduce water-column primary productivity. If the nutrient load associated with the freshwater input (Figs. 2.18, 2.19) is converted to biomass, though, productivity on an areal basis will depend on the relationship between turbidity and nutrient load. If physical forcing is reduced, particulates can settle out of the water, leaving dissolved nutrients in a more transparent water column and setting the stage for enhanced primary productivity. A comprehensive model of light-nutrient relationships is beyond the scope of this study. Light and nutrient limitation of productivity are briefly discussed below.

Seasonal Pattern

The most obvious seasonal pattern was in temperature (Fig. 2.1), which is certain to influence rates of biological utilization. Many of the other measured parameters showed significant variation between months (i.e. sampling periods; Table 2.2), but simple seasonal variation is difficult to discern, in large part because inferred freshwater input did not show a simple annual cycle.

For example, freshwater events in November 1984 and July 1985 were scarcely noticeable in the record of nitrate concentration (Figs. 2.2, 2.8), whereas similar patterns of salinity were associated with relatively high concentrations of nitrate during the spring of 1985 and December 1985. Temperature alone cannot explain the contrast, as waters were cool (about 15°C) in November 1984 and near 30°C in July 1985. Perhaps biological demand for nutrients builds up during the summer and fall and declines sharply in the winter. Measurements of chlorophyll are consistent with such an explanation. In November 1984 and July 1985, chlorophyll concentrations were higher upriver (Fig. 2.12), indicating that biological utilization of freshwater-associated nutrients had occurred. When high nitrate concentrations were observed in low-salinity water during the spring of 1985, chlorophyll was more concentrated downriver, indicating that flushing of the bay system can force a temporal and spatial separation of nutrient input and biological utilization. Such a simple explanation cannot be supported by the data on hand because we have no information on the temporal development of nutrient-salinity relationships on the scale of days after a runoff event. The low-nutrient/high biomass/low-salinity pattern of November 1984 might be due primarily to the long interval (3-4 weeks) between a major freshwater event and sampling as compared to the high-nutrient/low-biomass/low-salinity pattern that would be found as the bay was being flushed out by runoff.

We conclude that available data are insufficient to resolve questions concerning seasonality in nutrient utilization, not only because of the complexity of the relationships but because the patterns of nutrients as related to salinity are almost certainly strongly affected by the time of sampling after a freshwater input event.

Spatial Patterns

Compared to the range of replicate determinations, differences between station means in the study area were clearly significant for most parameters (see Figs. 2.1-2.14). Seasonally consistent differences between stations can be discerned with two-way analysis of variance (Table 2.2). When spatial patterns across the environmental gradient differ according to sampling period (as was clearly the case for chlorophyll: compare November 1984 and early spring 1985), interpretation of results must be modified. Because the data record is too short to resolve statistically any consistent temporal differences in the spatial patterns of nutrients and suspended or dissolved organic material, we cannot specify where and when nutrients are utilized maximally in the upper estuary. It seems clear, however, that the influence of nutrient input on the lower bay is largely indirect, as high concentrations of nutrients are confined to the sites closest to sources of freshwater.

Nutrient Interactions

It is sometimes desirable to try to specify a single factor which limits production in a given aquatic ecosystem. Nitrogen is commonly identified as such a factor, i.e. the limiting nutrient. The simplified picture is that production will be proportional to the supply of nitrogenous nutrients and independent of other variables. If the supply of the nitrogen exceeds a threshold, some other nutrient, such as phosphate, might limit production, or perhaps biomass levels will increase to the point that light limits photosynthesis. Experimentally, the N-limited system should respond to added nitrogen alone and should be insensitive to other nutrients or increased light availability in the absence of added nitrogen. To be valid, controlled experiments should be on the ecosystem scale, clearly not a simple matter.

During this study, in higher salinity water, the concentrations of nitrogenous nutrients were often near the limit of detection whereas levels of dissolved phosphate were low but detectable--high enough to support additional algal growth if nitrogen were available (Figure 2.20). The pattern is consistent with nitrogen-limited primary production in the estuary. Experimental evidence to support this conclusion is lacking, however. One might also wonder why nitrogen should limit production in an environment where nitrogen fixation might make an important contribution to nutrient dynamics.

The question of nutrient limitation on the ecosystem scale can be addressed by mass-balance analyses (Smith, 1984, Smith *et al.* 1984). It is argued by S. V. Smith that if a system has a net demand for phosphorus and exports nitrogen, it must be limited by P rather than nitrogen. Smith has discussed oligotrophic environments in which the data indicate that N is not limiting. The nature of the Lavaca Bay estuary is such that the assumptions of the mass-balance analysis are not satisfied (see Smith, 1984), but it is instructive nonetheless to discuss patterns of N and P during the study.

Dissolved phosphate, nitrate, and total P concentrations were lower in the dry year and in higher-salinity water, consistent with biological utilization of N and P and net deposition of P in the estuary (Figs. 2.20, 2.21). Total Kjeldahl nitrogen (organic N and ammonium) weakly shows an inverse pattern, apparently reflecting the conversion of nitrate to organic nitrogen and little or no net deposition of N in the study area. Accordingly, total N (nitrite + nitrate + TKN) shows no consistent relationship with freshwater but the ratio (Total P/Total N) declines rather sharply with salinity (Fig. 2.21). Little is known as to what determines the chemical composition of the salty end-member of the estuarine water, so non-conservative behavior of phosphorus has been clearly demonstrated. Thus, the patterns of N and P observed during this study do not justify any firm generalizations. Nonetheless, the apparent relationship between the two nutrients is provocative. It can be inferred from the relationship between N and P that any losses of N associated with the loss of P to the system (i.e. by deposition of organic material) are more than compensated by processes which act on N but not P, for example nitrogen fixation. The relatively high concentration of TKN in the dry second year is consistent with this scenario.

Denitrification can be an important loss term in the estuarine nitrogen cycle. At the Lavaca Bay study site, denitrification as well as organic deposition was apparently compensated.

A net demand for P in a system does not demonstrate P limitation. Nitrogen may limit primary production proximately, but phosphorus input, if restricted, might ultimately limit production in the system. If freshwater input were restricted to the extent that dissolved inorganic P concentrations declined to near the limit of detection, one might expect to see some fundamental changes in the dynamics of the Lavaca Bay estuarine system. Focussed study on nitrogen-phosphorus relationships could be fruitful.

Light-Nutrient Interactions

If only primary production is considered, the subject of light- versus nutrient limitation can be approached. The distinction is not as simple as it sounds. Consider a well-mixed water column typical of the upper Lavaca Bay where the depth is equal to the 1% light level. The average light intensity is 21% incident (assuming uniform extinction of light with depth). Primary productivity is dependent on incident light and sensitive to changes in the clarity of the water (Fig. 2.22). A simple model of light and primary productivity demonstrates that light limits primary productivity at times in many parts of Lavaca Bay (Tables 2.31, 2.32).

Light-limitation of primary productivity, as described above, does not exclude nutrient-limitation. Concentrations of nitrate and ammonium were generally very low in Lavaca Bay and there were indications that an increase in chlorophyll concentration was one of the responses to nutrient input. It is thus reasonable to suggest that the net increase of phytoplankton is limited by nitrogen even if it is not possible to assess the nutrient-limitation of phytoplankton growth rates. Independent of changes in light, an increase of phytoplankton biomass in a well-mixed water column will lead to a nearly proportional increase in production (note that light absorption by phytoplankton accounts for a small percentage of light extinction in the muddy waters of Lavaca Bay). Primary productivity can thus be limited by light and nutrients.

Phytoplankton

The quantitative importance of very small phytoplankton in marine and estuarine systems has only recently been fully appreciated due to the advent of epifluorescence microscopy (Johnson and Sieburth 1979; Krempin and Sullivan 1981). Because epifluorescence microscopy was not employed in this and in previous studies of Texas bays, the phytoplankton assemblages have not been fully described. It is thus not surprising that relationships between chlorophyll and phytoplankton abundance were not clear: correlations between cell counts and chlorophyll were poor in both years as were the correlations between biovolume and chlorophyll. Cell counts were a poor estimator of phytoplankton biomass because cell size is not considered. We suspect that the poor relationship between biovolume and chlorophyll is due in large part to uncertainty in counting and sizing the smallest phytoplankton and also in the highly variable chlorophyll content of microalgae (Cullen 1982). The cell counts and biovolume estimates from this study are rather poor indicators of phytoplankton biomass. The counts do show that small forms are important and do contain a substantial amount of information on relative abundance of identifiable taxa during the course of the study. An overview of the taxonomic trends (Figs. 2.16, 2.17; Table 2.30) demonstrates that cyanobacteria dominated the autotrophic community. Small coccoid cyanobacteria, solitary and in small colonies, were by far the most abundant. Clearly, more appropriate methods should be employed to look at the autorophs in this estuarine community. Epifluorescence microscopy should be employed and extraction of pigments into other solvents, as compared to acetone, should be studied.

Temporal and Spatial Variability

A proper analysis of temporal and spatial variability in the Lavaca Bay estuary would take years and thousands of samples. On the basis of the data collected during this study, a few qualitative statements can be made.

By sampling at the surface, we made the implicit assumption the water column was vertically uniform. Profiles made with the Hydrolab sonde at each station and thorough measurements at station 85 (Davis, 1986) indicate that the waters in the shallow bay system were almost always mixed top-to-bottom. Some stratification was commonly observed at the river stations, however. Freshwater introduced to a rather salty bay system formed a lens over the river in June 1986, restricting vertical mixing and promoting anoxia below the surface at stations 45 and 65. This phenomenon should be considered when assessing the impact of intermittent freshwater input to a high-salinity estuary.

The presentation of the data implies subliminally that each measurement is representative of a particular site over the time scale of a month or more. Of course, this has not been demonstrated nor do we believe it to be true. Duplicate measurements separated by 20 minutes are very similar, so small scale variability is probably not important. Over the course of a day, chlorophyll concentration was observed to vary as much as twofold (Figs. 2.23, 2.24; Davis 1986). Our experience with day-to-day variability is that wind-induced mixing and sediment resuspension can have a pronounced influence on observations. For example, on 3 June 1986, 10:10h, the air was calm at station 85. Chlorophyll concentration at the surface was 1.67 μg/l (Table of

Chlorophyll values). The wind was blowing on the next day and the concentration of chlorophyll at the surface ranged from about 11 to 15 μg/l over the day (Davis, 1986; Fig. 2.24).

Primary Productivity

This study was constrained to measure concentrations of organisms and materials rather than rate processes such as primary productivity. Only with a systematic program of rate measurements would it be possible to assess directly the influences of freshwater input on primary productivity. Even with a good understanding of that link, it would be difficult to describe mechanistically the ultimate effects of freshwater input on higher trophic levels.

Several experiments were performed at station 85 to examine processes associated with primary production. Some results have been presented (Davis, 1986) but the analysis is not complete. In the results that we have considered to date (e.g. Fig. 2.25, Table 2.33), photosynthetic rates normalized to chlorophyll compared favorably to healthy cultures. We have seen no other indication of severe nutrient limitation of photosynthesis by microalgae. Studies of benthic and water-column primary productivity are presently underway in the San Antonio Bay estuary.

The biomass of the microphytobenthos is substantial and distributed well below the upper millimeter of sediment where net photosynthesis is possible (H.L. MacIntyre, unpubl.). This algal biomass appears to act as a reservoir of photoautotrophic potential capable of significant primary production during resuspension. The seasonal pattern of benthic pigments at two stations is presented in Fig. 2.26 (H.L. MacIntyre, in prep.). The amount of pigment in the upper 5 mm of sediment is on the same order as that suspended in the water column. Novel measurements of photosynthesis vs irradiance on benthic samples have demonstrated that the benthic pigments are photosynthetically active (Fig. 2.27). The effects of sediment resuspension and the associated inoculum of autotrophs on water-column primary productivity are currently being studied as part of a research program in the San Antonio Bay.

CONCLUSIONS

Measurements of salinity showed that the Lavaca Bay estuary was influenced by freshwater. High nutrient concentrations were associated with freshwater input and biological utilization of the nutrients was indicated by nutrient depletion away from the input and in the dry year as compared to the wet year. The flushing action of freshwater inflow was evident during sampling periods when nutrients were high and chlorophyll was relatively low in low-salinity water. Our results are consistent with the notion that as flow subsides, nutrients are utilized and phototrophic biomass increases in the fresher water. Thus, there is no reason to expect stable relationships between salinity, nutrients and phytoplankton in an estuarine system subject to episodic perturbations, at least on the time scale of those perturbations. Over months or years though, freshwater input nutrients and primary production are likely to be related. The differences between a wet year and a dry year at Lavaca Bay are consistent with the proposition that freshwater input has a strong influence on primary production. The relationship has by no means been proven, however.

The ratio of phosphorus to nitrogen in the water column declined as a function of salinity. There is a large amount of scatter in the data, but it appears that phosphorus declined more sharply than would be predicted from mixing of different water types (i.e. P was removed from the water column) whereas there was no indication of a net demand for nitrogen. Even though inorganic nitrogen levels were often very low and the potential for phytoplankton growth may have been limited by the supply of nitrogen, it is possible that the supply of phosphorus could ultimately exert an important control on productivity of the system. More study on nitrogen-phosphorus relationships is clearly warranted.

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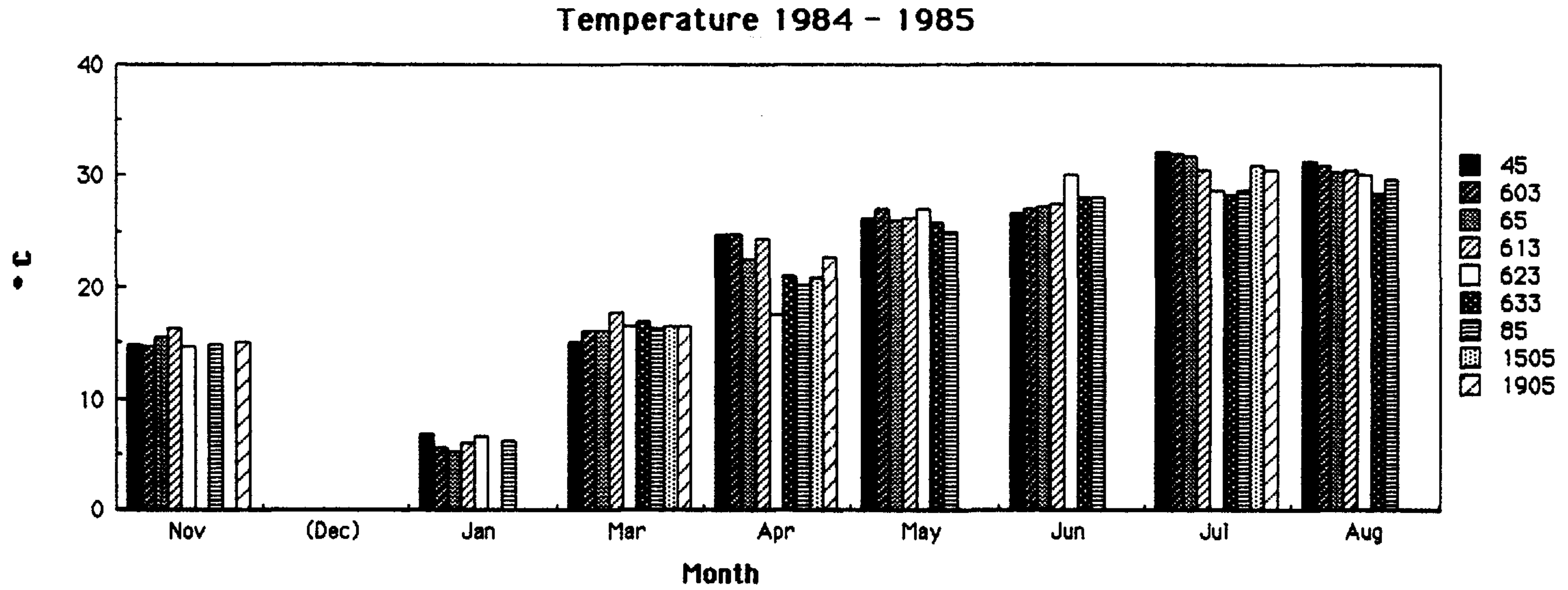
Figure 2.1. Temperature measurements made during the Lavaca Bay study, 1984-86. Error bars represent range of duplicate samples taken about 20 minutes apart. Hydrographic parameters were not determined in duplicate during the first year.


Temperature 1984 - 1985
40
30
20
10
0
°C
Nov
(Dec)
Jan
Mar
Apr
May
Jun
Jul
Aug
Month
45
603
65
613
623
633
85
1505
1905

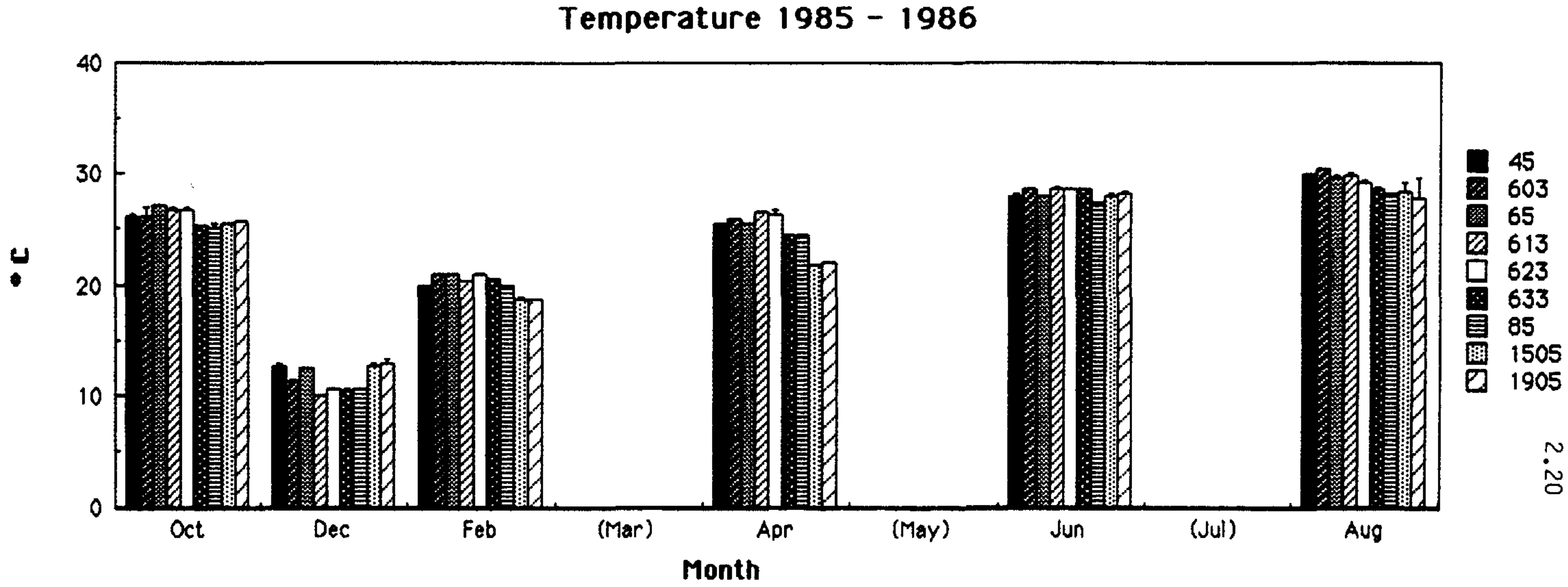
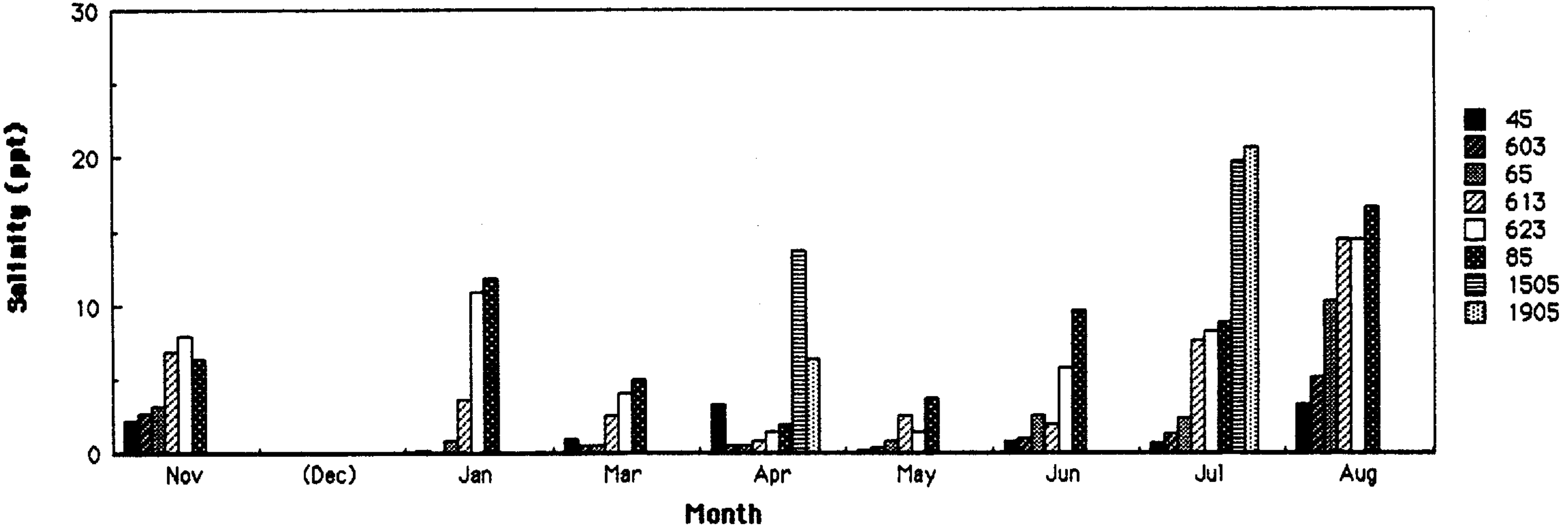

Temperature 1985 - 1986
40
30
20
10
0
°C
Oct
Dec
Feb
(Mar)
Apr
(May)
Jun
(Jul)
Aug
Month
45
603
65
613
623
633
85
1505
1905

Figure 2.2. Salinity measurements made during the Lavaca Bay study, 1984-1986. Error bars represent range of duplicate samples taken about 20 minutes apart. Hydrographic parameters were not determined in duplicate during the first year.

Salinity 1984 - 1985



Salinity 1985 - 1986

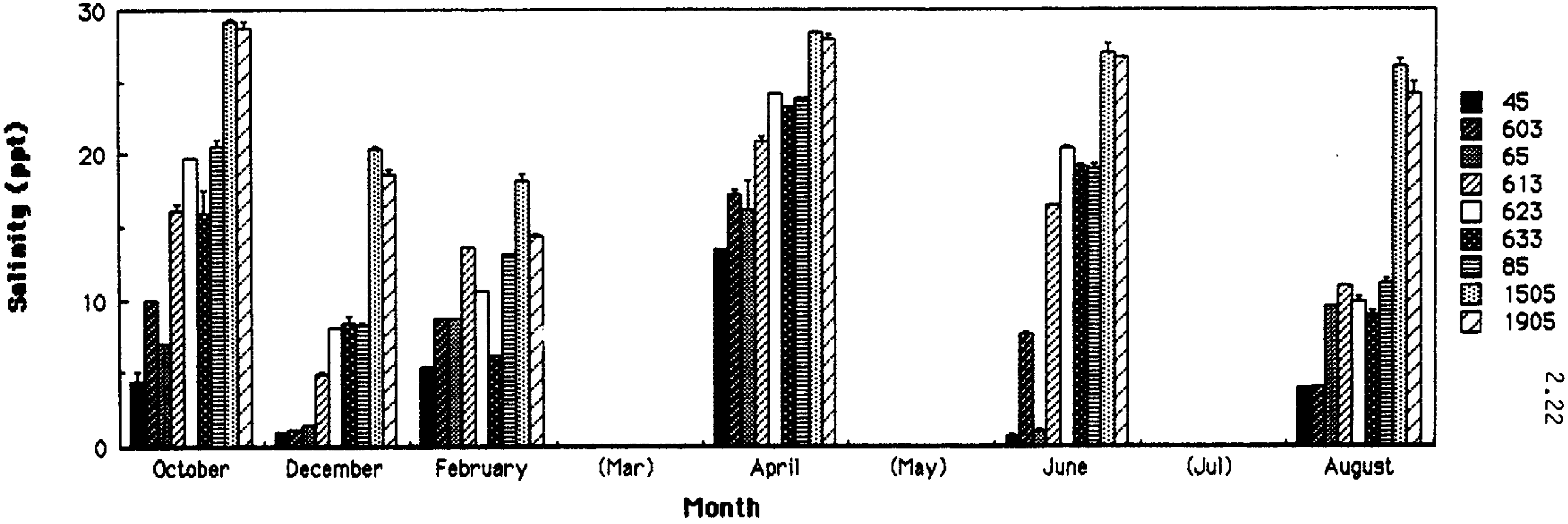
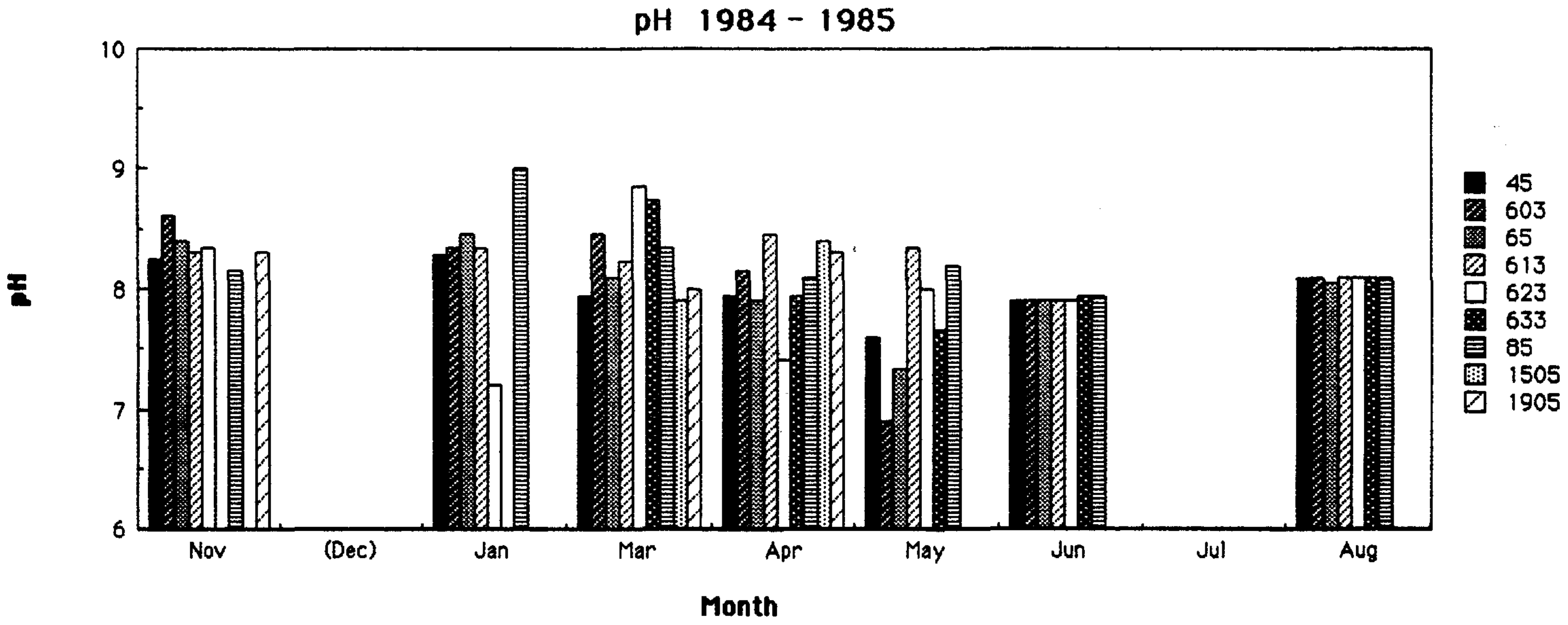


Figure 2.3. pH measurements made during the Lavaca Bay study, 1984-1986. Error bars represent range of duplicate samples taken about 20 minutes apart. Hydrographic parameters were not determined in duplicate during the first year.


pH 1984 - 1985

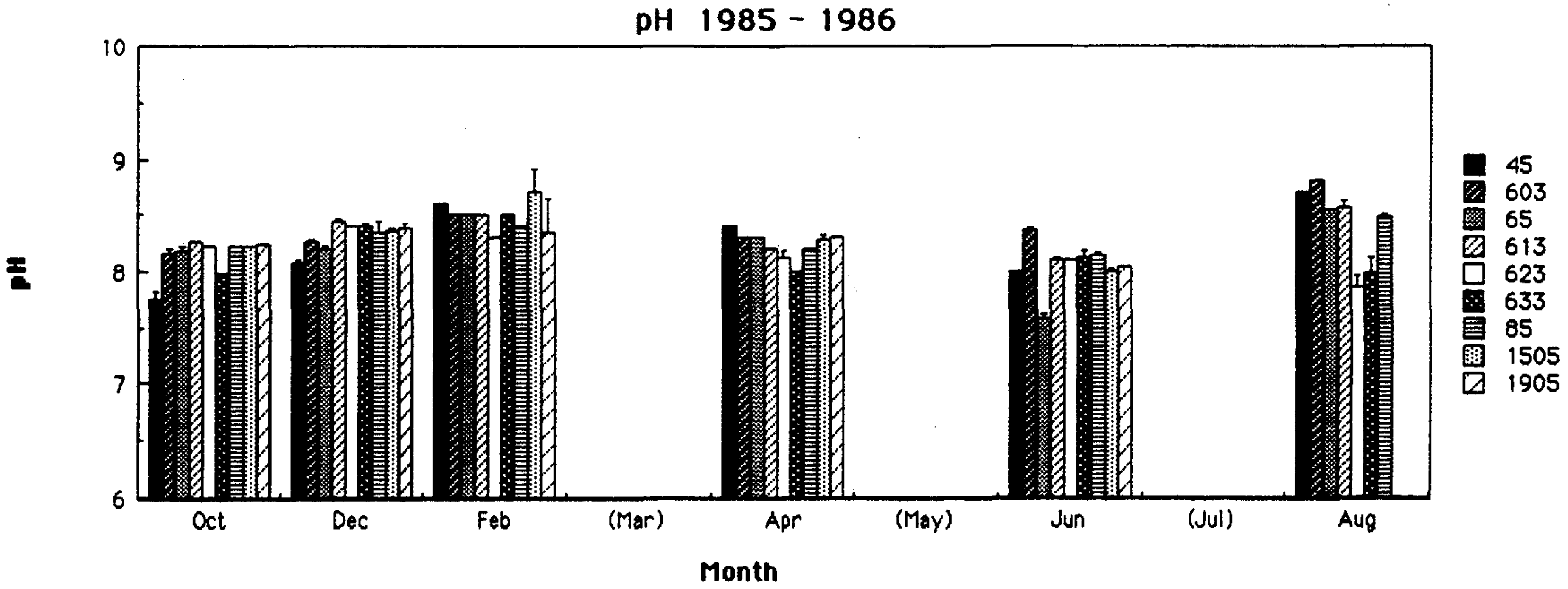
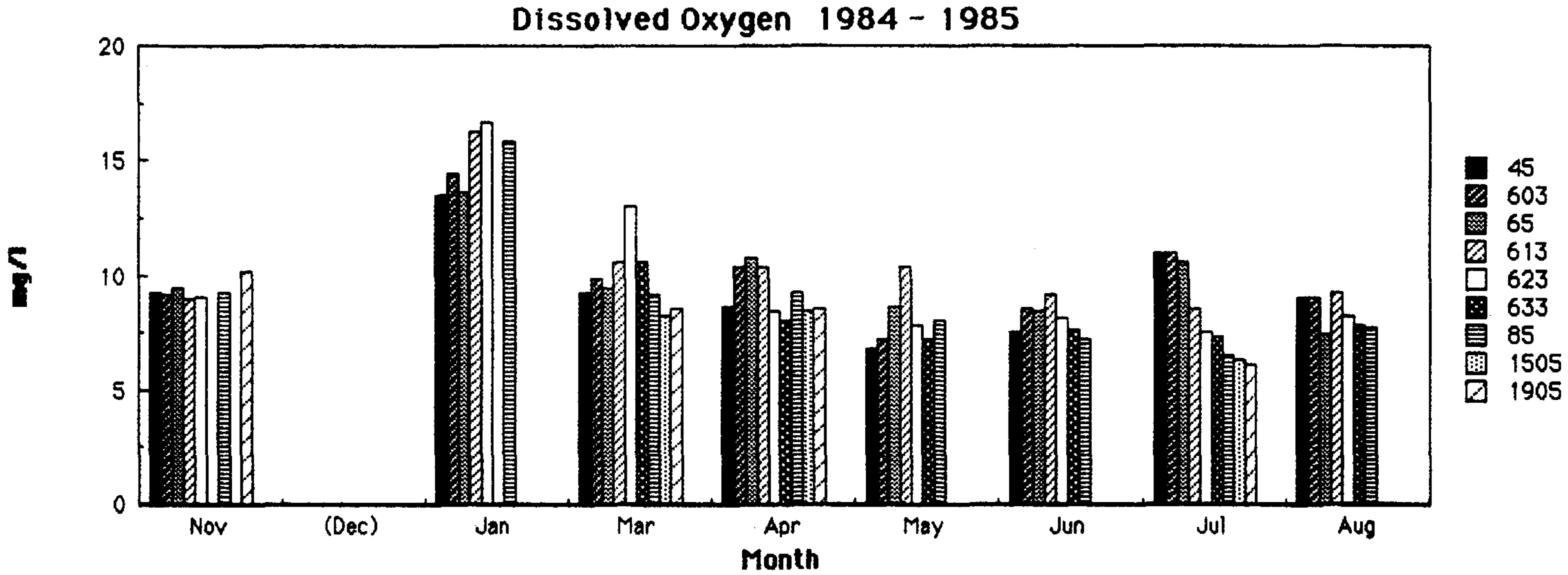

pH 1985 - 1986

Figure 2.4. Dissolved oxygen measurements made during the Lavaca Bay study, 1984-1986. Error bars represent range of duplicate samples taken about 20 minutes apart. Hydrographic parameters were not determined in duplicate during the first year.


Dissolved Oxygen 1984 - 1985
mg/L
0
5
10
15
20
Nov
(Dec)
Jan
Mar
Apr
May
Jun
Jul
Aug
Month
45
603
65
613
623
633
85
1505
1905

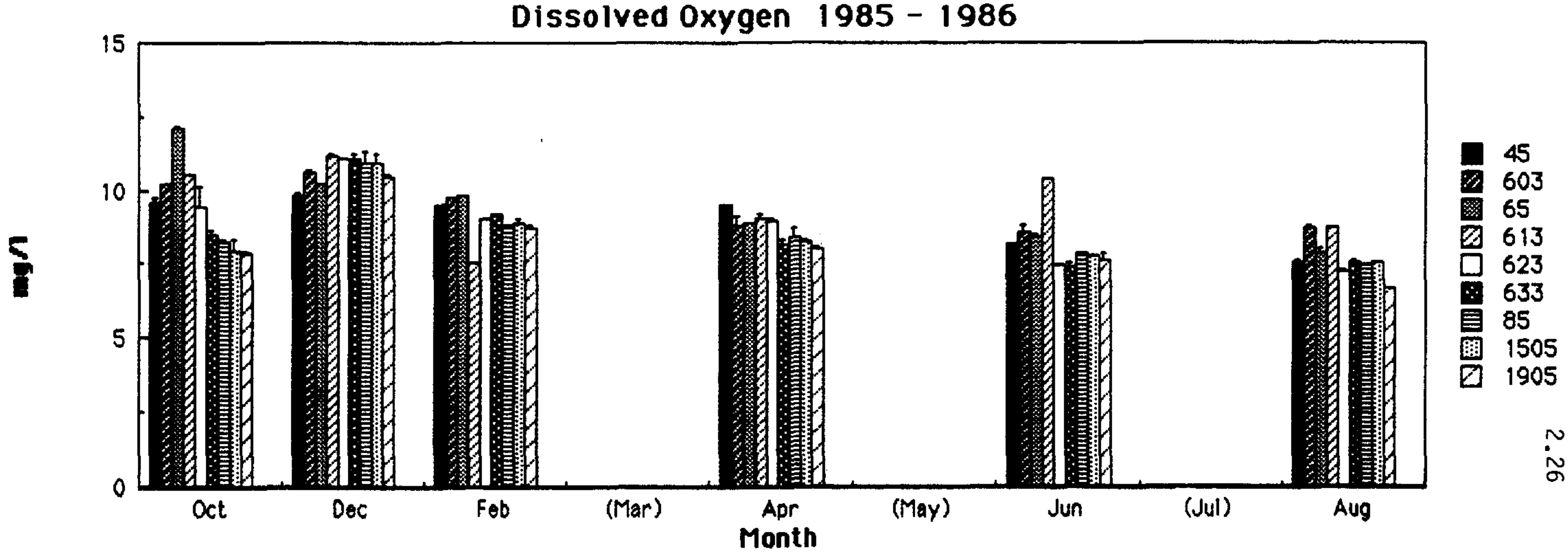
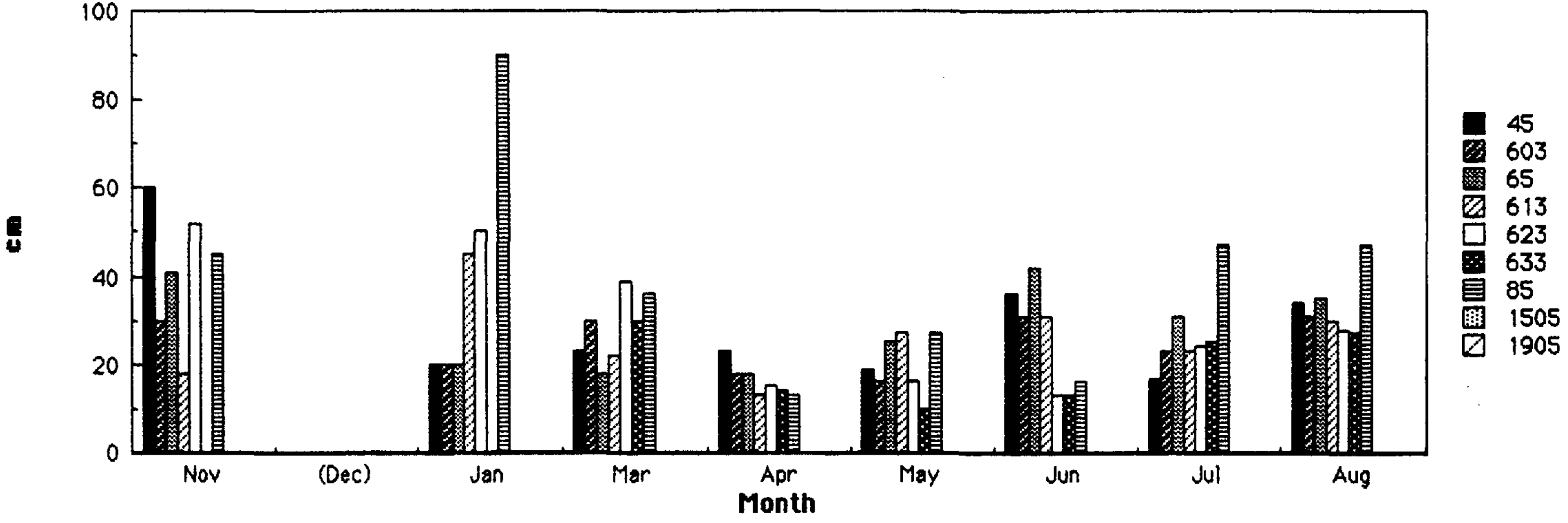

Dissolved Oxygen 1985 - 1986
mg/L
0
5
10
15
Oct
Dec
Feb
(Mar)
Apr
(May)
Jun
(Jul)
Aug
Month
45
603
65
613
623
633
85
1505
1905

Figure 2.5. Secchi depth measurements made during the Lavaca Bay study, 1984-1986. Error bars represent range of duplicate samples taken about 20 minutes apart. Hydrographic parameters were not determined in duplicate during the first year.

Secchi Depth 1984 - 1985



Secchi Depth 1985 - 1986

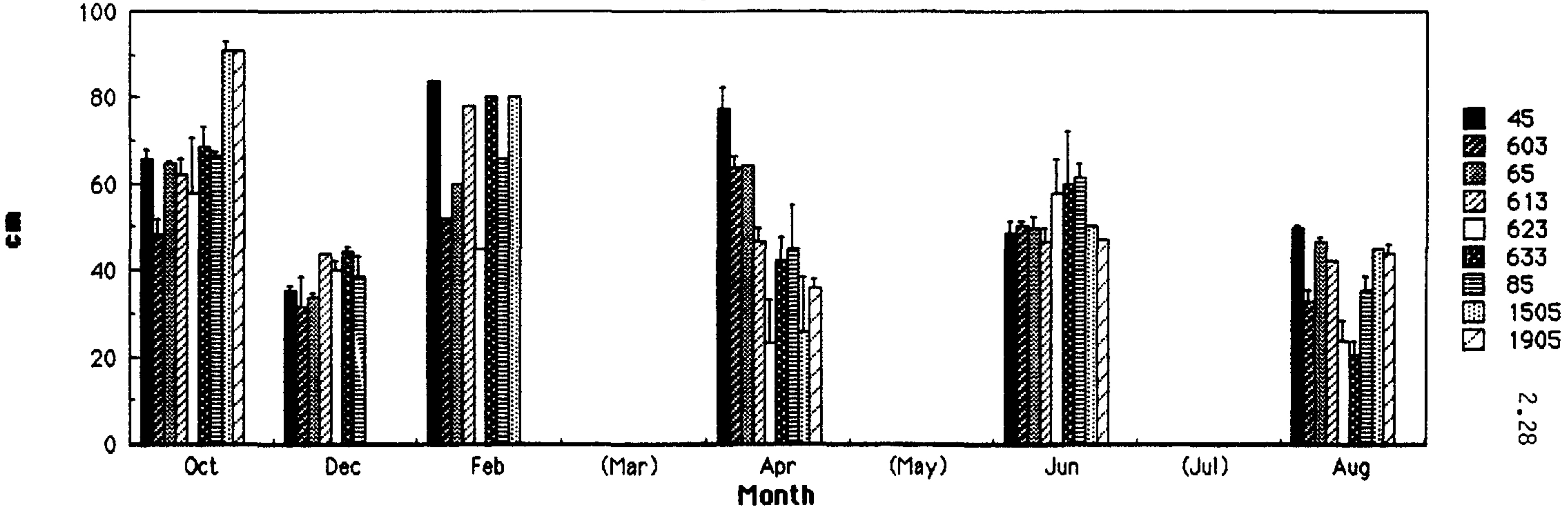
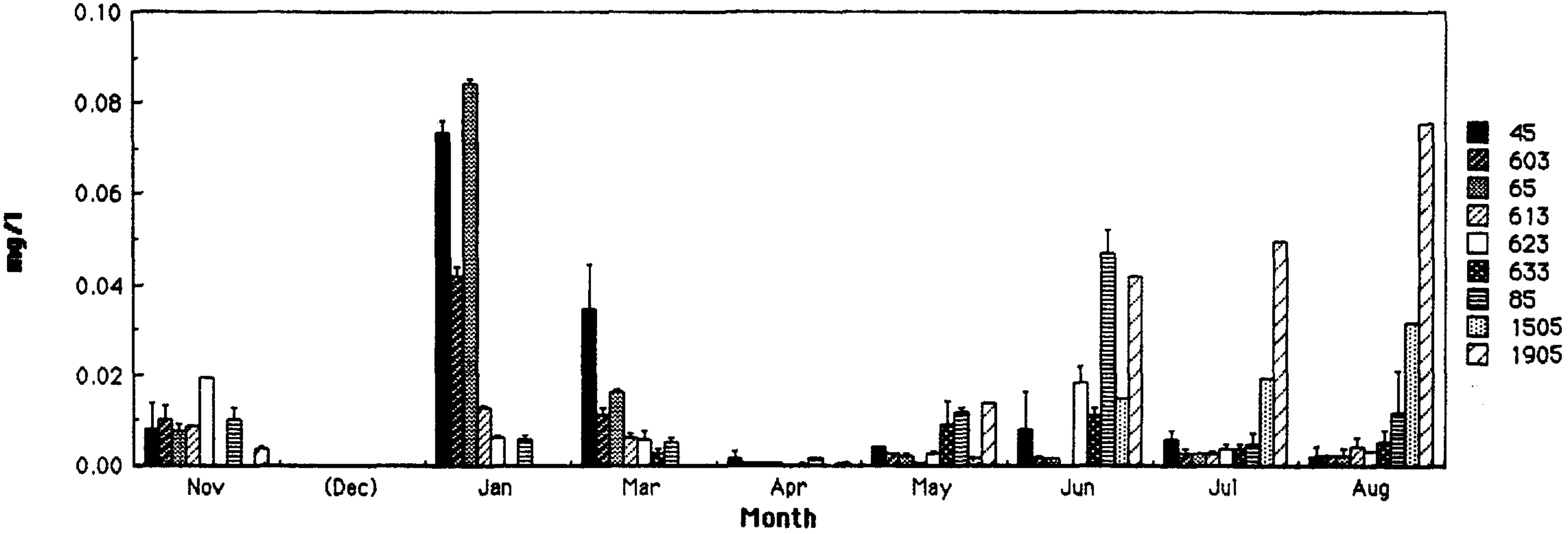


Figure 2.6. Ammonium measurements made during the Lavaca Bay study, 1984-1986. Units are mg N/liter. Error bars represent range of duplicate samples taken about 20 minutes apart.


Ammonium 1984 - 1985

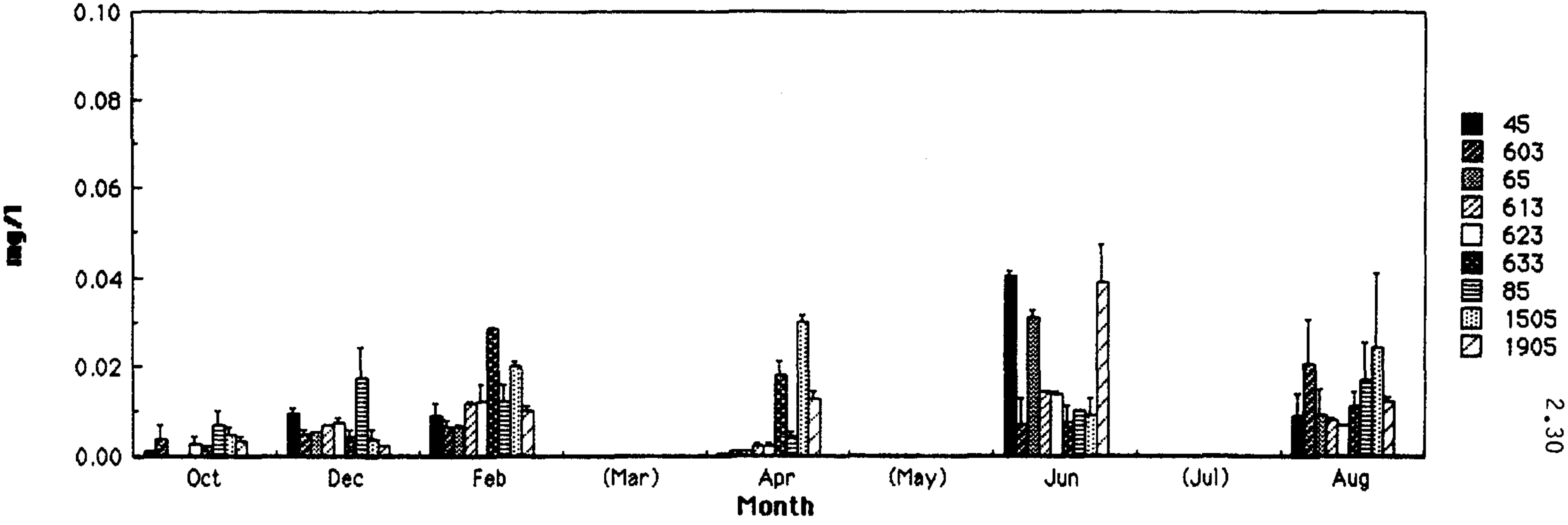
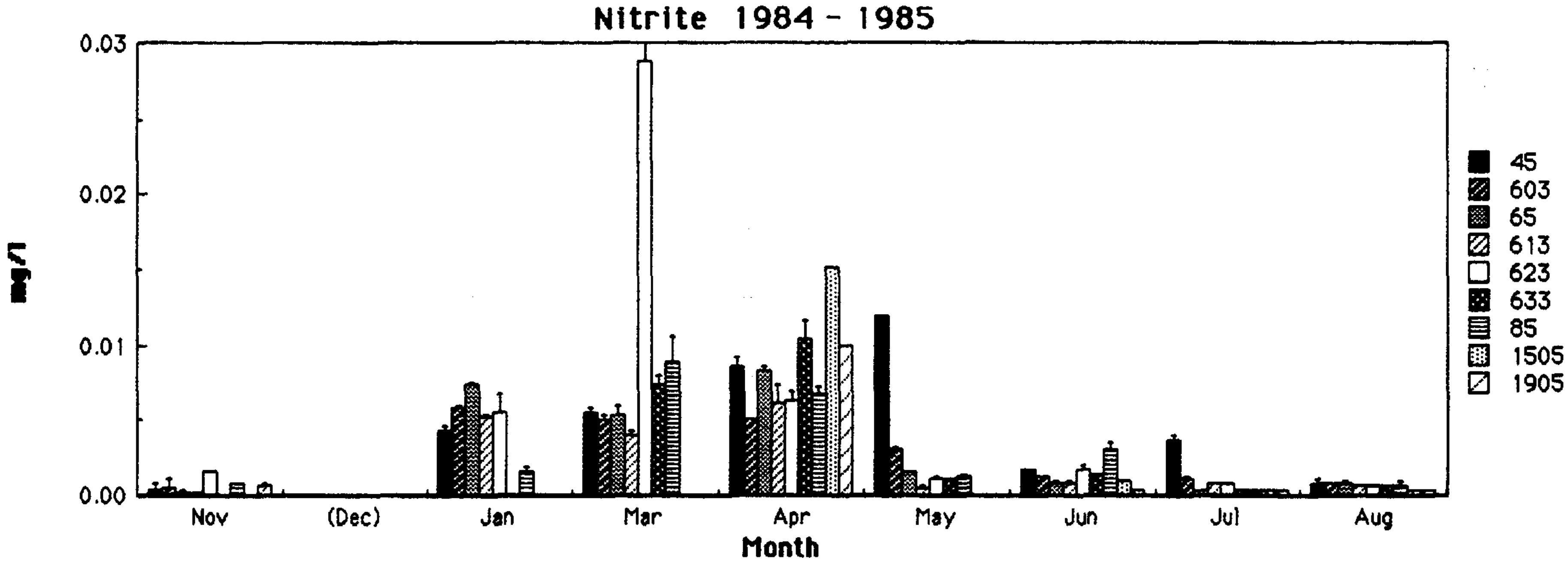

Ammonium 1985 - 1986

Figure 2.7. Nitrite measurements made during the Lavaca Bay study, 1984-1986. Units are mg N/liter. Error bars represent range of duplicate samples taken about 20 minutes apart.


Nitrite 1984 - 1985
mg/L
0.03
0.02
0.01
0.00
Nov
(Dec)
Jan
Mar
Apr
May
Jun
Jul
Aug
Month
45
603
65
613
623
633
85
1505
1905

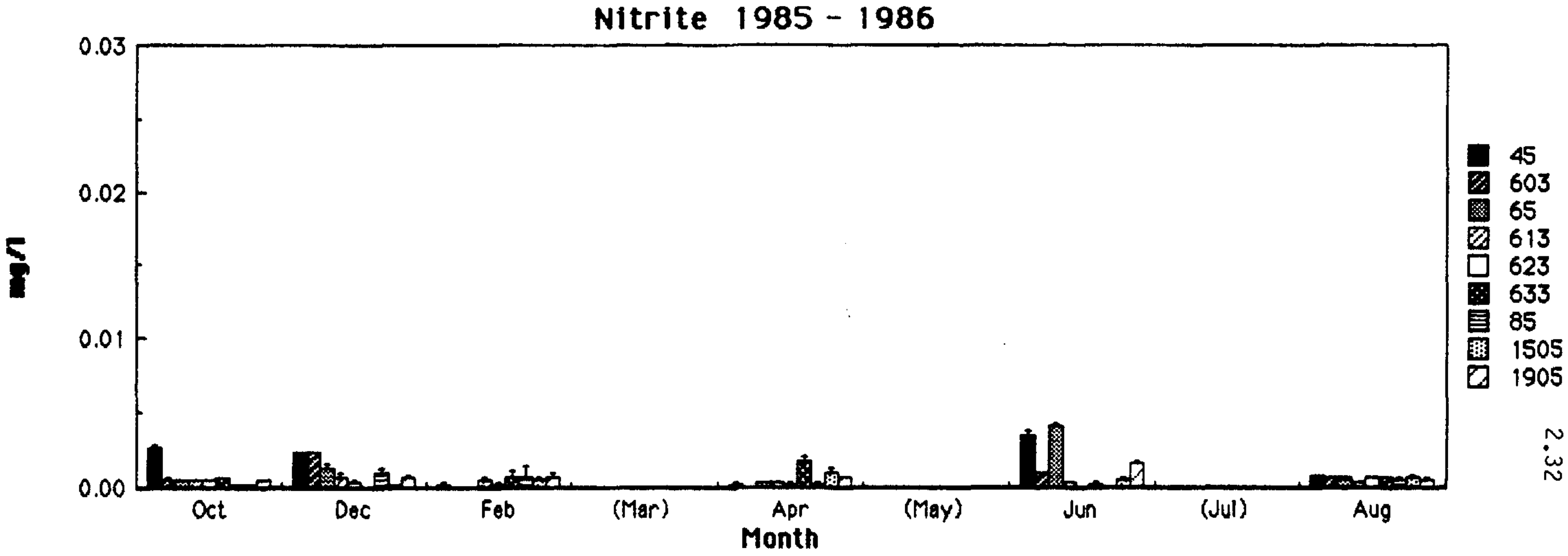
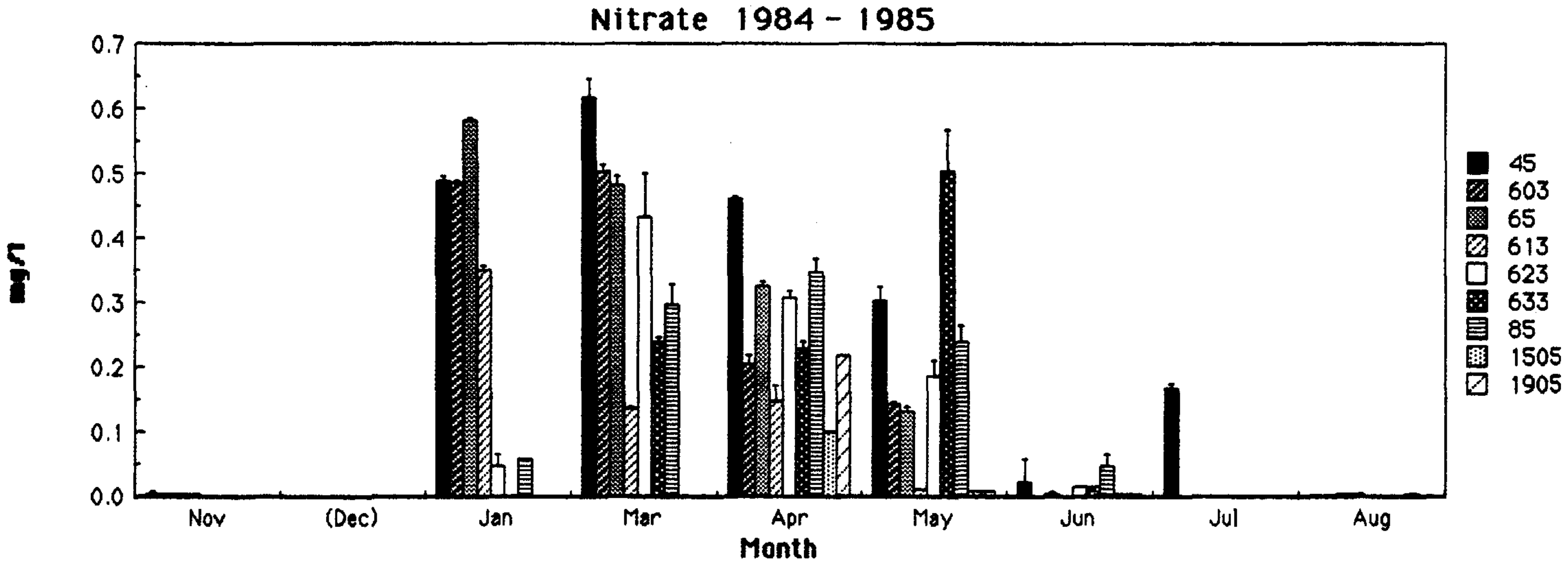

Nitrite 1985 - 1986
mg/L
0.03
0.02
0.01
0.00
Oct
Dec
Feb
(Mar)
Apr
(May)
Jun
(Jul)
Aug
Month
45
603
65
613
623
633
85
1505
1905

Figure 2.8. Nitrate measurements made during the Lavaca Bay study, 1984-1986. Units are mg N/liter. Error bars represent range of duplicate samples taken about 20 minutes apart.


Nitrate 1984 - 1985

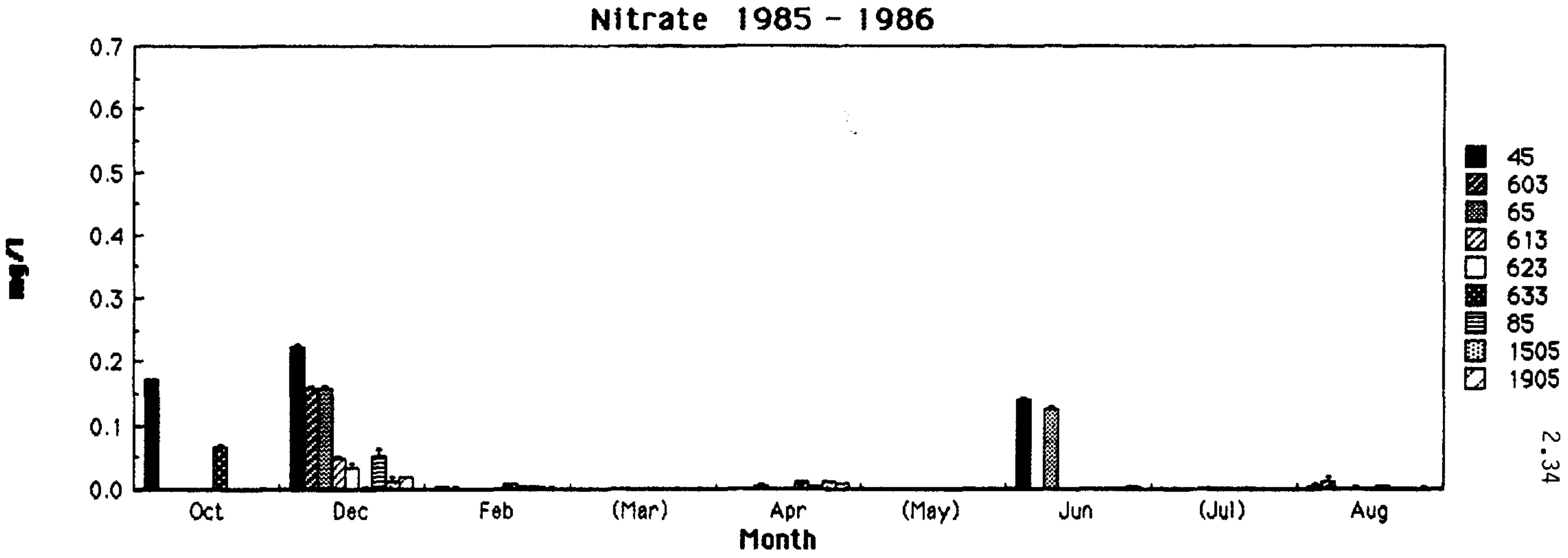
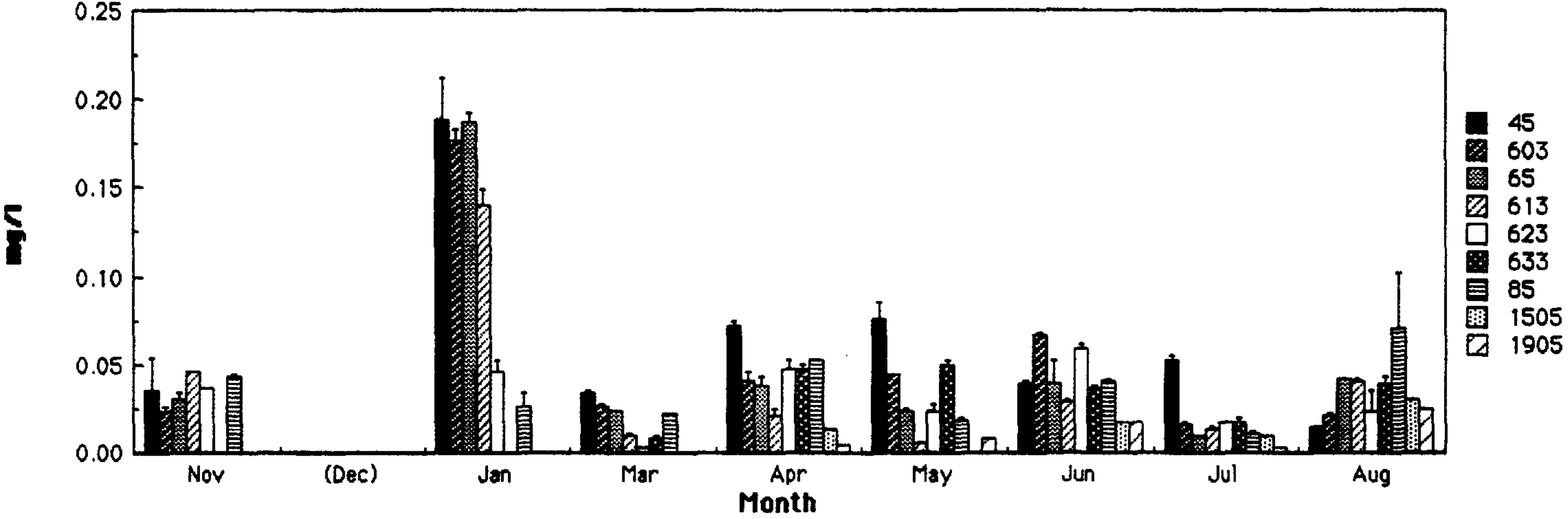
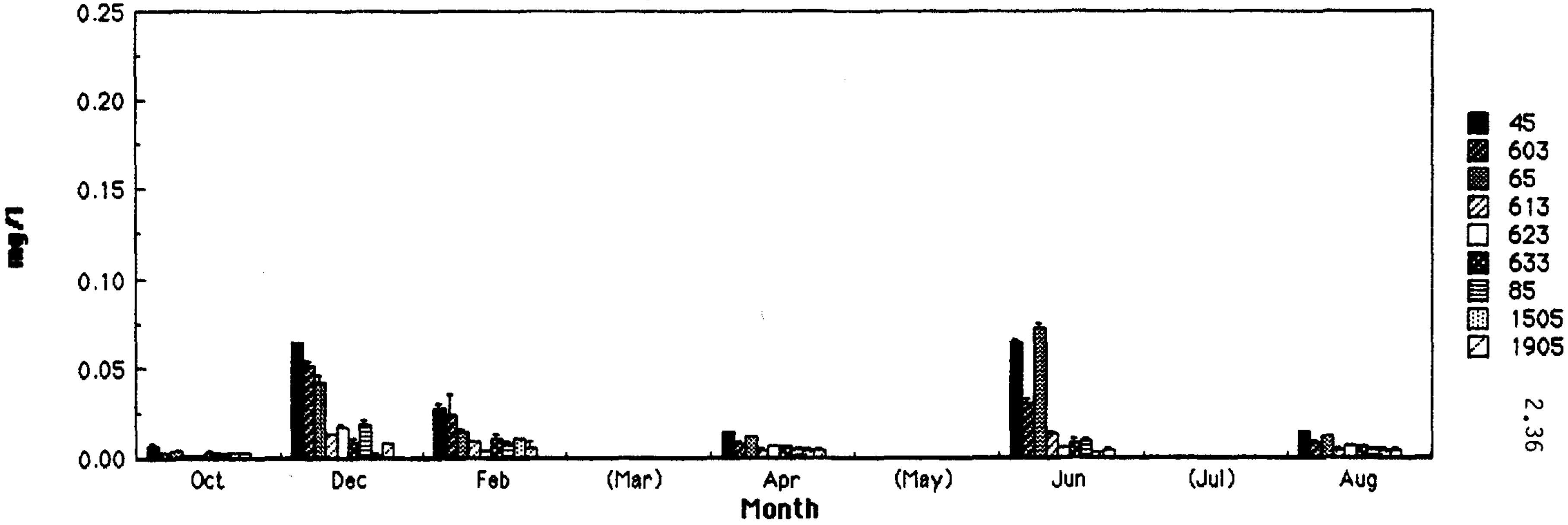

Nitrate 1985 - 1986

Figure 2.9. Phosphate measurements made during the Lavaca Bay study, 1984-1986. Units are mg P/liter. Error bars represent range of duplicate samples taken about 20 minutes apart.

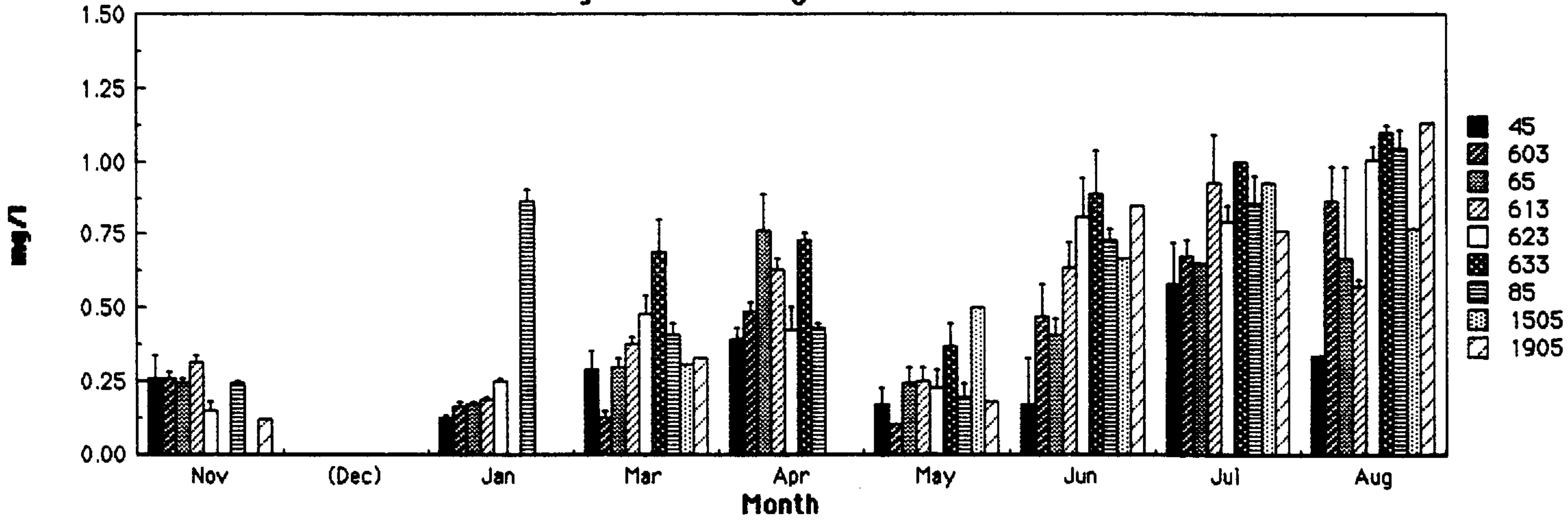


Phosphate 1984 - 1985



Phosphate 1985 - 1986

Figure 2.10. Total Kjeldahl nitrogen measurements made during the Lavaca Bay study, 1984-1986. Units are mg N/liter. Error bars represent range of duplicate samples taken about 20 minutes apart.


Total Kjeldahl Nitrogen 1984 - 1985

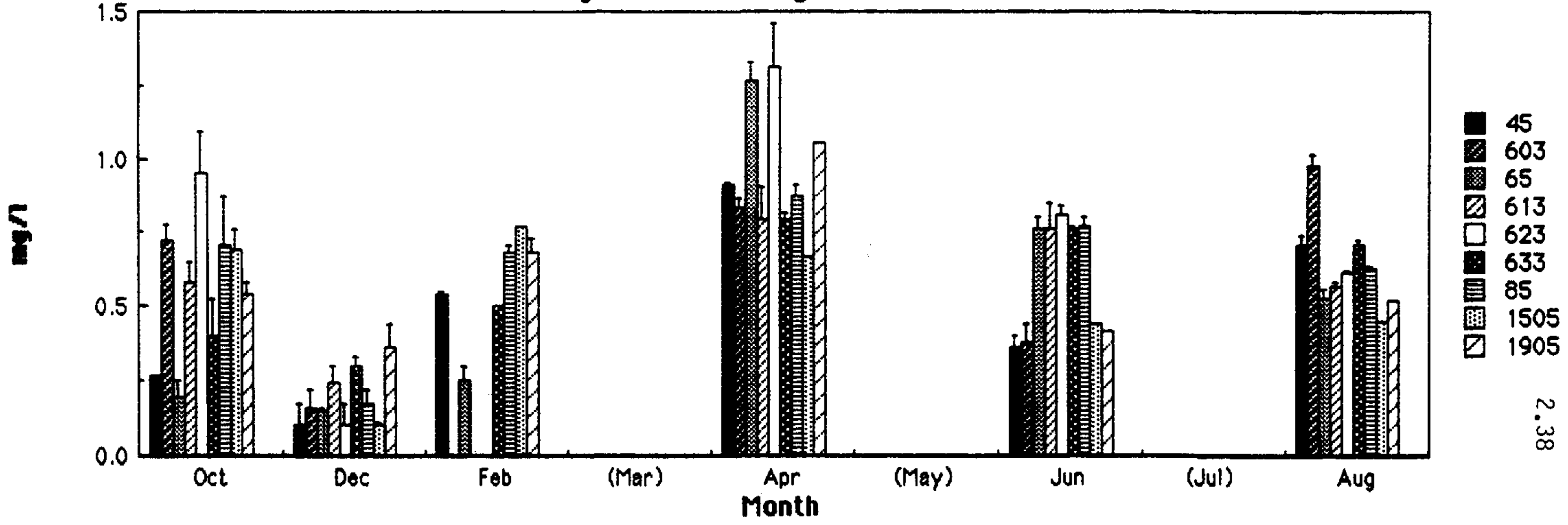
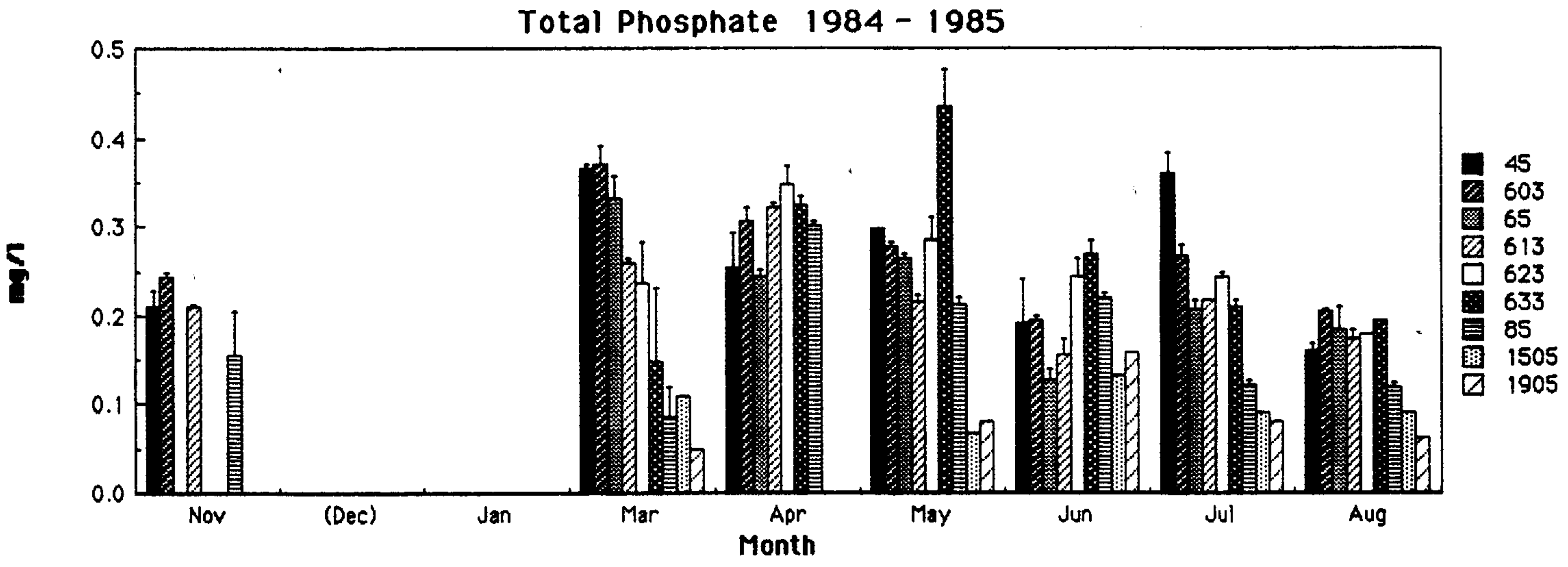

Total Kjeldahl Nitrogen 1985 - 1986

Figure 2.11. Total phosphate measurements made during the Lavaca Bay study, 1984-1986. Units are mg P/liter. Error bars represent range of duplicate samples taken about 20 minutes apart.


Total Phosphate 1984 - 1985

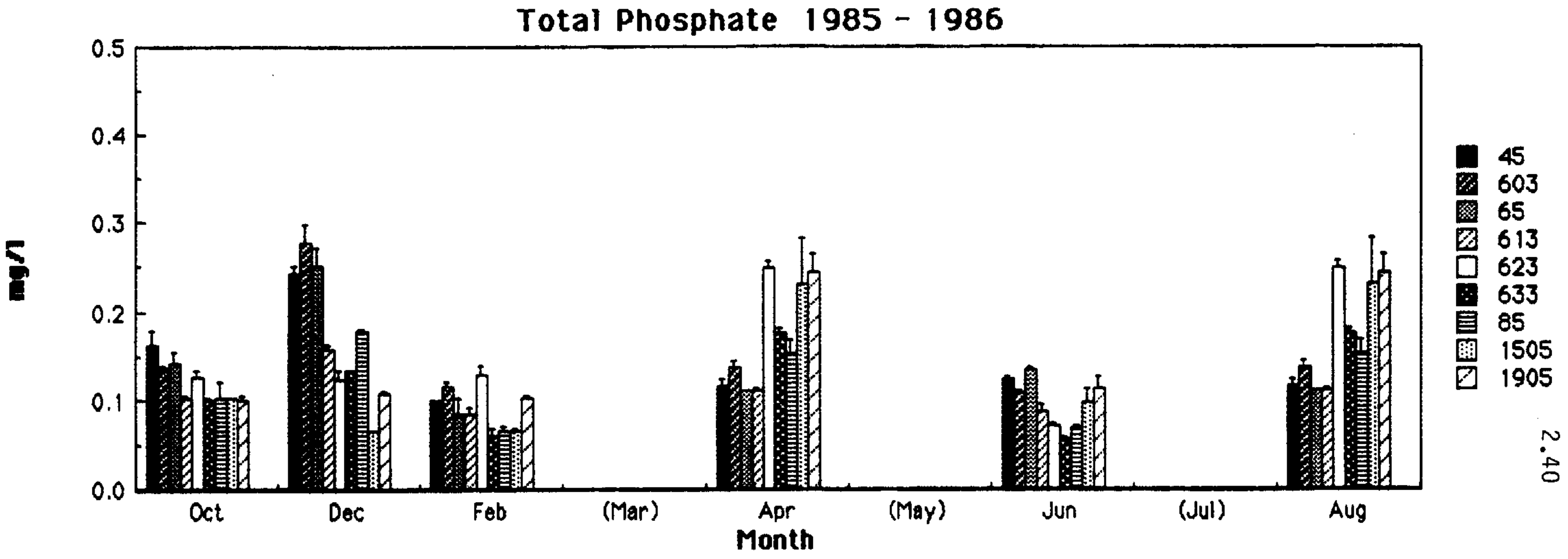
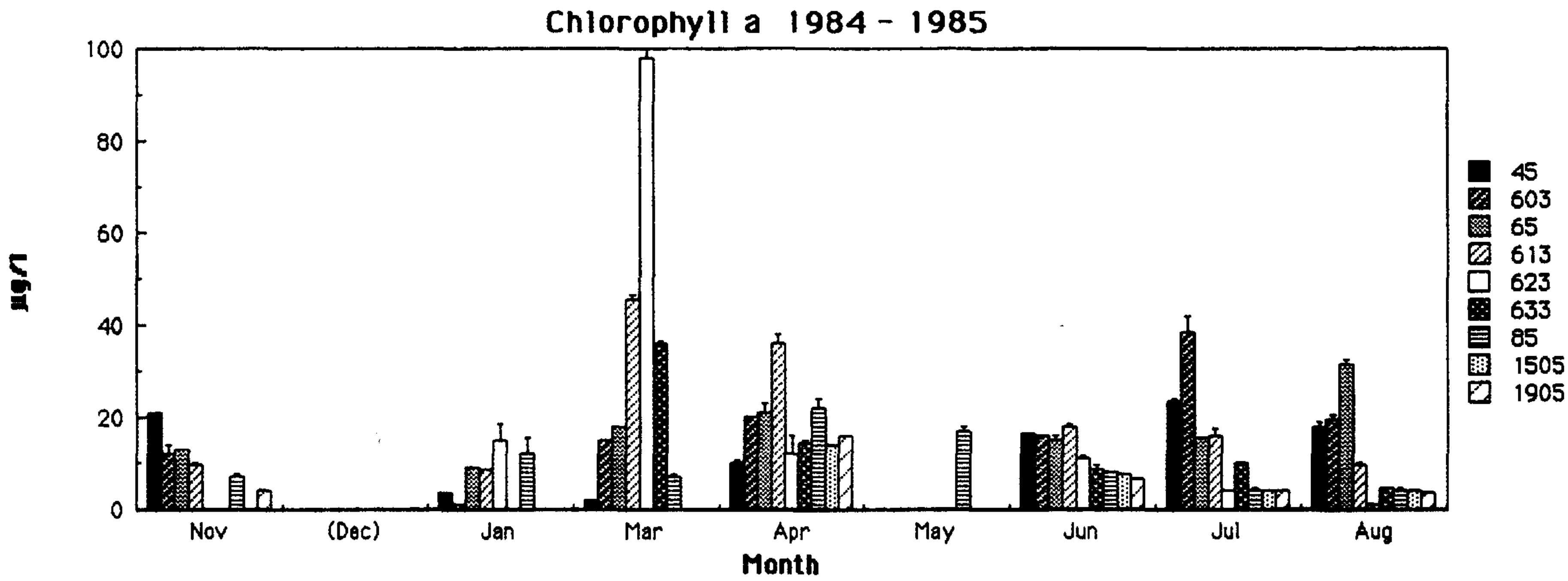

Total Phosphate 1985 - 1986

Figure 2.12. Chlorophyll a measurements made during the Lavaca Bay study, 1984-1986. Error bars represent range of duplicate samples taken about 20 minutes apart.


Chlorophyll a 1984 - 1985
100
80
60
40
20
0
µg/l
Nov
(Dec)
Jan
Mar
Apr
May
Jun
Jul
Aug
Month
45
603
65
613
623
633
85
1505
1905

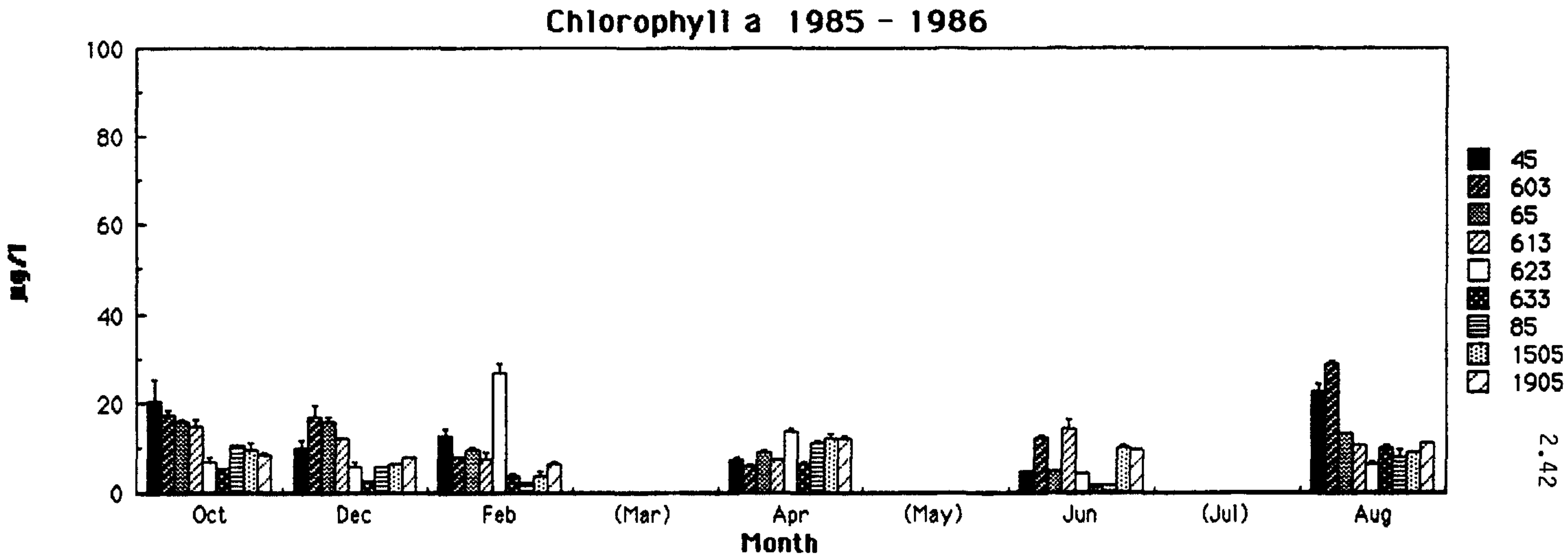
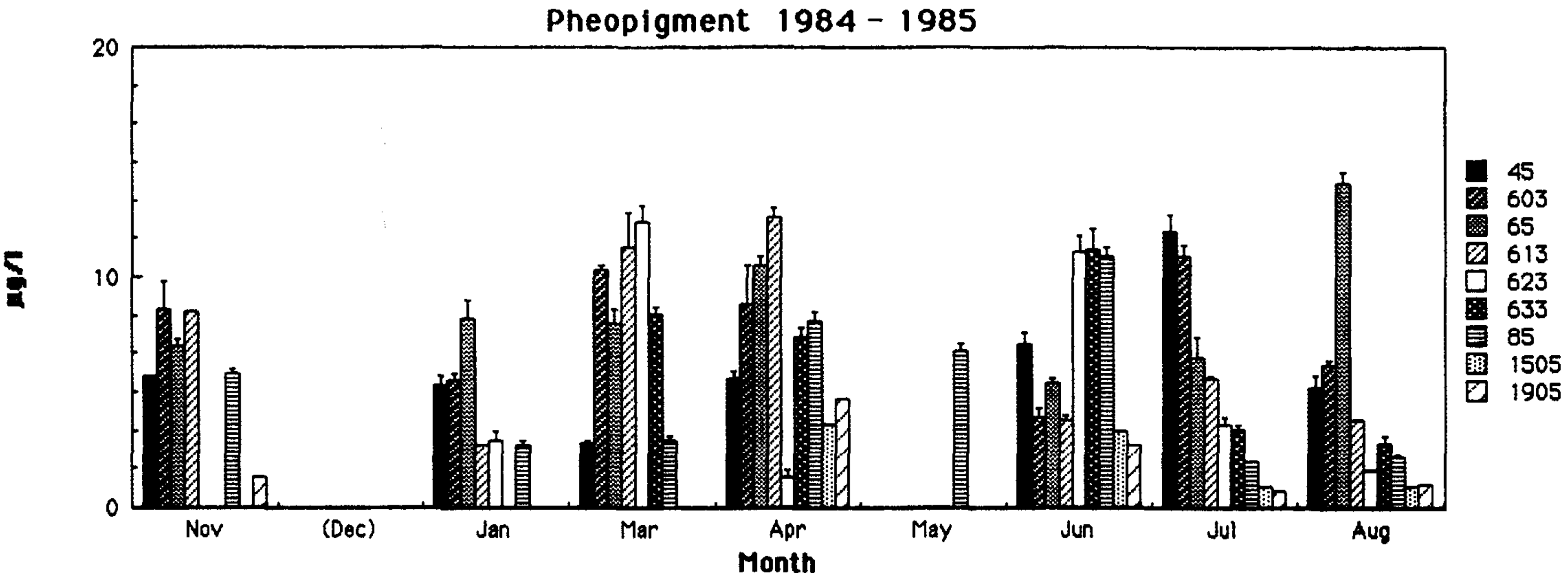

Chlorophyll a 1985 - 1986
100
80
60
40
20
0
µg/l
Oct
Dec
Feb
(Mar)
Apr
(May)
Jun
(Jul)
Aug
Month
45
603
65
613
623
633
85
1505
1905

Figure 2.13. Pheopigment measurements made during the Lavaca Bay study, 1984-1986. Units are μg chlorophyll equivalents/liter. Error bars represent range of duplicate samples taken about 20 minutes apart.


Pheopigment 1984 - 1985
µg/l
20
10
0
Nov
(Dec)
Jan
Mar
Apr
May
Jun
Jul
Aug
Month
45
603
65
613
623
633
85
1505
1905

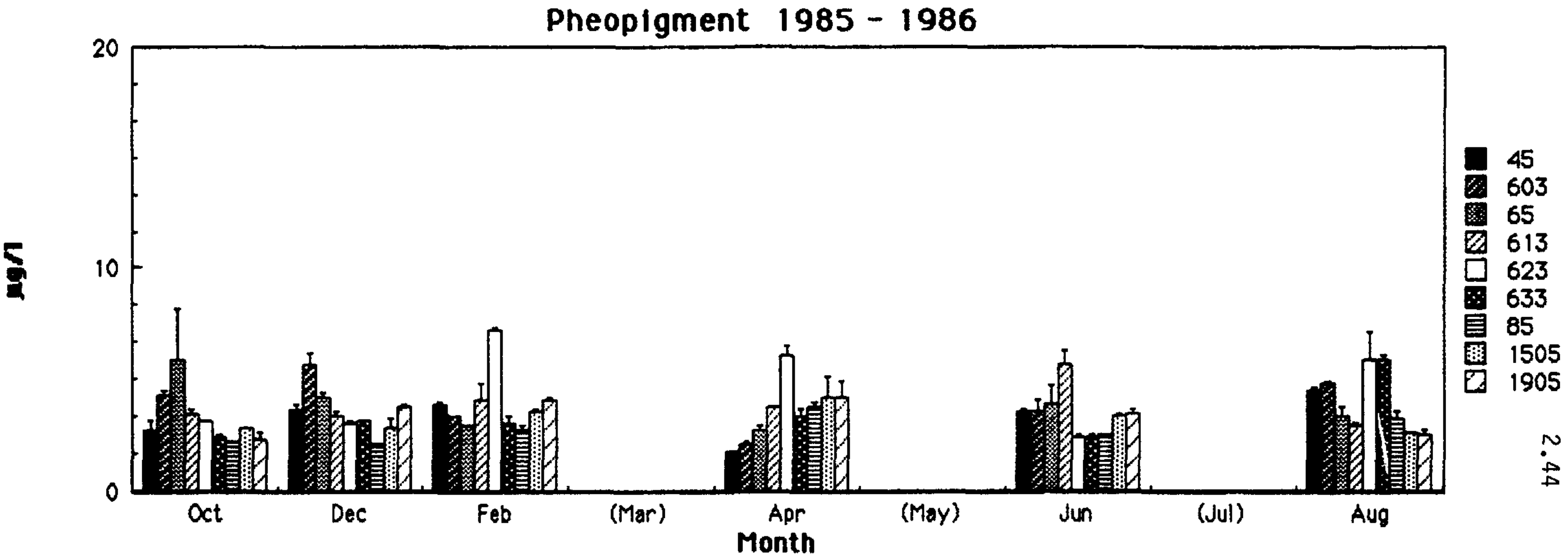
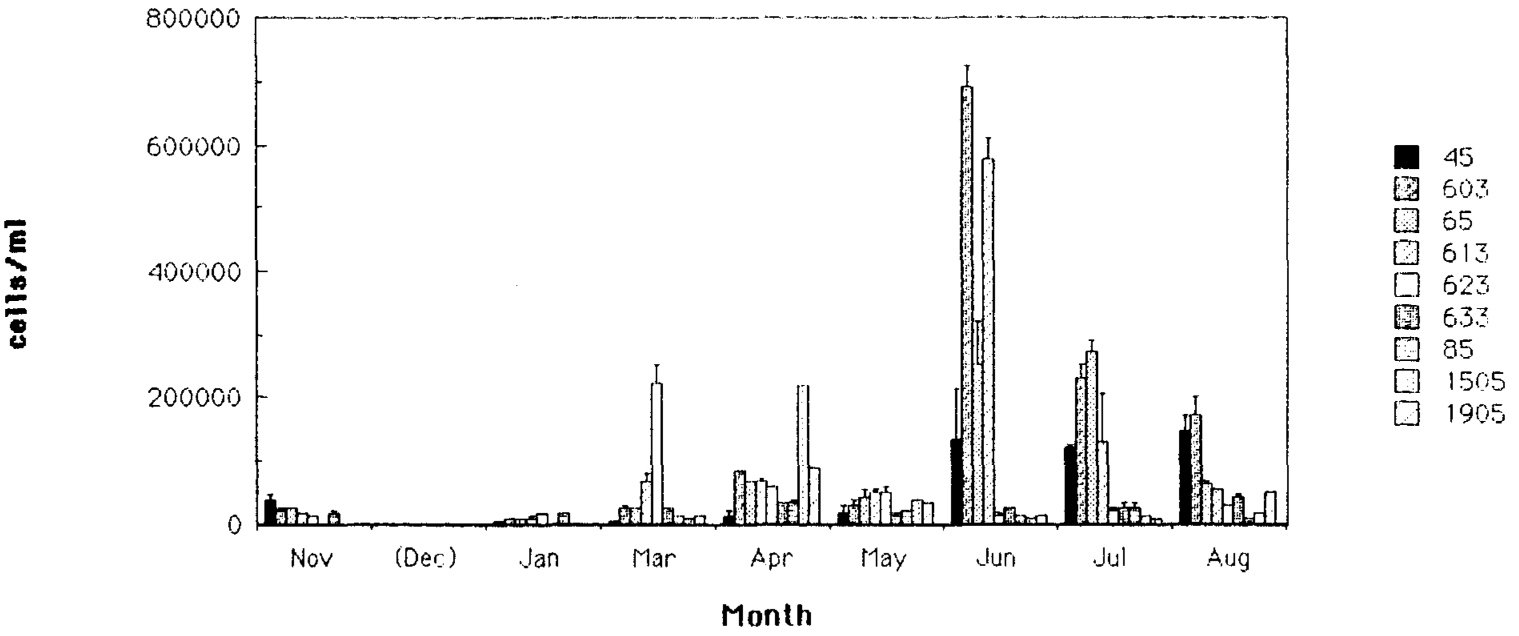

Pheopigment 1985 - 1986
µg/l
20
10
0
Oct
Dec
Feb
(Mar)
Apr
(May)
Jun
(Jul)
Aug
Month
45
603
65
613
623
633
85
1505
1905

Figure 2.14. Phytoplankton cell counts and biovolume estimates made during the Lavaca Bay study, 1984-1985. Error bars represent range of duplicate samples taken about 20 minutes apart.


Phytoplankton Cell Counts 1984 - 1985

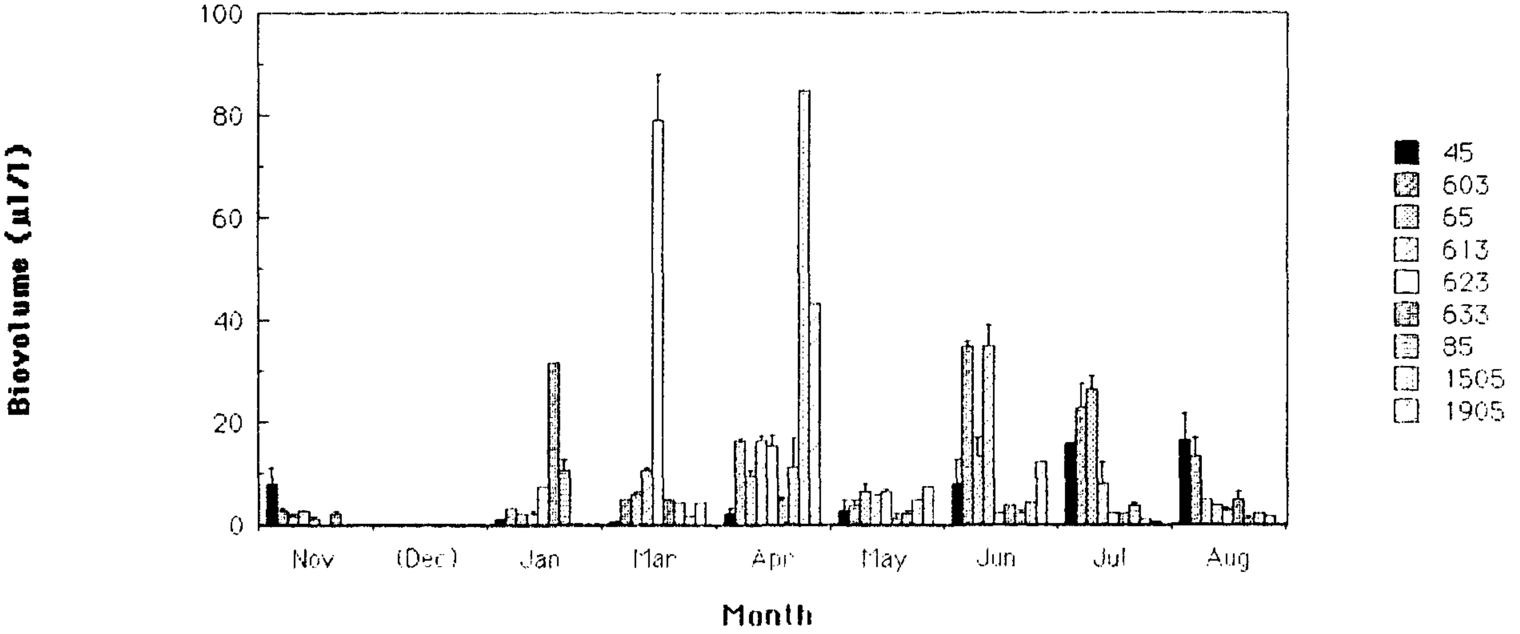
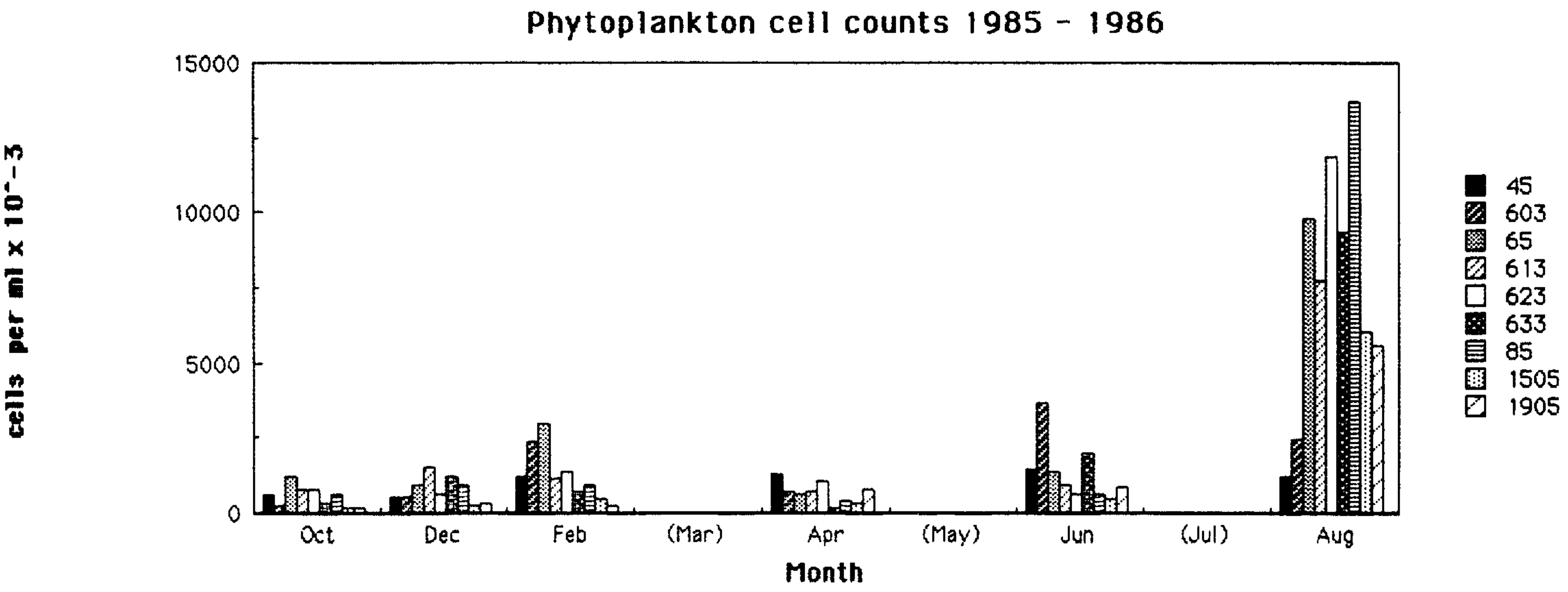

Phytoplankton Biovolume Estimates 1984 - 1985

Figure 2.15. Phytoplankton cell counts and biovolume estimates made during the Lavaca Bay study, 1985-1986. Error bars represent range of duplicate samples taken about 20 minutes apart.


Phytoplankton cell counts 1985 - 1986

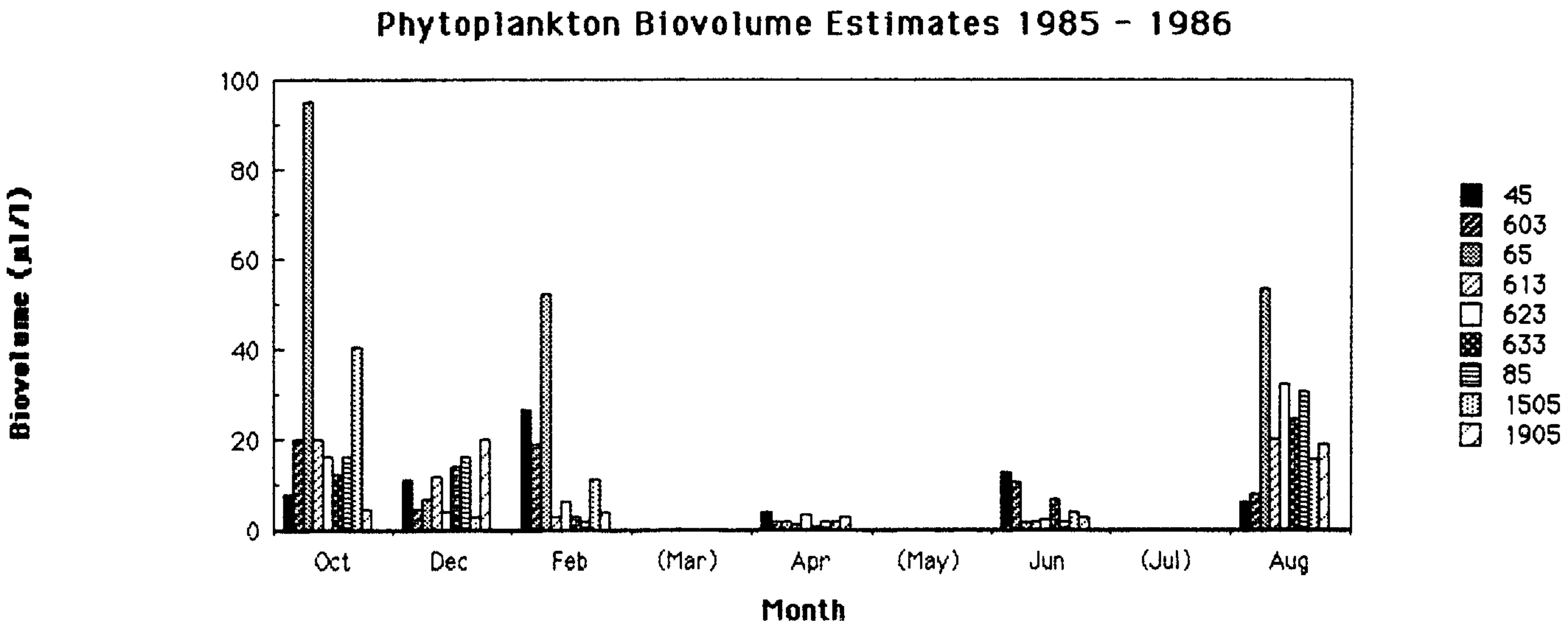

Phytoplankton Biovolume Estimates 1985 - 1986

Figure 2.16 Relative abundance of phytoplankton taxa during the Lavaca Bay study, 1985-86. All stations combined.

Lavaca Bay Phytoplankton 1985-86
Relative Abundance

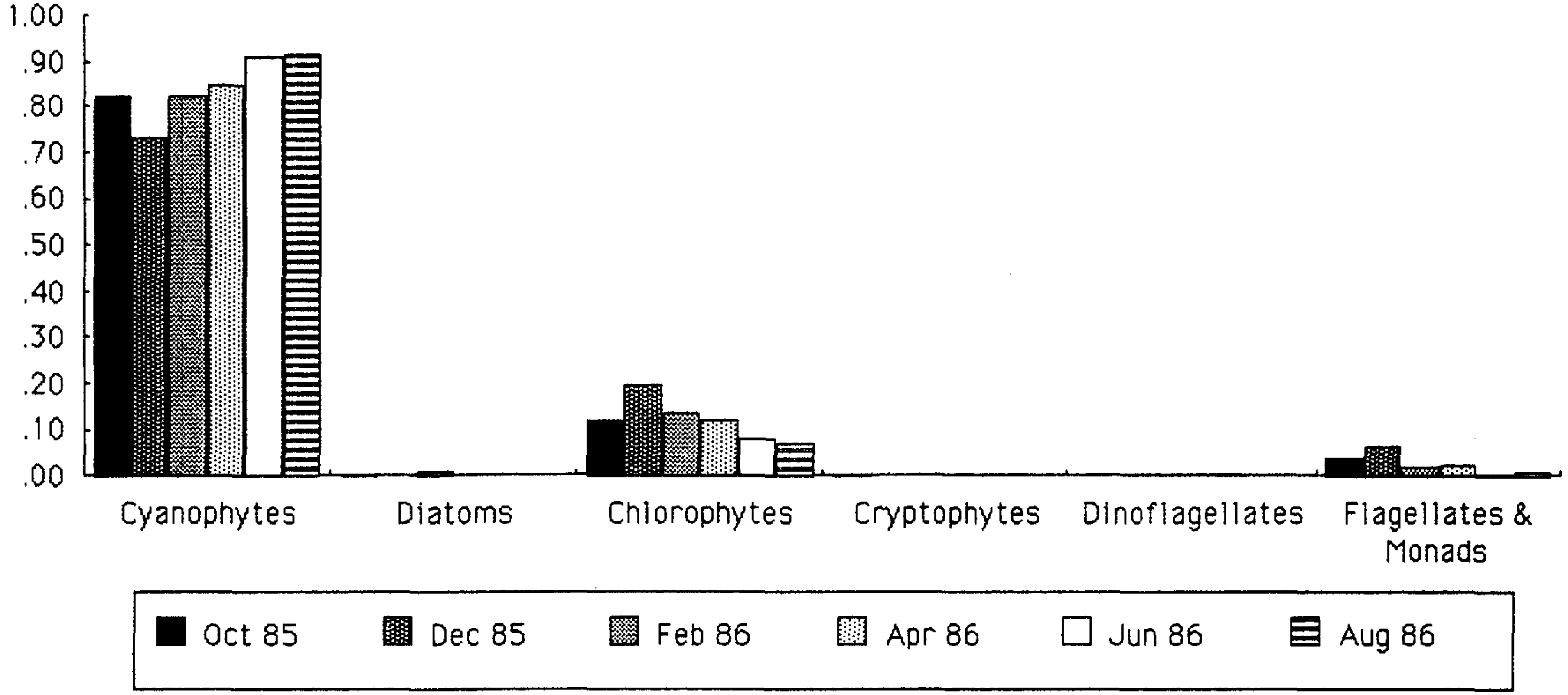


Figure 2.17. Relative total biovolume of phytoplankton taxa during the Lavaca Bay study, 1985-1986. All stations combined.

Lavaca Bay Phytoplankton 1985-86
Relative Biovolume

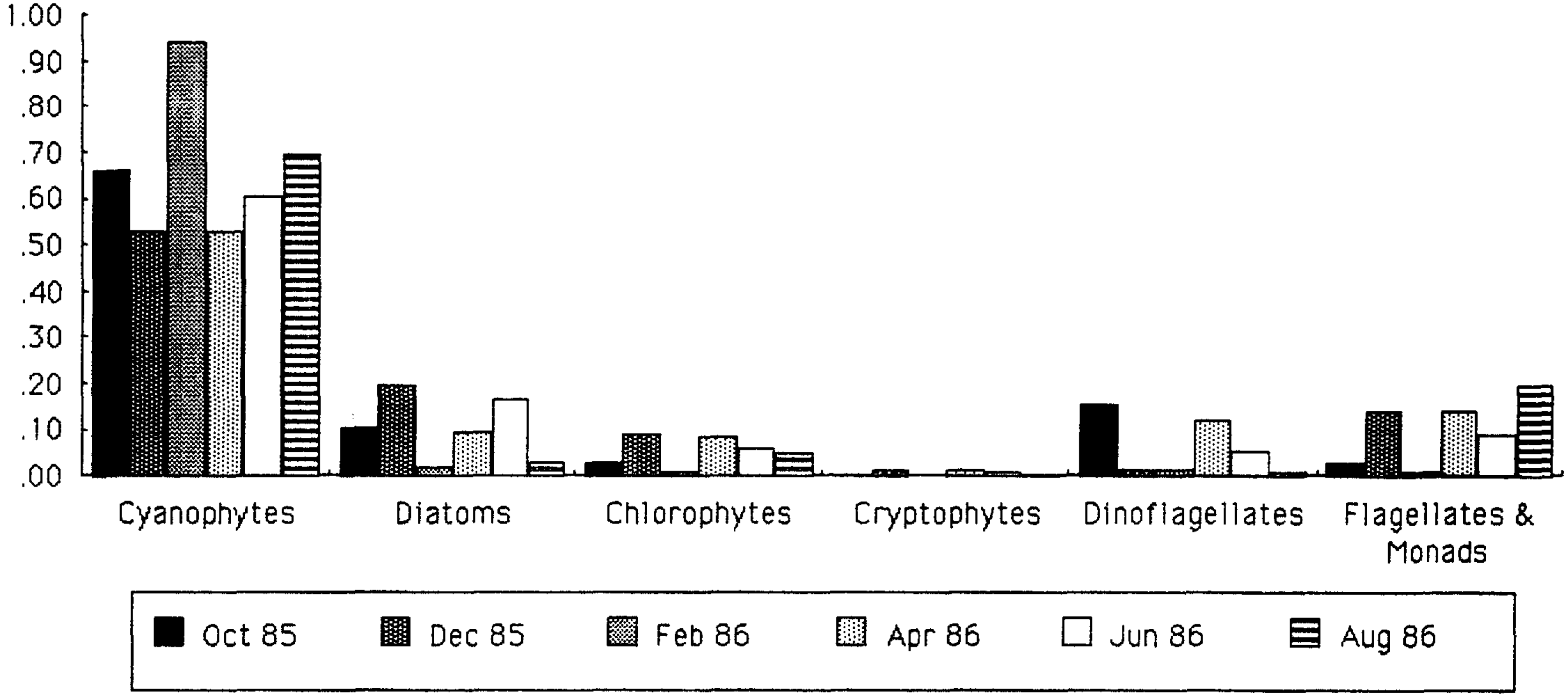


Figure 2.18. Total phosphorus (mg P/l) vs light extinction during the Lavaca Bay study. Y1 = 1984-85, Y2 = 1985-86. The extinction coefficient, k (m^{-1}), was estimated from secchi depth assuming that the depth of 1% surface irradiance is 3x the secchi depth. The equation is k = secchi depth/1.54. Regression lines are included to show the trends in each year.

Lavaca Bay - Total P vs Extinction Coefficient

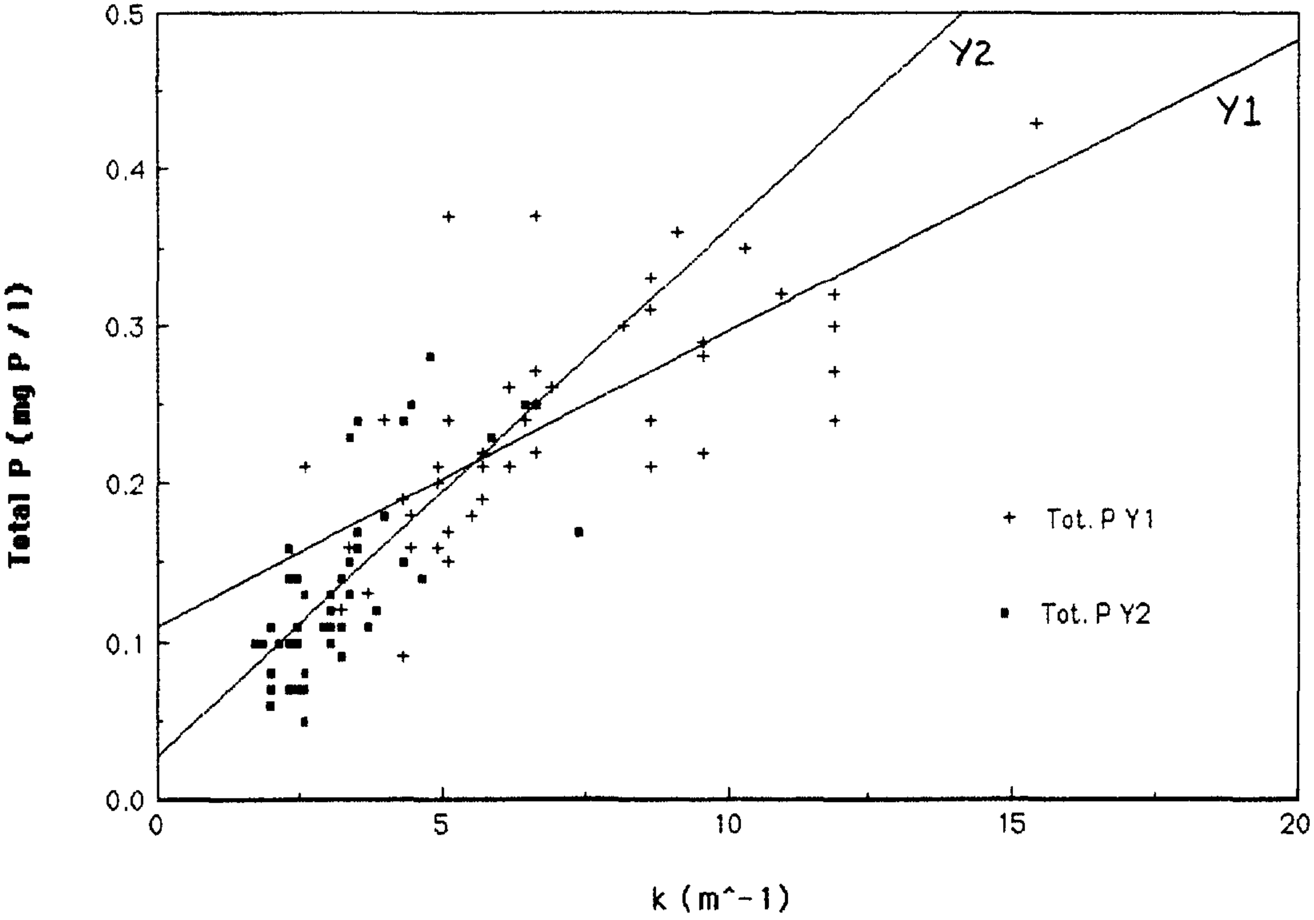
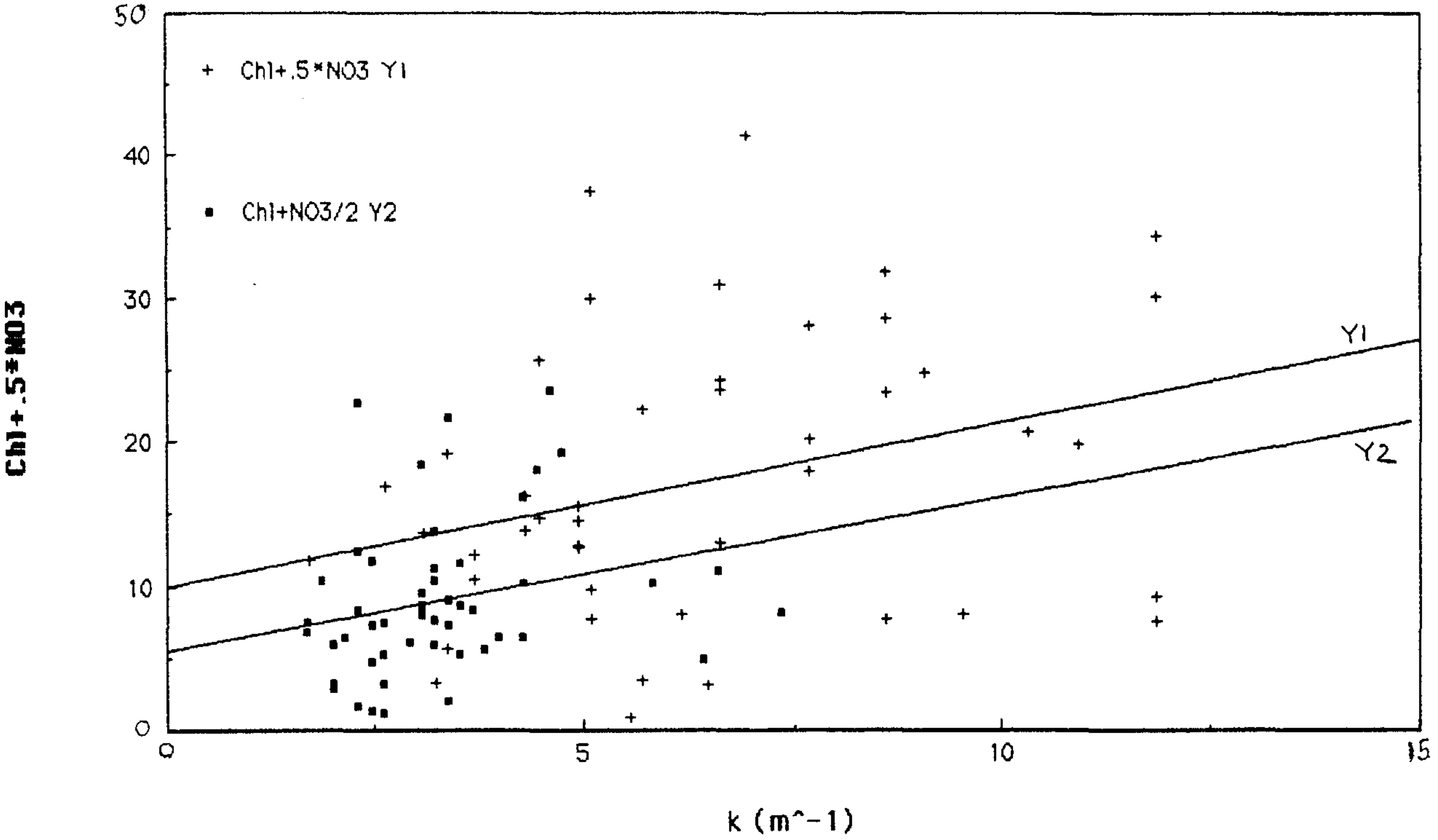
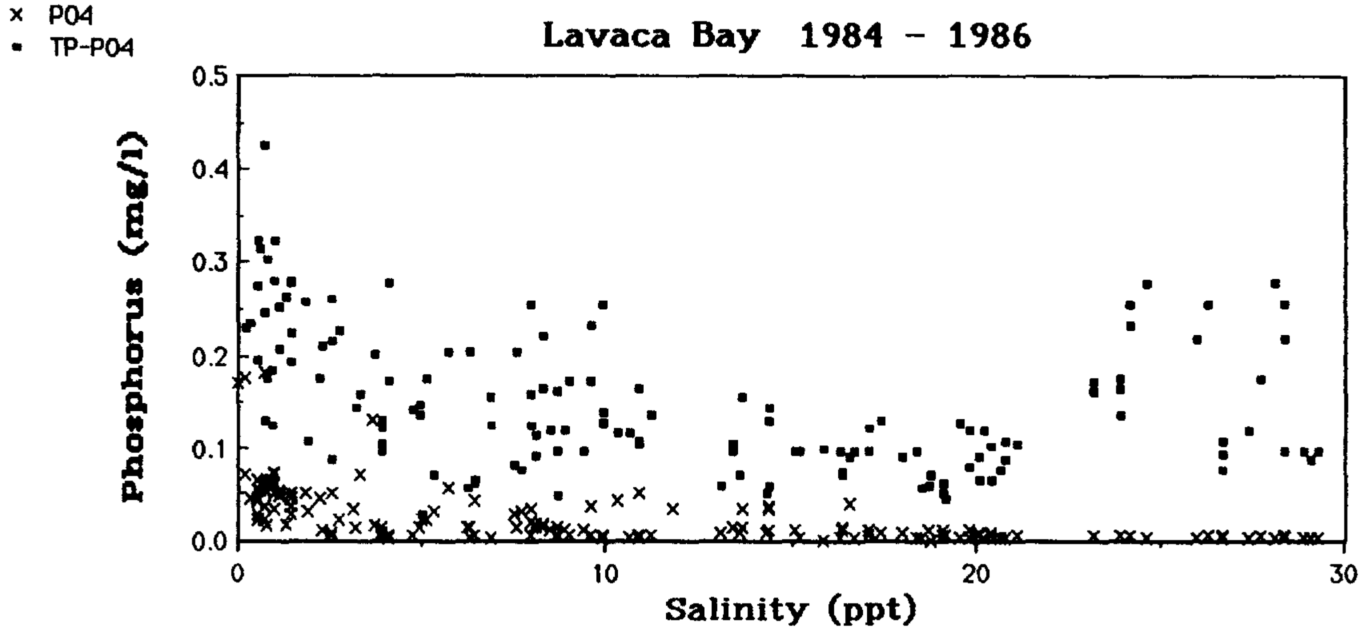


Figure 2.19. Chlorophyll (μg/l) + NO_3 (μM/2) vs light extinction during the Lavaca Bay study. Chlorophyll + NO_3 is a very rough estimate of the potential for light-dependent primary productivity in terms of nitrogen. In phytoplankton, 1 μg Chl a corresponds roughly 0.5 μmole cell nitrogen (C:Chl $\simeq$ 50; C:N $\simeq$ 7). Y1 = 1984-85, Y2 = 1985-86. The extinction coefficient, k, was estimated as in Fig. 2.18. Regression lines are included to show the (weak) trends in each year. One extreme value from Sta. 623 in March 1985 has been excluded.



Lavaca Bay - Chl (µg/l)+NO3 (µM)/2 vs k

Figure 2.20. Phosphorus and nitrogen in Lavaca Bay 1984-1986. Upper graph: x - dissolved phosphate (mg P/l), filled boxes - total phosphate (mg P/l). Lower graph: x - nitrate (mg N/l); filled boxes - total Kjeldahl nitrogen (mg N/l). Note that high phosphorus values between 23-30 ppt are from station 1505 and 1905. Human perturbation of sediments in and near the channel is a suspected influence.


× P04
▪ TP-P04
Lavaca Bay 1984 - 1986
Phosphorus (mg/l)
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
Salinity (ppt)

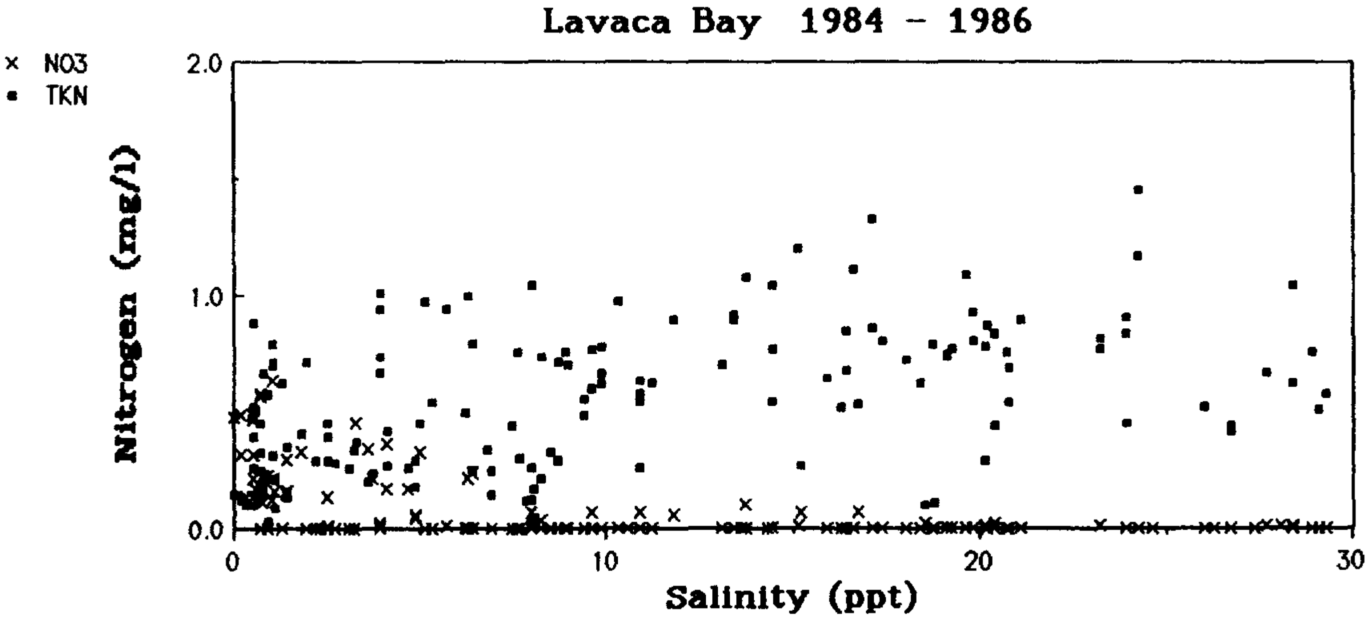

× N03
▪ TKN
Lavaca Bay 1984 - 1986
Nitrogen (mg/l)
2.0
1.0
0.0
0
10
20
30
Salinity (ppt)

Figure 2.21. Phosphorus (mg P/l) and nitrogen (mg N/l) in Lavaca Bay 1984-1986. Note that high phosphorus values between 23-30 ppt are from station 1505 and 1905. Human perturbation of sediments in and near the channel is a suspected influence.

Lavaca Bay 1984 - 1986

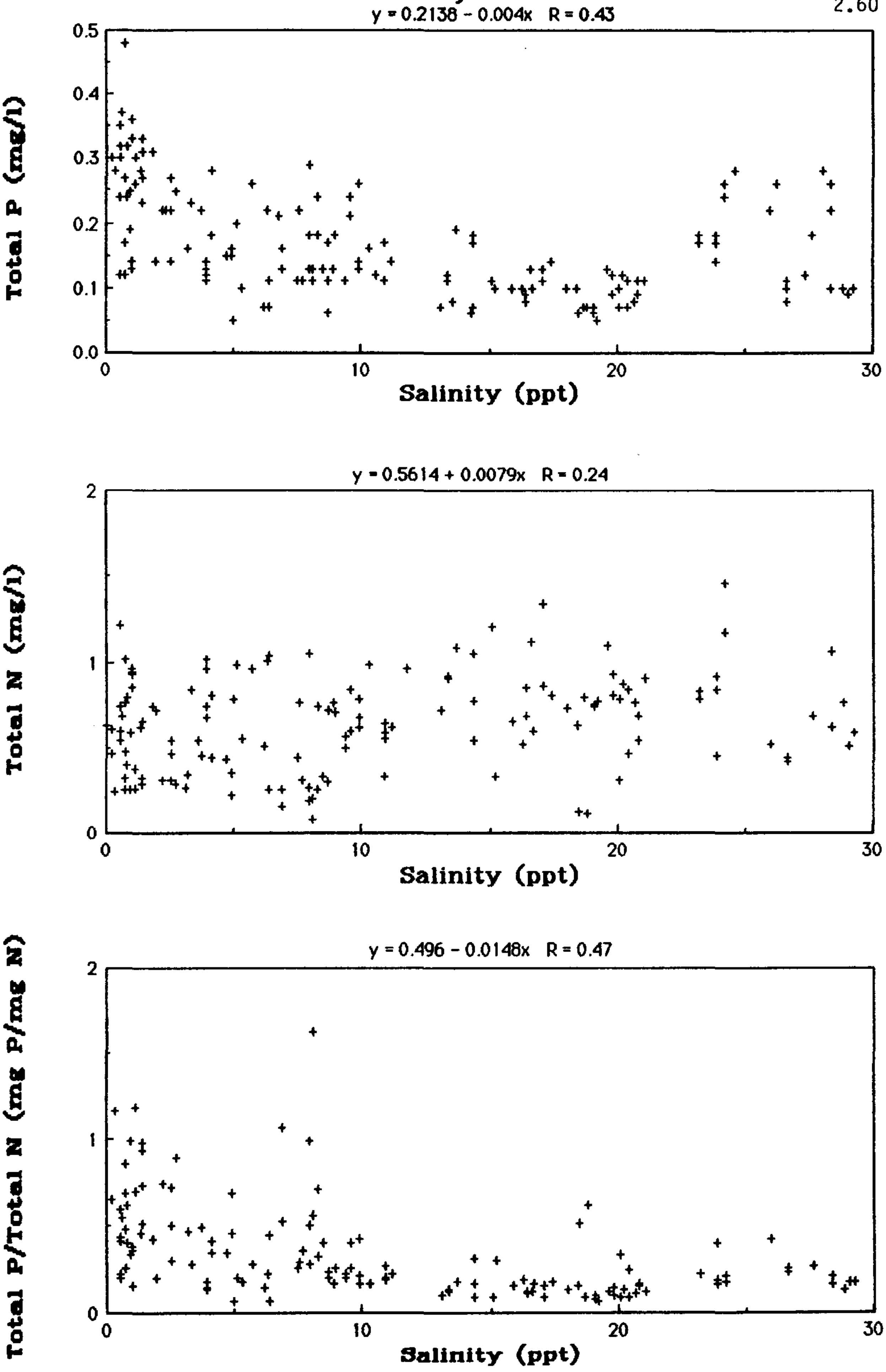


Figure 2.22. Light-limitation of primary productivity as a function of water clarity and incident irradiance, scaled to that which saturates photosynthesis. From Table 2.31 (Cullen, unpubl.). This figure shows that when the depth of the mixed layer is greater than the 1% light level ($k/z > 4.61$), photosynthesis per unit chlorophyll in the mixed layer is light-limited.

Light Limitation of Net Photosynthesis in Mixed Layers
Curves for Different Values of Io/Is

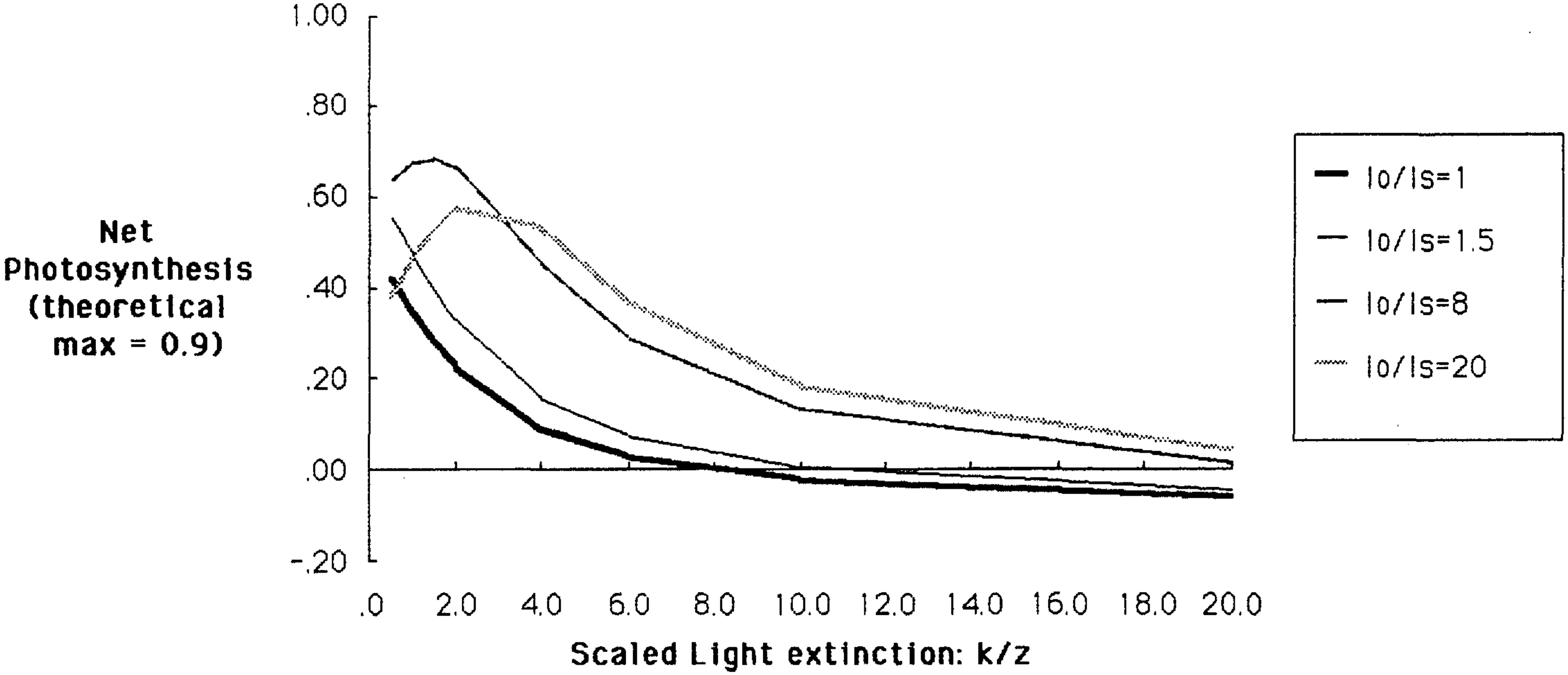
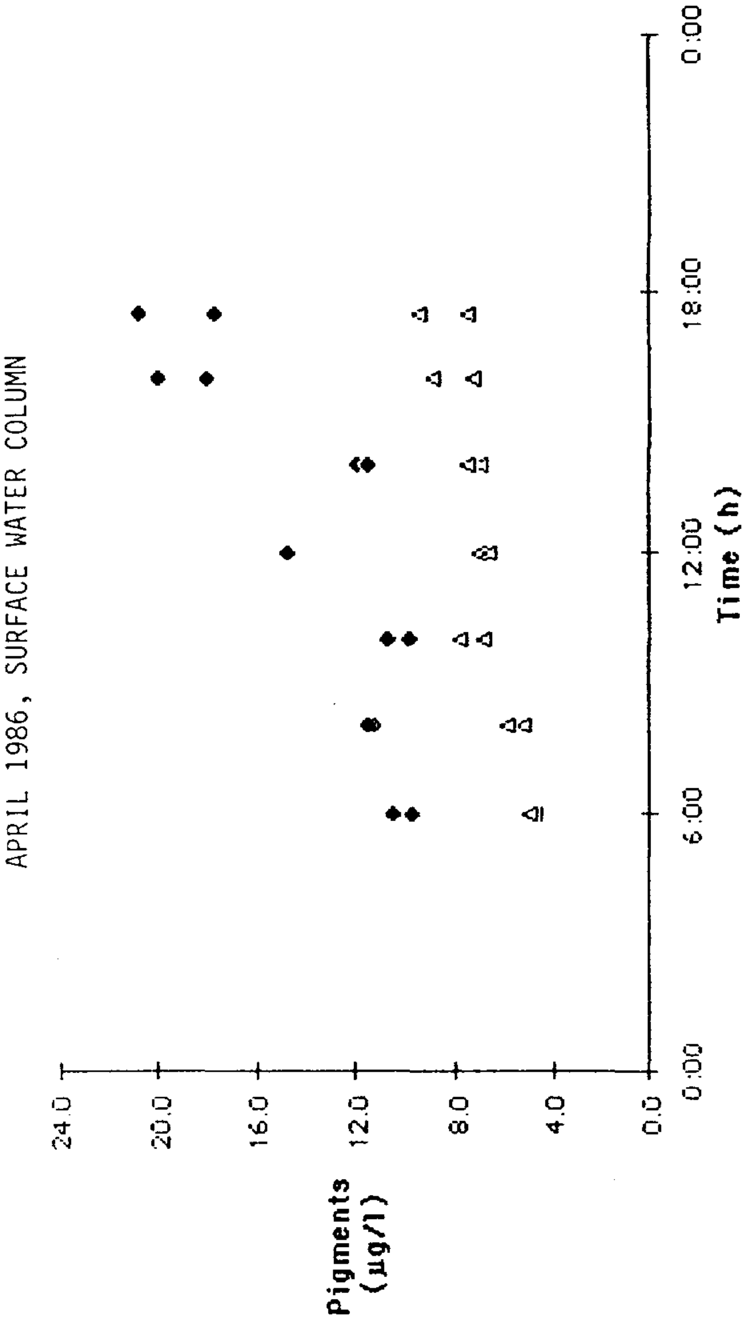
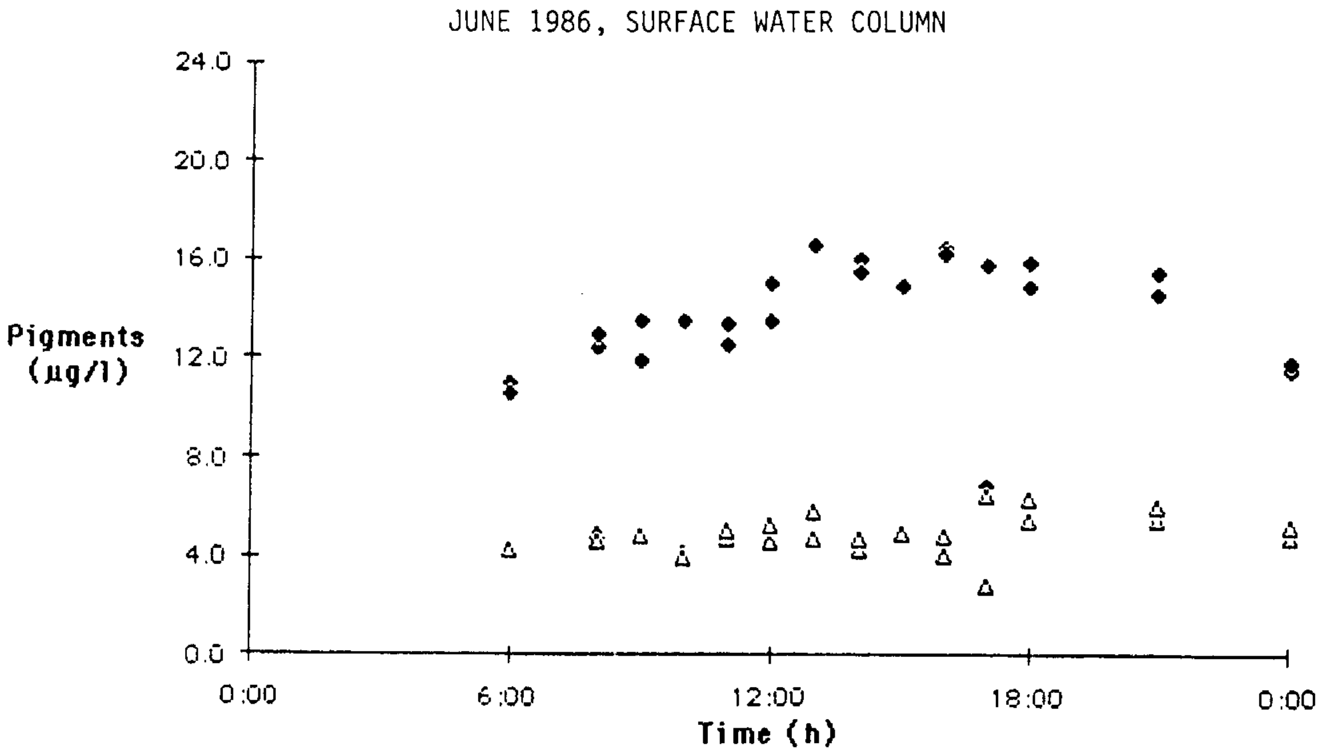


Figure 2.23. Chlorophyll (filled diamonds) and pheopigment (open triangles) at Station 85 at the surface on April 9, 1986. From Davis, 1986.



APRIL 1986, SURFACE WATER COLUMN

Figure 2.24. Chlorophyll (filled diamonds) and pheopigment (open triangles) at Station 85 at the surface on June 6, 1986. From Davis, 1986.


JUNE 1986, SURFACE WATER COLUMN
Pigments (µg/l)
24.0
20.0
16.0
12.0
8.0
4.0
0.0
0:00
6:00
12:00
18:00
0:00
Time (h)

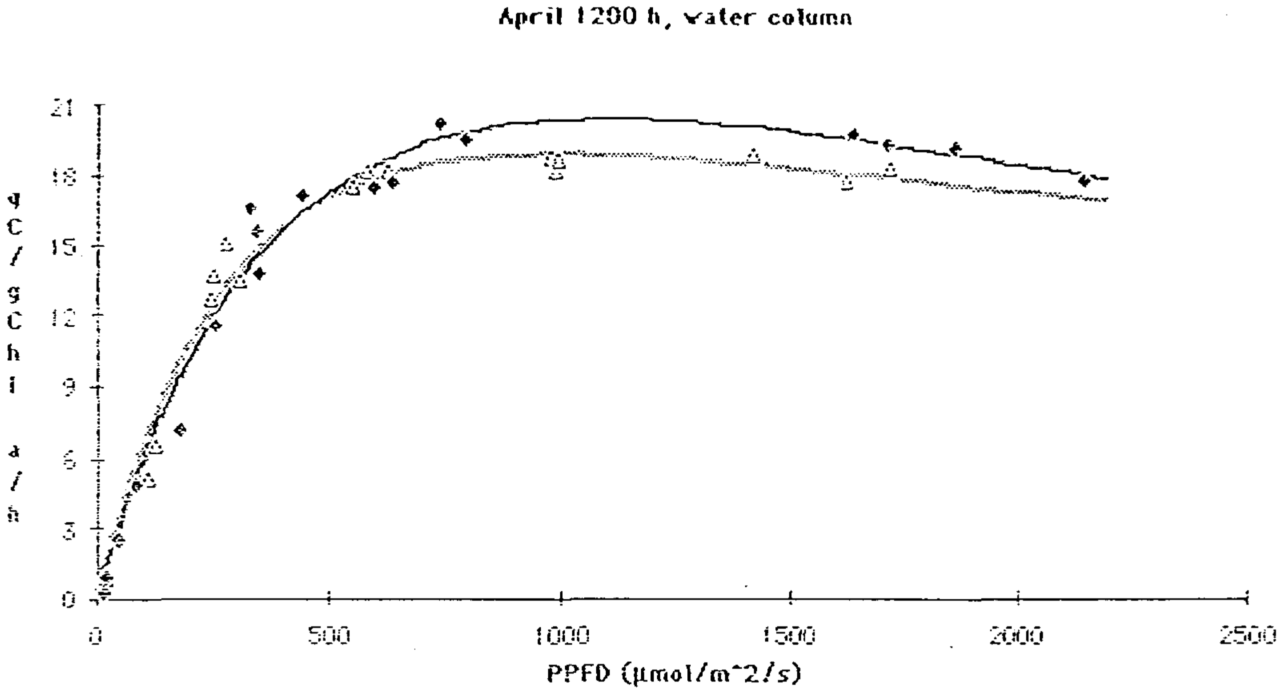
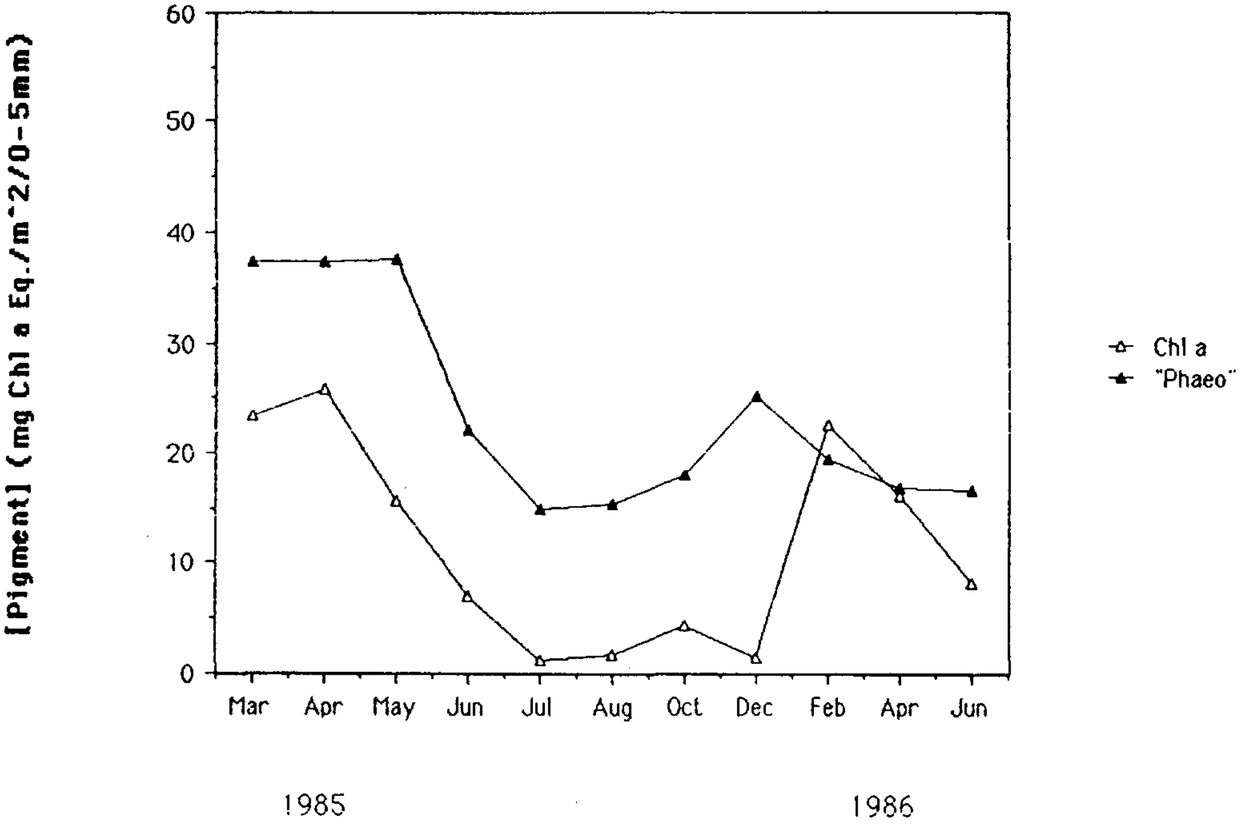


Figure 2.25. Photosynthetic performance of phytoplankton at station 85 in April 1986. From Davis (1986). Photosynthesis vs. irradiance was determined for samples from the surface (triangles) and bottom (1.4 m; filled diamonds). These data and other measurements showed that the water column was uniform with respect to phytoplankton biomass and physiological capacity and that rates of photosynthesis were inconsistent with severe nutrient-limitation of growth rate. Data such as these can be used to model light-limitation of primary production and to estimate daily primary production in a turbid estuary (Davis *et al.*, in prep.).

Figure 2.26. Pigments associated with the microphytobenthos at stations 613 and 623. Data collected by H.L. MacIntyre. Pigments determined fluorometrically after extraction in acetone. Pigment data collected in this manner must be intrepeted cautiously. These figures show that benthic pigment can vary consistently between stations and that the amount of pigment in the upper 5 mm of sediment is similar in magnitude to the amount in the overlying water.

Seasonal Variation in Pigments, LVB613



Seasonal variation in Pigments, LVB623

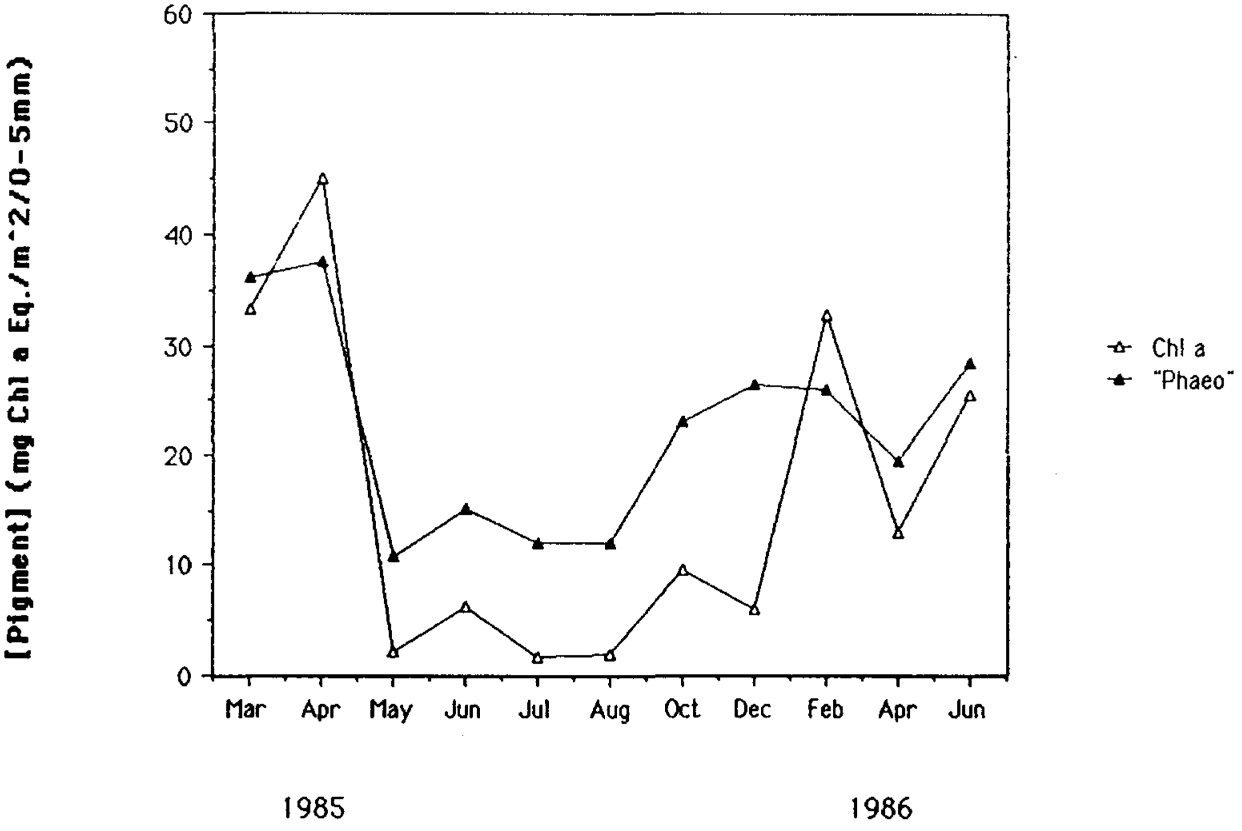
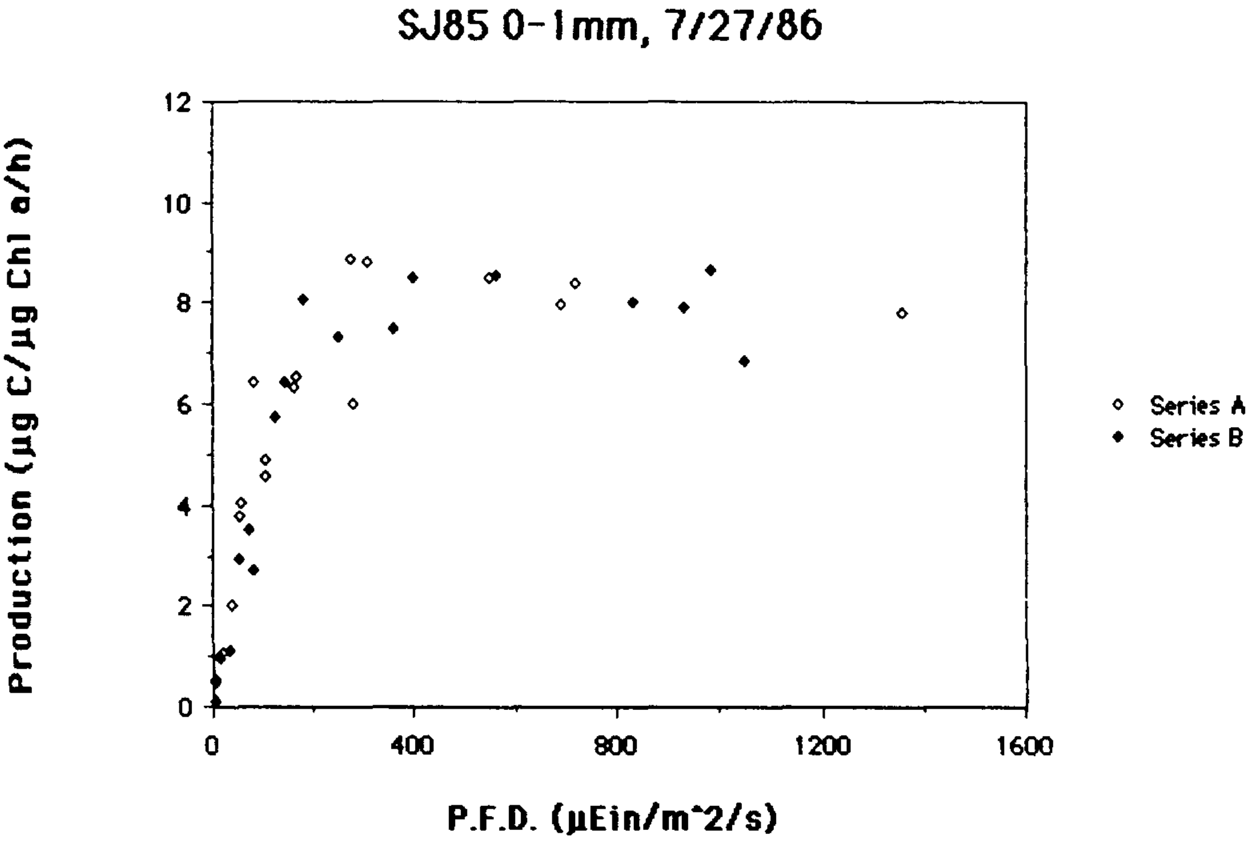


Figure 2.27. Photosynthetic performance of the microphytobenthos. Photosynthesis vs irradiance for two adjacent samples of sediment, 0-1 mm. Autotrophic potential is demonstrated. Similar results have been obtained for sections of sediment deeper than 5 mm. (MacIntyre, in prep).


SJ85 0-1mm, 7/27/86
Production (µg C/µg Chl a/h)
0
2
4
6
8
10
12
0
400
800
1200
1600
P.F.D. (µEin/m^2/s)
◇ Series A
◆ Series B

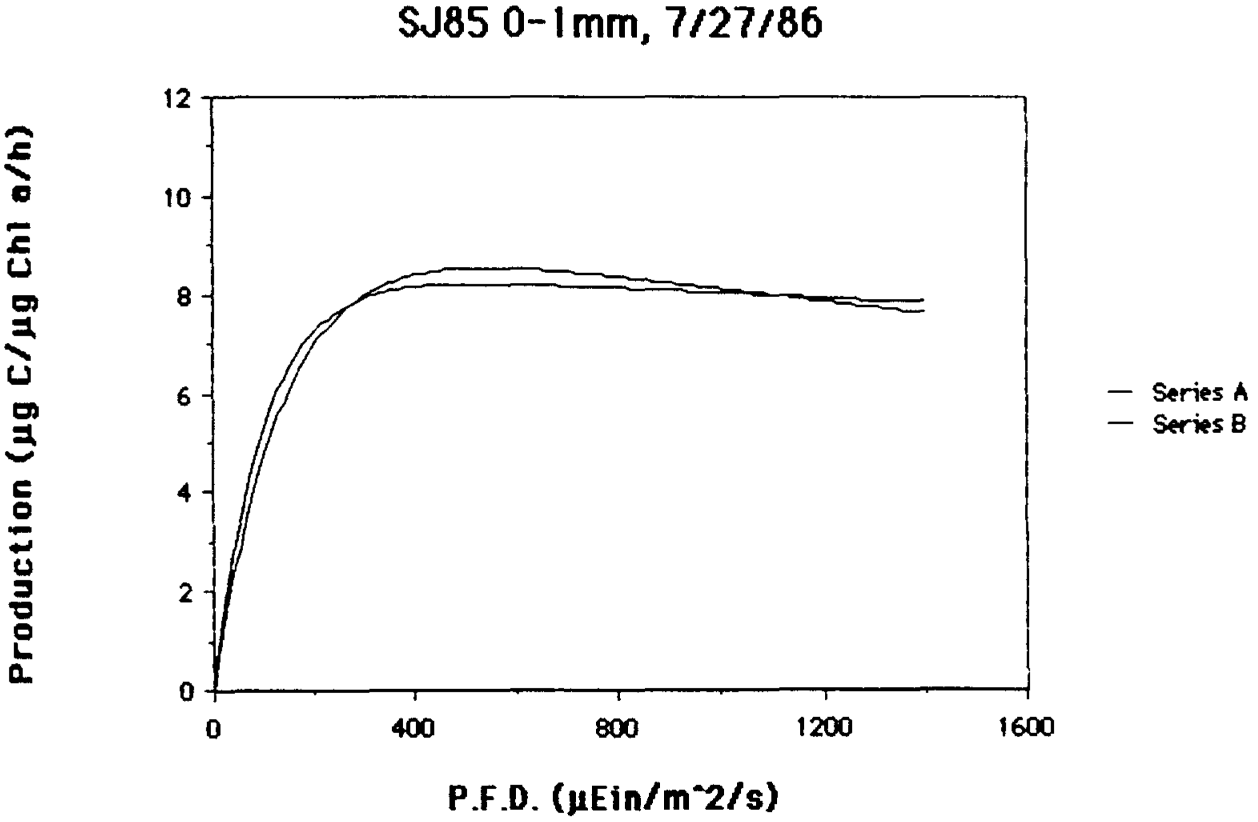

SJ85 0-1mm, 7/27/86
Production (µg C/µg Chl a/h)
0
2
4
6
8
10
12
0
400
800
1200
1600
P.F.D. (µEin/m^2/s)
— Series A
— Series B

Table 2.1

LAVACA BAY 1984 - 1986
Comparison of Year 1 vs Year 2
Nonparametric Mann-Whitney U Test
(stations 1505 and 1905 excluded from this analysis)

	1984 - 1985 Median	1985 - 1986 Median	Significance
Air Temperature (°C)	24.0	27.6	**
Water Temperature (°C)	24.8	25.5	ns
Salinity (ppt)	2.50	9.13	***
Secchi Depth (cm)	24.5	47.3	***
pH	8.10	8.22	*
Dissolved Oxygen (mg/l)	9.00	8.80	ns
Ammonium (mg/l)	.004	.007	.10>p>.05
Nitrite (mg/l)	.001	.000	***
Nitrate (mg/l)	.017	.001	***
Phosphate (mg/l)	.035	.008	***
Total Kjeldahl Nitrogen (mg/l)	.400	.585	*
Total Phosphate mg/l)	.217	.115	***
Chlorophyll a (µg/l)	9.84	6.34	**
Pheopigment (µg/l)	4.60	2.68	***

The symbols indicate the probablility level. No correction for multiple testing has been applied.

*	<.05
**	<.01
***	<.001

Table 2.2

LAVACA BAY 1984 - 1986
2-Way Analysis of Variance
(nonparametric)

	By Months		By Stations	
	1984-85	1985-86	1984-85	1985-86
Temperature	***	***	ns	+
Salinity	**	***	**	***
Secchi Depth	.10>p>.05	**	ns	ns
pH	*	*	ns	ns
Dissolved Oxygen	**	***	ns	+
Ammonium	**	***	--	ns
Nitrite	***	ns	ns	ns
Nitrate	***	*	ns	ns
Phosphate	**	***	.10>p>.05 (+)	+++
Total Kjeldahl Nitrogen	***	.10>p>.05	--	ns
Total Phosphate	ns	**	+	ns
Chlorophyll a	ns	.10>p>.05	+	+
Pheopigment	ns	ns	+	ns

"+" means the quantity is higher at the stations more affected by freshwater.
"-" means the quantity is lower at the stations more affected by freshwater.
The number of symbols indicates the probablility level, correcting for making two tests for each analysis.

*	<.05
**	<.01
***	<.001

Table 2.3
Lavaca Bay
CONDUCTIVITY AND SALINITY 1984 - 1985

Measurements on the day of Nutrient Sampling

Note: values from 1905 and 1505 in April are questionable.

mmho/cm

	November	January	March	April	May	June	July	August
45	4.8	.6	2.5	6.1	.5	1.5	1.3	6.0
603	5.8	.2	1.2	1.1	.7	2.0	2.7	9.0
65	6.5	1.8	1.2	1.1	1.5	4.8	4.4	17.0
613	13.1	7.5	5.5	1.8	4.8	3.7	13.0	23.0
623	14.9	20.0	8.4	2.8	2.8	10.0	14.0	23.0
633			12.5	2.2	1.6	13.5	11.0	22.0
85	12.5	21.5	10.0	3.6	6.8	16.0	15.0	26.0
1505				21.9			30.5	
1905				10.9			31.7	

Salinity algorithm: S (ppt)= a*(C^b) where C is conductivity
(determined by log regression of conductivity
vs salinity in laboratory calibration)

	a	b
Up to March	0.3708	1.129
After March	0.4321	1.119

Salinity ppt

	November	January	March	April	May	June	July	August	Average	s.d.
45	2.2	.2	1.0	3.3	.2	.7	.6	3.2	1.42	1.28
603	2.7	.0	.5	.5	.3	.9	1.3	5.1	1.40	1.69
65	3.1	.7	.5	.5	.7	2.5	2.3	10.3	2.55	3.29
613	6.6	3.6	2.5	.8	2.5	1.9	7.6	14.4	5.02	4.48
623	7.9	10.9	4.1	1.4	1.4	5.7	8.3	14.4	6.75	4.57
633			6.4	1.0	.7	8.0	6.3	13.7	6.03	4.82
85	6.4	11.8	5.0	1.8	3.7	9.6	8.9	16.6	7.98	4.78
1505				13.7			19.8			
1905				6.3			20.7			
Average	4.83	4.55	2.86	1.33	1.35	4.18	5.05	11.10	**4.39**	
s.d.	2.46	5.45	2.37	.98	1.30	3.58	3.55	5.14		**4.36**

(note: stations 1505 and 1905 excluded from averages)

Table 2.4
Lavaca Bay
HYDROGRAPHIC PARAMETERS 1984 - 1985

Temp.°C

	November	January	March	April	May	June	July	August	Average	s.d.
45	14.9	6.8	15.2	24.8	26.3	26.5	32.3	31.3	22.22	9.00
603	14.7	5.5	16.1	24.8	27.0	27.0	32.0	31.0	22.24	9.25
65	15.5	5.2	16.1	22.5	26.0	27.3	31.8	30.3	21.82	8.99
613	16.3	6.0	17.8	24.3	26.3	27.5	30.5	30.5	22.39	8.48
623	14.6	6.5	16.5	17.5	27.0	30.0	28.8	30.0	21.35	8.79
633			17.0	21.0	25.8	28.0	28.3	28.5	24.75	4.73
85	14.9	6.3	16.3	20.3	25.0	28.0	28.8	29.8	21.14	8.28
1505			16.5	20.8			31.0		22.77	7.45
1905	15.1		16.4	22.7			30.5		21.18	7.05
Average	15.11	6.03	16.42	22.06	26.17	27.75	30.42	30.18	**22.14**	
s.d.	.61	.59	.72	2.41	.69	1.13	1.51	.91		**7.84**

Dissolved Oxygen, mg/l

	November	January	March	April	May	June	July	August	Average	s.d.
45	9.2	13.5	9.2	8.6	6.8	7.5	11.0	9.0	9.35	2.09
603	9.1	14.4	9.8	10.4	7.2	8.5	11.0	9.0	9.93	2.15
65	9.4	13.6	9.4	10.8	8.6	8.4	10.6	7.4	9.78	1.91
613	8.9	16.2	10.6	10.4	10.4	9.1	8.5	9.2	10.41	2.47
623	9.0	16.6	13.0	8.4	7.8	8.1	7.5	8.2	9.83	3.25
633			10.6	8.0	7.2	7.7	7.3	7.8	8.09	1.27
85	9.2	15.8	9.1	9.2	8.0	7.2	6.5	7.7	9.09	2.89
1505			8.2	8.4			6.3		7.63	1.16
1905	10.2		8.5	8.5			6.1		8.33	1.69
Average	9.29	15.02	9.82	9.19	8.00	8.06	8.31	8.33	**9.37**	
s.d.	.43	1.36	1.45	1.06	1.22	.66	2.05	.73		**2.31**

*St 45 is 8/17

Table 2.5

Lavaca Bay
HYDROGRAPHIC PARAMETERS 1984 - 1985

pH

	November	January	March	April	May	June	July	August	Average	s.d.
45	8.3	8.3	8.0	8.0	7.6	7.9		8.1	8.00	.23
603	8.6	8.4	8.5	8.2	6.9	7.9		8.1	8.06	.56
65	8.4	8.5	8.1	7.9	7.3	7.9		8.1	8.02	.37
613	8.3	8.4	8.2	8.5	8.4	7.9		8.1	8.24	.19
623	8.4	7.2	8.9	7.4	8.0	7.9		8.1	7.97	.56
633			8.8	8.0	7.7	8.0		8.1	8.08	.41
85	8.2	9.0	8.4	8.1	8.2	8.0		8.1	8.26	.35
1505			7.9	8.4			7.5		7.93	.45
1905	8.3		8.0	8.3			7.2		7.95	.52
Average	8.34	8.27	8.29	8.07	7.72	7.91	7.35	8.09	**8.07**	
s.d.	.14	.59	.34	.32	.51	.02	.21	.02		**.40**

Secchi Depth, cm

	November	January	March	April	May	June	July	August	Average	s.d.
45	60	20	23	23	19	36	17	34	29.0	14.3
603	30	20	30	18	16	31	23	31	24.9	6.3
65	41	20	18	18	25	42	31	35	28.8	9.9
613	18	45	22	13	27	31	23	30	26.1	9.7
623	52	50	39	15	16	13	24	28	29.6	15.6
633			30	14	10	13	25	27	19.8	8.5
85	45	90	36	13	27	16	47	47	40.1	24.2
Average	41.0	40.8	28.3	16.3	20.0	26.0	27.1	33.1	**28.6**	
s.d.	15.2	27.6	7.7	3.6	6.5	11.9	9.7	6.8		**14.4**

Table 2.6

Lavaca Bay
DISSOLVED AMMONIUM 1984 - 1985

Replicate A mg/l

Station	November	January	March	April	May	June	July	August
45	.011	.075	.040	.002	.004	.004	.007	.003
603	.007	.044	.009	.001	.003	.002	.004	.002
65	.006	.085	.016	.001	.002	.002	.003	.004
613		.012	.006	.000	.000	.000	.003	.002
623		.006	.003	.000	.003	.022	.005	.003
633			.003	.000	.014	.010	.004	.002
85	.013	.007	.006	.001	.013	.052	.007	.021
1505				.000	.001	.015	.019	.032
1905	.004			.001	.014	.042	.050	.075

Replicate B mg/l

Station	November	January	March	April	May	June	July	August
45	.006	.073	.030	.000	.004	.012	.005	.001
603	.013	.039	.013	.000	.002	.002	.002	.002
65	.009	.083	.017	.000	.003	.001	.003	.001
613	.009	.013	.007	.000	.000	.000	.002	.006
623	.019	.005	.008	.000	.002	.015	.003	.003
633			.002	.000	.004	.013	.003	.008
85	.007	.005	.004	.001	.011	.042	.002	.003
1505								
1905	.004							

Mean mg/l

Station	November	January	March	April	May	June	July	August	Average	s.d.
45	.008	.074	.035	.001	.004	.008	.006	.002	.017	.024
603	.010	.042	.011	.001	.002	.002	.003	.002	.009	.013
65	.008	.084	.017	.000	.002	.001	.003	.002	.015	.028
613	.009	.013	.006	.000	.000	.000	.002	.004	.004	.004
623	.019	.006	.005	.000	.002	.019	.004	.003	.007	.007
633			.003	.000	.009	.011	.004	.005	.005	.005
85	.010	.006	.005	.001	.012	.047	.004	.012	.012	.015
1505				.000	.001	.015	.019	.032	.013	.013
1905	.004			.001	.014	.042	.050	.075	.031	.029
Average	.010	.037	.012	.001	.005	.016	.010	.015	**.011**	
s.d.	.005	.033	.011	.001	.005	.017	.012	.019		**.017**

Mean µg-at/l

Station	November	January	March	April	May	June	July	August	Average	s.d.
45	.59	5.26	2.47	.09	.28	.58	.41	.16	1.23	1.75
603	.72	2.98	.79	.04	.17	.12	.19	.14	.64	.96
65	.55	6.01	1.18	.03	.16	.09	.19	.16	1.05	1.97
613	.62	.90	.45	.02	.03	.00	.17	.29	.31	.32
623	1.38	.42	.39	.01	.17	1.33	.27	.21	.52	.49
633			.19	.02	.67	.81	.25	.36	.38	.34
85	.71	.42	.36	.10	.83	3.37	.31	.85	.87	1.05
1505				.02	.09	1.06	1.38	2.26	.96	.94
1905	.26			.04	.97	2.99	3.55	5.38	2.20	2.07
Average	.69	2.66	.83	.04	.38	1.15	.75	1.09	**.75**	
s.d.	.33	2.38	.78	.04	.35	1.20	.86	1.37		**1.22**

Table 2.7
Lavaca Bay
NITRITE 1984 - 1985

Replicate A mg/l

Station	November	January	March	April	May	June	July	August
45	.000	.004	.005	.009	.012	.002	.004	.001
603	.000	.006	.005	.005	.003	.001	.001	.001
65	.000	.008	.006	.008	.002	.001	.000	.001
613		.005	.004	.007	.000	.001	.001	.001
623		.007	.023	.006	.001	.002	.001	.001
633			.007	.012	.001	.001	.000	.001
85	.001	.002	.011	.006	.001	.003	.000	.001
1505				.015	.000	.001	.000	.000
1905	.001			.010	.000	.000	.000	.000

Replicate B mg/l

Station	November	January	March	April	May	June	July	August
45	.000	.004	.006	.008	.012	.002	.004	.001
603	.001	.006	.005	.005	.003	.001	.001	.001
65	.000	.007	.005	.009	.002	.001	.000	.001
613	.000	.005	.004	.005	.001	.001	.001	.001
623	.001	.004	.035	.007	.001	.001	.001	.001
633		.014	.008	.009	.001	.001	.000	.001
85	.001	.001	.007	.007	.001	.003	.000	.000
1505								
1905	.000							

Mean mg/l

Station	November	January	March	April	May	June	July	August	Average	s.d.
45	.000	.004	.006	.009	.012	.002	.004	.001	.005	.004
603	.000	.006	.005	.005	.003	.001	.001	.001	.003	.002
65	.000	.007	.005	.008	.002	.001	.000	.001	.003	.003
613	.000	.005	.004	.006	.000	.000	.001	.001	.002	.002
623	.001	.005	.029	.006	.001	.002	.001	.001	.006	.010
633			.007	.010	.001	.001	.000	.001	.004	.005
85	.001	.002	.009	.007	.001	.003	.000	.001	.003	.003
1505				.015	.000	.001	.000	.000	.003	.007
1905	.001			.010	.000	.000	.000	.000	.002	.004
Average	.001	.005	.009	.009	.002	.001	.001	.001	**.004**	
s.d.	.001	.003	.009	.003	.004	.001	.001	.000		**.005**

Mean µg-at/l

Station	November	January	March	April	May	June	July	August	Average	s.d.
45	.00	.31	.40	.61	.85	.12	.27	.06	.33	.28
603	.03	.41	.37	.37	.21	.08	.07	.06	.20	.16
65	.01	.53	.39	.59	.12	.05	.02	.05	.22	.24
613	.01	.37	.29	.44	.03	.00	.06	.04	.15	.17
623	.10	.39	2.05	.45	.07	.12	.06	.04	.41	.70
633			.53	.74	.08	.10	.02	.04	.25	.35
85	.05	.11	.63	.48	.09	.22	.02	.04	.21	.23
1505				1.08	.00	.06	.02	.02	.24	.47
1905	.04			.71	.00	.02	.02	.02	.14	.26
Average	.04	.35	.66	.61	.16	.09	.06	.04	**.26**	
s.d.	.04	.22	.62	.19	.27	.06	.08	.02		**.35**

Table 2.8
Lavaca Bay
NITRATE 1984 - 1985

Replicate A mg/l

Station	November	January	March	April	May	June	July	August
45	.004	.487	.633	.458	.315	.002	.172	.001
603	.003	.480	.490	.219	.139	.001	.001	.001
65	.002	.584	.470	.316	.128	.002	.001	.002
613		.341	.141	.118	.012	.000	.000	.003
623		.063	.364	.296	.159	.015	.001	.000
633			.235	.220	.568	.010	.000	.000
85	.001	.059	.328	.324	.213	.064	.001	.000
1505				.099	.006	.005	.002	.002
1905	.000			.218	.006	.005	.002	.000

Replicate B mg/l

Station	November	January	March	April	May	June	July	August
45	.001	.493	.604	.462	.292	.038	.164	.001
603	.001	.490	.514	.192	.145	.001	.001	.000
65	.002	.577	.496	.331	.139	.006	.001	.002
613	.002	.359	.129	.171	.010	.001	.000	.001
623	.000	.033	.501	.316	.212	.014	.000	.000
633			.245	.238	.441	.015	.001	.000
85	.001	.053	.268	.369	.265	.029	.000	.000
1505								
1905	.001							

Mean mg/l

Station	November	January	March	April	May	June	July	August	Average	s.d.
45	.003	.490	.618	.460	.304	.020	.168	.001	.258	.237
603	.002	.485	.502	.205	.142	.001	.001	.000	.167	.208
65	.002	.581	.483	.323	.133	.004	.001	.002	.191	.231
613	.002	.350	.135	.145	.011	.000	.000	.002	.081	.124
623	.000	.048	.433	.306	.185	.015	.001	.000	.123	.166
633			.240	.229	.505	.013	.001	.000	.164	.194
85	.001	.056	.298	.346	.239	.046	.000	.000	.123	.142
1505				.099	.006	.005	.002	.002	.023	.043
1905	.000			.218	.006	.005	.002	.000	.039	.082
Average	.001	.335	.387	.259	.170	.012	.019	.001	**.148**	
s.d.	.001	.220	.165	.107	.160	.017	.057	.001		**.188**

Mean µg-at/l

Station	November	January	March	April	May	June	July	August	Average	s.d.
45	.19	34.97	44.17	32.87	21.69	1.43	12.02	.10	18.43	16.96
603	.13	34.61	35.86	14.67	10.12	.06	.06	.02	11.94	14.89
65	.14	41.47	34.47	23.10	9.53	.28	.06	.16	13.65	16.50
613	.14	24.98	9.65	10.35	.80	.00	.00	.14	5.75	8.84
623	.02	3.45	30.91	21.89	13.23	1.05	.04	.00	8.82	11.88
633			17.14	16.35	36.05	.90	.06	.00	11.75	13.85
85	.08	4.00	21.27	24.73	17.08	3.30	.03	.00	8.81	10.16
1505				7.11	.41	.35	.11	.13	1.62	3.07
1905	.04			15.59	.46	.35	.11	.02	2.76	5.83
Average	.11	23.91	27.64	18.52	12.15	.86	1.39	.06	**10.54**	
s.d.	.08	15.74	11.79	7.61	11.41	1.24	4.09	.07		**13.43**

Table 2.9

Lavaca Bay
DISSOLVED PHOSPHATE 1984 - 1985

Replicate A mg/l

Station	November	January	March	April	May	June	July	August
45	.045	.177	.035	.071	.070	.038	.054	.015
603	.022	.170	.027	.045	.045	.066	.017	.023
65	.034	.182	.024	.043	.023	.052	.010	.043
613		.131	.008	.017	.005	.031	.015	.038
623		.052	.003	.052	.028	.056	.017	.035
633			.007	.050	.053	.035	.015	.035
85	.044	.034	.023	.052	.018	.038	.010	.040
1505				.013	.000	.016	.010	.030
1905				.003	.008	.016	.002	.025

Replicate B mg/l

Station	November	January	March	April	May	June	July	August
45	.025	.200	.034	.073	.080	.040	.052	.015
603	.026	.183	.024	.036	.043	.068	.015	.020
65	.027	.193	.023	.034	.025	.026	.010	.043
613	.046	.150	.010	.024	.005	.028	.012	.043
623	.037	.040	.003	.041	.020	.061	.017	.013
633			.010	.045	.046	.038	.020	.043
85	.042	.018	.022	.052	.020	.042	.012	.103
1505								
1905								

Mean mg/l

Station	November	January	March	April	May	June	July	August	Average	s.d.
45	.035	.189	.034	.072	.075	.039	.053	.015	.064	.053
603	.024	.177	.026	.041	.044	.067	.016	.021	.052	.051
65	.031	.187	.023	.038	.024	.039	.010	.043	.049	.055
613	.046	.141	.009	.021	.005	.029	.014	.040	.038	.044
623	.037	.046	.003	.046	.024	.059	.017	.024	.032	.019
633			.008	.048	.050	.036	.017	.039	.033	.016
85	.043	.026	.023	.052	.019	.040	.011	.071	.036	.023
1505				.013	.000	.016	.010	.030	.014	.011
1905				.003	.008	.016	.002	.025	.011	.010
Average	.036	.128	.018	.037	.028	.038	.017	.034	**.041**	
s.d.	.009	.070	.011	.019	.024	.016	.014	.021		**.041**

Mean µg-at/l

Station	November	January	March	April	May	June	July	August	Average	s.d.
45	1.13	6.09	1.11	2.33	2.43	1.25	1.71	.48	2.07	1.70
603	.78	5.70	.83	1.31	1.42	2.16	.52	.69	1.67	1.65
65	.98	6.03	.75	1.24	.77	1.25	.32	1.37	1.59	1.78
613	1.49	4.53	.29	.67	.16	.95	.44	1.29	1.23	1.42
623	1.18	1.49	.09	1.50	.77	1.90	.56	.77	1.03	.62
633			.26	1.54	1.62	1.18	.56	1.25	1.07	.53
85	1.39	.84	.73	1.69	.61	1.29	.36	2.30	1.15	.73
1505				.41	.00	.53	.32	.97	.44	.35
1905				.11	.24	.53	.08	.81	.35	.31
Average	1.16	4.11	.58	1.20	.89	1.23	.54	1.10	**1.33**	
s.d.	.30	2.27	.36	.62	.77	.52	.46	.68		**1.32**

Table 2.10

Lavaca Bay
TOTAL KJELDAHL NITROGEN 1984 - 1985

Replicate A mg/l

Station	November	January	March	April	May	June	July	August
45	.30	.12	.32	.37	.14	.25	.51	.34
603	.28	.15	.10	.52	.10	.58	.62	.98
65	.26	.17	.26	.89	.19	.46		.98
613	.34	.20	.40	.67	.30	.72	.76	.54
623	.12	.26	.42	.35	.16	.94	.74	1.05
633			.80	.71	.45	1.04	1.00	1.08
85	.25	.90	.45	.41	.24	.77	.76	1.11
1505			.31		.50	.67	.93	.77
1905	.12		.33		.18	.85	.76	1.13

Replicate B mg/l

Station	November	January	March	April	May	June	July	August
45	.22	.13	.26	.41	.20	.09	.65	
603	.24	.18	.15	.46	.10	.36	.73	.75
65	.22	.18	.33	.63	.30	.36	.65	.35
613	.29	.18	.36	.59	.20	.56	1.09	.60
623	.18	.24	.54	.50	.29	.67	.85	.96
633			.58	.75	.29	.73	.99	1.12
85	.23	.82	.37	.45	.16	.69	.95	.98
1505								
1905								

Mean mg/l

Station	November	January	March	April	May	June	July	August	Average	s.d.
45	.26	.13	.29	.39	.17	.17	.58	.34	.291	.155
603	.26	.17	.13	.49	.10	.47	.68	.87	.394	.277
65	.24	.18	.30	.76	.25	.41	.65	.67	.430	.257
613	.32	.19	.38	.63	.25	.64	.93	.57	.488	.250
623	.15	.25	.48	.43	.23	.81	.80	1.01	.517	.314
633			.69	.73	.37	.89	1.00	1.10	.795	.263
85	.24	.86	.41	.43	.20	.73	.86	1.05	.596	.310
1505			.31		.50	.67	.93	.77	.636	.240
1905	.12		.33		.18	.85	.76	1.13	.562	.410
Average	.226	.294	.368	.551	.249	.626	.796	.832	**.500**	
s.d.	.065	.268	.168	.161	.114	.254	.164	.275		**.299**

Mean µg-at/l

Station	November	January	March	April	May	June	July	August	Average	s.d.
45	18.6	8.9	20.7	27.9	12.1	12.1	41.4	24.3	20.76	11.04
603	18.6	11.8	8.9	35.0	7.1	33.6	48.2	61.8	28.13	19.79
65	17.1	12.5	21.1	54.3	17.5	29.3	46.4	47.5	30.71	18.39
613	22.5	13.6	27.1	45.0	17.9	45.7	66.1	40.7	34.82	17.84
623	10.7	17.9	34.3	30.4	16.1	57.5	56.8	71.8	36.92	22.39
633			49.3	52.1	26.4	63.2	71.1	78.6	56.79	18.78
85	17.1	61.4	29.3	30.7	14.3	52.1	61.1	74.6	42.59	22.16
1505			22.1		35.7	47.9	66.4	55.0	45.43	17.14
1905	8.6		23.6		12.9	60.7	54.3	80.7	40.12	29.27
Average	16.17	21.01	26.27	39.34	17.78	44.68	56.87	59.44	**35.74**	
s.d.	4.66	19.13	11.99	11.50	8.15	18.15	11.72	19.65		**21.37**

Table 2.11

Lavaca Bay
TOTAL PHOSPHATE 1984 - 1985

Replicate A mg/l

Station	November	January	March	April	May	June	July	August
45	.22		.36	.23	.30	.17	.37	.16
603	.25		.35	.32	.28	.19	.28	.20
65			.30	.24	.27	.14	.22	.16
613	.21		.27	.32	.22	.14	.22	.17
623			.28	.33	.31	.26	.24	.18
633			.07	.33	.48	.29	.22	.19
85	.11		.05	.31	.22	.21	.13	.13
1505			.11		.07	.13	.09	.09
1905			.05		.08	.16	.08	.06

Replicate B mg/l

Station	November	January	March	April	May	June	July	August
45	.20		.37	.27	.30	.22	.35	.16
603	.24		.39	.29	.27	.20	.26	.21
65			.36	.25	.26	.11	.20	.21
613	.21		.25	.33	.21	.17	.22	.18
623			.19	.37	.26	.22	.25	.18
633			.23	.31	.39	.26	.20	.19
85	.20		.12	.30	.21	.22	.11	.11
1505								
1905								

Mean mg/l

Station	November	January	March	April	May	June	July	August	Average	s.d.
45	.21		.37	.25	.30	.19	.36	.16	.263	.079
603	.24		.37	.31	.28	.20	.27	.20	.266	.059
65			.33	.24	.26	.13	.21	.18	.226	.070
613	.21		.26	.32	.22	.16	.22	.17	.222	.054
623			.24	.35	.29	.24	.24	.18	.256	.060
633			.15	.32	.43	.27	.21	.19	.264	.106
85	.16		.09	.30	.21	.22	.12	.12	.174	.076
1505			.11		.07	.13	.09	.09	.098	.024
1905			.05		.08	.16	.08	.06	.086	.042
Average	.205		.217	.300	.237	.188	.200	.152	**.224**	
s.d.	.042		.122	.039	.100	.051	.082	.043		**.086**

Mean µg-at/l

Station	November	January	March	April	May	June	July	August	Average	s.d.
45	6.8		11.8	8.2	9.6	6.2	11.6	5.2	8.47	2.55
603	7.8		11.9	9.9	9.0	6.3	8.6	6.6	8.59	1.91
65			10.7	7.9	8.5	4.1	6.7	5.9	7.28	2.25
613	6.8		8.4	10.4	7.0	5.0	7.0	5.6	7.17	1.73
623			7.6	11.2	9.2	7.9	7.9	5.7	8.25	1.93
633			4.8	10.5	14.0	8.7	6.8	6.3	8.50	3.43
85	5.1		2.8	9.7	6.9	7.1	3.9	3.9	5.60	2.44
1505			3.5		2.2	4.3	2.9	2.9	3.15	.79
1905			1.6		2.6	5.1	2.6	2.0	2.76	1.35
Average	6.60		7.01	9.66	7.65	6.06	6.44	4.90	**7.21**	
s.d.	1.36		3.93	1.27	3.21	1.64	2.65	1.38		**2.79**

Table 2.12

Lavaca Bay
CHLOROPHYLL a 1984 - 1985

Replicate A µg/l

(Corrected algorithm)

Station	November	January	March	April	May	June	July	August
45	21.0	3.1	1.9	9.1		16.2	23.8	18.8
603	9.7	.9	15.2	20.0		16.1	34.7	20.4
65	12.4	9.2	18.1	19.4		13.8		32.4
613	9.9	8.6	44.2	38.2		17.9	14.5	10.0
623		11.2	101.3	16.0		11.4	3.5	1.2
633			36.5	13.8		9.5	9.9	4.1
85	7.7	8.6	6.5	20.4	16.0	7.7	3.5	4.6
1505				13.8		7.6	3.9	3.9
1905	3.8			15.8		6.6	3.8	3.4

Replicate B µg/l

Station	November	January	March	April	May	June	July	August
45	20.6	3.6	2.1	10.6		16.6	23.1	17.4
603	14.2	.9	14.6	1.2		15.6	41.9	18.3
65	13.1	9.1	18.2	23.1		15.9	15.7	31.1
613	9.1	8.1	46.7	34.3		18.4	17.6	8.8
623		18.4	94.5	8.4		10.2	4.1	1.1
633			35.3	15.2		7.9	9.8	4.6
85	6.4	15.5	7.3	23.8	17.8	8.0	4.5	3.4

Mean µg/l

Station	November	January	March	April	May	June	July	August	Average	s.d.
45	20.8	3.3	2.0	9.8		16.4	23.4	18.1	13.42	8.15
603	11.9	.9	14.9	20.0		15.8	38.3	19.4	17.32	11.71
65	12.8	9.2	18.1	21.2		14.8	15.7	31.7	17.66	7.32
613	9.5	8.3	45.4	36.2		18.2	16.0	9.4	20.45	14.12
623		14.8	97.9	12.2		10.8	3.8	1.1	23.44	35.23
633			35.9	14.5		8.7	9.8	4.4	14.66	11.72
85	7.0	12.1	6.9	22.1	16.9	7.8	4.0	4.0	10.11	6.44
1505				13.8		7.6	3.9	3.9	7.29	4.68
1905				15.8		6.6	3.8	3.4	7.42	5.25
Average	12.41	8.11	31.59	18.41		11.88	13.20	10.61	**15.51**	
s.d.	5.43	5.42	31.78	9.32		4.23	12.10	10.32		**15.39**

Table 2.13

Lavaca Bay
PHEOPIGMENTS 1984 - 1985

Replicate A µg/l

(Corrected algorithm)

Station	November	January	March	April	May	June	July	August
45	5.7	5.7	2.7	5.9		7.6	11.3	5.7
603	7.5	5.8	10.2	10.5		3.6	11.4	6.0
65	6.6	7.4	8.6	10.2		5.6	5.6	14.6
613	8.4	2.7	12.8	13.0		4.0	5.6	3.8
623		3.3	11.7	1.6		11.8	3.9	1.6
633			8.7	6.9		12.1	3.3	2.6
85	6.0	2.5	3.1	7.8	7.1	10.6	1.9	2.3
1505				3.6		3.3	.9	.9
1905	1.3			4.7		2.7	.7	1.0

Replicate B µg/l

Station	November	January	March	April	May	June	July	August
45	5.7	5.0	2.9	5.3		6.7	12.7	4.7
603	9.8	5.2	10.5	7.1		4.3	10.3	6.4
65	7.3	9.0	7.5	10.9		5.1	7.4	13.7
613	8.5	2.7	9.7	12.3		3.6	5.7	3.8
623		2.6	13.1	1.0		10.4	3.3	1.6
633			8.0	7.8		10.3	3.6	3.1
85	5.7	2.9	2.7	8.5	6.6	11.3	2.0	2.1

Mean µg/l

Station	November	January	March	April	May	June	July	August	Average	s.d.
45	5.7	5.3	2.8	5.6		7.1	12.0	5.2	6.25	2.77
603	8.6	5.5	10.3	8.8		3.9	10.9	6.2	7.76	2.63
65	7.0	8.2	8.0	10.5		5.4	6.5	14.1	8.54	2.90
613	8.5	2.7	11.3	12.6		3.8	5.6	3.8	6.90	3.83
623		2.9	12.4	1.3		11.1	3.6	1.6	5.49	4.73
633			8.4	7.4		11.2	3.4	2.8	6.65	3.34
85	5.8	2.7	2.9	8.1	6.8	10.9	2.0	2.2	5.19	3.17
1505				3.6		3.3	.9	.9	2.19	1.49
1905				4.7		2.7	.7	1.0	2.27	1.54
Average	7.12	4.57	8.02	6.96		6.61	5.07	4.21	**6.28**	
s.d.	2.22	2.14	3.76	3.55		3.46	3.94	4.10		**3.56**

Table 2.14

Lavaca Bay
PHYTOPLANKTON CELL COUNTS 1984 - 1985

Replicate A cells/ml

Station	November	January	March	April	May	June	July	August
45	32524	4305	3968	3968	383	214717	124883	173669
603	14823	9545	28945	28945	37270	726216	212029	203237
65	22876	9181	25936	25936	54777	162851	255731	56723
613	15523	9026	52832	52832	52754	610216	206972	51043
623	14006	14395	254435	254435	58201	11230	24536	28011
633			24588	24588	5356		15648	40772
85	13352	15717			20114	8870	15095	7876
1505			8501	8501	38360	8384	12320	16690
1905			13020	13020	34314	10634	9843	50316

Replicate B cells/ml

Station	November	January	March	April	May	June	July	August
45	45985	4694	3354	8429	31201	54116	118270	123561
603	23382		23913	83878	22201	653465	251712	145347
65	24471	6640	24588	64893	30454	319250	289700	66060
613	14589	11230	78898	66604	46296	546218	50731	56334
623	9921		194678	56541	40616	17075	20619	27000
633		18052	24691	34703	18324	24834	32783	44974
85	20593	13772	13889	32291	21203	12232	31746	8170
1505								
1905								

Mean cells/ml

Station	November	January	March	April	May	June	July	August	Average	s.d.
45	39255	4500	3661	6199	15792	134417	121576	148615	59252	69365
603	19102	9545	26429	56411	29736	689841	231871	174292	154653	228680
65	23673	7911	25262	45414	42616	251050	272716	61391	91254	106572
613	15056	10128	65865	59718	49525	578217	128852	53688	120131	184903
623	11963	14395	224556	155488	49409	14153	22578	27505	65006	88209
633		18052	24639	29645	11840	24834	24216	42873	25157	11127
85	16973	14745	13889	32291	20658	10551	23420	8024	17569	7744
1505			8501	8501	38360	8384	12320	16690	15459	11685
1905			13020	13020	34314	10634	9843	50316	21858	16683
Average	21004	11325	45091	45188	32472	191342	94155	64822	**74043**	
s.d.	10081	10081	73604	61317	16816	272574	103799	59868		**127737**

Table 2.15

Lavaca Bay

PHYTOPLANKTON BIOVOLUME 1984 - 1985

Replicate A µl/l

Station	November	January	March	April	May	June	July	August
45	4.90	1.23	.71	3.43	.05	12.42	15.55	21.32
603	1.81	3.34	4.65	16.94	4.49	35.94	18.01	17.02
65	1.48	2.35	5.06	8.57	7.65	9.64	23.10	4.98
613	2.63	2.65	10.34	17.42	5.73	38.69	12.33	3.86
623	1.59	7.20	88.14	12.96	6.88	1.72	2.18	2.92
633			4.92	4.46	.58		1.94	2.93
85	1.70	12.43		16.90	2.03	1.85	4.18	.97
1505			1.50	84.73	4.83	4.32	.98	1.89
1905			4.21	43.32	7.19	12.12	.72	1.47

Replicate B µl/l

Station	November	January	March	April	May	June	July	August
45	11.00	1.08	.59	1.30	4.72	3.12	15.90	10.81
603	3.31		4.83	15.62	3.03	33.58	27.34	9.74
65	1.91	1.72	6.26	10.37	5.11	16.62	29.20	4.76
613	2.84	1.56	11.17	15.48	5.61	30.95	2.97	3.45
623	.84		69.96	17.35	5.70	2.24	2.34	2.18
633		31.60	4.60	5.06	1.99	3.58	2.11	6.20
85	2.67	8.87	4.20	5.05	2.57	2.55	3.29	1.38
1505								
1905								

Mean µl/l

Station	November	January	March	April	May	June	July	August	Average	s.d.
45	7.95	1.16	.65	2.36	2.39	7.77	15.73	16.07	6.76	6.75
603	2.56	3.34	4.74	16.28	3.76	34.76	22.68	13.38	12.69	11.49
65	1.69	2.04	5.66	9.47	6.38	13.13	26.15	4.87	8.67	7.93
613	2.74	2.10	10.76	16.45	5.67	34.82	7.65	3.65	10.48	10.80
623	1.22	7.20	79.05	15.15	6.29	1.98	2.26	2.55	14.46	26.65
633		31.60	4.76	4.76	1.29	3.58	2.03	4.56	7.51	8.28
85	2.18	10.65	4.20	10.97	2.30	2.20	3.74	1.18	4.68	4.56
1505			1.50	84.73	4.83	4.32	.98	1.89	16.38	33.52
1905			4.21	43.32	7.19	12.12	.72	1.47	11.50	16.13
Average	3.06	8.30	12.84	22.61	4.45	12.74	9.10	5.51	**9.80**	
s.d.	2.72	2.72	26.49	20.47	2.31	13.84	10.06	5.91		**14.61**

Table 2.16

Lavaca Bay
Salinity 1985 - 1986
(Pratical Salinity from Hydrolab Conductivity)

Replicate A, ppt

Station	October	December	February	April	June	August
45	4.7	.8	5.3	13.4	.5	3.9
603	9.9	1.1	8.7	17.1	7.5	3.9
65	6.9	1.4	8.7	17.1	1.0	9.4
613	15.9	4.9	13.6	20.8	16.4	10.9
623	19.6	8.1	10.6	24.2	20.1	9.6
633	15.2	8.0	6.2	23.2	19.1	8.7
85	20.8	8.0	13.1	23.9	19.1	10.9
1505	28.9	18.8	14.4	27.7	26.7	23.9
1905	29.1	20.4	18.0	28.4	26.7	26.0

Replicate B, ppt

Station	October	December	February	April	June	August
45	4.1	.9		13.4	.7	3.9
603	9.9	1.1		17.4	7.7	3.9
65	6.9	1.4		15.1	1.0	9.4
613	16.3	4.9		21.1	16.4	10.9
623	19.8	8.1		24.2	20.4	9.9
633	16.7	8.5		23.2	19.2	9.0
85	20.2	8.3		23.9	18.7	11.2
1505	28.4	18.5	14	28.1	26.7	24.6
1905	29.3	20.1	18	28.4	27.4	26.3

Mean, ppt

Station	October	December	February	April	June	August	Average	s.d.
45	4.4	.9	5.3	13.4	.6	3.9	4.31	4.66
603	9.9	1.1	8.7	17.2	7.6	3.9	7.37	5.76
65	6.9	1.4	8.7	16.1	1.0	9.4	6.52	5.74
613	16.1	4.9	13.6	20.9	16.4	10.9	12.67	6.58
623	19.7	8.1	10.6	24.2	20.3	9.8	14.55	7.76
633	16.0	8.3	6.2	23.2	19.1	8.9	13.09	7.36
85	20.5	8.2	13.1	23.9	18.9	11.0	14.84	7.40
1505	28.7	18.7	14.4	27.9	26.7	24.2	23.41	5.45
1905	29.2	20.3	18.2	28.4	27.0	26.1	24.87	4.34
Average	16.82	7.97	7.29	21.70	15.29	12.01	**13.51**	
s.d.	8.52	7.00	6.88	5.06	9.70	7.70		**9.00**

Lavaca Bay
WATER TEMPERATURE 1985 - 1986

Replicate A °C

Station	October	December	February	April	June	August
45	26.1	12.8	20.0	25.5	27.8	30.0
603	25.7	11.3	21.0	26.0	28.4	30.5
65	27.2	12.5	21.0	25.5	28.0	29.6
613	26.8	10.0	20.4	26.5	28.6	29.7
623	26.8	10.5	21.0	26.0	28.7	29.2
633	25.3	10.2	20.5	24.5	28.5	28.6
85	25.0	10.6	20.0	24.5	27.4	28.2
1505	25.5	12.7	18.5	21.7	27.8	28.0
1905	25.6	13.0	18.8	22.0	28.0	27.0

Replicate B, °C

Station	October	December	February	April	June	August
45	26.3	12.5		25.5	28.0	30.0
603	26.5	11.2		26.0	28.6	30.5
65	27.1	12.5		25.5	28.0	29.7
613	26.7	10.0		26.5	28.7	30.0
623	26.7	10.5		26.5	28.7	29.3
633	25.2	10.4		24.5	28.6	28.7
85	25.3	10.6		24.5	27.4	28.2
1505	25.5	12.5	19.0	21.8	28.0	28.8
1905	25.6	12.6	18.4	22.0	28.2	28.7

Mean, °C

Station	October	December	February	April	June	August	Average	s.d.
45	26.2	12.7	20.0	25.5	27.9	30.0	24.0	6.2
603	26.1	11.3	21.0	26.0	28.5	30.5	24.2	6.9
65	27.2	12.5	21.0	25.5	28.0	29.7	24.2	6.3
613	26.8	10.0	20.4	26.5	28.7	29.9	24.0	7.4
623	26.8	10.5	21.0	26.3	28.7	29.3	24.0	7.1
633	25.3	10.3	20.5	24.5	28.6	28.7	23.2	6.8
85	25.2	10.6	20.0	24.5	27.4	28.2	22.9	6.5
1505	25.5	12.6	18.8	21.8	27.9	28.4	22.5	5.8
1905	25.6	12.8	18.6	22.0	28.1	27.9	22.5	5.7
Average	26.1	11.5	19.9	24.7	28.2	29.2	**23.5**	
s.d.	.7	1.1	1.0	1.7	.4	.9		**6.3**

Table 2.18

Lavaca Bay
SECCHI DEPTH 1985 - 1986

Replicate A, cm

Station	October	December	February	April	June	August
45	67	35	84	80	50	50
603	50	35	52	62	50	34
65	65	34	60	64	51	46
613	60	44	78	45	45	42
623	64	39	45	18	62	26
633	71	44	80	40	66	19
85	67	36	66	50	60	34
1505	92		80	32	50	45
1905	91			35	47	43

Replicate B, cm

Station	October	December	February	April	June	August
45	65	36		75	47	49
603	46	28		65	51	31
65	64	33		64	48	47
613	64	44		48	48	42
623	51	41		28	54	21
633	66	45		45	54	22
85	66	41		40	63	37
1505	90			19		45
1905				37		45

Mean, cm

Station	October	December	February	April	June	August	Average	s.d.
45	66	36	84	78	49	50	58.0	17.1
603	48	32	52	64	51	33	45.6	12.3
65	65	34	60	64	50	47	52.4	11.9
613	52	44	78	47	47	42	50.9	11.5
623	58	40	45	23	58	24	40.8	16.1
633	69	45	80	43	60	21	50.2	19.5
85	67	39	66	45	62	36	50.9	13.6
1505	91		80	26	50	45	56.6	27.4
1905	91			36	47	44	49.7	20.8
Average	67.0	38.2	68.1	47.1	52.9	37.7	**50.4**	
s.d.	13.3	5.1	14.6	18.1	6.4	10.1		**16.7**

Table 2.19

Lavaca Bay
pH 1985 - 1986

Replicate A

Station	October	December	February	April	June	August
45	7.8	8.1	8.6	8.4	8.0	8.7
603	8.2	8.3	8.5	8.3	8.4	8.8
65	8.2	8.2	8.5	8.3	7.6	8.6
613	8.3	8.5	8.5	8.2	8.1	8.6
623	8.2	8.4	8.3	8.1	8.1	7.9
633	8.0	8.4	8.5	8.0	8.1	8.1
85	8.2	8.3	8.4	8.2	8.1	8.5
1505	8.2	8.4	8.8	8.3	8.0	
1905	8.3	8.4	8.2	8.3	8.1	

Replicate B

Station	October	December	February	April	June	August
45	7.7	8.1		8.4	8.0	8.7
603	8.2	8.3		8.3	8.4	8.8
65	8.2	8.2		8.3	7.6	8.6
613	8.3	8.4		8.2	8.1	8.6
623	8.2	8.4		8.2	8.1	7.8
633	8.0	8.4		8.0	8.2	7.9
85	8.2	8.4		8.2	8.2	8.5
1505		8.4	8.5	8.3	8.0	
1905		8.4	8.6	8.3	8.1	

Mean

Station	October	December	February	April	June	August	Average	s.d.
45	7.8	8.1	8.6	8.4	8.0	8.7	8.23	.35
603	8.2	8.3	8.5	8.3	8.4	8.8	8.39	.22
65	8.2	8.2	8.5	8.3	7.6	8.6	8.19	.34
613	8.3	8.4	8.5	8.2	8.1	8.6	8.33	.17
623	8.2	8.4	8.3	8.1	8.1	7.9	8.15	.19
633	8.0	8.4	8.5	8.0	8.1	8.0	8.13	.21
85	8.2	8.4	8.4	8.2	8.1	8.5	8.29	.13
1505	8.2	8.4	8.6	8.3	8.0		8.31	.23
1905	8.3	8.4	8.4	8.3	8.1		8.28	.18
Average	8.13	8.32	8.48	8.23	8.05	8.42	**8.25**	
s.d.	.17	.11	.16	.12	.20	.35		**.24**

Table 2.20

Lavaca Bay
DISSOLVED OXYGEN 1985 - 1986

Replicate A, mg/l

Station	October	December	February	April	June	August
45	9.7	9.9	9.5	9.5	8.2	7.4
603	10.2	10.5	9.7	9.1	8.4	8.7
65	12.0	10.2	9.8	8.9	8.2	8.0
613	10.6	11.1	7.5	9.2	10.3	8.7
623	8.7	11.1	9.0	9.0	7.4	7.1
633	8.4	11.2	9.2	8.3	7.3	7.6
85	8.3	11.3	8.8	8.2	7.8	7.5
1505	7.6	10.7	9.0	8.3	7.8	7.5
1905	7.7	10.5	8.8	8.0	7.9	6.7

Replicate B, mg/l

Station	October	December	February	April	June	August
45	9.5	9.8		9.5	8.2	7.7
603	10.2	10.7		8.5	8.8	8.8
65	12.2	10.2		8.8	8.5	7.7
613	10.4	11.2		8.9	10.4	8.7
623	10.2	11.1		8.9	7.5	7.3
633	8.6	10.9		8.1	7.5	7.4
85	8.2	10.6		8.7	7.9	7.5
1505	8.3	11.2	8.6	8.2	7.8	7.5
1905	7.9	10.4	8.8	8.1	7.4	6.7

Mean, mg/l

Station	October	December	February	April	June	August	Average	s.d.
45	9.6	9.9	9.5	9.5	8.2	7.5	8.98	.93
603	10.2	10.6	9.7	8.8	8.6	8.8	9.41	.86
65	12.1	10.2	9.8	8.9	8.4	7.9	9.50	1.53
613	10.5	11.2	7.5	9.1	10.4	8.7	9.73	1.18
623	9.4	11.1	9.0	8.9	7.4	7.2	8.83	1.46
633	8.5	11.1	9.2	8.2	7.4	7.5	8.59	1.34
85	8.3	11.0	8.8	8.4	7.8	7.5	8.61	1.25
1505	8.0	10.9	8.8	8.3	7.8	7.5	8.54	1.21
1905	7.8	10.5	8.8	8.0	7.6	6.7	8.23	1.23
Average	9.37	10.69	8.98	8.67	8.17	7.69	**8.93**	
s.d.	1.40	.47	.62	.49	.89	.66		**1.28**

Table 2.21

Lavaca Bay
DISSOLVED AMMONIUM 1985 - 1986

Replicate A mg/l

Station	October	December	February	April	June	August
45	.001	.011	.012	.001	.041	.013
603	.001	.006	.008	.001	.001	.030
65	.000	.005	.006	.001	.029	.003
613	.000	.007	.012	.003	.014	.008
623	.001	.008	.008	.001	.014	.007
633	.002	.006	.029	.021	.004	.014
85	.010	.024	.016	.005	.010	.025
1505	.006	.001	.021	.028	.012	.041
1905	.002	.002	.009	.011	.031	.013

Replicate B mg/l

Station	October	December	February	April	June	August
45	.001	.008	.006	.000	.040	.004
603	.007	.004	.005	.001	.012	.010
65	.000	.005	.007	.001	.032	.015
613	.000	.007	.011	.001	.014	.007
623	.004	.007	.016	.003	.013	
633	.002	.003	.028	.014	.011	.008
85	.004	.011	.008	.003	.010	.008
1505	.003	.006	.019	.032	.005	.007
1905	.004	.002	.011	.014	.047	.011

Mean mg/l

Station	October	December	February	April	June	August	Average	s.d.
45	.001	.009	.009	.001	.040	.009	.012	.014
603	.004	.005	.006	.001	.007	.020	.007	.008
65	.000	.005	.006	.001	.031	.009	.009	.011
613	.000	.007	.011	.002	.014	.008	.007	.005
623	.002	.007	.012	.002	.014	.007	.007	.005
633	.002	.004	.029	.018	.008	.011	.012	.010
85	.007	.017	.012	.004	.010	.017	.011	.007
1505	.005	.003	.020	.030	.009	.024	.015	.013
1905	.003	.002	.010	.012	.039	.012	.013	.013
Average	.003	.007	.013	.008	.019	.013	**.010**	
s.d.	.003	.005	.007	.010	.014	.010		**.010**

Mean µg-at/l

Station	October	December	February	April	June	August	Average	s.d.
45	.08	.66	.62	.04	2.89	.64	.82	1.02
603	.27	.34	.46	.08	.47	1.45	.51	.59
65	.01	.36	.44	.08	2.20	.64	.62	.79
613	.01	.47	.81	.14	.99	.57	.50	.36
623	.18	.53	.84	.14	.97	.50	.53	.37
633	.13	.31	2.04	1.26	.54	.78	.84	.70
85	.50	1.24	.84	.31	.73	1.21	.80	.51
1505	.34	.25	1.42	2.14	.63	1.72	1.08	.92
1905	.20	.17	.72	.89	2.78	.85	.93	.95
Average	.19	.48	.91	.56	1.36	.95	**.74**	
s.d.	.20	.36	.53	.71	.99	.71		**.73**

Table 2.22

Lavaca Bay
DISSOLVED NITRITE 1985 - 1986

Replicate A mg/l

Station	October	December	February	April	June	August
45	.003	.002	.000	.000	.004	.001
603	.000	.002	.000	.000	.001	.001
65	.000	.001	.000	.000	.004	.001
613	.000	.001	.000	.000	.000	.000
623	.000	.000	.000	.000	.000	.001
633	.001	.000	.000	.002	.000	.001
85	.000	.001	.001	.000	.000	.001
1505	.000	.000	.001	.001	.001	.001
1905	.000	.001	.000	.001	.001	.001

Replicate B mg/l

Station	October	December	February	April	June	August
45	.003	.002	.000	.000	.003	.001
603	.001	.002	.000	.000	.001	.001
65	.000	.002	.000	.000	.004	.001
613	.000	.000	.001	.000	.000	.000
623	.000	.000	.000	.000	.000	.001
633	.001	.000	.001	.001	.000	.001
85	.000	.000	.000	.000	.000	.000
1505	.000	.000	.000	.001	.000	.001
1905	.000	.000	.001	.001	.002	.000

Mean mg/l

Station	October	December	February	April	June	August	Average	s.d.
45	.003	.002	.000	.000	.003	.001	.002	.001
603	.001	.002	.000	.000	.001	.001	.001	.001
65	.000	.001	.000	.000	.004	.001	.001	.001
613	.000	.001	.000	.000	.000	.000	.000	.000
623	.000	.000	.000	.000	.000	.001	.000	.000
633	.001	.000	.001	.002	.000	.001	.001	.001
85	.000	.001	.001	.000	.000	.000	.000	.000
1505	.000	.000	.000	.001	.000	.001	.000	.000
1905	.000	.001	.001	.001	.002	.000	.001	.000
Average	.001	.001	.000	.000	.001	.001	**.001**	
s.d.	.001	.001	.000	.001	.002	.000		**.001**

Mean μg-at/l

Station	October	December	February	April	June	August	Average	s.d.
45	.19	.17	.02	.02	.24	.05	.11	.10
603	.04	.17	.00	.00	.06	.04	.05	.06
65	.03	.09	.00	.02	.30	.04	.08	.11
613	.03	.05	.03	.02	.02	.02	.03	.02
623	.03	.02	.02	.02	.00	.04	.02	.02
633	.05	.00	.05	.13	.02	.04	.05	.05
85	.01	.06	.10	.02	.00	.03	.03	.03
1505	.01	.01	.03	.06	.03	.05	.03	.02
1905	.03	.04	.04	.04	.11	.03	.05	.03
Average	.05	.07	.02	.03	.09	.04	**.05**	
s.d.	.06	.07	.03	.04	.11	.01		**.06**

Table 2.23

Lavaca Bay
DISSOLVED NITRATE 1985 - 1986

Replicate A mg/l

Station	October	December	February	April	June	August
45	.172	.226	.001	.002	.136	.008
603	.002	.157	.002	.000	.000	.002
65	.001	.161	.000	.002	.127	.002
613	.000	.052	.000	.000	.000	.003
623	.000	.028	.001	.000	.001	.001
633	.063	.002	.005	.011	.001	.002
85	.000	.063	.003	.003	.001	.000
1505	.000	.005	.003	.010	.002	.001
1905	.000	.019	.001	.009	.003	.003

Replicate B mg/l

Station	October	December	February	April	June	August
45	.172	.222	.003	.000	.143	.001
603	.001	.162	.001	.000	.001	.020
65	.000	.151	.001	.006	.122	.000
613	.000	.043	.001	.001	.001	.001
623	.001	.039	.001	.001	.000	.001
633	.071	.000	.006	.011	.000	.002
85	.000	.037	.002	.005	.001	.001
1505	.000	.018	.003	.011	.001	.001
1905	.001	.016	.002	.009	.004	.001

Mean mg/l

Station	October	December	February	April	June	August	Average	s.d.
45	.172	.224	.002	.001	.139	.004	.090	.096
603	.001	.159	.001	.000	.001	.011	.029	.061
65	.001	.156	.001	.004	.124	.001	.048	.069
613	.000	.048	.001	.001	.001	.002	.009	.018
623	.000	.034	.001	.000	.001	.001	.006	.013
633	.067	.001	.005	.011	.000	.002	.015	.025
85	.000	.050	.003	.004	.001	.001	.010	.020
1505	.000	.011	.003	.010	.001	.001	.005	.005
1905	.000	.017	.002	.009	.004	.002	.006	.006
Average	.027	.078	.002	.004	.030	.003	**.024**	
s.d.	.057	.078	.002	.004	.056	.005		**.052**

Mean µg-at/l

Station	October	December	February	April	June	August	Average	s.d.
45	12.26	16.01	.15	.05	9.96	.31	6.46	6.82
603	.09	11.39	.09	.00	.06	.76	2.06	4.37
65	.04	11.13	.08	.29	8.89	.07	3.41	4.92
613	.02	3.41	.05	.04	.05	.13	.62	1.31
623	.03	2.39	.06	.03	.04	.05	.43	.93
633	4.77	.09	.39	.78	.03	.16	1.04	1.77
85	.02	3.56	.19	.27	.04	.06	.69	1.40
1505	.02	.81	.23	.73	.11	.08	.33	.39
1905	.03	1.23	.13	.61	.25	.12	.40	.44
Average	1.92	5.56	.15	.31	2.15	.19	**1.71**	
s.d.	4.06	5.59	.12	.31	4.01	.32		**3.72**

Table 2.24

Lavaca Bay
DISSOLVED PHOSPHATE 1985 - 1986

Replicate A mg/l

Station	October	December	February	April	June	August
45	.007	.064	.030	.014	.065	.014
603	.002	.053	.013	.007	.027	.007
65	.004	.038	.013	.012	.075	.012
613	.001	.013	.009	.002	.015	.002
623	.002	.018	.004	.007	.005	.007
633	.003	.005	.013	.007	.010	.007
85	.003	.020	.009	.005	.007	.005
1505	.003	.000	.011	.005	.002	.005
1905	.002	.008	.009	.002	.005	.002

Replicate B mg/l

Station	October	December	February	April	June	August
45	.007	.064	.025	.014	.062	.014
603	.002	.048	.035	.009	.032	.009
65	.003	.046	.016	.012	.070	.012
613	.002	.013	.009	.005	.010	.005
623	.002	.015	.004	.005	.005	.005
633	.003	.010	.009	.007	.005	.007
85	.002	.015	.006	.005	.010	.005
1505	.003	.003	.009	.002	.002	.002
1905	.002	.008	.002	.005	.002	.005

Mean mg/l

Station	October	December	February	April	June	August	Average	s.d.
45	.007	.064	.028	.014	.064	.014	.032	.024
603	.002	.051	.024	.008	.030	.008	.021	.018
65	.003	.042	.015	.012	.072	.012	.026	.025
613	.001	.013	.009	.004	.012	.004	.007	.005
623	.002	.017	.004	.006	.005	.006	.006	.005
633	.003	.008	.011	.007	.007	.007	.007	.003
85	.003	.018	.008	.005	.009	.005	.008	.005
1505	.003	.003	.010	.004	.002	.004	.004	.003
1905	.002	.008	.005	.004	.004	.004	.004	.003
Average	.003	.024	.012	.007	.023	.007	**.013**	
s.d.	.002	.021	.009	.004	.026	.004		**.016**

Mean µg-at/l

Station	October	December	February	April	June	August	Average	s.d.
45	.23	2.05	.89	.46	2.05	.46	1.02	.79
603	.08	1.64	.78	.27	.97	.27	.67	.58
65	.11	1.35	.47	.38	2.33	.38	.84	.81
613	.04	.41	.28	.11	.40	.11	.23	.16
623	.05	.53	.13	.19	.16	.19	.21	.16
633	.10	.25	.36	.23	.24	.23	.23	.10
85	.08	.57	.24	.15	.28	.15	.25	.17
1505	.09	.08	.32	.11	.08	.11	.13	.10
1905	.07	.25	.17	.11	.12	.11	.14	.08
Average	.10	.79	.40	.22	.74	.22	**.41**	
s.d.	.05	.69	.29	.12	.84	.12		**.53**

Table 2.25

Lavaca Bay

TOTAL KJELDAHL NITROGEN 1985 - 1986

Replicate A mg/l

Station	October	December	February	April	June	August
45	.26	.17	.55	.90	.40	.67
603	.67	.22		.86	.44	1.01
65	.25	.16	.30	1.33	.80	.49
613	.65	.30		.69	.85	.58
623	1.09	.17		1.17	.78	.60
633	.27	.26	.50	.77	.75	.72
85	.54	.12	.71	.91	.74	.64
1505	.76	.11	.77	.67	.44	.45
1905	.51	.44	.73	1.05	.42	.52

Replicate B mg/l

Station	October	December	February	April	June	August
45	.27	.03	.54	.92	.33	.74
603	.78	.09		.81	.31	.94
65	.15	.14	.21	1.20	.72	.56
613	.52	.18		.90	.68	.55
623	.81	.04		1.46	.84	.62
633	.53	.33		.82	.77	.70
85	.87	.22	.65	.84	.80	.62
1505	.62	.10				
1905	.58	.29	.63			

Mean mg/l

Station	October	December	February	April	June	August	Average	s.d.
45	.27	.10	.55	.91	.37	.71	.482	.286
603	.73	.16		.84	.38	.98	.613	.324
65	.20	.15	.26	1.27	.76	.53	.526	.412
613	.59	.24		.80	.77	.57	.590	.222
623	.95	.11		1.32	.81	.61	.758	.433
633	.40	.30	.25	.80	.76	.71	.584	.215
85	.71	.17	.68	.88	.77	.63	.638	.246
1505	.69	.11	.39	.34	.22	.23	.490	.268
1905	.55	.37	.68	.53	.21	.26	.574	.219
Average	.563	.187	.559	.956	.629	.651	**.584**	
s.d.	.252	.106	.183	.226	.199	.150		**.301**

Mean µg-at/l

Station	October	December	February	April	June	August	Average	s.d.
45	18.93	7.14	38.93	65.00	26.07	50.36	34.40	20.46
603	51.79	11.07		59.64	26.79	69.64	43.79	23.15
65	14.29	10.71	18.21	90.36	54.29	37.50	37.56	29.43
613	41.79	17.14		56.79	54.64	40.36	42.14	15.87
623	67.86	7.50		93.93	57.86	43.57	54.14	30.93
633	28.57	21.07	17.86	56.79	54.29	50.71	41.69	15.36
85	50.36	12.14	48.57	62.50	55.00	45.00	45.60	17.54
1505	49.29	7.50	27.50	23.93	15.71	16.07	35.00	19.11
1905	38.93	26.07	48.57	37.50	15.00	18.57	41.03	15.64
Average	40.20	13.37	39.93	68.30	44.96	46.47	**41.69**	
s.d.	18.00	7.60	13.10	16.16	14.18	10.75		**21.52**

Table2.26

Lavaca Bay
TOTAL PHOSPHATE 1985 - 1986

Replicate A mg/l

Station	October	December	February	April	June	August
45	.15	.24	.10	.12	.12	.12
603	.14	.26	.11	.13	.11	.13
65	.13	.23	.06	.11	.14	.11
613	.10	.16	.08	.11	.09	.11
623	.13	.11	.12	.24	.07	.24
633	.10	.13	.07	.17	.06	.17
85	.09	.18	.07	.17	.07	.17
1505	.10	.07	.07	.18	.11	.18
1905	.09	.11	.10	.22	.10	.22

Replicate B mg/l

Station	October	December	February	April	June	August
45	.18	.25	.10	.11	.12	.11
603	.13	.30	.12	.14	.11	.14
65	.16	.27	.10	.11	.13	.11
613	.10	.15	.09	.11	.08	.11
623	.12	.13	.14	.26	.07	.26
633	.10	.13	.05	.18	.05	.18
85	.12	.18	.06	.14	.07	.14
1505	.10	.06	.06	.28	.08	.28
1905	.10	.10	.10	.26	.12	.26

Mean mg/l

Station	October	December	February	April	June	August	Average	s.d.
45	.16	.24	.10	.11	.12	.11	.143	.052
603	.14	.28	.11	.14	.11	.14	.151	.061
65	.14	.25	.08	.11	.13	.11	.138	.058
613	.10	.16	.08	.11	.09	.11	.108	.026
623	.13	.12	.13	.25	.07	.25	.158	.071
633	.10	.13	.06	.17	.05	.17	.116	.051
85	.10	.18	.07	.15	.07	.15	.120	.047
1505	.10	.06	.07	.23	.10	.23	.132	.081
1905	.10	.11	.10	.24	.11	.24	.151	.069
Average	.119	.170	.090	.169	.095	.169	**.135**	
s.d.	.025	.071	.024	.060	.028	.060		**.059**

Mean µg-at/l

Station	October	December	February	April	June	August	Average	s.d.
45	5.25	7.84	3.22	3.69	4.00	3.69	4.62	1.67
603	4.36	8.92	3.67	4.38	3.50	4.38	4.87	1.96
65	4.56	8.06	2.70	3.51	4.33	3.51	4.44	1.86
613	3.26	5.07	2.72	3.55	2.77	3.55	3.49	.84
623	4.05	3.95	4.13	8.05	2.26	8.05	5.08	2.30
633	3.24	4.31	1.98	5.64	1.73	5.64	3.76	1.65
85	3.31	5.76	2.14	4.93	2.17	4.93	3.88	1.53
1505	3.31	2.08	2.14	7.39	3.13	7.39	4.24	2.60
1905	3.19	3.46	3.28	7.83	3.61	7.83	4.87	2.24
Average	3.84	5.50	2.89	5.44	3.06	5.44	**4.36**	
s.d.	.79	2.30	.77	1.94	.90	1.94		**1.91**

Table 2.27

Lavaca Bay
CHLOROPHYLL a 1985 - 1986

Replicate A µg/l (corrected algorithm)

Station	October	December	February	April	June	August
45	24.88	8.99	14.04	7.11	4.69	21.66
603	15.85	14.67	7.92	5.57	11.20	29.18
65	14.95	14.52	9.72	8.45	4.90	13.23
613	16.00	12.22	5.97	7.56	11.50	9.85
623	5.31	4.20	28.87	14.15	3.98	5.54
633	5.02	2.39	4.44	5.32	1.49	10.08
85	10.42	5.80	1.96	11.03	1.80	6.77
1505	10.77	5.91	2.88	12.98	9.57	9.06
1905	8.14	7.67	6.29	12.14	9.49	10.38

Replicate B µg/l

Station	October	December	February	April	June	August
45	16.27	11.40	11.55	7.59	4.49	23.84
603	18.33	19.30	7.33	6.24	12.75	28.25
65	16.16	16.75	8.85	9.45	4.03	12.79
613	13.36	12.24	8.74	7.25	16.32	10.69
623	7.94	6.88	24.90	13.41	4.23	6.85
633	5.09	2.59	2.48	6.98	1.56	10.23
85			2.16	11.28	1.55	9.44
1505	8.06	6.52	4.85	11.52	10.61	9.03
1905	8.91	7.52	6.59	12.35	9.14	11.10

Mean µg/l

Station	October	December	February	April	June	August	Average	s.d.
45	20.57	10.20	12.79	7.35	4.59	22.75	13.04	7.21
603	17.09	16.99	7.63	5.91	11.97	28.71	14.72	7.98
65	15.56	15.64	9.28	8.95	4.46	13.01	11.15	4.23
613	14.68	12.23	7.35	7.41	13.91	10.27	10.97	3.30
623	6.63	5.54	26.88	13.78	4.10	6.19	10.52	8.38
633	5.05	2.49	3.46	6.15	1.53	10.15	4.81	3.02
85	10.42	5.80	2.06	11.16	1.67	8.10	6.22	4.13
1505	9.42	6.21	3.87	12.25	10.09	9.05	8.48	2.96
1905	8.52	7.59	6.44	12.25	9.32	10.74	9.14	2.03
Average	12.09	9.39	8.86	9.47	6.85	13.22	**9.96**	
s.d.	5.50	4.97	7.36	2.90	4.51	7.29		**5.91**

Table 2.28

Lavaca Bay
PHEOPIGMENT 1985 - 1986

Replicate A µg/l (corrected algorithm)

Station	October	December	February	April	June	August
45	3.12	3.87	3.94	1.81	3.48	4.65
603	4.18	5.19	3.34	2.17	4.09	4.92
65	3.65	4.03	2.98	2.60	2.99	3.02
613	3.31	3.23	3.38	3.80	4.97	3.03
623	3.08	2.92	7.29	6.52	2.48	4.58
633	2.23	3.04	3.32	2.99	2.55	6.09
85	2.18	2.12	2.51	3.67	2.46	3.56
1505	2.77	2.49	3.58	3.22	3.47	2.57
1905	2.66	3.88	4.15	3.45	3.28	2.69

Replicate B µg/l

Station	October	December	February	April	June	August
45	3.12	3.87	3.94	1.81	3.48	4.65
603	4.18	5.19	3.34	2.17	4.09	4.92
65	3.65	4.03	2.98	2.60	2.99	3.02
613	3.31	3.23	3.38	3.80	4.97	3.03
623	3.08	2.92	7.29	6.52	2.48	4.58
633	2.23	3.04	3.32	2.99	2.55	6.09
85	2.18	2.12	2.51	3.67	2.46	3.56
1505	2.77	2.49	3.58	3.22	3.47	2.57
1905	2.66	3.88	4.15	3.45	3.28	2.69

Mean µg/l

Station	October	December	February	April	June	August	Average	s.d.
45	3.12	3.87	3.94	1.81	3.48	4.65	3.48	.92
603	4.18	5.19	3.34	2.17	4.09	4.92	3.98	1.05
65	3.65	4.03	2.98	2.60	2.99	3.02	3.21	.50
613	3.31	3.23	3.38	3.80	4.97	3.03	3.62	.68
623	3.08	2.92	7.29	6.52	2.48	4.58	4.48	1.93
633	2.23	3.04	3.32	2.99	2.55	6.09	3.37	1.32
85	2.18	2.12	2.51	3.67	2.46	3.56	2.75	.65
1505	2.77	2.49	3.58	3.22	3.47	2.57	3.02	.45
1905	2.66	3.88	4.15	3.45	3.28	2.69	3.35	.58
Average	3.02	3.42	3.83	3.36	3.31	3.90	**3.47**	
s.d.	.63	.90	1.34	1.32	.81	1.17		**1.08**

Table 2.29

Lavaca Bay
PHYTOPLANKTON 1985 - 1986

(Note that Units for Cell Numbers are Cells/µl)

Phytoplankton Cell Numbers, cells/µl

Station	October	December	February	April	June	August	Average	s.d.
45	580	510	1240	1280	1490	1210	1052	405
603	247	569	2380	654	3710	2450	1668	1382
65	1230	901	3020	624	1350	9800	2821	3520
613	762	1500	1130	656	948	7730	2121	2764
623	757	611	1390	1040	606	11900	2717	4509
633	289	1190	663	191	1970	9350	2276	3527
85	590	881	933	420	641	13700	2861	5313
1505	128	246	448	285	477	6080	1277	2356
1905	124	309	213	745	825	5610	1304	2129
Average	523	746	1269	655	1335	7537	**2011**	
s.d.	365	411	909	346	1014	4141		**3041**

Phytoplankton Biovolume, µl/l

Station	October	December	February	April	June	August	Average	s.d.
45	7.9	11.1	26.5	4.2	12.9	6.1	11.4	8.0
603	20.1	4.4	18.9	1.7	10.6	7.9	10.6	7.6
65	94.9	6.8	52.2	1.9	1.5	53.5	35.1	38.1
613	20.1	11.6	3.0	1.2	1.5	20.0	9.6	9.0
623	16.0	3.9	6.0	3.3	2.1	32.3	10.6	11.8
633	12.4	14.0	3.0	0.6	6.9	24.6	10.2	8.7
85	16.3	15.9	1.6	1.7	1.4	30.6	11.3	11.8
1505	40.5	2.8	11.2	1.8	4.2	15.5	12.6	14.6
1905	4.5	20.1	3.9	2.5	3.0	19.1	8.8	8.4
Average	25.8	10.1	14.1	2.1	4.9	23.3	**13.4**	
s.d.	27.8	6.0	16.6	1.1	4.3	14.5		**16.7**

Table 2.30

Lavaca Bay
PHYTOPLANKTON TAXONOMIC COMPOSITION 1985-1986
(all stations combined)

Relative fraction of total concentration (cells/ ml)

Taxon	October	December	February	April	June	August	Average
Cyanophytes	.826	.733	.828	.850	.911	.919	.844
Diatoms	.006	.003	.009	.001	.001	.000	.003
Chlorophytes	.121	.197	.140	.125	.080	.070	.122
Cryptophytes	.003	.002	.001	.001	.000	.000	.001
Dinoflagellates	.001	.000	.000	.000	.000	.000	.000
Flagellates & Monads	.043	.064	.021	.023	.008	.010	.028
Monthly relative fraction:	.127	.175	.256	.217	.035	.191	1.00

Relative fraction of total biovolume (µl/ml)

Taxon	October	December	February	April	June	August	Average
Cyanophytes	.666	.530	.942	.529	.605	.700	.662
Diatoms	.106	.199	.021	.098	.168	.030	.104
Chlorophytes	.034	.094	.011	.087	.062	.051	.057
Cryptophytes	.003	.014	.002	.017	.010	.005	.009
Dinoflagellates	.159	.017	.014	.122	.059	.009	.063
Flagellates & Monads	.033	.143	.009	.146	.092	.201	.104
Monthly relative fraction:	.208	.077	.454	.031	.031	.200	1.00

John Cullen
2/24/87

Light-Limitation Model

(photosynthesis Model from Platt et al. 1980, J. Mar. Res. 38: 687-701)

Model of photosynthesis: Pi = Ps*(1 - exp((-a*I)/Ps))*exp((-b*I)/Ps)
Definition of saturating light: Is = Ps/a
Scaling of photosynthesis: P` = Pi/Ps
Scaling of light: I` = I/Is
Scaling of attenuation coefficient: k` = k/z where z is depth of the well-mixed layer
Scaled Photosynthesis equation: P` = (1 - exp(-I`))*exp((-b*I`)/a)

6 April 1986 1200 h			
water column avg.	Ps	23.95	
from MA thesis	alpha	.072	
of R.F. Davis:	beta	.0034	
	Is	333 µmol/m^2/s	
	Io	586 µmol/m^2/s	(cloudy)
	k	2.4 m^-1	
	water depth	1.7 m	
	k`	1.41	
	I`	1.76	

Table of relative photosynthesis in a mixed layer as a function of incident light and water clarity

Across: Extinction coefficient k`.
(water column depth = 1% light depth when k` = 4.61)
Down: I` = Io/Is (Incident light/Saturating light)

Correcting for Respiration, Relative to Reference Rate from Sampling Date

	k` --->								
I`	.5	1.0	1.5	2.0	4.0	6.0	10.0	20.0	40.0
.5	.55	.41	.30	.22	.02	-.07	-.14	-.19	-.22
1.0	1.07	.87	.71	.57	.23	.08	-.05	-.15	-.20
1.5	1.39	1.19	$\boxed{1.00}$	.83	.39	.19	.01	-.12	-.18
2.0	1.60	1.41	1.21	1.03	.53	.28	.07	-.09	-.17
4.0	1.82	1.76	1.63	1.47	.86	.52	.21	-.02	-.14
8.0	1.62	1.71	1.73	1.68	1.15	.73	.34	.04	-.11
10.0	1.49	1.62	1.69	1.68	1.22	.79	.38	.06	-.10
15.0	1.20	1.38	1.51	1.58	1.31	.88	.44	.09	-.09
20.0	.96	1.16	1.33	1.45	1.34	.93	.47	.10	-.08

The outlined cell represents the approximate conditions midday on the day of sampling.

Water column photosynthesis is clearly sensitive to incident light and water clarity.

Table 2.31 (cont.)

Light-Limitation Model

Lavaca Bay April 1986

Correcting for Respiration = Pmax* .1

I`	k` --> .5	1.0	1.5	2.0	4.0	6.0	10.0	20.0	40.0
.5	.22	.16	.12	.09	.01	-.03	-.06	-.08	-.09
1.0	.42	.35	.28	.22	.09	.03	-.02	-.06	-.08
1.5	.55	.47	.40	.33	.16	.07	.01	-.05	-.07
2.0	.63	.56	.48	.41	.21	.11	.03	-.04	-.07
4.0	.72	.70	.65	.58	.34	.20	.08	-.01	-.06
8.0	.64	.68	.69	.66	.45	.29	.14	.02	-.04
10.0	.59	.64	.67	.66	.48	.31	.15	.02	-.04
15.0	.47	.54	.60	.63	.52	.35	.17	.04	-.03
20.0	.38	.46	.52	.57	.53	.37	.18	.04	-.03

Relative Rate of Gross Photosynthesis - Maximum = 1.0

	0.5	1	1.5	2	4	6	10	20	40
0.5	.32	.26	.22	.19	.11	.07	.04	.02	.01
1	.52	.45	.38	.32	.19	.13	.08	.04	.02
1.5	.65	.57	.50	.43	.26	.17	.11	.05	.03
2	.73	.66	.58	.51	.31	.21	.13	.06	.03
4	.82	.80	.75	.68	.44	.30	.18	.09	.04
8	.74	.78	.79	.76	.55	.39	.24	.12	.06
10	.69	.74	.77	.76	.58	.41	.25	.12	.06
15	.57	.64	.70	.73	.62	.45	.27	.14	.07
20	.48	.56	.62	.67	.63	.47	.28	.14	.07

LVBLightTableApr86

Table 2.32

John Cullen
2/24/87

Light-Limitation Model

(photosynthesis Model from Platt et al. 1980, J. Mar. Res. 38: 687-701)

Model of photosynthesis: Pi = Ps*(1 - exp((-a*I)/Ps))*exp((-b*I)/Ps)
Definition of saturating light: Is = Ps/a
Scaling of photosynthesis: P` = Pi/Ps
Scaling of light: I` = I/Is
Scaling of attenuation coefficient: k` = k/z where z is depth of the well-mixed layer
Scaled Photosynthesis equation: P` = (1 - exp(-I`))*exp((-b*I`)/a)

4 June 1986 1200 h			
water column avg.	Ps	12.72	
from MA thesis	alpha	.059	
of R.F. Davis:	beta	.0013	
	Is	216 µmol/m^2/s	
	Io	1768 µmol/m^2/s	(cloudy)
	k	2.0 m^-1	
	water depth	1.7 m	
	k`	1.18	
	I`	8.20	

Table of relative photosynthesis in a mixed layer as a function of incident light and water clarity

Across: Extinction coefficient k`.
(water column depth = 1% light depth when k` = 4.61)
Down: I` = Io/Is (Incident light/Saturating light)

Correcting for Respiration, Relative to Reference Rate from Sampling Date

I` \ k` -->	.5	1.0	1.5	2.0	4.0	6.0	10.0	20.0	40.0
.5	.28	.21	.16	.11	.01	-.03	-.07	-.10	-.11
1.0	.55	.45	.36	.29	.12	.04	-.03	-.08	-.10
2.0	.84	.74	.64	.54	.27	.15	.04	-.04	-.08
4.0	1.01	.96	.88	.79	.46	.28	.12	-.01	-.07
6.0	1.01	1.00	.96	.89	.56	.35	.16	.02	-.06
8.0	.98	1.00	.99	.94	.63	.40	.19	.03	-.05
10.0	.95	.98	.99	.96	.68	.44	.22	.04	-.04
15.0	.86	.91	.95	.96	.75	.50	.26	.06	-.03
20.0	.78	.84	.89	.92	.79	.54	.28	.08	-.03

The outlined cell represents the approximate conditions midday on the day of sampling.

Water column photosynthesis is near maximal for the likely range of incident light and water clarity.

Light-Limitation Model

Correcting for Respiration = Pmax* .1

	k` -->								
I`	.5	1.0	1.5	2.0	4.0	6.0	10.0	20.0	40.0
.5	.22	.17	.12	.09	.01	-.03	-.06	-.08	-.09
1.0	.43	.35	.29	.23	.09	.03	-.02	-.06	-.08
2.0	.66	.58	.50	.42	.21	.12	.03	-.03	-.07
4.0	.79	.75	.69	.61	.36	.22	.09	.00	-.05
6.0	.79	.79	.75	.70	.44	.27	.13	.01	-.04
8.0	.77	.78	.77	.74	.49	.31	.15	.02	-.04
10.0	.74	.77	.77	.75	.53	.34	.17	.03	-.03
15.0	.67	.71	.74	.75	.59	.39	.20	.05	-.03
20.0	.61	.66	.70	.72	.62	.42	.22	.06	-.02

Relative Rate of Gross Photosynthesis - Maximum = 1.0

	0.5	1	1.5	2	4	6	10	20	40
0.5	.32	.27	.22	.19	.11	.07	.04	.02	.01
1	.53	.45	.39	.33	.19	.13	.08	.04	.02
2	.76	.68	.60	.52	.31	.22	.13	.07	.03
4	.89	.85	.79	.71	.46	.32	.19	.10	.05
6	.89	.89	.85	.80	.54	.37	.23	.11	.06
8	.87	.88	.87	.84	.59	.41	.25	.12	.06
10	.84	.87	.87	.85	.63	.44	.27	.13	.07
15	.77	.81	.84	.85	.69	.49	.30	.15	.07
20	.71	.76	.80	.82	.72	.52	.32	.16	.08

Table 2.33. **Photosynthethic parameters for April and June, 1986, Lavaca Bay,** (from Davis,1986)

9 April 1986

Time	**I.D.**	**Ps**	**Stnd Err**	**Alpha**	**Stnd Err**	**Beta**	**Stnd Err**	**Pm**	**Stnd Err**	**Ik**
6:00	surface	12.20	0.63	.063	.003	.0041	.0075	9.54	0.34	152
6:00	bottom	15.07	0.86	.077	.005	.0045	.0009	12.00	0.49	157
12:00	surface	21.81	2.02	.078	.005	.0025	.0017	18.92	1.13	241
12:00	bottom	26.09	4.20	.067	.005	.0044	.0029	20.41	2.16	304
12:00	sur inc	15.11	3.57	.047	.004	.0000	.0025	15.11	2.84	323
12:00	bot inc	21.99	3.43	.066	.005	.0009	.0024	20.52	1.86	309
16:00	sur inc	10.08	1.07	.043	.003	.0005	.0010	9.44	0.61	221
16:00	bot inc	20.93	3.68	.052	.003	.0032	.0028	16.56	1.83	318
16:00	sur-bot inc	14.57	1.07	.063	.004	.0015	.0009	12.99	0.63	208
16:00	bot-sur inc	17.52	2.11	.060	.006	.0015	.0014	15.59	1.27	261
18:00	surface	17.32	1.67	.075	.006	.0041	.0017	13.99	0.92	186
18:00	bottom	18.55	2.24	.063	.005	.0058	.0021	13.53	1.11	216

4 June 1986

Time	**I.D.**	**Ps**	**Stnd Err**	**Alpha**	**Stnd Err**	**Beta**	**Stnd Err**	**Pm**	**Stnd Err**	**Ik**
6:00	surface	10.18	1.12	.062	.007	.0023	.0013	8.66	0.68	141
6:00	bottom	8.79	0.30	.054	.003	.0016	.0003	7.68	0.19	142
12:00	surface	12.14	1.54	.058	.006	.0011	.0014	11.01	0.92	192
12:00	bottom	13.30	0.55	.059	.003	.0013	.0004	11.93	0.35	201
13:00	sur inc	8.48	1.31	.032	.003	.0006	.0011	7.72	0.72	245
13:00	bot inc	11.68	0.61	.056	.003	.0016	.0005	10.24	0.38	183
16:00	sur inc	5.58	0.73	.031	.004	.0006	.0007	5.07	0.46	164
16:00	bot inc	15.00	0.63	.064	.002	.0035	.0006	12.11	0.36	190
16:00	sur-bot inc	10.76	1.25	.053	.005	.0015	.0012	9.47	0.75	177
16:00	bot-sur inc	10.96	0.58	.051	.003	.0010	.0005	9.94	0.37	195
18:00	surface	9.91	0.90	.053	.005	.0016	.0009	8.67	0.55	163
18:00	bottom	10.56	0.37	.055	.002	.0010	.0003	9.62	0.25	173

See text for details and units.

CHAPTER 3

BENTHIC RESPIRATION RATE AND AMMONIUM FLUX

INTRODUCTION

Benthic nutrient regeneration provides a significant proportion of inorganic nutrients for primary production in shallow marine environments (Fisher *et al.* 1982, Nixon and Pilson 1983, Boynton and Kemp 1985). The potential for nutrient regeneration in sediments is primarily dependent upon deposition of organic matter from the water column. Estuarine sediments with higher organic content support higher microbial metabolism (Waksman and Hotchkiss 1938) and result in more regeneration of inorganic nutrients (Seki *et al.* 1968, Aller and Yingst 1980). Nixon and Pilson (1983) reported that the benthic remineralization of a marine environment was closely related to the primary production plus organic input into that area. Therefore, higher primary production in the water column may result in more nutrient flux from sediments in an estuary, unless particulate organic matter in the water column is substantially flushed out to the open sea.

Freshwater inflow is also an important source of inorganic nutrients for primary production (Barlow *et al.* 1963, Sharp 1982, Nixon and Pilson 1983) and terrestrial organic matter in estuarine environments (Shultz and Calder 1976). Therefore, it is likely that benthic flux of inorganic nutrients may be affected by freshwater inflow into an estuarine environment.

However, little information is available about long term effects of freshwater inflow upon benthic nutrient regeneration in an estuarine environment. Benthic ammonium flux and oxygen consumption rates were measured in the Lavaca Bay estuary, Texas, monthly or bimonthly for two consecutive years. During the study period, freshwater inflow into the estuary was much greater for Year 1 (November 1984-August 1985) than for Year 2 (October 1985-August 1986).

METHODS

Deployment of Chambers

Two opaque fiberglass chambers, A and B (18 liter volume), were deployed at station 85 to determine benthic respiration and *in situ* ammonium flux across the sediment-water interface. The chambers were set carefully on the seafloor to minimize disturbance of sediments. An oxygen probe (YSI 5139) connected to a dissolved oxygen meter was installed only in Chamber A. Chamber water was circulated by a deck-mounted Masterflex pump (Barnant Co.) through Tygon tubing (ID 0.63cm, length 2x15m) wrapped with black electrical tape to exclude light. Chamber water was sampled whenever desired, via a two-way valve connected to the outlet of the Masterflex pump. Circulation of water within the chamber was gentle enough not to disturb the surface sediment inside of the chamber. The turnover time of water in the chamber via tubing was about 0.5 hour.

Benthic Respiration Rate

Benthic respiration rate was determined by measuring the dissolved oxygen concentration in the chamber water through time and correcting for water volume and chamber area. Since chemical oxygen demand was not determined, these respiration rates are really total oxygen demand (Dale, 1978). The concentration of dissolved oxygen was measured by both the Winkler method and with a polarographic electrode (chamber A), or only by the Winkler method (chamber B). Before each experiment, the dissolved oxygen meter was calibrated by comparison with Winkler determinations on identical samples of bottom water. During each experiment (about 4 hours), triplicate 20 ml samples of the chamber water were collected and fixed every 40-50 minutes for titration. The first sample of chamber water was not collected until at least 30 minutes after setting the chambers because oxygen was rapidly consumed at the onset presumably due to disturbance of sediments. All Winkler titrations were completed within two hours of sampling.

Ammonium Analysis of Sediment Pore Water

Sediment cores were sampled with a core sampler (ID 6.5 cm, height 25 cm) without disturbing textures of the sediment from seven stations in the Lavaca Bay estuary. Sediment cores were sectioned at 1 cm intervals over the top 10 cm. Sectioning at 1 cm intervals was judged to be appropriate because 0.5 ml, the minimum amount of pore water for ammonium assay, was extracted from each section. Each section was put into a sterile plastic petri dish which was then sealed with black electrical tape to avoid any loss of pore water. Replicate samples were frozen immediately and were kept frozen until analyzed. Pore water from each sediment section was extracted by centrifugation (5000 x g). Ammonium concentration was determined colorimetrically (Solorzano 1969) using a spectrophotometer (Beckman Model 24).

Ammonium Flux

Benthic ammonium flux across the sediment-water interface was determined in two ways. At station 85 the change in ammonium concentration of chamber water was measured *in situ*. Chamber water samples were filtered through glass fiber filters (GF/F) and were kept frozen until analyzed.

Theoretical ammonium flux (calculated ammonium flux) of each station was independently calculated from the profile of ammonium concentrations in sediment pore waters. The theoretical calculation is based on Fick's first law, and the following equations were used (Klump and Martens 1981).

$$J_s = -\, \o_o D_s \left(\frac{\partial C}{\partial Z}\right)_{pw}$$

J_s = flux of ammonium across the sediment (μg-at N m^{-2} hour^{-1})

$\o_o$ = porosity at the sediment-water interface (unitless)

D_s = bulk sediment diffusivity (cm$^2{}_{pw}$.sec^{-1})

$$D_s = \frac{Do}{\o_o F}$$

where

D_o = molecular diffusivity of ammonium (cm$^2{}_{pw}$ sec^{-1}) (Klump and Martens 1981)

F = formation resistivity factor (Ullman and Aller 1982)

$$F = \frac{1}{\o^m} \text{(for } \o \geq 0.7,\ m = 3;\ \text{for } \o < 0.7,\ m = 2)$$

$\left(\frac{\partial C}{\partial Z}\right)_{pw}$ = gradient of ammonium concentration at the sediment-water interface

The gradient was calculated by three different ways as described below. The method used depended on the pattern of the profile of ammonium concentration in the sediments.

1) When the ammonium concentration increased linearly with depth into the sediment, the gradient was obtained from the slope of concentration versus depth.

2) When ammonium concentration increased exponentially with sediment depth, the gradient was obtained as follows (Klump and Martens 1981):

$$\left(\frac{\partial C}{\partial Z}\right)_{pw} = \alpha \ (C \ \ - Co) \ e^{-\alpha z}$$

α = constant

z = depth (cm)

C_z, C , C_0; concentration of ammonium at depths z, infinity and zero (the sediment-water interface) respectively (μg-at N l^{-1})

3) When the ammonium concentration of the top sediment section (0-1 cm) was equal to or higher than that of pore water of the next lower sediment section (1-2 cm), the gradient was calculated using the following equation:

$$\left(\frac{\partial C}{\partial Z}\right)_{pw} = \frac{[NH_4^+] \text{ of the top sediment} - [NH_4^+] \text{ of the overlying water}}{0.5 \text{ cm}}$$

This calculation is based on arbitrary assumptions that; (1) ammonium concentration in the pore water increases linearly with depth within the upper 1 cm of sediment, and (2) that the ammonium concentration at the sediment-water interface was identical to that of overlying water. These assumptions may not be appropriate in all cases. However, this calculation may provide relative values of theoretical flux and allow us to compare the flux at different stations when ammonium concentration is maximal in the top sediment section.

Porosity of sediments (Table 3.1) was determined using the following equation:

Porosity (ø) = water content of sediment/volume of sediment

Water content of the sediment was measured as the difference in weight between the wet sediment and the dry sediment (dried at 45°C for two weeks).

The porosity at the sediment-water interface ($\varnothing_0$) was the intercept at the zero depth of sediments when extrapolating the slope of the porosity versus the depth of sediments (upper few cm).

RESULTS

Dissolved Oxygen Concentration

Dissolved oxygen concentration of bottom water at Lavaca Bay station 85 generally decreased as temperature increased. During Year 1, the highest oxygen concentration (12.0 mg/l) was in January and the lowest concentration (6.8 mg/l) was in July. During Year 2, the highest concentration (9.8 mg/l) was in December and the lowest concentration (5.94 mg/l) was in August. Through the seasons, dissolved oxygen concentration was higher in Year 1 than in Year 2 (Fig. 3.1). The percent saturation of dissolved oxygen was also higher during year 1 than during Year 2 (Fig. 3.2). The highest saturation (122.8%) was in April of 1985 and the lowest (80.8%) was in August of 1986. The percent saturation was generally higher in the winter than in the summer during the two year study period.

Benthic Respiration Rate (total oxygen consumption rate in the chamber water)

Seasonal patterns of benthic respiration rates of Year 1 and Year 2 were different (Fig. 3.3). Benthic respiration rate is generally related to temperature (Hargrave, 1969). In this study area, benthic respiration rate appeared to be not significantly related to temperature ($r = 0.15$; $p > 0.1$) or to salinity ($r = 0.45$, $p > 0.05$) during the two year study period (Fig. 3.4.1, Fig. 3.4.2). During Year 1, the highest respiration rate (311 mg O_2 m^{-2} h^{-1}) was in the coldest month (January) and the lowest value (106 mg O_2 m^{-2} h^{-1})

was in June. During Year 2, the highest oxygen consumption rate (412 mg 0_2 m^{-2} h^{-1}) was in June and the lowest rate (132 mg 0_2 m^{-2} h^{-1}) was in October (Fig. 3.3).

The range of oxygen consumption rates in the study area was much higher than that observed in North Carolina estuaries (Fisher *et al.* 1982), or that measured along the salinity gradient of Chesapeake Bay (Boynton and Kemp 1985). However, the range of respiration rates in the study area were similar to those observed in Corpus Christi Bay (Flint and Kalke 1985).

Ammonium Concentration in Sediment Pore Water

In general, ammonium concentrations in pore waters of surface sediments, particularly in the upper few cm, were higher during Year 1 than during Year 2 for all stations in the Lavaca Bay estuary (Table 3.2, 3.3, 3.4). However, ammonium concentration in pore water of sediments did not show a trend along the salinity gradient. The most conspicuous result of this study was the difference in the dominant pattern of ammonium concentration profiles between Year 1 and Year 2. During Year 2, ammonium concentration generally increased with depth of sediments except station 65 (Fig. 3.5.1, 3.5.2.2, 3.5.3.2, 3.5.4.2, 3.5.5.2, 3.5.6.2, 3.5.7.2). In contrast, during Year 1 the dominant pattern of ammmonium profiles was reversed; ammonium concentration of the top sediment pore water (0 - 1 cm) was generally higher than those of deeper sediments (Fig. 3.5.1, 3.5.2.1, 3.5.3.1, 3.5.4.1, 3.5.5.1, 3.5.7.1).

During Year 1, the range of ammonium concentration in pore water of upper 10 cm sediments was 9.6 - 1793 μg-at N l^{-1}. More than 1700 μg-at N l^{-1} was observed in pore waters of station 45, 603, 613, 623, 633, and 1505. The range for Year 2 was 27.1 - 1033 μg-at N l^{-1}. The range of ammonium concentration of sediment pore water in the study area is greater than that of the Tarmar Estuary of England (Watson *et al.* 1985) and that of Indian River estuary, Florida (Montgomery *et al.* 1979). However, it is smaller than that of Cape Lookout, North Carolina (Klump and Martens 1981); that of the White Oak River estuary, North Carolina (Martens and Goldhaber 1978); or that of Ronbjerg Harbour in Denmark (Henriksen *et al.* 1980).

Ammonium Flux

During three of the seven chamber experiments in Year 1, the ammonium flux was from the water column into sediments rather than from sediments to the water column in (April, 1985) or was not significantly different from zero (January, July 1985) (Fig. 3.6). However, in March 1985, ammonium flux from sediments was greater than 2000 μg-at N m^{-2} h^{-1}. The ammonium flux for Year 2 was greater than for Year 1 for all months except March, 1985. The variation of the flux during Year 2 was smaller than that of Year 1. The range of *in situ* ammonium flux was from 94 μg-at N m^{-2} h^{-1} to 2397 μg-at N m^{-2} h^{-1} at station 85 over the two year study period. This range is greater than those observed by Fisher *et al.* (1982) in a North Carolina estuary, Klump and Martens (1981) in Cape Lookout Bight, or Boynton and Kemp (1985) in the Chesapeake Bay estuary. The measured flux did not show any significant relationship to temperature ($r = -0.23$; $p > 0.1$) or to the salinity ($r = 0.04$; $p > 0.1$) in this study area (Fig. 3.7.1, Fig. 3.7.2).

The theoretical fluxes (calculated fluxes) of year 1 were higher than those of Year 2 (Fig. 3.8). During Year 1, the calculated flux ranged from 40.3 μg-at N m^{-2} h^{-1} to 1058 μg-at N m^{-2} h^{-1}, and during Year 2, it ranged from 3.6 μg-at N m^{-2} h^{-1} to 240 μg-at N m^{-2} h^{-1}. The theoretical flux (calculated flux) also did not show any relationship to temperature ($r = -0.42$; $p > 0.05$) during the study period (Fig. 3.9.1). However, the theoretical flux decreased as salinity increased at station 85 ($r = -0.63$, $p < 0.01$) (Fig. 3.9.2). Theoretical fluxes at station 85 were calculated using mostly ammonium concentration of top sediment section (0 - 1 cm) and that of the overlying water (Fig. 3.10). Therefore, higher ammonium concentrations of top sediment pore waters in Year 1 (wet year) relative to those in Year 2 (dry year) seems to be responsible for such a relationship. Relatively high calculated fluxes were shown right before the coldest season (November in the first year, October in the second year) and at mid summer (August for both Year 1 and year 2). The calculated flux was generally higher (except for March 1985) than the measured flux during Year 1, while the measured flux was higher than the calculated flux during Year 2 (Fig. 3.10). We expected that the calculated flux would positively correlate with the measured flux as reported by Klump and Martens (1981). However, substantial discrepancy between calculated and measured flux was observed in this study (Fig. 3.10). But the highest peak of both the measured and the calculated flux at station 85 commonly appeared in March 1985.

All raw data from this study are presented in appendices Tables 3.1 - 3.7.

DISCUSSION

Ammonium concentration in pore water of sediments depends on ammonium regeneration rate and utilization rate by microbes (Blackburn 1979, Williams *et al.* 1985) and also on advection and diffusion of pore water across the sediment-water interface (Aller 1980, Watson *et al.* 1985). In general, ammonium regeneration rates are relatively high near the sediment-water interface and decrease with depth (Blackburn 1979, Aller and Yingst 1980, Nixon and Pilson 1983), while ammonium concentration in sediment pore water is relatively lower at the interface and increases with depth (Klump and Martens 1981). Ammonium in pore water closer to the interface is more readily utilized by benthic algae or nitrifying bacteria, and is more easily transported into the water column. Therefore, higher turnover rates of ammonium are probably responsible for relatively lower concentration in upper sediment pore water compared to deeper sediments in typical estuarine environments.

It is rarely reported that ammonium concentration in pore water of the upper 1 cm of sediments is higher than that of deeper sediment. However such a profile predominated during Year 1 (Figs. 3.5.1, 3.5.2.1, 3.5.3.1, 3.5.4.1, 3.5.5.1, 3.5.6.1, 3.5.7.1). A similar profile was reported from the tributary area of Chesapeake Bay (Boynton and Kemp 1985). In general, during Year 2, ammonium concentrations were either uniform through the depth of sediments or increased with depth.

It is possible that the difference in freshwater inflow between Year 1 and Year 2 may be responsible for the difference in ammonium concentrations of pore waters and their profiles between Year 1 and 2. Primary productivity measurements for Year 1 are not available for comparison with Year 2. However, freshwater inflow and inorganic nutrient concentrations were much higher during Year 1 than during Year 2 (Chapter 2 of this report). Chlorophyll a concentration also appeared to be higher during Year 1 than during Year 2 (Chapter 2 of this report). Therefore, primary production of Year 1 might have been higher than that of Year 2. Higher percent saturation of dissolved oxygen during Year 1 supports higher photosynthetic activity in

Year 1 because higher dissolved oxygen is usually observed in seawater where photosynthetic activity is more active (Sharp *et al.* 1982). Higher primary production in the water column due to greater freshwater inflow may have increased the deposition of organic matter and eventually enhanced ammonium regeneration in upper surface sediments.

Freshwater inflow with its terrestrial organic matter may directly increase organic deposition. In general, terrestrial organic matter contains a high proportion of humic substances (Beck and Reuter 1974) which are refractory to bacterial metabolism. However, it cannot be ruled out that an increase in deposition of terrestrial organic matter may have been responsible for higher ammonium concentrations in pore water in the upper sediments during Year 1.

Even though we don't know either the pool size of total nitrogen in surface sediments or main processes related to ammonium remineralization, we can state that the ammonium pool in surface sediments was larger with greater freshwater inflow in the Lavaca Bay estuary.

Ammonium flux is usually determined by *in situ* measurement using benthic chambers or by using the profile of ammonium concentrations in sediment pore waters to calculate a flux. Each of these two methods has intrinsic limitations and assumptions. When a benthic chamber is used for measurement, the following problems may cause erroneous results: (1) ammonium concentration in the chamber water may change due to disturbance of sediments; (2) non-chamber water may enter during sampling of chamber water; (3) significant amounts of ammonium may be utilized or produced inside the chamber; and (4) measurements in a closed system may not represent the natural system. Calculation of the theoretical flux is based on the following assumptions: (1) diffusion of ammonium is the main factor controlling mobility of ammonium in sediment pore waters; (2) the ammonium concentration profile in the pore water of upper sediments is in steady state; and (3) there are no physical, chemical or biological barriers between sediments and the sediment-water interface which may influence diffusivity of ammonium. However, these assumptions are not always met. For example, ammonium flux is sometimes enhanced by bioturbation (Aller 1980; Henrikson *et al.* 1980; Calender and Hammond, 1982; Lyons *et al.*, 1982), and benthic microalgae (Henriksen *et al.*, 1980; Williams *et al.* 1985) and other microorganisms in the upper sediments may utilize ammonium substantially prior to diffusion into the overlying water.

Flux of inorganic nutrients measured *in situ* generally yields higher values than calculated flux due to bioturbation in surface sediments. For example, Lyons *et al.* (1982) reported that the measured flux was 3-6 times higher than the calculated flux at Potomac River Estuary in Chesapeake Bay, and Callender and Hammond (1982) reported than the measured flux was 1-10 times higher than the calculated flux in Great Bay Estuary in New Hampshire. At station 85 in the Lavaca Bay estuary, the measured flux of ammonium was 2-200 times higher than the calculated flux during Year 2. In contrast, the calculated flux was generally higher than the measured flux during Year 1. The sharp ammonium gradient probably existed within a very shallow depth of sediments during Year 1. However, ammonium concentration of the top sediment (0-1 cm) pore water and that of the overlying water were used for calculation of the theoretical flux because ammonium concentration of the top sediment (0-1 cm) pore water was higher than that of the adjacent deeper sediments through the year. Calculated fluxes of Year 1 are probably overestimated because the ammonium concentration at the sediment-water interface is presumably much higher than that of the overlying water. Therefore, ammonium flux measured from the chamber experiment is more reliable than calculated flux. A primary cause of discrepancy between calculated and measured flux is the excessively high fluxes of ammonium calculated when ammonium concentration was maximal in the top sediment (0-1cm) during Year 1 (Fig. 3.8).

In situ ammonium flux measured at station 85 in March of Year 1 was extraordinarily high (more than 2000 μg-at N m^{-2} h^{-1}). This was probably related to the very high concentration of ammonium in pore water (1590 μg-at N l^{-1} in the top sediment). Such a non-seasonal, short term peak pulse of sediment nutrient regeneration was probably due to rapid degradation of newly sedimented material at the sediment surface (Fisher *et al.* 1982).

During Year 1, measured ammonium flux was not significantly different from zero in January and July (95% confidence interval was -10.8 ± 472.4 μg-atm N $m^{-2}h^{-1}$ and -7.0 ± 17.6 μg-atm N $m^{-2}h^{-1}$ respectively), and negative ammonium flux (from the water column to sediments rather than from sediments to the water column) was found in April (95% confidence interval was -94.2 ± 5.1 μg-atm N $m^{-2}h^{-1}$). During those periods when a flux was zero or negative, most regenerated ammonium might have been consumed by microorganisms or benthic algae near the sediment-water interface prior to diffusion into the water column. Williams *et al.* (1985) also reported that negative flux may occur if regenerated ammonium is substantially utilized by benthic algae or nitrifying bacteria in surface sediments.

Edwards (1981) discussed that alteration of freshwater inflow causes change in salinity of benthic environments, resulting in alteration in physical and chemical parameters of sediments in addition to biological metabolism. We did not measure physical parameters of surface sediments like pH and redox potential. However, we can speculate that alteration in such physical parameters may be the other possible explanation for the difference in ammonium flux between Year 1 and Year 2 because pH and redox potential are important factors to mobility of ammonium (Graetz *et al.*, 1973).

Fisher et al. (1982) reported that there was no significant relationship between oxygen consumption rate and *in situ* ammonium flux in North Carolina estuaries. We also did not observe a strong relationship between those two parameters in the study area. Klump and Martens (1981) observed that ammonium release from sediment was strongly dependent on temperature in the Cape Lookout Bight. In our study area, no significant relationship was observed between temperature and *in situ* ammonium flux. Other processes or parameters probably played more important roles in releasing ammonium from sediments in our study area.

The demand for regenerated nitrogen in the water column was not directly assessed in this study. However, simple calculations can be made to obtain rough estimates for comparison with benthic flux measurements.

For example, one can multiply primary production (mg C·m^{-2}·d^{-1}; Davis, 1986) by a conversion factor relating nitrogen uptake to carbon assimilation. The Redfield ratio of phytoplankton (by weight 6.0 mg C·mg N^{-1}; Redfield *et al.* 1963) is commonly used for this purpose. Two examples are presented:

Month: April 1986

Primary Production: 1111 mg C·m^{-2} d^{-1}

Demand for N: 1111 mg C·m^{-1} 6.0 mg C·mg N^{-1}

= 185.2 mg N·m^{-2}·d^{-1}

= 13.2 mg-at N·m^{-2}·d^{-1}

Month: June 1986

Primary Production: 1819 mg C·m^{-2}·d^{-1}

$$\text{Demand for N: } 1819 \text{ mg C}\cdot\text{m}^{-2}\cdot\text{d}^{-1} \quad 6.0 \text{ mg C}\cdot\text{mg N}^{-1}$$

$$= 303.2 \text{ mg N}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$$

$$= 21.6 \text{ mg-at N}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$$

These daily rates could be divided by 24 to get very rough estimates of the demand for nitrogen in units comparable to the benthic flux measurements: April calculated demand = 550 μg-at $N\cdot m^{-2}\cdot h^{-1}$, June demand = 900 μg-at $N\cdot m^{-2}\cdot h^{-1}$. There are many problems associated with this method of estimation: the Redfield ratio may not represent the chemical composition of the phytoplankton (C/N might be higher, thus nitrogen demand would be overestimated, perhaps by up to two times); bacterial demand for ammonium is not assessed (Wheeler and Kirchman 1986) leading to a potentially sizeable underestimation of the demand for nitrogen; nocturnal respiration of the phytoplankton is not considered and thus the true ratio of carbon taken up during the day to nitrogen assimilated over 24 h is underestimated and the demand for nitrogen is overestimated, maybe by as much as 1.5 - 2 times. There is also a problem associated with interpretation of ^{14}C incorporation. Does the method measure gross or net production? Without getting involved in further discussion we can state that demand for regenerated nitrogen in the water column is on the same order of magnitude as the measured benthic flux (442 μg-at $N\cdot m^{-2}\cdot h^{-1}$ in April, 682 μg-at $N\cdot m^{-2}\cdot h^{-1}$ in June) and that quantitative relationships must be determined with more involved techniques including studies with nitrogen and carbon tracers.

CONCLUSION

The ammonium pool in surface sediments, particularly the upper few cm, was generally higher during Year 1 (wet year) than during Year 2 (dry year) in the study area. The profiles of ammonium concentrations in sediment pore waters for the wet year were different from those for the dry year. During the wet year, ammonium concentrations in the upper few cm of sediment pore waters were generally higher than in deeper sediments. In contrast, during the dry year, ammonium concentrations in the upper few cm were generally lower than in the deeper sediments. Calculated ammonium fluxes were greater than *in situ* measured fluxes in the wet year, whereas calculated fluxes were smaller than the measured fluxes in the dry year. Discrepancy between calculated and measured ammonium flux may be due to overestimation of calculated flux when ammonium concentration was maximal in top sediment (0-1 cm) during the wet year. Therefore, the measured flux represents more reliable estimate of ammonia flux. Neither the calculated flux nor the measured flux was correlated with temperature. Though measured ammonium flux did not show a significant relationship with salinity, calculated flux decreased as salinity increased. Benthic respiration rate did not show a significant relationship with temperature or salinity during the study period.

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Figure 3.1. **Stn*85 Bottom Water Dissolved Oxygen** (Station 85)
Data in Appendix 3.1

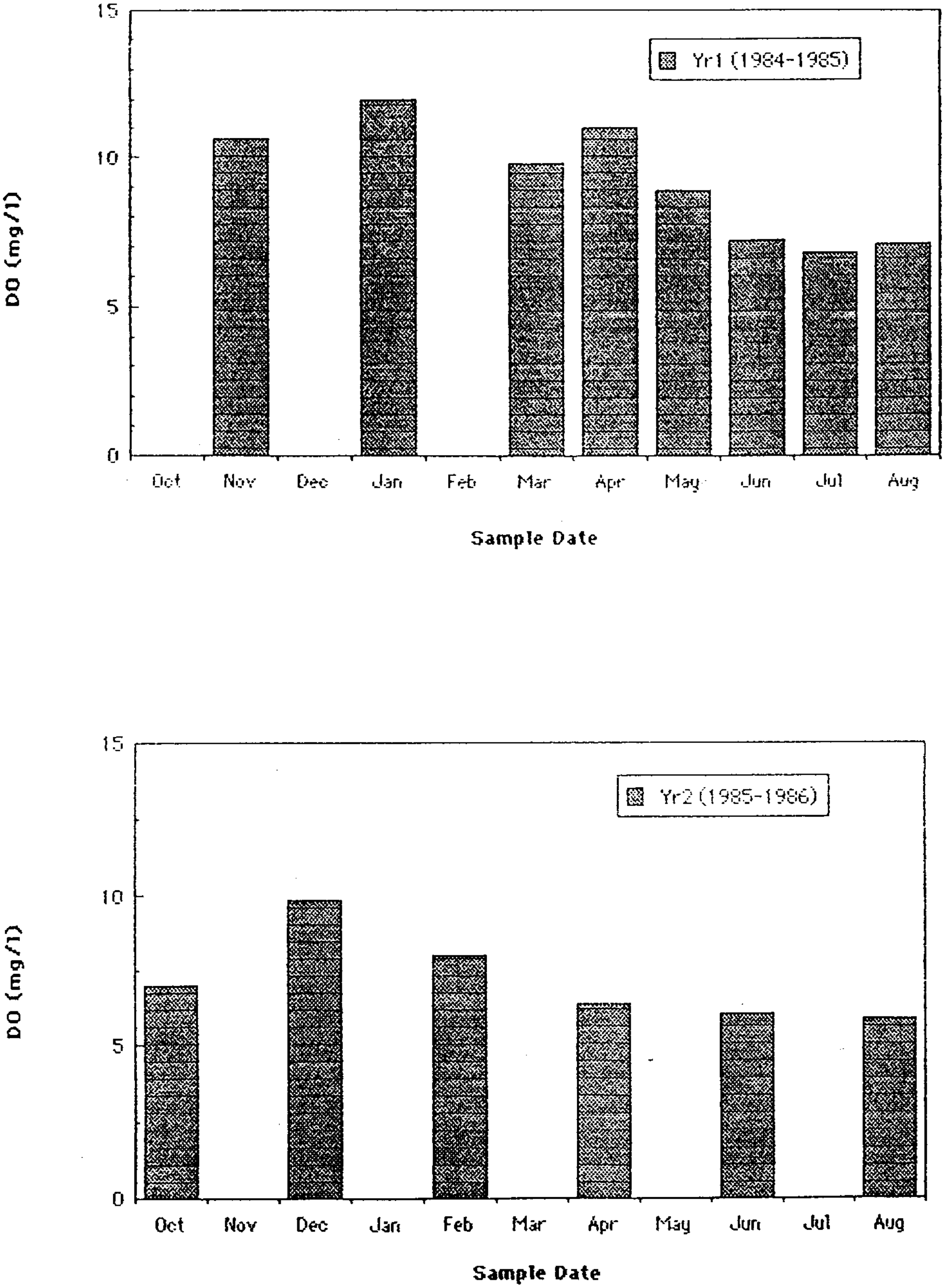


Figure 3.2. **Percent Saturation of Dissolved Oxygen** (Station 85)

Data in Appendix 3.2

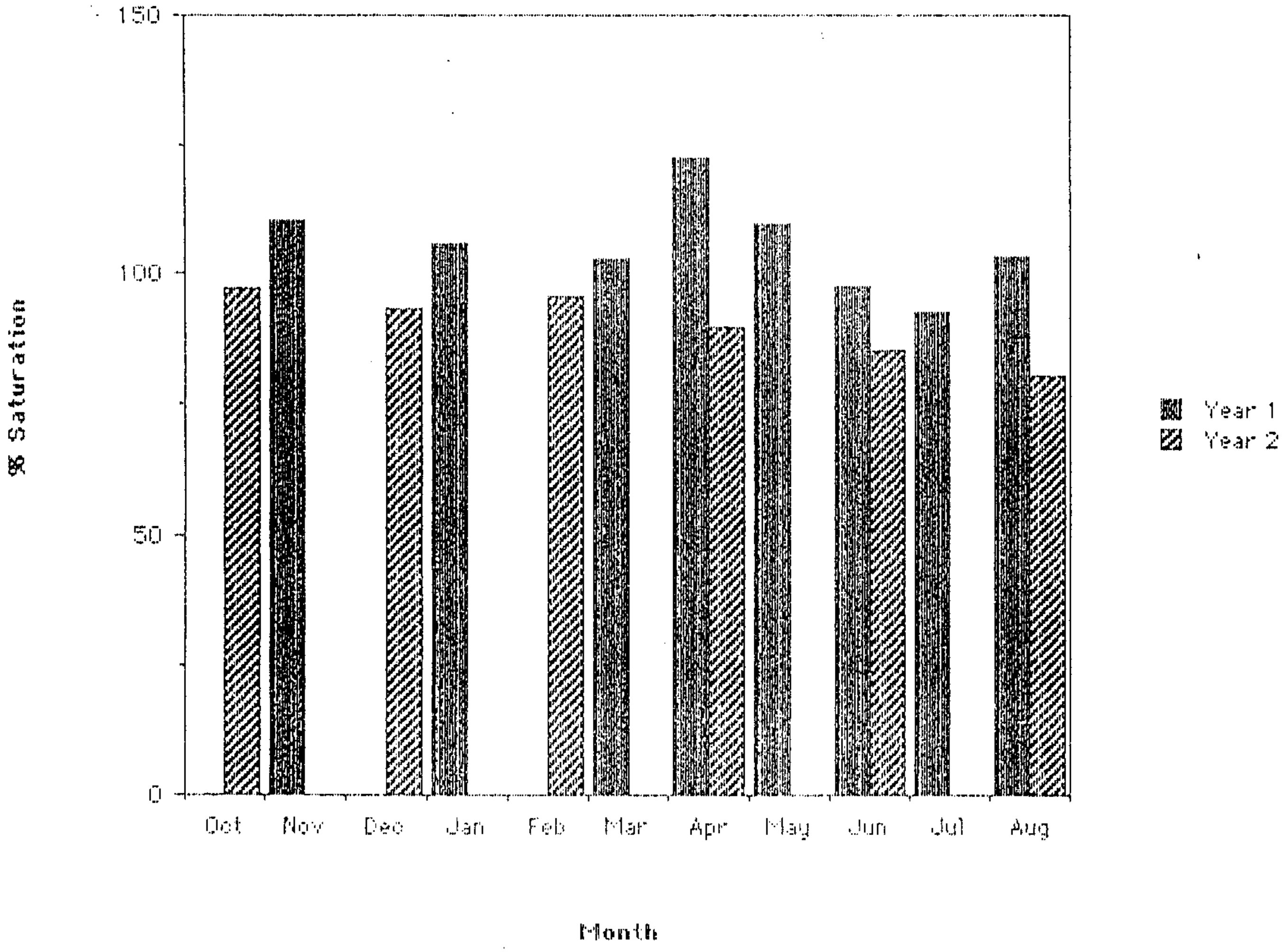


Figure 3.3. Benthic chamber respiration rate. (station 85) (Data in Appendix 3.3).

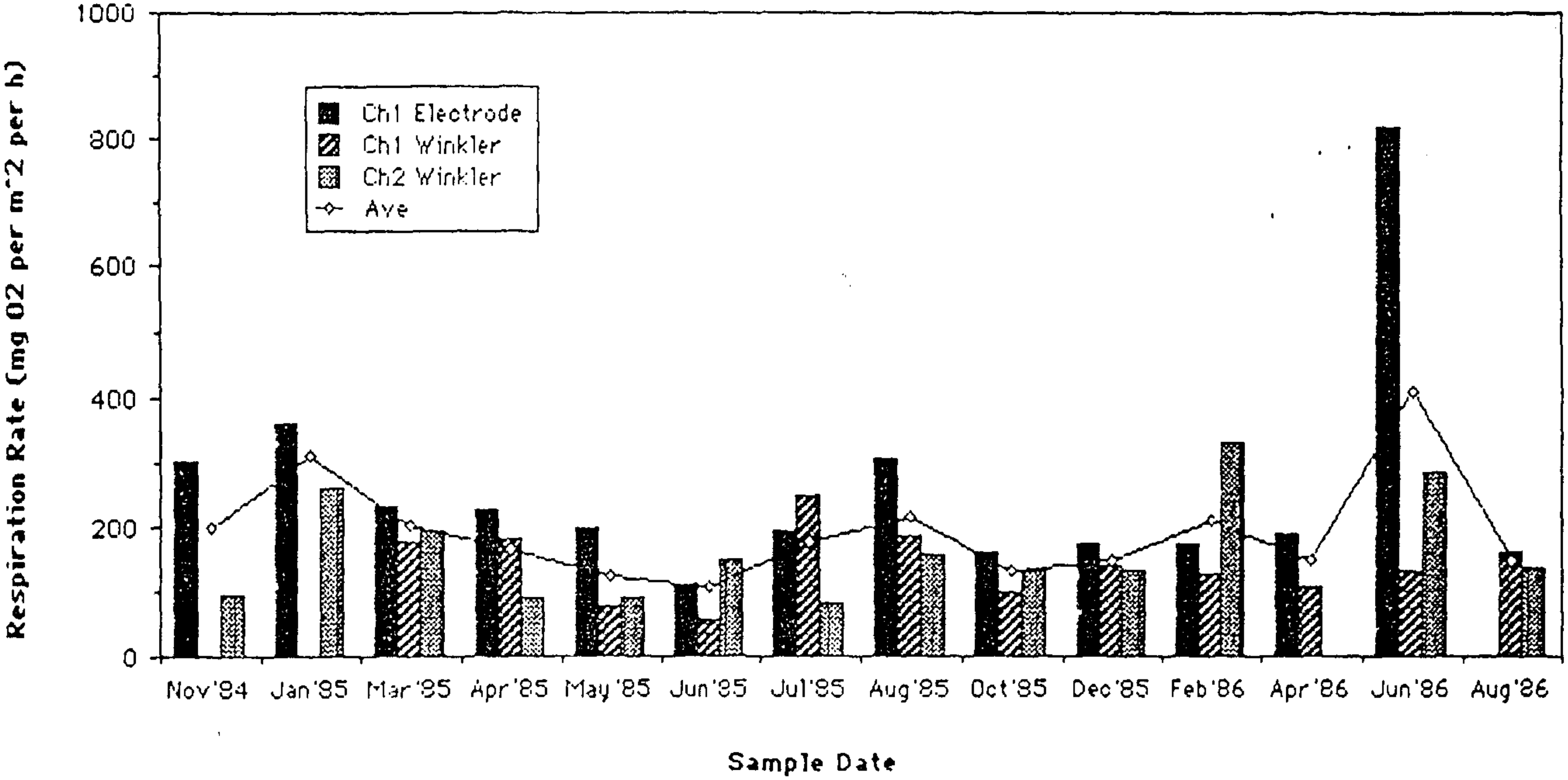


Figure 3.4.1. Relationship of Benthic Chamber Respiration Rate To Temperature at Station 85 (1984-1986)

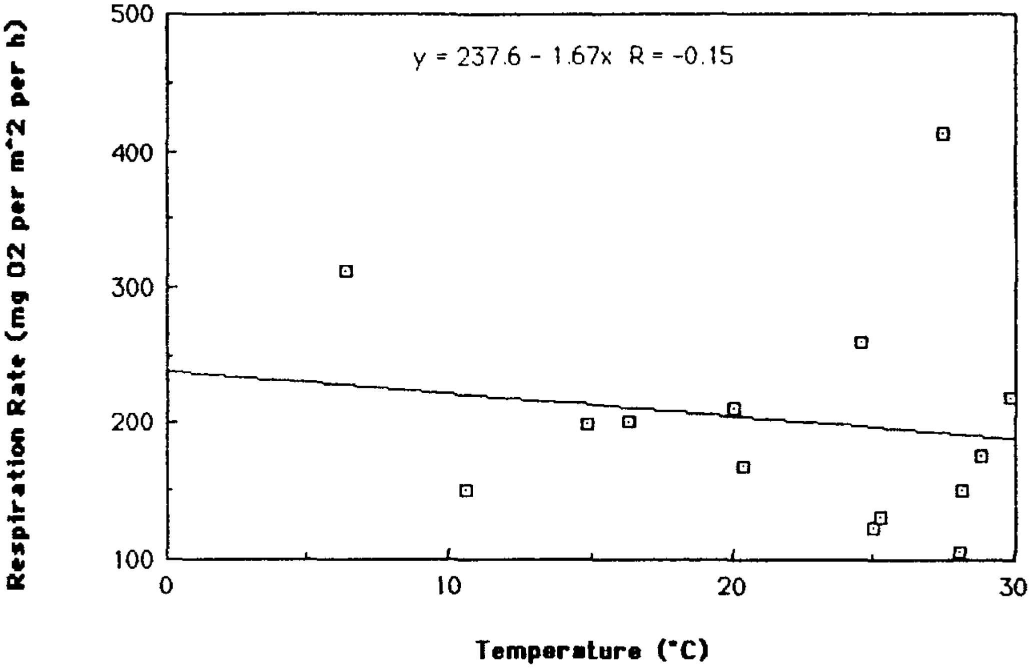


Figure 3.4.2. Relationship of Benthic Chamber Respiration Rate To Salinity at Station 85 (1984-1986)

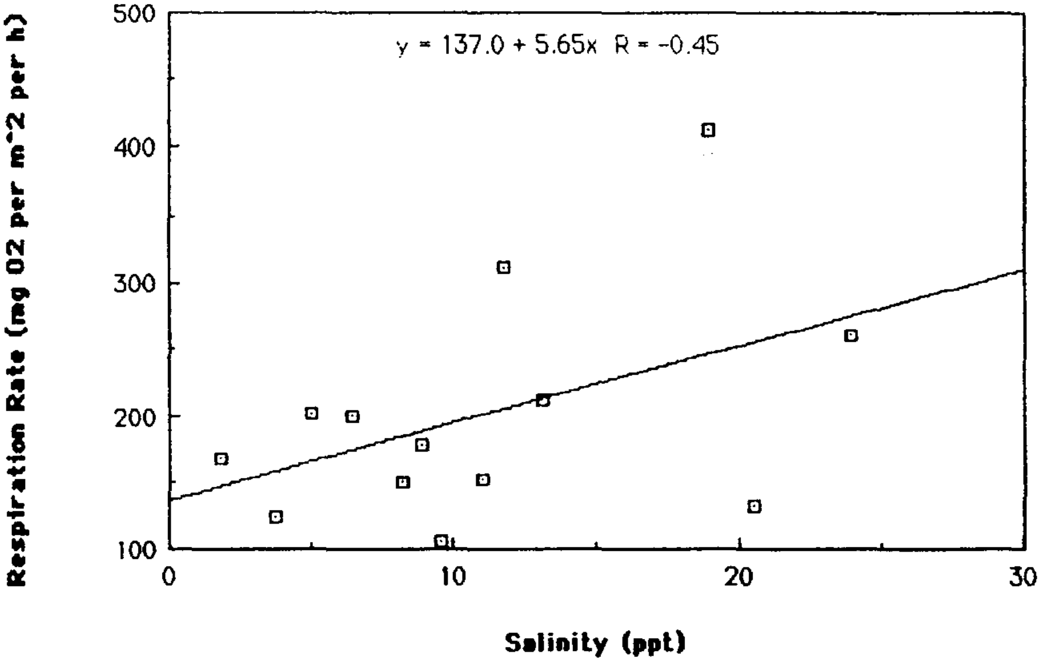


Figure 3.5.1. Profiles of ammonium concentrations in sediment pore waters at station 45. (Data in Appendix 3.4)

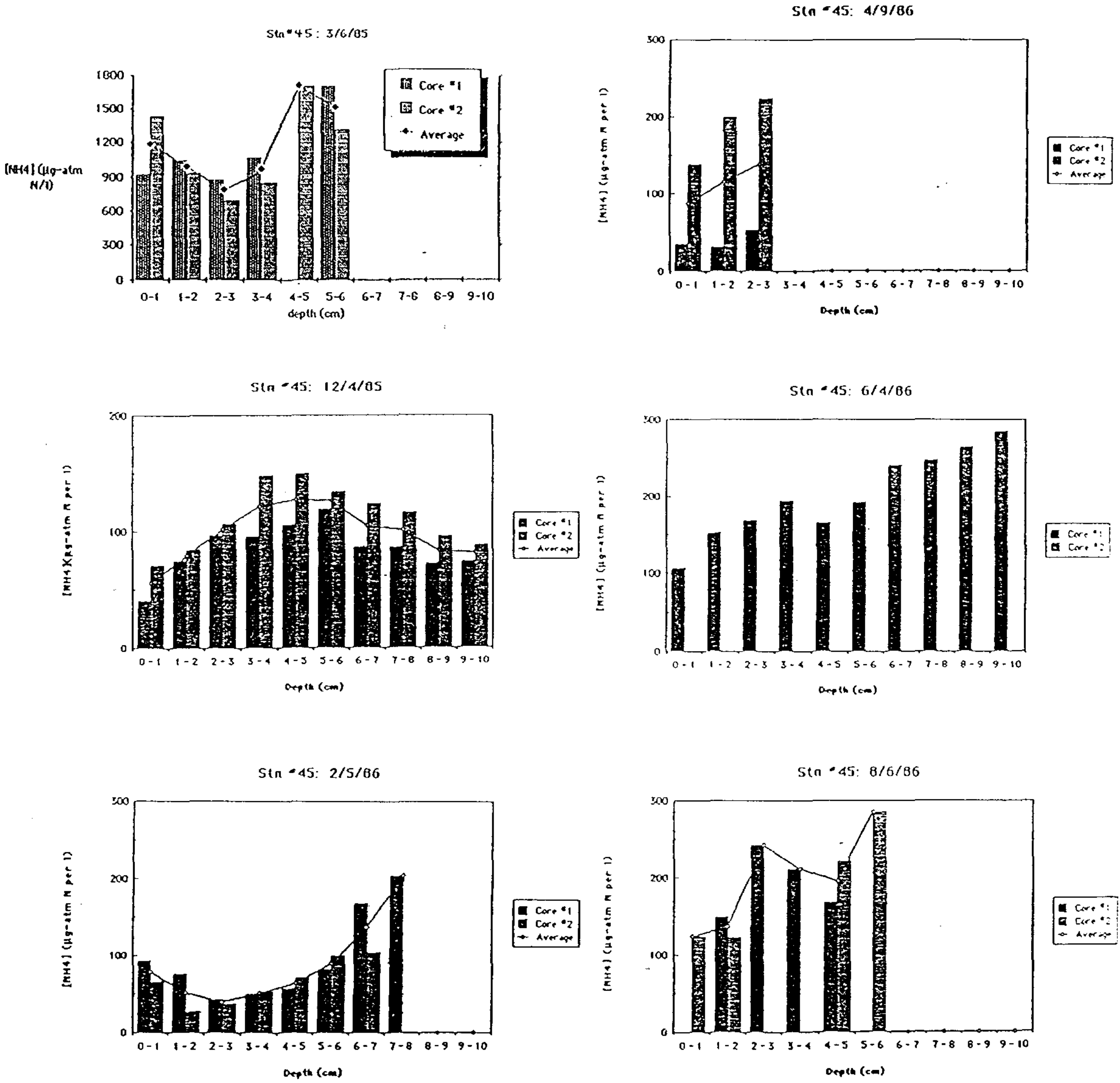


Figure 3.5.2.1. Profiles of ammonium concentrations in sediment pore waters at station 603 in Year 1 (Data in Appendix 3.4)

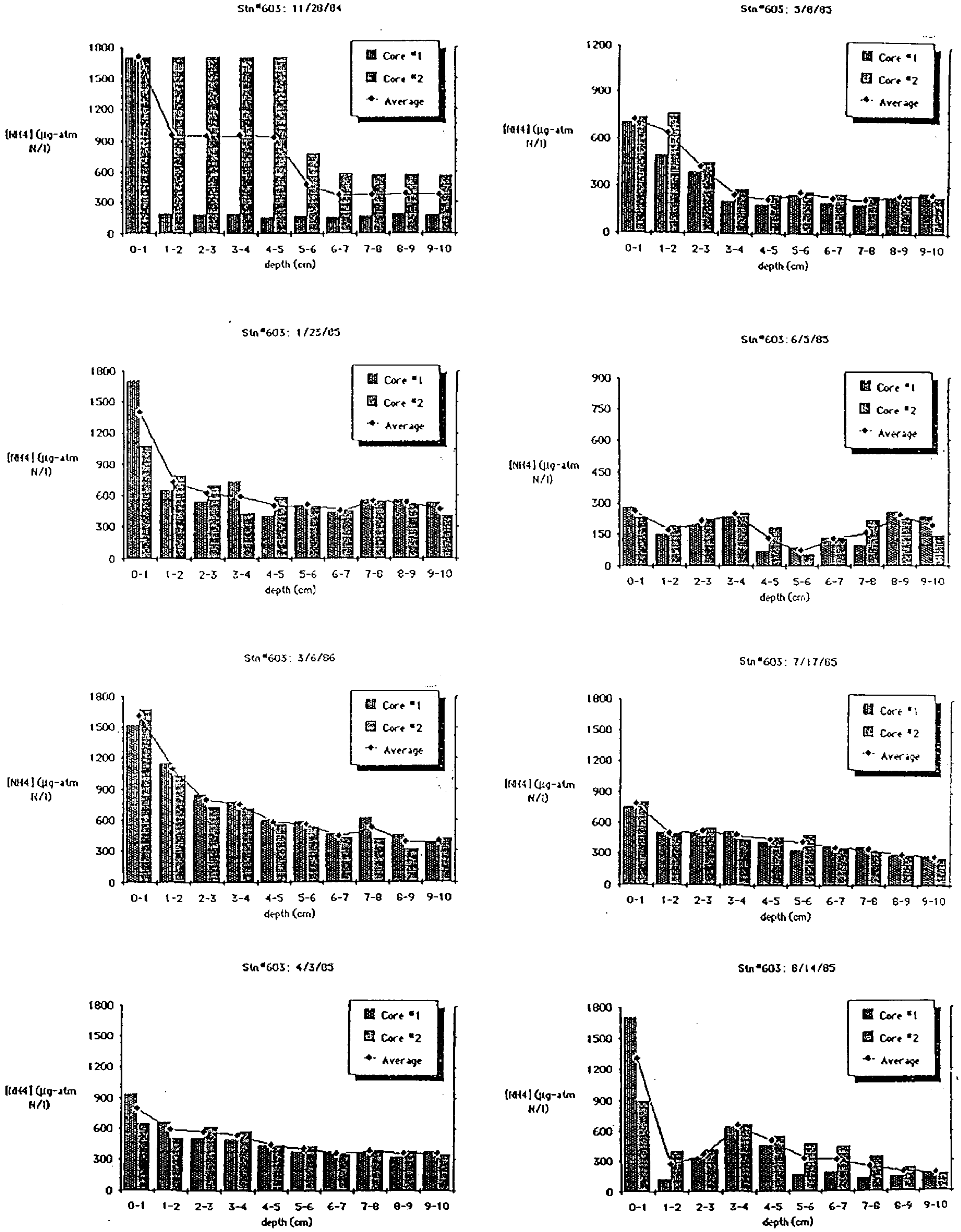


Figure 3.5.2.2. Profiles of ammonium concentrations in sediment pore waters at station 603 in Year 2 (Data in Appendix 3.4)

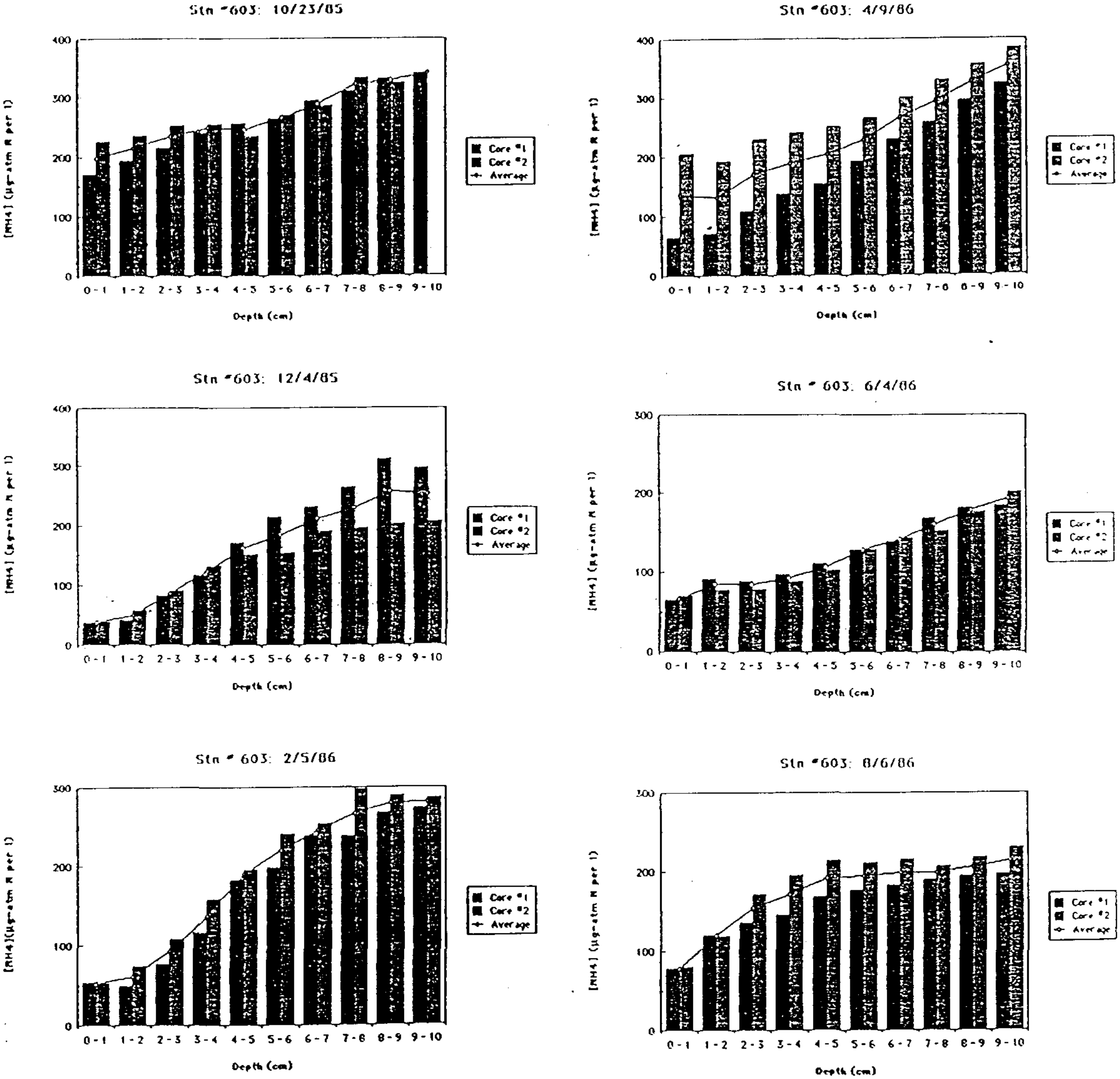


Figure 3.5.3.1. Profiles of ammonium concentrations in sediment pore waters at station 65 in Year 1. (Data in Appendix 3.4)

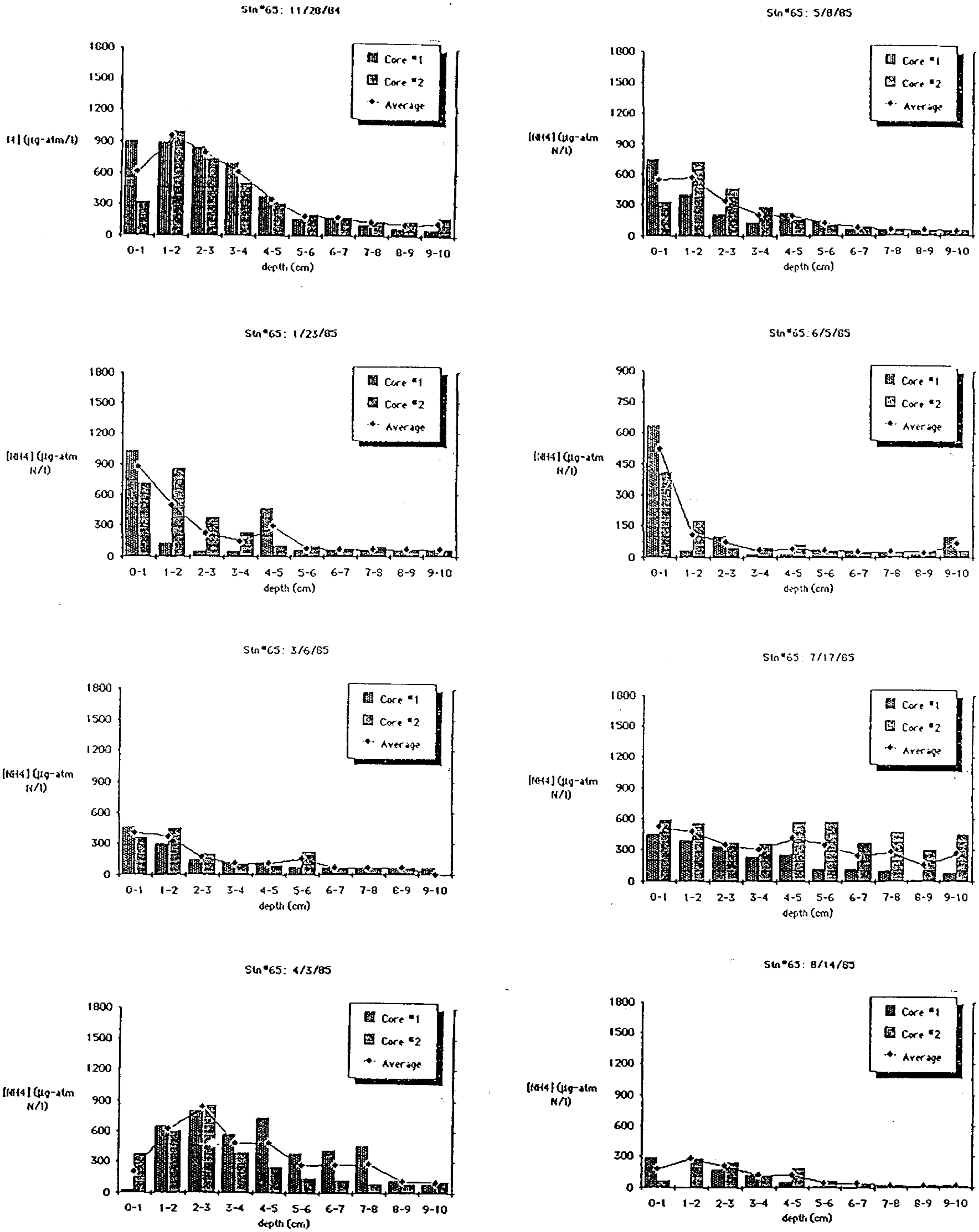
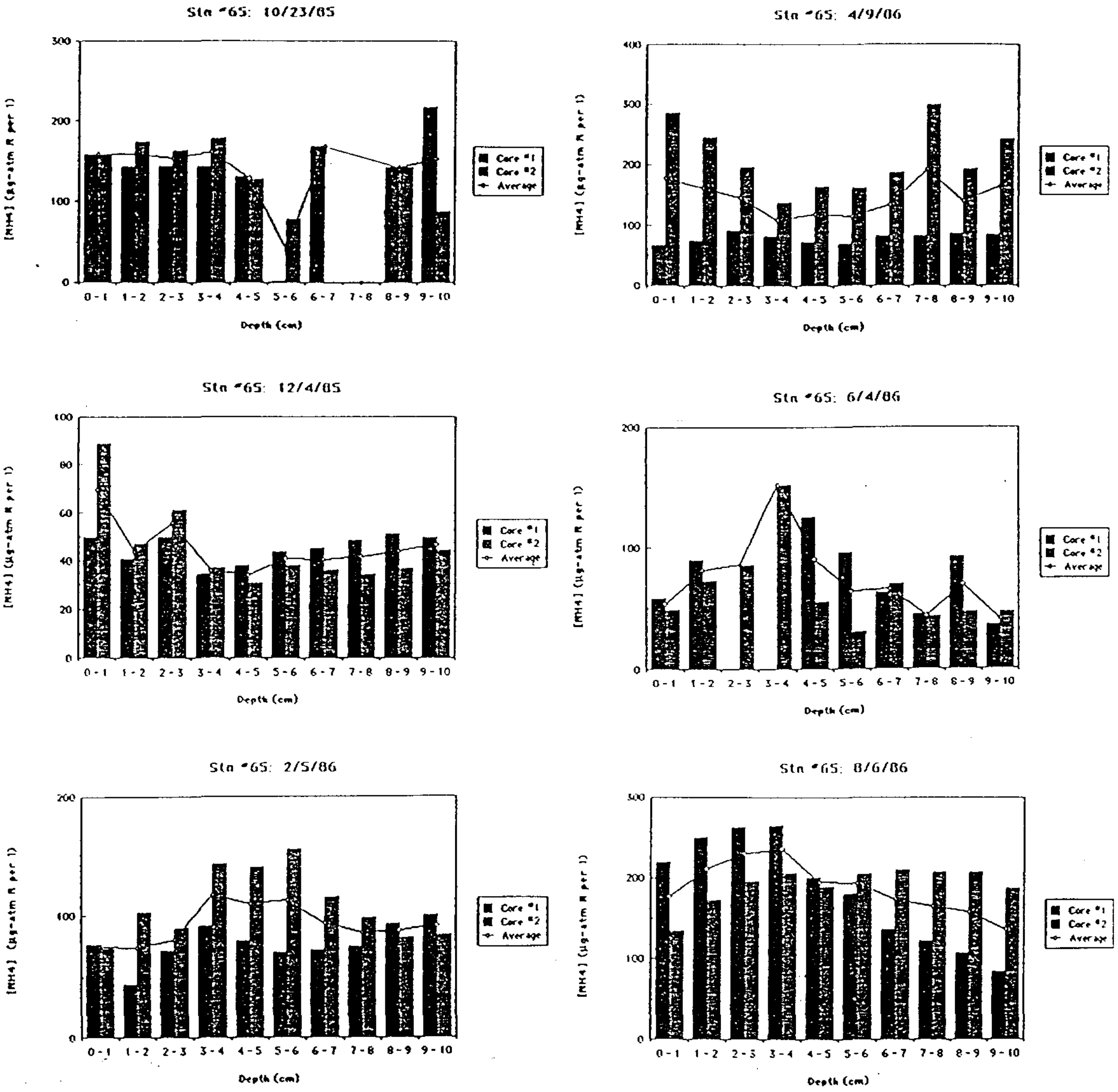


Figure 3.5.3.2. Profiles of ammonium concentrations in sediment pore waters at station 65 in Year 2. (Data in Appendix 3.4).



Stn #65: 10/23/85

Stn #65: 4/9/86

Stn #65: 12/4/85

Stn #65: 6/4/86

Stn #65: 2/5/86

Stn #65: 8/6/86

Figure 3.5.4.1. Profiles of ammonium concentrations in sediment pore waters at station 613 in Year 1. (Data in Appendix 3.4).

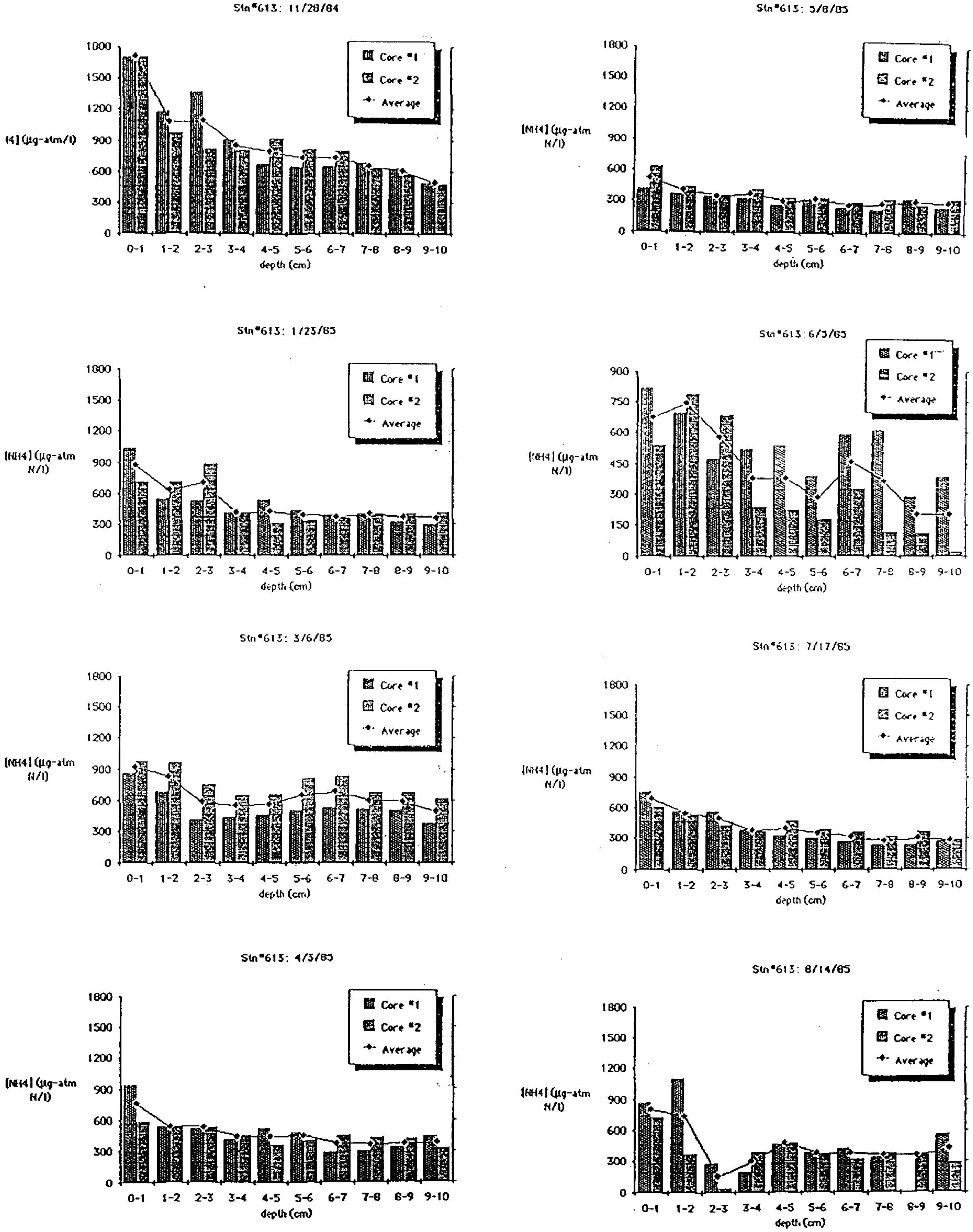
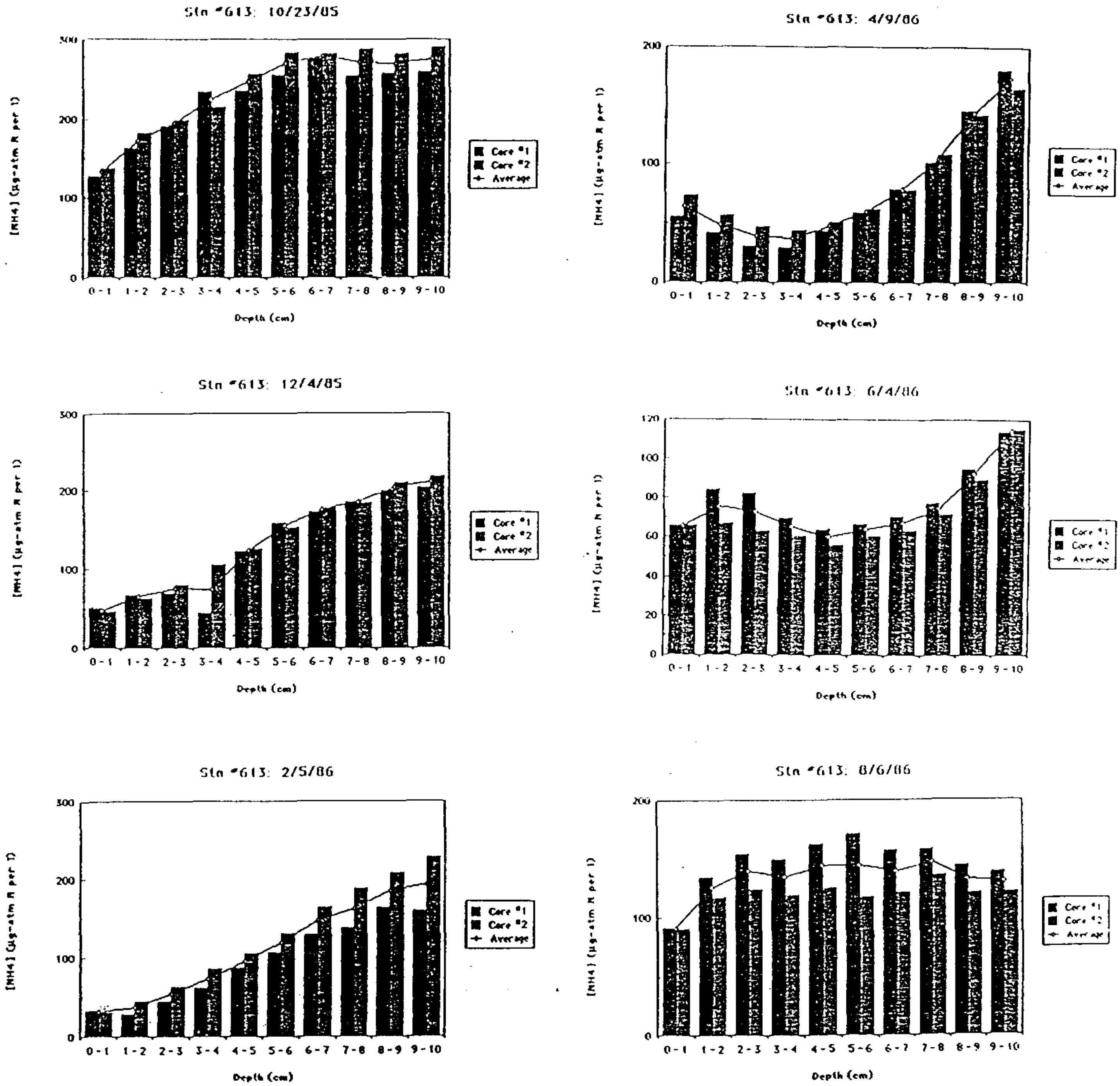


Figure 3.5.4.2. Profiles of ammonium concentrations in sediment pore waters at station 613 in Year 2. (Data in Appendix 3.4).



Stn #613: 10/23/85

Stn #613: 4/9/86

Stn #613: 12/4/85

Stn #613: 6/4/86

Stn #613: 2/5/86

Stn #613: 8/6/86

Figure 3.5.5.1. Profiles of ammonium concentrations in sediment pore waters at station 623 in Year 1. (Data in Appendix 3.4).

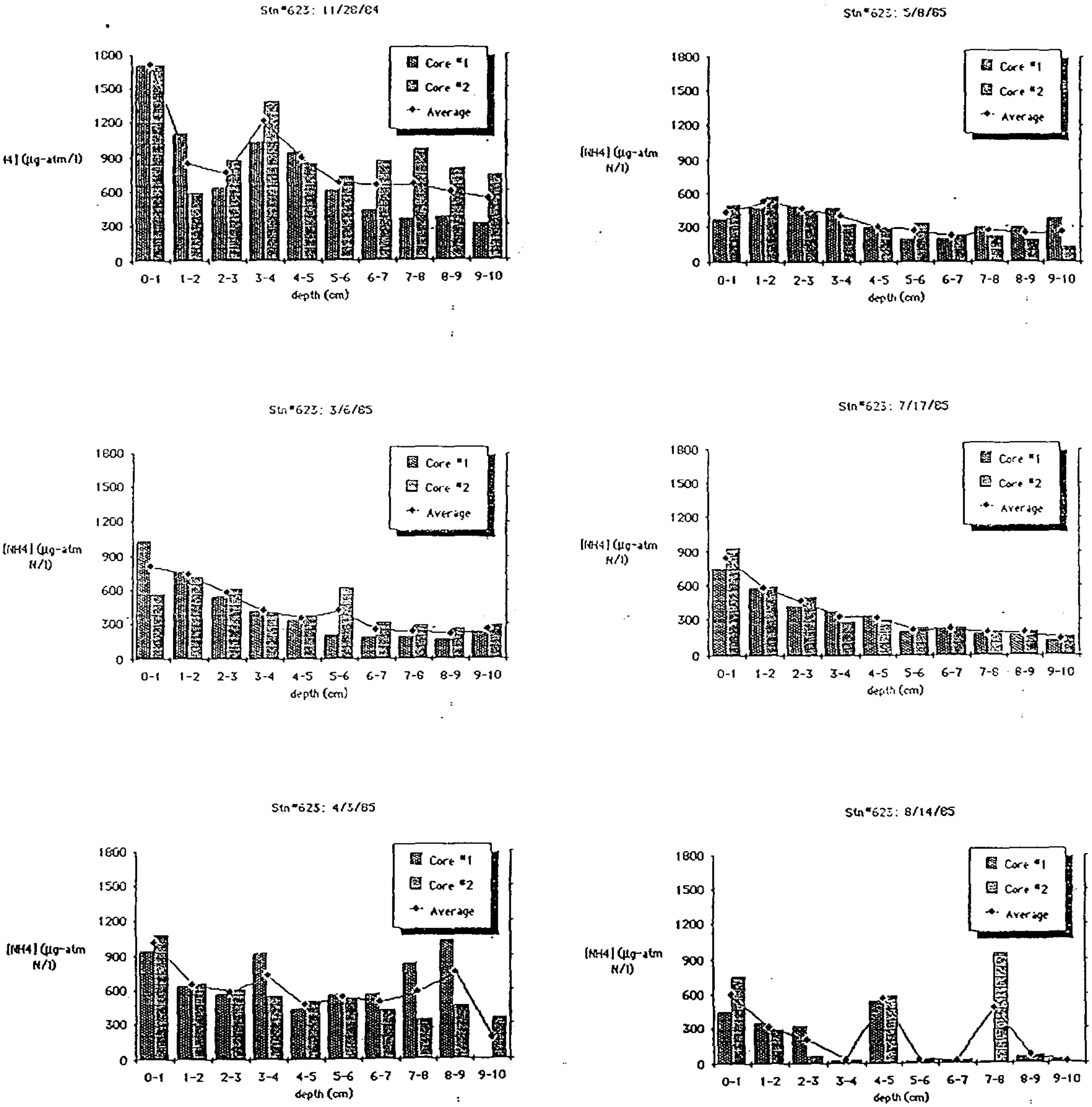


Figure 3.5.5.2. Profiles of ammonium concentrations in sediment pore waters at station 623 in Year 2. (Data in Appendix 3.4).

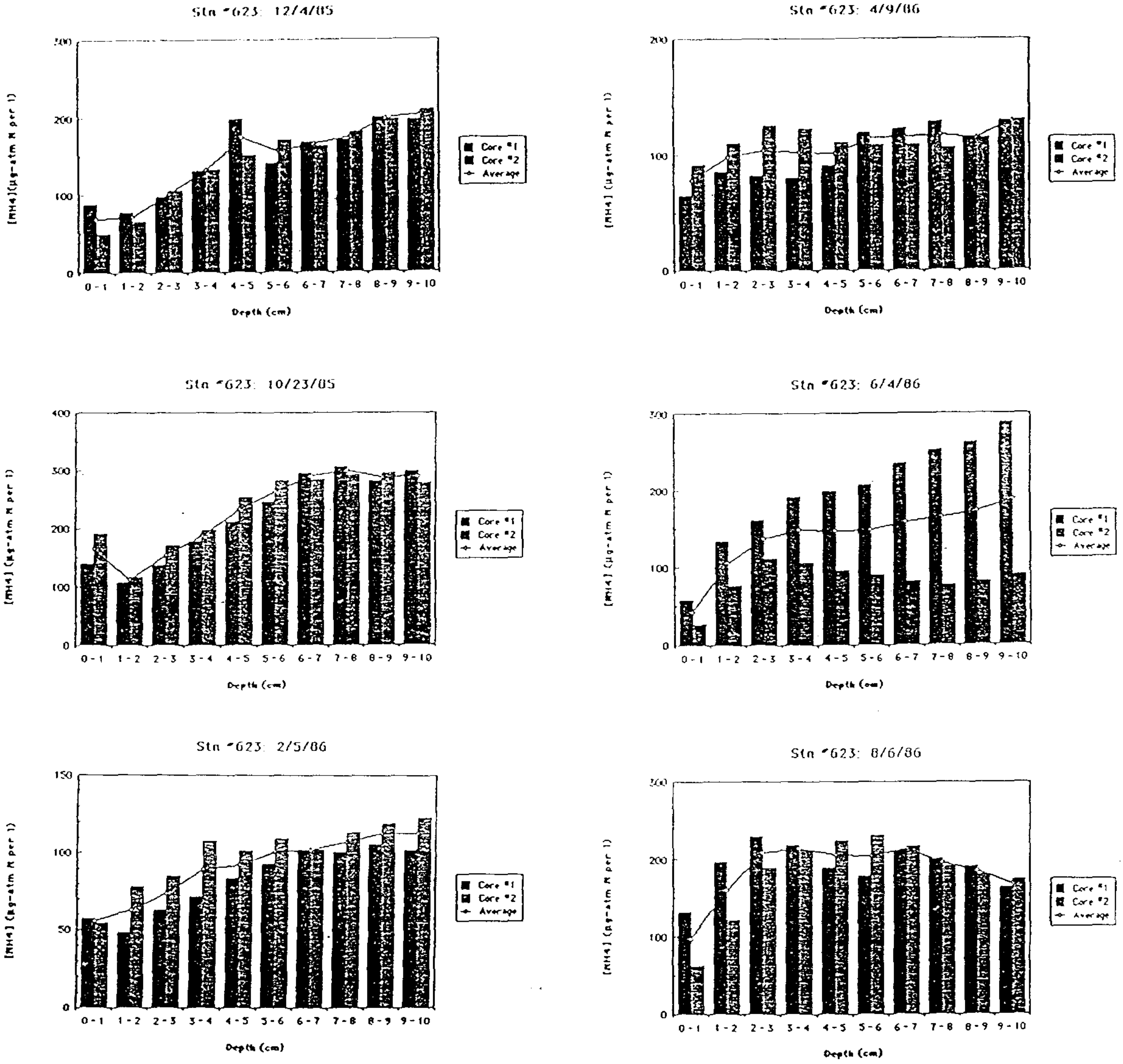


Figure 3.5.6.1. Profiles of ammonium concentrations in sediment pore waters at station 633 in Year 1. (Data in Appendix 3.4).

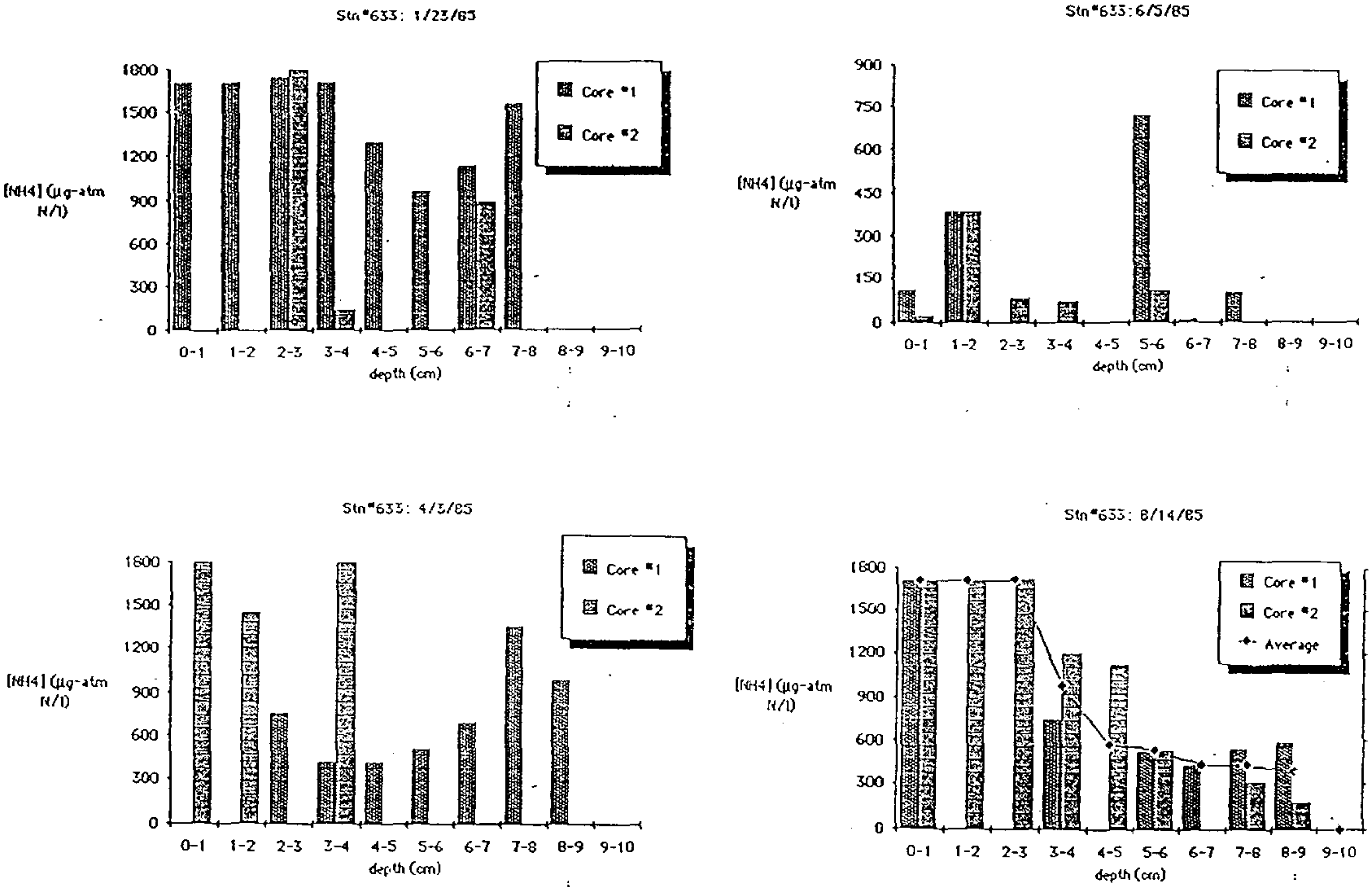


Figure 3.5.6.2. Profiles of ammonium concentrations in sediment pore waters at station 633 in Year 2. (Data in Appendix 3.4).

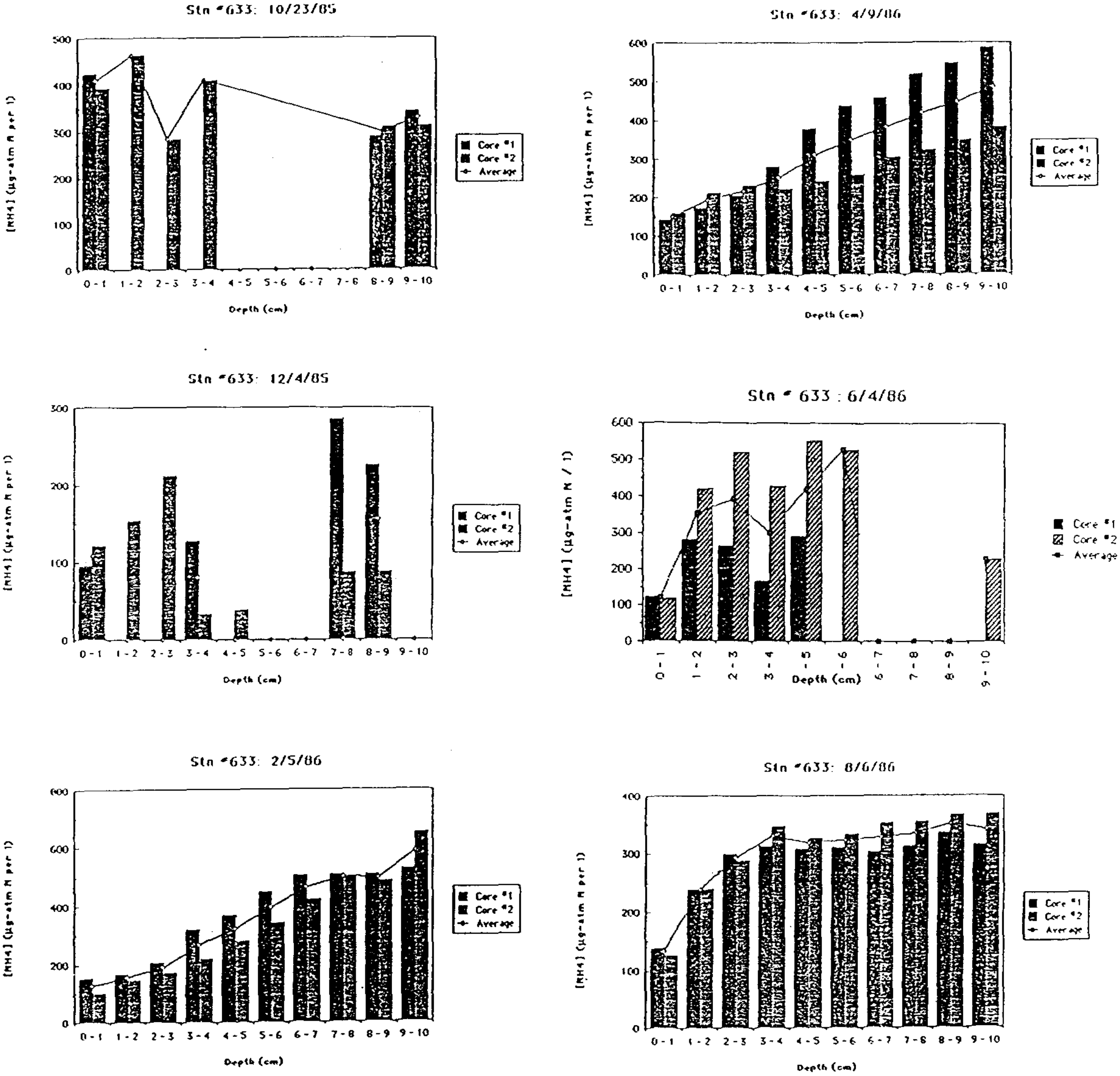


Figure 3.5.7.1. Profiles of ammonium concentrations in sediment pore waters at station 85 in Year 1. (Data in Appendix 3.4).

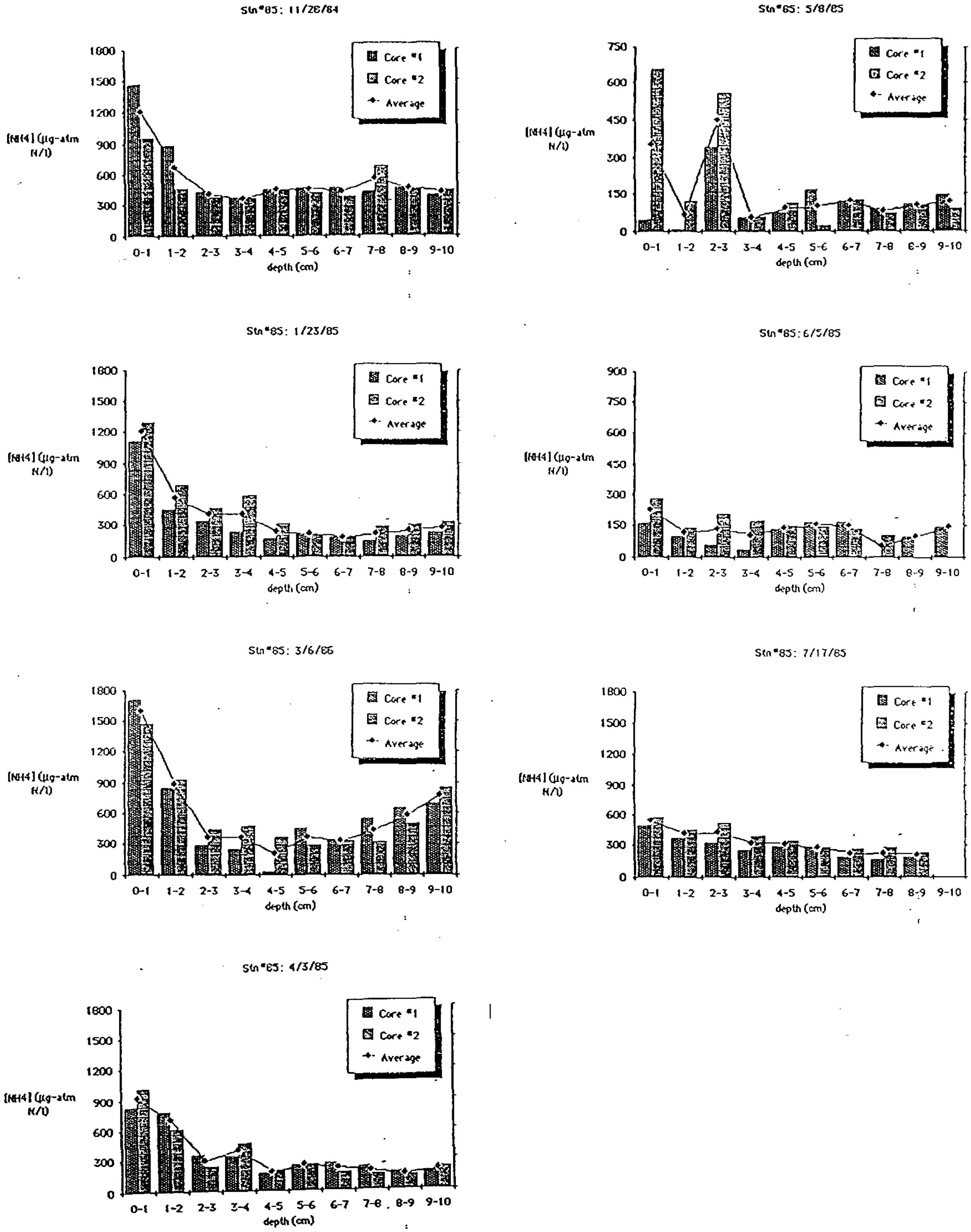


Figure 3.5.7.2. Profiles of ammonium concentrations in sediment pore waters at station 85 in Year 2. (Data in Appendix 3.4).

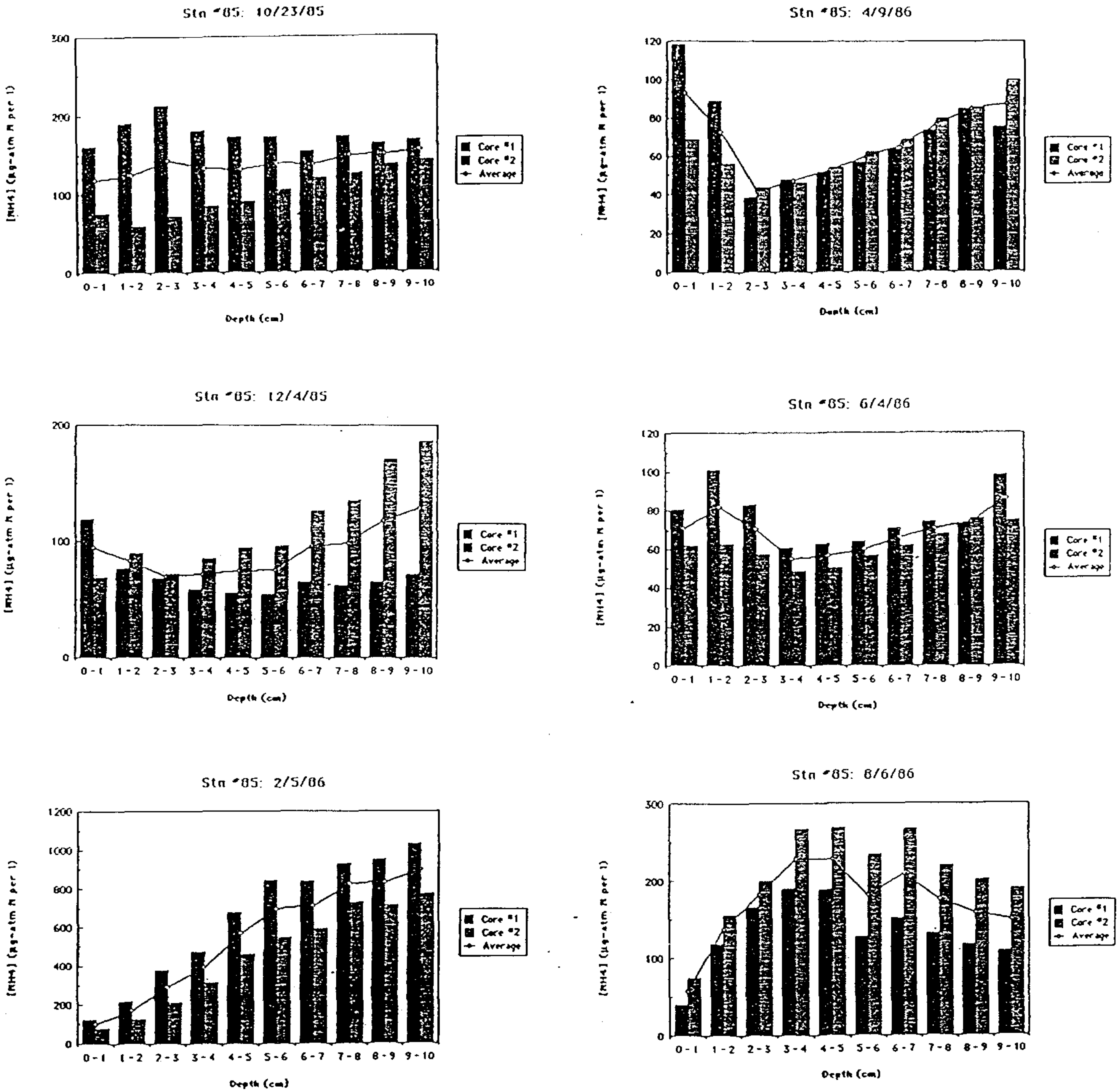


Figure 3.7.1. Relationship of Measured Ammonium Flux From In Situ Chambers To Temperature at Station 85 (1984-1986)

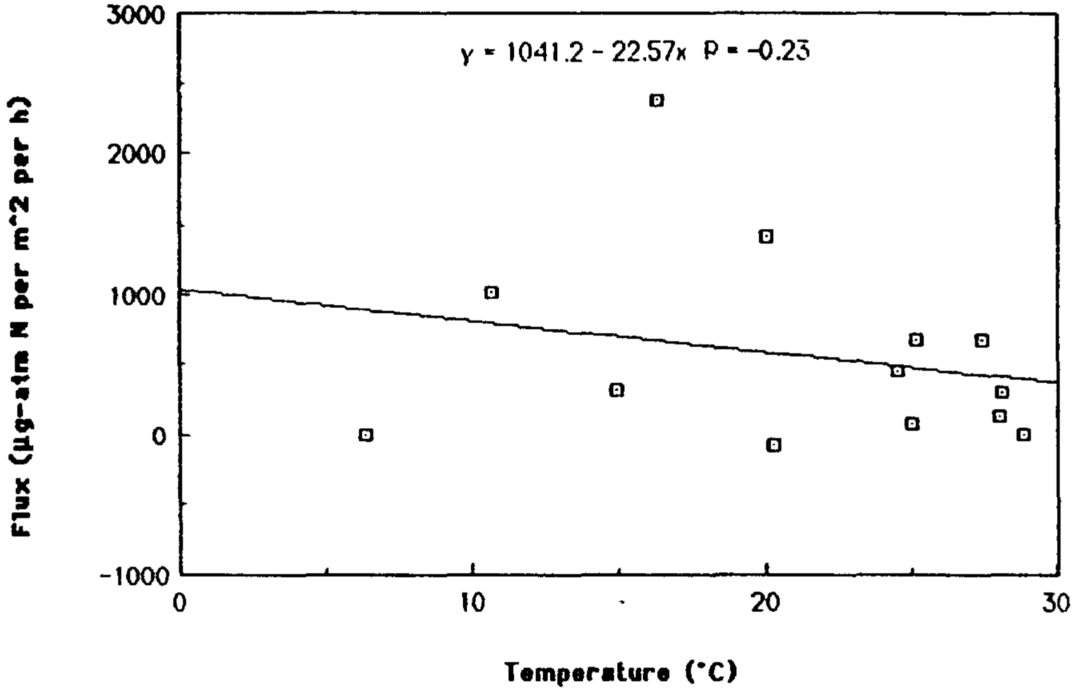


Figure 3.7.2. Relationship of Measured Ammonium Flux From In Situ Chambers To Salinity at Station 85 (1984-1986)

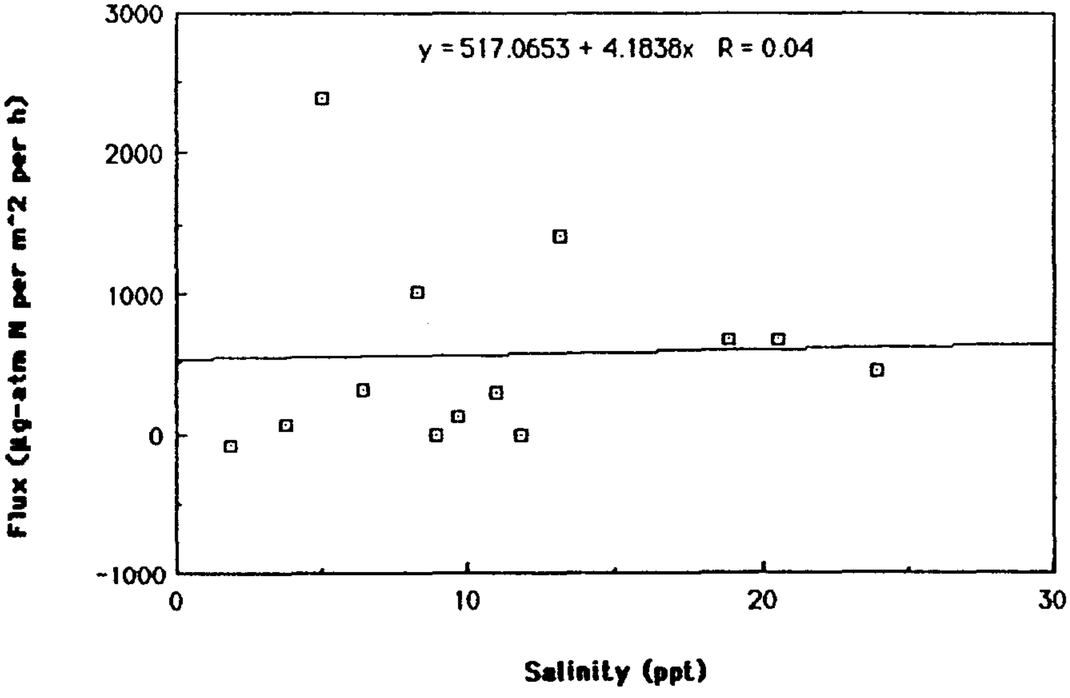


Figure 3.6. Ammonium flux measured from *in situ* chambers at station 85. (Data in Appendix 3.6).

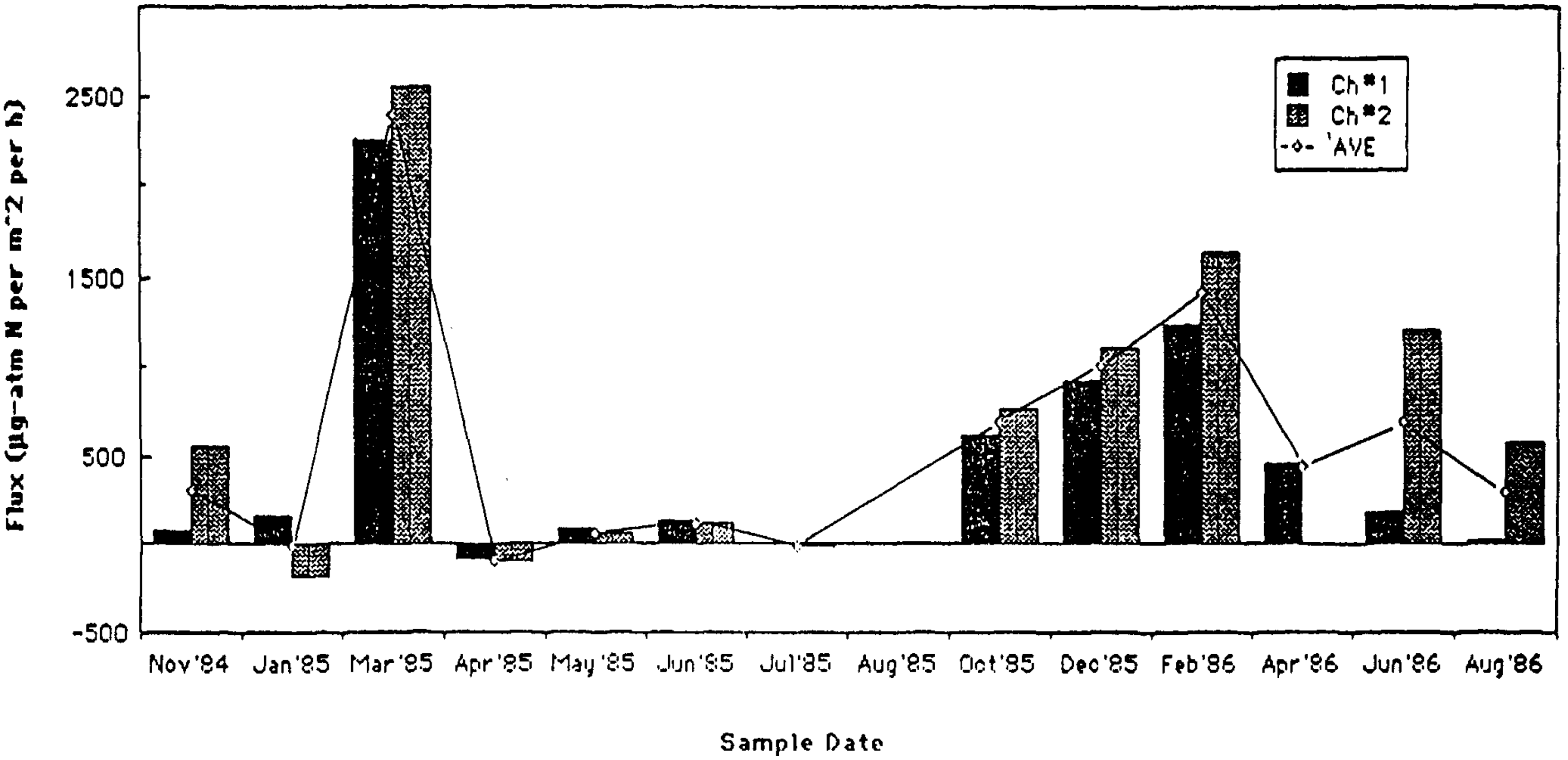


Figure 3.8. Theoretical ammonium flux (calculated from ammonium concentration profiles in sediments).
Data in Appendix 3.7 .

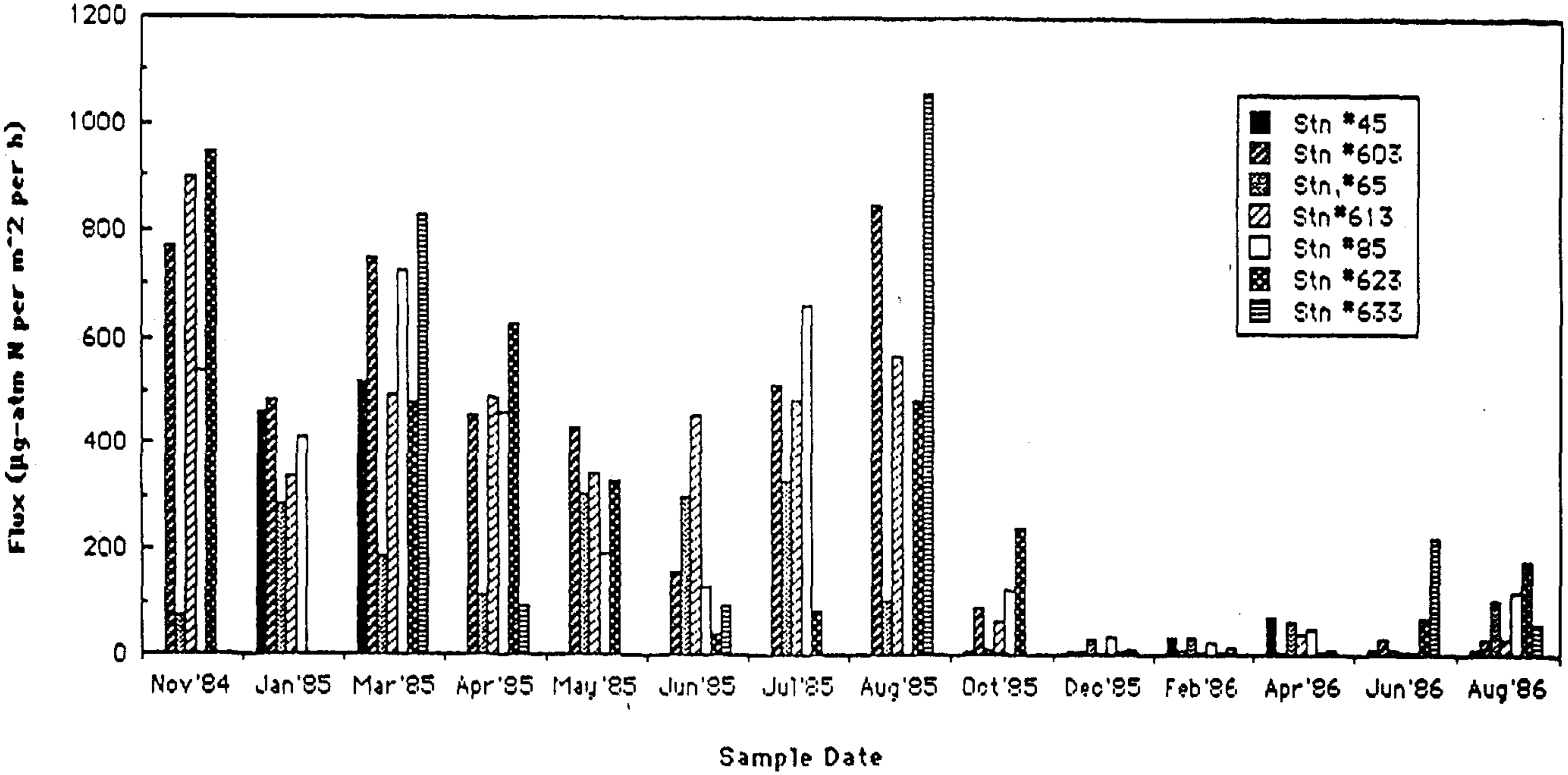


Figure 3.9.1. Relationship of Theoretical Ammonium Flux To Temperature at Station 85 (1984-1986)

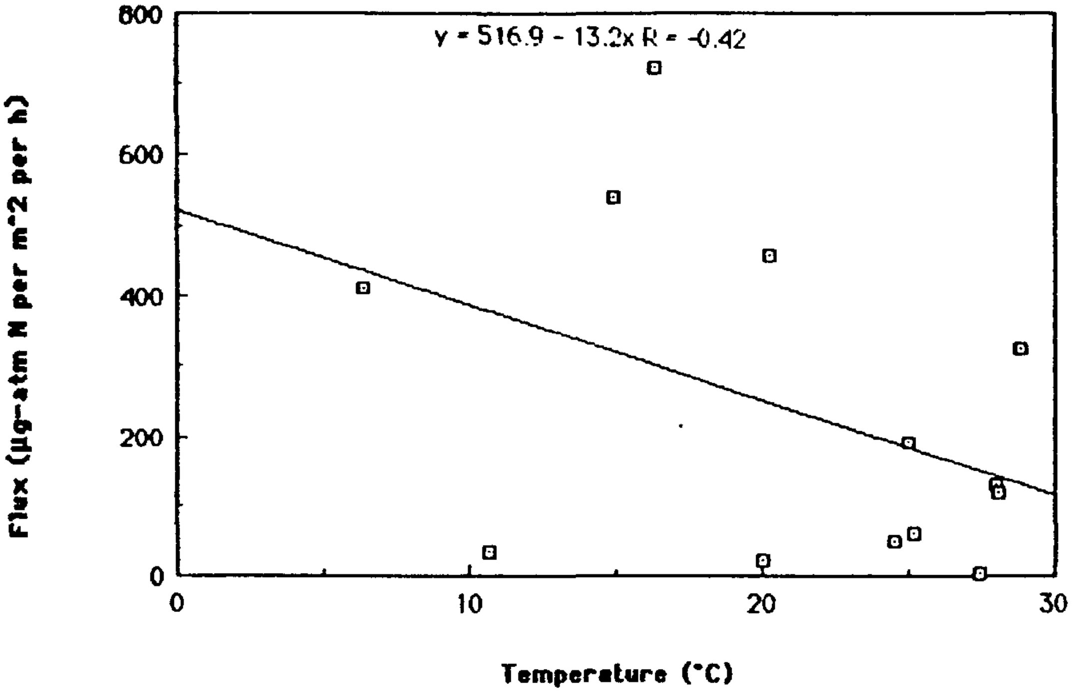


Figure 3.9.2. Relationship of Theoretical Ammonium Flux To Salinity at Station 85 (1984-1986)

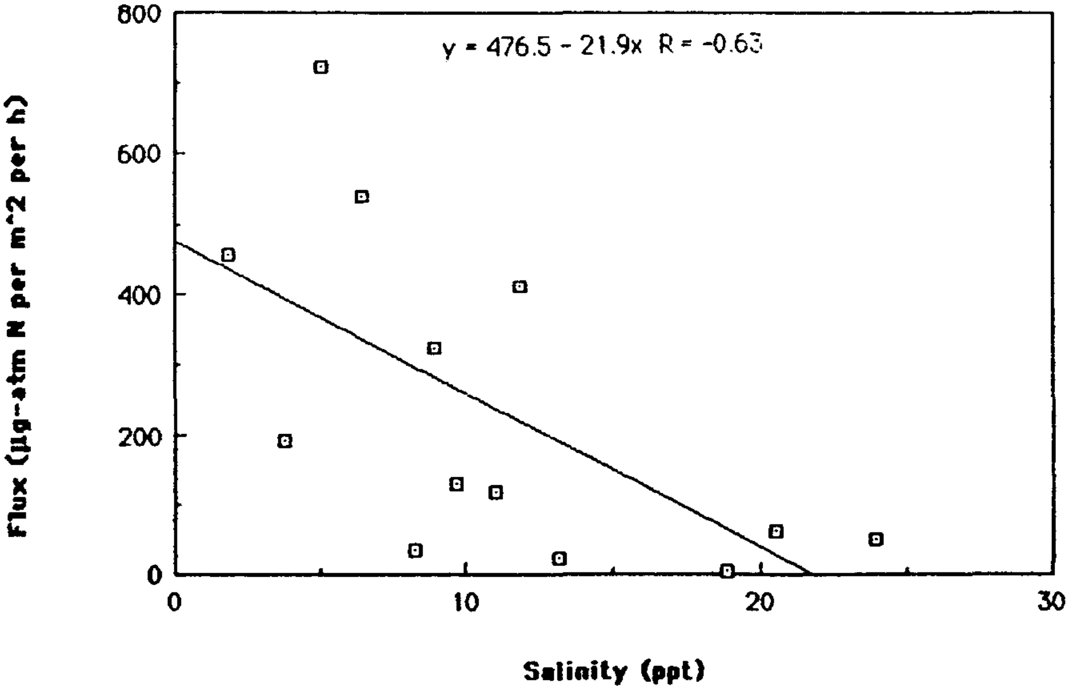
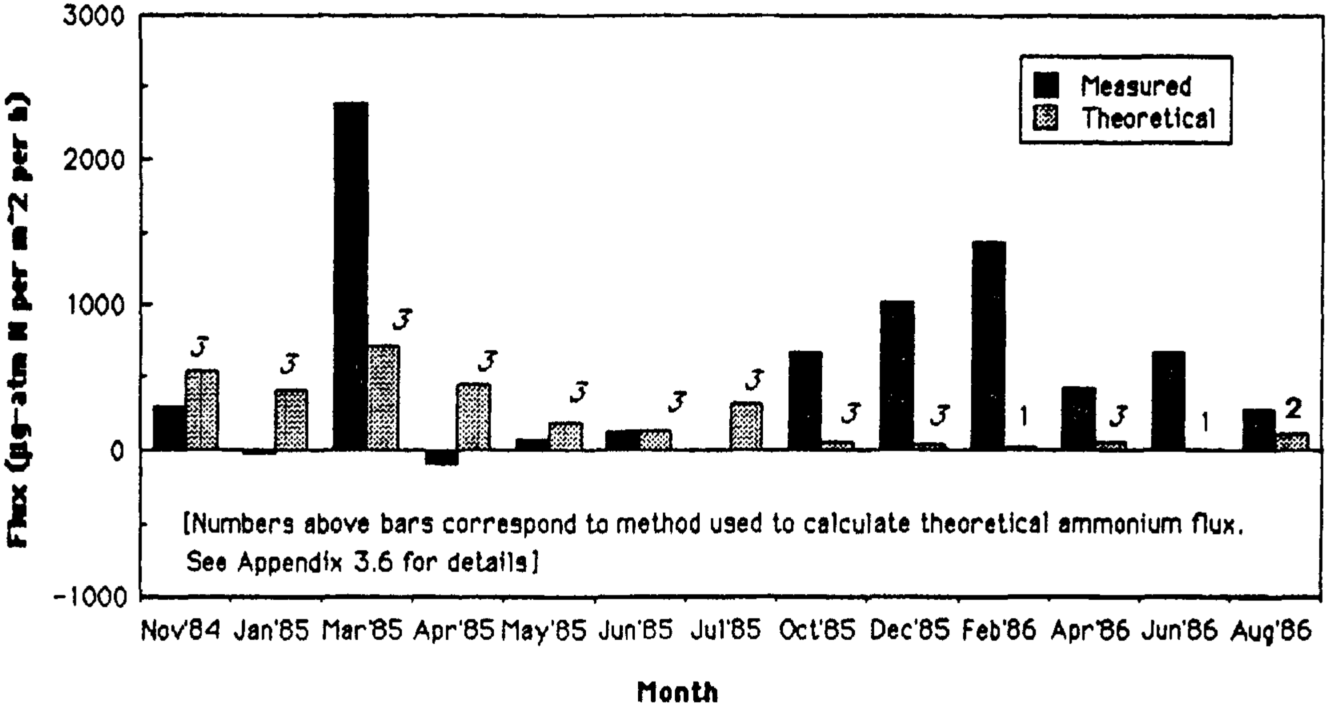


Figure 3.10. Comparison of Theoretical Ammonium Flux With Measured Flux at Station 85



[Numbers above bars correspond to method used to calculate theoretical ammonium flux. See Appendix 3.6 for details]

Table 3.1. Porosity of Sediments

Porosity = ((sample wet weight-sample dry weight)/sample volume)*100
Sample Volume = (3.3)^2 * 3.14 = 34.19 cm^3

Station #	Depth (cm)	Apr'86	Jun'86	Aug'86	AVE
		% (g/cm^3)			
45	0-1	58.9	71.7	69.9	66.8
	1-2	68.7	89.9	48.5	69.0
	2-3	61.8	58.0	46.2	55.3
	3-4	56.8	68.1	48.3	57.7
	4-5	53.9	80.4	50.2	61.5
	5-6	41.3	85.9	46.6	57.9
	6-7	48.2	73.4	43.9	55.2
	7-8	44.5	78.2	37.9	53.5
	8-9	45.4	70.1	41.2	52.2
	9-10	34.1	62.9	46.1	47.7
65	0-1	86.2	56.0	61.9	68.0
	1-2	61.3	44.1	54.2	53.2
	2-3	41.1	36.8	55.1	44.3
	3-4	37.4	38.4	57.1	44.3
	4-5	66.2	38.9	49.9	51.7
	5-6	61.5	35.1	58.3	51.6
	6-7	60.0	31.7	51.4	47.7
	7-8	64.9	39.9	45.9	50.2
	8-9	47.4	54.3	43.3	48.3
	9-10	60.7	43.4	45.8	50.0
85	0-1	79.4	70.9	69.4	73.2
	1-2	60.3	68.1	71.3	66.6
	2-3	64.8	67.5	71.5	67.9
	3-4	61.0	73.9	54.1	63.0
	4-5	62.1	73.9	60.1	65.4
	5-6	89.4	68.9	70.1	76.1
	6-7	64.7	62.8	55.0	60.8
	7-8	82.4	61.6	72.4	72.1
	8-9	75.5	61.9	51.8	63.1
	9-10	74.0	77.8	63.7	71.8

Station #	Depth (cm)	Apr'86	Jun'86	Aug'86	AVE
		% (g/cm^3)			
603	0-1	71.5	86.5	67.5	75.2
	1-2	87.4	80.1	65.9	77.8
	2-3	89.9	85.9	63.9	79.9
	3-4	83.3	87.9	70.9	80.7
	4-5	84.9	86.2	71.3	80.8
	5-6	78.9	89.3	61.6	76.6
	6-7	77.1	84.9	78.5	80.2
	7-8	86.5	87.8	68.6	81.0
	8-9	86.3	91.3	72.8	83.5
	9-10	87.1	82.1	64.6	77.9
613	0-1	61.6	65.3	80.0	69.0
	1-2	77.6	82.2	77.8	79.2
	2-3	80.3	80.2	85.4	82.0
	3-4	74.7	69.1	93.4	79.1
	4-5	75.7	65.6	81.8	74.4
	5-6	73.0	64.4	77.5	71.6
	6-7	70.3	72.3	79.8	74.1
	7-8	71.5	68.3	80.7	73.5
	8-9	75.6	64.2	76.3	72.0
	9-10	69.5	90.2	78.9	79.5
623	0-1	81.6	68.6	81.6	77.3
	1-2	69.8	80.7	61.5	70.7
	2-3	58.9	69.2	64.3	64.1
	3-4	60.8	58.9	60.9	60.2
	4-5	59.6	55.1	58.0	57.6
	5-6	58.1	61.3	59.8	59.7
	6-7	60.1	59.4	55.2	58.2
	7-8	69.6	61.0	60.5	63.7
	8-9	55.8	57.1	50.9	54.6
	9-10	56.0	54.8	59.3	56.7
633	0-1	73.0	69.9	72.7	71.9
	1-2	51.9	56.8	67.3	58.7
	2-3	54.9	47.4	63.7	55.3
	3-4	60.3	43.6	65.1	56.3
	4-5	59.1	45.9	60.9	55.3
	5-6	59.6	38.3	75.1	57.7
	6-7	66.0	42.4	68.8	59.1
	7-8	68.9	37.8	61.6	56.1
	8-9	63.0	31.8	65.2	53.3
	9-10	54.4	47.4	63.8	55.2

Table 3.2.

AMMONIUM CONCENTRATION IN SURFACE AND DEEP SEDIMENTS -- YEAR #1 vs. YEAR #2, APRIL

Depth Interval (cm)	Station 603 Mean		Station 65 Mean		Station 613 Mean	
	Yr#1	Yr#2	Yr#1	Yr#2	Yr#1	Yr#2
0 - 1	793.1	135.54	207.5	177.04	763.3	63.9
1 - 2	590.4	131.93	629.2	160.37	539.8	48.8
2 - 3	569.6	169.88	834.6	144.00	528.6	38.9
7 - 8	384.6	294.0	278.0	191.9	365.7	105.1
8 - 9	360.5	325.9	108.7	139.0	378.3	143.7
9 - 10	365.4	354.2	98.5	163.7	387.3	172.9

Depth Interval (cm)	Station 85 Mean		Station 623 Mean		Station 633 Mean	
	Yr#1	Yr#2	Yr#1	Yr#2	Yr#1	Yr#2
0 - 1	922.3	93.4	1011.4	78.0	1793.5	151.1
1 - 2	702.1	72.6	644.9	98.2	1444.0	192.9
2 - 3	291.6	41.0	582.2	103.9	756.0	218.5
7 - 8	182.8	76.8	582.8	117.5	1356.0	421.2
8 - 9	148.5	85.2	749.2	114.8	994.0	449.2
9 - 10	188.0	87.7	174.1	129.8	---	486.0

Data are for April 1985 (Year #1) and April 1986 (Year #2).

Ammonium concentration units = µg-atm N per liter of pore water.

Table 3.3.

AMMONIUM CONCENTRATION IN SURFACE AND DEEP SEDIMENTS -- YEAR #1 vs. YEAR #2, JUNE

Depth Interval (cm)	Station 603		Station 65		Station 613	
	Mean		Mean		Mean	
	Yr#1	Yr#2	Yr#1	Yr#2	Yr#1	Yr#2
0 - 1	259.5	67.8	521.1	53.6	678.6	65.7
1 - 2	169.9	84.3	104.1	81.0	747.3	75.6
2 - 3	213.0	84.0	74.4	85.5	582.2	72.6
7 - 8	160.5	159.6	26.2	44.0	365.4	74.8
8 - 9	243.8	178.0	21.2	69.3	200.9	92.5
9 - 10	192.2	193.1	64.9	41.3	202.1	115.1

Depth Interval (cm)	Station 85		Station 623		Station 633	
	Mean		Mean		Mean	
	Yr#1	Yr#2	Yr#1	Yr#2	Yr#1	Yr#2
0 - 1	225.7	71.1	16.0	43.1	66.6	121.4
1 - 2	120.7	81.9	117.2	105.4	372.0	352.7
2 - 3	133.4	70.2	30.1	136.5	84.3	393.4
7 - 8	54.3	71.1	89.8	165.1	105.4	---
8 - 9	103.0	74.4	51.8	172.6	---	---
9 - 10	148.2	86.5	30.7	189.2	---	227.9

Data are for June 1985 (Year #1) and June 1986 (Year #2)

Ammonium concentration units = µg-atm N per liter of pore water.

Table 3.4.

AMMONIUM CONCENTRATION IN SURFACE AND DEEP SEDIMENTS -- YEAR #1 vs. YEAR #2, AUGUST

Depth Interval (cm)	Station 603		Station 65		Station 613	
	Mean		Mean		Mean	
	Yr #1	Yr #2	Yr #1	Yr #2	Yr #1	Yr #2
0 - 1	1305.4	79.2	175.3	177.71	802.7	91.0
1 - 2	266.6	119.6	286.7	212.05	735.2	125.6
2 - 3	374.4	153.6	215.7	229.52	159.6	138.9
7 - 8	245.8	198.4	25.0	164.5	364.2	146.6
8 - 9	194.9	206.3	22.0	157.5	365.1	132.2
9 - 10	173.5	213.9	23.2	135.5	428.6	130.4

Depth Interval (cm)	Station 85		Station 623		Station 633	
	Mean		Mean		Mean	
	Yr #1	Yr #2	Yr #1	Yr #2	Yr #1	Yr #2
0 - 1	---	74.1	605.7	43.1	1709.9	133.1
1 - 2	---	155.4	319.3	105.4	1712.0	240.1
2 - 3	---	200.6	197.9	136.5	1712.7	294.9
7 - 8	---	219.9	479.8	165.1	430.4	335.2
8 - 9	---	201.2	61.4	172.6	381.9	352.7
9 - 10	---	189.8	12.0	189.2	---	342.5

Data are for August 1985 (Year #1) and August 1986 (Year #2)

Ammonium concentration units = µg-atm N per liter of pore water.

Appendix 3.1
Bottom Water Dissolved Oxygen Concentration (Station 85)

Sample Date	Bottom Water DO (mg/l)
Year 1	
11/28/84	10.7
1/23/85	12.0
3/6/86	9.8
4/3/85	11.0
5/8/85	8.9
6/5/85	7.2
7/17/85	6.8
8/14/85	7.1
Year 2	
10/23/85	7.0
12/4/85	9.8
2/5/86	8.0
4/9/86	6.4
6/4/86	6.0
8/6/86	5.9

Dissolved oxygen concentration determined by Winkler method.

Appendix 3.2
Percent Saturation of Dissolved Oxygen (bottom water of Station 85)

Sample Date	% Saturation
Year 1	
11/28/84	110.5
1/23/85	105.9
3/6/85	103.2
4/3/85	122.8
5/8/85	110.0
6/5/85	97.5
7/17/85	93.0
8/14/85	103.8
Year 2	
10/23/85	97.1
12/4/85	93.2
2/5/86	96.0
4/9/86	89.8
6/4/86	85.5
8/6/86	80.8

Appendix 3.3. Benthic Respiration Rate
Station #85 Chamber Experiments

Sample Date	Temp (°C)	Salinity (ppt)	Turbidity (JTU)	DO (mg/l)	Respiration Rate						
					(mg O2 per l per h)					(mg O2 per m2 per h)	
					Ch#1		Ch#2				
					electrode	winkler	winkler	AVE	±STD	AVE	±STD
YEAR #1											
11/28/84	14.9	6.4	—	10.7	1.07	—	0.34	0.71	0.52	198.4	145.3
1/23/85	6.3	11.8	3.6	12.0	1.28	—	0.93	1.11	0.25	311.0	69.7
3/6/85	16.3	5.0	6.1	9.8	0.82	0.64	0.69	0.72	0.09	201.7	26.1
4/3/85	20.3	1.8	68.3	11.0	0.81	0.65	0.33	0.60	0.24	167.5	68.2
5/8/85	25.0	3.7	21.4	8.9	0.71	0.28	0.33	0.44	0.24	123.8	66.2
6/5/85	28.0	9.6	78.4	7.2	0.40	0.20	0.53	0.38	0.17	106.0	46.8
7/17/85	28.8	8.9	0	6.8	0.70	0.88	0.30	0.63	0.30	176.4	83.5
8/14/85	29.8	16.6	4.4	7.1	1.09	0.67	0.56	0.77	0.28	217.6	78.7
YEAR #2											
10/23/85	25.2	20.5	1.5	7.0	0.57	0.36	0.48	0.47	0.11	131.8	29.6
12/04/85	10.6	8.2	7.1	9.8	0.62	0.51	0.47	0.53	0.08	149.6	22.1
2/05/86	20.0	13.1	2.6	8.0	0.62	0.46	1.18	0.75	0.38	211.1	105.9
4/09/86	24.5	23.9	9	6.4	0.68	0.38	1.72	0.92	0.70	259.9	197.4
6/04/86	27.4	18.9	5.4	6.0	2.92	0.47	1.02	1.47	1.29	412.3	361.8
8/06/86	28.1	11.0	62	5.9	—	0.58	0.49	0.54	0.06	150.6	17.9

Chambers were either mixed or not mixed as follows:

Year #1. [Nov'84, Jan'85, and Mar'85], mixed by an "automobile windshield wiper pump" mounted in a water tight housing attached to respiration chambers; 2. [Apr and May], no mixing; and 3. [Jun, Jul, and August], mixed by a Masterflex pump mounted on the deck of R/V Katy.

Year #2. Mixed by a Masterflex pump mounted on the deck of R/V Katy.

Hydrographic data from Hydrolab data set (see Cullen's data).

Appendix 3.4 Ammonium concentrations of pore waters in sediments of the Lavaca Bay estuary.

Port Lavaca: Ammonium Concentration Analyses — 11/28/84 Sediment Core Samples

CORE #603: 11/84

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	2.841	2.843	2.834	1706.63	1707.83	1707.23	0.85
1 - 2	0.331	2.843	1.579	194.58	1707.83	951.20	1070.03
2 - 3	0.303	2.843	1.565	177.71	1707.83	942.77	1081.96
3 - 4	0.324	2.843	1.576	190.36	1707.83	949.10	1073.01
4 - 5	0.268	2.843	1.548	156.63	1707.83	932.23	1096.87
5 - 6	0.293	1.312	0.795	171.69	785.54	478.61	434.06
6 - 7	0.262	0.98	0.613	153.01	585.54	369.28	305.84
7 - 8	0.279	0.96	0.612	163.25	573.49	368.37	290.08
8 - 9	0.319	0.969	0.636	187.35	578.92	383.13	276.88
9 - 10	0.304	0.956	0.622	178.31	571.08	374.70	277.73

CORE #85: 11/84

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	2.448	1.587	2.010	1469.88	951.20	1210.54	366.76
1 - 2	1.482	0.772	1.119	887.95	460.24	674.10	302.44
2 - 3	0.726	0.633	0.672	432.53	376.51	404.52	39.62
3 - 4	0.601	0.602	0.594	357.23	357.83	357.53	0.43
4 - 5	0.762	0.739	0.743	454.22	440.36	447.29	9.80
5 - 6	0.806	0.712	0.751	480.72	424.10	452.41	40.04
6 - 7	0.795	0.653	0.716	474.10	388.55	431.33	60.49
7 - 8	0.723	0.688	0.698	430.72	682.87	556.80	178.29
8 - 9	0.778	0.762	0.762	463.86	454.22	459.04	6.82
9 - 10	0.665	0.743	0.696	395.78	442.77	419.28	33.23

Appendix 3.4 (Continued)

Port Lavaca: Ammonium Concentration Analyses -- 11/28/84 Sediment Core Samples

CORE #65: 11/84

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	1.518	0.543	1.023	909.64	322.29	615.96	415.32
1 - 2	1.504	1.667	1.578	901.20	999.40	950.30	69.43
2 - 3	1.416	1.226	1.313	848.19	733.73	790.96	80.93
3 - 4	1.181	0.857	1.011	706.63	511.45	609.04	138.01
4 - 5	0.644	0.538	0.583	383.13	319.28	351.20	45.15
5 - 6	0.287	0.358	0.315	168.07	210.84	189.46	30.24
6 - 7	0.293	0.305	0.291	171.69	178.92	175.30	5.11
7 - 8	0.198	0.243	0.213	114.46	141.57	128.01	19.17
8 - 9	0.131	0.241	0.178	74.10	140.36	107.23	46.86
9 - 10	0.122	0.298	0.202	68.67	174.70	121.69	74.97

CORE #623: 11/84

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	2.845	2.843	2.836	1709.04	1707.83	1708.43	0.85
1 - 2	1.829	0.984	1.399	1096.99	587.95	842.47	359.94
2 - 3	1.062	1.466	1.256	634.94	878.31	756.63	172.09
3 - 4	1.721	2.293	1.999	1031.93	1376.51	1204.22	243.65
4 - 5	1.564	1.409	1.479	937.35	843.98	890.66	66.03
5 - 6	1.026	1.207	1.109	613.25	722.29	667.77	77.10
6 - 7	0.744	1.436	1.082	443.37	860.24	651.81	294.77
7 - 8	0.599	1.607	1.095	356.02	963.25	659.64	429.38
8 - 9	0.628	1.334	0.973	373.49	798.80	586.14	300.73
9 - 10	0.526	1.242	0.876	312.05	743.37	527.71	304.99

Appendix 3.4 (Continued)

Port Lavaca: Ammonium Concentration Analyses -- 11/28/84 Sediment Core Samples

CORE #613: 11/84

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	2.841	2.844	2.835	1706.63	1708.43	1707.53	1.28
1 - 2	1.962	1.638	1.792	1177.11	981.93	1079.52	138.01
2 - 3	2.264	1.367	1.808	1359.04	818.67	1088.86	382.09
3 - 4	1.514	1.343	1.421	907.23	804.22	855.72	72.84
4 - 5	1.136	1.526	1.323	679.52	914.46	796.99	166.13
5 - 6	1.1001	1.363	1.224	657.89	816.27	737.08	111.99
6 - 7	1.1009	1.348	1.216	658.37	807.23	732.80	105.26
7 - 8	1.159	1.053	1.098	693.37	629.52	661.45	45.15
8 - 9	1.062	0.97	1.008	634.94	579.52	607.23	39.19
9 - 10	0.838	0.817	0.820	500.00	487.35	493.67	8.95

Appendix 3.4 (Continued)

Port Lavaoa: Ammonium Concentration Analyses -- 1/23/85 Sediment Core Samples

CORE #603: 1/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	00640			µg-atm N			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	2.848	1.795	2.314	1710.84	1076.51	1393.67	448.54
1 - 2	1.096	1.325	1.203	655.42	793.37	724.40	97.55
2 - 3	0.908	1.175	1.034	542.17	703.01	622.59	113.73
3 - 4	1.237	0.718	0.970	740.36	427.71	584.04	221.08
4 - 5	0.692	0.995	0.836	412.05	594.58	503.31	129.07
5 - 6	0.849	0.843	0.838	506.63	503.01	504.82	2.56
6 - 7	0.744	0.766	0.747	443.37	456.63	450.00	9.37
7 - 8	0.928	0.911	0.912	554.22	543.98	549.10	7.24
8 - 9	0.938	0.851	0.887	560.24	507.83	534.04	37.06
9 - 10	0.892	0.678	0.777	532.53	403.61	468.07	91.16

CORE #85: 1/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	00640			µg-atm N			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	1.852	2.167	2.002	1110.84	1300.60	1205.72	134.18
1 - 2	0.765	1.149	0.949	456.02	687.35	571.69	163.57
2 - 3	0.575	0.785	0.672	341.57	468.07	404.82	89.45
3 - 4	0.393	0.981	0.679	231.93	586.14	409.04	250.47
4 - 5	0.281	0.525	0.395	164.46	311.45	237.95	103.94
5 - 6	0.365	0.348	0.349	215.06	204.82	209.94	7.24
6 - 7	0.299	0.303	0.293	175.30	177.71	176.51	1.70
7 - 8	0.256	0.468	0.354	149.40	277.11	213.25	90.31
8 - 9	0.318	0.513	0.408	186.75	304.22	245.48	83.06
9 - 10	0.378	0.544	0.453	222.89	322.89	272.89	70.71

Appendix 3.4 (Continued)

Port Lavaca: Ammonium Concentration Analyses -- 1/23/85 Sediment Core Samples

CORE #65: 3/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	1.718	1.193	1.448	1030.12	713.86	871.99	223.63
1 - 2	0.225	1.436	0.823	130.72	860.24	495.48	515.85
2 - 3	0.101	0.649	0.367	56.02	386.14	221.08	233.43
3 - 4	0.091	0.408	0.242	50.00	240.96	145.48	135.03
4 - 5	0.805	0.184	0.487	480.12	106.02	293.07	264.53
5 - 6	0.109	0.175	0.134	60.84	100.60	80.72	28.11
6 - 7	0.09	0.143	0.109	49.40	81.33	65.36	22.58
7 - 8	0.098	0.146	0.114	54.22	83.13	68.67	20.45
8 - 9	0.102	0.12	0.103	56.63	67.47	62.05	7.67
9 - 10	0.125	0.119	0.114	70.48	66.87	68.67	2.56

CORE #623: 1/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1			#DIV/0!	-4.82	-4.82	-4.82	0.00
1 - 2			#DIV/0!	-4.82	-4.82	-4.82	0.00
2 - 3			#DIV/0!	-4.82	-4.82	-4.82	0.00
3 - 4			#DIV/0!	-4.82	-4.82	-4.82	0.00
4 - 5			#DIV/0!	-4.82	-4.82	-4.82	0.00
5 - 6			#DIV/0!	-4.82	-4.82	-4.82	0.00
6 - 7			#DIV/0!	-4.82	-4.82	-4.82	0.00
7 - 8			#DIV/0!	-4.82	-4.82	-4.82	0.00
8 - 9			#DIV/0!	-4.82	-4.82	-4.82	0.00
9 - 10			#DIV/0!	-4.82	-4.82	-4.82	0.00

Appendix 3.4 (Continued)

Port Lavaca: Ammonium Concentration Analyses -- 1/23/85 Sediment Core Samples

CORE #613: 1/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	1.737	1.198	1.460	1041.57	716.87	879.22	229.60
1 - 2	0.932	1.191	1.054	556.63	712.65	634.64	110.33
2 - 3	0.891	1.472	1.174	531.93	881.93	706.93	247.49
3 - 4	0.704	0.708	0.698	419.28	421.69	420.48	1.70
4 - 5	0.912	0.528	0.712	544.58	313.25	428.92	163.57
5 - 6	0.747	0.564	0.648	445.18	334.94	390.06	77.95
6 - 7	0.661	0.607	0.626	393.37	360.84	377.11	23.00
7 - 8	0.676	0.693	0.677	402.41	412.65	407.53	7.24
8 - 9	0.559	0.682	0.613	331.93	406.02	368.98	52.39
9 - 10	0.507	0.702	0.597	300.60	418.07	359.34	83.06

CORE #633: 1/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	2.848		2.840	1710.84		1710.84	#DIV/0!
1 - 2	2.849		2.841	1711.45		1711.45	#DIV/0!
2 - 3	0.586	0.479	0.525	1740.96	2837.35	2289.16	775.26
3 - 4	2.849	0.056	1.445	1711.45	144.58	928.01	1107.94
4 - 5	1.298		1.290	1295.44		1295.44	#DIV/0!
5 - 6	1.605		1.597	962.05		962.05	#DIV/0!
6 - 7	1.904	1.484	1.686	1142.17	889.16	1015.66	178.91
7 - 8	0.527		0.519	1563.25		1563.25	#DIV/0!
8 - 9			#DIV/0!			#DIV/0!	#DIV/0!
9 - 10			#DIV/0!			#DIV/0!	#DIV/0!

Appendix 3.4 (Continued)

Port Lavaca: Ammonium Concentration Analyses -- 1/23/85 Sediment Core Samples

CORE #1505: 11/84

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	2.849	2.85	2.842	1711.45	1712.05	1711.75	0.43
1 - 2	2.85	2.159	2.497	1712.05	1295.78	1503.92	294.34
2 - 3	2.492	2.547	2.512	1496.39	1529.52	1512.95	23.43
3 - 4	1.696	1.878	1.779	1016.87	1126.51	1071.69	77.53
4 - 5	1.398	1.669	1.526	837.35	1000.60	918.98	115.44
5 - 6	1.118	1.358	1.230	668.67	813.25	740.96	102.23
6 - 7	1.106	0.963	1.027	661.45	575.30	618.37	60.91
7 - 8	0.847	1.095	0.963	505.42	654.82	580.12	105.64
8 - 9	0.818	0.699	0.751	487.95	416.27	452.11	50.69
9 - 10	0.902	0.675	0.781	538.55	401.81	470.18	96.69

CORE #45: 1/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	1.209	1.438	1.316	1808.73	861.45	1335.09	669.83
1 - 2		2.238	2.230		1343.37	1343.37	#DIV/0!
2 - 3			#DIV/0!			#DIV/0!	#DIV/0!
3 - 4	2.398		2.390	1439.76		1439.76	#DIV/0!
4 - 5	1.967		1.959	1180.12		1180.12	#DIV/0!
5 - 6	1.508		1.500	903.61		903.61	#DIV/0!
6 - 7	2.847		2.839	2137.80		2137.80	#DIV/0!
7 - 8			#DIV/0!			#DIV/0!	#DIV/0!
8 - 9			#DIV/0!			#DIV/0!	#DIV/0!
9 - 10			#DIV/0!			#DIV/0!	#DIV/0!

Appendix 3.4 (Continued)

Port Lavaca: Pore Water Ammonium Concentration -- 3/6/85 Sediment Core Samples

CORE #603:3/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	---------OD640-- ------			---------µg-atm N/l of Pore Water--------			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	2.541	2.793	2.659	1525.90	1677.71	1601.81	107.34
1 - 2	1.917	1.716	1.809	1150.00	1028.92	1089.46	85.62
2 - 3	1.427	1.221	1.316	854.82	730.72	792.77	87.75
3 - 4	1.303	1.198	1.243	780.12	716.87	748.49	44.73
4 - 5	1.006	0.937	0.964	601.20	559.64	580.42	29.39
5 - 6	0.982	0.889	0.928	586.75	530.72	558.73	39.62
6 - 7	0.778	0.718	0.740	463.86	427.71	445.78	25.56
7 - 8	1.046	0.704	0.867	625.30	419.28	522.29	145.68
8 - 9	0.767	0.538	0.645	457.23	319.28	388.25	97.55
9 - 10	0.618	0.706	0.654	367.47	420.48	393.98	37.49

CORE #85:3/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	---------OD640-- ------			---------µg-atm N/l of Pore Water---------			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	2.844	2.453	2.641	1708.43	1472.89	1590.66	166.55
1 - 2	1.414	1.551	1.475	846.99	929.52	888.25	58.36
2 - 3	0.473	0.741	0.599	280.12	441.57	360.84	114.16
3 - 4	0.427	0.798	0.605	252.41	475.90	364.16	158.03
4 - 5	0.061	0.612	0.329	31.93	363.86	197.89	234.71
5 - 6	0.756	0.473	0.607	450.60	280.12	365.36	120.55
6 - 7	0.543	0.557	0.542	322.29	330.72	326.51	5.96
7 - 8	0.91	0.524	0.709	543.37	310.84	427.11	164.42
8 - 9	1.079	0.838	0.951	645.18	500.00	572.59	102.66
9 - 10	1.161	1.417	1.281	694.58	848.80	771.69	109.05

Appendix 3.4 (Continued)

Port Lavaca: Pore Water Ammonium Concentration -- 3/6/85 Sediment Core Samples

CORE *65: 3/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l in Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.769	0.607	0.680	458.43	360.84	409.64	69.01
1 - 2	0.516	0.753	0.627	306.02	448.80	377.41	100.95
2 - 3	0.243	0.334	0.281	141.57	196.39	168.98	38.76
3 - 4	0.203	0.176	0.182	117.47	101.20	109.34	11.50
4 - 5	0.203	0.162	0.175	117.47	92.77	105.12	17.46
5 - 6	0.137	0.383	0.252	77.71	225.90	151.81	104.79
6 - 7	0.119	0.095	0.099	66.87	52.41	59.64	10.22
7 - 8	0.117	0.122	0.112	65.66	68.67	67.17	2.13
8 - 9	0.113	0.116	0.107	63.25	65.06	64.16	1.28
9 - 10	0.113	---	0.105	63.25	0.00	0.00	0.00

CORE *623: 3/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	1.734	0.954	1.336	1039.76	569.88	804.82	332.25
1 - 2	1.273	1.197	1.227	762.05	716.27	739.16	32.37
2 - 3	0.915	1.015	0.957	546.39	606.63	576.51	42.60
3 - 4	0.708	0.679	0.686	421.69	404.22	412.95	12.35
4 - 5	0.564	0.619	0.584	334.94	368.07	351.51	23.43
5 - 6	0.365	1.048	0.699	215.06	626.51	420.78	290.94
6 - 7	0.318	0.538	0.420	186.75	319.28	253.01	93.71
7 - 8	0.322	0.49	0.398	189.16	290.36	239.76	71.56
8 - 9	0.295	0.446	0.363	172.89	263.86	218.37	64.32
9 - 10	0.375	0.492	0.426	221.08	291.57	256.33	49.84

Appendix 3.4 (Continued)

Port Lavaca: Pore Water Ammonium Concentration -- 3/6/85 Sediment Core Samples

CORE #613:3/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l in Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	1.434	1.628	1.523	859.04	975.90	917.47	82.64
1 - 2	1.154	1.616	1.377	690.36	968.67	829.52	196.80
2 - 3	0.699	1.276	0.980	416.27	763.86	590.06	245.78
3 - 4	0.742	1.104	0.915	442.17	660.24	551.20	154.20
4 - 5	0.781	1.116	0.941	465.66	667.47	566.57	142.70
5 - 6	0.847	1.356	1.094	505.42	812.05	658.73	216.82
6 - 7	0.901	1.394	1.140	537.95	834.94	686.45	210.00
7 - 8	0.873	1.134	0.996	521.08	678.31	599.70	111.18
8 - 9	0.847	1.133	0.982	505.42	677.71	591.57	121.83
9 - 10	0.641	1.035	0.830	381.33	618.67	500.00	167.83

Appendix 3.4 (Continued)

Port Lavaoa: Pore Water Ammonium Concentration -- 3/6/85 Sediment Core Samples

CORE #45: 3/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640 A	OD640 B	OD640 NET AVE	µg-atm N/l of Pore Water A	µg-atm N/l of Pore Water B	µg-atm N/l of Pore Water AVE	±STD
0 - 1	1.535	2.395	1.957	919.88	1437.95	1178.92	366.33
1 - 2	1.749	1.552	1.643	1048.80	930.12	989.46	83.92
2 - 3	1.467	1.154	1.303	878.92	690.36	784.64	133.33
3 - 4	1.779	1.429	1.596	1066.87	856.02	961.45	149.09
4 - 5		2.846	2.838		1709.64	1709.64	#DIV/0!
5 - 6	2.847	2.197	2.514	1710.24	1318.67	1514.46	276.88
6 - 7			#DIV/0!	-4.82	-4.82	-4.82	0.00
7 - 8			#DIV/0!	-4.82	-4.82	-4.82	0.00
8 - 9			#DIV/0!	-4.82	-4.82	-4.82	0.00
9 - 10			#DIV/0!	-4.82	-4.82	-4.82	0.00

Appendix 3.4 (Continued)

Port Lavaoa: Pore Water Ammonium Concentration -- 4/3/85

CORE #603: 4/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	1.573	1.076	1.317	942.77	643.37	793.07	211.71
1 - 2	1.124	0.852	0.980	672.29	508.43	590.36	115.86
2 - 3	0.855	1.052	0.946	510.24	628.92	569.58	83.92
3 - 4	0.826	0.969	0.890	492.77	578.92	535.84	60.91
4 - 5	0.747	0.748	0.740	445.18	445.78	445.48	0.43
5 - 6	0.643	0.716	0.672	382.53	426.51	404.52	31.10
6 - 7	0.622	0.595	0.601	369.88	353.61	361.75	11.50
7 - 8	0.619	0.674	0.639	368.07	401.20	384.64	23.43
8 - 9	0.56	0.653	0.599	332.53	388.55	360.54	39.62
9 - 10	0.643	0.586	0.607	382.53	348.19	365.36	24.28

CORE #85: 4/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	1.382	1.696	1.531	827.71	1016.87	922.29	133.75
1 - 2	1.314	1.033	1.166	786.75	617.47	702.11	119.70
2 - 3	0.582	0.402	0.484	345.78	237.35	291.57	76.67
3 - 4	0.451	0.317	0.376	333.58	465.36	399.47	93.18
4 - 5	0.295	0.329	0.304	172.89	193.37	183.13	14.48
5 - 6	0.41	0.418	0.406	242.17	246.99	244.58	3.41
6 - 7	0.431	0.278	0.347	254.82	162.65	208.73	65.17
7 - 8	0.382	0.241	0.304	225.30	140.36	182.83	60.06
8 - 9	0.284	0.225	0.247	166.27	130.72	148.49	25.13
9 - 10	0.277	0.363	0.312	162.05	213.86	187.95	36.63

Appendix 3.4 (Continued)

Port Lavaca: Pore Water Ammonium Concentration -- 4/3/85

CORE #65: 4/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.062	0.643	0.345	32.53	382.53	207.53	247.49
1 - 2	1.093	1.012	1.045	653.61	604.82	629.22	34.50
2 - 3	1.351	1.436	1.386	809.04	860.24	834.64	36.21
3 - 4	0.974	0.659	0.809	581.93	392.17	487.05	134.18
4 - 5	1.232	0.412	0.814	737.35	243.37	490.36	349.29
5 - 6	0.661	0.241	0.443	393.37	140.36	266.87	178.91
6 - 7	0.709	0.211	0.452	422.29	122.29	272.29	212.13
7 - 8	0.786	0.153	0.462	468.67	87.35	278.01	269.64
8 - 9	0.219	0.158	0.181	127.11	90.36	108.73	25.98
9 - 10	0.155	0.188	0.164	88.55	108.43	98.49	14.06

CORE #623: 4/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	1.576	1.798	1.679	944.58	1078.31	1011.45	94.56
1 - 2	1.059	1.098	1.071	633.13	656.63	644.88	16.61
2 - 3	0.951	0.998	0.967	568.07	596.39	582.23	20.02
3 - 4	0.62	0.904	0.754	921.69	539.76	730.72	270.06
4 - 5	0.728	0.834	0.773	433.73	497.59	465.66	45.15
5 - 6	0.927	0.871	0.891	553.61	519.88	536.75	23.85
6 - 7	0.957	0.694	0.818	571.69	413.25	492.47	112.03
7 - 8	0.284	0.563	0.416	831.33	334.34	582.83	351.42
8 - 9	0.353	0.767	0.552	1039.16	457.23	748.19	411.49
9 - 10		0.594	0.586	-4.82	353.01	174.10	253.02

Appendix 3.4 (Continued)

Port Lavaca: Pore Water Ammonium Concentration -- 4/3/85

CORE *613: 4/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	-OD640-			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	1.567	0.983	1.267	939.16	587.35	763.25	248.77
1 - 2	0.916	0.892	0.896	546.99	532.53	539.76	10.22
2 - 3	0.873	0.898	0.878	521.08	536.14	528.61	10.65
3 - 4	0.712	0.767	0.732	424.10	457.23	440.66	23.43
4 - 5	0.864	0.604	0.726	515.66	359.04	437.35	110.75
5 - 6	0.823	0.682	0.745	490.96	406.02	448.49	60.06
6 - 7	0.497	0.761	0.621	294.58	453.61	374.10	112.46
7 - 8	0.509	0.721	0.607	301.81	429.52	365.66	90.31
8 - 9	0.571	0.701	0.628	339.16	417.47	378.31	55.38
9 - 10	0.746	0.556	0.643	444.58	330.12	387.35	80.93

CORE *633: 4/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	-00640-			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1		1.794	1.786		1793.53	1793.53	*DIV/0!
1 - 2		2.405	2.397		1443.98	1443.98	*DIV/0!
2 - 3	1.263		1.255	756.02		756.02	*DIV/0!
3 - 4	0.709	0.147	0.420	422.29	4186.75	2304.52	2661.87
4 - 5	0.706		0.698	420.48		420.48	*DIV/0!
5 - 6	0.848		0.840	506.02		506.02	*DIV/0!
6 - 7	1.152		1.144	689.16		689.16	*DIV/0!
7 - 8	2.259		2.251	1356.02		1356.02	*DIV/0!
8 - 9	1.658		1.650	993.98		993.98	*DIV/0!
9 - 10			*DIV/0!			*DIV/0!	*DIV/0!

Appendix 3.4 (Continued)

Port Lavaca: Pore Water Ammonium Concentration -- 5/8/85 Sediment Core Samples

CORE #603: 5/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	1.176	1.224	1.192	703.61	732.53	718.07	20.45
1 - 2	0.842	1.282	1.054	502.41	767.47	634.94	187.43
2 - 3	0.663	0.762	0.705	394.58	454.22	424.40	42.17
3 - 4	0.362	0.487	0.417	213.25	288.55	250.90	53.25
4 - 5	0.323	0.423	0.365	189.76	250.00	219.88	42.60
5 - 6	0.431	0.464	0.440	254.82	274.70	264.76	14.06
6 - 7	0.349	0.429	0.381	205.42	253.61	229.52	34.08
7 - 8	0.326	0.404	0.357	191.57	238.55	215.06	33.23
8 - 9	0.401	0.426	0.406	236.75	251.81	244.28	10.65
9 - 10	0.447	0.395	0.413	264.46	233.13	248.80	22.15

CORE #85: 5/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.081	1.099	0.582	43.98	657.23	350.60	433.64
1 - 2	0.021	0.211	0.108	7.83	122.29	65.06	80.93
2 - 3	0.575	0.936	0.748	341.57	559.04	450.30	153.77
3 - 4	0.103	0.097	0.092	57.23	53.61	55.42	2.56
4 - 5	0.131	0.192	0.154	74.10	110.84	92.47	25.98
5 - 6	0.293	0.045	0.161	171.69	22.29	96.99	105.64
6 - 7	0.207	0.215	0.203	119.88	124.70	122.29	3.41
7 - 8	0.154	0.123	0.131	87.95	69.28	78.61	13.21
8 - 9	0.188	0.178	0.175	108.43	102.41	105.42	4.26
9 - 10	0.251	0.154	0.195	146.39	87.95	117.17	41.32

Appendix 3.4 (Continued)

Port Lavaca: Pore Water Ammonium Concentration -- 5/8/85

CORE *65: 5/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	---------OD640-- ------			---------µg-atm N/l of Pore Water--------			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	1.257	0.546	0.894	752.41	324.10	538.25	302.86
1 - 2	0.681	1.221	0.943	405.42	730.72	568.07	230.02
2 - 3	0.358	0.775	0.559	210.84	462.05	336.45	177.63
3 - 4	0.223	0.469	0.338	129.52	277.71	203.61	104.79
4 - 5	0.378	0.259	0.311	222.89	151.20	187.05	50.69
5 - 6	0.254	0.165	0.202	148.19	94.58	121.39	37.91
6 - 7	0.122	0.149	0.128	68.67	84.94	76.81	11.50
7 - 8	0.095	0.108	0.094	52.41	60.24	56.33	5.54
8 - 9	0.102	0.101	0.094	56.63	56.02	56.33	0.43
9 - 10	0.076	0.092	0.076	40.96	50.60	45.78	6.82

CORE *623: 5/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	---------00640-- ------			---------µg-atm N/l of Pore Water--------			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.627	0.828	0.720	372.89	493.98	433.43	85.62
1 - 2	0.794	0.971	0.875	473.49	580.12	526.81	75.40
2 - 3	0.816	0.732	0.766	486.75	436.14	461.45	35.78
3 - 4	0.793	0.551	0.664	472.89	327.11	400.00	103.08
4 - 5	0.507	0.501	0.496	300.60	296.99	298.80	2.56
5 - 6	0.336	0.569	0.445	197.59	337.95	267.77	99.25
6 - 7	0.344	0.406	0.367	202.41	239.76	221.08	26.41
7 - 8	0.512	0.385	0.441	303.61	227.11	265.36	54.10
8 - 9	0.513	0.322	0.410	304.22	189.16	246.69	81.36
9 - 10	0.647	0.237	0.434	384.94	137.95	261.45	174.65

Appendix 3.4 (Continued)

Port Lavaca: Pore Water Ammonium Concentration -- 5/8/85

CORE *613: 5/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.696	1.059	0.870	414.46	633.13	523.80	154.63
1 - 2	0.629	0.736	0.675	374.10	438.55	406.33	45.58
2 - 3	0.591	0.603	0.589	351.20	358.43	354.82	5.11
3 - 4	0.547	0.702	0.617	324.70	418.07	371.39	66.03
4 - 5	0.463	0.572	0.510	274.10	339.76	306.93	46.43
5 - 6	0.544	0.563	0.546	322.89	334.34	328.61	8.09
6 - 7	0.411	0.52	0.458	242.77	308.43	275.60	46.43
7 - 8	0.378	0.556	0.459	222.89	330.12	276.51	75.82
8 - 9	0.56	0.46	0.502	332.53	272.29	302.41	42.60
9 - 10	0.42	0.557	0.481	248.19	330.72	289.46	58.36

CORE *633: 5/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1			*DIV/0!			*DIV/0!	*DIV/0!
1 - 2			*DIV/0!			*DIV/0!	*DIV/0!
2 - 3	0.394		0.386	2325.30		2325.30	*DIV/0!
3 - 4	1.648		1.640	987.95		987.95	*DIV/0!
4 - 5			*DIV/0!			*DIV/0!	*DIV/0!
5 - 6	0.817		0.809	1218.37		1218.37	*DIV/0!
6 - 7			*DIV/0!			*DIV/0!	*DIV/0!
7 - 8			*DIV/0!			*DIV/0!	*DIV/0!
8 - 9			*DIV/0!			*DIV/0!	*DIV/0!
9 - 10			*DIV/0!			*DIV/0!	*DIV/0!

Appendix 3.4 (Continued)

Port Lavaca: Pore Water Ammonium Concentration -- 6/5/85

CORE #603: 6/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.482	0.163	0.315	285.54	233.43	259.49	36.85
1 - 2	0.257	0.134	0.188	150.00	189.76	169.88	28.11
2 - 3	0.335	0.16	0.240	196.99	228.92	212.95	22.58
3 - 4	0.402	0.178	0.282	237.35	256.02	246.69	13.21
4 - 5	0.132	0.133	0.125	74.70	188.25	131.48	80.29
5 - 6	0.152	0.043	0.090	86.75	52.71	69.73	24.07
6 - 7	0.228	0.094	0.153	132.53	129.52	131.02	2.13
7 - 8	0.176	0.154	0.157	101.20	219.88	160.54	83.92
8 - 9	0.445	0.157	0.293	263.25	224.40	243.83	27.47
9 - 10	0.401	0.106	0.246	236.75	147.59	192.17	63.04

CORE #85: 6/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.284	0.523	0.396	166.27	285.16	225.71	84.07
1 - 2	0.179	0.256	0.210	103.01	138.46	120.74	25.07
2 - 3	0.106	0.382	0.236	59.04	207.69	133.36	105.12
3 - 4	0.075	0.322	0.191	40.36	174.73	107.54	95.01
4 - 5	0.236	0.277	0.249	137.35	150.00	143.67	8.95
5 - 6	0.292	0.269	0.273	171.08	145.60	158.34	18.02
6 - 7	0.288	0.251	0.262	168.67	135.71	152.19	23.31
7 - 8	0.016	0.193	0.097	4.82	103.85	54.33	70.02
8 - 9	0.179		0.171	103.01		103.01	#DIV/0!
9 - 10	0.254		0.246	148.19		148.19	#DIV/0!

Appendix 3.4 (Continued)

Port Lavaca: Pore Water Ammonium Concentration -- 6/5/85

CORE #65: 6/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	--------OD640--	------		---------µg-atm N/l of Pore Water----------			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	1.063	0.278	0.663	635.54	406.63	521.08	161.87
1 - 2	0.066	0.123	0.087	34.94	173.19	104.07	97.76
2 - 3	0.18	0.038	0.101	103.61	45.18	74.40	41.32
3 - 4	0.036	0.039	0.030	16.87	46.69	31.78	21.09
4 - 5	0.035	0.048	0.034	16.27	60.24	38.25	31.10
5 - 6	0.07	0.026	0.040	37.35	27.11	32.23	7.24
6 - 7	0.062	0.022	0.034	32.53	21.08	26.81	8.09
7 - 8	0.055	0.024	0.032	28.31	24.10	26.20	2.98
8 - 9	0.036	0.025	0.023	16.87	25.60	21.23	6.18
9 - 10	0.171	0.029	0.092	98.19	31.63	64.91	47.07

CORE #623: 6/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	--------OD640--	------		---------µg-atm N/l of Pore Water--------			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.037	0.032	0.027	17.47	14.46	15.96	2.13
1 - 2	0.388	0.017	0.195	228.92	5.42	117.17	158.03
2 - 3	0.026	0.09	0.050	10.84	49.40	30.12	27.26
3 - 4	0.031	0.043	0.029	13.86	21.08	17.47	5.11
4 - 5	0.022	0.026	0.016	8.43	10.84	9.64	1.70
5 - 6	0.015	0.552	0.276	4.22	327.71	165.96	228.74
6 - 7	0.098	0.069	0.076	54.22	36.75	45.48	12.35
7 - 8	0.189	0.125	0.149	109.04	70.48	89.76	27.26
8 - 9	0.168	0.02	0.086	96.39	7.23	51.81	63.04
9 - 10	0.103	0.015	0.051	57.23	4.22	30.72	37.49

Appendix 3.4 (Continued)

Port Lavaca: Pore Water Ammonium Concentration -- 6/5/85

CORE #613: 6/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	--------OD640-------			---------µg-atm N/l of Pore Water----------			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	1.365	0.904	1.127	817.47	539.76	678.61	196.37
1 - 2	1.173	1.324	1.241	701.81	792.77	747.29	64.32
2 - 3	0.802	1.147	0.967	478.31	686.14	582.23	146.96
3 - 4	0.877	0.406	0.634	523.49	239.76	381.63	200.63
4 - 5	0.901	0.383	0.634	537.95	225.90	381.93	220.65
5 - 6	0.661	0.304	0.475	393.37	178.31	285.84	152.07
6 - 7	0.99	0.552	0.763	591.57	327.71	459.64	186.57
7 - 8	1.026	0.203	0.607	613.25	117.47	365.36	350.57
8 - 9	0.486	0.197	0.334	287.95	113.86	200.90	123.10
9 - 10	0.647	0.04	0.336	384.94	19.28	202.11	258.56

CORE #633: 6/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	--------OD640-------			---------µg-atm N/l of Pore Water---------			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.046	0.033	0.032	114.46	18.83	66.64	67.62
1 - 2	0.127	0.072	0.092	358.43	385.54	371.99	19.17
2 - 3		0.022	0.014		84.34	84.34	#DIV/0!
3 - 4		0.069	0.061		73.49	73.49	#DIV/0!
4 - 5			#DIV/0!			#DIV/0!	#DIV/0!
5 - 6	0.128	0.192	0.152	722.89	110.84	416.87	432.78
6 - 7	0.028		0.020	12.05		12.05	#DIV/0!
7 - 8	0.078		0.070	105.42		105.42	#DIV/0!
8 - 9			#DIV/0!			#DIV/0!	#DIV/0!
9 - 10			#DIV/0!			#DIV/0!	#DIV/0!

Appendix 3.4 (Continued)

Port Lavaca: Pore Water Ammonium Concentration -- 6/5/85

CORE #45: 6/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.108	0.494	0.293	60.24	292.77	176.51	164.42
1 - 2			#DIV/0!			#DIV/0!	#DIV/0!
2 - 3			#DIV/0!			#DIV/0!	#DIV/0!
3 - 4			#DIV/0!			#DIV/0!	#DIV/0!
4 - 5			#DIV/0!			#DIV/0!	#DIV/0!
5 - 6			#DIV/0!			#DIV/0!	#DIV/0!
6 - 7			#DIV/0!			#DIV/0!	#DIV/0!
7 - 8			#DIV/0!			#DIV/0!	#DIV/0!
8 - 9			#DIV/0!			#DIV/0!	#DIV/0!
9 - 10	0.091		0.083	50.00		50.00	#DIV/0!

Appendix 3.4 (Continued)

Port Lavaca: Pore Water Ammonium Concentration --7/17/85

CORE #603: 7/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	1.268	1.349	1.301	759.04	807.83	783.43	34.50
1 - 2	0.854	0.829	0.834	509.64	494.58	502.11	10.65
2 - 3	0.832	0.925	0.871	496.39	552.41	524.40	39.62
3 - 4	0.874	0.743	0.801	521.69	442.77	482.23	55.80
4 - 5	0.708	0.782	0.737	421.69	466.27	443.98	31.52
5 - 6	0.562	0.829	0.688	333.73	494.58	414.16	113.73
6 - 7	0.634	0.595	0.607	377.11	353.61	365.36	16.61
7 - 8	0.627	0.546	0.579	372.89	324.10	348.49	34.50
8 - 9	0.496	0.478	0.479	293.98	283.13	288.55	7.67
9 - 10	0.472	0.443	0.450	279.52	262.05	270.78	12.35

CORE #85: 7/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.842	0.975	0.901	502.41	582.53	542.47	56.65
1 - 2	0.622	0.767	0.687	369.88	457.23	413.55	61.77
2 - 3	0.544	0.882	0.705	322.89	526.51	424.70	143.98
3 - 4	0.445	0.664	0.547	263.25	395.18	329.22	93.29
4 - 5	0.499	0.58	0.532	295.78	344.58	320.18	34.50
5 - 6	0.467	0.469	0.460	276.51	277.71	277.11	0.85
6 - 7	0.327	0.449	0.380	192.17	265.66	228.92	51.97
7 - 8	0.284	0.472	0.370	166.27	279.52	222.89	80.08
8 - 9	0.332	0.408	0.362	195.18	240.96	218.07	32.37
9 - 10			#DIV/0!	-4.82	-4.82	-4.82	0.00

Appendix 3.4 (Continued)

Port Lavaoa: Pore Water Ammonium Concentration --7/17/85

CORE *65: 7/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	--------OD640--------			--------µg-atm N/l of Pore Water--------			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.762	0.987	0.867	454.22	589.76	521.99	95.84
1 - 2	0.661	0.929	0.787	393.37	554.82	474.10	114.16
2 - 3	0.567	0.621	0.586	336.75	369.28	353.01	23.00
3 - 4	0.403	0.611	0.499	237.95	363.25	300.60	88.60
4 - 5	0.432	0.959	0.688	255.42	572.89	414.16	224.49
5 - 6	0.211	0.976	0.586	122.29	583.13	352.71	325.87
6 - 7	0.219	0.628	0.416	127.11	373.49	250.30	174.22
7 - 8	0.171	0.799	0.477	98.19	476.51	287.35	267.51
8 - 9	0.013	0.508	0.253	3.01	301.20	152.11	210.85
9 - 10	0.129	0.768	0.441	72.89	457.83	265.36	272.19

CORE *623: 7/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	--------OD640--------			--------µg-atm N/l of Pore Water--------			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	1.257	1.558	1.400	752.41	933.73	843.07	128.22
1 - 2	0.967	0.982	0.967	577.71	586.75	582.23	6.39
2 - 3	0.711	0.839	0.767	423.49	500.60	462.05	54.52
3 - 4	0.63	0.476	0.545	374.70	281.93	328.31	65.60
4 - 5	0.572	0.506	0.531	339.76	300.00	319.88	28.11
5 - 6	0.346	0.394	0.362	203.61	232.53	218.07	20.45
6 - 7	0.379	0.4	0.382	223.49	236.14	229.82	8.95
7 - 8	0.314	0.338	0.318	184.34	198.80	191.57	10.22
8 - 9	0.288	0.348	0.310	168.67	204.82	186.75	25.56
9 - 10	0.202	0.267	0.227	116.87	156.02	136.45	27.69

Appendix 3.4 (Continued)

Port Lavaca: Pore Water Ammonium Concentration --7/17/85

CORE #613: 7/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	1.276	1.025	1.143	763.86	612.65	688.25	106.92
1 - 2	0.947	0.872	0.902	565.66	520.48	543.07	31.95
2 - 3	0.957	0.725	0.833	571.69	431.93	501.81	98.82
3 - 4	0.648	0.609	0.621	385.54	362.05	373.80	16.61
4 - 5	0.546	0.797	0.664	324.10	475.30	399.70	106.92
5 - 6	0.521	0.666	0.586	309.04	396.39	352.71	61.77
6 - 7	0.459	0.616	0.530	271.69	366.27	318.98	66.88
7 - 8	0.395	0.524	0.452	233.13	310.84	271.99	54.95
8 - 9	0.409	0.609	0.501	241.57	362.05	301.81	85.19
9 - 10	0.448	0.496	0.464	265.06	293.98	279.52	20.45

CORE #633: 7/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.23		0.222	6686.75		6686.75	#DIV/0!
1 - 2			#DIV/0!			#DIV/0!	#DIV/0!
2 - 3	0.977		0.969	583.73		583.73	#DIV/0!
3 - 4	0.165		0.157	236.45		236.45	#DIV/0!
4 - 5	1.032		1.024	6168.67		6168.67	#DIV/0!
5 - 6	0.898	0.923	0.903	536.14	689.01	612.58	108.09
6 - 7	0.852	0.371	0.604	508.43	546.69	527.56	27.05
7 - 8	0.709	0.492	0.593	422.29	291.57	356.93	92.44
8 - 9		0.818	0.810		609.94	609.94	#DIV/0!
9 - 10			#DIV/0!			#DIV/0!	#DIV/0!

Appendix 3.4 (Continued)

Port Lavaoa: Pore Water Ammonium Conoentration --7/17/85

CORE #45: 7/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	-OD640-			-µg-atm N/l of Pore Water-			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	1.132	0.924	1.020	677.11	551.81	614.46	88.60
1 - 2			#DIV/0!			#DIV/0!	#DIV/0!
2 - 3	0.648		0.640	385.54		385.54	#DIV/0!
3 - 4	0.584		0.576	867.47		867.47	#DIV/0!
4 - 5			#DIV/0!			#DIV/0!	#DIV/0!
5 - 6			#DIV/0!			#DIV/0!	#DIV/0!
6 - 7			#DIV/0!			#DIV/0!	#DIV/0!
7 - 8			#DIV/0!			#DIV/0!	#DIV/0!
8 - 9			#DIV/0!			#DIV/0!	#DIV/0!
9 - 10			#DIV/0!			#DIV/0!	#DIV/0!

Appendix 3.4 (Continued)

Port Lavaca: Pore Water Ammonium Concentration -- 8/14/85 Sediment Core Samples

CORE #603: 8/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	--00640-- A	B	NET AVE	--µg-atm N/l of Pore Water-- A	B	AVE	±STD
0 - 1	2.845	1.505	2.167	1709.04	901.81	1305.42	570.80
1 - 2	0.219	0.682	0.443	127.11	406.02	266.57	197.22
2 - 3	0.561	0.698	0.622	333.13	415.66	374.40	58.36
3 - 4	1.088	1.124	1.098	650.60	672.29	661.45	15.33
4 - 5	0.776	0.922	0.841	462.65	550.60	506.63	62.19
5 - 6	0.286	0.816	0.543	167.47	486.75	327.11	225.76
6 - 7	0.327	0.754	0.533	192.17	449.40	320.78	181.89
7 - 8	0.236	0.596	0.408	137.35	354.22	245.78	153.35
8 - 9	0.256	0.407	0.324	149.40	240.36	194.88	64.32
9 - 10	0.303	0.289	0.288	177.71	169.28	173.49	5.96

CORE #85: 8/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	--00640-- A	B	NET AVE	--µg-atm N/l of Pore Water-- A	B	AVE	±STD
0 - 1							#DIV/0!
1 - 2							#DIV/0!
2 - 3							#DIV/0!
3 - 4							#DIV/0!
4 - 5							#DIV/0!
5 - 6							#DIV/0!
6 - 7							#DIV/0!
7 - 8							#DIV/0!
8 - 9							#DIV/0!
9 - 10							#DIV/0!

Appendix 3.4 (Continued)

Port Lavaca: Pore Water Ammonium Concentration -- 8/14/85 Sediment Core Samples

CORE #65: 8/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	--------OD640--	------		---------µg-atm N/l of Pore Water----------			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.49	0.108	0.291	290.36	60.24	175.30	162.72
1 - 2		0.484	0.476		286.75	286.75	#DIV/0!
2 - 3	0.304	0.428	0.358	178.31	253.01	215.66	52.82
3 - 4	0.217	0.195	0.198	125.90	112.65	119.28	9.37
4 - 5	0.089	0.319	0.196	48.80	187.35	118.07	97.97
5 - 6	0.027	0.123	0.067	11.45	69.28	40.36	40.89
6 - 7		0.073	0.065		39.16	39.16	#DIV/0!
7 - 8	0.032	0.067	0.042	14.46	35.54	25.00	14.91
8 - 9	0.023	0.066	0.037	9.04	34.94	21.99	18.32
9 - 10	0.058	0.035	0.039	30.12	16.27	23.19	9.80

CORE #623: 8/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	--------OD640--	------		---------µg-atm N/l of Pore Water----------			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.752	1.275	1.006	448.19	763.25	605.72	222.78
1 - 2	0.588	0.488	0.530	349.40	289.16	319.28	42.60
2 - 3	0.557	0.116	0.329	330.72	65.06	197.89	187.85
3 - 4	0.056	0.067	0.054	28.92	35.54	32.23	4.69
4 - 5	0.91	0.982	0.938	543.37	586.75	565.06	30.67
5 - 6	0.037	0.076	0.049	17.47	40.96	29.22	16.61
6 - 7	0.031	0.057	0.036	13.86	29.52	21.69	11.08
7 - 8	0.013	1.596	0.797	3.01	956.63	479.82	674.31
8 - 9	0.098	0.122	0.102	54.22	68.67	61.45	10.22
9 - 10	0.035	0.021	0.020	16.27	7.83	12.05	5.96

Appendix 3.4 (Continued)

Port Lavaca: Pore Water Ammonium Concentration -- 8/14/85 Sediment Core Samples

CORE *613: 8/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	1.467	1.214	1.333	878.92	726.51	802.71	107.77
1 - 2	1.831	0.626	1.221	1098.19	372.29	735.24	513.29
2 - 3	0.476	0.07	0.265	281.93	37.35	159.64	172.94
3 - 4	0.351	0.657	0.496	206.63	390.96	298.80	130.35
4 - 5	0.804	0.812	0.800	479.52	484.34	481.93	3.41
5 - 6	0.656	0.631	0.636	390.36	375.30	382.83	10.65
6 - 7	0.721	0.558	0.632	429.52	331.33	380.42	69.43
7 - 8	0.577	0.648	0.605	342.77	385.54	364.16	30.24
8 - 9		0.614	0.606		365.06	365.06	*DIV/0!
9 - 10	0.952	0.487	0.712	568.67	288.55	428.61	198.08

CORE *633: 8/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	2.845	2.848	2.839	1709.04	1710.84	1709.94	1.28
1 - 2		2.85	2.842		1712.05	1712.05	*DIV/0!
2 - 3		2.851	2.843		1712.65	1712.65	*DIV/0!
3 - 4	1.253	2.017	1.627	750.00	1210.24	980.12	325.44
4 - 5	0.01	1.876	0.935	1.20	1125.30	563.25	794.86
5 - 6	0.877	0.897	0.879	523.49	535.54	529.52	8.52
6 - 7	0.72		0.712	428.92		428.92	*DIV/0!
7 - 8	0.91	0.535	0.715	543.37	317.47	430.42	159.74
8 - 9	0.982	0.302	0.634	586.75	177.11	381.93	289.66
9 - 10			*DIV/0!			*DIV/0!	*DIV/0!

Appendix 3.4 (Continued)

CORE #603: 10/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	-------OD640------			---------µg-atm N/l of Pore Water--			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.291	0.385	0.330	170.48	227.11	198.80	40.04
1 - 2	0.331	0.399	0.357	194.58	235.54	215.06	28.97
2 - 3	0.366	0.428	0.389	215.66	253.01	234.34	26.41
3 - 4	0.411	0.431	0.413	242.77	254.82	248.80	8.52
4 - 5	0.436	0.397	0.409	257.83	234.34	246.08	16.61
5 - 6	0.448	0.456	0.444	265.06	269.88	267.47	3.41
6 - 7	0.498	0.482	0.482	295.18	285.54	290.36	6.82
7 - 8	0.524	0.562	0.535	310.84	333.73	322.29	16.19
8 - 9	0.557	0.546	0.544	330.72	324.10	327.41	4.69
9 - 10	0.575	--	0.567	341.57		341.57	

CORE #85: 10/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	-------OD640------			---------µg-atm N/l of Pore Water--			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.275	0.134	0.197	160.84	75.90	118.37	60.06
1 - 2	0.323	0.106	0.207	189.76	59.04	124.40	92.44
2 - 3	0.361	0.127	0.236	212.65	71.69	142.17	99.68
3 - 4	0.307	0.148	0.220	180.12	84.34	132.23	67.73
4 - 5	0.294	0.158	0.218	172.29	90.36	131.33	57.93
5 - 6	0.293	0.182	0.230	171.69	104.82	138.25	47.28
6 - 7	0.263	0.207	0.227	153.61	119.88	136.75	23.85
7 - 8	0.293	0.216	0.247	171.69	125.30	148.49	32.80
8 - 9	0.279	0.235	0.249	163.25	136.75	150.00	18.74
9 - 10	0.286	0.244	0.257	167.47	142.17	154.82	17.89

Appendix 3.4 (Continued)

CORE #65: 10/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.272	0.269	0.263	159.04	157.23	158.13	1.28
1 - 2	0.245	0.297	0.263	142.77	174.10	158.43	22.15
2 - 3	0.244	0.279	0.254	142.17	163.25	152.71	14.91
3 - 4	0.245	0.186	0.208	142.77	178.75	160.76	25.44
4 - 5	0.223	0.218	0.213	129.52	126.51	128.01	2.13
5 - 6	0.163	0.139	0.143	1.52	78.92	40.22	54.73
6 - 7	0.036	--	0.028	168.67		168.67	
7 - 8	--	--				--	
8 - 9	0.245	0.103	0.166	142.77	143.07	142.92	0.21
9 - 10	0.371	0.155	0.255	218.67	88.55	153.61	92.01

CORE #623: 10/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.239	0.328	0.276	139.16	192.77	165.96	37.91
1 - 2	0.184	0.202	0.185	106.02	116.87	111.45	7.67
2 - 3	0.236	0.294	0.257	137.35	172.29	154.82	24.71
3 - 4	0.305	0.337	0.313	178.92	198.19	188.55	13.63
4 - 5	0.361	0.433	0.389	212.65	256.02	234.34	30.67
5 - 6	0.419	0.478	0.441	247.59	283.13	265.36	25.13
6 - 7	0.5	0.481	0.483	296.39	284.94	290.66	8.09
7 - 8	0.519	0.496	0.500	307.83	293.98	300.90	9.80
8 - 9	0.478	0.5	0.481	283.13	296.39	289.76	9.37
9 - 10	0.509	0.473	0.483	301.81	280.12	290.96	15.33

Appendix 3.4 (Continued)

CORE *613: 10/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.219	0.237	0.220	127.11	137.95	132.53	7.67
1 - 2	0.277	0.311	0.286	162.05	182.53	172.29	14.48
2 - 3	0.326	0.337	0.324	191.57	198.19	194.88	4.69
3 - 4	0.399	0.365	0.374	235.54	215.06	225.30	14.48
4 - 5	0.401	0.436	0.411	236.75	257.83	247.29	14.91
5 - 6	0.433	0.481	0.449	256.02	284.94	270.48	20.45
6 - 7	0.466	0.478	0.464	275.90	283.13	279.52	5.11
7 - 8	0.43	0.488	0.451	254.22	289.16	271.69	24.71
8 - 9	0.437	0.477	0.449	258.43	282.53	270.48	17.04
9 - 10	0.44	0.493	0.459	260.24	292.17	276.20	22.58

CORE *633: 10/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.713	0.661	0.679	424.70	393.37	409.04	22.15
1 - 2	--	0.162	0.154		463.86	463.86	
2 - 3	--	0.102	0.094		283.13	283.13	
3 - 4	--	0.076	0.068		409.64	409.64	
4 - 5	--	--	--			--	
5 - 6	--	--	--			--	
6 - 7	--	--	--			--	
7 - 8	--	--	--			--	
8 - 9	0.488	0.522	0.497	289.16	309.64	299.40	14.48
9 - 10	0.579	0.525	0.544	343.98	311.45	327.71	23.00

Appendix 3.4 (Continued)

CORE #603: 12/4/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640 A	OD640 B	OD640 NET AVE	µg-atm N/l of Pore Water A	B	AVE	±STD
0 - 1	0.068	0.074	0.065	37.35	38.55	37.95	0.85
1 - 2	0.077	0.105	0.083	42.77	57.23	50.00	10.22
2 - 3	0.143	0.158	0.143	82.53	89.16	85.84	4.69
3 - 4	0.198	0.229	0.206	115.66	131.93	123.80	11.50
4 - 5	0.291	0.261	0.268	171.69	151.20	161.45	14.48
5 - 6	0.363	0.267	0.307	215.06	154.82	184.94	42.60
6 - 7	0.393	0.326	0.352	233.13	190.36	211.75	30.24
7 - 8	0.445	0.337	0.383	264.46	196.99	230.72	47.71
8 - 9	0.524	0.348	0.428	312.05	203.61	257.83	76.67
9 - 10	0.5	0.356	0.420	297.59	208.43	253.01	63.04

CORE #85: 12/4/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640 A	OD640 B	OD640 NET AVE	µg-atm N/l of Pore Water A	B	AVE	±STD
0 - 1	0.208	0.124	0.156	119.28	68.67	93.98	35.78
1 - 2	0.136	0.158	0.137	75.90	89.16	82.53	9.37
2 - 3	0.123	0.129	0.116	68.07	71.69	69.88	2.56
3 - 4	0.107	0.151	0.119	58.43	84.94	71.69	18.74
4 - 5	0.101	0.167	0.124	54.82	94.58	74.70	28.11
5 - 6	0.1	0.17	0.125	54.22	96.39	75.30	29.82
6 - 7	0.118	0.22	0.159	65.06	126.51	95.78	43.45
7 - 8	0.112	0.236	0.164	61.45	136.14	98.80	52.82
8 - 9	0.117	0.294	0.196	64.46	171.08	117.77	75.40
9 - 10	0.129	0.32	0.215	71.69	186.75	129.22	81.36

Appendix 3.4 (Continued)

CORE #65: 12/4/85

DILUTION FACTOR: 10

)EPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.093	0.154	0.116	50.00	89.16	69.58	27.69
1 - 2	0.078	0.084	0.073	40.96	46.99	43.98	4.26
2 - 3	0.093	0.108	0.093	50.00	61.45	55.72	8.09
3 - 4	0.068	0.068	0.060	34.94	37.35	36.14	1.70
4 - 5	0.073	0.057	0.057	37.95	30.72	34.34	5.11
5 - 6	0.083	0.069	0.068	43.98	37.95	40.96	4.26
6 - 7	0.085	0.066	0.068	45.18	36.14	40.66	6.39
7 - 8	0.091	0.064	0.070	48.80	34.94	41.87	9.80
8 - 9	0.095	0.068	0.074	51.20	37.35	44.28	9.80
9 - 10	0.093	0.08	0.079	50.00	44.58	47.29	3.83

CORE #623: 12/4/85

DILUTION FACTOR: 10

)EPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.149	0.09	0.115	86.75	50.60	68.67	25.56
1 - 2	0.132	0.114	0.118	76.51	65.06	70.78	8.09
2 - 3	0.166	0.182	0.169	96.99	106.02	101.51	6.39
3 - 4	0.224	0.226	0.220	131.93	132.53	132.23	0.43
4 - 5	0.334	0.258	0.291	198.19	151.81	175.00	32.80
5 - 6	0.24	0.291	0.261	141.57	171.69	156.63	21.30
6 - 7	0.285	0.277	0.276	168.67	163.25	165.96	3.83
7 - 8	0.29	0.306	0.293	171.69	180.72	176.20	6.39
8 - 9	0.336	0.334	0.330	199.40	197.59	198.49	1.28
9 - 10	0.332	0.355	0.339	196.99	210.24	203.61	9.37

Appendix 3.4 (Continued)

CORE #45: 12/4/85

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640 A	OD640 B	OD640 NET AVE	µg-atm N/l of Pore Water A	B	AVE	±STD
0 - 1	0.076	0.127	0.092	39.76	70.48	55.12	21.72
1 - 2	0.134	0.093	0.104	74.70	83.35	79.02	6.12
2 - 3	0.042	0.187	0.105	96.39	106.63	101.51	7.24
3 - 4	0.168	0.256	0.202	95.18	148.19	121.69	37.49
4 - 5	0.185	0.26	0.213	105.42	150.60	128.01	31.95
5 - 6	0.208	0.233	0.211	119.28	134.34	126.81	10.65
6 - 7	0.152	0.215	0.174	85.54	123.49	104.52	26.84
7 - 8	0.153	0.203	0.168	86.14	116.27	101.20	21.30
8 - 9	0.128	0.168	0.138	71.08	95.18	83.13	17.04
9 - 10	0.132	0.156	0.134	73.49	87.95	80.72	10.22

Appendix 3.4 (Continued)

CORE #613: 12/4/85

DILUTION FACTOR: 10

)EPTH INTERVAL (cm)	-------OD640------			---------µg-atm N/l of Pore Water--			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.093	0.085	0.081	50.00	45.18	47.59	3.41
1 - 2	0.122	0.115	0.111	67.47	63.25	65.36	2.98
2 - 3	0.127	0.143	0.127	70.48	80.12	75.30	6.82
3 - 4	0.083	0.186	0.127	43.98	106.02	75.00	43.87
4 - 5	0.213	0.219	0.208	122.29	125.90	124.10	2.56
5 - 6	0.273	0.263	0.260	158.43	152.41	155.42	4.26
6 - 7	0.297	0.305	0.293	172.89	177.71	175.30	3.41
7 - 8	0.318	0.317	0.310	185.54	184.94	185.24	0.43
8 - 9	0.341	0.358	0.342	199.40	209.64	204.52	7.24
9 - 10	0.35	0.372	0.353	204.82	218.07	211.45	9.37

CORE #633: 12/4/85

DILUTION FACTOR: 10

)EPTH INTERVAL (cm)	-------OD640------			---------µg-atm N/l of Pore Water--			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.164	0.207	0.180	95.18	121.08	108.13	18.32
1 - 2	--	0.263	0.257	--	154.82	--	--
2 - 3	--	0.36	0.354	--	213.25	--	--
3 - 4	0.09	0.061	0.070	126.51	33.13	79.82	66.03
4 - 5	--	0.071	0.065	--	39.16	--	--
5 - 6	--	--	--	--	--	--	--
6 - 7	--	--	--	--	--	--	--
7 - 8	0.481	0.586	0.528	286.14	87.35	--	140.57
8 - 9	0.382	0.592	0.481	226.51	88.25	157.38	97.76
9 - 10	--	--	--	--	--	--	--

Appendix 3.4 (Continued)

CORE #603: 2/5/86

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.097	0.095	0.088	53.61	52.41	53.01	0.85
1 - 2	0.091	0.131	0.103	50.00	74.10	62.05	17.04
2 - 3	0.136	0.188	0.154	77.11	108.43	92.77	22.15
3 - 4	0.202	0.271	0.229	116.87	158.43	137.65	29.39
4 - 5	0.311	0.334	0.315	182.53	196.39	189.46	9.80
5 - 6	0.337	0.408	0.365	198.19	240.96	219.58	30.24
6 - 7	0.404	0.43	0.409	238.55	254.22	246.39	11.08
7 - 8	0.404	0.501	0.445	238.55	296.99	267.77	41.32
8 - 9	0.455	0.489	0.464	269.28	289.76	279.52	14.48
9 - 10	0.464	0.484	0.466	274.70	286.75	280.72	8.52

CORE #85: 2/5/86

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.221	0.141	0.173	128.31	80.12	104.22	34.08
1 - 2	0.373	0.221	0.289	219.88	128.31	174.10	64.75
2 - 3	0.632	0.356	0.486	375.90	209.64	292.77	117.57
3 - 4	0.793	0.532	0.655	472.89	315.66	394.28	111.18
4 - 5	1.138	0.775	0.949	680.72	462.05	571.39	154.63
5 - 6	1.414	0.921	1.160	846.99	550.00	698.49	210.00
6 - 7	1.398	0.996	1.189	837.35	595.18	716.27	171.24
7 - 8	1.552	1.224	1.380	930.12	732.53	831.33	139.72
8 - 9	1.594	1.191	1.385	955.42	712.65	834.04	171.67
9 - 10	1.724	1.295	1.502	1033.73	775.30	904.52	182.74

Appendix 3.4 (Continued)

CORE #65: 2/5/86

DILUTION FACTOR: 10

EPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.135	0.08	0.100	76.51	72.30	74.40	2.97
1 - 2	0.08	0.178	0.121	43.37	102.41	72.89	41.74
2 - 3	0.126	0.157	0.134	71.08	89.76	80.42	13.21
3 - 4	0.159	0.245	0.194	90.96	142.77	116.87	36.63
4 - 5	0.139	0.241	0.182	78.92	140.36	109.64	43.45
5 - 6	0.123	0.265	0.186	69.28	154.82	112.05	60.49
6 - 7	0.126	0.2	0.155	71.08	115.66	93.37	31.52
7 - 8	0.131	0.171	0.143	74.10	98.19	86.14	17.04
8 - 9	0.163	0.144	0.146	93.37	81.93	87.65	8.09
9 - 10	0.176	0.148	0.154	101.20	84.34	92.77	11.93

CORE #623: 2/5/86

DILUTION FACTOR: 10

EPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.103	0.098	0.093	57.23	54.22	55.72	2.13
1 - 2	0.088	0.137	0.105	48.19	77.71	62.95	20.87
2 - 3	0.112	0.149	0.123	62.65	84.94	73.80	15.76
3 - 4	0.126	0.187	0.149	71.08	107.83	89.46	25.98
4 - 5	0.147	0.176	0.154	83.73	101.20	92.47	12.35
5 - 6	0.162	0.189	0.168	92.77	109.04	100.90	11.50
6 - 7	0.178	0.178	0.170	102.41	102.41	102.41	0.00
7 - 8	0.175	0.196	0.178	100.60	113.25	106.93	8.95
8 - 9	0.184	0.206	0.187	106.02	119.28	112.65	9.37
9 - 10	0.178	0.212	0.187	102.41	122.89	112.65	14.48

Appendix 3.4 (Continued)

CORE #45: 2/5/86

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.163	0.116	0.132	93.37	65.06	79.22	20.02
1 - 2	0.134	0.053	0.086	75.90	27.11	51.51	34.50
2 - 3	0.079	0.069	0.066	42.77	36.75	39.76	4.26
3 - 4	0.09	0.095	0.085	49.40	52.41	50.90	2.13
4 - 5	0.103	0.127	0.107	57.23	71.69	64.46	10.22
5 - 6	0.142	0.174	0.150	80.72	100.00	90.36	13.63
6 - 7	0.036	0.06	0.040	168.67	104.41	136.54	45.44
7 - 8	0.042	--	0.034	204.82	--	204.82	--
8 - 9	--	--	--	--	--	--	--
9 - 10	--	--	--	--	--	--	--

Appendix 3.4 (Continued)

CORE #613: 2/5/86

DILUTION FACTOR: 10

)EPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.062	0.057	0.052	32.53	29.52	31.02	2.13
1 - 2	0.056	0.081	0.061	28.92	43.98	36.45	10.65
2 - 3	0.082	0.113	0.090	44.58	63.25	53.92	13.21
3 - 4	0.11	0.15	0.122	61.45	85.54	73.49	17.04
4 - 5	0.153	0.183	0.160	87.35	105.42	96.39	12.78
5 - 6	0.186	0.227	0.199	107.23	131.93	119.58	17.46
6 - 7	0.224	0.281	0.245	130.12	164.46	147.29	24.28
7 - 8	0.238	0.321	0.272	138.55	188.55	163.55	35.36
8 - 9	0.28	0.354	0.309	163.86	208.43	186.14	31.52
9 - 10	0.274	0.387	0.323	160.24	228.31	194.28	48.13

CORE #633: 2/5/86

DILUTION FACTOR: 10

)EPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.26	0.172	0.208	151.81	98.80	125.30	37.49
1 - 2	0.285	0.251	0.260	166.87	146.39	156.63	14.48
2 - 3	0.351	0.292	0.314	206.63	171.08	188.86	25.13
3 - 4	0.539	0.367	0.445	319.88	216.27	268.07	73.27
4 - 5	0.623	0.471	0.539	370.48	278.92	324.70	64.75
5 - 6	0.753	0.574	0.656	448.80	340.96	394.88	76.25
6 - 7	0.848	0.708	0.770	506.02	421.69	463.86	59.64
7 - 8	0.854	0.832	0.835	509.64	496.39	503.01	9.37
8 - 9	0.854	0.818	0.828	509.64	487.95	498.80	15.33
9 - 10	0.885	1.097	0.983	528.31	656.02	592.17	90.31

Appendix 3.4 (Continued)

CORE #603: 4/9/86

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	-------OD640-------			---------µg-atm N/l of Pore Water--			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.114	0.347	0.226	65.66	205.42	135.54	98.82
1 - 2	0.123	0.326	0.220	71.08	192.77	131.93	86.05
2 - 3	0.186	0.389	0.283	109.04	230.72	169.88	86.05
3 - 4	0.232	0.408	0.315	136.75	242.17	189.46	74.54
4 - 5	0.262	0.423	0.338	154.82	251.20	203.01	68.15
5 - 6	0.324	0.448	0.381	192.17	266.27	229.22	52.39
6 - 7	0.388	0.507	0.443	230.72	301.81	266.27	50.26
7 - 8	0.435	0.552	0.489	259.04	328.92	293.98	49.41
8 - 9	0.495	0.598	0.542	295.18	356.63	325.90	43.45
9 - 10	0.541	0.646	0.589	322.89	385.54	354.22	44.30

CORE #85: 4/9/86

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	-------OD640-------			---------µg-atm N/l of Pore Water--			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.204	0.12	0.156	118.07	68.67	93.37	34.93
1 - 2	0.156	0.099	0.122	89.16	56.02	72.59	23.43
2 - 3	0.072	0.078	0.069	38.55	43.37	40.96	3.41
3 - 4	0.087	0.082	0.079	47.59	45.78	46.69	1.28
4 - 5	0.093	0.095	0.088	51.20	53.61	52.41	1.70
5 - 6	0.102	0.109	0.100	56.63	62.05	59.34	3.83
6 - 7	0.113	0.12	0.111	63.25	68.67	65.96	3.83
7 - 8	0.13	0.139	0.129	73.49	80.12	76.81	4.69
8 - 9	0.149	0.148	0.143	84.94	85.54	85.24	0.43
9 - 10	0.133	0.172	0.147	75.30	100.00	87.65	17.46

Appendix 3.4 (Continued)

CORE *65: 4/9/86

DILUTION FACTOR: 10

EPTH INTERVAL (cm)	-------OD640------			---------µg-atm N/l of Pore Water--			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.117	0.292	0.199	66.87	287.21	177.04	155.80
1 - 2	0.13	0.251	0.185	74.70	246.03	160.37	121.15
2 - 3	0.159	0.201	0.174	92.17	195.82	144.00	73.29
3 - 4	0.142	0.142	0.136	81.93	136.57	109.25	38.64
4 - 5	0.125	0.17	0.142	71.69	164.69	118.19	65.76
5 - 6	0.121	0.165	0.137	69.28	159.67	114.47	63.92
6 - 7	0.141	0.191	0.160	81.33	185.78	133.55	73.86
7 - 8	0.143	0.306	0.219	82.53	301.27	191.90	154.67
8 - 9	0.149	0.197	0.167	86.14	191.81	138.98	74.71
9 - 10	0.146	0.248	0.191	84.34	243.02	163.68	112.21

CORE *623: 4/9/86

DILUTION FACTOR: 10

EPTH INTERVAL (cm)	-------OD640------			---------µg-atm N/l of Pore Water--			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.113	0.157	0.130	64.46	91.57	78.01	19.17
1 - 2	0.149	0.188	0.164	86.14	110.24	98.19	17.04
2 - 3	0.142	0.214	0.173	81.93	125.90	103.92	31.10
3 - 4	0.139	0.209	0.169	80.12	122.89	101.51	30.24
4 - 5	0.156	0.189	0.168	90.36	110.84	100.60	14.48
5 - 6	0.203	0.186	0.190	118.67	109.04	113.86	6.82
6 - 7	0.21	0.185	0.193	122.89	108.43	115.66	10.22
7 - 8	0.22	0.181	0.196	128.92	106.02	117.47	16.19
8 - 9	0.198	0.194	0.191	115.66	113.86	114.76	1.28
9 - 10	0.221	0.221	0.216	129.52	130.12	129.82	0.43

Appendix 3.4 (Continued)

CORE #45: 4/9/86

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.064	0.238	0.146	35.54	138.55	87.05	72.84
1 - 2	0.058	0.141	0.095	31.93	200.30	116.11	119.06
2 - 3	0.092	0.305	0.194	52.41	223.64	138.03	121.08
3 - 4	--	--	--	--	--	--	--
4 - 5	--	--	--	--	--	--	--
5 - 6	--	--	--	--	--	--	--
6 - 7	--	--	--	--	--	--	--
7 - 8	--	--	--	--	--	--	--
8 - 9	--	--	--	--	--	--	--
9 - 10	--	--	--	--	--	--	--

Appendix 3.4 (Continued)

CORE #613: 4/9/86

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.096	0.126	0.106	54.82	72.89	63.86	12.78
1 - 2	0.074	0.098	0.081	41.57	56.02	48.80	10.22
2 - 3	0.056	0.083	0.065	30.72	46.99	38.86	11.50
3 - 4	0.054	0.078	0.061	29.52	43.98	36.75	10.22
4 - 5	0.078	0.089	0.079	43.98	50.60	47.29	4.69
5 - 6	0.103	0.107	0.100	59.04	61.45	60.24	1.70
6 - 7	0.136	0.135	0.131	78.92	78.31	78.61	0.43
7 - 8	0.174	0.185	0.175	101.81	108.43	105.12	4.69
8 - 9	0.247	0.24	0.239	145.78	141.57	143.67	2.98
9 - 10	0.306	0.278	0.287	181.33	164.46	172.89	11.93

CORE #633: 4/9/86

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1	0.243	0.27	0.250	143.07	159.04	151.05	11.29
1 - 2	0.294	0.358	0.319	173.80	212.05	192.92	27.05
2 - 3	0.346	0.391	0.362	205.12	231.93	218.52	18.96
3 - 4	0.192	0.376	0.277	280.87	222.89	251.88	41.00
4 - 5	0.258	0.408	0.326	380.27	242.17	311.22	97.65
5 - 6	0.738	0.439	0.582	441.27	260.84	351.05	127.58
6 - 7	0.767	0.512	0.633	458.73	304.82	381.78	108.83
7 - 8	0.869	0.541	0.698	520.18	322.29	421.23	139.93
8 - 9	0.916	0.587	0.745	548.49	350.00	449.25	140.36
9 - 10	0.982	0.643	0.806	588.25	383.73	485.99	144.62

Appendix 3.4 (Continued)

CORE #603: 6/4/86

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1				65.06	70.48	67.77	3.83
1 - 2				90.96	77.71	84.34	9.37
2 - 3				89.16	78.92	84.04	7.24
3 - 4				97.59	88.55	93.07	6.39
4 - 5				110.84	102.41	106.63	5.96
5 - 6				128.92	128.31	128.62	0.43
6 - 7				139.16	143.37	141.27	2.98
7 - 8				168.00	151.20	159.60	11.88
8 - 9				180.72	175.30	178.01	3.83
9 - 10				184.94	201.20	193.07	11.50

CORE #85: 6/4/86

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1				80.72	61.45	71.09	13.63
1 - 2				101.20	62.65	81.93	27.26
2 - 3				83.13	57.23	70.18	18.31
3 - 4				60.84	48.80	54.82	8.51
4 - 5				62.65	50.00	56.33	8.94
5 - 6				63.86	56.63	60.25	5.11
6 - 7				71.08	61.45	66.27	6.81
7 - 8				74.10	68.07	71.09	4.26
8 - 9				72.89	75.90	74.40	2.13
9 - 10				98.19	74.70	86.45	16.61

Appendix 3.4 (Continued)

CORE #65: 6/4/86

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1				58.43	48.80	53.62	6.81
1 - 2				89.76	72.29	81.03	12.35
2 - 3				--	85.54	85.54	--
3 - 4				--	152.41	152.41	--
4 - 5				125.90	55.42	90.66	49.84
5 - 6				96.38	30.72	63.55	46.43
6 - 7				62.65	69.28	65.97	4.69
7 - 8				45.18	42.77	43.98	1.70
8 - 9				92.17	46.38	69.28	32.38
9 - 10				36.14	46.39	41.27	7.25

CORE #623: 6/4/86

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	OD640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1				59.04	27.11	43.08	22.58
1 - 2				134.34	76.51	105.43	40.89
2 - 3				162.05	110.84	136.45	36.21
3 - 4				190.96	105.42	148.19	60.49
4 - 5				198.80	95.78	147.29	72.85
5 - 6				207.83	90.36	149.10	83.06
6 - 7				235.54	80.72	158.13	109.47
7 - 8				252.41	77.71	165.06	123.53
8 - 9				263.25	81.93	172.59	128.21
9 - 10				288.55	89.76	189.16	140.57

Appendix 3.4 (Continued)

Core #613 - 6/4/86

Depth Interval (cm)	µg-atm N/l of Pore Water			
	A	B	AVE	±STD
0 - 1	65.66	65.66	65.66	0.00
1 - 2	84.34	66.87	75.61	12.35
2 - 3	82.53	62.65	72.59	14.06
3 - 4	69.88	60.84	65.36	6.39
4 - 5	63.86	56.02	59.94	5.54
5 - 6	66.86	60.84	63.85	4.26
6 - 7	71.08	63.25	67.17	5.54
7 - 8	77.71	72.89	75.30	3.41
8 - 9	95.18	89.76	92.47	3.83
9 - 10	114.46	115.66	115.03	0.81

Appendix 3.4 (Continued)

CORE #45: 6/4/86

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	-------OD640------			---------µg-atm N/l of Pore Water--			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1				107.23	--	107.23	--
1 - 2				153.01	--	153.01	--
2 - 3				168.07	--	168.07	--
3 - 4				194.58	--	194.58	--
4 - 5				165.06	--	165.06	--
5 - 6				193.37	--	193.37	--
6 - 7				241.57	--	241.57	--
7 - 8				248.80	--	248.80	--
8 - 9				266.27	--	266.27	--
9 - 10	--	--	--	286.14	--	286.14	--

Appendix 3.4 (Continued)
Table . Core #633 - 6/4/86

Depth Interval (cm)	μg-atm N/l of Pore Water			
	A	B	AVE	±STD
0 - 1	124.70	118.07	121.39	4.69
1 - 2	283.13	422.29	352.71	98.40
2 - 3	265.06	521.69	393.38	181.46
3 - 4	168.67	428.31	298.49	183.59
4 - 5	291.16	554.22	422.69	186.01
5 - 6	-	-	-	-
6 - 7	-	-	-	-
7 - 8	-	-	-	-
8 - 9	-	-	-	-
9 - 10	-	227.91	227.91	-

Appendix 3.4 (Continued)

CORE #603: 8/6/86

DILUTION FACTOR: 10

EPTH INTERVAL (cm)	00640 A	00640 B	00640 NET AVE	µg-atm N/l of Pore Water A	µg-atm N/l of Pore Water B	µg-atm N/l of Pore Water AVE	µg-atm N/l of Pore Water ±STD
0 - 1				78.31	80.12	79.22	1.28
1 - 2				120.48	118.67	119.58	1.28
2 - 3				136.14	171.08	153.61	24.71
3 - 4				146.39	196.38	171.39	35.35
4 - 5				169.28	213.86	191.57	31.52
5 - 6				177.71	210.84	194.28	23.43
6 - 7				182.53	215.06	198.80	23.00
7 - 8				189.76	207.00	198.38	12.19
8 - 9				194.58	218.07	206.33	16.61
9 - 10				196.99	230.72	213.86	23.85

CORE #85: 8/6/86

DILUTION FACTOR: 10

EPTH INTERVAL (cm)	00640 A	00640 B	00640 NET AVE	µg-atm N/l of Pore Water A	µg-atm N/l of Pore Water B	µg-atm N/l of Pore Water AVE	µg-atm N/l of Pore Water ±STD
0 - 1				40.36	74.10	57.23	23.86
1 - 2				119.28	155.42	137.35	25.55
2 - 3				165.06	200.60	182.83	25.13
3 - 4				189.76	267.47	228.62	54.95
4 - 5				189.16	268.07	228.62	55.80
5 - 6				127.11	234.34	180.73	75.82
6 - 7				151.20	267.47	209.34	82.22
7 - 8				131.32	219.88	175.60	62.62
8 - 9				116.87	201.20	159.04	59.63
9 - 10				109.04	189.76	149.40	57.08

Appendix 3.4 (Continued)

CORE #65: 8/6/86

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	00640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1				220.48	134.94	177.71	60.49
1 - 2				250.60	173.49	212.05	54.53
2 - 3				262.65	196.39	229.52	46.85
3 - 4				265.06	205.42	235.24	42.17
4 - 5				200.00	189.16	194.58	7.67
5 - 6				179.52	204.82	192.17	17.89
6 - 7				135.54	210.24	172.89	52.82
7 - 8				121.08	207.83	164.46	61.34
8 - 9				107.83	207.23	157.53	70.29
9 - 10				83.73	187.35	135.54	73.27

CORE #623: 8/6/86

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	00640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1				131.93	62.65	97.29	48.99
1 - 2				197.59	121.69	159.64	53.67
2 - 3				229.52	188.55	209.04	28.97
3 - 4				218.67	210.84	214.76	5.54
4 - 5				187.95	224.10	206.03	25.56
5 - 6				176.51	230.72	203.62	38.33
6 - 7				210.84	217.47	214.16	4.69
7 - 8				200.60	189.76	195.18	7.67
8 - 9				190.36	178.31	184.34	8.52
9 - 10				162.65	172.89	167.77	7.24

Appendix 3.4 (Continued)

Core #45 - 8/6/86

Depth Interval (cm)	µg-at N/l of Pore Water A	B	Ave.	±STD
0 - 1	-	124.70	124.70	-
1 - 2	150.60	122.74	136.67	19.70
2 - 3	242.47	-	242.47	-
3 - 4	211.45	-	211.45	-
4 - 5	168.67	211.69	195.18	37.49
5 - 6	-	286.14	286.14	-
6 - 7	-	-	-	-
7 - 8	-	-	-	-
8 - 9	-	-	-	-
9 - 10	-	-	-	-

Appendix 3.4 (Continued)

CORE #613: 8/6/86

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	00640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1				91.57	90.36	90.97	0.86
1 - 2				134.33	116.87	125.60	12.35
2 - 3				154.22	123.49	138.86	21.73
3 - 4				149.40	119.28	134.34	21.30
4 - 5				163.25	124.70	143.98	27.26
5 - 6				171.08	117.47	144.28	37.91
6 - 7				157.23	120.48	138.86	25.99
7 - 8				158.30	134.94	146.62	16.52
8 - 9				143.37	121.08	132.23	15.76
9 - 10				139.16	121.69	130.43	12.35

CORE #633: 8/6/86

DILUTION FACTOR: 10

DEPTH INTERVAL (cm)	00640			µg-atm N/l of Pore Water			
	A	B	NET AVE	A	B	AVE	±STD
0 - 1				139.76	126.51	133.14	9.37
1 - 2				240.36	239.76	240.06	0.42
2 - 3				300.00	289.76	294.88	7.24
3 - 4				315.06	348.80	331.93	23.86
4 - 5				310.84	328.31	319.58	12.35
5 - 6				313.25	336.14	324.70	16.19
6 - 7				305.42	354.82	330.12	34.93
7 - 8				315.06	355.42	335.24	28.54
8 - 9				337.95	367.47	352.71	20.87
9 - 10				316.26	368.67	342.47	37.06

Appendix 3.5. **Ammonium Concentration in the Water Column**

Station #	Nov'84	Jan'85	Mar'85	Apr'85	May'85	Jun'85	Jul'85	Aug'85	Oct'85	Dec'85	Feb'86	Apr'86	Jun'86	Aug'86
45	0.59	5.26	2.47	0.09	0.28	0.58	0.41	0.16	0.08	0.66	0.62	0.04	2.89	0.64
603	0.72	2.98	0.79	0.04	0.17	0.12	0.19	0.14	0.27	0.34	0.46	0.08	0.47	1.45
65	0.55	6.01	1.18	0.03	0.16	0.09	0.19	0.16	0.01	0.36	0.44	0.08	2.20	0.64
613	0.62	0.90	0.45	0.02	0.03	0.00	0.17	0.29	0.01	0.47	0.81	0.14	0.99	0.57
85	0.71	0.42	0.36	0.10	0.83	3.37	0.31	0.85	0.50	1.24	0.84	0.31	0.73	1.21
623	1.38	0.42	0.39	0.01	0.17	1.33	0.27	0.21	0.18	0.53	0.84	0.14	0.97	0.50
633	---	---	0.19	0.02	0.67	0.81	0.25	0.36	0.13	0.31	2.04	1.26	0.54	0.78

Units = µg-atm N per 1.
Data from J. Cullen

Appendix 3.6. **Measured Ammonium Flux**
Station #85 Chamber Experiments

Sample Date	NH4-FLUX*						
	(µg-atm N per l per h)			(µg-atm N per m2 per h)			
	Ch#1	Ch#2	AVE	Ch#1	Ch#2	AVE	±STD
YEAR #1							
11/28/84	0.24	2.04	1.14	65.1	545.0	305.1	339.3
1/23/85	0.59	-0.68	-0.05	160.1	-181.7	-10.8	241.7
3/6/85	8.28	9.54	8.91	2247.4	2548.5	2398.0	212.9
4/3/85	-0.34	-0.36	-0.35	-92.3	-96.2	-94.2	2.7
5/8/85	0.31	0.21	0.26	84.1	56.1	70.1	19.8
6/5/85	0.47	0.41	0.44	133.2	114.4	123.8	13.3
7/17/85	0.00	-0.05	-0.03	0.0	-14.0	-7.0	9.9
8/14/85	**	**	**	**	**	**	**
YEAR #2							
10/23/85	2.14	2.70	2.42	606.5	753.7	680.1	104.0
12/4/85	3.24	3.95	3.60	918.3	1102.6	1010.5	130.3
2/5/86	4.33	5.83	5.08	1227.2	1627.4	1427.3	283.0
4/9/86	1.56	---	1.56	442.1	---	442.1	---
6/4/86	0.59	4.29	2.44	167.2	1197.5	682.4	728.5
8/6/86	0.07	2.02	1.05	19.8	563.9	291.9	384.7

* "-" = net NH4 flux INTO sediment from water column; "+" = net flux OUT OF sediment into water column.

** Samples lost.

Units: Ammonium flux as either 1) µg-atm N per liter of pore water per hour or
2) µg-atm N per m^2 of sediment per hour.

Appendix 3. 7. Theoretical Ammonium Flux

Station •	Nov'84	Jan'85	Mar'85	Apr'85	May'85	Jun'85	Jul'85	Aug'85	Oct'85	Dec'85	Feb'86	Apr'86	Jun'86	Aug'86
45	—	462.2	519.8	—	—	—	—	—	—	4.7	36.4	74.5	8.3	11.2
603	*770.8*	*484.2*	*751.3*	*455.4*	*431.3*	*157.0*	*515.9*	*848.2*	5.0	6.1	7.6	5.8	27.0	**29.5**
65	75.2	*285.8*	*185.0*	110.5	*302.8*	*298.8*	*328.0*	*104.4*	*88.9*	*27.4*	*35.6*	*61.9*	9.0	**101.5**
613	*897.5*	*339.8*	*496.1*	*488.5*	*340.9*	*456.8*	*486.4*	*568.1*	9.4	2.2	5.0	*38.5*	3.6	**31.0**
85	*539.6*	*410.0*	*724.0*	*458.6*	*188.6*	*129.6*	*322.2*	—	*62.6*	*34.6*	24.5	*49.7*	3.2	**118.1**
623	*947.5*	—	*481.7*	*626.4*	328.3	40.3	*660.6*	*486.7*	*122.4*	5.8	3.6	4.7	**69.1**	*175.3*
633	—	—	*825.5*	*95.4*	—	95.4	*83.9*	*1058.4*	*240.8*	10.8	13.3	10.8	**221.8**	**60.8**

Units • µg-atm N per m^2 per h.

Theoretical ammonium flux calculated from pore water ammonium gradient:

Method 1	Calculated from linear increase in ammonium concentration with increasing depth.
Method 2	Calculated from nonlinear increase in ammonium concentration with depth.
Method 3	Calculated from theoretical gradient resulting from difference in ammonium concentration in top sediment segment and ammonium concentration in overlying water column.

CHAPTER 4

ZOOPLANKTON

INTRODUCTION

Zooplankton sampling was conducted to monitor the effects of freshwater inflow on the spatial and temporal distribution of zooplankton at seven stations in upper Lavaca Bay from November 1984 through August 1985 (Year 1) and October 1985 through August 1986 (Year 2). In Year 2, sampling effort was increased to cover marine input from the lower bay by adding six stations along a transect from state highway 35 causeway south along the Matagorda Ship Channel to markers 35 and 36. Historical and concurrent stream flow data indicate that Year 1 was a wet year and Year 2 was a drier year. Zooplankton data reflect these differences.

METHODS

Zooplankton surface samples were collected in duplicate at each station with the exception of the river stations 45 and 65 where a third oblique tow from the bottom to the surface was taken during Year 2. Tows were not replicated at stations 1, 2, 3, 1505, 1905, and 35-36 during Year 2. A 0.5 m diameter #10 mesh (153 μm) plankton net equipped with a General Oceanics 2030R flowmeter was used for sampling. Tows were of one minute duration. Ctenophores collected were volumetrically measured then dissolved in a weak solution of chlorox and washed through the plankton net to retain any other zooplankton which may have adhered to the jelly. Plankton samples were then washed into a 1 liter jar and preserved with 5% buffered formalin.

Zooplankton densities/m^3 were determined from species counts of aliquots taken with a Hensen-Stemple pipette. Each sample was diluted to a measured volume (200 to 500 ml) and subsampled twice. The first sample (1 to 10 ml) was used to determine the most abundant organisms, and the second (10-20 ml) was used to estimate organisms not represented in the first subsample. The remainder of the sample was then scanned at 12X for the larger, usually less abundant zooplankton. Aliquots were placed in a Ward zooplankton counting wheel and examined with a dissecting microscope at 25X. Triplicate 10 ml subsamples were taken from replicate A for dry weight. These samples were filtered onto a pre-weighed glass fiber filter, dried at 60°C for 24 hours, and weighed using an analytical balance.

Statistical analyses included linear regressions and Spearman correlations to test for the significance of freshwater inflow and salinity at stations 45, 65 and 85 and for *Acartia tonsa* length versus salinity correlations.

Organisms were identified to species where possible. Counts and biomass measurements are reported in numbers per cubic meter of water sampled. A zooplankton species list is given in Table 4.1.

RESULTS

Community Description

Zooplankton total abundance for Year 1 and Year 2 is presented in Table 4.2. Although there was a major difference in inflow into upper Lavaca Bay for the two sampling periods, there was basically no difference in the overall zooplankton average standing crop for stations 45 through 633. On the basis of these data the upper bay stations are characterized throughout most of the year as having low densities. During this study, highest densities in the upper bay occurred in the summer months of June 1985 and August 1986. These density peaks occurred at stations 623 and 633. Additional data from stations established in Year 2 depict a zone of higher zooplankton abundance associated with a salinity gradient from the upper to lower bay. These data will be presented in detail under another topic.

Zooplankton dry weights (mg/m^3) by stations are listed in Table 4.3. Since formalin preservation results in a significant loss of dry weight, the weights for zooplankton were adjusted by adding a 29.5% correction factor to the original dry weights (Durbin and Durbin, 1978). Stations 45, 65, and 603 in close proximity to the major source of freshwater inflow, were consistently lower than other sites. Biomass weights overall for the upper bay were higher in Year 1 than Year 2. During Year 1 environmental factors, i.e. high wind and freshwater inflows, increased the detritus and sediment load in the water column which resulted in artificially higher biomass weights at certain stations (Table 4.3). Secchi disc measurements (Fig. 1.5) are also indicative of higher sediment and detritus loads in the water column in Year 1. Attempts were made to develop a correction factor for stations with detritus but apparent variation in weight of different species of zooplankton made it unfeasable. In Narragansett Bay, Rhode Island zooplankton collected on the same day from different stations sometimes showed significant differences in weight for a given length (Durbin and Durbin, 1978). The differences in the condition factor appeared to be related to food availability.

The average weight per individual zooplankter in Lavaca Bay was 0.017 mg. When this value was used as a correction factor the biomass at some of the stations with large amounts of detritus decreased while others increased. The weight of 0.017 mg was comparable to adult weights for *Acartia tonsa* which range from approximately 0.01 mg for adults to 0.005 mg for first stage copepodites (Miller *et al.*, 1977). A correction factor which may be adequate for one species, i.e. *A. tonsa*, is not adequate when other species with different weights are represented in a sample.

During Year 2 sediment loading was not a problem and biomass measurements were usually indicative of zooplankton standing crops. With few exceptions the upper bay biomass was always lower than the stations south of the state highway 35 causeway.

Inflow Effects

The presence of freshwater zooplankton is indicative of freshwater inflow into the study area prior to or during a sampling trip and the extent of spatial distribution of freshwater species throughout the study area relates to the magnitude of the event. From March 1985 through May 1985, persistent low salinities allowed the dispersal of a freshwater zooplankton community throughout the upper bay (Table 4.4). A decline in numbers of freshwater species was evident from June 1985 through August 1986 with the exception of minor influxes of freshwater species in December 1985 and June 1986. Inflow events in December 1985 and June 1986 were small compared to flood events from March and May 1985 and were restricted principally to river stations 45 and 65 and lake stations 603 and 613.

Due to the shallow depth of most stations, only surface plankton tows were made with the exception of stations 45 and 65 in the river where depths of 4.5 and 4.9 m were measured. On occasion, stratification was noted at these stations, so in Year 2 an additional oblique tow was added to check for zooplankton stratification (Table 4.5). These data present surface standing crop abundance versus abundance for oblique tows and their relation to salinity and oxygen, which can be used to verify stratification. In October 1985 (stations 45 and 65), December 1985 (station 65) and in June 1986 (station 65), stratification was evident from salinity measurements and was also apparent from the surface and oblique tow standing crop values. Lower standing crops were generallly associated with lower salinity surface waters while higher counts of estuarine species were found in bottom water. In June 1986, stratification resulted in low dissolved oxygen below 1.0 m at stations 45 and 65. Standing crops were low in the surface and subsurface waters at station 45 while higher standing crops were found subsurface at station 65. These data support the stratification conditions at the deeper river sites as noted in the hydrographic sections of Chapter 2.

The incremental increase of estuarine and the decrease of freshwater zooplankton with distance, starting from the source of freshwater (station 45) and going downriver (station 65) to the open bay (station 85), is shown in Figure 4.1. Obvious trends are for estuarine zooplankton to decline, especially upriver during periods of peak inflow. Freshwater species increase during the inflow events and decrease in density as they move downstream. The results of linear regressions with estuarine and freshwater zooplankton, versus salinity and inflow, and inflow versus salinity using Spearman Correlations are as follows:

Spearman Correlation

Variables	Stations:	45	65	85
Streamflow vs. Salinity		-0.7 <0.005	-0.91 <0.0001	-0.68 <0.008
Salinity vs. Estuarine species		0.42	0.77 <0.002	-0.15

Salinity vs. Freshwater species	-0.76 <0.002	-0.92 <0.0001	-0.74 <0.0003
Streamflow vs. Estuarine species	-0.67 0.009	-0.71 <0.005	-0.26
Streamflow vs. Freshwater species	0.93 <0.0001	0.94 <0.001	0.7 <0.005

These tests indicate that changes in response to inflow and salinity on standing crop values of estuarine and freshwater zooplankton are significant in most cases at the river stations 45 and 65 and at station 85 which is the nearest open bay station to the river mouth.

Species Accounts

Acartia tonsa was the most abundant copepod collected during this study and in most other estuarine zooplankton studies. Abundance, spatial and temporal distributions for *A. tonsa* are shown in Table 4.6. *A. tonsa* was found throughout the study at all stations with the exception of surface tows at station 45 in March and May 1985 when the streamflow was highest, 926 c.f.s. and 1913 c.f.s. and the salinity was low, 0.8 and 0.2 ‰ respectively. The lowest densities were associated with the lower salinity stations 45, 65 and 603. Highest seasonal densities in the upper bay occurred in the summer months of June 1985 and August 1986 at stations 623 and 633. These peaks correspond to the peak densities for the total zooplankton standing crop. Apparent seasonal lows were in the winter or early spring months of March 1986 and February 1986 in the upper and lower bay. It is difficult to distinguish between salinity related lows and normal seasonal lows in the upper bay since this area is subject to periodic freshwater flushing. The upper bay lows for *A. tonsa* were associated with salinities from 0.5 to 6.4% in March 1985 and from 5.3 to 13.6‰ in February 1986.

A bloom of *A. tonsa* occurred at the lower bay stations in April 1986 but was not evident in the upper bay.

In Year 2 *A. tonsa* was always more abundant in the lower than the upper bay, with the exception of August 1986 where a bloom of *A. tonsa* was found at stations 633 and 623. Note that the upper bay was recovering from a freshwater inflow event in June 1986 and the salinity at stations 623 and 633 was 9.8 and 8.9 respectively. These salinities were at the low end of the salinity range for the ctenophore, *Mnenopsis mccradyii*, a copepod predator; which was at peak abundance at station 85 and most of the lower bay. High densities of *M. mccradyi* in the lower bay may have been responsible for this *A. tonsa* density shift.

The total length of approximately 20 adult *A. tonsa* males and 20 females with spermatophores attached were measured at each station from October 1985 through August 1986 to test for a length relationship along a salinity gradient. Measurements were taken from the tip of the prosome to the end of the 5th thoracic segment at 50X using an ocular micrometer with a dissecting microscope. The salinity ranged from 0.1 to 35.2‰. Female lengths ranged from 0.56 to 1.0 mm with a mean of 0.7mm and the male lengths ranged from 0.48 to 0.88 mm with a mean of 0.62 mm. Linear regression of length versus salinity demonstrated a significant length increase with salinity increase ($P < 0.0005$; Figs. 4.2-4.3). Three dimensional graphs (Figs. 4.4-4.5) indicate two peaks for males and females, one at low salinity of small individuals and one at higher salinity of larger individuals.

The ctenophore, *Mnemiopsis mccradyi*, a zooplankton predator, was absent or in low numbers in the upper bay from November 1984 through June 1985 during persistent low salinities (Table 4.7). Highest density occurred in August

1985 and 1986. In August 1985 it was found upriver to station 65 and throughout the rest of the upper bay while in August 1986 its distribution was from the lower bay up to station 85. Although similar salinity was encountered in the upper bay during August 1985-1986 (Table 2.3), ctenophore colonization was more wide spread in 1985 at the time of sampling. The presence or absence of ctenophores from an area may affect zooplankton density as was hypothesized to explain the decreased *A. tonsa* densities in the lower bay in August 1986.

From October 1985 through August 1986, a 24-mile-long transect was sampled from station 45 near the source of freshwater inflow along a gradient to markers 35 and 36 in the Matagorda Ship Channel which were usually influenced by marine input from Pass Cavallo and the Matagorda Ship Channel. When average zooplankton densities for Year 2 by station are plotted from station 45 to 35-36 along the salinity gradient, the trend is for zooplankton density to increase from upper bay to the lower bay (Fig. 4.6). Salinity, densities of freshwater zooplankton, and the most abundant estuarine and marine species are plotted in Tables 4.8-4.10. Freshwater species abundance increased in December 1985 and June 1986 at stations 45 and 65 corresponding to surface salinities of 0.8 and 1.4, and 0.6 and 1.0 $^{o}/oo$ respectively. Throughout the year, typical estuarine species, i.e. barnacle nauplii, *Acartia tonsa*, *Paracalanus crassirostris*, *Pseudodioptomus coronatus*, and *Oithona colcarva*, reached peak abundance in a mid-bay zone between the freshwater and marine input. Incursions of marine fauna are indicated by the densities of the marine species *Sagitta* sp., *Oikopleura*, and *Noctiluca scintillans*. In October 1985, densities of the larvacean *Oikopleura* ranged from $0.1/m^3$ at station 45 to $2,620/m^3$ at station 35-36. *Noctiluca scintillans*, a neritic dinoflagellate, was collected only in February and April 1986 with densities ranging from 0.1 at station 3 to 385,368/m^3 at station 35-36 in February 1986.

CONCLUSIONS

Zooplankton occurrence and abundance in upper and lower Lavaca Bay were effected by freshwater inflow events and seasonality. As reported in previous studies (Holland et al. 1975, Gilmore et al. 1976, Matthews 1980, Kalke 1981) flood events in an estuarine system usually result in the physical displacement of estuarine zooplankton with a population of freshwater species. In most cases the event is short term and salinity increases allow displaced estuarine species, i.e. *Acartia tonsa*, to recolonize quickly. The occurrence and distribution of freshwater zooplankton in upper Lavaca Bay from March through May 1985 reflect the influence of persistent low salinities during Year 1 of this study. The two freshwater events associated with Year 2 that occurred in December 1985 and June 1986, mainly affected zooplankton populations at the river and lake stations. Although freshwater inflows were high in Year 1 compared to Year 2, there was no discernable difference in zooplankton numerical abundance between the two years. The seasonal highs for zooplankton abundance in the upper bay obviously occurred during the summer months of June 1985 in Year 1 and August 1986 in Year 2 as shown in Table 4.2. Seasonal cycles in the upper bay are sometimes difficult to ascertain because sporadic freshwater inflow events usually result in decreased zooplankton densities.

Zooplankton dry weight biomass measurements in most cases were indicative of zooplankton abundance. During Year 1 there were problems with detritus and sediment in some samples due to heavy runoff and windy conditions. Biomass results indicate that the river stations 45 and 65, and the upper lake station 603 are unstable in relation to zooplankton communities due to periodic flushing with freshwater. As the nutrients are transported to the bay and made available under more stable conditions, the resulting higher zooplankton abundance increases biomass. According to biomass measurements in Year 2, the estuary is organized in zones grading from low salinity areas with low freshwater-estuarine zooplankton biomass, to a mid-bay zone with estuarine-zooplankton of high abundance and biomass, to a higher salinity zone of estuarine and neritic zooplankton which often has a biomass lower than the mid-zone of maximum production.

The time of sampling in relation to the initiation and duration of a freshwater event is important. For example, if this study had begun in September 1984 the first trip would reflect conditions following a dry period; whereas, we first sampled in November 1984 following a peak freshwater event in October resulting in a freshwater signal. Freshwater zooplankton in an estuary can be used as tracers to follow incursions of freshwater inflow events. Estuarine and marine fauna can also be used to detect incursions of higher salinity waters into low salinity areas.

A close relationship of zooplankton standing crop and *Acartia tonsa* density plots indicate the importance of *A. tonsa* as a dominant estuarine species. The lowest *A. tonsa* abundances were associated with the river stations 45 and 65 and the upper lake station 603 which were most influenced by freshwater inflow. Relatively lower numbers of *A. tonsa* and other estuarine species in the upper bay during Year 1 indicated a need for expanded coverage to the lower bay to define the zone of maximum zooplankton density. Declines of *A. tonsa* densities in the upper bay in March 1985 and February

1986 were probably a seasonal decline; however freshwater inflows in March 1985 may have also caused low densities. While the seasonal highs for *A. tonsa* in the upper bay occurred in June 1985 and August 1986, principally at stations 623 and 633 some distance from the mouth of the river, a comparable peak abundance in the lower bay area occurred in April 1986. These densites remained relatively high but declined through August 1986. In August 1986 a decline of *A. tonsa* occurred in the lower bay, where densities were normally higher than those in the upper bay. This decline may be related to the result of ctenophore predation by *Mnemiopsis mccradyi*, which were abundant in Matagorda Bay from station 1905 to station 85 in upper Lavaca Bay.

The total length of adult *A. tonsa* males and females along a salinity gradient may provide data which can be linked with optimal growth conditions. Bagnall (1976) found *A. tonsa* males and females in the Gulf of Mexico to be larger than estuarine individuals from Christmas Bay near San Luis Pass, Texas. Males were reported as being smaller than females and the largest individuals occurred from February through May. Multiple regression of size on surface water temperature and salinity did not explain a significant amount of variation in size observed in either males or females (Bagnall 1976). Similar results occurred in Lavaca Bay for male and female size differences, and a significant positive correlation of increased lengths with increased salinity was found. These data may be indicative of two different *A. tonsa* populations in the same estuary or of size variations due to other environmental factors, i.e. a temperature/salinity effect.

The greatest concentration of *Mnemiopsis mccradyi* in Lavaca Bay occurred during the summer months of August 1985 and 1986 which corresponds with large concentrations of copepods. The absence of *Mnemiopsis* from the upper bay during most of Year 1 indicates a low tolerance for low salinity conditions. Salinity increases during the August 1985 ctenophore bloom expanded the distribution of *Mnemiopsis* up river to station 65, but during their bloom in August 1986, low salinity in the upper bay above station 85 restricted distribution to the middle bay stations. Concentration of *Acartia tonsa* during August 1986 apparently decreased as a result of *Mnemiopsis* predation in the lower bay, while peak densities of *Acartia tonsa* were found in the upper bay in the absence of *Mnemiopsis*. Declines in zooplankton standing crop in Sandy Hook Bay, N.J. in July and August, 1969 were correlated with the presence of cnidarians and ctenophores (Sage and Herman, 1972).

Zooplankton data collected in Year 2 along a 24 mile transect from station 45 to markers 35-36 were useful for determining extent of freshwater inflow events and incursions of marine influence into the estuary. It also made it possible to determine areas of maximum zooplankton standing crop and biomass. In Table 4.8 through 4.10, freshwater inflow events in December and June 1986 were minor and mainly influenced areas associated directly with the river, i.e. stations 45 and 65. Streamflow data shows that increased inflow the week after our June 1986 sampling trip was more extensive and most likely influenced areas beyond the river mouth. Periods of low river flow, i.e. October 1985, February and April 1986, result in higher salinities upriver and the encroachment of estuarine and marine species into the upper bay and river. One example is the distribution of the marine species, *Oikopleura* sp. in October 1985, from a high of $2620/m^3$ at station 35-36 to $0.1/m^3$ at station 45.

As indicated by biomass during Year 2, distribution of freshwater, estuarine and marine zooplankton partitions the estuary into three zones. The upper zone near sources of freshwater inflow is subject to sporadic environmental changes associated with salinity changes and the physical displacement of zooplankton communities by freshwater flood events. Estuarine species compete with fresh and brackish water species in this zone of low salinity tolerance.

In a middle bay zone the salinities are normally more stable resulting in a buffer zone between the upper low salinity and lower high salinity marine environment. The area which represents this zone in Lavaca Bay is approximately between stations 85 and 1905. The most common zooplankton in this zone are considered estuarine species, i.e. barnacle nauplii, *Acartia tonsa, Paracalanus crassiortus, Pseudodiaptomus coronatus*, and *Oithona colcarva.* The highest concentrations are normally found within this zone.

The lower zone, of which station 35-36 seems to be on the inner edge of, is exposed to marine input from the Matagorda Ship Channel and Pass Cavallo. Although high densities of some estuarine species occur here it also supports numbers of marine species associated with the neritic waters of the Gulf of Mexico. The extent to which marine species range into the middle and upper bay is dependent on the salinity gradient established by freshwater inflow waters.

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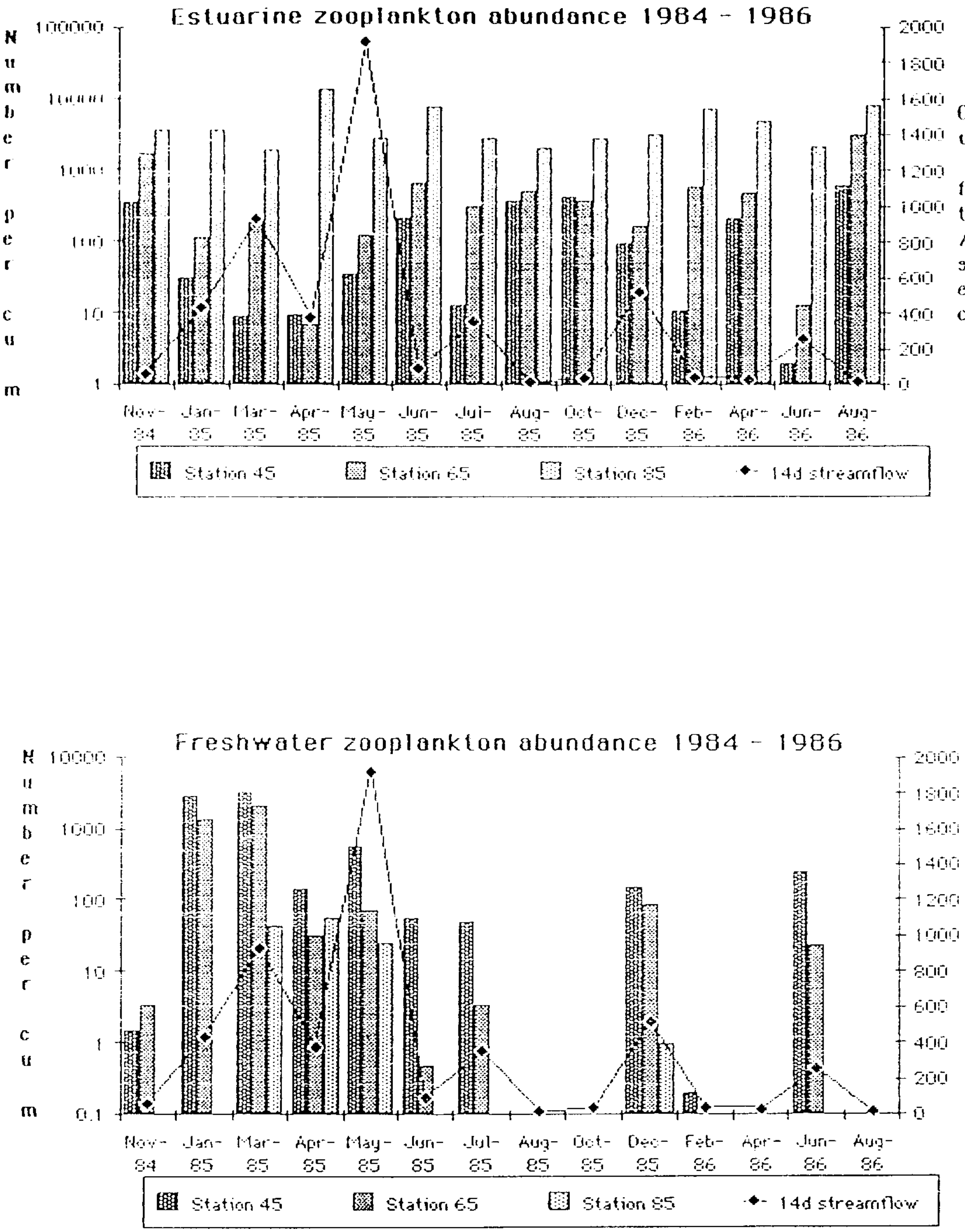
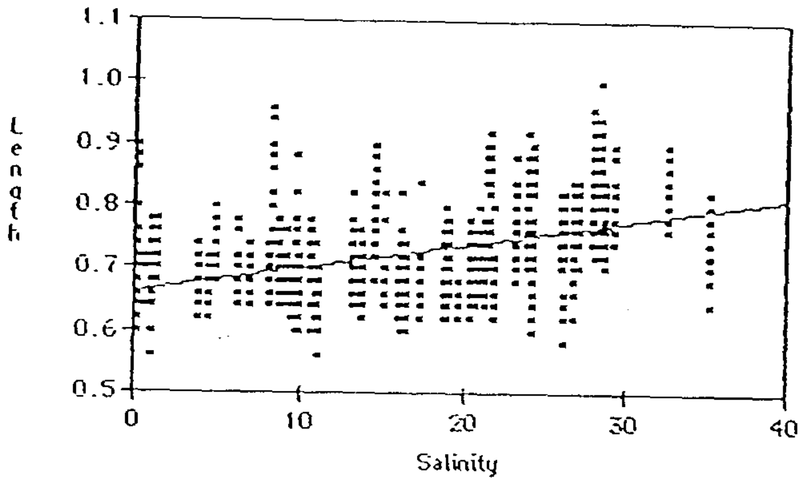


Figure 4.1. Total abundance of estuarine and freshwater zooplankton species vs. the 14 day average streamflow for stations 45, 65, and 85 from November 1984 through August 1986.



Data File: Femdata.sw

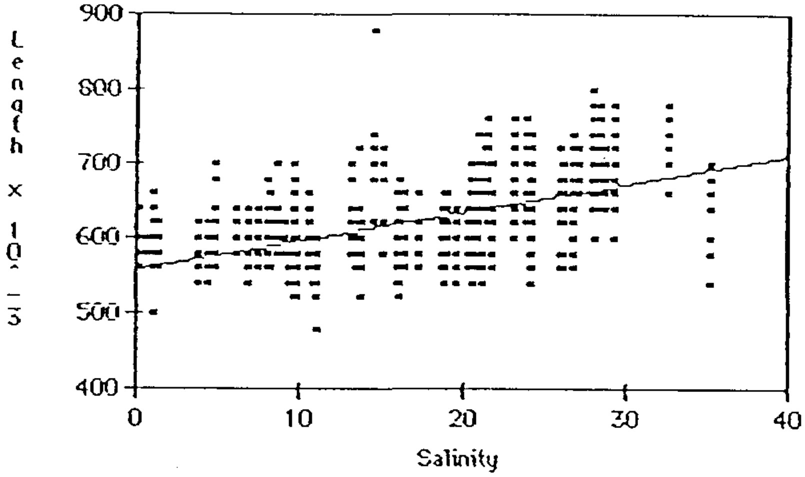
Variable Name	Coefficient	Std. Err. Estimate	t Statistic	Prob > t
Constant	0.66333	0.00363	182.95262	0.000
Salinity	0.00377	0.00020	18.82668	0.000

Data File: Femdata.sw

Source	Sum of Squares	Deg. of Freedom.	Mean Squares	F-Ratio	Prob>F
Model	1.56823	1	1.56823	354.44382	0.000
Error	6.06153	1370	0.00442		
Total	7.62975	1371			

Coefficient of Determination	0.20554
Coefficient of Correlation	0.45337
Standard Error of Estimate	0.06652
Durbin-Watson Statistic	0.67098

Figure 4.2. Linear regression of Acartia tonsa female total length vs. salinity for all stations from October 1985 through August 1986.



Data File: Maledata.sw

Variable Name	Coefficient	Std. Err. Estimate	t Statistic	Prob > t
Constant	0.55826	0.00287	194.74557	0.000
Salinity	0.00385	0.00015	24.87882	0.000

Data File: Maledata.sw

Source	Sum of Squares	Deg. of Freedom	Mean Squares	F-Ratio	Prob>F
Model	1.46967	1	1.46967	619.00528	0.000
Error	3.07228	1294	0.00237		
Total	4.54196	1295			

Coefficient of Determination	0.32358
Coefficient of Correlation	0.56884
Standard Error of Estimate	0.04873
Durbin-Watson Statistic	0.98011

Figure 4.3. Linear regression of Acartia tonsa male total length vs. salinity for all stations from Ocober 1985 through August 1986.

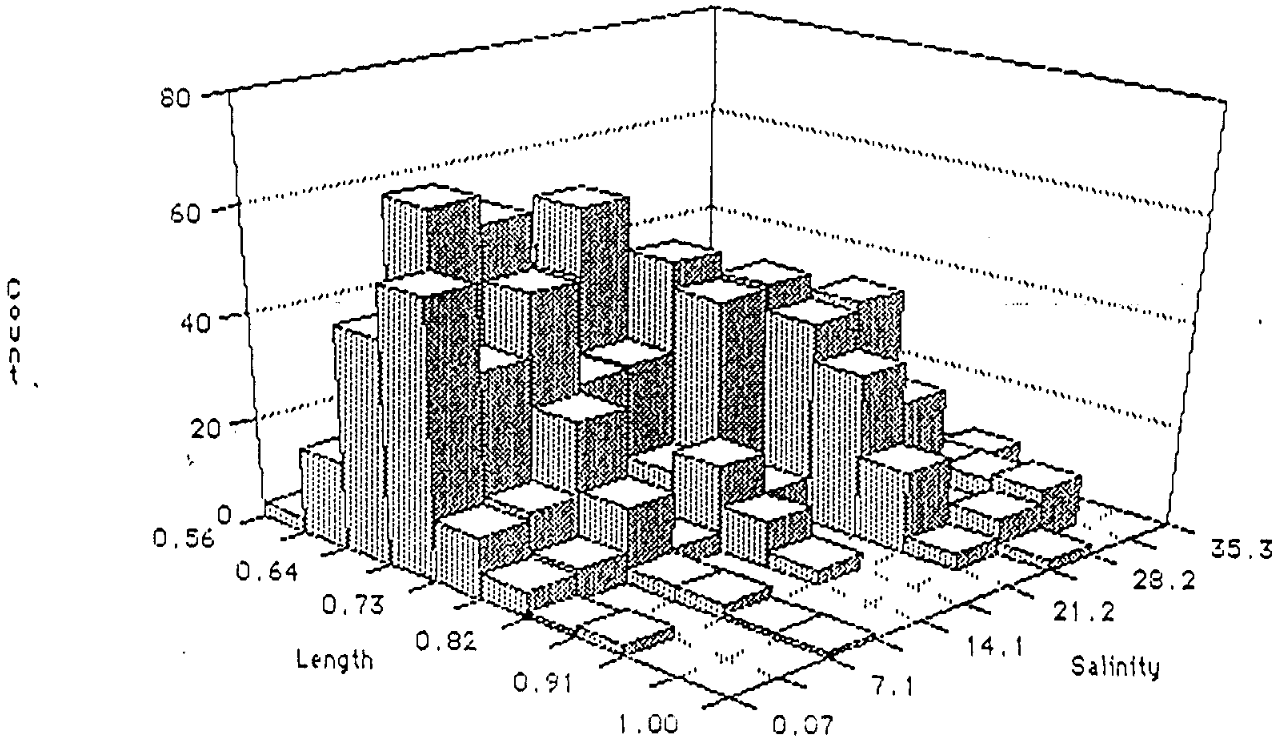


Figure 4.4. Three dimensional plot of *Acartia tonsa* female length data vs. salinity for all stations from October 1985 through August 1986.

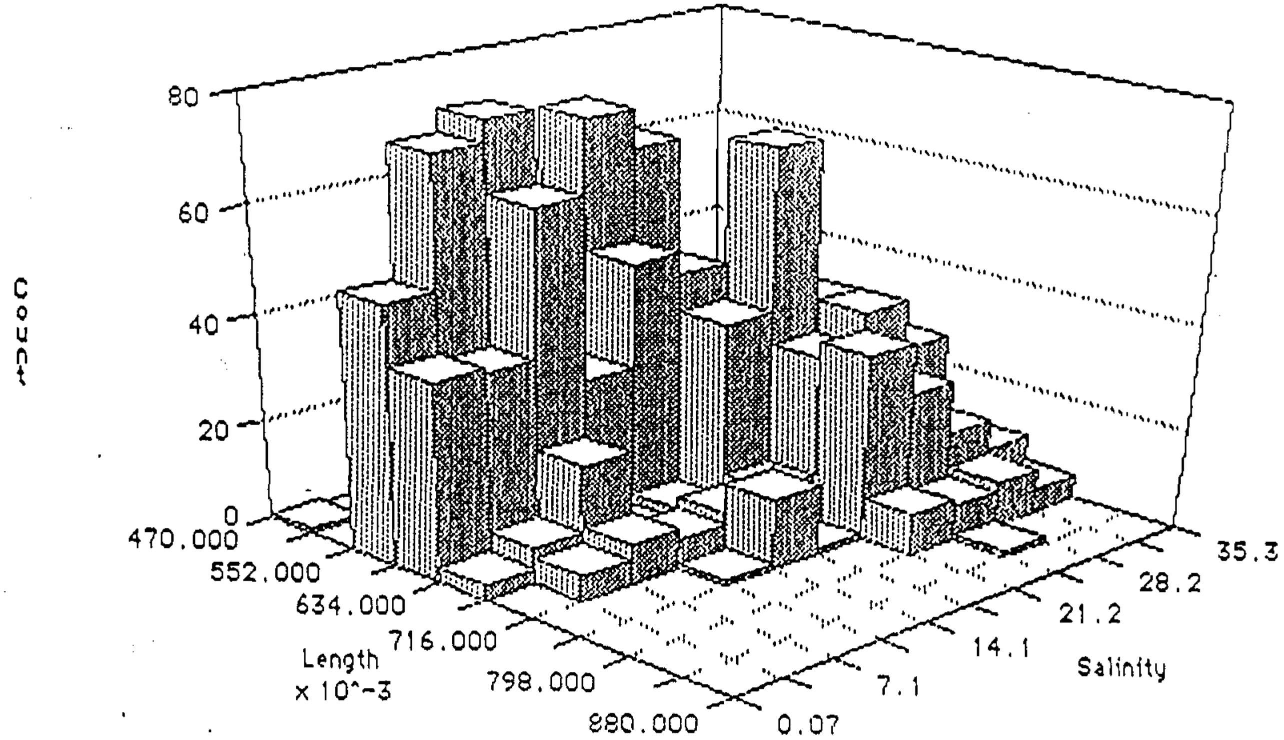


Figure 4.5. Three dimensional plot of <u>Acartia tonsa</u> male length data vs. salinity for all stations from October 1985 through August 1986.

Figure 4.6. Average Zooplankton Count per cubic meter
Oct 1985 - Aug 1986

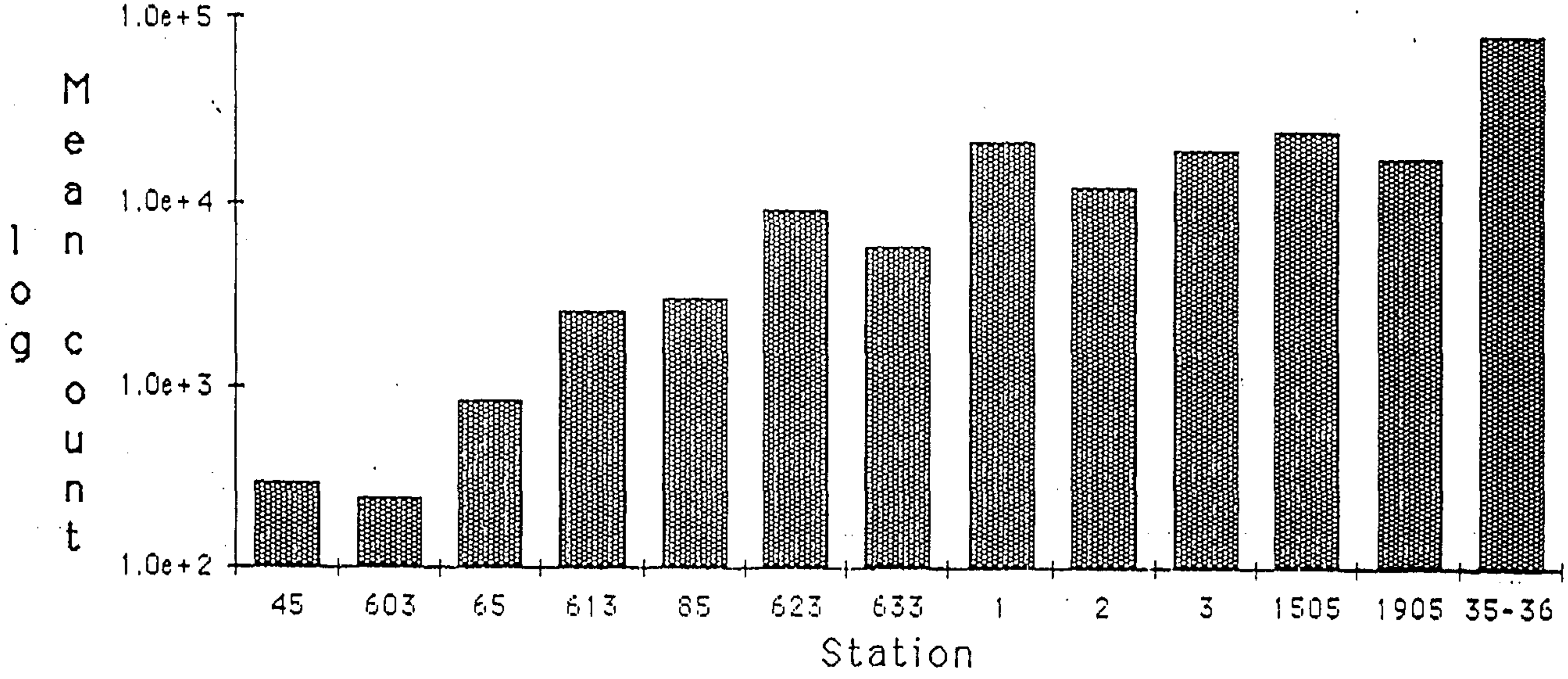


Table 4.1. Lavaca Bay Zooplankton Species List, November 1984 - Aug. 1986.

PHYLUM PROTOZOA			
	Class Mastigophora		
		Order Dinoflagellata	
			Noctiluca scintillans
PHYLUM COELENTERATA			
	Class Hydrozoa		*Solmaris* sp.
	Class Scyphozoa		
			Chrysaora quinquecirrha
			Stomolophus meleagris
			Medusae
	Class Anthozoa		
			Anemone
PHYLUM CTENOPHORA			
	Class Tentaculata		
			Mnemiopsis mccradyi
	Class Atentaculata (Nuda)		
			Beroe ovata
PHYLUM PLATYHELMINTHES			
	Class Turbellaria		
		Order Acoela	
			Flatworm
PHYLUM NEMERTINEA			
			Nemertean
PHYLUM ROTIFERA			
			Keratella sp.
			Brachionus plicatilis
			Platyias quadricornis
			Platyias patulus
			Rotifer (unidentified)
			Rotifer (colonial form)
			Rotifer (large, soft body)
PHYLUM KINORYNCHA			
			Kinorynch
PHYLUM NEMATODA			
			Nematode
PHYLUM ANNELIDA			
	Class Polychaeta		
			Polychaete larvae
			Autolytus prolifer

- Class Oligochaeta
    - Oligochaetes
- Class Hirudinea
    - Leech

PHYLUM MOLLUSCA

- Class Gastropoda
    - Gastropod larvae
    - Pteropoda
- Class Pelecypoda
    - Pelecypod larvae
- Class Cephalopoda
    - *Loligunculus brevis*

PHYLUM ARTHROPODA

- Class Arachnida
    - Order Acarina
        - Hydracarina (water mites)
- Class Crustacea
    - Order Diplostraca
        - *Penilia avirostris*
        - Sididae
            - *Diaphanosoma* sp.
        - Daphnidae
            - *Ceriodaphnia* sp.
            - *Daphnia* sp.
            - *Moina* sp.
            - *Moinodaphnia* sp.
        - Bosminidae
            - *Bosmina* sp.
        - Macrothricidae
            - *Ilyocryptus spinifer*
            - *Macrothrix* sp.
        - Chidoridae
            - *Leydigea acanthoceroides*
            - *Chydorus* sp.
            - *Cladocera* (unidentified)
    - Order Myodocopina
        - *Eusarsiella zostericola*
    - Order Podocopa
        - Ostracod (unidentified)

Order Calanoida
        Calanoid (unidentified)
        Paracalanidae
        Paracalanus crassirostris
        Paracalanus sp.

    Centropagidae
        Centropages hamatus
        Centropages velificatus

    Diaptomidae
        Diaptomus spp.
        Pseudodiaptomus coronatus

    Calanidae
        Eucalanus sp.

    Temoridae
        Eurytemora hirundoides
        Temora turbinata

    Pontellidae
        Labidocera aestiva
        Labidocera scotti
        Pontella sp.

    Acartiidae
        Acartia tonsa
        Acartia tonsa copepodids
        Acartia tonsa adults
        Acartia liljeborgii

    Tortanidae
        Tortanus setacaudatus

Order Harpacticoida
    Ameiridae
        Nitocra sp.
    Canuellidae
        Scottolana canadensis

    Harpacticidae
        Harpacticus sp.
        Zausodes arenicolus

    Metidae
        Metis sp.

    Peltidiidae
        Alteutha depressa

    Tachiidae
        Euterpinna acutifrons
        Microarthridion littorale

Tegastidae
    Parategastes sp.

Unidentified
    Harpacticoid

Order Cyclopoida
    Oithonidae
        Oithona colcarva
        Oithona plumifera

    Cyclopidae
        Cyclopoid copepodids
        Cyclops sp.
        Eucyclops agilis
        Eucyclops speratus
        Halicyclops sp.
        Hemicyclops sp.
        Macrocyclops albidus
        Mesocyclops edax
        Tropocyclops prasinus

    Clausidiidae
        Saphirella sp. A (narrow)
        Saphirella sp. B (wide)

    Ergasilidae
        Ergasilis sp.

    Lichomolgidae
        Lichomolgid A (Cyclopoid commensal)

    Oncaeidae
        Oncaea sp.

    Corycaeidae
        Corycaeus sp.

    Sabelliphilidae
        Sabelliphilid sp. (*Lubbockia*)

    Unidentified
        Cyclopoid Copepodids
        Copepod Nauplii (Calanoid,
            Harpacticoid and Cyclopoid
            combined)

Order Caligoida
    Caligidae
        Caligus sp. metanauplius
        Caligus sp.

    Argulidae
        Argulus alosae

- Order Thoracica
    - Barnacle nauplii
    - Barnacle cypris larvae
- Order Stomatopoda
    - Stomatopod antizoea
    - Stomatopod pseudozoea
- Order Mysidacea
    - Mysidae
        - *Mysidopsis bahia*
        - *Mysidopsis almyra*
        - *Mysidopsis* sp. (juvenile)
        - *Metamysidopsis swifti*
- Order Cumacea
    - Cumacean (Juvenile)
    - *Oxyurostylis salinoi*
    - *Cyclaspis varians*
- Order Tanaidacea
    - *Leptochelia rapax*
- Order Isopoda
    - Idoteidae
        - *Edotea mantosa*
    - Cymothoidae
        - *Aegathoa oculata*
    - Bopyridae
        - Bopyrid A
    - Munnidae
        - *Munna* sp.
- Order Amphipoda
    - Ampeliscidae
        - *Ampelisca abdita*
    - Amphithoidae
        - *Cymadusa compta*
    - Bateidae
        - *Batea catharinensis*
    - Corophiidae
        - *Corophium louisianum*
        - *Corophium acherusicum*

Gammaridae
- *Gammarus mucronatus*
- *Microprotopus* sp.

Oedicerotidae
- *Monoculodes nyei*

Caprellidae
- Caprellid (immature)

Order Decapoda

Palaemonidae
- *Macrobrachium* sp. Zoea
- *Palaemonetes* sp. Zoea
- *Palaemonetes pugio*

Alpheidae
- *Alpheus* sp. zoea
- *Lucifer faxoni*
- *Lucifer faxoni* protozoea

Penaeidae
- *Penaeus aztecus* postlarvae
- *Penaeus setiferus* postlarvae

Sergestidae
- *Acetes americanus louisianensis*
- *Acetes americanus louisianensis* protozoea

Ogyrididae
- *Ogyrides limicola* Zoea
- *Ogyrides limicola* post larvae

Callianassidae
- *Callianassa* sp. Zoea
- *Callianassa* sp. juvenile
- *Callianassa* sp. Zoea #2
- Porcellanid Zoea
  - *Upogebia affinis* zoea

Hippolytidae
- *Tozeuma carolinense* zoea
- *Hippolyte* sp. zoea
  - *Hippolysmata wurdemanni*

Porcellanidae
- *Petrolisthes armatus zoea*
- *Petrolisthes armatus* megalops

Paguridae
- *Clibanarias vittatus* zoea
- *Pagurus* sp. zoea
- Glaucothoe larvae

Portunidae
- *Callinectes* spp. megalops
- *Callinectes sapidus*

Xanthidae
- *Rithropanopeus harrissi* Zoea

Pinnotheridae
- *Pinnixa* sp. Zoea
- *Pinnotheres* sp. Zoea
- *Pinnotherid* zoea A

Ocypodidae
- *Uca* sp. Zoea

Unidentified
- Brachyuran Zoea
- Brachyuran megalops
- Decapod larvae (Galatheid type)

Class Insecta
- Order Ephemeroptera
  - Insect larvae
  - Mayfly larvae
- Order Chironomidae
  - Midgefly larave
  - Midgefly pupae

Class Tardigrada
- Tardigrade (water bears)

PHYLUM PHORONIDA
- Actinotroch larvae

PHYLUM ECHINODERMATA
- Ophiopluteus larvae
- Echinopluteus larvae
- Bipinnaria larvae

PHYLUM BRYOZOA
- Cyphonautes larvae A
- Cyhonautes larvae B

PHYLUM CHAETOGNATHA	
	Saggita sp.
PHYLUM CHORADATA	
Class Ascidiacea	
	Ascidian larvae
Class Larvacea	
	Oikopleura sp.
Class Osteichthyes	
	Fish eggs

Lavaca Bay

Table 4.2 Zooplankton abundance 1984 - 1986

1984 - 1985 (individuals/ m cubed)

Station	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	379	3018	3294	158	608	279	62	382	1022.5	1328.8
603	1573	1255	657	66	74	1064	40	808	692.13	591.02
65	1742	1468	2316	40	200	705	322	548	917.63	824.6
613	7424	906	1801	2328	833	1722	568	2279	2232.6	2200.6
85	3671	3656	1985	14220	2905	7781	2916	2074	4901	4185.4
623	3938	4515	983	1984	400	24440	3868	1417	5193.1	7923.7
633			7961	1218	2469	34889	6685	3061	9380.5	12762
Average	3121.2	2469.7	2713.9	2859.1	1069.9	10126	2065.9	1509.9	**3258**	
s.d.	2502.1	1470.7	2470.4	5096.7	1139.6	13917	2540	1001.2		**5910**

1985 - 1986 (individuals/ m cubed)

Station	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	448	257	11	221	257	633	304.5	212.66
603	131	194	179	250	175	533	243.67	146.84
65	395	267	598	494	37	3353	857.33	1238
613	482	1981	234	351	478	12171	2616.2	4725
85	2847	319	7447	4902	2235	829	3096.5	2677.6
623	3573	2861	1436	15840	2968	30585	9543.8	11590
633	102	2407	631	3244	191	28938	5918.8	11349
1		5992	4580	77184	9600	12321	21935	31034
2		7766	15849	20314	10111	9775	12763	5183.4
3		5963	8093	48821	24971	11601	19890	17781
1505	38482	12686	33572	31900	22848	11465	25159	11333
1905	20716	7413	20346	22504	16197	20544	17953	5567.1
35-36	12633	8376	398108		6613	7130	86572	174170
Average	7980.9	4344.8	37776	18835	7437	11529	**14864**	
s.d.	12711	3985.3	108734	23944	8856.3	9966.3		**47071**

Average st 45-633	**3226**
s.d.	**6798**

Lavaca Bay

Table 4.3 Zooplankton biomass 1984 - 1986

1984 - 1985 (mg dry wt/ m cubed)

Station	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	1.0	7.0	5.6	2.6	3.2	3.4	1.2	3.0	3.4	2.0
603	**52.1**	**11.7**	6.3	7.8	2.3	14.6	2.6	3.9	12.7	16.5
65	**15.2**	3.2	3.4	5.4	0.6	4.9	2.5	4.9	5.0	4.4
613	**390.2**	**49.9**	8.2	**36.8**	7.6	8.2	13.0	8.8	65.3	132.2
85	5.8	12.7	1.3	**69.9**	5.8	46.0	23.6	32.1	24.7	23.8
623	**72.0**	40.7	38.6	**1473.8**	24.3	**158.8**	44.5	17.5	233.8	503.0
633			41.4	**355.3**	22.1	101.7	17.9	16.6	92.5	132.7
Average	89.4	20.8	15.0	278.8	9.5	48.2	15.0	12.4	61.4	
s.d.	150.0	19.4	17.3	541.7	9.7	60.1	15.6	10.5		208.9

1985 - 1986 (mg dry wt/ m cubed)

Station	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	1.2	1.3	2.2	6.0	0.4	1.0	2.0	2.0
603	3.1	0.5	3.6	1.3	0.3	4.7	2.2	1.8
65	1.2	1.0	0.6	**6.7**	3.4	7.1	3.3	2.9
613	1.8	7.3	26.7	1.3	2.2	19.2	9.7	10.7
85	13.3	13.7	2.6	17.0	3.6	22.9	12.2	7.8
623	12.0	7.5	17.9	55.0	10.7	175.2	46.4	65.5
633	7.3	27.6	6.7	28.4	6.2	53.9	21.7	18.9
1		28.0	**87.4**	308.7	112.8	23.3	112.0	116.4
2		37.3	21.4	207.3	33.8	37.4	67.4	78.5
3		7.8	14.1	220.9	82.9	76.3	80.4	85.8
1505		18.5	21.6	112.7	82.8	34.8	54.1	41.7
1905		25.6	19.8	97.9	56.1	49.1	49.7	31.0
35-36		43.0	137.1		12.2	23.8	54.0	56.8
Average	5.7	16.9	27.8	88.6	31.3	40.7	36.9	
s.d.	5.2	14.3	39.8	104.2	39.0	45.7		57.3

Average @ 45-633	13.9
s.d. @ 45-s.d.	28.5

bold = Detritus in sample

Lavaca Bay
Table 4.4 Freshwater zooplankton abundance 1984 - 1986

1984 - 1985 (individuals/ m cubed)

Station	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	1.5	2985	3285	148	572	58	50	0.1	887.45	1401.8
603	1.5	666	358	9	17	23	1.3	0	134.48	247.26
65	3.4	1352	2096	33	73	0.5	3.5	0	445.18	814.35
613	0	104	81	41	70	0	1	0	37.125	42.983
85	0.1	0	45	57	25	0	0	0	15.888	23.542
623	0.1	1.5	19	56	69	0	0	0	18.2	28.31
633			5	84	252	0	1	0	57	101.09
Average	1.1	851.42	841.29	61.143	154	11.643	8.1143	0.0143	**234.2**	
s.d.	1.3282	1169.9	1314.5	44.771	200.24	22.152	18.507	0.0378		**673**

1985 - 1986 (individuals/ m cubed)

Station	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0.1	159	0.2	0.1	255	0	69.067	111.07
603	0	61	0	0	0.8	0	10.3	24.84
65	0	89	0	0	24	0	18.833	35.69
613	0	18	0	0	0.1	0	3.0167	7.3404
85	0	1	0	0	0.1	0	0.1833	0.4021
623	0	0	0	0	0	0	0	0
633	0	0	0	0	0	0	0	0
1		0	0	0	0	0	0	0
2		0	0	0	0	0	0	0
3		0	0	0	0	0	0	0
1505	0	0	0	0	0	0	0	0
1905	0	0	0	0	0	0	0	0
35-36	0	0	0		0	0	0	0
Average	0.01	25.231	0.0154	0.0083	21.538	0	**8.222**	
s.d.	0.0316	49.136	0.0555	0.0289	70.457	0		**36.61**

Average st 45-633	**14.49**
s.d.	**47.89**

Lavaca Bay
Table 4.5 Surface and bottom standing crop vs stratification

1985 - 1986	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86
Mean 14 d flow, cu ft/sec	33	521	43	32	258	15
Station						
45 Standing crop, surface tow	448	257	11	221	257	633
45 surface salinity, ppt	4.4	0.9	5.3	13.4	0.6	3.9
45 surface dissolved Oxygen, mg/l	9.7	9.9	9.5	9.5	8.2	7.4
45 standing crop, oblique tow	1524	372	264	539	456	2321
45 bottom salinity, ppt	17.6	2.8	6.8	13.8	18.1	4.4
45 bottom dissolved Oxygen, mg/l	1.4	9.7	7	9.5	0.3	5.6
65 Standing crop, surface tow	395	267	598	494	37	3353
65 surface salinity, ppt	6.9	1.4	8.7	16.1	1	9.4
65 surface dissolved Oxygen, mg/l	6	10.2	9.8	8.9	8.2	8
65 standing crop, oblique tow	1721	1287	588	625	2521	8953
65 bottom salinity, ppt	17.7	8	13.1	17.4	18.3	9.9
65 bottom dissolved Oxygen, mg/l	4.2	10.1	7.4	8.5	0.3	7.1

Lavaca Bay
Table 4.6 **Acartia tonsa abundance 1984 - 1986**

1984 - 1985 (individuals/cu m)

Station	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	355	17	0	0.1	0	136	4	290	100.26	145.65
603	1128	119	95	28	19	886	18	568	357.63	444.25
65	1123	94	32	0	76	124	285	496	278.75	377.54
613	3646	258	270	846	518	1291	301	2231	1170.1	1207
85	2590	2265	182	11513	2953	6420	2686	1228	3729.9	3621.3
623	3283	3639	125	1130	263	11092	2740	1185	2932.1	3556.6
633			424	849	1287	25608	6494	2391	6175.5	9771.3
Average	2020.8	1065.3	161.14	2052.3	730.86	6508.1	1790	1198.4	**1956**	
s.d.	1336.9	1526.6	147.03	4198.8	1078.7	9363.2	2403.1	837.21		**4088**

1965 - 1986 (individuals/ m cubed)

Station	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	327	11	8	15	0.3	557	153.05	235.39
603	95	83	11	20	45	479	122.17	177.96
65	36	148	43	1.1	10	2009	374.52	802.45
613	432	2845	43	84	408	12242	2675.7	4803.5
85	1667	2784	228	3602	558	7852	2781.8	2796.1
623	577	1344	74	1200	221	29542	5493	11793
633	64	1922	141	2401	34	28152	5452.3	11168
1		3397	124	48781	4389	11637	13666	20075
2		4378	227	29674	1328	8104	8742.2	12094
3		3095	353	30522	19917	9387	12655	12504
1505	27448	4835	1700	22269	11468	8618	12723	10101
1905	8855	3437	104	14690	10559	14157	8633.7	5843
35-36	5529	5085	974		4437	543	3313.6	2369.5
Average	4503	2566.5	310	12772	4105.7	10252	**5707**	
s.d.	8583.1	1757.8	489.3	16421	6203.5	9483.1		**9532**

Average st 45-633	**2436**
s.d.	**6397**

Lavaca Bay
Table 4.7 **Mnemiopsis mccradyi abundance 1984 - 1986**

1984 - 1985 (volume ml / cu m)

Station	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	1.3	0	0	0	0	0	0	0	0.1625	0.4596
603	0	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	70.4	8.8	24.89
613	0	0	0	0	0	0	6.8	27	4.225	9.5051
85	0	0	0	0	0	0	48	54	12.75	23.663
623	0.4	0	0	0	0	0	6.7	0.2	0.9125	2.343
633	0	0	0	0	0	0	5.1	40	5.6375	13.999
Average	0.2429	0	0	0	0	0	9.5143	27.371	**4.641**	
s.d.	0.4894	0	0	0	0	0	17.26	28.743		**14.41**

1985 - 1986 (volume ml / cu m)

Station	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	0	0.2	0	0	0	0.0333	0.0816
603	2.2	0	1.9	0	0	0	0.6833	1.0629
65	0	1.7	0.3	0	0.1	0.1	0.3667	0.6623
613	4.5	0	1.3	0	0.2	0	1	1.7877
85	20	5.3	0	1.3	0.7	42	11.55	16.696
623	19.5	10.2	0.1	0.1	0	0	4.9833	8.1891
633	80	13.4	2	1.5	0.6	0	16.25	31.628
1		0.7	0.1	16	0.1	11	5.58	7.4469
2		0.8	0.1	32	0.1	139	34.4	60.06
3		0.2	0.1	0	0	18	3.66	8.0167
1505	0.5	0.2	0.8	2.3	0.1	29	5.4833	11.548
1905	0.6	0.5	0	17	0	14	5.35	7.9231
35-36	0.5	0	2.6		0.1	0	0.64	1.1149
Average	12.78	2.5385	0.7308	5.85	0.1538	19.469	**6.697**	
s.d.	24.884	4.3995	0.9096	10.303	0.2295	38.34		**19.71**

Average st 45-633	**4.981**
s.d.	**14.19**

Lavaca Bay
Table 4.8 Dominant zooplankton - Spatial distribution

October 85 Individuals / m^3

Station	45	65	85	1	2	3	1505	1905	35-36
Nautical miles	0	4.4	9	10.7	12	13.6	15.4	18.6	24
Salinity, ppt	4.4	6.9	20.5				28.7	29.2	32.6
Freshwater spp.	0.1								
Estuarine spp.									
Barnacle nauplii	108	352	303				103	211	72
Acartia tonsa	327	36	1667				27448	8855	5529
Paracalanus crassirostris	2	0.1	575				8067	6476	2957
Pseudodiaptomas coronatus	0.1	0	0.1				29	301	5
Oithona colcarva	3	0	125				1134	2289	457
Marine spp.									
Sagitta spp.	0	0	0				99	78	173
Oikopleura spp.	0.1	0	117				825	1296	2620
Noctiluca scintillans	0	0	0				0	0	0

December 85 Individuals / m^3

Station	45	65	85	1	2	3	1505	1905	35-36
Nautical miles	0	4.4	9	10.7	12	13.6	15.4	18.6	24
Salinity, ppt	0.9	1.4	8.2	10	12	12	18.7	20.3	22
Freshwater spp.	236	88	1	0	0	0	0	0	0
Estuarine spp.									
Barnacle nauplii	3	18	925	904	1089	1204	3715	736	74
Acartia tonsa	11	148	2784	3397	4378	3095	4835	3437	5085
Paracalanus crassirostris	0	0	7	199	289	363	1489	859	731
Pseudodiaptomas coronatus	0	0	43	884	833	248	369	450	244
Oithona colcarva	0	0	139	407	756	525	1523	1227	1748
Marine spp.									
Sagitta spp.	0	0	0	0.6	2.1	1.4	73	7	28
Oikopleura spp.	0	0	0	0	9	0.4	7	19	127
Noctiluca scintillans	0	0	0	0	0	0	0	0	0

Lavaca Bay

Table 4.9 **Dominant zooplankton - Spatial distribution**

February 86 Individuals / m^3

Station	45	65	85	1	2	3	1505	1905	35-36
Nautical miles	0	4.4	9	10.7	12	13.6	15.4	18.6	24
Salinity, ppt	5.3	8.7	13.1	9.2	15	20	14.4	18.2	20.4
Freshwater spp.	0	0	0	0	0	0	0	0	0
Estuarine spp.									
Barnacle nauplii	1.4	534	7120	3766	15267	7513	13733	2374	8737
Acartia tonsa	8	43	228	124	227	353	1700	104	974
Paracalanus crassirostris	0	0	4	0.5	0.6	22	80	10	237
Pseudodiaptomas coronatus	0.1	0.1	0.4	102	58	0.3	47	7	79
Oithona colcarva	0	0.4	47	43	62	58	713	176	1605
Saltwater spp.									
Sagitta spp.	0	0	0	0	0	0.3	0.8	0.1	0
Oikopleura spp.	0	0	0	0	0	0	0	3	79
Noctiluca scintillans	0	0	0	0	0	0.1	17067	17463	385368

April 85 Individuals / m^3

Station	45	65	85	1	2	3	1505	1905	35-36
Nautical miles	0	4.4	9	10.7	12	13.6	15.4	18.6	24
Salinity, ppt	13.4	16.1	23.9	26	26	27.3	27.9	28.4	
Freshwater spp.	0	0	0	0	0	0	0	0	
Estuarine spp.									
Barnacle nauplii	198	469	847	24573	6250	10522	1111	1083	
Acartia tonsa	15	1.1	3602	48781	29674	30522	22269	14690	
Paracalanus crassirostris	0	0	0.1	31	16	299	417	0	
Pseudodiaptomas coronatus	0.1	0.7	0.1	549	380	746	324	57	
Oithona colcarva	0	0	3	165	125	224	602	412	
Saltwater spp.									
Sagitta spp.	0	0	0	1.2	0.1	0.7	0.7	0.5	
Oikopleura spp.	0	0	149	427	1957	746	926	1083	
Noctiluca scintillans	0	0	0	0	0	0	0	155	

Lavaca Bay

Table 4.10 Dominant zooplankton - Spatial distribution

June 86 Individuals / m^3

Station	45	65	85	1	2	3	1505	1905	35-36
Nautical miles	0	4.4	9	10.7	12	13.6	15.4	18.6	24
Salinity, ppt	0.6	1	18.9	21.8	20.7	26	26.7	27	28.1
Freshwater spp.	255	24	0						
Estuarine spp.									
Barnacle nauplii	0.5	0.9	1460	1727	3379	672	707	446	269
Acartia tonsa	0.3	10	558	4389	1328	19917	11468	10669	4457
Paracalanus crassirostris	0	0	1.3	0	4	168	271	670	495
Pseudodiaptomas coronatus	0	0	0.4	809	801	378	1848	580	44
Oithona colcarva	0	0	0.4	0	4	168	217	179	124
Saltwater spp.									
Sagitta spp.	0	0	0	0	0	0.8	5	27	2
Oikopleura spp.	0	0	0.4	4	8	210	2005	446	3
Noctiluca scintillans	0	0	0	0	0	0	0	0	0

August 86 Individuals / m^3

Station	45	65	85	1	2	3	1505	1905	35-36
Nautical miles	0	4.4	9	10.7	12	13.6	15.4	18.6	24
Salinity, ppt	3.9	9.4	11	16.1	18.7	21.3	24.2	26.1	35.3
Freshwater spp.	0	0	0	0	0	0	0	0	0
Estuarine spp.									
Barnacle nauplii	41	403	292	303	1485	434	293	107	0
Acartia tonsa	557	2099	7852	11637	8104	9383	8618	14157	543
Paracalanus crassirostris	0	0.1	1.5	3	0	124	130	656	509
Pseudodiaptomas coronatus	0	3	5	61	0	433	520	1406	8
Oithona colcarva	0	0	31	76	6	247	553	1594	335
Saltwater spp.									
Sagitta spp.	0	0	0	0	0	0.4	0	2.6	1.6
Oikopleura spp.	0	0	0	0	0	62	98	250	5
Noctiluca scintillans	0	0	0	0	0	0	0	0	0

CHAPTER 5

BENTHOS

INTRODUCTION

Benthic macrofauna consisting primarily of polychaete worms, molluscs, and small crustaceans are secondary producers associated with the sediment. These organisms transfer energy from the primary producers, i.e. bacteria, microphytobenthos, and the phytoplankton, to higher trophic levels. The benthic macrofauna in the upper Lavaca Bay during this study was limited to a few dominant organisms consisting of the polychaetes, *Mediomastus californiensis* and *Streblospio benedicti*, Chironomid midge fly larvae, and the molluscs *Macoma mitchelli* and *Mulinia lateralis.* A list of species collected is given in Table 5.1.

METHODS

Benthic core sampling was accomplished using SCUBA or snorkeling. Triplicate samples were collected at each site with 7.5 cm diameter, 30 cm long aluminum cores which were capped and placed upright in a bucket of ambient water. The walls of each sediment core were split to aid in sectioning the sediment horizontally by depth.

Each core was sectioned at the following depths: 0-3, 3-10, and 10-20 cm. Sections were placed in a 1 liter jar and preserved with 10% formalin in seawater stained with rose bengal. In the lab, each sediment section was sieved through 0.5 mm mesh and the retained organisms were identified and counted. Wet weight biomass was measured on dominant individuals and on the entire sample.

The effect of freshwater inflow of Lavaca Bay benthos was determined by analyzing bay-wide abundance and biomass with physical parameters, i.e., salinity and temperature (Table 5.2). The $\bar{x}$ 14 day Lavaca River streamflow rate calculated from the U.S. Geological Survey data from streamflow gauge number 08164000 near Edna, Texas was also used. The $\bar{x}$ 14 day flow period was chosen to assess the impact on recent flow regimes on the fauna. Lagged effects of flow were also examined. For example, benthic reproduction and migration time is on the order of 1 month and a flow event may not result in measurable short term changes in the benthic community. Pearson Correlation Coefficients were calculated for benthos with salinity, temperature, $\bar{x}$ 14 day flow and the $\bar{x}$ 14 day lag flow. The lag flow was achieved by shifting the flow data forward by one sampling trip. Since Table 5.2 contains 50 correlation tests, it is prudent to take the Bon Ferroni approach and reject at $P = 0.001$ (i.e., .05/50).

RESULTS

Distribution Patterns

The benthic community in upper Lavaca Bay is typical of a low to moderate salinity environment with only a few dominant species. Very little change was seen in the total benthic faunal abundance between Year 1 and Year 2, but stations 623 and 633 had an abundance increase in Year 2 (Table 5.3). Monthly standing crop increases were evident in March and June 1985 and in February and April 1986. No significant calculations were found with faunal abundance and any of the physical parameters measured (Table 5.2).

The distribution of infauna by depth in the sediment was typical for most estuaries. Highest concentrations of organisms were found in the upper 0-3 cm, decreasing with depth with the lowest numbers found in the 10-20 cm core sections (Table 5.3, Fig. 5.1). Average abundance within sections was similar for both years.

Benthic biomass was in direct contrast to the abundance distributional patterns (Table 5.4, Fig. 5.2). Average biomass comparisons indicates an overall increase in biomass for Year 2. Biomass increases occurred from March through June 1985, August 1985, and February through August 1986. Biomass measurements, unlike individual abundance, increased with depth. The largest biomass the 10-20 cm depth range. The average biomass at each depth was greater in Year 2. Benthic biomass was positively correlated with salinity; r = 0.70820** (Table 5.2).

When molluscan biomass was examined and compared to the total benthic biomass a similar pattern was obvious which indicated that any distributional trends in the total biomass data were most likely due to the mollusc weights (Table 5.5 and Fig. 5.3). Mollusc biomass measurements are indicative of a larger mollusc population during low inflows. Weight increases were evident, especially in the 3-10 and 10-20 cm sections in Year 2. An increase occurred in the 10-20 cm section from April through June 1986. Mollusc biomass also had a positive correlation with salinity, r = 0.73330** (Table 5.2).

Benthic biomass minus the mollusc biomass results in a biomass comprised mainly of polychaetes, chironomids, and a few crustaceans (Table 5.6 and Fig. 5.4). This distribution indicates no response to freshwater inflow, which was confirmed by correlation coefficient calculations (Table 5.2). Seasonal highs are evident in January through April 1985, and December through June 1986. A longer term data base would be necessary to verify this apparent seasonal pattern.

Species Distributions

Chironomid midge fly larvae was one of the benthic species that had a response related to freshwater inflow (Table 5.7 and Fig. 5.5). Adult midge flies are terrestrial while their larvae are associated with freshwater systems. When their abundance is correlated with streamflow, there is a lag response which is apparent the month following an inflow event, r = 0.84126*** (Table 5.2). They are concentrated mainly in the upper 0-3 cm of sediment and, as with freshwater zooplankton species, they are good indicators of freshwater influence. Their distribution is mainly restricted to the Lavaca River (stations 45 and 65), lakes (stations 603 and 613), and stations 623 and 633 which are associated with inflow from Venado Creek and Garcitas Creek. Higher numbers and wider distributions in Year 1 are evidence of high inflow during this period.

The polychaete, *Streblospio benedicti*, is a surface dwelling suspension, deposit feeder which increased in density increase during low flow periods (Table 5.8, and Fig. 5.6). Its lowest density was during high inflow events and its lowest density during both years was at station 45 upriver. The correlation coefficient of *S. benedicti* abundance versus salinity was significant, r = 0.55725* (Table 5.2). The few incidental occurrences in the 0-20 cm core sections are indicative of its preference for the surface sediments.

Mediomastus califoriensis is a burrowing polychaete, distributed throughout the sediment to at least a depth of 20 cm (Table 5.9 and Fig. 5.7). Densities, as with *Streblospio benedicti*, increased during February-June 1986. Significant correlation was calculated for *M. califoriensis* versus salinity, r = 0.74885** (Table 5.2). Comparable densities were found in sections 0-3 and 3-

10 cm with a decline below 10 cm. At stations 85 and 623 in May through August 1985 and at stations 85, 613, 623 and 633 in June and August 1986 there was an increase in density in the 10-20 cm depth sections which may be related to the burrowing activity of the bivalve *Macoma mitchelli* which was abundant.

Two polychaetes which were not numerically dominant, *Hobsonia florida* and *Laeonereis culveri*, occurred sporadically throughout most of the study (Tables 5.10 and 5.11). *Hobsonia florida* had a preference for surface sediments while *L. culveri* was found at all depths sampled. Highest densities of *H. florida* corresponded to Year 1 during high flows and had a significant correlation with the $\bar{x}$ 14 day lag flow, while *L. culveri* densities increased only slightly in Year 2.

The two molluscs which comprised most of the benthic biomass were *Mulinia lateralis* (Table 5.12 and Fig. 5.8) and *Macoma mitchelli* (Table 5.13 and Fig. 5.9). While both species were present in Year 1 during high inflows, their peaks in abundance occurred in February and April 1986. *Mulinia lateralis* is a surface dweller with most of its numbers and biomass in the upper 0-3 cm. When *Macoma mitchelli* first settles in the benthos it is found in the surface sediments as illustrated in December 1985 and February 1986 (Table 5.10). As *Macoma* matures, its numbers decline due to natural mortality, and it begins to burrow deeper in the sediment. It ultimately leaves the surface and most individuals are found in the deeper sediment. Deep burrowing activity of *Macoma* may be important in increasing available habitat to other small burrowing infauna, i.e. *Mediomastus califoriensis.* Although density peaks were high for both *Mulinia* and *Macoma* during low flow periods, longer term sampling is necessary to describe annual cycles in relation to inflow events.

CONCLUSIONS

Benthic communities in upper Lavaca Bay varied between the two years but it is difficult to relate these variables to freshwater inflow. The only species which were affected by inflow on a short term was the aquatic chironomid larva and *Hobsonia florida* which had a lag response to inflow. The molluscs, *Mulinia lateralis* and *Macoma mitchelli* both increased in the low flow period which resulted in higher benthic-biomass. Once these effects were separated from the rest of the benthos no apparent differences between the two years were discernable.

Higher biomass in Year 2 was a result of increased mollusc populations while the remaining biomass for the rest of the benthos was similar in Year 1 and 2. Lower density and higher biomass in the deeper sediment indicates that most of the deep burrowing infauna are large individuals.

Although some distributional patterns were apparently related to fluctuations in freshwater inflow, longer term monitoring is necessary to distinguish between seasonal cycles and freshwater inflow events.

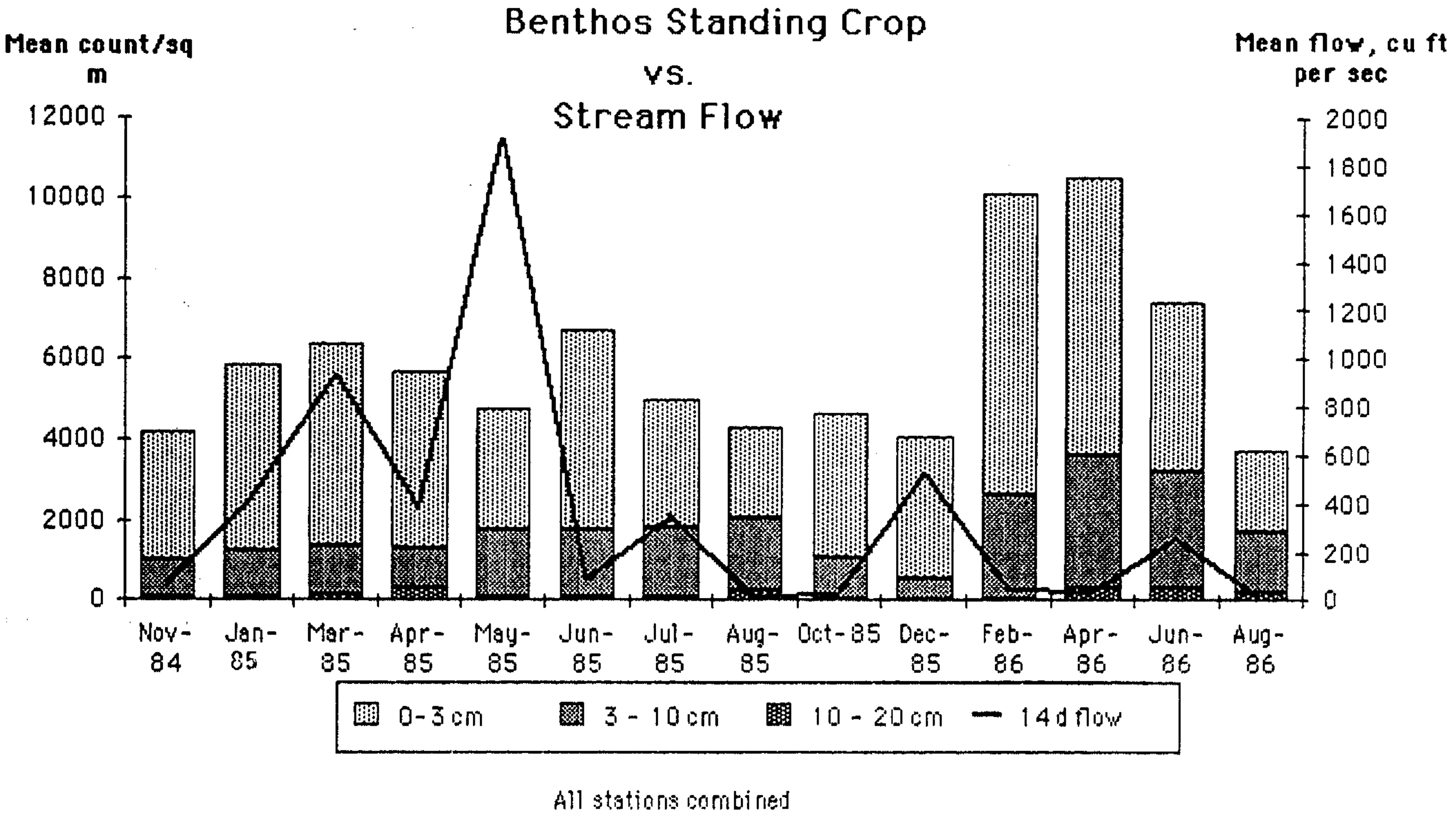
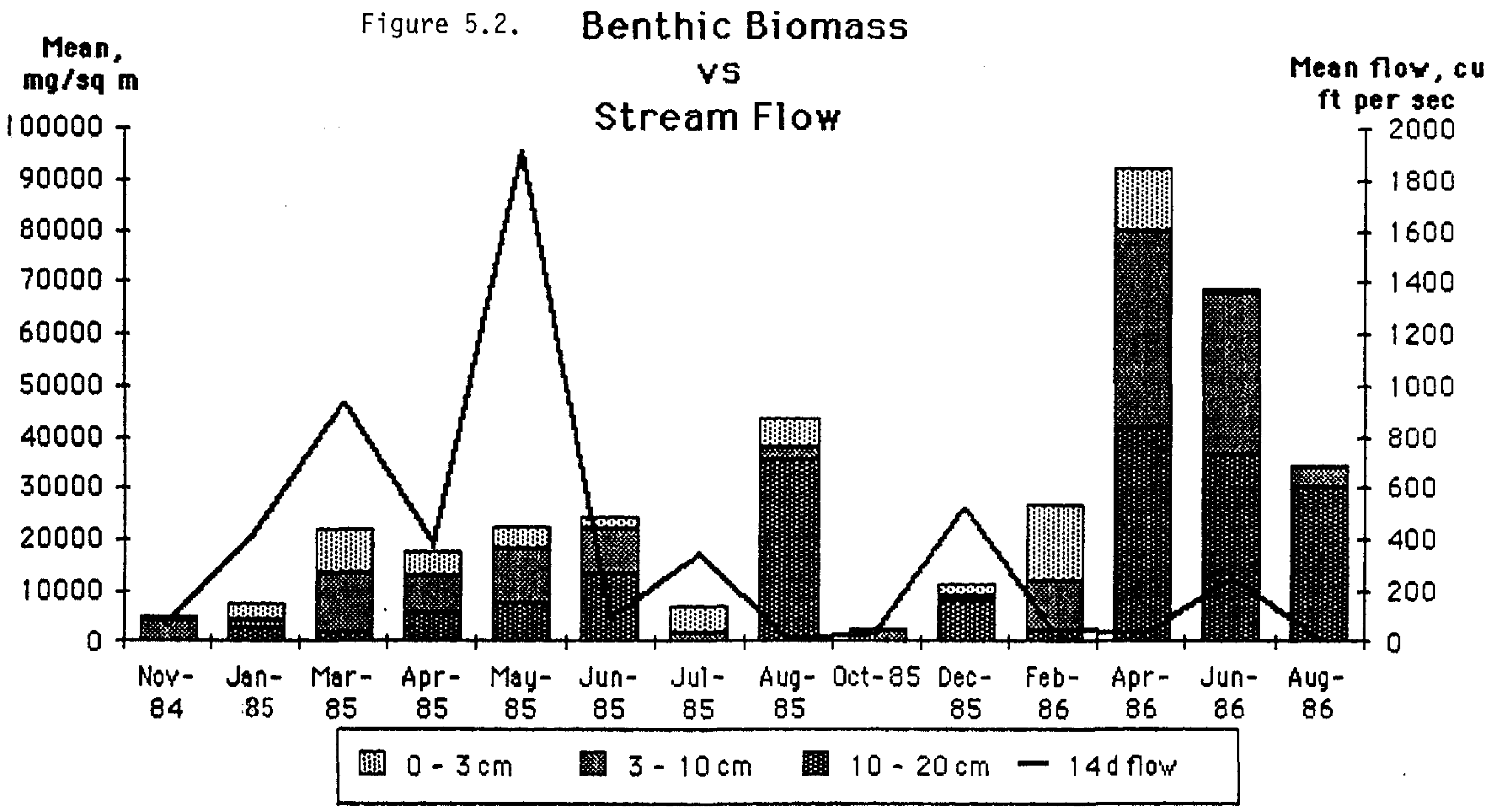


Figure 5.1. Benthos standing crop average abundance/m^2 vs 14 day average stream flow by sampling trip from November 1984 through August 1986. Stippling denotes abundance by sediment depth: 0-3, 3-10, and 10-20.

Figure 5.2.



All stations combined

Figure 5.2. Benthos biomass vs 14 day average streamflow by sampling trip from November 1984 through August 1986. Stippling denotes biomass wet weight (mg/m^2) by sediment depth: 0-3, 3-10, and 10-20 cm.

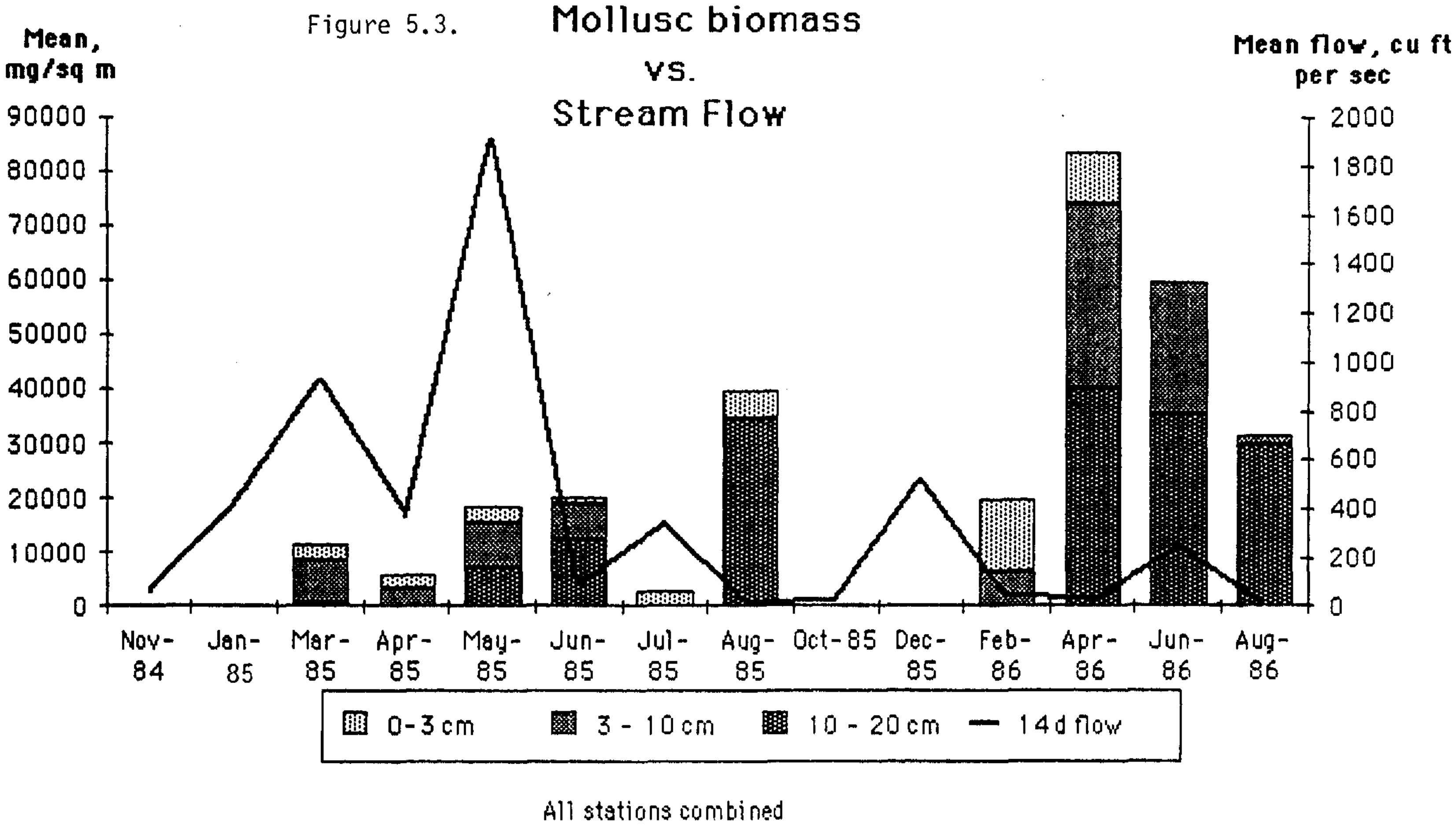


Figure 5.3. Mollusc biomass vs 14 day average streamflow by sampling trip. Stippling denotes wet weight (mg/m^2) by sediment depth: 0-3, 3-10, and 10-20 cm.

Figure 5.4.

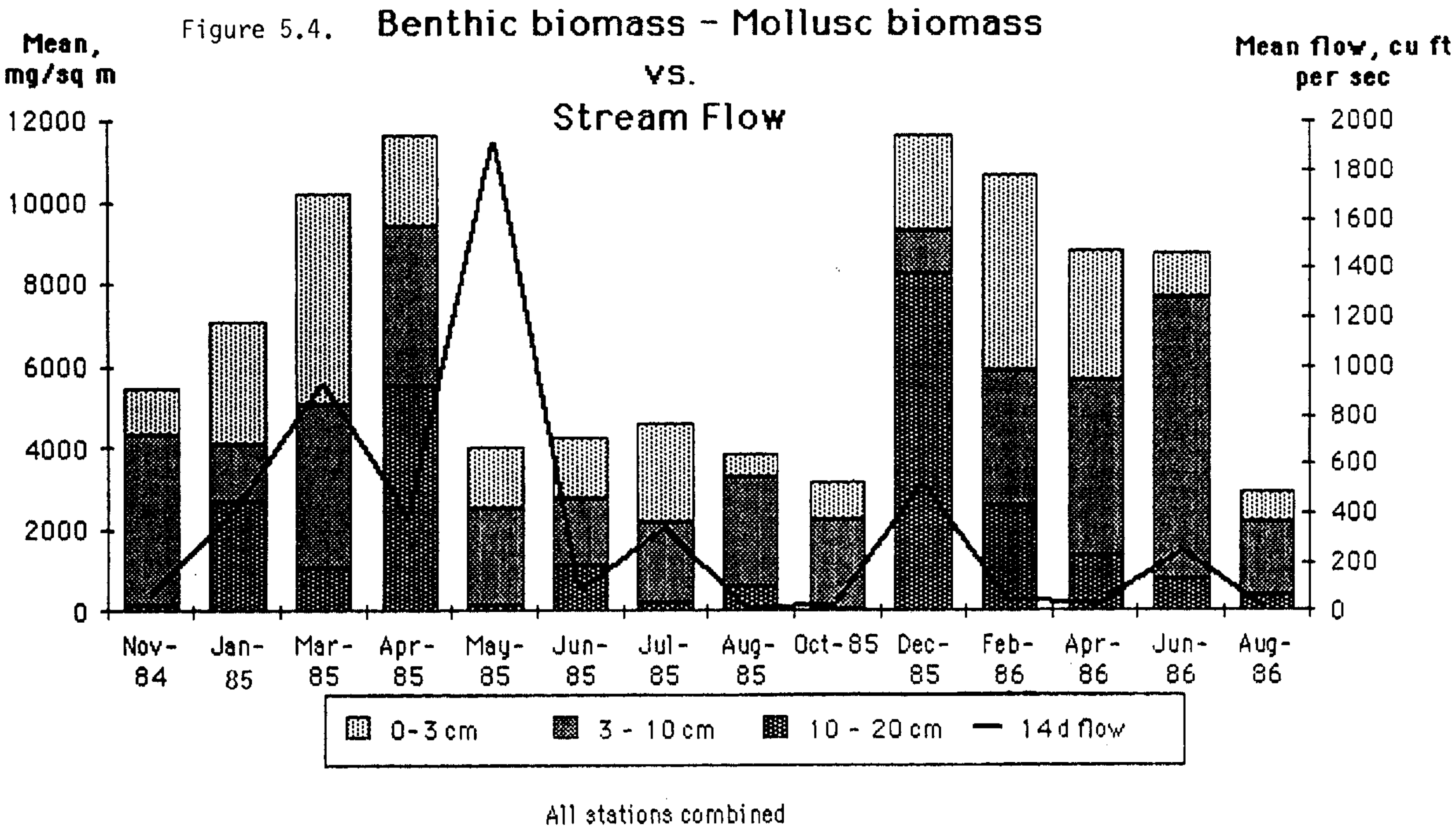


Fig. 5.4. Benthos biomass minus mollusc biomass vs 14 day average streamflow by sampling trip from November 1984 through August 1986. Stippling denotes biomass wet weight (mg/m^2): by sediment depth: 0-3, 3-10, and 10-20 cm.

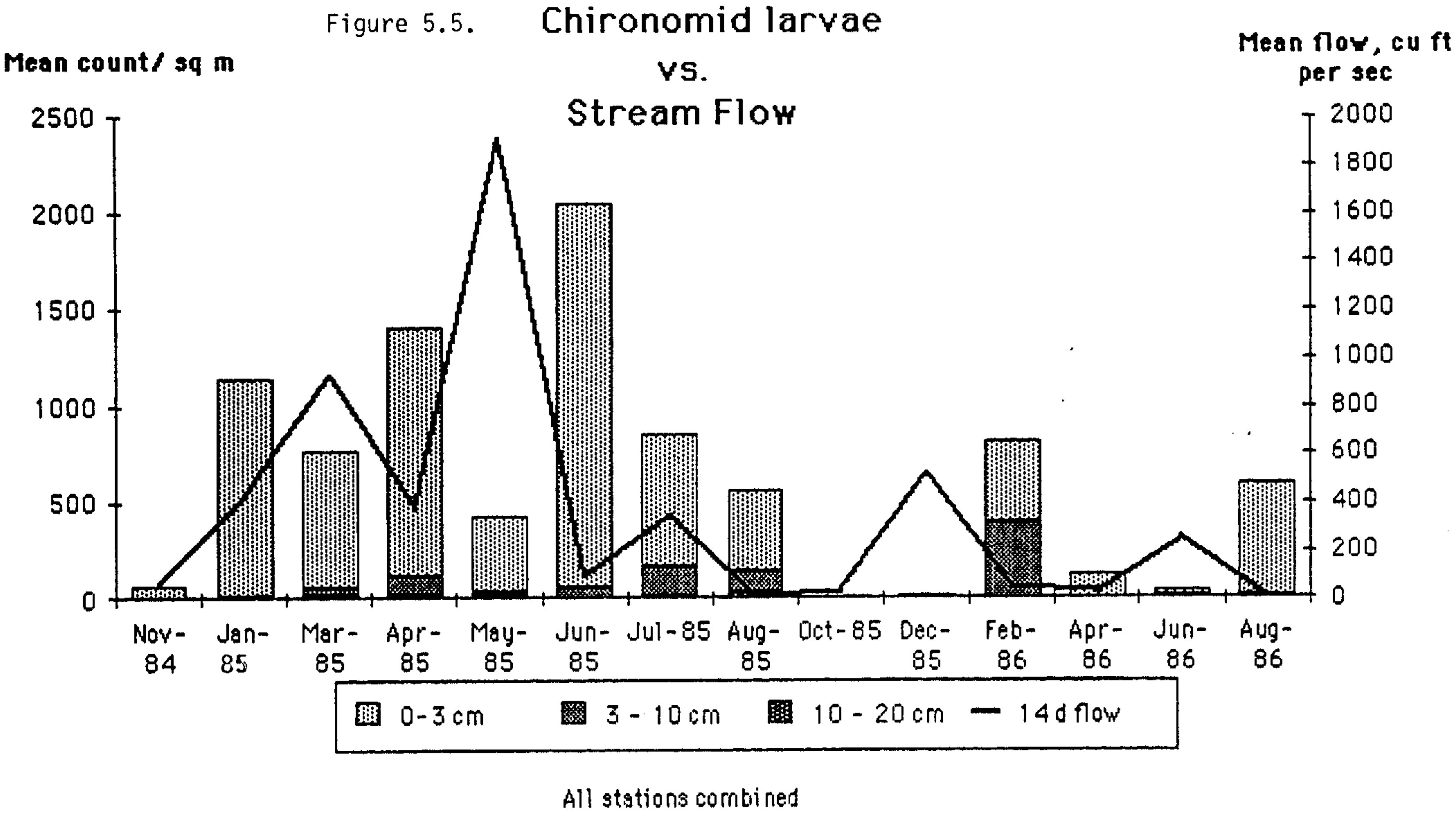


Figure 5.5. Chironomid average abundance/m^2 vs 14 day average streamflow by sampling trip from November 1984 through August 1986. Stippling denotes abundance by sediment depth: 0-3, 3-10, and 10-20 cm.

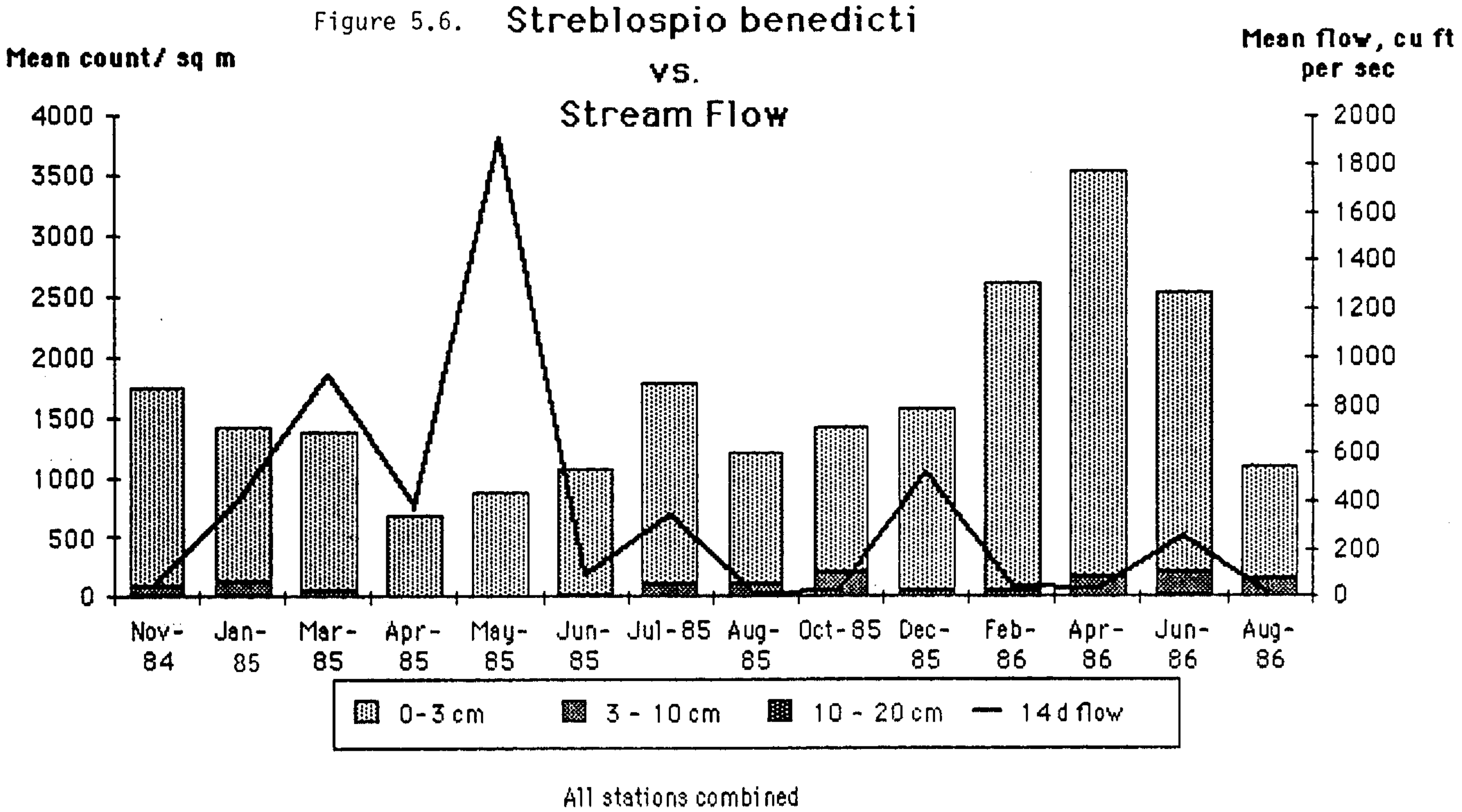


Figure 5.6. *Streblospio benedicti* average abundance/m^2 vs 14 day average streamflow by sampling trip from November 1984 through August 1986. Stippling denotes abundance by sediment depth: 0-3, 3-10, and 10-20 cm.

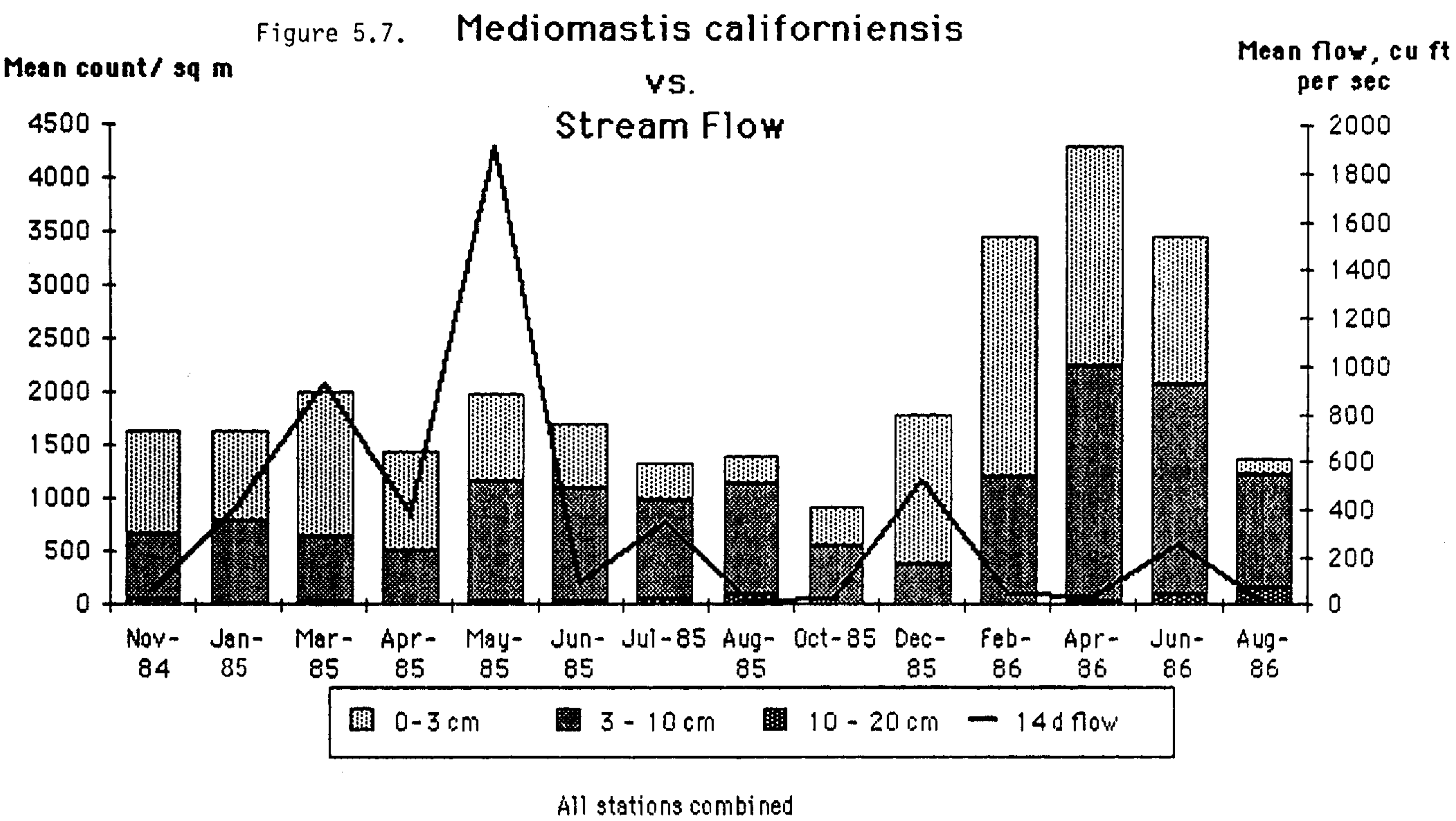


Figure 5.7. *Mediomastis californiensis* average abundance/m^2 vs 14 day average streamflow by sampling trip from November 1984 through August 1986. Stippling denotes abundance by sediment depth: 0-3, 3-10, and 10-20 cm.

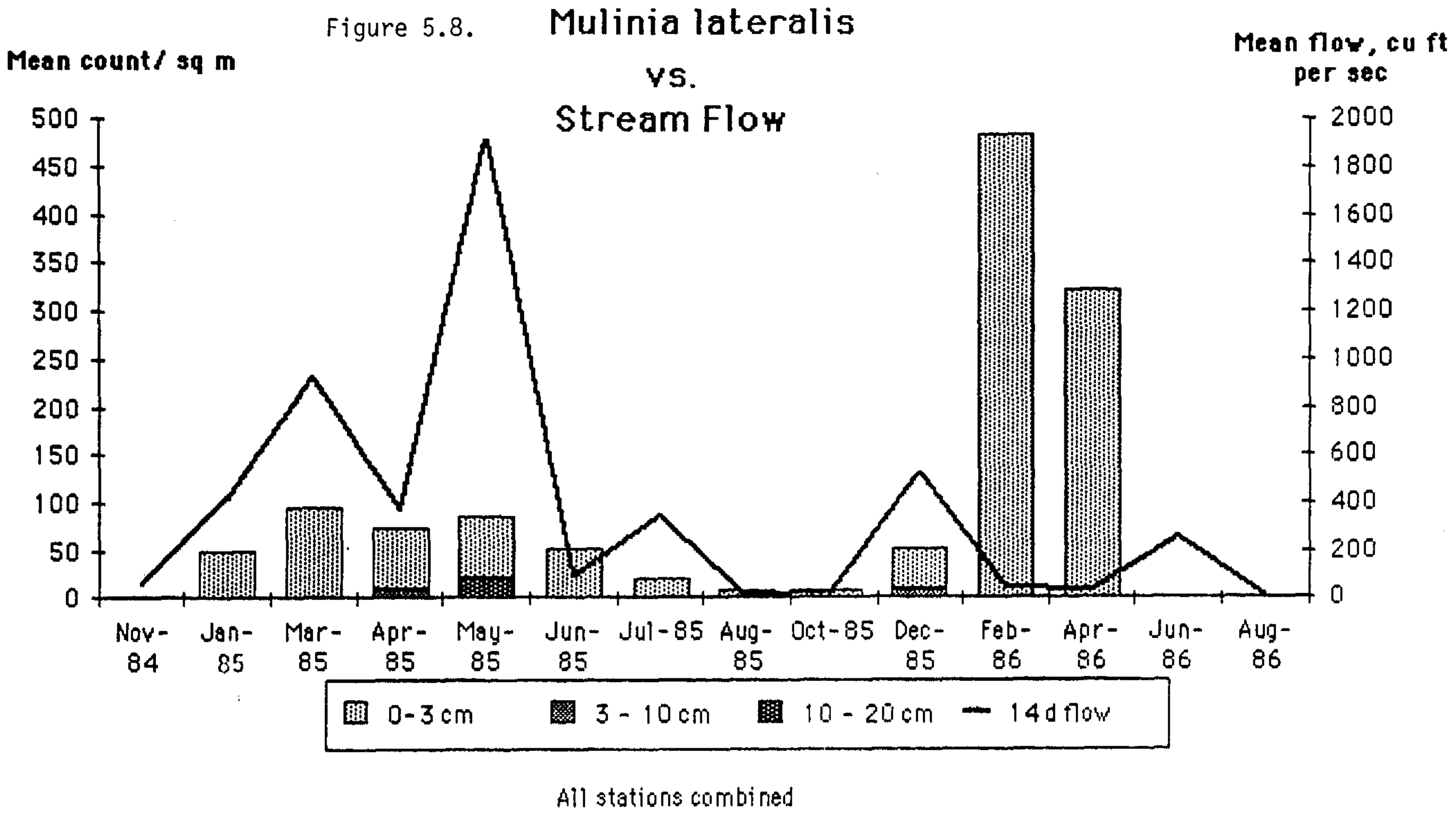


Figure 5.8. *Mulinia lateralis* average abundance/m^2 vs 14 day average streamflow by sampling trip from November 1984 through August 1986. Stippling denotes abundance by sediment depth: 0-3, 3-10, and 10-20 cm.

Figure 5.9.

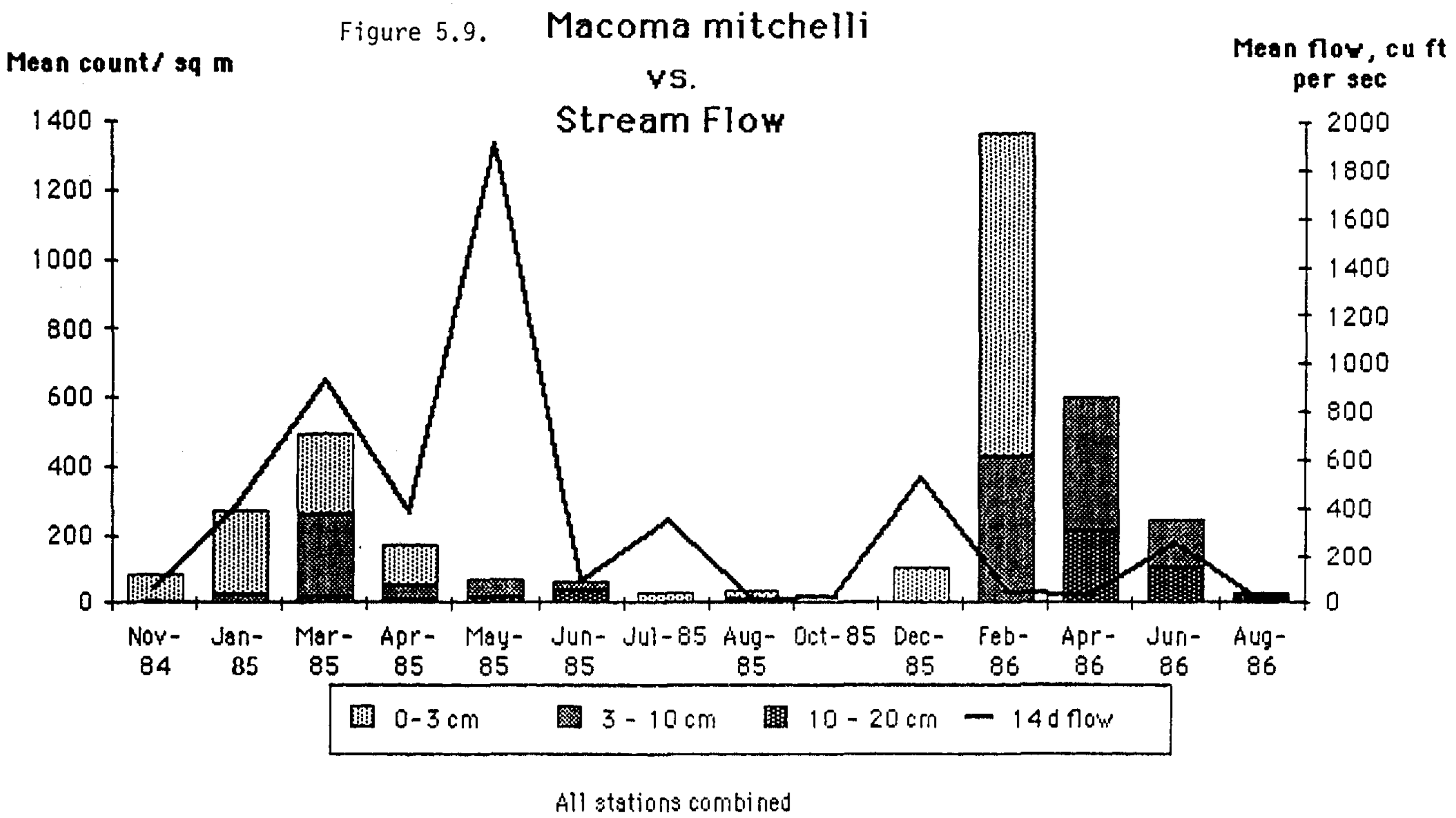


Figure 5.9. *Macoma mitchelli* average abundance/m^2 vs 14 day average streamflow by sampling trip from November 1984 through August 1986. Stippling denotes abundance by sediment depth: 0-3, 3-10, and 10-20 cm.

Table 5.1. Lavaca Bay Macrobenthos Species List, November 1984-August 1986

PHYLUM PLATYHELMINTHES
Flatworms (unidentified)

PHYLUM NEMERTINIA (=Rynchocoela)
Nemerteans (unidentified)

PHYLUM MOLLUSCA
Class Gastropoda
Pyramidellidae
Odostomia laevigata
Odostomia cf. *gibbosa*

Acteonidae
Acteon punctostriatus

Class Pelicypoda
Solenidae
Ensis minor

Tellinidae
Macoma mitchelli
Macoma tenta
macoma sp.

Mactridae
Mulinia lateralis
Rangia cuneata

Solecurtidae
Congeria leucophaeta
Tagelus plebius

PHYLUM ANNELIDA
Class Polychaeta
Phyllodicidae
Eteone heteropoda
Pilargiidae
Sigambra tentaculata
Ancistrosyllis jonesi
Loandalia americana
Parandalia sp.
Pilargidae unidentified

Hesionidae
Gyptis vittata

Neriidae
Nereid juvenile
Laeoneris culveri
Neanthes succinia

Glyceridae
Glycera capitata

Spionidae
Polydora socialis
Streblospio benedicti
Scolelepis texana

Cossuridae
Cossura delta

Orbinidae
Haploscloplos foliosus

Capitellidae
Capitella capitata
Mediomastus californiensis
Heteromastus filiformis

Ampharetidae
Hobsonia florida

Class Oligochaeta
Oligochaetes (unidentified)

Class Hirudinea
Leeches (unidentified)

PHYLUM ARTHROPODA

Class Crustacea
Subclass Copepoda

Order Cyclopoida
Cyclopidae
Hemicyclops sp.

Lichomolgidae
Cyclopoid copepod (commensal)

Subclass Malacostraca
Order Mysidacea
Mysidopsis sp. juvenile
Mysidopsis almrya

Order Cumacea
Cyclaspis varians
Cumacean unidentified

Order Tanaidacea
Tanaidae
Leptochelia rapax

Order Isopoda
    Idoteidae
        Edotea montosa

Order Amphipoda
    Ampeliscidae
        Ampelisca abdita

    Oedicerotidae
        Monoculodes nyei

    Corophiidae
        Corophium louisianum

Order Decapoda
    suborder Reptantia
    Callianassidae
        Callianassa juvenile
        Callianassa jamaicense
        Callianassa latispina

    Portunidae
        Callinectes sapidus

Class Insecta
        Insect larva (unidentified)
Order Diptera
    Chironomidae
        Chironomid larva
        Chironomid pupa

Table 5.2. Pearson correlation coefficients (r values) for Lavaca Bay benthos monthly means for all stations and sampling trips, r values without * indicates the correlation is not significant.

	Lavaca River x 14 day Stream Flow	$\bar{x}$ 14 day Lag Flow	$\bar{x}$ Salinity by Trip	$\bar{x}$ Temp. by Trip
Lag Flow	-0.04769			
$\bar{x}$ Salinity	-0.55474*	-0.39186		
$\bar{x}$ Temperature	-0.13715	0.18238	0.35454	
Standing crop/m^2	-0.18115	0.11435	0.50946	0.11346
Total Biomass/m^2	-0.18946	-0.11796	0.70820**	0.41330
Mollusc Biomass/m^2	-0.20574	-0.11272	0.73330**	0.47492
Total Biomass minus Mollusc Biomass	0.10491	-0.05955	-0.10174	-0.44063
Chironomid Larvae	-0.02554	0.84126***	-0.48240	0.07840
Streblospio benedicti	-0.35877	-0.38948	0.74885**	0.02836
Mediomastus californiensis	-0.07520	-0.14925	0.55725*	0.03951
Mulinia lateralis	-0.08770	0.03833	0.33979	-0.08005
Macoma mitchelli	-0.12045	-0.01789	0.25877	-0.20552
Hobsonia florida	0.27929	0.78998***	-0.46502	0.13728
Laeonereis culveri	-0.29870	-0.44134	0.82217**	0.26598

* $.05 \leq P < 0.01$
** $0.01 \leq P < 0.001$
*** $0.001 \leq P < 0.0001$

Table 5.3. **Benthos standing crop** **Individuals/m^2**

Totals

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	1285	10042	4984	6116	1435	10269	6040	3549	5465	3226
603	5889	2794	3549	7777	2417	5437	1360	1133	3795	2377
65	4229	4530	6795	5437	7701	9287	7551	5588	6390	1631
613	378	1057	2718	1586	1813	4229	4833	2945	2445	1394
85	8533	8985	7702	6116	7551	8079	7475	5814	7532	1100
623	5134	7853	13214	7777	11024	7550	6720	8305	8447	2324
633	0	0	5739	5210	1588	2190	1284	2794	2351	2095
Average	3635	5037	6386	5717	4790	6720	5038	4304	**5203**	
s.d.	3189	3981	3474	2090	3894	2889	2700	2404		**3094**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	1511	1058	6041	5890	2719	4758	3663	2196
603	1511	3247	3020	7248	2114	906	3008	2258
65	5966	5892	12005	14422	12534	2719	8923	4673
613	1963	2039	11476	7778	6871	2719	5474	3873
85	3549	2114	6040	14572	7626	5814	6619	4358
623	17668	9061	16988	9967	9438	6871	11666	4516
633	680	5437	15629	13968	10721	2416	8142	6204
Average	4693	4121	10171	10549	7432	3743	**6785**	
s.d.	5987	2822	5269	3730	3910	2122		**4837**

0 - 3 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	982	9664	4908	5663	1208	10193	3775	2492	4861	3419
603	5436	2492	3247	7399	2341	4606	755	831	3388	2323
65	3096	3171	4530	4606	5587	8532	5814	3171	4813	1850
613	227	755	1963	755	1133	2492	3851	1737	1614	1106
85	4757	7248	6569	4379	3096	4983	4228	2567	4728	1708
623	4681	4379	9589	5889	6418	2114	2643	2567	4785	2701
633			4153	2114	1135	1435	1284	2265	2064	1120
Average	3197	4618	4994	4401	2988	4908	3193	2233	**3813**	
s.d.	2163	3286	2475	2286	2198	3338	1761	750.9		**2438**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	1435	831	3096	5512	2341	4304	2920	1765
603	906	2794	2718	6342	1510	755	2504	2072
65	4153	3929	7248	8381	10344	1661	5953	3244
613	1661	1888	7248	4002	2416	1133	3058	2275
85	2341	1812	4832	7701	2643	1510	3473	2379
623	14345	8305	14647	4379	4455	2869	8167	5223
633	529	5361	12835	12080	5587	1963	6393	5091
Average	3624	3560	7518	6914	4185	2028	**4638**	
s.d.	4873	2575	4638	2789	3056	1205		**3766**

Table 5.3 (Cont.) **Benthos standing crop** **Individuals/m^2**

3-10 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	227	227	76	302	227	76	2114	1057	538.3	754.4
603	302	302	302	378	76	755	529	302	368.3	213.5
65	906	1208	1661	453	2114	604	1661	2190	1350	687.5
613	151	302	604	831	604	1586	906	1057	755.1	410.1
85	3398	1586	1133	1586	4228	2869	2869	2794	2558	1069
623	453	3247	3398	1586	4304	5134	4077	4681	3360	1173
633			1586	1510	453	755	0	378	780.3	641.9
Average	906.2	1145	1251	949.4	1715	1683	1737	1780	**1410**	
s.d.	1250	1173	1126	595.9	1867	1770	1418	1571		**1356**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	76	151	2869	302	302	378	679.7	1078
603	529	453	302	906	604	151	490.8	260.5
65	1586	1963	4379	5965	2114	982	2832	1921
613	302	151	4228	2945	2869	906	1900	1676
85	1208	302	1208	6418	4681	3851	2945	2405
623	3247	680	2341	4908	4681	3700	3260	1577
633	151	0	2794	1586	5134	453	1686	1992
Average	1014	528.6	2589	3290	2912	1489	**1970**	
s.d.	1134	671.1	1484	2490	1999	1590		**1872**

10-20 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	76	151	0	151	0	0	151	0	66.13	80.71
603	151	0	0	0	0	76	76	0	37.88	37.08
65	227	151	604	378	0	151	76	227	226.8	204.5
613	0	0	151	0	76	151	76	151	75.63	67.9
85	378	151	0	151	227	227	378	453	245.6	151.1
623	0	227	227	302	302	302	0	1057	302.1	331.5
633	0	0	0	1586	0	0	0	151	217.1	592.6
Average	118.9	97.14	140.3	366.9	86.43	129.6	108.1	291.3	**167.3**	
s.d.	143.8	94.76	224.1	555.7	126.6	113	129.8	371		**268.1**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	76	76	76	76	76	63.33	31.03
603	76	0	0	0	0	0	12.67	31.03
65	227	0	378	76	76	76	138.8	138.6
613	0	0	0	831	1586	680	516.2	643.4
85	0	0	0	453	302	453	201.3	227.3
623	76	76	0	680	302	302	239.3	250.1
633	0	76	0	302	0	0	63	121
Average	54.14	32.57	64.86	345.4	334.6	226.7	**176.4**	
s.d.	84.22	40.62	141	322.9	566.5	261.6		**307**

Table 5.4. **Benthic biomass** **µg wet wt/m^2**

Totals

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	6349	10601	1925	2915	7717	3413	3020	687	4578	3522
603	5373	3277	2870	6946	1133	1488	816	506	2801	2243
65	14783	3775	13567	26727	19337	4093	4402	3904	11324	9283
613	348	2363	30379	6130	3043	27911	2454	3095	9465	12638
85	3254	8623	13492	11975	30834	1E+05	4952	1570	22757	37272
623	3142	17811	55546	36685	46720	9951	28222	3E+05	57720	88796
633	0	0	36927	33235	48781	19902	8985	34294	22766	17138
Average	4750	6636	22101	17802	22509	24873	7550	43963	**18773**	
s.d.	5006	6142	19709	14048	20043	37636	9468	97642		**38309**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	2024	9017	27730	26063	3587	1986	11735	12035
603	1035	959	1948	4138	2159	747	1831	1266
65	2250	33234	12949	1E+05	81337	34300	45207	40726
613	763	1578	18905	1E+05	3E+05	29679	74385	1E+05
85	1314	1057	46236	1E+05	1E+05	2E+05	75457	70215
623	14068	20506	39713	1E+05	13643	6200	39964	53014
633	816	16482	40555	96745	23496	890	29831	36029
Average	3181	11833	26862	92865	68970	34925	**39773**	
s.d.	4835	12263	16362	56269	90819	61499		**57529**

0 - 3 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	1306	2514	1895	2069	1601	3224	1155	498	1783	889.9
603	1344	2205	1435	6463	944	1050	619	317	1797	2118
65	438	2522	6251	3179	17418	3058	3352	1933	4769	5478
613	8	1638	8129	2008	491	8818	1510	664	2908	3565
85	1336	7694	10094	6146	3835	2469	732	672	4122	3597
623	2575	4047	17207	6070	2643	566	21238	35598	11243	12809
633			14058	6584	1963	264	8985	461	5386	5510
Average	1168	3437	8438	4646	4128	2778	5370	5735	**4542**	
s.d.	887.3	2233	5887	2125	5963	2917	7590	13180		**6348**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	355	644	6922	17546	657	1102	4538	6847
603	589	642	1608	2356	287	619	1017	794.6
65	1019	1389	7943	6644	2711	1450	3526	3002
613	559	1434	6455	1993	642	196	1880	2335
85	385	853	26863	4409	914	619	5674	10488
623	2977	8396	27475	2401	1155	914	7220	10290
633	544	4153	24458	54519	1699	649	14337	21717
Average	918.3	2502	14532	12838	1152	792.7	**5456**	
s.d.	933.4	2872	11193	19172	820.5	404		**10432**

Table 5. 4(Cont.) **Benthic biomass** **µg wet wt/m^2**

3-10 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	4590	914	30	793	6116	189	581	189	1675	2167
603	4021	1072	1435	453	189	166	189	189	964.3	516.4
65	14322	951	7029	17093	1896	1012	1050	740	5512	6085
613	340	725	16157	4122	2446	1253	649	2242	3492	5520
85	1465	838	3398	5640	3050	31937	4062	196	6323	11144
623	559	4832	30766	446	13877	4115	6946	10230	8971	10067
633			22869	23805	46818	19638	0	4916	19674	16547
Average	4216	1555	11669	7479	10627	8330	1925	2672	**6177**	
s.d.	5259	1609	11835	9284	16584	12513	2604	3754		**9695**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	1669	2778	2356	2741	1865	378	1965	898
603	446	272	340	1782	1835	68	790.5	798.3
65	1231	1744	5006	77795	76957	15749	29747	37263
613	189	144	12450	40060	80483	748	22346	32379
85	929	151	19373	92563	23911	4825	23625	35186
623	10676	1872	12238	12095	11982	4908	8962	4457
633	272	68	16097	40135	21737	241	13092	16212
Average	2202	1004	9694	38167	31253	3845	**14361**	
s.d.	3775	1105	7212	36045	33559	5667		**24358**

10-20 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	453	7173	0	53	0	0	1284	0	1120	2670
603	8	0	0	30	0	272	8	0	39.75	101
65	23	302	287	6455	23	23	0	1231	1043	2362
613	0	0	6093	0	106	17840	295	189	3065	6703
85	453	91	0	189	23949	72948	158	702	12311	27454
623	8	8932	7573	30169	30200	5270	38	2E+05	37506	78089
633			0	2846	0	0	0	28917	5294	11629
Average	157.5	2750	1993	5677	7754	13765	254.7	35556	**8749**	
s.d.	229	4147	3335	11063	13321	26899	466.9	81086		**31475**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	5595	18452	5776	1065	506	5232	6961
603	0	45	0	0	37	60	23.67	26.96
65	0	30101	0	22733	1669	17101	11934	13142
613	15	0	0	99449	2E+05	28735	50160	71366
85	0	53	0	31808	79856	2E+05	46158	66192
623	415	10238	0	1E+05	506	378	23783	52753
633	0	12261	0	2091	60	0	2402	4901
Average	61.43	8328	2636	41859	36565	30287	**19956**	
s.d.	156	10856	6974	52271	66918	60551		**43649**

Table 5.5. **Mollusc biomass** **µg wet wt/m^2**

Totals

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	0	0	0	0	0	0	0	0	0	0
603	0	0	324.7	0	0	0	0	0	40.58	122.7
65	0	226.5	3035	9226	15681	566.3	0	1125	3733	5979
613	0	2001	23669	5187	1865	25783	0	0	7313	11331
85	52.85	883.4	6674	9596	26621	98429	45.3	105.7	17801	35683
623	7.55	649.3	21216	3299	38890	173.7	19728	3E+05	41941	90890
633	0	0	28101	15440	46697	19132	709.7	27573	17206	16475
Average	8.629	537.1	11860	6107	18536	20583	2926	40053	**12576**	
s.d.	19.7	734.5	12036	5662	19347	35948	7414	93824		**36497**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	0	0	14028	0	0	2338	5727
603	0	0	0	286.9	0	0	47.82	117.1
65	0	211.4	6667	93809	75039	31582	34551	40768
613	0	75.5	13643	1E+05	2E+05	27165	70187	1E+05
85	0	52.85	36572	1E+05	98301	2E+05	69879	68050
623	0	0	22975	1E+05	0	0	26487	54405
633	0	717.3	59230	91529	528.5	75.5	25347	40079
Average	0	151	19869	84003	60175	31947	**32691**	
s.d.	0	260.8	21758	55390	92314	60212		**57147**

0 - 3 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	0	0	0	0	0	0	0	0	0	0
603	0	0	324.7	0	0	0	0	0	40.58	122.7
65	0	226.5	2673	1374	15681	566.3	0	1102	2703	5623
613	0	1442	1548	1774	0	7960	0	0	1593	2832
85	52.85	883.4	6674	4545	2718	0	45.3	105.7	1878	2626
623	7.55	0	4100	3299	98.15	173.7	19728	34632	7755	13333
633			7777	5670	0	30.2	709.7	196.3	2397	3426
Average	10.07	425.3	3299	2380	2643	1250	2926	5148	**2336**	
s.d.	21.18	604.3	3035	2201	5837	2975	7414	13007		**5854**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	0	0	14028	0	0	2338	5727
603	0	0	0	286.9	0	0	47.82	117.1
65	0	0	4145	2250	0	0	1066	1757
613	0	75.5	3835	0	0	0	651.8	1560
85	0	52.85	25021	173.7	0	0	4208	10196
623	0	0	16738	302	0	0	2840	6810
633	0	717.3	44553	50419	317.1	75.5	16014	24450
Average	0	120.8	13470	9637	45.3	10.79	**3881**	
s.d.	0	264.8	16598	18682	119.9	28.54		**11082**

Table 5.5 (Cont.) **Mollusc biomass** **µg wet wt/m^2**

3-10 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	0	0	0	0	0	0	0	0	0	0
603	0	0	0	0	0	0	0	0	0	0
65	0	0	362.4	7218	0	0	0	15.1	949.4	2708
613	0	558.7	16029	3413	1865	0	0	0	2733	5832
85	0	0	0	5051	0	28048	0	0	4137	10454
623	0	649.3	17116	0	9007	0	0	0	3347	6734
633			20325	9770	46697	19102	0	0	15982	17444
Average	0	201.3	7690	3636	8224	6736	0	2.157	**3430**	
s.d.	0	313.2	9567	3919	17281	11790	0	5.707		**8611**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	0	0	0	0	0	0	0
603	0	0	0	0	0	0	0	0
65	0	52.65	2522	69241	75039	14481	26889	35505
613	0	0	9807	33779	76527	0	20019	30624
85	0	0	11552	88690	19064	0	19884	34613
623	0	0	6236	6055	0	0	2049	3174
633	0	0	14677	39388	211.4	0	9046	15974
Average	0	7.55	6399	33879	24406	2069	**11127**	
s.d.	0	19.98	5826	35011	35780	5473		**23551**

10-20 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	0	0	0	0	0	0	0	0	0	0
603	0	0	0	0	0	0	0	0	0	0
65	0	0	0	634.2	0	0	0	7.55	80.22	239.2
613	0	0	6093	0	0	17803	0	0	2987	6739
85	0	0	0	0	23903	70381	0	0	11786	26630
623	0	0	0	0	29785	0	0	2E+05	30840	80882
633			0	0	0	0	0	27376	4563	11176
Average	0	0	870.4	90.6	7670	12598	0	34903	**7276**	
s.d.	0	0	2303	239.7	13208	26330	0	80914		**31238**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	0	0	0	0	0	0	0
603	0	0	0	0	0	0	0	0
65	0	158.6	0	22318	0	17101	6596	10291
613	0	0	0	99109	2E+05	27165	49517	70754
85	0	0	0	30676	79237	2E+05	45787	66035
623	0	0	0	1E+05	0	0	21598	52904
633	0	0	0	1721	0	0	286.9	702.8
Average	0	22.65	0	40487	35723	29868	**17684**	
s.d.	0	59.93	0	52572	66492	60481		**43778**

Table 5.6. **Benthic biomass - mollusc biomass µg wet wt/m^2**

Totals

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	6349	10601	1925	2915	7717	3413	3020	687	4578	3522
603	5373	3277	2545	6946	1133	1488	816	506	2761	2236
65	14783	3549	10532	17501	3656	3527	4402	2779	7591	5494
613	348	362.3	6710	943.2	1759	2128	2454	3095	2225	2072
85	3201	7740	6818	2379	4213	8925	4907	1464	4956	2766
623	3134	17162	34331	33386	7830	9777	8494	12117	15779	11539
633	0	0	8826	17795	2084	770.3	8275	6721	5559	6200
Average	4741	6099	10241	11695	4056	4290	4624	3910	**6207**	
s.d.	5009	6190	11068	11856	2755	3602	2893	4186		**6994**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	2024	9017	23730	12035	3587	1986	8730	8401
603	1035	959	1948	3851	2159	747	1783	1163
65	2250	33023	6282	13363	6298	2718	10656	11657
613	763	1503	5262	8614	6531	2514	4198	3098
85	1314	1004	9664	9241	6380	5867	5578	3740
623	14068	20506	16738	9710	13643	6200	13478	5051
633	816	15765	11325	5216	22968	814.5	9484	8867
Average	3181	11682	10707	8862	8795	2978	**7701**	
s.d.	4835	12177	7454	3407	7219	2223		**7435**

0 - 3 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	1306	2514	1895	2069	1601	3224	1155	498	1783	889.9
603	1344	2205	1110	6463	944	1050	619	317	1757	2132
65	438	2296	3578	1805	1737	2492	3352	830.7	2066	957.3
613	8	196	6581	233.8	491	837.7	1510	664	1315	2283
85	1283	6811	3420	1601	1117	2469	686.7	566.3	2244	2201
623	2567	4047	13107	2771	2545	392.4	1510	966.2	3488	4359
633			6282	914	1963	233.8	8275	264.7	2989	3440
Average	1158	3011	5139	2265	1485	1528	2444	586.7	**2207**	
s.d.	883.1	2229	4063	2022	688.6	1180	2728	256.3		**2398**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	355	644	2922	3518	657	1102	1533	1342
603	589	642	1608	2069	287	619	969	701.1
65	1019	1389	3798	4394	2711	1450	2460	1403
613	559	1359	2620	1993	642	196	1228	937.5
85	385	800.2	1842	4235	914	619	1466	1445
623	2977	8396	10737	2099	1155	914	4380	4150
633	544	3436	9905	4100	1382	573.5	3323	3550
Average	918.3	2381	4776	3201	1107	781.9	**2194**	
s.d.	933.4	2824	3863	1107	793.6	409.5		**2431**

Table 5.6.(Cont) Benthic biomass - mollusc biomass µg wet wt/m^2

3-10 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	4590	914	30	793	6116	189	581	189	1675	2167
603	4021	1072	1435	453	189	166	189	189	964.3	516.4
65	14322	951	6667	9875	1896	1012	1050	724.9	4562	3625
613	340	166.3	128.4	709.4	581.2	1253	649	2242	758.7	731.9
85	1465	838	3398	589.1	3050	3889	4062	196	2186	1678
623	559	4183	13650	446	4870	4115	6946	10230	5625	4386
633			2544	14035	121.3	536.5	0	4916	3692	5406
Average	4216	1354	3979	3843	2403	1594	1925	2670	**2747**	
s.d.	5259	1422	4831	5672	2380	1694	2604	3755		**3677**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	1669	2778	2356	2741	1865	378	1965	898
603	446	272	340	1782	1835	68	790.5	798.3
65	1231	1691	2484	8554	1918	1268	2858	2829
613	189	144	2643	6281	3956	748	2327	2458
85	929	151	7822	3873	4847	4825	3741	2824
623	10676	1872	6002	6040	11982	4908	6913	3765
633	272	68	1420	746.6	21526	241	4046	8577
Average	2202	996.6	3295	4288	6847	1777	**3234**	
s.d.	3775	1099	2647	2788	7398	2147		**4114**

10-20 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	453	7173	0	53	0	0	1284	0	1120	2670
603	8	0	0	30	0	272	8	0	39.75	101
65	23	302	287	5821	23	23	0	1224	962.8	2126
613	0	0	0.15	0	687.2	37.1	295	189	151.1	254.2
85	453	91	0	189	45.7	2567	158	702	525.7	925.7
623	8	8932	7573	30169	415.3	5270	38	920.8	6666	10567
633			0	2846	0	0	0	1541	731.1	1206
Average	157.5	2750	1123	5587	167.3	1167	254.7	653.7	**1484**	
s.d.	229	4147	2846	11058	274.3	2037	466.9	613.2		**4482**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	5595	18452	5776	1065	506	5232	6961
603	0	45	0	0	37	60	23.67	26.96
65	0	29942	0	415.2	1669	0	5338	12071
613	15	0	0	340.1	1933	1570	643	875.9
85	0	53	0	1132	618.8	423	371.2	451.7
623	415	10238	0	1571	506	378	2185	3980
633	0	12261	0	369.6	60	0	2115	4973
Average	61.43	8305	2636	1372	841.2	419.6	**2273**	
s.d.	156	10803	6974	2015	746.7	549.9		**5750**

Lavaca Bay

Table 5.7. **Chironomid larvae** **Individuals/m^2**

Totals

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	151	5965	3171	3398	830.5	8909	3775	2341	3567	2641
603	75.5	528.5	377.5	2945	981.5	1812	604	755	1010	924.1
65	226.5	226.5	1208	830.5	679.5	1888	679.5	679.5	802.2	528
613	0	75.5	604	0	226.5	1359	906	226.5	424.7	498.6
85	0	0	0	151	151	0	0	0	37.75	73.68
623	0	75.5	75.5	2039	75.5	75.5	0	0	292.6	752.3
633	0	0	0	528.5	75.5	302	75.5	0	122.7	201.8
Average	64.71	981.5	776.6	1413	431.4	2049	862.9	571.6	**893.9**	
s.d.	91.73	2205	1141	1378	386.7	3130	1335	844		**1604**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	75.5	4757	377.5	0	4002	1535	2220
603	0	0	0	151	0	151	50.33	77.98
65	0	0	830.5	151	0	75.5	176.2	326.2
613	0	75.5	151	151	151	0	88.08	74.23
85	0	0	0	0	0	0	0	0
623	0	0	0	151	151	0	50.33	77.98
633	0	0	0	0	75.5	0	12.58	30.82
Average	0	21.57	819.7	140.2	53.93	604	**273.2**	
s.d.	0	36.84	1762	126.6	71.81	1499		**944**

0 - 3 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	151	5889	3096	3171	831	8909	3096	1888	3379	2718
603	76	529	302	2567	906	1812	453	529	896.6	851.8
65	227	227	906	755	529	1888	680	453	707.8	536.9
613	0	76	604	0	227	906	529	76	302	340
85	0	0	0	151	151	0	0	0	37.75	73.68
623	0	76	76	1963	76	76	0	0	283.1	723.8
633			0	453	76	302	76	0	151	184.9
Average	75.5	1133	711.9	1294	399.1	1985	690.3	420.6	**847.3**	
s.d.	95.5	2338	1104	1263	356	3151	1095	684.9		**1579**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	76	2190	378	0	3926	1095	1623
603	0	0	0	151	0	151	50.33	77.98
65	0	0	604	151	0	76	138.4	236
613	0	76	151	151	76	0	75.5	67.53
85	0	0	0	0	0	0	0	0
623	0	0	0	151	151	0	50.33	77.98
633	0	0	0	0	76	0	12.58	30.82
Average	0	21.57	420.6	140.2	43.14	593.2	**203.1**	
s.d.	0	36.84	810.7	126.6	59.4	1471		**683.8**

Table 5.7 (Cont) **Chironomid larvae** **Individuals/m^2**

3-10 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	0	76	76	76	0	0	680	453	169.9	264.6
603	0	0	76	378	0	0	151	227	103.8	143.6
65	0	0	151	76	151	0	0	0	47.19	71.81
613	0	0	0	0	0	453	302	151	113.3	183.5
85	0	0	0	0	0	0	0	0	0	0
623	0	0	0	76	0	0	0	0	9.438	28.54
633			0	76	0	0	0	0	12.58	30.82
Average	0	12.58	43.14	97.07	21.57	64.71	161.8	118.6	**67.11**	
s.d.	0	30.82	59.4	128.7	57.07	171.2	255.8	173.6		**140.4**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	0	2567	0	0	76	440.4	1042
603	0	0	0	0	0	0	0	0
65	0	0	227	0	0	0	37.75	92.47
613	0	0	0	0	76	0	12.58	30.82
85	0	0	0	0	0	0	0	0
623	0	0	0	0	0	0	0	0
633	0	0	0	0	0	0	0	0
Average	0	0	399.1	0	10.79	10.79	**70.11**	
s.d.	0	0	959.7	0	28.54	28.54		**396.5**

10-20 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	0	0	0	151	0	0	0	0	18.88	57.07
603	0	0	0	0	76	0	0	0	9.438	28.54
65	0	0	151	0	0	0	0	227	47.19	94.64
613	0	0	0	0	0	0	76	0	9.438	28.54
85	0	0	0	0	0	0	0	0	0	0
623	0	0	0	0	0	0	0	0	0	0
633			0	0	0	0	0	0	0	0
Average	0	0	21.57	21.57	10.79	0	10.79	32.36	**12.58**	
s.d.	0	0	57.07	57.07	28.54	0	28.54	85.61		**43.38**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	0	0	0	0	0	0	0
603	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0
613	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0
623	0	0	0	0	0	0	0	0
633	0	0	0	0	0	0	0	0
Average	0	0	0	0	0	0	**0**	
s.d.	0	0	0	0	0	0		**0**

Table 5.7. **Streblospio benedicti** **Individuals / m^2**

Totals

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	227	982	0	378	0	0	76	0	207.6	369.1
603	4153	1510	2341	1888	1284	1208	151	0	1567	858
65	76	76	76	227	227	1133	4002	1737	943.8	1440
613	227	76	0	227	680	1208	3624	1888	990.9	1304
85	1661	2794	1133	906	1359	2643	2869	1208	1821	877.1
623	4153	3096	4228	755	2492	1435	1359	1963	2435	1186
633			1963	529	151	0	529	1737	817.9	829
Average	1749	1422	1391	701	884	1089	1801	1219	**1271**	
s.d.	1949	1305	1578	583	891	907	1674	867		**1249**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	453	76	76	755	1133	0	415.3	454.9
603	1057	2945	2869	5512	2039	378	2466	1800
65	3247	151	453	6795	5134	982	2794	2736
613	1888	1586	5965	3775	2265	1284	2794	1781
85	831	76	755	1963	529	906	843.1	625.2
623	2341	4908	5210	3096	4606	2945	3851	1200
633	227	1359	3020	2945	2190	1208	1825	1092
Average	1435	1586	2621	3549	2556	1100	**2141**	
s.d.	1098	1805	2337	2055	1706	934		**1831**

0 - 3 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	227	982	0	378	0	0	76	0	207.6	369.1
603	3926	1435	2341	1888	1284	1208	76	0	1519	869.5
65	76	76	0	227	227	1133	3624	1661	877.7	1316
613	227	76	0	227	680	1133	3247	1586	896.6	1152
85	1359	2643	1133	906	1359	2643	2869	906	1727	894.2
623	4077	2492	4002	755	2492	1359	1359	1888	2303	1069
633			1888	529	151	0	529	1737	805.3	808.5
Average	1648	1284	1337	701	884	1068	1683	1111	**1205**	
s.d.	1881	1126	1517	583	891	901	1540	820		**1177**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	453	76	0	755	1057	0	390.1	443.9
603	604	2567	2718	5361	1359	378	2164	1842
65	2945	151	378	6116	5134	906	2605	2558
613	1661	1586	5814	3549	2265	1133	2668	1754
85	755	76	755	1812	529	906	805.3	572.3
623	1963	4908	5210	3096	3926	2190	3549	1365
633	227	1359	3020	2945	2114	1133	1799	1097
Average	1230	1532	2556	3376	2341	949	**1997**	
s.d.	991	1763	2324	1873	1647	688		**1758**

Table 5.7 (Cont.) **Streblospio benedicti** **Individuals / m^2**

3-10 cm

year 1	Nov-84	Jan85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	0	0	0	0	0	0	0	0	0	0
603	151	0	0	0	0	0	76	0	28.31	28.54
65	0	0	76	0	0	0	378	76	66.06	137.8
613	0	0	0	0	0	76	378	302	94.38	162.3
85	302	151	0	0	0	0	0	302	94.38	118.8
623	76	604	227	0	0	76	0	76	132.1	219.8
633 b			76	0	0	0	0	0	12.58	30.82
Average	88	126	54	0	0	22	119	108	**62.92**	
s.d.	121	242	84	0	0	37	179	137		**126.8**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	0	76	0	76	0	25.17	38.99
603	453	378	151	151	680	0	302	248.1
65	302	0	76	680	0	76	188.8	264.8
613	227	0	151	227	0	151	125.8	103.2
85	76	0	0	151	0	0	37.75	63.17
623	378	0	0	0	604	755	289.4	339.1
633	0	0	0	0	76	76	25.17	38.99
Average	205	54	65	173	205	151	**142**	
s.d.	183	143	68	242	301	272		**212.4**

10-20 cm

year 1	Nov-84	Jan85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	0	0	0	0	0	0	0	0	0	0
603	76	76	0	0	0	0	0	0	18.88	28.54
65	0	0	0	0	0	0	0	0	0	0
613	0	0	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0	0	0
623	0	0	0	0	0	0	0	0	0	0
633			0	0	0	0	0	0	0	0
Average	13	13	0	0	0	0	0	0	**2.796**	
s.d.	31	31	0	0	0	0	0	0		**14.39**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	0	0	0	0	0	0	0
603	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0
613	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0
623	0	0	0	0	76	0	12.58	30.82
633	0	0	0	0	0	0	0	0
Average	0	0	0	0	11	0	**1.798**	
s.d.	0	0	0	0	29	0		**11.65**

Table 5.8. **Mediomastis californiensis Individuals/m^2**

Totals

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	76	76	0	76	378	0	0	0	75.5	137.8
603	604	0	0	0	76	76	76	0	103.8	40.36
65	2341	1963	2794	2794	2643	2567	1359	1435	2237	630
613	0	680	151	529	378	453	76	151	302	225.9
85	6267	4077	5587	4077	5210	3851	4153	3700	4615	721.5
623	680	3096	4530	2039	5059	4077	3775	4530	3473	1024
633			1133	680	227	982	0	76	515.9	483.2
Average	1661	1648	2028	1456	1995	1715	1348	1413	**1658**	
s.d.	2409	1686	2312	1554	2316	1762	1654	1929		**1877**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	151	151	151	755	453	0	276.8	277.1
603	0	0	76	529	302	0	151	218.8
65	680	4757	6644	4379	6191	604	3876	2645
613	982	227	1812	1963	1586	906	1246	659.5
85	2265	1812	755	9287	5814	4379	4052	3152
623	2265	3171	7852	4832	3775	3096	4165	1997
633	151	2567	7097	8532	6267	831	4241	3517
Average	928	1812	3484	4325	3484	1402	**2572**	
s.d.	975	1809	3538	3543	2693	1677		**2713**

0 - 3 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	76	76	0	0	378	0	0	0	66.06	140.8
603	529	0	0	0	76	0	76	0	84.94	36.84
65	2039	1057	2190	2643	2492	2416	680	378	1737	954.9
613	0	453	151	151	0	0	0	0	94.38	168
85	2945	2718	4530	2567	1057	1284	1057	1208	2171	1299
623	302	755	2265	680	1586	76	680	151	811.6	784.3
633			529	453	227	453	0	76	289.4	221
Average	982	843	1381	928	831	604	356	259	**767.6**	
s.d.	1218	1002	1703	1172	932	926	440	440		**1038**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	151	151	151	680	453	0	264.3	251.5
603	0	0	0	378	151	0	88.08	154.1
65	0	3020	4228	378	4757	76	2076	2187
613	982	151	378	227	0	0	289.4	368.1
85	1208	1510	151	4606	1661	302	1573	1611
623	76	2492	5965	604	302	302	1623	2303
633	151	2567	5059	7550	2416	529	3045	2817
Average	367	1413	2276	2060	1391	173	**1280**	
s.d.	505	1308	2676	2877	1731	208		**1903**

Table 5.8 (Cont.) **Mediomastis califoroniensis Individuals/m^2**

3-10 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	0	0	0	76	0	0	0	0	9.438	28.54
603	0	0	0	0	0	76	0	0	9.438	28.54
65	302	906	378	151	151	151	604	1057	462.4	379.7
613	0	227	0	378	302	453	76	151	198.2	163.1
85	3020	1359	982	1510	4077	2492	2718	2190	2293	1044
623	378	2190	2265	1284	3247	3700	3096	3926	2510	941.7
633			604	227	0	529	0	0	226.5	278.4
Average	617	780	604	518	1111	1057	928	1046	**837.5**	
s.d.	1189	879	821	616	1762	1448	1373	1510		**1198**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	0	0	76	0	0	12.58	30.82
603	0	0	76	151	151	0	62.92	74.23
65	680	1661	2416	3851	1435	529	1762	1233
613	0	76	1435	1661	906	378	742.4	704.1
85	1057	302	604	4681	4077	3700	2403	1956
623	2190	680	1888	4228	3398	2492	2479	1231
633	0	0	2039	906	3851	302	1183	1517
Average	561	388	1208	2222	1974	1057	**1235**	
s.d.	834	614	981	1986	1762	1448		**1449**

10-20 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	0	0	0	0	0	0	0	0	0	0
603	76	0	0	0	0	0	0	0	9.438	0
65	0	0	227	0	0	0	76	0	37.75	85.61
613	0	0	0	0	76	0	0	0	9.438	28.54
85	302	0	76	0	76	76	378	302	151	149.2
623	0	151	0	76	227	302	0	453	151	167.2
633			0	0	0	0	0	0	0	0
Average	63	25	43	11	54	54	65	108	**53.13**	
s.d.	121	62	86	29	84	113	141	189		**109.4**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	0	0	0	0	0	0	0
603	0	0	0	0	0	0	0	0
65	0	76	0	151	0	0	37.75	63.17
613	0	0	0	76	680	529	213.9	307.3
85	0	0	0	0	76	378	75.5	151
623	0	0	0	0	76	302	62.92	121
633	0	0	0	76	0	0	12.58	30.82
Average	0	11	0	43	119	173	**57.52**	
s.d.	0	29	0	59	250	225		**147.1**

Table 5.9. **Hobsonia florida** **Individuals/m^2**

3-10 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	0	0	0	0	0	0	453	0	56.63	171.2
603	0	0	0	0	0	0	0	0	0	0
65	0	0	0	0	76	0	0	0	9.438	28.54
613	0	0	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0	0	0
623	0	0	76	0	151	76	0	0	37.75	59.4
633			0	0	0	0	0	0	0	0
Average	0	0	11	0	32	11	65	0	**15.38**	
s.d.	0	0	29	0	59	29	171	0		**66.21**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	0	0	0	0	0	0	0
603	0	0	0	76	0	0	12.58	30.82
65	0	0	0	0	0	0	0	0
613	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0
623	0	0	76	0	0	0	12.58	30.82
633	0	0	0	0	0	0	0	0
Average	0	0	11	11	0	0	**3.595**	
s.d.	0	0	29	29	0	0		**16.27**

10-20 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	0	0	0	0	0	0	0	0	0	0
603	0	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0	0	0
613	0	0	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0	0	0
623	0	0	0	0	0	0	0	0	0	0
633			0	0	0	0	0	0	0	0
Average	0	0	0	0	0	0	0	0	**0**	
s.d.	0	0	0	0	0	0	0	0		**0**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	0	0	0	0	0	0	0
603	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0
613	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0
623	0	0	0	0	0	0	0	0
633	0	0	0	0	0	0	0	0
Average	0	0	0	0	0	0	**0**	
s.d.	0	0	0	0	0	0		**0**

Table 5.9 (Cont.) **Hobsonia florida** **Individuals/m^2**

Totals

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	0	680	0	604	0	529	1057	0	358.6	417.8
603	0	0	0	529	76	0	0	0	75.5	197
65	0	0	0	227	227	2114	76	76	339.8	766.8
613	0	151	0	76	0	151	0	0	47.19	71.81
85	0	0	0	76	378	302	0	0	94.38	162.3
623	0	76	227	906	1133	227	0	0	320.9	460.1
633			151	151	151	76	0	0	88.08	74.23
Average	0	151	54	367	280	485	162	11	**192.9**	
s.d.	0	266	95	319	399	738	396	29		**380.1**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	76	76	76	604	0	0	138.4	231.1
603	0	0	0	76	0	0	12.58	30.82
65	0	0	0	76	0	0	12.58	30.82
613	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0
623	0	0	302	0	0	0	50.33	123.3
633	0	0	0	0	0	0	0	0
Average	11	11	54	108	0	0	**30.56**	
s.d.	29	29	113	222	0	0		**104.2**

0 - 3 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	0	680	0	604	0	529	604	0	302	325.8
603	0	0	0	529	76	0	0	0	75.5	197
65	0	0	0	227	151	2114	76	76	330.3	770
613	0	151	0	76	0	151	0	0	47.19	71.81
85	0	0	0	76	378	302	0	0	94.38	162.3
623	0	76	151	906	982	151	0	0	283.1	428.7
633			151	151	151	76	0	0	88.08	74.23
Average	0	151	43	367	248	475	97	11	**177.6**	
s.d.	0	266	74	319	348	743	225	29		**358.4**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	76	76	76	604	0	0	138.4	231.1
603	0	0	0	0	0	0	0	0
65	0	0	0	76	0	0	12.58	30.82
613	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0
623	0	0	227	0	0	0	37.75	92.47
633	0	0	0	0	0	0	0	0
Average	11	11	43	97	0	0	**26.96**	
s.d.	29	29	86	225	0	0		**99.8**

Table 5.10. **Laeonereis culveri** **Individuals/m^2**

Totals

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	76	151	0	0	76	76	0	0	47.19	59.4
603	76	0	0	0	0	0	0	0	9.438	0
65	0	0	76	76	0	0	0	76	28.31	40.36
613	76	0	0	0	0	0	0	0	9.438	0
85	76	0	0	0	0	0	0	76	18.88	28.54
623	0	151	76	227	0	0	680	453	198.2	254.2
633			0	0	227	0	76	378	113.3	156.6
Average	50	50	22	43	43	11	108	140	**58.72**	
s.d.	39	78	37	86	86	29	254	192		**125.9**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	76	151	227	1737	302	151	440.4	639.6
603	0	0	0	0	0	0	0	0
65	76	0	0	378	0	0	75.5	151
613	0	0	76	0	227	0	50.33	91.44
85	0	0	76	0	0	0	12.58	30.82
623	453	151	0	0	151	151	151	165.4
633	76	227	0	0	0	0	50.33	91.44
Average	97	76	54	302	97	43	**111.5**	
s.d.	161	97	84	648	129	74		**280.6**

0 - 3 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	76	76	0	0	0	0	0	0	18.88	28.54
603	0	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0	0	0
613	0	0	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	76	9.438	28.54
623	0	0	76	0	0	0	302	302	84.94	142.7
633			0	0	227	0	76	227	88.08	111.1
Average	13	13	11	0	32	0	54	86	**26.56**	
s.d.	31	31	29	0	86	0	113	127		**72.09**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	76	0	151	1510	151	0	314.6	589.5
603	0	0	0	0	0	0	0	0
65	76	0	0	227	0	0	50.33	91.44
613	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0
623	76	76	0	0	76	0	37.75	41.35
633	76	151	0	0	0	0	37.75	63.17
Average	43	32	22	248	32	0	**62.92**	
s.d.	40	59	57	563	59	0		**235.2**

Table 5.10 (Cont.) **Laeonereis culveri** **Individuals/m^2**

3-10 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	0	0	0	0	76	76	0	0	18.88	36.84
603	76	0	0	0	0	0	0	0	9.438	0
65	0	0	76	76	0	0	0	76	28.31	40.36
613	76	0	0	0	0	0	0	0	9.438	0
85	0	0	0	0	0	0	0	0	0	0
623	0	76	0	151	0	0	378	76	84.94	135.9
633			0	0	0	0	0	76	12.58	30.82
Average	25	13	11	32	11	11	54	32	**23.77**	
s.d.	39	31	29	59	29	29	143	40		**60.16**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	76	0	151	76	76	62.92	56.83
603	0	0	0	0	0	0	0	0
65	0	0	0	151	0	0	25.17	61.65
613	0	0	76	0	0	0	12.58	30.82
85	0	0	76	0	0	0	12.58	30.82
623	302	0	0	0	0	151	75.5	126.3
633	0	0	0	0	0	0	0	0
Average	43	11	22	43	11	32	**26.96**	
s.d.	114	29	37	74	29	59		**61.99**

10-20 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	0	76	0	0	0	0	0	0	9.438	28.54
603	0	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0	0	0
613	0	0	0	0	0	0	0	0	0	0
85	76	0	0	0	0	0	0	0	9.438	0
623	0	76	0	76	0	0	0	76	28.31	40.36
633			0	0	0	0	0	76	12.58	30.82
Average	13	25	0	11	0	0	0	22	**8.389**	
s.d.	31	39	0	29	0	0	0	37		**23.95**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	76	76	76	76	76	62.92	30.82
603	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0
613	0	0	0	0	227	0	37.75	92.47
85	0	0	0	0	0	0	0	0
623	76	76	0	0	76	0	37.75	41.35
633	0	76	0	0	0	0	12.58	30.82
Average	11	32	11	11	54	11	**21.57**	
s.d.	29	40	29	29	84	29		**45.01**

Table 5.11. **Mulinia lateralis** **Individuals/m ^2**

Totals

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	0	0	0	0	0	0	0	0	0	0
603	0	0	0	0	0	0	0	0	0	0
65	0	76	76	151	227	0	0	76	75.5	80.71
613	0	0	76	0	0	0	0	0	9.438	28.54
85	0	227	151	378	227	302	0	0	160.4	143.6
623	0	0	227	0	151	0	76	0	56.63	91.73
633			151	0	0	76	76	0	50.33	61.65
Average	0	50	97	76	86	54	22	11	**50.33**	
s.d.	0	91	84	145	111	113	37	29		**90.41**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	0	0	378	0	0	62.92	154.1
603	0	0	0	0	0	0	0	0
65	0	76	151	453	0	0	113.3	177.1
613	0	0	453	0	0	0	75.5	184.9
85	0	76	1284	151	0	0	251.7	509.1
623	0	0	151	76	0	0	37.75	63.17
633	76	227	1359	1208	0	0	478.2	631.1
Average	11	54	485	324	0	0	**145.6**	
s.d.	29	84	591	429	0	0		**340.7**

0 - 3 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	0	0	0	0	0	0	0	0	0	0
603	0	0	0	0	0	0	0	0	0	0
65	0	76	76	76	227	0	0	76	66.06	75.5
613	0	0	76	0	0	0	0	0	9.438	28.54
85	0	227	151	378	76	302	0	0	141.6	147.4
623	0	0	227	0	151	0	76	0	56.63	91.73
633			151	0	0	76	76	0	50.33	61.65
Average	0	50	97	65	65	54	22	11	**46.14**	
s.d.	0	91	84	141	92	113	37	29		**86.04**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	0	0	378	0	0	62.92	154.1
603	0	0	0	0	0	0	0	0
65	0	0	151	453	0	0	100.7	182.9
613	0	0	453	0	0	0	75.5	184.9
85	0	76	1284	151	0	0	251.7	509.1
623	0	0	151	76	0	0	37.75	63.17
633	76	227	1359	1208	0	0	478.2	631.1
Average	11	43	485	324	0	0	**143.8**	
s.d.	29	86	591	429	0	0		**341.3**

Table 5.11 (Cont) **Mulinia lateralis** **Individuals/m ^2**

3-10 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	0	0	0	0	0	0	0	0	0	0
603	0	0	0	0	0	0	0	0	0	0
65	0	0	0	76	0	0	0	0	9.438	28.54
613	0	0	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0	0	0
623	0	0	0	0	0	0	0	0	0	0
633			0	0	0	0	0	0	0	0
Average	0	0	0	11	0	0	0	0	**1.398**	
s.d.	0	0	0	29	0	0	0	0		**10.27**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	0	0	0	0	0	0	0
603	0	0	0	0	0	0	0	0
65	0	76	0	0	0	0	12.58	30.82
613	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0
623	0	0	0	0	0	0	0	0
633	0	0	0	0	0	0	0	0
Average	0	11	0	0	0	0	**1.798**	
s.d.	0	29	0	0	0	0		**11.65**

10-20 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	0	0	0	0	0	0	0	0	0	0
603	0	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0	0	0
613	0	0	0	0	0	0	0	0	0	0
85	0	0	0	0	151	0	0	0	18.88	57.07
623	0	0	0	0	0	0	0	0	0	0
633			0	0	0	0	0	0	0	0
Average	0	0	0	0	22	0	0	0	**2.796**	
s.d.	0	0	0	0	57	0	0	0		**20.55**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	0	0	0	0	0	0	0
603	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0
613	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0
623	0	0	0	0	0	0	0	0
633	0	0	0	0	0	0	0	0
Average	0	0	0	0	0	0	**0**	
s.d.	0	0	0	0	0	0		**0**

Table 5.12 **Macoma mitchilli** **Individuals/m ^2**

Totals

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	0	0	0	0	0	0	0	0	0	0
603	0	0	0	0	0	0	0	0	0	0
65	0	76	151	151	0	0	0	0	47.19	71.61
613	0	529	1435	378	76	151	0	0	320.9	511
85	453	982	453	378	76	227	151	227	368.1	304.2
623	76	76	680	151	302	0	76	0	169.9	242.1
633			755	151	76	76	0	76	188.8	281.5
Average	88	277	496	173	76	65	32	43	**155.2**	
s.d.	181	399	515	155	107	92	59	86		**278.4**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	0	0	0	0	0	0	0
603	0	0	0	0	0	0	0	0
65	0	0	1737	831	378	76	503.3	683.1
613	0	76	1737	1435	982	76	717.3	769.6
85	0	76	2265	906	227	0	578.8	894.2
623	0	0	1057	529	0	0	264.3	442.2
633	0	604	2794	529	151	76	692.1	1059
Average	0	108	1370	604	248	32	**393.7**	
s.d.	0	222	1076	512	353	40		**685.6**

0 - 3 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	0	0	0	0	0	0	0	0	0	0
603	0	0	0	0	0	0	0	0	0	0
65	0	76	0	76	0	0	0	0	18.88	36.84
613	0	453	906	227	0	0	0	0	198.2	346
85	453	982	453	302	0	0	151	227	320.9	340.4
623	76	0	151	151	0	0	76	0	56.63	71.81
633			151	76	0	0	0	0	37.75	63.17
Average	88	252	237	119	0	0	32	32	**92.28**	
s.d.	181	399	336	114	0	0	59	86		**206.2**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	0	0	0	0	0	0	0
603	0	0	0	0	0	0	0	0
65	0	0	1284	0	0	0	213.9	524
613	0	76	302	0	0	0	62.92	121
85	0	76	1812	0	0	0	314.6	734.2
623	0	0	906	0	0	0	151	369.9
633	0	604	2265	0	0	76	490.8	900.6
Average	0	108	938	0	0	11	**176.2**	
s.d.	0	222	895	0	0	29		**495.1**

Table 5.12 (Cont.) **Macoma mitchilli** **Individuals/m ^2**

3-10 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	0	0	0	0	0	0	0	0	0	0
603	0	0	0	0	0	0	0	0	0	0
65	0	0	151	0	0	0	0	0	18.88	57.07
613	0	76	378	151	76	0	0	0	84.94	135.9
85	0	0	0	76	0	76	0	0	18.88	36.84
623	0	76	529	0	227	0	0	0	103.8	199.1
633			604	76	76	76	0	0	138.4	231.1
Average	0	25	237	43	54	22	0	0	**48.94**	
s.d.	0	39	263	59	84	37	0	0		**122.8**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	0	0	0	0	0	0	0
603	0	0	0	0	0	0	0	0
65	0	0	453	680	378	76	264.3	281.5
613	0	0	1435	680	302	0	402.7	572.3
85	0	0	453	755	151	0	226.5	313.1
623	0	0	151	151	0	0	50.33	77.98
633	0	0	529	453	151	0	188.8	242.3
Average	0	0	431	388	140	11	**161.8**	
s.d.	0	0	495	333	154	29		**299.5**

10-20 cm

year 1	Nov-84	Jan-85	Mar-85	Apr-85	May-85	Jun-85	Jul-85	Aug-85	Average	s.d.
45	0	0	0	0	0	0	0	0	0	0
603	0	0	0	0	0	0	0	0	0	0
65	0	0	0	76	0	0	0	0	9.438	28.54
613	0	0	151	0	0	151	0	0	37.75	73.68
85	0	0	0	0	76	151	0	0	28.31	59.4
623	0	0	0	0	76	0	0	0	9.438	28.54
633			0	0	0	0	0	76	12.58	30.82
Average	0	0	22	11	22	43	0	11	**13.98**	
s.d.	0	0	57	29	37	74	0	29		**39.01**

year 2	Oct-85	Dec-85	Feb-86	Apr-86	Jun-86	Aug-86	Average	s.d.
45	0	0	0	0	0	0	0	0
603	0	0	0	0	0	0	0	0
65	0	0	0	151	0	0	25.17	61.65
613	0	0	0	755	680	76	251.7	362.6
85	0	0	0	151	76	0	37.75	63.17
623	0	0	0	378	0	0	62.92	154.1
633	0	0	0	76	0	0	12.58	30.82
Average	0	0	0	216	108	11	**55.73**	
s.d.	0	0	0	270	254	29		**164.3**

CHAPTER 6
FINFISH AND SHELLFISH

PURPOSE

The purpose of this study was to provide data on the utilization of the Lavaca River delta estuarine zone as a nursery habitat by finfish and selected macro-invertebrates. The sampling design was such that both seasonal and spatial patterns could be investigated.

METHODS

Sampling sites and schedules are described in the Introduction. Finfish and macro-invertebrates (henceforth referred to as fish except when specific species are mentioned) were sampled with four types of collecting gear.

Ichthyoplankton were sampled with a 0.5 m diameter conical net made of 505 μm mesh and a filtering cod end. This net, fitted with a flowmeter to measure water volume filtered, was towed at the surface for three minutes. Duplicate samples were taken at each station.

Postlarval and juvenile fish were collected along the shoreline with a benthic sled and a bag seine. The benthic sled was a 17.8 by 53.3 cm box on steel runners with a 1800 μm mesh net attached to one end. This net was towed 30 m by hand and sampled an area of 12 m^2. The seine was 6.1 m long and 1.8 m high with a 1.8 x 1.8 m bag. The entire seine was made of 2 mm mesh nylon. This net was pulled along the shoreline for 15 m and sampled an area of approximately 47 m^2. Duplicate sled and seine samples were taken at each sampling site.

Juvenile fish were collected in open water (i.e. away from shorelines) with a 3 m otter trawl of 1.9 cm stretched mesh in both the wings and cod end and in addition, the cod end was fitted with a liner of .64 cm delta mesh. This net was towed for 3 minutes at 1200 rpm. Tows were made down-stream at the river stations and with the wind at all other sites. Trawl samples were taken in triplicate. Ichthyoplankton and trawl samples, along with zooplankton samples, were taken at the same sites on the same day. Sled and seine samples were taken at the same sites on the same day but on different days from the above mentioned samples. (Sled and seine samples were generally taken the following day.)

All samples were preserved immediately in 5 percent seawater formalin (10 percent for trawl samples) and returned to the laboratory for processing. In the lab, all individuals were counted and up to 50 individuals of each species were measured (standard length to 1 mm) and weighed (to the nearest 0.01 g). When more than 50 individuals of one species were present the total weight for all individuals was obtained. A voucher collection was established and all other material was discarded.

The basic analytical tool used for these data was cluster analysis. Cluster analysis involves the computation of the dissimilarity coefficients between all possible pairs of entities (i.e., collections) based on the attributes (i.e., density of each species) of those entities. These coefficients are then sorted into clusters or groups with high inter-group similarity and the results are presented in the form of a tree diagram (dendrogram) (see Clifford and Stevenson 1975, Romberg 1984 for complete discussion of cluster analysis).

The dissimilarity measure used here was the Canberra-Metric (Lance and Williams 1967a cited by Clifford and Stevenson 1975) which is:

$$(1/n) \quad \sum_{i=1}^{n} \frac{X_{ij} - X_{ik}}{(X_{ij} = X_{ik})}$$

Where X is the abundance of the $_i$th species at the $_j$th and $_k$th stations and n = the number of species.

Since this coefficient is the mean of a series of fractions, an outstandingly large value will contribute to only one of the fractions, giving abundant and uncommon species equal influence. On the other hand, it is strongly influenced by presence/absence data. If X_1j is 0 and X_2j is any whole number the result is unity; therefore, differences of 0 and 1000 and of 0 and 1 carry the same weight, which does not make good ecological sense. The solution to this is to replace the 0 values with a number which is 1/5 of the smallest recorded value (Clifford and Stevenson 1975). In this case our smallest values are 1 so the 0 values were replaced by 0.20. We used the flexible sorting strategy with a ß value of -0.25 (Lance and Williams 1967, Sneath and Sokol 1973). All computations were done on an IBM 3081 in the Computation Center at the University of Texas at Austin.

Many similarity and dissimilarity measures and clustering strategies have been developed but only a few are commonly used in ecological research (Romberg 1984). The variety of dissimilarity measures is much greater than clustering strategies. Although we had chosen Canberra-metric *a priori* for these data, we examined them using three measures: Euclidian distance, Bray-Curtis, and Canberra-metric. Canberra-metric gives equal weight to all species, a desirable property in the investigation, whereas the other two give considerable weighing to abundant species. The results from the three analysis were generally similar however, in that temporal patterns predominated and were roughly similar among the analysis. Spatial patterns were minor to non-existent in all analysis. This indicates to us that the temporal/spatial patterns presented here are the true patterns in the data and are relatively unaffected by choice of analytical methods.

Our approach was to put each time/site (i.e. Nov 1984 station 45 as one "time/site" and July 1985 station 603 as another) into the analysis simultaneously and cluster them based on the species composition and abundance at each of the 98 time/sites. The results of such an analysis could take two substantially different forms. First, if temporal patterns are the dominant feature in the fish community, then the clusters would separate time periods and spatial patterns would be manifested only within the time period. Conversely, if spatial patterns were the dominant feature, then the major clusters would be site groupings with any time groupings imbedded within them. We performed both "normal" (using site/times as entities and individual species densities as attributes to yield site/time groups) and "inverse" (using species as entities and their density at each site/time as attributes to yield species groups) analysis.

Separate analyses were run for ichthyoplankton, trawl, and combined sled and seine data based on the assumption that the behavior and particularly habitat preferences of the fish might change with age, and these gears sample different age groups.

For ease of comparing the relative distribution of abundant and uncommon species, the mean density of each species in each cluster was calculated and converted to percent occurrence per cluster. These values are given in table form with the species and time/sites arranged to conform to the results of cluster analysis.

RESULTS

During the study 882 samples (14 trips x 7 sites x 9 samples/site) were taken yielding 170,907 individual organisms with a total weight of 968.5 kg. As is typical of fish populations in other estuarine systems, a small number of species comprised the bulk of the population. The seven most abundant species accounted for 75% of the total number of individuals collected (Table 6.1). The collecting gears were chosen to thoroughly sample the youngest segment of the fish population occupying the area. The mean length of all individuals collected with all gear types was 34.43 mm standard length.

Cluster Analysis

Dendrograms from the three sets of cluster analyses are presented in Figures 6.1 - 6.6. Each of the time/site dendrograms was separated into three or four major groups by dividing the dendrogram near the highest levels of dissimilarity. This created time/site clusters which had maximum differences in species composition. Species dendograms were generally divided into 5-7 groups. The correspondence between site/time groups and species groups are shown in two-way tables (Tables 6.2 - 6.4).

There were two general patterns which were common to all three data sets. The most significant of these was that temporal patterns dominanted. The strength of the temporal pattern varied among gear types. Time groupings were strongest in the seine-sled data and weakest in the ichthyoplankton. Three "seasons" are indicated by the fish data: November through January; March through June, and July through October. Placement of February and to a lesser extent the June samples varied somewhat by gear type. These three "seasons" were relatively consistent between the two years despite significant differences in salinity. The second generalization was that spatial patterns were a minor factor in the groupings. Even within the major seasonal groups the primary factor separating minor clusters was time. In most cases, when collections from several different months are in one major cluster, the minor divisions within that cluster would separate the months rather than producing separate station groups which include collections from several months.

Ichthyoplankton

This was the least "seasonal" of the data sets. Four major groups were identified in the dendrogram (Fig. 6.1) for the ichthyoplankton data:

Group I contains most of the sites from Oct85, Nov84, Dec85, Feb86, and Aug86 as well as a few samples from other months throughout the year. All of the samples in this large group had no larvae (Table 6.2). In essence, there are few planktonic fish larvae in the Lavaca River delta during the fall through mid-winter (October through February). It is noteworthy that only two Jan85 sites (85 and 633) are in this group. The other Jan85 sites had ichthyoplankton and in fact, ichthyoplankton were relatively abundant in Jan85 samples.

Group II contains primarily collections from the river and the upper lakes (603 and 613) during Jan85, Mar85, Apr85, and Apr86. Average salinity for this group was relatively low at 4.0 ppt and average temperature (16.6°C) was the lowest of all groups. Group II was characterized by relatively high densities of Gulf menhaden, striped mullet, tidewater silverside and white shrimp and low densities of most other species.

Group III is composed primarily of sites from May85, Jun85 (no Jan86 sites), Jul85 sites 45 and 603, plus the Nov84 and Dec85 samples with fish. Average salinity is low (3.6 ppt) and average temperature (23.8°C) is moderate. Densities of bay anchovy, rough silverside, and Atlantic croaker are relatively high in this group. Densities of gulf menhaden, and brown shrimp are relatively low and white shrimp are absent.

Group IV contains most of the sites from Apr86, Jun86, Jul85, and the Aug86 sites with fish. Average salinity (10.9 ppt) is higher here than in the other groups as is temperature (26.0°C). Several species had their highest densities in this group, especially pinfish, naked goby, and brown shrimp.

Groups III & IV share similar months. They basically differ in containing sites from different years. Differences in species composition and abundance were substantial. Group III had higher bay anchovy and Atlantic croaker densitites whereas Group IV had higher densities of Gulf menhaden and both white and brown shrimp. Salinities were much higher at sites in Group IV except for Jul85. It is interesting to note that the lowest salinity Jul85 sites (45 and 603) are grouped with low salinity Group III.

Sled-Seine

The major clusters derived from the dendrogram from sled-seine samples (Fig. 6.3) represent very discrete time groups. In only two cases was a time/site placed in the "wrong" seasonal group, in spite of the fact that there were substantial salinity differences between similar time periods in the two years. Three major time/site groups were identified from the dendrogram.

Group I contains sites from Nov84, Dec85, and Jan85. This group has the highest density of various species of killifish and of striped mullet (Table 6.3) but has the lowest catches of many other species; notably Atlantic croaker, Gulf menhaden, and brown shrimp. Approximately one half of the red drum occurred in this group but red drum were relatively rare throughout the entire study in all gear types.

Group II contains sites from Feb85, Mar85, Apr85, Apr86, May85. This group has the highest density of several of the most abundant species including Gulf menhaden, brown shrimp, Atlantic croaker, blue crab, and southern flounder. The highest density of some less common species, such as pinfish, red drum, sand seatrout and freshwater shrimp occurred here. Most of these species are offshore winter spawners.

Group III consist of sites from Jun85, Jun86, Jul85, Aug85, Aug86, and Oct85. The highest abundance of some less common species including leatherjacket, spotfin mojarra, blackcheek tonguefish, and scaled sardine occurred in this group. These are species which typically invade upper estuarine areas in warm weather as older juveniles (i.e. not postlarvae). This group also has the highest density of white shrimp and bay anchovy.

Differences in temperature among the groups is clearly reflected in the temporal nature of the groups, with a range in means of 10.9°C in Group I to 28.3°C in Group III. Mean salinity among the groups ranges from 4.4 ppt in Group I to 9.1 ppt in Group III.

There is no evidence of a salinity signal in these data.

Trawl

The temporal pattern in the major clusters is obviously the major factor here but it is not as dominant as in the sled-seine data (Fig. 6.5).

Group I consists of essentially all the sites from Jul85, Aug85, Aug86, and

Oct85. The highest densities of many species in the trawl collections are in this group including postlarvae and juveniles of several spring-summer spawners such as sand seatrout, silver perch, and bay anchovy (Table 6.4). This group also has high density of older juveniles and adults of species caught in the upper estuary in warm months including hogchoker, lined sole, and least puffer.

Group II contains some of the sites from Apr86, May85, Jun85, and Jun86 except there are no collections from stations 45 or 65 in the group. The highest densities for most winter spawners like Atlantic croaker, Gulf menhaden, brown shrimp, spot, and Southern flounder were in this group. There were relatively low densities of white shrimp, various species of killifish, and gizzard and threadfin shad in this group.

Group III consist of all sites from Nov84, Dec85, and Feb85 plus stations 45 and 65 from Apr86, Jun85, and Jun86. While densities of most species are at intermediate levels in this group, a few species, particularly white shrimp and bighead searobin had relatively high densities here. Several species had relatively low densities, especially Atlantic croaker, brown shrimp, and spot.

Group IV was made up primarily of sites from Jan85, Mar85, (Apr85, and two sites (45 and 633) from May85). The highest densities of striped mullet, threadfin and gizzard shad, tidewater silverside, freshwater shrimp, blue crab, and several species of killifish were in this group. The lowest densities of some of the most abundant species, especially brown shrimp, white shrimp, and sand seatrout occurred here.

Groups I and II had higher mean salinity and temperature than groups III and IV.

Two groupings in the trawl data might indicate a salinity effect in the fish population. In the first situation, Group IV (Jan85 - Mar85 - Apr85) and Group II (Apr86 - May86 - Jun85 and 86) share April collections from two years and two May sites are in group IV (Fig. 6.3). Average salinity is low in Group IV (2.3 ppt) and relatively high in Group II (12.4 ppt). Species densities are quite different between groups. Group IV has much higher densities of threadfin and gizzard shad and several species of killifish as well as higher densities of freshwater shrimp, blue catfish, blue crab and striped mullet. Group II had much higher densities of Atlantic croaker, brown shrimp, spot, and sand seatrout among others. These species differences appear to be related more to temperature than salinity. Water temperature in April 1985 was 3 degrees cooler than April 1986. The cool April was grouped with cooler months of January and March, while the warmer April grouped with the warmer months of May and June. The species differences described above reflect this temporal difference rather than a salinity effect. Additionally, low and high salinity collections from June 1985 and 1986, respectively, are in the same group (Group II).

Size Distributions

Cluster analysis provides a clear picture of seasonal patterns in the fish population in the Lavaca River delta and would have shown obvious spatial patterns if there were any. Much additional information concerning the organisms utilizing the delta can be gained by examining their size distribution over time. More than 50% of the species captured in the study are not permanent residents but are in the area for only part of their life cycle. The vast majority of these transient species are in the area during the early stages of their life and use the area as a "nursery". The following discussion will be limited to the utilization of the area as a nursery by the dominant species or those species of commercial or recreational importance.

Tables 6.5 to 6.8 show the mean standard length for each of the 23 most abundant species (plus spotted seatrout) for each month. The data are pooled over all stations and presented by gear type. Tables 6.9 - 6.12 give the mean abundance for each species in the same format. This presentation allows an examination of the seasonal size trends for each species.

The smallest specimens were caught, obviously, in the ichthyoplankton samples. From Table 6.5 it can be seen that the very smallest individuals represent those species which spawn in the study area. These include clown goby, tidewater silverside, and bay anchovy. Bay anchovy eggs were common in the study area during the summer. This table also reveals that several species which spawn in the lower estuary or offshore move into the Lavaca River delta while still in the planktonic stage. Atlantic croaker, Gulf menhaden, brown and white shrimp, and blue crab fall into this category. There are several species whose demersal postlarvae or juveniles were relatively common in the study area but were rare or absent from the ichthyoplankton samples. Species such as southern flounder, spot, sand seatrout, and silver perch apparently move up the estuary at a slower rate and, therefore, have grown substantially prior to arrival in the delta. Another interesting situation is with spotted seatrout which is known to spawn in estuaries but was never taken in our plankton samples, even though several were taken with both sled and seine. This indicates that spotted seatrout do not spawn in the study area and that planktonic larvae do not disperse rapidly up-estuary from the lower-estuary spawning sites.

Sled samples and seine samples were taken at the same time and at the same sites and capture roughly the same size individuals. Data from the sled shows a better representation of time of recruitment of the youngest (smallest) individuals into the nursery habitat, especially when the period of recruitment is protracted, whereas the seine data reflects the initial period of recruitment but subsequently reflects growth in the cohort, masking continual recruitment of small individuals.

Mean lengths of fish from the seine and sled data (tables 6.6 and 6.7) show three general patterns of larval recruitment into the Lavaca River delta. The most dominant pattern is the arrival of postlarvae of fall and winter spawners. Out of 11 species which show a clear change (increase) in size for the population over time, the initial recruitment time for seven of those is the November to January period (see Fig. 6.7 as an example). Postlarvae of the remaining four species initially arrive in the delta in early to mid-summer. The final pattern is shown by those species which show essentially no change in size over time. This pattern (or lack of pattern) is seen in species which are only captured occasionally, but is also seen in common resident species with small adult size. This is most obvious in bay anchovy which clearly spawns in the summer based on ichthyoplankton data but has essentially the same mean length throughout the year due to the dominance of adults in the collections.

A uniform pattern of growth can be seen for the winter spawners from initial recruitment in the late winter throughout the summer until large individuals are no longer caught in the seine in the late summer and the next year's recruits arrive in the fall (see Fig. 6.8 as an example). The departure of larger fish is difficult to interpret. Although all of these species will leave the delta area and return to the spawning area or adult habitat, the size selectivity of the seine makes it impossible to determine for most species whether they have left the delta or simply evade the net. This will be addressed further in connection with the trawl data.

The temporal pattern in size distribution is less obvious for most species in the trawl data (Table 6.8) than in the seine and sled data. This is due primarily to the under representation of the smaller individuals in the trawl, despite the presence of a 6.4 mm liner. The lower abundance of smaller individuals in the trawl may also represent intraspecific differences in habitat preference by different size classes.

Results of both trawl and sled-seine cluster analysis show the year is roughly divided into three "seasons" based on species composition. Species which are using the delta as a nursery are influential in developing these seasonal patterns. "Winter" (November - February) is a period of low diversity and density of fishes using the delta as a nursery area. Striped mullet is the only species whose highest density consistently occurs in the January-February period at a mean size of about 23 mm. They grow rapidly through the spring and summer and though striped mullet are relatively common in the study area they are rare in our samples due to net avoidance.

"Spring" is the period of highest density of fishes in the nursery area with the young of fall-winter spawners predominating the catches. The two dominant species taken during this time are Atlantic croaker and Gulf menhaden. Atlantic croaker initially arrive in the delta in the December to February period but their highest densities are in March and April in the seine collections (Fig. 6.7) and in April to June in the trawl collections. The earliest arriving individuals average 15-20 mm and the cohort grows uniformly to about 70 mm in July when they either leave the delta or successfully avoid our collecting gear (Fig. 6.8). Gulf menhaden had a quite similar abundance pattern with initial arrival of the postlarvae in November to February and peak densities of juveniles in March to June. The slow increase in mean length of menhaden in the seine data suggest a prolonged recruitment period; presumably due to an extended spawning period in this species. Brown shrimp appear to have two recruitment periods, one in late winter-early spring (February-May) and the other in late summer (August-October). The abundance data suggest that the late summer recruitment period is less important than the one in the spring. Red drum, blue crab, southern flounder and pinfish also exhibit this winter to spring overlap in nursery utilization. Southern flounder was something of an anomaly compared to other species in the delta in that they were caught primarily with the trawl and were relatively uncommon in the sled-seine samples. All the previously mentioned species were taken commonly in both shoreline and open water samples. The smallest southern flounder were in the 12-17 mm range in the December to January period and grew to 70-80 mm in August.

Several species of recreational or commercial importance were at their highest density during the "summer-fall" season but most were not as abundant as several of the "spring" species. Spotted seatrout were collected almost exclusively during this season and were only taken in shoreline collections at a size of 15-30 mm. White shrimp arrive in the delta in May to July at 14-18 mm. Their highest densities are typically in August and they leave the delta in October or November at 50-60 mm.

Comparisons with other studies

Several studies dealing with macro-invertebrates and fishes have been done in the Lavaca Bay area. Results from most of these investigations are in reports to government agencies or private firms and were unavailable to the author (i.e. Blanton *et al.* 1971, Mackin 1971, and Lyons 1973; all cited in Gilmore *et al.* 1976). Gilmore *et al.* (1973) used nonreplicated-10 minute trawls at 7 sites in a 30 month survey of fishes and invertebrates in Lavaca Bay. They reported that fish densities were higher in the spring and summer and lower in the winter, which essentially agreed with our findings. The list of eight most abundant species essentially agrees with ours, though not quite in the same order. The major discrepancies are due to our inclusion of shoreline samples (i.e. grass shrimp and tidewater silversides). They found no correlation between freshwater inflow and the occurrence of nekton in their samples.

Moseley and Copeland (1974) reported on a long-term study of nekton in Cox Bay, a portion of lower Lavaca Bay, in relation to the construction of an electric generating station. They showed a strong seasonal pattern in the fish population structure with the lowest densities in the winter. They examined the salinity relationships for 11 selected species and found that most exhibited no relationship; however, Gulf menhaden, sand seatrout, hardhead catfish, and Atlantic croaker decreased in abundance with increasing salinity while bay squid increased with salinities > 12 ppt.

The results of these two studies concur with our conclusions that seasonal patterns are the dominant feature of fish populations in Lavaca Bay. These seasonal patterns are quite consistent year to year for each species and are minimally affected by short term variations in freshwater inflow.

A report by Texas Department of Water Resources (TDWR 1980) utilizes a more long-term data set to examine the influence of freshwater inflows on fisheries production. A complex stepwise multiple regression model was used to compare seasonal freshwater inflows with various components of the 1962 through 1976 inshore commercial fisheries harvest. These analyses indicated that all fisheries harvest components except blue crab were positively related to April-June inflows and negatively related to July-August inflows. The numerous fisheries components examined yielded a variety of responses to inflows for other seasons. It was shown that when inflow needs of the fisheries components are similar, the components reinforce each other, but when they have different responses, management decisions must be made to balance divergent needs of the various components or preference must be given to one particular component.

Salinity relationships

Direct comparison of the relationship between salinity and the density of three abundant species was made through calculation of least squares regression. The results of these analyses present difficulties in interpretation. Table 6.13 shows statistically significant relationships ($P > .0003$) for all three analysis. There is positive relationship with salinity for brown shrimp and a negative relationship for Atlantic croaker and Gulf menhaden. The difficulty is that the R-square values are all quite low. The highest R-square value was for brown shrimp ($R^2 = 0.0496$) but this still indicates that variation in salinity accounts for less than 5% of the variation in brown shrimp density. Plots of these data (Figs. 6.9-6.11) clearly show the scatter of the data about the calculated linear relationship. This indicates that although there is a significant relationship between salinity and the density of these species, the relationship is relatively unimportant since greater than 95% of the variability in density is still unexplained.

CONCLUSIONS

The primary factor influencing changes in fish species composition in the Lavaca River delta is the sequential arrival and departure of a variety of postlarval and juvenile fish and invertebrate species. These fishes are moving into the delta from the area in which they were spawned, generally some distance from the delta in the lower estuary or from offshore. Most species depart from the delta after six to eight months. Those species which remain in the delta for a longer period grow rapidly and are ultimately able to avoid our collecting gears, which are highly size specific. Spawning periods are relatively short for most species, in some cases only a month or two, but seldom more than six months, and are fairly consistent year-to-year. This results in quite discrete and relatively predictable pulses of various species entering and leaving the delta, producing the strong temporal pattern in the data. Salinity (as a surrogate for freshwater inflow) effects are seen only as a perturbation within these major temporal patterns and is not the major driving force regulating the community composition of the fish in this system on a short term basis. A significant, long-term alteration of freshwater inflow could have an effect on the overall functioning of the biological system and may indeed influence the relative value of the delta as a nursery, either to an individual species or the fish community as a whole.

Our data show that the Lavaca River delta is utilized extensively as a nursery area by most estuarine dependent species which are of commercial or recreational importance in the western Gulf of Mexico. There are also numerous other species, many of which are important components of the food web leading to commercial or recreational species, utilizing the delta as a nursery area. The spring-early summer period (February through June) has the greatest diversity of species and the highest biomass due to the preponderance of winter spawners whose offspring utilize the estuary as a nursery. Conversely, the fall-early winter period has the lowest diversity due to small number of summer spawners whose larvae move to the upper estuary.

The seasonal pattern is a reflection of spawning times of those species utilizing the delta as a nursery area. In general, the "seasons" reflect the juveniles of winter spawners in March-June; spring and early-summer spawners in July-October. The low number of species spawning in late summer are reflected in the relatively low diversity of the November-February period. Both diversity and density of the fish community would be even more reduced during this period were it not for the occurrence of several species of killifish (Cyprinodontidae) which are apparently driven from their preferred habitat in submerged marsh by cold and/or low water levels during the winter.

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Table 6.1 List of species taken during the study ranked by total abundance. Mean length, total weight and total abundance were computed with all dates, stations, and gear types combined.

		Mean Length (mm)	Total Weight (gm)	Total Abundance
1	GULF MENHADEN	29.9	231375	50185
2	BAY ANCHOVY	26.9	255059	47423
3	ATLANTIC CROAKER	37.6	65563	21701
4	GROOVED SHRIMP	36.1	64879	14602
5	GRASS SHRIMP	-	2666	10692
6	WHITE SHRIMP	39.2	15847	9971
7	SPOT	39.4	7061	3210
8	TIDEWATER SILVERSIDE	32.7	2547	2332
9	BLUE CRAB	20.9	35584	2184
10	STRIPED MULLET	35.1	6824	2063
11	SHEEPSHEAD MINNOW	27.0	1619	1222
12	ROUGH SILVERSIDE	21.4	105458	578
13	SAND SEATROUT	50.1	1704	525
14	BLUE CATFISH	39.8	26588	486
15	PINFISH	31.4	21559	483
16	FRESHWATER SHRIMP	-	1442	417
17	NAKED GOBY	17.8	3599	341
18	SOUTHERN FLOUNDER	37.3	1700	338
19	GULF KILLIFISH	43.6	630	316
20	HARDHEAD CATFISH	45.9	3416	230
21	CLOWN GOBY	8.0	99089	224
22	SILVER PERCH	32.6	187	219
23	GAFFTOPSAIL CATFISH	51.4	2216	153
24	RHITHR. HARRISII	7.1	645	152
25	ATLANTIC THREADFIN	60.3	682	111
26	BAY WHIFF	36.3	153	66
27	HOGCHOKER	42.8	413	58
28	MOSQUITOFISH	18.7	11	54
29	BLACKCHEEK TONGUEFISH	51.1	101	44
30	LINED SOLE	29.1	63	43
31	DIAMOND KILLIFISH	21.1	12	42
32	LADYFISH L	26.6	68	41
33	SPOTTED SEATROUT	23.0	100	37
34	THREADFIN SHAD	53.2	85	36
35	LEAST PUFFER	26.3	41	35
36	BIGHEAD SEAROBIN	33.2	46	29
37	GULF PIPEFISH	60.3	10	26
38	GIZZARD SHAD	73.3	255	23
39	MUD CRAB	10.0	6	17
40	STRIPED BLENNY	3.3	2364	16
41	SPOTFIN MOJARRA	45.3	51	15
42	GOBY SP.	5.5	613	12
43	THUMBSTALL SQUID	53.3	131	12
44	SCALED SARDINE	29.1	4	11
45	RAINWATER KILLIFISH	24.7	3	10
46	SKILLETFISH	24.8	9	10
47	SPECKLED WORM-EEL	45.0	5372	10

Table 6.1 (continued)

48	DARTER GOBY	17.4	85	8
49	LADYFISH A	50.1	45	8
50	BLACK DRUM	28.4	286	7
51	ATLANTIC MIDSHIPMAN	39.3	25	6
52	RED DRUM	31.7	129	6
53	SHEEPSHEAD	41.2	641	6
54	LEATHERJACKET	51.5	12	5
55	MENIPPE MERCENARIA	12.4	4	5
56	PETROLISTHES ARMATUS	6.6	1	5
57	INSHORE LIZARDFISH	33.8	40	4
58	XANTHIDAE SP.	5.0	0	4
59	ATLANTIC NEEDLEFISH	76.0	2	3
60	BAYOU KILLIFISH	36.3	3	3
61	CHAIN PIPEFISH	31.0	4	3
62	PIGFISH	15.0	0	3
63	SAILFIN MOLLY	28.0	1	3
64	GREEN GOBY	26.0	1	2
65	SOUTHERN KINGFISH	80.0	17	2
66	STRIPED ANCHOVY	40.0	1	2
67	ATLANTIC BUMPER	25.0	0	1
68	BLACK CRAPPIE	120.0	58	1
69	CENTRARCHID SP.	20.0	0	1
70	CLINGFISH	10.0	0	1
71	CODE GOBY	16.0	0	1
72	CRAVALLE JACK	96.0	25	1
73	EURYPANOPEUS DEPRESSUS	11.3	1	1
74	GULF KINGFISH	11.0	26	1
75	GULF TOADFISH	11.0	46	1
76	LONGNOSE KILLIFISH	28.0	0	1
77	MOTTLED MOJARA	64.0	0	1
78	PAGURID SP	6.0	0	1
79	SHRIMP EEL	41.0	80	1
80	SOUTHERN HAKE	62.0	3	1
81	STAR DRUM	9.0	0	1
82	STRIPED BURRFISH	3.0	0	1
83	SUNFISH SP.	61.0	6	1
84	WHITE CRAPPIE	170.0	150	1

Figure 6.1 Site/time dendrogram from cluster analysis of ichthyoplankton data.

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                 ^....,....^....,....^....,....^....,....^....,....^....,....^....,....^....,....^....,....^
623 AUG 1986     I
633 AUG 1986     I
85  NOV 1984     I
613 AUG 1986     I
85  AUG 1986     I
603 AUG 1986     I
65  AUG 1986     I
633 JUN 1986     I
45  AUG 1986     I
45  JUN 1986     I
65  JUN 1986     I
85  FEB 1986     I
633 FEB 1986     I
603 FEB 1986     I
613 FEB 1986     I
623 DEC 1985     I
45  FEB 1986     I
633 OCT 1985     I
65  DEC 1985     I
85  OCT 1985     I
623 OCT 1985     I
603 OCT 1985     I
65  OCT 1985     I
85  JUL 1985     I
65  AUG 1985     I
85  JAN 1985     I
633 JAN 1985     I
633 NOV 1984     I
633 DEC 1985     I
603 JUN 1986     I
45  NOV 1984     I
603 DEC 1985     I
85  DEC 1985     I
613 AUG 1985     I
613 OCT 1985     I
65  NOV 1984     I
603 AUG 1985     I--------------------------------------------------------------------------------------------------------------------I
603 NOV 1984     I                                                                                                                    I
603 JAN 1985     --I                                                                                                                  I
603 APR 1985     --I------------I                                                                                                     I
613 MAR 1985     I              I                                                                                                     I
623 MAR 1985     I---------I    I------------I                                                                                        I
65  APR 1985     ----------I-I  I            I                                                                                        I
603 MAR 1985     ------------I--I            I-------------------------------I                                                        I
45  JAN 1985     ----------------------------I                               I                                                        I
65  MAR 1985     I                                                           I                                                        I
45  APR 1985     I-----------I                                               I                                                        I
85  MAR 1985     ------------I----------I                                    I--------------------------------------------------------I
65  JAN 1985     ------------I          I---------------------I              I                                                        I
45  MAR 1985     ------------I----------I                     I              I                                                        I
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Figure 6.1 (continued)

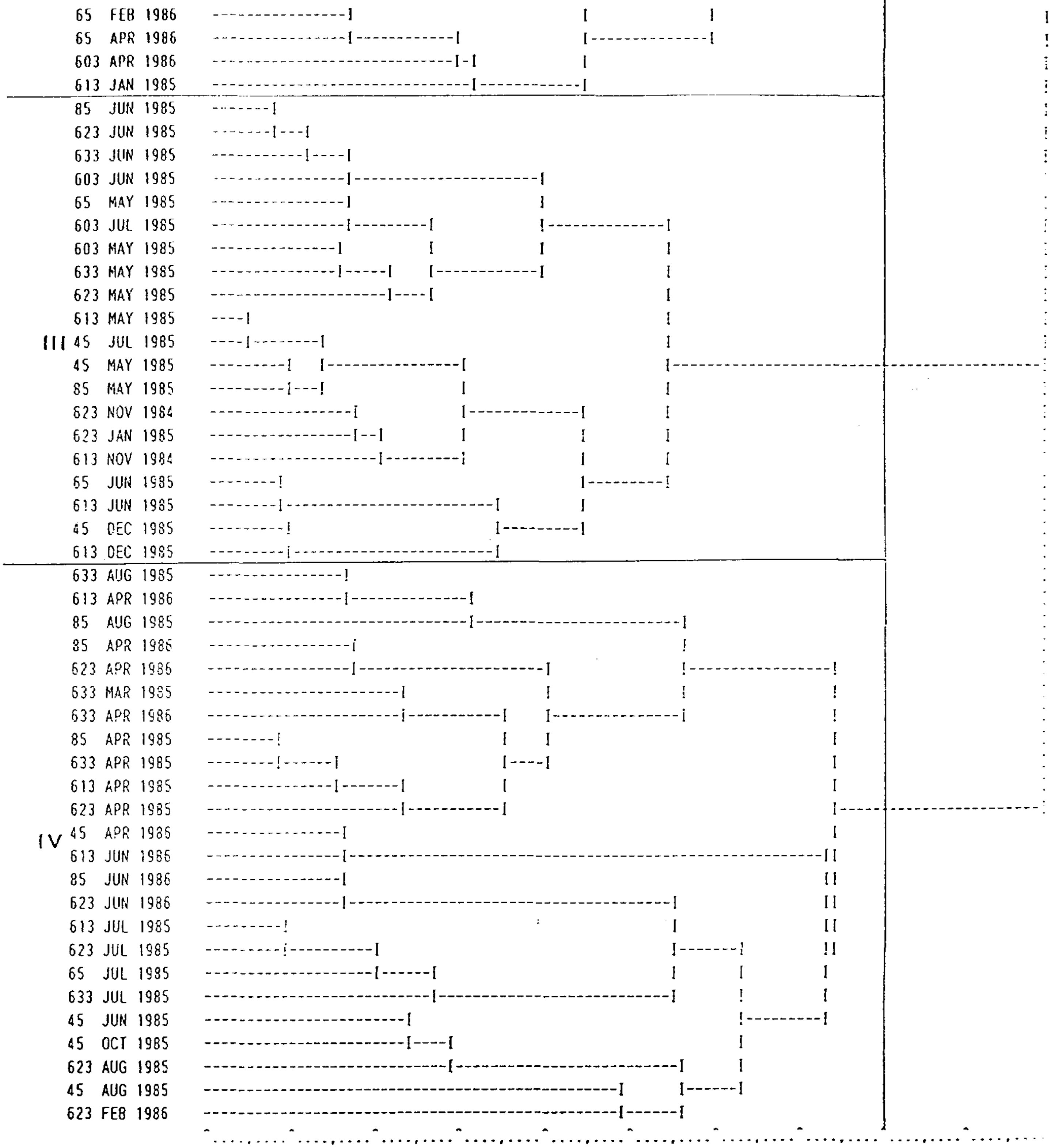

Figure 6.2 Species dendrogram from cluster analysis of ichthyoplankton data.

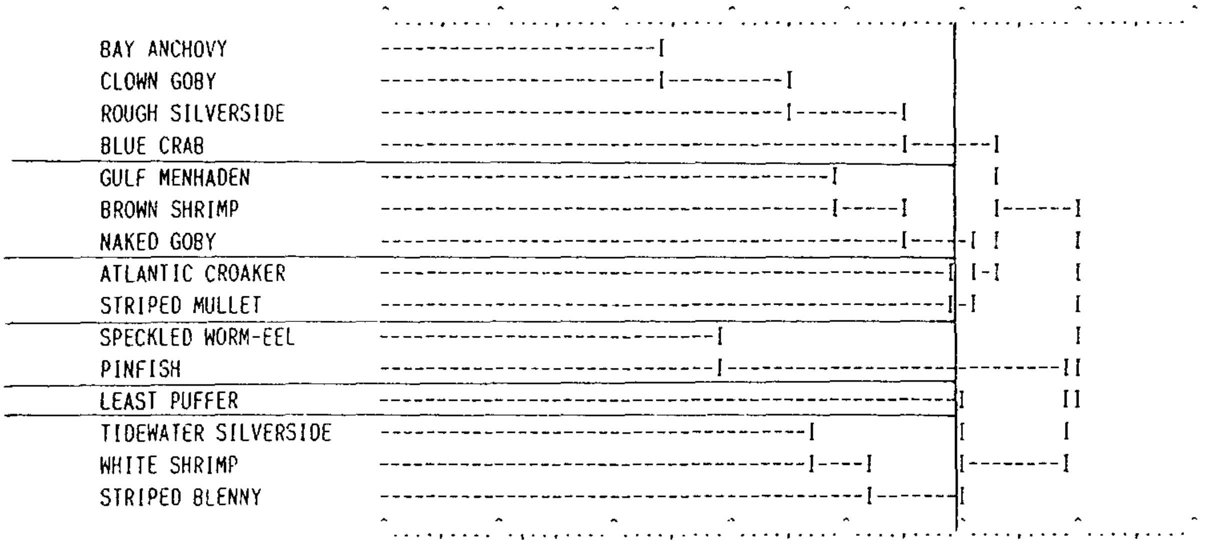

Figure 6.3 Site/time dendrogram from cluster analysis of combined sled-seine data.

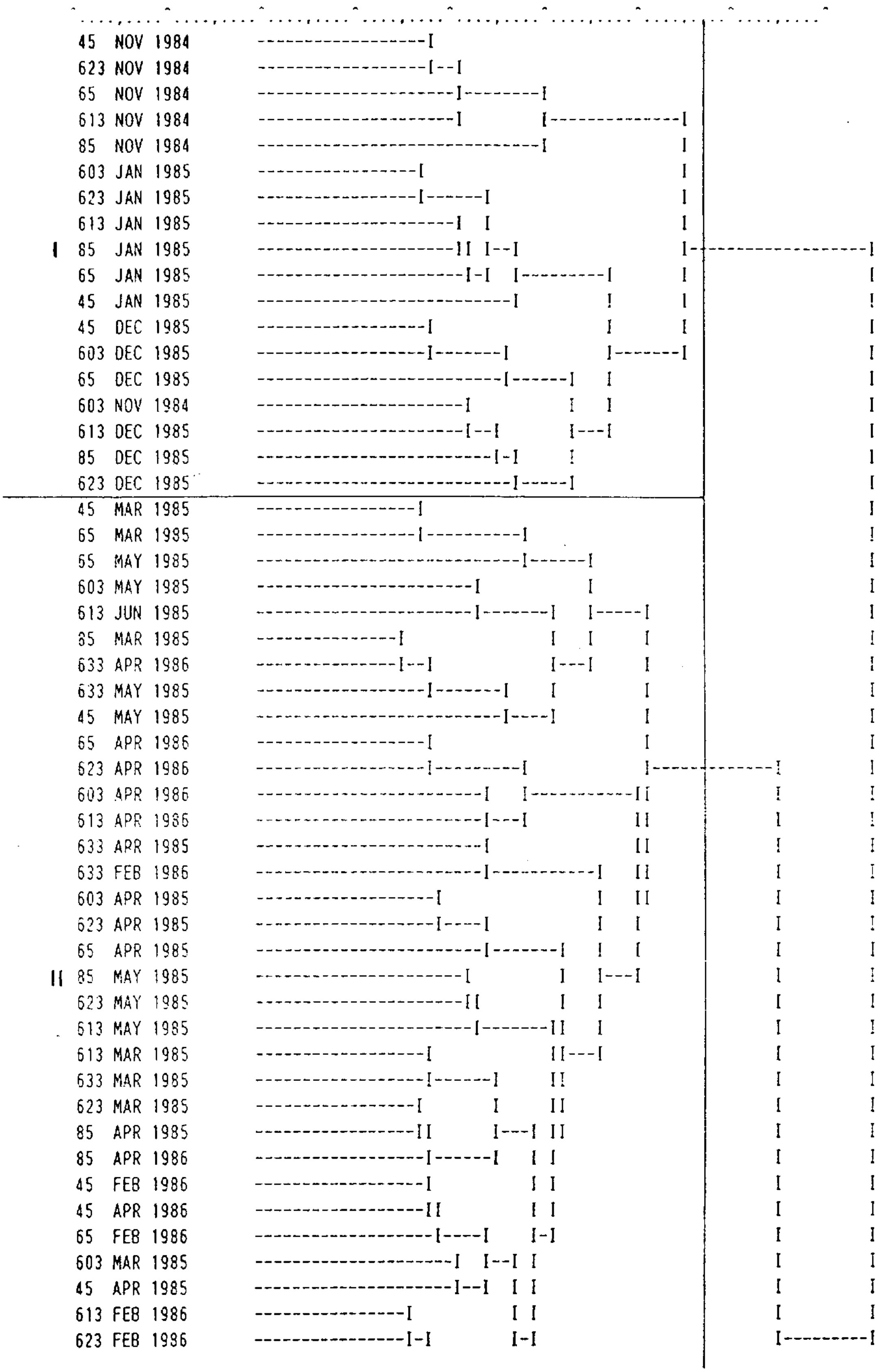

Figure 6.3 (continued)

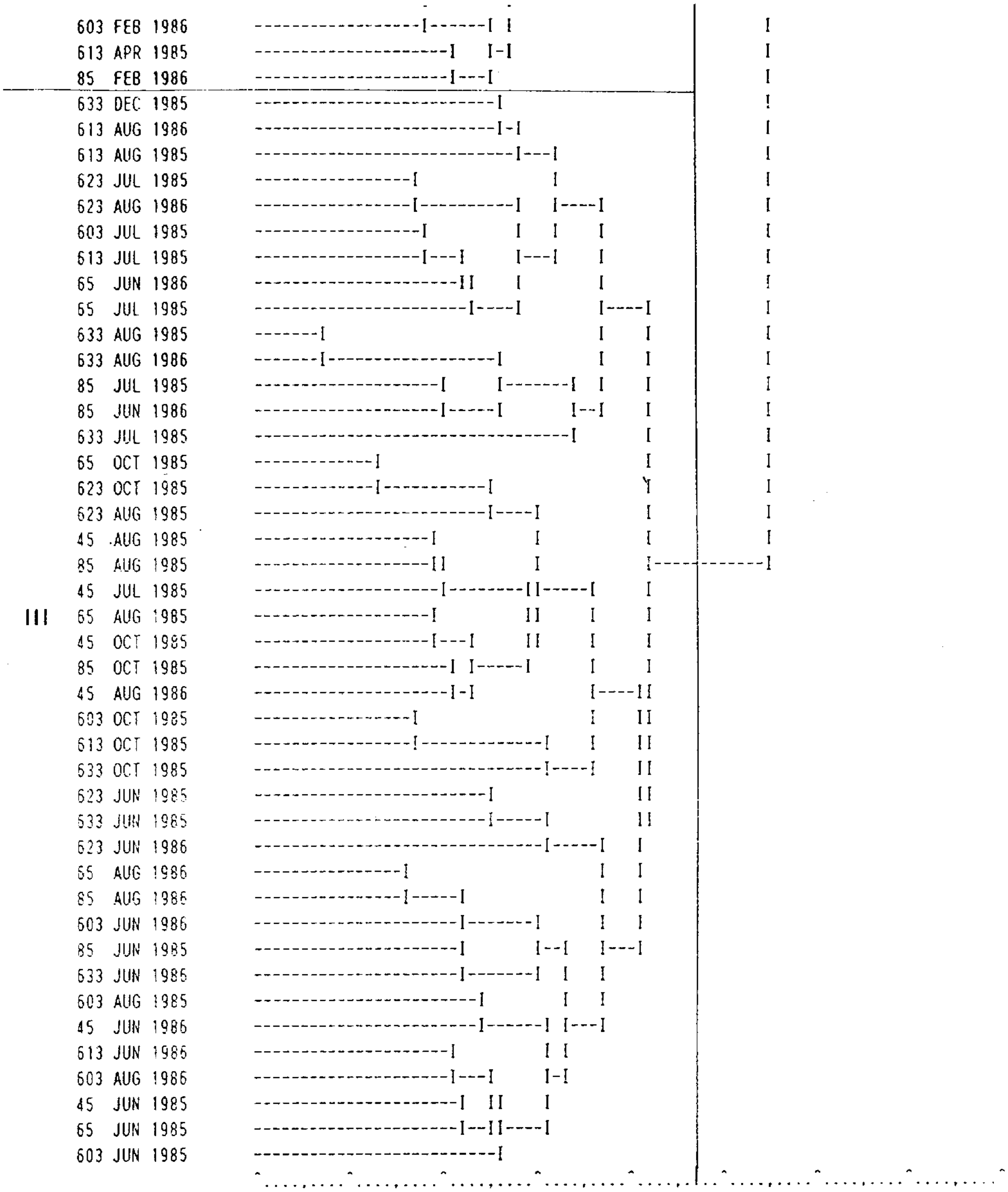

Figure 6.4 Species dendrogram from cluster analysis of combined sled-seine data.

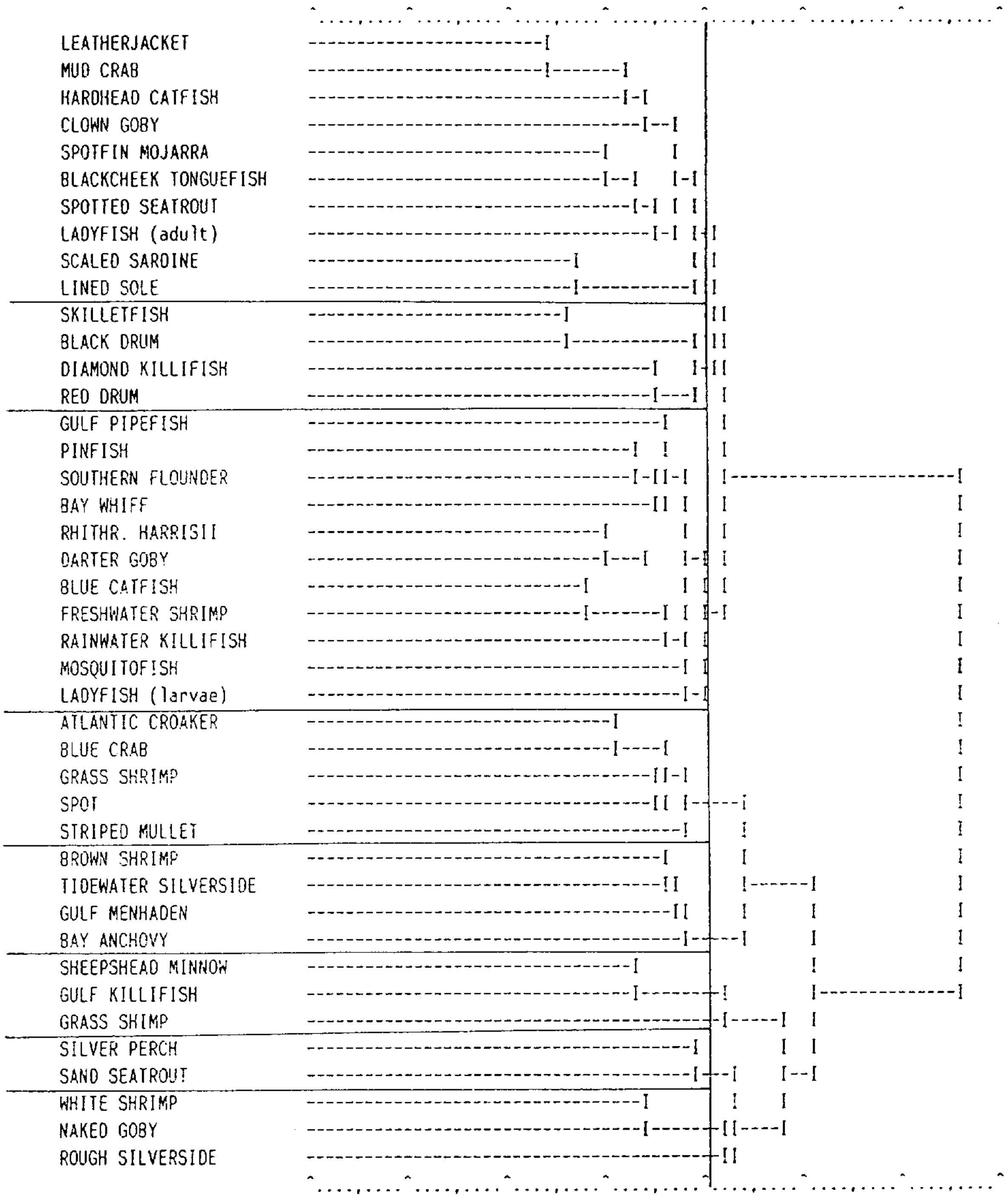

Figure 6.5 Site/time dendrogram from cluster analysis of trawl data.

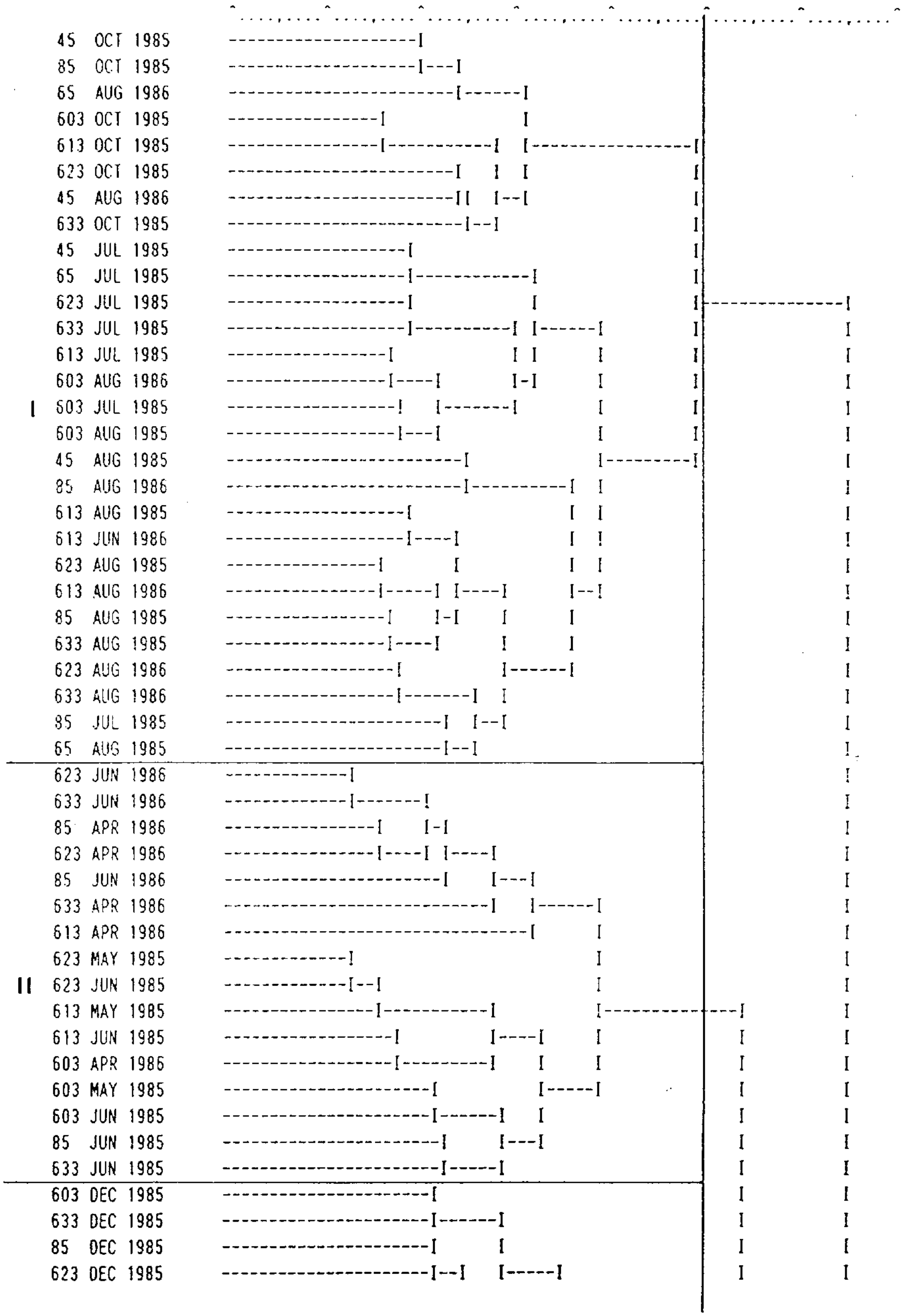

Figure 6.5 (continued)

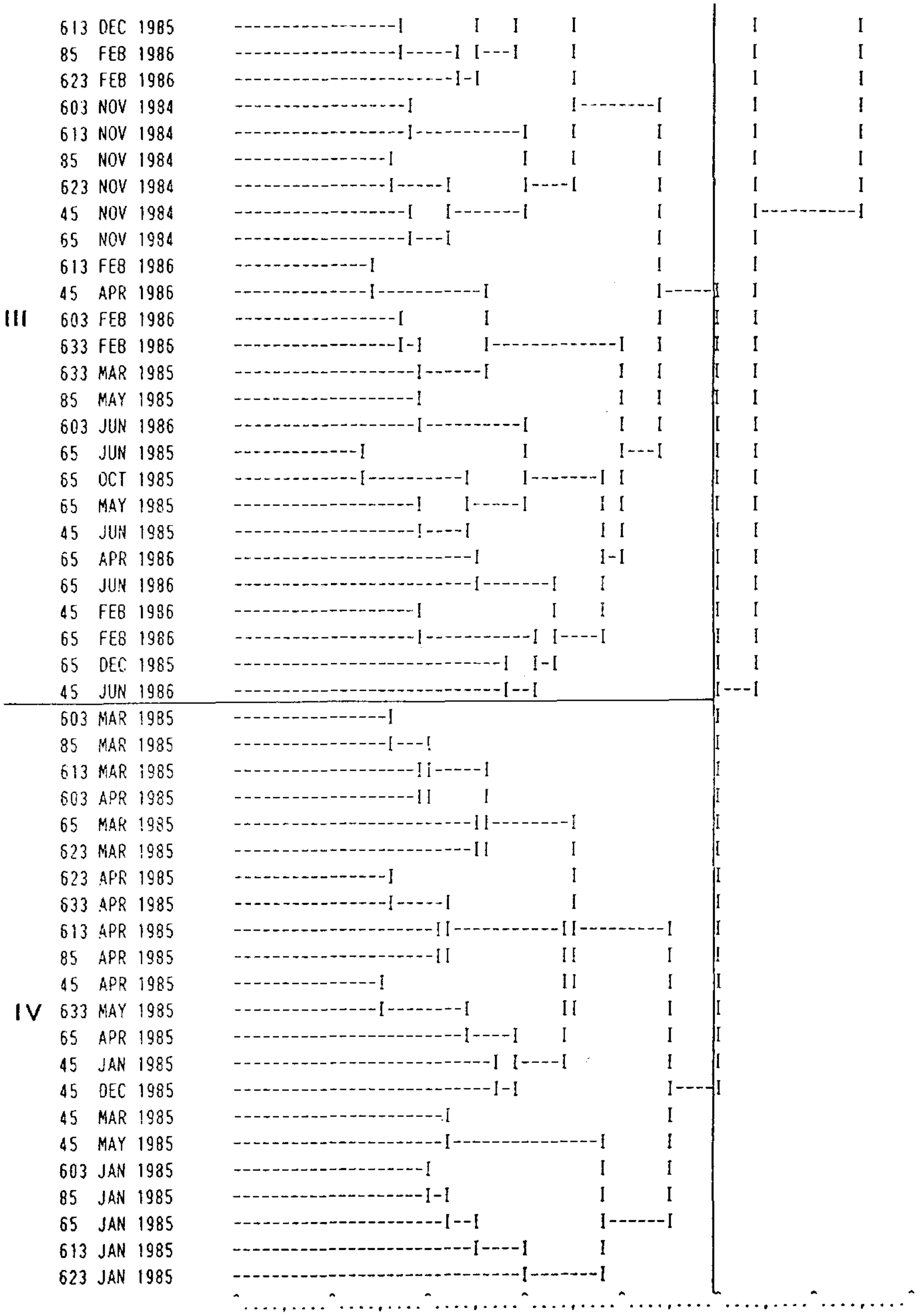

Figure 6.6 Species dendrogram from cluster analysis of trawl data.

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                                 ^....,....^....,....^....,....^....,....^....,....^....,....^.
BIGHEAD SEAROBIN                 -------------------------------I
NAKED GOBY                       -------------------------------II
RHITHR  HARRISII                 --------------------------------I--I
MUD CRAB                         -----------------------------------I--I
HOGCHOKER                        ----------------------------------I   I
ATLANTIC MIDSHIPMAN              ----------------------------------I---I-I
LINED SOLE                       -----------------------------------I  I I
LEAST PUFFER                     -----------------------------------I--I I
PINFISH                          --------------------------------I       I---I
THUMBSTALL SQUID                 --------------------------------I-----I I   I
BLACKCHEEK TONGUEFISH            --------------------------------I     I I   I
BAY WHIFF                        --------------------------------I--I  I-I   I
ATLANTIC THREADFIN               -----------------------------------I--I     I--------------I
SHEEPSHEAD MINNOW                ----------------------------------I         I              I
GULF KILLIFISH                   ----------------------------------I------I  I              I
THREADFIN SHAD                   -------------------------------I         I  I              I
GIZZARD SHAD                     -------------------------------I---I     I--I              I
TIDEWATER SILVERSIDE             ----------------------------------II     I                 I
SHEEPSHEAD                       ----------------------------------II-----I                 I
STRIPED MULLET                   -----------------------------------I                       I
ATLANTIC CROAKER                 --------------------------------I                          I
BROWN SHRIMP                     --------------------------------I----I                     I
WHITE SHRIMP                     -------------------------------------I-----------I         I
GAFFTOPSAIL CATFISH              --------------------------------I                I         I
SILVER PERCH                     --------------------------------I--I             I         I
HARDHEAD CATFISH                 -----------------------------------I--I          I         I
SAND SEATROUT                    --------------------------------------I-------I  I---------I
BLUE CATFISH                     -----------------------------------I          I  I
FRESHWATER SHRIMP                -----------------------------------I-------I  I  I
BAY ANCHOVY                      ---------------------------------I         I  I--I
BLUE CRAB                        ---------------------------------I-I       I  I
GULF MENHADEN                    -----------------------------------I--I    I--I
SOUTHERN FLOUNDER                --------------------------------------I-I  I
SPOT                             ----------------------------------------I  I
GRASS SHRIMP                     ----------------------------------------I--I
                                 ^....,....^....,....^....,....^....,....^....,....^....,....^....,....^
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Table 6.2 Percentage of occurrence in each time/site group for each species in the icthtyoplankton data. Lines defining the boxes were derived from the dendrogram.

	Time/site Groups			
	I	II	III	IV
Bay Anchovy		1	89	10
Clown Goby			99	1
Rough Silverside		1	90	9
Blue Crab		5	50	5
Gulf Menhaden		72	5	23
Brown Shrimp		1	16	83
Naked Goby				100
Atlantic Croaker		6	89	5
Striped Mullet		100		
Speckled Worm-eel				100
Pinfish				100
Least Puffer		27		73
Tidewater Silverside		58	12	30
White Shrimp		69	31	
Striped Blenny		35	65	
Mean Salinity	8.7	4.0	3.6	10.9
Mean Temperature	22.8	16.6	23.8	26.0

Table 6.3 Percentage of occurrence in each time/site group for each species in the combined sled-seine data.

	Time/Site Groups		
	I	II	III
Leatherjacket			100
Mud Crab	34		62
Hardhead Catfish			100
Clown Goby			100
Spotfin Mojarra	18		82
Blackcheek Tonguefish	21	21	59
Spotted Seatrout		7	93
Ladyfish (adult)			100
Scaled Sardine			100
Lined Sole			100
Skilletfish		15	85
Black Drum		23	77
Diamond Killifish	98		
Red Drum	50	50	
Gulf Pipefish	43	36	21
Pinfish	4	94	3
Southern Flounder		96	4
Bay Whiff		90	11
Rhithr. harrisii	27	26	45
Darter Goby	22	78	
Blue Catfish		30	70
Freshwater Shrimp		81	19
Rainwater Killifish	61	8	31
Mosquitofish	98	2	4
Ladyfish (larvae)		96	
Atlantic Croaker	39	60	1
Blue Crab	31	43	26
Grass Shrimp	60	32	7
Spot	7	89	3
Striped Mullet	93	6	1
Brown Shrimp	4	70	25
Tidewater Silverside	62	19	20
Gulf Menhaden	10	75	15
Bay Anchovy	18	1	59
Sheepshead Minnow	98	1	1
Gulf Killifish	97	2	1
Silver Perch		20	79
Sand Seatrout		90	10
White Shrimp	1		99
Naked Goby	28	20	51
Rough Silverside		6	94
Mean Salinity	4.4	6.8	9.1
Mean Temperature	10.8	22.3	28.3

Table 6.4 Percentage of occurrence in each time/site group for each species in the trawl data.

	Time/site Groups			
	I	II	III	IV
Bighead Searobin		6	89	5
Naked Goby	100			
Rhithr. harrisii	9	13	43	35
Mud Crab			100	
Hogchoker	40	20	2	39
Atlantic Midshipman	70	30		
Lined Sole	66		27	7
Least Puffer	94		6	
Pinfish	13	81	2	3
Thumbstall Squid	11	89		
Blackcheek Tonguefish	38	28	34	
Bay Whiff	24	68	8	
Atlantic Treadfin	7	66	27	
Sheepshead Minnow	1		8	92
Gulf Killifish			2	98
Threadfin Shad	17		2	81
Gizzard Shad				100
Tidewater Silverside		12		88
Sheepshead	16			84
Striped Mullet	7		15	78
Atlantic Croaker	2	67	6	24
Brown Shrimp	12	81	6	
White Shrimp	43		56	
Gafftopsail Catfish	100			
Silver Perch	66	34		
Hardhead Catfish	63	36	1	
Sand Seatrout	36	52	7	6
Blue Catfish	63	9	1	26
Freshwater Shrimp	1	3	6	90
Bay Anchovy	34	35	17	14
Blue Crab	7	23	20	58
Gulf Menhaden	6	47	16	31
Southern Flounder	8	52	26	14
Spot	3	83	6	14
Grass Shrimp		8	10	81
Mean Salinity	10.0	12.4	6.2	2.3
Mean Temperature	29.2	27.1	19.5	16.1

Table 6.5 Monthly mean length (mm) by species, all stations combined, for the ichthyoplankton collections.

SPECIES	November	January	March	April	May	June	July	August	October	December	February	April	June	August	Average	s.d.
ATLANTIC CROAKER	14.0	10.9		16.2						12.0					13.3	2.3
BAY ANCHOVY	20.0	21.1		24.8	14.3	15.8	12.2	9.7	17.0	20.3		5.3	20.5		16.5	5.7
BLUE CATFISH															0.0	-
BLUE CRAB			8.0	16.1	13.0	8.1	15.0	7.0	3.6			23.0			11.7	6.3
BROWN SHRIMP			13.0	12.4	7.8	13.8		10.4				11.9			11.6	2.2
CLOWN GOBY					5.5	4.5	4.0	4.0							4.5	0.7
FRESHWATER SHRIMP															0.0	-
GAFFTOPSAIL CATFISH															0.0	-
GRASS SHRIMP															0.0	-
GULF KILLIFISH															0.0	-
GULF MENHADEN.	20.7	23.2	21.4	23.5	20.0	51.0	37.0				20.5	25.2			26.9	10.4
HARDHEAD CATFISH															0.0	-
NAKED GOBY				3.5											3.5	-
PINFISH	12.0			14.0							13.0	12.0			12.8	1.0
ROUGH SILVERSIDE			5.0	12.4	6.1	7.7	6.1								7.5	2.9
SAND SEATROUT															0.0	-
SHEEPSHEAD MINNOW	31.0	29.0													30.0	1.4
SILVER PERCH															0.0	-
SOUTHERN FLOUNDER															0.0	-
SPOT		8.0													8.0	-
SPOTTED SEATROUT															0.0	-
STRIPED MULLET															0.0	-
TIDEWATER SILVERSIDE		37.4				7.2						4.4			16.3	18.3
WHITE SHRIMP						9.0	8.5	9.0				11.0			9.4	1.1
Average	19.5	21.6	11.9	15.4	11.1	14.6	13.8	8.0	10.3	16,2	16.8	13.3	20.5	0.0	14.6	
s.d.	7.4	11.0	7.2	6.7	5.7	15.1	12.0	2.6	9.5	5.9	5.3	8.0	-	-		9.2

Table 6.6 Monthly mean length (mm) by species, all stations combined, for the seine collections.

SPECIES	November	January	March	April	May	June	July	August	October	December	February	April	June	August	Average	s.d.
ATLANTIC CROAKER	17.8	17.1	25.5	37.6	44.3	64.3	74.8	63.0	13.5	21.4	19.0	41.7	80.3	100.0	44.3	27.8
BAY ANCHOVY	23.5	21.4	28.8	27.3	23.2	24.8	27.1	24.6	23.5	23.6	31.1	28.3	25.1	28.9	25.8	2.8
BLUE CATFISH				139.6	12.5	40.0	33.0	12.5			12.0	13.0	57.0		40.0	43.6
BLUE CRAB	16.0	13.0	15.6	15.8	17.8	10.5	16.1	12.0	6.0	8.6	9.5	30.5	34.3	12.2	15.6	7.9
BROWN SHRIMP	29.4		13.6	17.6	28.8	52.5	41.1	25.9	50.5	16.0	15.3	40.4	47.7	41.6	32.3	14.1
CLOWN GOBY															0.0	-
FRESHWATER SHRIMP															0.0	-
GAFFTOPSAIL CATFISH								54.5							54.5	-
GRASS SHRIMP															0.0	-
GULF KILLIFISH	45.0	34.3	39.0	56.3	49.0		56.0	26.0		33.1	60.0				44.3	11.9
GULF MENHADEN	21.7	22.3	22.4	22.2	22.2	31.0	38.5	33.3		21.7	21.6	22.5	32.8	43.7	27.4	7.6
HARDHEAD CATFISH							10.7	13.5	84.0				95.0	13.0	43.2	42.4
NAKED GOBY	18.5		23.0	25.3	33.0	17.5	12.5	7.7	16.0	18.0	15.0			34.0	20.0	8.1
PINFISH	12.0	20.0	14.3	17.0	38.0	56.0	80.0		11.0		14.5	27.4	65.5	74.5	35.9	26.1
ROUGH SILVERSIDE				61.4	52.8	34.8			39.9		35.0		28.1	33.3	40.8	11.9
SAND SEATROUT					36.6	41.5	34.8	49.8						45.8	41.7	6.2
SHEEPSHEAD MINNOW	25.1	26.6	30.0					29.7		22.7	24.0				26.4	3.0
SILVER PERCH					10.5	27.6	47.5	60.0					18.3	55.5	36.6	20.6
SOUTHERN FLOUNDER				36.6	42.5						19.0	42.6			35.2	11.1
SPOT	12.3	16.1	28.4	46.5	59.9	73.0	81.0			11.0	17.0	38.0	50.0	55.8	40.8	24.1
SPOTTED SEATROUT						18.5	36.7	16.4	37.0				13.8	20.0	23.7	10.4
STRIPED MULLET	21.0	23.7	25.6	39.7	34.9	66.1	71.2	46.8	96.0	20.5	24.4	29.0	55.6		42.7	23.4
TIDEWATER SILVERSIDE	28.5	31.9	35.4	50.7	28.6	23.1	35.8	36.2		31.7	26.1	41.6		34.3	33.7	7.4
WHITE SHRIMP	43.0						29.7	27.4	54.1	51.8		10.0	28.4	42.2	35.8	14.7
Average	24.1	22.6	25.1	42.4	33.4	38.7	42.7	31.7	39.2	23.3	22.9	30.4	45.1	42.3	33.7	
s.d.	10.3	6.8	8.0	31.7	14.2	19.6	22.7	17.5	29.9	11.4	12.4	11.1	23.8	23.0		20.2

Table 6.7 Monthly mean length (mm) by species, all stations combined, for the sled collections.

SPECIES	November	January	March	April	May	June	July	August	October	December	February	April	June	August	Average	s.d.
ATLANTIC CROAKER	13.4		24.6	28.1	38.1	66.0	80.0		11.9	16.0	19.9	34.6	16.0		31.7	22.3
BAY ANCHOVY	18.1		21.3	25.0	19.0	21.5	20.3	19.6	18.3	20.4	31.3	17.0	21.8	25.5	21.5	3.9
BLUE CATFISH					11.0										11.0	-
BLUE CRAB	23.4		10.8	13.3	17.9	19.9	8.8	19.1	7.1	9.4	12.8	11.6	13.9	73.0	18.5	17.1
BROWN SHRIMP	19.6		13.2	15.0	25.5	48.4	27.5	22.3	37.0	17.7	15.0	24.7	42.7	26.1	25.7	10.9
CLOWN GOBY							15.3		10.2						12.8	3.6
FRESHWATER SHRIMP															0.0	-
GAFFTOPSAIL CATFISH															0.0	-
GRASS SHRIMP															0.0	-
GULF KILLIFISH	46.2														46.2	-
GULF MENHADEN	19.8		21.4	20.2	19.0	26.0					22.1	19.9			21.2	2.4
HARDHEAD CATFISH															0.0	-
NAKED GOBY	15.8		21.2	23.7	23.4	14.9	13.5	11.1	13.4	16.8	19.9	22.7	11.7	19.7	17.5	4.5
PINFISH	12.5		14.3	18.5							13.7	32.0	50.5		23.6	15.0
ROUGH SILVERSIDE													21.0		21.0	-
SAND SEATROUT					15.0										15.0	-
SHEEPSHEAD MINNOW	23.1		35.5							23.4	31.0				28.3	6.1
SILVER PERCH							10.3						12.0	11.9	11.4	1.0
SOUTHERN FLOUNDER			28.5	25.9							20.4	38.0	52.3		33.0	12.5
SPOT	11.3		13.3	22.1							15.0	34.7	49.0	60.0	29.3	19.1
SPOTTED SEATROUT							22.0						11.5	10.0	14.5	6.5
STRIPED MULLET											22.0				22.0	-
TIDEWATER SILVERSIDE	20.0			40.8	13.7										24.8	14.2
WHITE SHRIMP	35.1					22.3	17.0	18.7	22.7	52.0		11.0	14.1	30.4	24.8	12.7
Average	21.5	0.0	20.4	23.3	20.3	31.3	23.9	17.6	17.2	22.2	20.3	24.6	26.4	32.1	23.3	
s.d.	10.0	-	7.8	7.8	8.1	18.7	21.9	4.2	10.1	13.8	6.3	9.9	16.9	22.6		13.2

Table 6.8 Monthly mean length (mm) by species, all stations combined, for the trawl collections.

SPECIES	November	January	March	April	May	June	July	August	October	December	February	April	June	August	Average	s.d.
ATLANTIC CROAKER	26.9	23.0	31.5	41.4	48.8	58.6	74.8	73.1	46.0	27.8	32.4	45.5	65.3	70.9	47.6	18.3
BAY ANCHOVY	36.0	26.2	36.1	34.7	35.4	39.9	39.3	40.3	38.7	30.5	28.0	34.4	38.5	42.4	35.7	4.7
BLUE CATFISH	17.0	20.5	17.2	134.7	21.3	14.3	15.0	13.1		14.5				16.5	28.4	37.4
BLUE CRAB	21.9	17.0	23.2	34.6	38.0	40.7	40.2	40.5	32.2	19.7	16.3	46.5	25.7	26.2	30.2	10.0
BROWN SHRIMP	52.6		14.0	36.5	51.7	68.4	58.6	58.5	52.0	47.4	39.8	51.6	69.6	45.2	49.7	14.4
CLOWN GOBY		27.5								24.0					25.8	2.5
FRESHWATER SHRIMP															0.0	-
GAFFTOPSAIL CATFISH							70.3	57.4						28.4	52.0	21.5
GRASS SHRIMP															0.0	-
GULF KILLIFISH	65.0	53.0													59.0	8.5
GULF MENHADEN	41.2	25.9	27.7	31.3	38.6	58.3	48.8	61.0	57.9	53.0	26.6	27.9	39.1	44.7	41.6	12.7
HARDHEAD CATFISH				256.0	13.6	33.0	19.6	40.7	73.0			79.9	31.9	42.5	65.6	74.7
NAKED GOBY		22.0	28.5	29.0			31.0			32.0	25.5	23.0			27.3	3.9
PINFISH	13.0		36.0	31.0		64.0	68.6	83.7			72.0	27.6	60.8	68.0	52.5	23.5
ROUGH SILVERSIDE															0.0	-
SAND SEATROUT	58.3				38.1	54.8	52.6	63.0		82.0			40.0	53.6	55.3	13.7
SHEEPSHEAD MINNOW	32.5	32.2						28.0		30.7					30.9	2.1
SILVER PERCH						26.5		73.3					27.0	51.3	44.5	22.4
SOUTHERN FLOUNDER	52.2	16.3	20.0	38.3	41.6	57.2	78.9	78.3		12.3	26.4	45.7	51.5	83.5	46.3	23.9
SPOT	78.1	83.0	96.0	36.6	49.0	67.0	76.4	86.7	91.0		24.2	43.1	57.6	62.2	65.5	22.4
SPOTTED SEATROUT															0.0	-
STRIPED MULLET		16.6	13.3				47.0	91.0		14.6				87.0	44.9	36.4
TIDEWATER SILVERSIDE	85.0	48.5		86.0	37.0										64.1	25.1
WHITE SHRIMP	59.3		72.0				62.1	39.4	70.3	57.8	53.6	35.2	16.5	61.6	52.8	17.4
Average	45.6	31.7	34.6	65.8	37.6	48.6	52.2	58.0	57.6	34.3	34.5	41.9	43.6	52.3	45.9	
s.d.	23.5	21.8	30.4	83.3	11.9	15.6	19.5	21.0	13.7	24.0	20.1	19.3	15.4	18.2		26.9

Table 6.9 Monthly total abundance for all stations by species in the ichthyoplankton collections

SPECIES	November	January	March	April	May	June	July	August	October	December	February	April	June	August	Average	s.d.
ATLANTIC CROAKER	4	49		5						1					14.8	22.9
BAY ANCHOVY	62	59	37		146	200	22	4	1	16		22	2		51.9	64.5
BLUE CATFISH															0.0	-
BLUE CRAB			1	5	2	38	1	1	5			1			6.8	12.7
BROWN SHRIMP			1	66	5	17		7				65			26.8	30.4
CLOWN GOBY					27	183	3	1							53.5	87.1
FRESHWATER SHRIMP															0.0	-
GAFFTOPSAIL CATFISH															0.0	-
GRASS SHRIMP															0.0	-
GULF KILLIFISH															0.0	-
GULF MENHADEN	7	158	148	254	23	1	1				2	11			67.2	94.5
HARDHEAD CATFISH															0.0	-
NAKED GOBY				17											17.0	-
PINFISH	1			2							1	1			1.3	0.5
ROUGH SILVERSIDE			6	10	129	28	18								38.2	51.5
SAND SEATROUT															0.0	-
SHEEPSHEAD MINNOW	1	1													1.0	0.0
SILVER PERCH															0.0	-
SOUTHERN FLOUNDER															0.0	-
SPOT		2													2.0	-
SPOTTED SEATROUT															0.0	-
STRIPED MULLET		2	1												1.5	0.7
TIDEWATER SILVERSIDE		22				6								19	15.7	8.5
WHITE SHRIMP						11	2	2				2			4.3	4.5
Average	15.0	41.9	32.3	51.3	55.3	60.5	7.8	3.0	3.0	8.5	1.5	17.0	2.0	19.0	30.4	
s.d.	26.4	56.4	58.4	92.1	64.6	81.8	9.5	2.5	2.8	10.6	0.7	24.9	-	-		55.0

Table 6.10 Monthly total abundance for all stations by species in the seine collections

SPECIES	November	January	March	April	May	June	July	August	October	December	February	April	June	August	Average	s.d.
ATLANTIC CROAKER	520	41	573	1194	190	25	5	3	2	168	453	358	3	2	252.6	343.2
BAY ANCHOVY	318	11	1586	2193	3800	5597	2129	4258	9286	3684	71	1615	5892	3912	3168.0	2598.6
BLUE CATFISH				6	2	20	3	2			1		1	2	4.6	6.4
BLUE CRAB	64	2	34	107	32	246	15	3	1	4	41	4	3	15	40.8	66.3
CLOWN GOBY															0.0	-
BROWN SHRIMP	79	14	432	625	580	504	41	84	1	467	689	329		46	299.3	261.6
FRESHWATER SHRIMP				14	2	1									5.7	7.2
GAFFTOPSAIL CATFISH								2							2.0	-
GRASS SHRIMP	1954	796	586	381	1649	126	567	25		380	1125	44	45	117	599.6	629.2
GULF KILLIFISH	76	41	3	4	2		3	1		128	1				28.8	45.3
GULF MENHADEN	653	1181	21722	1206	5504	666	13	124		310	961	2379	8269	59	3311.3	6044.2
HARDHEAD CATFISH							3	2	1				1	1	1.6	0.9
NAKED GOBY	9	3	3	1	10	11	37	1	1	2	1			1	6.7	10.3
PINFISH	1	1	3	3	4	1	1		2		193	38	5	2	21.2	55.1
ROUGH SILVERSIDE				7	8	110			53		1		200	8	55.3	74.9
SAND SEATROUT					58	25	3	4						2	18.4	24.1
SHEEPSHEAD MINNOW	99	491	1					14		246	23				145.7	192.3
SILVER PERCH					6	50	4	1					11	4	12.7	18.6
SOUTHERN FLOUNDER				6	4						3	8			5.3	2.2
SPOT		51	57	82	14	16	2	1		1	398	396	18	17	87.8	146.6
SPOTTED SEATROUT						3	13	6	4				3	1	5.0	4.2
STRIPED MULLET	1	1671	65	19	8	7	29	3	1	45	106	3	7		151.2	457.7
TIDEWATER SILVERSIDE	303	357	65	45	66	175	166	73	10	293	106	286	217	93	161.1	112.6
WHITE SHRIMP	1						1272	1341	211	5		1	129	2332	661.5	879.5
Average	313.7	358.5	1933.1	368.3	663.3	446.1	239.2	313.1	797.8	441.0	260.8	455.1	986.9	389.1	546.7	
s.d.	536.5	542.0	5962.8	636.4	1532.3	1340.8	567.5	1002.6	2673.8	987.2	365.7	754.5	2515.5	1066.5		1913.8

Table 6.11 Monthly total abundance for all stations by species in the sled collections

SPECIES	November	January	March	April	May	June	July	August	October	December	February	April	June	August	Average	s.d.
ATLANTIC CROAKER	216		90	52	6	1	1		5	25	64	6			46.6	67.1
BAY ANCHOVY	24		17	43	73	12	86	7	3	18	4	1	16	2	23.5	27.4
BLUE CATFISH					1										1.0	-
BLUE CRAB	97	60	89	34	45	35	22	9	21	52	30	8		10	39.4	28.8
BROWN SHRIMP	72		137	175	165	201	181	67	78	5	811	1219	226	105	264.8	348.8
CLOWN GOBY							3		4						3.5	0.7
FRESHWATER SHRIMP					2	1	2						1		1.5	0.6
GAFFTOPSAIL CATFISH															0.0	-
GRASS SHRIMP		796	49	63	83	71	226	19		121	310	18	21	16	149.4	223.0
GULF KILLIFISH	11														11.0	-
GULF MENHADEN	4		1260	71	2	1					16	8			194.6	470.5
HARDHEAD CATFISH															0.0	-
NAKED GOBY	29		9	9	5	22	43	18	52	5	6	11	19	6	18.0	15.2
PINFISH	6		4	2							156	2	3		28.8	62.3
ROUGH SILVERSIDE													1		1.0	-
SAND SEATROUT					6										6.0	-
SHEEPSHEAD MINNOW	169	2								25	1				49.3	80.6
SILVER PERCH							21						91	9	40.3	44.3
SOUTHERN FLOUNDER			2	18							23	1	3		9.4	10.3
SPOT	3		33	6							361	3	2	1	58.4	133.9
SPOTTED SEATROUT							3						3	1	2.3	1.2
STRIPED MULLET											1				1.0	-
TIDEWATER SILVERSIDE	1			3	3								1		2.0	1.2
WHITE SHRIMP	9					3	437	86	21	1		1	262	80	100.0	151.6
Average	53.4	286.0	169.0	43.3	35.5	38.6	93.2	34.3	26.3	31.5	148.6	116.2	49.9	25.6	75.3	
s.d.	26.2	561.4	506.8	29.5	32.5	30.1	166.9	39.0	ERR	56.3	149.3	6.4	79.2	30.5		186.9

Table 6.12 Monthly total abundance for all stations by specie in the trawl collections.

SPECIES	November	January	March	April	May	June	July	August	October	December	February	April	June	August	Average	s.d.
ATLANTIC CROAKER	364	437	2234	2484	1567	7061	279	122	6	315	452	1836	377	105	1259.9	1870.7
BAY ANCHOVY	58	57	53	62	81	93	132	218	60	363	24	548	28	509	163.3	178.9
BLUE CATFISH	1	4	39	32	32	21	162	147	1	7				2	40.7	58.0
BLUE CRAB	141	19	271	208	120	46	55	12	7	21	78	43	12	14	74.8	81.9
BROWN SHRIMP	113		1	36	790	1268	730	73	128	78	43	2221	1458	169	546.8	707.7
CLOWN GOBY		2								1					1.5	0.7
FRESHWATER SHRIMP				112	268	8	6								98.5	123.4
GAFFTOPSAIL CATFISH							29	76						46	50.3	23.8
GRASS SHRIMP		412	481	47		1				49	48	66			157.7	199.3
GULF KILLIFISH	1	45													23.0	31.1
GULF MENHADEN	147	120	126	3183	307	277	83	9	17	201	257	1560	358	326	497.9	862.2
HARDHEAD CATFISH				1	3	3	21	70	2			18	33	70	24.6	28.0
NAKED GOBY		1	2	2		2				1	2	1			1.6	0.5
PINFISH	1		1	1		1	5	3			1	24	12	2	5.1	7.5
ROUGH SILVERSIDE															0.0	-
SAND SEATROUT	18				51	158	95	27		3			2	73	53.4	53.7
SHEEPSHEAD MINNOW	4	133						1		11					37.3	64.0
SILVER PERCH						4	3						1	14	5.5	5.8
SOUTHERN FLOUNDER	9	5	19	24	43	31	16	6		3	74	34	4	2	20.8	20.8
SPOT	12	1	1	175	3	8	35	11	1		38	1300	150	40	136.5	354.2
SPOTTED SEATROUT															0.0	-
STRIPED MULLET		64	4				5	1		18				2	15.7	24.5
TIDEWATER SILVERSIDE		20										2			11.0	12.7
WHITE SHRIMP	2047		1				656	209	134	131	15	4	2	563	376.2	632.6
Average	224.3	94.3	248.7	489.8	296.8	598.8	144.5	65.7	39.6	85.9	93.8	589.0	203.1	129.1	239.1	
s.d.	557.3	146.4	613.2	1051.9	479.9	1816.6	226.9	75.7	55.0	122.4	138.4	827.9	418.4	186.3		695.8

Table 6.13. Results of regression analysis of salinity and density of three species taken in the sled and seine collections.

Species	Correlation Coefficient	R^2	Significance
Atlantic croaker	-0.216	0.0444	$P > 0.0001$
Gulf menhaden	-0.188	0.0352	$P > 0.0003$
Brown shrimp	0.222	0.0496	$P > 0.0001$

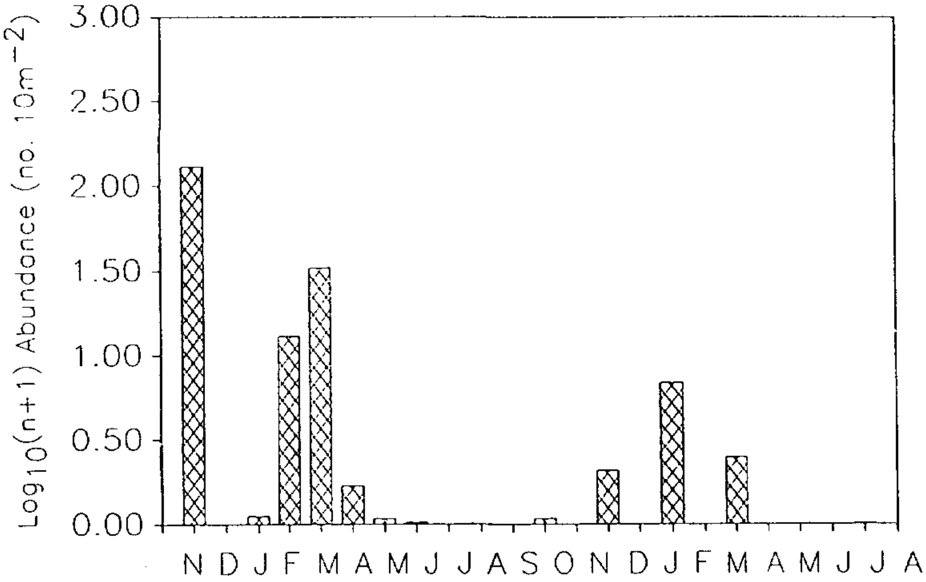

Fig. 6.7 Mean number of Atlantic croaker per 10m^{-2} by month for combined seine and sled data

Fig 6.8 Mean length of Atlantic croaker from trawl and seine data for each month.

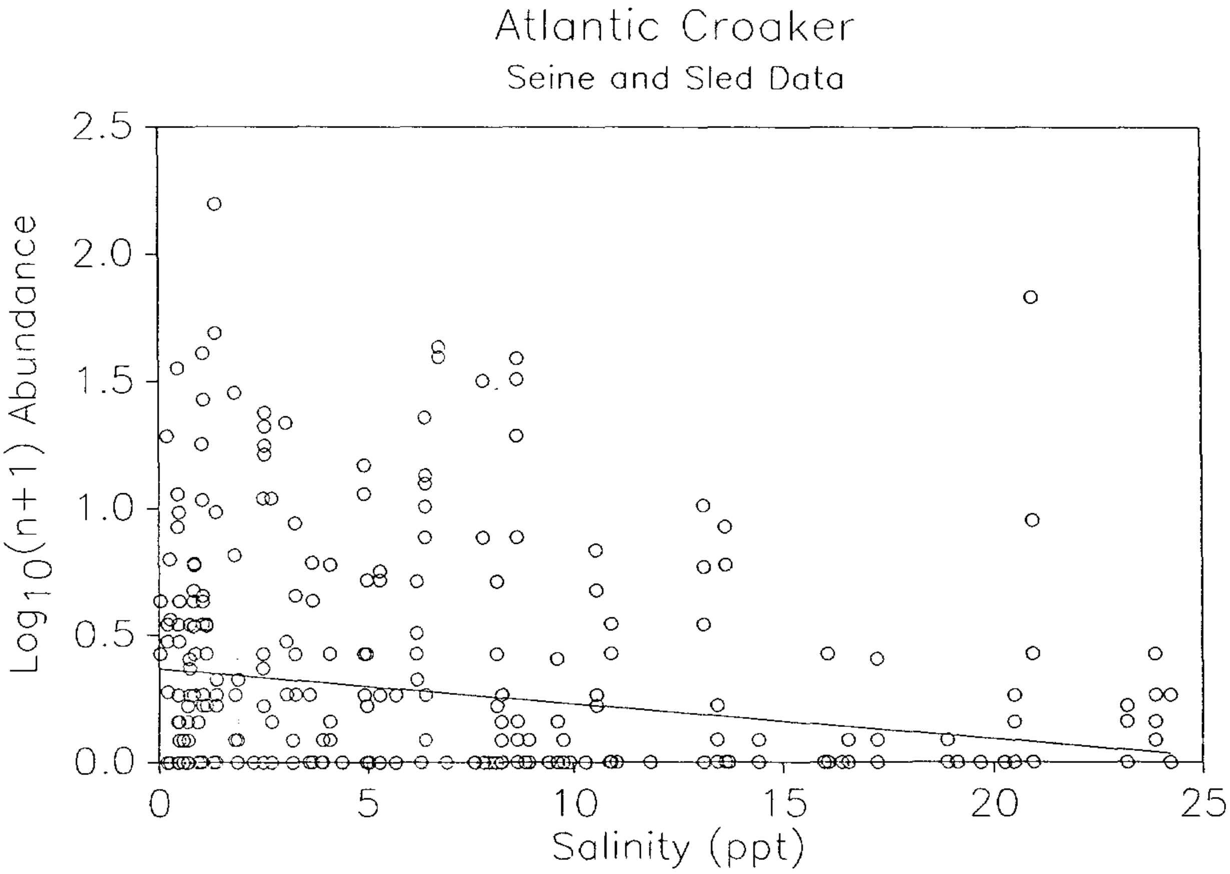

Fig. 6.10 The relationship between salinity and density of brown shrimp.

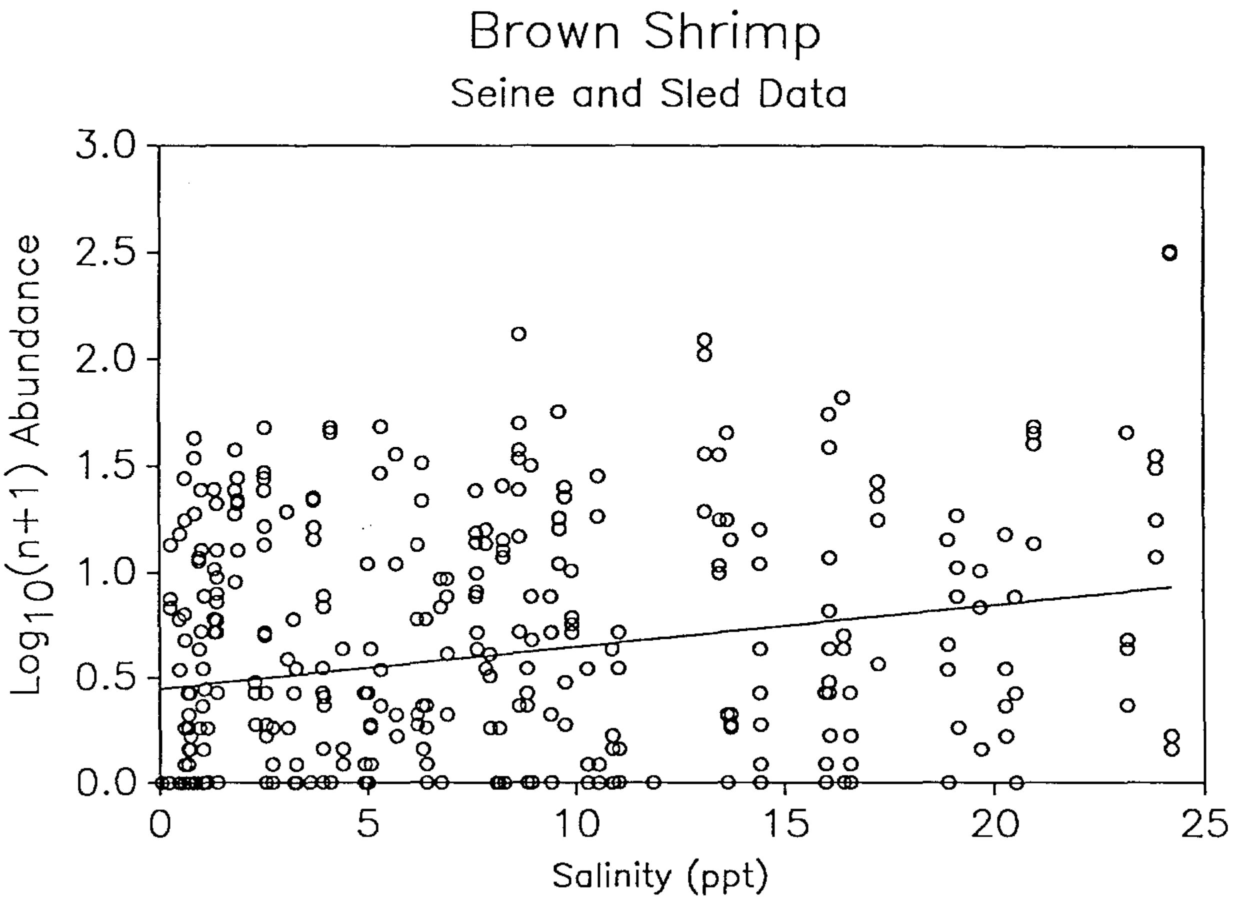

Fig. 6.9 The relationship between salinity and density

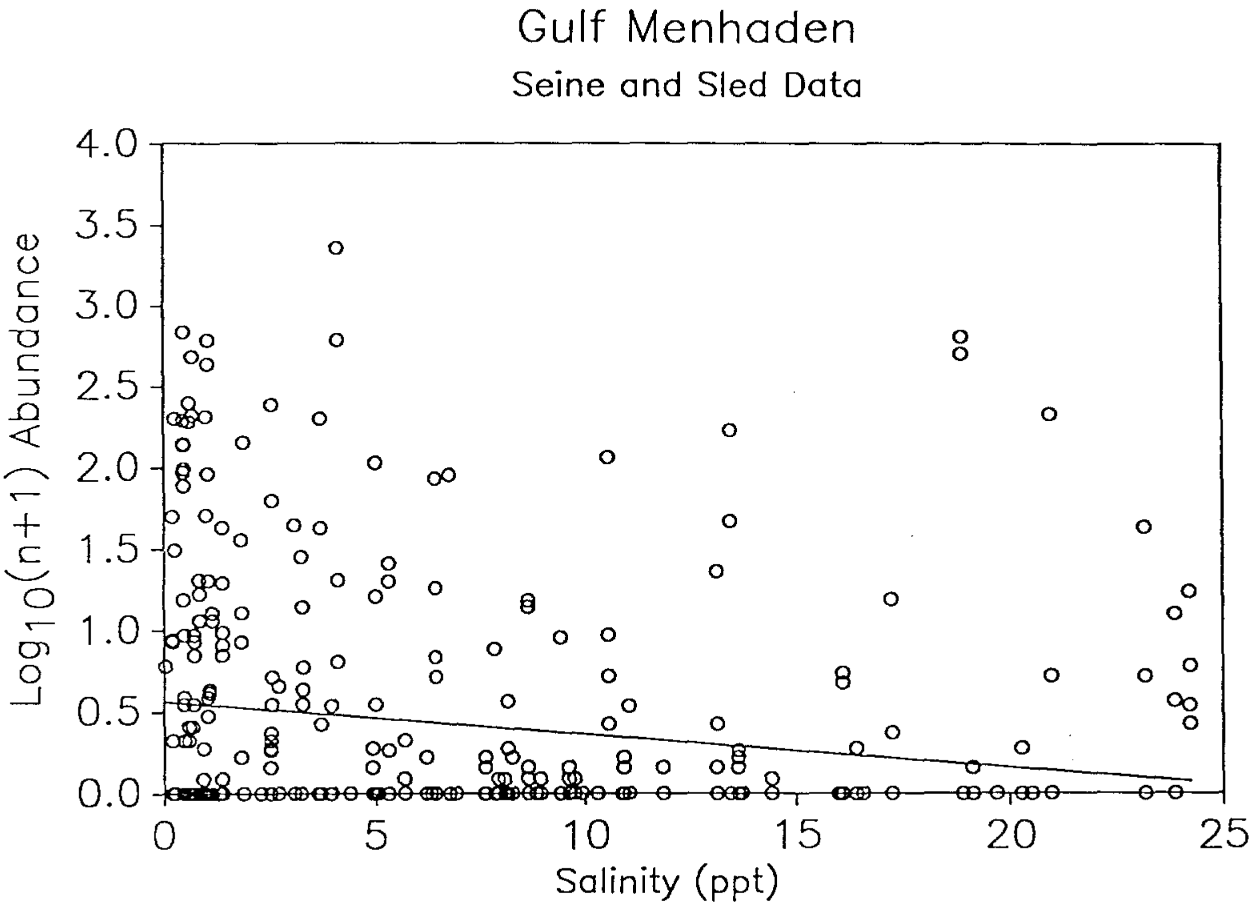

Fig 6.11 The relationship between salinity and density of Gulf menhaden.

CHAPTER 7

STABLE ISOTOPE STUDIES

INTRODUCTION

There are two stable isotopes of carbon and two of nitrogen with the ratios:

$$\frac{^{13}C}{^{12}C} = \frac{1.11}{98.89} \qquad \frac{^{15}N}{^{14}N} = \frac{0.37}{99.63}$$

It has been known for sometime that these ratio values are slightly different for materials from various sources. The chemical principles which control these variations are well understood so that measurements of the ratios can be used to study mechanisms of natural processes. As a result of small kinetic isotope effects in the biological carbon and nitrogen cycles the major reservoirs of carbon and nitrogen have fairly distinct isotope ratios. Modern mass spectrometers make it possible to measure variations in these ratios on a large number of samples at a high precision. By custom, isotope ratio data are reported using the δ (del) terminology[1].

Carbon reservoirs relevant to this study include C_3 plants, phytoplankton, seagrasses and C_4 plants. Because these are the end members for the mixing model that will be used to estimate the sources of organic matter in the diet of animals it is important to note their $\delta^{13}C$ values as well as their abundance

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[1]

$$\delta^{13}C = \frac{R_X - R_S}{R_S} \times 1000$$

where $R_X = {}^{13}C/{}^{12}C$ of a sample
$R_S = {}^{13}C/{}^{12}C$ of a standard carbonate rock, PDB.

A similar definition applies to $\delta^{15}N$ where the standard is atmospheric nitrogen. The units are per mil.

and distribution. Phytoplankton are distributed throughout the study area; $\delta^{13}C$ for marine phytoplankton are ~ -20. The C_3 plants are mostly associated with the extensive *Juncus* marsh in upper Lavaca Bay and with other vascular plant detritus which is being transported downstream by the river and streams; $\delta^{13}C$ for C_3 plants is ~ -26. Seagrasses do not occur in Lavaca Bay, although they do grow in Matagorda Bay; $\delta^{13}C$ for seagrasses is ~ -10. *Spartina* does occur in upper Lavaca Bay, but it is not nearly as abundant as *Juncus*; as a C_4 plant it has a $\delta^{13}C$ of ~ -13. Given these distributions and $\delta^{13}C$ ranges a good, but not perfect, $\delta^{13}C$ tracer model can be made for the study area.

To a first approximation a number of investigators have found that "you are what you eat ± 1.0 per mil" applies to food webs as diverse as insects (Fry et al 1978) and African browsing animals like the kudu (Van Der Merwe, 1982). The opportunity for a natural tracer experiment of carbon flow in coastal food webs is obvious and has been undertaken by several researchers. These studies are reviewed by Fry and Sherr (1984).

Nitrogen isotope ratios, as expressed by $\delta^{15}N$, do not behave exactly like carbon. Rather than staying almost constant as organic nitrogen moves up a food chain, $\delta^{15}N$ shifts 2 to 5 per mil in the plus direction at each trophic level (DeNiro and Epstein 1978). The exact value of this shift is species dependent and is not well understood. However in a general sense the position of a species in a food chain will be reflected in the $\delta^{15}N$ value of that species. For example zooplankton are ~ +5, while rainbow trout are ~ +12, in Lake Iliamna, Alaska.

The results of a two year study of $\delta^{13}C$ and $\delta^{15}N$ of the components of the Lavaca River Delta and Bay are reported and analyzed in this report.

METHODS

Table 7.8 reports $\delta^{13}C$ values for approximately 700 samples of biota, sediment and dissolved organic carbon. In order to interpret this data an estimate of error must be made.

The $\delta^{13}C$ values were measured on a VG Micromass isotope ratio mass spectrometer. The measurements were made on CO_2 which was prepared by sealed tube oxidation, sample plus cupric oxide in a pyrex tube. Routine duplicate analyses and daily calibration checks indicate that the analytical error for a single analysis does not exceed ± 0.2 per mil. As may be anticipated this is considerably less than the variability associated with biological samples. Table 7.1 provides two examples of the range associated with organisms taken in the same trawl haul.

These animals, like most in this study, are small and respond quickly to changes in diet. The 1.0 to 1.5 per mil variability reflects the random utilization of isotopically dissimilar diet items by these animals. Captive shrimp offered a single diet resemble each other in $\delta^{13}C$ values to ± 0.3 (Anderson et al 1987).

Samples were taken for isotopic studies during the regular sampling periods, refrigerated, returned to the laboratory and kept frozen until processed. The sampling schedule is shown in Table 7.2.

RESULTS

The major goal of the carbon isotope study was to assess the level of utilization of river/marsh derived organic matter by biota in upper Lavaca Bay and to establish whether a gradient of that organic signal extends toward the lower bay. In order to evaluate the data-base (Table 7.8) it is necessary to establish end members for the organic reservoirs which are subject to mixing. The following values are consistent with generally accepted ones with the major uncertainty being the net phytoplankton:

C_3 terrestrial plants, e.g. elm	~ -26
C_3 marsh plants, e.g. *Juncus*	~ -26
C_4 marsh plants, e.g. *Spartina*	~ -13
Seagrasses	~ -10
Blue-green algae	~ -14
Net phytoplankton	~ -20

The model for Lavaca Bay is a simple one wherein more negative organic carbon derived from river transported C_3 plants and from marsh derived *Juncus* (also C_3) is mixing with phytoplankton to yield organisms, sedimentary carbon and DOC with intermediate $\delta^{13}C$ values. As has been pointed out seagrasses are absent from Lavaca Bay and *Spartina* is not very abundant. For the Matagorda Bay station seagrass must be taken into consideration.

A series of $\delta^{13}C$ measurements were made on gut contents and muscle tissue to establish the relationship between the tissue and the most recent feeding of each organism (Table 7.3). With only one exception, a flounder, the animal tissue is between 1 and 3 per mil enriched in ^{13}C (i.e. $\delta^{13}C$ more positive) with respect to the gut contents. The muscle is a time integrated quantity while the gut content is short term. Nevertheless it appears that there is a small metabolic isotope effect for carbon. Other workers have made similar observations for other ecosystems. Based on this argument one can argue that $\delta^{13}C$ values of animal tissue shown in Table 7.8 should be corrected 1 or 2 per mil to represent the food source. No such correction has been made, but the argument should be kept in mind.

Marine sediments contain several types of organic matter including macro-infauna which was removed. Thus $\delta^{13}C$ determined on the remaining material provides data which should record a time integrated indicator of the source of organic matter. In Figure 7.1 $\delta^{13}C$ of all sediment samples are plotted against station number to test the simple model that the amount of river transported organic matter which is deposited in sediment decreases with distance from the river. There is a clear trend which verifies the model; station 623 does not fit the trend, being too heavy in $\delta^{13}C$. The ordering of the stations on the x-axis is somewhat arbitrary, but it does follow the average salinity trend. The average $\delta^{13}C$ values for sedimentary organic matter range between -22.5 and -17.5. This is not unexpected since even the river station has a plankton source for some fraction of its organic matter. The bay stations 1505, 1905 and 35/36 appear to have received very little river transported higher plant organic matter. Once again station 623 is more positive, ^{13}C enriched, than the trend would place it.

Infauna were picked from sediment, identified and subjected to $\delta^{13}C$ determination. The same trend is seen for infauna (Figure 7.2) as for sediment; a strong higher plant/river signal near the river which grades into a phytoplankton signal at the bay station. Infauna are ideal organisms for ^{13}C tracer studies because they do not move substantial distances and thus make a true record of $\delta^{13}C$ of organic matter which comes their way. If -23 is taken as the $\delta^{13}C$ value which represents a 50 percent higher plant source and a 50 percent plankton source then infauna from stations 45, 603 and 65 are mostly higher plant supported while the other stations are mostly plankton based. Station 623 is again a special case. Bivalves, like infauna, are non-mobile and good $\delta^{13}C$ recorders. Figure 7.3 shows a clear trend of $\delta^{13}C$ with distance from the river mouth for bivalves. Bivalves are often used as indicators of pollution and they may be useful indicators of the source of organic carbon.

Zooplankton are at the base of the food web and thus important to an understanding of the food web. The samples shown in Figure 7.4 represent hand picked zooplankton which are free of detritus. Each point represents more than one species, but the species are known and recorded in Table 7.8. Once again station 623 does not follow the trend. A strong input of river transported higher plant material is suggested by the fact that the Lavaca Bay/River stations (except 623) are more negative than -23.5. This observation confirms the suggestion that *Spartina* is not very important in this food-web relative to C_3 material. In order to more critically examine $\delta^{13}C$ zooplankton, individual *Acartia* (100-200) were hand picked from selected collections and submitted for $\delta^{13}C$ analysis. The *Acartia* show the same trend with relation to station number (Fig. 7.5), as the mixed zooplankton but they have end members of -21.8 and -26.4 similar to our model. *Acartia* fall on the river source side of the mixing curve with an overall average of -24.0 ± 1.9. This supports the idea that zooplankton may be deriving substantial nutrition from higher plant detritus or from microorganisms that are consuming detritus. In other words in this estuarine system zooplankton are not just consuming phytoplankton, they are interacting with higher plant detritus. Crude net tows were also studied, but that data is not included in Figures 7.4 or 7.5. It is included in Table 7.8.

Particulate organic carbon, POC, contains zooplankton, phytoplankton and detritus. The $\delta^{13}C$ values for POC in Fig. 7.6 do not correlate with station location very well, but it is interesting to note that most values are more negative than minus 23, indicating a strong river/C_3 plant source; station 623 again bucks the trend. Based on the fact that strong C_3 and weak C_4 signals have been detected in Figures 7.1 to 7.5 it seems clear that the Bay POC values of -20.3 represents marine plankton and not a mixture of C_3 and C_4/seagrass; open bay stations less negative than -20 may represent a seagrass influence. Dissolved organic carbon, DOC, shows little relation to station and only a modest river signal (Fig. 7.7). DOC is too complex to yield to a simple model.

The fish samples were taken with the net used in the distribution and abundance study, which catches fish of a few cm length. The plot of $\delta^{13}C$ of all fish vs station number (Fig. 7.8) shows a fairly strong correlation, especially if station 623 is ignored. The average $\delta^{13}C$ values of all fish, sorted by station range between -21.5 and -19.0, a range which in Figure 7.8, is suggestive of plankton as a source of carbon. Since fish are one or more steps up the trophic scale the small metabolic effect described in Table 7.3 is probably shifting them 1.0 or 1.5 per mil in the plus direction relative to their food. At this time it is not appropriate to make a correction based on this but one should be aware of the idea. Not all individual fish fall in this narrow range. Table 7.4 shows the average $\delta^{13}C$ value of the same 198 fish sorted according to type wherein the range is -17.1 to -24.6. The average $\delta^{13}C$ value of all fish used in the study is -20.6 ± 2.6. Individual species do not correlate with station as well as all species do, as shown in Figure 7.9. Specialized feeding patterns for Cyprinodon (avg. $\delta^{13}C$ = -17.3), and Fundulus (avg. $\delta^{13}C$ = -17.6) are evident.

Shrimp are like fish in being mobile and thus more able to seek food. The plot of $\delta^{13}C$ of all penaeid shrimp (Fig. 7.10) shows a fairly strong correlation with station. The average $\delta^{13}C$ values of all Lavaca Bay samples are more positive than -23 suggesting a mixed higher plant and plankton food source. The shrimp value at the Bay station (-17.4) compares with offshore

Gulf shrimp (-16.5) (Fry, 1981). However it is possible that both samples may have been slightly influenced by seagrass. Shrimp taken from seagrass beds in the Laguna Madre have $\delta^{13}C$ values in the -12 to -13 range (Fry and Sherr, 1984). Table 7.5 shows $\delta^{13}C$ of shrimp as a function of station and month. July collections at the river stations stand-out, but the data is inadequate to make a firm conclusion. The same trend is seen for $\delta^{13}C$ of fish vs station and time of collection (Table 7.6).

A suite of samples was selected for the determination of $\delta^{15}N$. These samples were subsamples of freeze-dried and powdered material for which $\delta^{13}C$ had been determined. $\delta^{15}N$ is not generally viewed as a tracer of the source of organic matter, i.e. terrestrial plant vs phytoplankton. It is rather an indicator of the level of an organism on the trophic food scale. The samples for $\delta^{15}N$ were selected to span the trophic structure of the river/bay ecosystem. Table 7.7 illustrates this trophic relationship in a gross way. Higher plants and macroalgae are at the less positive end of the Table. The trophic shift of $\delta^{15}N$, mentioned earlier, of 2 to 4 per mil is evident in Table 7.7 with infauna as a group being the most positive. This does not indicate that infauna are at the top of the food-web, because no doubt several food-webs are represented in the data. However it does indicate that infauna, fish and shrimp are fairly near the top. Among fish, croaker at +13 to +14 are higher than Cyprinodon at +7. In another study large redfish were +17, clearly a top carnivore. Station number was not expected to correlate with $\delta^{15}N$, however based on Fig. 7.11 that expectation is reconsidered. Figure 7.11 shows a weak trend for $\delta^{15}N$ to become more positive with distance from the river. If higher plant organic nitrogen is +2 to +3, while phytoplankton nitrogen is +5 to +7, then a weak station to $\delta^{15}N$ relationship might be superimposed over the stronger trophic nitrogen pattern. While the $\delta^{15}N$ relationships are interesting, at this time the data base is too small to completely resolve specific food-webs. Almost all of the samples used for $\delta^{13}C$ are achieved as a dry powder which could be used for future $\delta^{15}N$ studies.

CONCLUSIONS

The $\delta^{13}C$ data combined with a simple, conceptual mixing model indicate that substantial river transported higher plant, C_3 and marsh C_4 plant organic carbon is being taken up and assimilated by organisms in the Lavaca Bay ecosystem. The degree of assimilation correlated with distance from the river for sedimentary organic matter and for a number of biota. The utilization of river transported organic matter is most intense in bivalves and surprisingly in zooplankton, *Acartia.* Shrimp and infauna show the river signal but less so than bivalves and *Acartia.* Fish show the least utilization of river transported, C_3-higher plants. This is taken to indicate a plankton rich diet because the role of the sparse *Spartina* stands do not appear to be generally significant. The generalizations, based on $\delta^{13}C$ data, combine with abundance data for the various species indicate that river and its associated marsh is important in the food-webs of the estuarine system. A similar, but much less extensive, one year survey of $\delta^{13}C$ of samples from the study area (Ward et al 1982) found trends like those discussed. Taken together the two years of data of this study and the one year survey are a sound argument for the importance of freshwater for the Lavaca Bay system.

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FIGURE 7.1

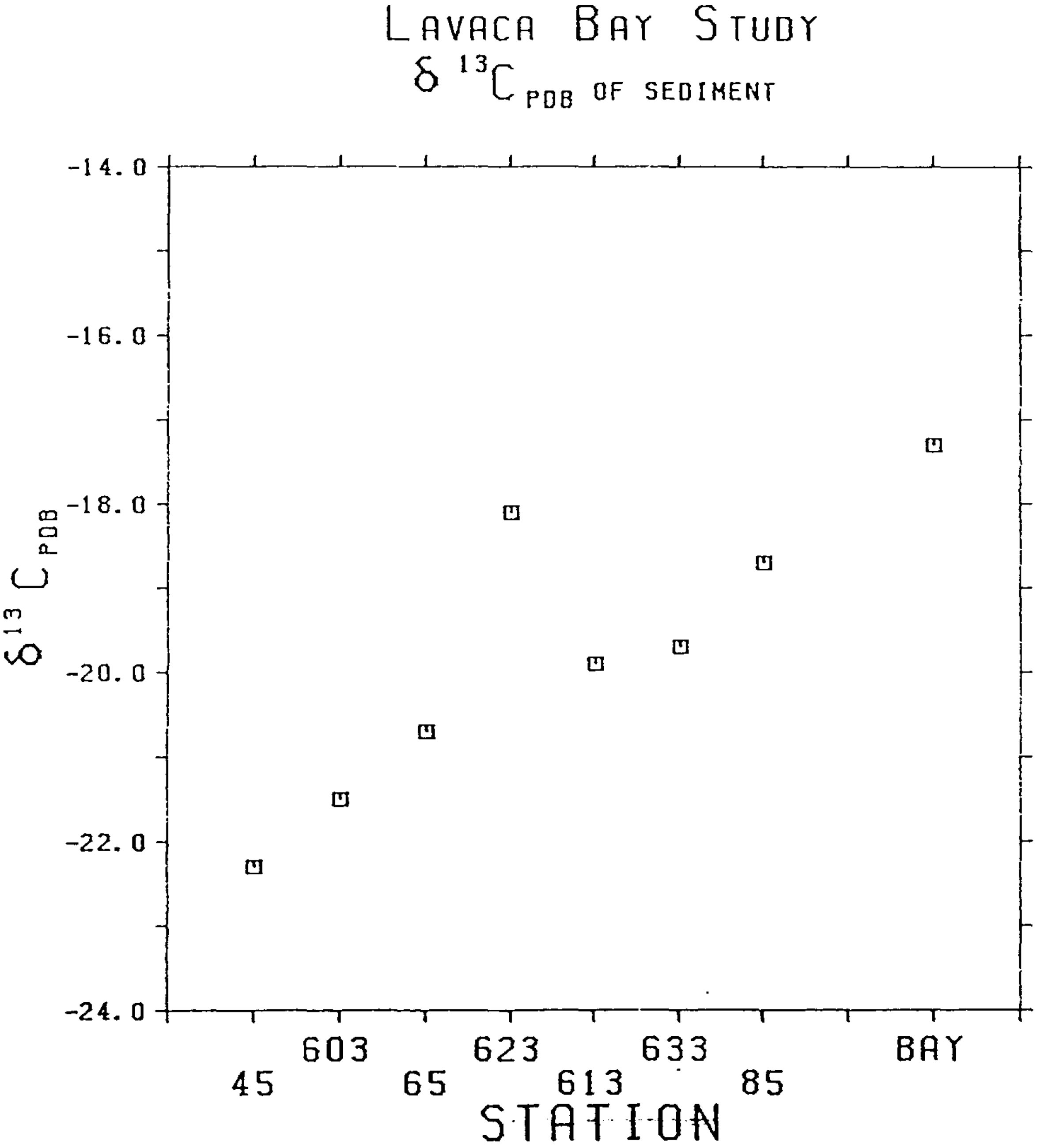

LAVACA BAY STUDY
δ 13C PDB OF SEDIMENT
δ 13C PDB
-14.0
-16.0
-18.0
-20.0
-22.0
-24.0
45
603
65
623
613
633
85
BAY
STATION

Figure 7.1- Data

Station(s)	Average	Std. Dev.	Number
45	-22.3	0.7	3.0
603	-21.5	0.3	3.0
65	-20.7		1.0
623	-18.1		1.0
613	-19.9		1.0
633	-19.7	0.6	2.0
85	-18.7	1.2	2.0

FIGURE 7.2

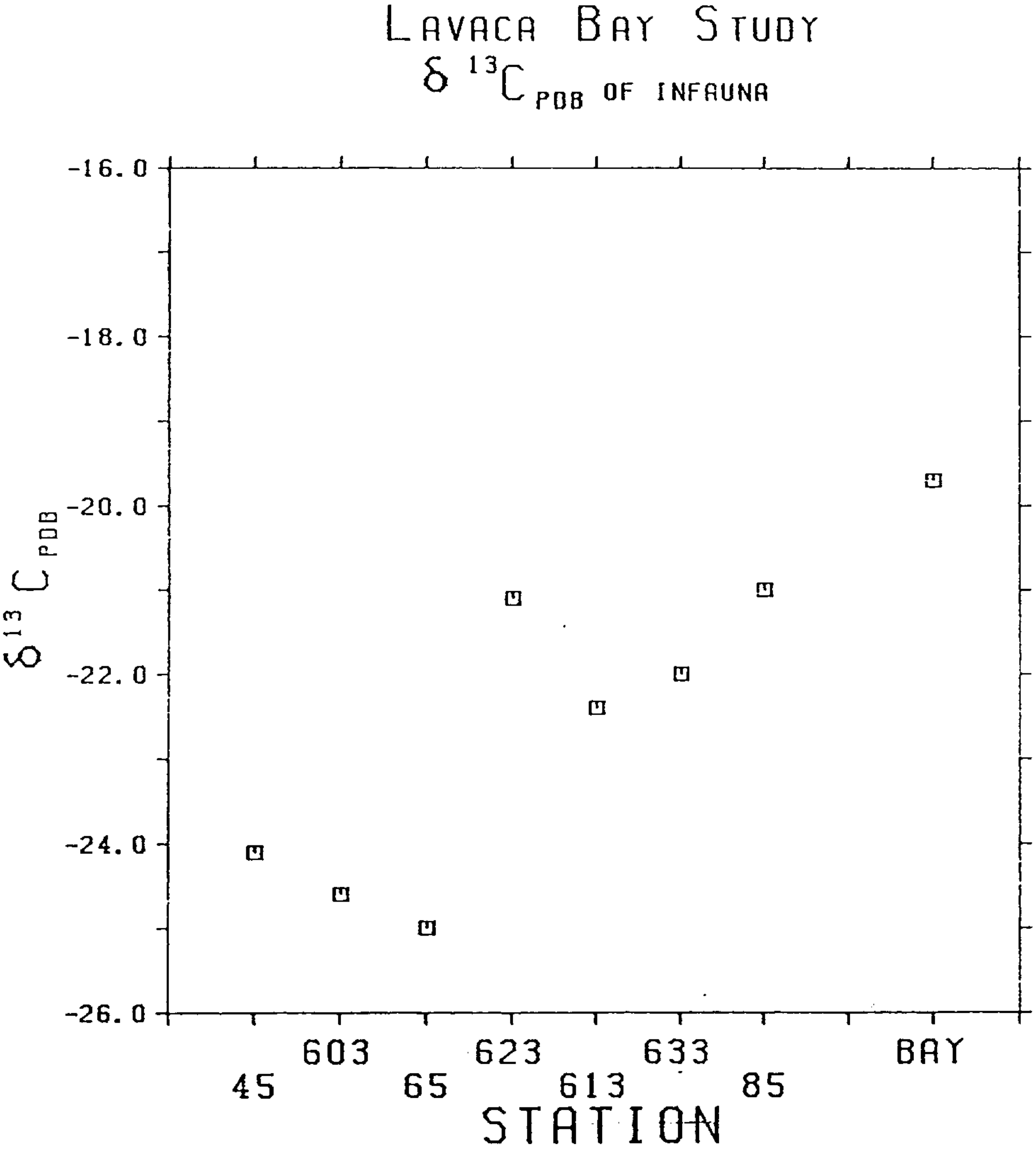

Lavaca Bay Study
$\delta^{13}C_{PDB}$ of infauna
-16.0
-18.0
-20.0
-22.0
-24.0
-26.0
$\delta^{13}C_{PDB}$
45
603
65
623
613
633
85
BAY
STATION

FIGURE 7.2 - DATA

Station(s)	Average	Std. Dev.	Number
45	-24.1	2.54	13
603	-24.6	1.14	8
65	-25.0	1.52	5
623	-21.1	0.87	6
613	-22.4	0.11	2
633	-22.0	1.80	9
85	-21.0	2.10	17
BAY	-19.7	1.45	68
ALL	-21.1	2.49	128

FIGURE 7.3

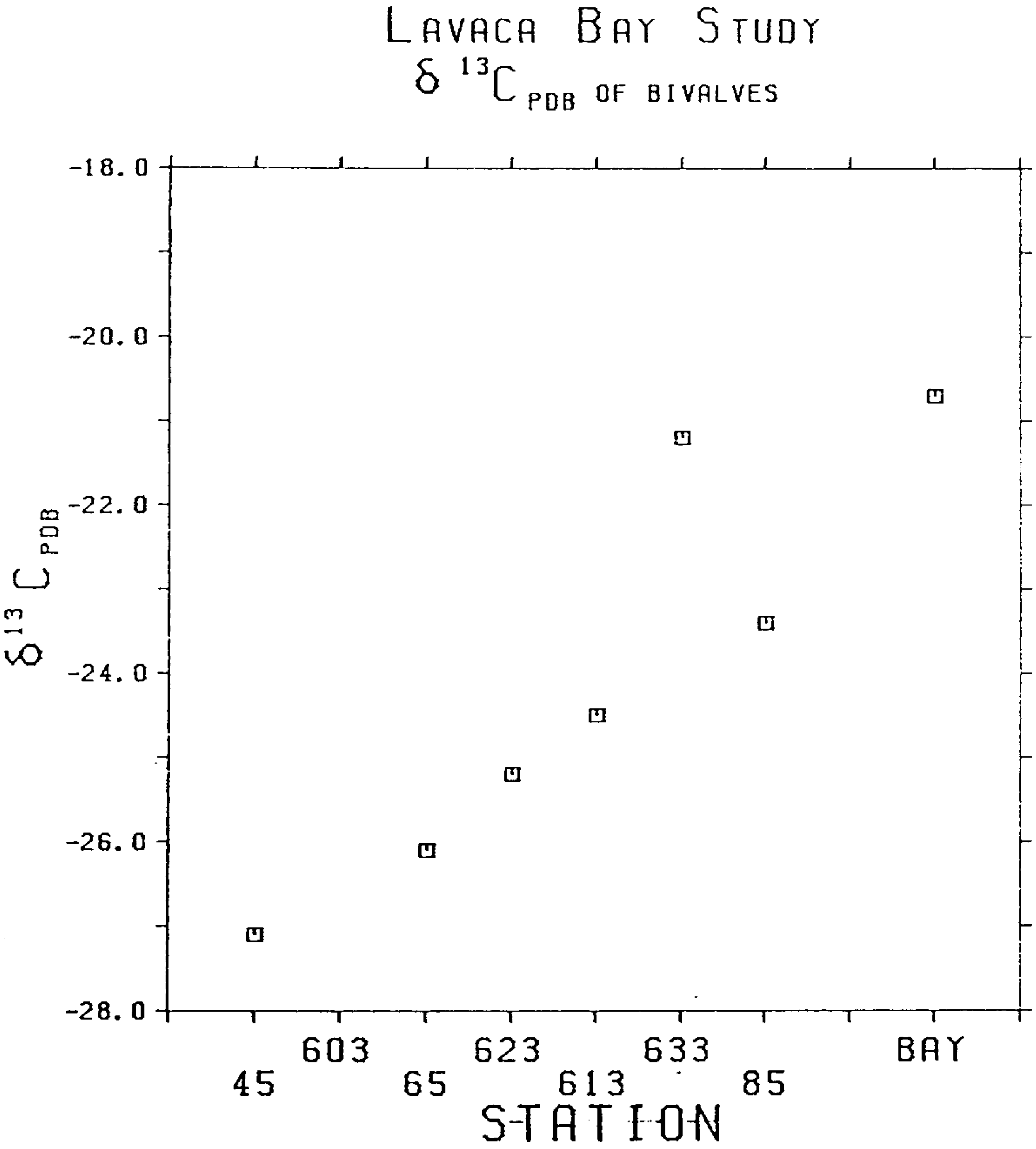
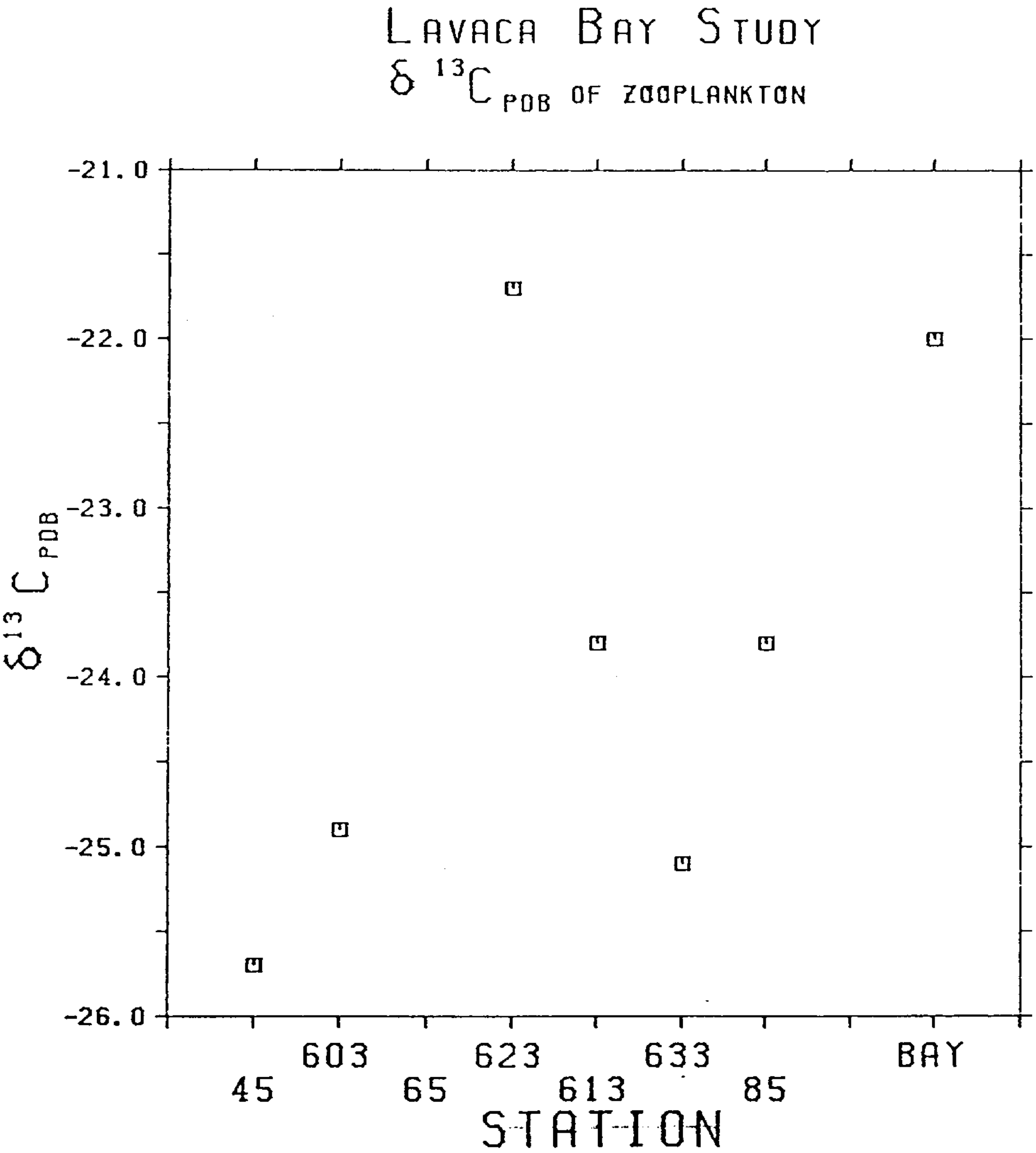

LAVACA BAY STUDY
δ 13C PDB OF BIVALVES
δ 13C PDB
-18.0
-20.0
-22.0
-24.0
-26.0
-28.0
45
603
65
623
613
633
85
BAY
STATION

FIGURE 7.3 - DATA

Station(s)	Average	Std. Dev.	(N)
45	-27.1		1
603			
65	-26.1		1
623	-25.2	1.55	4
613	-24.5	1.34	3
633	-21.2	2.31	4
85	-23.4	2.50	8
BAY	-20.7	1.44	5
ALL	-23.2	2.69	26

FIGURE 7.4



LAVACA BAY STUDY
$\delta^{13}C_{PDB}$ OF ZOOPLANKTON
-21.0
-22.0
-23.0
-24.0
-25.0
-26.0
$\delta^{13}C_{PDB}$
45
603
65
623
613
633
85
BAY
STATION

Figure 7.4 - Data

Station(s)	Average	Std. Dev.	Number
45	-25.7	0.79	7
603	-24.9	1.12	7
65			
623	-21.7	1.98	3
613	-23.8		1
633	-25.1	1.12	3
85	-23.8	1.88	8
Bay	-22.0	0.99	16
All	-23.5	1.97	45

FIGURE 7.5

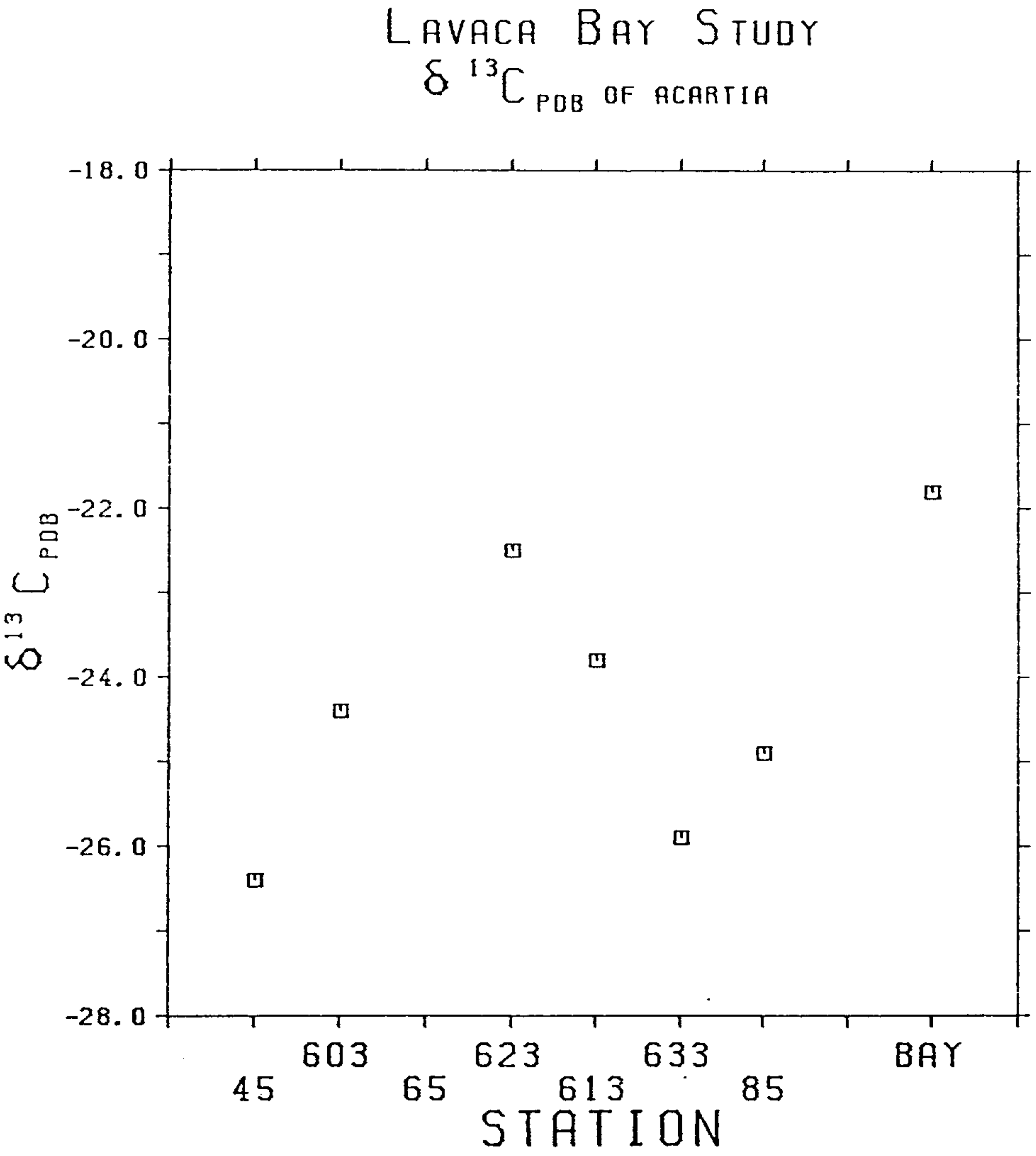

LAVACA BAY STUDY
$\delta^{13}C_{PDB}$ OF ACARTIA
$\delta^{13}C_{PDB}$
-18.0
-20.0
-22.0
-24.0
-26.0
-28.0
45
603
65
623
613
633
85
BAY
STATION

Figure 7.5- Data

Station(s)	Average	Std. Dev.	Number
45	-26.4	0.30	3
603	-24.4	1.26	4
65			
623	-22.5		1
613	-23.8		1
633	-25.9	0.08	2
85	-24.9		
Bay	-21.8	0.92	6
All	-24.0	1.90	20

FIGURE 7.6

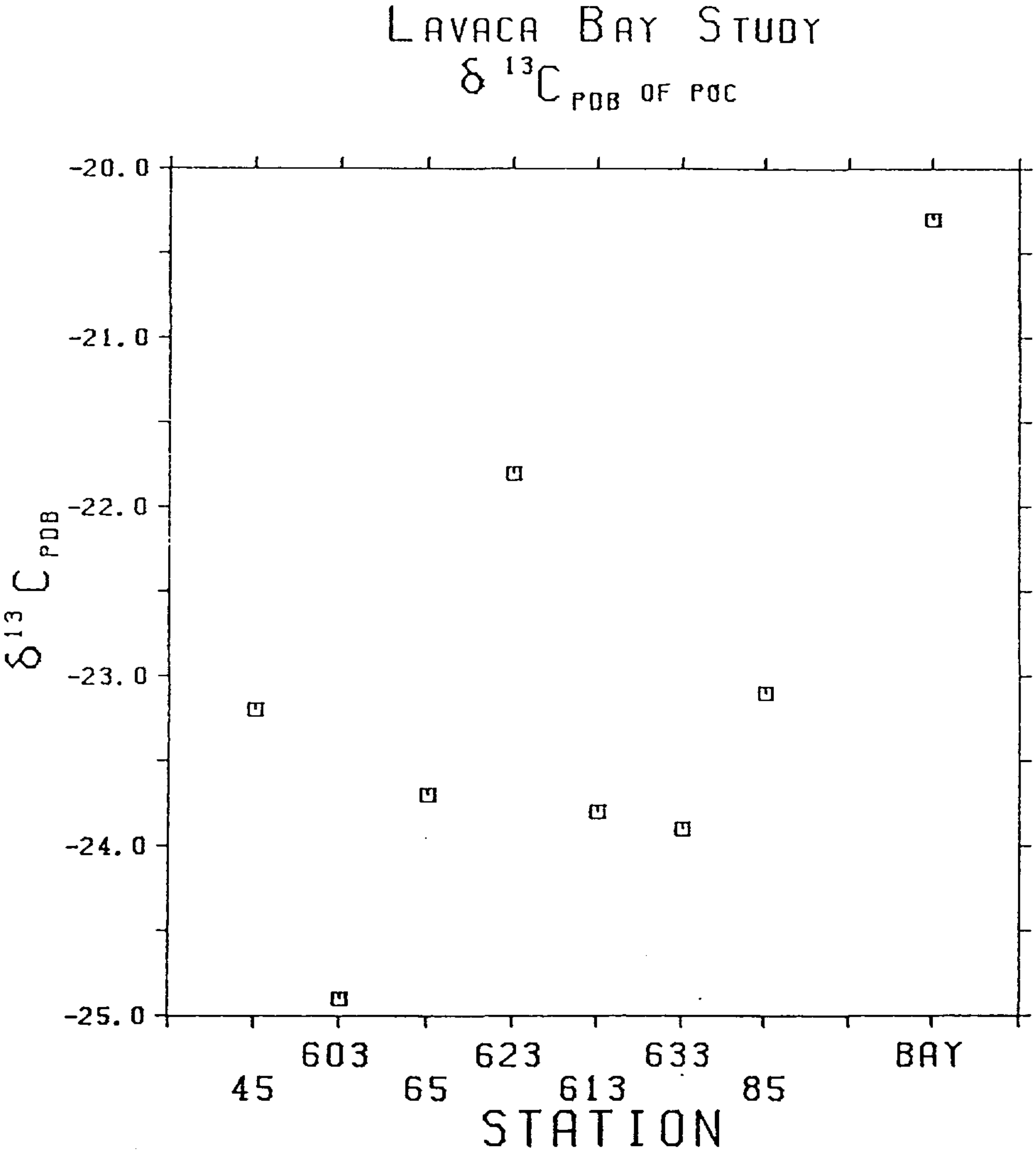

LAVACA BAY STUDY
$\delta^{13}C_{PDB}$ OF POC
$\delta^{13}C_{PDB}$
-20.0
-21.0
-22.0
-23.0
-24.0
-25.0
45
603
65
623
613
633
85
BAY
STATION

FIGURE 7.6 - DATA

Station(s)	Average	Std. Dev.	(N)
45	-23.2	1.76	4
603	-24.9	1.67	6
65	-23.7	2.82	3
623	-21.8	0.42	3
613	-23.8	1.08	4
633	-23.9	0.23	2
85	-23.1	1.40	5
BAY	-20.3	1.62	10
ALL	-22.7	2.31	37

FIGURE 7.7

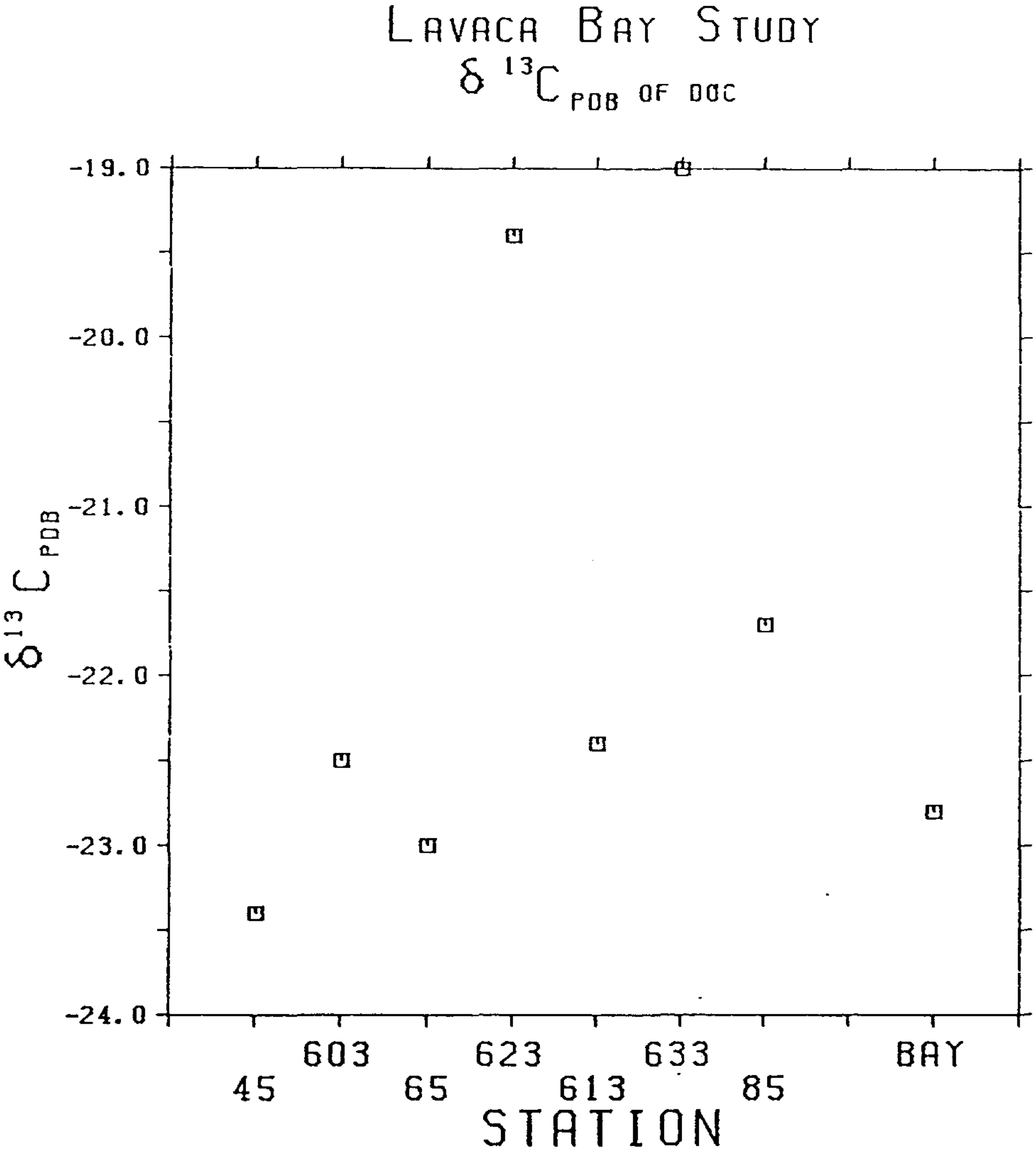

LAVACA BAY STUDY
$\delta^{13}C_{PDB}$ OF DOC
$\delta^{13}C_{PDB}$
-19.0
-20.0
-21.0
-22.0
-23.0
-24.0
603
623
633
BAY
45
65
613
85
STATION

FIGURE 7.7 - DATA

Station(s)	Average	Std. Dev.	(N)
45	-23.4	0.80	4
603	-22.5	0.04	2
65	-23.0	0.69	3
623	-19.4	1.57	3
613	-22.4	1.87	4
633	-19.0		1
85	-21.7	1.35	4
BAY	-22.8	1.77	8
ALL	-22.2	1.89	29

FIGURE 7.8

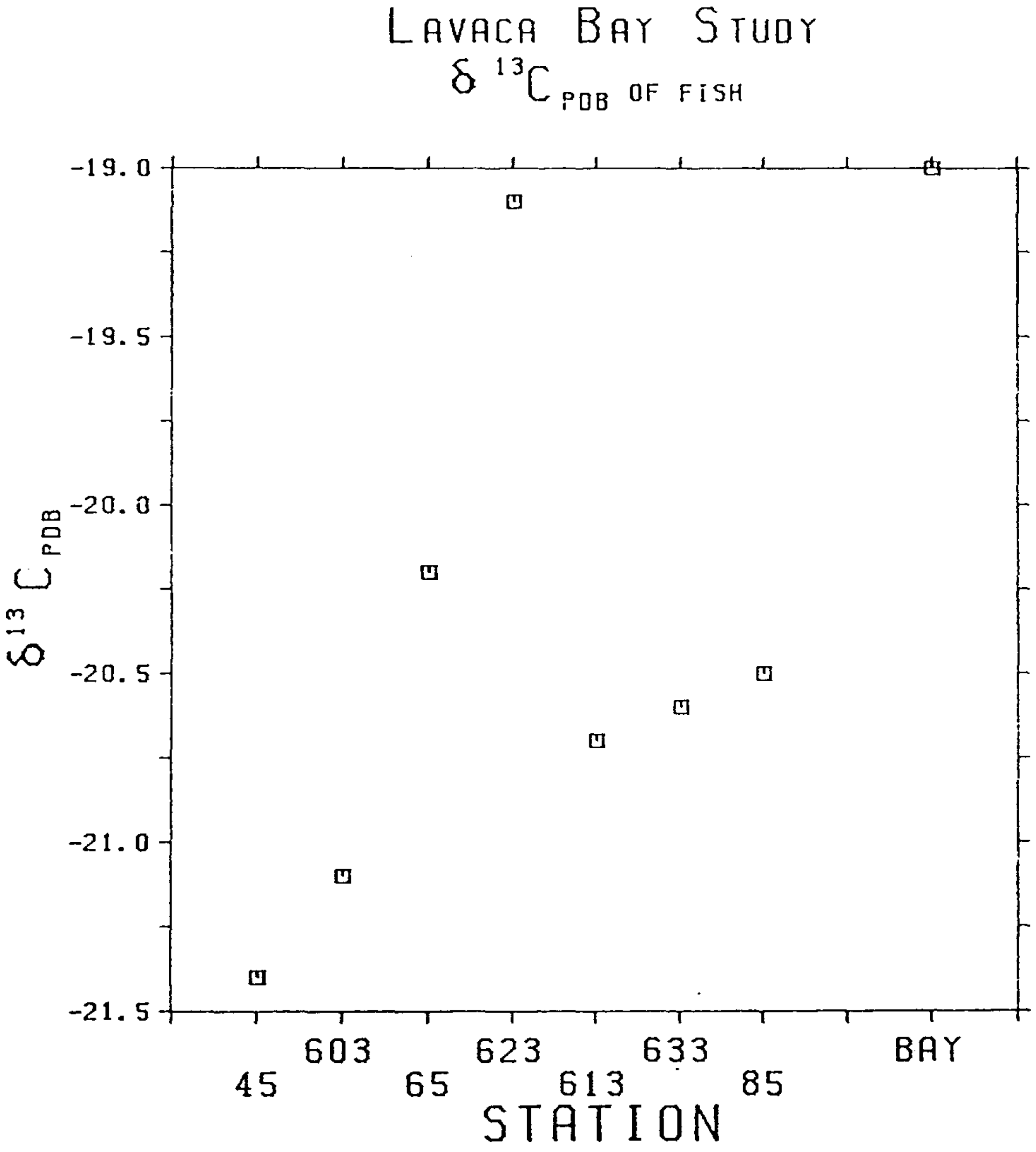

LAVACA BAY STUDY
δ 13C PDB OF FISH
δ13C PDB
-19.0
-19.5
-20.0
-20.5
-21.0
-21.5
45
603
65
623
613
633
85
BAY
STATION

FIGURE 7.8 - DATA

Station(s)	Average	Std. Dev.	Number
45	-21.45	2.79	36
603	-21.09	2.35	39
65	-20.24	2.86	24
623	-19.12	2.86	24
613	-20.66	2.54	20
633	-20.65	2.08	13
85	-20.50	1.80	37
BAY	-19.01	1.22	5
ALL	-20.58	2.57	198

FIGURE 7.9

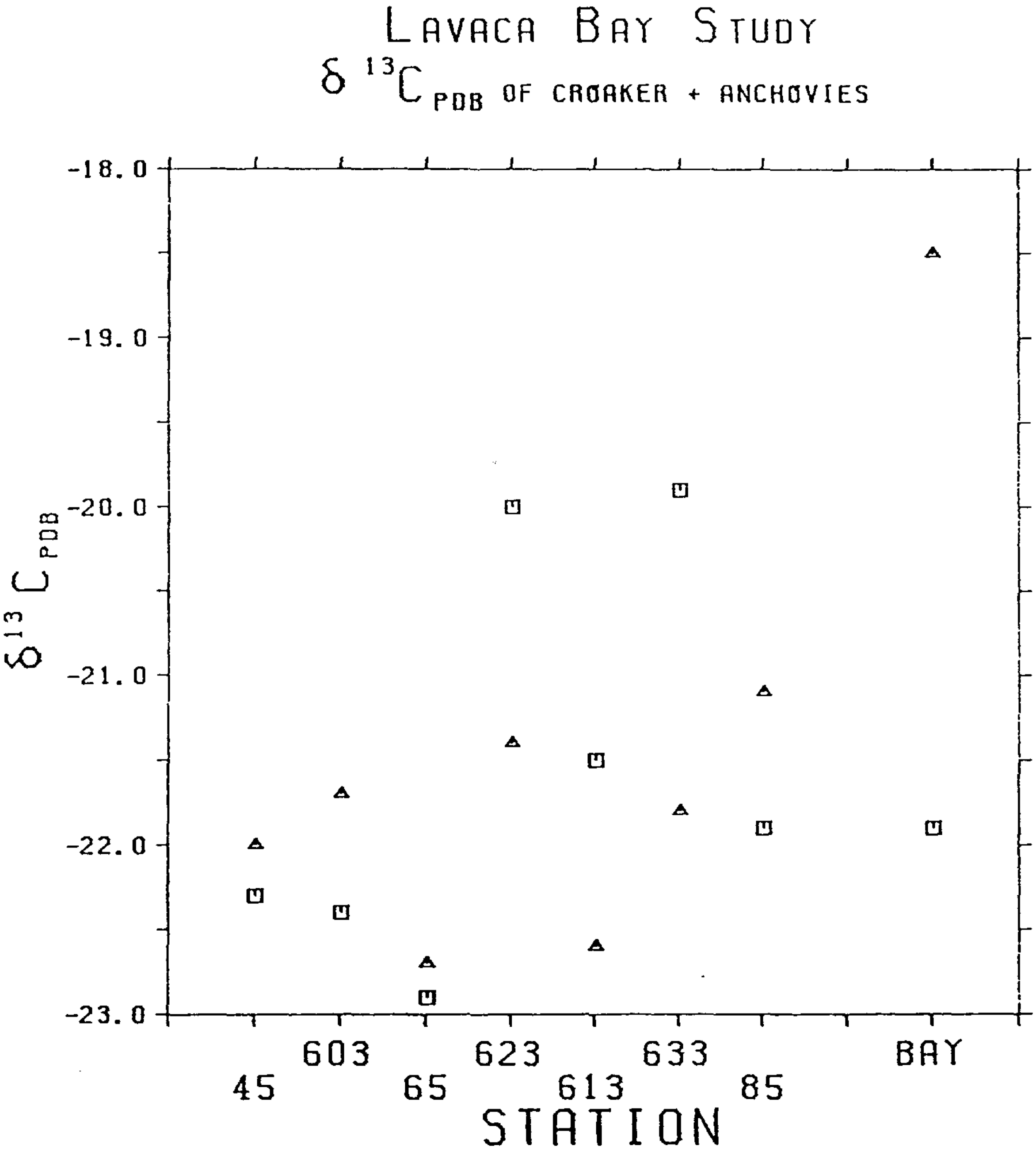

LAVACA BAY STUDY
$\delta^{13}C_{PDB}$ OF CROAKER + ANCHOVIES
$\delta^{13}C_{PDB}$
-18.0
-19.0
-20.0
-21.0
-22.0
-23.0
45
603
65
623
613
633
85
BAY
STATION

Figure 7.9- Data

Del 13-C Croaker

Station(s)	Average	Std. Dev	Number
45	-22.3	1.63	6
603	-22.4	1.60	7
65	-22.9	1.42	7
623	-20.0	1.97	5
613	-21.5	1.35	5
633	-19.9	2.04	4
85	-21.9	1.16	12
Bay	-21.9	1.16	12
All	-21.6	1.88	50

Del 13-C Anchovy

Station(s)	Average	Std. Dev	Number
45	-22.0	1.21	6
603	-21.7	1.05	6
65	-22.7	0.28	3
623	-21.4	0.23	2
613	-22.6	2.33	3
633	-21.8	0.88	3
85	-21.1	1.18	5
Bay	-18.5	0.04	2
All	-21.6	1.53	30

FIGURE 7.10

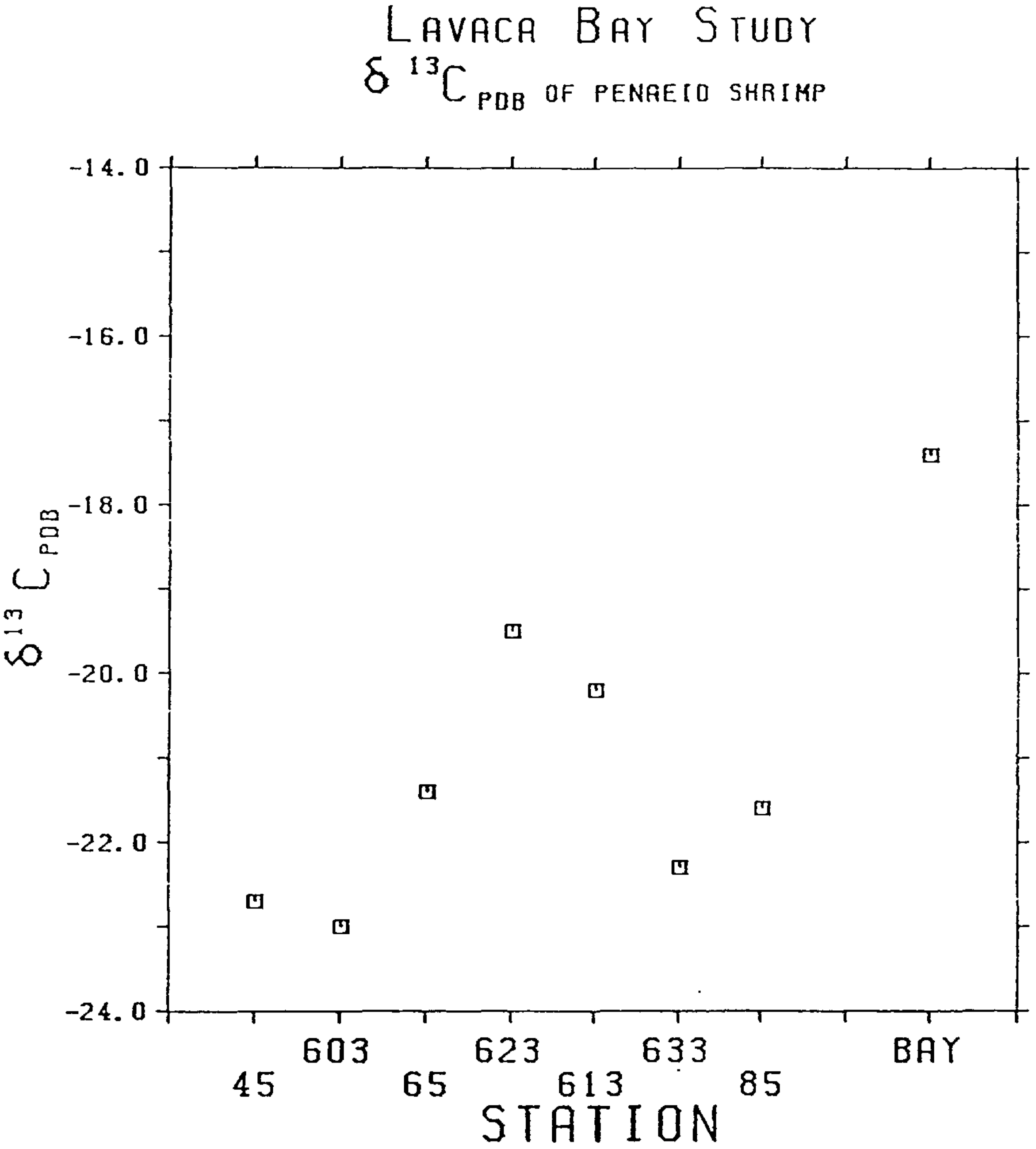

LAVACA BAY STUDY
$\delta^{13}C_{PDB}$ OF PENAEID SHRIMP
-14.0
-16.0
-18.0
-20.0
-22.0
-24.0
$\delta^{13}C_{PDB}$
45
603
65
623
613
633
85
BAY
STATION

FIGURE 7.10 - DATA

Station(s)	Average	Std. Dev.	Number
45	-22.7	2.07	8
603	-23.0	1.18	9
65	-21.4	0.34	3
623	-19.5		1
613	-20.2	1.22	14
633	-22.3	0.02	2
85	-21.6	1.49	10
BAY	-17.4	1.28	3
ALL	-21.4	2.02	50

FIGURE 7.11

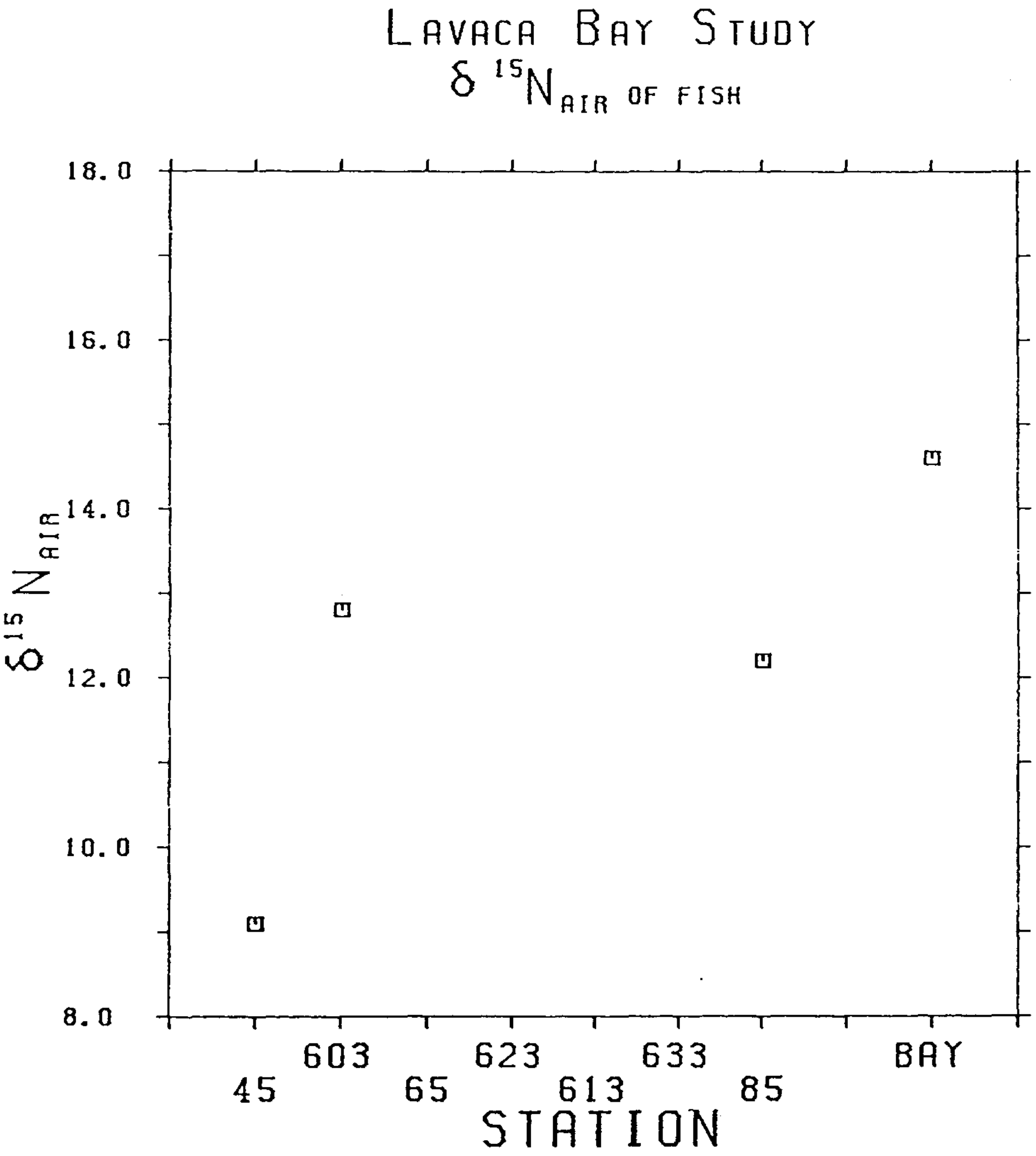

LAVACA BAY STUDY
δ 15N AIR OF FISH
18.0
16.0
14.0
12.0
10.0
8.0
δ 15N AIR
603
623
633
BAY
45
65
613
85
STATION

FIGURE 7.11 - DATA

Station(s)	Average	Std. Dev.	Number
45	9.10	2.82	3
603	12.80	0.67	3
65			0
623			0
613			0
633			0
85	12.23	2.25	6
BAY	14.58	0.00	1
ALL	11.82	2.62	13

TABLE 7.1

$\delta^{13}C$ of Organisms Taken In the Same Trawl

Individual	Sta. 613 w. shrimp	Sta. 85 croaker
1	-21.39 (2)*	-22.46 (2.1)
2	-18.98 (2.5)	-23.24 (2.5)
3	-19.16 (3)	-23.18 (2.7)
4	-22.32 (3)	-23.13 (3.3)
5	-18.42 (3)	-22.28 (3.3)
6	-18.55 (3.5)	-22.52 (3.8)
7	-19.12 (3.5)	-22.27 (4.5)
8	-20.43 (6)	-20.10 (4.8)
x ± s.d.	-19.71 ± 1.52	-22.4 ± 1.01

* length in cm

TABLE 7.2
SAMPLING SCHEDULE
ISOTOPE STUDY

	Station									
Date	45	603	65	613	623	85	633	1505	1905	35/36
27-29 Nov. 1984	+	+	+	+	+	+			+	
22-24 Jan. 1985	+	+	+	+	+	+				
2-3 Apr. 1985	+	+	+	+	+	+	+	$+^{s}$	$+^{s}$	$+^{s}$
16-17 Jul. 1985	+	+	+	+	+	+	+			
22-24 Oct. 1985	+	+			$+^{o}$	+	+	+	+	+
4-5 Feb. 1986	+	+				+	+	+	+	+
8-10 Apr. 1986	+	+	$+^{POC}$			+	+	+	+	+

s = sediment only
POC = water column POC only
o = oysters only

Table 7.3. Comparison of $\delta^{13}C$ values for muscle tissue and gut contents of some samples.

Species	#	Size (cm)	Muscle	Gut	Station	Date
White shrimp	8	5	-24.3	-27.2	45	7/85
Mullet	2	5	-19.2	-19.3	45	7/85
Menhaden	4	3.5	-24.6	-25.7	45	7/85
Blue catfish	2	9	-25.7	-27.0	45	7/85
Anchovy	12	2.5	-24.0	-26.4	45	7/85
Anchovy	6	2.5	-23.9	-25.7[a]	603	7/85
Sea trout	1	6	-21.3	-22.0	603	9/85
Blue catfish	2	11	-24.7	-24.9	603	9/85
Croaker	4	7	-24.2	-26.4	603	7/85
Flounder	1	14	-21.3	-20.4	603	4/85
Flounder	4	7.5	-24.7	-26.0	603	7/85
Menhaden	2	4.5	-24.1	-24.5	603	7/85
Menidia	3	3.5	-23.5	-23.7	603	7/85
Mullet	2	7	-21.6	-22.7	603	7/85
Brown shrimp	6	6	-23.3	-25.3	603	7/85
White shrimp	7	7.5	-23.2	-24.3	603	7/85
Croaker	3	5	-20.1	-23.2	65	4/85
Menhaden	8	2.5	-21.0	-26.2	65	4/85
Mullet	1	4	-17.5	-21.2	65	4/85
Rangia	1		-24.0	-26.3	613	11/84
Menhaden	8	2.5	-20.8	-23.1	613	4/85
Anchovy	7	4	-20.7	-21.5	613	4/85
Flounder	4	3	-20.4	-23.2	613	4/85
Croaker	8	3	-21.0	-22.3	613	4/85
Macoma	1		-23.6	-23.9	633	8/85
Mullet	2	2.3	-19.6	-20.5	633	4/85
Anchovy	3	3	-22.6	-25.7	633	7/85
Paleomonetes	8	2.5	-18.2	-19.3[b]	623	4/85
Anchovy	6	4.5	-22.9	-24.8	85	7/85
Anchovy	9	2.2	-21.3	-21.9	85	4/85
Croaker	6	3.5	-20.7	-22.0	85	4/85
Croaker	1	6	-19.6	-21.0	85	4/85
Fundulus	1	6	-17.7	-19.4	85	4/85
Hardhead catfish	1	12	-20.2	-22.2	85	7/85
Menhaden	7	2.5	-19.1	-20.6	85	4/85
Sea trout	1	4	-21.6	-23.2	85	7/85
Tonguefish	1	7.5	-20.9	-22.6	85	7/85

Species	#	Size (cm)	Muscle	Gut	Station	Date
Oyster	2		-23.2	-25.5[c]	85	4/85
Brown shrimp	5	4.5	-22.2	-22.3	85	7/85
Macrobranchium	1	3	-19.1	-21.6[a]	85	7/85
Paleomonetes	6	3	-19.3	-19.9	85	7/85
White shrimp	5	7.5	-22.5	-23.4	85	7/85
Oyster	2		-20.3	-23.4[a]	1905	11/84

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[a] Whole animal.

[b] Eggs only.

[c] Fat only.

TABLE 7.4

Del 13-C Fish

Del 13-C of Selected Fish Species

Species	Average	Std.Dev.	Number
Anchovy	-21.6	1.53	30
Catfish	-24.1	1.69	8
Croaker	-21.6	1.88	50
Cyprinodon	-17.3	1.04	18
Flounder	-21.8	2.54	5
Fundulus	-17.6	1.79	24
Menhaden	-21.8	1.92	24
Menidia	-20.3	1.65	14
Mullet	-18.8	1.09	14
Speckled Trout	-21.1	0.62	3
Others	-22.0	2.78	8
All	-20.6	2.57	198

TABLE 7.5

Del 13-C Shrimp

Station	Month JAN	FEB	APR	JUL	OCT	NOV	All	(N)	s.d.
45	-20.1	-21.7	-22.0	-24.1	-21.3	-20.6	-22.2	15.0	1.96
603	-22.0	22.8	-20.3	-23.9	-21.7	-20.2	-22.1	15.0	1.99
65	-20.0		-22.8			-20.4	-21.2	9.0	2.04
623	-18.5		-19.9			-19.6	-19.6	6.0	1.34
613	-20.1		-19.4		-20.4	-20.2	-20.2	15.0	1.18
633		-21.8	-21.3	-21.7			-21.6	6.0	2.12
85	-18.8	-21.3	-21.5	-21.9	-22.2	-20.3	-21.2	19.0	1.79
Bay					-17.4	-17.3	-17.4	3.0	1.28
All	-20.2	-21.9	-21.3	-23.0	-20.8	-20.1	-21.2	90	2.12
(N)	7.0	4.0	20.0	18.0	13.0	28.0	90.0		
s.d.	2.00	0.56	2.54	1.69	1.80	1.35	2.12		

TABLE 7.6

Del 13-C Fish

Station(s)	Month							
	JAN	APR	JUL	OCT	NOV	All	(N)	s.d.
45	-20.65	-21.14	-24.35	-20.54	-20.25	-21.45	36	2.79
602	-18.93	-21.06	-23.82	-21.38	-20.39	-21.09	39	2.35
65	-20.82	-20.81			-19.09	-20.24	24	2.86
623	-17.29	-19.59			-19.86	-19.12	24	2.86
613	-21.79	-20.35		-20.35	-20.40	-20.66	20	2.54
633		-20.46	-21.09	-20.41		-20.65	13	2.08
95	-19.20	-19.53	-21.11	-19.97	-21.47	-20.50	37	1.80
Bay				-18.08	-20.41	-19.01	5	1.22
All	-19.82	-20.45	-22.83	-20.15	-20.37	-20.58	198	2.57
(N)	43	53	26	13	63		198	
s.d.	2.59	1.83	2.42	1.27	2.82	2.57		

TABLE 7.7
$\delta^{15}N$ BY SAMPLE TYPE

	$\delta^{15}N$
Infauna	+11.9 ± 2.6
Fish	11.6 ± 2.5
Oyster	11.4 ± 1.1
Shrimp	11.1 ± 1.1
Zooplankton (Acartia)	10.1 ± 0.5
Crab	10.0 ± 1.1
Bivalve (Rangia)	8.5 --
Bivalve (Mulinia)	8.1 ± 0.2
Amphipods	7.6 --
Detritus	5.9 ± 0.9
Sediment	5.4 ± 5.4
Plants	4.7 ± 1.9

TABLE 7.8

Station	Date	Sample Type	Organism	#	Size	Body part	del-C13	del-N15
1505	1986 Apr	bivalve	Mulinia lateralis				-19.2	
1505	1985 Apr	DOC	DOC				-22.6	
1505	1985 Mar	DOC	DOC				-20.0	
1505	1985 Oct	fish	Anchoa mitchilli	3	4cm	tail	-18.5	
1505	1985 Oct	fish	A. mithilli	1		guts		
1505	1986 Apr	infauna	Glycera capitata				-18.1	
1505	1986 Feb	infauna	Maldanidae				-20.1	11.5
1505	1986 Feb	infauna	Cossura delta				-21.9	
1505	1986 Feb	infauna	Mediomastus calif.				-21.9	
1505	1986 Feb	infauna	Dorvilleidae				-20.6	
1505	1986 Feb	infauna	Nemertinea				-21.8	
1505	1986 Feb	infauna	Glycera sp.				-19.8	
1505	1986 Feb	infauna	Ogyrides limicola				-20.5	
1505	1986 Feb	infauna	Eudorella				-19.5	
1505	1986 Feb	infauna	Spionidae				-18.9	
1505	1986 Feb	infauna	Armandia				-17.5	
1505	1985 Oct	infauna	Haploscoloplos				-20.5	
1505	1985 Oct	infauna	Paronidae				-21.4	
1505	1985 Oct	infauna	G. americana				-19.9	
1505	1985 Oct	infauna	Ogyrides				-18.8	
1505	1985 Oct	infauna	C. delta				-22.0	
1505	1985 Oct	infauna	Heteromastus fil.				-20.1	
1505	1985 Apr	POC	POC				-22.4	
1505	1985 Mar	POC	POC				-19.8	
1505	1985 Apr	sediment	sediment				-18.5	
1505	1986 Jun	sediment	sediment				-17.8	
1505	1985 Oct	shrimp	Penaeus aztecus	2	6.5cm	tail	-15.9	
1505	1985 Oct	squid	Loligunculus brevis	5	5.2cm	muscle	-18.1	
1505	1986 Feb	zoopl	Barnacle nauplii-a	150			-24.3	
1505	1986 Feb	zoopl	Barnacle nauplii-b	150			-22.6	
1505	1986 Feb	zoopl	Acartia tonsa	125			-22.8	
1505	1985 Oct	zoopl	Paracalanus	150			-21.9	
1505	1985 Oct	zoopl	Petrolisthes	10			-21.2	
1505	1985 Oct	zoopl	Chaetognatha	55			-21.4	
1505	1985 Oct	zoopl	A. tonsa	125			-21.6	
1505	1985 Oct	zoopl	A. tonsa	150			-22.7	
1505+1905	1985 Dec	DOC	DOC-RepA				-23.9	
1505+1905	1985 Dec	DOC	DOC-RepB				-25.1	

Station	Date	Sample Type	Organism	‖	Size	Body part	del-C13	del-N15
1505+1905	1985 Dec	POC	POC				-21.8	
1505+1905	1986 Feb	POC	POC-b				-18.5	
1505+1905	1986 Feb	POC	POC-a				-18.5	
1505+1905	1985 Oct	POC	POC				-21.8	
1905	1986 Feb	bivalve	M. lateralis				-20.6	8.2
1905	1984 Nov	crab	Callinectes sapidus	1		muscle	-18.4	
1905	1985 Apr	DOC	DOC				-22.6	
1905	1985 Aug	DOC	DOC				-23.7	
1905	1985 Mar	DOC	DOC				-20.0	
1905	1984 Nov	fish	Micropogonias und.	4	<3cm	tail	-20.6	
1905	1984 Nov	fish	M. undulatus	5	3.5cm	tail	-20.2	14.6
1905	1985 Oct	fish	A. mitchelli	5	4.5cm	tail	-18.4	
1905	1986 Apr	infauna	Nereis sp.				-20.6	
1905	1986 Apr	infauna	Drilonereis magna				-19.1	
1905	1986 Apr	infauna	G. capitata				-19.4	
1905	1985 Aug	infauna	Nemertinea				-19.5	
1905	1985 Aug	infauna	Phyllodocidae				-21.6	
1905	1986 Feb	infauna	Ogyrides				-18.6	11.7
1905	1986 Feb	infauna	Magelona				-20.8	
1905	1986 Feb	infauna	Nemertinea				-20.4	
1905	1986 Feb	infauna	Maldanidae				-21.8	
1905	1986 Feb	infauna	G. americana				-19.7	13.2
1905	1986 Feb	infauna	Mediomastus				-21.2	
1905	1986 Feb	infauna	Paronidae				-20.5	
1905	1986 Feb	infauna	Nereis				-20.0	
1905	1986 Feb	infauna	Drilonereis				-20.6	
1905	1986 Feb	infauna	Haploscoloplos				-16.8	
1905	1986 Feb	infauna	Dorvilleidae				-21.3	
1905	1986 Feb	infauna	C. delta				-20.2	
1905	1985 Oct	infauna	Nemertinea				-18.9	
1905	1985 Oct	infauna	Paronidae				-20.5	
1905	1985 Oct	infauna	Spirochaetopterus				-21.9	
1905	1985 Oct	infauna	Glycera americana				-19.5	
1905	1985 Oct	infauna	Tharyx setigera				-21.7	
1905	1985 Oct	infauna	Ogyrides limicola				-18.7	10.6
1905	1985 Oct	infauna	M. californiensis				-22.9	
1905	1985 Oct	infauna	Drilonereis				-19.6	
1905	1985 Oct	infauna	C. delta				-20.4	

Station	Date	Sample Type	Organism	#	Size	Body part	del-C13	del-N15
1905	1984 Nov	bivalve	Crassostrea virg.	2		muscle	-20.3	11.2
1905	1984 Nov	bivalve	C. virginica	2		whole	-23.4	11.5
1905	1984 Nov	plankton	Net tow				-25.3	
1905	1985 Apr	POC	POC				-22.4	
1905	1985 Mar	POC	POC				-19.8	
1905	1985 Apr	sediment	sediment				-18.8	5.9
1905	1986 Feb	sediment	sediment				-17.2	
1905	1986 Jun	sediment	sediment				-18.1	
1905	1984 Nov	shrimp	P. setiferus	4	large	tail	-17.3	9.8
1905	1985 Oct	squid	L. brevis	5	3-7cm	muscle	-17.9	
1905	1986 Feb	zoopl	Barnacle nauplii	150			-22.2	
1905	1985 Oct	zoopl	Chaetognatha	47			-22.1	
1905	1985 Oct	zoopl	A. tonsa	160			-22.2	
1905	1985 Oct	zoopl	Ctenophora				-20.5	
1905	1985 Oct	zoopl	Paracalanus	200			-23.0	
35/36	1986 Feb	bivalve	M. lateralis				-19.9	
35/36	1985 Dec	DOC	DOC				-24.4	
35/36	1985 Oct	fish	M. undulatus	2	4cm	tail	-17.3	
35/36	1985 Aug	infauna	Nereis				-22.1	
35/36	1985 Aug	infauna	Nemertinea				-20.3	
35/36	1985 Aug	infauna	Phyllodocidae				-18.5	
35/36	1985 Aug	infauna	Ogyrides				-17.9	
35/36	1986 Feb	infauna	Nereidae				-20.3	
35/36	1986 Feb	infauna	Diopatra				-19.5	
35/36	1986 Feb	infauna	Maldanidae				-19.2	
35/36	1986 Feb	infauna	Nemertinea				-19.1	
35/36	1986 Feb	infauna	Drilonereis				-18.6	
35/36	1986 Feb	infauna	Mediomastus				-20.5	
35/36	1986 Feb	infauna	Magelona				-19.9	
35/36	1986 Feb	infauna	Glycera				-18.8	
35/36	1986 Feb	infauna	Cossura				-20.2	
35/36	1985 Oct	infauna	Clymenella				-18.5	
35/36	1985 Oct	infauna	Eudorella monodon				-18.3	
35/36	1985 Oct	infauna	Magelona phyllisae				-19.1	
35/36	1985 Oct	infauna	Ampelisca abdita				-17.5	
35/36	1985 Oct	infauna	Nereis				-18.7	
35/36	1985 Oct	infauna	Diopatra cuprae				-18.5	
35/36	1985 Oct	infauna	Ogyrides				-17.2	

Station	Date	Sample Type	Organism	‖	Size	Body part	del-C13	del-N15
35/36	1985 Oct	infauna	Drilonereis				-18.2	
35/36	1985 Oct	infauna	G. americana				-18.2	
35/36	1985 Oct	infauna	Laeonereis culveri				-19.0	
35/36	1985 Oct	infauna	Ampelisca verrilli				-17.1	
35/36	1985 Oct	infauna	Apreades				-15.7	
35/36	1986 Feb	plant	Noctiluca rep.1				-20.9	
35/36	1986 Feb	plant	Noctiluca rep.2				-20.3	
35/36	1985 Dec	POC	POC				-17.9	
35/36	1986 Feb	POC	POC				-19.9	
35/36	1985 Apr	sediment	Sediment				-19.0	
35/36	1986 Feb	sediment	sediment				-11.7	
35/36	1985 Oct	shrimp	P. aztecus	3	7.5cm	tail	-19.0	
35/36	1985 Oct	squid	L. brevis	1	7.5cm	muscle	-16.7	
35/36	1986 Feb	zoopl	A. tonsa	150			-21.0	
35/36	1985 Oct	zoopl	A. tonsa	100			-20.3	
35/36	1985 Oct	zoopl	Chaetognatha	60			-21.6	
35/36	1985 Oct	zoopl	Paracalanus	155				
45	1986 Apr	bivalve	M. lateralis				-27.1	
45	1985 Apr	crab	C. sapidus	2	6-7cm	claw	-21.8	
45	1984 Nov	crab	C. sapidus	1	large	body	-20.0	
45	1984 Nov	crab	C. sapidus	1	small	body	-19.9	
45	1984 Nov	crab	C. sapidus	1	large	claw	-20.5	9.4
45	1985 Apr	plant	Trawl detritus				-25.2	
45	1985 Jan	plant	Trawl detritus				-22.8	6.3
45	1984 Nov	plant	Trawl detritus				-26.7	
45	1985 Oct	plant	Trawl detritus				-26.5	
45	1985 Apr	DOC	DOC				-24.1	
45	1985 Jan	DOC	DOC				-22.6	
45	1985 Mar	DOC	DOC				-22.6	
45	1985 Apr	fish	M. undulatus	11	1-3cm	tail	-21.9	
45	1985 Apr	fish	Ictalurus sp.	1		tail	-21.4	
45	1985 Apr	fish	Mugil cephalus	4	3-4cm	tail	-19.6	
45	1985 Apr	fish	Brevortia patronus	9	3.5cm	tail	-22.3	
45	1985 Apr	fish	Menidia	3	3-4cm	tail	-21.1	
45	1985 Apr	fish	M. undulatus	6	4-5cm	tail	-19.7	
45	1985 Apr	fish	A. mitchilli	8	3-4cm	tail	-22.1	
45	1985 Jan	fish	M. cephalus			backbone	-18.1	
45	1985 Jan	fish	M. undulatus	10	2-3cm	tail	-21.0	

Station	Date	Sample Type	Organism	#	Size	Body part	del-C13	del-N15
45	1985 Jan	fish	M. cephalus		13cm	skin	-16.3	
45	1985 Jan	fish	A. felis	2	20cm	tail	-24.1	
45	1985 Jan	fish	M. cephalus			muscle	-18.0	
45	1985 Jan	fish	M. cephalus	10	2-3cm	whole	-19.1	
45	1985 Jan	fish	M. cephalus		13cm	liver	-20.4	
45	1985 Jan	fish	M. cephalus		13cm	scales	-14.1	
45	1985 Jan	fish	Cyprinodon varie.	10	2-3cm	tail	-17.6	
45	1985 Jan	fish	B. patronus	10	2cm	tail	-21.8	
45	1985 Jan	fish	Menidia sp.	5	4.2cm	tail	-19.4	
45	1985 Jan	fish	B. patronus	5	2cm	whole	-22.7	
45	1985 Jan	fish	Fundulus similis	2	>3cm	tail	-22.2	
45	1985 Jul	fish	M. cephalus	2		guts	-19.3	
45	1985 Jul	fish	Ictalurus sp.	2		guts	-27.0	
45	1985 Jul	fish	M. cephalus	2	5cm	tail	-19.2	
45	1985 Jul	fish	B. patronus	4	3.5cm	tail	-24.6	
45	1985 Jul	fish	Menidia sp.	4	3-4cm	tail	-21.7	
45	1985 Jul	fish	Ictalurus sp.	1	3cm	tail	-26.8	
45	1985 Jul	fish	B. patronus	4		guts	-25.7	
45	1985 Jul	fish	Ictalurus sp.	2	9-10cm	tail	-25.7	
45	1985 Jul	fish	M. undulatus	1	7cm	tail	-24.5	
45	1985 Jul	fish	A. mitchilli	12		guts	-26.4	
45	1985 Jul	fish	Trinectes maculatus	1	5cm	tail	-28.3	
45	1985 Jul	fish	A. mitchilli	12	2-3cm	tail	-24.1	
45	1984 Nov	fish	B. patronis	1	4cm	tail	-23.3	
45	1984 Nov	fish	M. undulatus	10	small	tail	-22.8	
45	1984 Nov	fish	Menidia sp.	8		tail	-20.4	
45	1984 Nov	fish	A. mitchilli	10	large	tail	-22.4	
45	1984 Nov	fish	F. similis	1	4cm	tail	-16.0	
45	1984 Nov	fish	C. variegatus	1	2.5cm	tail	-17.5	7.3
45	1984 Nov	fish	A. mitchilli	20	small	tail	-22.3	
45	1984 Nov	fish	F. similis	1	6cm	tail	-16.6	
45	1984 Nov	fish	M. undulatus	10	large	tail	-23.8	13.1
45	1984 Nov	fish	C. variegatus	1	3.5cm	tail	-17.4	6.9
45	1985 Oct	fish	A. mitchilli	8	1.8cm	tail	-20.4	
45	1985 Oct	fish	A. mitchilli	6	3.7cm	tail	-20.6	
45	1985 Apr	infauna	Myrophis	1			-21.7	
45	1985 Apr	infauna	Chironomid larvae				-29.0	
45	1986 Apr	infauna	Laeonereis culveri				-20.7	7.45

Station	Date	Sample Type	Organism	#	Size	Body part	del-C13	del-N15
45	1986 Apr	infauna	Chironomid larvae				-26.7	
45	1985 Apr	infauna	Nemertinea				-23.2	
45	1986 Apr	infauna	Capitella capitata				-21.8	
45	1986 Feb	infauna	Hobsonia				-23.9	
45	1986 Feb	infauna	Edotea				-24.6	
45	1986 Feb	infauna	Corophium				-27.5	
45	1986 Feb	infauna	Laeonereis				-22.1	
45	1986 Feb	infauna	Chironomid larvae				-26.7	6.4
45	1985 Oct	infauna	Laeonereis				-24.3	
45	1985 Oct	infauna	Chironomid larvae				-21.3	
45	1985 Jan	plant	Juncus romerianus				-25.5	
45	1985 Jan	plant	Spartina patens				-12.1	
45	1985 Jan	plant	Phragmites australis				-25.5	5.8
45	1985 Jan	plant	Iva frutescens				-27.9	
45	1985 Jul	plant	Algae off stick				-19.2	
45	1985 Oct	plant	Algae off stick				-24.1	5.5
45	1985 Oct	plant	Blue-green algae				-20.6	
45	1985 Apr	POC	POC				-25.4	
45	1985 Dec	POC	POC				-24.4	
45	1985 Jan	POC	POC				-21.1	
45	1985 Mar	POC	POC				-21.9	
45	1985 Apr	sediment	sediment				-23.3	
45	1986 Feb	sediment	sediment				-21.6	
45	1986 Jun	sediment	sediment				-22.1	
45	1985 Oct	shrimp	P. setiferus	3	8.5cm	tail	-21.4	
45	1985 Apr	shrimp	Palaemonetes	5	1-3cm	tail	-19.8	
45	1985 Apr	shrimp	Macrobranchium	4	3-4cm	tail	-24.3	12.9
45	1986 Feb	shrimp	Mysidae	9	0.6cm		-21.7	
45	1985 Jan	shrimp	Palaemonetes	10		tail	-20.1	
45	1985 Jul	shrimp	Palaemonetes	1	2.5cm	tail	-21.8	
45	1985 Jul	shrimp	P. setiferus	8	4-6cm	tail	-24.3	
45	1985 Jul	shrimp	Penaeus sp.	3	1.2cm	tail	-23.3	
45	1985 Jul	shrimp	P. setiferus	8		guts	-27.3	
45	1985 Jul	shrimp	Macrobranchium	4	5-8cm	tail	-23.7	12.1
45	1984 Nov	shrimp	Palaemonetes	10		tail	-20.0	
45	1984 Nov	shrimp	P. setiferus	8		tail	-21.2	
45	1985 Oct	shrimp	P. aztecus	3	1.2cm	tail	-20.6	
45	1985 Oct	shrimp	P. aztecus	4	6cm	tail	-21.8	

Station	Date	Sample Type	Organism	‖	Size	Body part	del-C13	del-N15
45	1985 Oct	shrimp	P. aztecus	3	5cm	tail	-21.6	
45	1985 Apr	zoopl	Diaptomus	59			-26.0	
45	1985 Apr	zoopl	Xanthidae zooea	17			-24.9	
45	1986 Feb	zoopl	Scyphozoa medusae				-24.7	
45	1986 Feb	zoopl	A. tonsa	160			-26.1	
45	1985 Oct	zoopl	Argulus	5			-24.7	
45	1985 Oct	zoopl	A. tonsa	115			-26.8	
45	1985 Oct	zoopl	A. tonsa	150			-26.3	
45+603	1985 Oct	POC	POC				-26.3	
45/65	1985 Aug	DOC	DOC				-24.3	
603	1985 Apr	crab	C. sapidus	1	5cm	claw	-21.2	
603	1985 Jan	crab	C. sapidus	2		claw	-18.9	
603	1984 Nov	crab	C. sapidus	2	small	whole	-17.0	
603	1984 Nov	crab	C. sapidus	1	7cm	muscle	-16.8	
603	1985 Jan	plant	Trawl detritus				-26.5	5.3
603	1984 Nov	plant	Trawl detritus				-25.6	
603	1985 Apr	DOC	DOC				-22.6	
603	1985 Jan	DOC	DOC				-22.5	
603	1985 Apr	fish	Fundulus	2	4.5cm	tail	-20.3	
603	1985 Apr	fish	M. undulatus	9	2-3cm	tail	-21.9	
603	1985 Apr	fish	P. lethostigma	1	14cm	skin	-19.5	
603	1985 Apr	fish	A. mitchilli	2	4cm	tail	-21.4	
603	1985 Apr	fish	M. undulatus	2	4.5cm	tail	-21.6	
603	1985 Apr	fish	M. undulatus	7	3.5cm	tail	-22.0	
603	1985 Apr	fish	Menidia sp.	1	5.5cm	tail	-20.7	
603	1985 Apr	fish	Fundulus	2	2cm	tail	-18.5	
603	1985 Apr	fish	B. patronus	9	2cm	tail	-19.1	
603	1985 Apr	fish	Cyprinodon	1	2.5cm	tail	-17.3	
603	1985 Apr	fish	T. maculatus	1	4.5cm	tail	-24.5	
603	1985 Apr	fish	P. lethostigma	1	14cm	tail	-21.3	13.8
603	1985 Apr	fish	P. lethostigma	1	14cm	guts	-20.4	
603	1985 Apr	fish	Ictalurus sp.	2	10cm	tail	-24.2	
603	1985 Apr	fish	P. lethostigma	1	14cm	liver	-21.6	
603	1985 Jan	fish	B. patronus	10	2cm	tail	-21.8	
603	1985 Jan	fish	Fundulus	3	>5cm	tail	-17.7	
603	1985 Jan	fish	M. cephalus			tail	-18.8	
603	1985 Jan	fish	Cyprinodon	10	2-3cm	tail	-16.4	
603	1985 Jan	fish	M. undulatus	5	1-3cm	tail	-19.3	

Station	Date	Sample Type	Organism	‖	Size	Body part	del-C13	del-N15
603	1985 Jan	fish	Fundulus	4	2cm	tail	-19.5	
603	1985 Jul	fish	M. undulatus	4		guts	-26.4	
603	1985 Jul	fish	Menidia sp.	3	3.5cm	tail	-23.5	
603	1985 Jul	fish	Ictalurus sp.	2		guts	-24.9	
603	1985 Jul	fish	A. mitchilli	6	2-3cm	tail	-23.9	
603	1985 Jul	fish	M. undulatus	4	7cm	tail	-24.2	12.4
603	1985 Jul	fish	P. lethostigma	4	7-8cm	tail	-24.7	12.3
603	1985 Jul	fish	P. lethostigma	4		guts	-26.0	10.8
603	1985 Jul	fish	Menidia sp.	3		guts	-23.7	
603	1985 Jul	fish	Ictalurus sp.	2	11cm	tail	-24.7	
603	1985 Jul	fish	A. mitchilli	6		guts	-25.7	
603	1985 Jul	fish	M. cephalus	2		guts	-22.7	
603	1985 Jul	fish	B. patronus	2	4.5cm	tail	-24.1	
603	1985 Jul	fish	M. cephalus	2	7cm	tail	-21.6	
603	1985 Jul	fish	B. patronus	2		guts	-24.5	
603	1984 Nov	fish	Cyprinodon	3		tail	-18.2	
603	1984 Nov	fish	Menidia sp.	1	2.5cm	tail	-20.8	
603	1984 Nov	fish	M. undulatus	1	2cm	tail	-24.3	
603	1984 Nov	fish	Fundulus	1	8cm	tail	-17.0	
603	1984 Nov	fish	Fundulus	5	4cm	tail	-17.4	
603	1984 Nov	fish	A. mitchilli	3	2.2cm	tail	-20.8	
603	1984 Nov	fish	Fundulus	2	3cm	tail	-20.2	
603	1984 Nov	fish	B. patronus	1	4cm	tail	-23.1	
603	1984 Nov	fish	M. undulatus	1	3cm	tail	-23.3	
603	1984 Nov	fish	Menidia sp.	1	3.5cm	tail	-18.9	
603	1985 Oct	fish	Cynoscion nebulosus	1	6cm	muscle	-21.3	
603	1985 Oct	fish	A. mitchilli	3	2cm	tail	-21.0	
603	1985 Oct	fish	A. mitchilli	1	2.5cm	ex trout	-22.0	
603	1985 Oct	fish	A. mitchilli	6	4cm	tail	-21.2	
603	1986 Feb	infauna	Nemertinea				-23.5	
603	1986 Feb	infauna	Nemertinea (rep)				-24.2	
603	1986 Feb	infauna	Chironomid larvae-a				-23.0	
603	1986 Feb	infauna	Corophium				-26.7	
603	1986 Feb	infauna	Chironomid larvae-b				-25.0	
603	1985 Oct	infauna	Streblospio				-25.1	
603	1985 Oct	infauna	Nemertinea				-23.7	
603	1985 Oct	infauna	Chironomid larvae				-25.5	
603	1985 Apr	insect	Backswimmer	1			-22.3	

Station	Date	Sample Type	Organism	#	Size	Body part	del-C13	del-N15
603	1985 Jan	plankton	Net Detritus				-24.0	
603	1984 Nov	plankton	Net tow				-22.1	
603	1985 Jan	plant	Cladophora				-31.5	
603	1985 Oct	plant	Cladophora				-20.5	3.8
603	1985 Oct	plant	Marsalia				-24.2	
603	1985 Apr	POC	POC				-24.3	
603	1985 Dec	POC	POC				-24.2	
603	1986 Feb	POC	POC-a				-26.8	
603	1986 Feb	POC	POC-b				-26.1	
603	1985 Jan	POC	POC				-21.9	
603	1985 Apr	sediment	sediment	2			-21.8	4.7
603	1986 Feb	sediment	sediment				-21.5	
603	1986 Jun	sediment	sediment				-21.1	
603	1985 Apr	shrimp	Palaemonetes	6	3cm	tail	-20.3	
603	1986 Feb	shrimp	Mysidae	11	0.5cm		-22.8	
603	1985 Jan	shrimp	Palaemonetes	6		tail	-19.1	
603	1985 Jan	shrimp	Mysidae	9		whole	-24.9	
603	1985 Jul	shrimp	P. setiferus	7		guts	-24.3	
603	1985 Jul	shrimp	P. setiferus	7	7-8cm	tail	-23.2	10.2
603	1985 Jul	shrimp	P. aztecus	6	6-7cm	tail	-23.3	10.2
603	1985 Jul	shrimp	P. aztecus	6		guts	-25.3	
603	1985 Jul	shrimp	P. aztecus	10	3-5cm	tail	-23.2	9.7
603	1984 Nov	shrimp	P. setiferus	4		tail	-22.5	11.7
603	1984 Nov	shrimp	Palaemonetes	10		tail	-19.0	
603	1984 Nov	shrimp	Palaemonetes	10		chitin	-19.0	
603	1985 Oct	shrimp	P. setiferus	3	9cm	tail	-21.3	
603	1985 Oct	shrimp	P. aztecus	5	5cm	tail	-22.0	
603	1985 Oct	shrimp	P. setiferus	3	4cm	tail	-21.9	
603	1985 Apr	zoopl	Xanthidae zooea	17			-24.9	
603	1985 Apr	zoopl	Diaptomus	59			-26.0	
603	1985 Apr	zoopl	A. tonsa	90			-22.9	
603	1986 Feb	zoopl	A. tonsa-a	100			-24.9	
603	1986 Feb	zoopl	Barnacle nauplii	110			-25.4	
603	1986 Feb	zoopl	A. tonsa-b	100			-23.8	
603	1985 Oct	zoopl	A. tonsa	200			-26.2	
613	1985 Jan	crab	C. sapidus	1	1cm	whole	-24.7	
613	1985 Apr	plant	Trawl detritus				-24.4	
613	1984 Nov	plant	Trawl detritus				-25.1	

Station	Date	Sample Type	Organism	‖	Size	Body part	del-C13	del-N15
613	1985 Apr	DOC	DOC				-23.9	
613	1985 Aug	DOC	DOC				-19.3	
613	1985 Jan	DOC	DOC				-22.4	
613	1985 Mar	DOC	DOC				-23.9	
613	1985 Apr	fish	B. patronus	8		guts	-23.1	
613	1985 Apr	fish	M. undulatus	8	2-3cm	tail	-21.0	
613	1985 Apr	fish	B. patronus	8	2.2cm	tail	-18.8	
613	1985 Apr	fish	B. patronus	8	2-3cm	tail	-20.8	
613	1985 Apr	fish	P. lethostigma	4	2-3cm	tail	-20.4	
613	1985 Apr	fish	M. undulatus	8		guts	-22.3	
613	1985 Apr	fish	A. mitchilli	7		guts	-21.5	
613	1985 Apr	fish	P. lethostigma	4		guts	-23.2	
613	1985 Apr	fish	A. mitchilli	7	3-5cm	tail	-20.7	
613	1985 Jan	fish	A. mitchilli	2	2.2cm	tail	-25.9	
613	1985 Jan	fish	Fundulus	1	5.5cm	muscle	-18.3	
613	1985 Jan	fish	Cyprinodon	6	2.7cm	tail	-17.9	
613	1985 Jan	fish	Fundulus	1	5.5cm	skin+scales	-17.6	
613	1985 Jan	fish	B. patronus	4	2.5cm	tail	-25.1	
613	1984 Nov	fish	Fundulus	2	5cm	tail	-16.6	
613	1984 Nov	fish	Menidia sp.	2	2cm	tail	-22.3	
613	1984 Nov	fish	B. patronus	8	2.2cm	tail	-20.4	
613	1984 Nov	fish	A. mitchilli	4	2.5cm	tail	-21.2	
613	1984 Nov	fish	M. undulatus	4	2.2cm	tail	-23.5	
613	1984 Nov	fish	B. patronus	6	2.2cm	tail	-23.3	
613	1984 Nov	fish	M. undulatus	6	1.6cm	tail	-22.5	
613	1984 Nov	fish	Fundulus	4	2.5cm	tail	-16.5	
613	1984 Nov	fish	M. undulatus	12	1cm	tail	-19.9	
613	1984 Nov	fish	Cyprinodon	8	3cm	tail	-17.6	
613	1985 Oct	fish	M. undulatus	1	2.5cm	muscle	-20.4	
613	1985 Apr	infauna	Mediomastus				-22.5	
613	1985 Apr	infauna	Oligochaeta				-22.3	
613	1985 Apr	bivalve	C. virginica			muscle	-23.1	
613	1984 Nov	bivalve	Rangia cuneata	1		gut	-26.3	
613	1984 Nov	bivalve	R. cuneata	1		muscle	-24.0	
613	1985 Jan	plankton	Net detritus				-24.2	
613	1985 Apr	POC	POC				-22.6	
613	1985 Jan	POC	POC				-23.9	
613	1985 Mar	POC	POC				-23.3	

Station	Date	Sample Type	Organism	#	Size	Body part	del-C13	del-N15
613	1985 Oct	POC	POC				-25.5	
613	1985 Apr	sediment	sediment				-19.9	
613	1985 Apr	shrimp	Penaeus sp.	5	1-2cm	tail	-19.4	
613	1985 Apr	shrimp	Palaemonetes sp.	8	2.5cm	tail		
613	1985 Jan	shrimp	Palaemonetes sp.	6		tail	-20.1	
613	1984 Nov	shrimp	P. setiferus	1	2.5cm	tail	-19.0	
613	1984 Nov	shrimp	P. setiferus	1	3.5cm	tail	-18.6	
613	1984 Nov	shrimp	P. setiferus	1	3.5cm	tail	-19.1	
613	1984 Nov	shrimp	P. aztecus	1	3.5cm	tail	-21.0	
613	1984 Nov	shrimp	P. setiferus	1	2cm	tail	-21.4	
613	1984 Nov	shrimp	P. setiferus	1	6cm	tail	-20.4	
613	1984 Nov	shrimp	P. setiferus	1	3cm	tail	-22.3	
613	1984 Nov	shrimp	P. aztecus	1	5cm	tail	-21.0	
613	1984 Nov	shrimp	P. aztecus	1	5cm	tail	-22.0	
613	1984 Nov	shrimp	P. setiferus	1	3cm	tail	-18.4	
613	1984 Nov	shrimp	P. setiferus	1	3cm	tail	-19.2	
613	1985 Oct	shrimp	P. setiferus	4	3.2cm	tail	-20.5	
613	1985 Oct	shrimp	P. aztecus	4	3.2cm	tail	-20.4	
613	1985 Jul	zoopl	A. tonsa	200			-23.8	
623	1985 Apr	crab	C. sapidus	2	3cm	claw	-19.1	
623	1984 Nov	crab	C. sapidus	4	small	whole	-24.0	
623	1984 Nov	crab	C. sapidus	1	large	muscle	-19.2	
623	1985 Jan	plant	Trawl detritus				-25.9	5.3
623	1985 Jun	plant	Trawl detritus				-22.3	
623	1984 Nov	plant	Trawl detritus				-25.0	
623	1985 Apr	DOC	DOC				-21.5	
623	1985 Jan	DOC	DOC				-19.0	
623	1985 Mar	DOC	DOC				-17.8	
623	1985 Apr	fish	B. patronus	11	2cm	tail	-18.3	
623	1985 Apr	fish	M. cephalus	3	2.4cm	tail	-19.1	
623	1985 Apr	fish	A. mitchilli	4	2-4cm	tail	-21.2	
623	1985 Apr	fish	Ictalurus sp.	1		tail	-24.5	
623	1985 Apr	fish	B. patronus	13	3cm	tail	-20.1	
623	1985 Apr	fish	M. undulatus	6	3.5cm	tail	-17.3	
623	1985 Apr	fish	M. undulatus	9	2.5cm	tail	-18.1	
623	1985 Apr	fish	P. lethostigma	1	6.5cm	tail	-18.0	
623	1985 Apr	fish	Gobidae	1	3cm	tail	-19.7	
623	1985 Jan	fish	Fundulus	5	3.7cm	tail	-16.0	

Station	Date	Sample Type	Organism	#	Size	Body part	del-C13	del-N15
623	1985 Jan	fish	Fundulus	2	6cm	tail	-16.2	
623	1985 Jan	fish	Cyprinodon	5	2.7cm	tail	-15.1	
623	1985 Jan	fish	M. cephalus	10	2cm	tail	-18.3	
623	1985 Jan	fish	Cyprinodon	7	2cm	tail	-17.4	
623	1985 Jan	fish	M. undulatus	7	<1cm	whole	-20.7	
623	1984 Nov	fish	B. patronus		5cm	tail	-24.4	
623	1984 Nov	fish	Cyprinodon	10	small	tail	-16.7	
623	1984 Nov	fish	Fundulus	1	9.5cm	tail	-15.4	
623	1984 Nov	fish	M. undulatus	8	>3cm	tail	-21.1	
623	1984 Nov	fish	B. patronus		4cm	tail	-24.1	
623	1984 Nov	fish	Fundulus	4	3.5cm	tail	-14.9	
623	1984 Nov	fish	M. undulatus	17	<2.5cm	tail	-22.6	
623	1984 Nov	fish	A. mitchilli	4	2.2cm	tail	-21.6	
623	1984 Nov	fish	Cyprinodon	1	large	tail	-17.9	
623	1985 Aug	infauna	Nemertinea				-21.7	
623	1985 Aug	infauna	Mediomastus				-22.0	
623	1985 Aug	infauna	Laeonereis				-21.2	
623	1985 Jun	bivalve	Macoma mitchilli				-21.8	
623	1985 Jun	infauna	Laeonereis				-20.7	
623	1985 Jun	infauna	Heteromastus				-19.4	
623	1985 Apr	bivalve	C. virginica			muscle	-22.9	
623	1985 Apr	bivalve	C. virginica			fat	-24.7	
623	1984 Nov	bivalve	Mussels	4		whole	-26.4	
623	1984 Nov	bivalve	C. virginica	7		whole	-26.8	11.5
623	1985 Jan	plant	Ectocarpus				-24.6	5.7
623	1985 Apr	POC	POC				-21.2	
623	1985 Jan	POC	POC				-22.1	
623	1985 Mar	POC	POC				-22.1	
623	1985 Apr	sediment	sediment	2			-18.1	4.9
623	1985 Apr	shrimp	Palaemonetes	8	2.5cm	tails	-18.2	
623	1985 Apr	shrimp	Macrobranchium	5	2cm	tail	-22.3	
623	1985 Apr	shrimp	Palaemonetes	8	2.5cm	eggs	-19.3	
623	1985 Jan	shrimp	Palaemonetes	10		tail	-18.5	
623	1984 Nov	shrimp	Palaemonetes	8	2cm	tail	-19.6	
623	1984 Nov	shrimp	P. setiferus	4	large	tail	-19.5	
623	1985 Jan	zoopl	Amphipoda	15			-19.0	
623	1985 Jul	zoopl	A. tonsa	120			-22.5	
623	1985 Jul	zoopl	Xanthidae zooea	30			-23.7	

Station	Date	Sample Type	Organism	#	Size	Body part	del-C13	del-N15
633	1986 Apr	bivalve	M. mitchelli				-18.9	
633	1986 Feb	bivalve	Ensis minor				-24.4	
633	1986 Feb	bivalve	M. mitchilli				-19.2	
633	1986 Feb	bivalve	M. lateralis				-22.4	8.3
633	1985 Apr	crab	C. sapidus	3	2cm	whole body	-20.9	
633	1985 Apr	crab	C. sapidus	2	4cm	claw	-18.5	
633	1985 Jul	crab	C. sapidus	1	16cm	claw	-23.3	
633	1985 Jul	plant	Trawl detritus				-28.0	
633	1985 Apr	DOC	DOC				-19.0	
633	1985 Apr	fish	M. undulatus	6	2cm	tail	-19.8	
633	1985 Apr	fish	B. patronus	9	2-3cm	tail	-20.4	
633	1985 Apr	fish	P. lethostigma	1	4.4cm	tail	-24.5	
633	1985 Apr	fish	M. undulatus	5	3-5cm	tail	-17.2	
633	1985 Apr	fish	A. mitchilli	1	3.8cm	tail	-22.4	
633	1985 Apr	fish	M. cephalus	2	2.3cm	tail	-19.6	
633	1985 Apr	fish	M. undulatus	8	2-3cm	tail	-19.5	
633	1985 Apr	fish	M. cephalus	2	2.3cm	Guts	-20.5	
633	1985 Jul	fish	M. cephalus	1	9.5cm	tail	-17.0	
633	1985 Jul	fish	A. mitchilli	3	3-3.5cm	tail	-22.6	
633	1985 Jul	fish	A. mitchilli	3		guts	-25.7	
633	1985 Jul	fish	Bagre marina	1	6cm	tail	-21.9	
633	1985 Jul	fish	M. undulatus	8	5-7cm	tail	-23.0	
633	1985 Oct	fish	A. mitchilli	4	1.8cm	tail	-20.6	
633	1985 Oct	fish	C. nebulosus	1	9.5cm	muscle	-20.2	
633	1985 Aug	bivalve	M. mitchilli	1		muscle	-23.6	
633	1985 Aug	bivalve	M. lateralis	1		muscle	-24.0	
633	1985 Aug	bivalve	M. mitchilli	1		guts	-23.9	
633	1986 Feb	infauna	Mediomastus				-23.7	
633	1986 Feb	infauna	Corophium				-22.3	
633	1986 Feb	infauna	Ampelisca				-19.0	
633	1986 Feb	infauna	Glycera				-21.3	
633	1986 Feb	infauna	Laeonereis				-20.8	9.9
633	1986 Feb	infauna	Edotea				-19.8	
633	1985 Apr	insect	Coleoptera	7		whole	-25.8	
633	1985 Apr	POC	POC				-23.7	
633	1986 Feb	POC	POC				-24.2	
633	1985 Apr	sediment	sediment				-20.2	6.0
633	1986 Jun	sediment	sediment				-19.1	

Station	Date	Sample Type	Organism	#	Size	Body part	del-C13	del-N15
633	1985 Apr	shrimp	Macrobranchium	3	4-5cm	tail	-24.8	12.3
633	1985 Apr	shrimp	Palaemonetes	2	3cm	tail	-17.8	
633	1986 Feb	shrimp	Mysidae	10	0.5cm		-21.8	
633	1985 Jul	shrimp	Palaemonetes	9	2-2.5cm	tail	-20.5	
633	1985 Jul	shrimp	P. aztecus	6	4.5-7cm	tail	-22.3	
633	1985 Jul	shrimp	P. setiferus	8	5-8cm	tail	-22.2	
633	1986 Feb	zoopl	A. tonsa	105			-26.0	
633	1986 Feb	zoopl	Barnacle nauplii	125			-23.5	
633	1985 Oct	zoopl	A. tonsa	65			-25.8	
65	1985 Apr	crab	C. sapidus	4	4-6cm	claw	-19.8	
65	1985 Jan	crab	C. sapidus	1	1.8cm	whole	-24.2	
65	1984 Nov	crab	C. sapidus	1		claw	-18.0	
65	1985 Apr	plant	Trawl detritus				-24.1	
65	1985 Jan	plant	Trawl detritus				-24.6	
65	1984 Nov	plant	Trawl detritus				-28.2	
65	1985 Apr	DOC	DOC				-24.0	
65	1985 Jan	DOC	DOC				-22.7	
65	1985 Mar	DOC	DOC				-22.4	
65	1985 Apr	fish	M. undulatus	6	2.5-3cm	tail	-21.9	
65	1985 Apr	fish	M. cephalus	1	4cm	guts	-21.2	
65	1985 Apr	fish	M. cephalus	1	4cm	tail	-17.5	
65	1985 Apr	fish	B. patronus	8		guts	-26.2	
65	1985 Apr	fish	M. undulatus	3		guts	-23.2	
65	1985 Apr	fish	A. felis	1		tail	-21.9	
65	1985 Apr	fish	M. undulatus	3	4-5.5cm	tail	-20.1	
65	1985 Apr	fish	A. mitchilli	14	2.5cm	tail	-22.6	
65	1985 Apr	fish	B. patronus	8	2.5-3cm	tail	-21.0	
65	1985 Jan	fish	A. mitchilli	2	2.2cm	tail	-22.5	
65	1985 Jan	fish	M. undulatus	6	1-2cm	whole	-23.6	
65	1985 Jan	fish	M. undulatus	12	1-2cm	tail	-22.9	
65	1985 Jan	fish	Fundulus	2	1.5cm	whole	-19.4	
65	1985 Jan	fish	Cyprinodon	5	3.5cm	tail	-17.6	
65	1985 Jan	fish	Fundulus	1		tail	-17.9	
65	1985 Jan	fish	Menidia	6	3cm	tail	-21.2	
65	1985 Jan	fish	M. cephalus	8	2.5cm	tail	-18.9	
65	1985 Jan	fish	M. undulatus	6	>2.5cm	tail	-23.3	
65	1985 Jan	fish	B. patronus	10	2-2.5cm	tail	-20.9	
65	1984 Nov	fish	M. undulatus	1	3cm	tail	-24.5	

Station	Date	Sample Type	Organism	#	Size	Body part	del-C13	del-N15
65	1984 Nov	fish	Cyprinodon	1	2.5cm	tail	-16.5	
65	1984 Nov	fish	Fundulus	1	6cm	tail	-16.4	
65	1984 Nov	fish	A. mitchilli	2		tail	-23.1	
65	1984 Nov	fish	Cyprinodon	1	3.5cm	tail	-15.8	
65	1984 Nov	fish	Fundulus	1	3.5cm	tail	-15.0	
65	1984 Nov	fish	Menidia sp.	8		muscle	-17.1	
65	1984 Nov	fish	M. undulatus	1	3.5cm	tail	-24.3	
65	1985 Apr	infauna	Oligochaeta				-23.8	
65	1985 Apr	bivalve	Tellina			whole	-23.4	
65	1985 Apr	bivalve	M. lateralis			whole	-27.1	
65	1985 Apr	infauna	Chironomid pupae				-26.6	
65	1985 Apr	infauna	Mediomastus sp.				-24.2	
65	1984 Nov	bivalve	R. cuneata			whole	-26.1	
65	1984 Nov	plankton	Net tow				-24.5	
65	1985 Jan	plant	Iva				-29.2	
65	1985 Apr	POC	POC				-27.6	
65	1985 Jan	POC	POC				-21.0	
65	1985 Mar	POC	POC				-22.5	
65	1985 Apr	sediment	sediment				-20.7	
65	1985 Apr	shrimp	Macrobranchium	4	2.5-3cm	tail	-24.0	
65	1985 Apr	shrimp	Macrobranchium	5	4cm	tail	-25.0	
65	1985 Apr	shrimp	Palaemonetes	8	2cm	tail	-19.4	
65	1985 Jan	shrimp	Palaemonetes	10	2.5cm	tail	-20.0	
65	1984 Nov	shrimp	P. setiferus	1	7cm	tail	-21.2	
65	1984 Nov	shrimp	P. setiferus	1	5cm	tail	-21.1	
65	1984 Nov	shrimp	Palaemonetes	1	2cm	tail	-18.6	
65	1984 Nov	shrimp	P. setiferus	1	6cm	tail	-21.9	
65	1984 Nov	shrimp	Palaemonetes	1	3cm	tail	-19.5	
85	1986 Feb	bivalve	M. mitchelli				-18.5	
85	1986 Apr	bivalve	M. mitchilli				-18.8	
85	1986 Apr	bivalve	M. lateralis				-21.3	
85	1986 Feb	bivalve	M. lateralis				-22.2	7.9
85	1985 Oct	bivalve	Tellina sp.				-23.4	
85	1985 Apr	crab	C. sapidus	2	3-4cm	claw + body	-21.4	
85	1985 Jan	crab	C. sapidus	1		claw	-21.0	
85	1985 Jul	crab	C. sapidus	2	6cm	claw	-21.7	11.2
85	1984 Nov	crab	C. sapidus	1	large	muscle	-21.0	
85	1984 Nov	crab	C. sapidus	4	<2cm	whole	-23.1	9.2

Station	Date	Sample Type	Organism	‖	Size	Body part	del-C13	del-N15
85	1985 Apr	plant	Trawl detritus				-27.2	7.3
85	1985 Jan	plant	Trawl detritus				-26.4	5.2
85	1984 Nov	plant	Trawl detritus				-21.0	
85	1985 Oct	plant	Trawl detritus				-26.9	
85	1985 Aug	DOC	DOC				-22.8	
85	1985 Jan	DOC	DOC				-22.8	
85	1985 Apr	fish	A. mitchilli		6cm	guts		
85	1985 Apr	fish	A. mitchilli	9		guts	-21.9	
85	1985 Apr	fish	M. undulatus	1	6cm	tail	-19.6	
85	1985 Apr	fish	B. patronus	7		guts	-20.6	
85	1985 Apr	fish	A. mitchilli	1	6cm	tail	-19.7	
85	1985 Apr	fish	M. undulatus	6	3-3.5cm	tail	-20.7	
85	1985 Apr	fish	M. undulatus	6	3-3.5cm	guts	-22.0	
85	1985 Apr	fish	Fundulus		6cm	guts	-19.4	
85	1985 Apr	fish	Fundulus	1	6cm	tail	-17.7	
85	1985 Apr	fish	A. mitchilli	9	2.2cm	tail	-21.3	
85	1985 Apr	fish	M. undulatus		6cm	guts	-21.0	
85	1985 Apr	fish	Menidia sp.	1	6cm	tail	-18.6	
85	1985 Apr	fish	B. patronus	7	2.5cm	tail	-19.1	
85	1985 Jan	fish	Cyprinodon	10	2.5cm	tail	-16.4	
85	1985 Jan	fish	B. patronus	14	2.2cm	tail	-22.2	
85	1985 Jan	fish	M. cephalus	10	2.2cm	tail	-18.2	
85	1985 Jan	fish	Fundulus	3	3cm	tail	-17.9	
85	1985 Jan	fish	M. undulatus	4	2.2cm	tail	-20.6	
85	1985 Jan	fish	M. cephalus	5	2.2cm	whole	-17.9	
85	1985 Jan	fish	Menidia sp.	3	5cm	tail	-18.2	
85	1985 Jan	fish	B. patronus	9	2.2cm	whole	-22.3	
85	1985 Jul	fish	Leiostomus xanthurus	1	7cm	tail	-20.0	11.7
85	1985 Jul	fish	Symphurus sp.	1	7.5cm	tail	-20.9	
85	1985 Jul	fish	Symphurus sp.			guts	-22.6	
85	1985 Jul	fish	C. nebulosus			guts	-23.2	11.7
85	1985 Jul	fish	A. mitchilli	6		guts	-24.8	10.1
85	1985 Jul	fish	A. felis	1	12cm	tail	-20.2	14.2
85	1985 Jul	fish	Gobidae	1	3.5cm	tail	-20.4	
85	1985 Jul	fish	M. undulatus	2	7cm	tail	-21.7	13.9
85	1985 Jul	fish	A. mitchilli	6	4-5cm	tail	-22.9	13.4
85	1985 Jul	fish	C. nebulosus	1	4cm	tail	-21.7	12.6
85	1985 Jul	fish	A. felis			guts	-22.2	

Station	Date	Sample Type	Organism	‖	Size	Body part	del-C13	del-N15
85	1984 Nov	fish	Cyprinodon		<3.5cm	tail	-18.3	7.6
85	1984 Nov	fish	M. undulatus		3.3cm	tail	-23.1	
85	1984 Nov	fish	Fundulus	18	mixed	tail	-19.1	
85	1984 Nov	fish	M. undulatus		4.8cm	tail	-20.1	
85	1984 Nov	fish	M. undulatus		2.5cm	tail	-23.2	
85	1984 Nov	fish	M. undulatus		2.1cm	tail	-22.5	
85	1984 Nov	fish	M. undulatus		2.7cm	tail	-23.2	
85	1984 Nov	fish	M. undulatus		3.3cm	tail	-22.3	
85	1984 Nov	fish	Menidia sp.	3		tail	-20.2	
85	1984 Nov	fish	A. mitchilli	3	2.2cm	tail	-21.9	
85	1984 Nov	fish	Cyprinodon	4	>3.5cm	tail	-19.9	
85	1984 Nov	fish	M. undulatus	8	mixed	tail	-21.9	
85	1984 Nov	fish	M. undulatus		4.5cm	tail	-22.3	
85	1984 Nov	fish	M. undulatus		3.8cm	tail	-22.5	
85	1985 Oct	fish	A. mitchilli	5	4.2cm	tail	-20.0	
85	1986 Apr	infauna	Glycera capitata				-14.9	
85	1985 Aug	infauna	Edotea				-22.4	
85	1985 Aug	infauna	Mediomastus				-22.7	
85	1985 Aug	infauna	Laeonereis				-22.0	
85	1986 Feb	infauna	Edotea				-21.9	
85	1986 Feb	infauna	Mediomastus				-22.9	
85	1986 Feb	infauna	Scotolana				-19.9	
85	1986 Feb	infauna	Ampelisca				-17.6	
85	1986 Feb	infauna	Glycera				-19.3	
85	1985 May	infauna	Nereis				-19.9	
85	1985 May	infauna	Edotea				-20.5	
85	1985 May	infauna	Chironomid larvae				-22.7	
85	1985 May	infauna	Loandalia				-21.6	
85	1985 May	infauna	Streblospio				-21.6	
85	1985 May	infauna	Hobsonia				-23.3	
85	1985 May	infauna	Mediomastus				-22.1	
85	1985 Oct	infauna	Edotea				-21.6	
85	1985 Apr	bivalve	C. virginica			fat	-25.5	10.7
85	1985 Apr	bivalve	C. virginica			muscle	-23.2	10.3
85	1984 Nov	bivalve	mussel	6		whole	-26.7	
85	1984 Nov	bivalve	C. virginica	10		whole	-26.2	13.3
85	1985 Jan	plankton	Net tow				-21.7	
85	1985 Jan	zoopl	Ctenophora				-20.5	

Station	Date	Sample Type	Organism	#	Size	Body part	del-C13	del-N15
85	1984 Nov	plankton	Net tow				-28.3	
85	1985 Apr	plant	Enteromorpha				-14.7	
85	1985 Jan	plant	Cladophora				-20.4	
85	1985 Jul	plant	Cladophora				-23.8	12.2
85	1985 Apr	POC	POC				-22.6	
85	1986 Feb	POC	POC				-21.0	
85	1985 Jan	POC	POC				-22.5	
85	1985 Apr	sediment	sediment				-19.9	5.7
85	1986 Jun	sediment	sediment				-17.4	
85	1985 Apr	shrimp	Palaemonetes	6	3cm	guts	-19.9	
85	1985 Apr	shrimp	Macrobranchium			green gland	-24.0	
85	1985 Apr	shrimp	P. setiferus	3	2cm	tail	-18.9	
85	1985 Apr	shrimp	Palaemonetes	6	3cm	tail	-19.3	
85	1985 Apr	shrimp	Macrobranchium	1	4cm	tail	-24.2	
85	1985 Apr	shrimp	Macrobranchium			head viscera	-25.4	
85	1985 Apr	shrimp	Macrobranchium	1	3cm	tail	-19.1	
85	1985 Apr	shrimp	Macrobranchium		3cm	eggs	-21.6	
85	1986 Feb	shrimp	Mysidae				-21.3	
85	1985 Jan	shrimp	Palaemonetes	10	2.5cm	tail	-18.8	
85	1985 Jul	shrimp	Palaemonetes	8	2.5-3cm	tail	-19.3	
85	1985 Jul	shrimp	P. setiferus	5	7-8cm	tail	-22.5	10.6
85	1985 Jul	shrimp	P. setiferus			guts	-23.4	
85	1985 Jul	shrimp	P. aztecus	5		guts	-22.3	
85	1985 Jul	shrimp	P. aztecus	5	4-5cm	tail	-22.2	11.7
85	1984 Nov	shrimp	Palaemonetes	10	2.5cm	tail	-18.8	
85	1984 Nov	shrimp	P. setiferus		large	tail	-19.7	
85	1984 Nov	shrimp	P. setiferus			chitin	-21.1	
85	1984 Nov	shrimp	P. setiferus		small	tail	-21.7	10.9
85	1985 Oct	shrimp	P. setiferus	4	7.2cm	tail	-23.9	
85	1985 Oct	shrimp	P. aztecus	3	6.8cm	tail	-20.5	
85	1985 Oct	squid	L. brevis	1	4cm	muscle	-19.0	
85	1986 Feb	zoopl	A. tonsa	125			-25.4	
85	1986 Feb	zoopl	Barnacle nauplii	150			-24.4	
85	1985 Jan	zoopl	Amphipoda	8			-20.6	7.6
85	1985 Jul	zoopl	Ctenophora				-22.5	
85	1985 Oct	zoopl	Ctenophora				-21.5	
85	1985 Oct	zoopl	A. tonsa	120			-24.5	
85	1985 Oct	zoopl	A. tonsa	133			-24.8	

Station	Date	Sample Type	Organism	#	Size	Body part	del-C13	del-N15
85	1985 Oct	zoopl	Paracalanus	58			-26.5	
85+633	1985 Dec	DOC	DOC				-19.5	
85+633	1985 Oct	DOC	DOC				-21.6	
85+633	1985 Dec	POC	POC				-24.2	
85+633	1985 Oct	POC	POC				-25.0	
603	1985 Oct	plant	Cladophora					2.1
603	1984 Nov		R. cuneata					8.5
85	1986 Apr		Mediomastus					12.2
45	1986 Apr		Mediomastus					16.2
603	1986 Apr		Mediomastus					16.2
633	1986 Apr		Mediomastus					13.0
1505	1986 Apr		Mediomastus					12.5
1905	1986 Apr		Mediomastus					13.0
35/36	1986 Feb		Ampelisca abdita					11.9
623	1984 Nov	plant	Cladophora					7.3
	1986 Aug	plant	Ulmus					2.5

TABLE 7.9

Station	Date	Sample Type	Organism	#	Size	Body part	del-C13	del-N15
1505	1986 Aug	plant	Ulmus					2.5
1505	1986 Feb	infauna	Maldanidae				-20.1	11.5
1905	1986 Apr	infauna	Mediomastus calif					12.5
1905	1984 Nov	bivalve	C. virginica	2		whole	-23.4	11.5
1905	1984 Nov	bivalve	Crassostrea virg.	2		muscle	-20.3	11.2
1905	1986 Feb	bivalve	M. lateralis				-20.6	8.2
1905	1984 Nov	fish	M. undulatus	5	3.5cm	tail	-20.2	14.6
1905	1985 Oct	infauna	Ogyrides limicola				-18.7	10.6
1905	1986 Apr	infauna	Mediomastus					13.0
1905	1986 Feb	infauna	G. americana				-19.7	13.2
1905	1986 Feb	infauna	Ogyrides				-18.6	11.7
1905	1985 Apr	sediment	sediment				-18.8	5.9
35/36	1984 Nov	shrimp	P. setiferus	4	large	tail	-17.3	9.8
45	1986 Feb	infauna	Ampelisca abdita					11.9
45	1984 Nov	crab	C. sapidus	1	large	claw	-20.5	9.4
45	1984 Nov	fish	M. undulatus	10	large	tail	-23.8	13.1
45	1984 Nov	fish	C. variegatus	1	2.5cm	tail	-17.5	7.3
45	1984 Nov	fish	C. variegatus	1	3.5cm	tail	-17.4	6.9
45	1986 Feb	infauna	Chironomid larvae				-26.7	6.4
45	1986 Apr	infauna	Mediomastus					16.2
45	1985 Jan	plant	Phragmites australis				-25.5	5.8
45	1985 Jan	plant	Trawl detritus				-22.8	6.3
45	1985 Oct	plant	Algae off stick				-24.1	5.5
45	1985 Jul	shrimp	Macrobranchium	4	5-8cm	tail	-23.7	12.1
603	1985 Apr	shrimp	Macrobranchium	4	3-4cm	tail	-24.3	12.9
603	1984 Nov	bivalve	R. cuneata					8.5
603	1985 Jul	fish	P. lethostigma	4		guts	-26.0	10.8
603	1985 Jul	fish	P. lethostigma	4	7-8cm	tail	-24.7	12.3
603	1985 Jul	fish	M. undulatus	4	7cm	tail	-24.2	12.4
603	1985 Apr	fish	P. lethostigma	1	14cm	tail	-21.3	13.8
603	1986 Apr	infauna	Mediomastus					16.2
603	1985 Oct	plant	Cladophora				-20.5	3.8
603	1985 Oct	plant	Cladophora					2.1

Station	Date	Sample Type	Organism	#	Size	Body part	del-C13	del-N15
603	1985 Jan	plant	Trawl detritus				-26.5	5.3
603	1985 Apr	sediment	sediment	2			-21.8	4.7
603	1984 Nov	shrimp	P. setiferus	4		tail	-22.5	11.7
603	1985 Jul	shrimp	P. setiferus	7	7-8cm	tail	-23.2	10.2
603	1985 Jul	shrimp	P. aztecus	10	3-5cm	tail	-23.2	9.7
623	1985 Jul	shrimp	P. aztecus	6	6-7cm	tail	-23.3	10.2
623	1984 Nov	bivalve	C. virginica	7		whole	-26.8	11.5
623	1984 Nov	plant	Cladophora					7.3
623	1985 Jan	plant	Trawl detritus				-25.9	5.3
623	1985 Jan	plant	Ectocarpus				-24.6	5.7
633	1985 Apr	sediment	sediment	2			-18.1	4.9
633	1986 Feb	bivalve	M. lateralis				-22.4	8.3
633	1986 Apr	infauna	Mediomastus					13.0
633	1986 Feb	infauna	Laeonereis				-20.8	9.9
633	1985 Apr	sediment	sediment				-20.2	6.0
85	1985 Apr	shrimp	Macrobranchium	3	4-5cm	tail	-24.8	12.3
85	1984 Nov	bivalve	C. virginica	10		whole	-26.2	13.3
85	1985 Apr	bivalve	C. virginica			muscle	-23.2	10.3
85	1985 Apr	bivalve	C. virginica			fat	-25.5	10.7
85	1986 Feb	bivalve	M. lateralis				-22.2	7.9
85	1984 Nov	crab	C. sapidus	4	<2cm	whole	-23.1	9.2
85	1985 Jul	crab	C. sapidus	2	6cm	claw	-21.7	11.2
85	1984 Nov	fish	Cyprinodon		<3.5cm	tail	-18.3	7.6
85	1985 Jul	fish	A. felis	1	12cm	tail	-20.2	14.2
85	1985 Jul	fish	M. undulatus	2	7cm	tail	-21.7	13.9
85	1985 Jul	fish	A. mitchilli	6	4-5cm	tail	-22.9	13.4
85	1985 Jul	fish	A. mitchilli	6		guts	-24.8	10.1
85	1985 Jul	fish	C. nebulosus			guts	-23.2	11.7
85	1985 Jul	fish	Leiostomus xanthurus	1	7cm	tail	-20.0	11.7
85	1985 Jul	fish	C. nebulosus	1	4cm	tail	-21.7	12.6
85	1986 Apr	infauna	Mediomastus					12.2
85	1985 Jul	plant	Cladophora				-23.8	12.2
85	1985 Jan	plant	Trawl detritus				-26.4	5.2

Station	Date	Sample Type	Organism	#	Size	Body part	del-C13	del-N15
85	1985 Apr	plant	Trawl detritus				-27.2	7.3
85	1985 Apr	sediment	sediment				-19.9	5.7
85	1984 Nov	shrimp	P. setiferus		small	tail	-21.7	10.9
85	1985 Jul	shrimp	P. aztecus	5	4-5cm	tail	-22.2	11.7
85	1985 Jul	shrimp	P. setiferus	5	7-8cm	tail	-22.5	10.6
	1985 Jan	zoopl	Amphipoda	8			-20.6	7.6