Semi-annual water column monitoring report: August - December 1997

Massachusetts Water Resources Authority

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Semi-Annual Water Column Monitoring Report 97-2
August – December 1997

Submitted to

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SEMI-ANNUAL WATER COLUMN REPORT 97-2

EXECUTIVE SUMMARY

The Massachusetts Water Resources Authority (MWRA) Harbor and Outfall Monitoring (HOM) Program has collected water quality data in Massachusetts and Cape Cod Bays since 1992. This monitoring is in support of the HOM Program mission to assess the potential environmental effects of effluent discharge relocation from Boston Harbor into Massachusetts Bay. The data are being collected to establish baseline water quality conditions and ultimately to provide the means to detect significant departure from that baseline. The data include physical water properties, nutrients, biological production and respiration, and plankton measurements. Two types of surveys are performed: nearfield surveys with stations located in the area around the future outfall site, and more comprehensive combined nearfield/farfield surveys that include stations in Boston Harbor, Massachusetts Bay, and Cape Cod Bay.

Water quality monitoring data presented in this report were collected during the second half of 1997 in the Massachusetts Bay system. The scope of this semi-annual report includes a synthesis of water column data, and a brief analysis of integrated physical and biological results. The objective of the report is to provide a visual presentation of the monitoring data submitted to MWRA five times per year in tabular format, and to discuss key biological events which occurred. To this end, graphical presentations of the horizontal and vertical distribution of water column parameters in the farfield and nearfield from August through December 1997 are presented. An overview of the data from the second semi-annual period is presented below.

The Massachusetts Bay system undergoes strong seasonal stratification of the water column, and the timing of the onset and breakdown of vertical stratification influences seasonal nutrient cycling and biological activity, and their effects on critical issues such as dissolved oxygen depletion in stratified bottom water. Results are discussed, therefore, in terms of the structure of the water column. In 1997, a moderate degree of salinity driven stratification began around the end of April, and was well established by mid-June. Coastal upwelling and storm-driven mixing of the surface layer influenced the water column structure early in this reporting period (during late August), while, the seasonal breakdown in stratification was not complete until the end of September. However, mixing did not reach the deeper water of the outer nearfield until late-October.

Evidence of coastal upwelling during late August (W9711) included decreasing bottom water temperature and increasing bottom salinity, areas of colder, more saline surface water at coastal stations, and prolonged onshore bottom water currents. A strong phytoplankton bloom was occurring during this period in Boston Harbor and along the coast, with maximum chlorophyll concentration >7 μgL^{-1} and areal production rates of 2,200 $mgCm^{-2}d^{-1}$. More seaward areas of Massachusetts Bay exhibited little phytoplankton activity (e.g., nearfield stations N18 and N04 exhibited chlorophyll concentrations <2 μgL^{-1} and productivity rates ≤1,000 $mgCm^{-2}d^{-1}$). A strong horizontal nutrient gradient in surface water was also evident, with the harbor and coastal waters high in nutrients relative to the more offshore stations.

The Harbor nutrients and associated bloom may have contributed to the high chlorophyll concentrations at coastal stations immediately adjacent to the Harbor; however, the phytoplankton assemblage further south differed from the Harbor and near-coastal assemblage. August was also a period of low river discharge, minimizing the potential contribution of nutrients from coastal runoff. The more southerly bloom may therefore have developed in response to nutrient release from sub-pycnocline water transported to the surface.

Between the August and October combined nearfield/farfield surveys, primary production rates in the outer nearfield remained low, but rates continuously increased at the more inshore station N18. Both sensor data and nutrient chemistry results indicated that the nearfield remained stratified through September and into October, and river discharges and storm activity remained low through the period. However, vertical cast data from the shallower inshore stations of the nearfield indicated a more uniform water column in late September, which was again coincidental with evidence of onshore advection and potential upwelling (onshore bottom currents and a prolonged three-week period of decreasing temperature and increasing salinity in bottom water). HOM data indicated little chlorophyll activity (< 1.5 μgL^{-1}) during the late September nearfield survey (W9713), although primary production rates at N18 in late September exceeded 3,000 $mgCm^{-2}d^{-1}$. However, continuously recorded data from the USGS mooring showed a substantial increase in chlorophyll shortly after the late September survey, which may have also been documented by elevated chlorophyll-specific production estimates during W9713.

HOM data did document a strong fall bloom during early October (W9714), particularly at the inshore stations and in northern Massachusetts Bay. Chlorophyll concentrations at the more offshore stations in Massachusetts Bay remained low. Given the mooring data record, the fall bloom may have developed inshore in late September in response to near-coastal phenomena and subsequently progressed further into Massachusetts Bay. As incomplete mixing at the deeper stations of the nearfield was still evident by the late October survey (W9715), it may be speculated that the continued release of unutilized sub-pycnocline nutrients continued to fuel the bloom during October after survey W9714. The scenario of a mid-month release of nutrients is particularly strong as mooring data indicated that substantial mixing event occurred (rapid increase in bottom water temperature and decrease in salinity over a three-day period). The seasonal peak in zooplankton abundance documented by the nearfield survey at month's end may infer bloom conditions during mid-October; however, there are no supporting data to directly document chlorophyll activity during this period.

The protracted sequence of water column mixing also affected results for bottom water DO concentration. The minimum average nearfield bottom water concentration (7.3 mg/L) was reported during early October (W9714). The average bottom water concentration over the nearfield rose by the late October survey (W9715), but since vertical mixing had yet to reach the deeper stations, individual minima for concentration (6.4 mgL^{-1}) and saturation (68.5 percent) were recorded during late October. These late-season minima caused by the delayed mixing might have very well been even lower had not the seasonal decline in bottom water DO concentration been mitigated by large-scale advection during July, when a 1.5 mgL^{-1} increase in bottom DO was observed (Cibik *et al.*, 1998). These events will be more fully discussed in the 1997 annual water column report.

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1.0 INTRODUCTION

1.1 Program Overview

The Massachusetts Water Resources Authority (MWRA) has implemented a long-term Harbor and Outfall Monitoring (HOM) Program in the Massachusetts Bay system. The objective of the HOM Program is to verify compliance with the discharge permit, and to assess the potential environmental effects of the relocated effluent discharge into Massachusetts Bay. To establish baseline water quality conditions with respect to nutrients, water properties, phytoplankton and zooplankton, and water-column respiration and productivity, ENSR is conducting water quality surveys in the nearfield and farfield region of Massachusetts and Cape Cod Bays.

This semi-annual report summarizes water column monitoring results for the second half of the 1997 monitoring year (Table 1-1). Two types of surveys were performed: eight nearfield-only surveys with stations located in the area over the future outfall site (Figure 1-1), and two more comprehensive surveys that included sampling of stations in Boston Harbor, Massachusetts Bay, and Cape Cod Bay (Figure 1-2). The stations in these surveys were further separated into regional groupings according to geographic location.

The November nearfield survey (W9716) included sampling at station F12 in Stellwagen Basin to assess late fall dissolved oxygen levels in the bottom water. The final winter survey, conducted in mid–December (W9717), included sampling coverage at stations outside of the nearfield to characterize winter nutrient levels in Massachusetts Bay.

Raw data summaries, along with specific field information, are available in individual survey reports submitted immediately following each survey. In addition, nutrient data reports (including calibration information, sensor, and water chemistry data), plankton data reports, and productivity and respiration data reports are each submitted five times annually. Raw data summarized within this or any of the other reports are available from MWRA in hard copy or electronic formats.

1.2 Organization of the Semi-Annual Report

The scope of the semi-annual report is focused primarily towards providing a compilation of all of the water column data collected during the reporting period. Secondarily, integrated physical and biological results are discussed for key water column events. The report first provides a summary of the survey and laboratory methods (Section 2). The bulk of the report, as discussed in further detail below, presents results of water column data from the last eight surveys of 1997 (Sections 3-5). Finally, the major findings of the semi-annual period, including integrated physical and biological water column results during water column events, are synthesized in Section 6.

In the results section, data are first provided in summary tables (Section 3). The data summary tables include the major results of water column surveys in the semi-annual period. A description of data selection, integration information, and summary statistics are included with that section.

Each of the summary results sections (Sections 4-5) includes presentation of the horizontal and vertical distribution of water column parameters in both the farfield and nearfield. The horizontal distribution of physical parameters is presented through regional contour plots. The vertical distribution of water column parameters is presented using both time-series plots of averaged surface and bottom water column parameters, and along vertical transects in the survey area (Figure 1-3). The time-series plots utilize average values of the surface water sample (the "A" depth, as described in Section 3), and the bottom water sample (the "E" depth). Examining data trends along three farfield transects (Boston-Nearfield, Cohassett, and Marshfield), and one nearfield transect, allows three-dimensional analysis of water column conditions during each survey.

Results of water column physical and chemical data, including water properties, nutrients, chlorophyll, and dissolved oxygen, are provided in Section 4. Survey results were organized according to the physical characteristics of the water column during the semi-annual period. For the second semi-annual period, the timing of fall water column turnover is the key event that, to a large degree, controls the ecological water quality parameters that form much of the basis for assessing the effects of the outfall. Because of the importance of this dynamic, this report describes the horizontal and vertical characterization of the water column during the pre-turnover stage, and processes that occurred during and subsequent to the fall turnover. Time-series data are commonly provided for the entire semi-annual period for clarity of data presentation.

Productivity, respiration, and plankton measurements, along with corresponding discussion of chlorophyll and dissolved oxygen results, are provided in Section 5. Discussion of the biological processes and trends during the semi-annual period is included in this section. A summary of the major water column events of the semi-annual period is presented in Section 6, and finally, references are provided in Section 7.

TABLE 1-1

Water Quality Surveys for W9710-W9717
August to December 1997

Survey #	Type of Survey	Survey Dates
W9710	Nearfield	August 5-6
W9711	Nearfield/Farfield	August 18-23
W9712	Nearfield	September 4-5
W9713	Nearfield	September 22-25
W9714	Nearfield/Farfield	October 6-10
W9715	Nearfield	October 29-30
W9716	Nearfield/Stellwagen Bank	November 21- December 4
W9717	Nearfield/Winter Nutrients	December 15-16

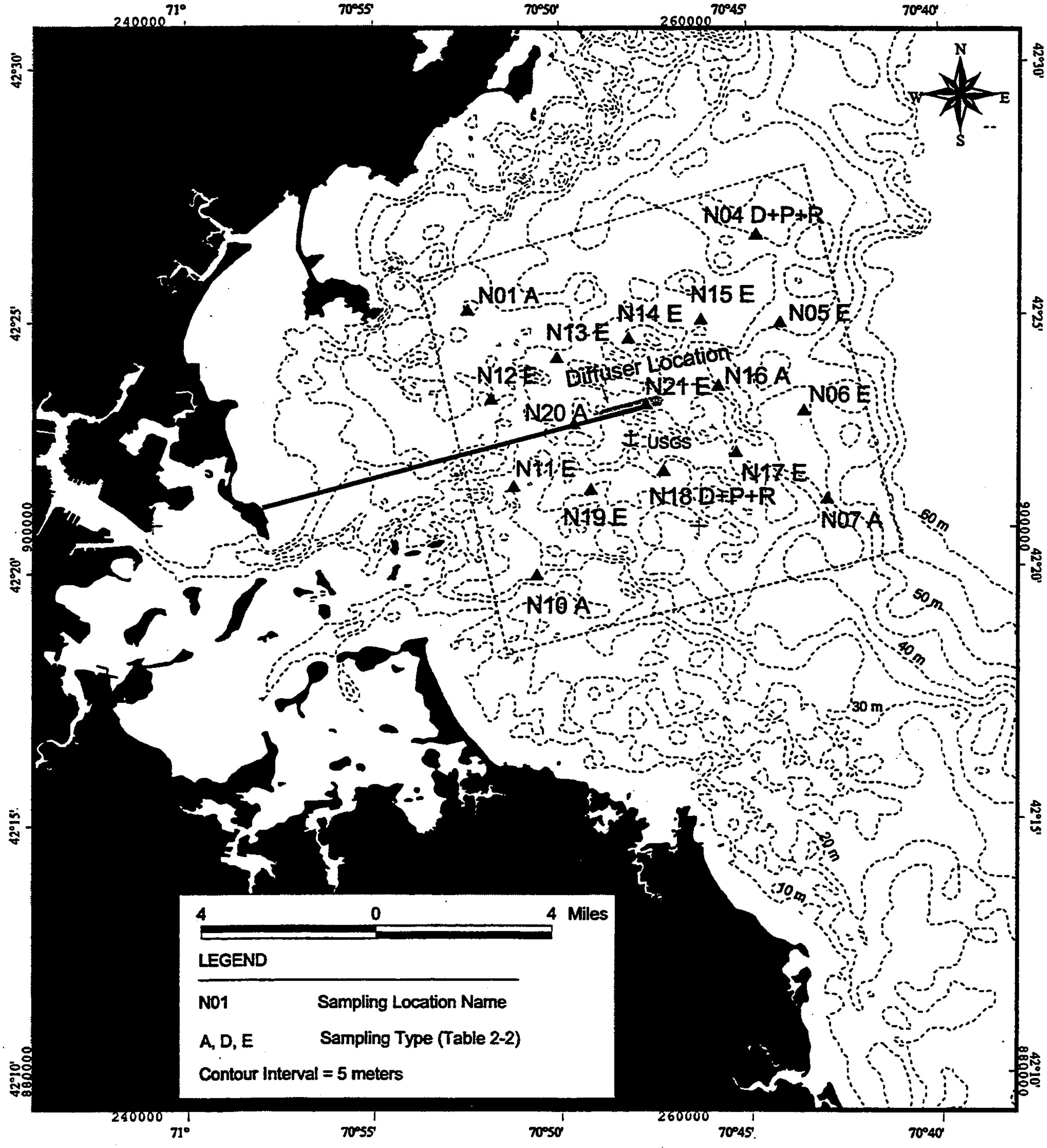


FIGURE 1-1
Location of Nearfield Stations and USGS Mooring

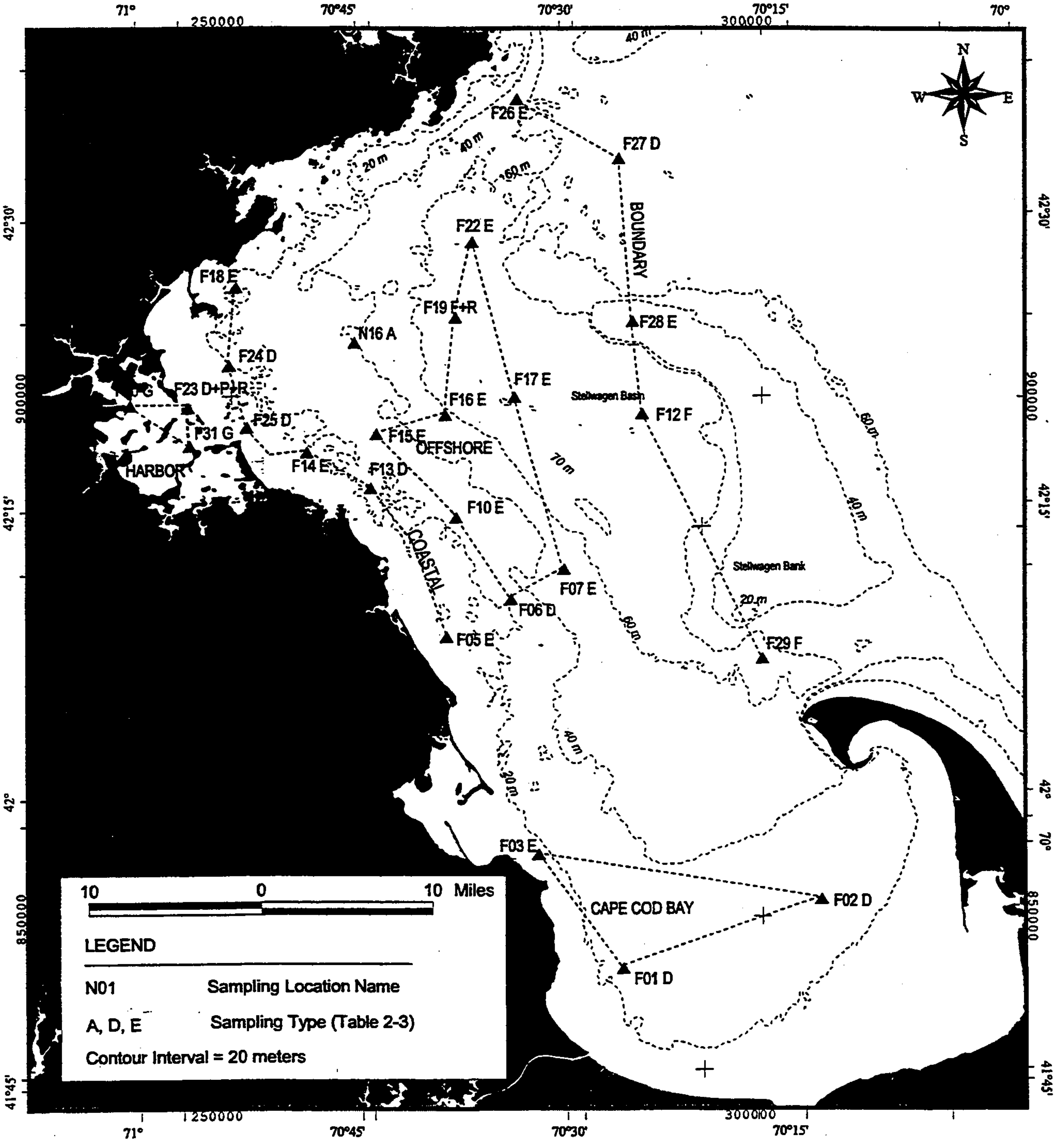


FIGURE 1-2
Location of Farfield Stations Showing Regional Geographic Classifications

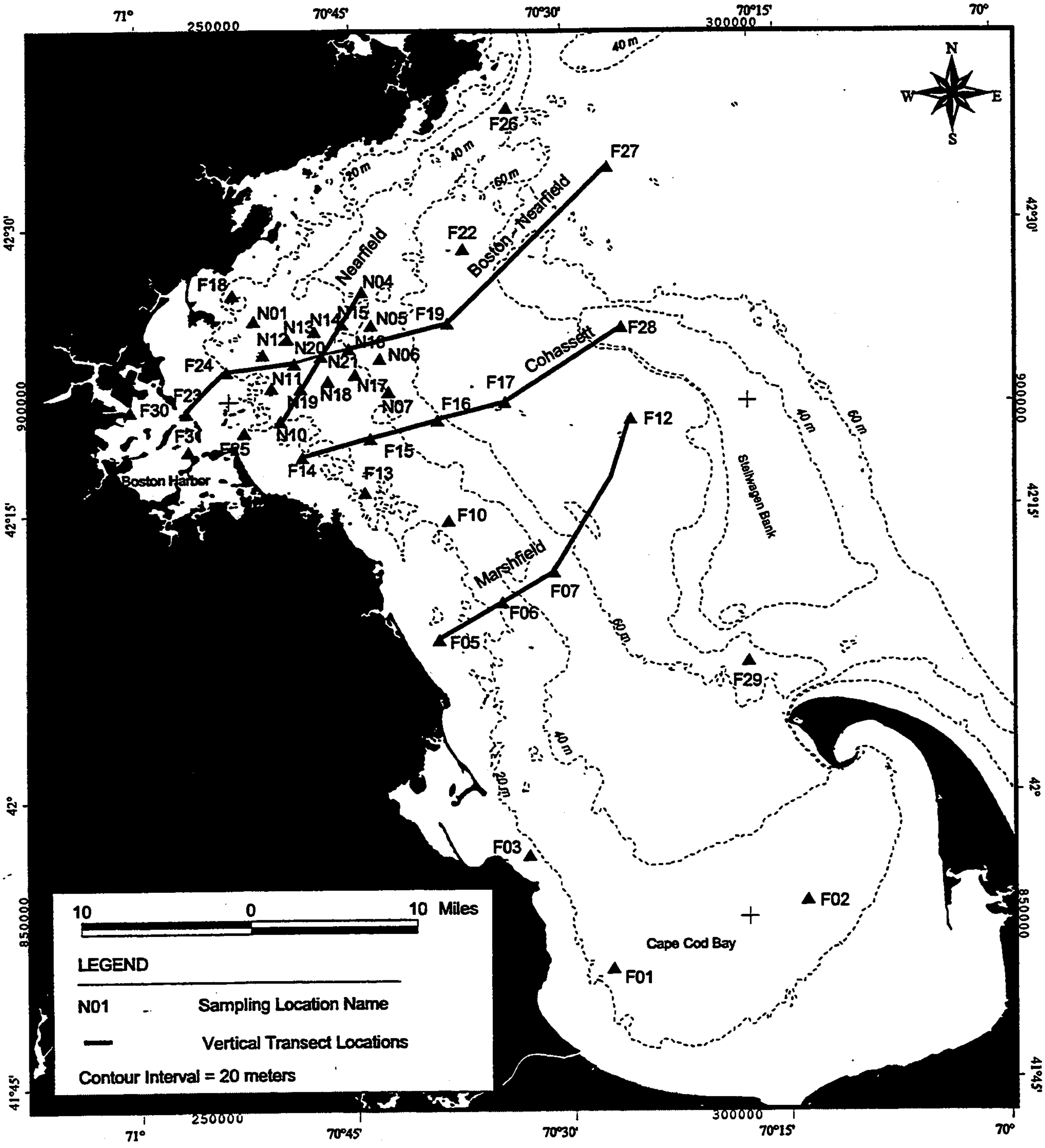


FIGURE 1-3

Location of Stations Selected for Vertical Transect Graphics Showing Transect Names

2.0 METHODS

This section describes general methods of data collection and sampling for the last eight water column monitoring surveys of 1997. Section 2.1 describes data collection methods, including survey dates, sampling platforms, and analyses performed. Section 2.2 describes the sampling scheme, and Section 2.3 details specific operations for the second 1997 semi-annual period. More specific details on field sampling and analytical procedures, laboratory sample processing and analysis, sample handling and custody, calibration and preventive maintenance, documentation, data evaluation, and data quality procedures are discussed in the Water Quality Monitoring CW/QAPP (Bowen *et al.*, 1997). Details on productivity sampling procedures and analytical methods are also available in the Water Quality Monitoring CW/QAPP, and in Taylor (1997).

2.1 Data Collection

Water quality data for this report were collected from the sampling platforms *R/V Christopher Andrew* and *R/V Isabel S.* Continuous vertical profiles of the water column and discrete water samples for analysis were collected using a CTD/Niskin bottle rosette system. This system includes a deck unit to control and store data, and an underwater unit comprised of several environmental sensors, including conductivity/salinity, temperature, depth, dissolved oxygen, transmissometry, irradiance, and relative fluorescence. These measurements were obtained at each station by deploying the CTD; in general, one cast was made at each station. Water column profile data were collected during the downcast, and water samples were collected during the upcast by closing the Niskin bottles at selected depths, as discussed below.

Water samples were collected at five depths at each station. These depths were selected during CTD deployment based on positions relative to the water column structure and presence of a subsurface chlorophyll maximum. The bottom depth (within 5 meters of the sea floor) and the surface depth (within 4 meters of the water surface) of each cast remained constant and the mid-bottom, middle and mid-surface depths were selected to represent any variability in the water column. In general, the selected middle depth corresponded with the chlorophyll maximum and/or pycnocline. Should the chlorophyll maximum have occurred closer to the surface or the bottom of the water column, the mid-surface or mid-bottom depths were selected to capture that layer. Water samples for analyses that are dependent on chlorophyll were taken from the bottles closed at the chlorophyll maximum, regardless of the depth at which the bottles were closed.

Exceptions to the water sampling procedure included productivity and respiration casts at Station F23 during each farfield survey, and at Stations N04 and N18 during each nearfield survey. At these stations, two casts were necessary in order to obtain a sufficient amount of water for the additional analyses. Productivity samples are also light dependent, and a "split-bottom" cast was sometimes necessary during the respiration and productivity cast in an attempt to capture not only bottom water, but also water associated with the 0.5% light level. This resulted in six to seven depths sampled, dependent upon the presence of stratification. These two casts were made in succession during a station visit, with time in between to relocate the vessel within a 300-meter radius of the station location.

Samples from each depth at each station were collected by subsampling from the Niskin bottles into the appropriate sample container. Analyses performed on the water samples are summarized in Table 2-1. Samples for dissolved inorganic nutrients (DINuts), dissolved organic carbon (DOC), total dissolved nitrogen (TDN) and phosphorous (TDP), particulate organic carbon (POC), biogenic silica, chlorophyll *a* and phaeopigments, total suspended solids (TSS), urea, and phytoplankton were filtered and preserved immediately after obtaining water from the appropriate Niskin bottles. Whole water phytoplankton samples (unfiltered) were obtained directly from the Niskin bottles and immediately preserved. Zooplankton samples were obtained by deploying a zooplankton net overboard and making an oblique tow of two-thirds of the water column or up to 30 meters of depth. In addition to survey replicates, ENSR added a rapid turnaround assessment of phytoplankton standing stock and presence of nuisance species dominant forms. Productivity and respiration samples were collected from the Niskin bottles and incubated on board the vessel during survey efforts.

2.2 Sampling Scheme

A synopsis of the sampling scheme for the analyses described above is outlined in Tables 2-1, 2-2, and 2-3. Stations were assigned a letter (A, D, E, F, or G) according to the types of analyses performed at that station. Productivity and respiration analyses were also conducted at certain stations and represented by the letters P and R, respectively. Since different analyses were performed at different depths, each depth at each station is assigned an analysis group (G1, G2, G3, G4, G5, G6, G7, G8, or G9; Table 2-1). Tables 2-2 (nearfield stations) and 2-3 (farfield stations) provide the station name and type, and give the analysis group that represents the analyses performed at each depth. Station N16 is considered both a nearfield station (where it is designated as type A) and a farfield station (where it is designated as type D).

2.3 Operations Summary

Changes in the 1997 sampling scheme from prior monitoring years included an alteration in sampling stations, and an increase in the number of samples taken at certain "nearfield only" and combined nearfield/farfield stations during stratified conditions. During this semi-annual period, respiration analyses were measured at four stations (N04, N18, F19, and F23) during combined nearfield/farfield surveys. Respiration measurements were made at two additional depths during the stratified period. Productivity was measured at three stations (N04, N18, and F23) during the combined events, a reduction of one station from the previous year's protocol. Additional productivity and respiration measurements in the water column at F23 were undertaken during August benthic flux survey. DCMU fluorescence measurements were added at productivity stations to provide data supporting the development of proxy measurements of productivity using bio-optical techniques. These results will be reported in the 1997 Annual Water Column Report.

2.3.1 Deviations in Scope

Principal deviations from the CW/QAPP plan for each survey and the sampling scheme are described below. For additional information about a specific survey, the individual survey reports may be consulted.

Early August Nearfield Survey (W9710):

- Due to weather delays, W9710 was postponed from Tuesday August 5th to Wednesday August 6th.

Mid-August Nearfield/Farfield Survey (W9711):

- Due to a shortage of water for the surface screened phytoplankton sample at F06, the remaining volume required for the analysis was acquired from filtered POCN water from the corresponding depth.

- Extra dissolved oxygen samples were collected at F19 at A, C, D, and E depths as duplicates.

- Due to high concentrations of particulate matter in the water column, the volume filtered for POCN was modified, and the WHOI laboratory was notified of the changes.

- Due to a small tear noticed at N04 on the screen in the zooplankton cup the zooplankton sample may have been partially lost, the tear was sealed with epoxy prior to subsequent sampling at station N18.

- The pump was accidentally shut off while firing Nisken bottles #7 (B depth) and #9 (C depth) which may affect in-situ data associated with these bottles. The pump was turned on and provided sufficient time to acclimate before the firing of bottle #10.

- To capture the chlorophyll peak at station N07 and F01, analyses performed at the B and C depths were switched.

Early September Nearfield Survey (W9712):

- Due to weather delays, survey W9712 was postponed from Wednesday September 3rd to Friday September 5th.

- To capture the chlorophyll peak at station N10, analyses performed at the B and C depths were switched.

Late September Nearfield Survey (W9713):

- An abundance of tunicates (salps) were caught in the zooplankton net at station N04 which may have resulted in the partial loss of organisms in the zooplankton sample as tunicates were removed from the sample.

- To capture the chlorophyll peak at station N10, analyses performed at the B and C depths were switched.

Early October Nearfield/Farfield Survey (W9714):

- An abundance of tunicates (salps) were caught in the zooplankton net at several stations and sent to ANS for supplementary analysis.

- Per request by the MWRA, additional secchi measurements were performed with two additional secchi disks.

- Due to a new bridge monitor, sample bottle firing times are incorrect.

- To capture the chlorophyll peak at station N07, N16, and N18 (nearfield), N16 (farfield), analyses performed at the B and C depths were switched.

Late October Nearfield Survey (W9715):

- Due to weather delays, survey W9715 was postponed from Tuesday October 28th to Thursday October 30th.

Late November Nearfield/Stellwagen Bank Survey(W9716):

- Station F12 (Stellwagen Bank) was sampled on Friday November 21st to collect dissolved oxygen samples

- Due to weather delays, continuation of survey W9716 was postponed from Saturday November 22nd to Thursday December 4th.

- Zooplankton and screened phytoplankton samples received insufficient formalin preservative due to degradation of shipboard stock from the cold temperatures. Formalin was added following the survey before shipment to ANS for laboratory analysis.

- One of the triplicate samples for dissolved oxygen from the bottom depth at station N07 (W97G1N07ET9) may be suspect due to handling. A portion of the sample was spilled, which was replaced with water from the chlorophyll *a* sample bottle at the corresponding depth.

- A third cast was performed in order to retrieve the PC/PN samples required from all depths and the dissolved oxygen sample required at the mid-bottom depth, which were inadvertently not collected during the initial cast.

Mid-December Nearfield/Winter Nutrients Survey (W9717):

- No deviations from the CW/QAPP occurred during this survey.

TABLE 2-1

Water Column Sample Analyses

Analysis	Analysis Group										
	G1	G2	G3	G4	G5	G6	G7	G8	G9	P	R
Dissolved Inorganic Nutrients	X	X	X	X	X	X	X	X			
Dissolved Organic Carbon	X	X	X								
Total Dissolved N & P	X	X	X								
Particulate C & N	X	X	X								
Particulate P	X	X	X								
Biogenic Silica	X	X	X								
Chlorophyll & Phaeopigments	X	X	X	X	X	X			X	X[1]	
Total Suspended Solids	X	X	X	X					X		
Dissolved Oxygen	X	X	X	X	X		X		X		X[1]
Urea	X	X									
All Phytoplankton	X	X									
Screened Phytoplankton	X	X									
Zooplankton	X										
Areal Productivity										X	
Respiration											X

X[1] Stratification dependent (see text)

TABLE 2-2

Analysis Group for Each Nearfield Station and Depth

Station Name	N01	N04	N05	N06	N07	N10	N11	N12	N13	N14	N15	N16	N17	N18	N19	N20	N21
Station Type	A	D+P+R	E	E	A	A	E	E	E	E	E	A	E	D+P+R	E	A	E
Nearfield Stations																	
Surface	G3	G1+P+R	G8	G8	G3	G3	G8	G8	G8	G8	G8	G3	G8	G1+P+R	G8	G3	G8
Mid-surface	G6	G6+P	G8	G8	G6	G6	G8	G8	G8	G8	G8	G6	G8	G6+P	G8	G6	G8
Middle	G3	G2+P+R	G8	G8	G3	G3	G8	G8	G8	G8	G8	G3	G8	G2+P+R	G8	G3	G8
Mid-bottom	G5	G5+P	G8	G8	G5	G8	G8	G8	G8	G8	G8	G5	G8	G5+P	G8	G5	G8
Bottom	G4	G3+P+R	G8	G8	G4	G8	G8	G8	G8	G8	G8	G4	G8	G3+P+R	G8	G4	G8

TABLE 2-3

Analysis Group for Each Farfield Station and Depth

Station Name[1]	F01	F02	F03	F05	F06	F07	F10	F12	F13	F14	F15	F16	F17	F18	F19	F22	F23	F24	F25	F26
Station Type	D	D	E	E	D	E	E	F	D	E	E	E	E	E	F+R	E	D+P+R	D	D	E
Farfield Stations																				
Surface	G1	G1	G8	G8	G1	G8	G8	G7	G1	G8	G8	G8	G8	G8	G7+R	G8	G1+P+R	G1	G1	G8
Mid-surface	G6	G6	G8	G8	G6	G8	G8	G8	G6	G8	G8	G8	G8	G8	G8	G8	G6+P	G6	G6	G8
Mid-depth	G2	G2	G8	G8	G2	G8	G8	G7	G2	G8	G8	G8	G8	G8	G7+R	G8	G2+P+R	G2	G2	G8
Mid-bottom	G5	G5	G8	G8	G5	G8	G8	G7	G5	G8	G8	G8	G8	G8	G7	G8	G5+P	G5	G5	G8
Bottom	G3	G3	G8	G8	G3	G8	G8	G7	G3	G8	G8	G8	G8	G8	G7+R	G8	G3+P+R	G3	G3	G8

Station Name	F27	F28	F29	F30	F31	N16
Station Type	D	E	F	G	G	D
Surface	G1	G8	G7	G1	G1	G1
Mid-surface	G6	G8	G8	G0	G0	G6
Mid-depth	G2	G8	G7	G2	G2	G2
Mid-bottom	G5	G8	G7	G0	G0	G5
Bottom	G3	G8	G7	G4	G4	G3

[1] Stations F04, F08, F09, F11, F20 and F21 have been replaced by or changed to stations F27, F28, F29, F30, F31 and N16.

3.0 DATA SUMMARY PRESENTATION

Data from each survey were compiled from the complete HOM Program 1997 database and organized to facilitate regional comparisons between surveys (Tables 3-1 through 3-8). Each table provides summary data from one survey; the survey dates are provided at the top of each table. A discussion of which parameters were selected, how the data were grouped and integrated, and the assumptions behind the calculation of statistical values (average, minimum, and maximum) are provided below. All raw data summarized in this report are available from MWRA either in hard copy or electronic form.

The spatial pattern of data summary follows the sample design over major geographic areas of interest in Massachusetts Bay, Cape Cod Bay, and Boston Harbor (Section 3.1). Compilation of data both horizontally by region and vertically over the entire water column was conducted in order to provide an efficient way of assessing the status of the regions during a particular survey. Maximum and minimum values are provided because of the need to assess extremes of conditions prior to outfall relocation relative to criteria being developed for contingency planning purposes (MWRA, 1997).

Regional compilations of nutrient and biological water column data were conducted first by averaging individual laboratory replicates, followed by field duplicates, and then by station visit. Significant figures for average values were selected based on the precision of the specific dataset. Detailed considerations for individual datasets are provided in the sections below.

3.1 Defined Geographic Areas

The primary partitioning of data is between the nearfield and farfield stations (Figures 1-1 and 1-2). Farfield data were additionally segmented into five geographic areas: three stations in Boston Harbor (F23, F30, and F31), six coastal stations (F05, F13, F14, F18, F24, F25), eight offshore stations (F06, F07, F10, F15, F16, F17, F19, and F22), five boundary region stations (F12, F26, F27, F28, F29), and three Cape Cod Bay stations (F01, F02, and F03). These regions are shown in Figure 1-2.

The data summary tables include data that are derived from all of the station data collected in each region. Average, maximum, and minimum values are reported from the cumulative horizontal and vertical datasets as described for each data type below.

3.2 Sensor Data

The six CTD profile parameters provided in the data summary tables include temperature, salinity, density (σ_t), fluorescence (chlorophyll *a*), transmissivity, and dissolved oxygen (DO) concentration. Statistical parameters (maximum, minimum, and average) were calculated from the five upcast sensor readings collected at five depths through the water column (defined as A-E). The five depth values, rather than the entire set of profile data, were selected in order to reduce the statistical weighting of deep-water data at the offshore and boundary stations.

Generally, the samples were collected in an even depth-distributed pattern. One of the mid-depth samples (B, C, or D) was typically located at the fluorescence (chlorophyll) peak in the water column (when present), depending on the relative depth of the chlorophyll maximum. Details of the collection, calibration, and processing of CTD data are available in the Water Column Monitoring CW/QAPP (Bowen *et al.*, 1997), and are summarized in Section 2.

Following standard oceanographic practice, patterns of variability in water density will be described using the derived parameter σ_t, which is calculated by subtracting 1,000 kg/m^3 from the recorded density. During this semi-annual period, density varied from 1,020.7 kg/m^3 to 1,026.2 kg/m^3, equivalent to σ_t values from 20.7 kg/m^3 to 26.2 kg/m^3.

Fluorescence data were calibrated to the amount of chlorophyll *a* in discrete water samples collected at the depth of the sensor reading for a subset of the stations (see CW/QAPP or Tables 2-1, 2-2, 2-3). The calibrated chlorophyll sensor values were used for all discussions of chlorophyll in this report. Phaeopigment concentrations were also included in the summary results.

In addition to DO concentration, the derived percent saturation was also provided. Percent saturation was calculated prior to averaging station visits from the potential saturation value of the water (a function of the physical properties of the water) and the calibrated DO concentration (see CW/QAPP). Beam attenuation was calculated from the ratio of light transmission relative to the initial light incidence, over a particular distance in the water column, and is provided in units of m^{-1}.

3.3 Nutrients

Analytical results for nutrient concentration were extracted from the HOM database and include ammonium (NH_4), nitrite (NO_2), nitrite + nitrate (NO_2+ NO_3), phosphate (PO_4), and silicate (SiO_4). Nutrients were measured in water samples collected at each of the A-E depths during the CTD casts. Information on the collection, processing, and analysis of nutrient samples can be found in the CW/QAPP (Bowen *et al.*, 1997).

3.4 Biological Water Column Parameters

Three productivity parameters were selected for inclusion in the data summary tables. Areal production, which is determined by integrating the measured productivity over the photic zone, is included for the productivity stations (F23 representing the harbor; N04 and N18 representing the nearfield). Because areal production is already depth-integrated, averages were calculated only among productivity stations for the two regions sampled. The derived parameters α ($gC[gChla]^{-1}h^{-1}[\mu Em^{-2}s^{-1}]^{-1}$), and P_{max} ($gC[gChla]^{-1}h^{-1}$) were also included (Taylor, 1997). Respiration rates were averaged over the respiration stations (the same harbor and nearfield stations as productivity, and additionally one offshore station, F19) and over the three to five water column depths sampled (dependent upon stratification). The water column depths of the respiration samples typically coincided with the water depths of the productivity measurements.

Dissolved and particulate organic parameters also summarized for the tables include biogenic silica (BIOSI), dissolved and particulate organic carbon (DOC and POC), particulate and total dissolved phosphate (PART P, TDP), particulate organic and total dissolved nitrogen (PON and TDN), and urea. Total suspended solids (TSS) data were provided as a baseline for total particulate matter in the water column. Dissolved and particulate constituents were measured from water samples collected from each of the five (A-E) depths during CTD casts. Detailed methods of sample collection, processing, and analysis are available in the CW/QAPP (Bowen *et al.*, 1997).

3.5 Plankton

Plankton results were extracted from the HOM database and include whole water phytoplankton, screened phytoplankton, and zooplankton. Phytoplankton measurements included whole-water collections at the surface (A depth) and at the water column chlorophyll *a* maximum (C depth) during the water column casts. Additional samples were taken at these two depths and screened through 20μm Nitex mesh to retain and concentrate dinoflagellate species and other larger taxa. Zooplankton measurements were collected through oblique tows at all stations. Detailed methods of sample collection, processing, and analysis are available in the CW/QAPP (Bowen *et al.*, 1997).

Final plankton values were derived for each cast by first averaging analytical replicates, then averaging station visits. Values were calculated from the data for the following parameters: nuisance algae (*Alexandrium tamarense, Phaeocystis pouchetii, and Pseudo-nitzschia pungens*), total phytoplankton, total zooplankton, and total centric diatoms. Only the maximum of each plankton parameter is presented in the summary tables due to the program emphasis on the magnitude of plankton response to nutrient concentrations.

3.6 Additional Data

Additional data sources were utilized during interpretation of HOM Program semi-annual water column data. Continuous monitoring data, collected from a mooring located between nearfield stations N21 and N18 (Figure 1-1) were provided by the USGS. Hourly temperature and salinity data from 22.4 m and 27.8 m USGS mooring data were averaged over each day, and plotted with HOM survey data from station. Discrete data from N16 were selected from water depths that were most consistent with the depths of mooring data, and plotted with the continuous data for comparison. Finally, major meteorological events that occurred over the year, including hurricanes, northeasters, and records of precipitation, were summarized for additional data interpretation.

TABLE 3-1
Semi-Annual Data Summary Table
Event W9710 (8/5/97)
Nearfield Survey

Region		Nearfield		
Parameter	Unit	Min	Max	Avg
Physical				
Chlorophyll a	µg/L	0.00	4.42	0.65
Salinity	psu	30.9	31.8	31.3
Sigma_T	kg/m^3	21.7	25.0	23.2
Temperature	°C	6.5	20.1	14.0
Transmissivity	m-1	0.79	1.91	1.06
Nutrients				
NH_4	µM	0.03	2.63	0.44
NO_2	µM	0.01	0.44	0.14
$NO_2 + NO_3$	µM	0.00	4.19	0.86
PO_4	µM	0.13	0.71	0.34
SiO_4	µM	1.4	11.4	3.8
Phaeopigment	µg/L	0.02	0.97	0.21
DO				
Concentration	mg/l	8.0	10.0	8.8
Saturation	%	86%	116%	104%
Productivity				
Alpha	see text	0.02	0.04	0.03
Areal Production	mgC/m^2/d	1183.5	1991.9	1587.7
Pmax	see text	2.9	12.3	8.2
Respiration	µmol/h	0.02	0.23	0.11
Water Column				
BIOSI	µM	0.4	3.1	0.9
DOC	mg/L	1.0	1.4	1.2
PART P	µM	0.08	0.25	0.17
POC	µM	10.3	41.5	22.5
PON	µM	1.15	6.62	3.29
TDN	µM			
TDP	µM			
TSS	mg/L	0.01	1.02	0.28
Urea	µM	0.34	0.79	0.49
Plankton				
Total Phytoplankton	Mcell/L		1.12	
Centric diatoms	Mcell/L		0.08	
Alexandrium tamarense	Mcell/L		NP	
Phaeocystis pouchetii	Mcell/L		NP	
Pseudo-nitzschia sp	Mcell/L		1.44E-06	
Total Zooplankton	#/m^3		33017	

NP - Not Present

TABLE 3-2
Semi-Annual Data Summary Table
Event W9711 (8/18/97 - 8/20/97)
Combined Nearfield/Farfield Survey

Region		Nearfield			Farfield														
					Harbor			Coastal			Offshore			Boundary			Cape Cod Bay		
Parameter	Unit	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Physical																			
Chlorophyll a	µg/L	0.00	6.22	0.63	1.90	7.22	3.18	0.64	3.72	1.88	0.00	2.26	0.55	0.00	2.41	0.50	0.05	4.27	1.19
Salinity	psu	28.3	31.9	31.5	30.9	31.4	31.2	31.1	31.7	31.4	31.1	32.1	31.7	31.0	32.2	31.7	31.2	31.8	31.5
Sigma_T	kg/m^3	20.7	25.0	23.8	22.3	23.6	22.9	22.3	24.5	23.5	22.0	25.3	24.3	22.2	25.4	24.3	22.3	24.9	24.0
Temperature	°C	6.4	19.2	11.9	12.9	17.3	15.4	8.8	17.9	13.1	6.5	19.4	9.9	6.4	19.0	10.4	6.9	18.2	11.3
Transmissivity	m-1	0.70	2.93	1.08	1.86	4.72	2.98	1.07	2.49	1.66	0.80	1.77	1.10	0.76	2.08	1.07	1.07	1.76	1.46
Nutrients																			
NH_4	µM	0.00	3.04	0.46	0.64	5.67	2.87	0.16	3.50	1.18	0.02	1.61	0.31	0.00	0.77	0.28	0.14	2.26	0.72
NO_2	µM	0.00	1.22	0.23	0.16	0.29	0.25	0.01	0.46	0.22	0.01	0.46	0.15	0.02	0.37	0.10	0.04	0.50	0.26
$NO_2 + NO_3$	µM	0.00	11.13	2.12	1.30	2.05	1.72	0.02	3.30	1.44	0.00	9.61	3.51	0.01	10.44	3.89	0.08	5.44	2.36
PO_4	µM	0.10	2.11	0.43	0.50	0.89	0.66	0.17	0.95	0.52	0.12	1.04	0.63	0.09	1.36	0.64	0.18	0.94	0.58
SiO_4	µM	0.55	22.89	4.28	2.52	4.07	3.50	1.12	7.77	3.90	0.58	9.76	4.17	0.47	13.73	4.60	0.86	11.81	5.36
Phaeopigment	µg/L	0.02	0.93	0.15	0.01	0.68	0.30	0.04	0.47	0.24	0.00	0.31	0.12	0.01	0.12	0.08	0.002	0.13	0.06
DO																			
Concentration	mg/l	7.4	10.3	8.8	7.6	8.5	8.1	7.7	9.6	8.6	8.1	10.7	8.9	7.9	10.0	8.7	8.1	9.0	8.5
Saturation	%	74%	122%	99%	93%	103%	99%	82%	118%	100%	79%	120%	96%	77%	111%	95%	82%	107%	95%
Productivity																			
Alpha	see text	0.00	0.02	0.01	0.11	0.20	0.16												
Areal Production	mgC/m^2/d	852.5	1016.4	934.4	2195.4	2195.4	2195.4												
Pmax	see text	0.2	6.3	3.7	48.4	62.2	53.8												
Respiration	µmol/h	0.01	0.16	0.09	0.21	0.27	0.25				0.02	0.25	0.13						
Water Column																			
BIOSI	µM	0.4	4.6	1.0	1.4	9.6	5.5	1.5	4.3	2.3	0.8	1.3	1.0	0.2	2.3	0.9	1.2	4.6	2.8
DOC	mg/L	0.8	1.4	1.2	1.3	1.5	1.4	1.1	1.4	1.3	1.1	1.3	1.1	1.0	1.2	1.1	1.0	1.4	1.2
PART P	µM	0.06	0.69	0.20	0.45	1.07	0.70	0.12	0.64	0.38	0.09	0.13	0.12	0.07	0.16	0.13	0.13	0.40	0.23
POC	µM	7.4	61.6	18.5	21.8	82.2	47.1	21.3	64.0	35.2	6.7	23.9	13.9	9.7	38.8	22.8	15.3	35.6	26.0
PON	µM	1.24	9.00	2.74	3.36	11.61	7.05	4.06	7.88	5.77	0.88	3.60	2.31	1.14	5.31	2.90	2.06	4.83	3.55
TDN	µM																		
TDP	µM																		
TSS	mg/L	0.1	3.3	1.2	2.4	8.3	5.2	0.8	4.2	2.0	0.2	0.5	0.4	0.5	1.8	1.2	0.3	2.2	1.3
Urea	µM	0.34	0.68	0.50	0.59	1.23	0.88	0.50	2.41	0.97	0.30	0.47	0.38	0.38	0.42	0.40	0.31	0.47	0.42
Plankton																			
Total Phytoplankton	Mcell/L		0.77			5.39			3.19			1.91			0.87			3.66	
Centric diatoms	Mcell/L		0.06			2.71			1.45			0.94			0.005			2.24	
Alexandrium tamarense	Mcell/L		NP			NP			NP			NP			NP			NP	
Phaeocystis pouchetii	Mcell/L		NP			NP			NP			NP			NP			NP	
Pseudo-nitzschia sp	Mcell/L		4.71E-03			5.89E-03			9.42E-03			5.18E-02			NP			1.88E-01	
Total Zooplankton	#/m^3		26522			80829			76381			32285			30037			53043	

NP - Not Present

TABLE 3-3
Semi-Annual Data Summary Table
Event W9712 (9/3/97)
Nearfield Survey

Region		Nearfield		
Parameter	**Unit**	**Min**	**Max**	**Avg**
Physical				
Chlorophyll a	μg/L	0.15	3.06	0.92
Salinity	psu	31.2	32.0	31.5
Sigma_T	kg/m^3	22.5	24.9	23.5
Temperature	°C	7.5	17.4	13.6
Transmissivity	m-1	0.76	2.18	1.23
Nutrients				
NH_4	μM	0.01	3.99	0.65
NO_2	μM	0.00	0.44	0.16
$NO_2 + NO_3$	μM	0.01	7.16	1.90
PO_4	μM	0.13	0.83	0.42
SIO_4	μM	2.2	8.7	4.2
Phaeopigment	μg/L	0.03	0.49	0.19
DO				
Concentration	mg/l	7.6	9.1	8.4
Saturation	%	84%	113%	99%
Productivity				
Alpha	see text	0.01	0.06	0.04
Areal Production	mgC/m^2/d	1297.0	2299.0	1798.0
Pmax	see text	0.8	16.0	9.2
Respiration	μmol/h	0.03	0.22	0.11
Water Column				
BIOSI	μM	0.3	1.4	0.6
DOC	mg/L	0.9	1.3	1.2
PART P	μM	0.07	0.35	0.19
POC	μM	8.1	40.6	21.6
PON	μM	0.81	5.03	2.85
TDN	μM			
TDP	μM			
TSS	mg/L	0.05	2.61	1.25
Urea	μM	0.49	1.18	0.72
Plankton				
Total Phytoplankton	Mcell/L		1.96	
Centric diatoms	Mcell/L		0.11	
Alexandrium tamarense	Mcell/L		NP	
Phaeocystis pouchetii	Mcell/L		NP	
Pseudo-nitzschia sp	Mcell/L		NP	
Total Zooplankton	#/m^3		37904	

NP - Not Present

TABLE 3-4
Semi-Annual Data Summary Table
Event W9713 (9/23/97)
Nearfield Survey

Region		Nearfield		
Parameter	Unit	Min	Max	Avg
Physical				
Chlorophyll a	µg/L	0.00	2.27	0.60
Salinity	psu	31.5	32.1	31.8
Sigma_T	kg/m^3	23.2	25.0	24.1
Temperature	°C	8.0	15.3	12.0
Transmissivity	m-1	0.81	2.23	1.38
Nutrients				
NH_4	µM	0.00	4.75	0.60
NO_2	µM	0.01	0.54	0.24
$NO_2 + NO_3$	µM	0.00	8.90	3.98
PO_4	µM	0.29	1.14	0.70
SIO_4	µM	0.5	10.1	4.6
Phaeopigment	µg/L	0.00	0.51	0.06
DO				
Concentration	mg/l	7.1	9.4	8.1
Saturation	%	77%	111%	92%
Productivity				
Alpha	see text	0.01	0.24	0.10
Areal Production	mgC/m^2/d	814.9	3360.7	2087.8
Pmax	see text	0.4	55.1	22.6
Respiration	µmol/h	0.05	0.28	0.14
Water Column				
BIOSI	µM	0.3	4.5	2.1
DOC	mg/L	0.9	1.3	1.2
PART P	µM	0.05	0.42	0.22
POC	µM	7.0	58.6	23.1
PON	µM	0.63	7.35	3.13
TDN	µM			
TDP	µM			
TSS	mg/L	0.12	2.99	1.68
Urea	µM	0.17	2.16	0.86
Plankton				
Total Phytoplankton	Mcell/L		3.45	
Centric diatoms	Mcell/L		1.08	
Alexandrium tamarense	Mcell/L		NP	
Phaeocystis pouchetii	Mcell/L		NP	
Pseudo-nitzschia sp	Mcell/L		NP	
Total Zooplankton	#/m^3		24269	

NP - Not Present

TABLE 3-5
Semi-Annual Data Summary Table
Event W9714 (10/6/97 - 10/8/97)
Combined Nearfield/Farfield Survey

		Nearfield			Farfield														
Region					Harbor			Coastal			Offshore			Boundary			Cape Cod Bay		
Parameter	Unit	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Physical																			
Chlorophyll a	µg/L	0.00	4.55	0.84	0.95	1.88	1.21	0.11	4.21	1.43	0.00	1.43	0.37	0.00	0.73	0.17	0.04	1.05	0.51
Salinity	psu	31.7	32.4	31.9	31.4	31.6	31.6	31.6	32.0	31.8	31.7	32.5	32.0	31.6	32.6	32.1	31.6	32.0	31.8
Sigma_T	kg/m^3	23.6	25.1	24.4	23.5	23.9	23.8	23.7	24.7	24.2	23.4	25.3	24.4	23.4	25.4	24.4	23.3	24.7	23.9
Temperature	°C	7.9	14.2	11.0	11.9	13.2	12.5	9.5	13.8	11.7	7.1	14.8	10.8	7.7	14.6	11.2	9.5	15.1	12.9
Transmissivity	m-1	0.94	3.09	1.58	2.19	3.06	2.55	1.09	2.80	1.81	0.82	2.09	1.22	0.78	1.42	1.02	0.82	1.73	1.37
Nutrients																			
NH_4	µM	0.04	2.71	0.47	4.43	10.28	8.03	0.24	7.01	1.38	0.11	0.86	0.38	0.12	1.21	0.55	0.26	1.43	0.65
NO_2	µM	0.01	0.49	0.23	0.51	0.69	0.60	0.01	0.49	0.26	0.01	0.32	0.11	0.03	0.37	0.14	0.01	0.40	0.16
$NO_2 + NO_3$	µM	0.06	11.76	5.26	6.50	7.36	6.88	0.10	8.57	4.31	0.15	12.36	5.48	0.22	11.91	5.49	0.08	8.44	2.98
PO_4	µM	0.23	1.52	0.74	1.16	1.55	1.37	0.25	1.13	0.73	0.12	1.52	0.73	0.38	1.52	0.88	0.26	1.13	0.61
SiO_4	µM	0.27	12.89	6.28	4.08	5.64	5.01	0.15	10.89	4.38	0.02	13.42	6.04	1.39	11.30	5.37	1.53	12.41	5.12
Phaeopigment	µg/L	0.00	0.10	0.03	0.001	0.11	0.04	0.00	0.71	0.07	0.01	0.15	0.04	0.001	0.03	0.01	0.01	0.05	0.02
DO																			
Concentration	mg/l	6.8	10.9	8.4	8.0	9.2	8.4	6.9	11.3	8.6	7.0	10.3	8.1	7.4	9.2	8.1	6.3	8.7	7.9
Saturation	%	73%	127%	93%	91%	105%	96%	74%	132%	97%	72%	120%	90%	77%	108%	91%	68%	104%	92%
Productivity																			
Alpha	see text	0.05	0.50	0.28	0.18	0.20	0.19												
Areal Production	mgC/m^2/d	2308.9	4230.7	3269.8	2232.6	2232.6	2232.6												
Pmax	see text	7.1	102.5	41.7	46.4	54.9	49.6												
Respiration	µmol/h	0.01	0.23	0.14	0.14	0.16	0.15				0.05	0.07	0.06						
Water Column																			
BIOSI	µM	1.5	6.0	3.7	2.9	6.7	5.0	2.1	5.4	4.0	1.2	4.8	3.2	0.8	2.0	1.4	1.0	3.7	2.1
DOC	mg/L	0.6	1.2	0.8	0.7	1.3	0.9	0.7	1.2	0.8	0.5	1.1	0.9	0.4	0.8	0.6	0.6	1.1	0.8
PART P	µM	0.08	0.55	0.30	0.27	0.59	0.50	0.08	0.53	0.33	0.10	0.33	0.23	0.06	0.32	0.15	0.09	0.47	0.21
POC	µM	6.7	82.1	36.6	34.3	50.8	39.2	9.8	78.4	36.8	6.4	32.5	16.8	7.8	23.3	13.2	11.1	25.8	18.5
PON	µM	0.73	9.04	4.41	4.78	6.81	5.87	1.06	9.31	4.78	1.11	3.95	2.17	0.84	4.08	2.05	1.22	4.37	2.59
TDN	µM																		
TDP	µM																		
TSS	mg/L	0.3	2.8	1.3	2.4	4.4	3.3	0.6	3.1	1.7	0.8	1.6	1.1	0.1	1.5	0.7	0.2	1.8	0.7
Urea	µM	0.12	0.25	0.18	0.26	0.44	0.37	0.01	0.21	0.12	0.30	0.50	0.40	0.07	0.23	0.15	0.15	0.41	0.31
Plankton																			
Total Phytoplankton	Mcell/L		13.31			3.77			5.03			3.14			1.68			3.07	
Centric diatoms	Mcell/L		7.84			1.53			2.47			1.80			0.39			1.29	
Alexandrium tamarense	Mcell/L		NP			NP			NP			NP			NP			NP	
Phaeocystis pouchetti	Mcell/L		NP			NP			NP			NP			NP			NP	
Pseudo-nitzschia sp	Mcell/L		2.43E-03			NP			NP			2.36E-03			9.42E-04			4.71E-03	
Total Zooplankton	#/m^3		26072			24208			59670			23315			5469			8215	

NP - Not Present

TABLE 3-6
Semi-Annual Data Summary Table
Event W9715 (10/28/97)
Nearfield Survey

Region		Nearfield		
Parameter	Unit	Min	Max	Avg
Physical				
Chlorophyll a	µg/L	0.00	1.99	0.68
Salinity	psu	31.6	32.3	32.0
Sigma_T	kg/m^3	24.2	25.2	24.5
Temperature	°C	8.1	11.5	10.7
Transmissivity	m-1	0.81	1.75	1.16
Nutrients				
NH_4	µM	0.07	14.26	2.43
NO_2	µM	0.14	0.74	0.28
$NO_2 + NO_3$	µM	1.91	12.59	4.20
PO_4	µM	0.52	1.63	0.81
SIO_4	µM	3.0	15.8	5.7
Phaeopigment	µg/L	0.00	0.04	0.01
DO				
Concentration	mg/l	6.4	8.6	8.1
Saturation	%	69%	97%	90%
Productivity				
Alpha	see text	0.02	0.04	0.03
Areal Production	mgC/m^2/d	359.9	415.7	387.8
Pmax	see text	1.8	4.1	2.6
Respiration	µmol/h			
Water Column				
BIOSI	µM	0.5	2.2	1.1
DOC	mg/L	1.0	26.6	2.9
PART P	µM	0.08	0.30	0.15
POC	µM	7.4	23.0	12.9
PON	µM	0.76	2.87	1.73
TDN	µM			
TDP	µM			
TSS	mg/L	0.17	2.75	1.01
Urea	µM	0.25	0.81	0.40
Plankton				
Total Phytoplankton	Mcell/L		1.42	
Centric diatoms	Mcell/L		0.02	
Alexandrium tamarense	Mcell/L		NP	
Phaeocystis pouchetii	Mcell/L		NP	
Pseudo-nitzschia sp	Mcell/L		NP	
Total Zooplankton	#/m^3		135177	

NP - Not Present

TABLE 3-7
Semi-Annual Data Summary Table
Event W9716 (11/25/97)
Nearfield/Stellwagen Bank Survey

Region		Nearfield			Boundary		
Parameter	Unit	Min	Max	Avg	Min	Max	Avg
In-situ							
Chlorophyll *a*	µg/L	0.00	0.79	0.28	1.34	3.98	2.35
Salinity	psu	31.9	32.5	32.3	32.1	32.3	32.1
Sigma_T	kg/m^3	25.02	25.29	25.16	24.82	25.00	24.89
Temperature	°C	6.85	8.15	7.75	8.95	9.00	8.97
Transmissivity	m-1	0.86	1.39	0.92	0.98	1.39	1.08
Nutrients							
NH_4	µM	0.10	2.77	0.46			
NO_2	µM	0.09	0.42	0.21			
$NO_2 + NO_3$	µM	6.75	8.11	7.26			
PO_4	µM	0.81	1.07	0.89			
SiO_4	µM	8.45	10.15	8.91			
Phaeopigment	µg/L	0.004	0.09	0.04			
DO							
Concentration	mg/l	9.20	9.59	9.41	8.27	8.71	8.47
Saturation	%	95%	98%	97%	86%	93%	90%
Productivity							
Alpha	see text	0.01	0.03	0.02			
Areal Production	mgC/m^2/d	262.43	326.88	294.65			
Pmax	see text	2.00	4.57	3.02			
Respiration	µmol/h	0.02	0.04	0.03			
Water Column							
BIOSI	µM	0.55	1.01	0.82			
DOC	mg/L	0.90	1.47	1.15			
PART P	µM	0.06	0.14	0.09			
POC	µM	6.75	21.71	10.27			
PON	µM	1.01	3.69	1.70			
TDN	µM						
TDP	µM						
TSS	mg/L	0.13	0.85	0.46			
Urea	µM	0.08	0.50	0.33			
Plankton							
Total Phytoplankton	Mcell/L		0.97				
Centric diatoms	Mcell/L		0.02				
Alexandrium tamarense	Mcell/L		NP				
Phaeocystis pouchetii	Mcell/L		NP				
Pseudo-nitzschia sp	Mcell/L		NP				
Total Zooplankton	#/m^3		30984				

NP - Not Present

TABLE 3-8
Semi-Annual Data Summary Table
Event W9717 (12/16/97)
Nearfield/Winter Nutrients Survey

		Nearfield			Farfield								
Region					Harbor			Coastal			Offshore		
Parameter	Unit	Min	Max	Avg									
In-situ													
Chlorophyll *a*	µg/L	0.00	2.49	0.83	0.42	0.79	0.55	0.63	2.15	1.09	0.00	6.05	1.79
Salinity	psu	31.9	32.5	32.4	31.8	32.0	32.0	32.0	32.3	32.1	32.1	32.5	32.3
Sigma_T	kg/m^3	25.2	25.4	25.39	25.13	25.27	25.23	25.24	25.36	25.29	25.20	25.42	25.34
Temperature	°C	4.9	7.2	6.71	5.25	5.38	5.34	5.20	6.36	5.73	5.89	7.45	6.64
Transmissivity	m-1	0.87	1.24	0.92	1.21	1.41	1.26	0.88	1.04	0.97	0.84	1.14	0.92
Nutrients													
NH_4	µM	0.12	6.55	1.07	5.56	13.33	7.52	0.88	4.38	2.99	0.21	1.24	0.67
NO_2	µM	0.13	0.54	0.23	0.39	0.42	0.40	0.29	0.51	0.41	0.13	0.35	0.25
$NO_2 + NO_3$	µM	7.22	9.37	8.00	7.85	7.95	7.89	7.59	8.74	8.25	6.68	8.36	7.61
PO_4	µM	0.90	1.36	1.00	1.17	1.59	1.29	0.98	1.22	1.11	0.90	1.01	0.94
SiO_4	µM	7.7	9.7	8.85	9.42	10.35	9.67	8.53	9.23	8.93	7.15	9.41	8.55
Phaeopigment	µg/L	0.002	0.26	0.05									
DO													
Concentration	mg/l	9.3	9.9	9.53	9.75	9.85	9.78	9.61	9.90	9.76	9.21	9.89	9.58
Saturation	%	94%	98%	96%	95%	96%	95%	95%	96%	96%	94%	99%	97%
Productivity													
Alpha	see text	0.01	0.03	0.02									
Areal Production	mgC/m^2/d	324.8	530.2	427.50									
Pmax	see text	1.6	7.5	3.51									
Respiration	µmol/h	0.03	0.05	0.04									
Water Column													
BIOSI	µM	0.1	2.2	0.97	1.07	1.49	1.34	0.95	0.98	0.97	0.60	0.93	0.76
DOC	mg/L	0.9	1.3	1.08	1.15	1.27	1.21	1.23	1.35	1.28	1.00	1.29	1.17
PART P	µM	0.05	0.15	0.08	0.11	0.23	0.16	0.06	0.11	0.09	0.05	0.07	0.06
POC	µM	6.9	19.1	9.73									
PON	µM	0.87	2.56	1.44									
TDN	µM												
TDP	µM												
TSS	mg/L	0.31	2.87	0.77	1.20	1.50	1.36	0.46	1.04	0.74	0.45	0.75	0.65
Urea	µM	0.46	1.74	1.13									
Plankton													
Total Phytoplankton	Mcell/L		0.65										
Centric diatoms	Mcell/L		0.02										
Alexandrium tamarense	Mcell/L		NP										
Phaeocystis pouchetii	Mcell/L		NP										
Pseudo-nitzschia sp	Mcell/L		NP										
Total Zooplankton	#/m^3		13827										

NP - Not Present

4.0 RESULTS OF WATER COLUMN MEASUREMENTS

The timing of the annual setup and breakdown of vertical stratification in the water column is an important determinant of water quality, primarily because of the trend towards continuously decreasing DO and increasing dissolved nutrient concentrations in bottom water during the summer and early fall. The seasonal breakdown of stratification, caused by cooling surface water and wind-driven mixing, terminates the seasonal decline in DO and releases nutrients to the upper water column.

The summer pycnocline, defined as a shallow water depth interval over which density increases rapidly, is caused by salinity (freshwater input from riverine discharges, which is typically more important in the spring) and temperature (seasonal warming of surface water, which dominates stratification during the summer). The surface water layer is generally well mixed above the pycnocline during the stratified period, while density typically increases more gradually below the pycnocline (e.g. surveys 10 through 12 in Figure 4-1). For the purposes of this report, vertical stratification will be defined when the difference between bottom density and surface density ($\Delta\sigma_t$) is greater than 1. Using this definition, the inner nearfield had completely broken down by late October (W9715; Figures 4-1 and 4-2), while mixing had yet to reach the deeper water of the outer nearfield.

Two of the eight surveys conducted during the semi-annual period were combined nearfield/farfield surveys (W9711 and W9714). Note the strong pycnocline at the outer nearfield station N16 through late September (W9713), while the more inshore station N10 showed less stability during late August and late September (surveys W9711 and W9713; Figure 4-1). Data from these surveys were evaluated for trends in regional water masses throughout Boston Harbor, Massachusetts Bay, and Cape Cod Bay. Regional water characteristics are presented using contour plots of surface water parameters, derived from the "A depth" (surface) water sample. A complete set of surface contour maps of water properties during farfield surveys is included in Appendix A.

The vertical distribution of water column parameters is presented in the following section using data from three farfield transects in the farfield survey area (see Figure 1-3 for locations of transects). Examining data trends along transects provides a three-dimensional perspective of water column conditions during each survey. Nearfield surveys (W9710-W9717) were conducted more frequently than farfield surveys, allowing better temporal resolution of the changes in water column parameters and the breakdown of stratification, especially when combined with continuous monitoring data provided by the USGS. In addition to the nearfield transect, vertical characteristics in nearfield results are examined and presented by comparing surface and bottom water concentrations ("A" and "E" depths), and by plotting individual parameters with depth in the water column.

Results presented in this section were organized by data type. Physical data (temperature, salinity, and density), are presented in Section 4.1. Transmissometer data are reported in Section 4.2. Nutrient results are presented in Section 4.3, chlorophyll *a* in Section 4.4, and dissolved oxygen in Section 4.5. Finally, a summary of the results of water column measurements (excepting biological measurements) is provided in Section 4.6.

4.1 Physical Characteristics

4.1.1 Horizontal Distribution

During the August combined nearfield/farfield survey (W9711), sea surface temperatures were between 12.8°C and 19.5°C, with coolest temperatures reported in the near-coastal regions off Scituate, Plymouth, and Boston Harbor (stations F10, F03, and F24, respectively; 4-3). These three areas also had slightly higher surface salinity readings, with the maximum reading of 31.44 off Scituate (Figure 4-4). Surface temperatures inside Boston Harbor were warmer than adjacent coastal stations. Surface salinity readings were only slightly lower than those in Massachusetts Bay as discharges from the Charles River were low during August and September (Figure 4-5).

The observed anomalies for *in situ* temperature and salinity from the coastal region may have been indicative of coastal upwelling around the time of the survey, although these data would suggest very localized expressions of this phenomenon. Storm-related vertical mixing may have also complicated the picture. Stations in northern Massachusetts Bay (north of the Cohasset transect with the exception of stations F13 and F14, see Figure 1-3) were sampled prior to storm activity on August 22. Sampling activity in Cape Cod Bay was conducted on August 22nd, and in fact was terminated by high wave activity. Sampling of stations from the Cohasset transect to Race Point was conducted after the storm passed, which may have produced some degree of mixing in the surface layer (e.g., lower surface temperatures and slightly higher surface salinities). However, vertical density profiles at stations N10 and N16, taken prior to the storm, also suggest a lifting of the pycnocline during W9711 relative to W9710 and W9712 (Figure 4-1). Evidence of potential upwelling will be further evaluated in subsequent sections.

By early October (W9714), regional surface temperatures were more uniform, with the warmest surface temperature in western Cape Cod Bay (15.1°C), and cooler temperatures in northern Massachusetts Bay and Boston Harbor (12-14°C; Appendix A). Surface salinity exceeded 31.5 PSU at all stations except for Boston Harbor.

4.1.2 Vertical Distribution

Farfield. During the August combined nearfield/farfield survey (W9711), the water column in Massachusetts Bay showed a strong surface to bottom density gradient in all regions except Boston Harbor (Figure 4-6). Salinity differences contributed to this gradient (Figure 4-7), but stratification was largely driven by temperature (Figure 4-8). By the October combined event (W9714), the salinity difference remained roughly the same, but a diminished temperature gradient was strongly evident. However, based on the density profile illustrated in Figure 4-1, the deeper stations in Massachusetts Bay remained stratified through October. The water column was isothermal by the December survey, indicating well-mixed conditions.

Vertical cast data and cross-sections of west to east transects in Massachusetts Bay (Figure 1-3) illustrate the vertical distribution of physical characteristics within the water column from Boston Harbor and coastal stations seaward (Appendix B). The cross-sections from August (W9711) also were suggestive of coastal upwelling, where cooler, more saline water displaced the warmer surface water evident in the more offshore water (particularly in the Boston-Nearfield transect; Figure 4-9 and Appendix B). Note again that August data from the Cohasset and Marshfield transects were obtained after a day of strong wave action, which may have homogenized the upper surface layer of the water column. Similar plots from early October (W9714) still indicated a fair degree of vertical density structure in the water column (Figure 4-10) as temperature strata remained (Appendix B).

Nearfield. Higher frequency sampling at the nearfield stations provides a more comprehensive documentation of the progression towards the seasonal turnover, as well as local variability, within the nearfield water column. Immediately obvious is the 1-2°C drop in bottom water temperature evident at station N01 during the August combined survey (W9711), a further indication of potential upwelling conditions in this region of the coast at the time (Figure 4-11). Also noteworthy is the fact that complete mixing had only occurred in the inner nearfield by the end of October (Figures 4-1, 4-11, and 4-12). A strong storm that passed through the region on October 27th (NRCC, 1998) appeared to homogenize the shallower inshore stations (N10 and N11), but complete mixing appeared to occur only to a depth of around 29 meters (see trace for survey 15 in Figure 4-1). The remaining stratification was likely short-lived, as a strong storm which produced significant wind damage in the northeast moved through the area on November 1st (NRCC, 1998).

Continuously recorded data from the USGS mooring in the center of the nearfield are shown in Figure 4-13. Surface sensors were not functional during the period, thus data from the sensors at 22.4 and 27.8 meters were plotted. These bottom data showed declining bottom temperature and increasing bottom salinity for the 10-day period preceding W9711, consistent with a scenario of onshore advection and potential upwelling. Further evidence can be found in bottom current meter data from the USGS mooring, depicted in Figure 4-14 using a progressive vector plot. Bottom currents between August 6th and August 18th showed a net movement to the west-southwest, and for several days during the period there was a strong continuous movement in that direction. This onshore motion of bottom water could have resulted in upwelling along the coast. Note that this plot is based on the movement of the water column past the mooring, thus reliability decreases with distance from the mooring. However, the constant onshore direction provides reasonable evidence that upwelling may have occurred.

The continuously recorded sensor data also confirm that some degree of mixing (increasing temperature and decreasing salinity at depth) occurred in late August (see Section 4.1.1) and again in early September. Of further interest is the continuous decline in bottom temperature and increase in bottom salinity between surveys W9713 and W9714, again suggestive of onshore advection of deeper water. These conditions remained in place until mid-October, at which time bottom temperature rapidly rose (3-4°) over a three-day period and salinity decreased.

4.2 Transmissometer Results

Water column beam attenuation was measured for each CTD cast at all nearfield and farfield stations. The transmissometer determines beam attenuation by measuring the percent transmission of light over a given path length in the water. Given that light transmission decays exponentially with beam attenuation and path length (which varies between instruments), the beam attenuation coefficient is computed over a standardized path length of 1 meter, signifying that the value is independent of light path length.

The beam attenuation coefficient is indicative of particulate concentration in the water column. The two possible sources of particles in coastal waters are biogenic material (plankton or organic detritus), or suspended sediment. To evaluate the contribution of biogenic material in the total particulate matter, beam attenuation was compared to fluorescence data (calibrated to chlorophyll *a*). Non-biogenic material may originate from suspended matter in coastal runoff or from resuspension of bottom sediment.

Transmissometer data from the combined nearfield/farfield surveys documented an inshore/offshore gradient. In August (W9711), the highest beam attenuation values were found in Boston Harbor and the adjacent coastal stations (maximum 4.47 m^{-1} at station F30), and the lowest in the nearfield (minimum 0.84 m^{-1} at station N16) (Figures 4-15 and 4-16). Beyond the near-coastal stations, stations showed little variation from approximately 1.0 m^{-1}. Fluorescence results during this period (Section 4.4) indicated that the higher attenuation inshore was due to phytoplankton. With the possible exception of Boundary stations, beam attenuation increased throughout most of Massachusetts Bay by the October combined survey (W9714, Appendix A), again in association with elevated fluorescence results.

4.3 Nutrients

Regional and nearfield nutrient data from the second semi-annual period of 1997 demonstrate the typical progress of seasonal events in the Massachusetts Bay system. The stratified period is exemplified by nutrients trapped below the pycnocline, while the surface mixed layer remains nutrient-depleted. Vertical mixing during the fall turnover releases these trapped nutrients into the upper water column.

Nutrient data from the reporting period were investigated using surface water contour maps (Appendix A) and vertical cross sections (Appendix B). Plots of nutrient relationships for each survey were also developed, including nutrients vs. depth, nutrient:nutrient relationships; and nutrient:salinity relationships (Appendix C).

4.3.1 Horizontal Distribution

Boston Harbor and coastal stations consistently had the highest surface concentrations of all nutrients measured during both combined nearfield/farfield surveys (Figure 4-17; Appendix A). Interestingly, stations that showed evidence of upwelling in their temperature and salinity profiles during August (stations F10, F03, and F24; see Section 4.1) also showed elevated surface nutrient concentrations (e.g., Figure 4-17 and 4-18, but see similar plots for SiO_4 and DIN in Appendix A). This observation would be consistent with the vertical transport of nutrient-rich sub-pycnocline water to the surface. More seaward stations exhibited low concentrations of nutrients in August, but note also the relatively high surface concentrations of phosphate at stations sampled after the storm event on August 22 (see discussion in Section 4.1.1) compared with stations in northern Massachusetts Bay sampled before the storm (Figure 4-18). This may have resulted from mixing within the surface layer during the storm.

A strong surface nutrient gradient was still evident during the October combined survey (W9714), with concentrations diminishing rapidly outside of the Harbor (e.g., Figure 4-19).

4.3.2 Vertical Distribution

Transect plots for nutrient concentrations showed nutrient stratification in the water column during both combined surveys during the reporting period (Appendix B). For example, bottom water nitrate concentrations remained greater than 10 µM at deeper stations in Massachusetts Bay through the October combined survey (Figure 4-20). Ammonium did not show the strong vertical gradient and was restricted to the Harbor and adjacent coastal stations (Figure 4-21).

More frequent sampling during nearfield surveys demonstrated that nutrient stratification in the deeper stations of the outer nearfield was still evident by the end of October (W9715; e.g., silicate at N04 in Figure 4-22). Bottom water silicate reached peak seasonal concentrations of close to 15 µM, whereas the shallower inner nearfield stations were vertically homogenous. Scatterplots of dissolved nutrients from W9716 in the early part of December showed that complete mixing had taken place in the nearfield as evidenced by vertically homogenous nutrient concentrations (Appendix C). The December nutrient survey showed nearly uniform conditions at the stations sampled for NO_3 + NO_2 and SiO_4, while a strong Harbor influence was still evident for NH_4 and PO_4 (Appendix C).

Further examination of silicate concentrations in Figure 4-22 also reveal the periods of peak diatom activity in surface water. With the exception of station N10, reductions in dissolved silicate at the surface was evident throughout the nearfield during late August. A rebound in silicate in early September was followed by increased uptake in late September, again with N10 being the main exception. Peak uptake appeared to occur during the early October combined survey. Phytoplankton activity is further examined by chlorophyll concentrations in the following section, and by the results of plankton sampling in Section 5.3.1.

4.4 Chlorophyll *a*

In situ fluorescence results, calibrated to chlorophyll *a* discrete samples, are presented in this section and are simply referred to as chlorophyll.

4.4.1 Horizontal Distribution

Maximum chlorophyll concentrations during the first combined nearfield/farfield survey (W9711) were found at the entrance to Boston's Inner Harbor (7.22 µg/L), and in the near-coastal stations along the North and South Shores (range 1.3 to 3.0 µg/L, Figure 4-23). Based on differences in dominant phytoplankton taxa (Section 5.3.1), it is likely that the chlorophyll peak off Marshfield and in western Cape Cod Bay was a separate bloom and not simply an extension of the Harbor plume. Given the evidence of potential coastal upwelling, it may be speculated that the more southerly chlorophyll activity may have developed in response to coastal upwelling.

By the final combined survey in early October (W9714), peak concentrations were found off Boston Harbor and northern Massachusetts Bay (Figure 4-24). Chlorophyll concentrations at near-coastal stations off Boston Harbor reached 11.6 µg/L (station F25), while stations in northern Massachusetts Bay off Nahant ranged from 7.3 to 8.3 µg/L. Harbor activity remained strong (4.8-5.9 µg/L), and a localized area of activity was observed off Marshfield (5.5 µg/L). Chlorophyll concentrations in central Massachusetts Bay and Boundary stations ranged from 1-2 µg/L.

4.4.2 Vertical Distribution

Farfield. The three farfield cross-sectional transects (Figure 1-3) were used to illustrate the vertical distribution of chlorophyll in the water column across regions. During late August (W9711), the Boston-Nearfield transect showed surface chlorophyll activity (2.5-3.0 µg/L) adjacent to the Harbor, and subsurface activity (2.0-2.5 µg/L) at the Boundary station F27 (Figure 4-25). Lower concentrations extended inshore to station F19 from the Boundary station, with a noticeable absence of chlorophyll in most of the nearfield. The Cohasset and Marshfield transects exhibited peak activity near the coastline, and a more uniform distribution of chlorophyll in the upper water column. Recall, however, that station F14 of the Cohasset transect was sampled prior to storm-driven mixing, while the remainder of the stations on these two transects were sampled after seas subsided. It is possible that the more uniform distribution in the upper water column resulted from the storm.

By the final combined survey in October (W9714), peak chlorophyll activity was evident to a depth of about 20m in the central nearfield and off Boston Harbor, with most chlorophyll results in the 6-8 µg/L range (Figure 4-26). Further offshore, water column chlorophyll was <2.0 µg/L. To the south, the coastal chlorophyll reached a similar depth as the nearfield but only exceeded 6 µg/L at station F14 immediately off Cohassett.

Nearfield. To demonstrate the progression of nearfield chlorophyll concentrations throughout the period, a plot similar to that developed for silicate (Figure 4-22) was prepared (Figure 4-27). Nearfield chlorophyll concentrations were, with few exceptions, uniformly low from August through September. Elevated chlorophyll concentrations were evident at all depths at station N10 during August, apparently associated with the bloom activity seen in the Harbor and adjacent stations at the time (Section 4.4.1). Somewhat elevated concentrations were also noted at mid-depth at station N01 through early September. A modest increase was also noted in mid-depth results at the other stations during early September (W9712).

Substantial increases in chlorophyll concentrations were observed in most regions of the nearfield during early October (W9714, Figure 4-27). Peak concentrations (11-12 µg/L) were found in mid-depth samples at station N01, and at the surface at station N10. Surface and mid-depth results at stations N04 and N18 were similar (6-8 µg/L). Station N07 did not exhibit the same level of activity, with peak concentrations at the surface only reaching 2 µg/L. This bloom event had subsided by the following survey at the end of the month (W9715), and generally low chlorophyll concentrations were found through the remainder of the year. However, a slight increase was observed during the final survey in December (W9717), particularly at stations N10 and N18.

Available data from the WETLabs spectrophotometer, located at a depth of 13.5 meters on the USGS mooring near the center of the nearfield (Figure 1-1), provided additional detail on chlorophyll concentrations (Figure 4-28). Data coverage included August and early September, corresponding with the first three surveys of the reporting period (W9710-W9712). After an approximate two-week gap in the record, coverage resumed just after survey W9713 (September 22-23). The record ended just prior to the late October survey (W9715).

WETLabs sensor results from August captured the small peak at station N10 seen in HOM results during W9711, and documented 1-2 µg/L concentrations over a 10-day period (Figure 4-28). Chlorophyll concentrations had diminished to around 1 µg/L when the data record dropped out in early September. When the data record resumed after W9713, the daily average chlorophyll concentration reached 6 µg/L, with peaks around 8 µg/L. These data suggest that the W9713 survey (which recorded concentrations between 1-2 µg/L) just missed the onset of this activity, although an increasing trend was evident in surface results from several stations (e.g., N01, N18, and N07).

The late-September peak documented by the WETLabs sensor was followed by a gradual decline that reached a minimum concentration of around 1.5-2 µg/L in early October (Figure 4-28). Coincident with the start of the early October combined survey (W9714) on October 6th, the WETLabs sensor documented the beginning of an eight day bloom on October 7th. The average concentration peaked at around 8 µg/L on October 12th, with an individual peak of around 12 µg/L. Subsequent to this event, concentrations fell to around 1 µg/L through the period of record.

These data indicate that survey coverage during late September and early October (W9713 and W9714) captured the both onset and peak of the second pulse of the fall bloom, but missed almost a week of activity during the first pulse when average chlorophyll concentrations were in excess of 3 µg/L.

4.5 Dissolved Oxygen

The distribution of dissolved oxygen (DO) in the water column was examined first for temporal and spatial trends in the farfield (Section 4.5.1) and then in the nearfield (Section 4.5.2). For purposes of threshold criteria evaluations, individual bottom water DO minima were also reported.

4.5.1 Regional Distribution

DO was measured throughout the study area during the two combined farfield/nearfield surveys conducted in August (W9711) and in October (W9714). Additional measurements were taken in Stellwagen Basin during November (W9716). During August, average regional bottom water DO concentrations at farfield stations exhibited a narrow range (8.1-8.5 mg/L), with the Harbor yielding the lowest average (Figure 4-29a). The minimum individual bottom water concentration during this survey was 7.5 mg/L, reported from Harbor station F31 (Table 3-2). During the October combined survey, average regional DO concentrations in bottom water had a range of 6.9-8.8 mg/L, with Boston Harbor producing the highest average concentration and Cape Cod Bay the lowest. The minimum individual bottom water concentration during this survey was 6.33 mg/L, reported from Cape Cod Bay station F03 (Table 3-5). The average bottom water DO concentration at Stellwagen Basin station F19 was 8.3 mg/L in November, while inshore regions sampled during December had a narrow range of 9.4 –9.8 mg/L.

Average regional bottom water DO saturations during the August combined survey ranged from 83 percent in the Boundary region to 97 percent in Boston Harbor (Figure 4-29b). The minimum saturation reported from the farfield during W9711 was 77 percent, reported near the bottom at station F12 (Table 3-2). With the exception of the Harbor, average DO saturations decreased in all regions during the October combined survey, with the lowest average saturations (75 percent) reported in Cape Cod Bay and at Offshore stations. The minimum individual bottom water saturation during this survey was 68 percent, reported from Cape Cod Bay station F03 (Table 3-5). Bottom DO saturation at Boundary stations averaged 89 percent in November, while inshore regions sampled in December were all around 96 percent.

Average surface and bottom water DO concentration and saturation from stations in Stellwagen Basin were plotted for surface (A) and bottom (E) water samples (Figure 4-30). Average surface DO concentrations were typically between 8.5-9.0 mg/L for surveys conducted in August, October, and November, with an increase to 9.5 mg/L in December (Figure 4-30a). Average bottom water DO concentrations fell from 8.2 mg/L in August to 7.4 mg/L in October. Concentrations increased to 8.3 mg/L in November and to 9.2 mg/L in December.

DO saturation in surface water at Stellwagen Bank stations was 107 percent during both the August and October surveys (Figure 4-30b), indicating excess production of oxygen through photosynthetic activity. In fact, oversaturated conditions were observed to a depth of more than 20 m (Figures 4-31 and 4-32). Average surface saturation fell to 93 percent during November, followed by an increase to 97 percent during December (Figure 4-30b). Average bottom DO saturation was 80 percent during the August survey, which declined to an average of 77 percent by early October. Bottom saturation increased by late November to 89 percent, with a further increase to 95 percent during December.

4.5.2 Nearfield Distribution

Nearfield DO results for concentration and saturation from surface (A) and bottom (E) samples were averaged by survey for the 17 nearfield stations and plotted (Figure 4-33). Average surface DO concentrations were between

8.5-8.8 mg/L for the first four surveys of the reporting period (W9710-W9713; Figure 4-33a). During the peak of chlorophyll activity in early October (W9714, Section 4.4), average surface DO concentration increased to 9.7 mg/L, followed by a decrease to 8.6 mg/L by late October. Surface averages during November and December surveys were around 9.5 mg/L.

The average nearfield bottom water DO concentration fell continuously from 8.8 mg/L in early August to 7.3 mg/L in early October. The minimum individual bottom water concentration during early October was 6.8 mg/L (Table 3-5). By late October, the average bottom concentration had risen slightly, but a high degree of spatial variability was observed (note large standard deviation for W9715 in Figure 4-33a). As discussed in earlier sections, the water column had completely mixed in the shallower inshore stations of the nearfield by the end of October (W9715), but the deeper stations of the nearfield remained stratified below around 30m (Section 4.1.2). Indeed, the minimum bottom water DO concentration was found at station N01 (6.4 mg/L). Average bottom water DO concentrations in November and December were similar to that reported from the surface, indicating complete mixing had occurred.

DO saturation in surface samples exceeded 100 percent through early October (Figure 4-33b), indicating a high degree of phytoplankton activity at the surface (despite the modest chlorophyll concentrations reported in the nearfield). The peak in surface DO saturation occurred during the early October bloom (W9714). Afterward, average surface DO saturation fell to around 95 percent for the remainder of the surveys.

Average nearfield bottom water DO saturation fell continuously from 92 percent in early August (W9710) to 77 percent in early October (W9714). The minimum nearfield bottom water saturation during survey W9714 was 73 percent (station N13). As with concentration, the average bottom water DO saturation rose to 79 percent during the late October survey, however, a high degree of spatial variability was reported due to incomplete vertical mixing at deeper stations. The minimum bottom water saturation was 68.5 percent, reported at station N07. Average nearfield bottom water saturation rose to 97 percent by November, almost identical to the minimum saturation value of 96 percent (station N16). Bottom water DO saturations were similar during the final survey in December.

4.6 Summary of Water Column Results

Physical Characteristics

- A strong pycnocline was evident in the outer nearfield through September. Complete mixing had not occurred at the deeper nearfield stations by the late October survey (W9715), however, strong winds passing through the area on November 1st likely completed the mixing process.

- Evidence of coastal upwelling during late August (W9711) included decreasing bottom water temperature and increasing bottom salinity, areas of colder, more saline surface water at coastal stations, and prolonged onshore bottom water currents.

- Storm-driven mixing which interrupted the late August combined nearfield/farfield survey may have also contributed to vertical mixing at the shallower coastal stations.

- Onshore advection was also evident during late September and early October, when onshore bottom currents produced a three-week decline in bottom water temperature and concurrent increase in bottom salinity. These observed conditions abruptly reversed over a three-day period in mid-October.

Nutrients

- A strong coastal nutrient gradient was evident in the surface water through the stratified period, with higher concentrations evident in Boston Harbor and the coast stations, and low concentrations offshore in Massachusetts Bay.

- The strong surface nutrient gradient remained through the early October farfield survey, and was still evident during the following survey in the nearfield.

- Coastal upwelling and wind-driven mixing may have contributed to higher nutrient concentrations along the coast during August.

Chlorophyll *a*

- Elevated chlorophyll concentrations (maximum of 7.2 µg/L) were present in Boston Harbor and along the North and South Shores during late August (W9711). A chlorophyll peak was also evident at the Boundary station F27 at mid-depth.

- Nearfield results and continuous sensor data from the USGS demonstrated low chlorophyll concentrations in the nearfield through early September. The USGS data indicated that the late September survey (W9713) just missed the onset of a substantial weeklong increase in chlorophyll in the nearfield.

- Results from early October (W9714) documented a strong bloom present off Boston Harbor (surface maximum of 11.6 µg/L) and in northern Massachusetts Bay (6-8 µg/L). Peak chlorophyll concentrations were also noted in mid-depth samples (maximum of 11 µg/L at station N01). Bloom activity continued in Boston Harbor (5-6 µg/L), but chlorophyll concentrations were low in central Massachusetts Bay and the Boundary region (1-2µg/L).

Dissolved Oxygen

- Boston Harbor exhibited the lowest average bottom water DO concentrations (around 8.0 mg/l) and the minimum individual measurement (7.5 mg/L) during the August farfield survey (W9711).

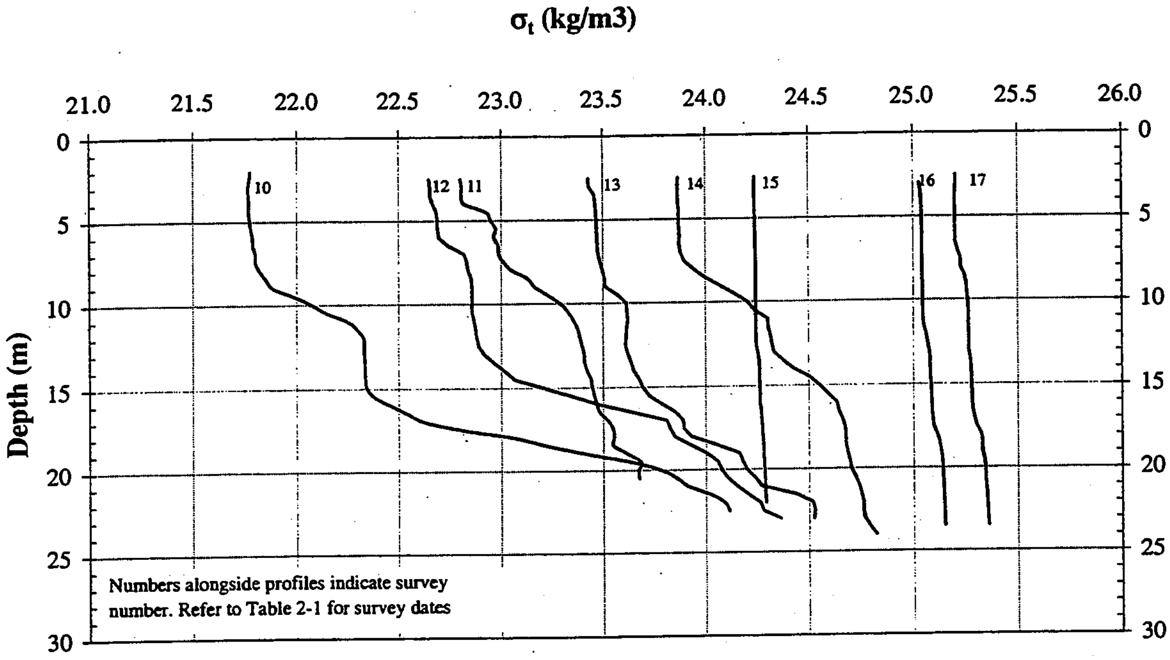
- During the October farfield survey (W9714), Boston Harbor had the highest average bottom water DO concentration (8.5 mg/L). Cape Cod Bay exhibited the lowest average (6.9 mg/L), the lowest individual concentration (6.33 mg/L at station F03), and the lowest individual DO saturation (68 percent, also at F03).

- Bottom water DO concentrations in Stellwagen Basin remained above 7.0 mg/L and 75 percent saturation during the October and November surveys.

- Bottom water DO concentration in the nearfield fell continuously through early October, reaching a minimum nearfield average of 7.3 mg/L during the last farfield survey (W9714).

- The average bottom water DO concentration rose by late October (W9715), but vertical mixing had not yet reached the deeper stations. The minimum individual nearfield bottom water concentration (6.4 mg/L) was recorded at station N01 during this survey, while the minimum saturation (68.5 percent) was recorded at station N07. Storm activity on November 1st may have terminated this seasonal bottom water DO decline.

(a) Station N10



(b) Station N16

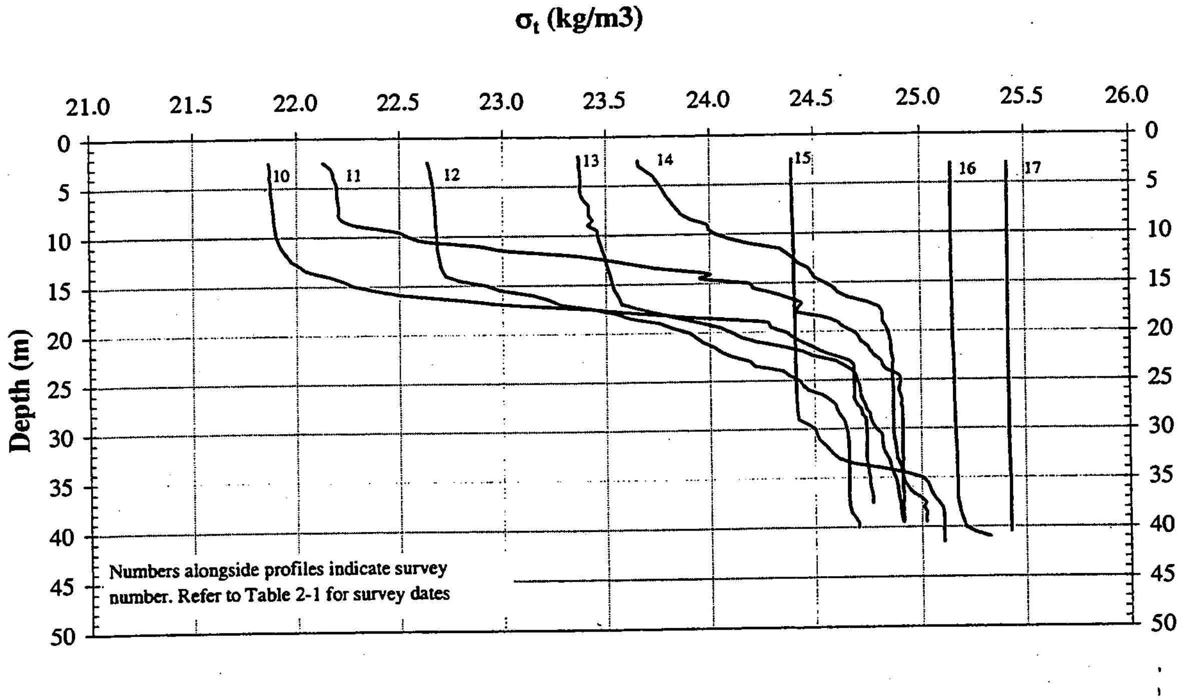
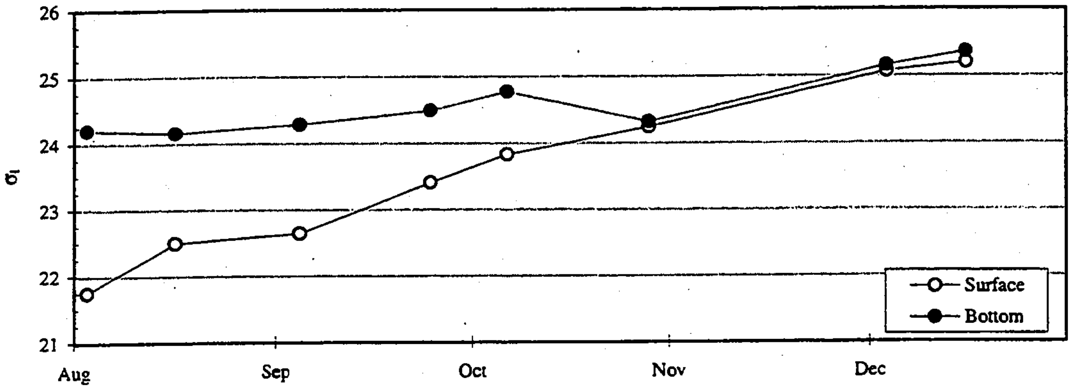


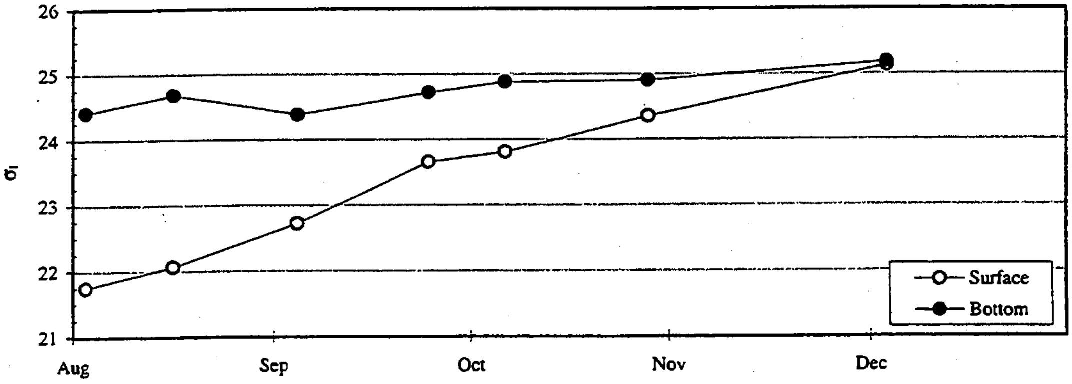
Figure 4-1

Density (σ_t) Profiles at Stations N10 and N16

(a) Inner Nearfield: N10, N11



(b) Broad Sound: N01



(c) Outer Nearfield: N04, N07, N16, N20

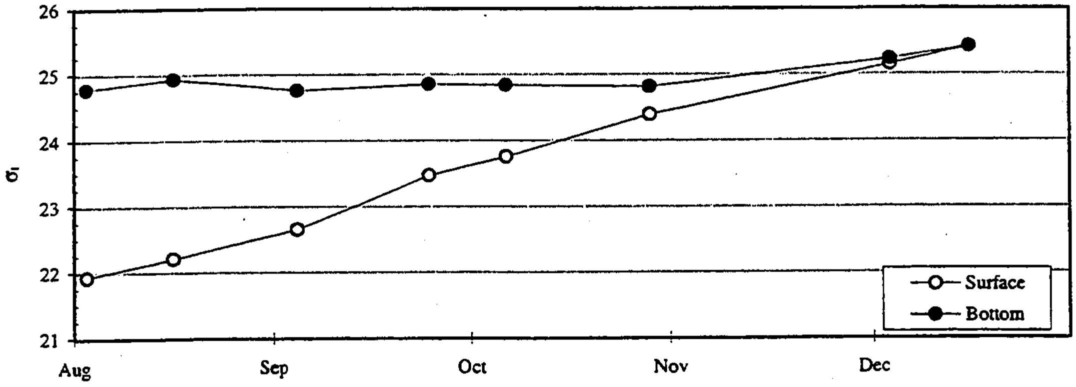


FIGURE 4-2

Times Series of Average Surface and Bottom Water Density (σ_t) in the Nearfield F4-2_sig.XLS

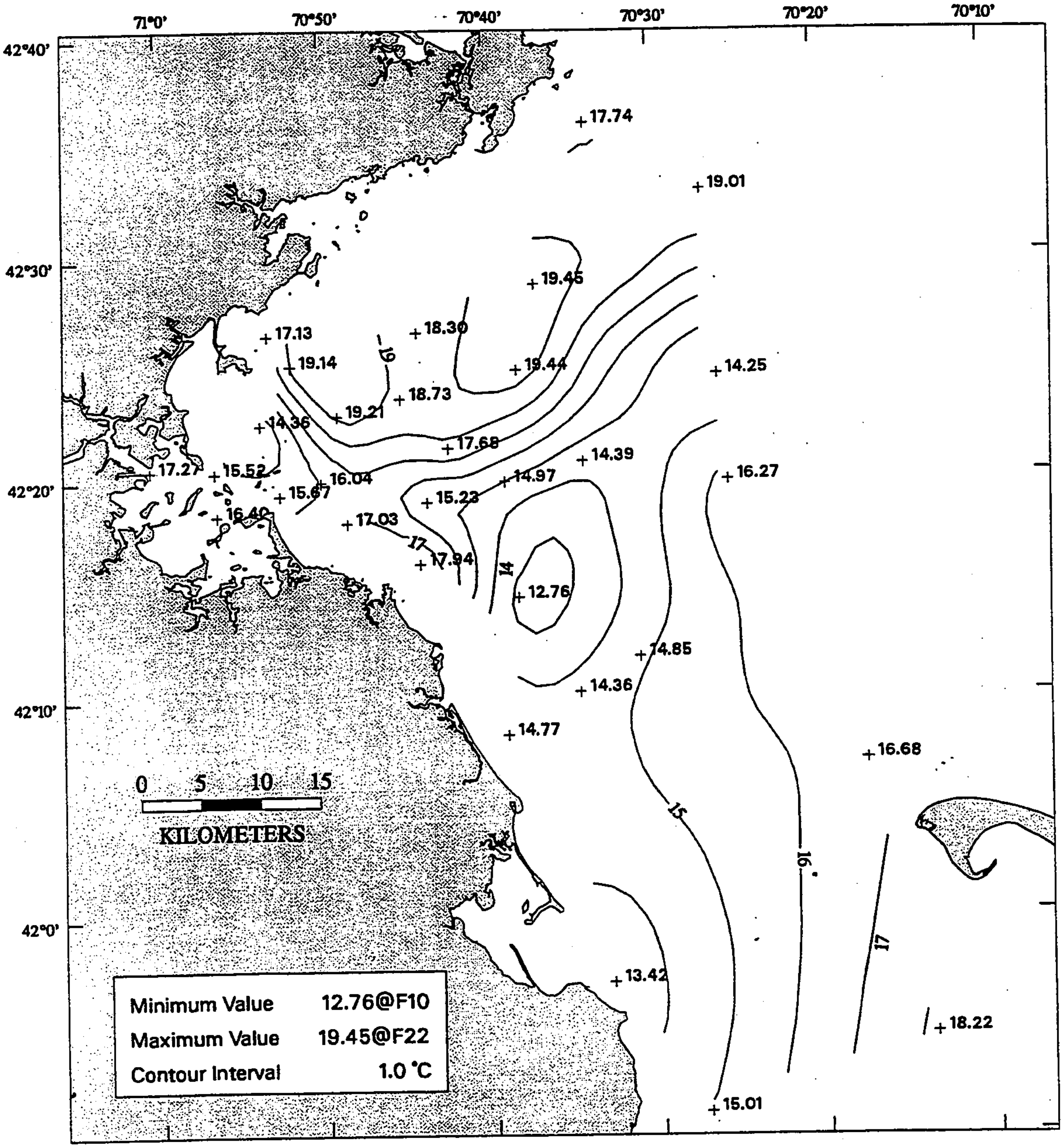


FIGURE 4-3

Surface Water Contour Plot of Temperature (°C) in Late August (W9711)

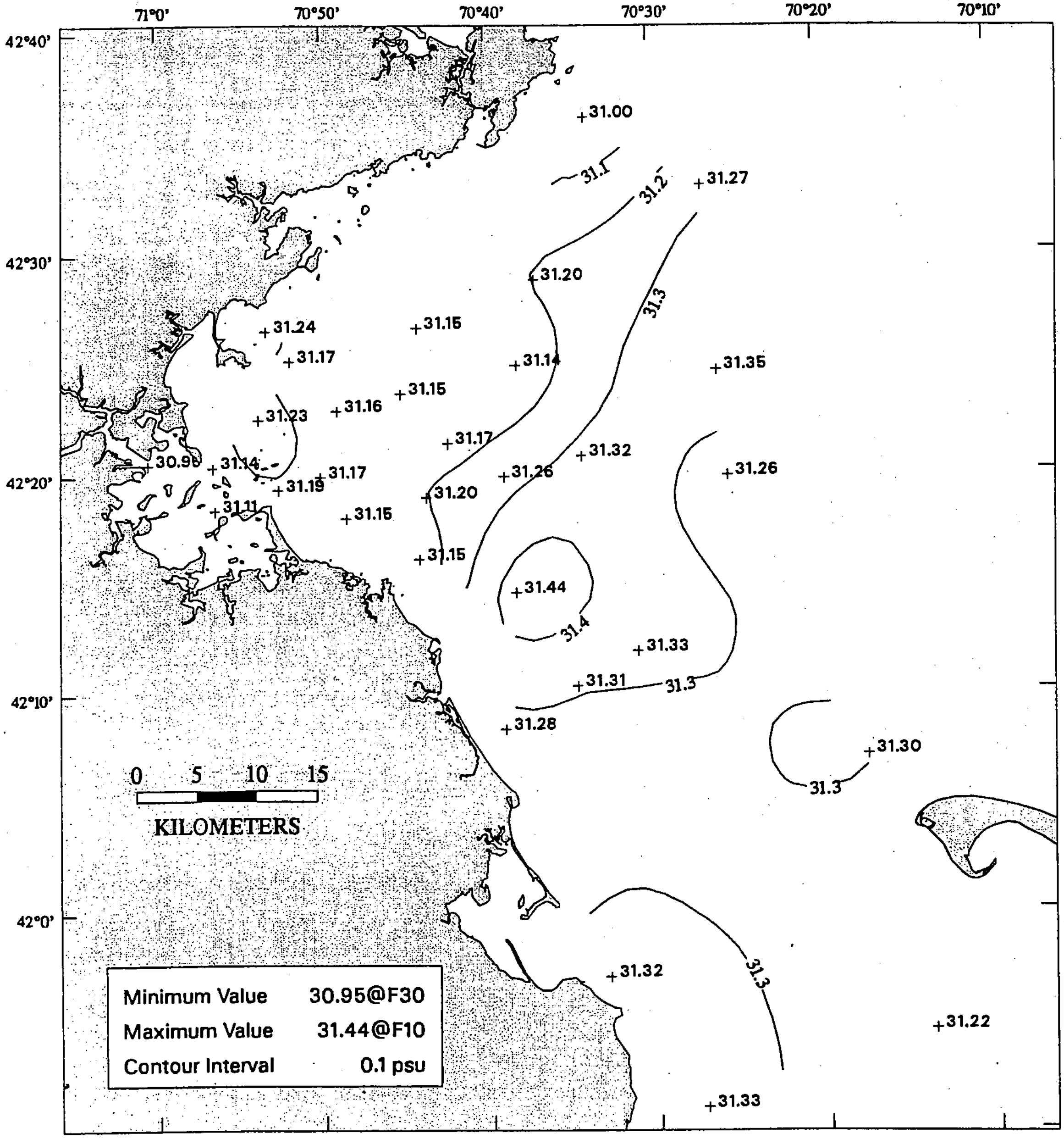
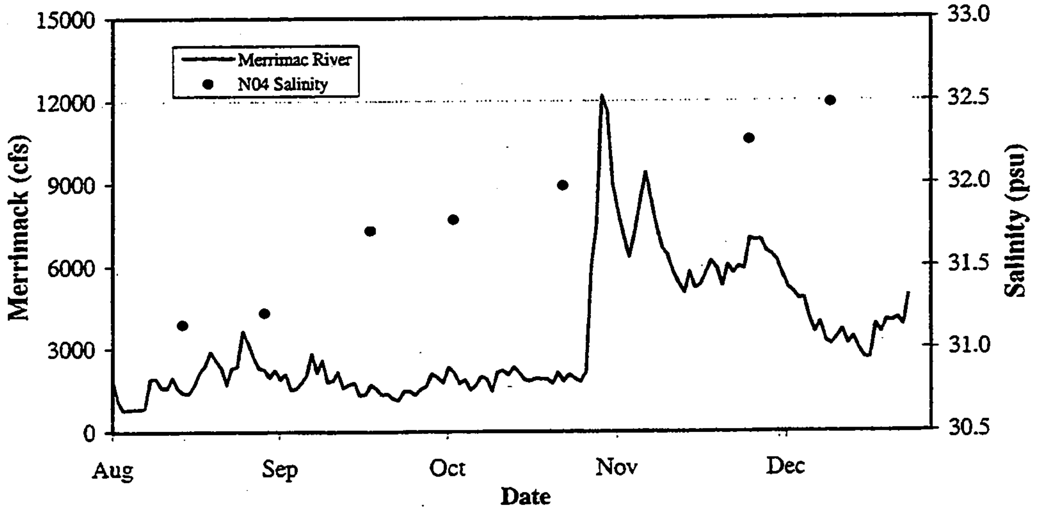


FIGURE 4-4

Surface Water Contour Plot of Salinity (PSU) in Late August (W9711)

Merrimac River Plume



Charles River Plume

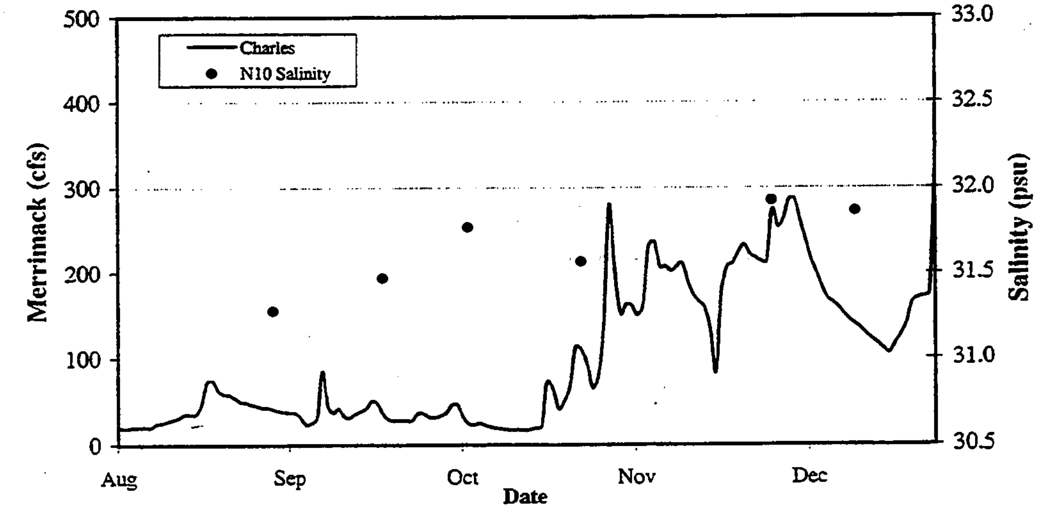
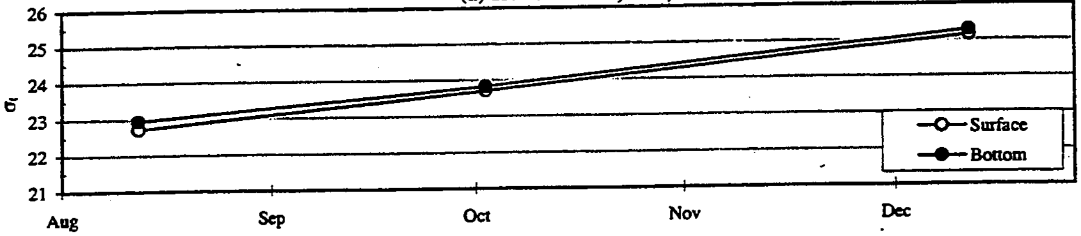


Figure 4-5

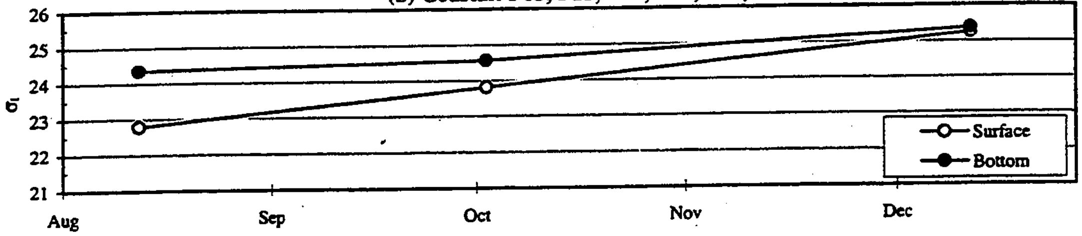
1997 Daily Precipitation (Logan International Airport) and River Discharge
Merrimack and Charles Rivers

F4_5riv.xls

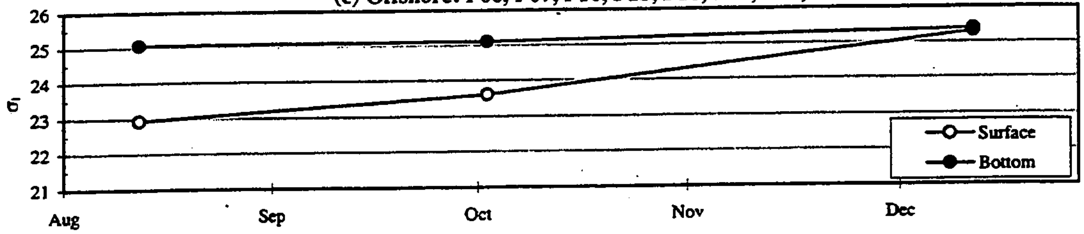
(a) Harbor: F23, F30, F31



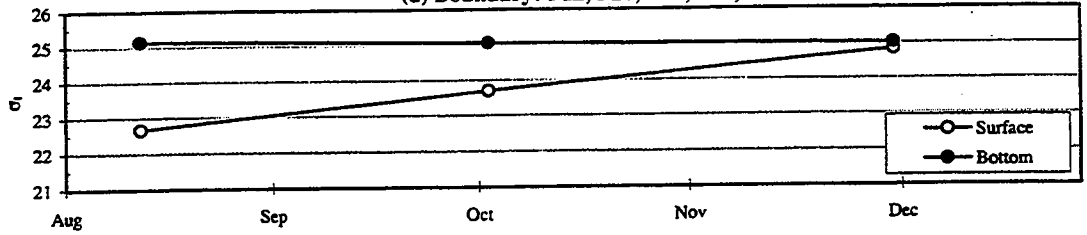
(b) Coastal: F05, F13, F14, F18, F24, F25



(c) Offshore: F06, F07, F10, F15, F16, F17, F19, F22



(d) Boundary: F12, F26, F27, F28, F29



(e) Cape Cod Bay: F01, F02, F03

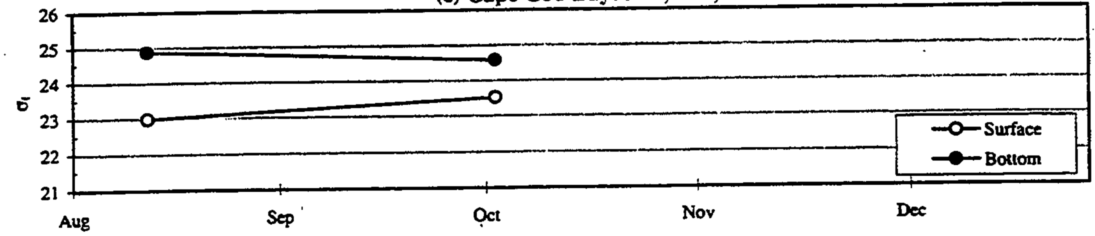
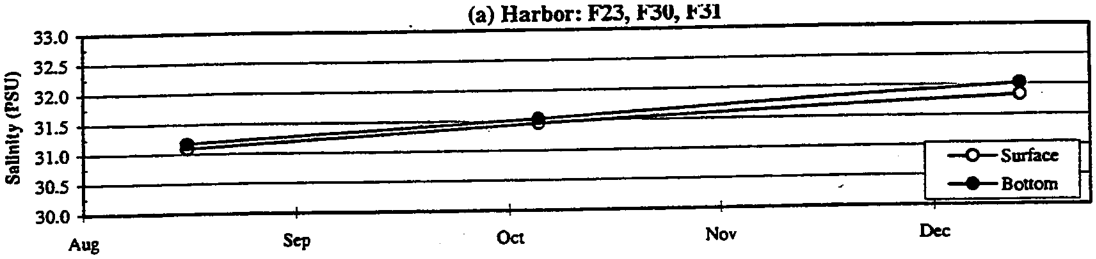


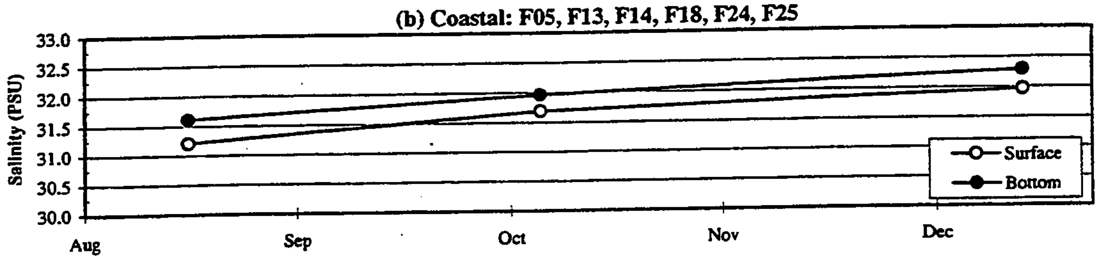
FIGURE 4-6

Times Series of Average Surface and Bottom Water Density (σ_t) in the Farfield F4-6sig.XLS

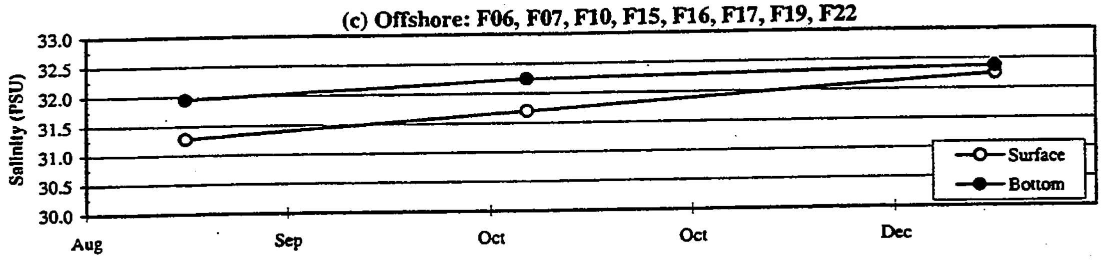
(a) Harbor: F23, F30, F31



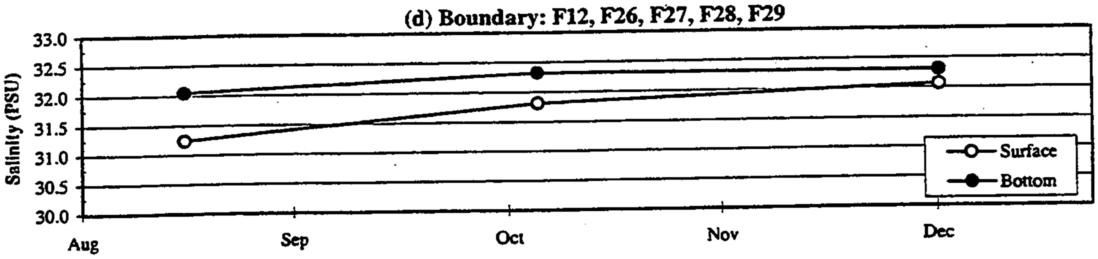
(b) Coastal: F05, F13, F14, F18, F24, F25



(c) Offshore: F06, F07, F10, F15, F16, F17, F19, F22



(d) Boundary: F12, F26, F27, F28, F29



(e) Cape Cod Bay: F01, F02, F03

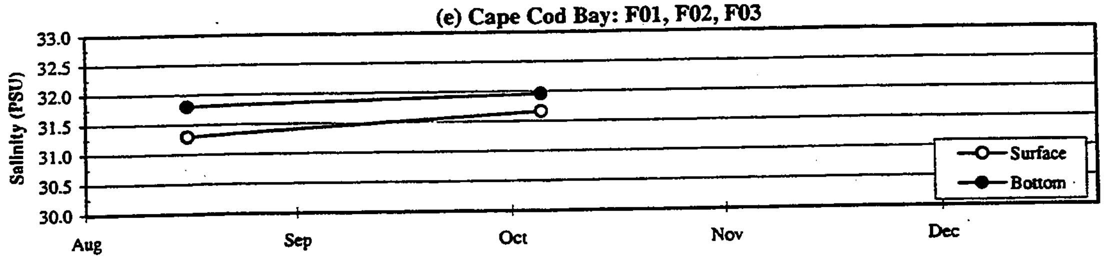
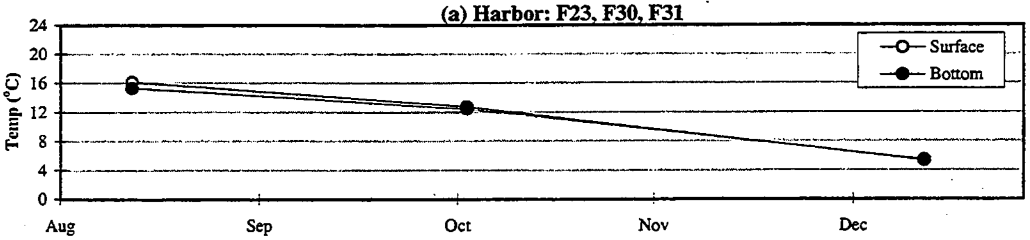
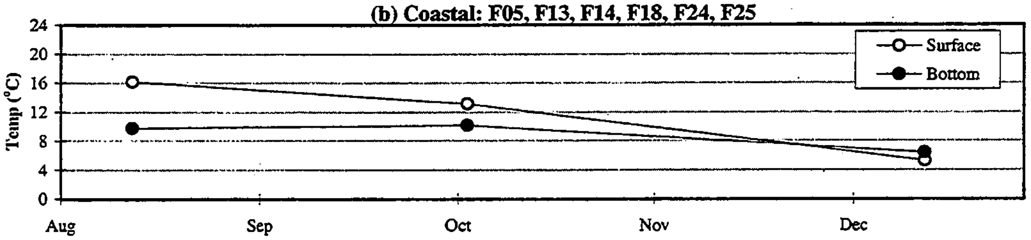
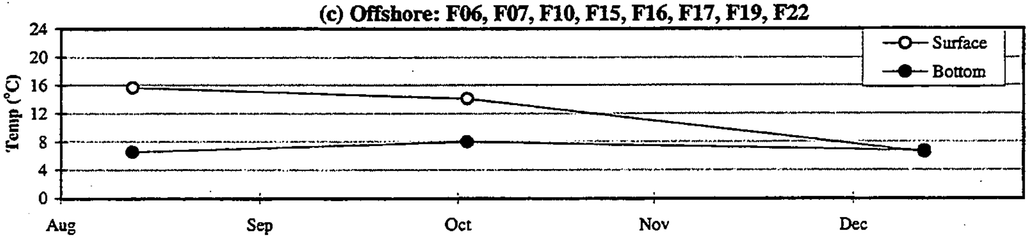


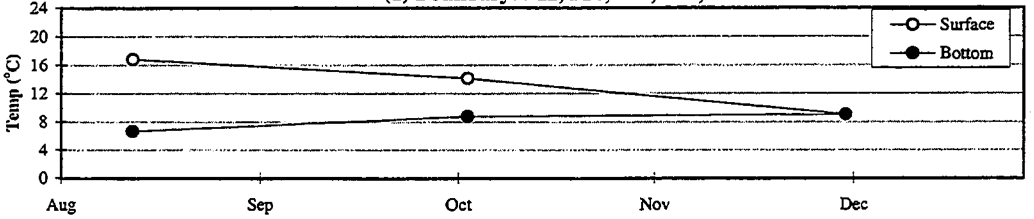
FIGURE 4-7
Time-Series of Average Surface and Bottom Water Salinity (PSU) in the Farfield

F4-7sal.XLS


(a) Harbor: F23, F30, F31


(b) Coastal: F05, F13, F14, F18, F24, F25


(c) Offshore: F06, F07, F10, F15, F16, F17, F19, F22


(d) Boundary: F12, F26, F27, F28, F29

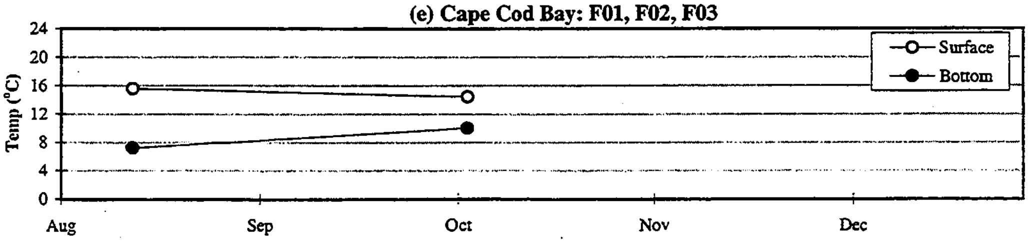
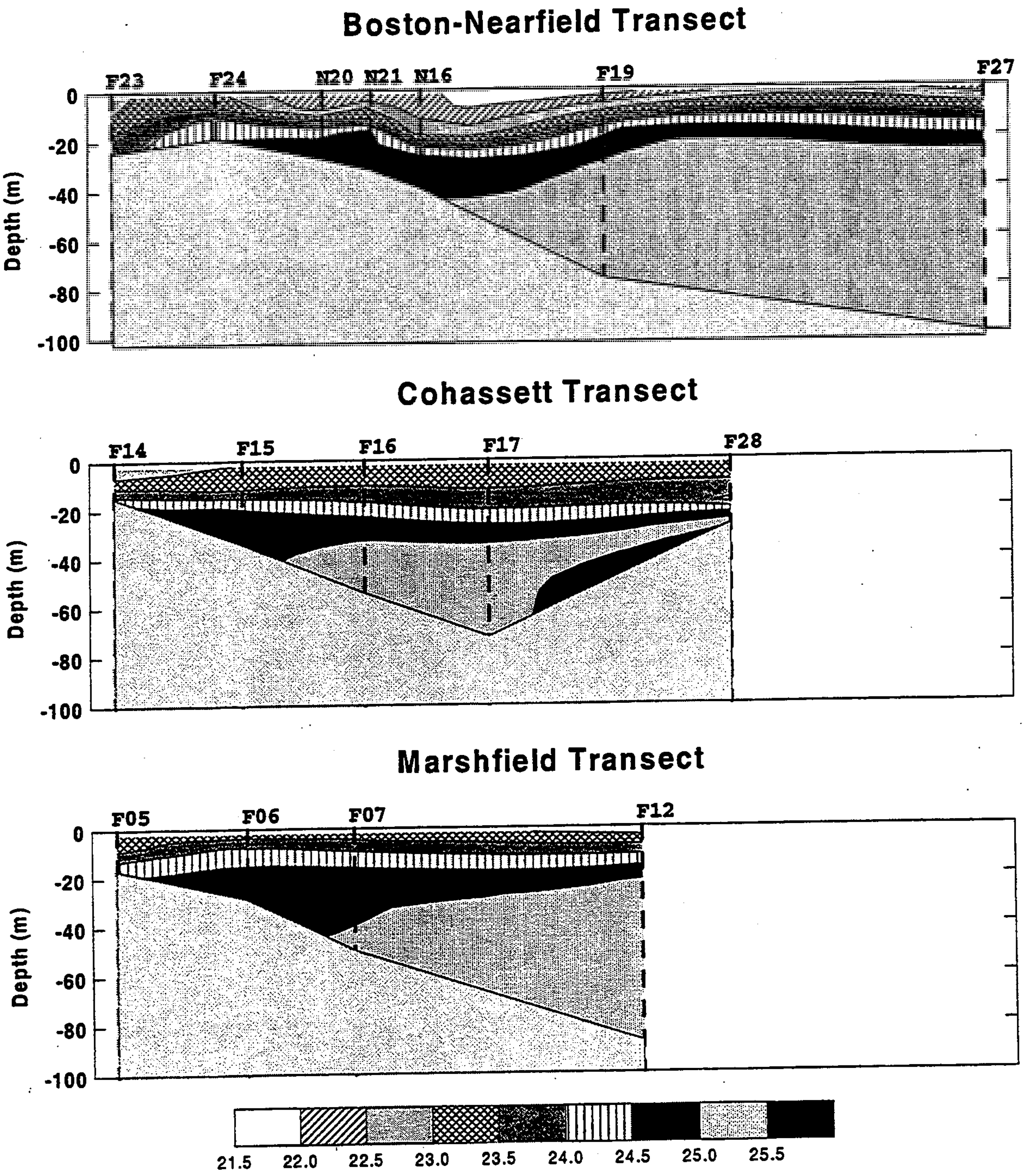

(e) Cape Cod Bay: F01, F02, F03

FIGURE 4-8

Time-Series of Average Surface and Bottom Water Temperature (°C) in the Farfield F4-8temp.xls


Boston-Nearfield Transect

Cohassett Transect

Marshfield Transect

FIGURE 4-9

Density (σ_T) Contours Along Three Farfield Transects in Late August (W9711)

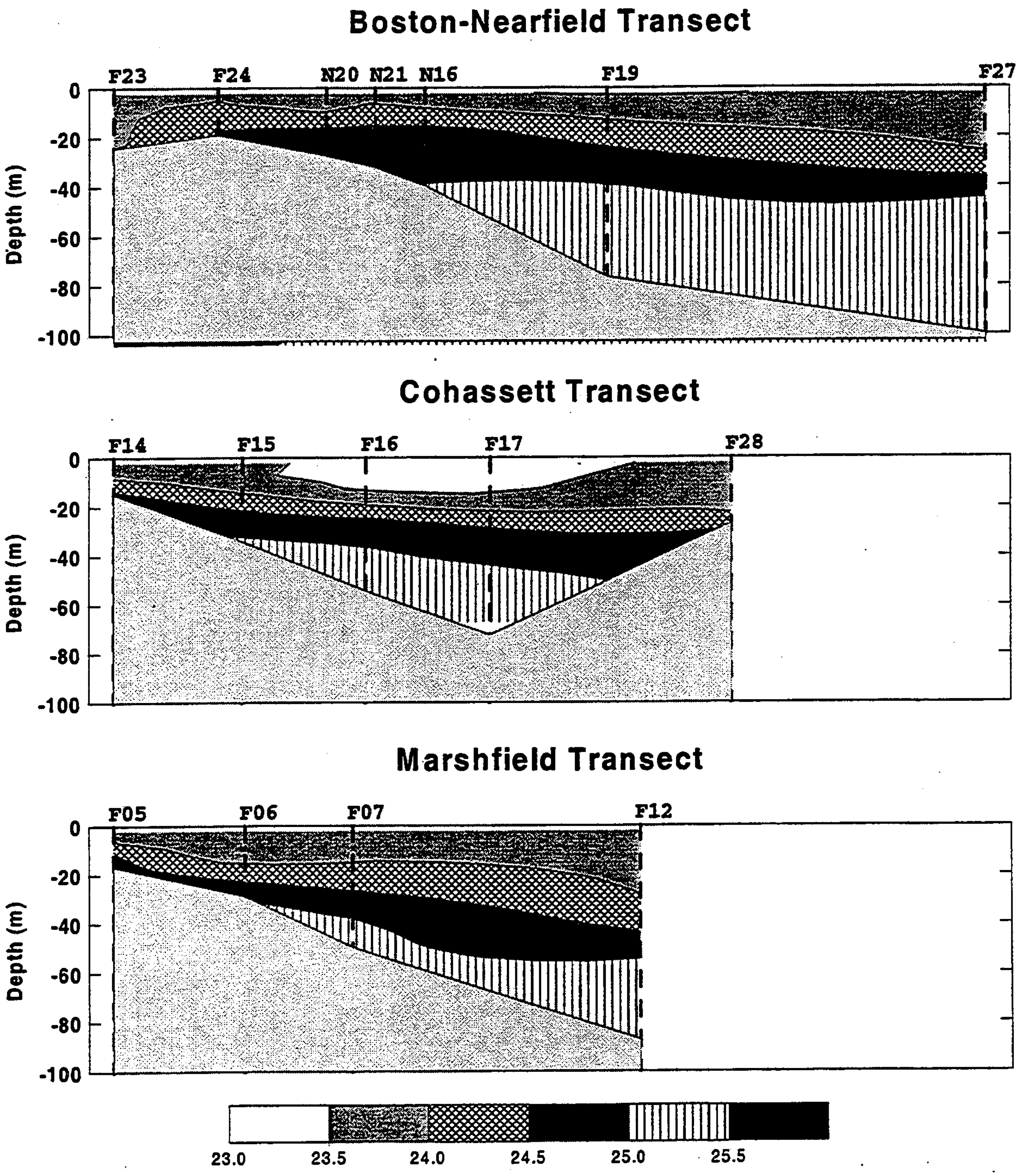
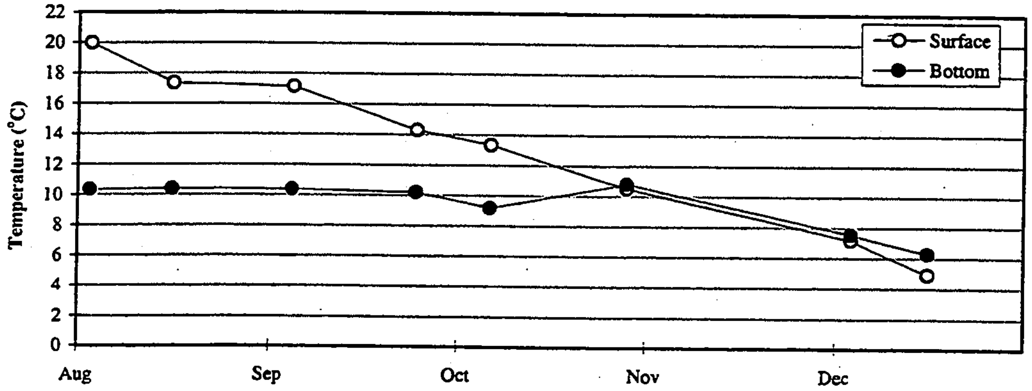


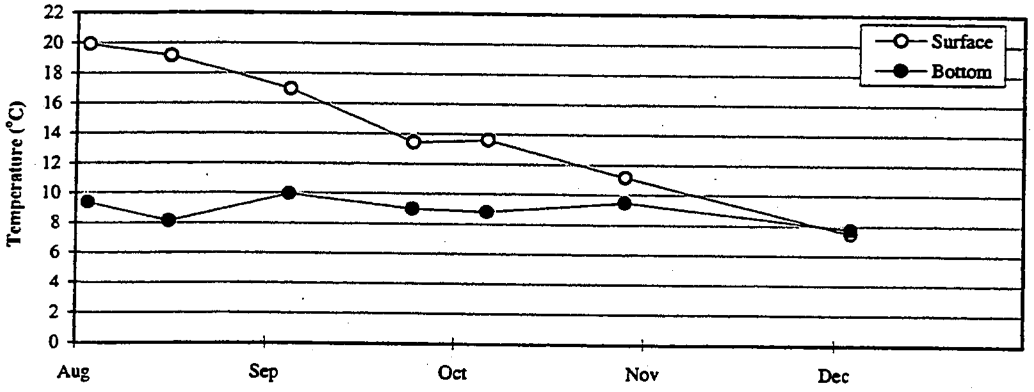
FIGURE 4-10

Density (σ_T) Contours Along Three Farfield Transects in Early October (W9714)

(a) Inner Nearfield: N10, N11



(b) Broad Sound: N01



(c) Outer Nearfield: N04, N07, N16, N20

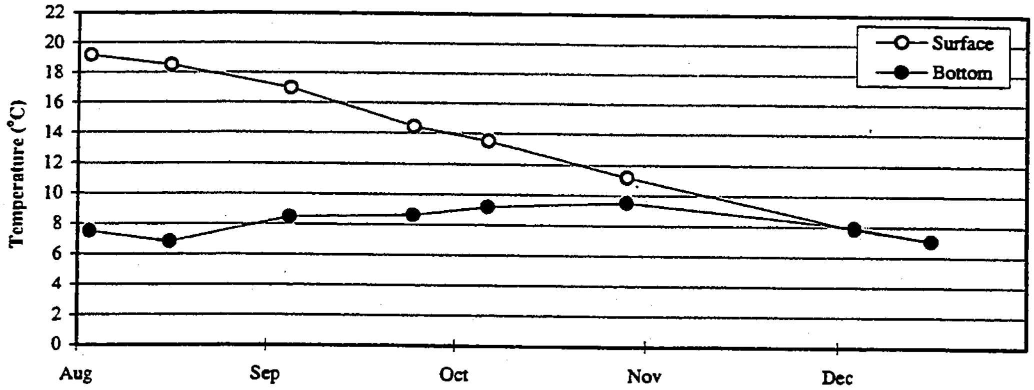
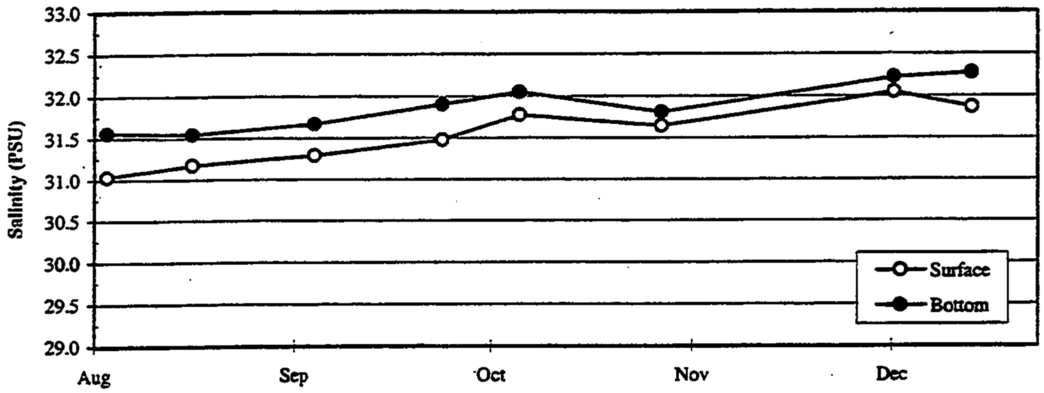


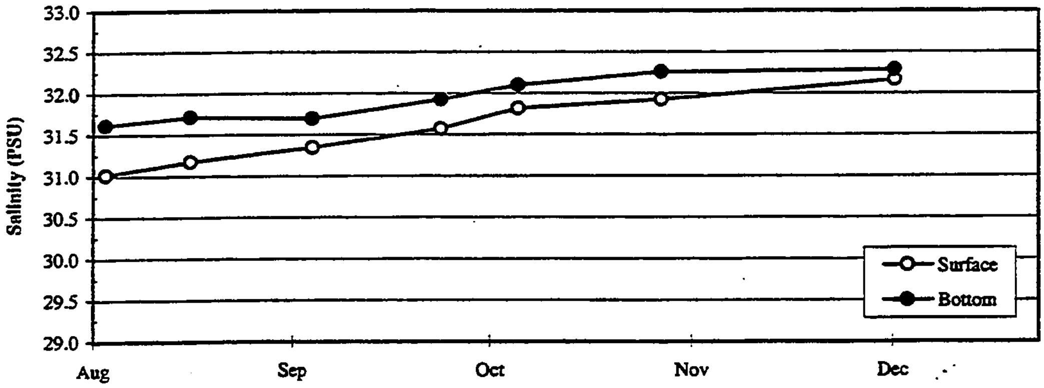
FIGURE 4-11
Time-Series of Average Surface and Bottom Water Temperature in the Nearfield

F4-11temp.XLS

(a) Inner Nearfield: N10, N11



(b) Broad Sound: N01



(c) Outer Nearfield: N04, N07, N16, N20

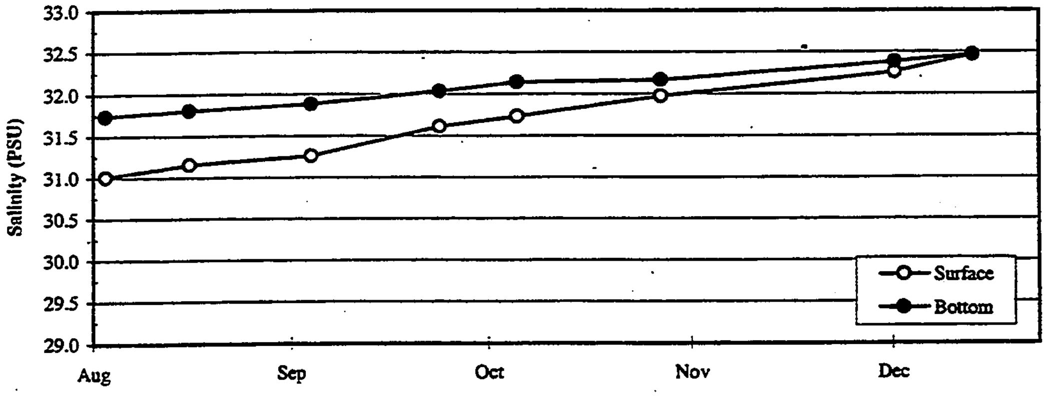
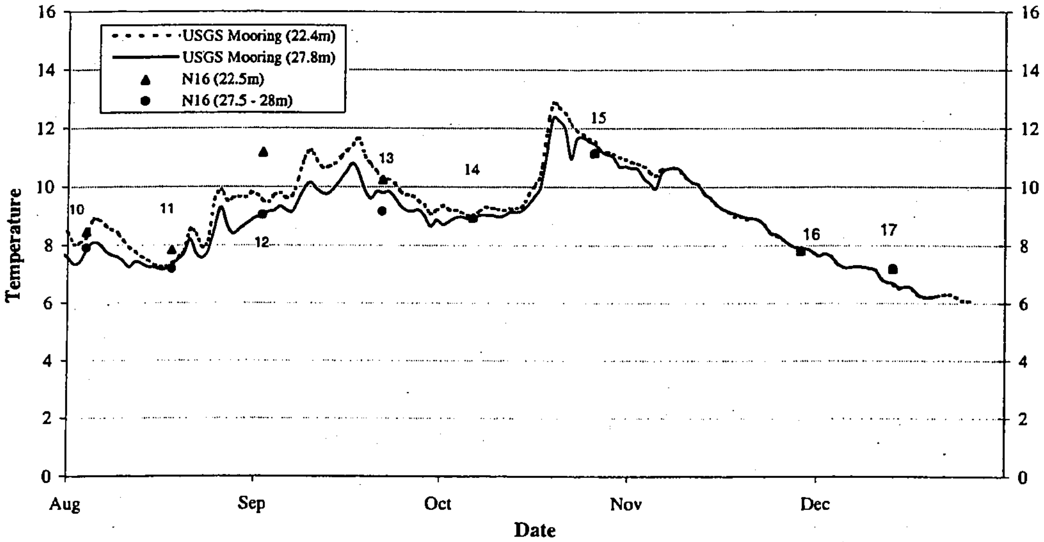


FIGURE 4-12

Time-Series of Average Surface and Bottom Waters Salinity (PSU) in the Nearfield

(a) Temperature



(b) Salinity

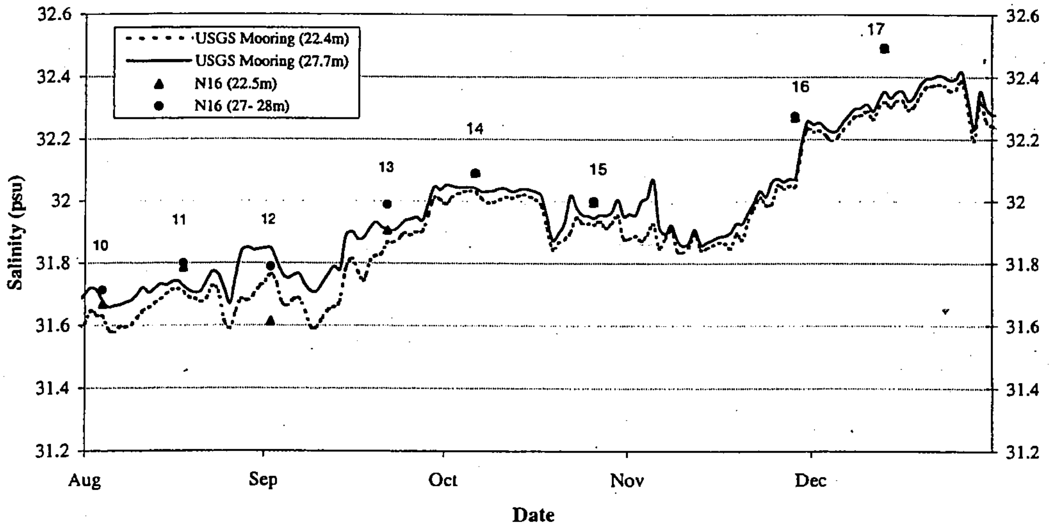
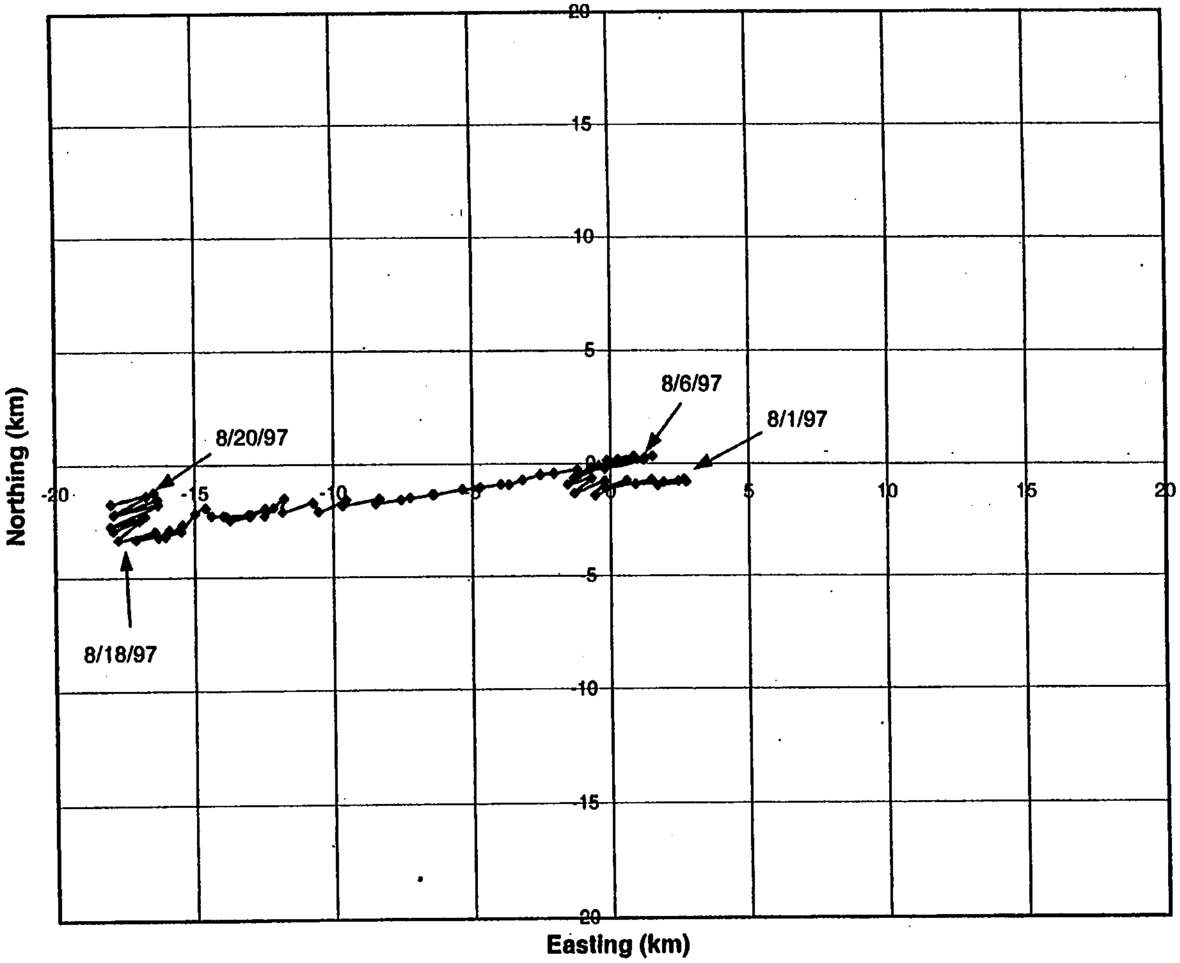


FIGURE 4-13
Moored Temperature and Salinity Sensor Data: August - December, 1997



Note: The origin (0,0) is located at 42° 22.6' N latitude, 70° 47.0' W longitude.

FIGURE 4-14
Progressive Vector Plot: August 1997
Depth = 29.2 meters (Bottom)

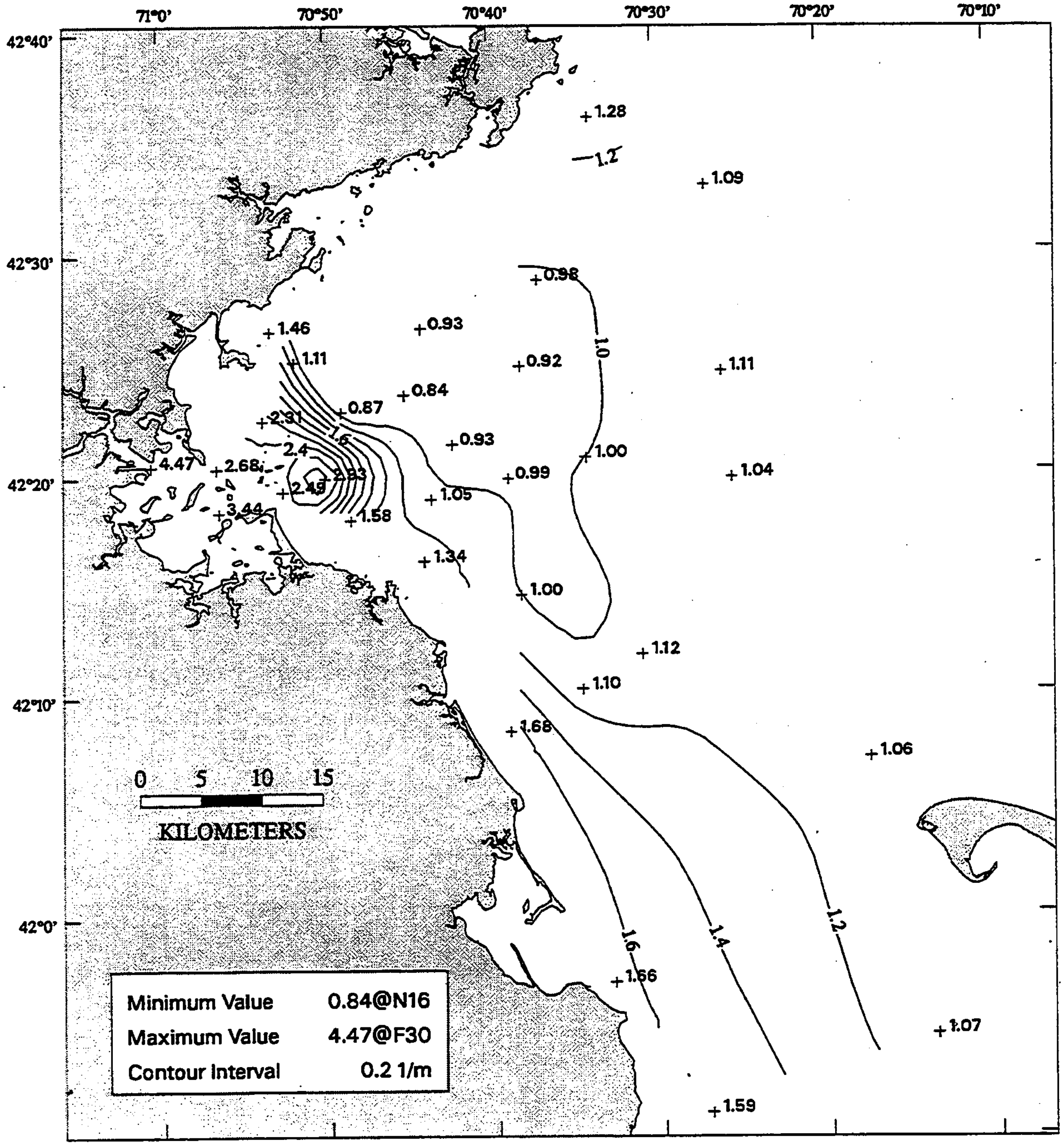


FIGURE 4-15
Surface Water Contour Plot of Beam Attenuation (/m) in Late August (W9711)

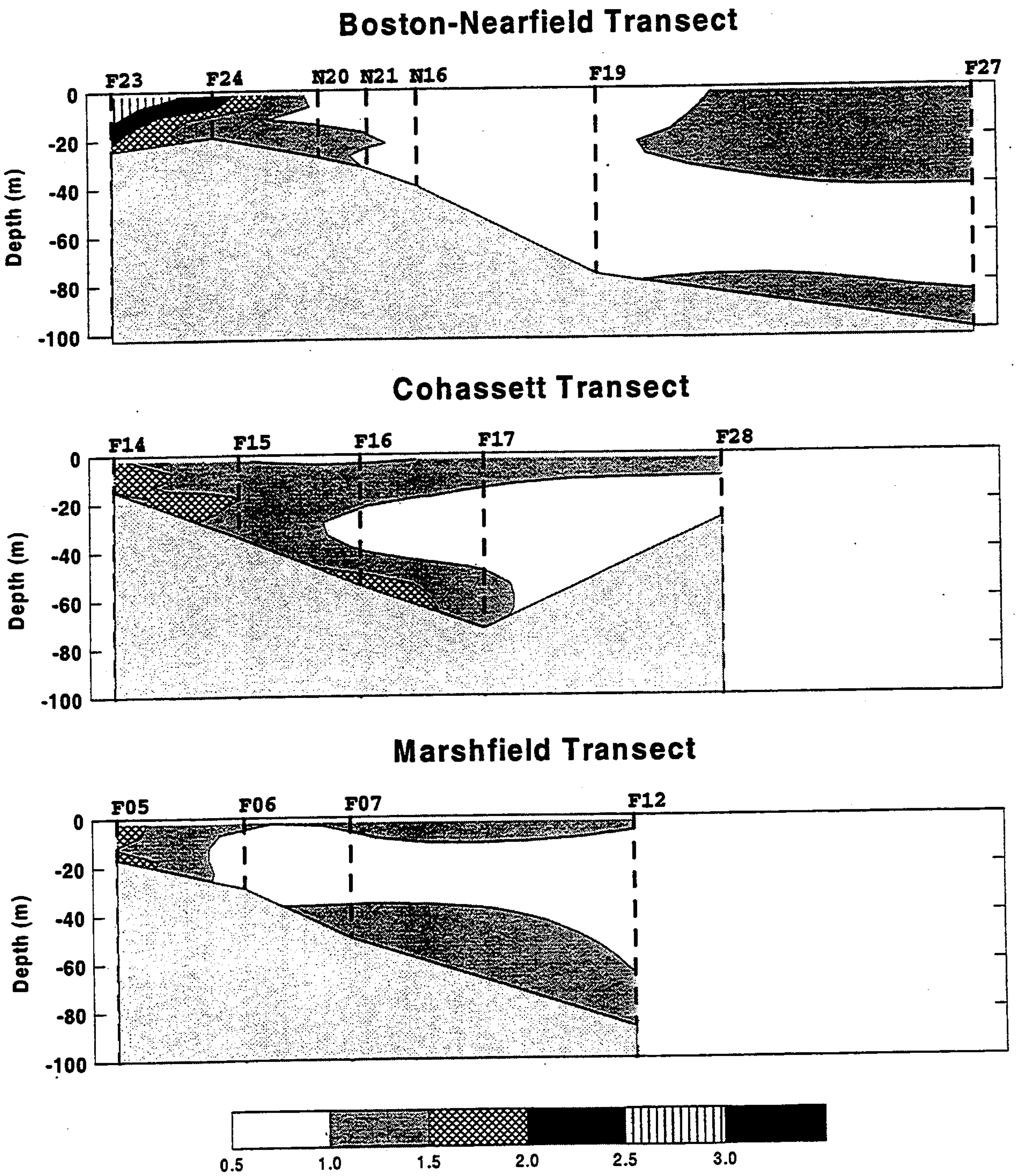


FIGURE 4-16
Beam Attenuation Contours Along Three Farfield Transects in Late August (W9711)

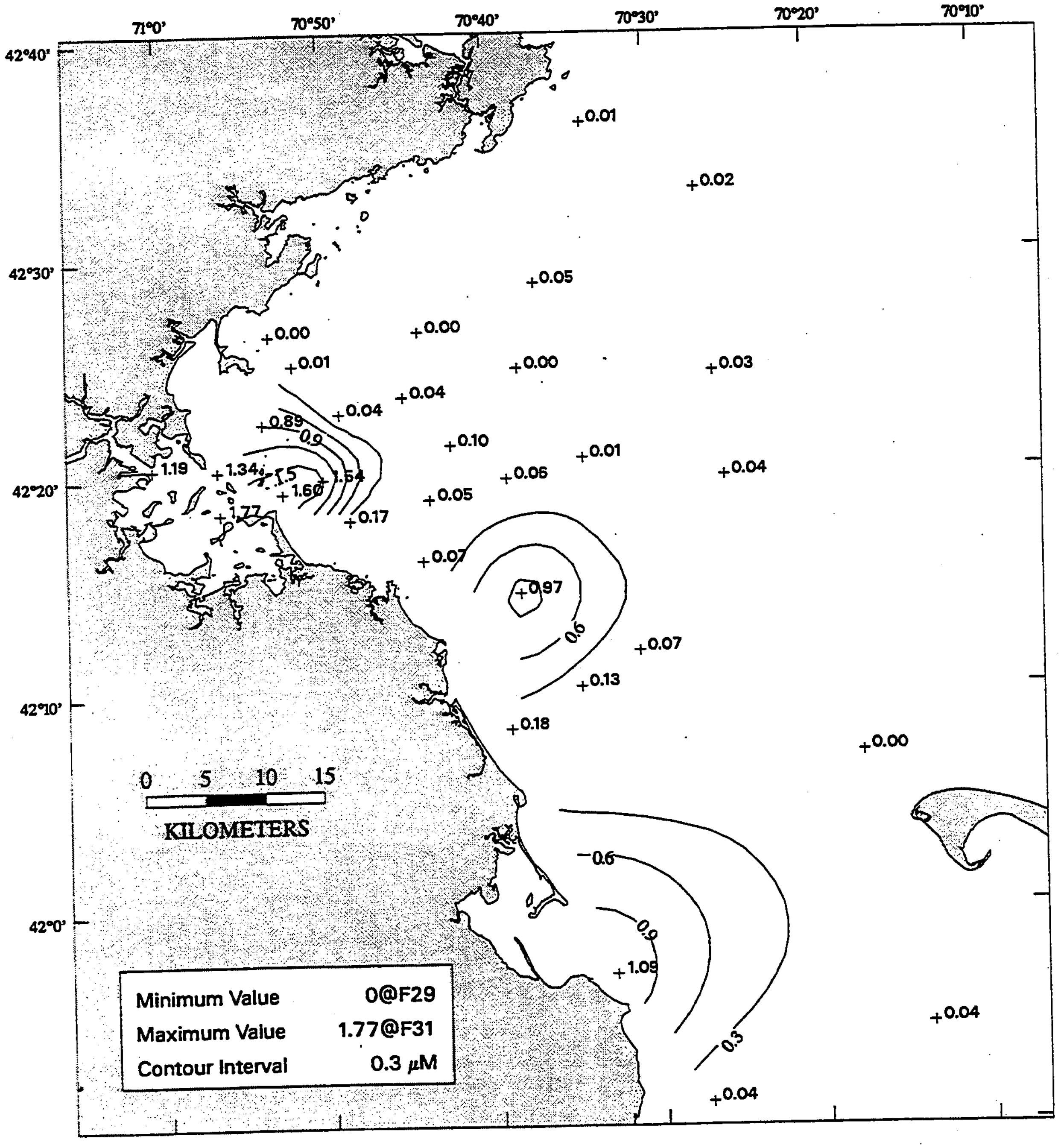


FIGURE 4-17
Surface Water Contour Plot of Nitrate (μM) in Late August (W9711)

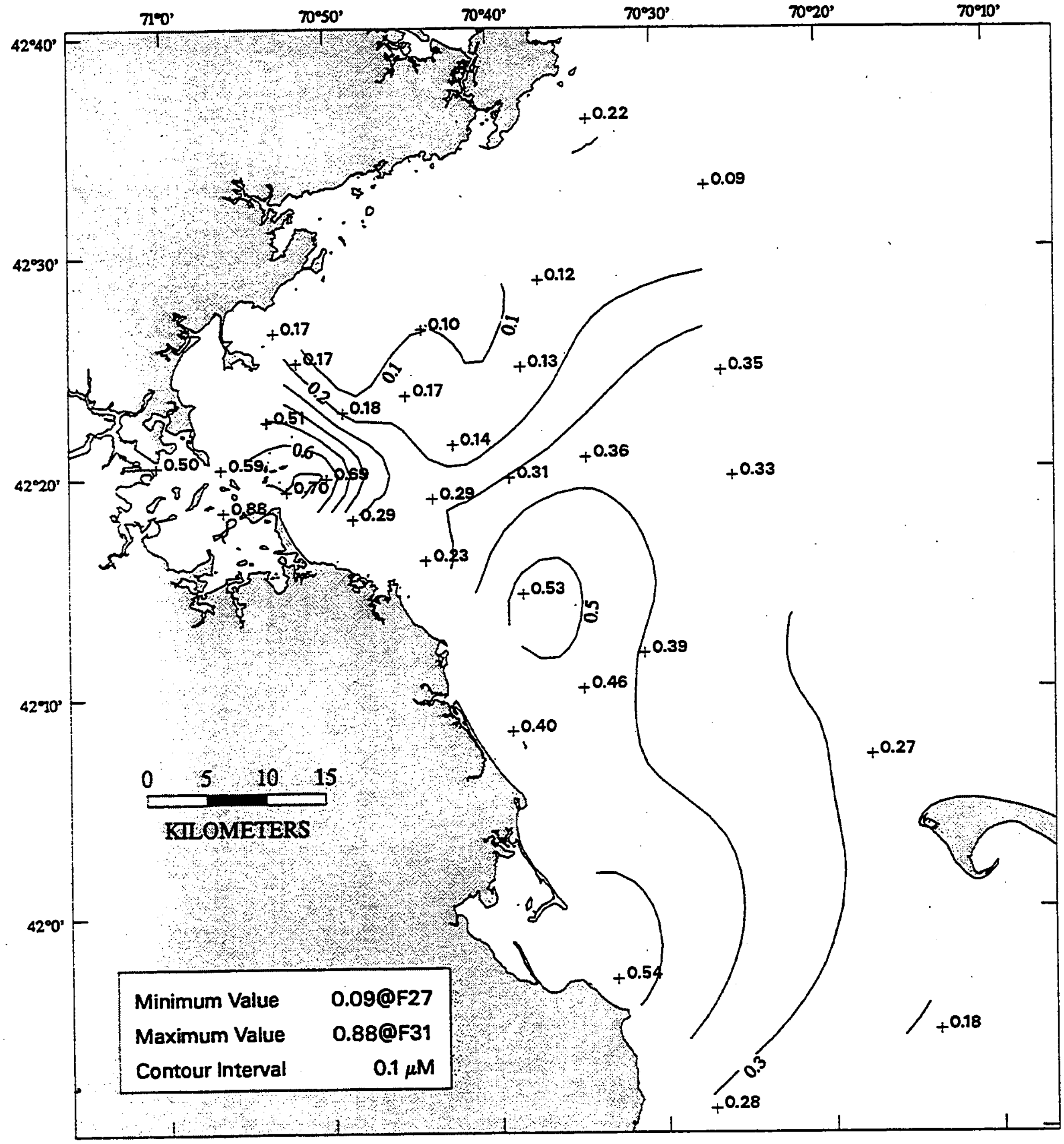


FIGURE 4-18
Surface Water Contour Plot of Phosphate (μM) in Late August (W9711)

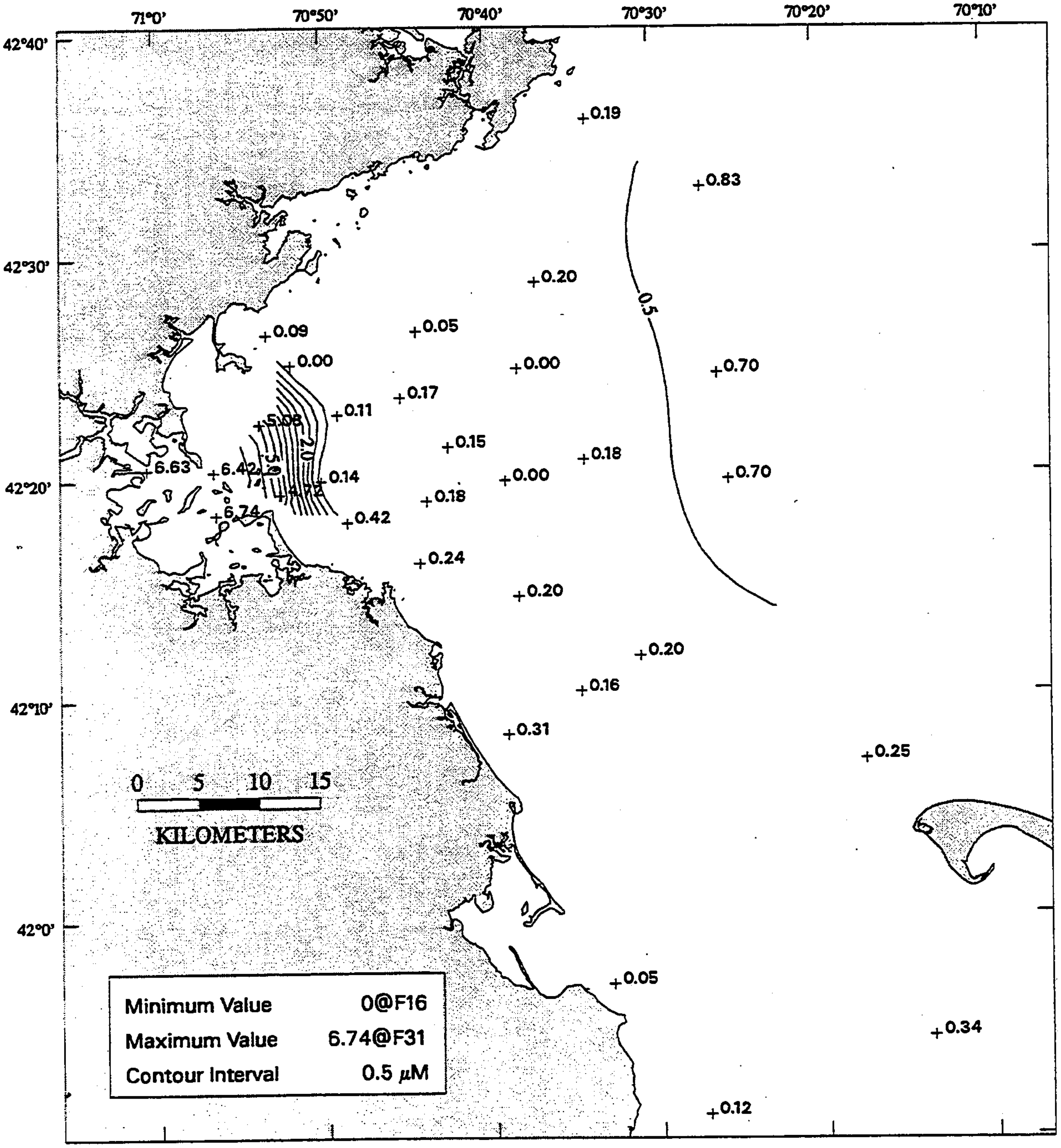


FIGURE 4-19

Surface Water Contour Plot of Nitrate (µM) in Early October (W9714)

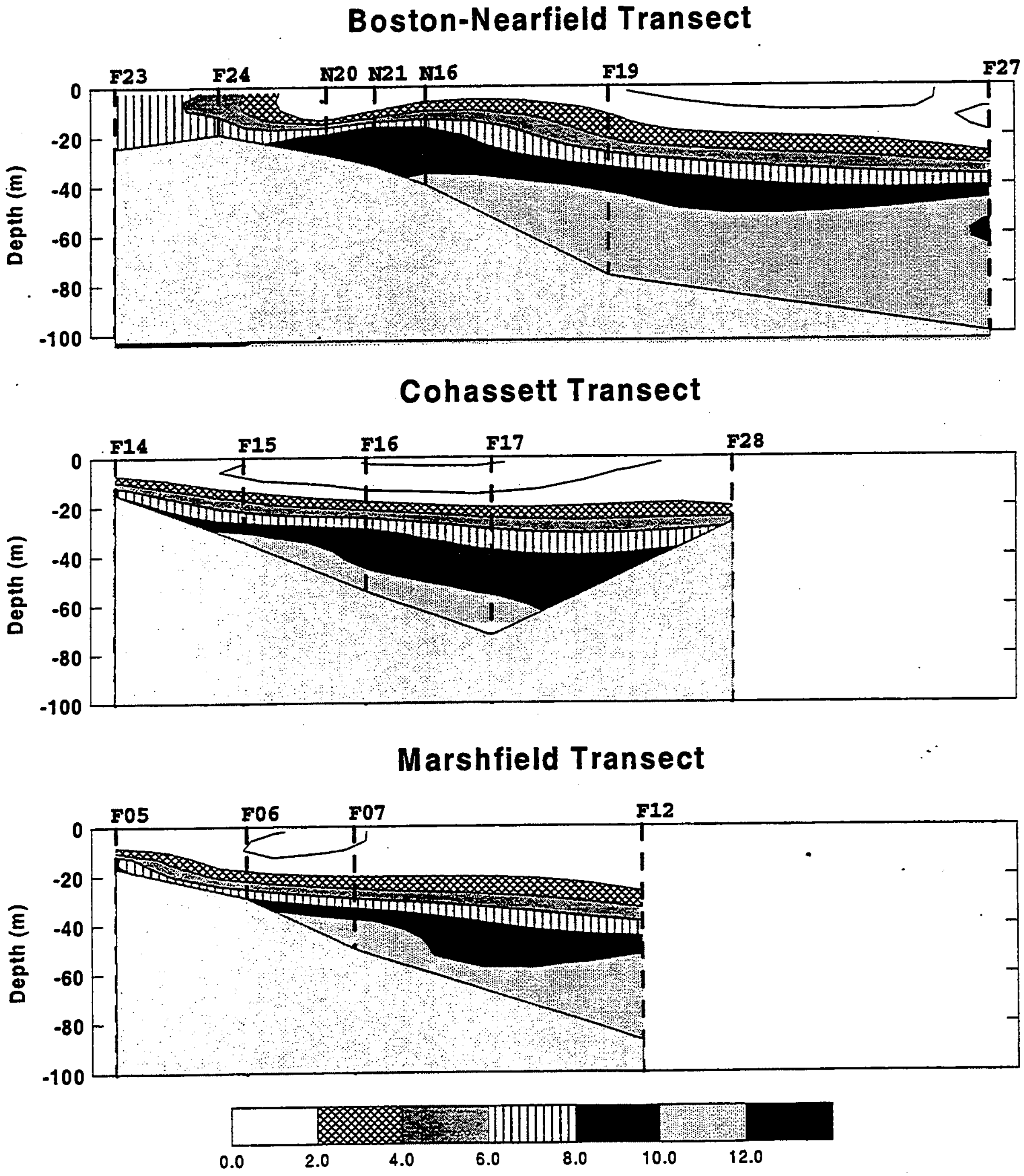
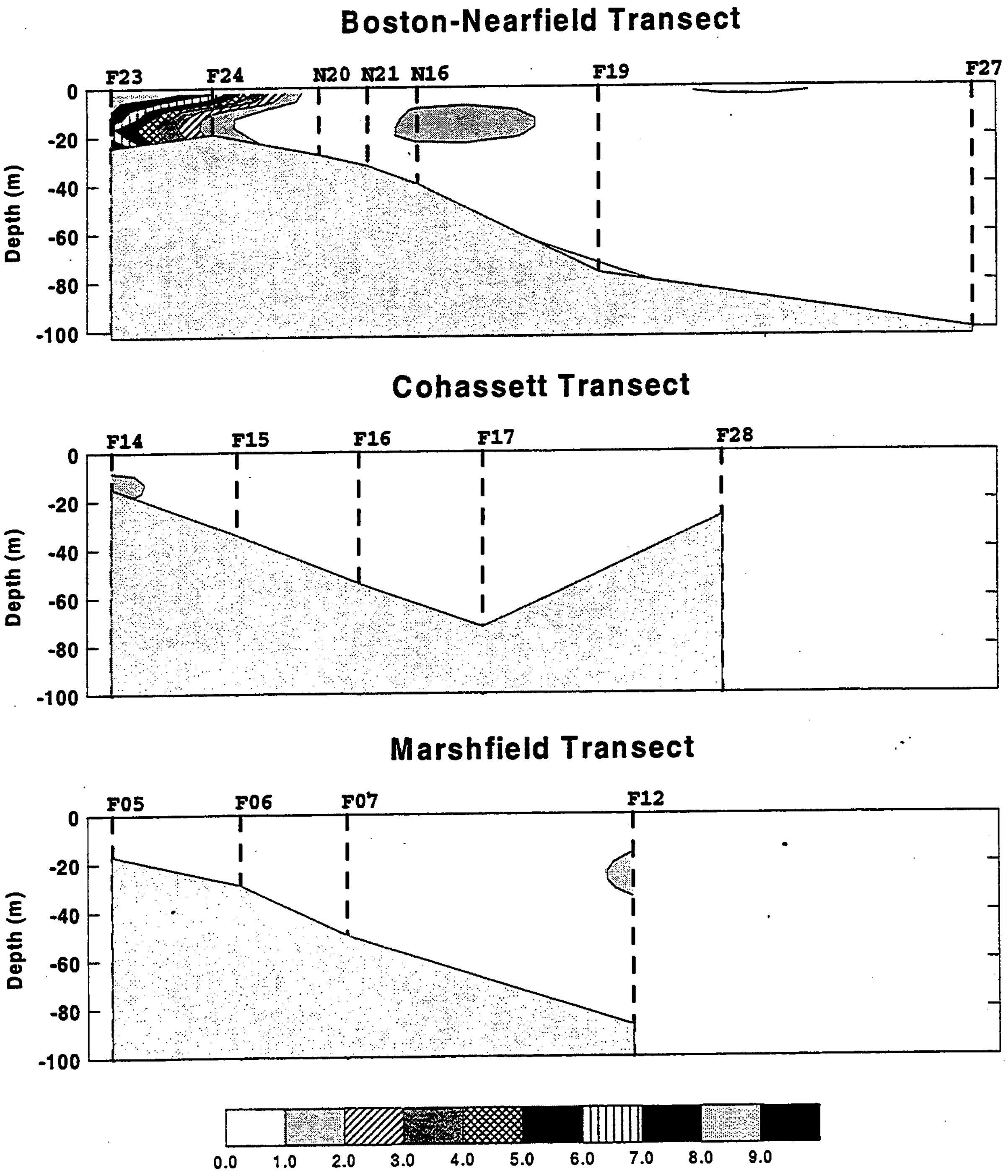


FIGURE 4-20
Nitrate + Nitrite (µM) Contours Along Three Farfield Transects in Early October (W9714)

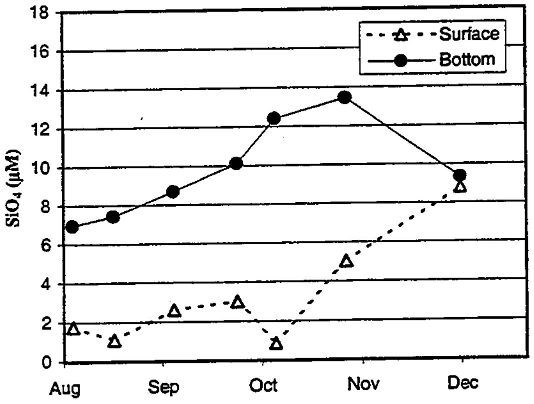


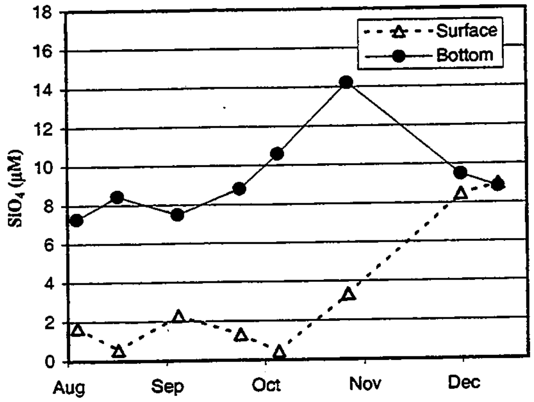
Boston-Nearfield Transect

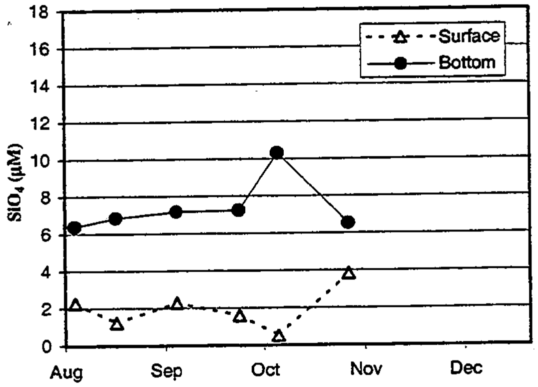
Cohassett Transect

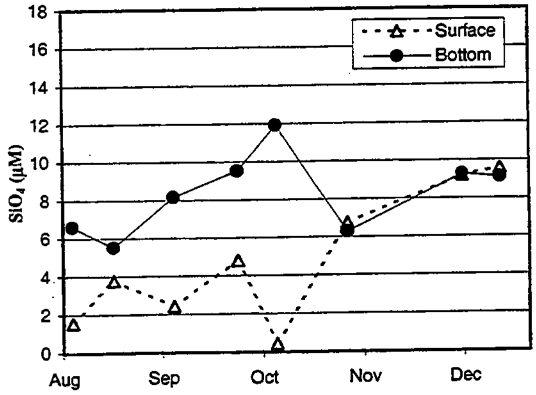
Marshfield Transect

FIGURE 4-21
Ammonium Contours Along Three Farfield Transects in Early October (W9714)


(a) Station N01


(b) Station N04


(c) Station N21


(d) Station N10

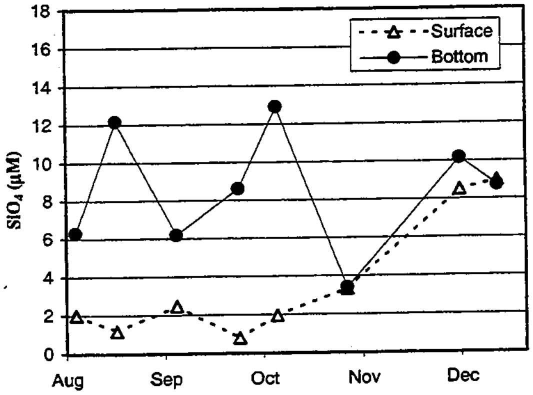

(e) Station N07

FIGURE 4-22
Time-Series of Surface and Bottom Water Silicate Concentrations at Five Nearfield Stations F4_22SiO4.xls

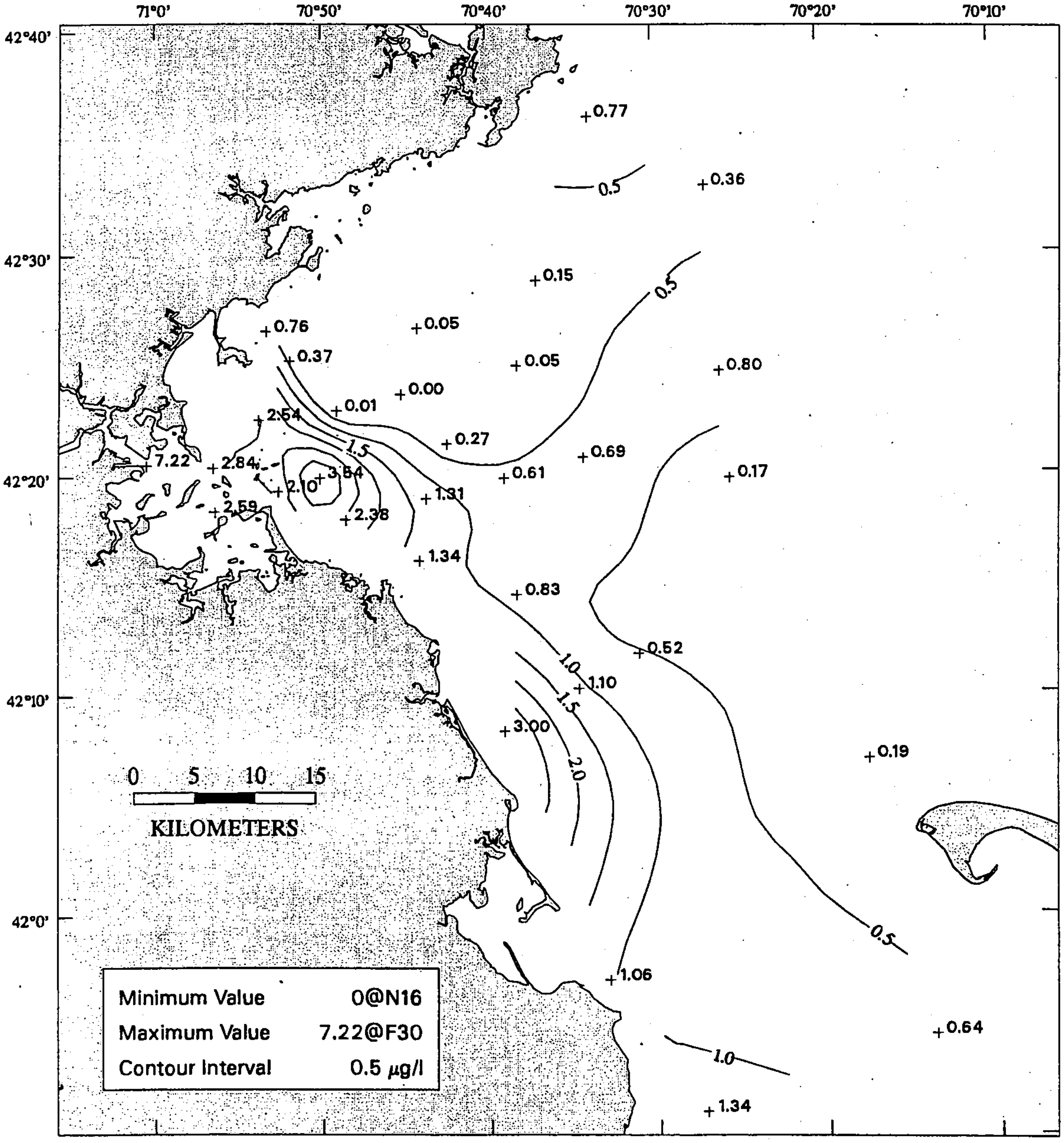


FIGURE 4-23
Surface Water Contour Plot of Chlorophyll *a* (µg/L) in Late August (W9711)

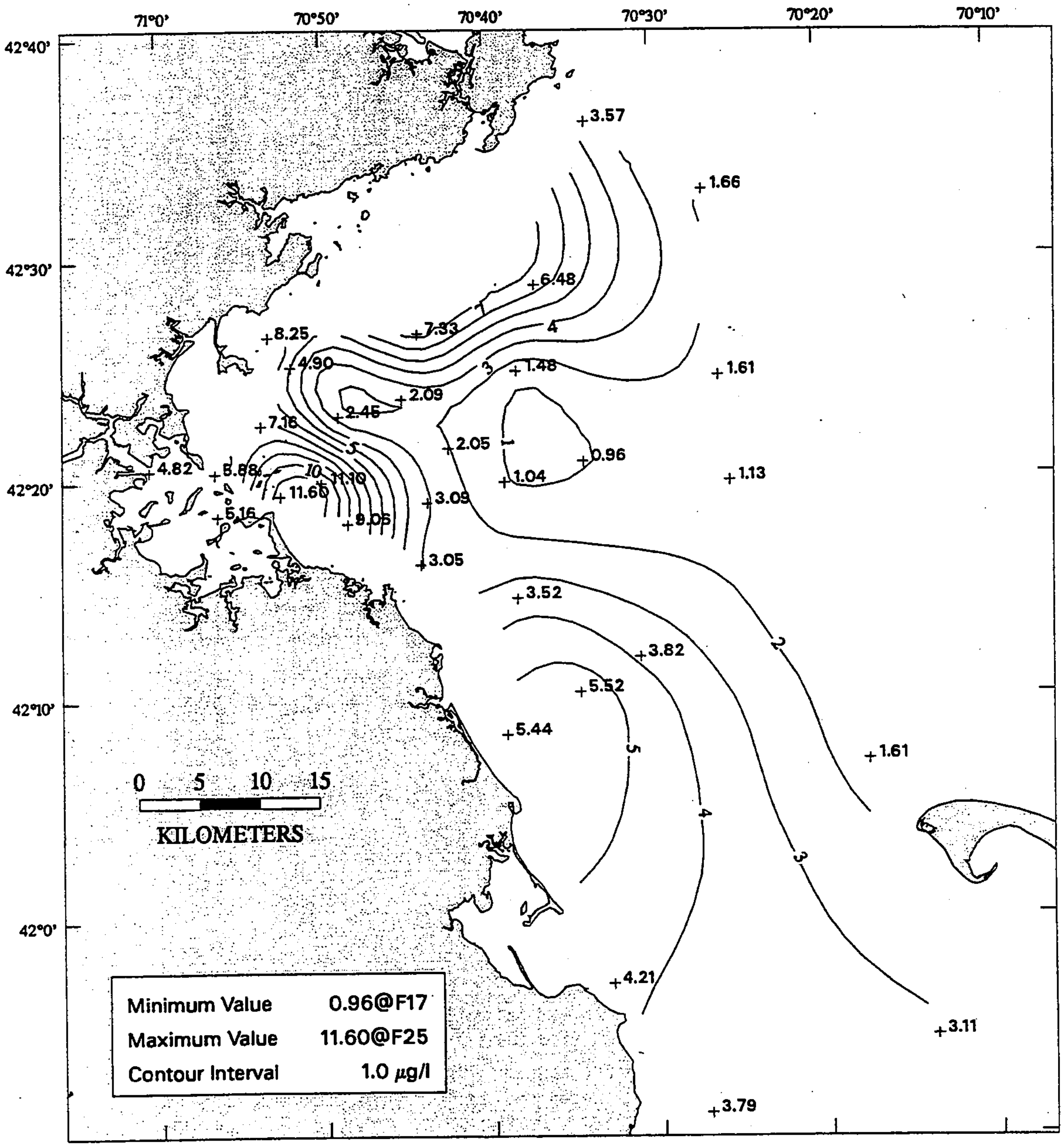


FIGURE 4-24

Surface Water Contour Plot of Chlorophyll *a* (µg/L) in Early October (W9714)

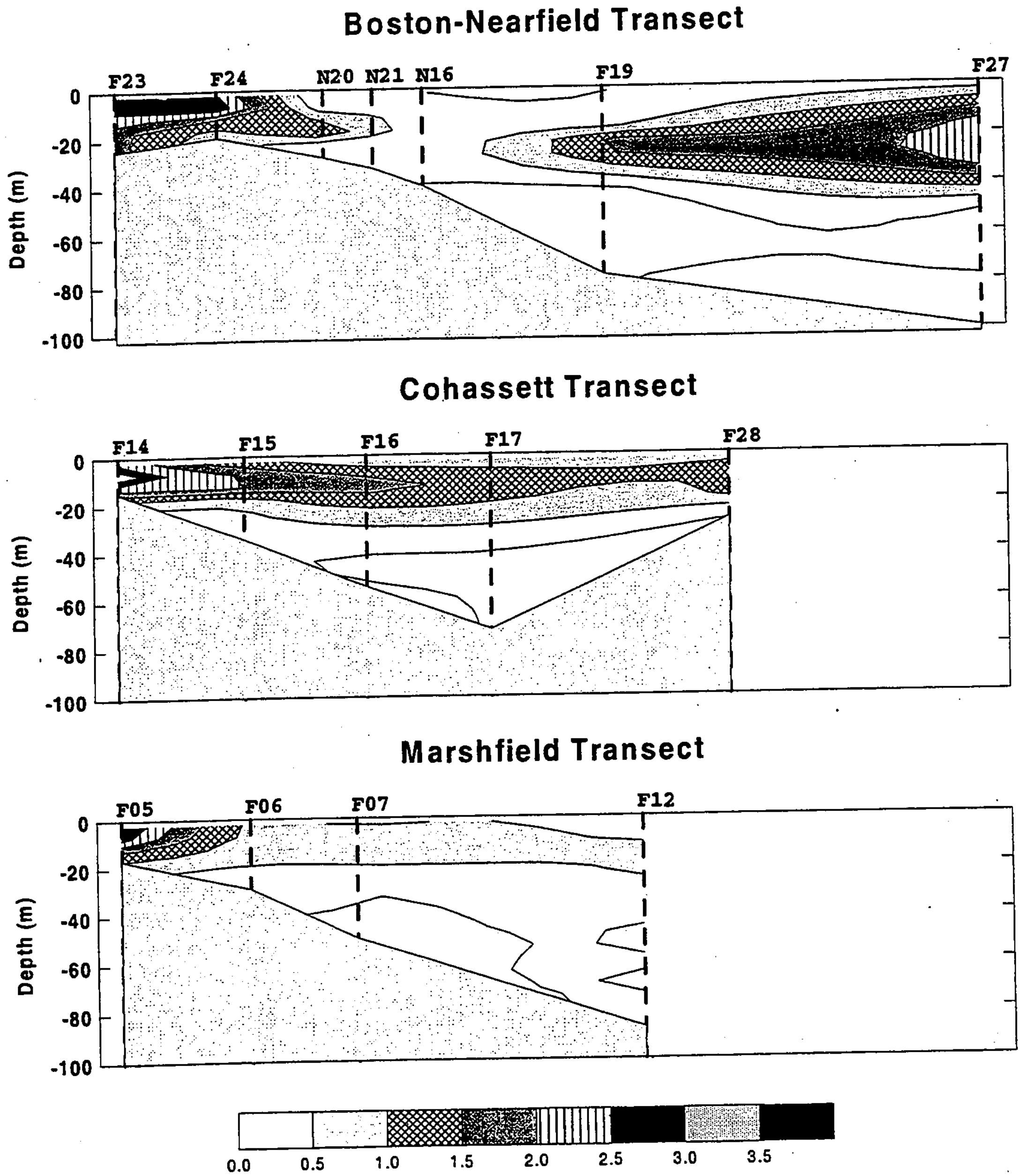


FIGURE 4-25
Chlorophyll *a* (µg/L) Contours Along Three Farfield Transects in Late August (W9711)

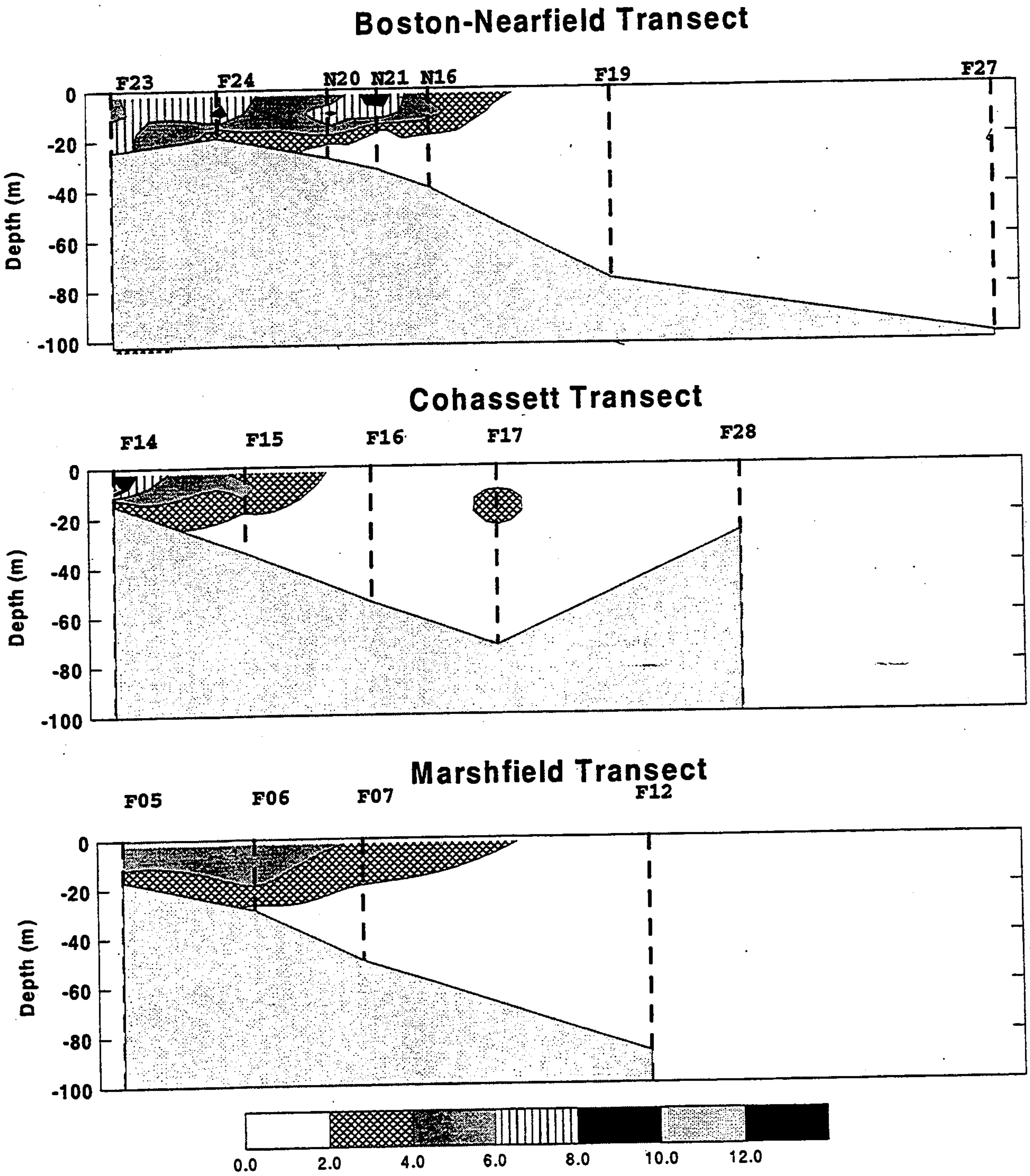
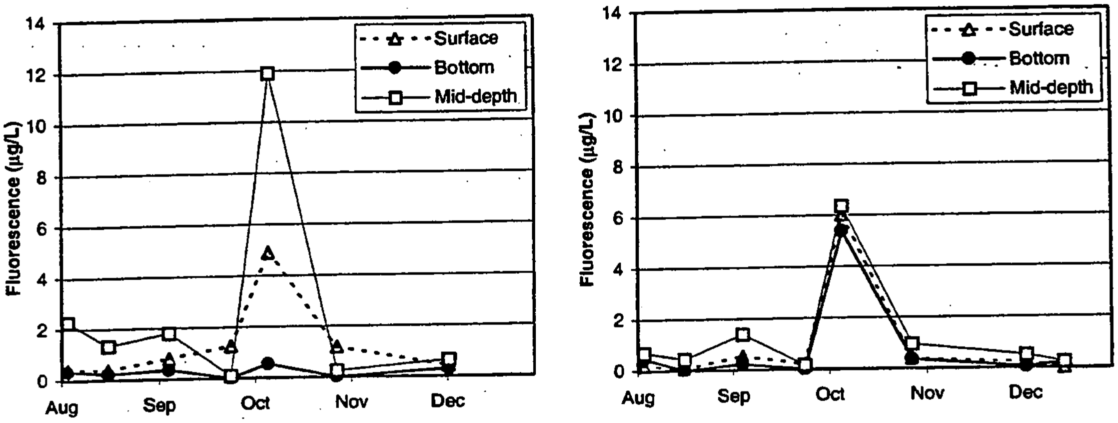


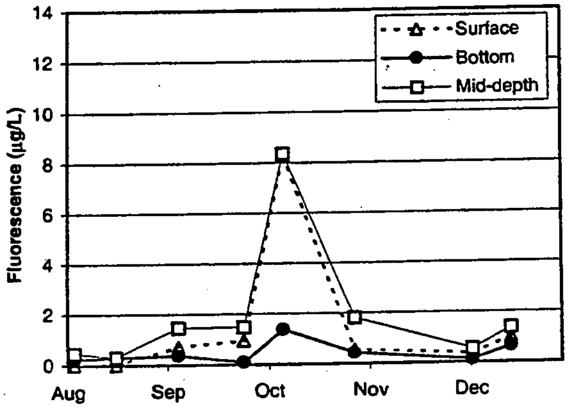
FIGURE 4-26

Chlorophyll *a* (µg/L) Contours Along Three Farfield Transects in Early October (W9714)

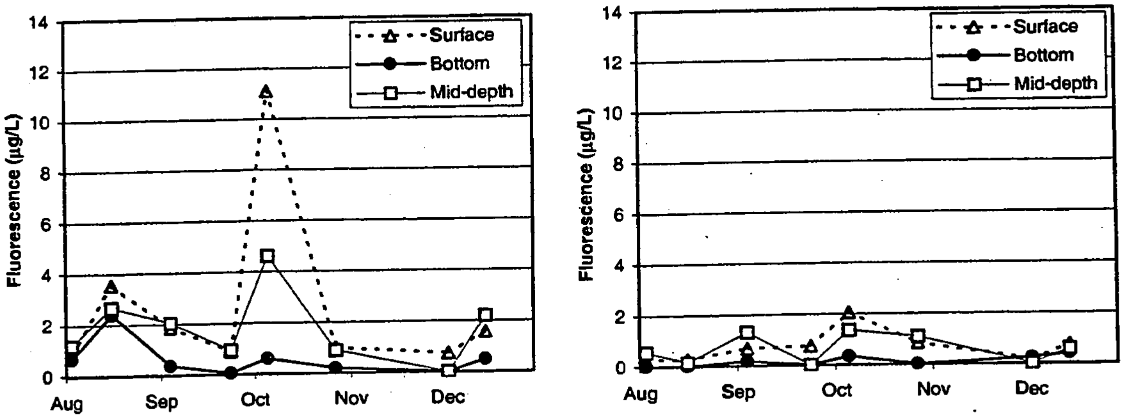


(a) Station N01

(b) Station N04



(c) Station N18



(d) Station N10

(e) Station N07

FIGURE 4-27
Time-Series of Surface and Bottom Water Chlorophyll *a* Concentrations at Five Nearfield Stations F4-27fluor.xls

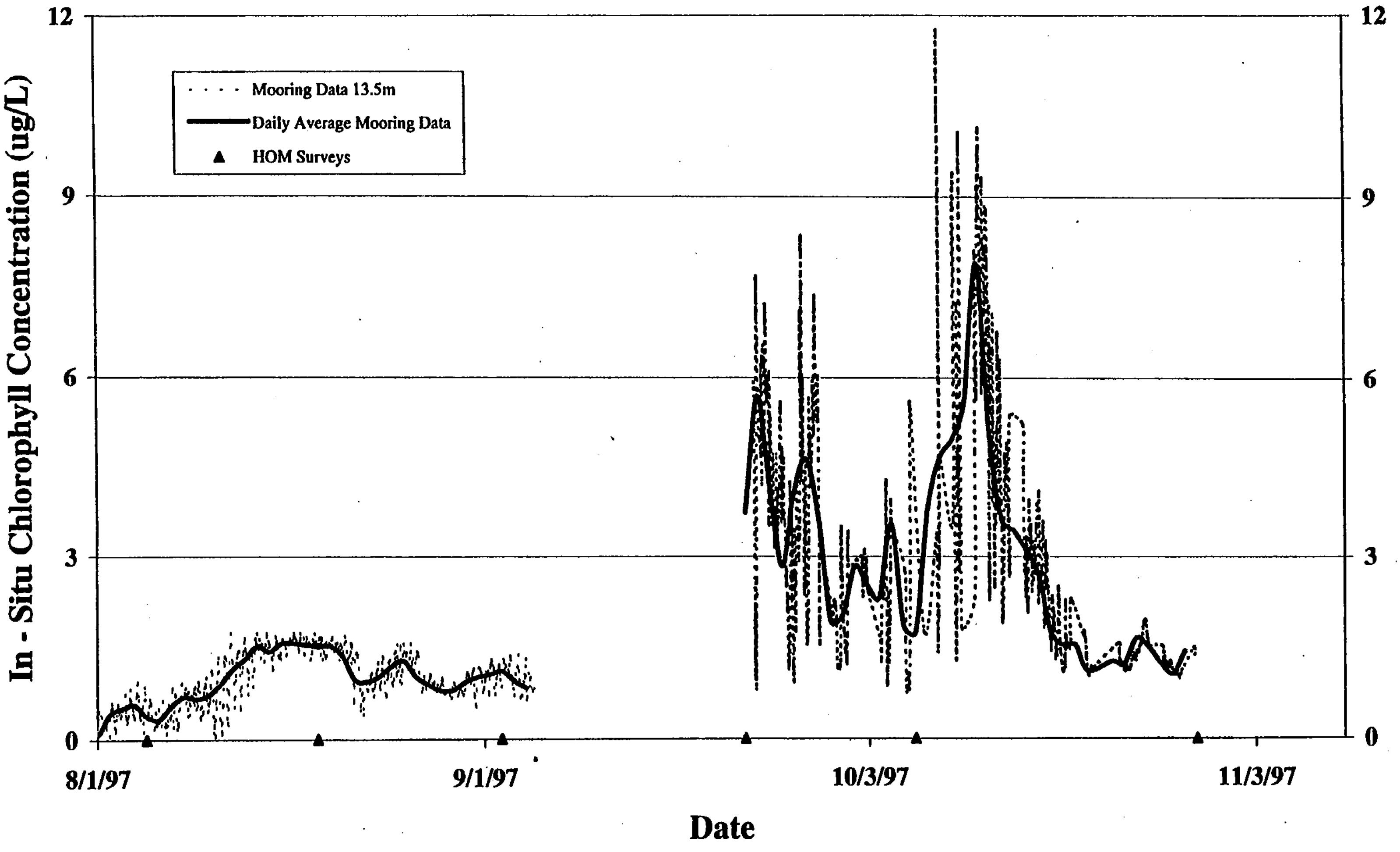
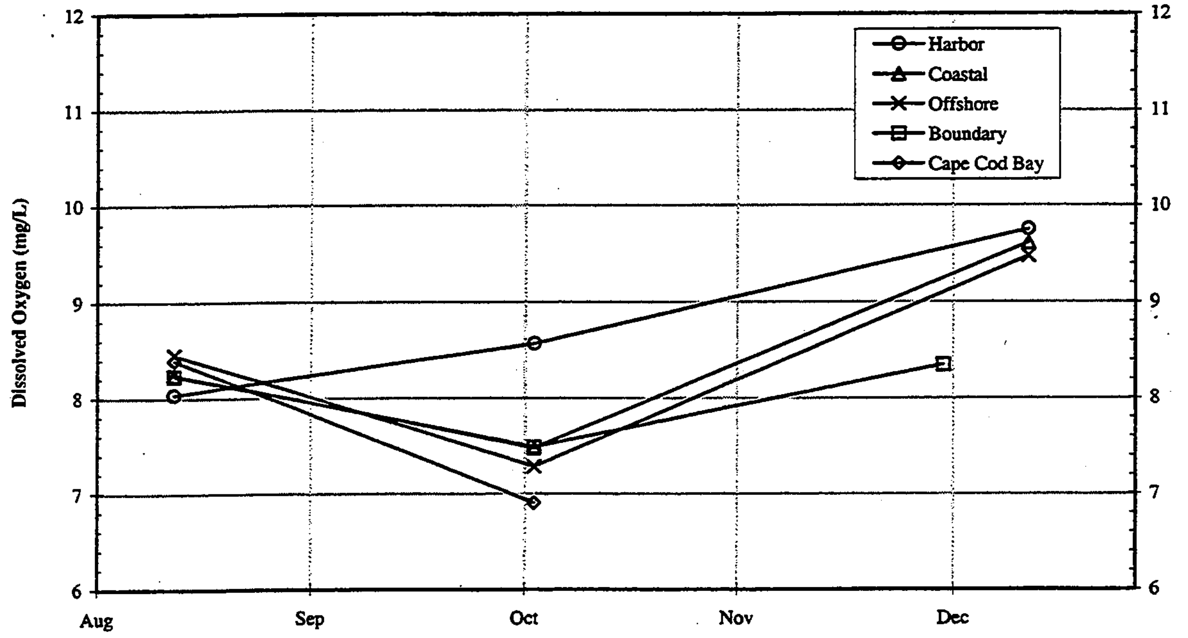


FIGURE 4-28
Wetlabs 13.5m Moored In-Situ Fluorometric Data
August 1, 1997 to October 28, 1997
Triangles on x-axis mark HOM survey dates

(a) Dissolved Oxygen Concentration



(b) Dissolved Oxygen Percent Saturation

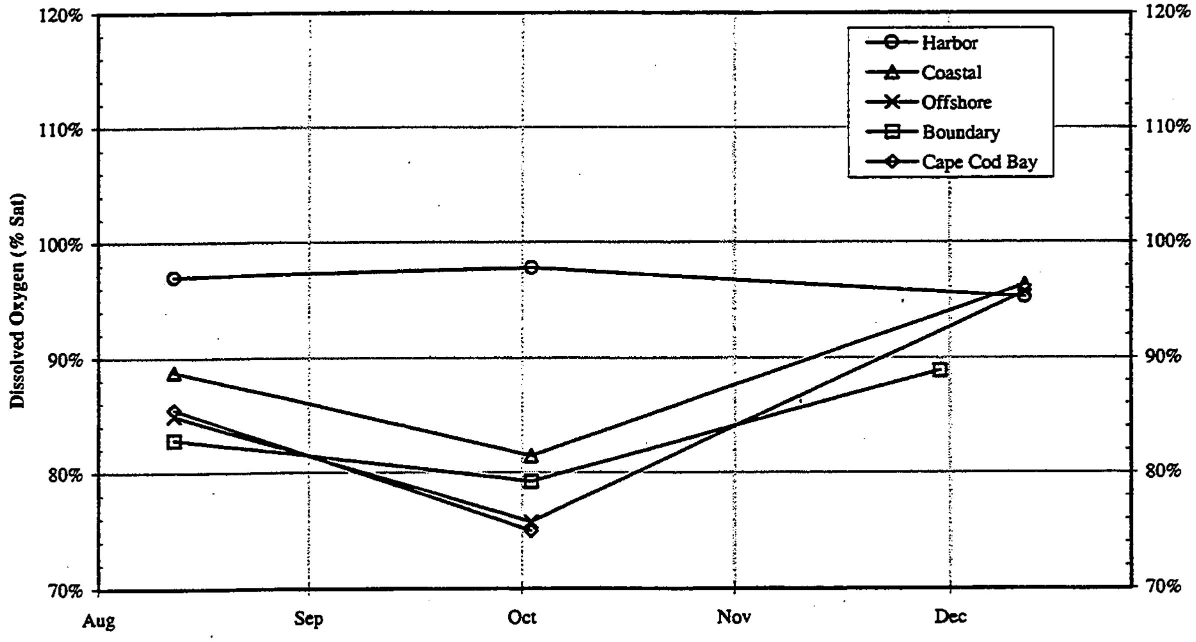
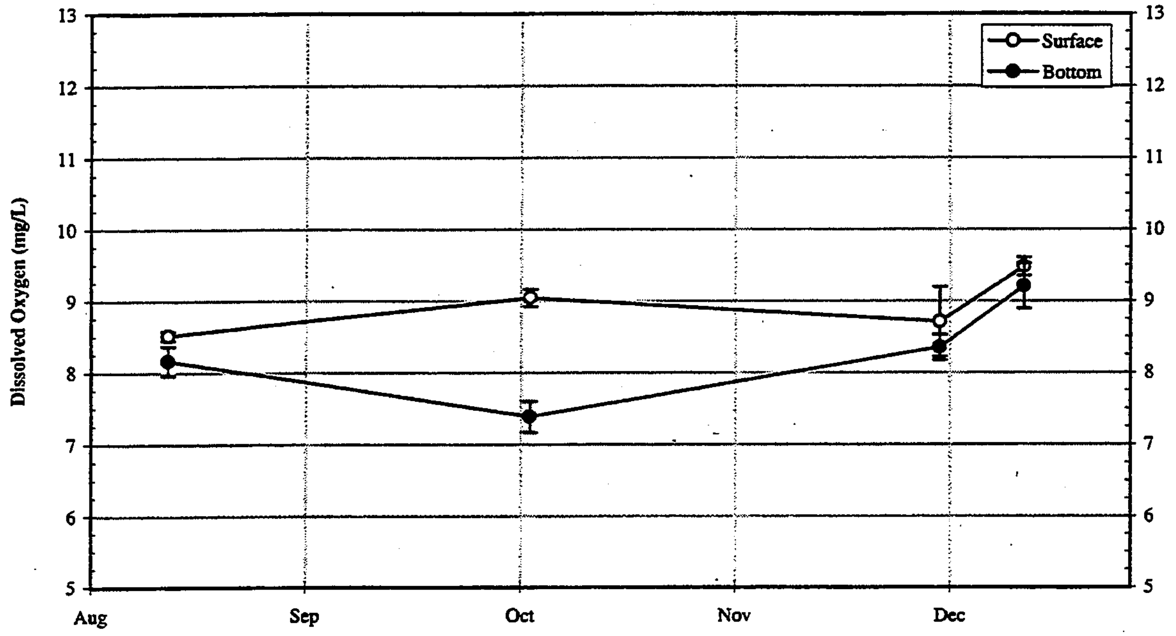


FIGURE 4-29
Time Series of Average Bottom Water Dissolved Oxygen Concentration (mg/L) and Saturation (%) in the Farfield

F4-29do.xls

(a) Dissolved Oxygen Concentration



(b) Dissolved Oxygen Percent Saturation

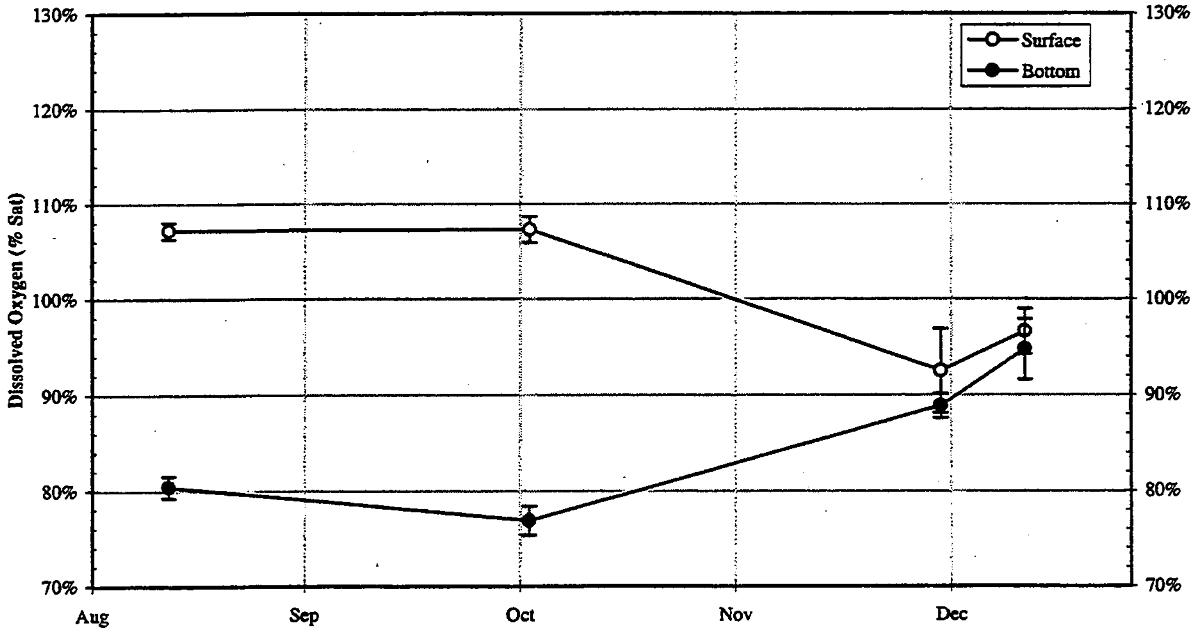
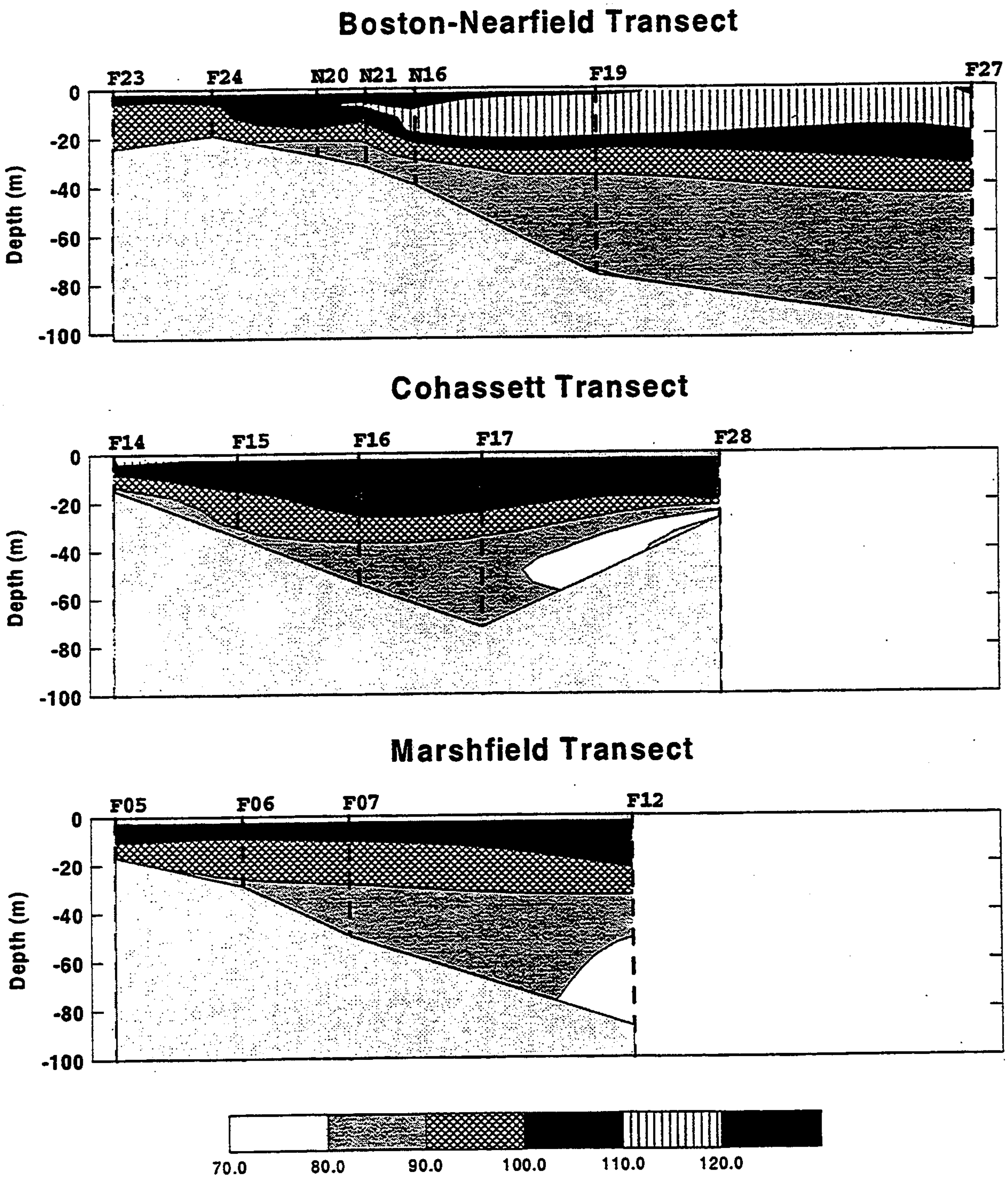


FIGURE 4-30
Time-Series of Average Surface and Bottom Water Dissolved Oxygen Concentration (mg/L) and Saturation (%) Among all Stellwagen Basin Stations

F4-30do.XLS


Boston-Nearfield Transect

Cohassett Transect

Marshfield Transect

FIGURE 4-31
Dissolved Oxygen Saturation (%) Contours Along Three Farfield Transects in Late August (W9711)

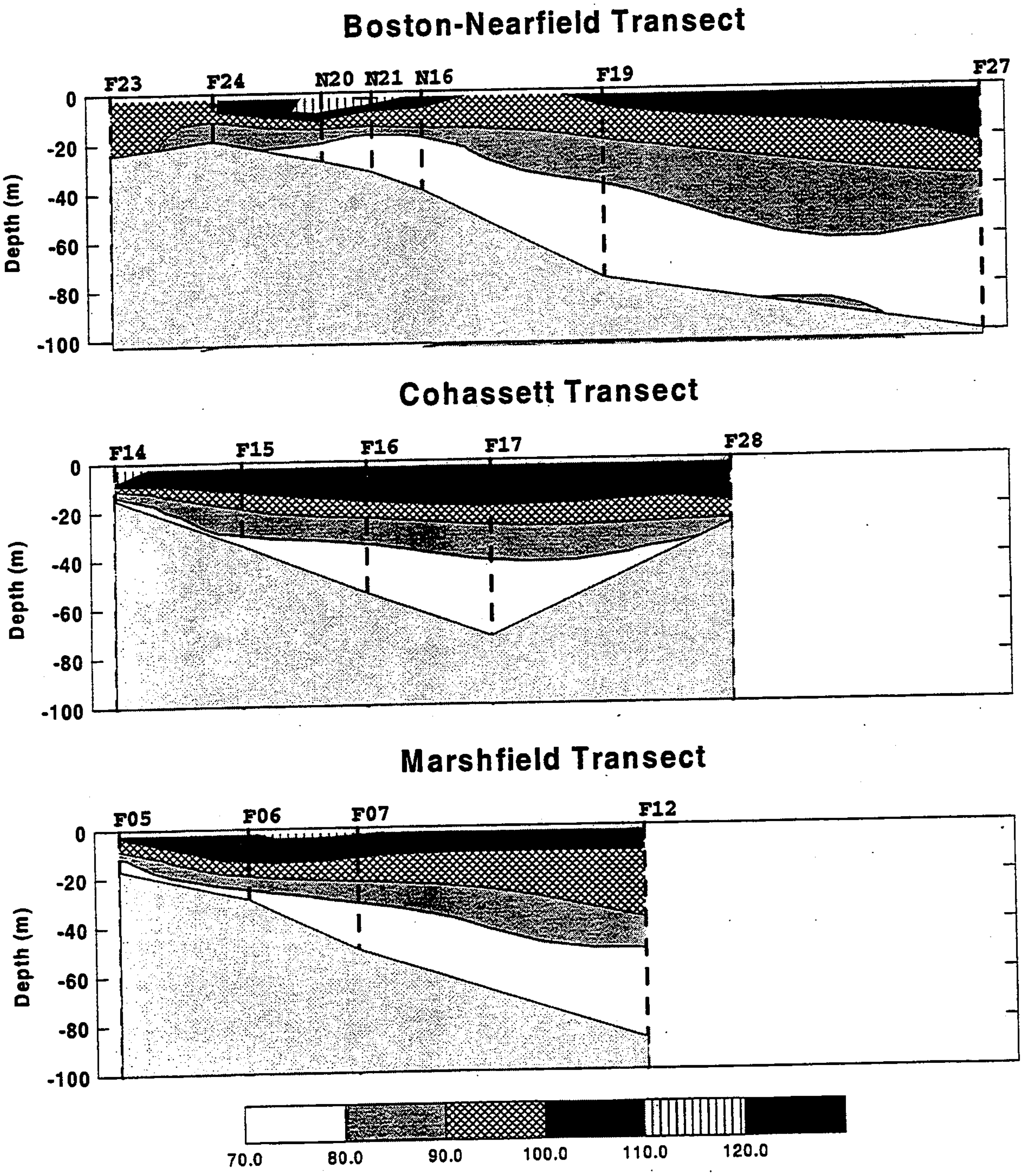
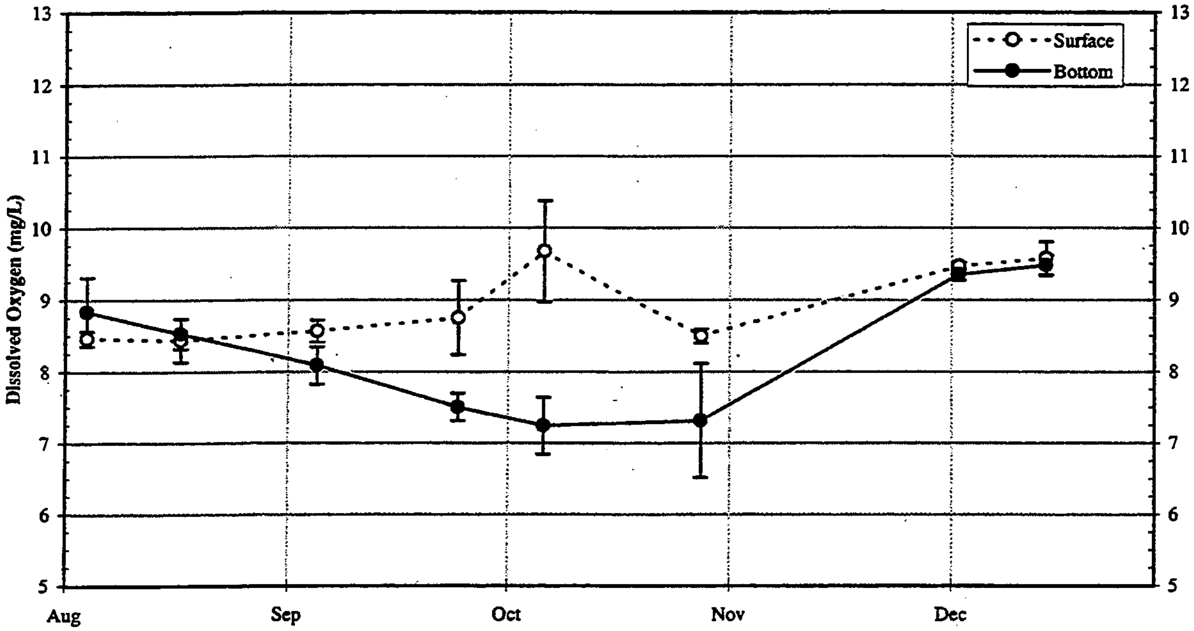


FIGURE 4-32
Dissolved Oxygen Saturation (%) Contours Along Three Farfield Transects in Early October (W9714)

(a) Dissolved Oxygen Concentration



(b) Dissolved Oxygen Percent Saturation

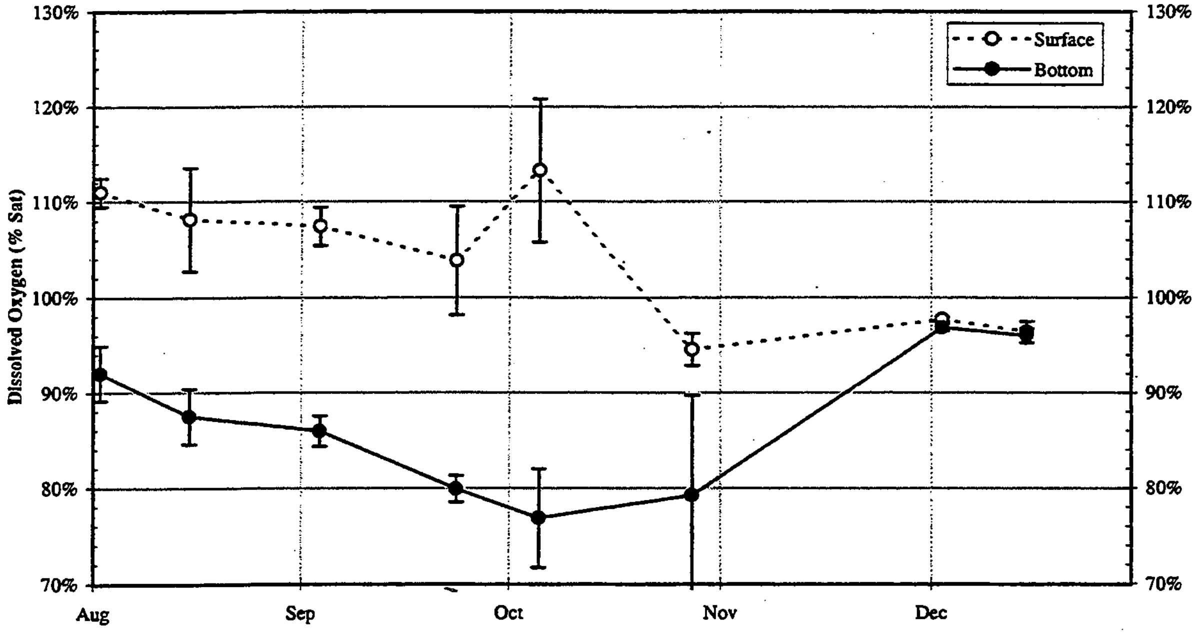


FIGURE 4-33

Times Series Average of Surface and Bottom Water Dissolved Oxygen Concentration (mg/L) and Saturation (%) Among all Nearfield Stations.

F4-33do.xls

5.0 PRODUCTIVITY, RESPIRATION, AND PLANKTON RESULTS

This section presents the results of the biological parameters measured in the HOM Program, including primary productivity, microbial respiration, phytoplankton, and zooplankton. They are discussed in the context of the physical and chemical results presented in Section 4. Additional productivity and respiration measurements taken at Boston Harbor station F23 during the late summer benthic flux survey, as well as additional water column respiration measurements taken during the August farfield survey, will be reported in the annual water column report.

5.1 Productivity

Production measurements were taken at two nearfield stations (N04, N18) and one farfield station (F23), at the entrance to Boston Harbor. All three stations were sampled during the two combined nearfield/farfield surveys conducted during this semi-annual reporting period (W9711 and W9714). Stations N04 and N18 were also sampled during the additional six nearfield-only surveys conducted during the period. Samples were collected at five depths throughout the euphotic zone. Production was determined by measuring ^{14}C uptake at varying light intensities as summarized below.

In addition to samples collected from the water column, productivity calculations also utilized light attenuation data from a CTD-mounted 4π sensor, and incident light time-series data from an on-deck 2π irradiance sensor. Upon collection of the productivity samples and addition of ^{14}C-bicarbonate, they were incubated in a temperature-controlled incubator. The resulting photosynthesis versus light intensity (P-I) curves (Figure 5-1 and comprehensively in Appendix D), were used, in combination with ambient light attenuation and incident light data, to calculate hourly production for each sampling depth for determination of daily areal rates of phytoplankton productivity.

For this semi-annual report, measured hourly production rates (mgCm^{-3}h^{-1}) were integrated over the photoperiod to calculate daily depth-dependent production rates (mgCm^{-3}d^{-1}), which were then integrated over the sampling depth interval to yield areal production (mgCm^{-2}d^{-1}). In addition, calibrated chlorophyll *a* sensor data were used to normalize daily productivity (provided for each of five water depths) for calculation of chlorophyll-specific production (mgCmgChla^{-1}d^{-1}), a measurement of the efficiency of production and physiological status of the phytoplankton population.

5.1.1 Areal Production

Peak rates for primary production were measured during the October bloom (W9714), although areal production at Harbor station F23 was similarly high during the August survey (W9711, Figure 5-2). The highest areal production rate for the period was around 4,200 mgCm^{-2}d^{-1} (station N18), culminating a steady increase in production rate that began in late August. The maximum carbon fixation rate at the outer nearfield station N04 was considerably lower (approx. 2,300 mgCm^{-2}d^{-1}) despite comparable chlorophyll concentrations (8 µg/L at

N18 vs. 6 µg/L at N04, see Figure 4-27). Areal production dropped substantially in the nearfield after survey W9714, to less than 500 $mgCm^{-2}d^{-1}$.

A time-series of daily production was also plotted relative to depth to examine the vertical distribution of production over the water column during the study period (Figure 5-3). The bulk of the production at the two nearfield stations was in the upper 10-15 m of the water column. These results also highlight the localized area of strong productivity near the center of the nearfield during the time of the early October survey (see Figure 4-26). The productivity results from N18 also seem to better capture the late September chlorophyll activity documented by the WETLabs data (Section 4.4.2).

5.1.2 Chlorophyll-Specific Production

Chlorophyll-specific production is an estimate of the efficiency of photosynthesis. The distribution of chlorophyll-specific production indicates that during August and early September, the efficiency of production was high at the nearfield stations (N04 and N18) relative to the amount of biomass present, as measured by chlorophyll *a* (Figure 5-4, also see Figure 4-27). At these two nearfield stations, chlorophyll-specific production was over 800 $mgCmgChla^{-1}d^{-1}$ during the late August survey (W9711).

Chlorophyll-specific production decreased in early September to less than 200 $mgCmgChla^{-1}d^{-1}$. However, an increase in chlorophyll-specific production rates (200-300 $mgCmgChla^{-1}d^{-1}$) was observed during the late September survey (W9713). This increase was also indicative of the onset of the late September bloom documented in the WETLabs data from the USGS mooring, which appeared to be just missed by this survey in terms of chlorophyll biomass (see Section 4.4.2). A late-season increase in chlorophyll-specific production was evident during the December survey, particularly at station N04. This late-season activity was also seen in chlorophyll data (Figure 4-27), but only at stations N18 and N10.

Chlorophyll-specific production at the harbor station (F23) was substantially lower (<100 $mgCmgChla^{-1}d^{-1}$) during the combined nearfield/farfield surveys (W9711 and W9714) in August and October.

5.2 Respiration

Respiration was measured at the same two nearfield stations (N04 and N18) and one harbor station (F23) as productivity, and at farfield station F19 in Stellwagen Basin (Figure 1-2). All stations were sampled during the two combined nearfield/farfield surveys (W9711 and W9714), and stations N04 and N18 were additionally sampled during the six other nearfield-only surveys during the semi-annual period. Samples were typically collected at three depths (surface, mid-depth, and bottom), and incubated without light at *in situ* temperatures.

Both respiration (in units of μMO_2hr^{-1}) and carbon-specific respiration ($\mu MO_2\mu MC^{-1}hr^{-1}$) rates at the three sampled depths are presented here. Carbon-specific respiration was calculated by normalizing respiration rates to the total measured particulate organic carbon (POC) at each respiration depth. Carbon-specific respiration provides an indicator of how biologically available (labile) the POC substrate material is for microbial breakdown.

5.2.1 Water Column Respiration

Maximum respiration rates for the period (0.28 μMO_2hr^{-1}) were measured at Boston Harbor station F23 during the late August survey (W9711), with similar rates reported at both the surface and bottom. Rates in the Harbor fell by early October to around 0.15 μMO_2hr^{-1}. While the late August surface rate was almost matched at offshore station F19, by early October surface respiration at F19 resembled the bottom rate of 0.05 μMO_2hr^{-1}.

Respiration rates at nearfield stations during the stratified period were typically 2-3 fold higher in surface than bottom waters (Figure 5-5). Following a surface water peak (ca. 0.22 μMO_2hr^{-1}) at station N04 in early August (W9710), surface water rates remained between 0.15-0.20 μMO_2hr^{-1} through early October. Surface respiration rates at N18 peaked at around 0.26 μMO_2hr^{-1} in late September (W9713) and remained above 0.2 μMO_2hr^{-1} in early October (W9714). After the fall turnover, both surface and bottom respiration at the nearfield stations fell to <0.05 μMO_2hr^{-1}.

The late September peak at N18 is another indication of the onset of bloom conditions documented in results for chlorophyll (Section 4.4.2) and productivity (Section 5.1). The peak in respiration at N18 in late September was accompanied by a large increase in surface water particulate organic carbon (from around 23 μM to 37 μM, Figure 5-6). This trend continued through early October, when maximum surface POC concentrations reached around 55 μM. Peaks in particulate organic carbon were also observed at N04 during the early October survey (W9714), after which surface and bottom concentrations were more uniform.

5.2.2 Carbon-Specific Respiration

Carbon-specific respiration normalizes microbial activity to the concentration of the available carbon substrate. Differences in carbon-specific respiration can therefore be attributed to variations in the quality of the available organic matter given similar environmental conditions such as temperature. Sources of organic carbon which are more easily oxidized (i.e., recently produced phytoplankton) will result in higher carbon-specific respiration. Stratification produces lower carbon-specific respiration in bottom water due the lower water temperature, and to typically lower substrate quality resulting from partial degradation during sinking.

Peaks in carbon-specific respiration were evident in the early August surface samples at both nearfield stations and at offshore station F19 (Figure 5-7). In fact, the highest C-specific rate measured during the reporting period was the surface sample at F19 (0.023 $\mu MO_2 \mu MC^{-1} hr^{-1}$), approximately twice that measured at the nearfield stations. With the exception of similarly high surface and bottom water rates reported from N04 during late September (W9713), C-specific respiration rates typically fell through October. A slight increase was documented in both surface and bottom samples in the nearfield during late November (station N18) and December (station N04).

These observations are consistent with indications of nearfield algal activity during late August, including depleted silicate concentrations (Section 4.3.2), oversaturated surface dissolved oxygen concentrations (Section 4.5.2), and high chlorophyll-specific production (Section 5.1.2). Although chlorophyll concentrations were relatively low during this period (e.g., Figure 4-27), it appears from the C-specific respiration that high metabolic activity was sustained by a high-quality substrate.

5.3 Plankton Results

The 1997 HOM Program included analysis of the plankton community in Boston Harbor, Massachusetts Bay, and Cape Cod Bay during 11 nearfield and six combined farfield surveys conducted from February to December. Two stations (N04 and N18) were occupied in the nearfield surveys, while an additional ten locations were sampled during the combined events (Figure 5-8). During 1997, station N16 continued to be sampled during the farfield segment of the combined events in lieu of a station revisit at one of the two nearfield stations. In this report, the second half of the 1997 plankton record is presented (surveys W9710 to W9717), including two of the six annual combined sampling events (W9711 and W9714). Comprehensive tabulations of results are available in periodic Plankton Data Reports.

Whole water and screened phytoplankton samples were collected at the surface and at mid-depth, with the latter often selected to coincide with the presence of a sub-surface chlorophyll maximum (as determined by in vivo fluorometry). Zooplankton samples were collected at each station by oblique tow. Details regarding sampling and analysis can be found in the Combined Work Plan/QAPP for water column monitoring (Bowen *et al.*, 1997). Quantitative taxonomic analyses and carbon equivalence estimates were made for the plankton communities using species-specific carbon data from the literature.

In this section, the plankton data are presented through an assessment of their seasonal and regional characteristics. Total abundance, relative abundance of major groups, and estimated carbon equivalence are presented for each plankton community. Nuisance algae issues are also addressed. Appendix E-1 tabulates dominant phytoplankton species (>5% of total abundance) for whole water surface samples, along with the associated cell densities and percent abundance. Appendix E-2 provides similar information for the mid-depth samples. Appendix F-1 tabulates dominant phytoplankton species (>5% of total abundance) for screened surface samples, along with the associated cell densities and percent abundance. Appendix F-2 provides similar information for the mid-depth samples. Appendix G presents zooplankton results.

Appendix H-1 tabulates dominant phytoplankton carbon contributors (>5% of total carbon) for whole water surface samples, along with the associated carbon densities and percent carbon contribution. Appendix H-2 provides similar information for the mid-depth samples. Appendix I-1 and I-2 includes similar information for screened phytoplankton results.

5.3.1 Phytoplankton

5.3.1.1 Seasonal Trends in Total Phytoplankton Abundance

Total phytoplankton densities in nearfield whole water surface samples (averaged results) demonstrated one major peak in early October (W9714) comprising the fall bloom (Figure 5-9a). Cell densities were slightly elevated in early August relative to the subsequent survey, and a small interim peak was seen in mid-depth results during early September (Figure 5-9b). Following the fall bloom, densities generally declined for the remainder of the reporting period, although a slight increase was noted in December. Densities at both depths were similar during the reporting period ranged from 0.6-11 million cellsL^{-1}.

During the first combined survey (W9711), Boston Harbor yielded the highest regional densities and the nearfield the lowest at both the surface and at mid-depth (Figure 5-9a and 5-9b). Average densities for the three Harbor stations were between 3-4 million cellsL^{-1}, and were only slightly higher than densities reported in Cape Cod Bay and Coastal stations. Surface densities from the Boundary station F27 were more similar to the nearfield (<1 million cellsL^{-1}), while at mid-depth the Offshore results were the lowest outside of the nearfield (1 million cellsL^{-1}).

During the second combined survey, the nearfield yielded the highest regional densities at both the surface and at mid-depth (Figure 5-9a and 5-9b). Average surface densities for the nearfield stations exceeded 10 million cellsL^{-1}. The nearfield surface results were followed in magnitude by Coastal, Harbor, Offshore, and Cape Cod Bay stations (2-3 million cellsL^{-1}), with Boundary station results found to be the lowest regionally. The pattern was similar at mid-depth, with even lower densities reported from the Boundary station (Figure 5-9b).

5.3.1.2 Nearfield Phytoplankton Community Structure

Phytoplankton abundance and community composition at the three nearfield stations were plotted for surface (Figure 5-10) and mid-depth samples (Figure 5-11). Note again that station N16 was only sampled during the two combined surveys conducted during the reporting period. Overall density patterns between stations and depths varied, but generally densities at N16 and N18 were highest (note scale differences in the two plots).

During the majority of the stratified period (W9710 through W9713), surface and mid-depth whole water samples from the nearfield were numerically dominated by microflagellates. Subdominants included *Cryptomonas* sp., and *Gymnodinium* sp. (Appendix E). However, during the two September surveys (W9712 and W9713), the centric diatoms *Rhizosolenia fragilissima* and *Cyclotella* sp., and the pennate diatom *Thalassionema nitzschoides* became co-dominant at station N18. These taxa may have been responsible for the increased productivity and respiration rates seen at this station (Sections 5.1.1 and 5.2.1).

By the early October survey (W9714), the overall contribution from centric diatoms increased dramatically at the nearfield stations (Figures 5-10 and 5-11). The dominant centric diatom was *Thalassiosira*, which exceeded 4 million cellsL^{-1} at the surface, and over 7 million cellsL^{-1} at mid-depth at N18 (Appendix E-1 and E-2). Co-dominants included the centric diatom *Cyclotella* sp., a small (<10 μm) unidentified pennate diatom, and microflagellates. Station N16 was also co-dominated by the pennate diatom *Asterionellopsis glacialis* and *R. fragilissima*, which were even more abundant at mid-depth (Appendix E). Following the bloom documented during W9714, nearfield phytoplankton densities decreased and again were dominated by microflagellates, cryptophytes, and *Gymnodinium* sp.

Plots of estimated phytoplankton carbon emphasize that the October peak in phytoplankton abundance was more productive than any other event during the period at both the surface and mid-depth (Figures 5-12 and 5-13). Dominant centric diatoms with respect to estimated phytoplankton carbon were *Rhizosolenia fragilissima* and *Thalassiosira* sp. (Appendix H; Lemieux, 1997). Note also the relative increase in carbon contributed by centric diatoms at station N18 during late September (Figures 5-12 and 5-13).

Dominant dinoflagellate species detected in screened sample results included *Ceratium longipes*, *C. fusus* and *C. tripos* (Appendix F). Densities typically did not exceed 1,000 cellsL^{-1}, except at N04 during the first survey of the second semi-annual period (W9710) when densities reached 1,680 cellsL^{-1} and 3,230 cellsL^{-1} at the surface and mid-depth, respectively (Appendix F-1 and F-2).

5.3.1.3 Regional Phytoplankton Assemblages

Abundance plots for whole water samples taken at farfield stations were used to demonstrate the differences in regional phytoplankton assemblages (Figures 5-14 and 5-15). Nearfield results were included to facilitate regional comparisons. Results from the late August farfield survey (W9711) further illustrate the harbor and coastal nature of the August bloom event (Figure 5-14, also see Section 4.4.1). During a time of low phytoplankton densities and dominance by small flagellates in the nearfield and Boundary regions, stations in Boston Harbor (F23, F30, and F31) and in the adjacent coastal region (F24 and F25) had a large contribution from centric diatoms (Figure 5-14).

The coastal bloom, however, showed differences in dominant taxa among the stations. Coastal stations to the south of the harbor and Cape Cod Bay (F06, F13, F01, and F02) were dominated by *Rhizosolenia fragilissima* at both surface and mid-depths (maximum density of 1.76 million cellsL^{-1}, Appendix E-2). *Skeletonema costatum*, while present in the southern assemblage, dominated in the harbor and adjacent waters (maximum density of 1.78 million cellsL^{-1}, Appendix E-2). Cryptophytes were co-dominant in the Harbor and adjacent stations, but were not present to the same degree south of the Harbor. Microflagellates contributed to the overall standing stock of phytoplankton in all regions, comprising 21 to 82 percent of phytoplankton densities.

The dinoflagellate flora in the early season farfield screened samples exhibited dominant taxa similar to those reported for the nearfield stations (*Ceratium longipes*, *C. tripos*, and *C. fusus*) (Appendix F). Densities for all dinoflagellate taxa were occasionally elevated at mid-depth, but overall these densities were low (typically less than 1,000 cellsL^{-1}).

Differences in regional assemblages were also evident during the fall bloom (early October farfield survey W9714). The centric diatom *Thalassiosira* dominated the nearfield assemblage, while microflagellates and the centric diatom *Cyclotella* were co-dominant (Appendix E). Dominant taxa at Cape Cod Bay stations were microflagellates, *Skeletonema costatum*, and *Cyclotella*. The Harbor assemblage was substantially different, with the pennate diatom *Asterionellopsis glacialis* and the centric diatoms *Leptocylindrus danicus* and *L. minimus* reported as dominant forms.

The dinoflagellate flora in the late season farfield samples exhibited dominant taxa similar to those reported for the nearfield stations (*Ceratium longipes* and *C. tripos*, Appendix F).

5.3.1.4 Nuisance Algae

Three nuisance algae species have been targeted in the HOM Program: *Alexandrium tamarense*, *Phaeocystis pouchetii*, and *Pseudo-nitzschia multiseries*. The seasonal distribution for *A. tamarense* and *P. pouchetii* encompasses the late winter and spring periods, and thus would not be expected to occur during this time of the year. Neither species was reported during the surveys reported herein.

The seasonal distribution of *Pseudo-nitzschia multiseries* does include the time frame of this semi-annual reporting period. It was not present in any great abundance, however, as its indicator species, *Pseudo-nitzschia pungens*, did not exceed 3,100 cellsL^{-1} during the reporting period. The maximum densities were reported during the August farfield survey (W9711), where *P. pungens* was reported in surface and mid-depth samples in Cape Cod Bay (F01 and F02) and offshore station F06 (Appendix F). In the early October farfield survey (W9714), *P. pungens* was again reported in samples from Cape Cod Bay stations F01 and F02 and offshore/coastal stations F06 and F13 (Appendix F). The highest reported density was 1,200 cellsL^{-1} (Appendix F). These results were well below the 100,000 cellL-1 threshold tentatively being used by the HOM Program based on domoic acid toxicity levels observed in Canadian waters (S. Bates, pers. comm.).

5.3.2 Zooplankton

5.3.2.1 Seasonal Trends in Total Zooplankton Abundance

Zooplankton densities in the nearfield also exhibited differences among stations, with station N18 exhibiting the greatest fluctuation through the period (Figure 5-16). Two peaks were evident at the two high-frequency sampling stations within the nearfield, in early September and again in late October (Figure 5-16). Initial total densities of between 30,000 m^{-3} (station N18) to 40,000 m^{-3} (N04) in early August increased to around 70,000 m^{-3} during the first peak. After returning to initial densities during late September and early October, late October samples from station N18 produced the highest densities for the semi-annual period (around 150,000 m^{-3}).

Results from station N04 did not exhibit the same dramatic increase, reaching only around 50,000 m^{-3}. After the late October peak, densities at these two stations generally decreased to around 20,000 m^{-3} by December.

Zooplankton densities from station N16, sampled only twice during the farfield events, were roughly double (around 55,000 m^{-3}) the other nearfield stations during the late August survey (Figure 5-16). Results at N16 were similar to N04 (around 40,000 m^{-3}) during the second farfield survey in early October (W9714). It should be noted that a small tear in the zooplankton net was discovered during sampling at N04 during late August (Section 2.3.1), thus the relatively low densities reported there during W9711 might have been a sampling artifact. It should also be noted that dense concentrations of salps were evident in the outer nearfield during the late September and early October surveys, which may have reduced densities both in the water column (from their feeding activity) and in samples (due to net clogging).

5.3.2.2 Nearfield Zooplankton Community Structure

Copepod adults and copepod nauplii dominated zooplankton community composition during most surveys in the reporting period (Figure 5-17). The main exception was during late October (W9715), when there was a substantial contribution from bivalve larvae. Although they comprised as much as 45 percent of the total assemblage (station N04, Appendix G), densities were almost twice as high at station N18 during this survey (42,300 m^{-3} at station N18 as compared with 22,800 m^{-3} at station N04).

The numerically dominant species among the copepods during the reporting period was *Oithona similis*, with copepodite densities around 35,300 m^{-3} during late August (W9712) and 18,800 m^{-3} during the zooplankton abundance peak in late October (W9715; Appendix G). Other dominant copepod taxa early in the semi-annual period included *Pseudocalanus newmani*, *Temora longicuris*, and *Acartia tonsa*. Later in the reporting period, *Pseudocalanus newmani*, *Centropages* sp. and *Temora longicuris* were dominant but in much smaller numbers.

5.3.2.3 Regional Zooplankton Assemblages

Regional data for the late August combined nearfield/farfield survey (W9711) showed highest zooplankton densities (around 140,000 m^{-3}) within Boston Harbor (station F30, Figure 5-18). Coastal stations and western Cape Cod Bay station F01 also exhibited relatively high zooplankton densities, with densities approaching 100,000 m^{-3}. Other stations were typically around 60,000 m^{-3}, although densities at nearfield stations N18 and N04 and Harbor station F31 were substantially lower. Copepod adults and nauplii numerically dominated each station, with bivalve larvae also important. Dominant copepod taxa included *Acartia tonsa* at the Harbor stations, and *Oithona similis* in Cape Cod Bay, the nearfield, and Boundary station F27 (Appendix G).

By the early October combined survey (W9714), the highest densities were found at the Coastal station F24 (Figure 5-19). Densities were typically between 30,000-40,000 m^{-3}, although densities in Cape Cod Bay and Boundary station F27 were $\leq$20,000 m^{-3}. Copepod nauplii were the dominant group (with the exception of Boundary station F27), and *Oithona similis* was the dominant copepod species (Appendix G).

5.4 Summary of Water Column Biological Events

Productivity

- Peak areal production rates for the period were measured in the nearfield during early October, which coincided with the fall phytoplankton bloom. The maximum rate was reported at station N18 (4,200 $mgCm^{-2}d^{-1}$), while N04 yielded a smaller peak (2,300 $mgCm^{-2}d^{-1}$).
- The majority of nearfield production was in the upper 10-15 m of the water column.
- Harbor production rates measured during the two farfield surveys (late August and early October) were around 2,200 mgCm-2d-1.
- Chlorophyll-specific production indicated that highly efficient photosynthesis was occurring in the nearfield during August. and early September. Maximum nearfield chlorophyll-specific production rates (>800 mgCmgChla-1d-1) were reported during late August (W9711).
- An increase in chlorophyll-specific production during late September (W9713) seemed to capture the onset of the fall bloom.
- A late-season increase in chlorophyll-specific production in the nearfield was evident during December (W9716-W9717).

Respiration

- Peak surface water respiration rates (0.28 µMhr-1) were reported in late August (W9711) at Boston Harbor station F23. A similarly high surface peak (0.25 µMhr-1) was seen at Offshore station F19 during this survey.
- Peak surface water respiration rates in the nearfield (0.26 µMhr-1) were reported in late September (W9713) at station N18, again apparently coinciding with the onset of the fall bloom. Peak nearfield bottom water respiration rates (around 0.08 µMhr-1) were also reported during this survey.
- Surface and bottom water respiration rates converged in early October at station F19 and late October at stations N04 and N18.
- Carbon-specific respiration in the nearfield peaked at both nearfield stations during the late August survey (W9711), and again in late September at station N04.
- Carbon-specific respiration at the farfield station also peaked during the late August survey (W9711), with the maximum rate for the period (0.023 µMO2µMC-1hr-1) reported at station F19.

Phytoplankton

- A phytoplankton bloom was evident in Boston Harbor and coastal stations during late August (W9711). The centric diatom *Skeletonema costatum* and cryptophytes dominated the Harbor assemblage, while the centric diatom *Rhizosolenia fragilissima* dominated the coastal assemblage to the south of the Harbor and in western Cape Cod Bay.

- Nearfield densities remained low through late September, with the assemblage dominated by microflagellates, cryptophytes, and a small dinoflagellate (*Gymnodinium*). An increase in diatom activity was evident at station N18 during late September, apparently an early indication of the onset of the fall bloom.

- Centric diatoms dominated a fall bloom evident in the nearfield by early October (W9714), with *Thalassiosira* spp. and *Cyclotella* the dominant forms, with *Rhizosolenia fragilissima* and the pennate diatom *Asterionellopsis glacialis* sub-dominant at some stations. After the bloom, the nearfield assemblage was similar to that seen in August and early September.

- The fall bloom evident in the nearfield also extended to the Harbor and Cape Cod Bay. The Harbor was dominated by *Asterionellopsis glacialis* and the centric diatoms *Leptocylindrus danicus* and *L. minimus*, while Cape Cod Bay was dominated by *S. costatum* and *Cyclotella.*

- The dinoflagellates *Ceratium longipes, C. tripos,* and *C. fusus* were present in low numbers (typically <1,000 cellsL-1) throughout the reporting period.

- Nuisance species were not of concern during the reporting period. The maximum density for the indicator species *Pseudo-nitzschia pungens* was 3,100 cellsL-1, reported in Cape Cod Bay during late August.

Zooplankton

- Peak zooplankton abundance in the nearfield occurred in late October (station N18), while the more offshore station N04 peaked in early September.

- Farfield results showed greatest densities in Boston Harbor and coastal stations, with the latter including Cape Cod Bay station F01 (August), and Coastal station F24 (October).

- The zooplankton community was dominated by copepod adults and copepod nauplii, with the numerical dominant being *Oithona similis*. Bivalve larvae contributed substantially to the late October (W9715) assemblage.

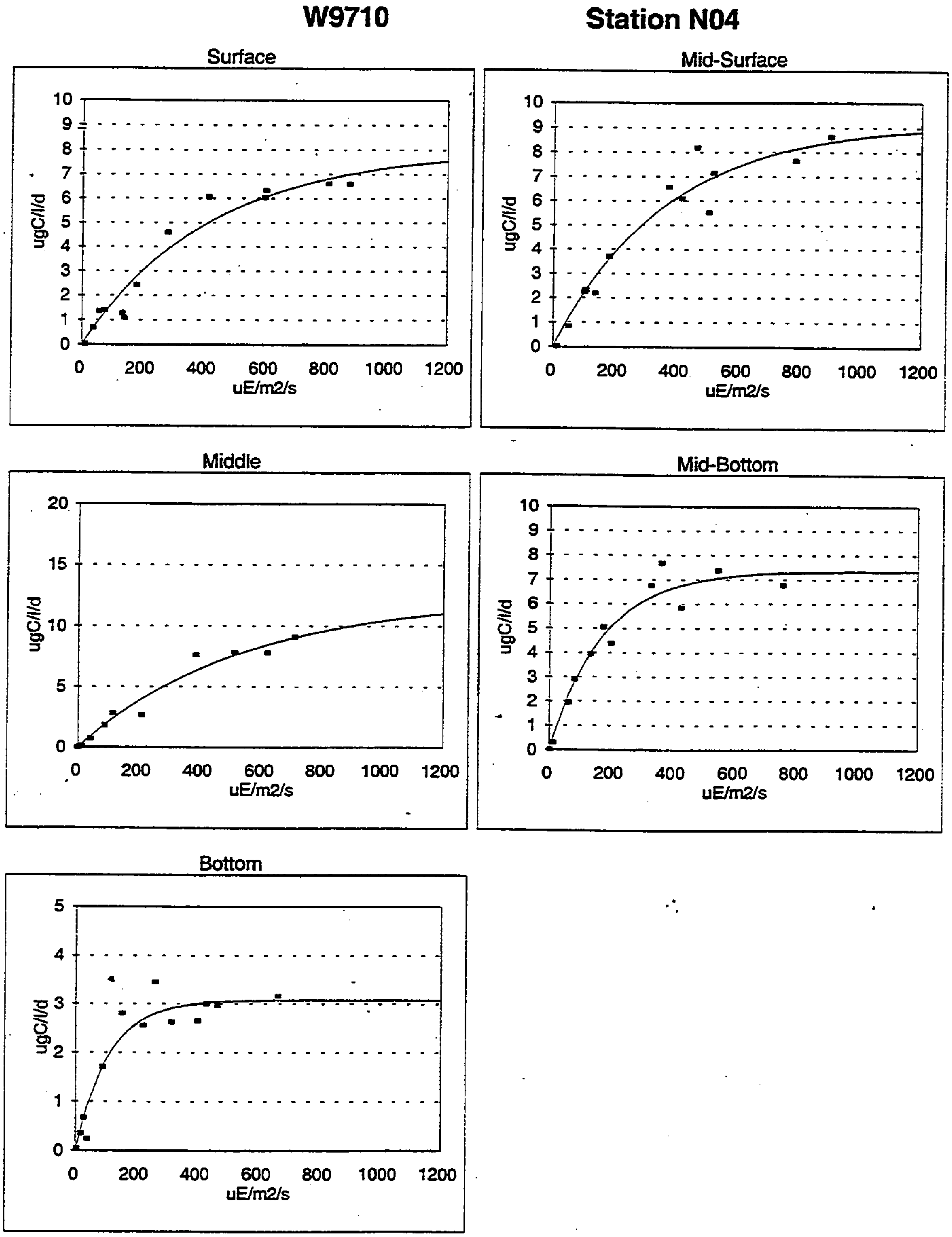
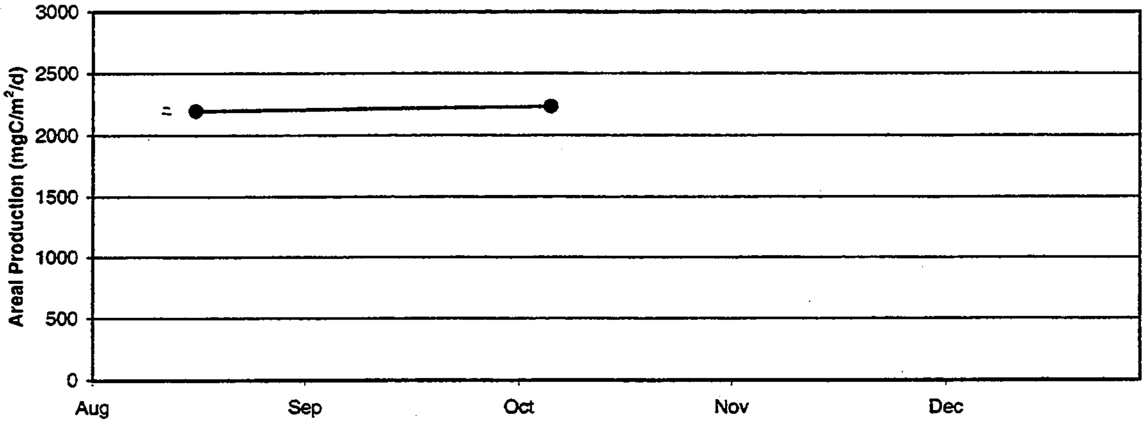
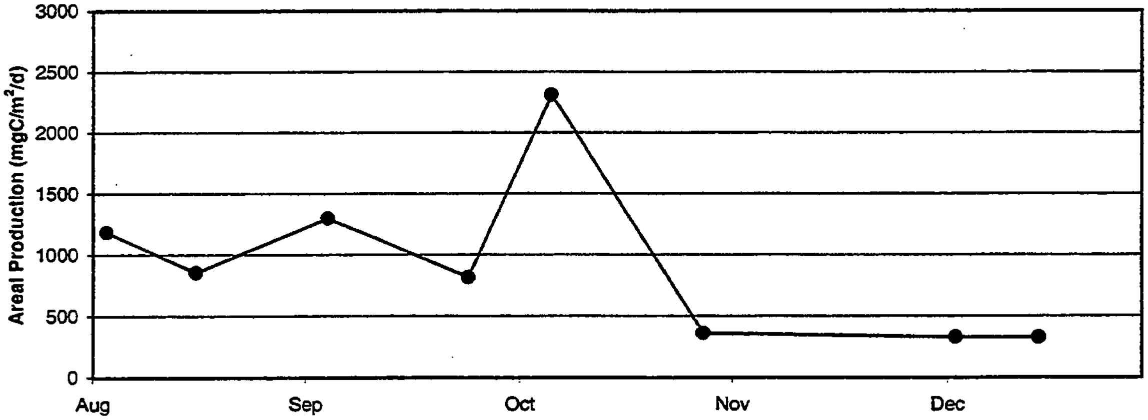


FIGURE 5-1
An example of Photosynthesis- Irradiance Curve from Station N04 Collected in August 1997

(a) Station F23



(b) Station N04



(c) Station N18

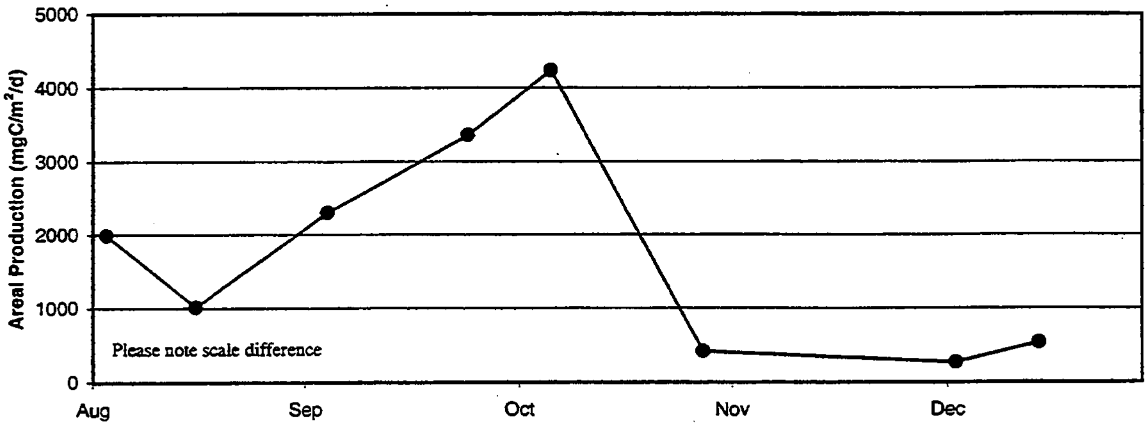


FIGURE 5-2
Time-Series of Areal Production for Productivity/Respiration Stations

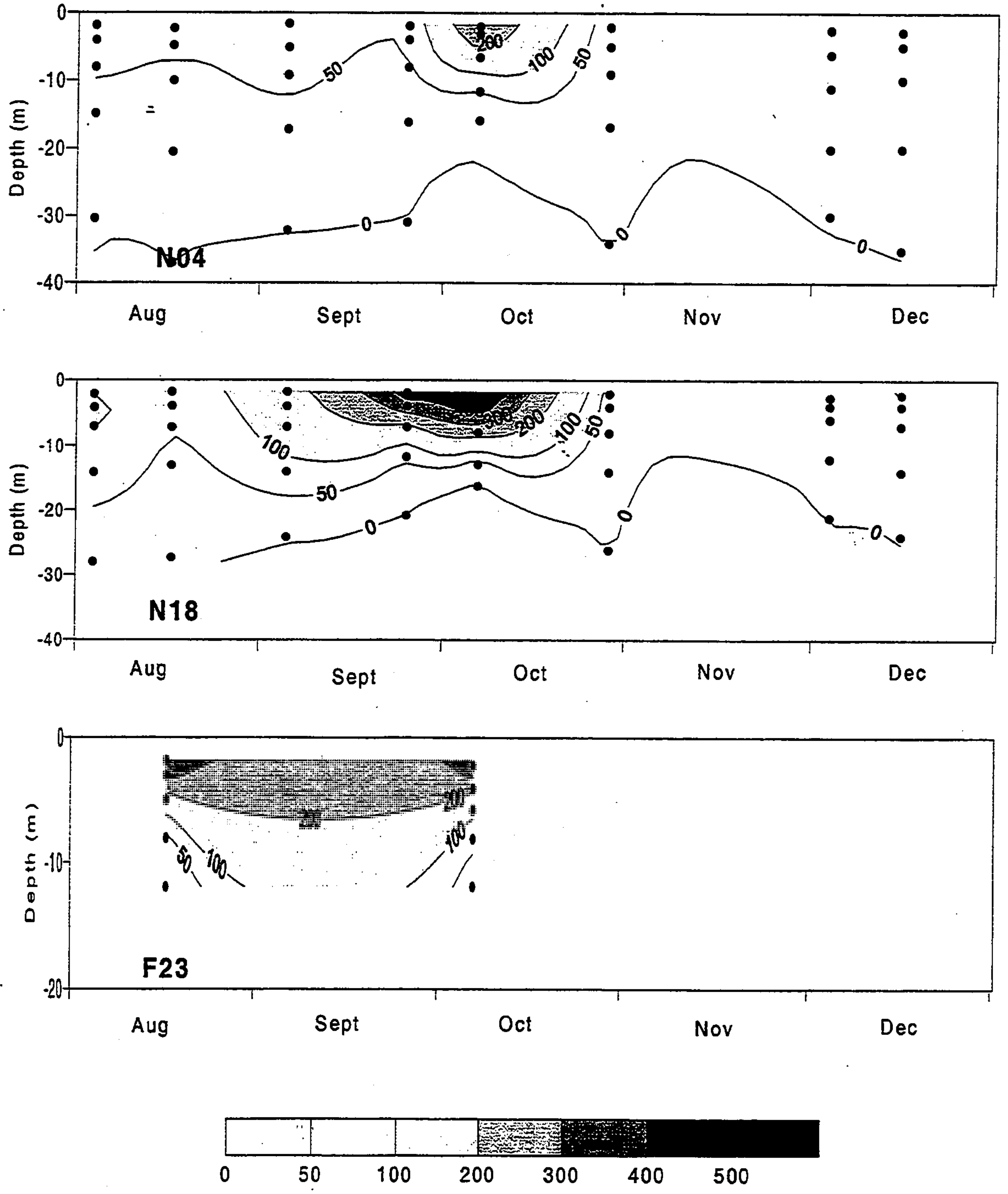


FIGURE 5-3
Time-Series of Contoured Daily Production (mgC/m3/d)
at Productivity/Respiration Stations

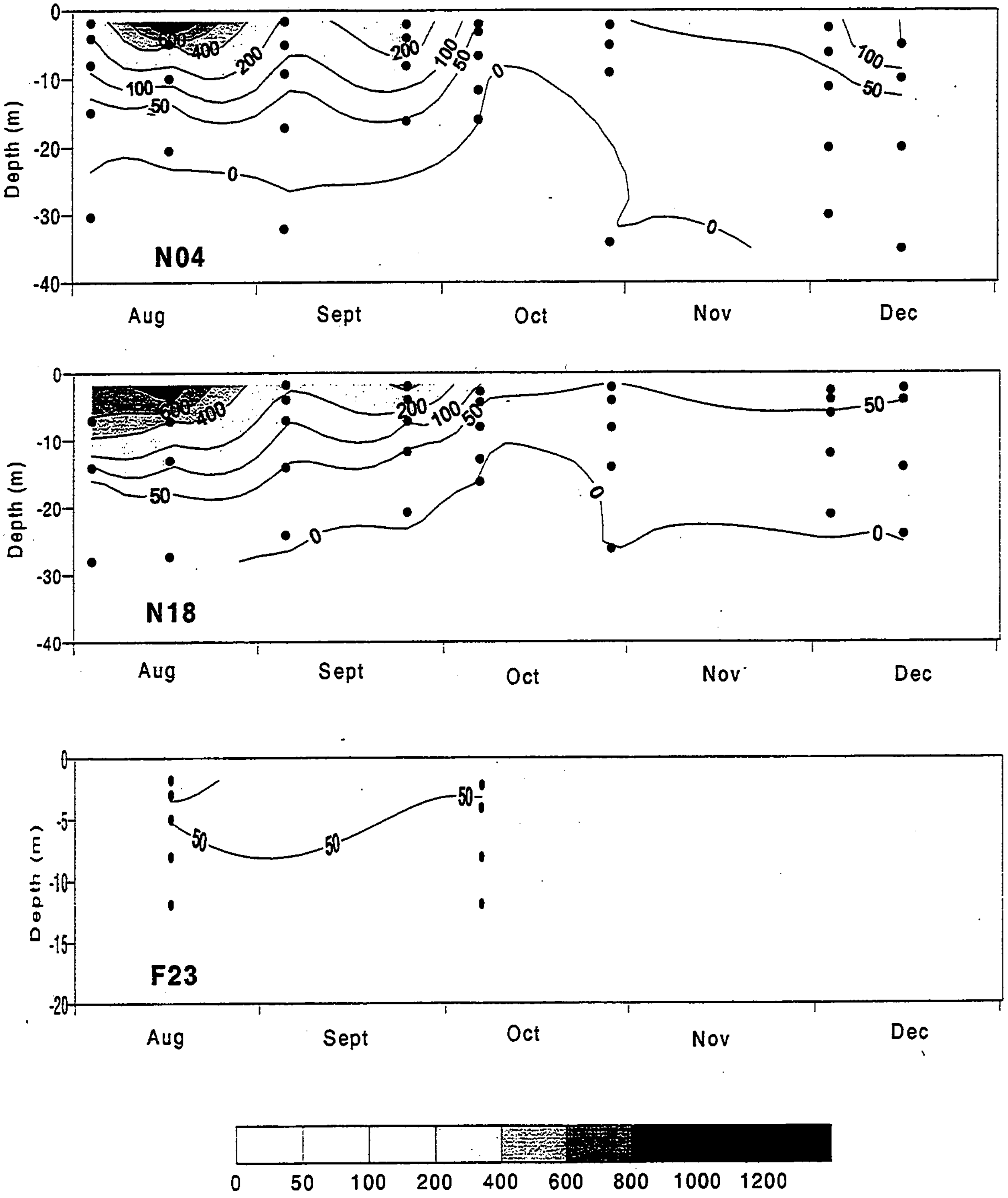


FIGURE 5-4
Time-Series of Contoured Chlorophyll-Specific Production (mgC/mgChl/d)
at Productivity/Respiration Stations

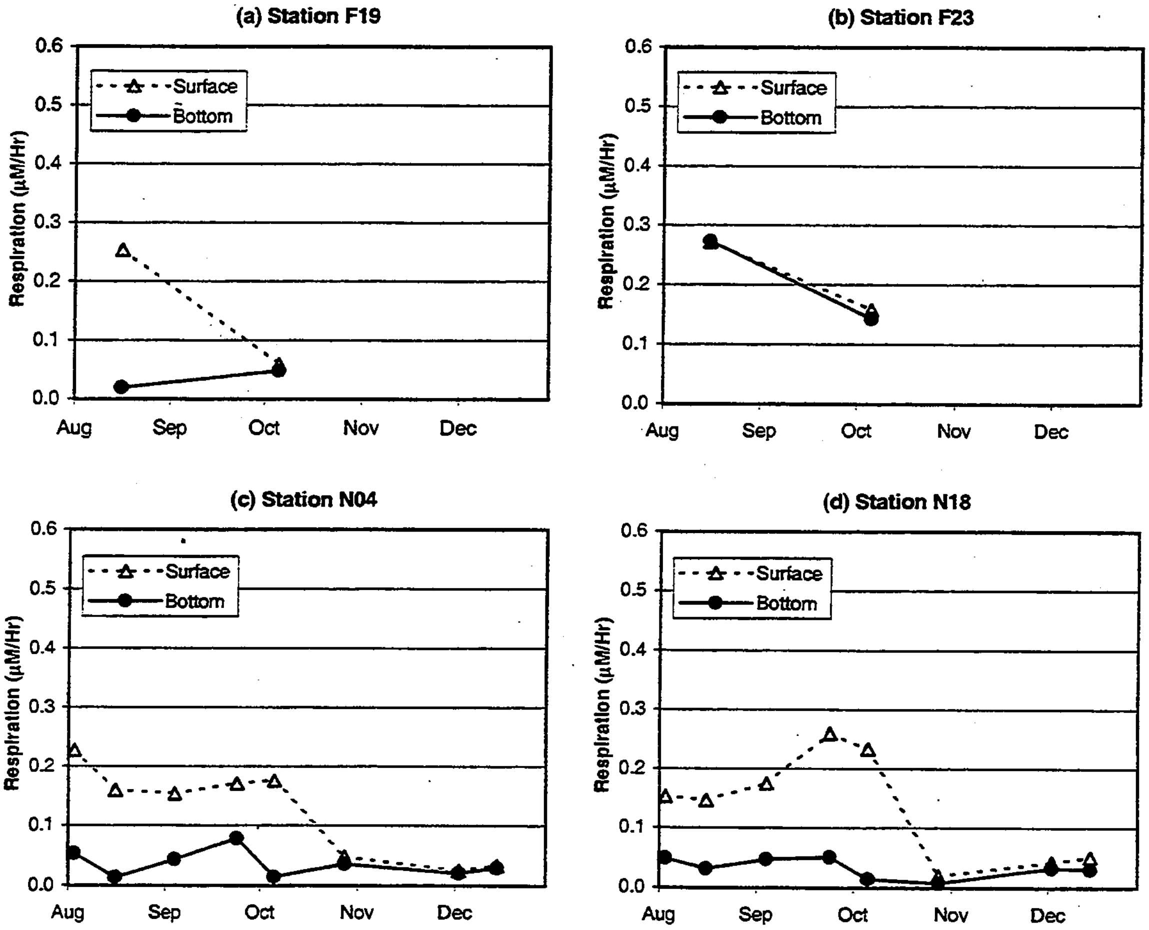
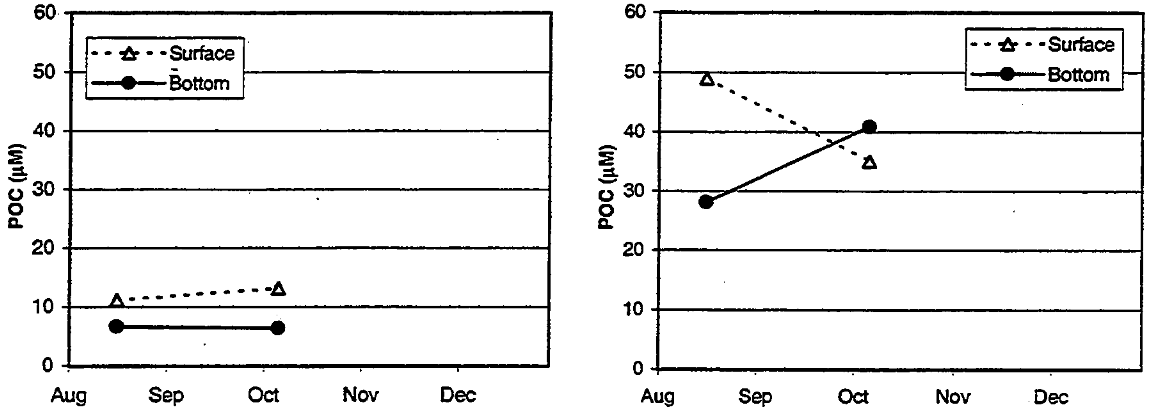
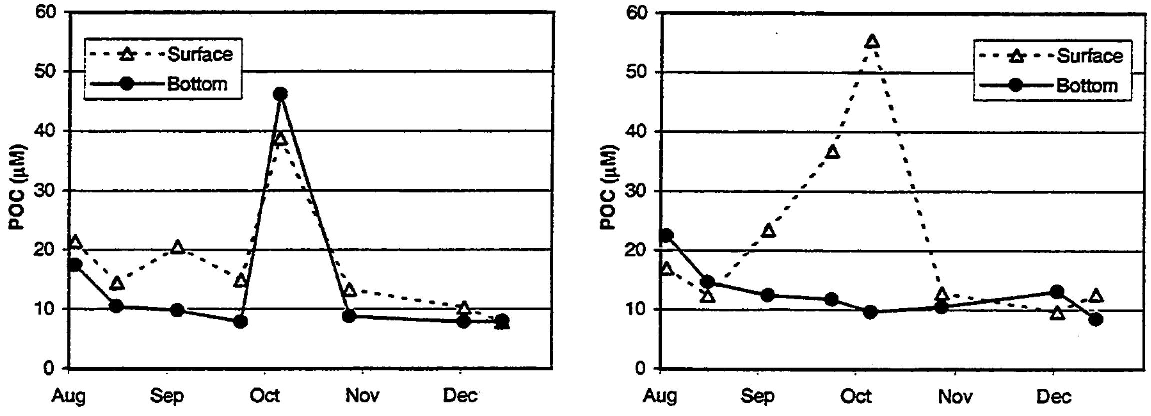


FIGURE 5-5
Time-Series of Water Column Respiration at Productivity/Respiration Stations


(a) Station F19

(b) Station F23


(c) Station N04

(d) Station N18

FIGURE 5-6
Time-Series of Particulate Organic Carbon at Productivity/Respiration Stations

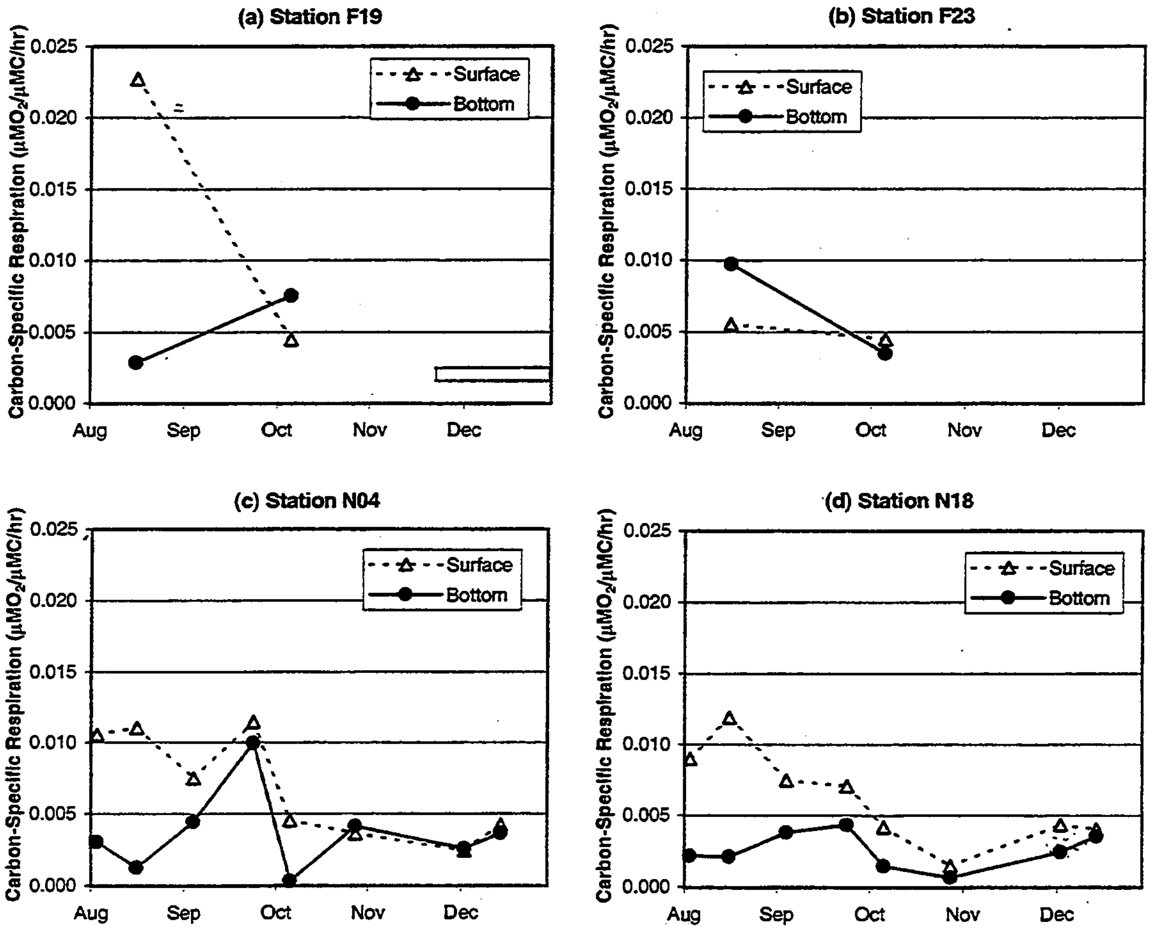


FIGURE 5-7
Time-Series of Carbon-Specific Respiration at Productivity/Respiration Stations

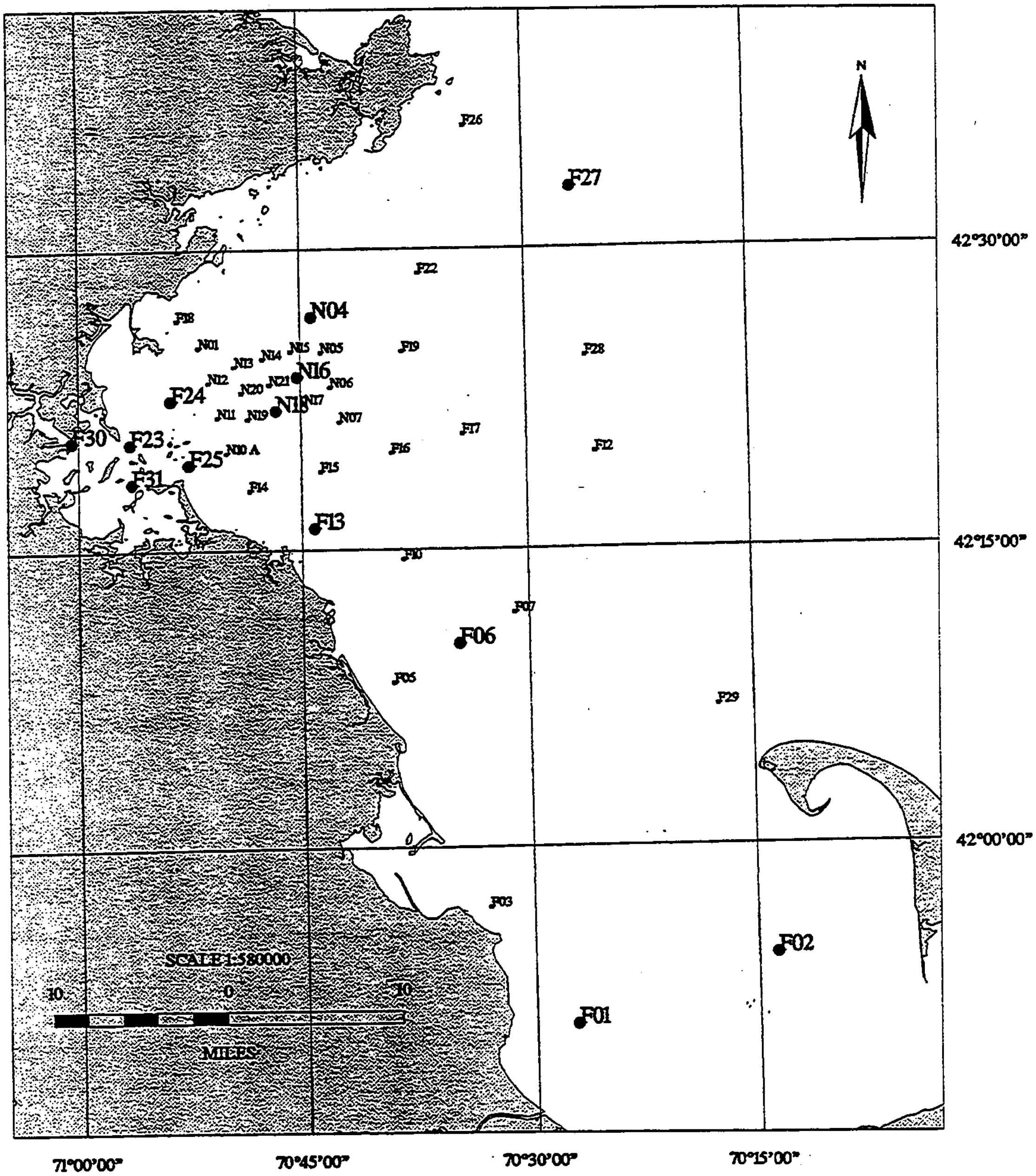


FIGURE 5-8
1997 Plankton Station Locations (Enlarged Text)

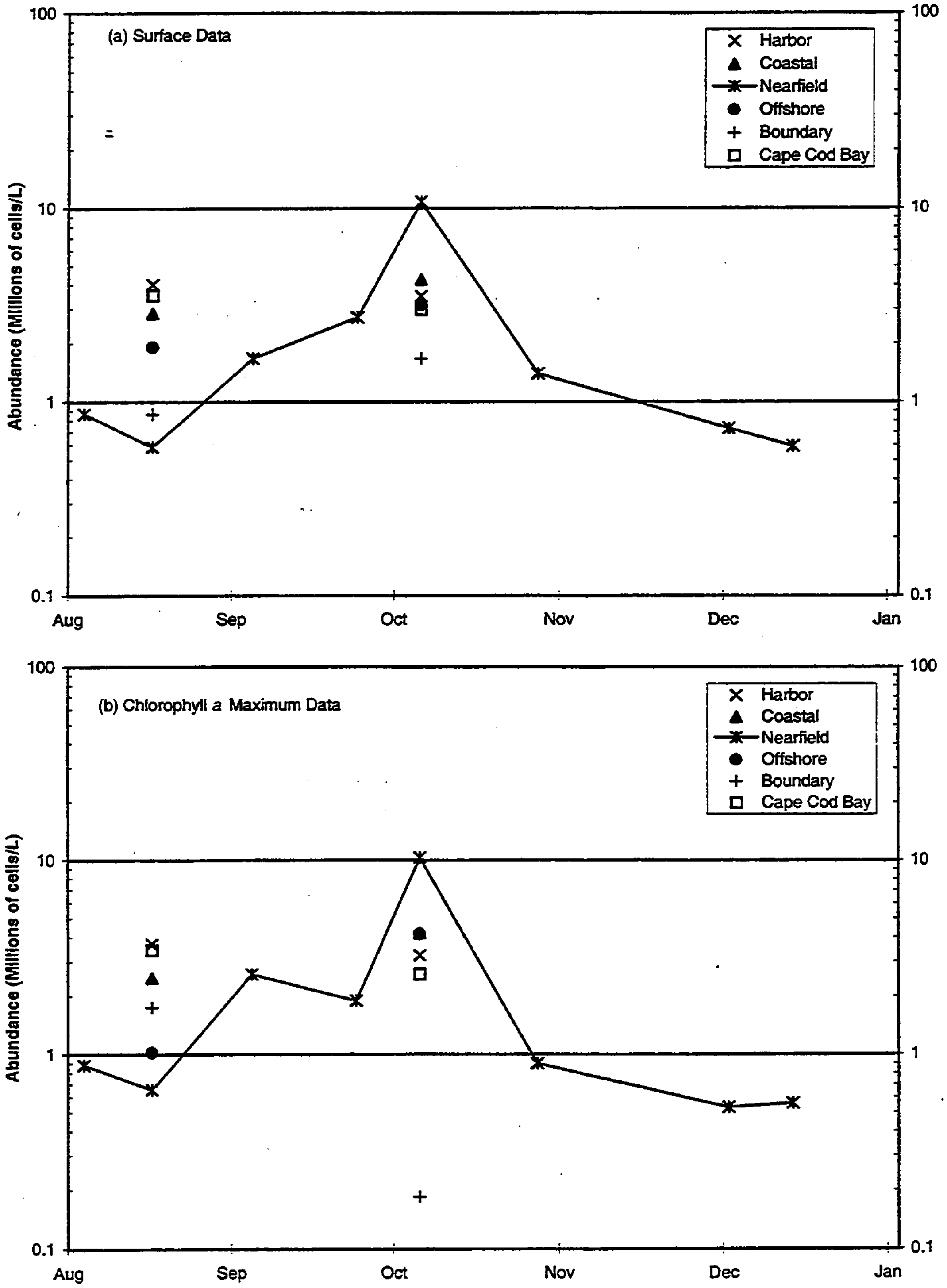


FIGURE 5-9
Regional Phytoplankton Abundance, Surveys W9710 - W9717

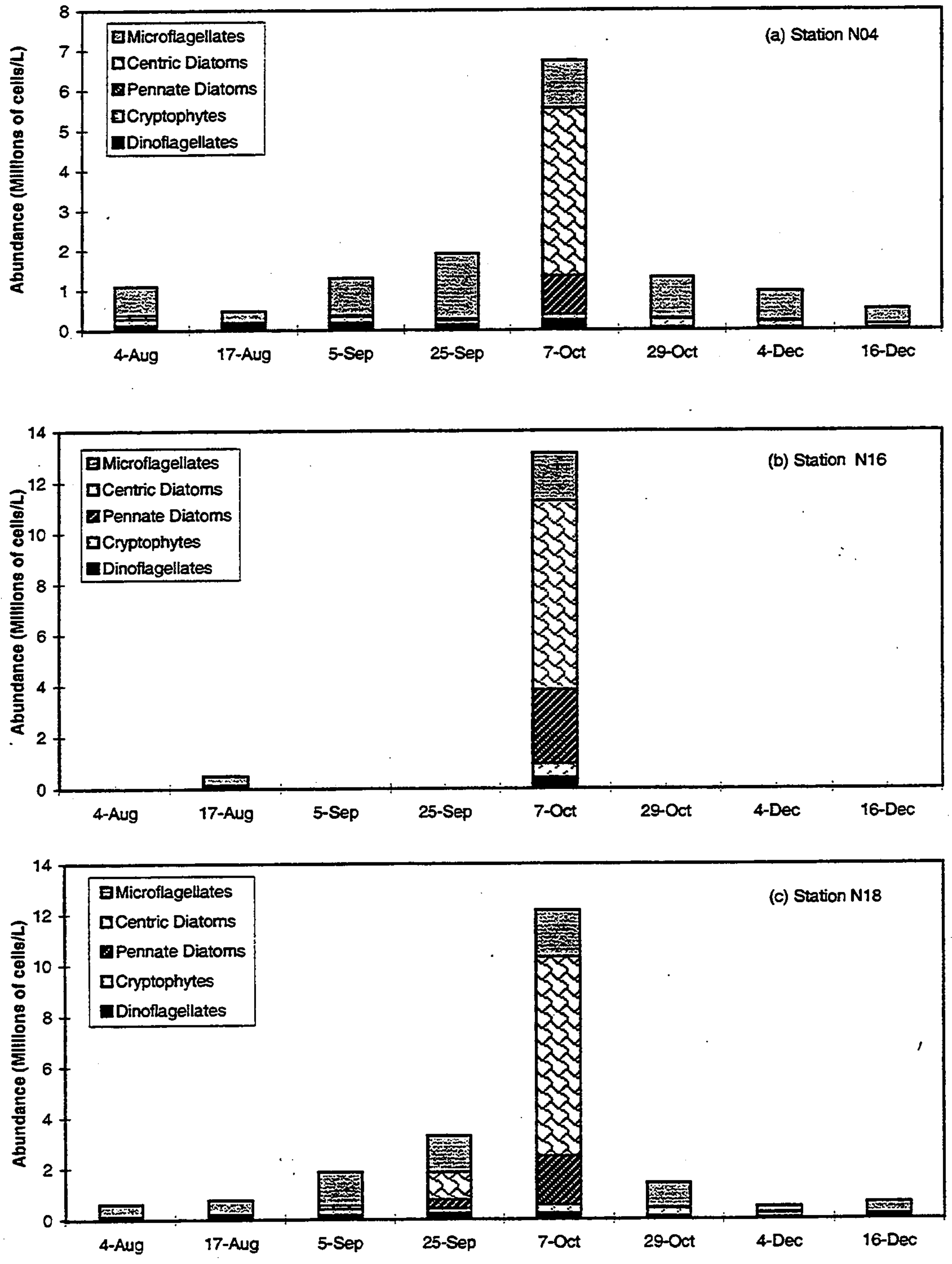


FIGURE 5-10
Phytoplankton Abundance by Major Taxonomic Group, Nearfield Surface Samples

F5-10phy.xls

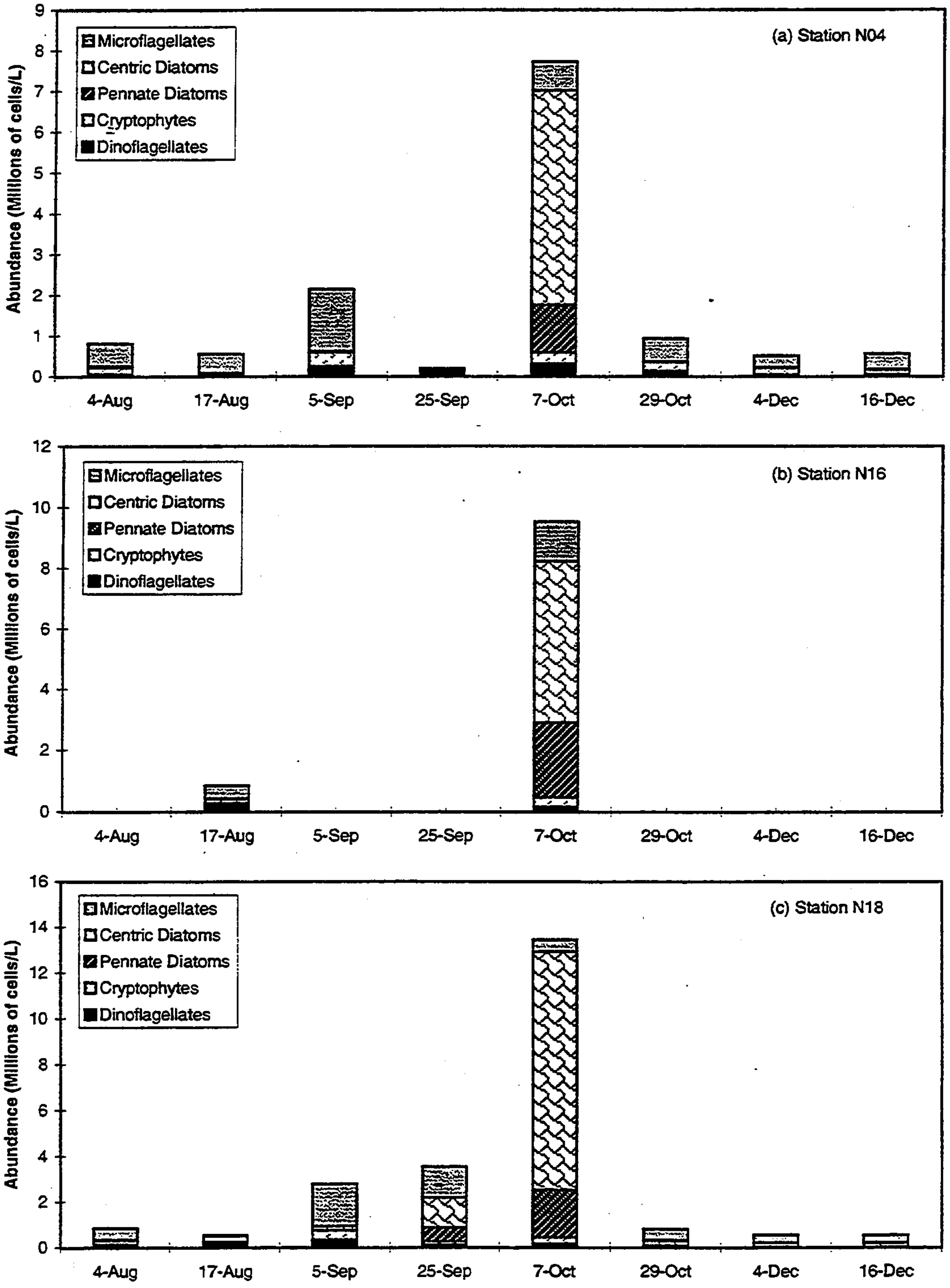


FIGURE 5-11

Phytoplankton Abundance by Major Taxonomic Group, Nearfield Mid-Depth Samples F5-11phy.xls

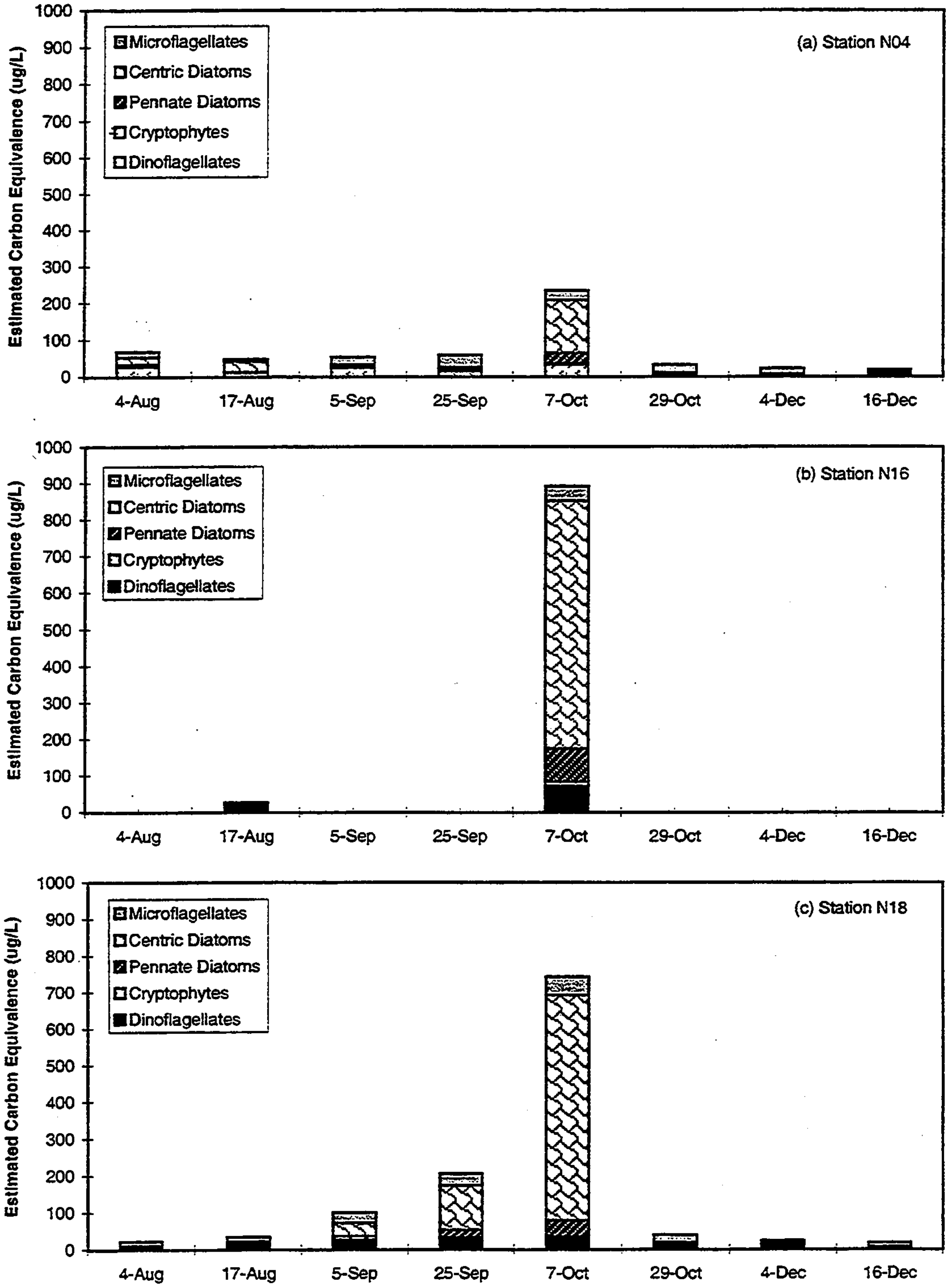


FIGURE 5-12

Phytoplankton Carbon by Major Taxonomic Group, Nearfield Surface Samples

F5-12.xls

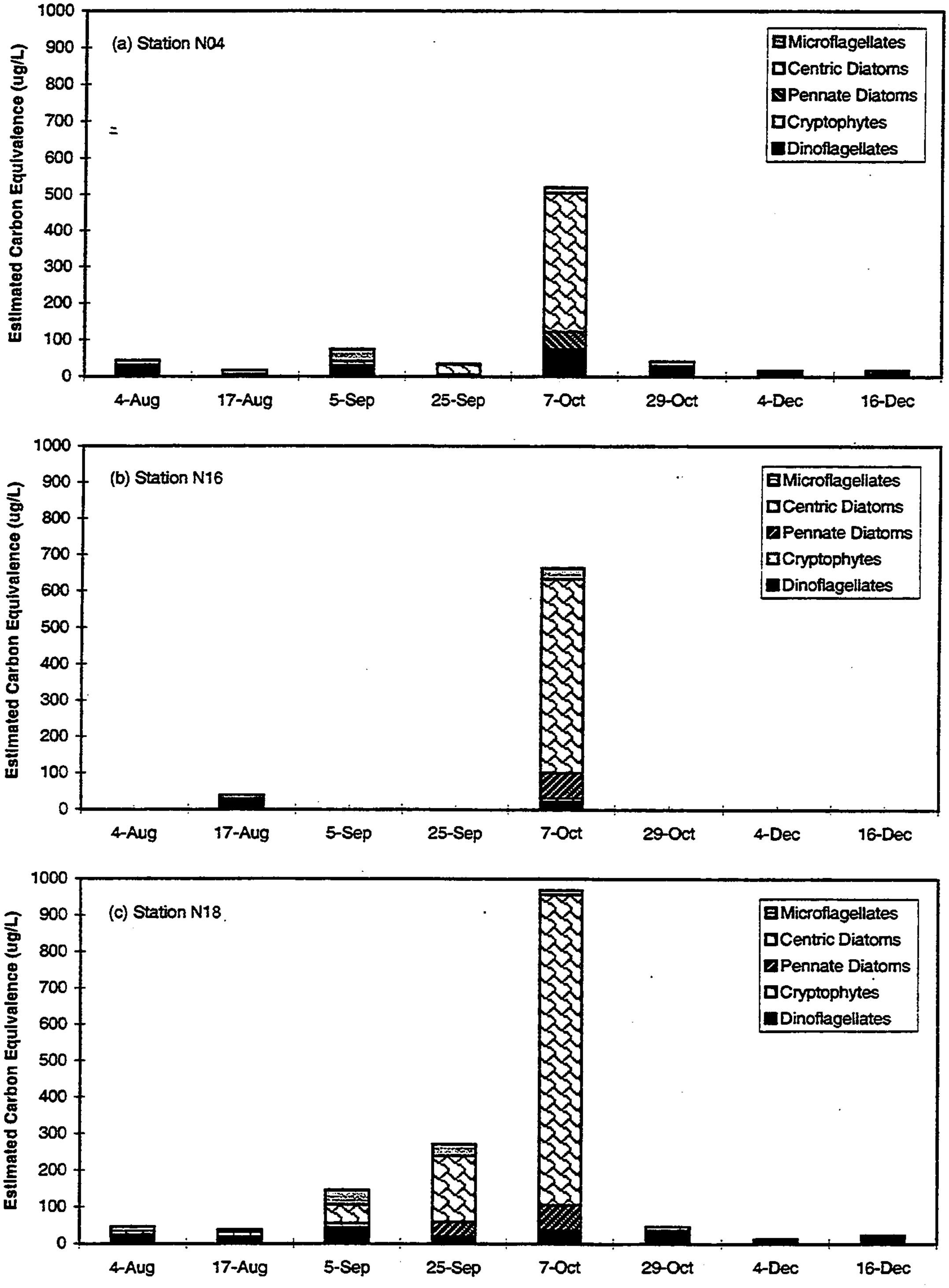


FIGURE 5-13
Phytoplankton Carbon by Major Taxonomic Group, Nearfield Mid-Depth Samples

F5-13.xls

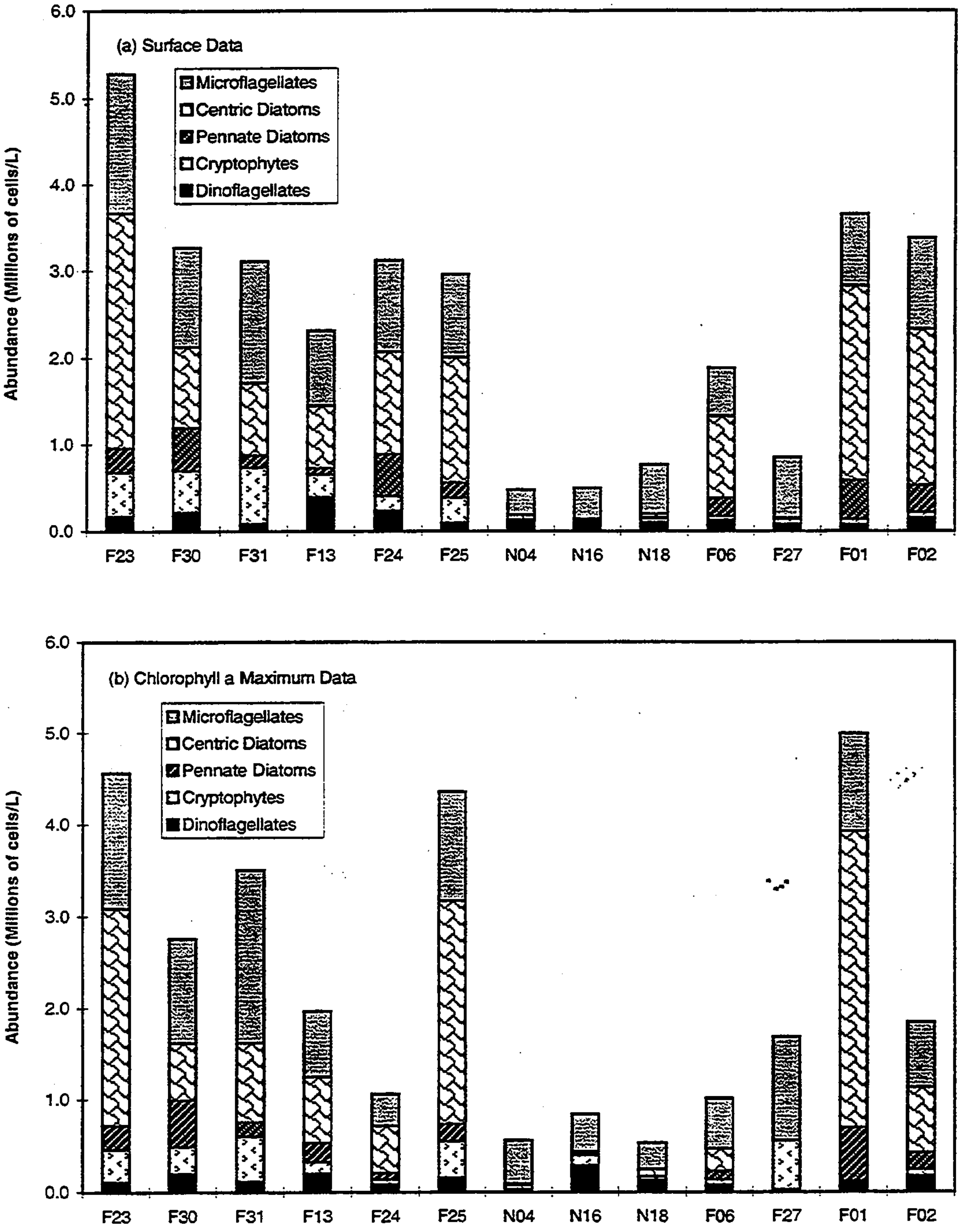


FIGURE 5-14
Phytoplankton Abundance by Major Taxonomic Group -W9711 Farfield Survey Results
August 18-20, 1997

F5-14.xls

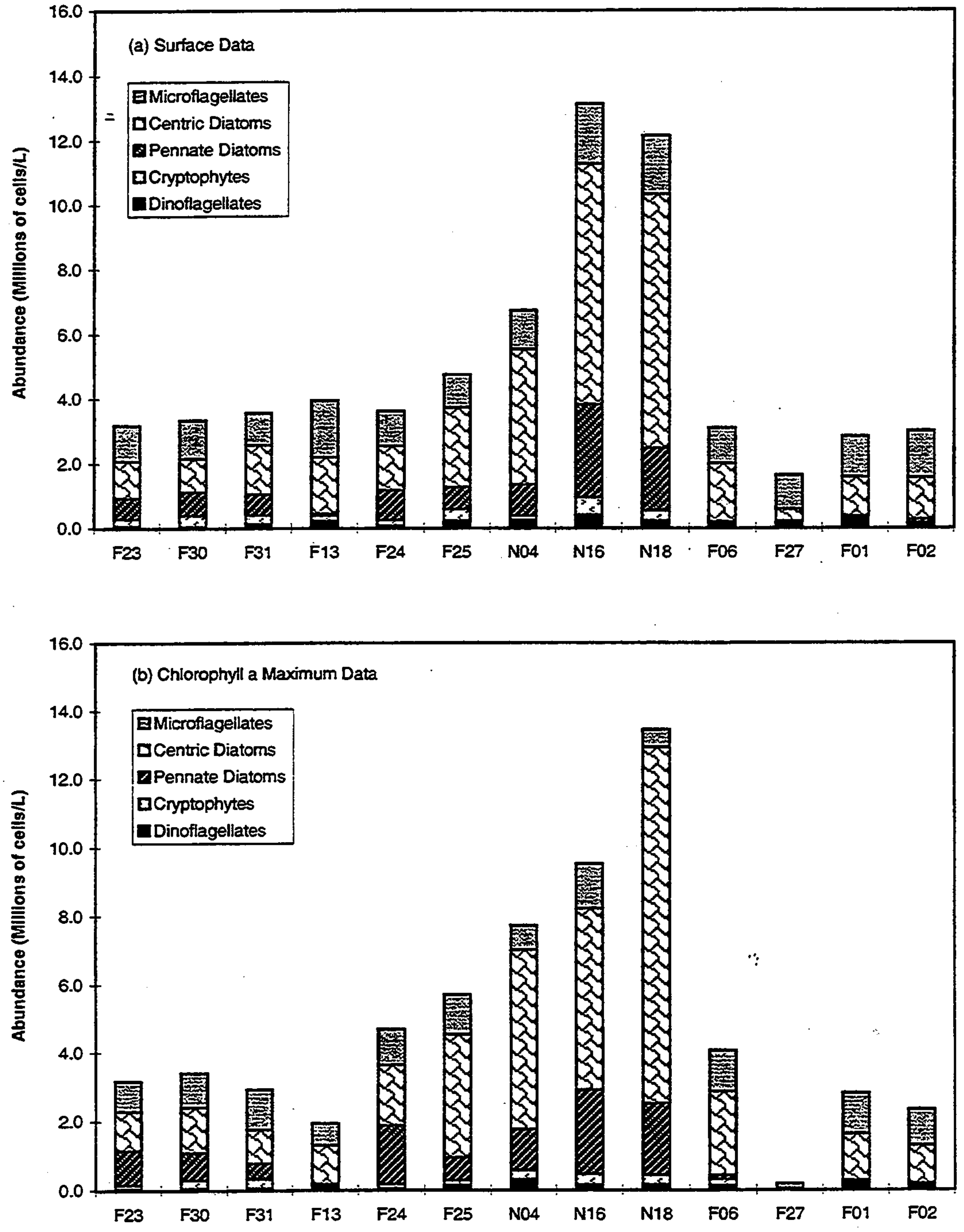


FIGURE 5-15

Phytoplankton Abundance by Major Taxonomic Group - W9714 Farfield Survey Results

October 6-8, 1997

F5-15.xls

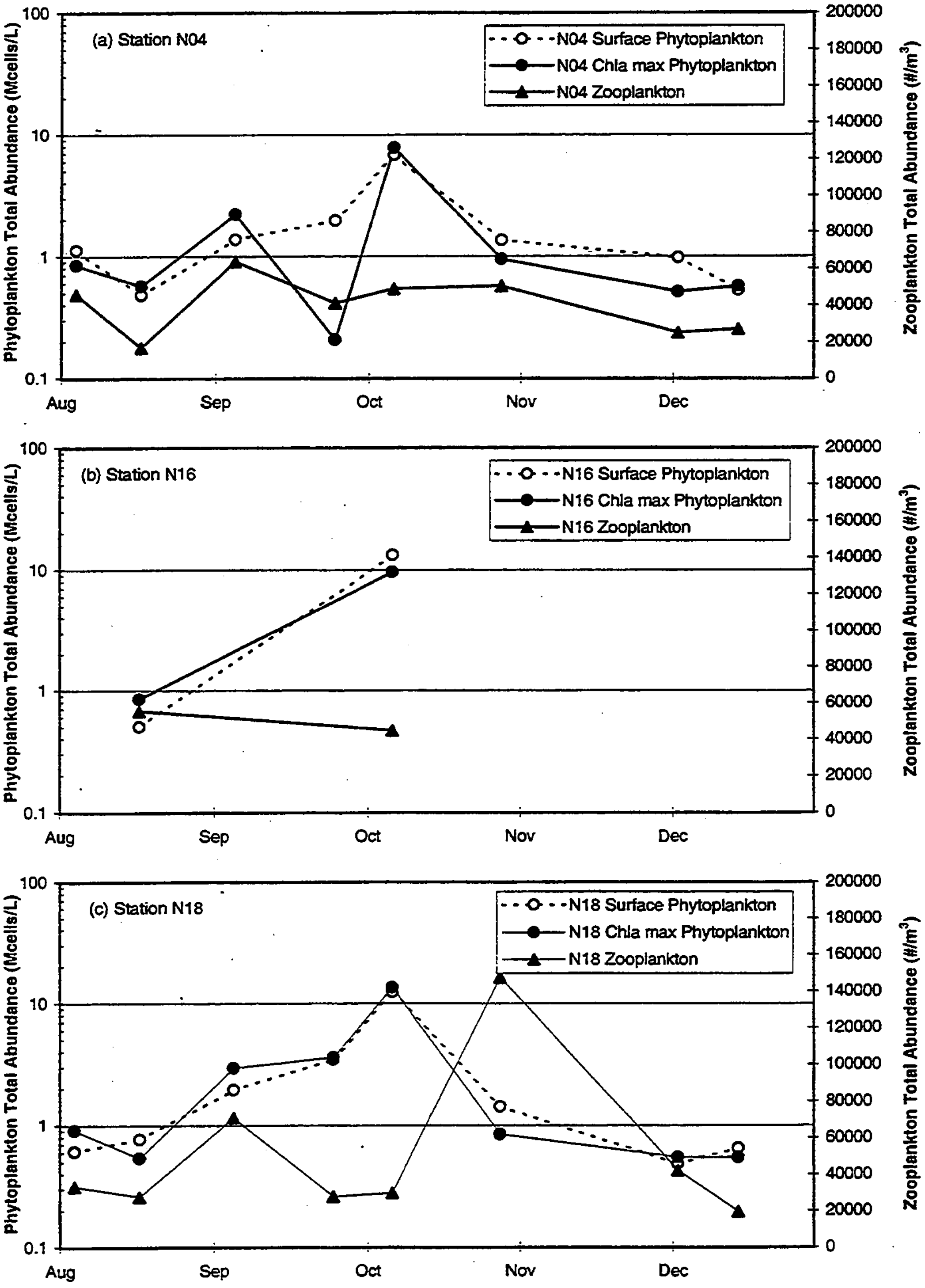


FIGURE 5-16

Nearfield Phytoplankton and Zooplankton Abundance, Surveys W9710 - W9717

F5-16.xls

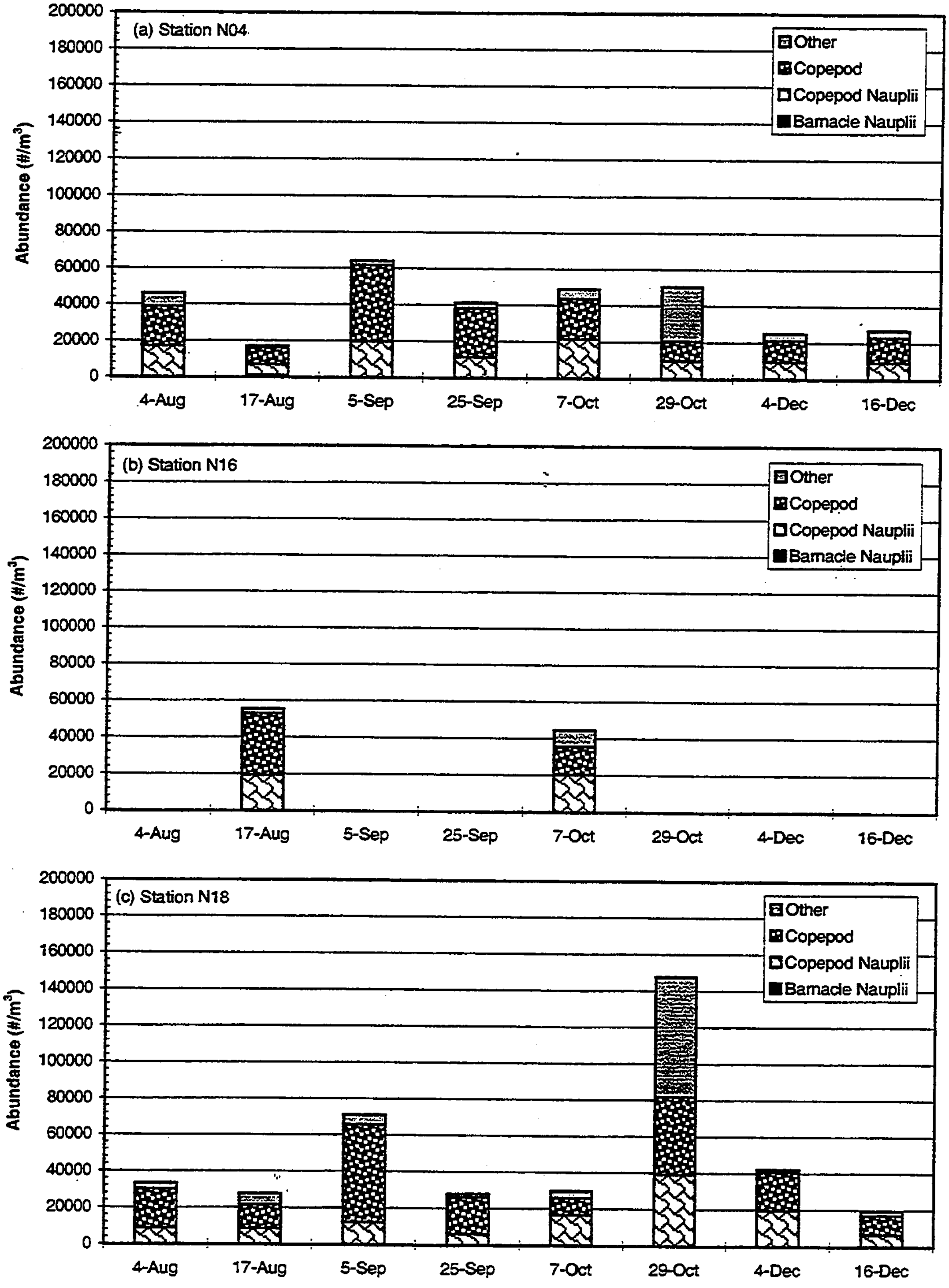


FIGURE 5-17
Nearfield Zooplankton Abundance by Major Taxonoimc Group

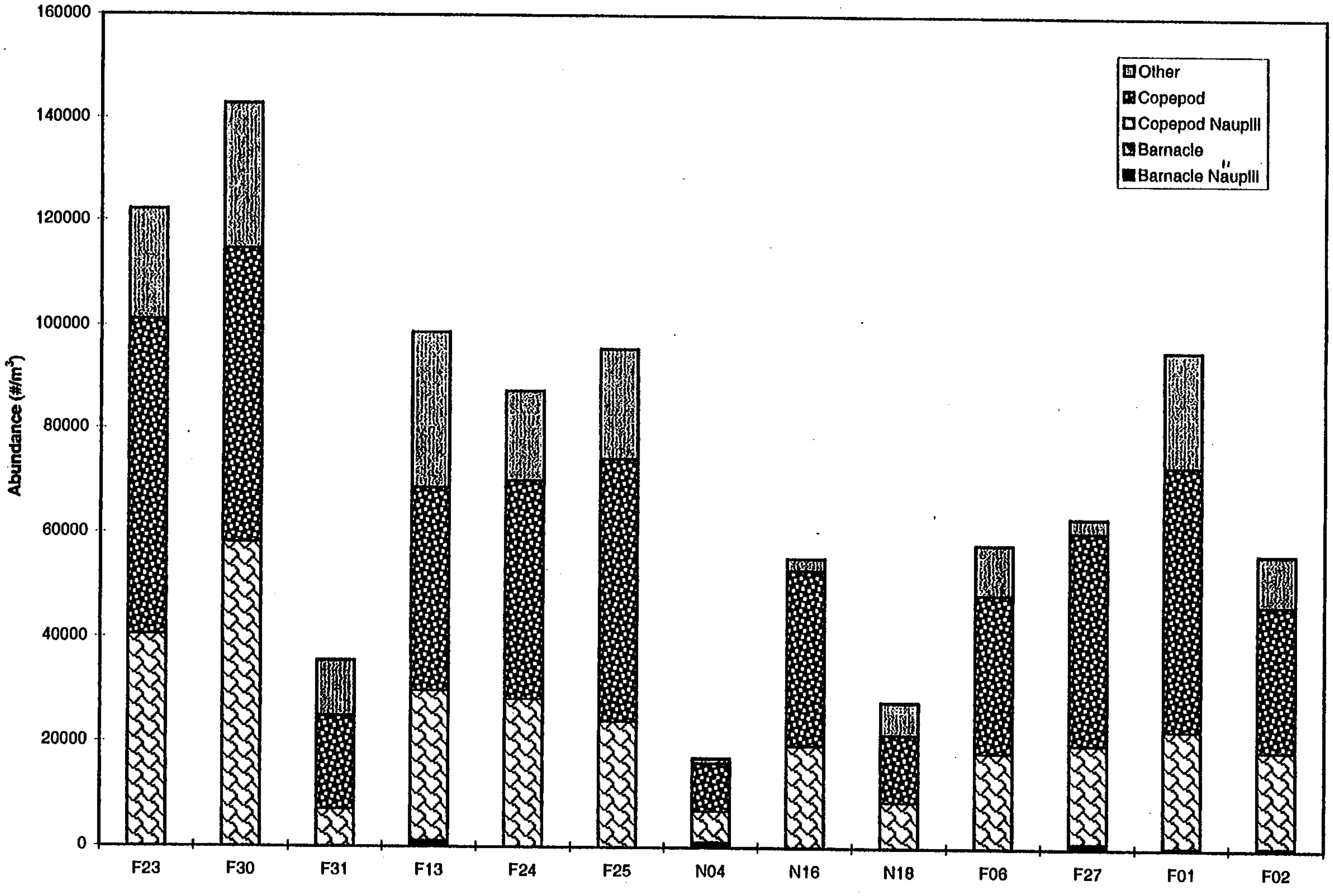


FIGURE 5-18
Zooplankton Densities by Major Taxonomic Group - W9711 Farfield Survey Results
August 18 - 20, 1997

F5-18.xls

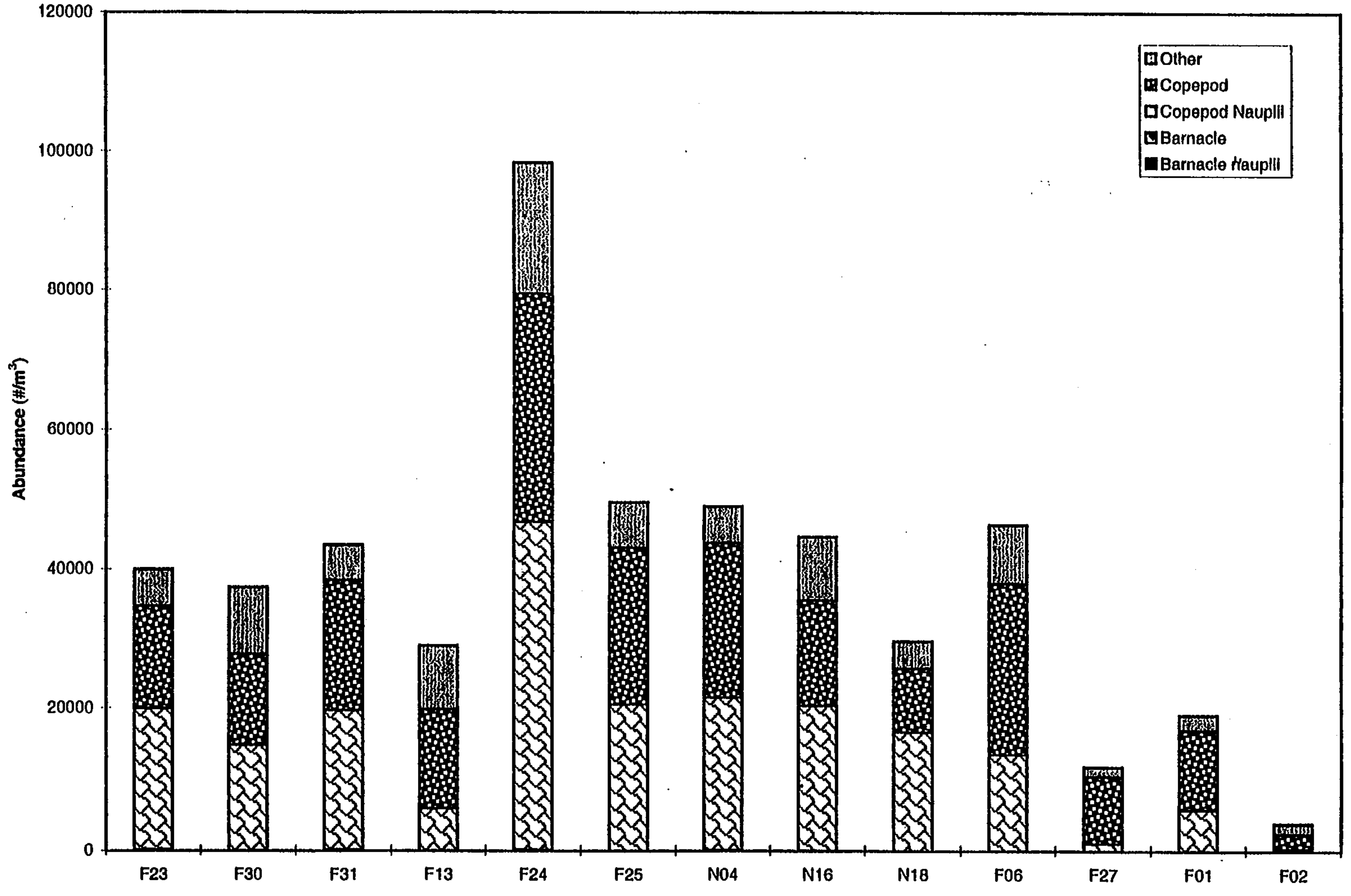


FIGURE 5-19
Zooplankton Densities by Major Taxonomic Group - W9714 Farfield Survey Results
October 6 - 8, 1997

F5-19.xls

6.0 A SUMMARY OF MAJOR WATER COLUMN EVENTS

This section provides an integrated summary of significant events that occurred in Massachusetts Bay, Cape Cod Bay and Boston Harbor during the latter part of 1997. Events that influenced the integrity of the stratified water column included coastal upwelling and storm-driven mixing of the surface layer during late August and September, and the seasonal breakdown in stratification that occurred during October. The breakdown of stratification caused the termination of the seasonal decline of bottom water dissolved oxygen (DO) concentration. Key biological events observed by the monitoring program included a phytoplankton bloom in the Harbor and coastal stations during August, and a fall bloom during early October.

Evidence of coastal upwelling during late August (W9711) included decreasing bottom water temperature and increasing bottom salinity, areas of colder, more saline surface water at coastal stations, and prolonged onshore bottom water currents. Although a strong phytoplankton bloom in Boston Harbor may have influenced adjacent coastal stations, the phytoplankton assemblage that produced elevated coastal chlorophyll concentrations further south differed from the Harbor assemblage. The more southerly bloom may therefore have developed in response to nutrient release from sub-pycnocline water transported to the surface.

Both sensor data and nutrient chemistry results indicated that the nearfield remained stratified in October in the bottom waters, with incomplete mixing at the deeper stations of the nearfield still evident by the late October survey (W9715). However, vertical cast data from the shallower inshore stations of the nearfield indicated a more uniform water column in late September, which was again coincidental with evidence of onshore advection and potential upwelling (onshore bottom currents and a prolonged period of decreasing temperature and increasing salinity in bottom water). HOM data indicated little chlorophyll activity during the late September survey (W9713), but documented a strong fall bloom during early October (W9714), particularly at the inshore stations and in northern Massachusetts Bay. Continuous data from the USGS mooring showed a substantial increase in chlorophyll shortly after the late September survey, which may have also been documented by elevated chlorophyll-specific production estimates during W9713.

The fall bloom may have therefore developed inshore in late September in response to near-coastal phenomena and subsequently progressed further into Massachusetts Bay. It may be speculated that the continued release of sub-pycnocline nutrients continued to fuel the bloom during October after survey W9714, particularly in mid-month when mooring data indicated that substantial mixing occurred (rapid increase in bottom water temperature and decrease in salinity over a three-day period). The seasonal peak in zooplankton abundance documented by the nearfield survey at month's end may infer bloom conditions during the period; however, there are no supporting data to directly document chlorophyll activity during this period.

The protracted sequence of water column mixing also affected results for bottom water DO concentration. The minimum average nearfield bottom water concentration (7.3 mg/L) was reported during early October (W9714). The average bottom water concentration over the nearfield rose by the late October survey (W9715), but since vertical mixing had yet to reach the deeper stations, individual minima for concentration (6.4 mgL^{-1}) and saturation (68.5 percent) were recorded during late October. These late-season minima caused by the delayed mixing might have very well been even lower had not the seasonal decline in bottom water DO concentration been mitigated by large-scale advection during July, when a 1.5 mgL^{-1} increase in bottom DO was observed (Cibik *et al.,* 1998). These events will be more fully discussed in the 1997 annual water column report.

7.0 REFERENCES

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Cibik, S.J., K.B. Lemieux, B.L. Howes, C.S. Davis, C.D. Taylor and T.C. Loder III. 1998. Semi-annual water column monitoring report: February – July 1997. Boston: Massachusetts Water Resources Authority. Report ENQUAD 98-17. 442 p.

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NRCC, 1998. Climate Impacts - January to December 1997. Northeast Regional Climate Center, Cornell University, Ithaca, New York. http://met-www.cit.cornell.edu/

Taylor, C. D. 1998. Procedures for the Measurement of Primary Production in Massachusetts Bay. Prepared for the Massachusetts Water Resources Authority, Boston, MA.

APPENDIX A

SURFACE CONTOUR PLOTS-FARFIELD SURVEYS

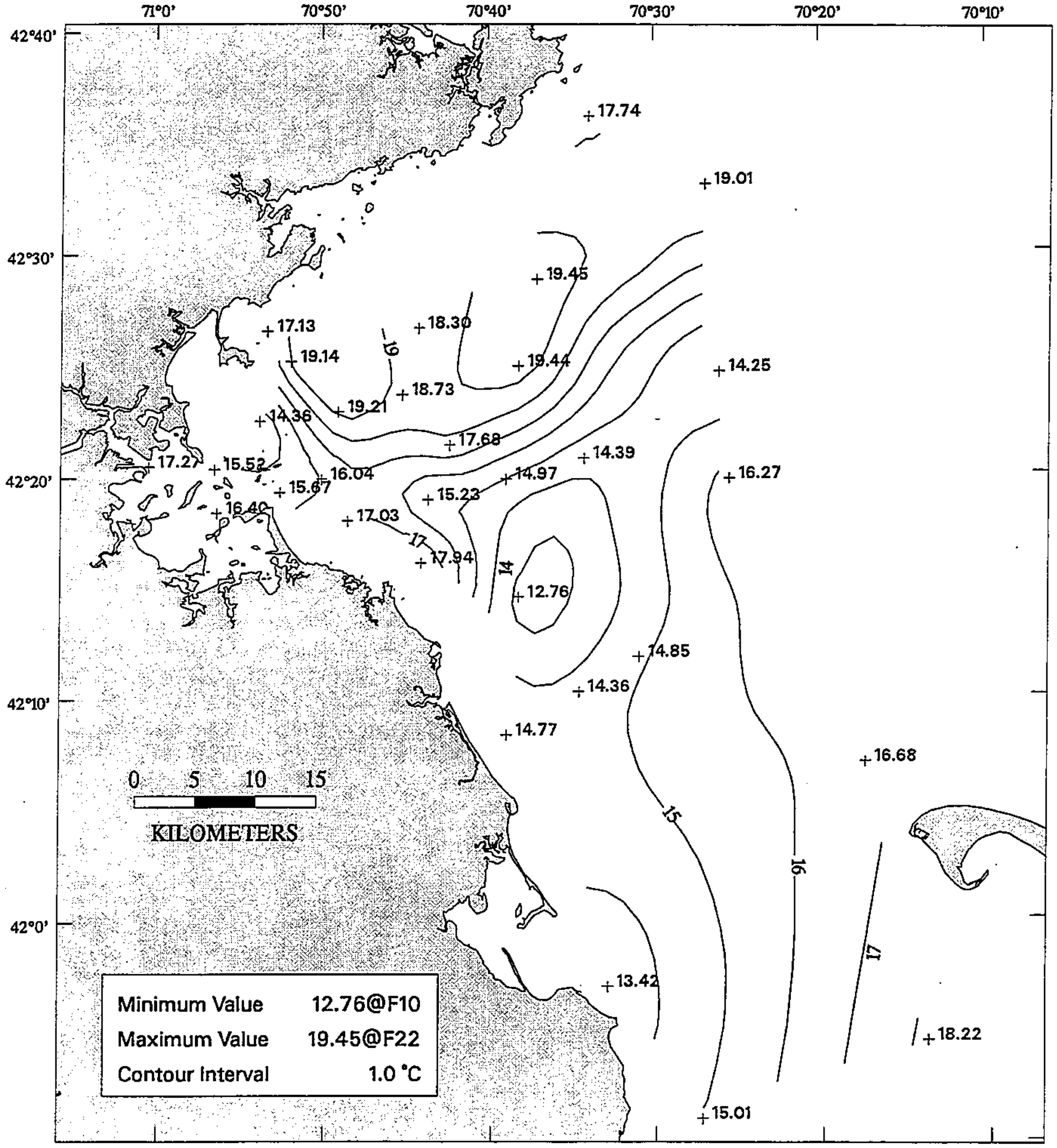
APPENDIX A
Surface Contour Plots - Farfield Surveys

All contour plots were created using data from the surface bottle sample (A). Each plot is labeled on the bottom right with the survey number ("9711"), and parameter as listed below. The minimum and maximum value, and the station where the value was measured, is provided for each plot, as well as the contour interval and parameter units.

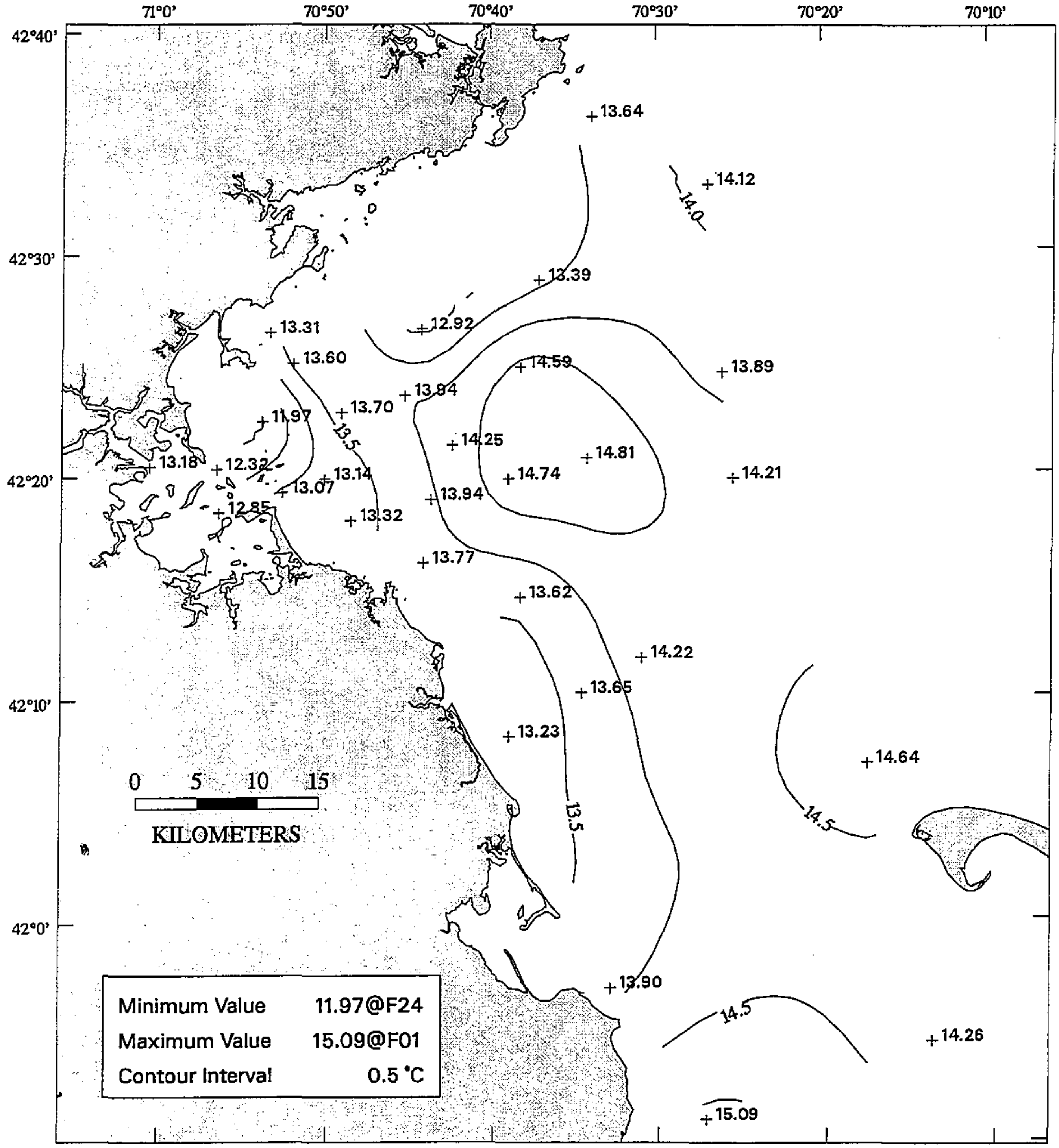
Appendix A: Table of Contents

Parameter Name	Map Parameter Name	Units
Temperature	temp_lin	°C
Salinity	sal_lin	PSU
Transmissivity (beam attenuation)	tran_lin	/m
Nitrate (NO$_3$)	no3_lin	µM
Phosphate (PO$_4$)	po4_lin	µM
Silicate (SiO$_4$)	sio4_lin	µM
Dissolved Inorganic Nitrogen (DIN*)	din_lin	µM
Chlorophyll *a*	fluo_lin	µg/L

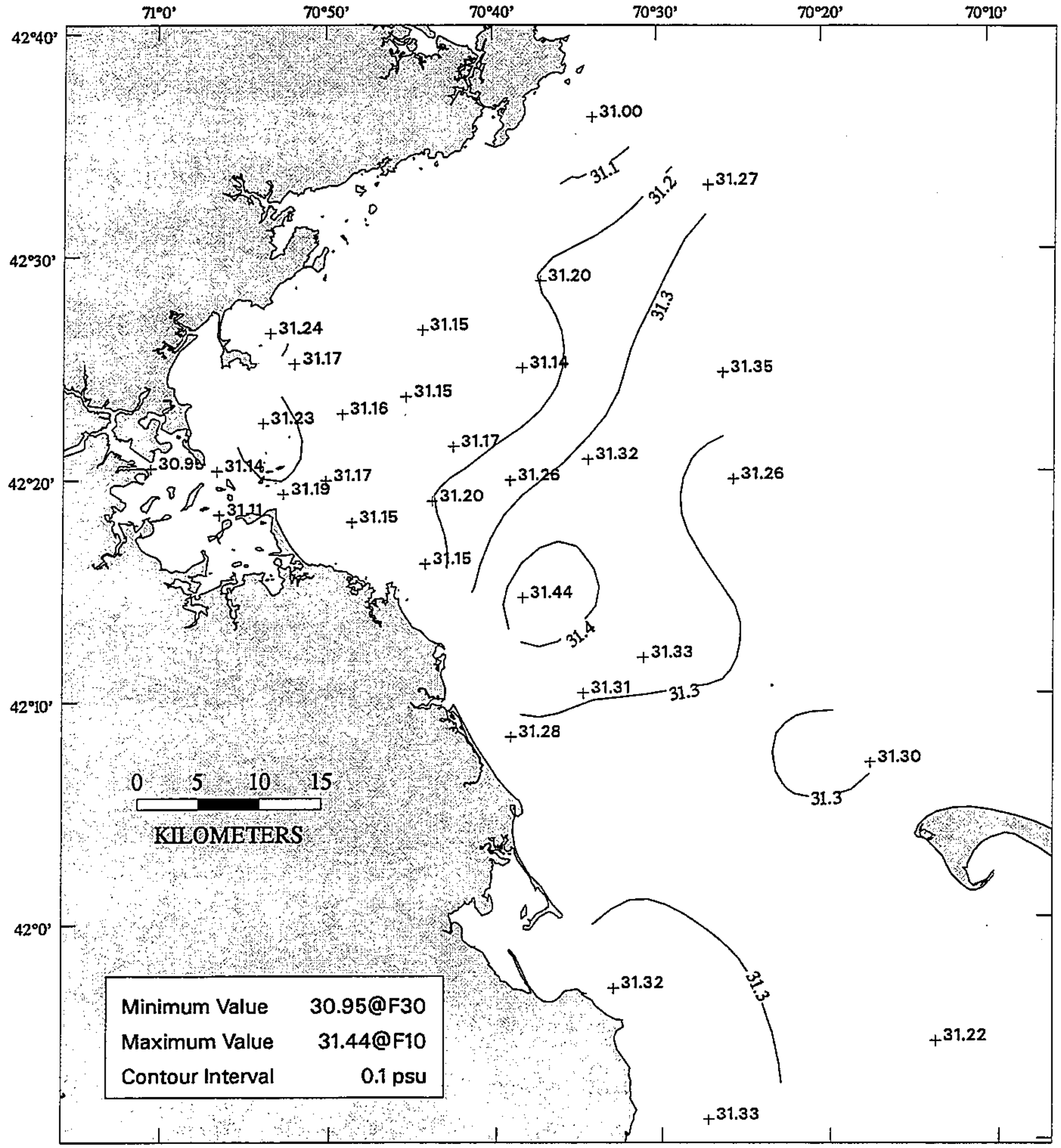
*$NO_3 + NO_2 + NH_4$



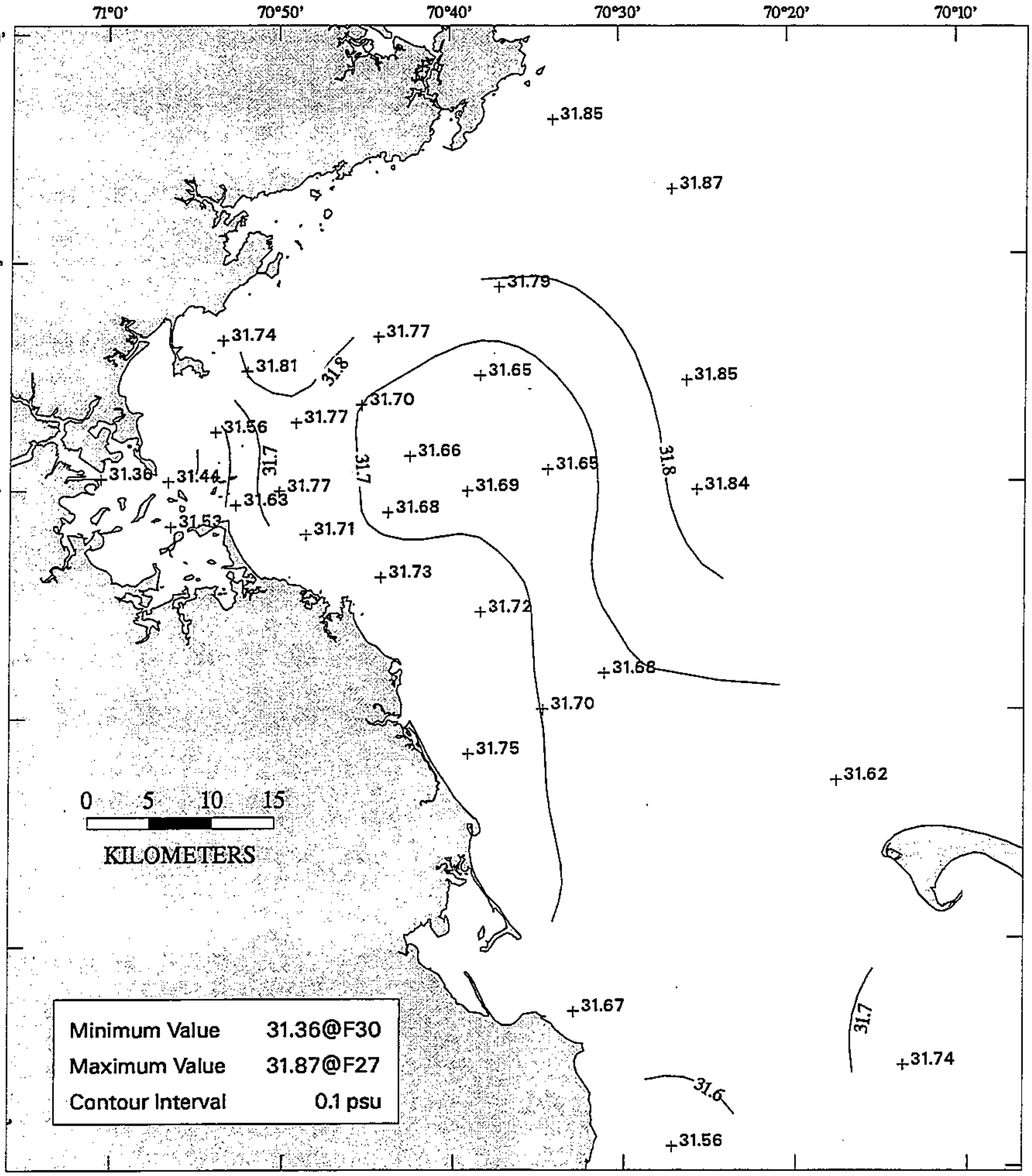
9711temp_lin
TEMP



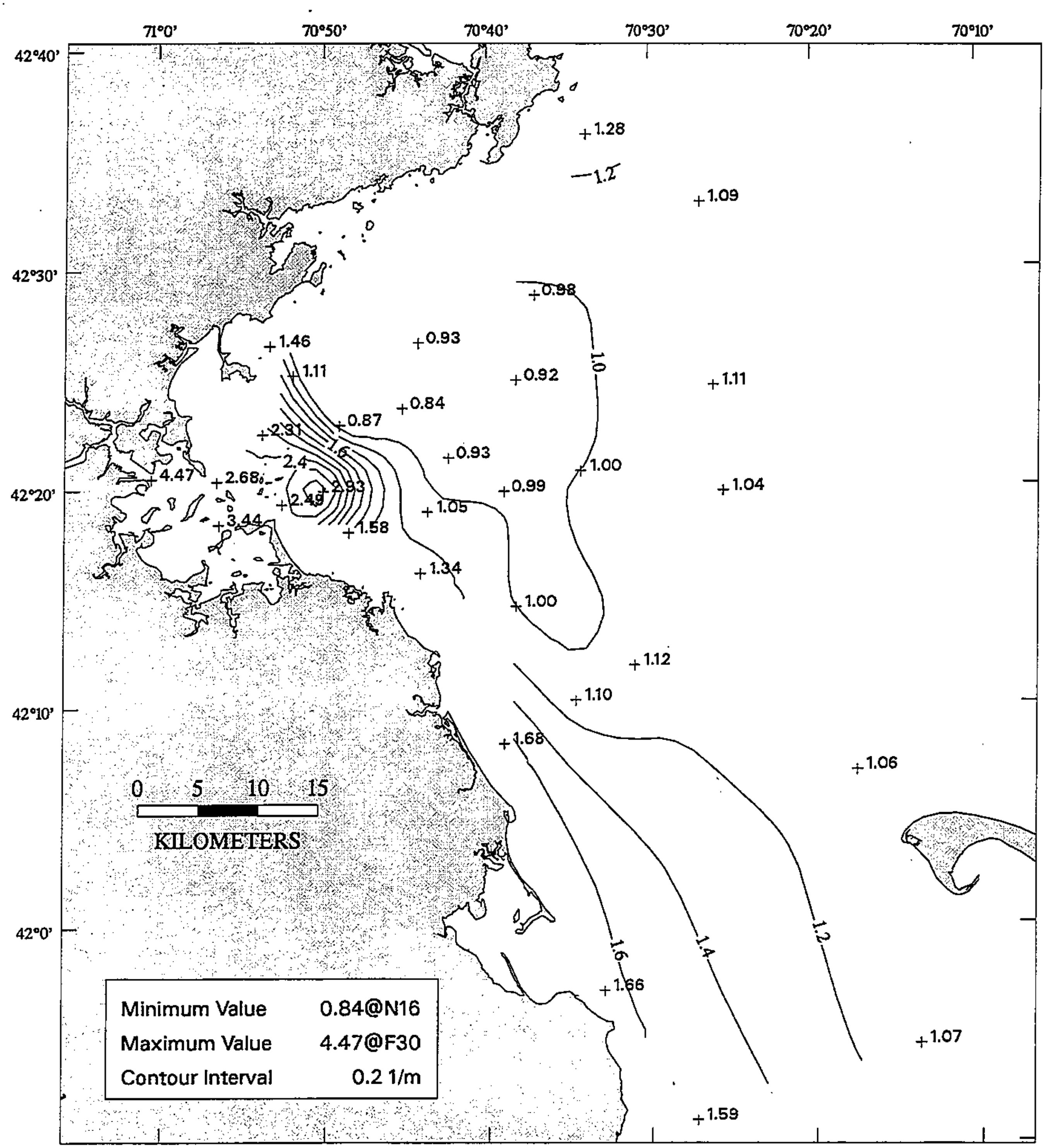
9714temp_lin
TEMP



9711sal_lin
SAL

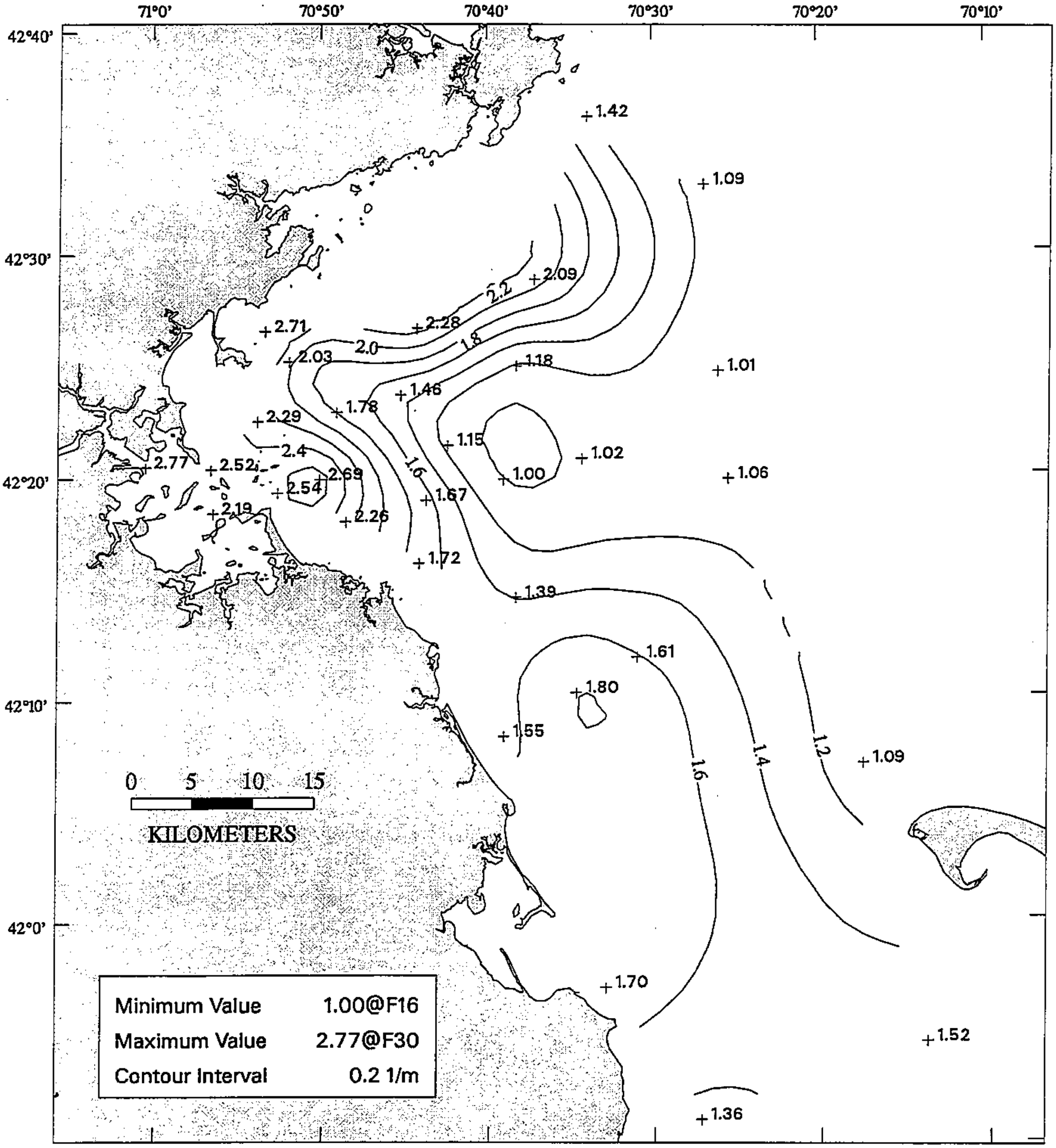


9714sal_lin
SAL

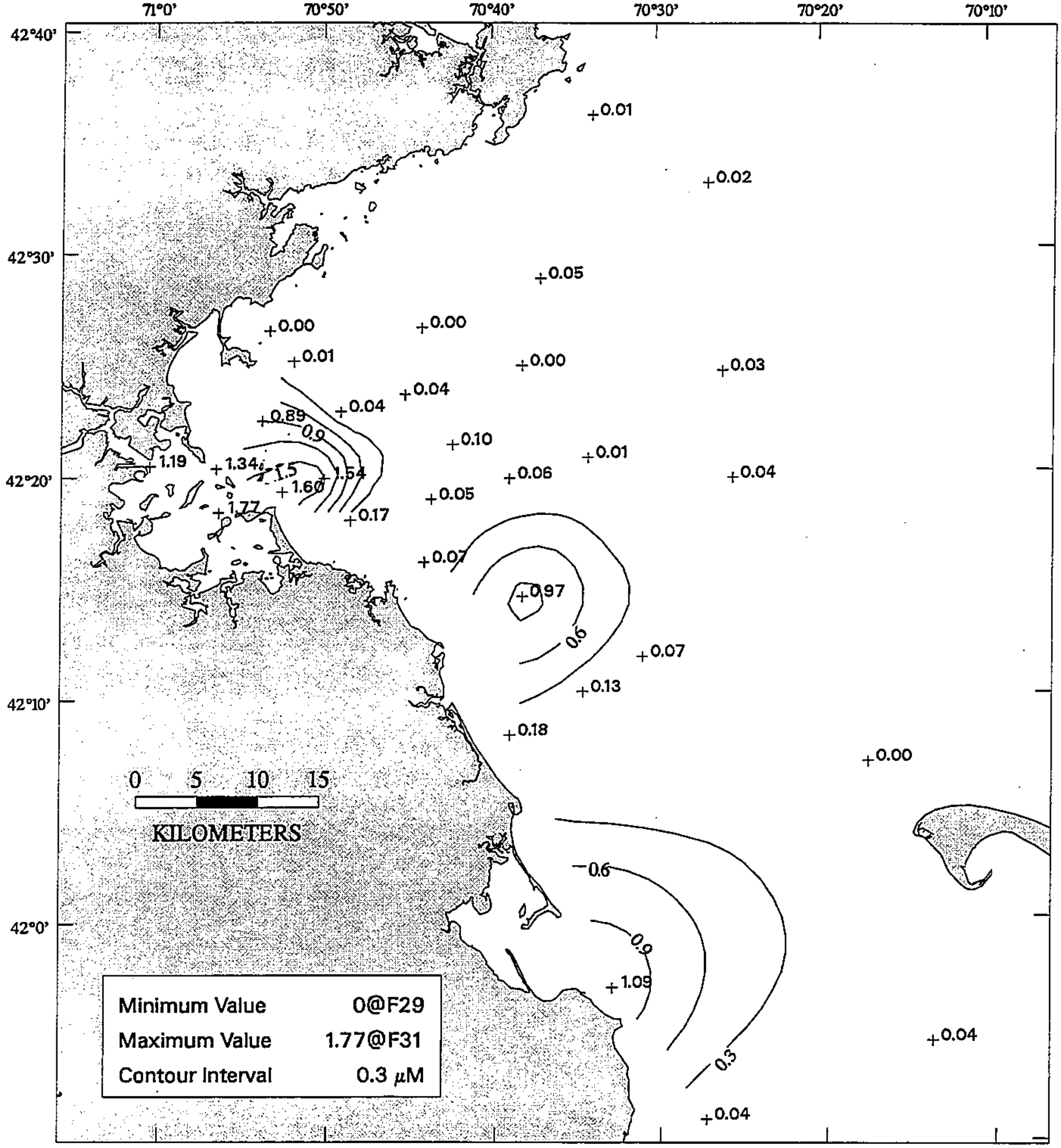


Minimum Value	0.84@N16
Maximum Value	4.47@F30
Contour Interval	0.2 1/m

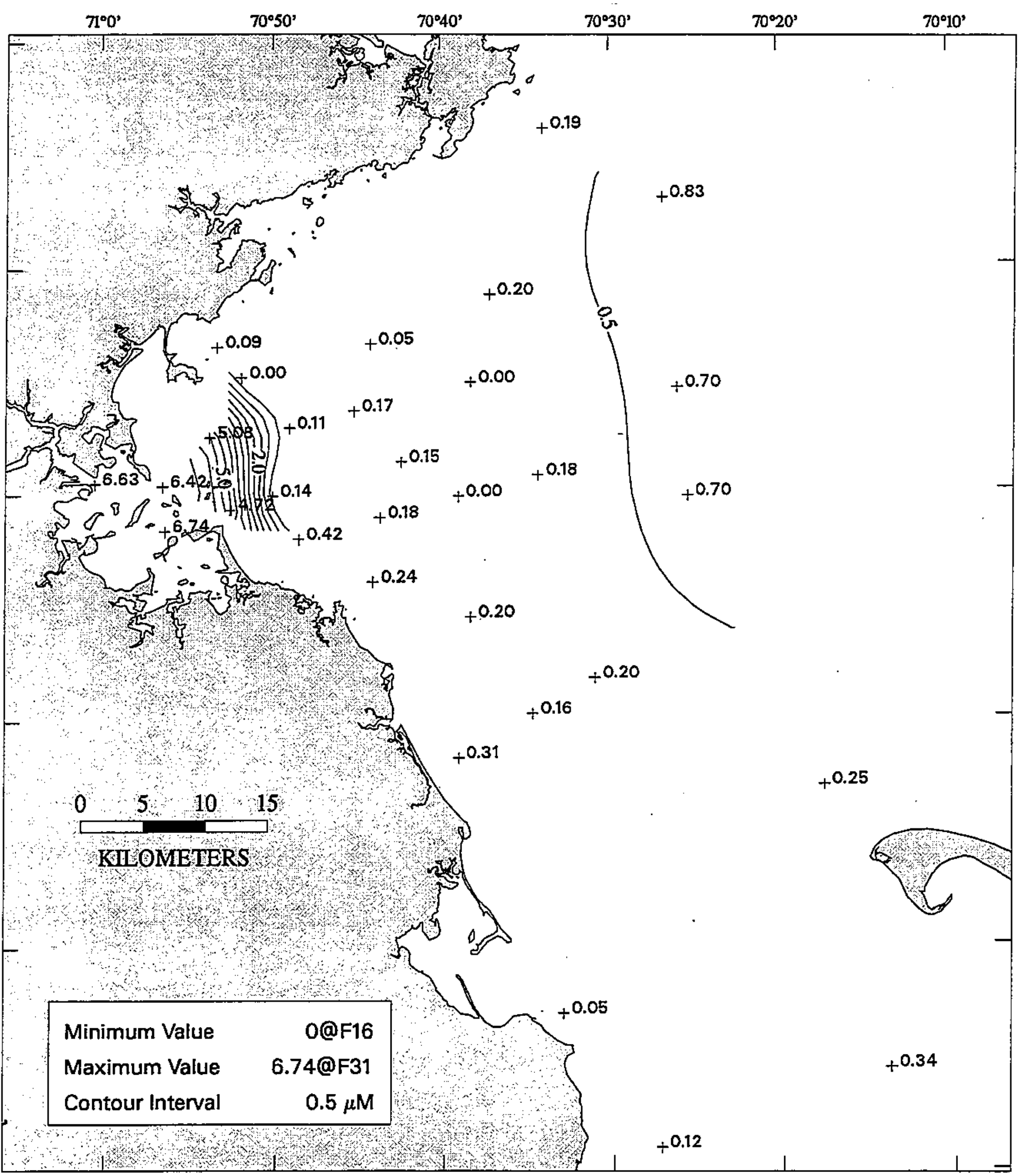
9711tran_lin
TRAN



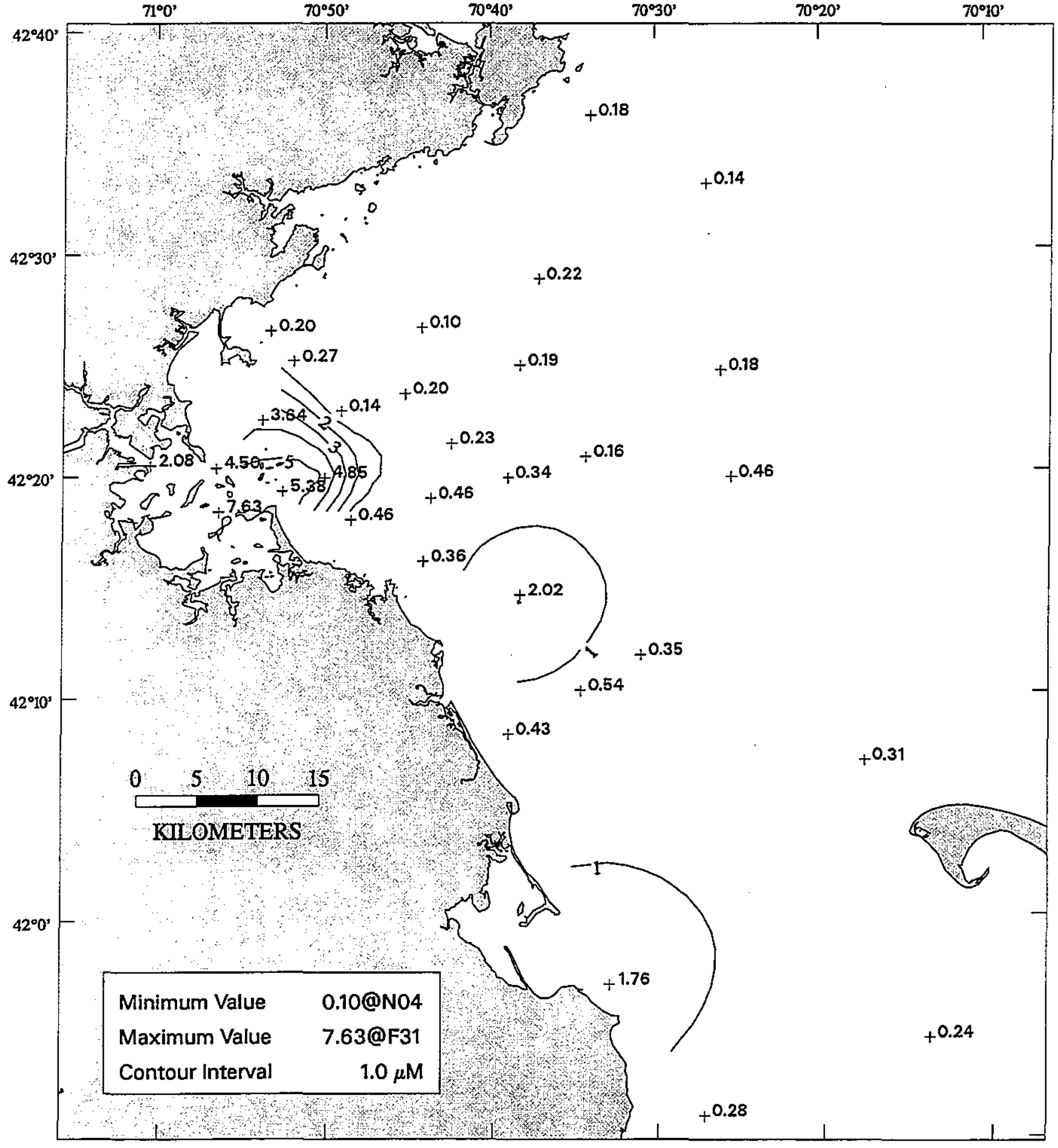
9714tran_lin
TRAN



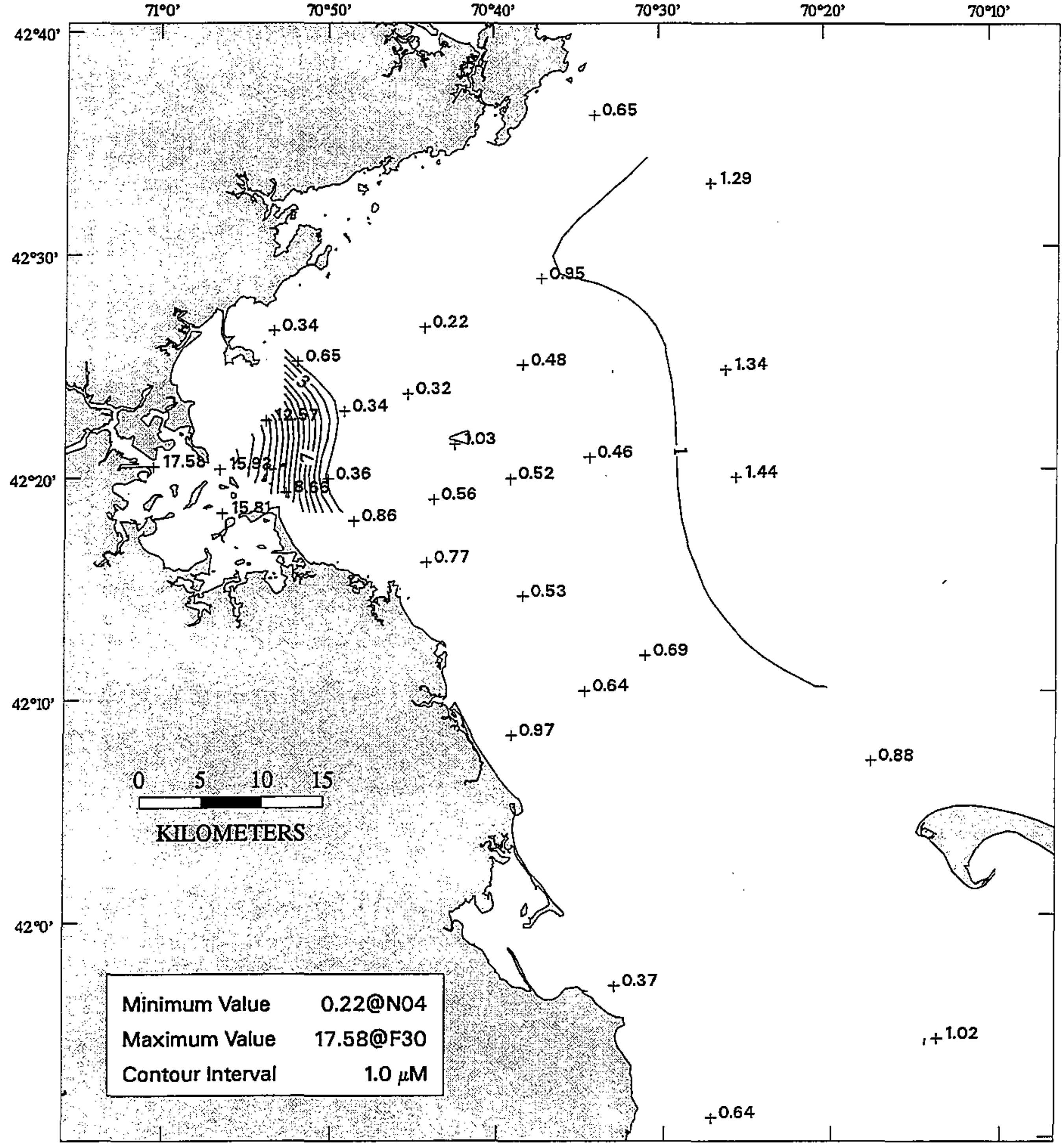
9711no3_lin
NO3



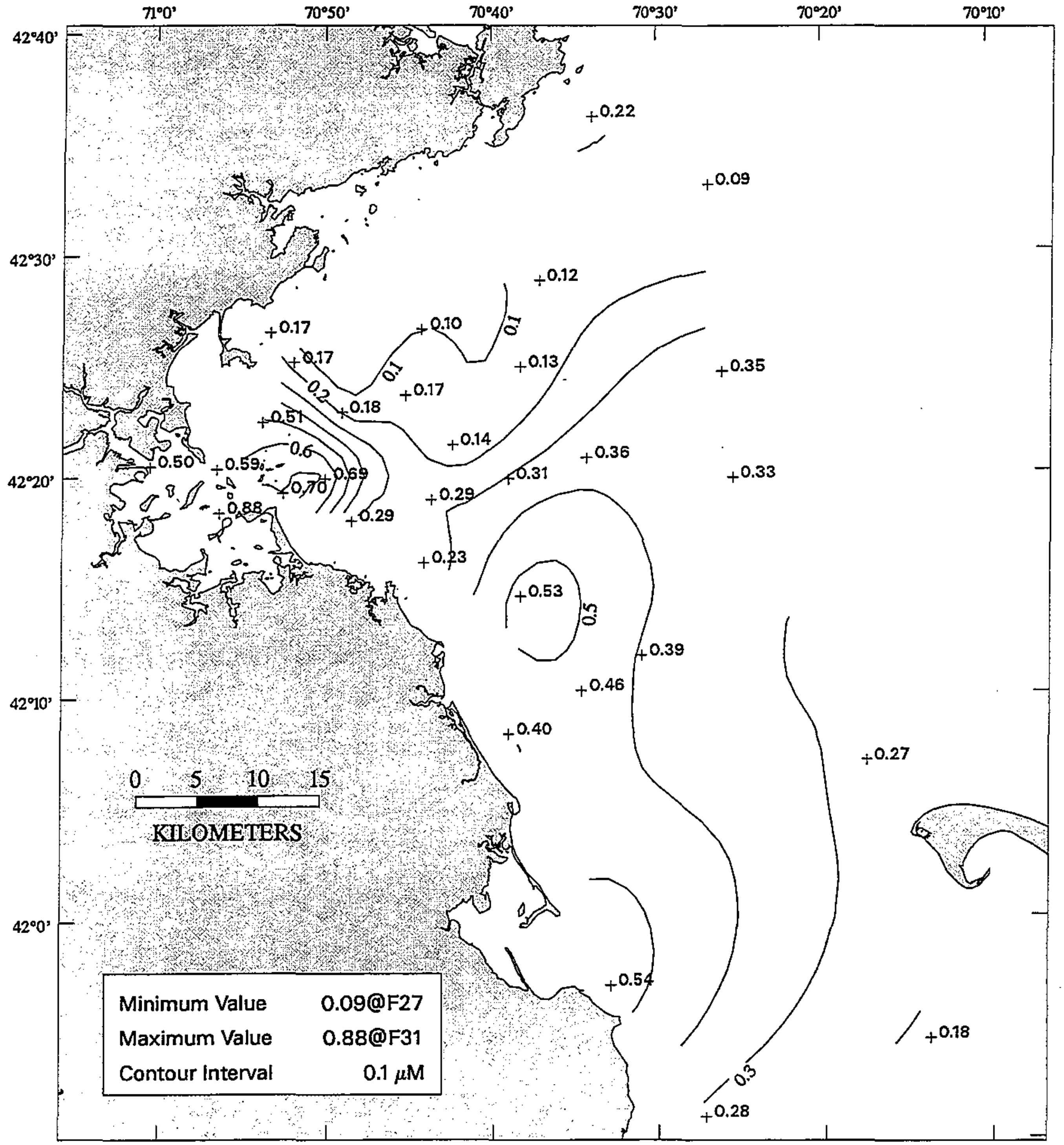
9714no3_lin
NO3



9711din_lin
DIN

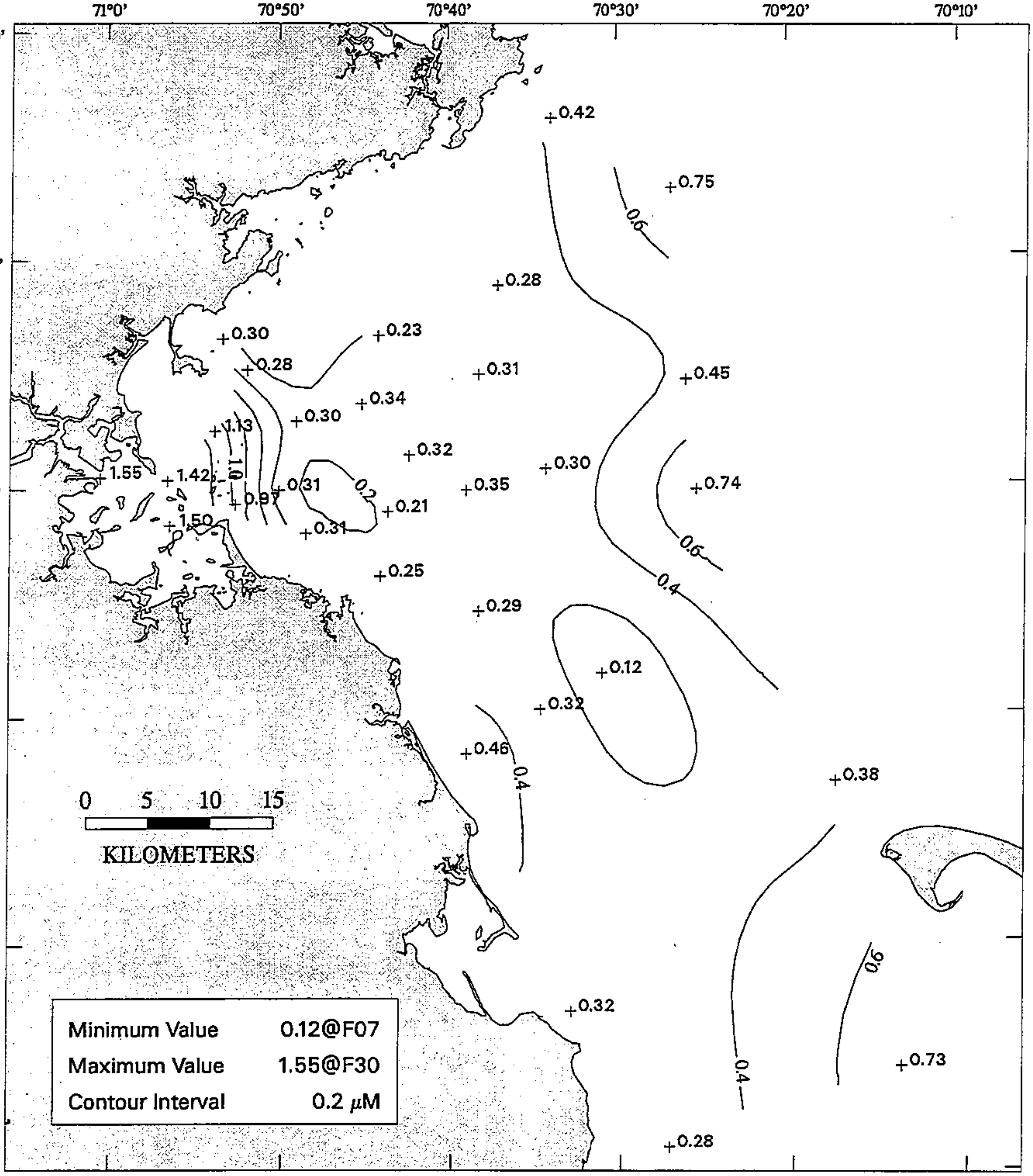


9714din_lin
DIN

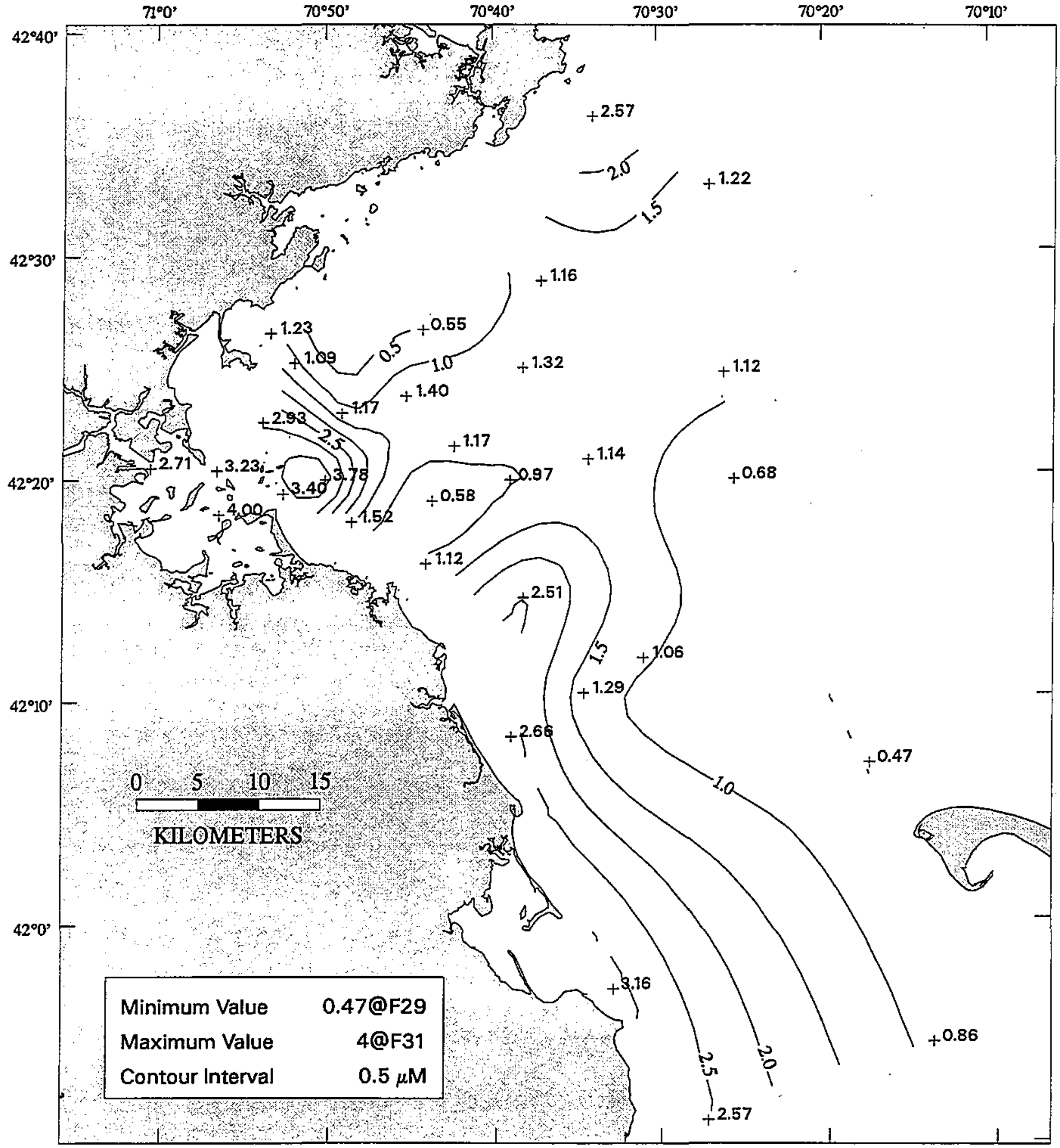


Minimum Value 0.09@F27
Maximum Value 0.88@F31
Contour Interval 0.1 μM

9711po4_lin
PO4

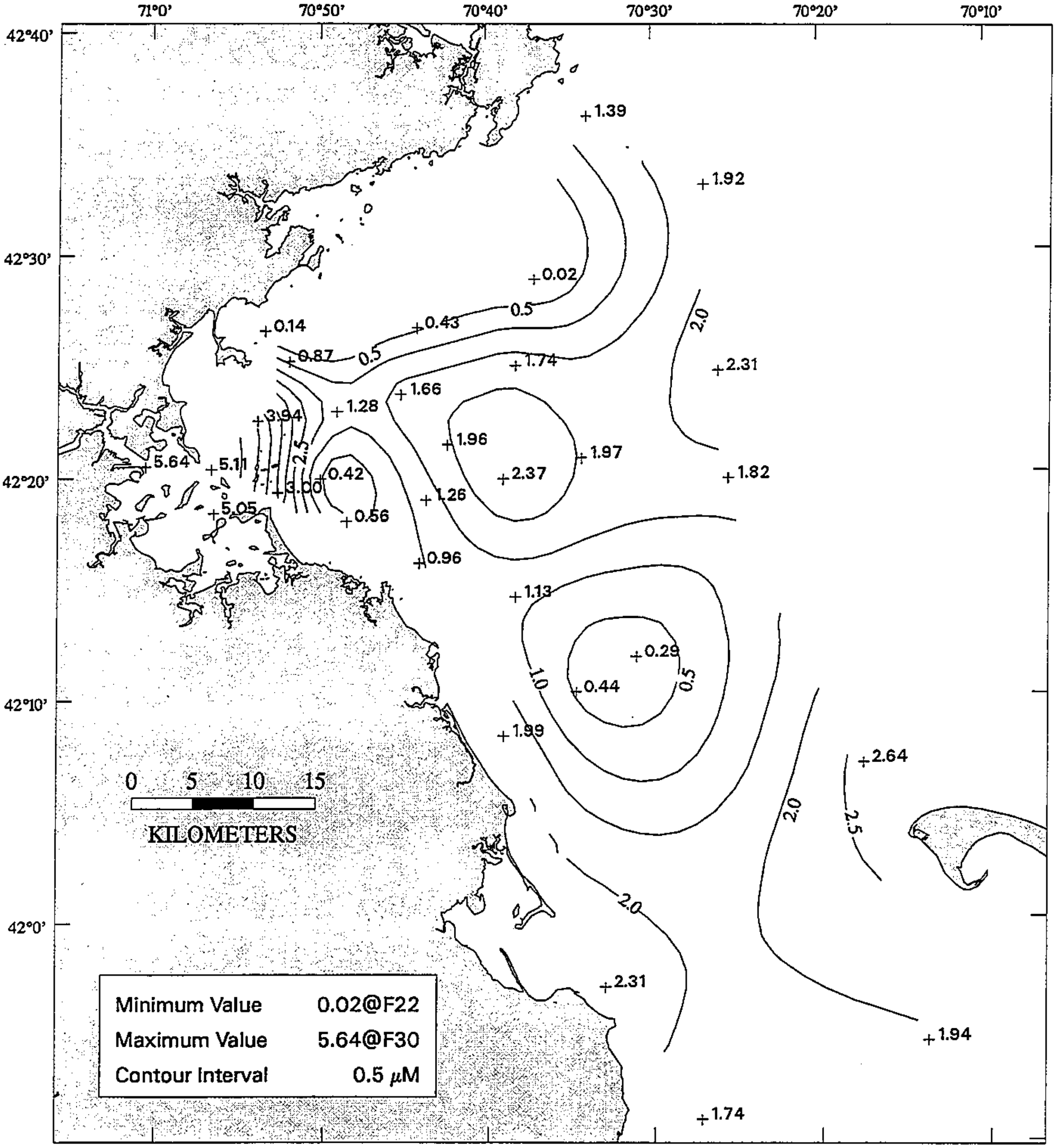


9714po4_lin
PO4

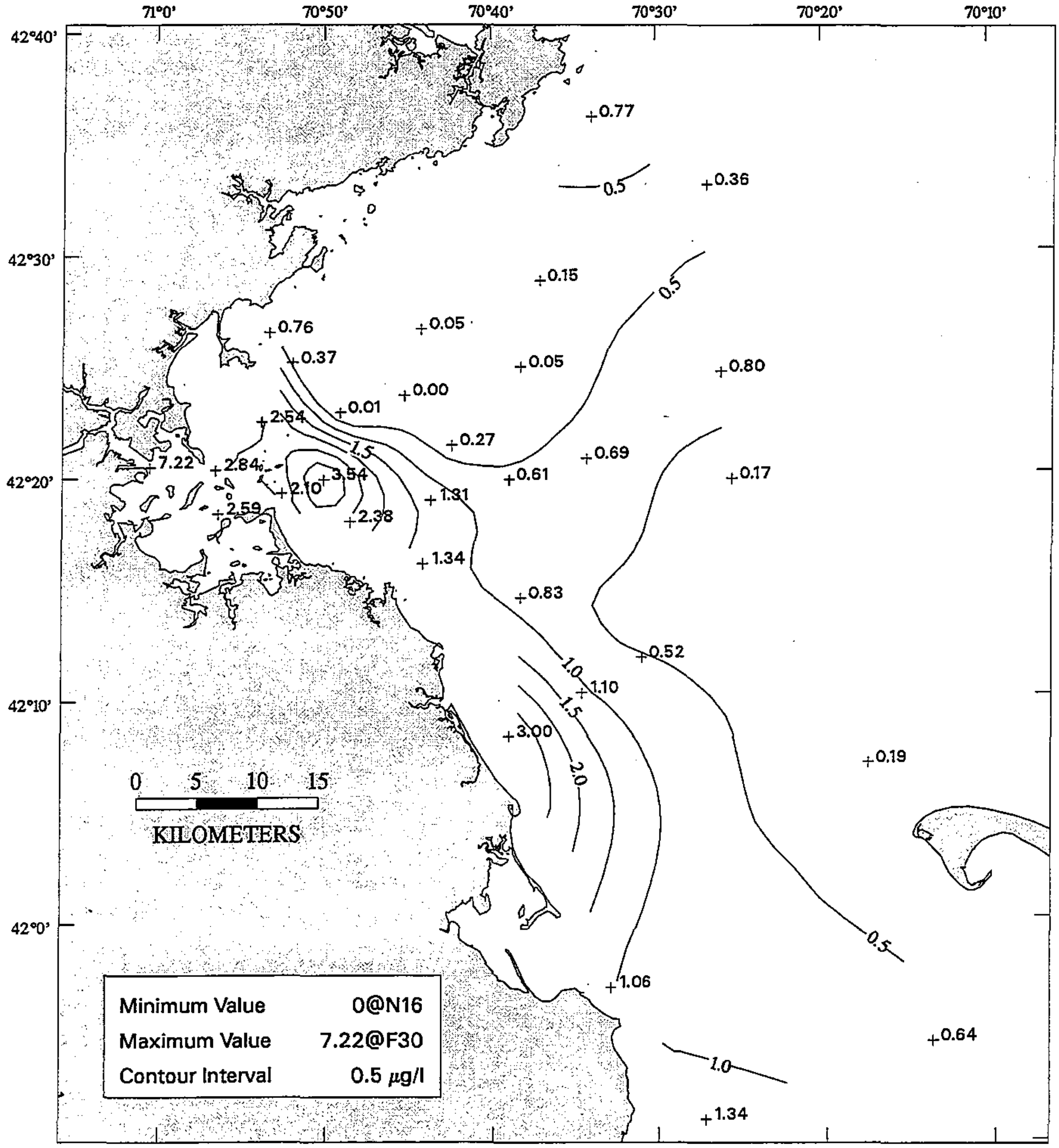


Minimum Value	0.47@F29
Maximum Value	4@F31
Contour Interval	0.5 μM

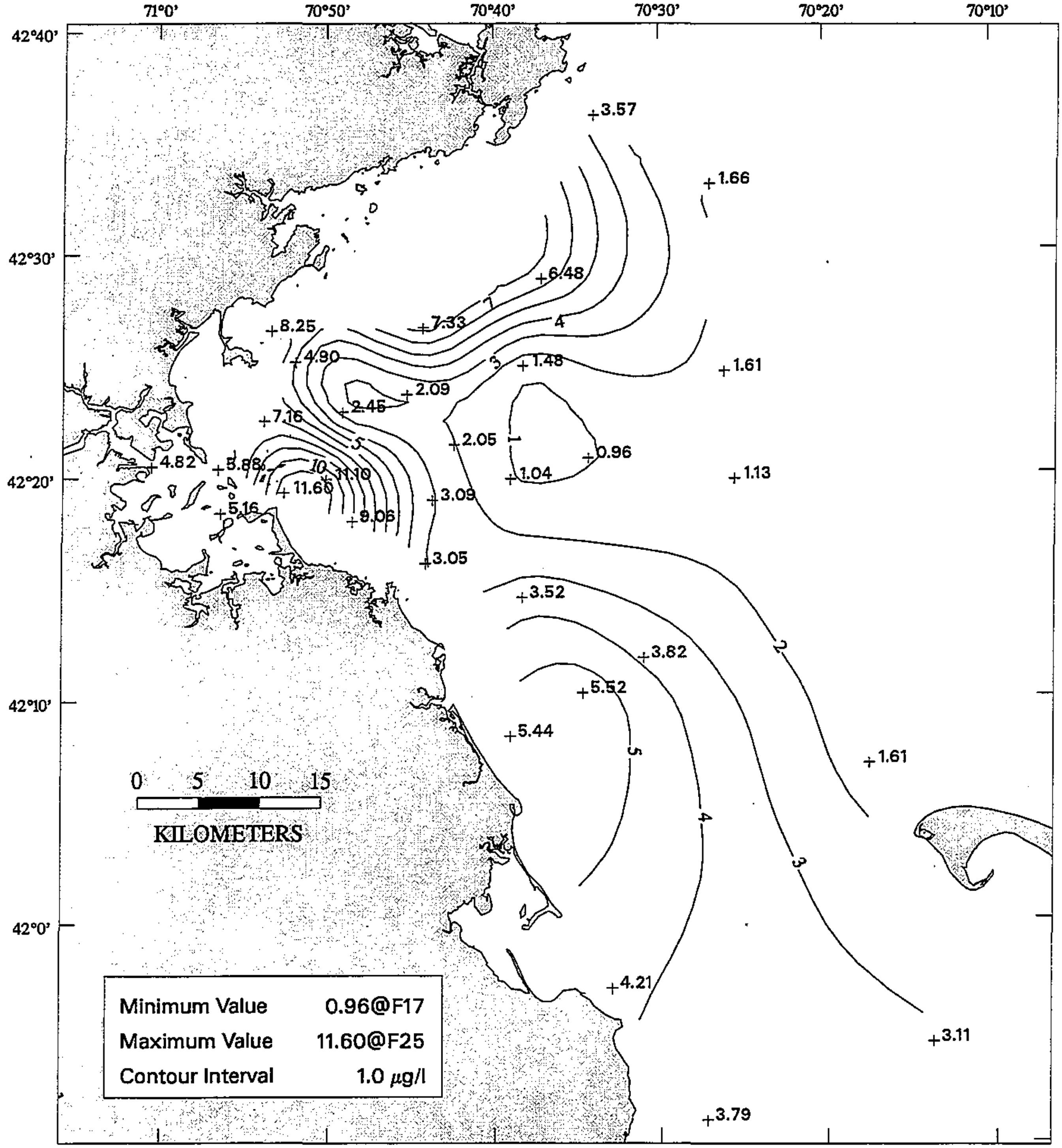
9711sio4_lin
SIO4



9714sio4_lin
SIO4



9711fluo_lin
FLUO



9714fluo_lin
FLUO

APPENDIX B

TRANSECT PLOTS

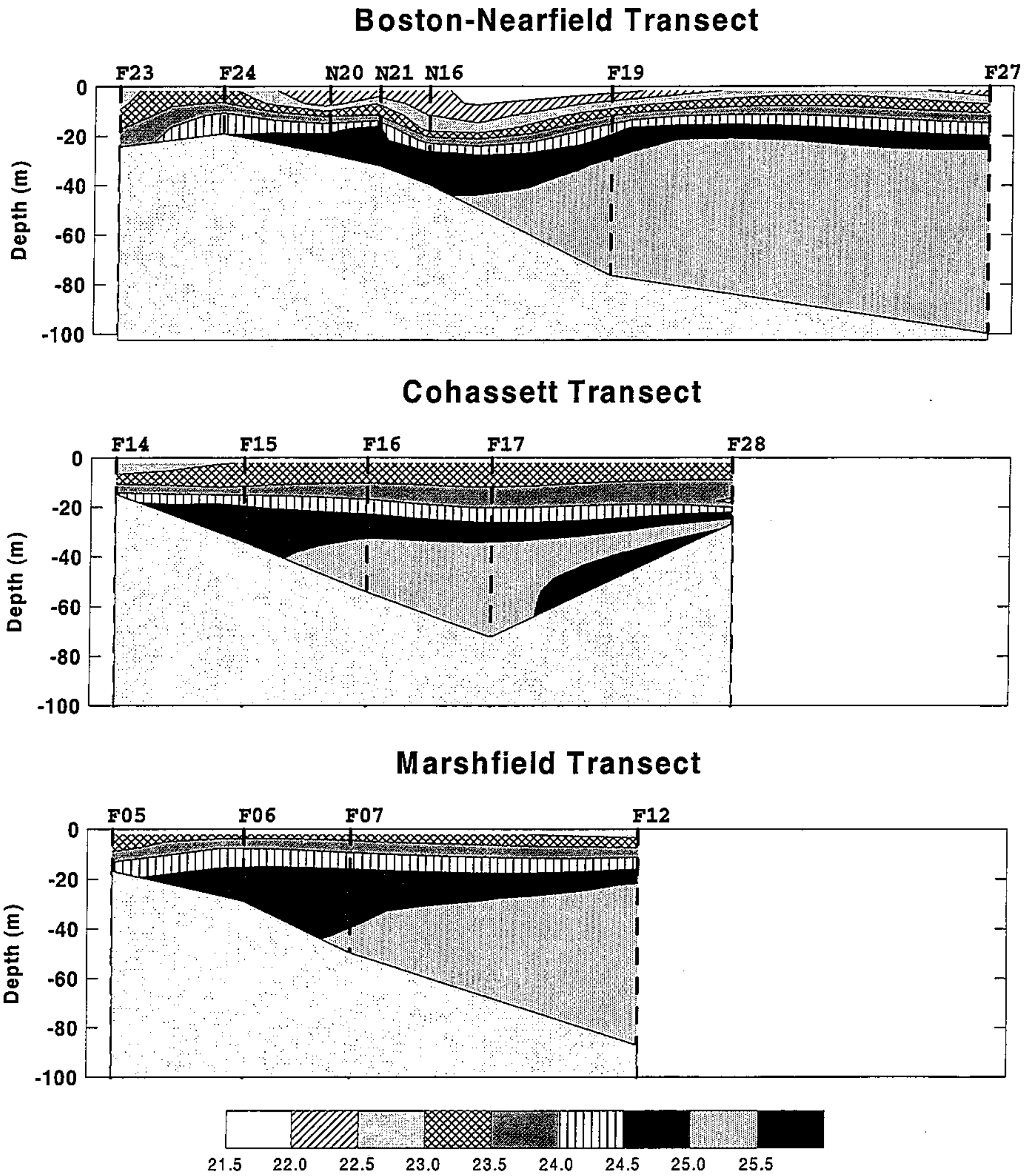
APPENDIX B

Transect Plots

Data were contoured relative to water depth and distance between stations as shown on the transects (Figure 1-3, text). Relative distances between stations and water depth at each station is shown on the transect. Water depth is labelled with negative values in meters, with zero depth at the sea surface, and shaded. Three transects (Boston-Nearfield, Cohasset, and Marshfield) are provided on each plot, as well as shaded contour levels on the scale bar at the bottom of the plot. Contour units are as noted on the table below. Each plot is labelled on the bottom right with the parameter as listed below, and the survey number ("9601").

Appendix B: Table of Contents

Parameter Name	Units
Sigma-T (σ_t)	n/a
Temperature	°C
Salinity	PSU
Beam Attenuation	/m
Nitrate + Nitrite	µM
Phosphate (PO_4)	µM
Silicate (SiO_4)	µM
Ammonium (NH_4)	µM
Fluorescence (clophylla)	µg/L
Dissolved Oxygen	mg/L



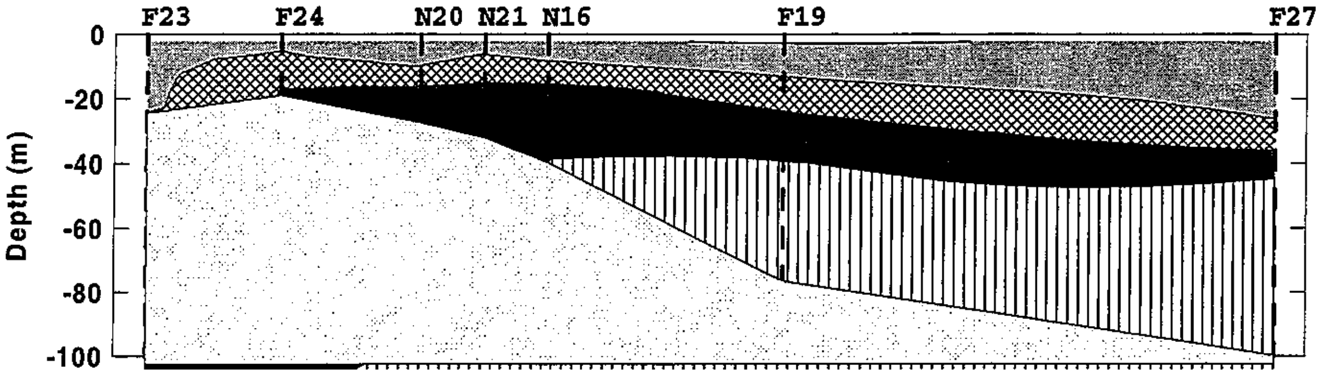
Boston-Nearfield Transect

Cohassett Transect

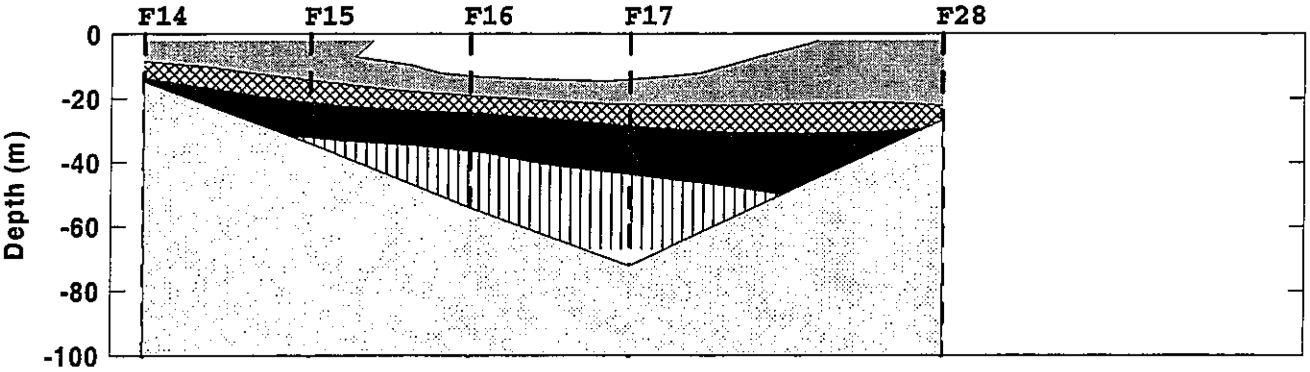
Marshfield Transect

Sigma-T 9711

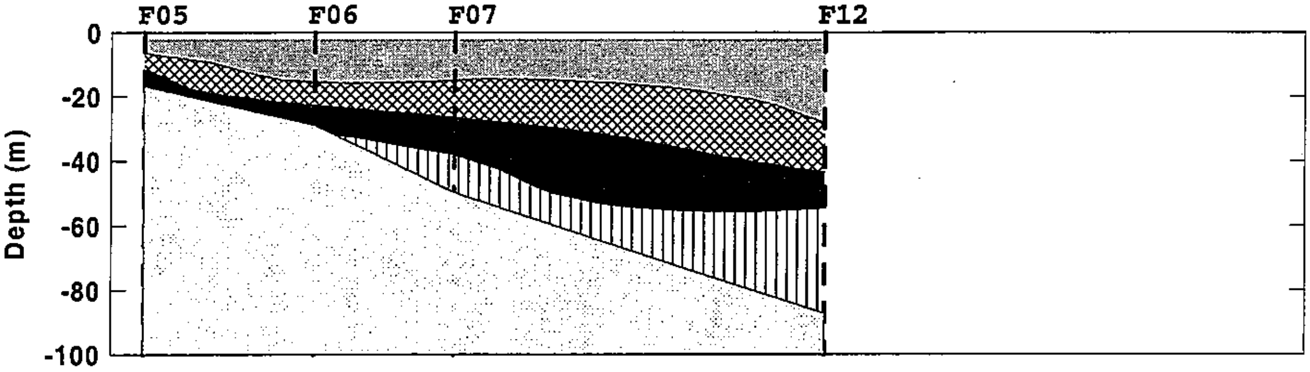
Boston-Nearfield Transect



Cohassett Transect

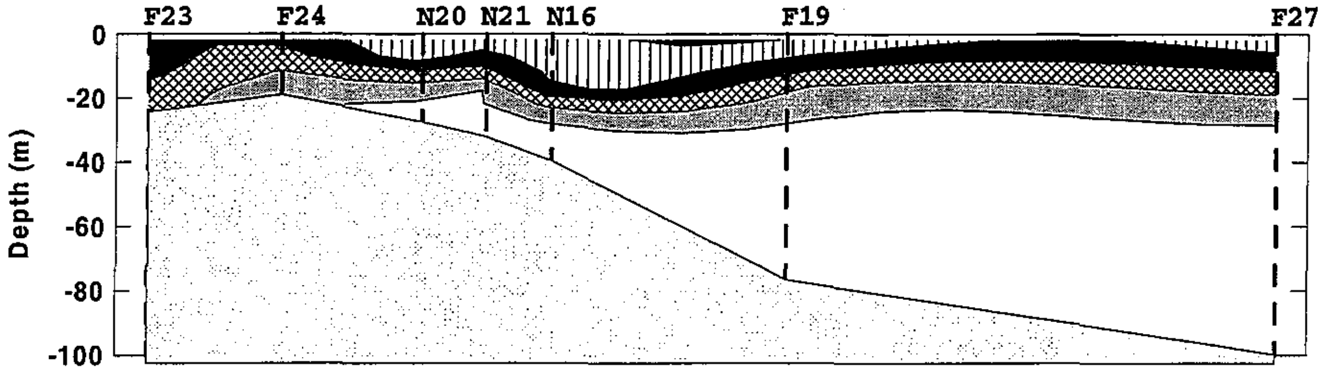


Marshfield Transect

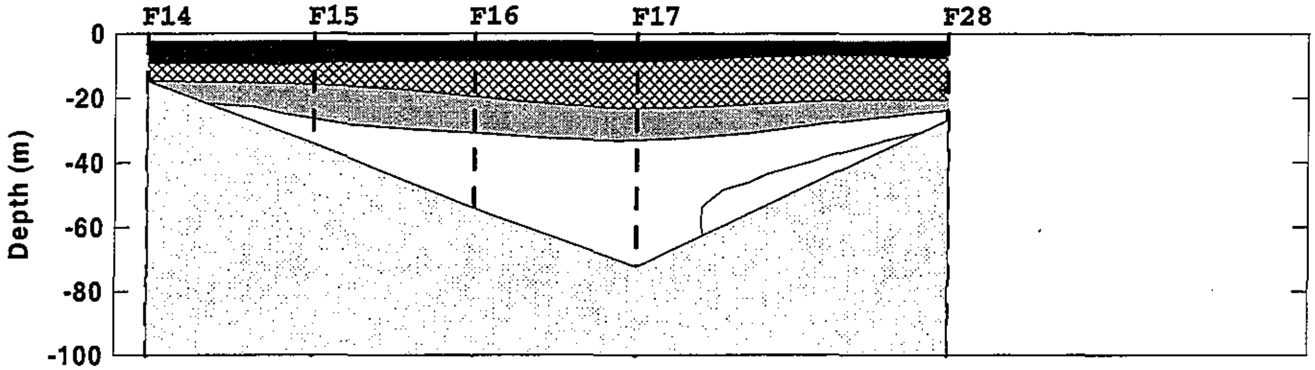


Sigma-T 9714

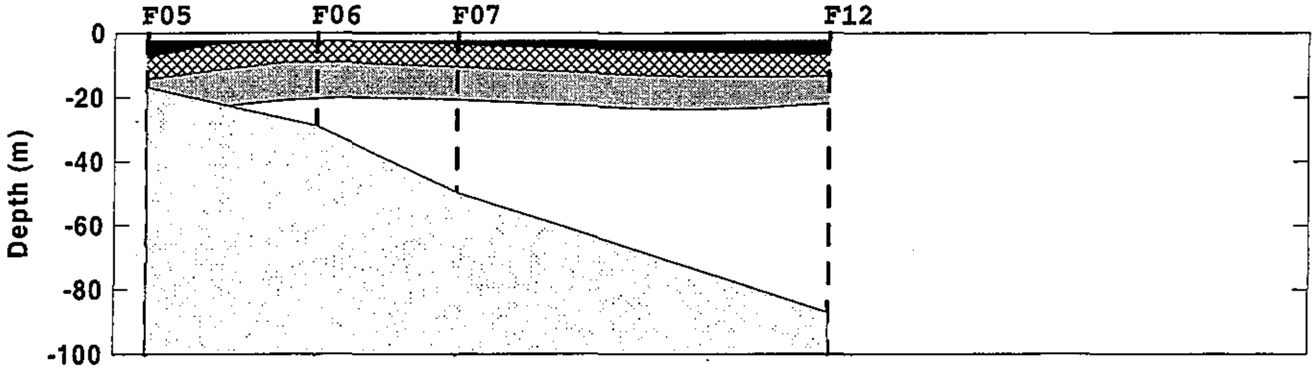
Boston-Nearfield Transect



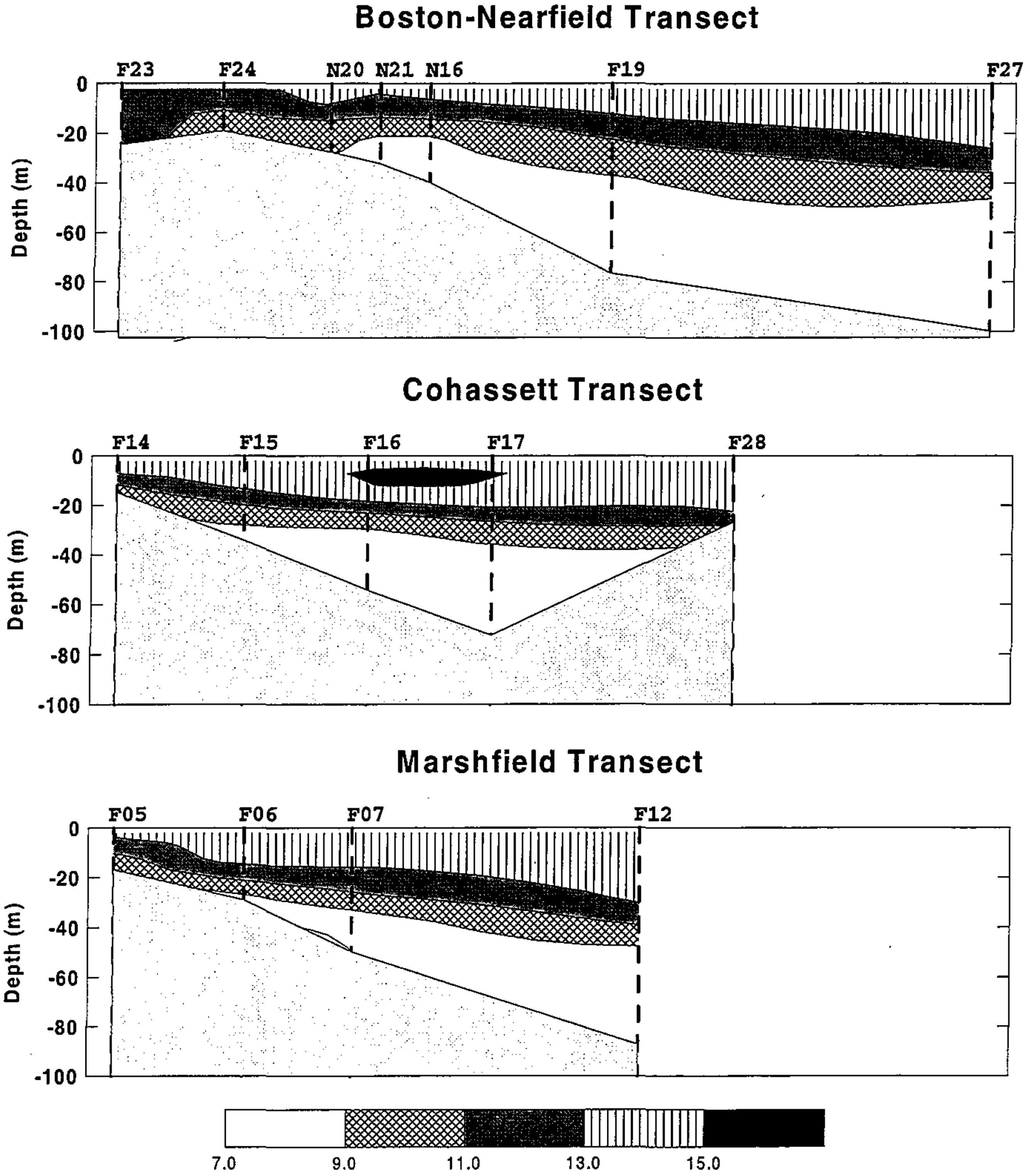
Cohassett Transect



Marshfield Transect



Temperature 9711

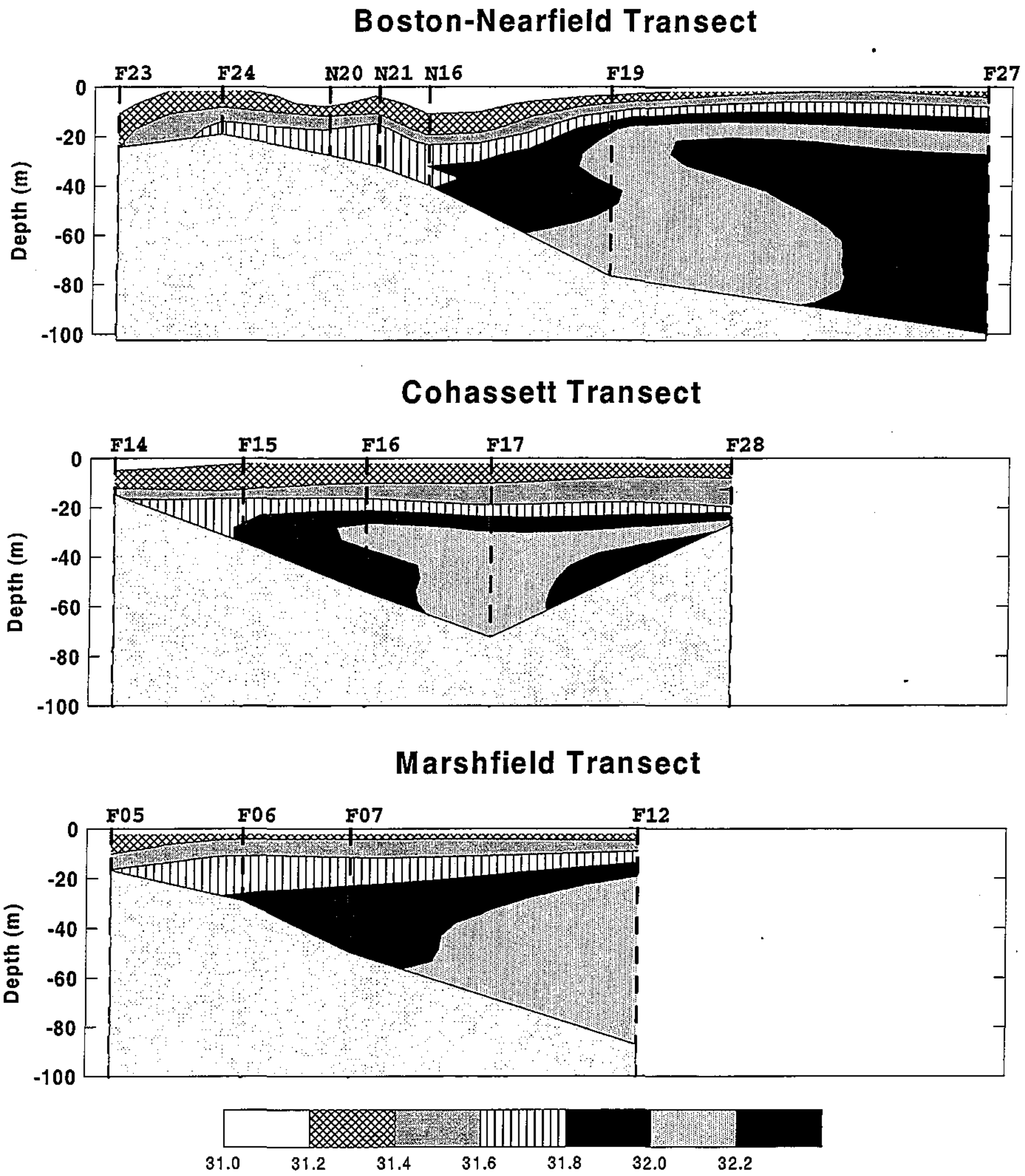


Boston-Nearfield Transect

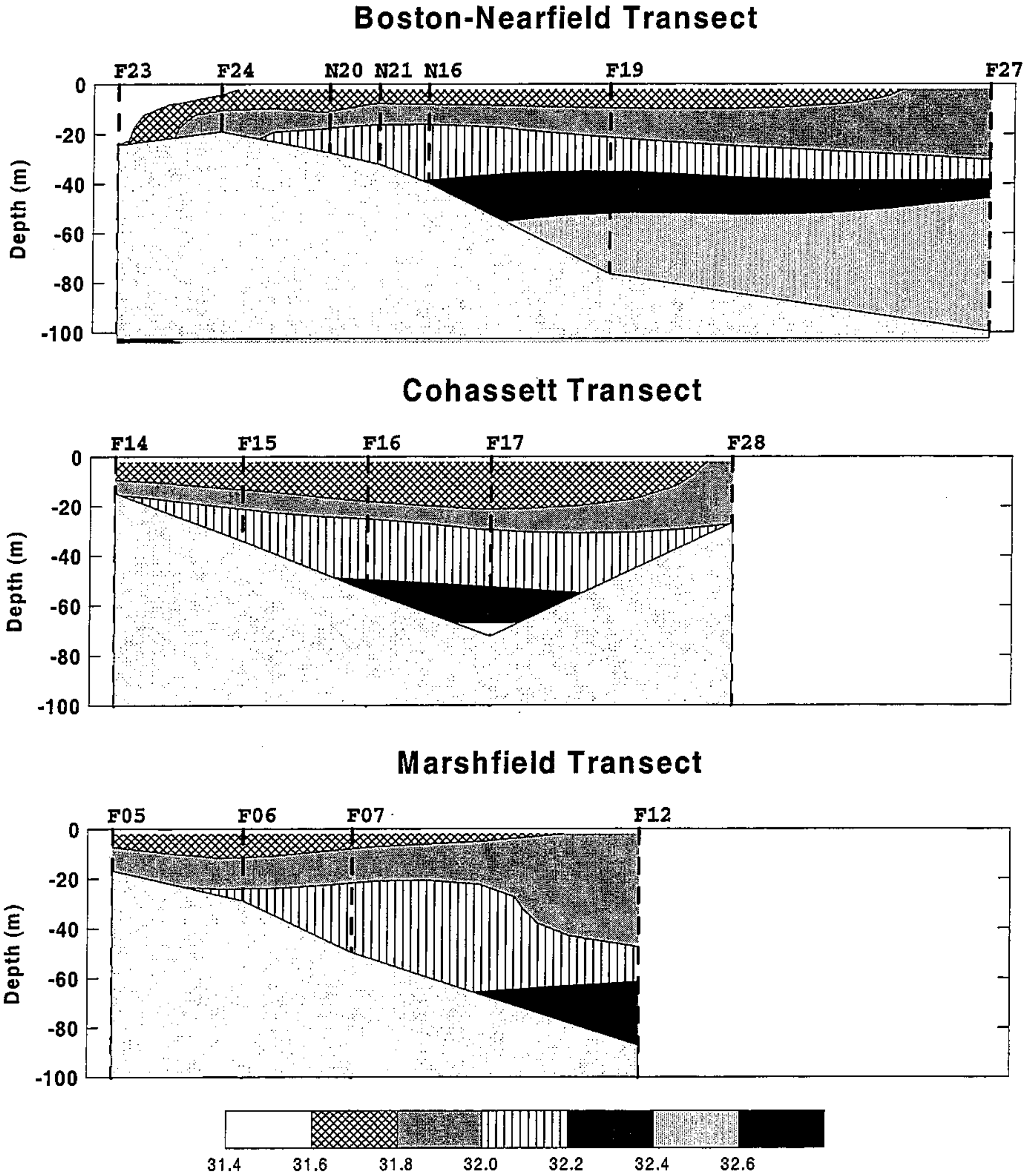
Cohassett Transect

Marshfield Transect

Temperature 9714



Salinity 9711

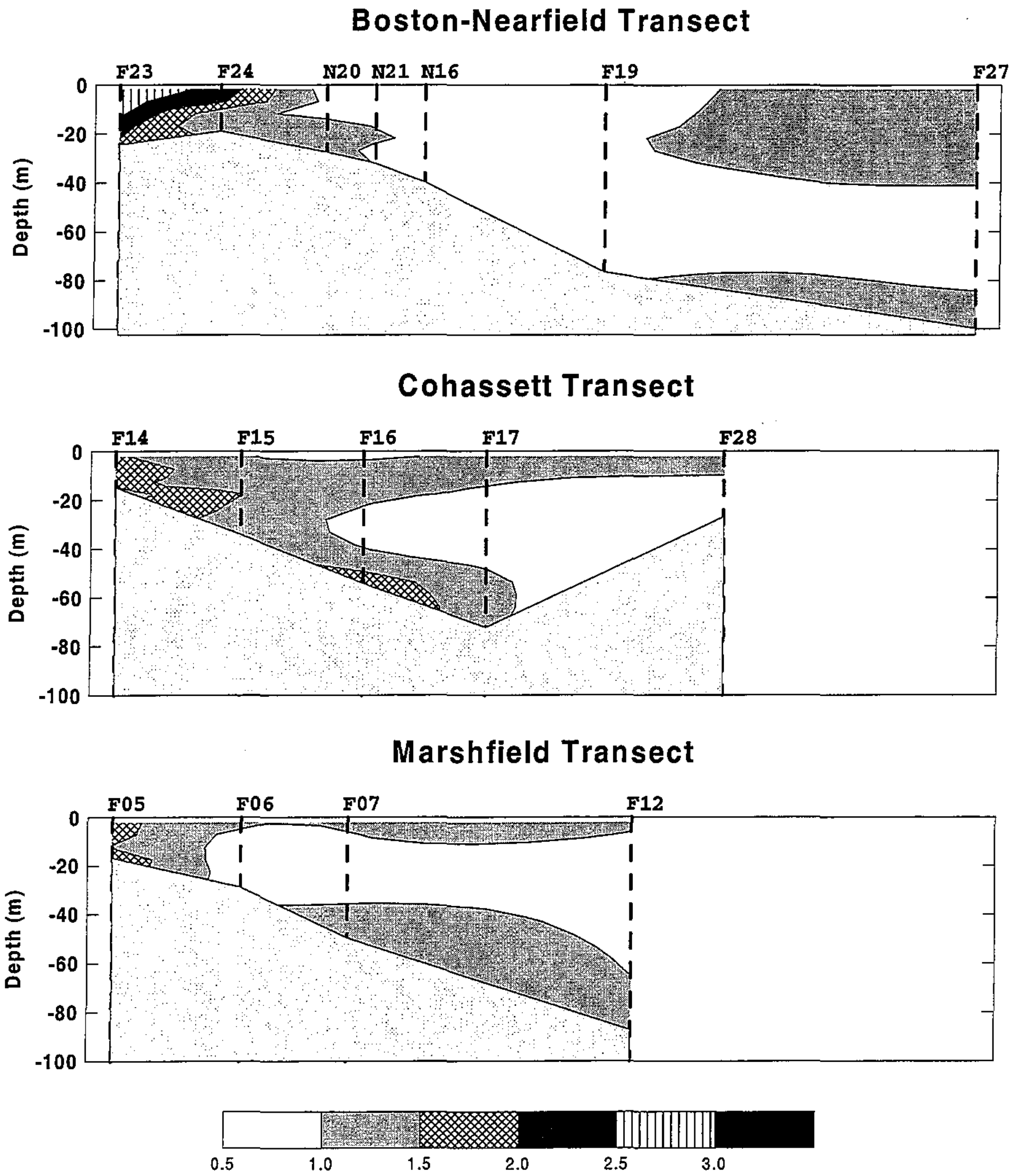


Boston-Nearfield Transect

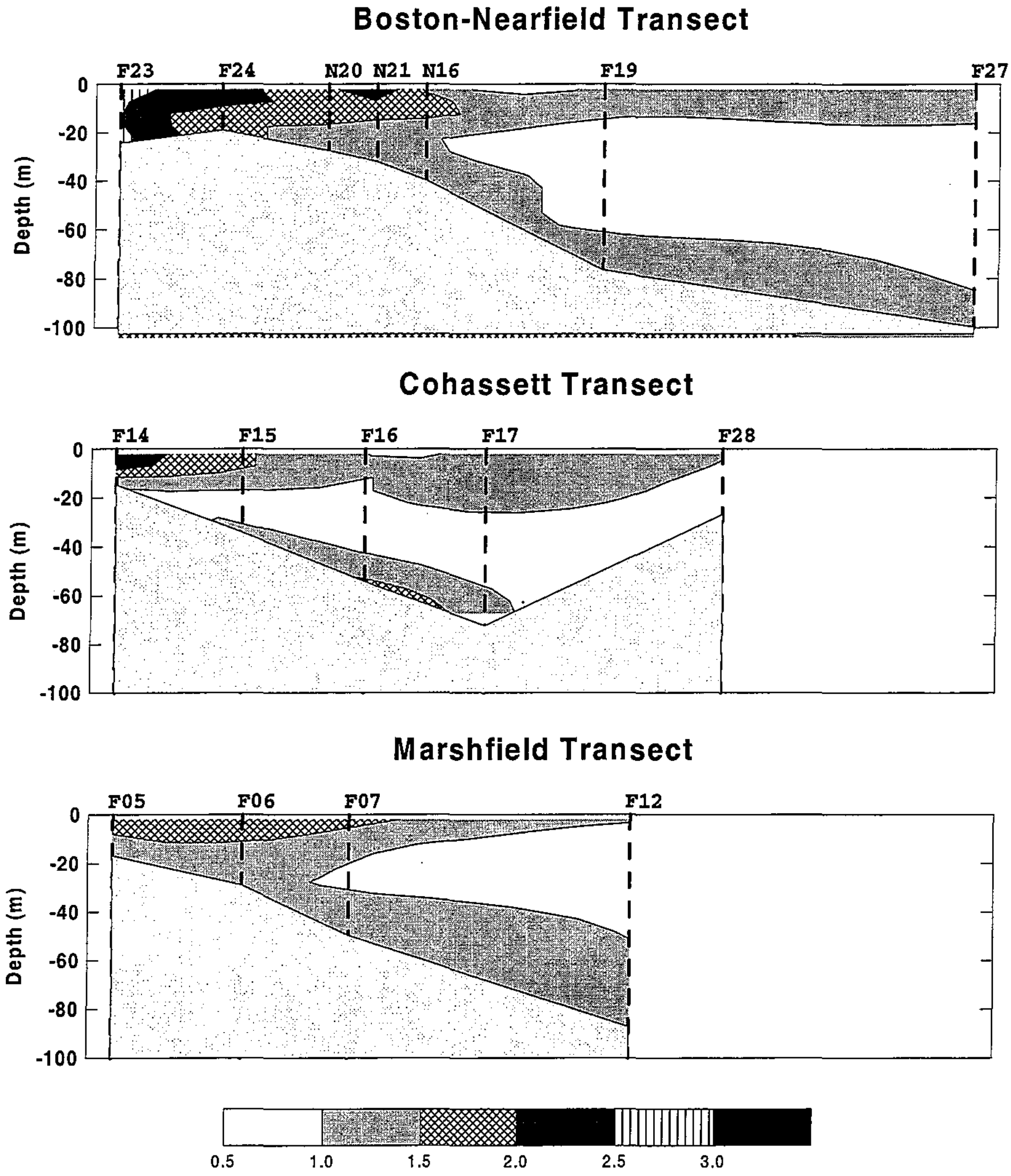
Cohassett Transect

Marshfield Transect

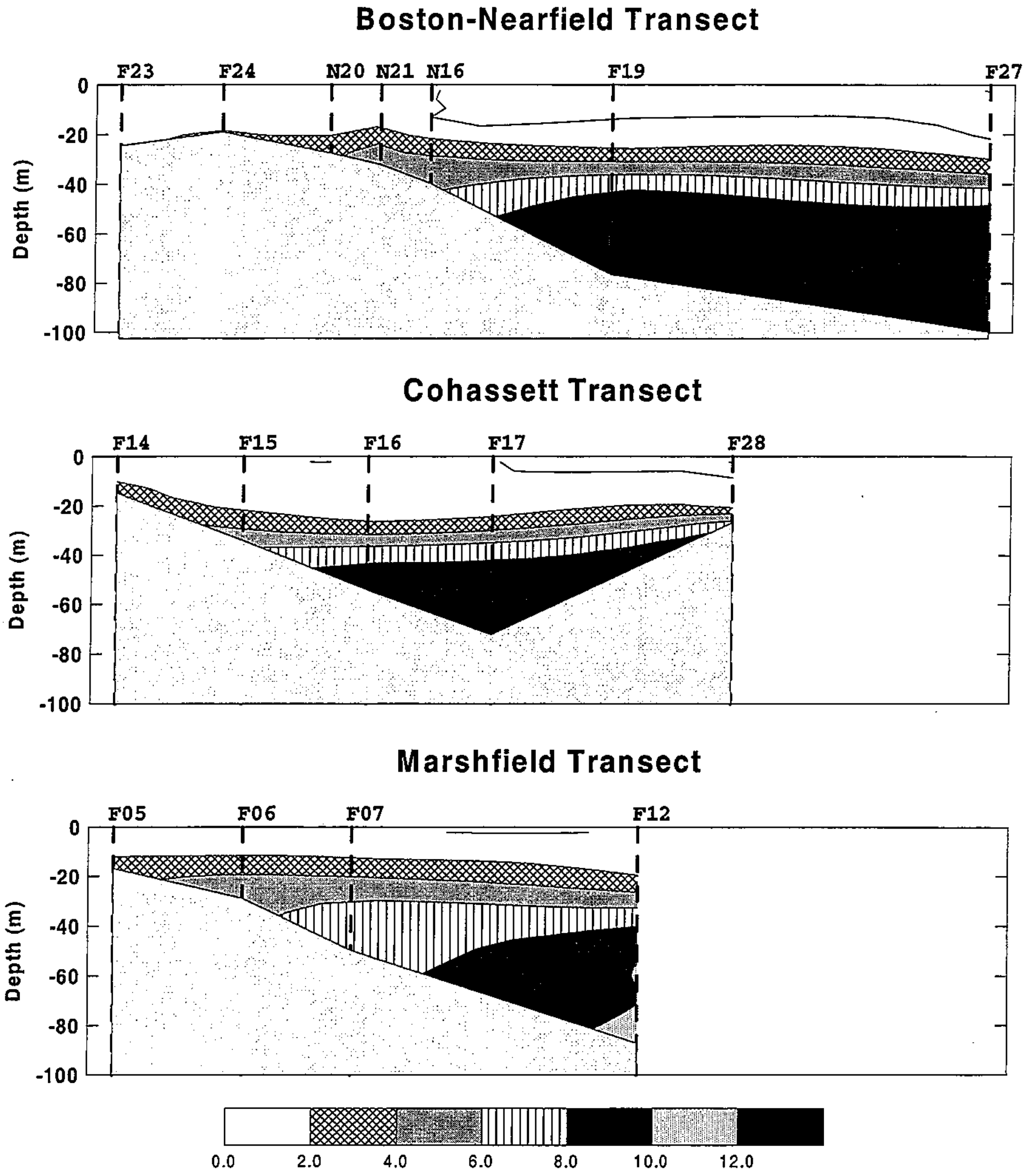
Salinity 9714



Beam Attenuation 9711



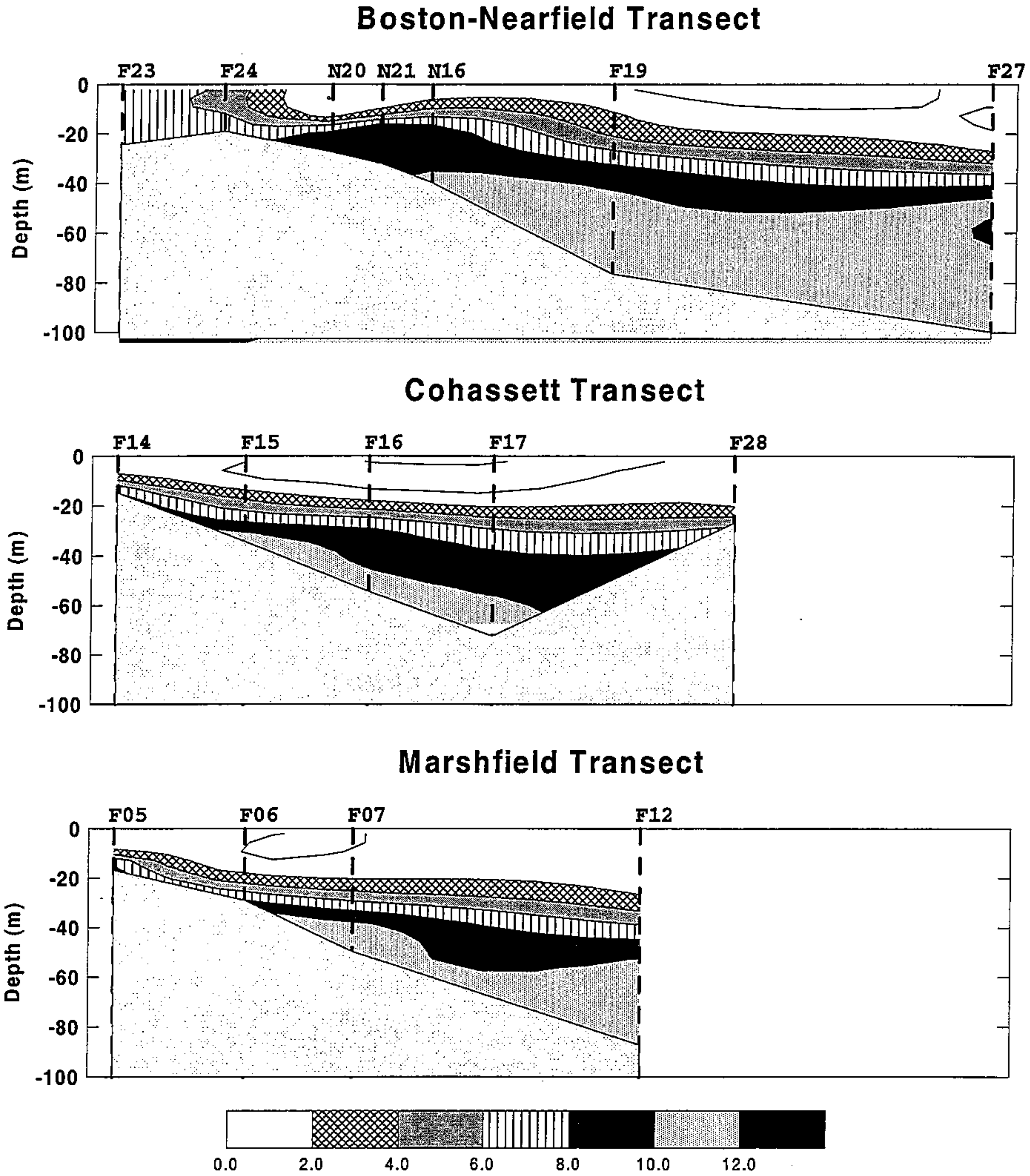
Beam Attenuation 9714


Boston-Nearfield Transect

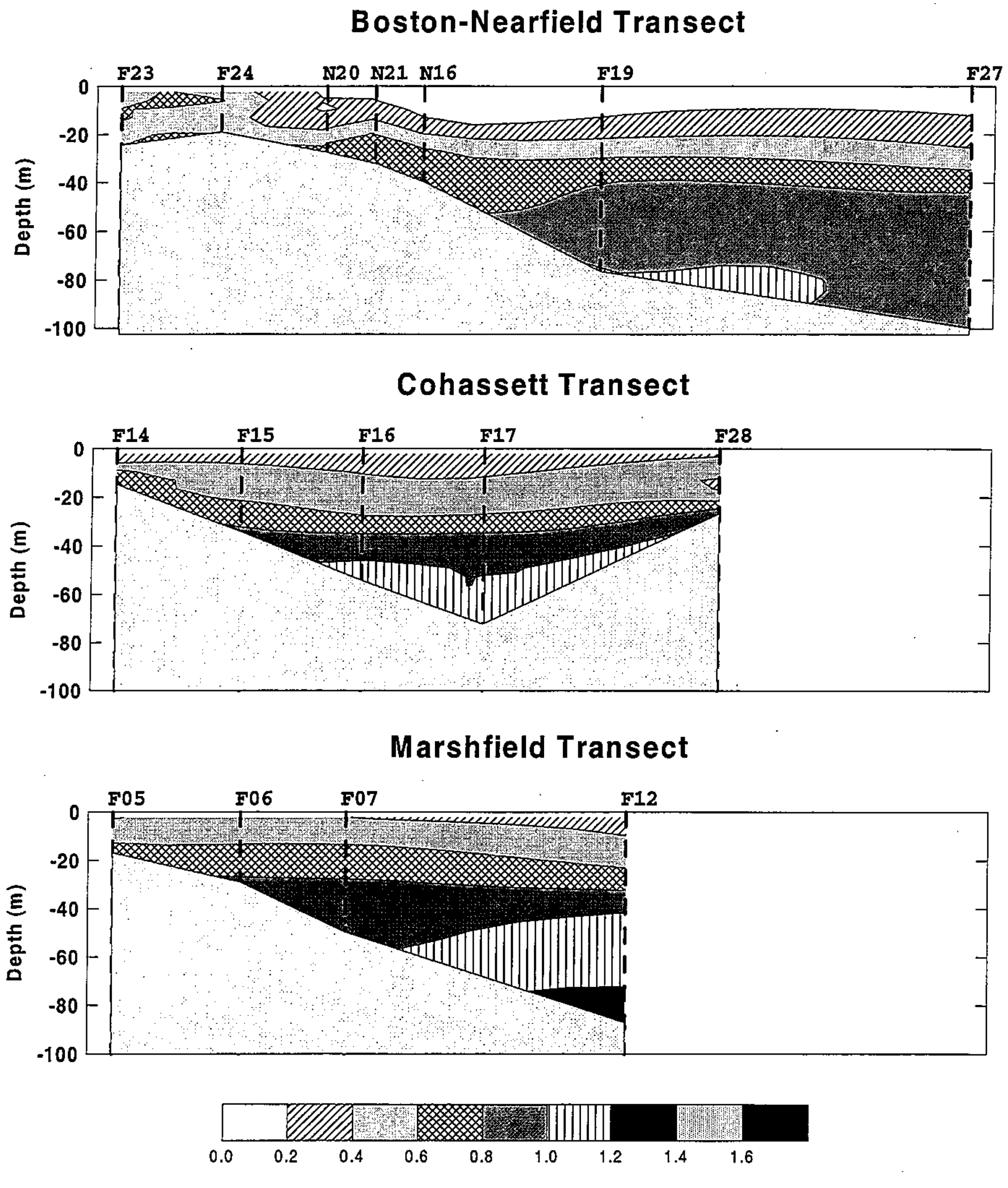
Cohassett Transect

Marshfield Transect

Nitrate + Nitrite 9711



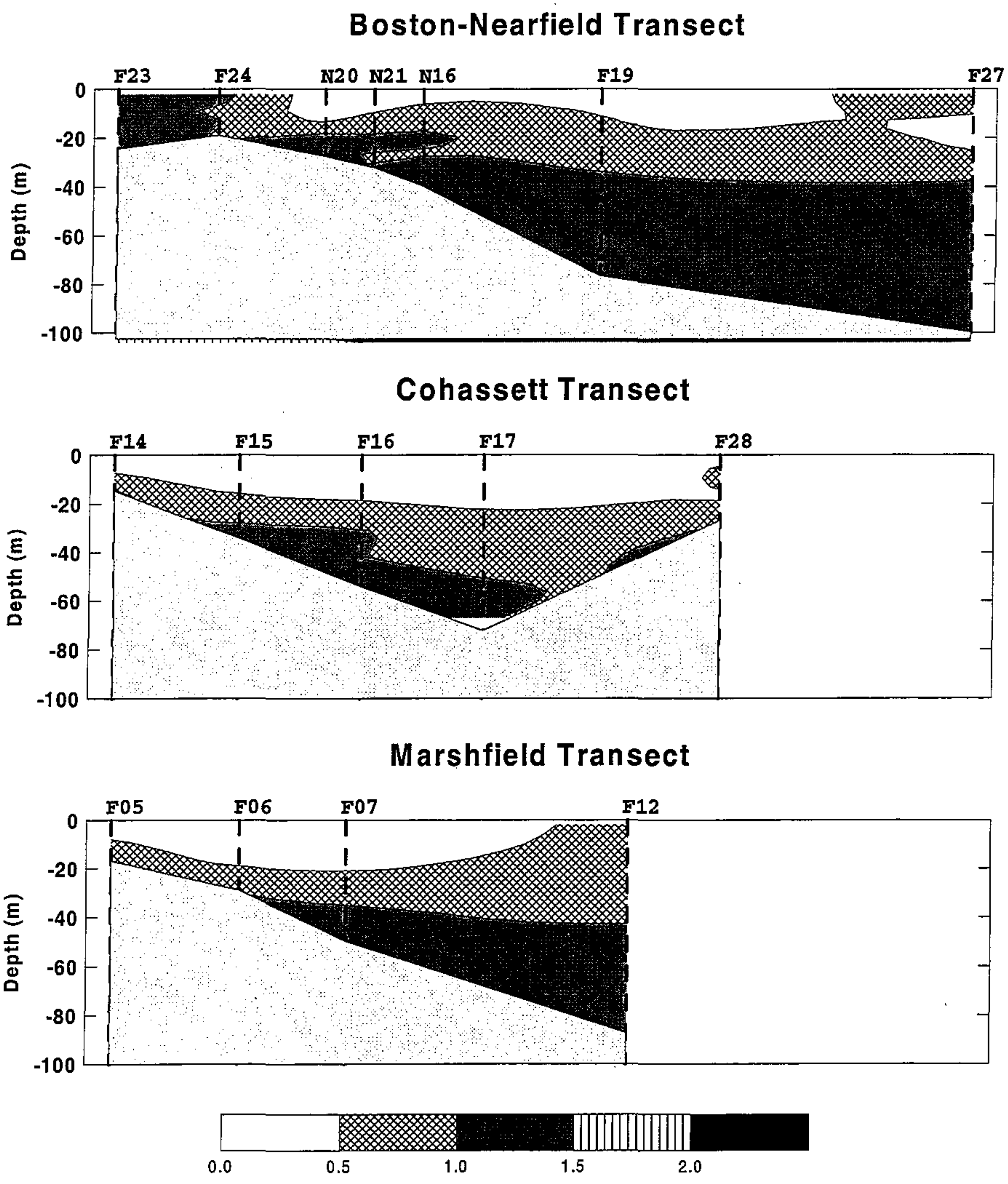
Nitrate + Nitrite 9714


Boston-Nearfield Transect

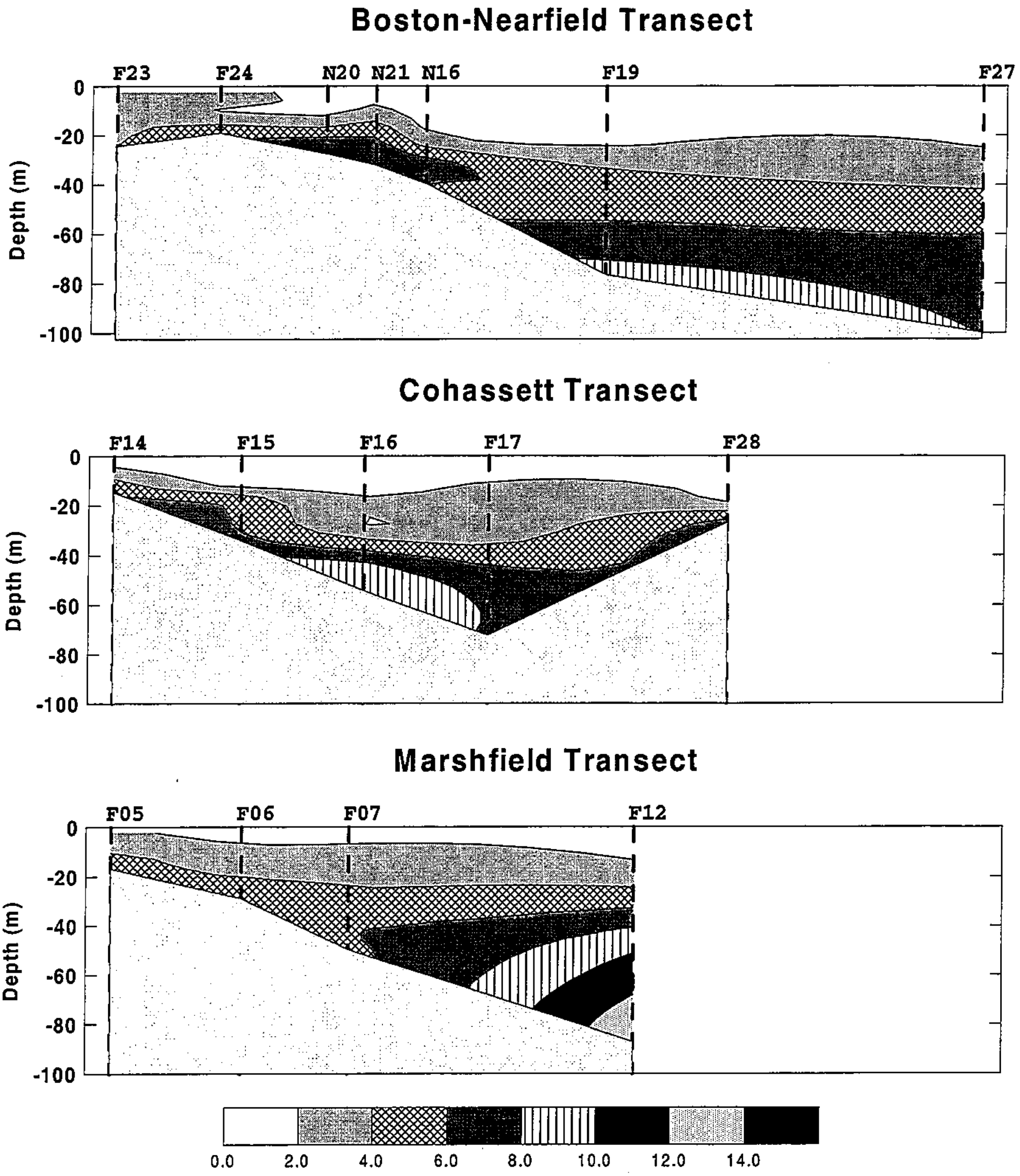
Cohassett Transect

Marshfield Transect

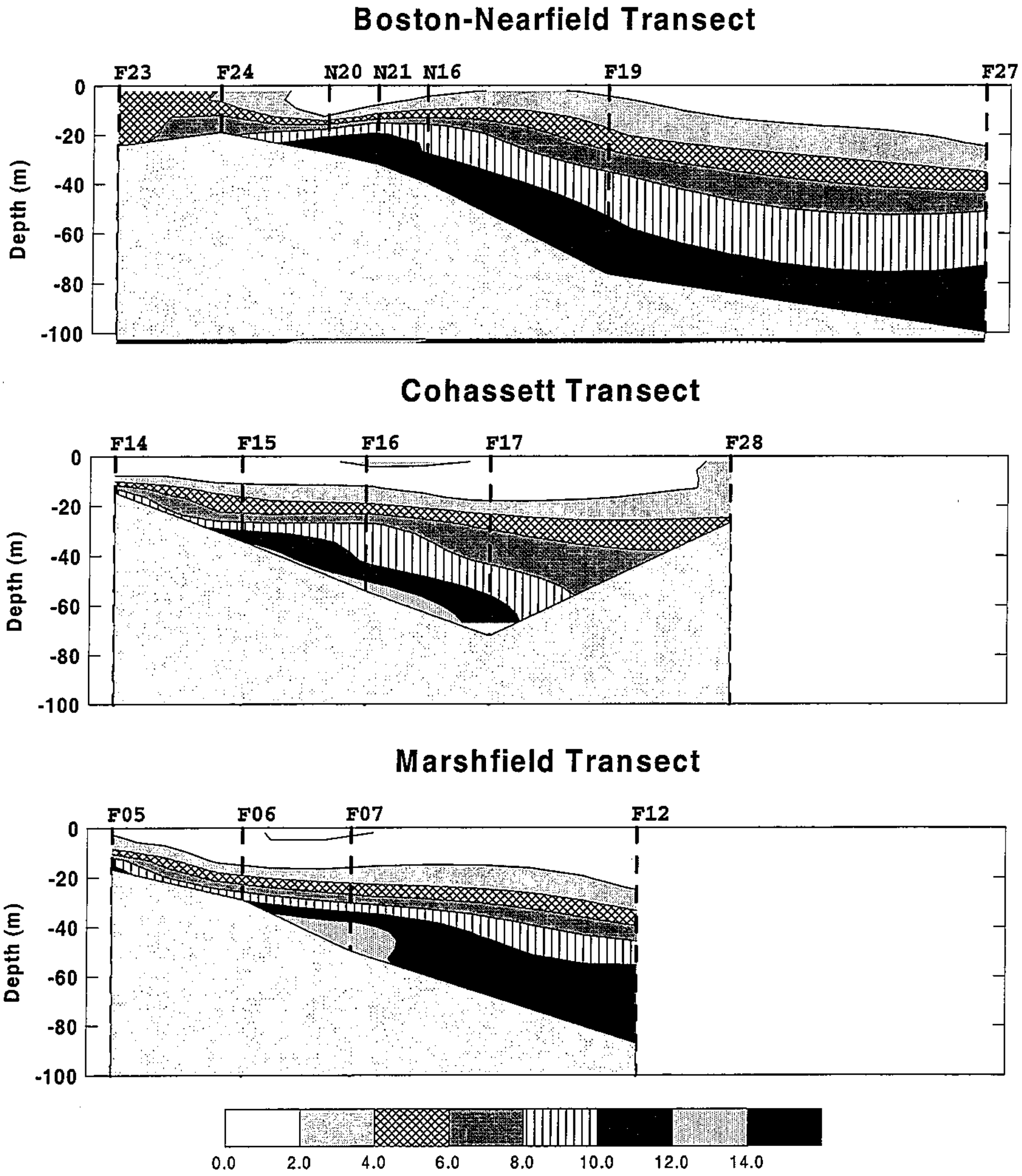
Phosphate 9711



Phosphate 9714



Silicate 9711

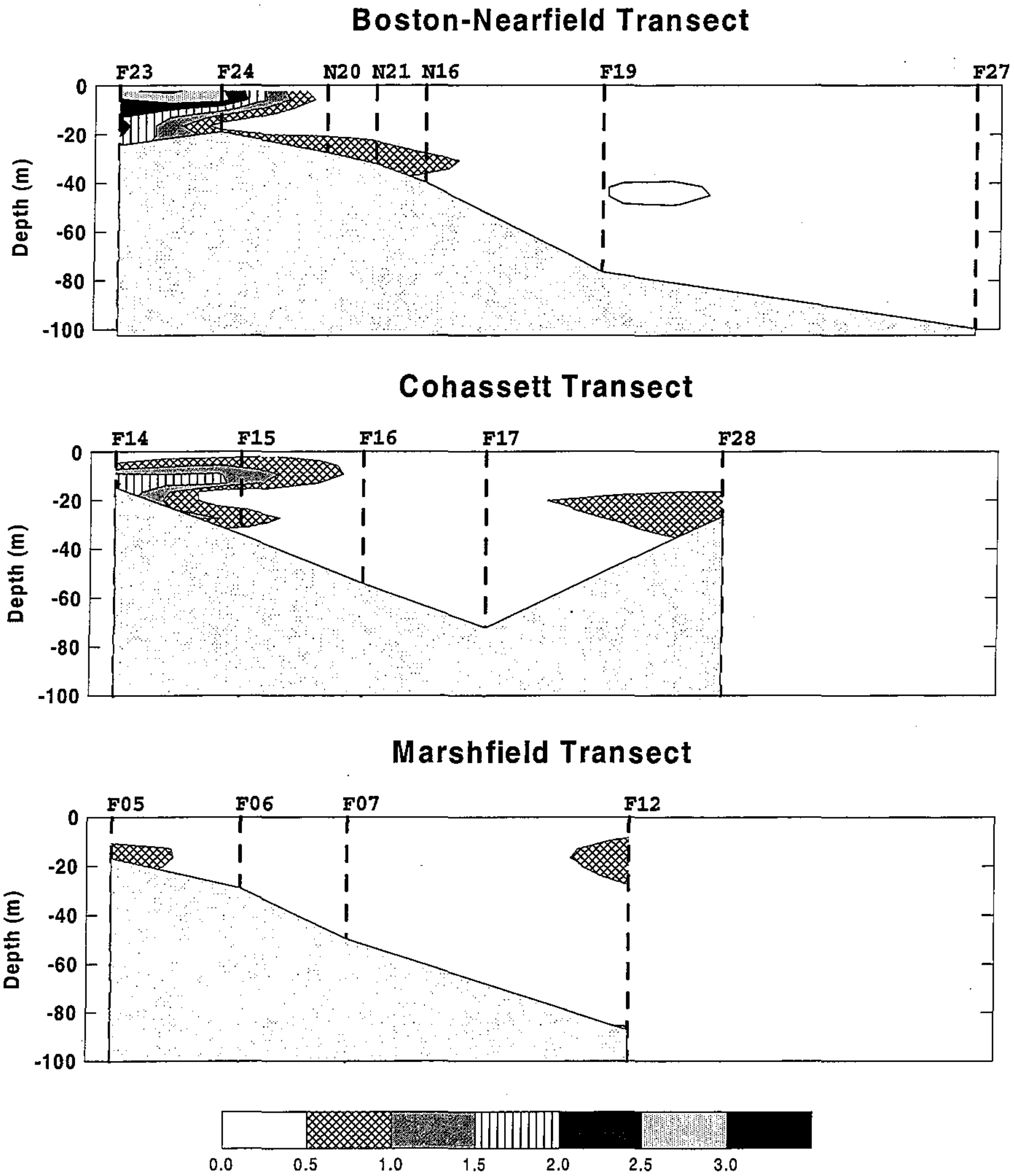


Boston-Nearfield Transect

Cohassett Transect

Marshfield Transect

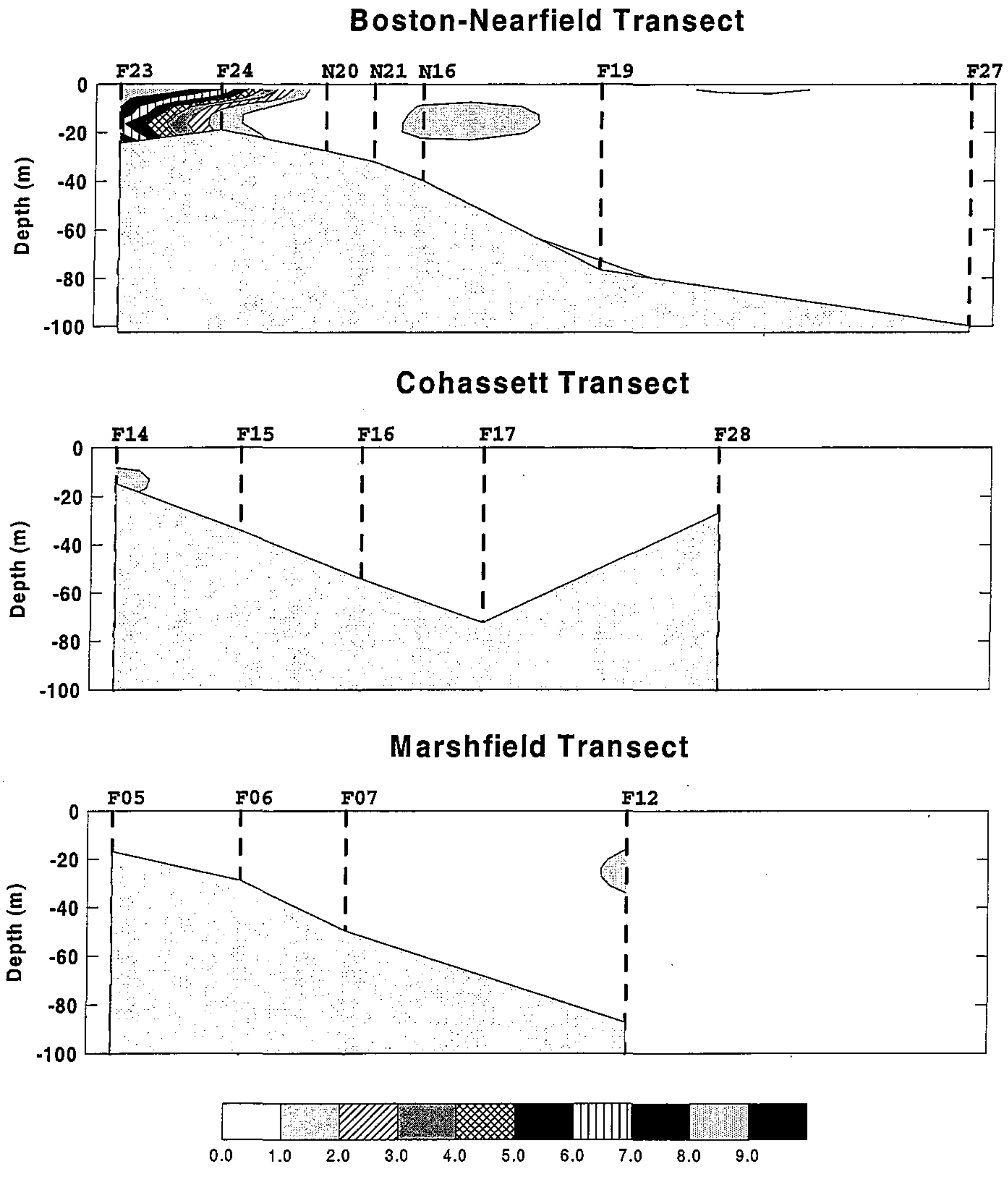
Silicate 9714


Boston-Nearfield Transect

Cohassett Transect

Marshfield Transect

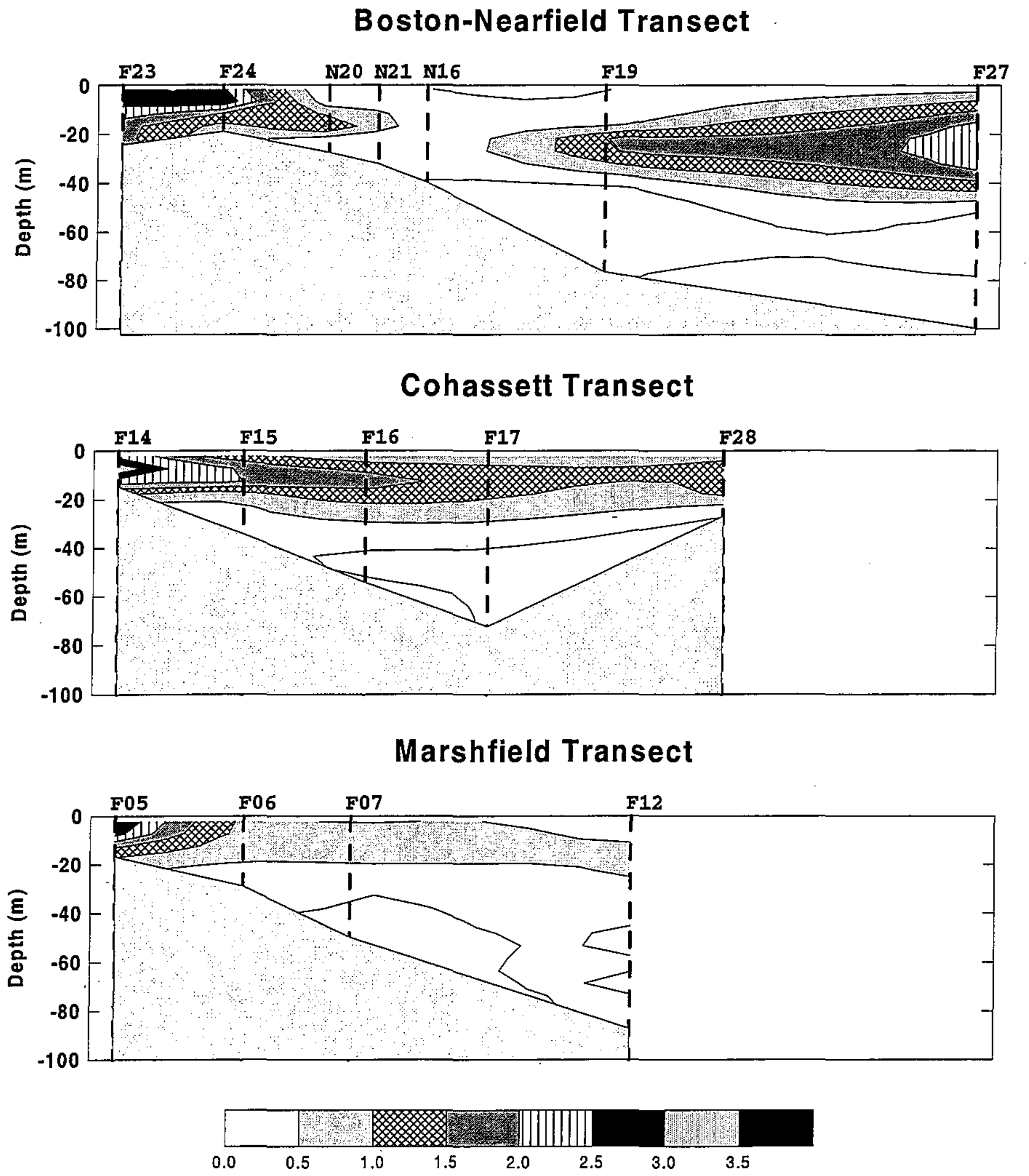
Ammonium 9711


Boston-Nearfield Transect

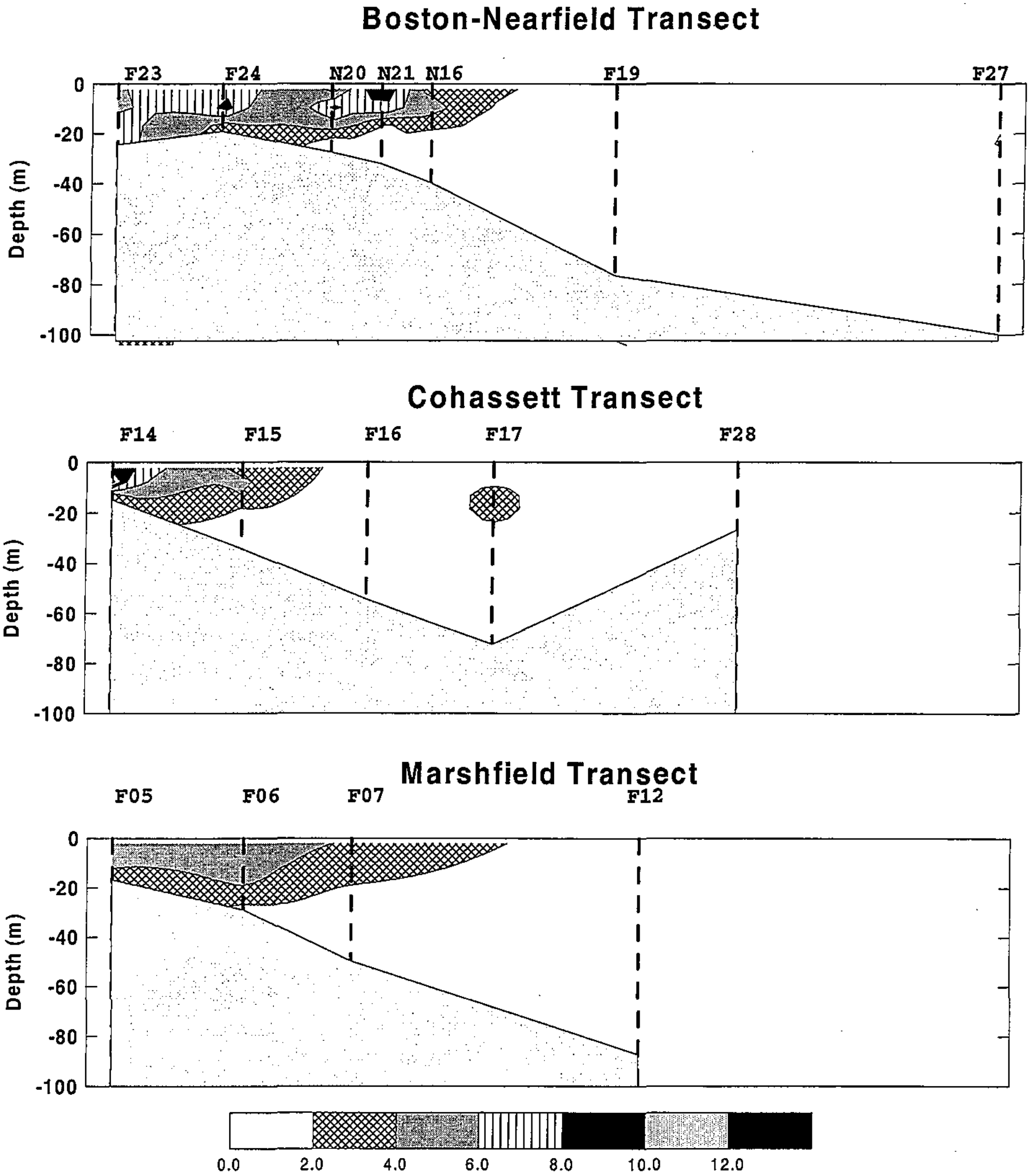
Cohassett Transect

Marshfield Transect

Ammonium 9714



Fluorescence 9711

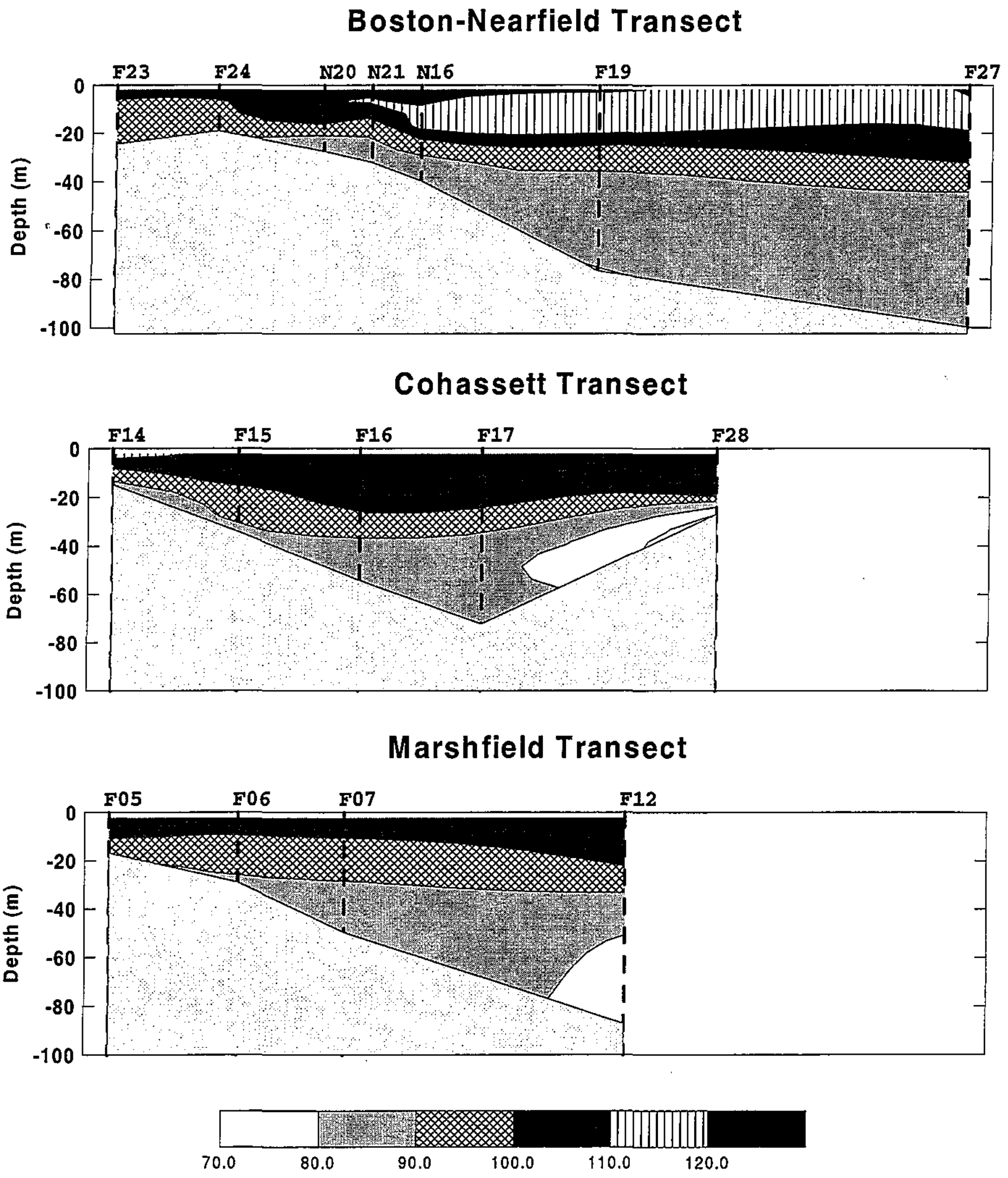


Boston-Nearfield Transect

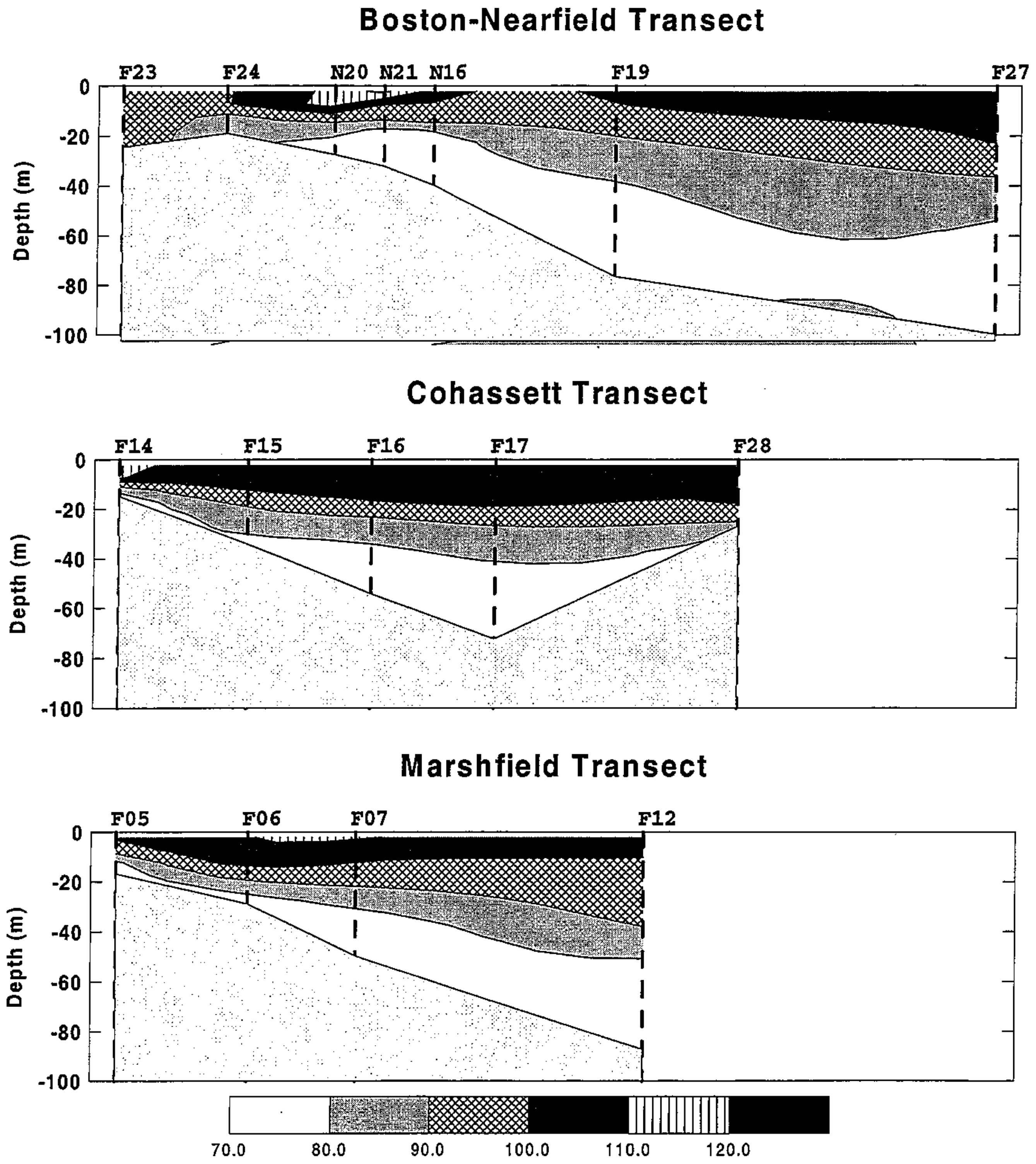
Cohassett Transect

Marshfield Transect

Fluorescence 9714



DO % Saturation 9711



Boston-Nearfield Transect

Cohassett Transect

Marshfield Transect

DO % Saturation 9714

APPENDIX C

NUTRIENT SCATTER PLOTS

APPENDIX C

Nutrient Scatter Plots

Scatter plots are included for every survey conducted during the semi-annual period. Each plot includes all stations and all depths. The plots are organized by type of plot, and then by survey. Combined nearfield/farfield surveys show the regions with different symbols, including Boundary, Cape Cod Bay, Coastal, Boston Harbor, Nearfield, and Offshore. Available plots are summarized in the text.

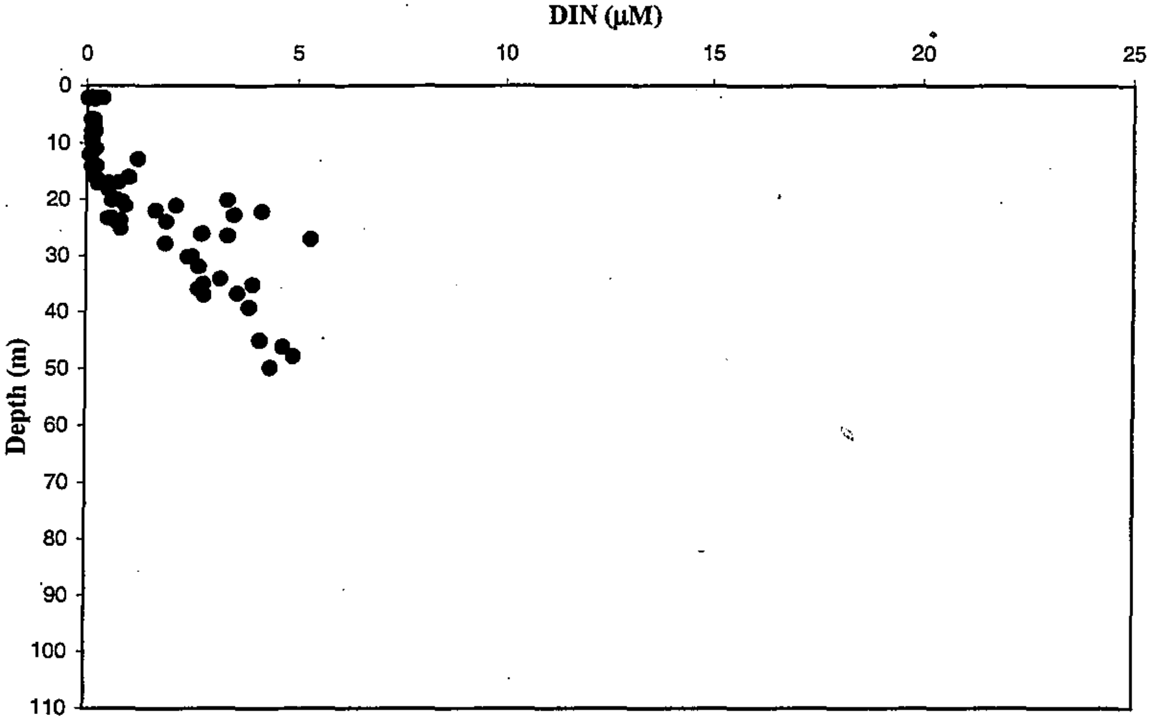


FIGURE 4-1
Depth vs. nutrient plots for nearfield survey W9710, (Aug 97)

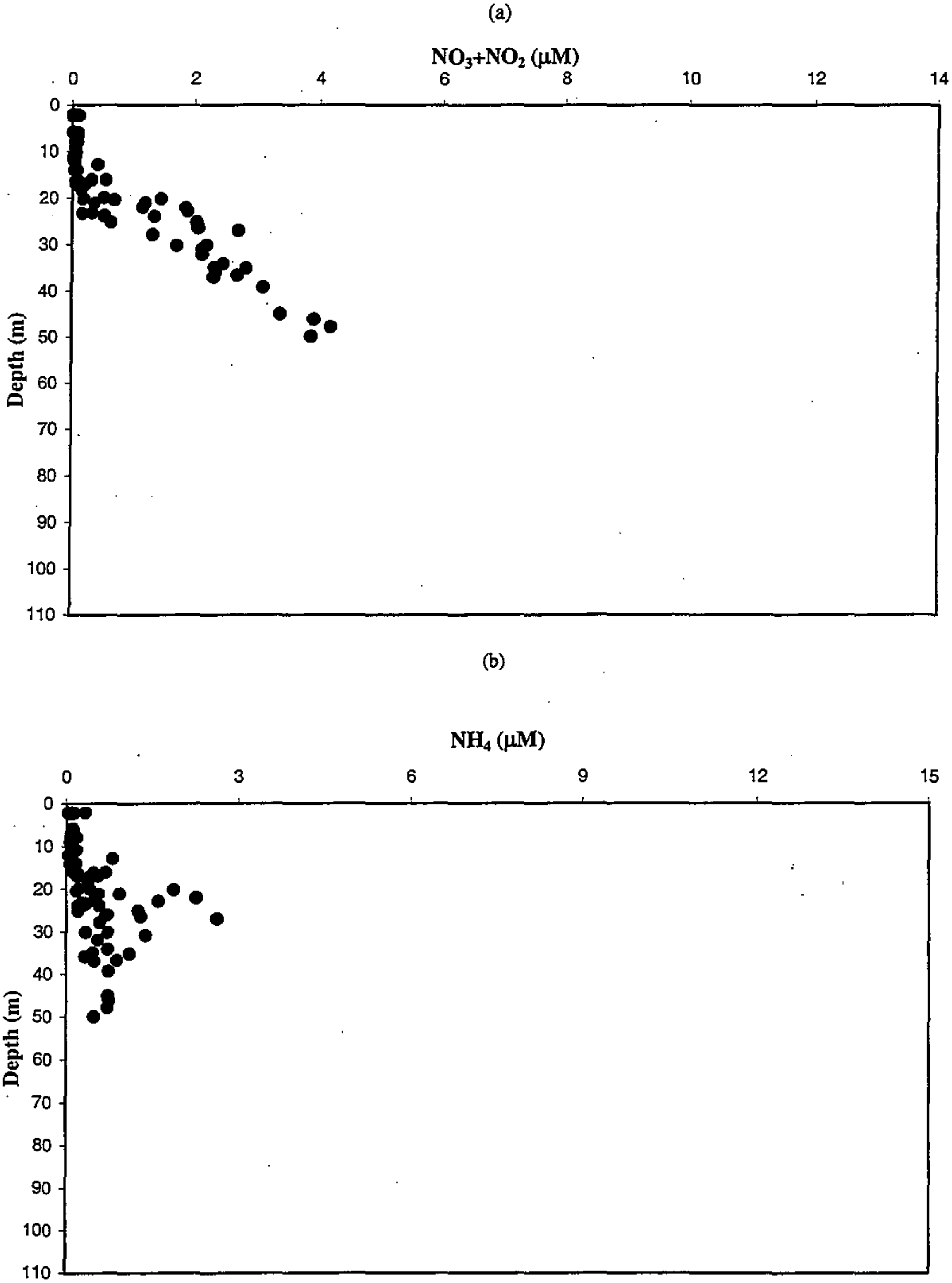
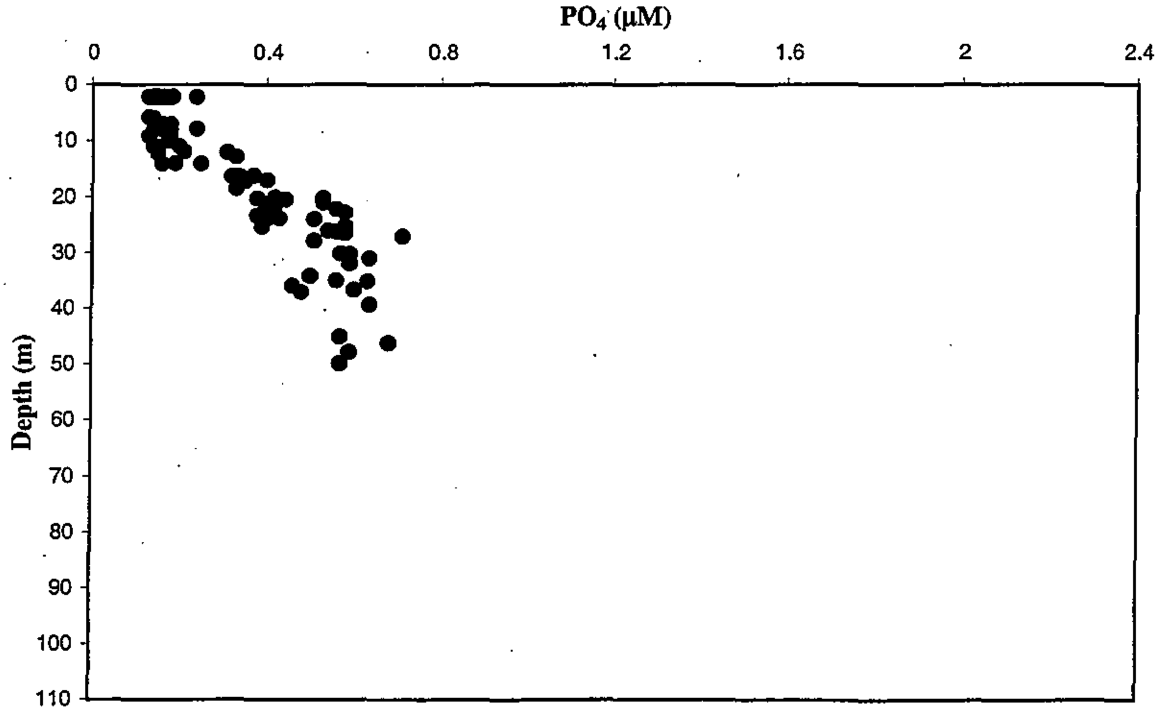


FIGURE 4-2
Depth vs. nutrient plots for nearfield survey W9710, (Aug 97)

(a)



(b)

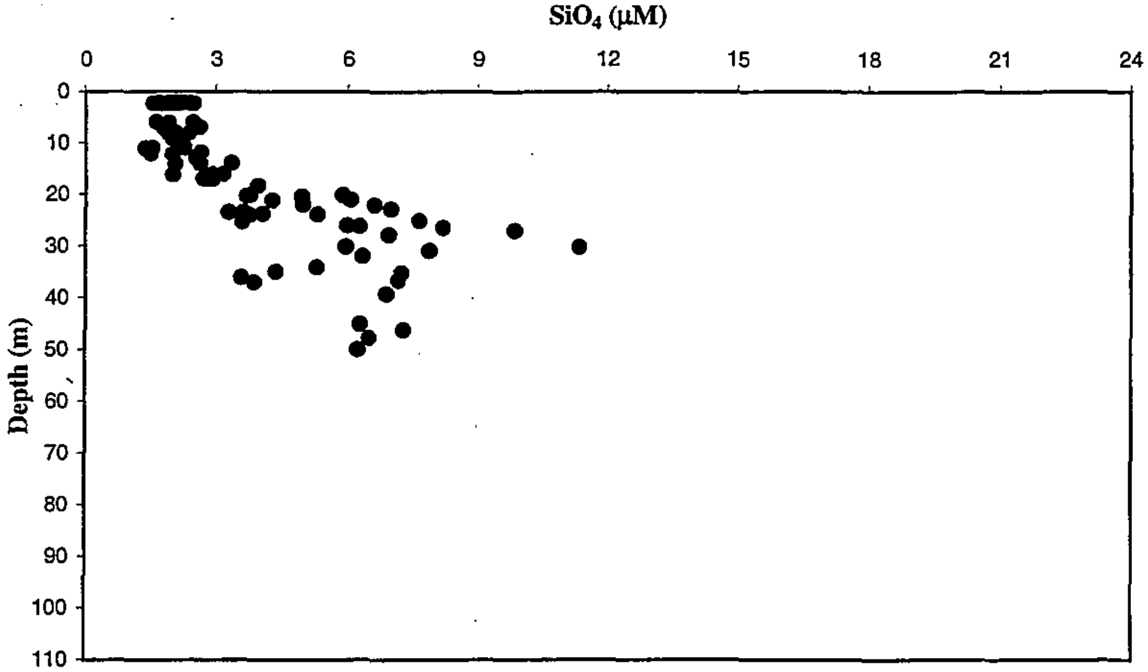


FIGURE 4-3

Depth vs. nutrient plots for nearfield survey W9710, (Aug 97)

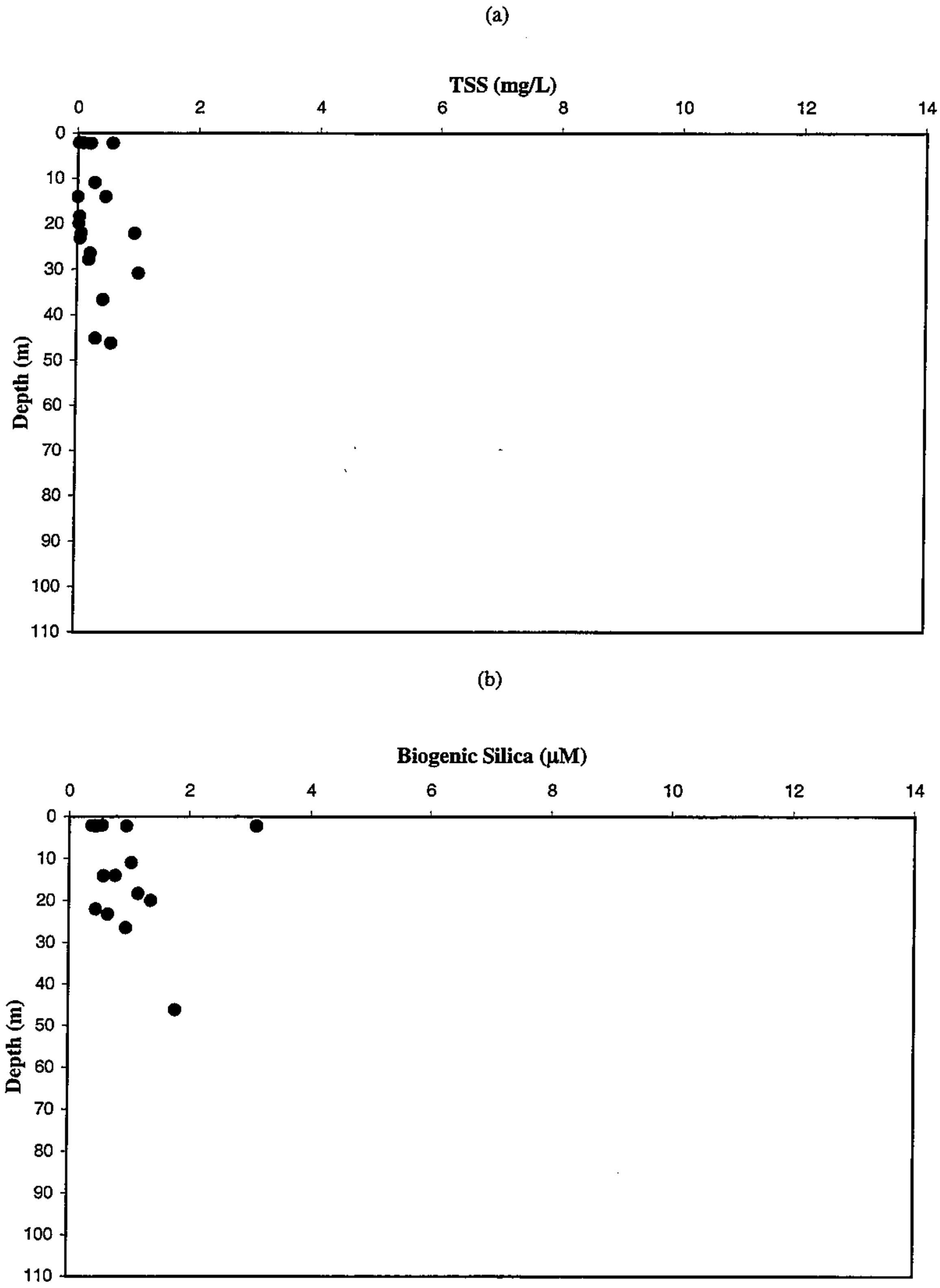


FIGURE 4-4
Depth vs. nutrient plots for nearfield survey W9710, (Aug 97)

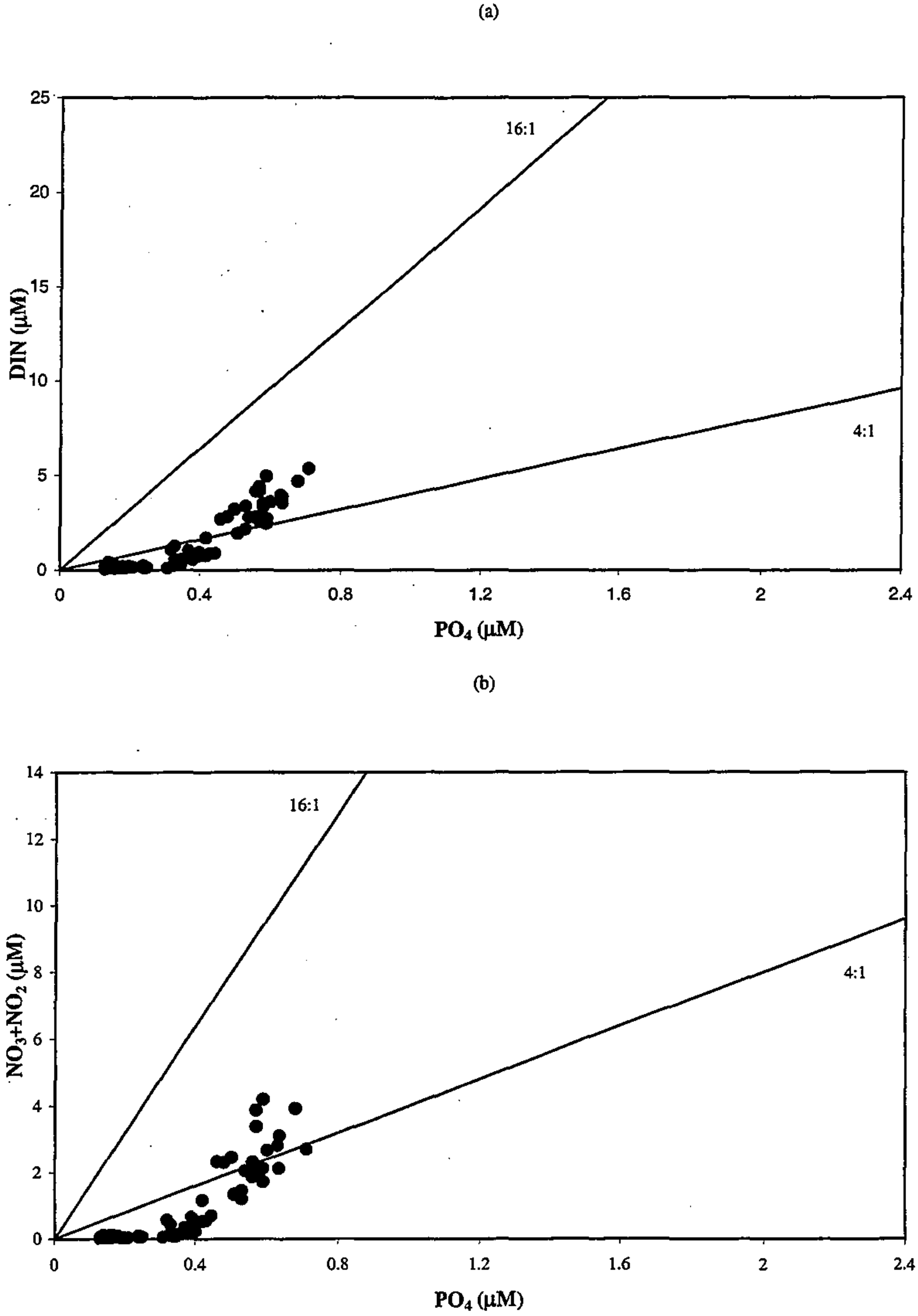


FIGURE 4-5

Nutrient vs. nutrient plots for nearfield survey W9710, (Aug 97)

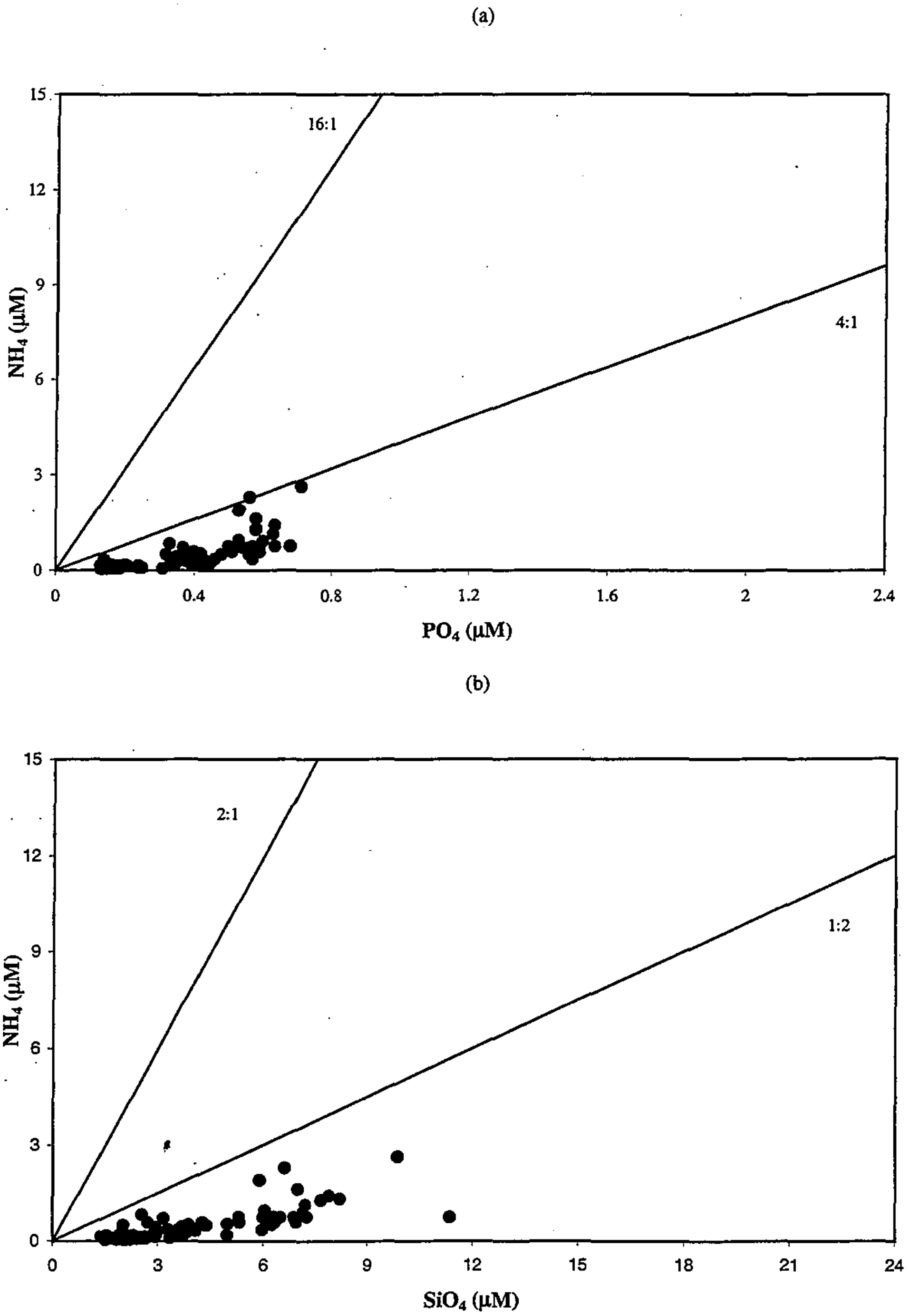


FIGURE 4-6

Nutrient vs. nutrient plots for nearfield survey W9710, (Aug 97)

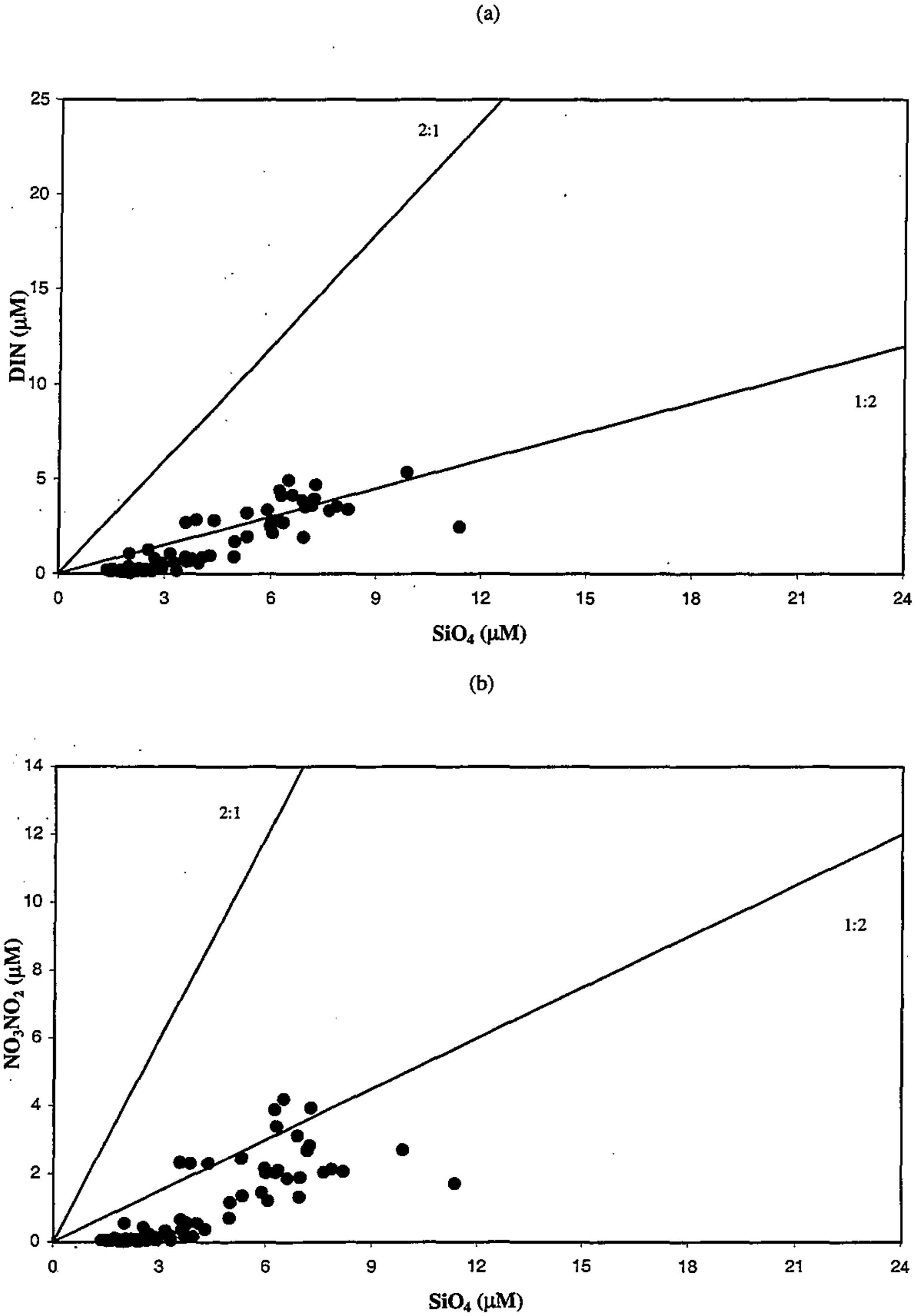


FIGURE 4-7

Nutrient vs. nutrient plots for nearfield survey W9710, (Aug 97)

(a)

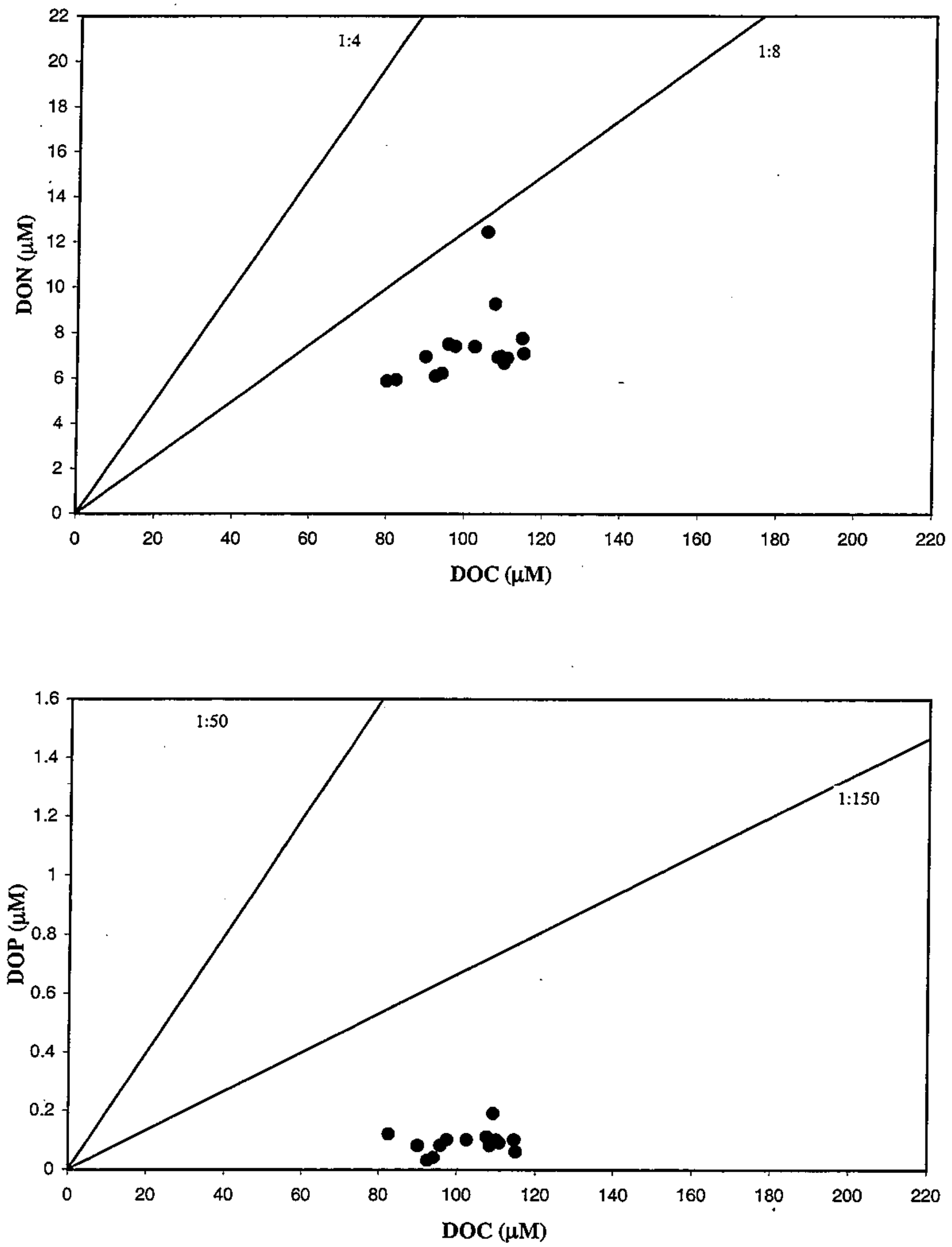


FIGURE 4-8

Nutrient vs. nutrient plots for nearfield survey W9710, (Aug 97)

(a)

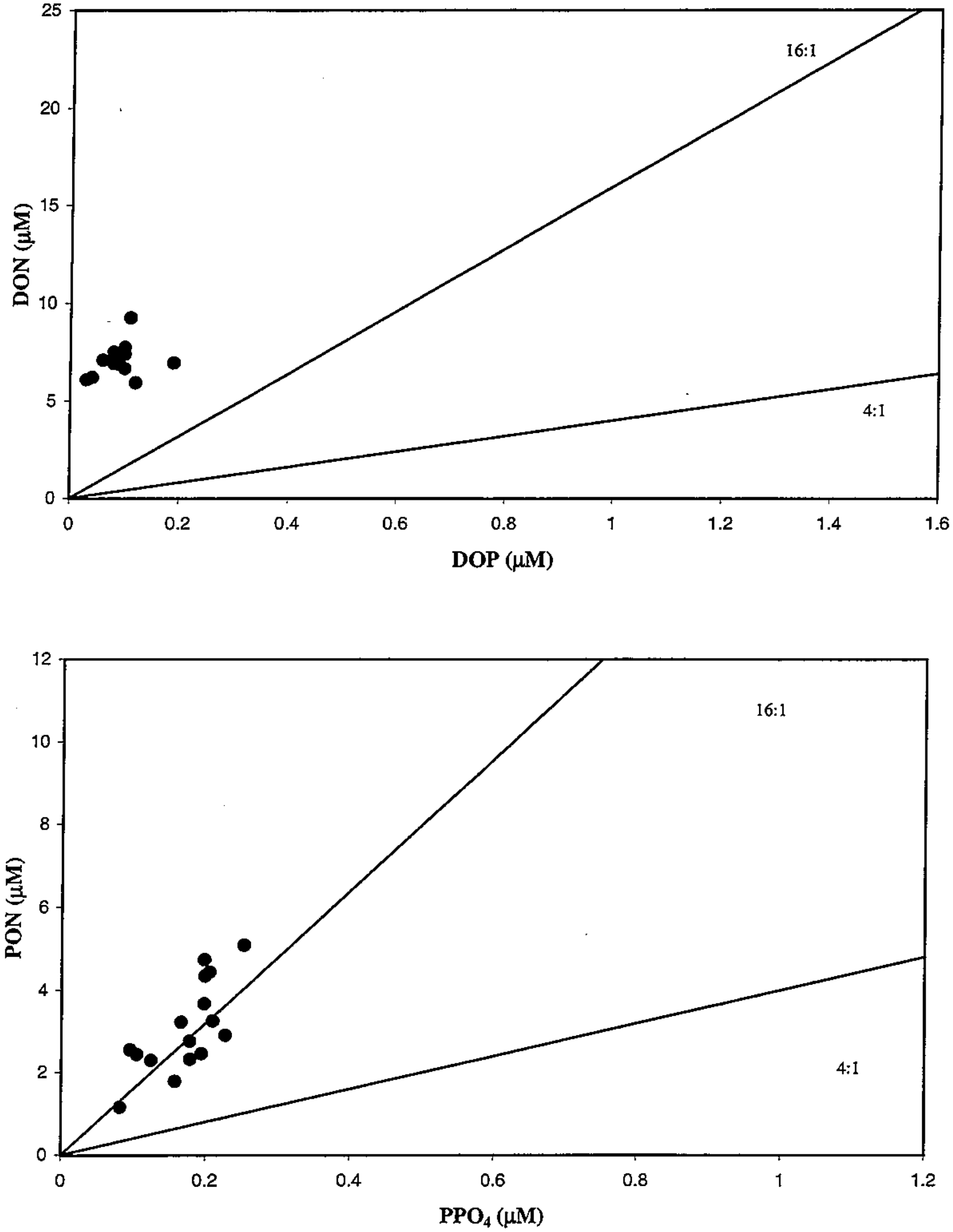


FIGURE 4-9

Nutrient vs. nutrient plots for nearfield survey W9710, (Aug 97)

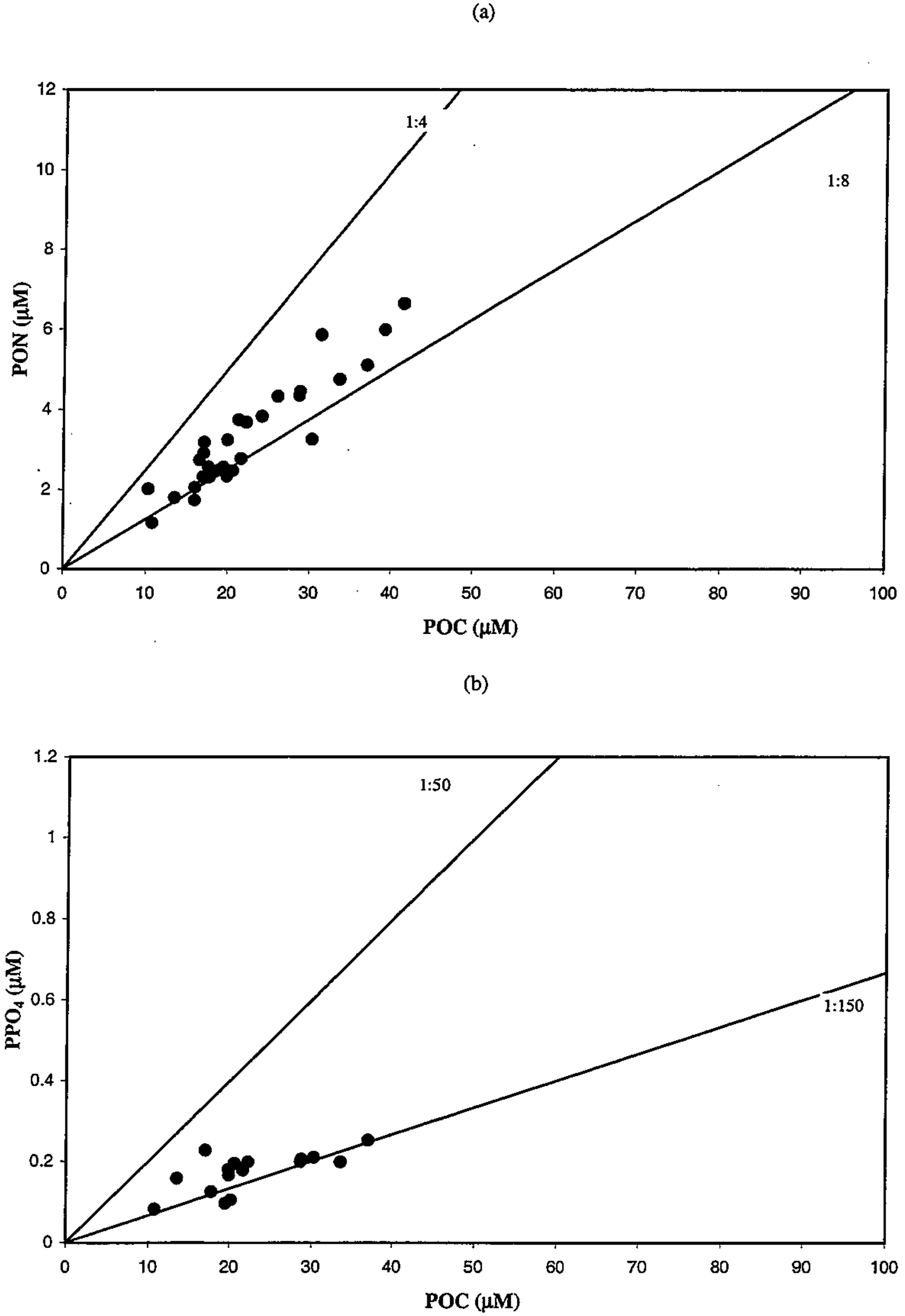


FIGURE 4-10

Nutrient vs. nutrient plots for nearfield survey W9710, (Aug 97)

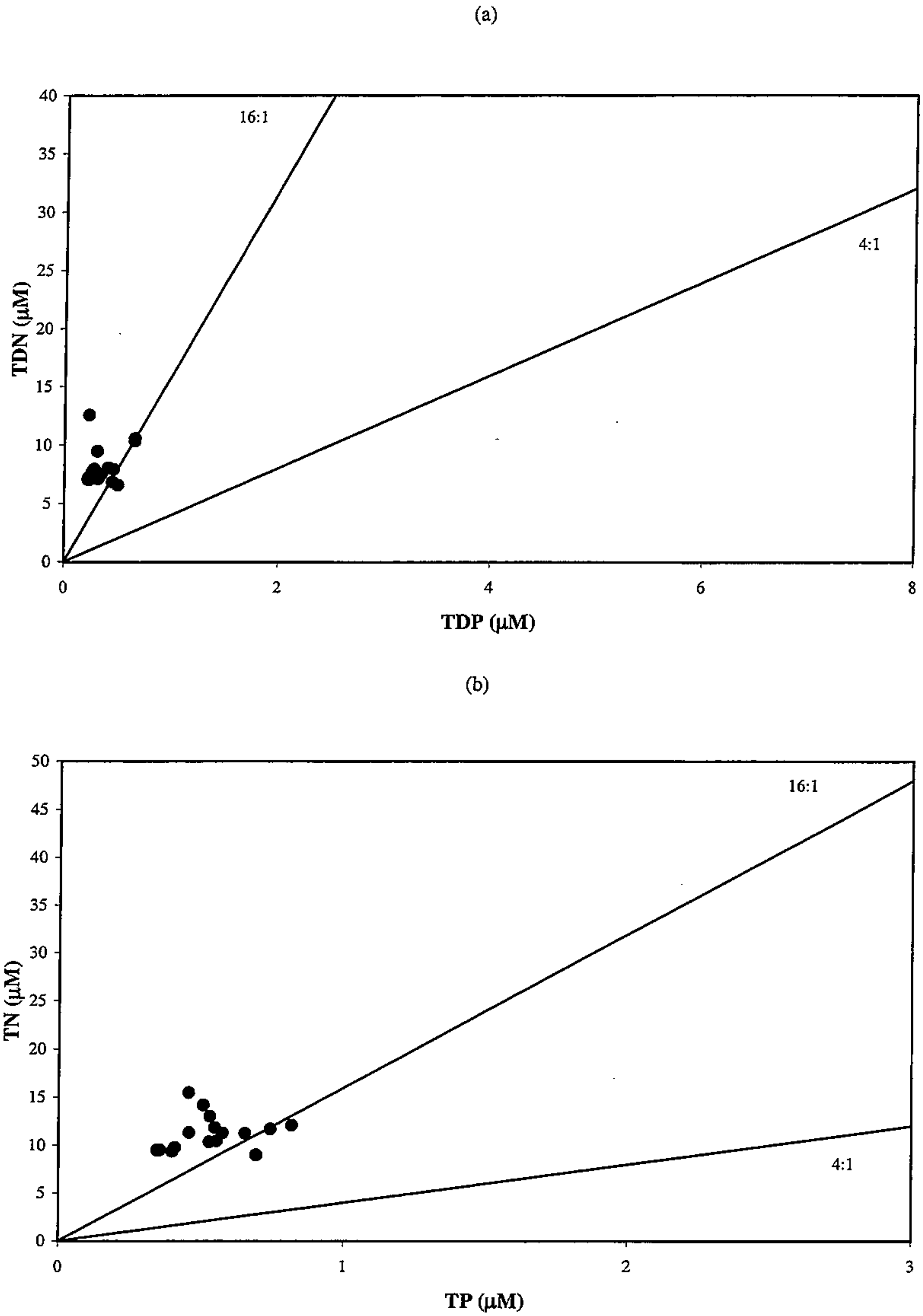


FIGURE 4-11
Nutrient vs. nutrient plots for nearfield survey W9710, (Aug 97)

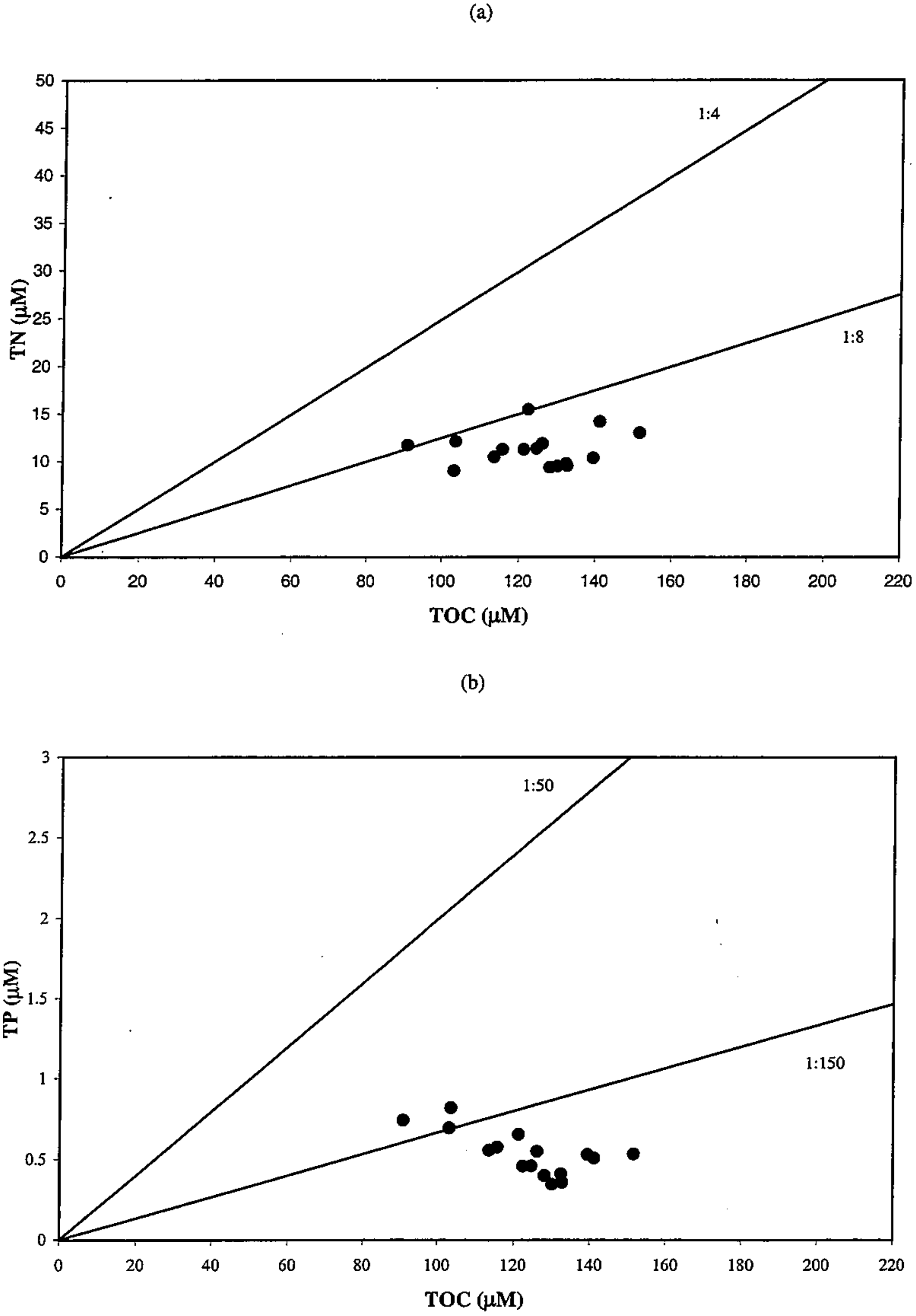


FIGURE 4-12
Nutrient vs. nutrient plots for nearfield survey W9710, (Aug 97)

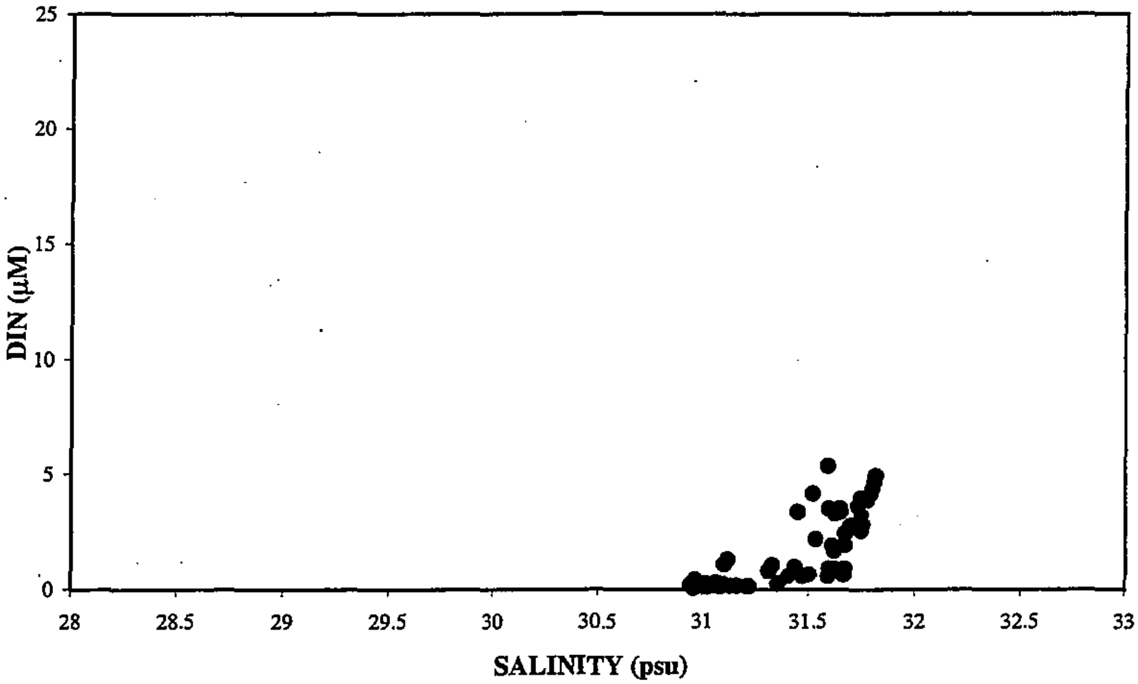


FIGURE 4-13
Nutrient vs. salinity plots for nearfield survey W9710, (Aug 97)

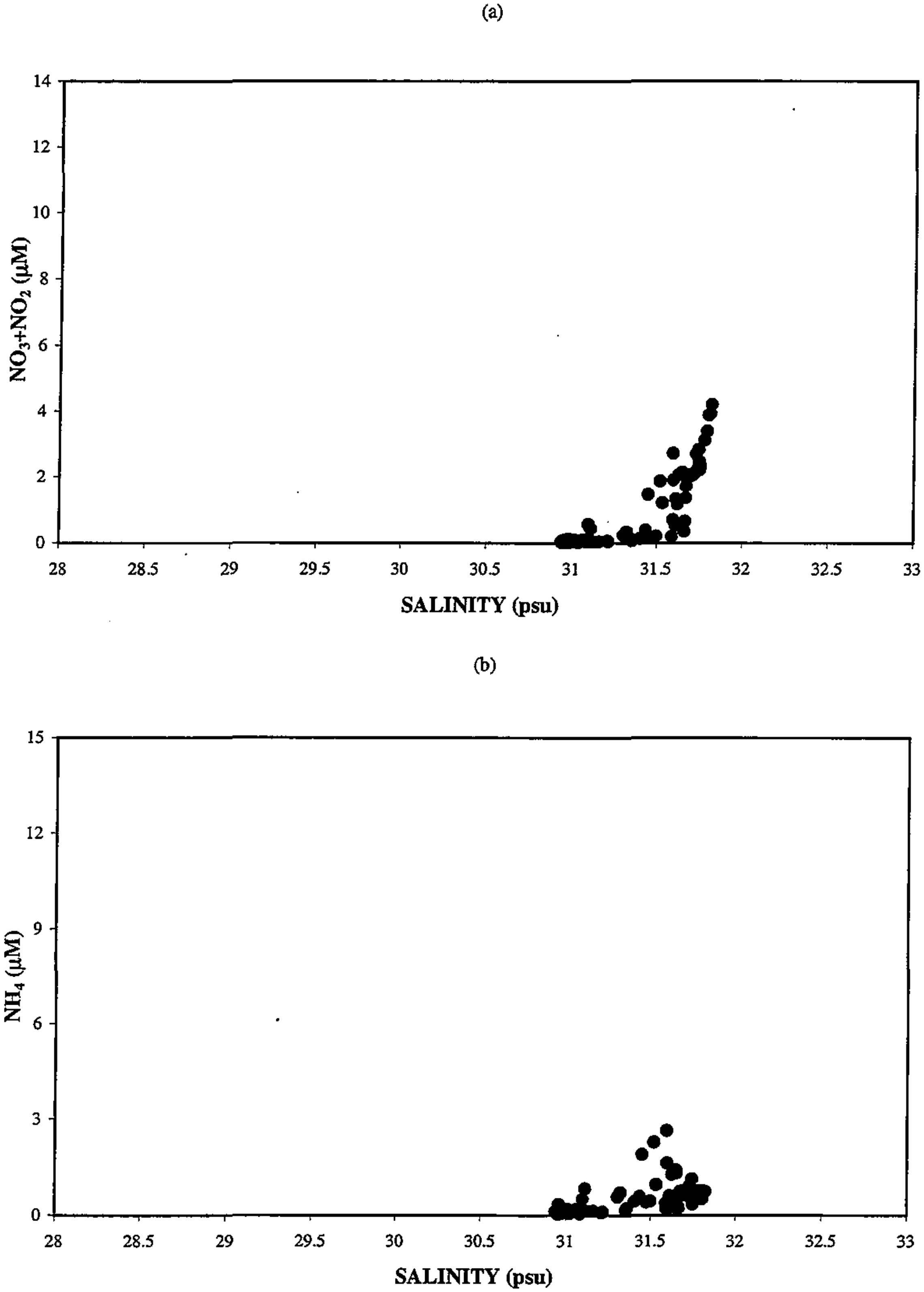


FIGURE 4-14

Nutrient vs. salinity plots for nearfield survey W9710, (Aug 97)

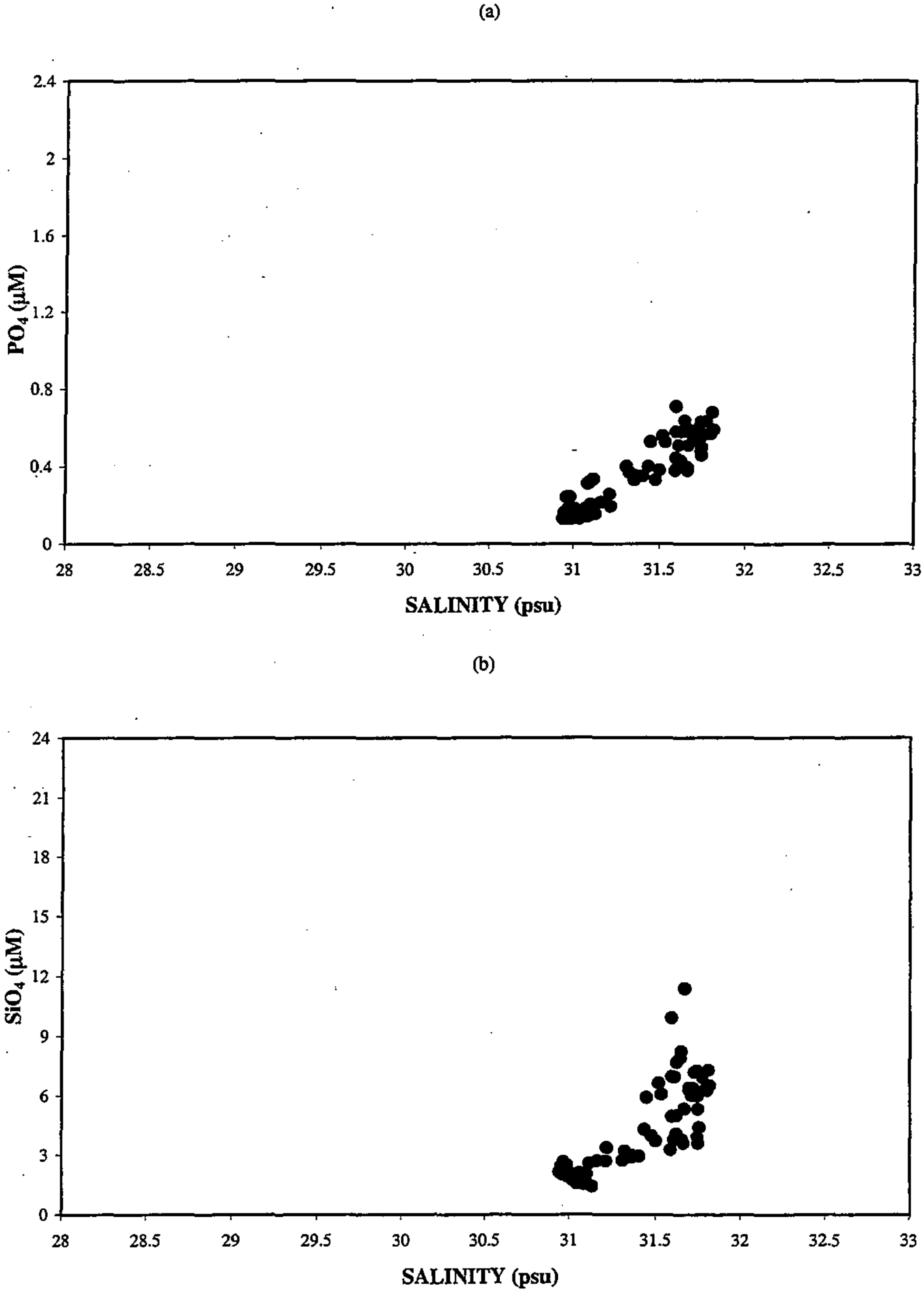


FIGURE 4-15

Nutrient vs. salinity plots for nearfield survey W9710, (Aug 97)

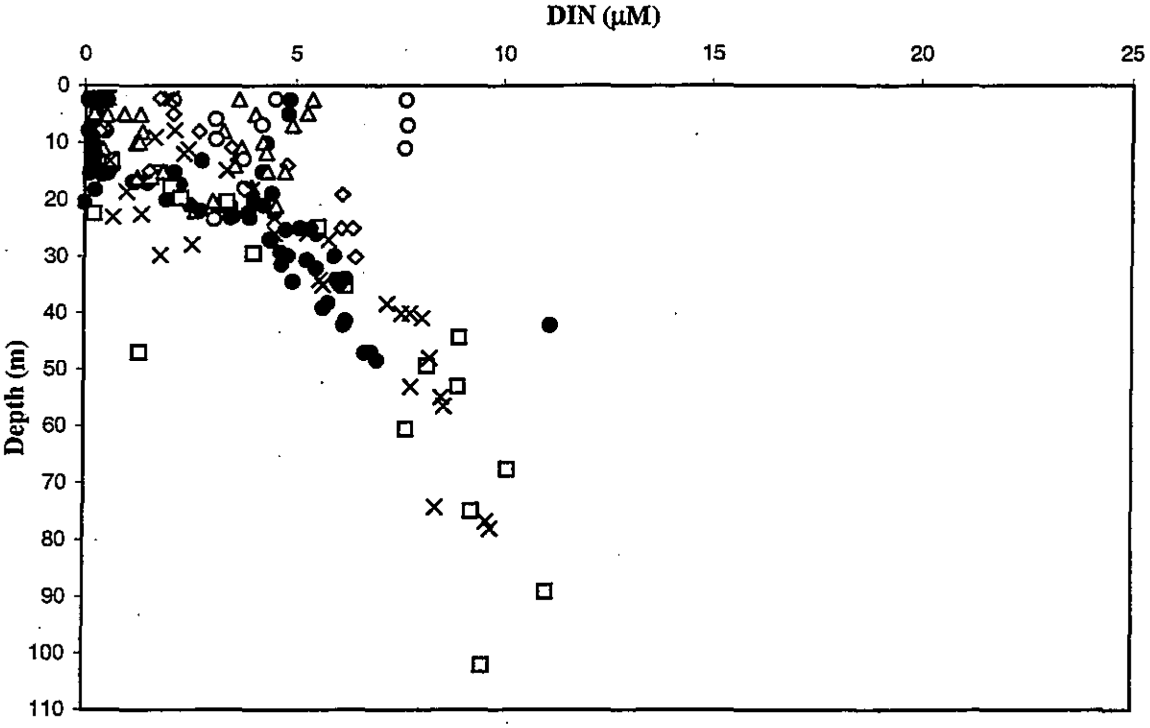


FIGURE 4-16

Depth vs. nutrient plots for nearfield survey W9711, (Aug 97)

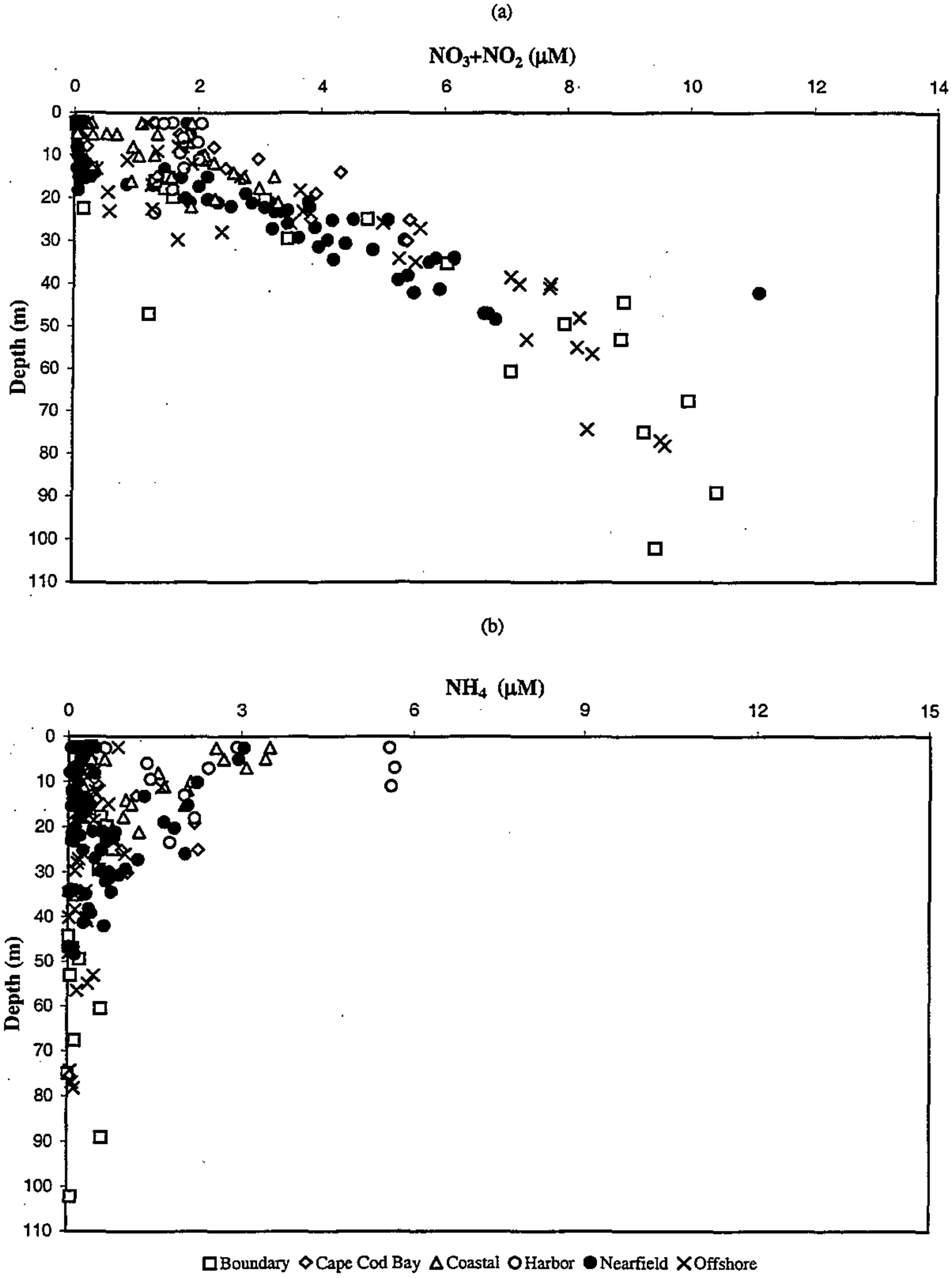


FIGURE 4-17
Depth vs. nutrient plots for nearfield survey W9711, (Aug 97)

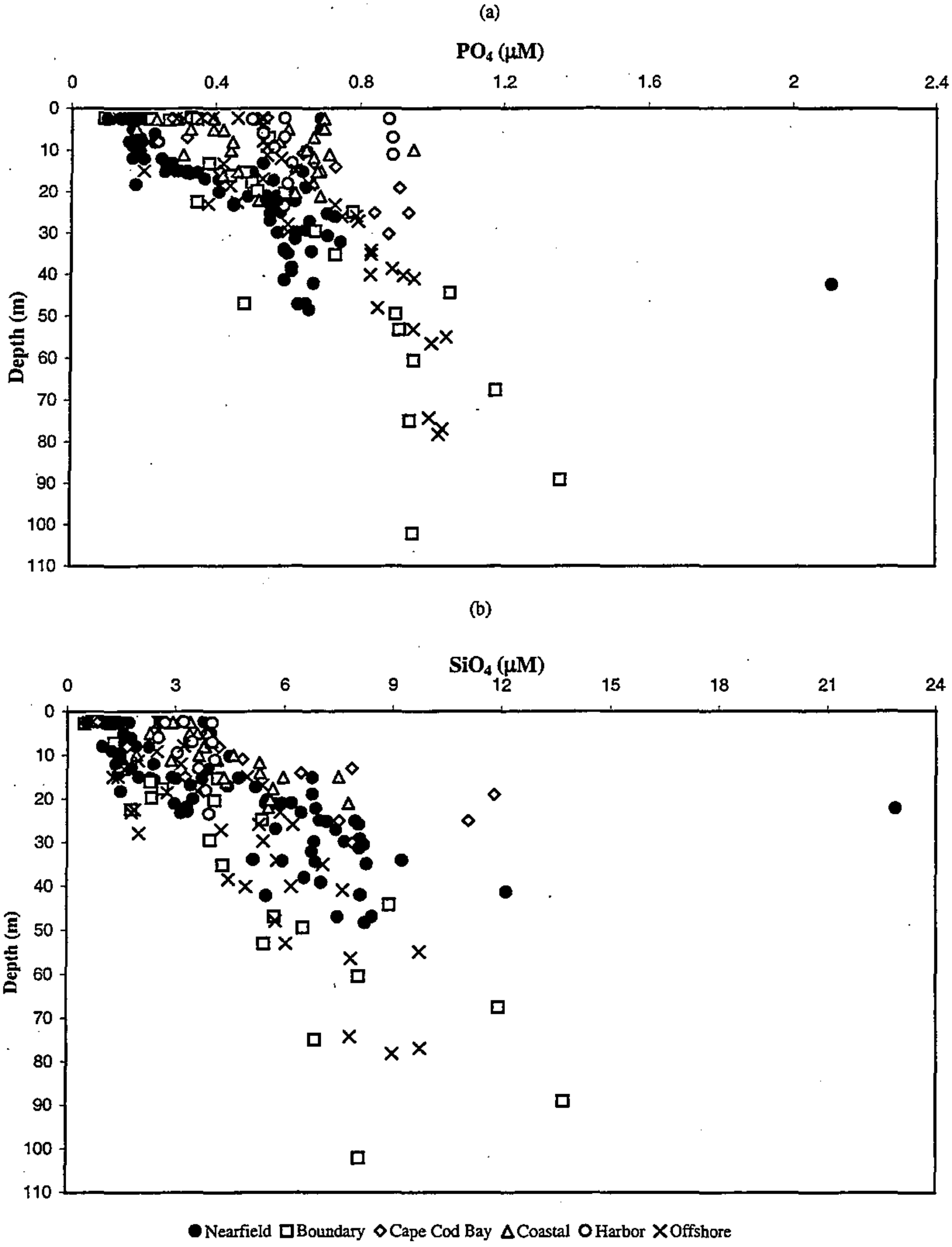


FIGURE 4-18
Depth vs. nutrient plots for nearfield survey W9711, (Aug 97)

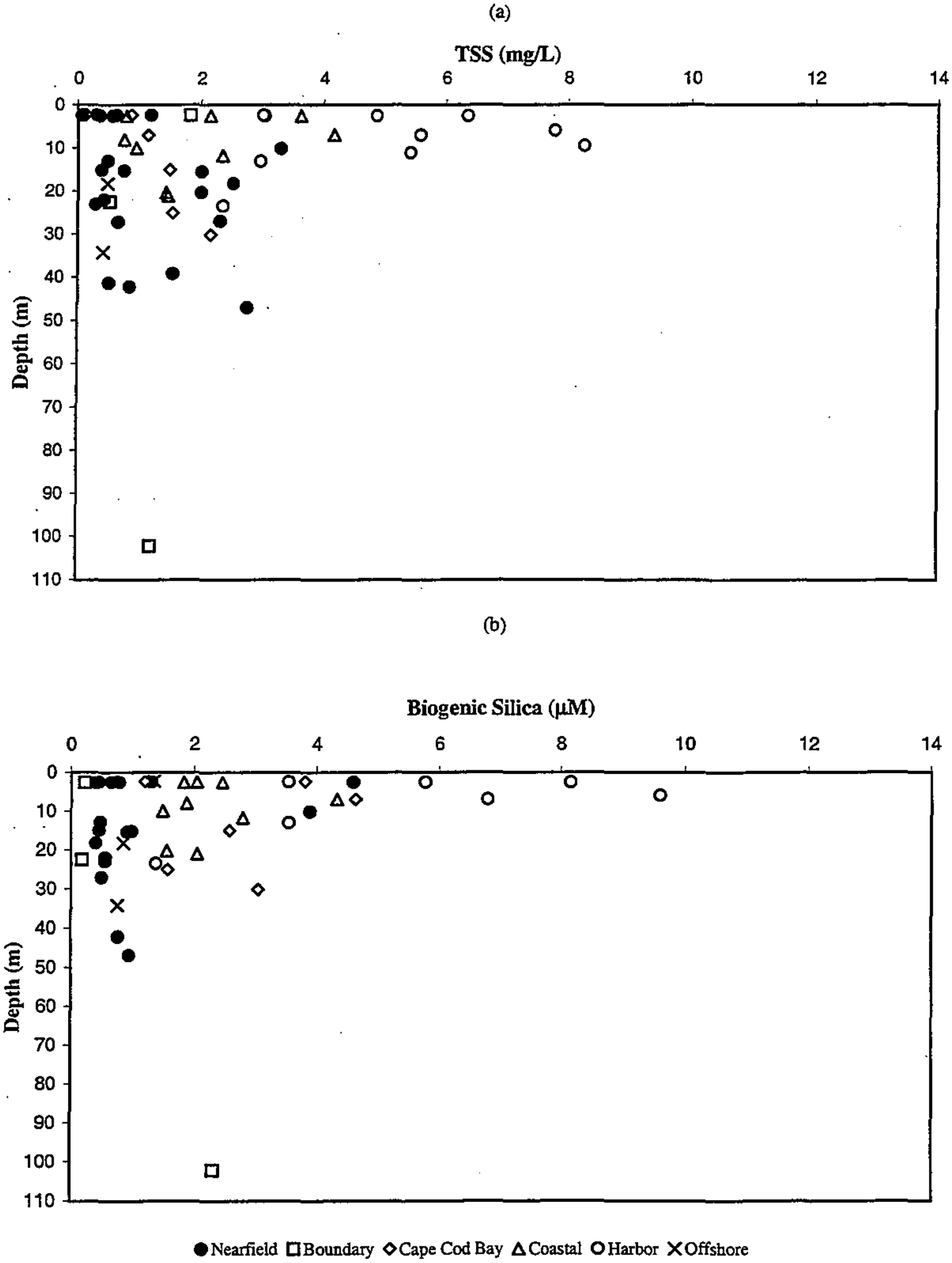


FIGURE 4-19
Depth vs. nutrient plots for nearfield survey W9711, (Aug 97)

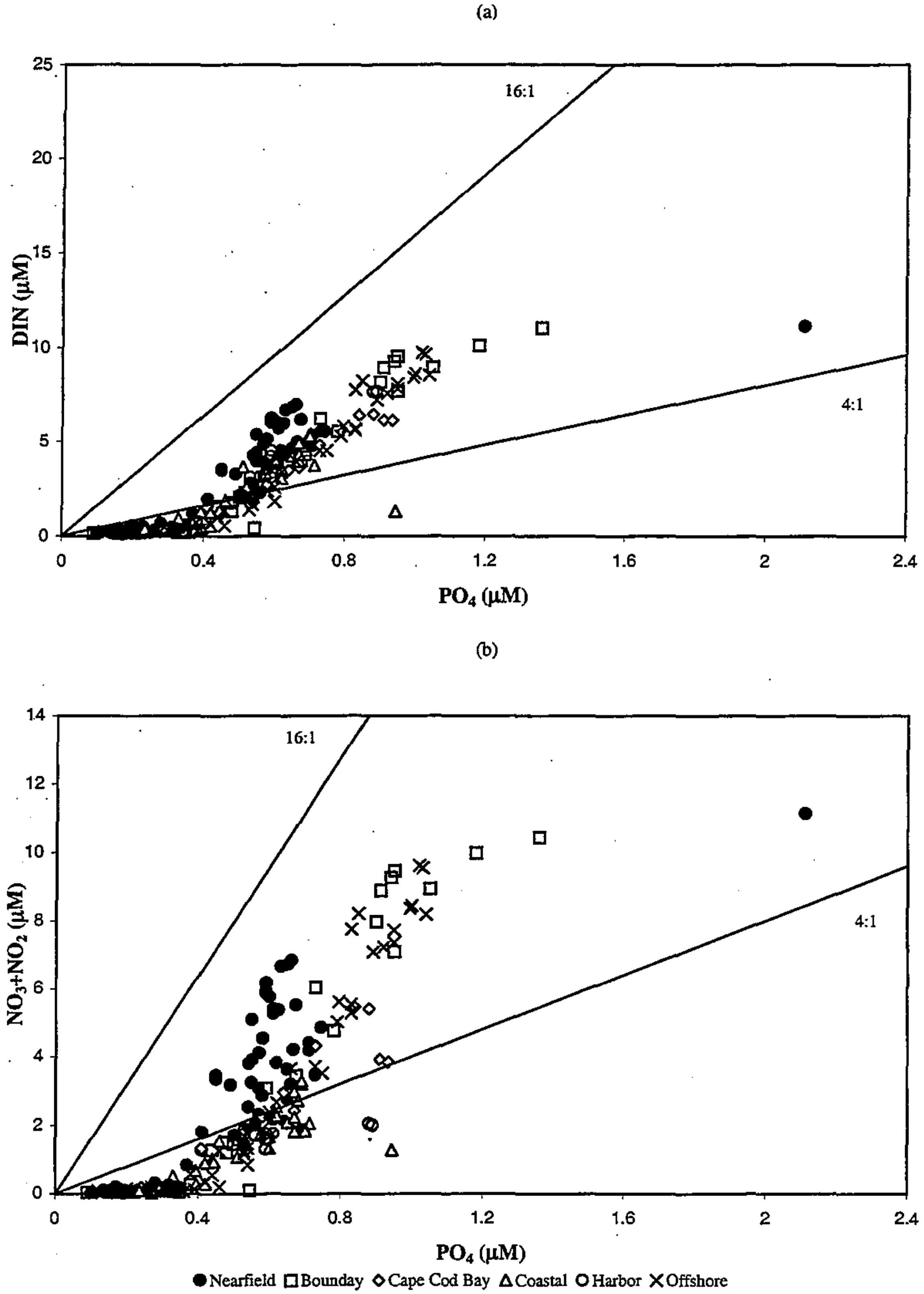


FIGURE 4-20

Nutrient vs. nutrient plots for nearfield survey W9711, (Aug 97)

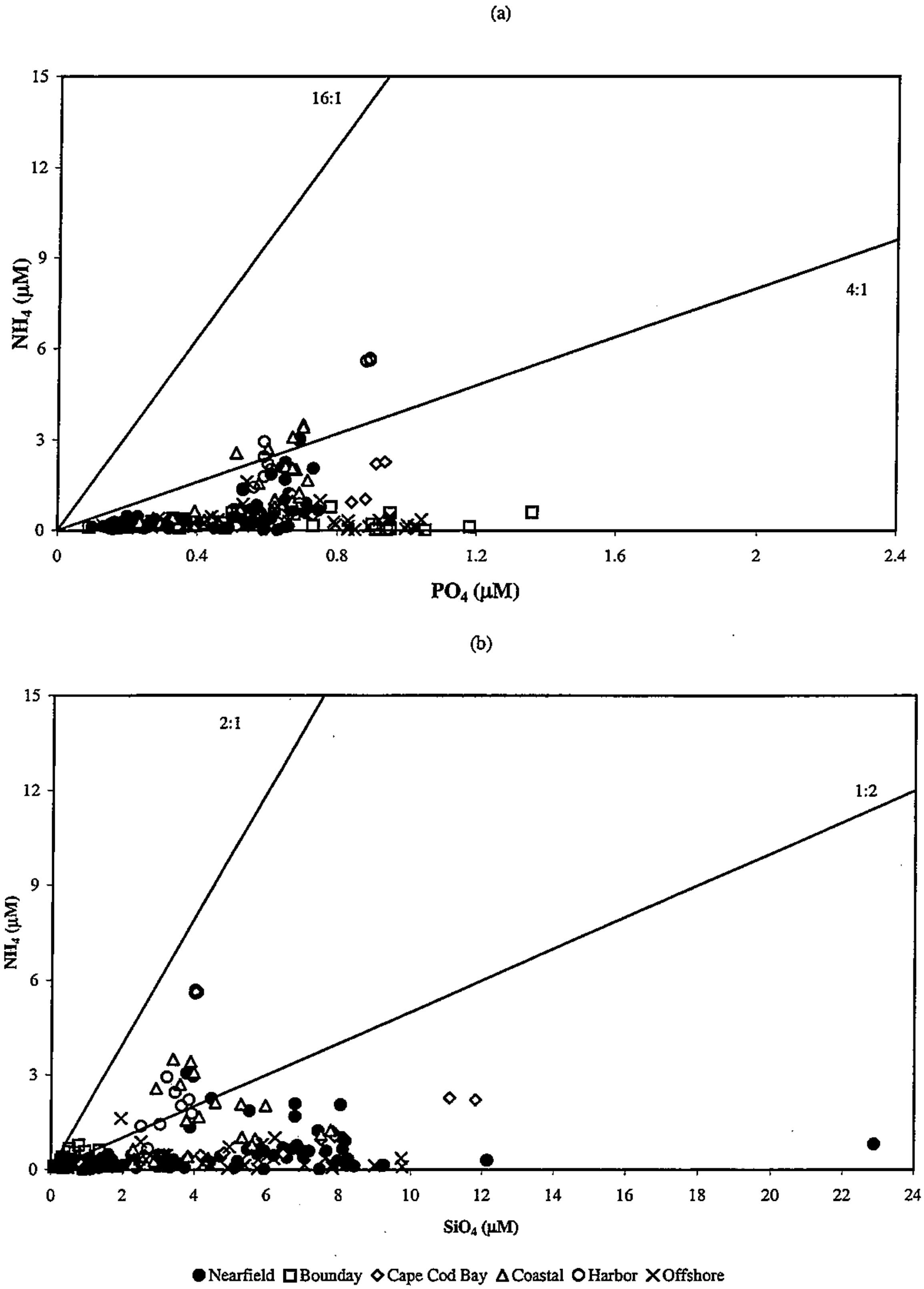


FIGURE 4-21
Nutrient vs. nutrient plots for nearfield survey W9711, (Aug 97)

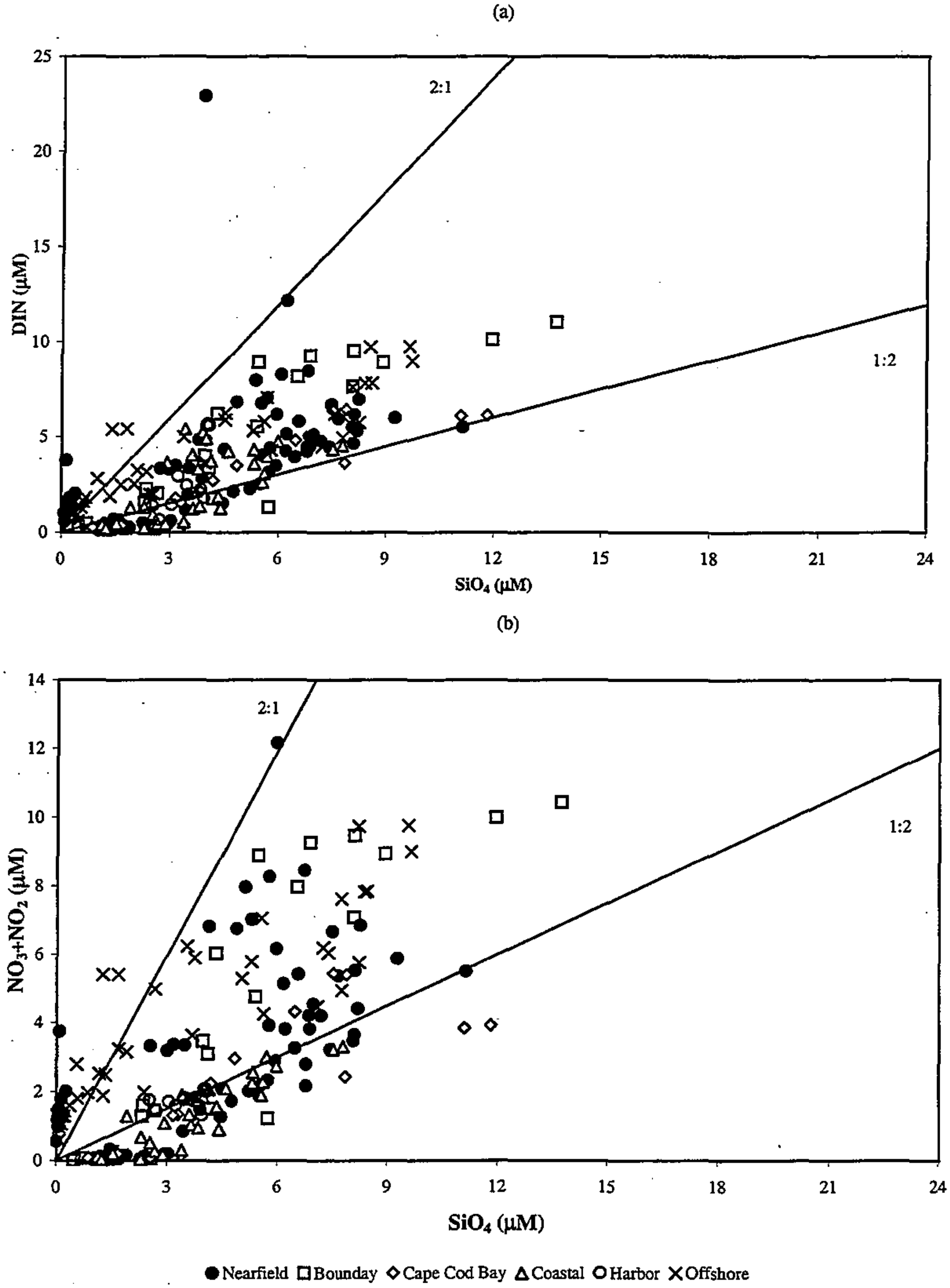
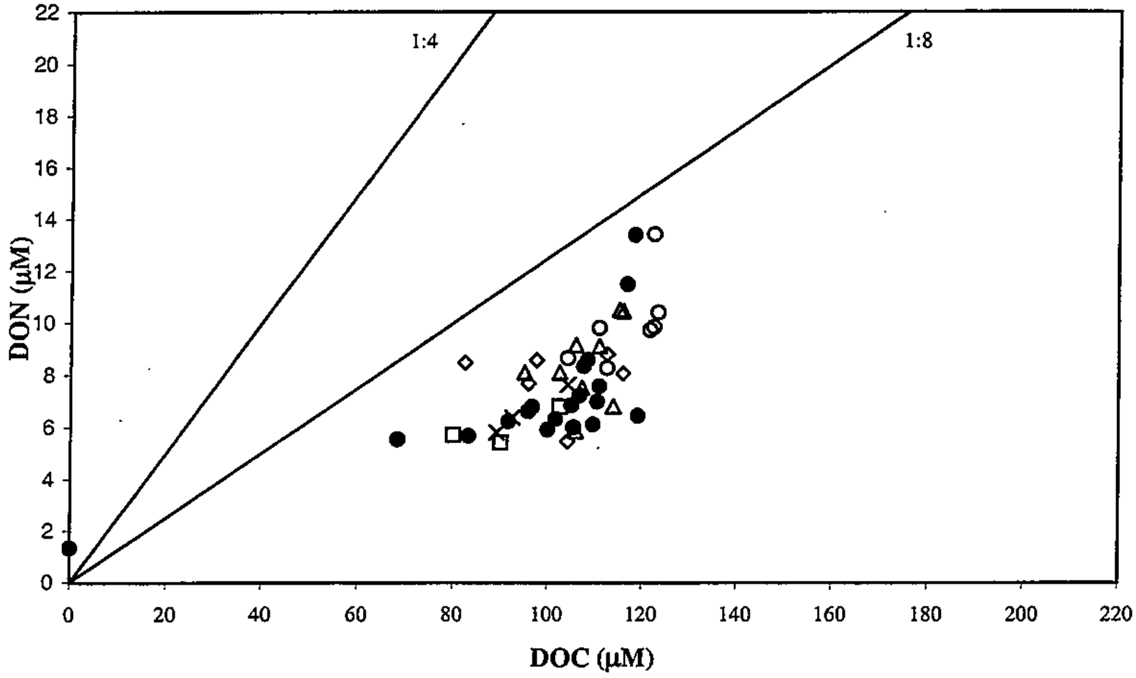


FIGURE 4-22
Nutrient vs. nutrient plots for nearfield survey W9711, (Aug 97)

(a)



(b)

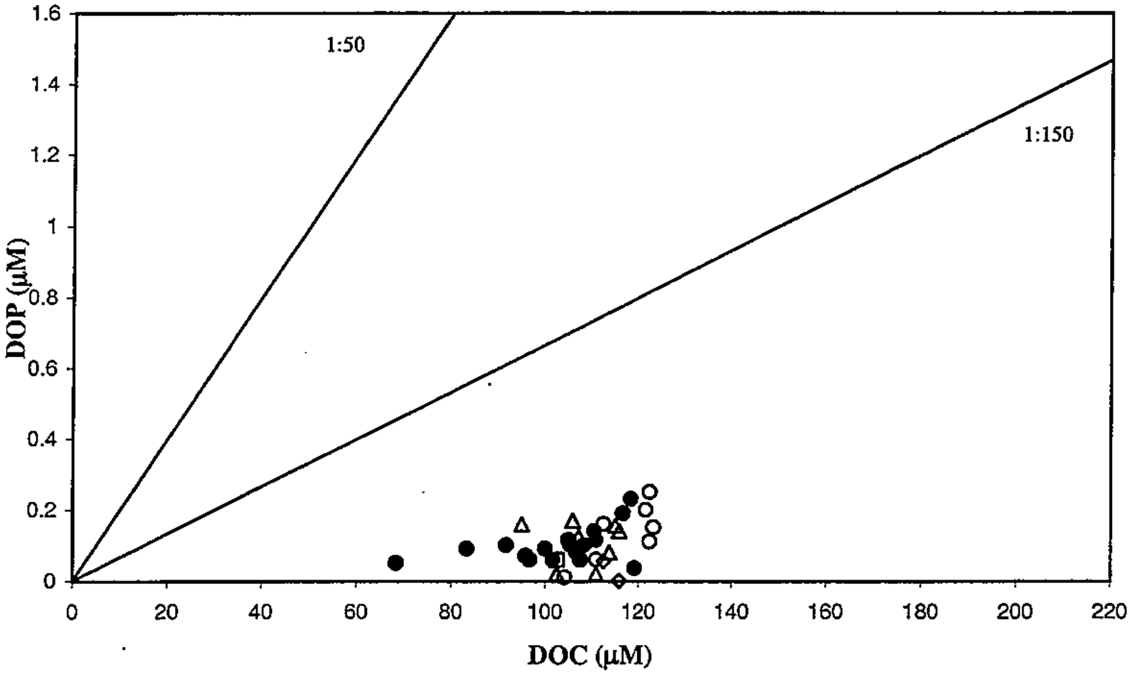


FIGURE 4-23

Nutrient vs. nutrient plots for nearfield survey W9711, (Aug 97)

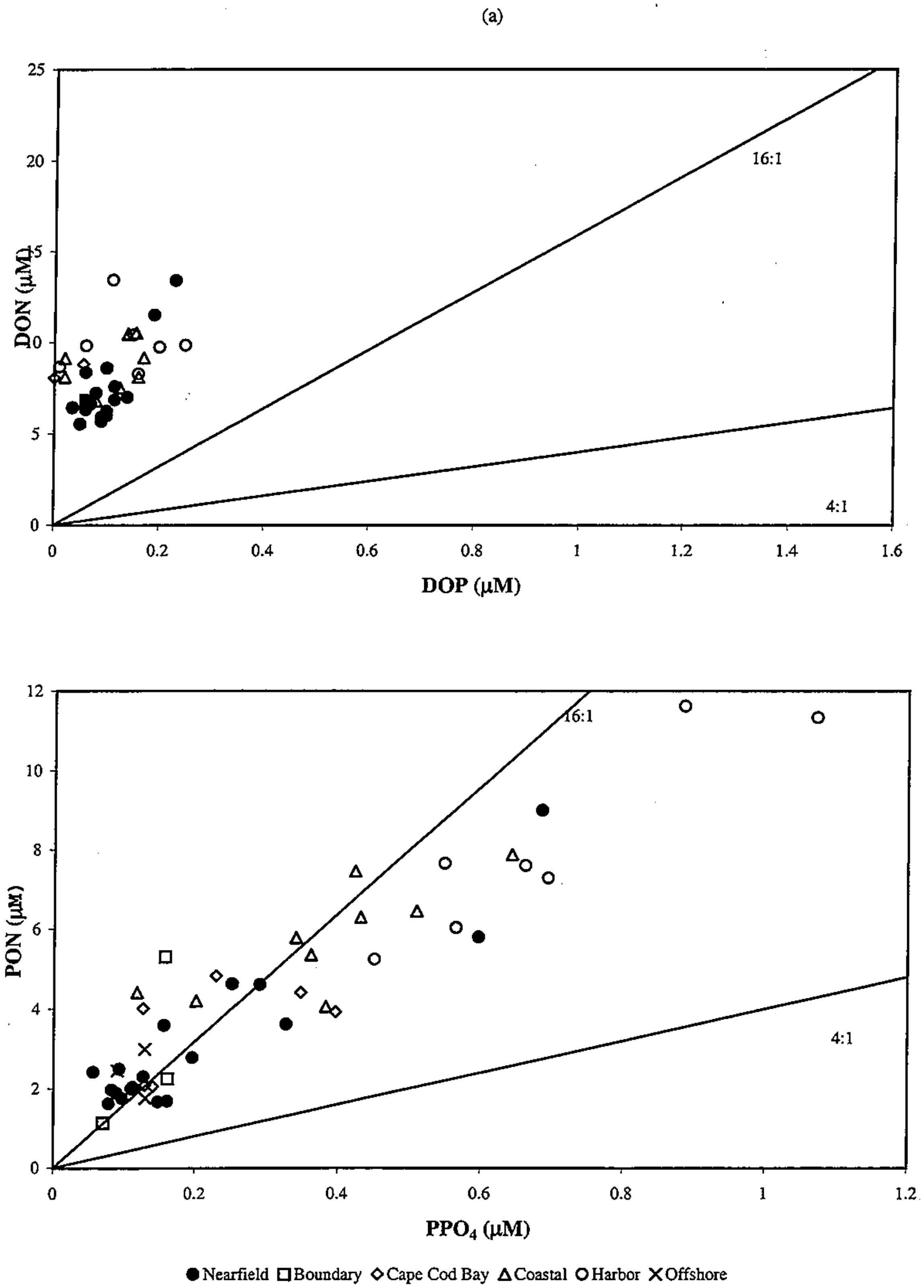


FIGURE 4-24

Nutrient vs. nutrient plots for nearfield survey W9711, (Aug 97)

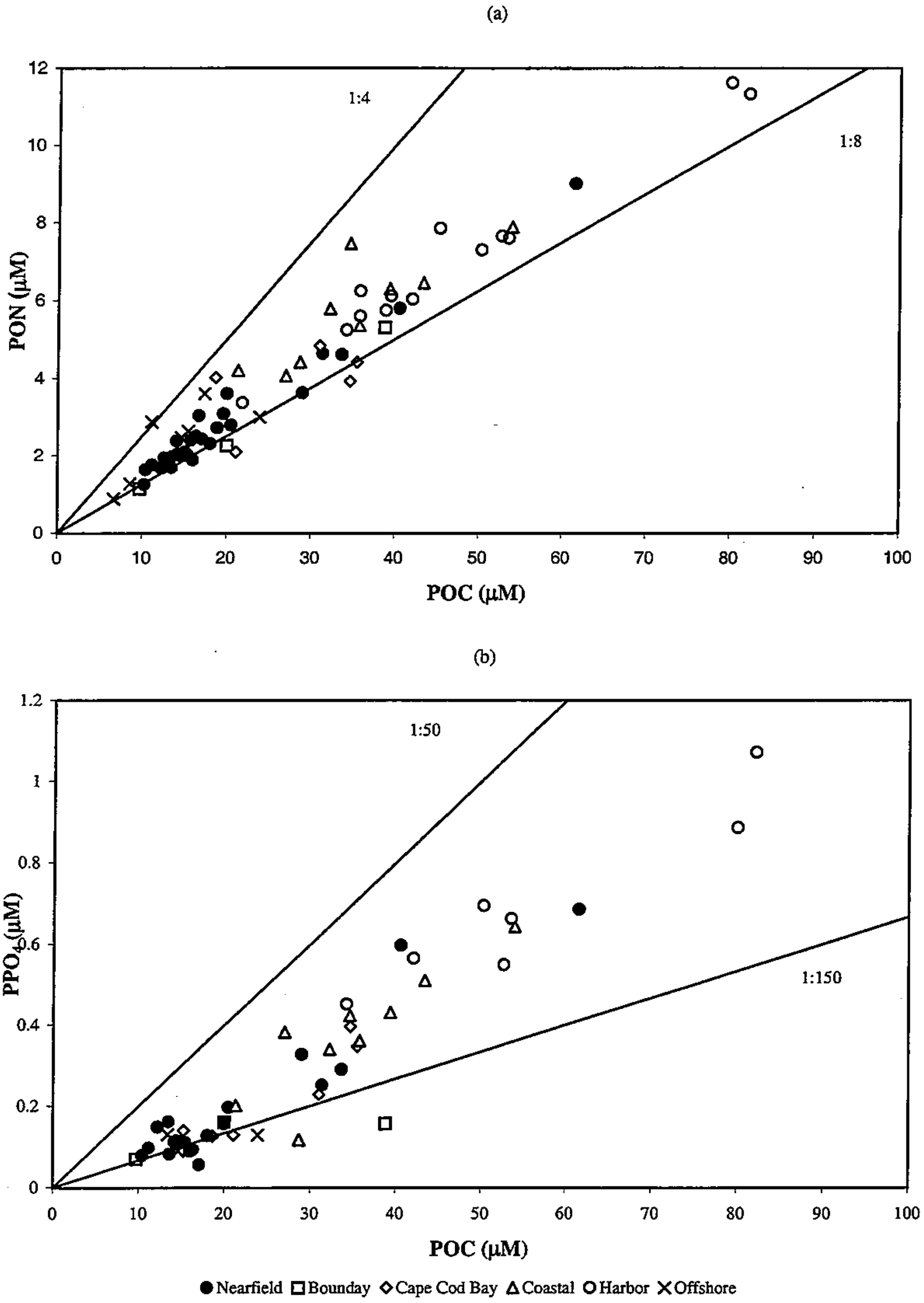
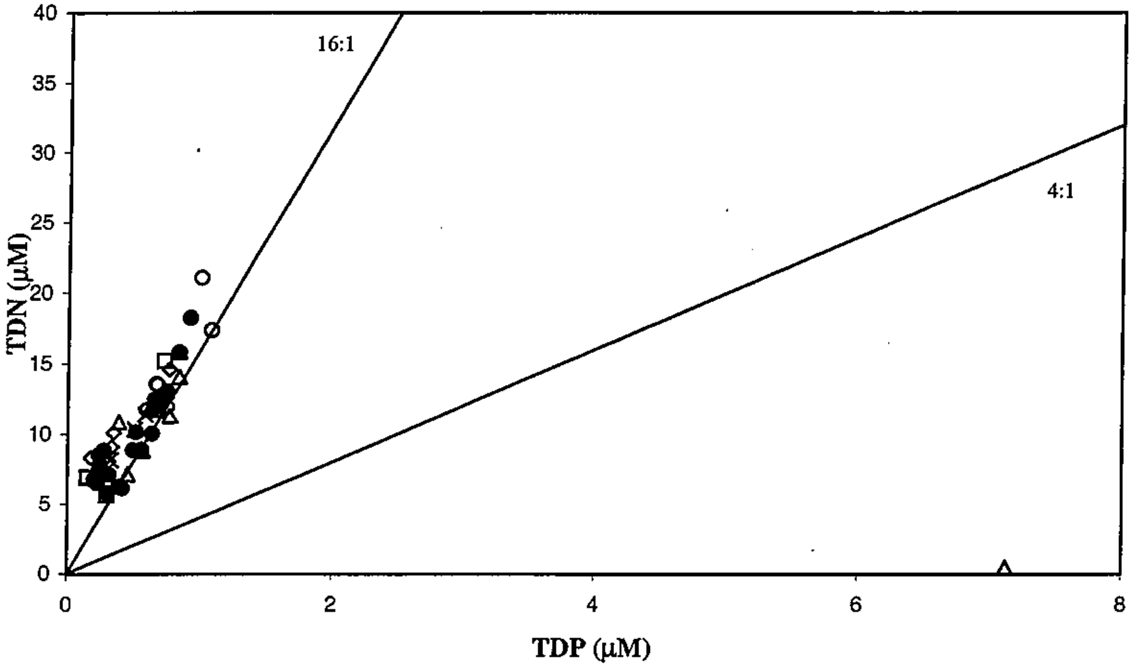


FIGURE 4-25
Nutrient vs. nutrient plots for nearfield survey W9711, (Aug 97)

(a)



(b)

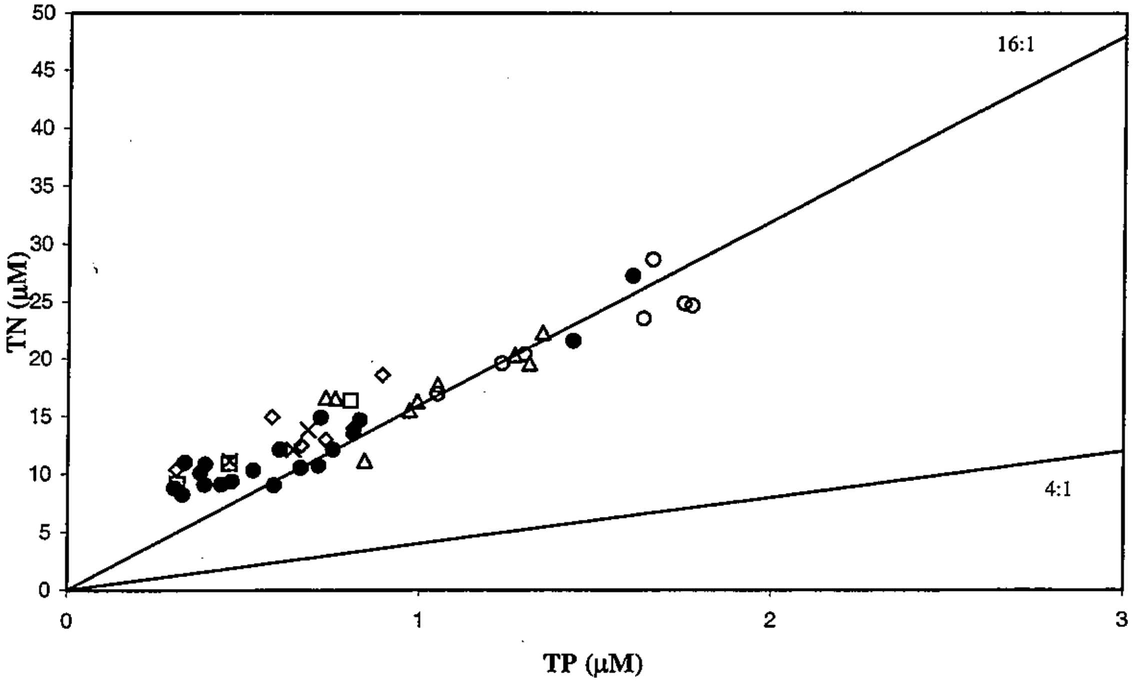
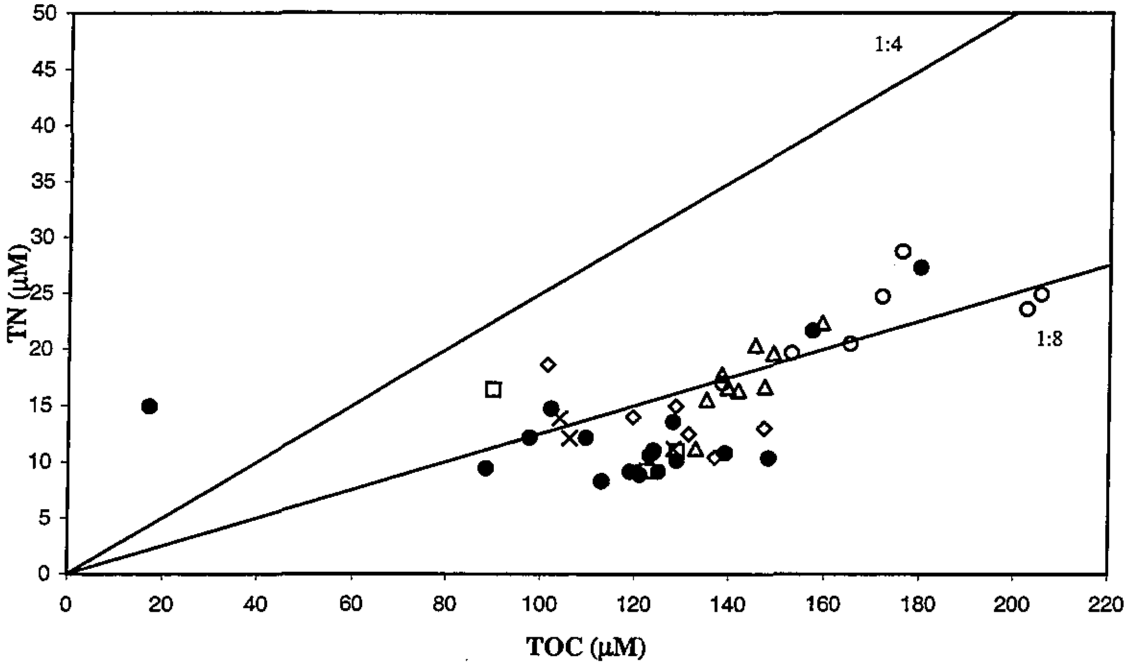


FIGURE 4-26

Nutrient vs. nutrient plots for nearfield survey W9711, (Aug 97)

(a)



(b)

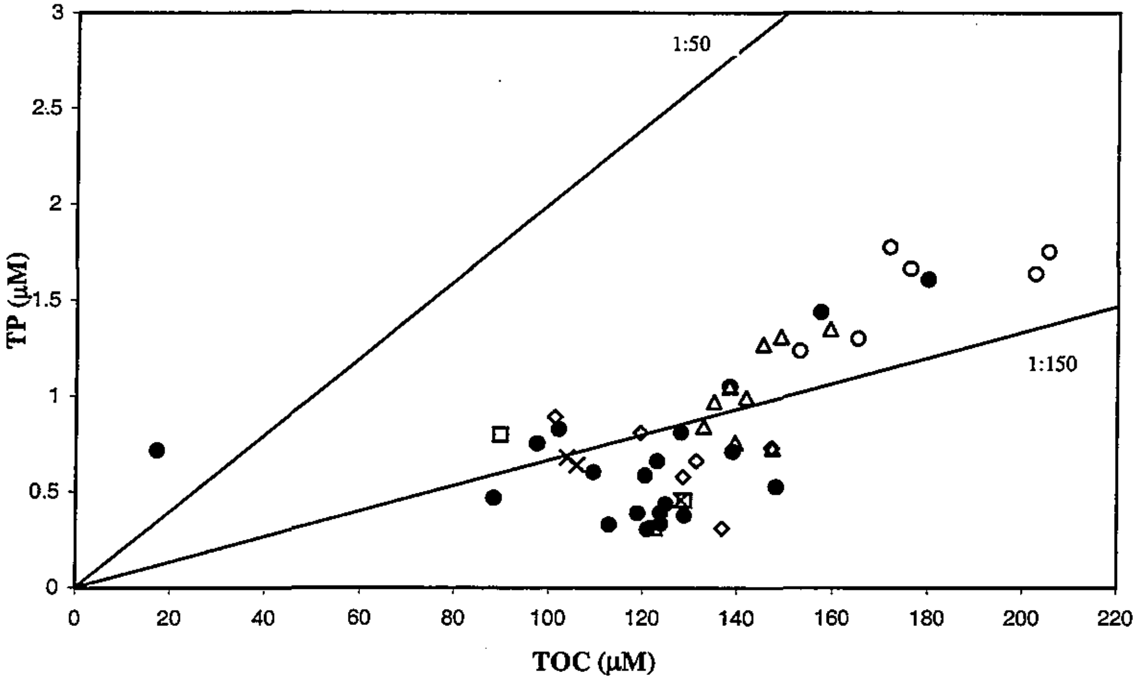


FIGURE 4-27

Nutrient vs. nutrient plots for nearfield survey W9711, (Aug 97)

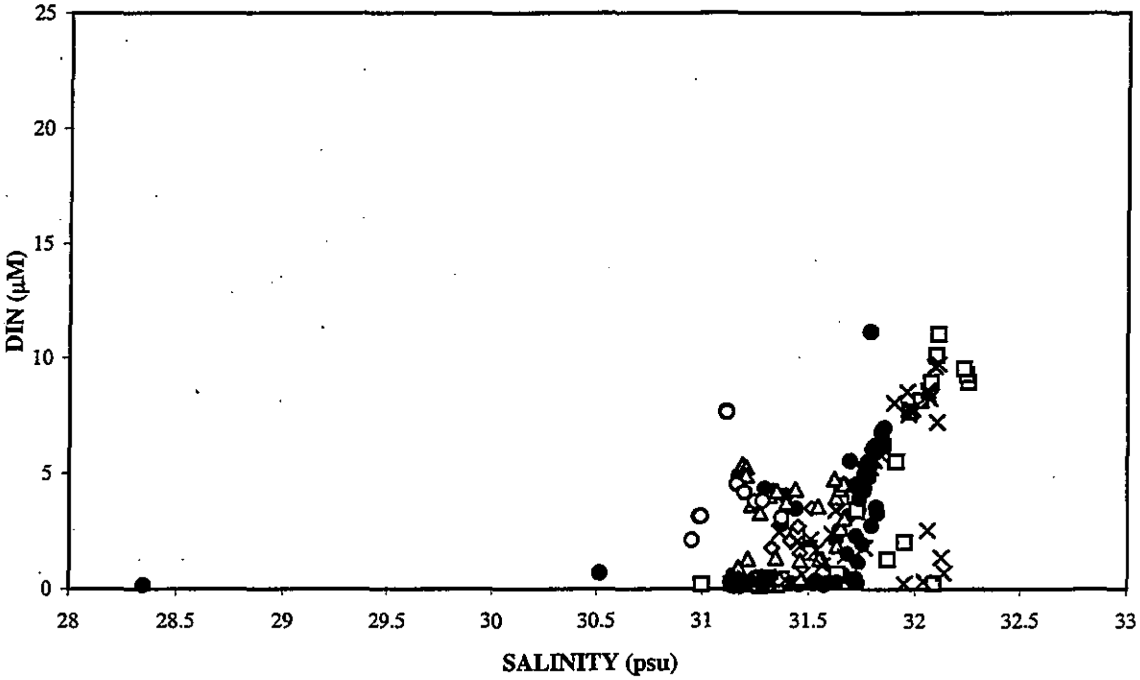


FIGURE 4-28
Nutrient vs. salinity plots for nearfield survey W9711, (Aug 97)

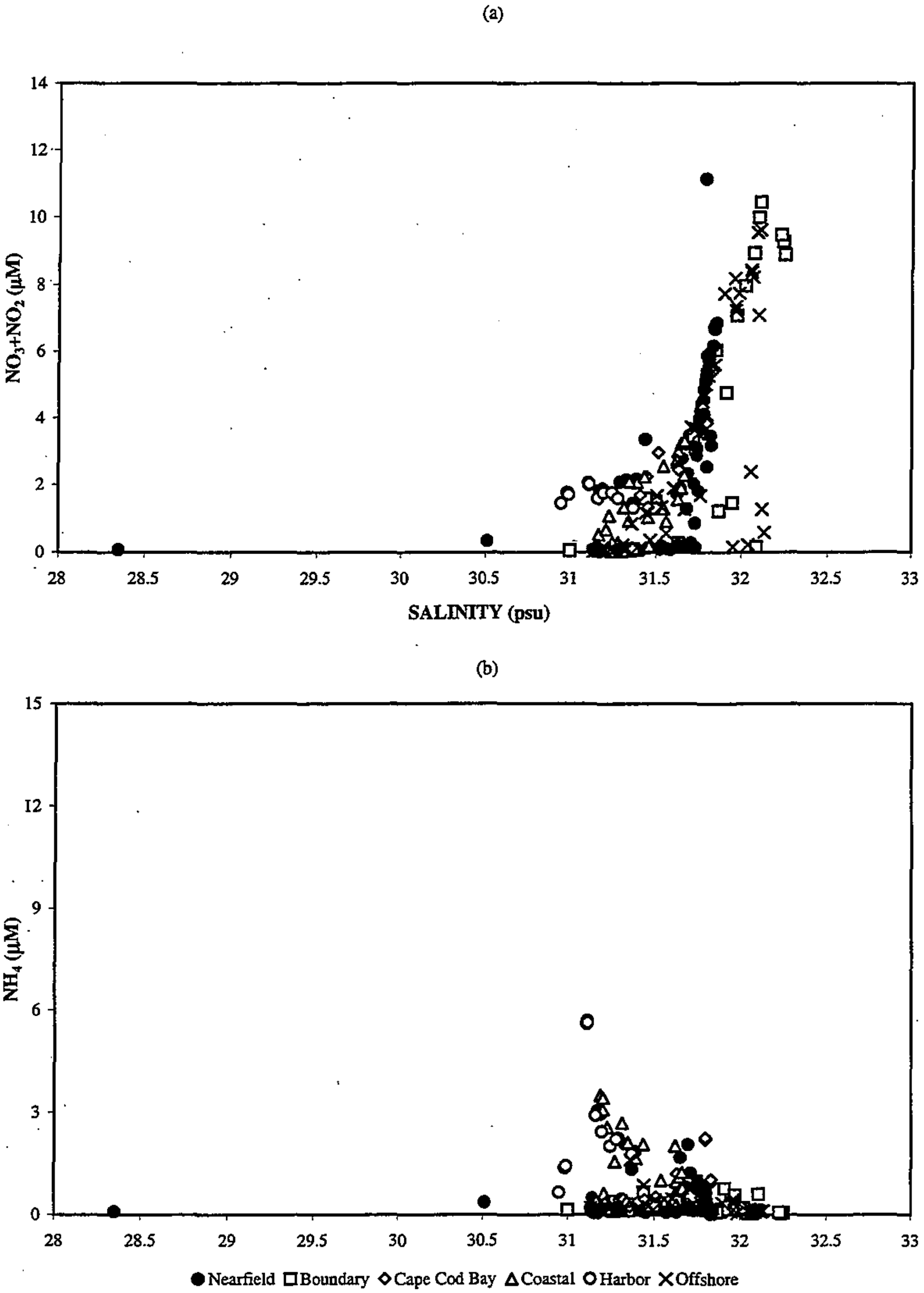


FIGURE 4-29

Nutrient vs. salinity plots for nearfield survey W9711, (Aug 97)

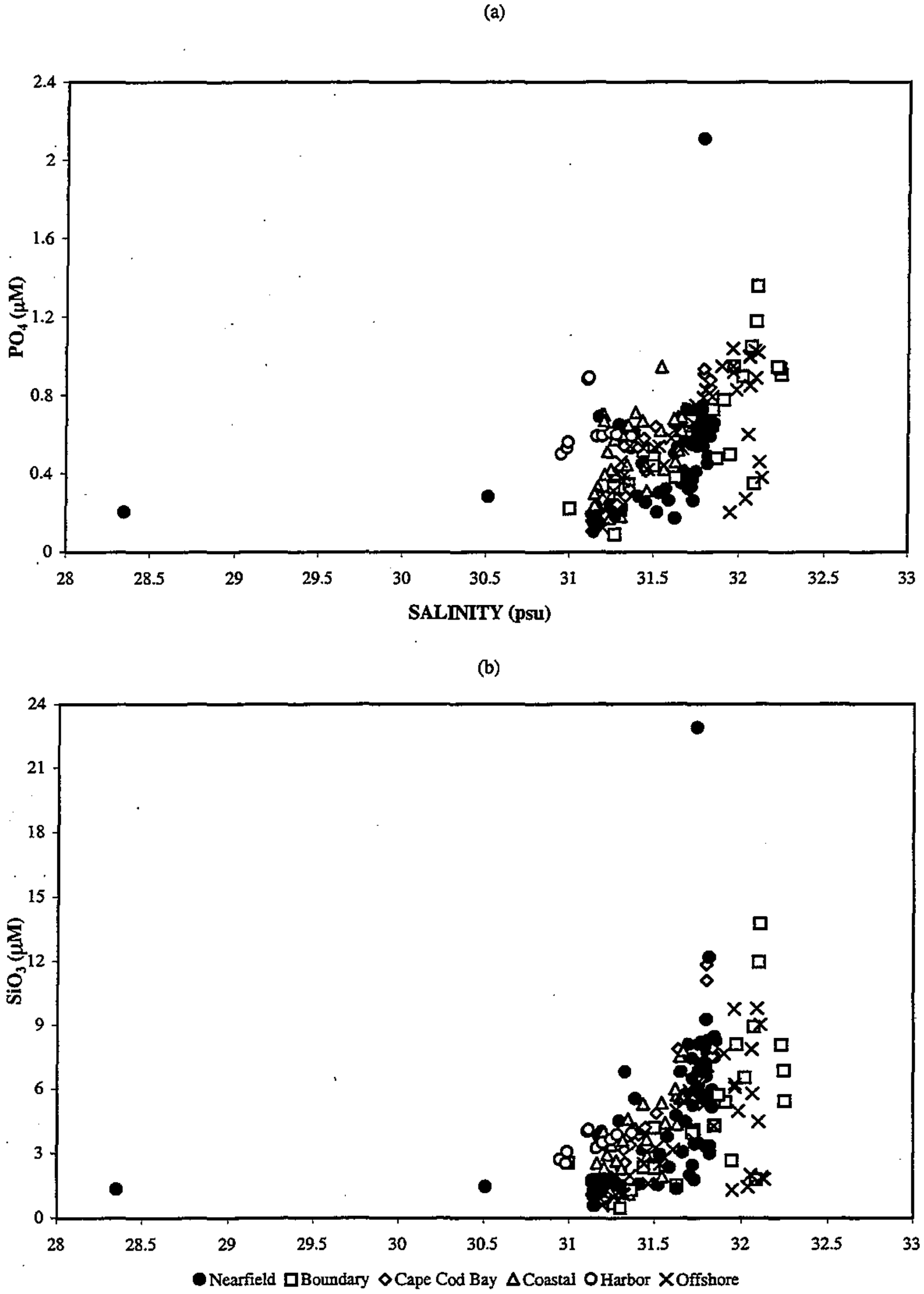


FIGURE 4-30

Nutrient vs. salinity plots for nearfield survey W9711, (Aug 97)

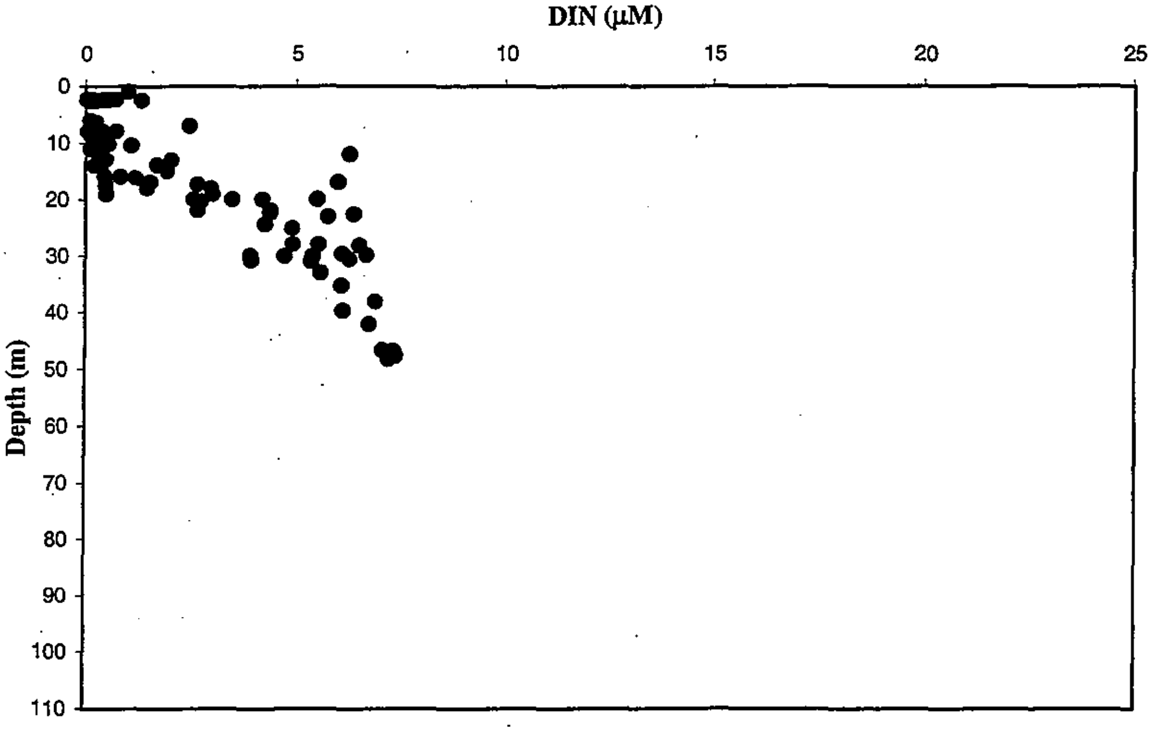


FIGURE 4-31

Depth vs. nutrient plots for nearfield survey W9712, (Sep 97)

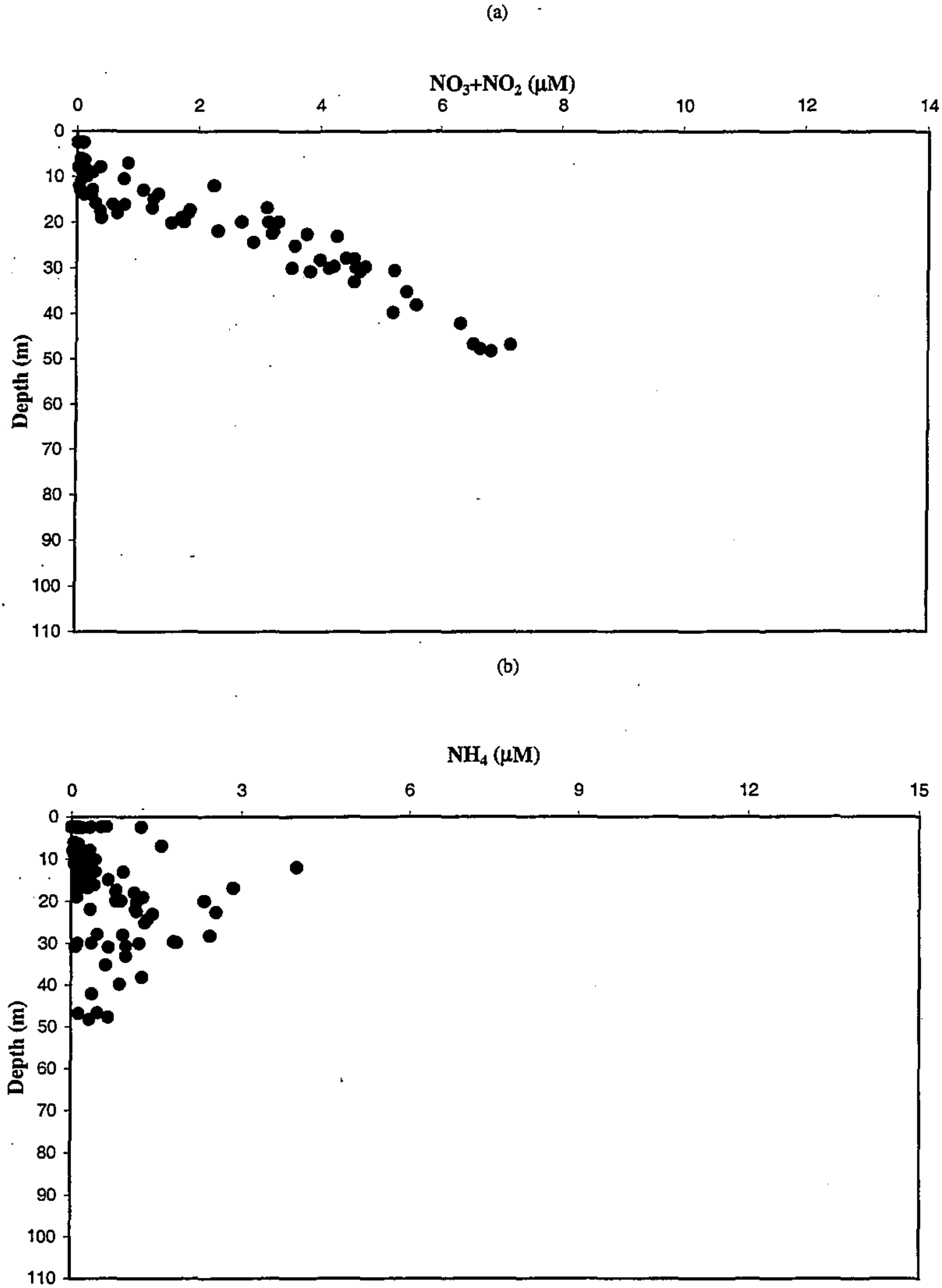
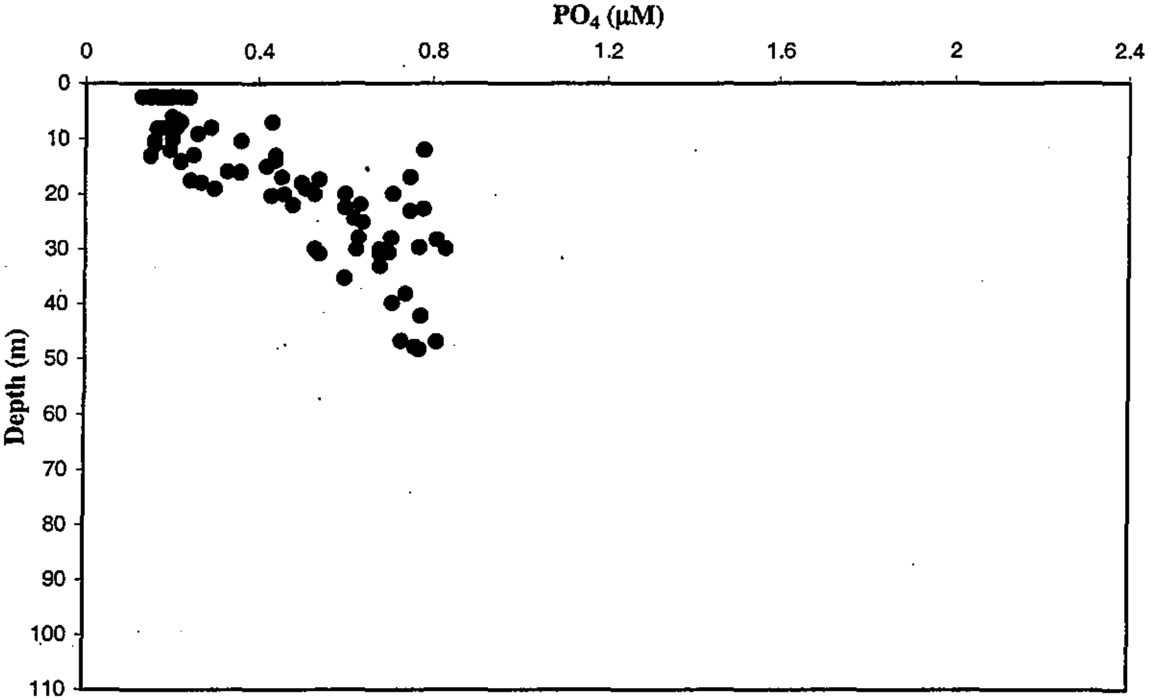


FIGURE 4-32

Depth vs. nutrient plots for nearfield survey W9712, (Sep 97)

(a)



(b)

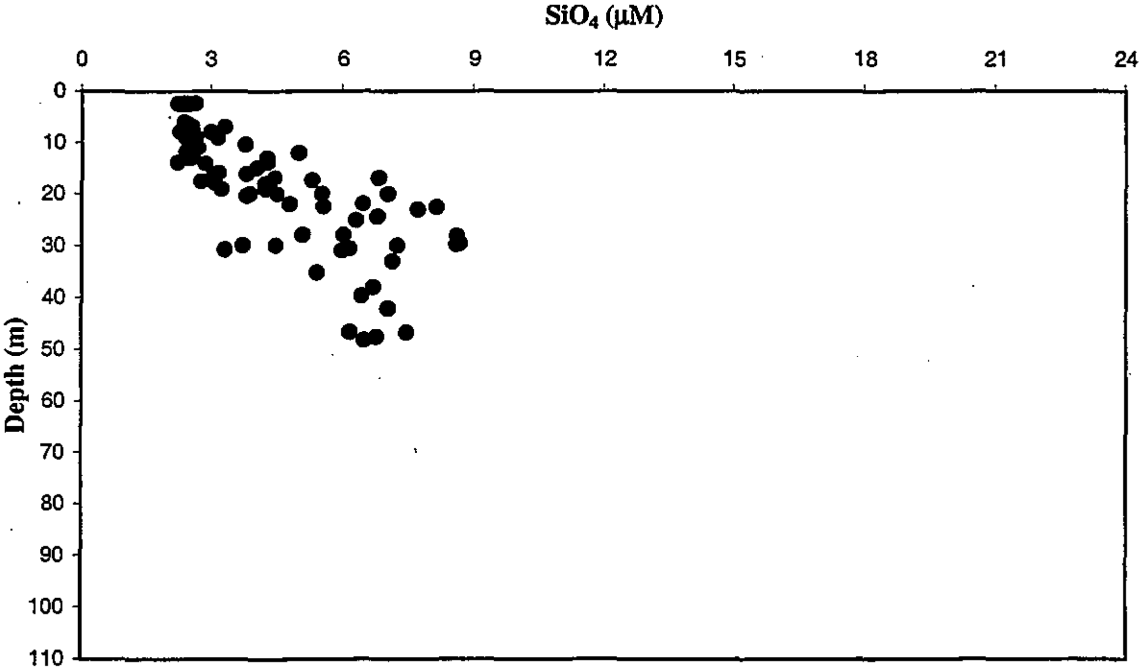


FIGURE 4-33

Depth vs. nutrient plots for nearfield survey W9712, (Sep 97)

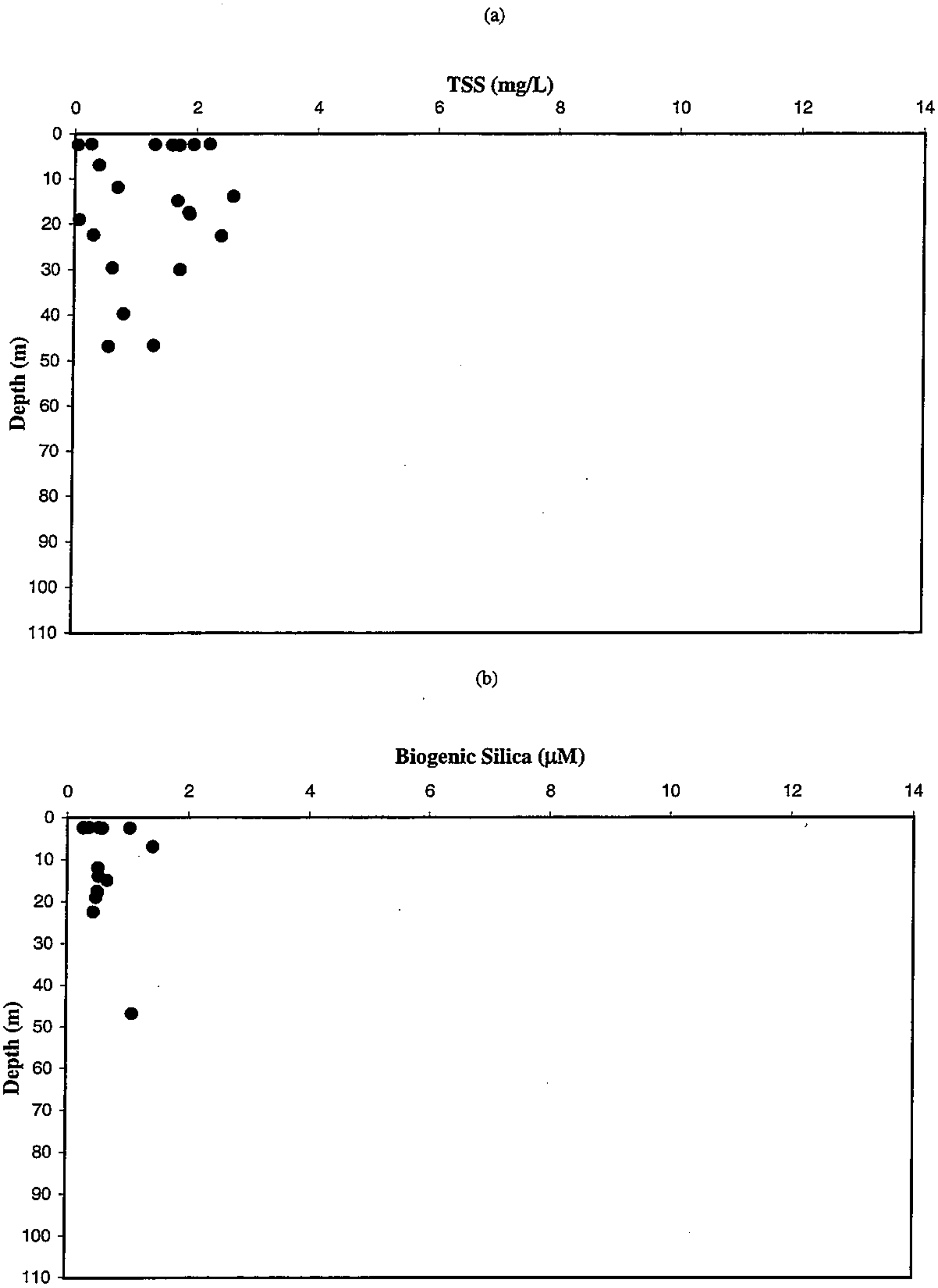
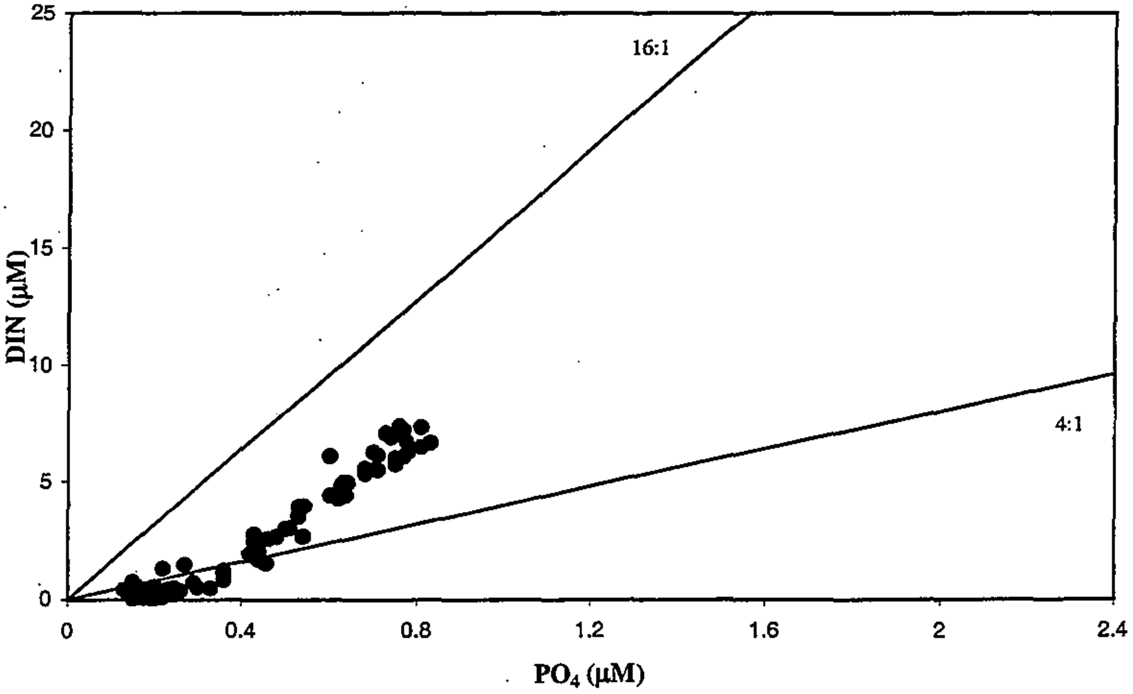


FIGURE 4-34

Depth vs. nutrient plots for nearfield survey W9712, (Sep 97)

(a)



(b)

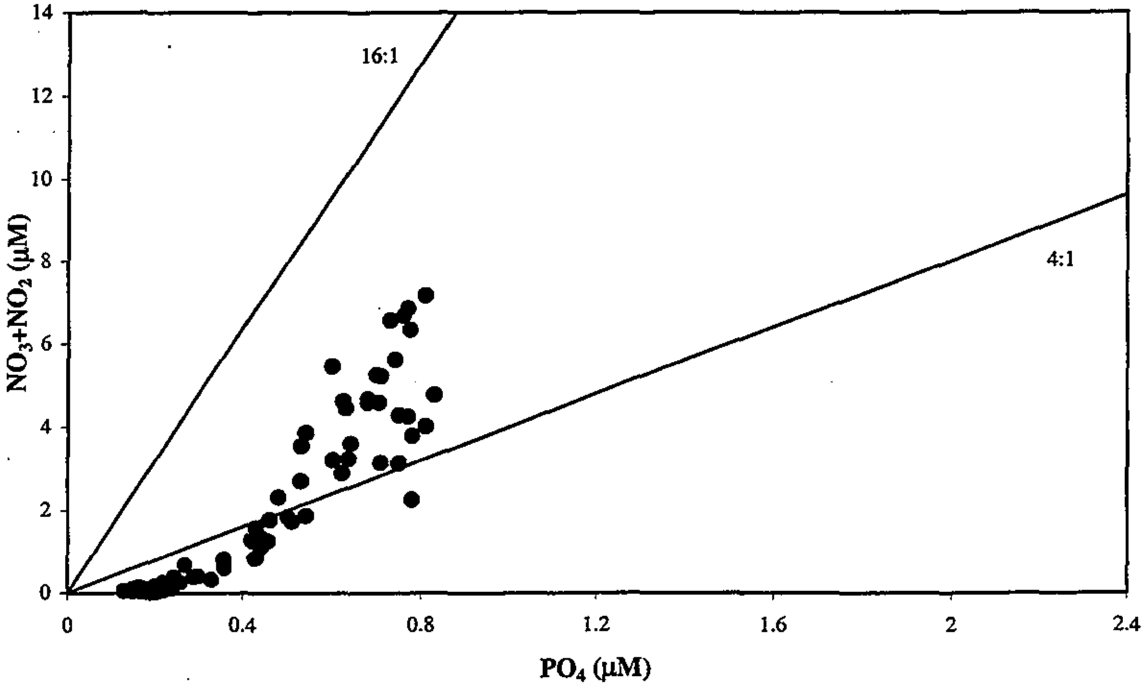
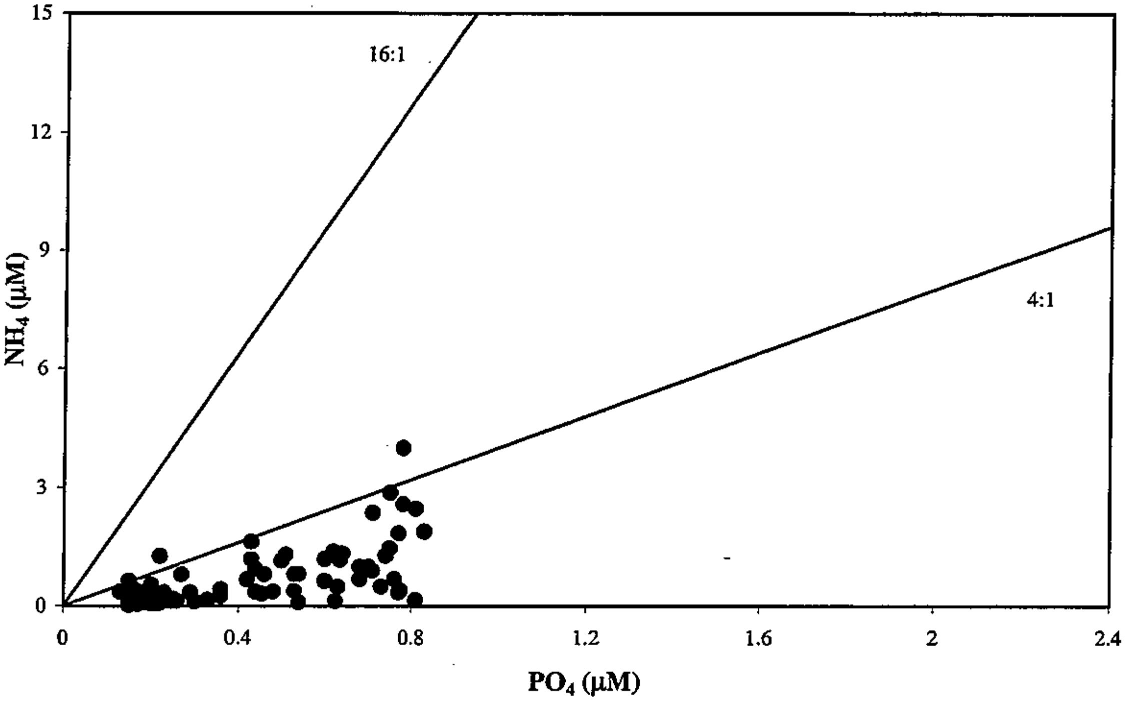


FIGURE 4-35

Nutrient vs. nutrient plots for nearfield survey W9712, (Sep 97)

(a)



(b)

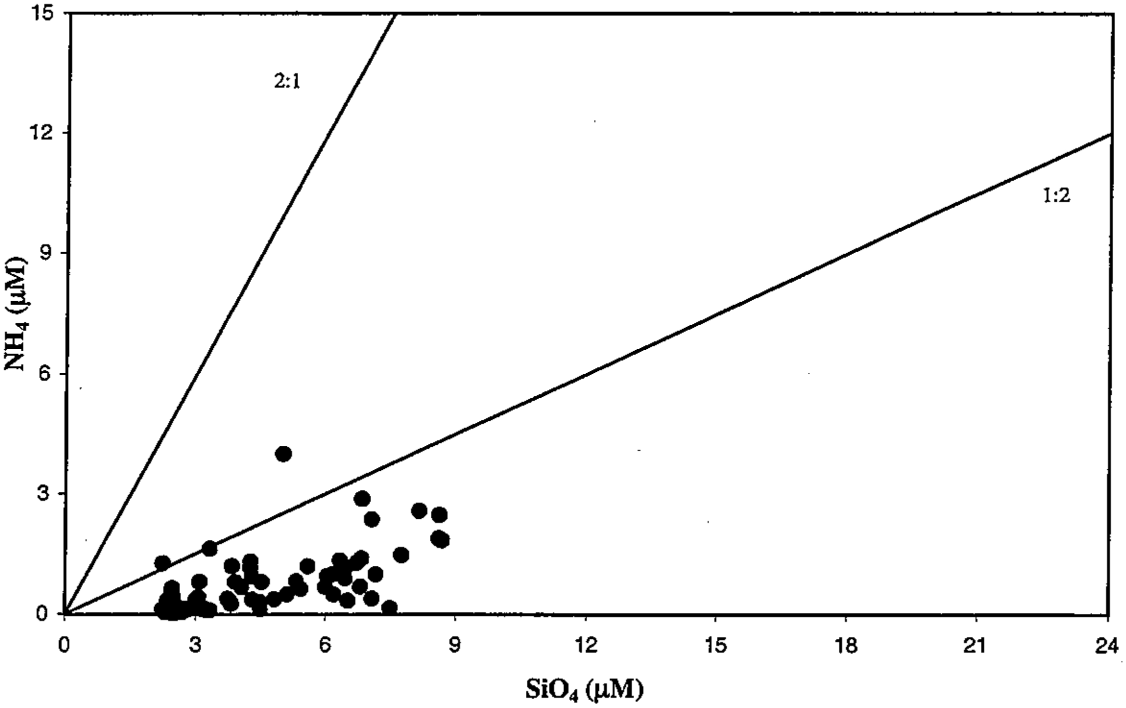


FIGURE 4-36

Nutrient vs. nutrient plots for nearfield survey W9712, (Sep 97)

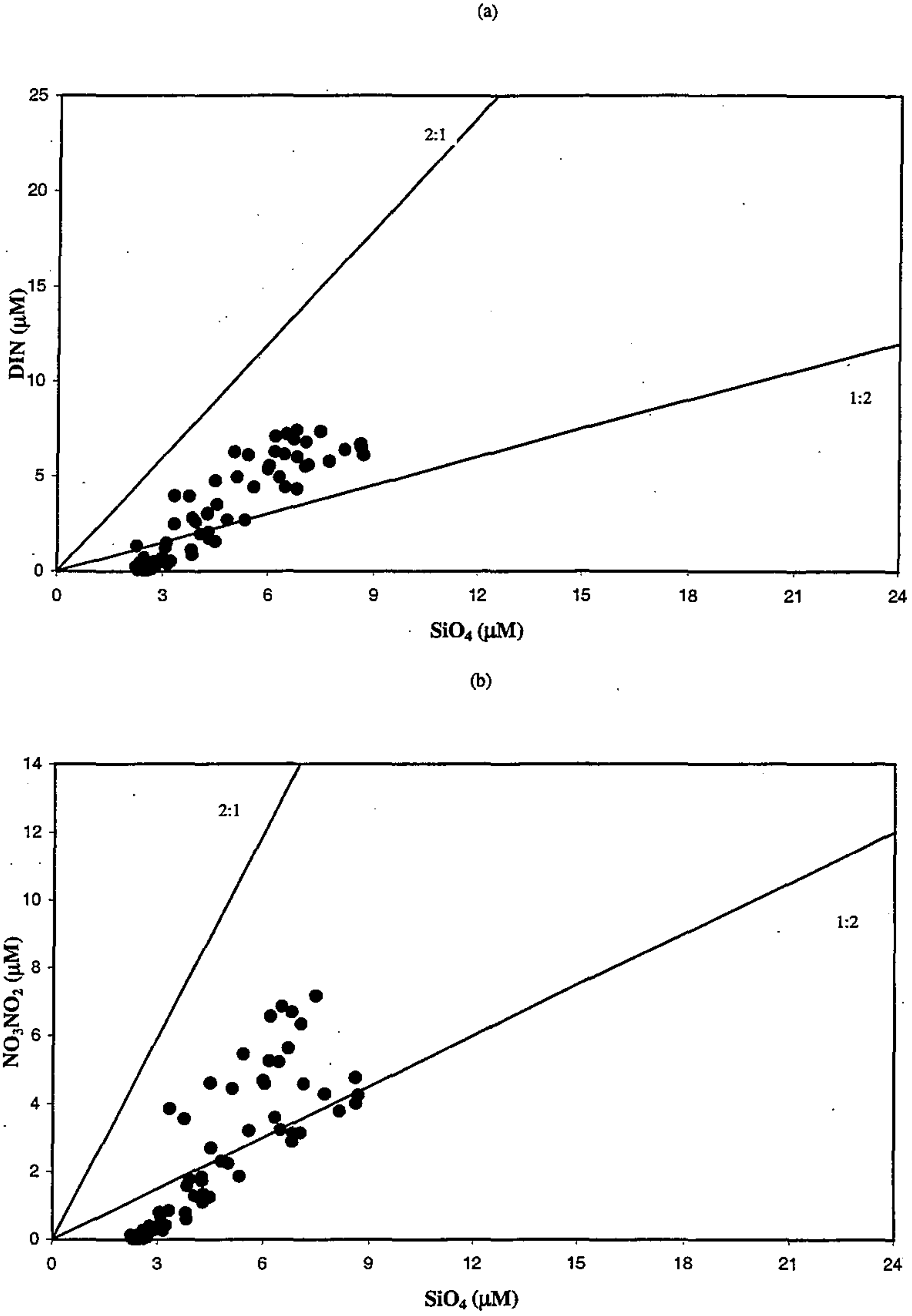
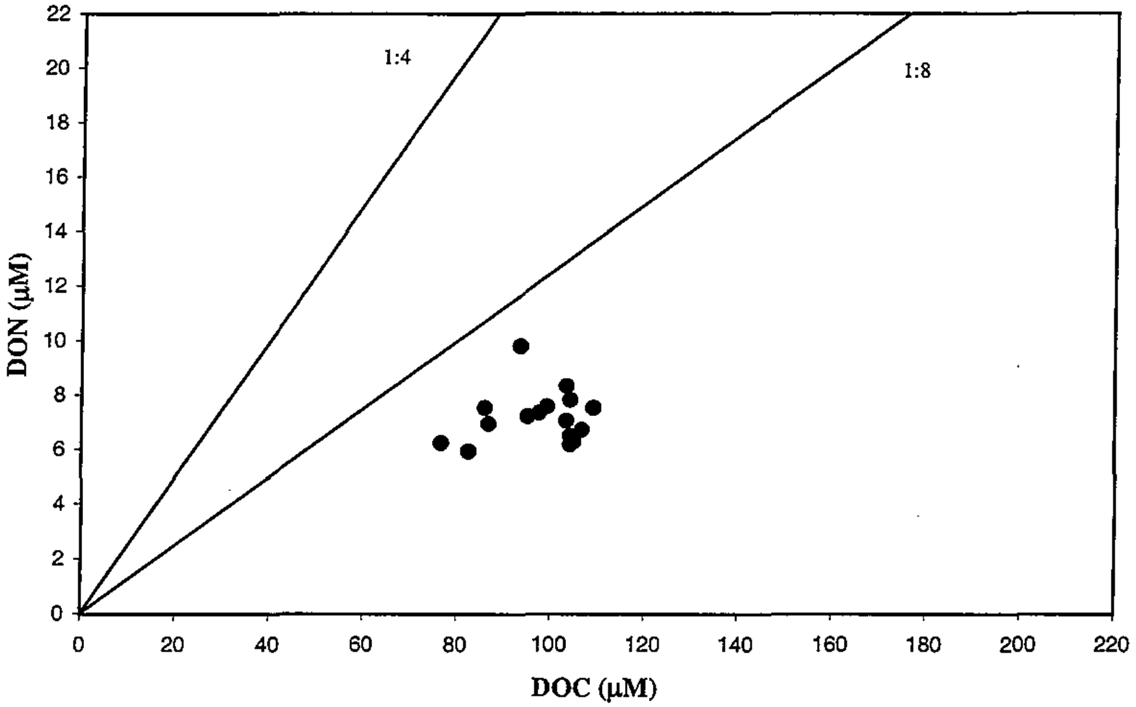


FIGURE 4-37

Nutrient vs. nutrient plots for nearfield survey W9712, (Sep 97)

(a)



(b)

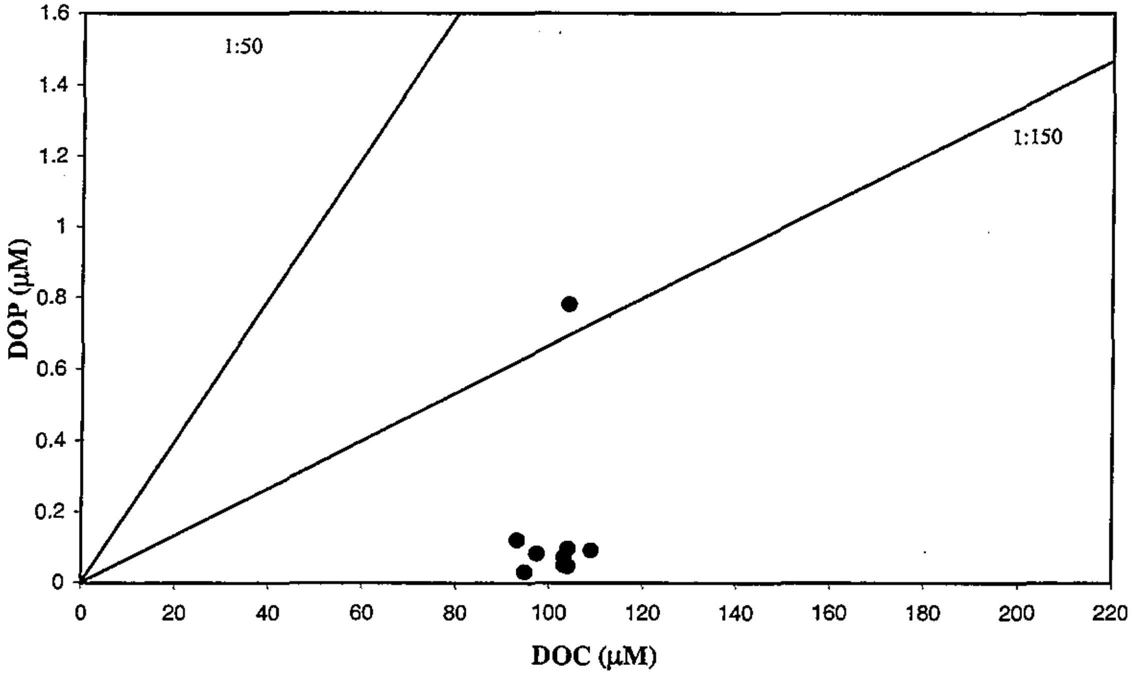
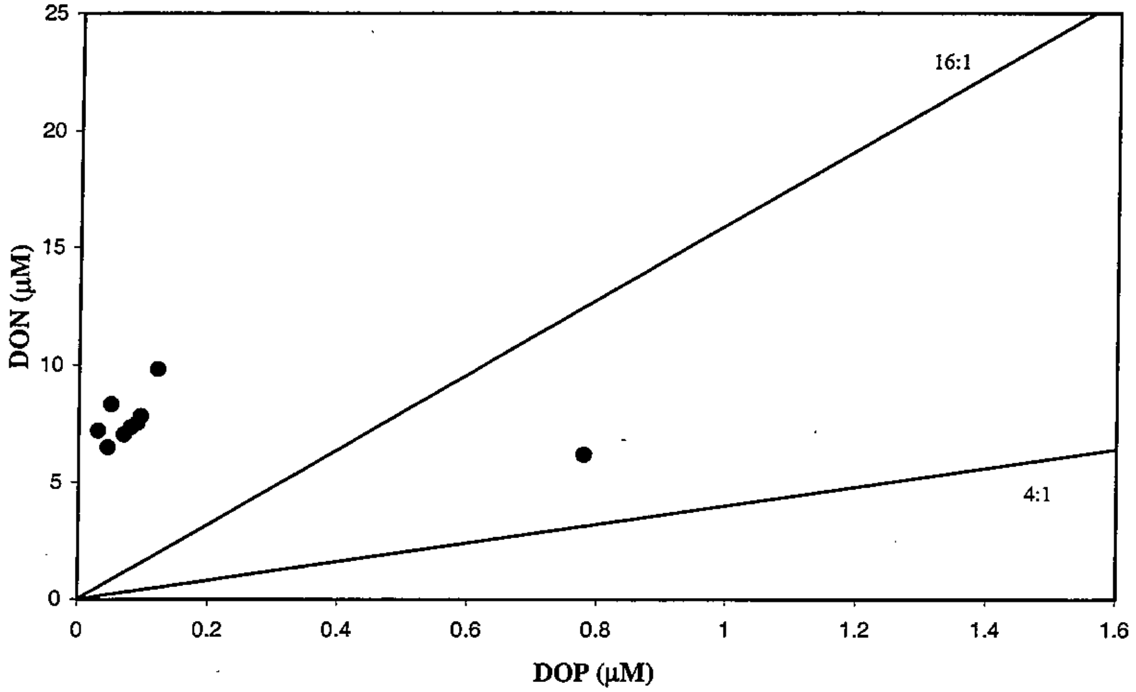


FIGURE 4-38

Nutrient vs. nutrient plots for nearfield survey W9712, (Sep 97)

(a)



(b)

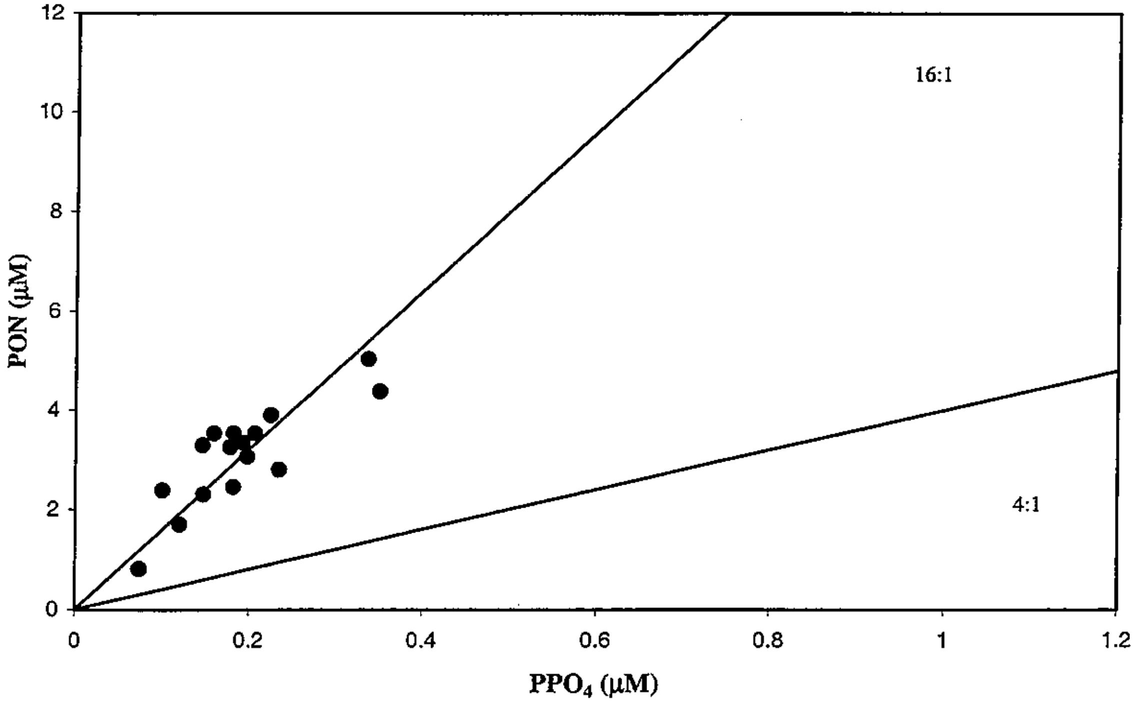
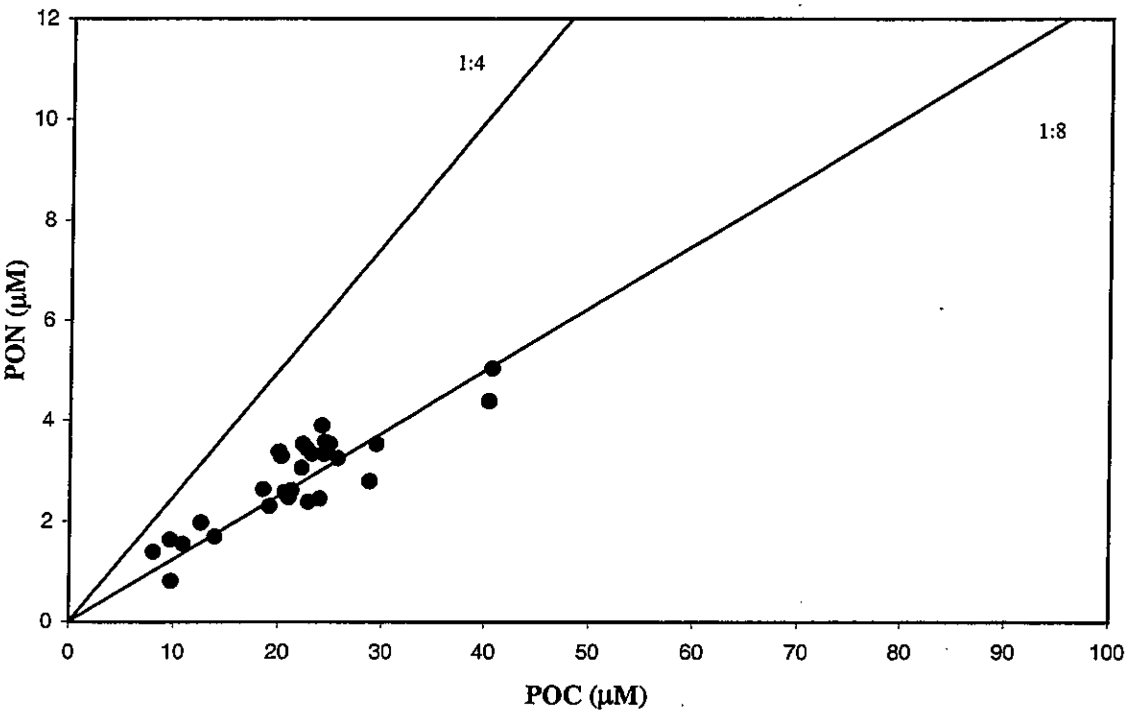


FIGURE 4-39

Nutrient vs. nutrient plots for nearfield survey W9712, (Sep 97)

(a)



(b)

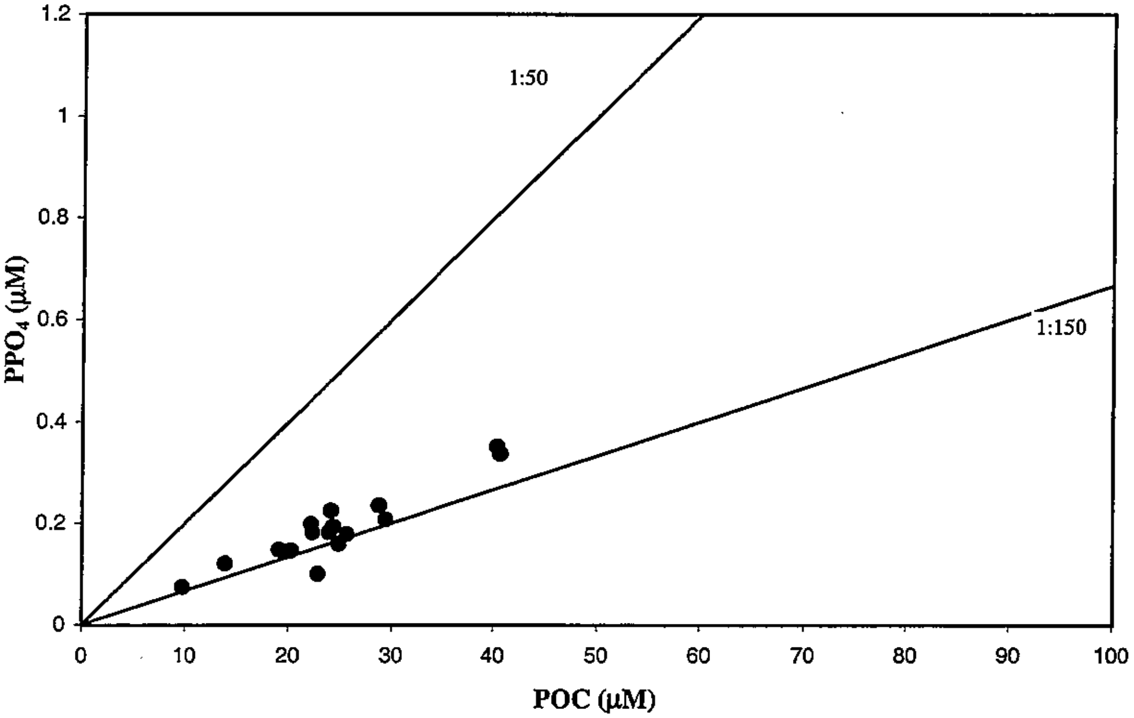
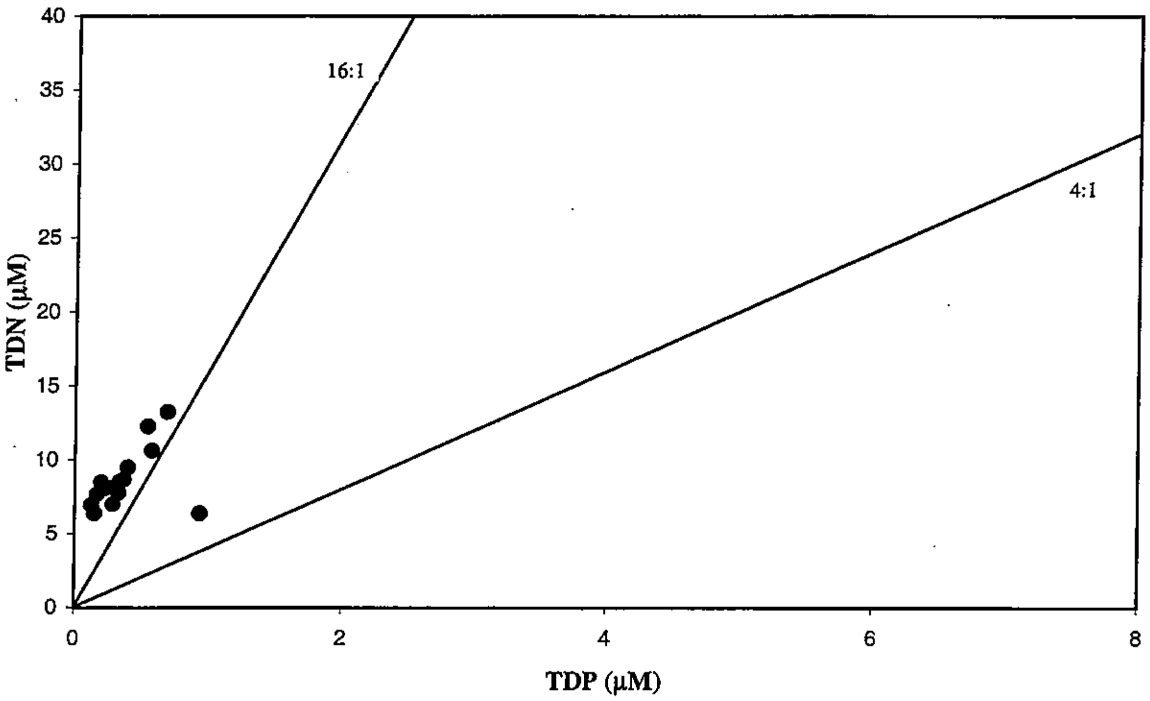


FIGURE 4-40

Nutrient vs. nutrient plots for nearfield survey W9712, (Sep 97)

(a)



(b)

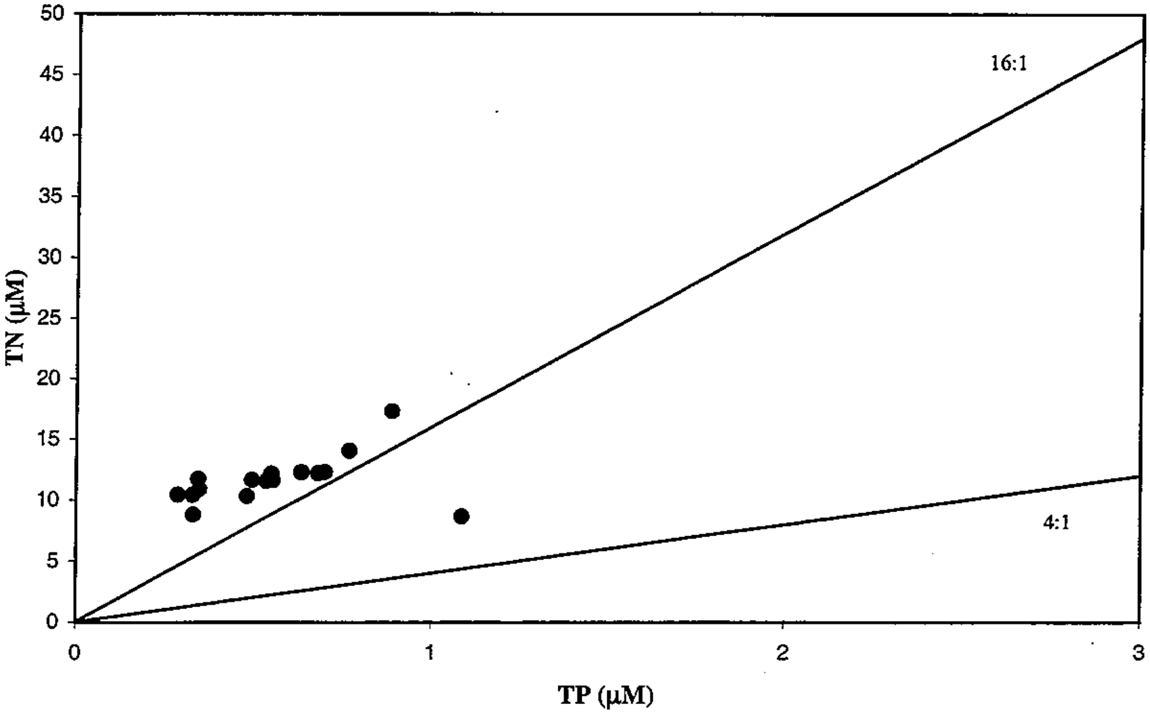
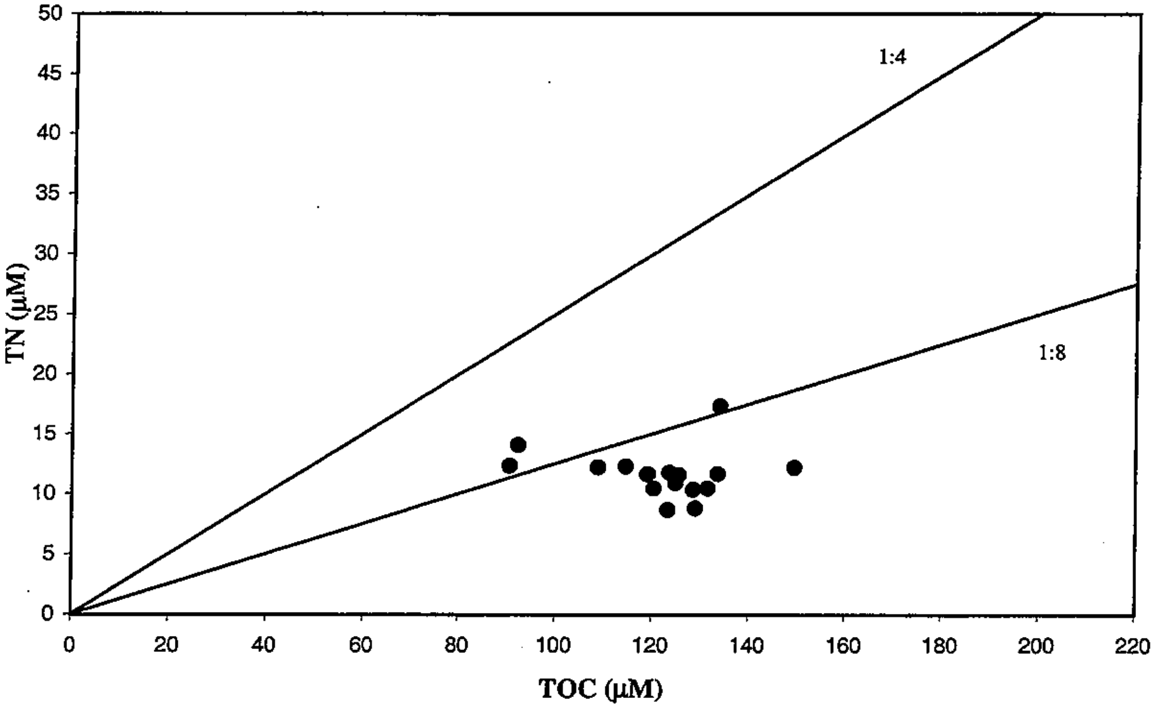


FIGURE 4-41

Nutrient vs. nutrient plots for nearfield survey W9712, (Sep 97)

(a)



(b)

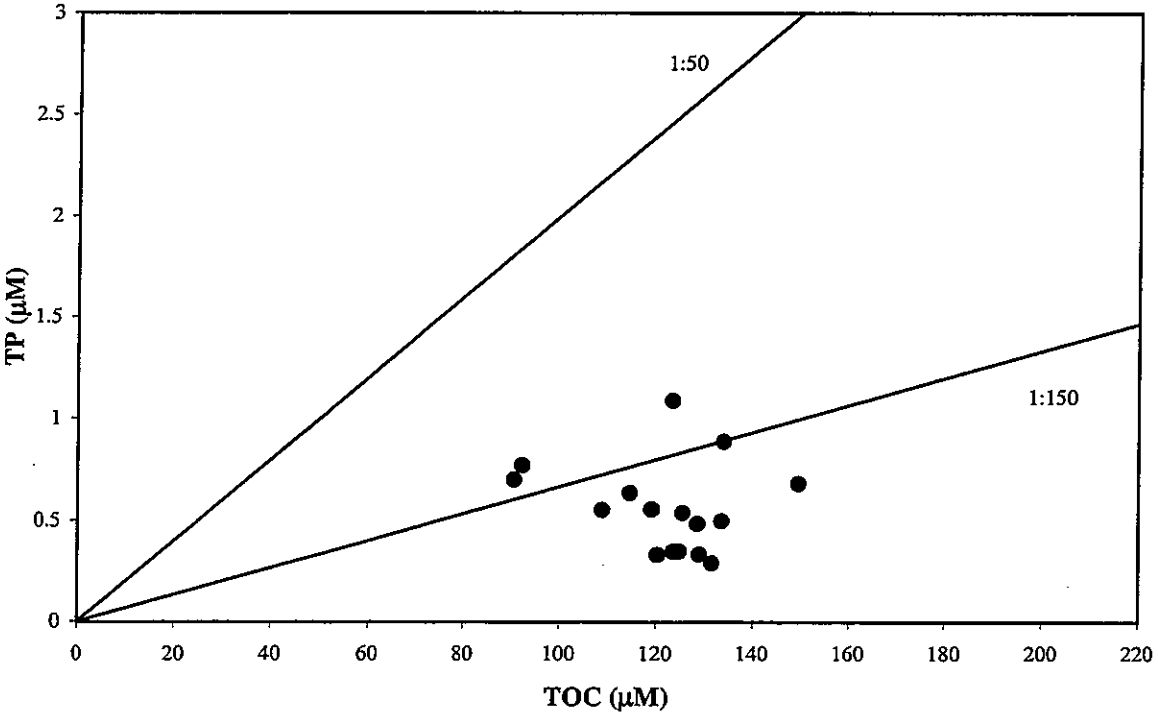


FIGURE 4-42

Nutrient vs. nutrient plots for nearfield survey W9712, (Sep 97)

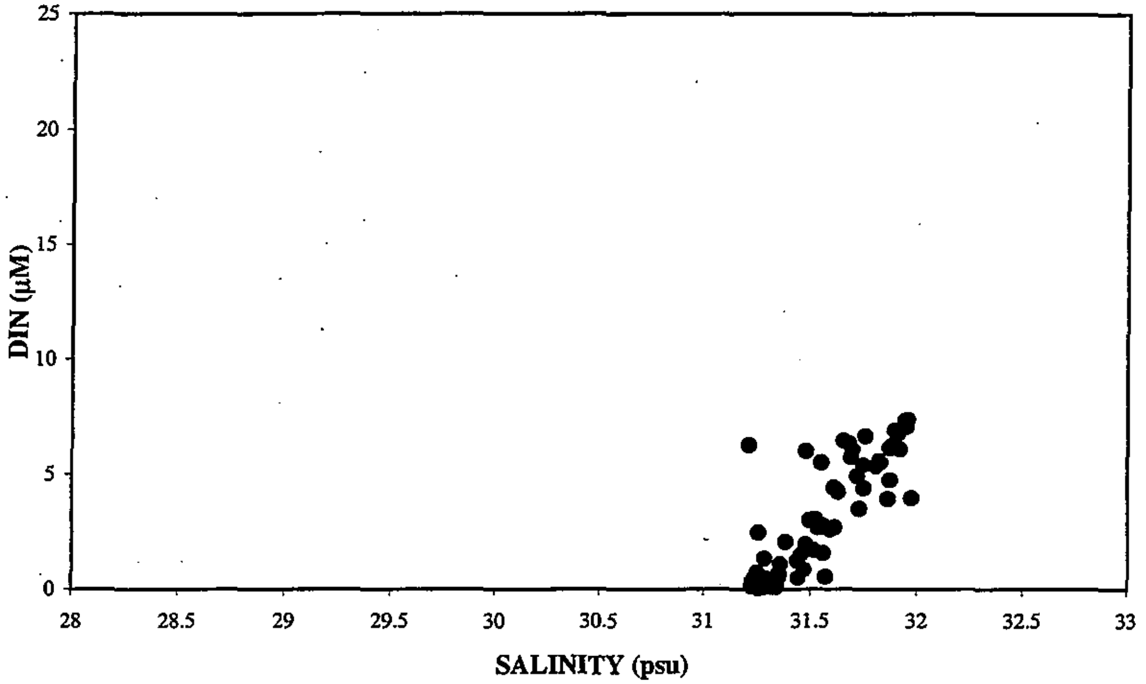
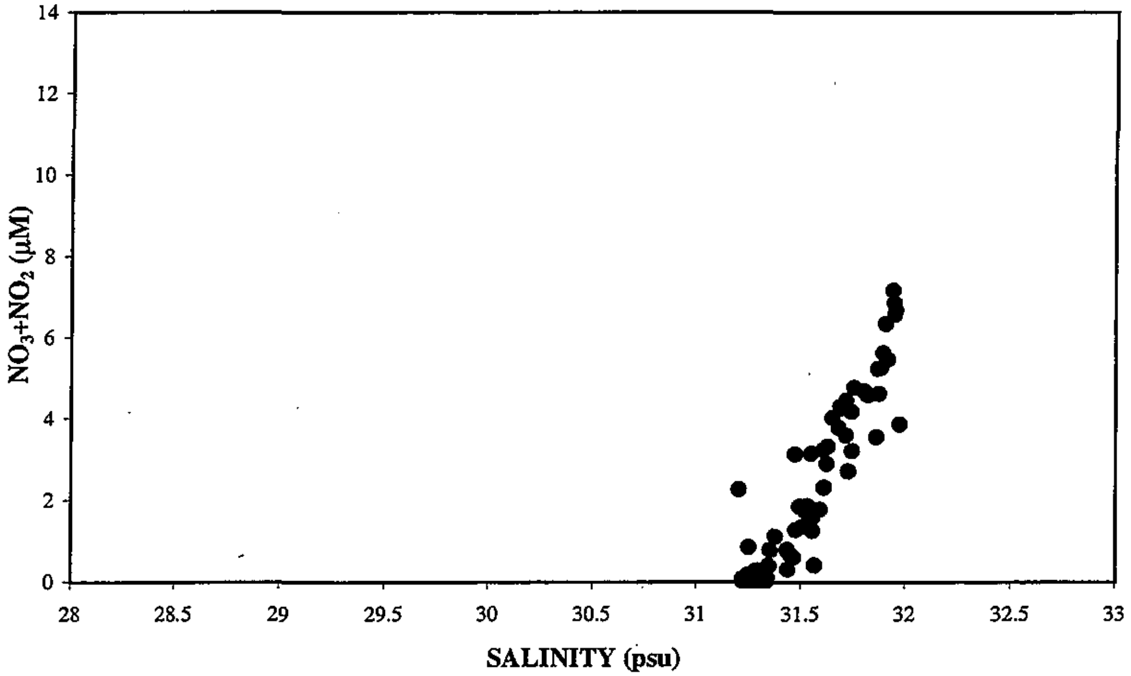


FIGURE 4-43
Nutrient vs. salinity plots for nearfield survey W9712, (Sep 97)

(a)



(b)

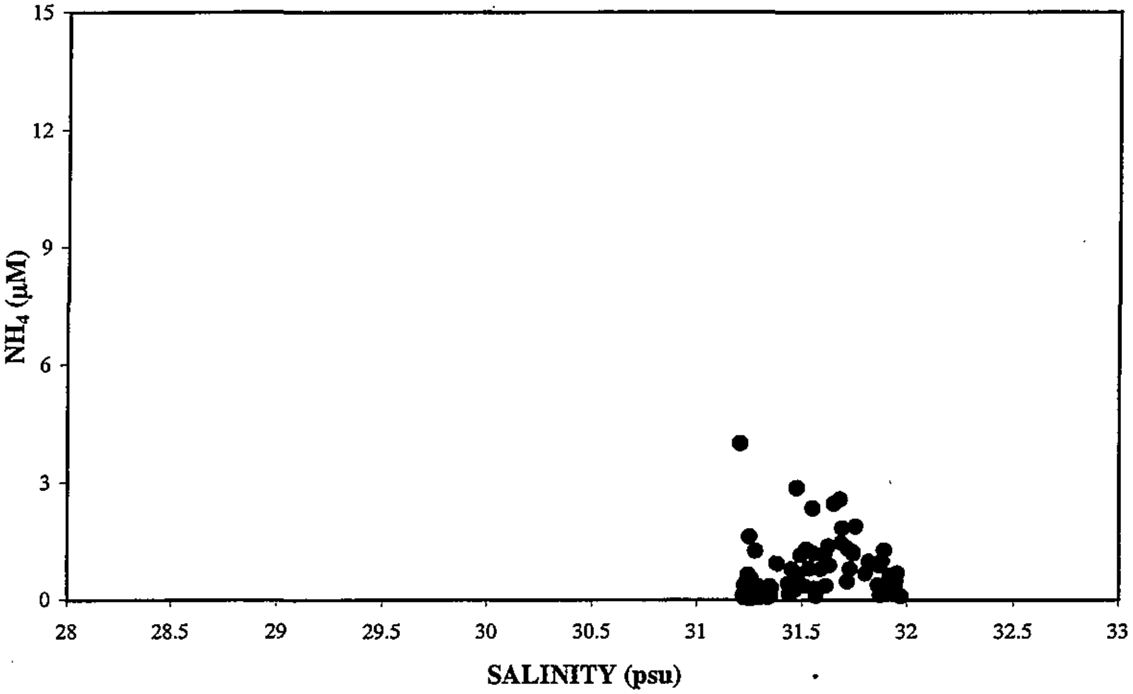
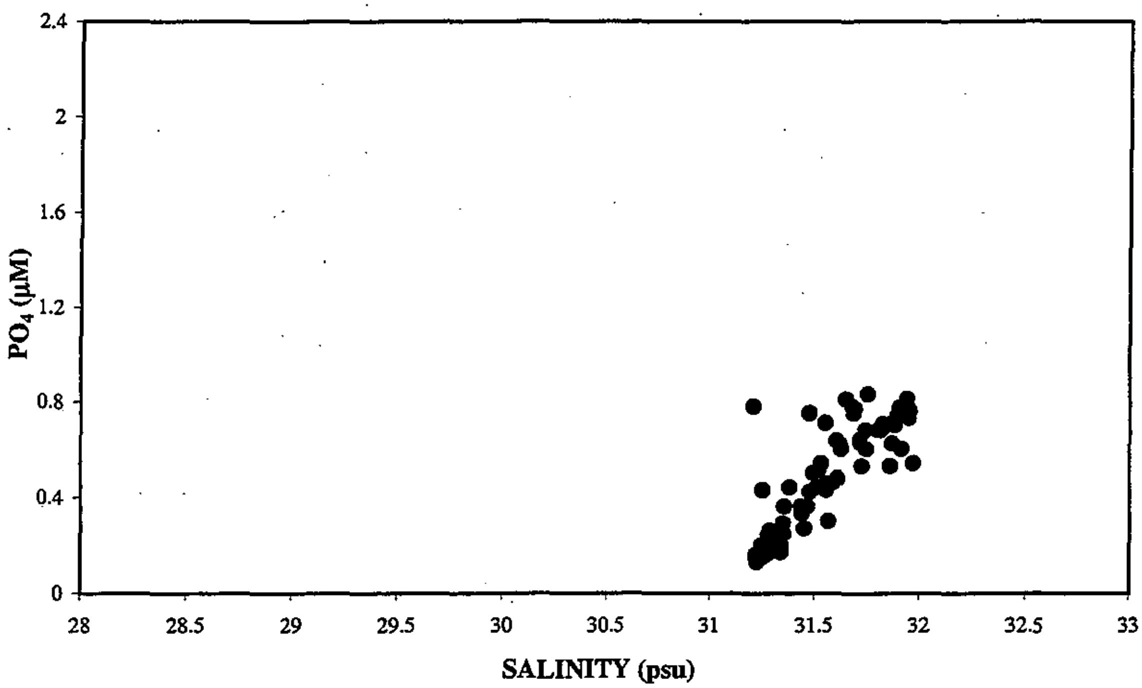


FIGURE 4-44

Nutrient vs. salinity plots for nearfield survey W9712, (Sep 97)

(a)



(b)

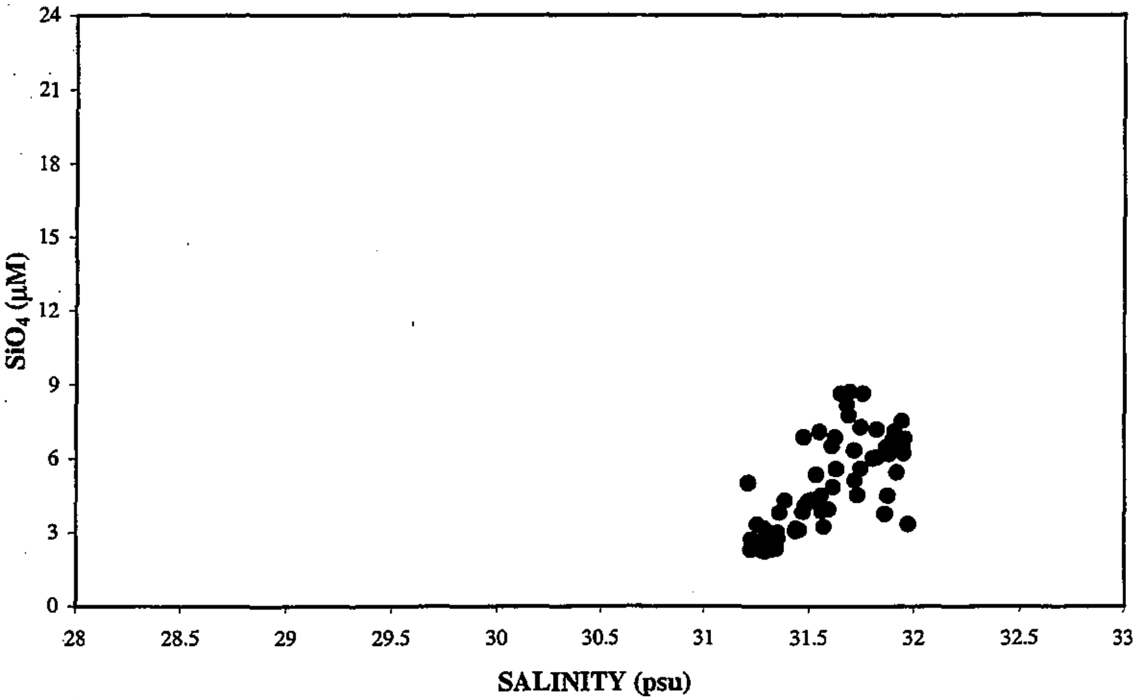


FIGURE 4-45

Nutrient vs. salinity plots for nearfield survey W9712, (Sep 97)

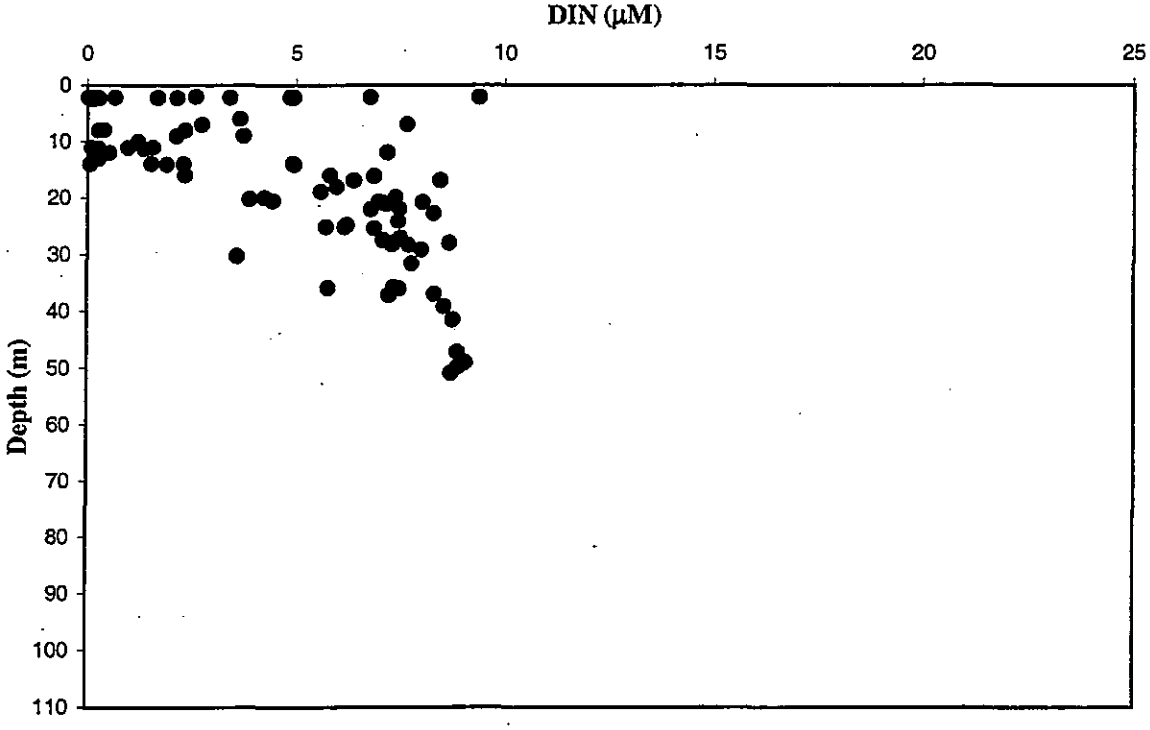
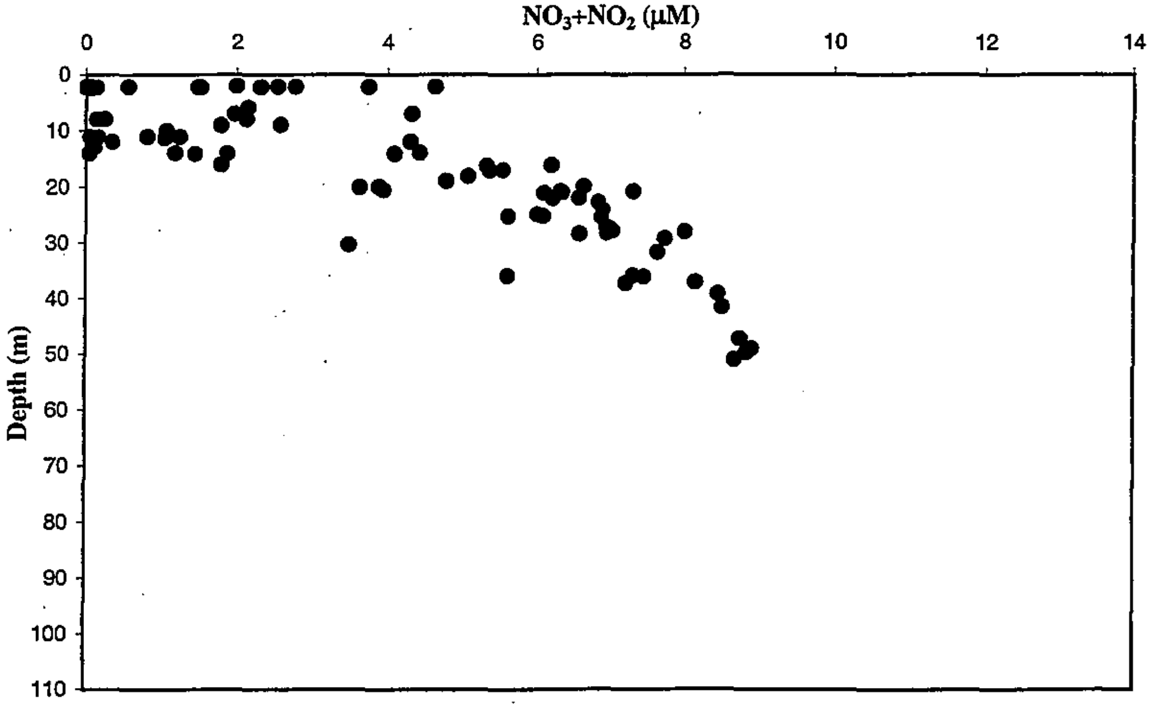


FIGURE 4-46
Depth vs. nutrient plots for nearfield survey W9713, (Sep 97)

(a)



(b)

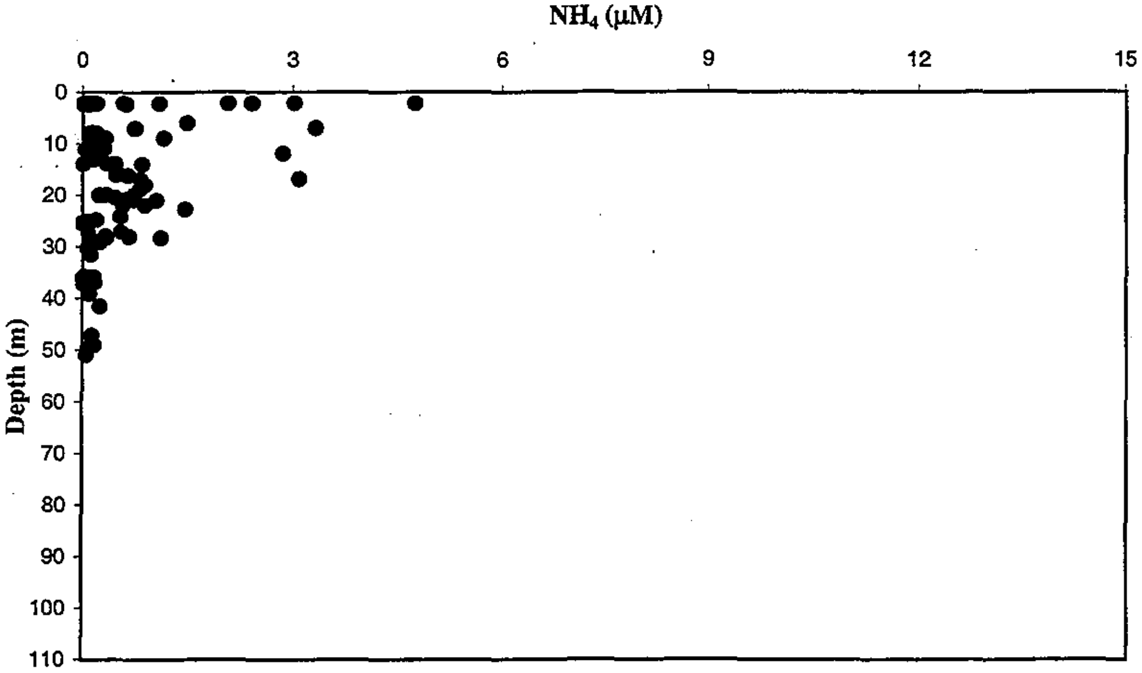
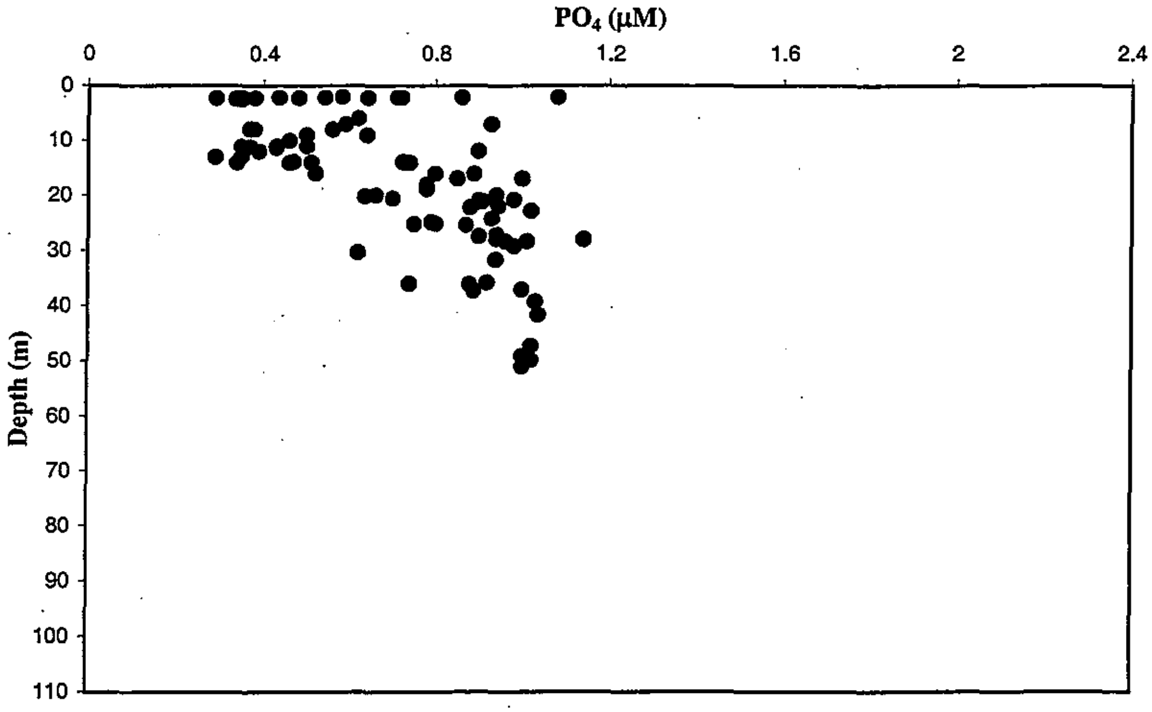


FIGURE 4-47
Depth vs. nutrient plots for nearfield survey W9713, (Sep 97)

(a)



(b)

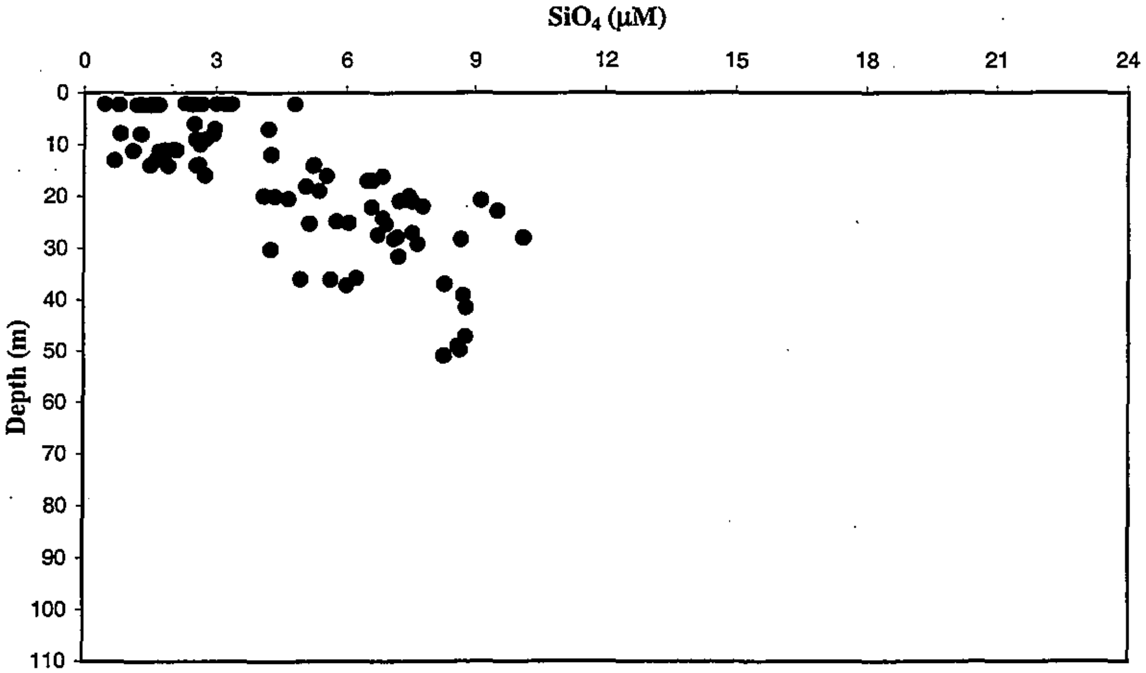
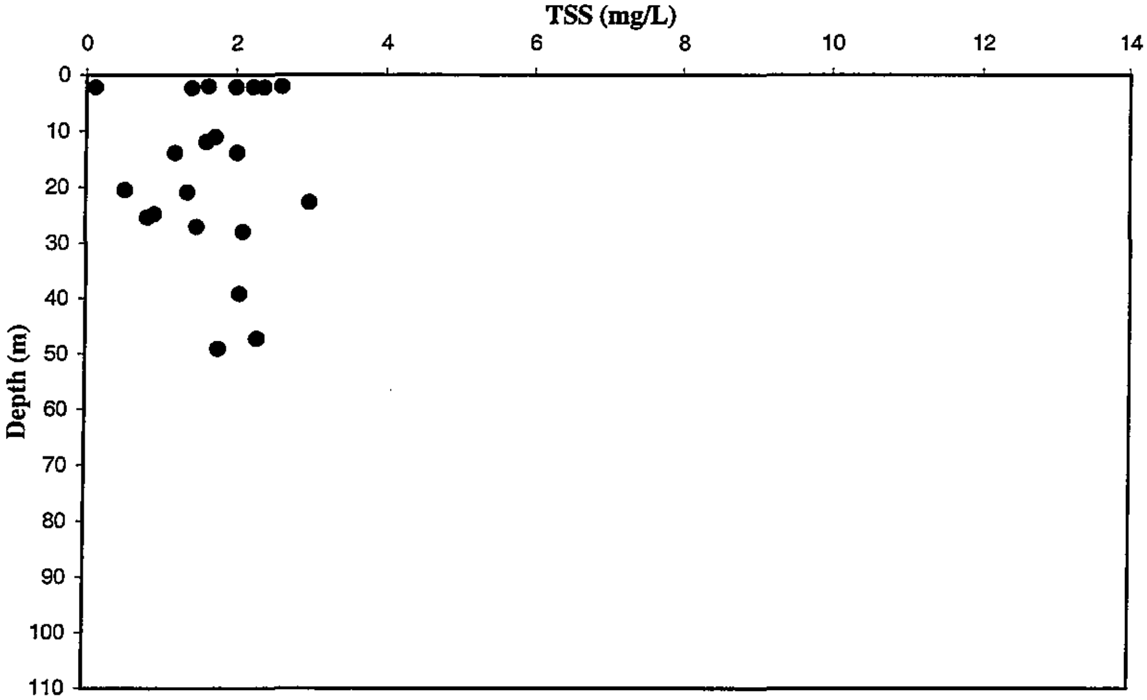


FIGURE 4-48

Depth vs. nutrient plots for nearfield survey W9713, (Sep 97)

(a)



(b)

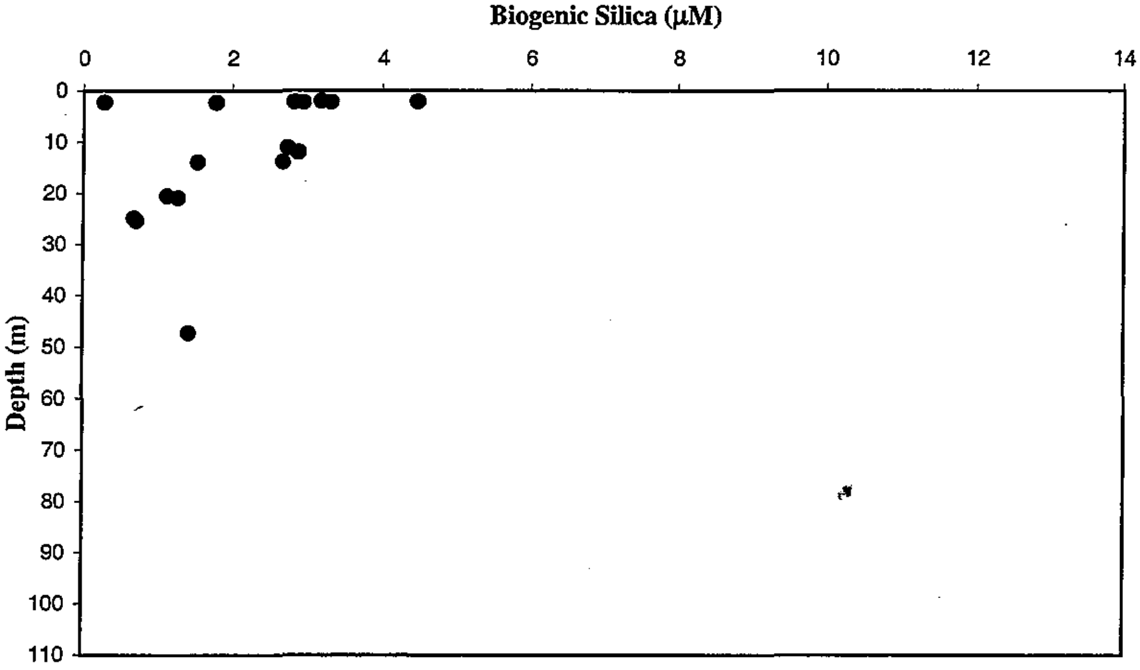


FIGURE 4-49

Depth vs. nutrient plots for nearfield survey W9713, (Sep 97)

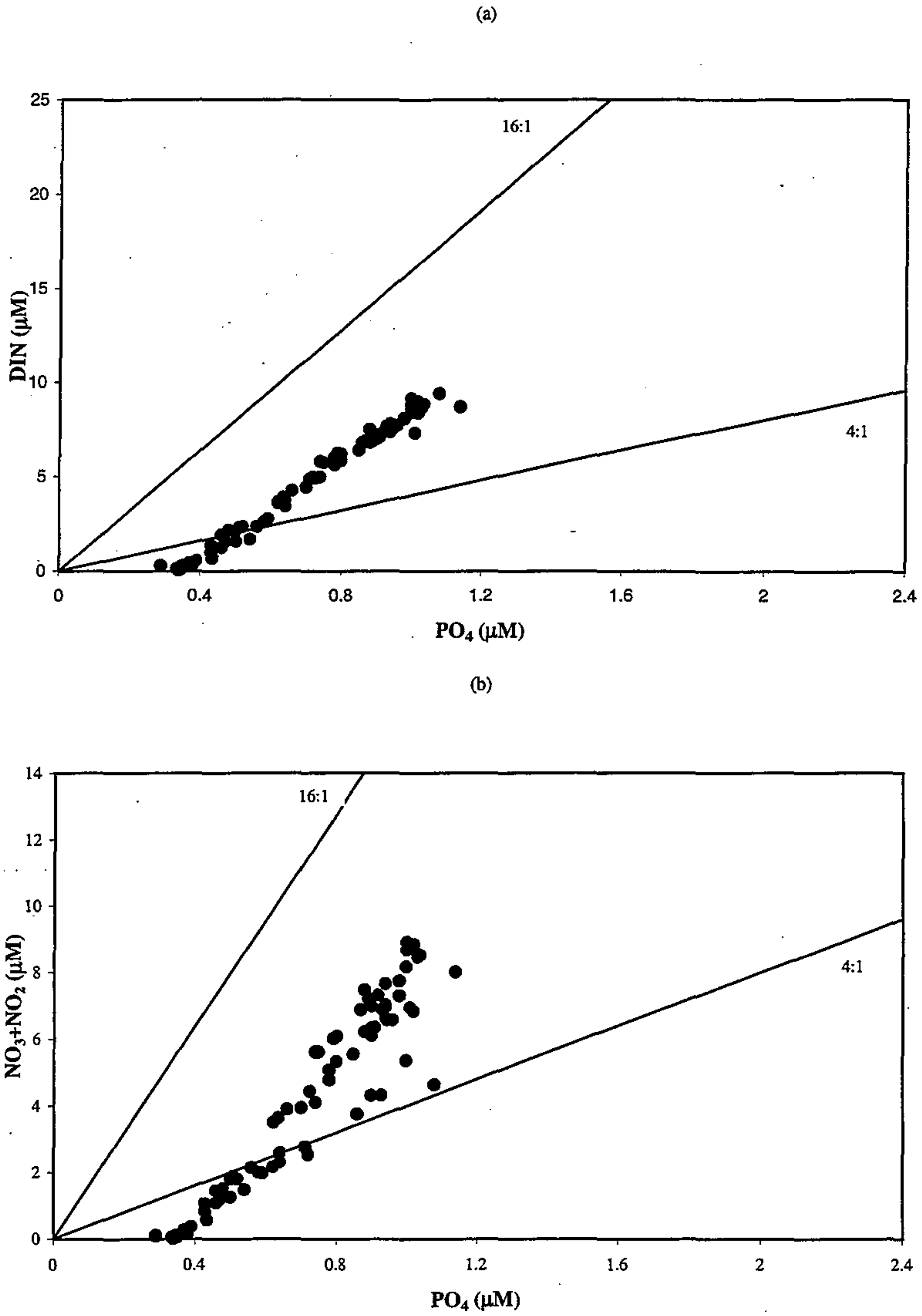


FIGURE 4-50
Nutrient vs. nutrient plots for nearfield survey W9713, (Sep 97)

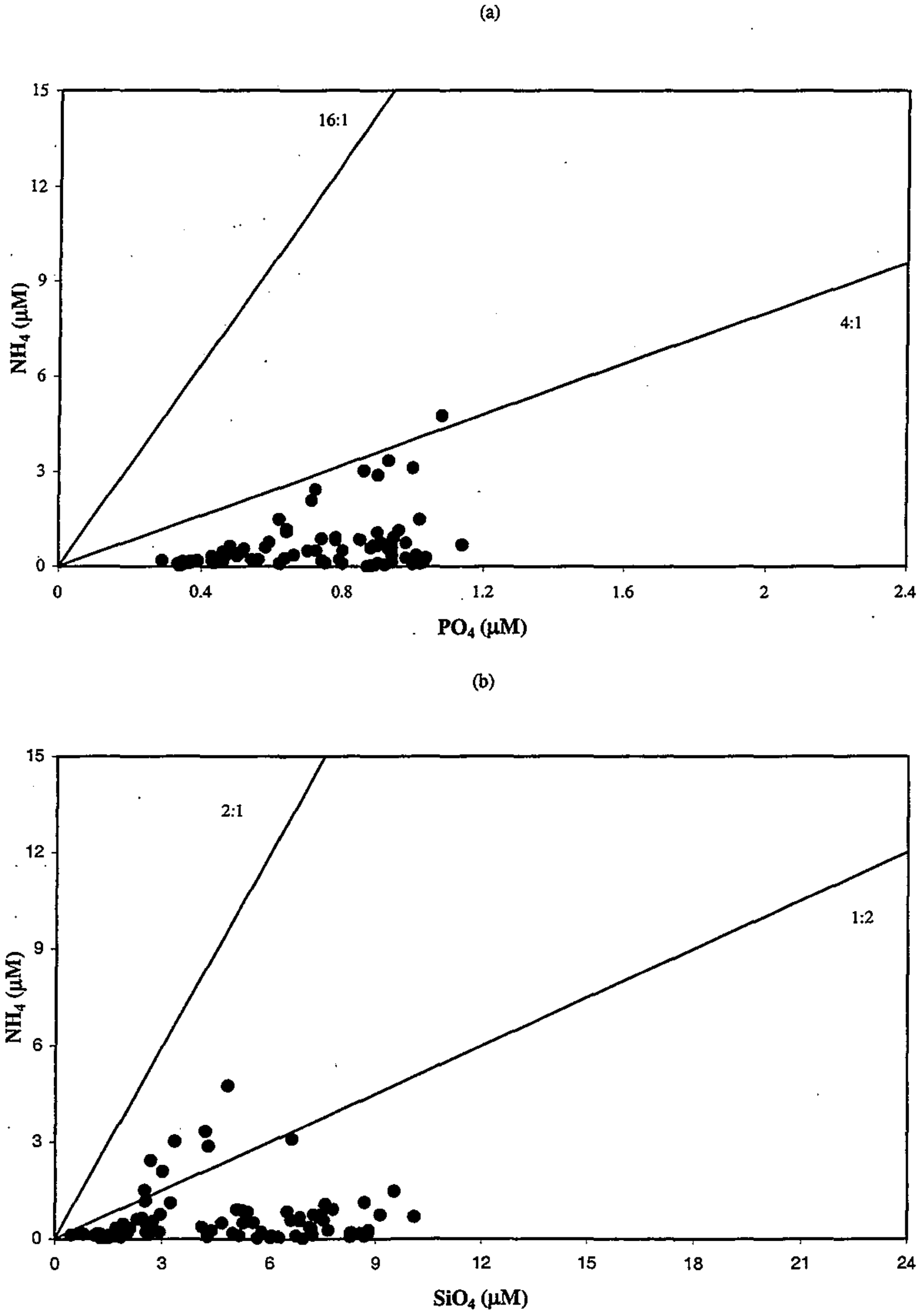


FIGURE 4-51

Nutrient vs. nutrient plots for nearfield survey W9713, (Sep 97)

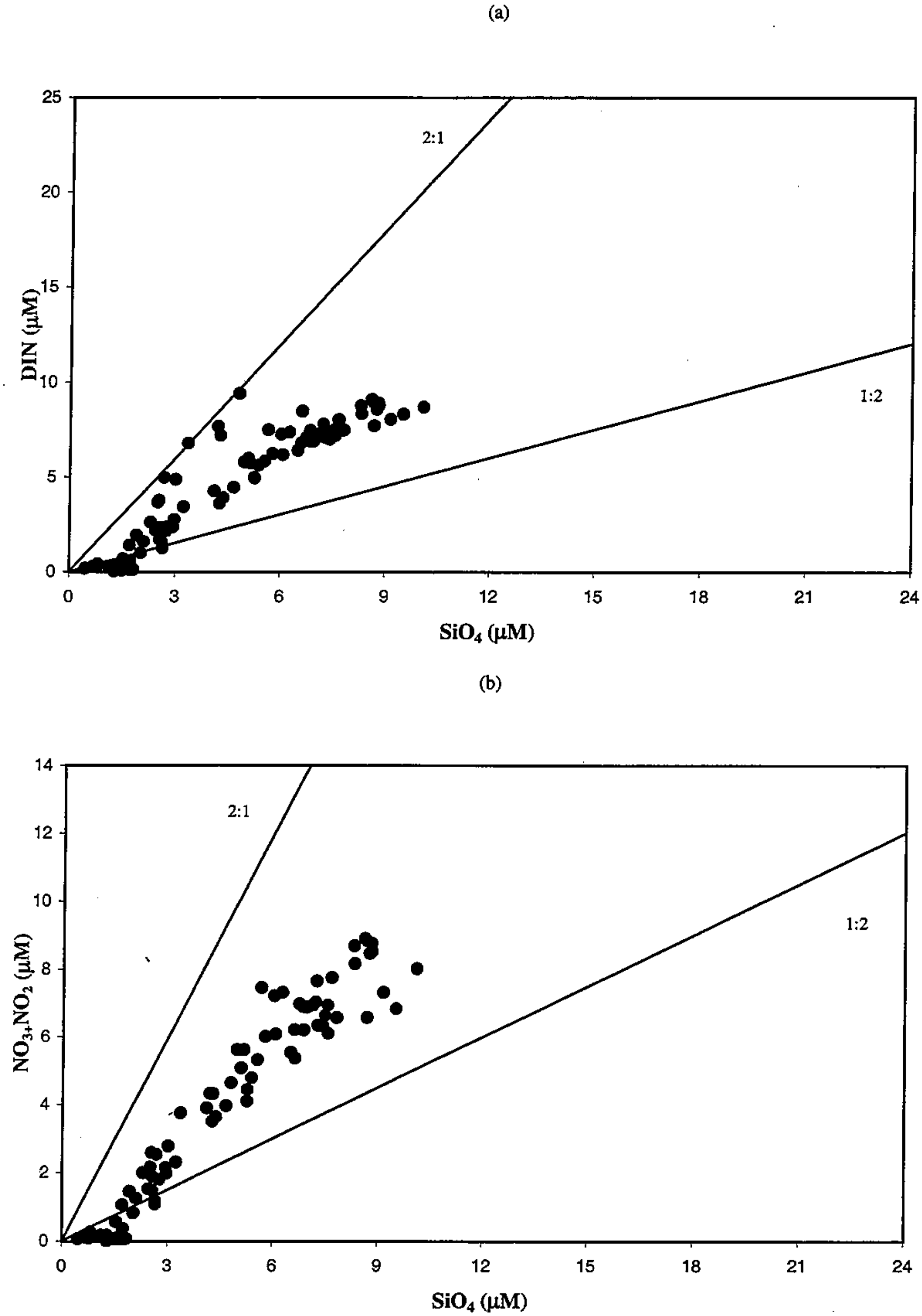


FIGURE 4-52
Nutrient vs. nutrient plots for nearfield survey W9713, (Sep 97)

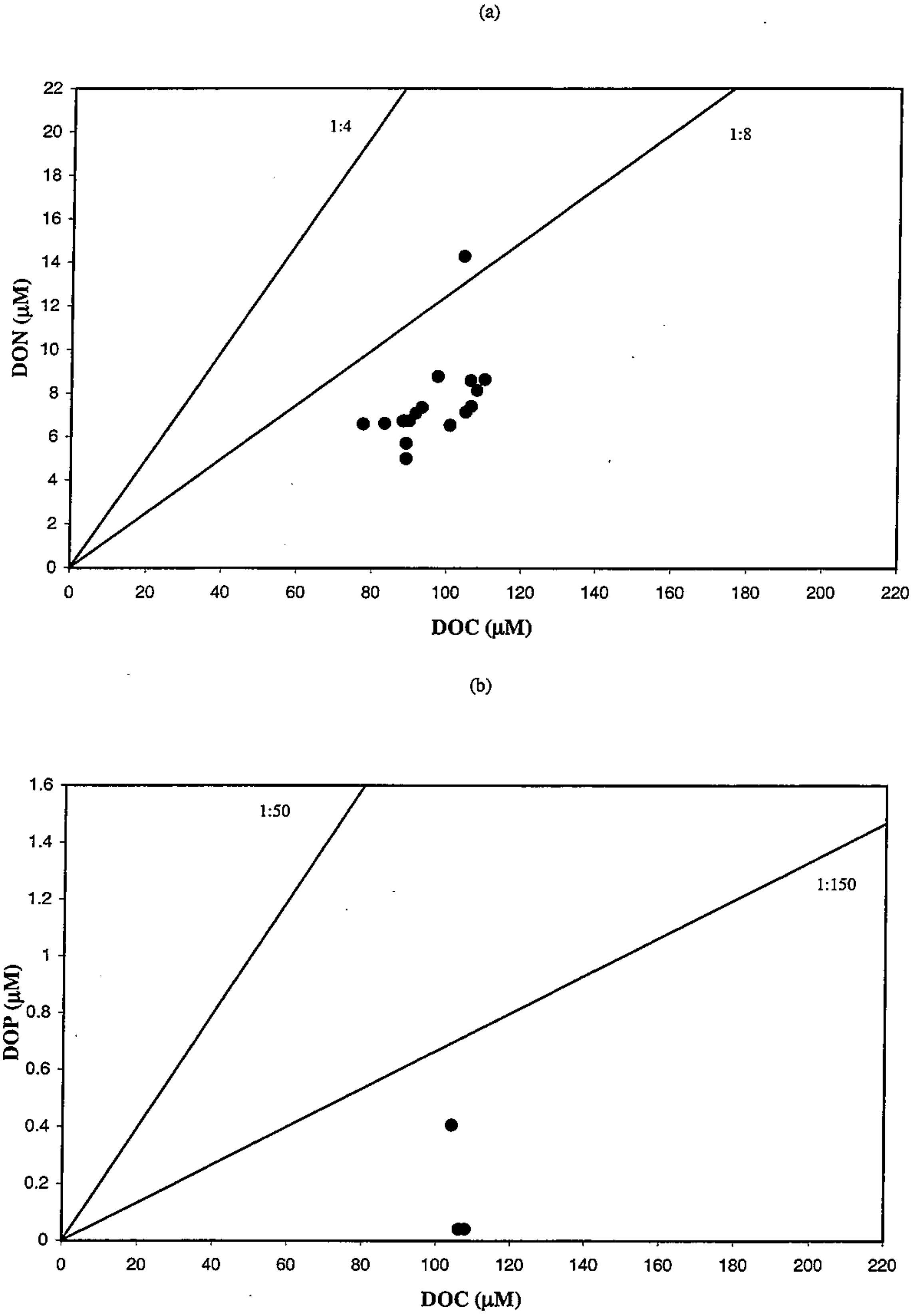
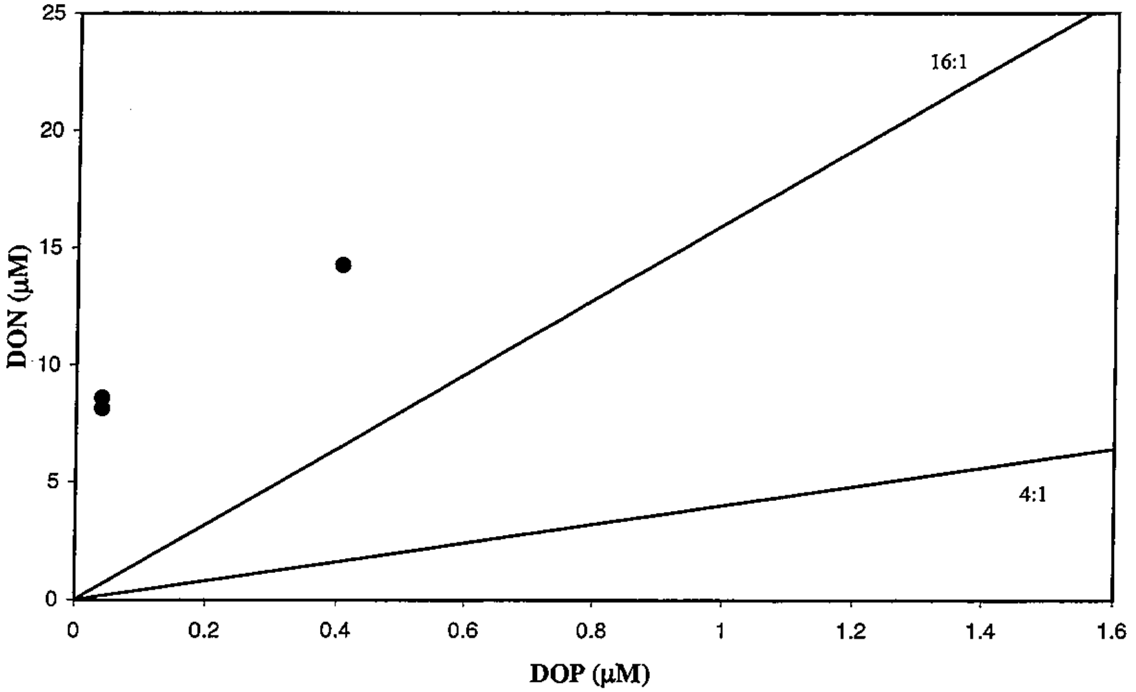


FIGURE 4-53
Nutrient vs. nutrient plots for nearfield survey W9713, (Sep 97)

(a)



(b)

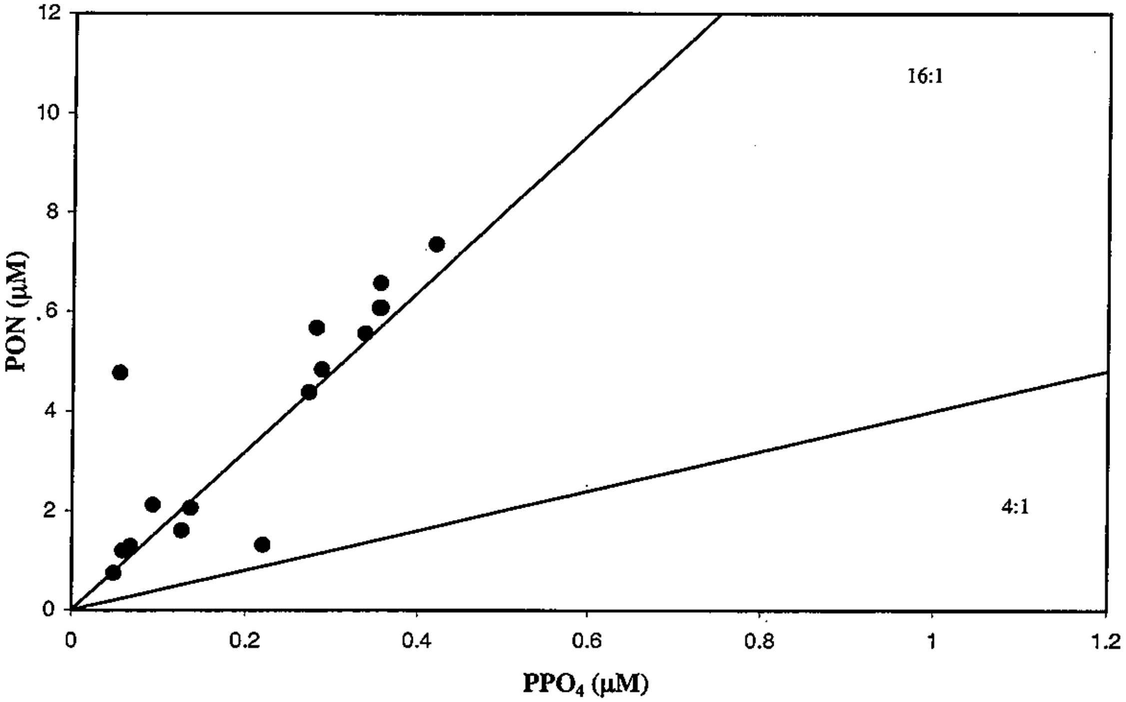


FIGURE 4-54
Nutrient vs. nutrient plots for nearfield survey W9713, (Sep 97)

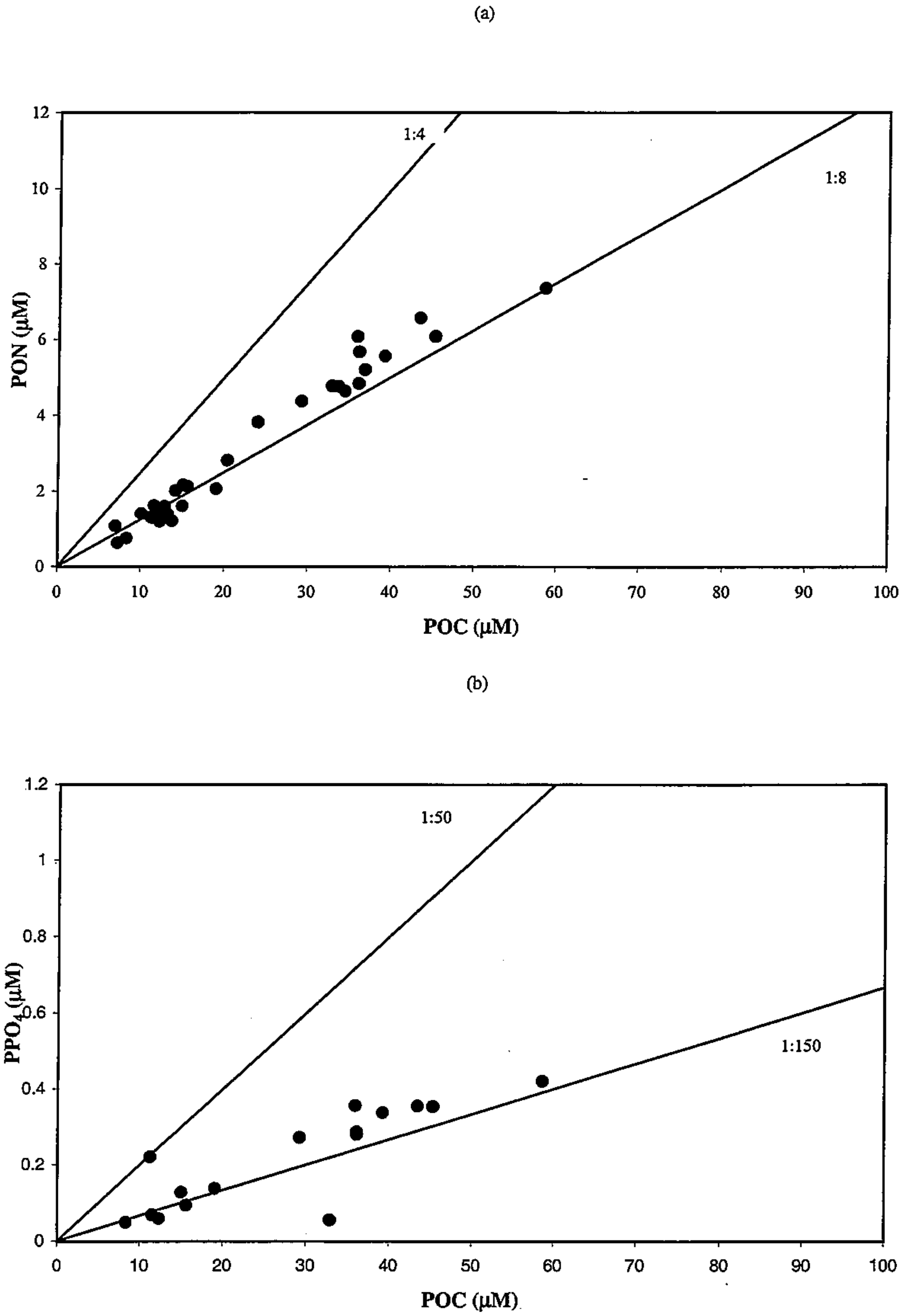
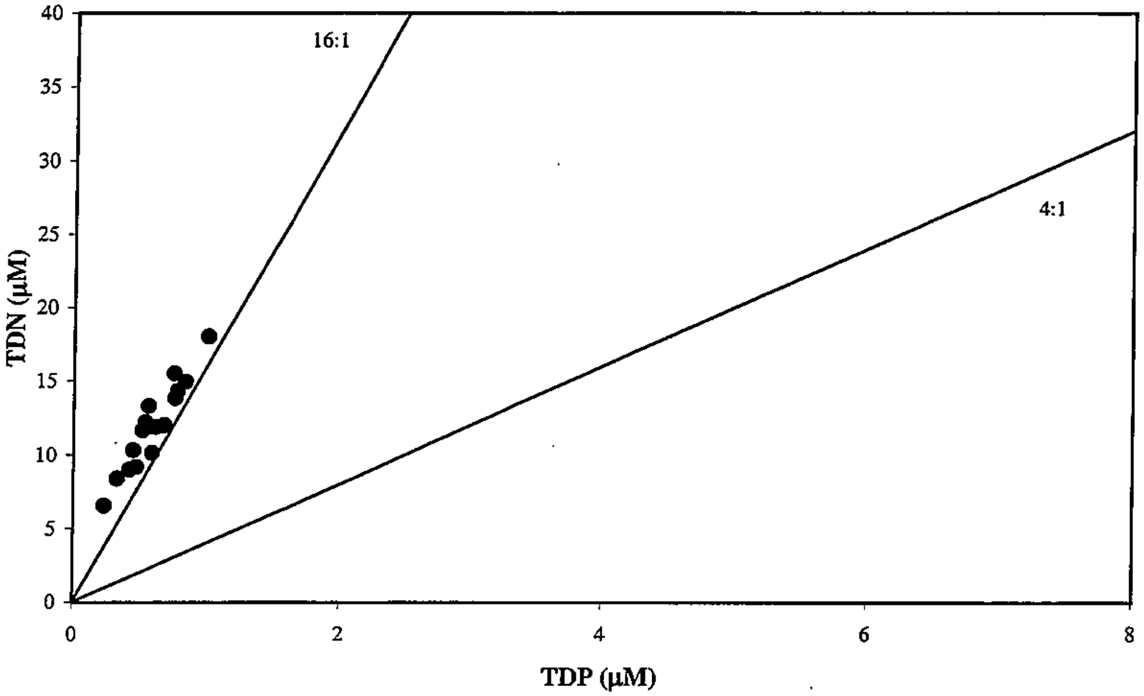


FIGURE 4-55
Nutrient vs. nutrient plots for nearfield survey W9713, (Sep 97)

(a)



(b)

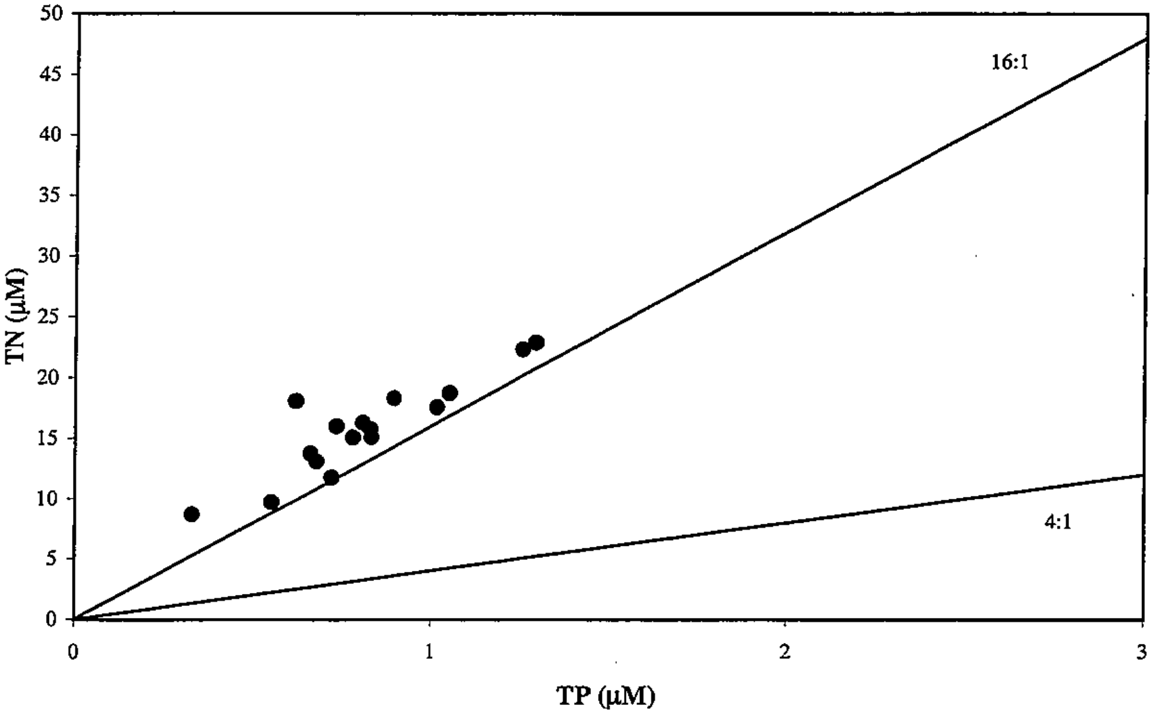


FIGURE 4-56

Nutrient vs. nutrient plots for nearfield survey W9713, (Sep 97)

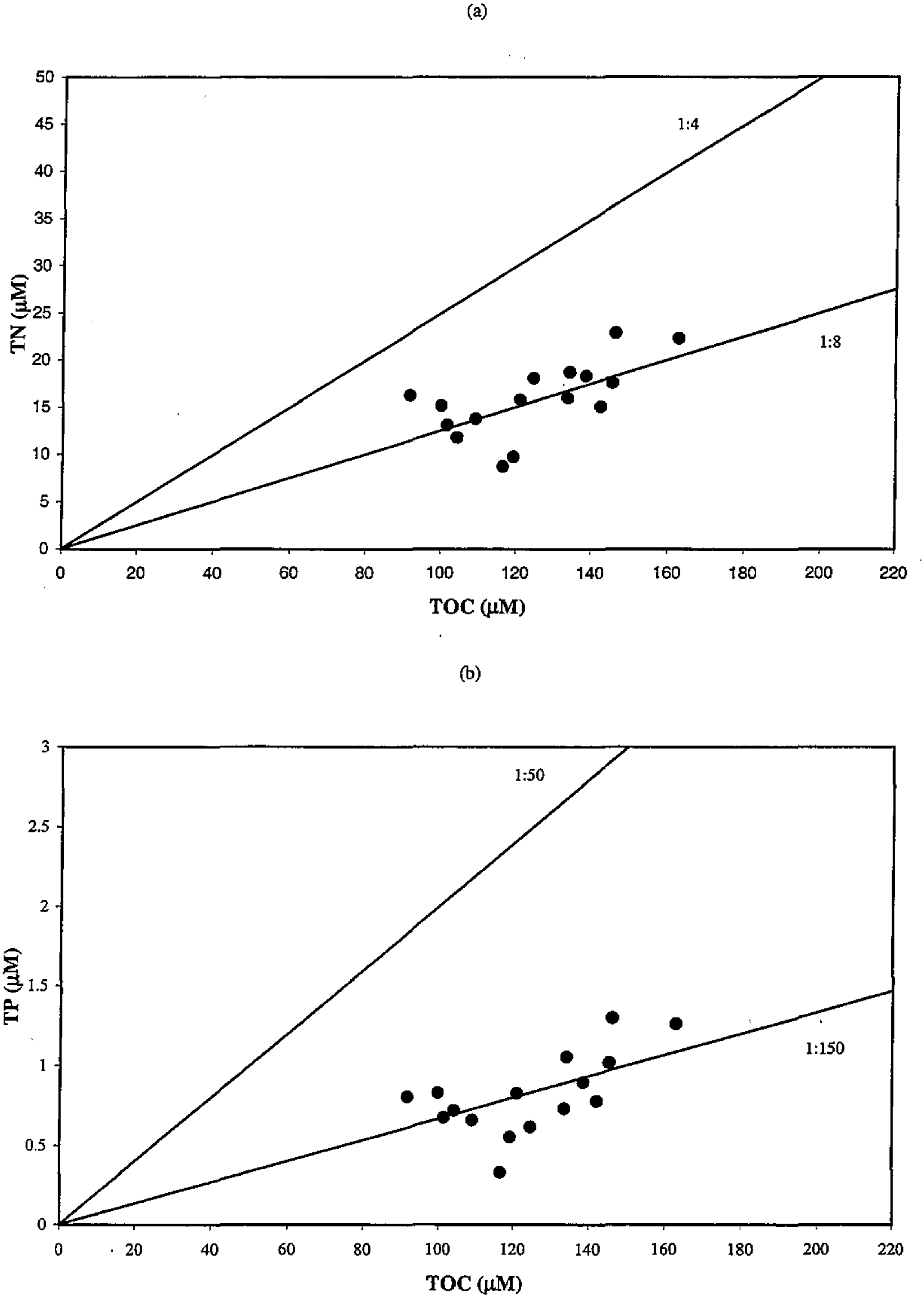


FIGURE 4-57

Nutrient vs. nutrient plots for nearfield survey W9713, (Sep 97)

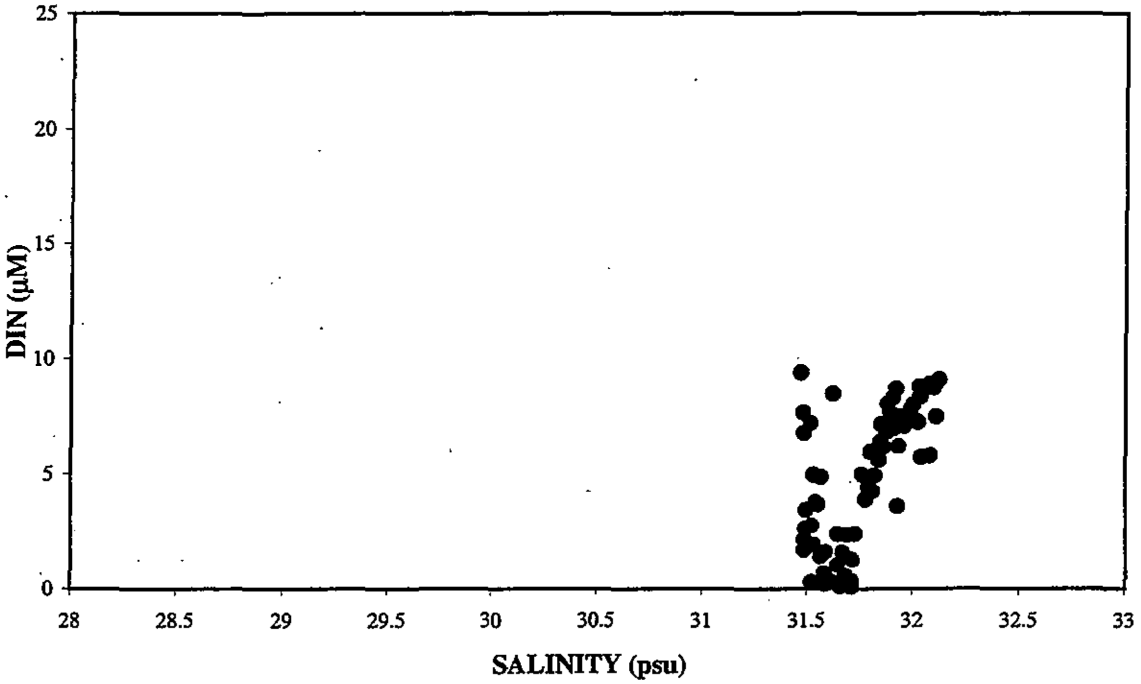


FIGURE 4-58
Nutrient vs. salinity plots for nearfield survey W9713, (Sep 97)

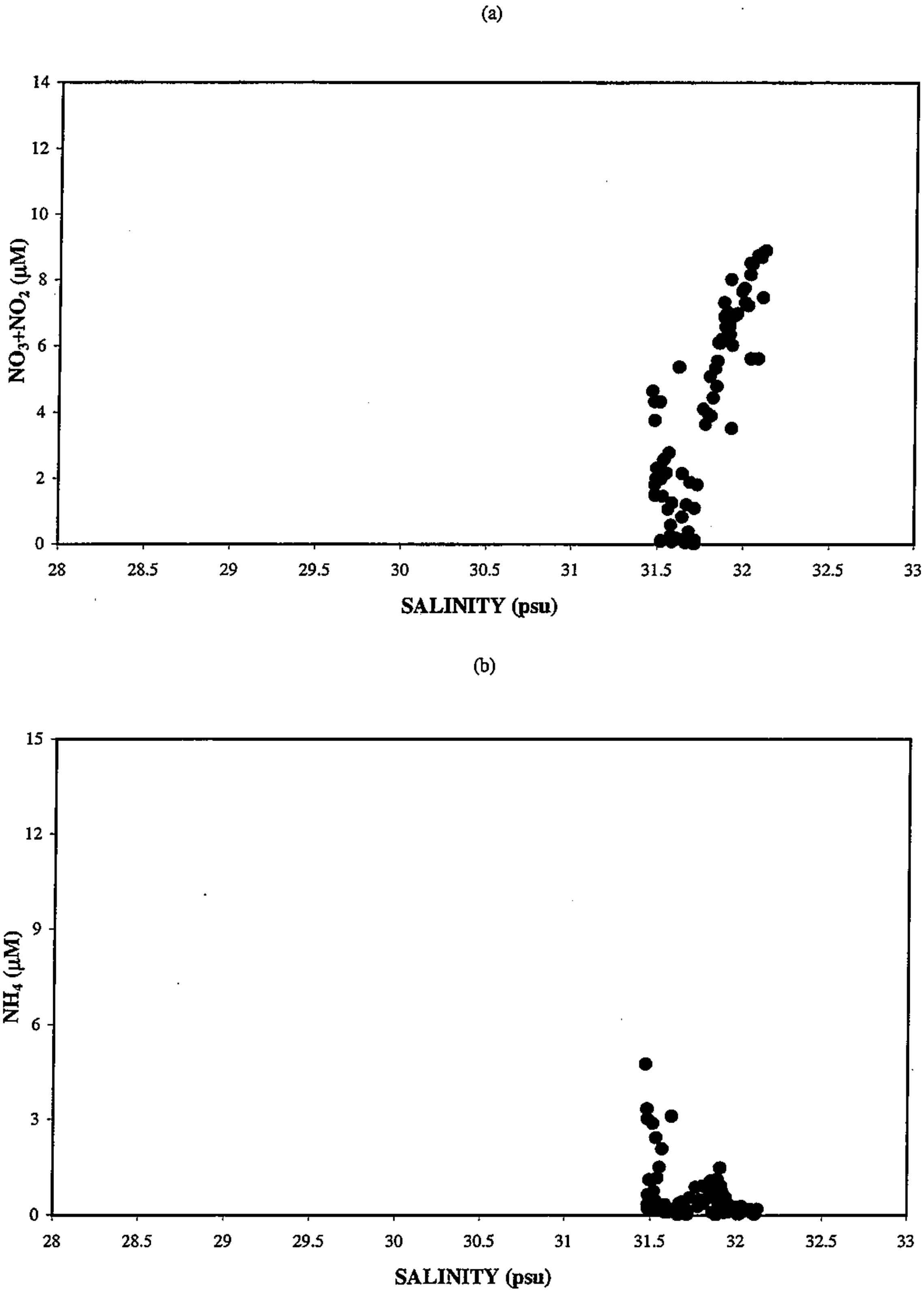


FIGURE 4-59

Nutrient vs. salinity plots for nearfield survey W9713, (Sep 97)

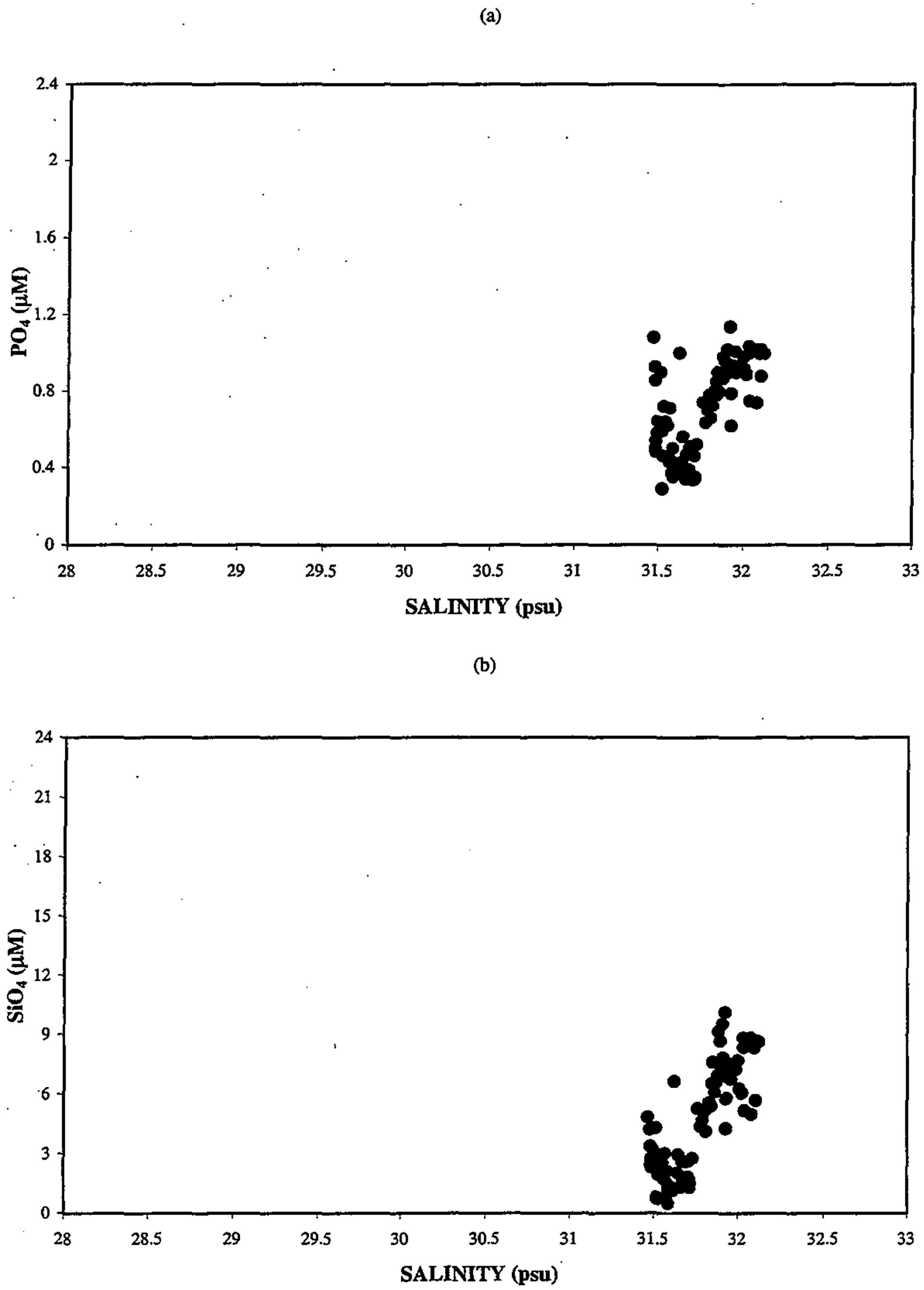


FIGURE 4-60

Nutrient vs. salinity plots for nearfield survey W9713, (Sep 97)

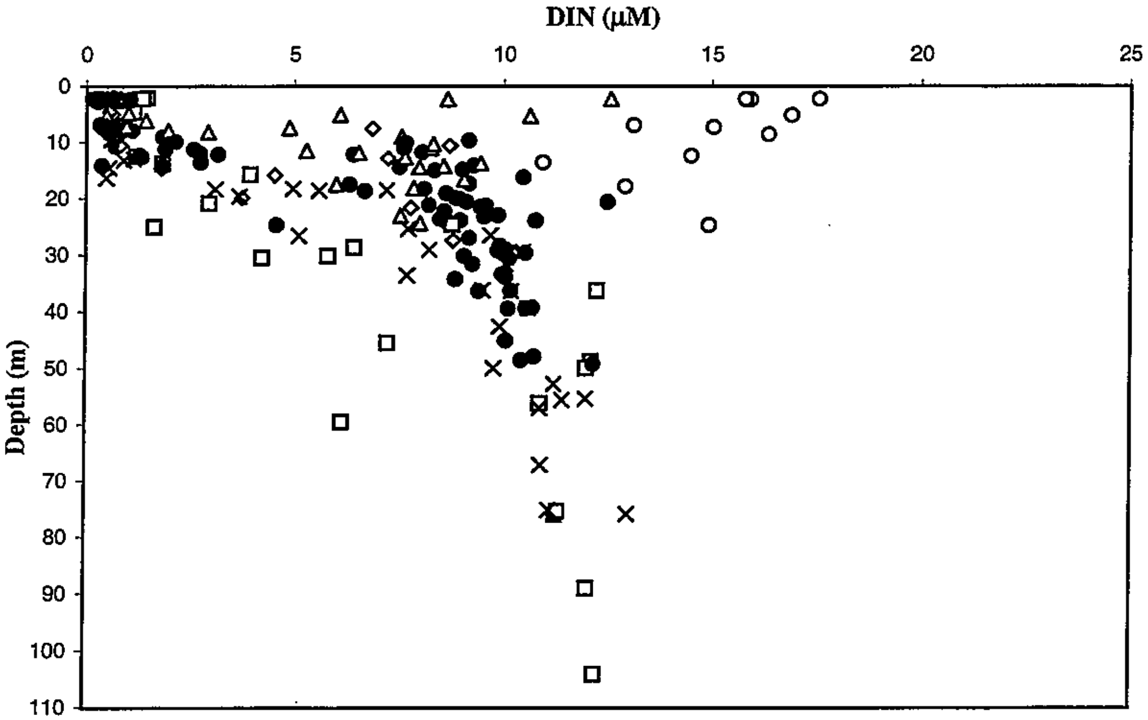


FIGURE 4-61
Nutrient vs. nutrient plots for nearfield survey W9714, (Oct 97)

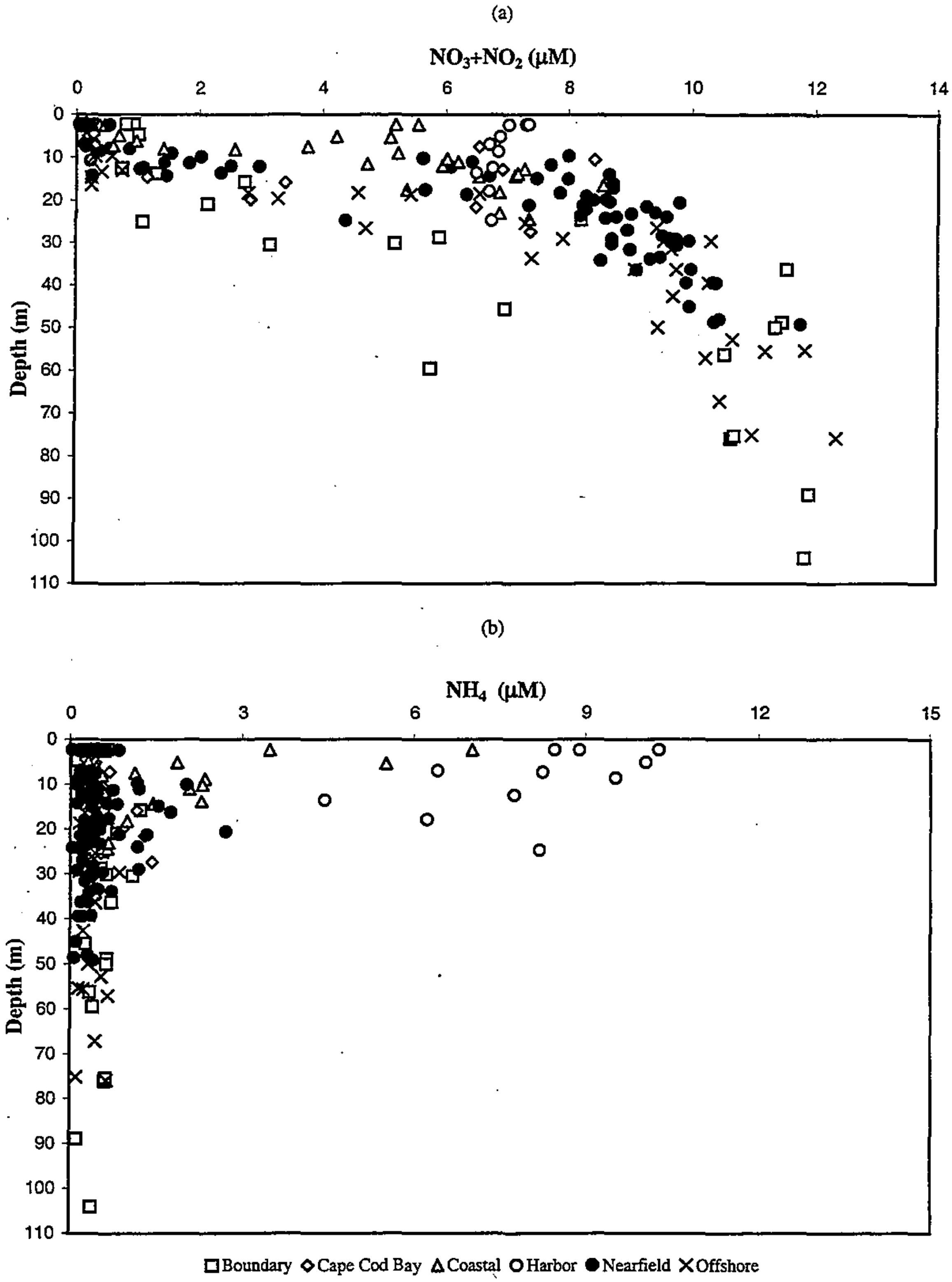
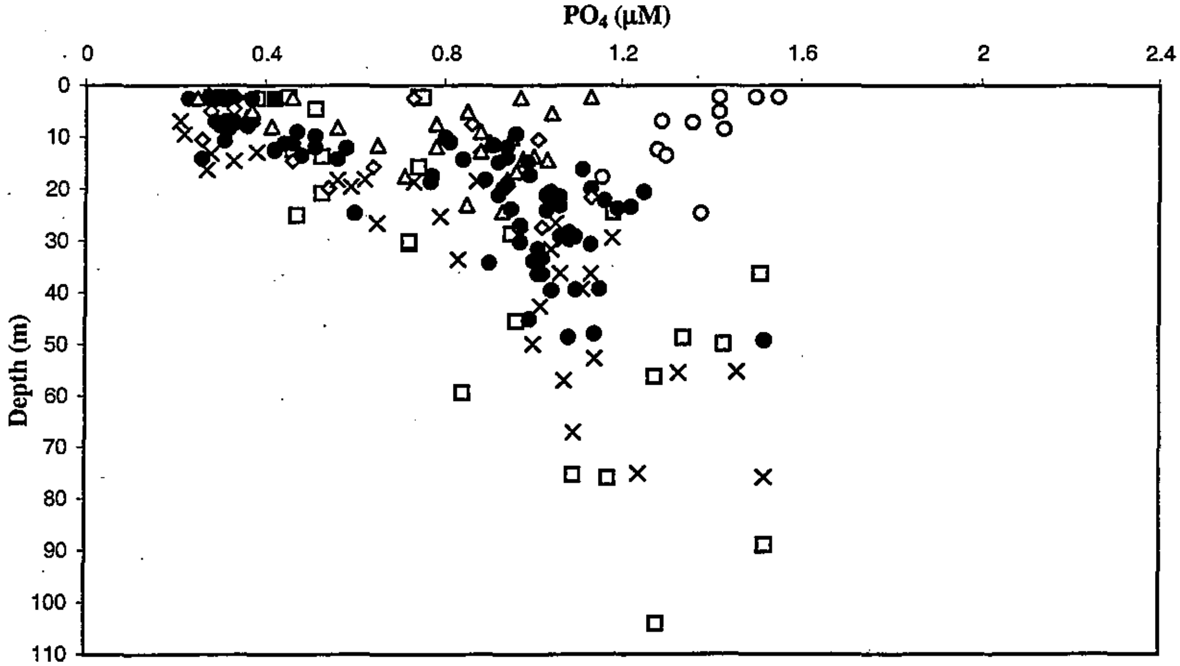


FIGURE 4-62

Nutrient vs. nutrient plots for nearfield survey W9714, (Oct 97)

(a)



(b)

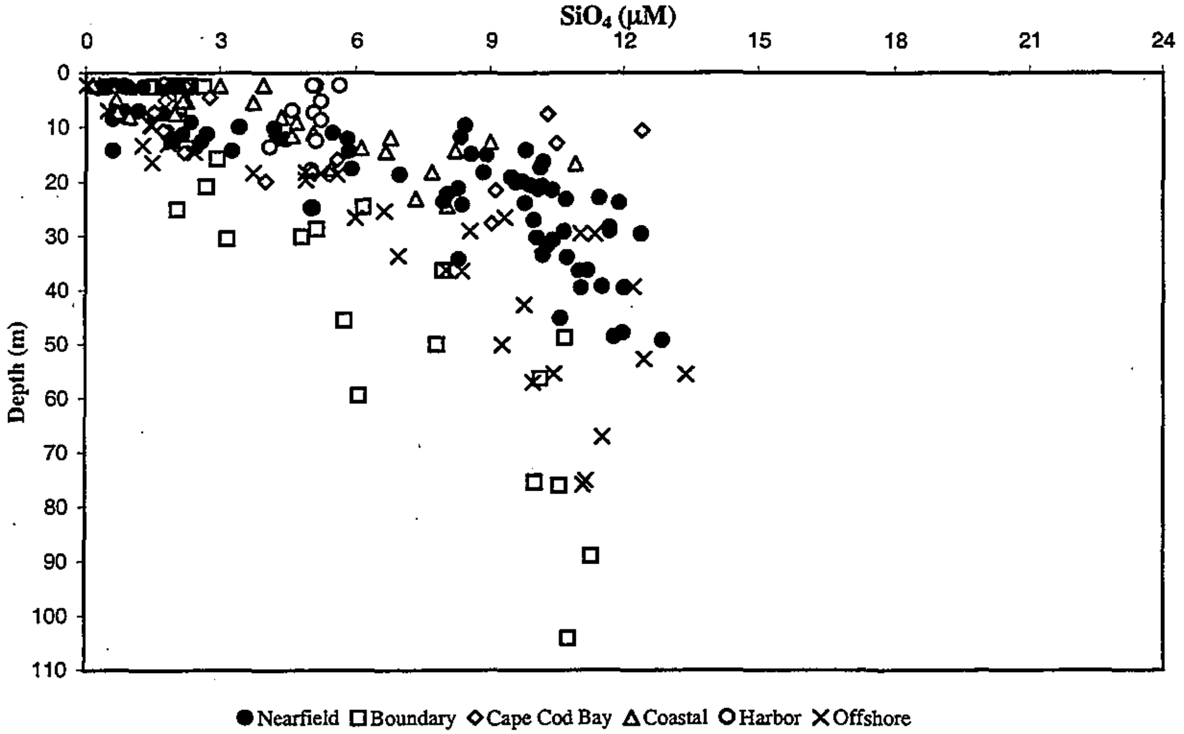


FIGURE 4-63

Nutrient vs. nutrient plots for nearfield survey W9714, (Oct 97)

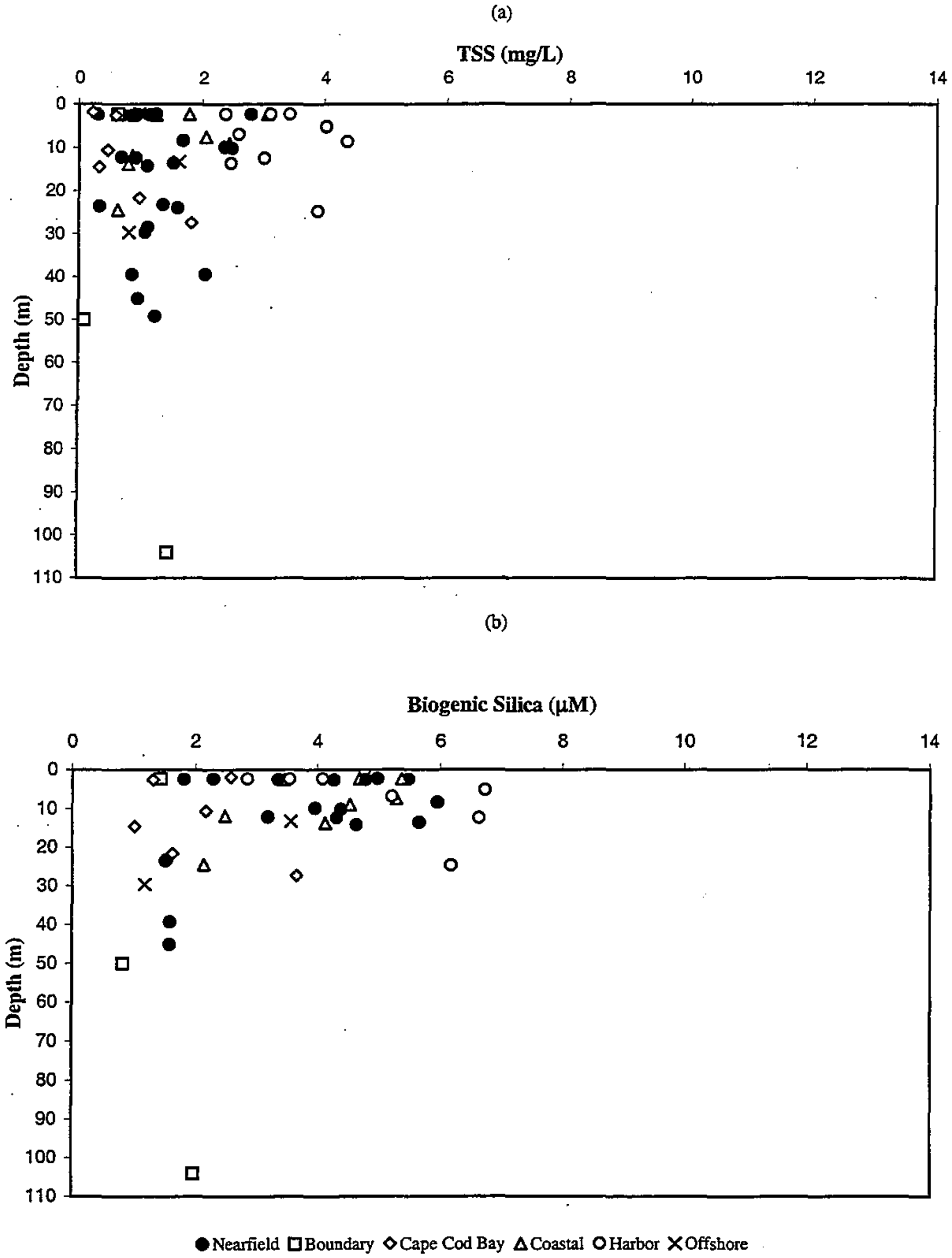


FIGURE 4-64

Nutrient vs. nutrient plots for nearfield survey W9714, (Oct 97)

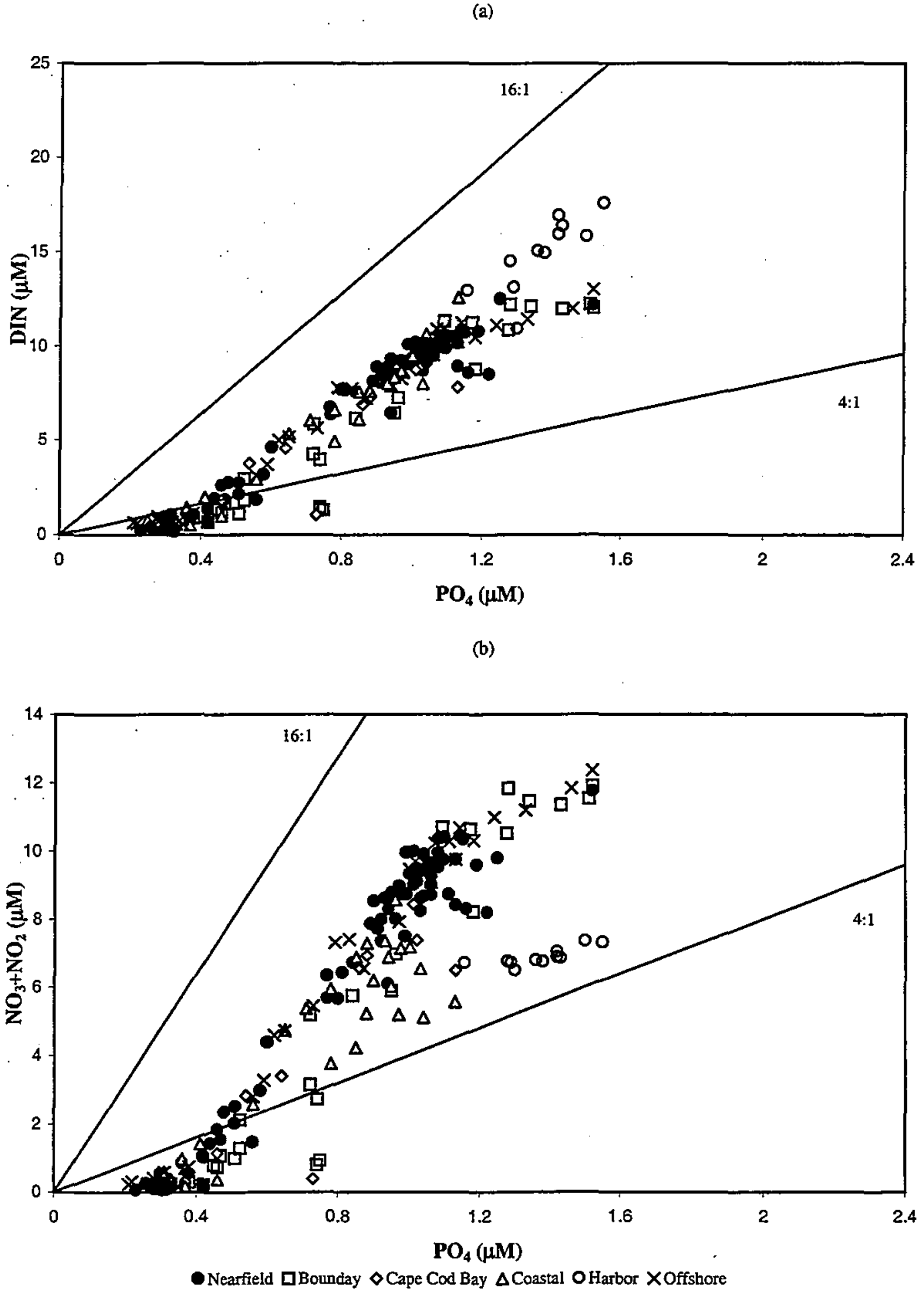


FIGURE 4-65
Nutrient vs. nutrient plots for nearfield survey W9714, (Oct 97)

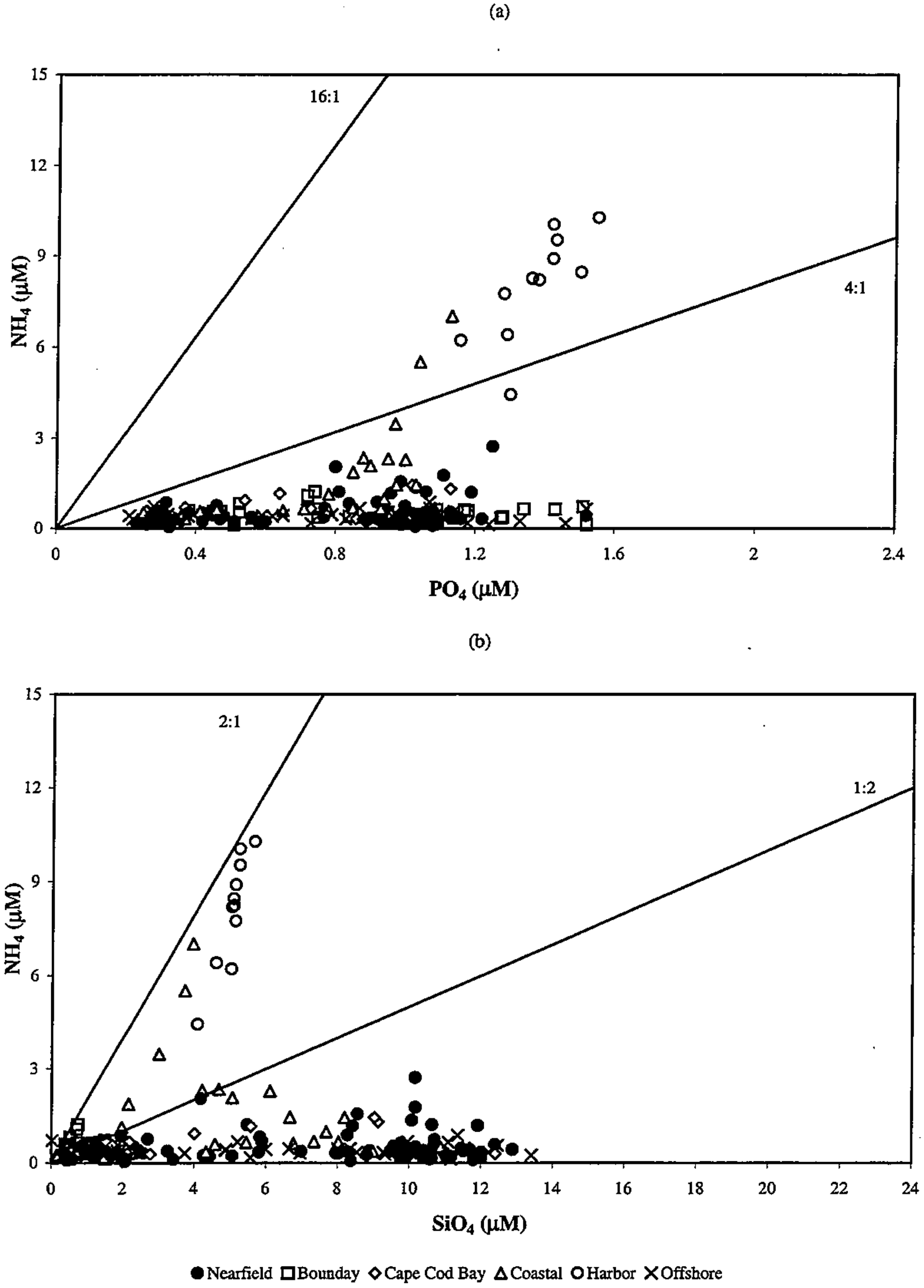


FIGURE 4-66

Nutrient vs. nutrient plots for nearfield survey W9714, (Oct 97)

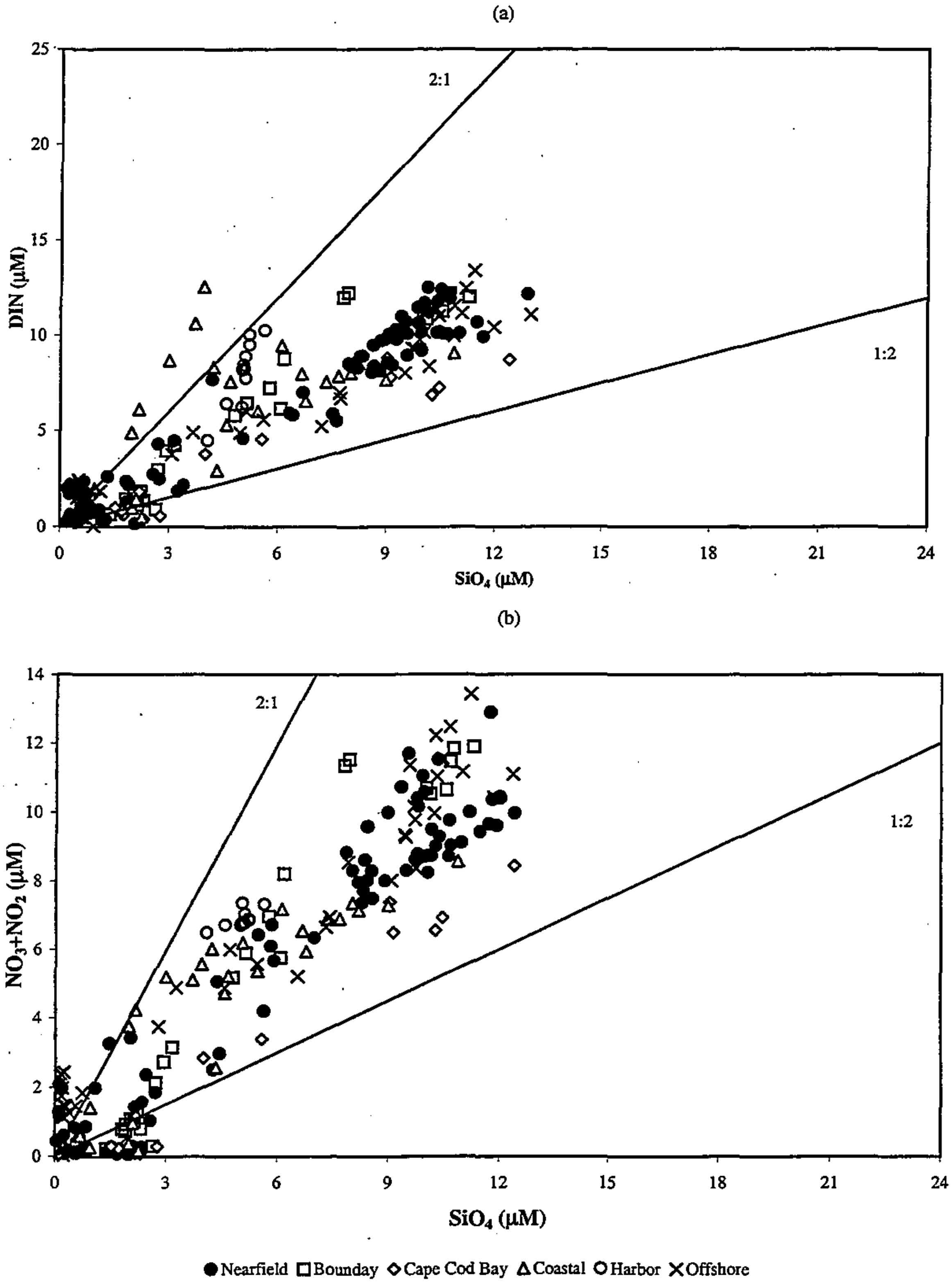


FIGURE 4-67
Nutrient vs. nutrient plots for nearfield survey W9714, (Oct 97)

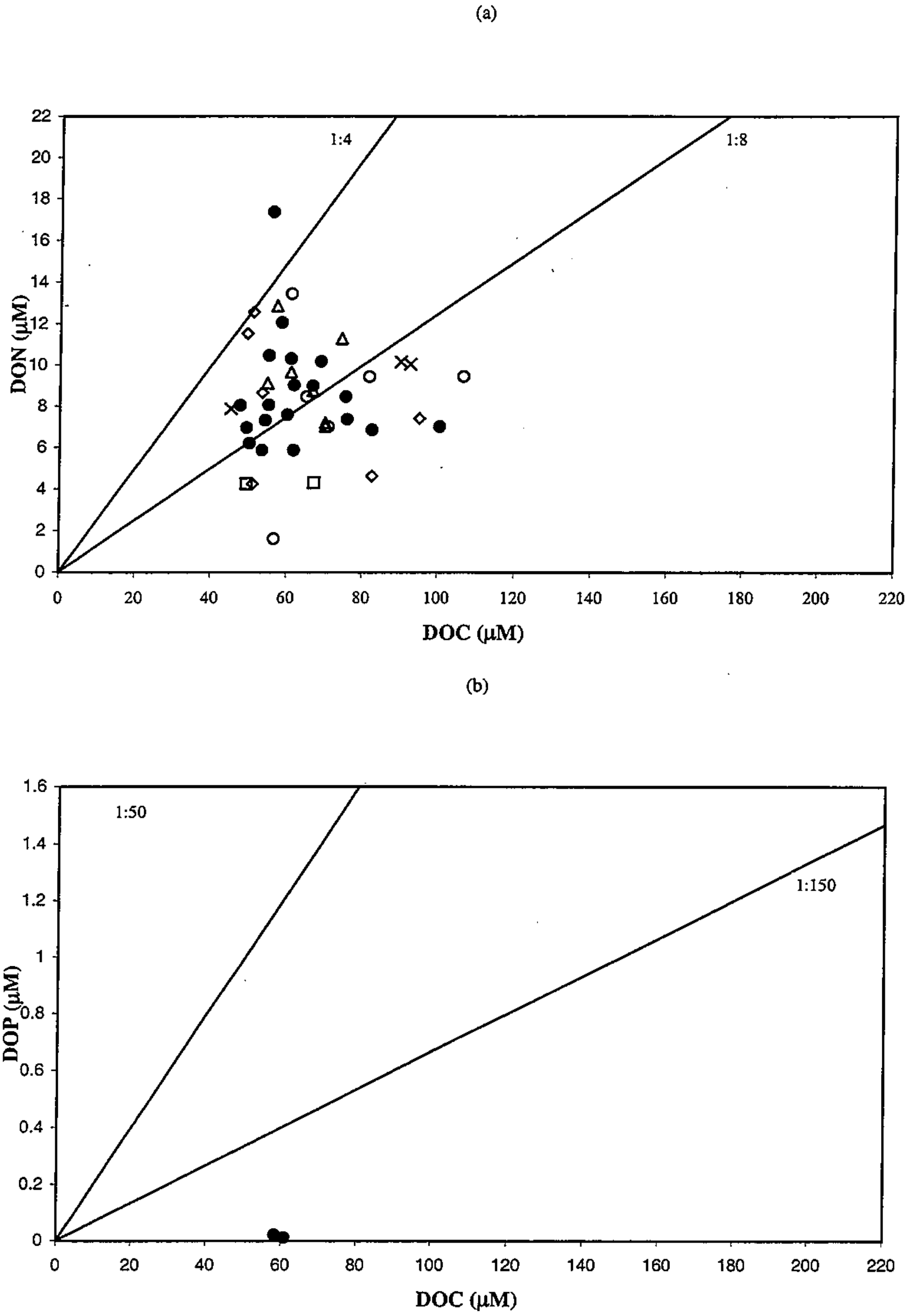


FIGURE 4-68

Nutrient vs. nutrient plots for nearfield survey W9714, (Oct 97)

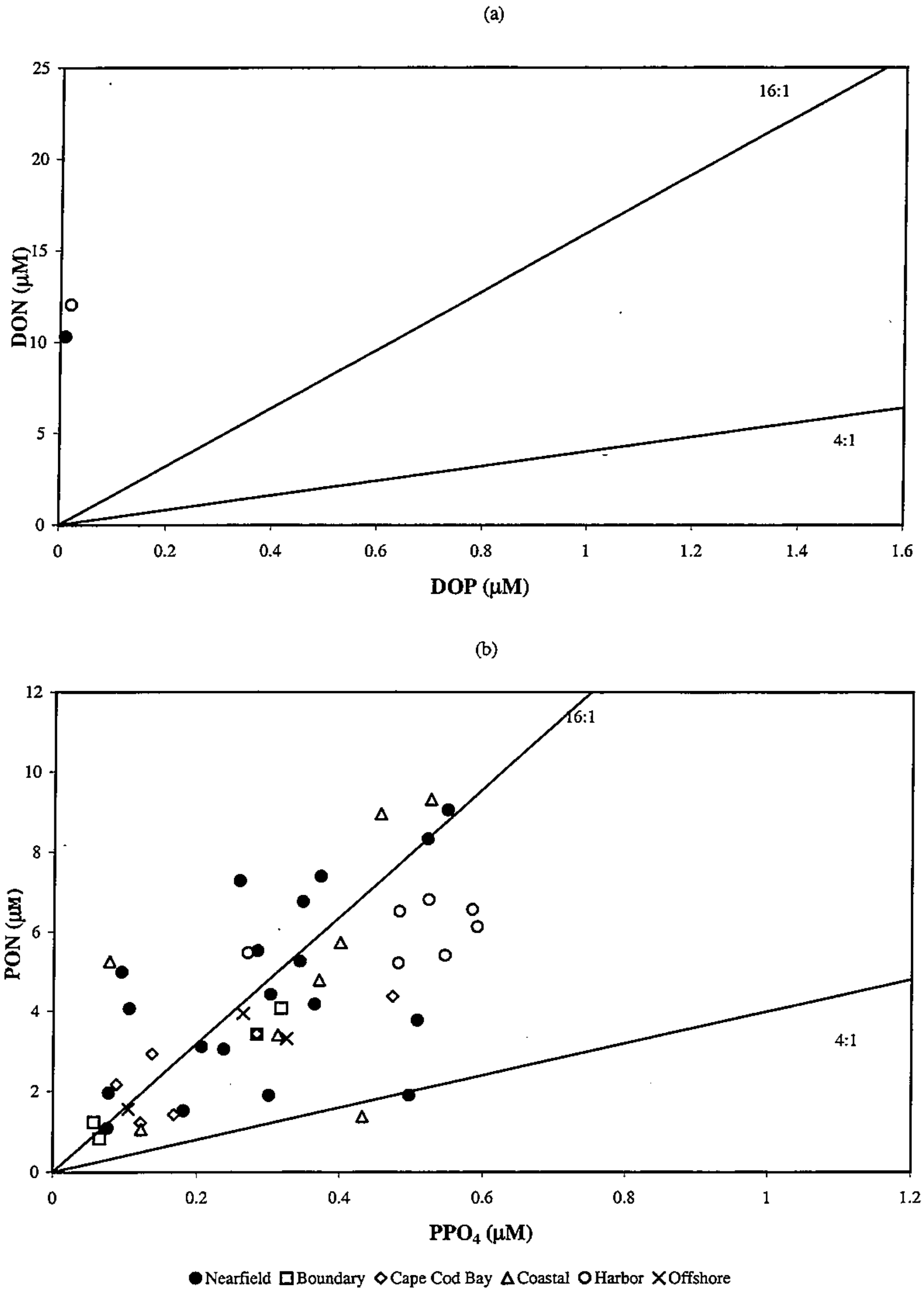
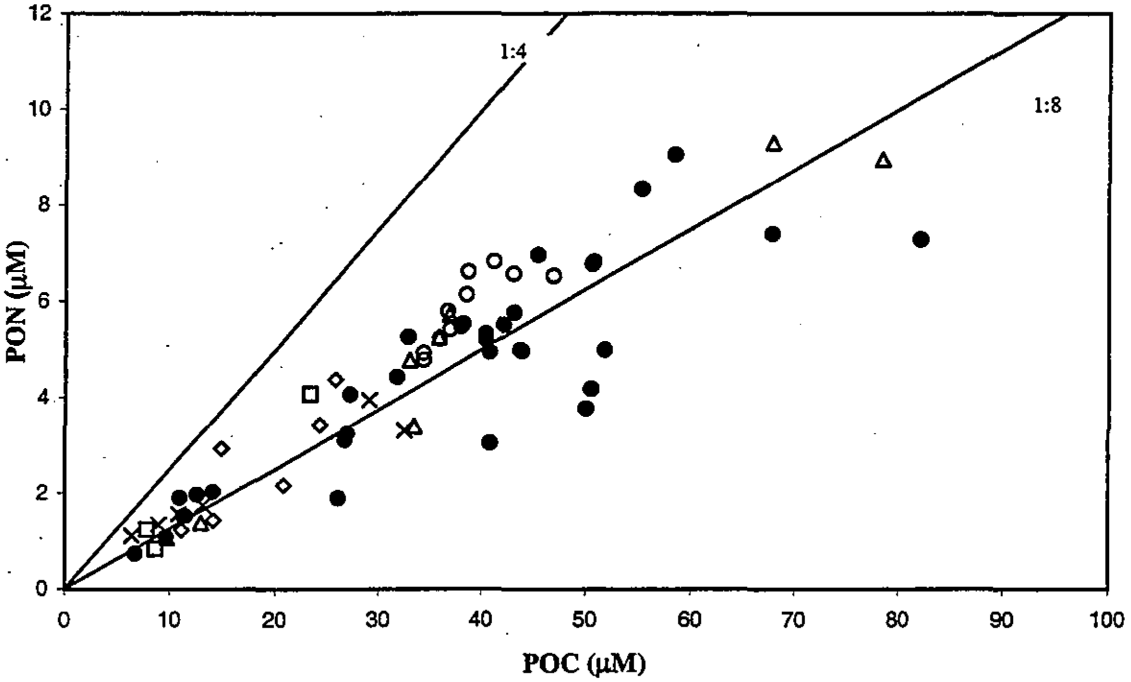


FIGURE 4-69

Nutrient vs. nutrient plots for nearfield survey W9714, (Oct 97)

(a)



(b)

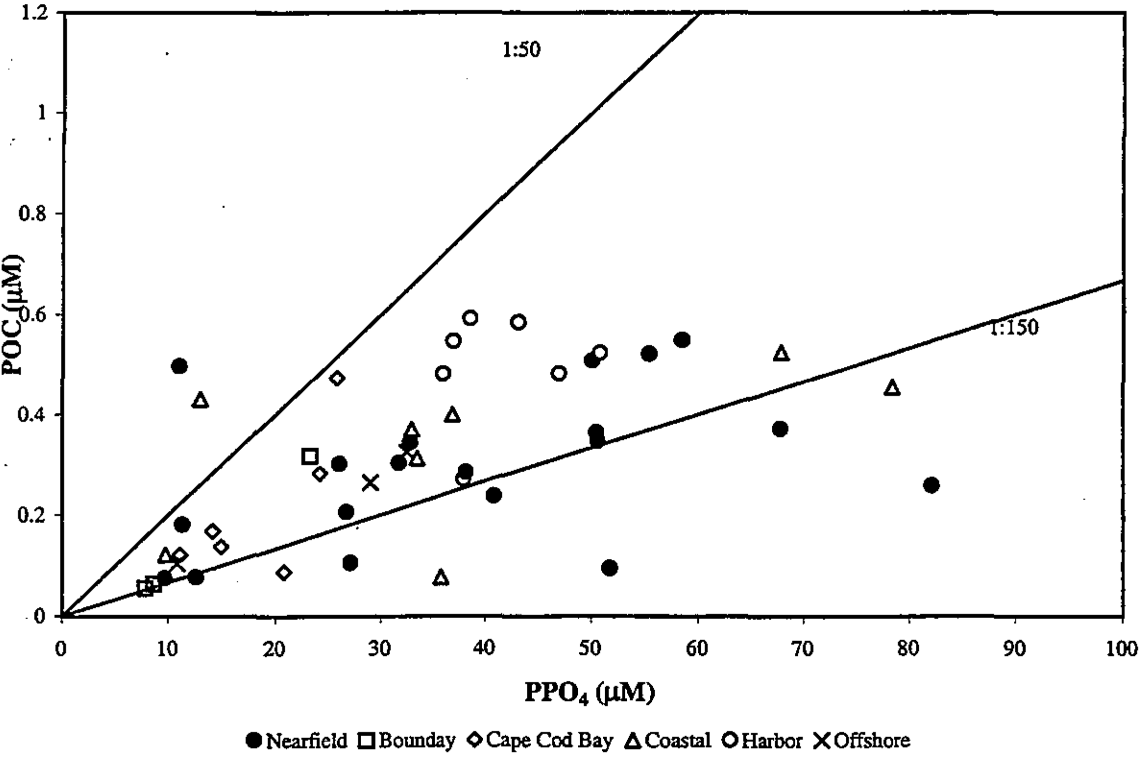
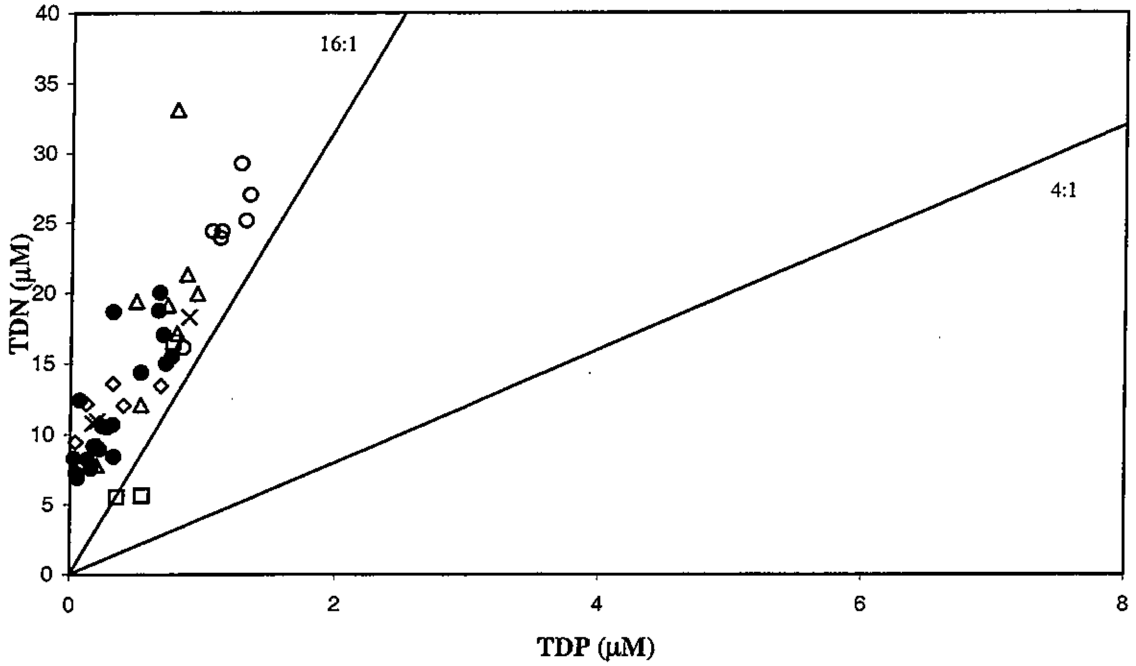


FIGURE 4-70

Nutrient vs. nutrient plots for nearfield survey W9714, (Oct 97)

(a)



(b)

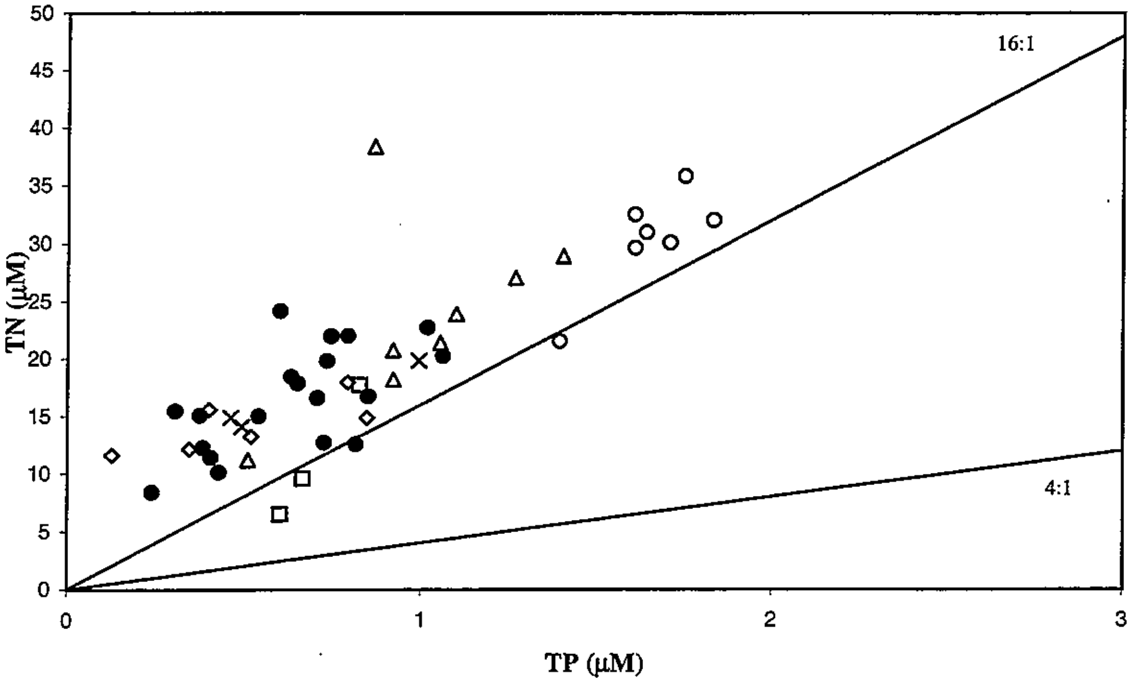
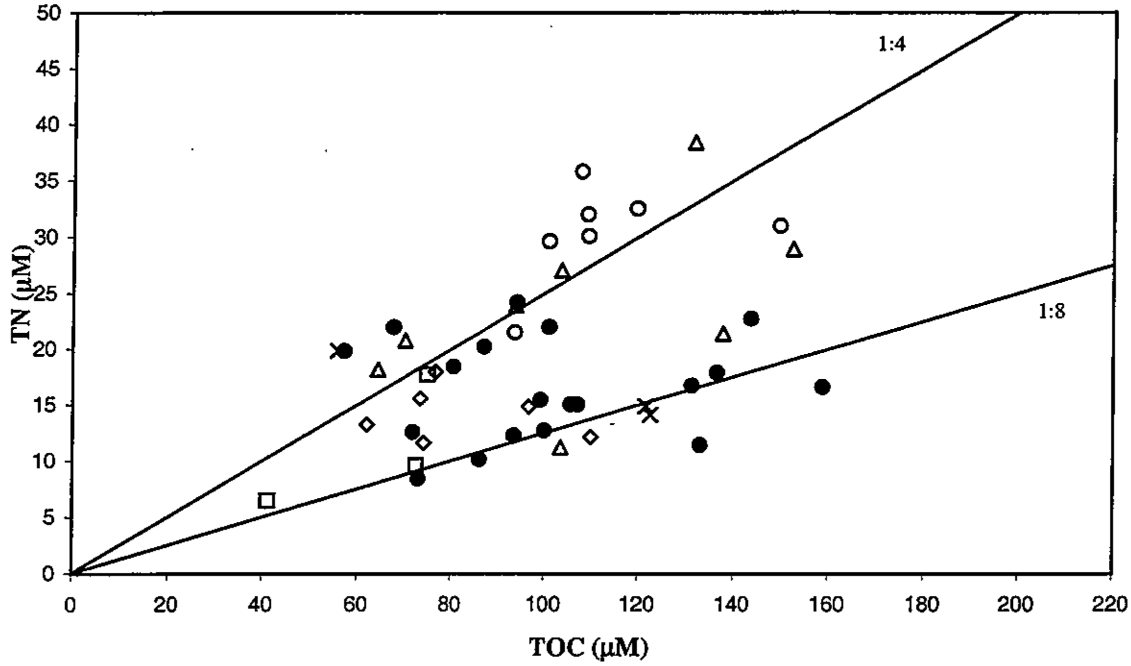


FIGURE 4-71

Nutrient vs. nutrient plots for nearfield survey W9714, (Oct 97)

(a)



(b)

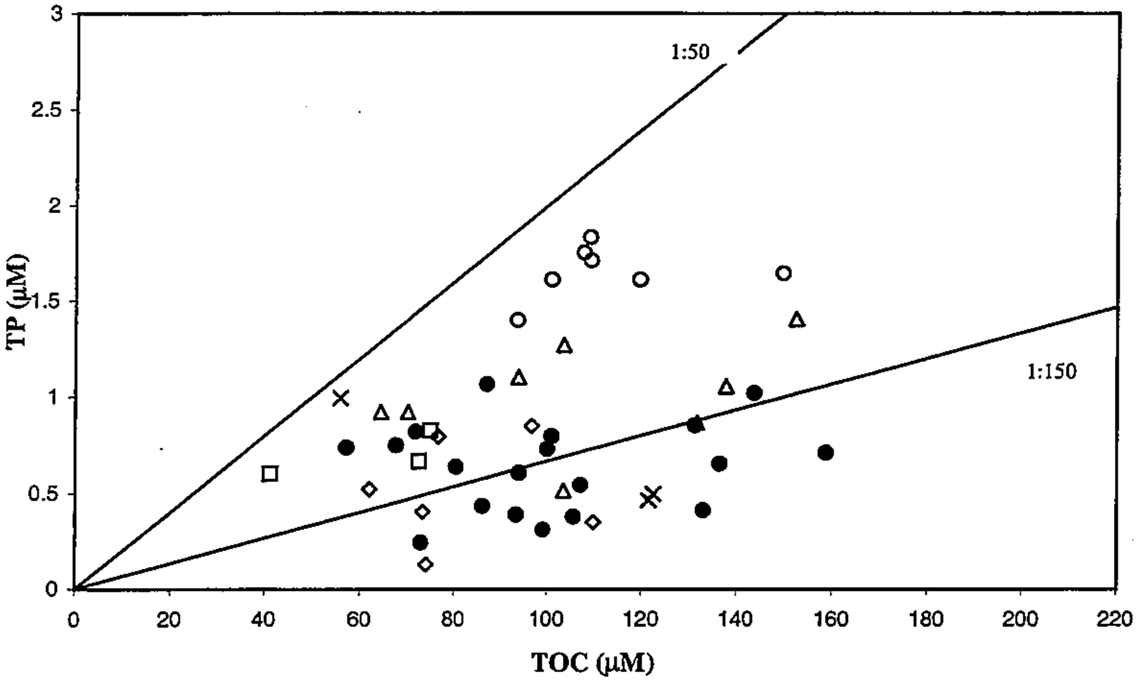


FIGURE 4-72

Nutrient vs. nutrient plots for nearfield survey W9714, (Oct 97)

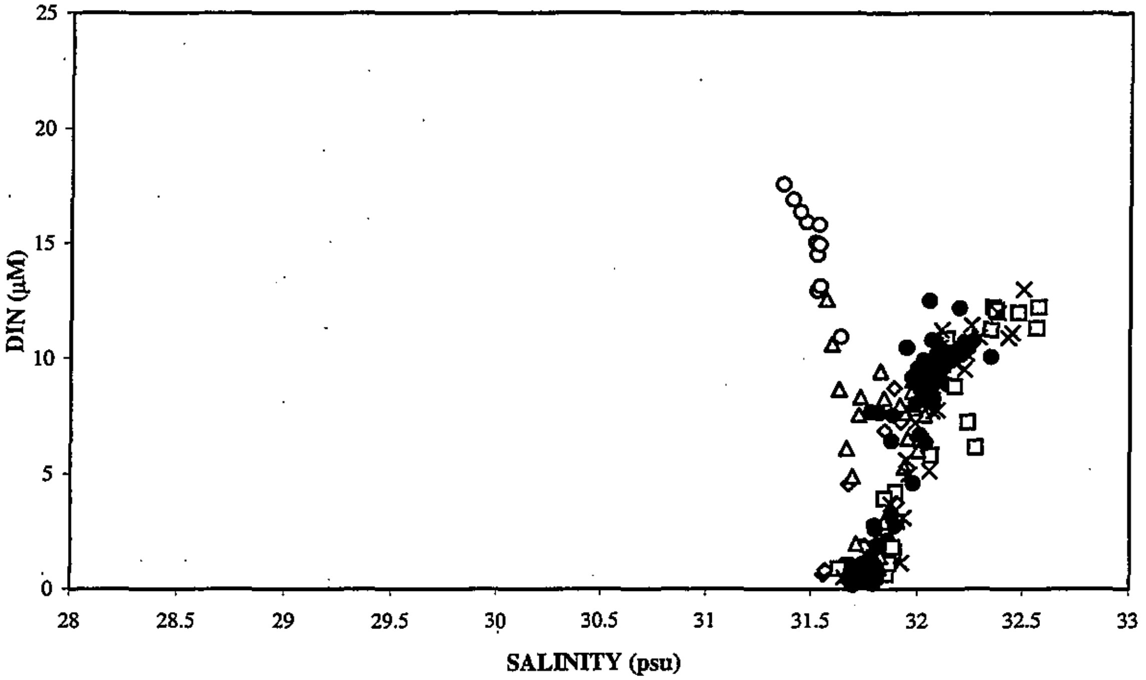


FIGURE 4-73
Nutrient vs. salinity plots for nearfield survey W9714, (Oct 97)

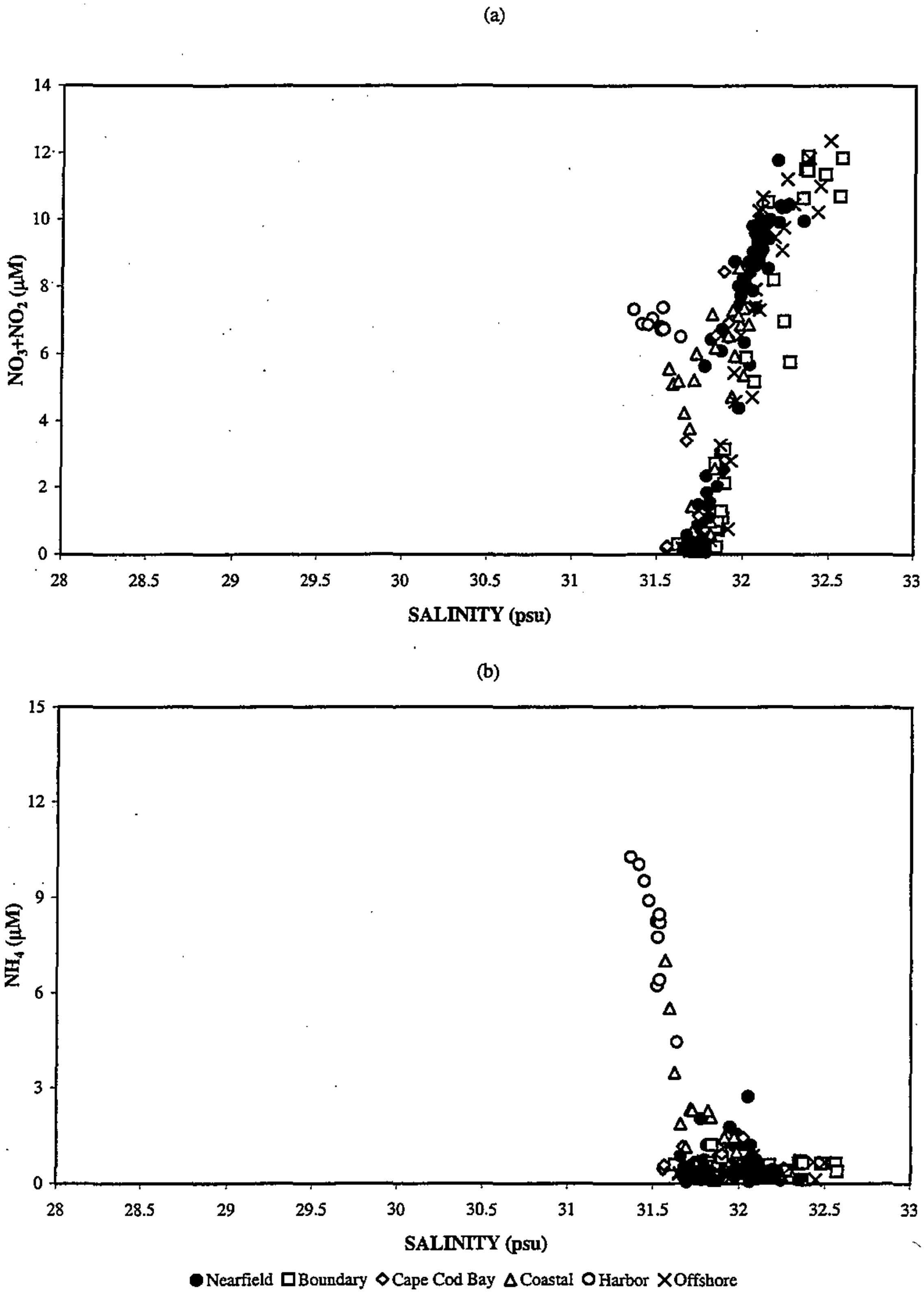


FIGURE 4-74

Nutrient vs. salinity plots for nearfield survey W9714, (Oct 97)

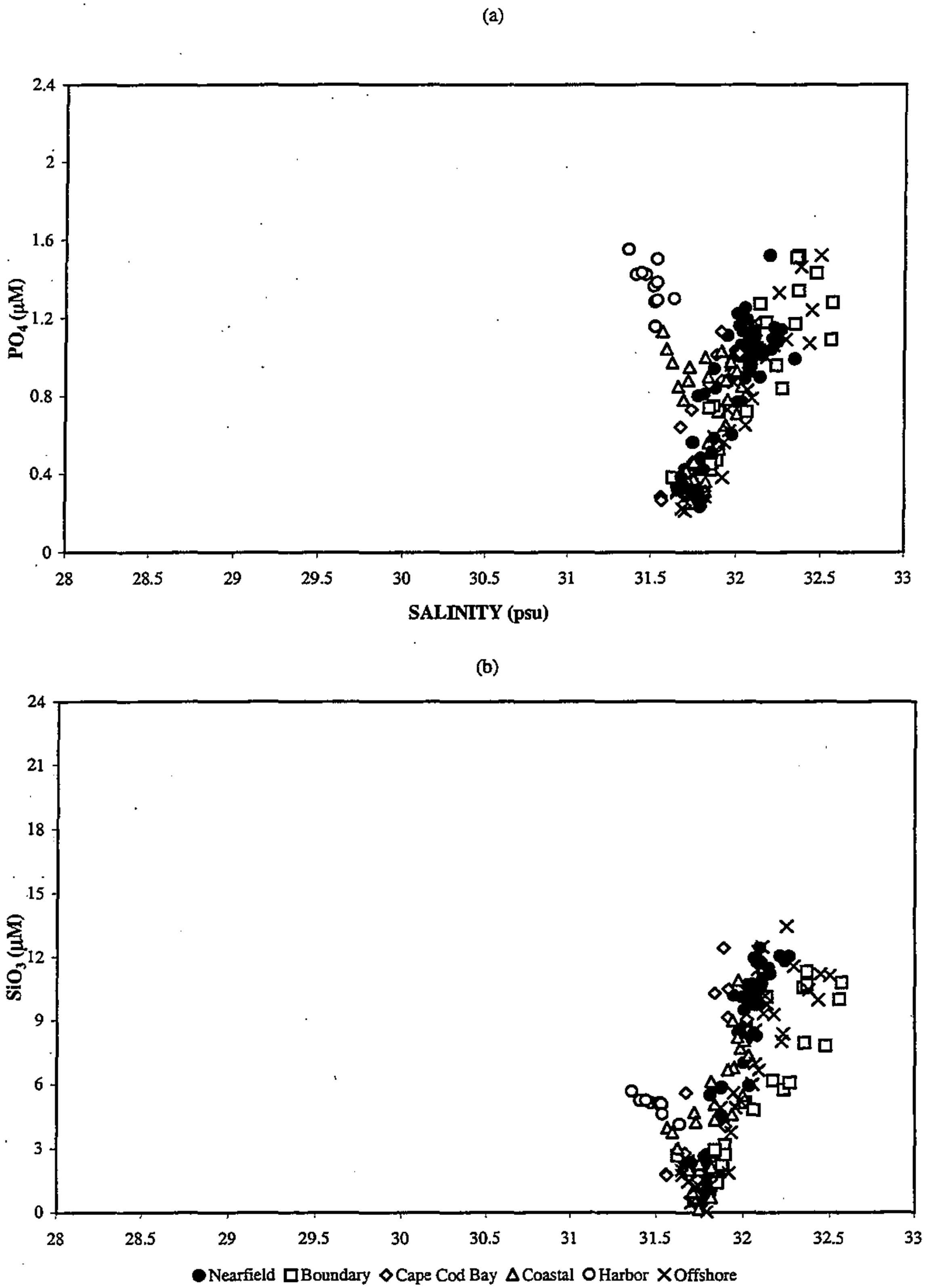


FIGURE 4-75
Nutrient vs. salinity plots for nearfield survey W9714, (Oct 97)

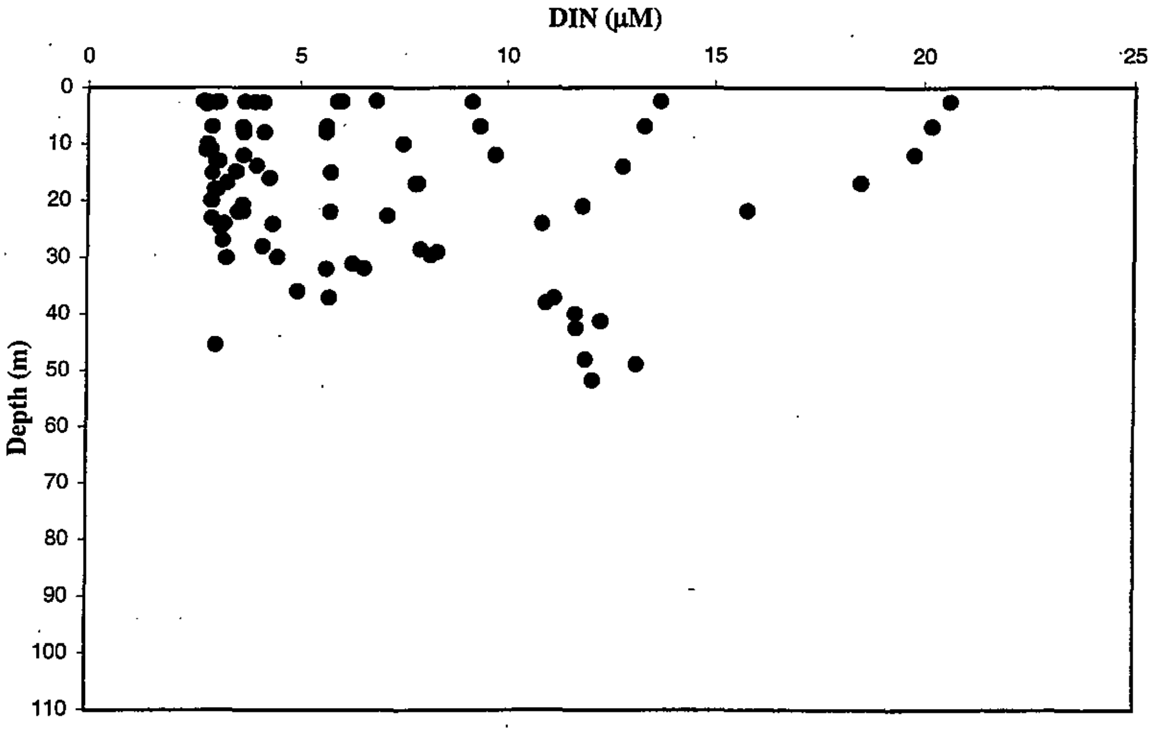
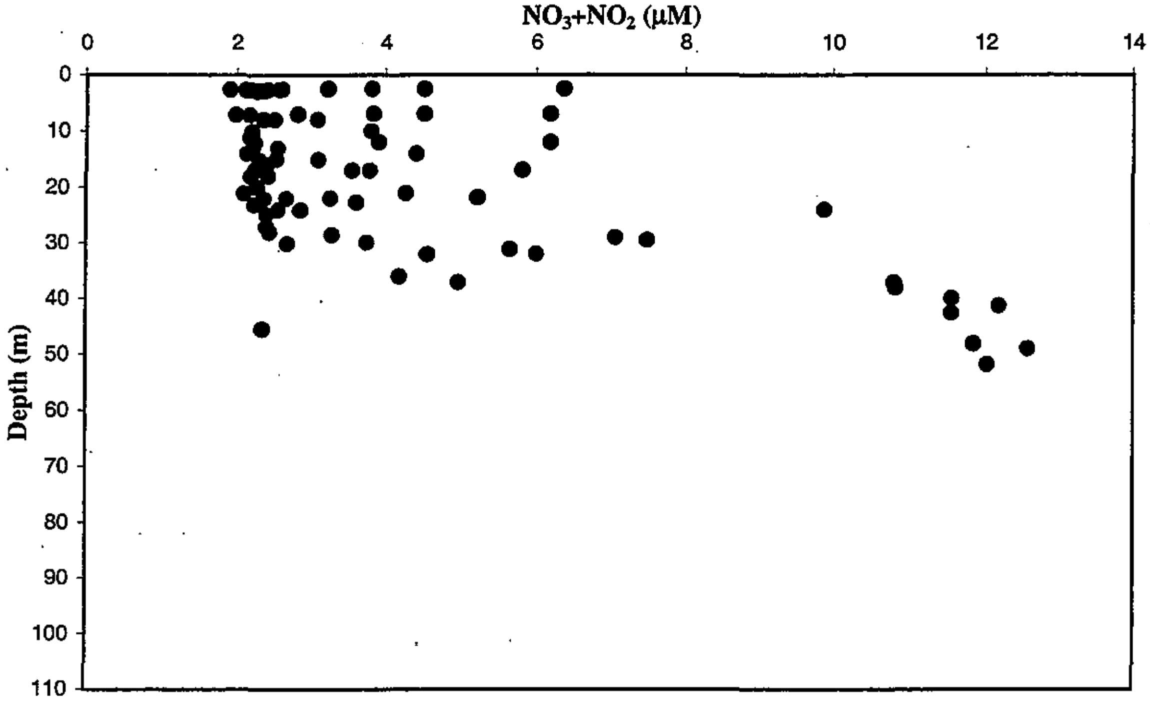


FIGURE 4-76

Depth vs. nutrient plots for nearfield survey W9715, (Oct 97)

(a)



(b)

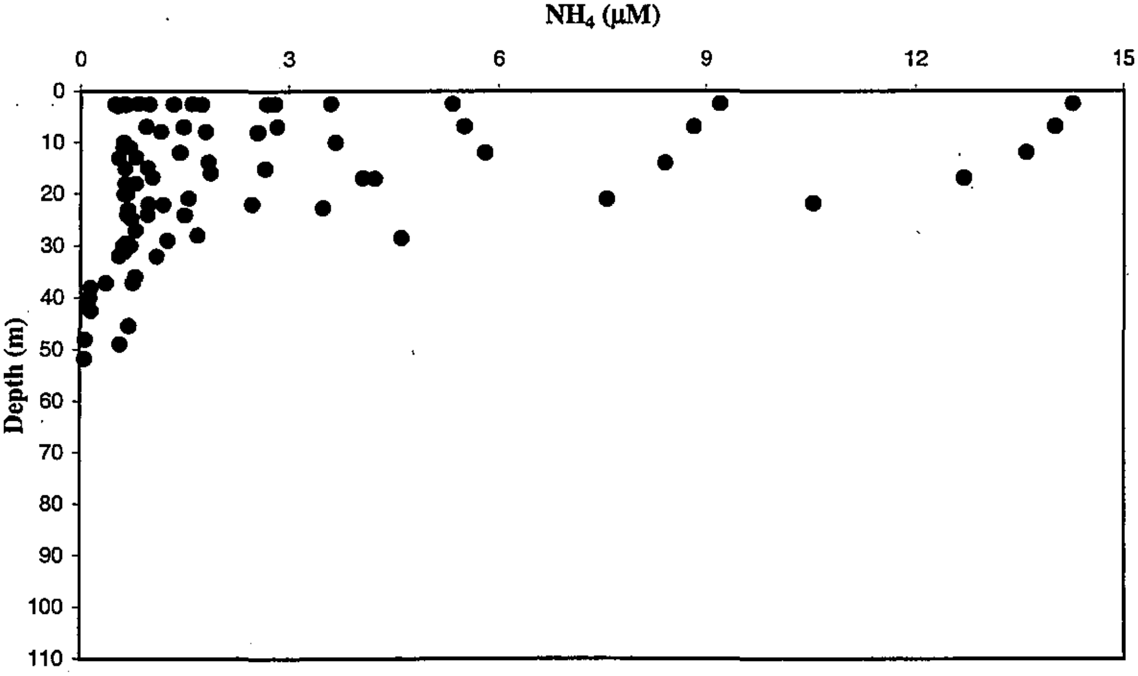
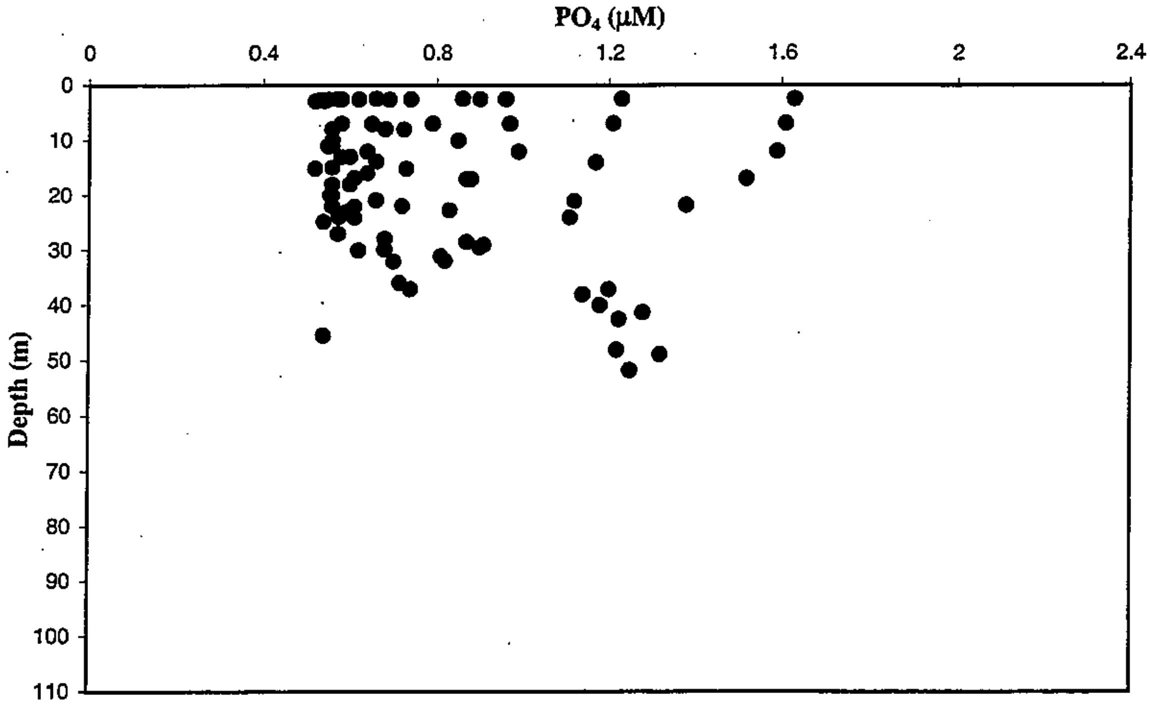


FIGURE 4-77

Depth vs. nutrient plots for nearfield survey W9715, (Oct 97)

(a)



(b)

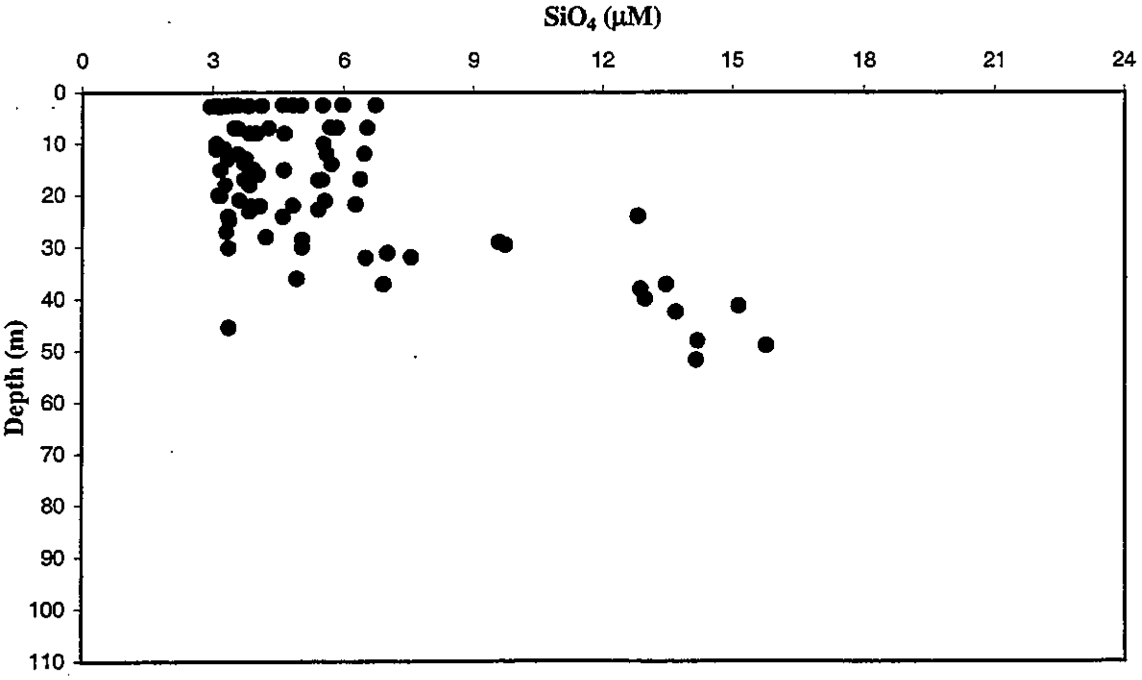


FIGURE 4-78

Depth vs. nutrient plots for nearfield survey W9715, (Oct 97)

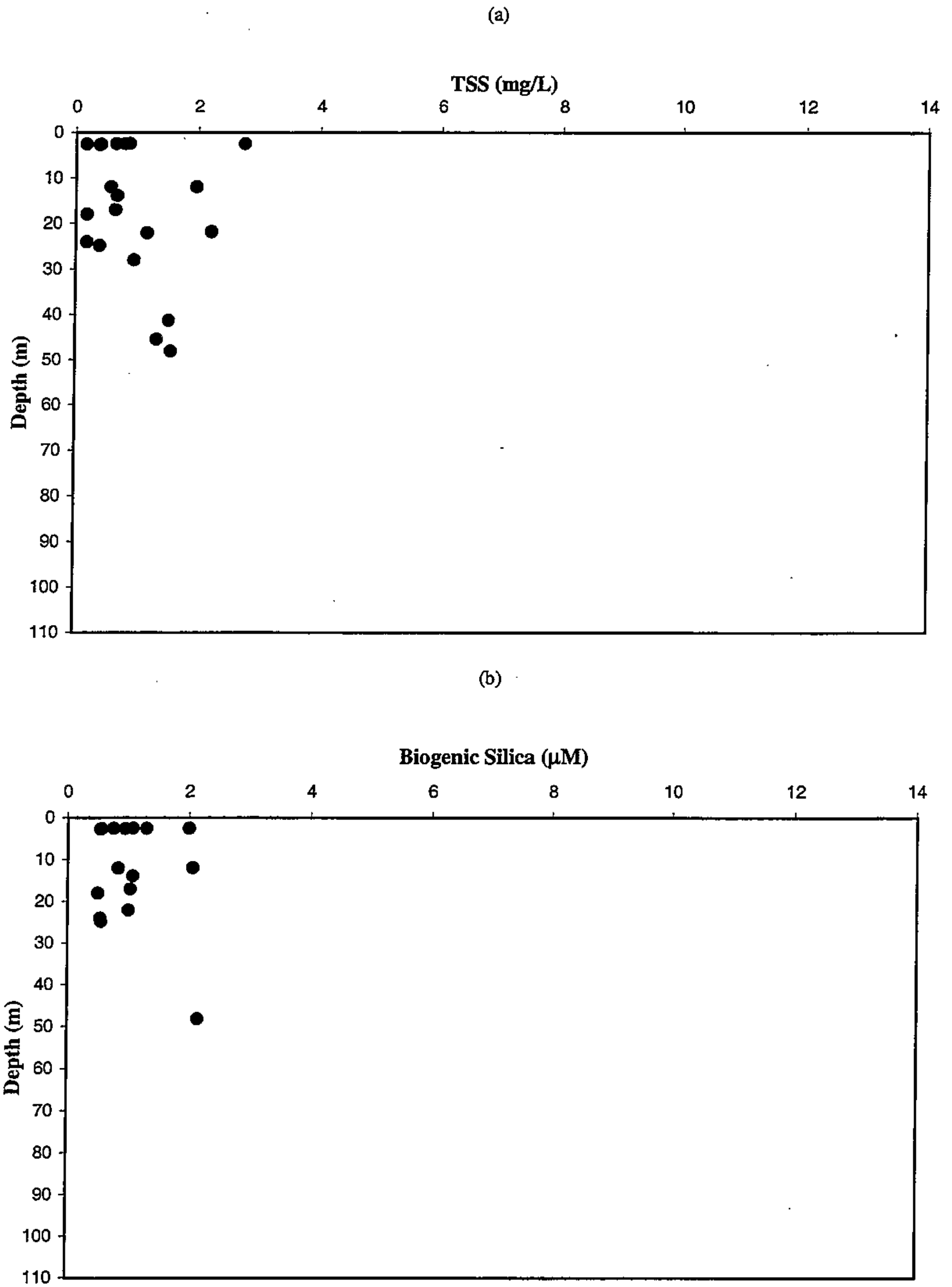


FIGURE 4-79

Depth vs. nutrient plots for nearfield survey W9715, (Oct 97)

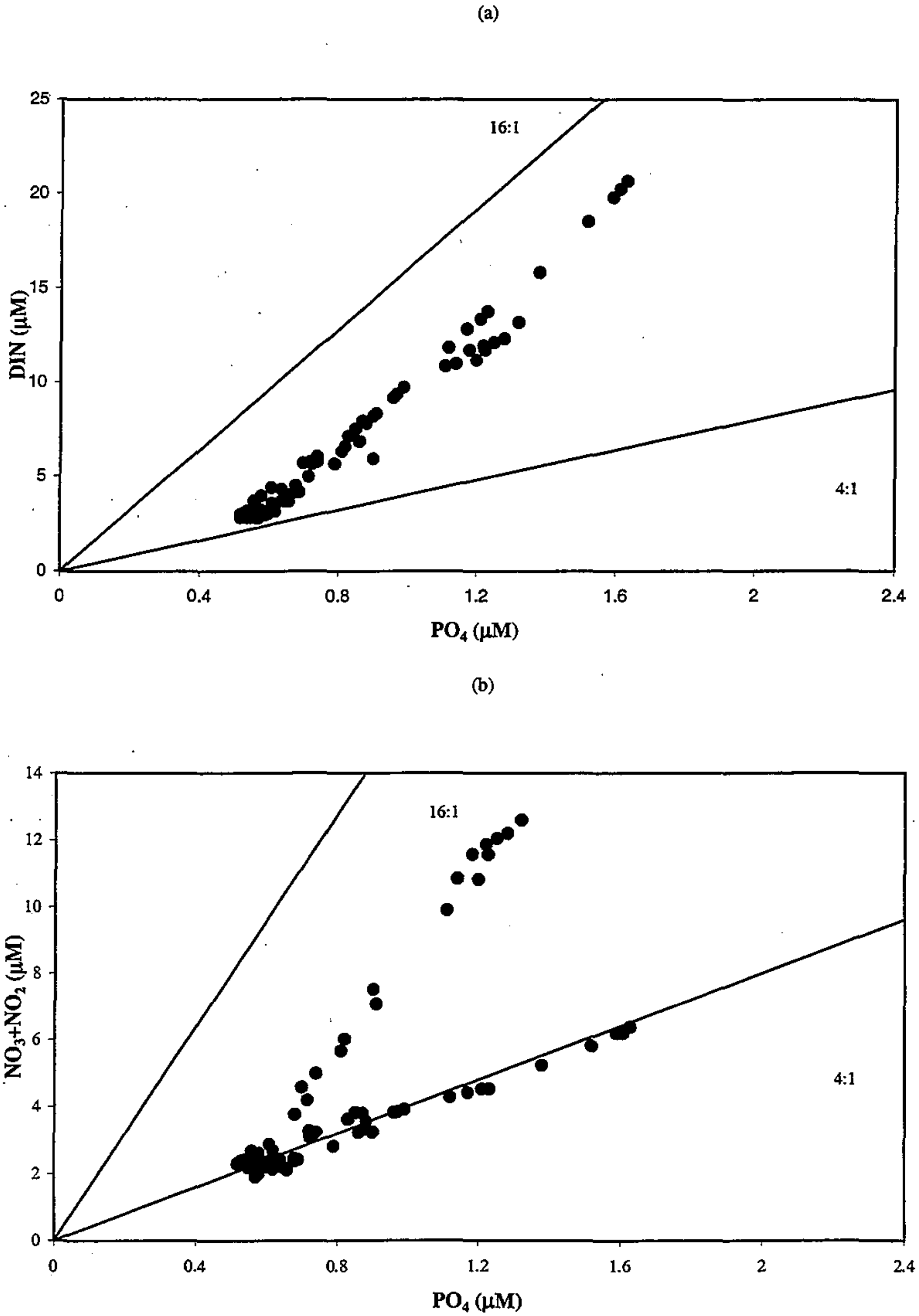


FIGURE 4-80

Nutrient vs. nutrient plots for nearfield survey W9715, (Oct 97)

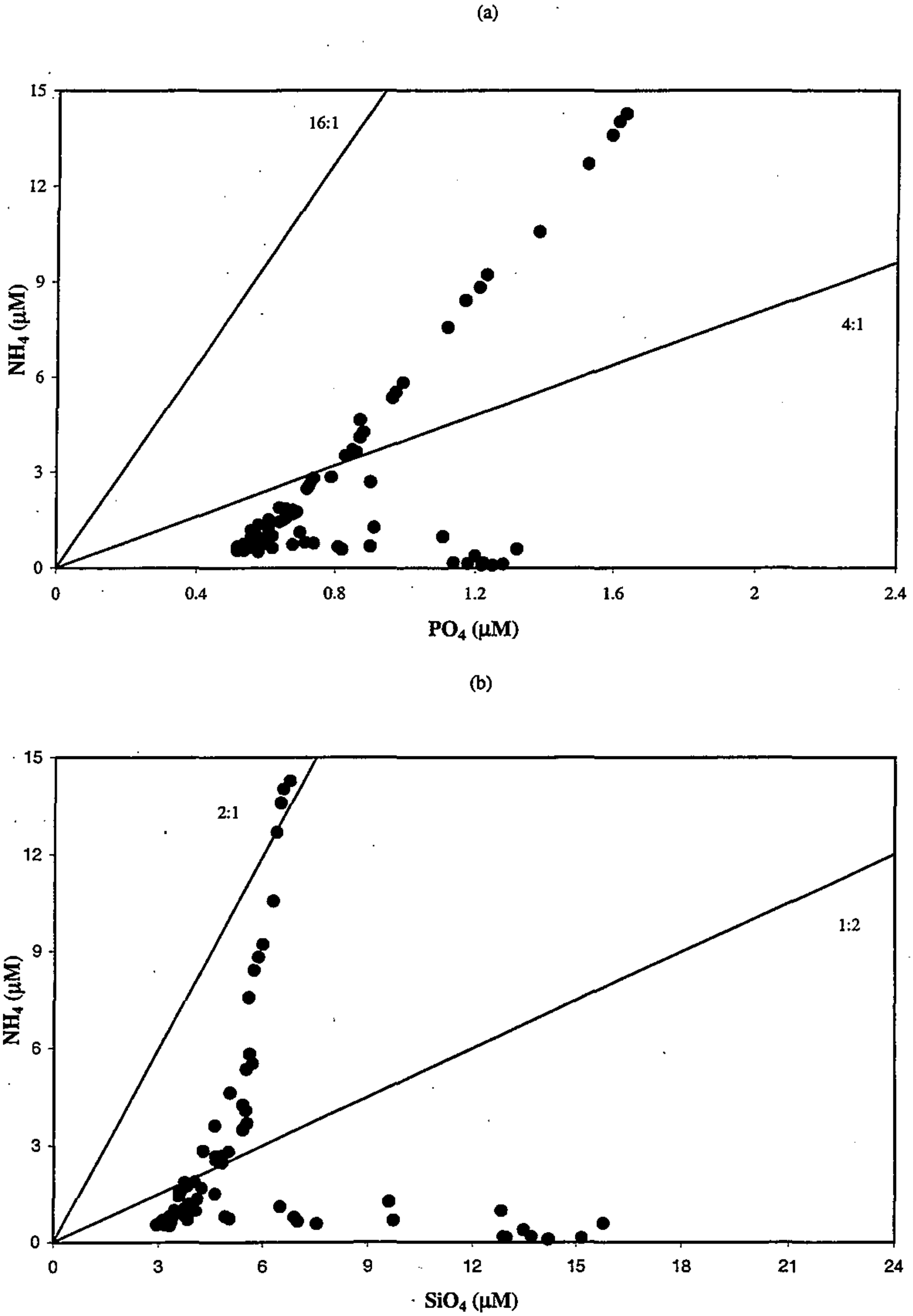


FIGURE 4-81

Nutrient vs. nutrient plots for nearfield survey W9715, (Oct 97)

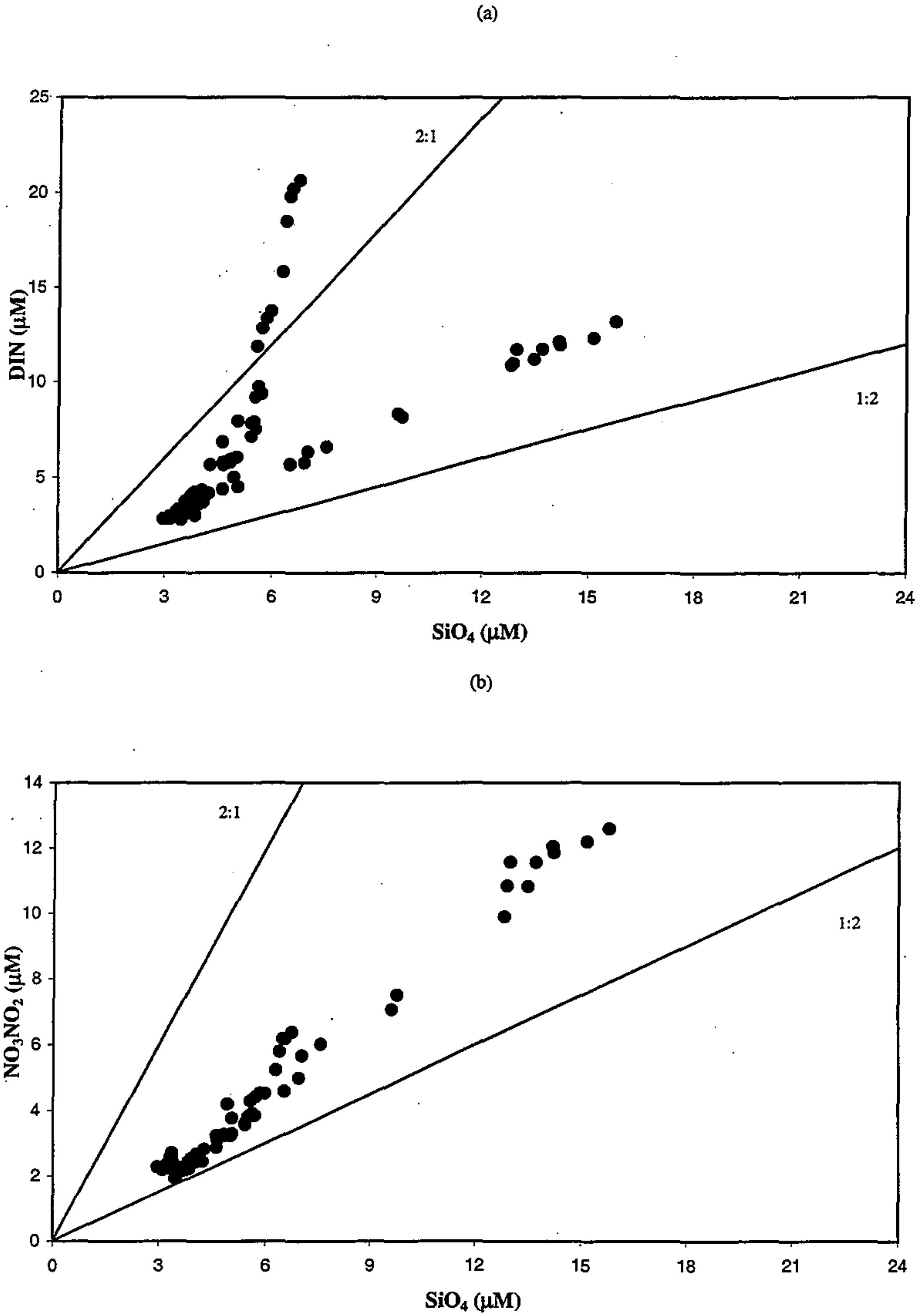


FIGURE 4-82

Nutrient vs. nutrient plots for nearfield survey W9715, (Oct 97)

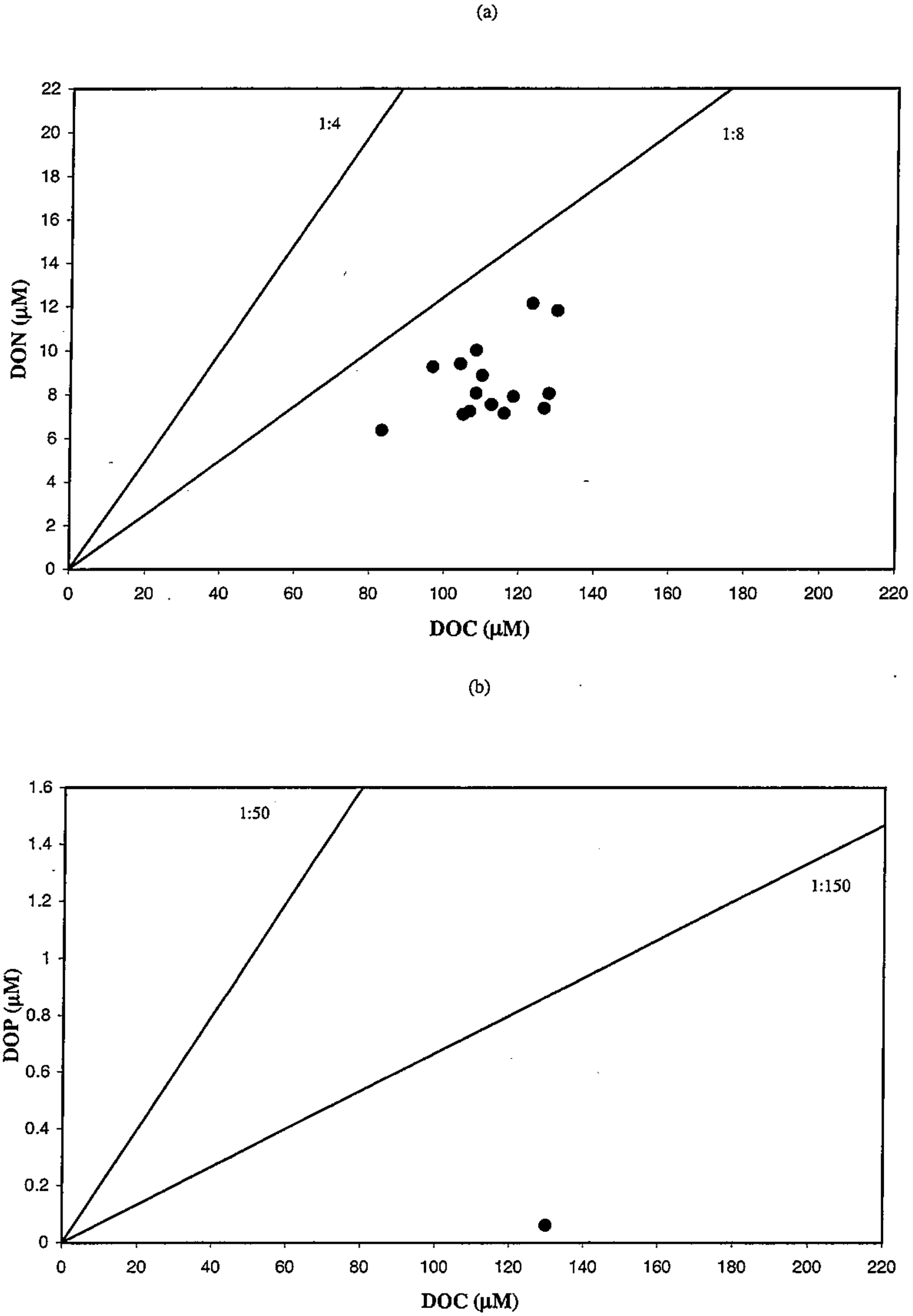


FIGURE 4-83

Nutrient vs. nutrient plots for nearfield survey W9715, (Oct 97)

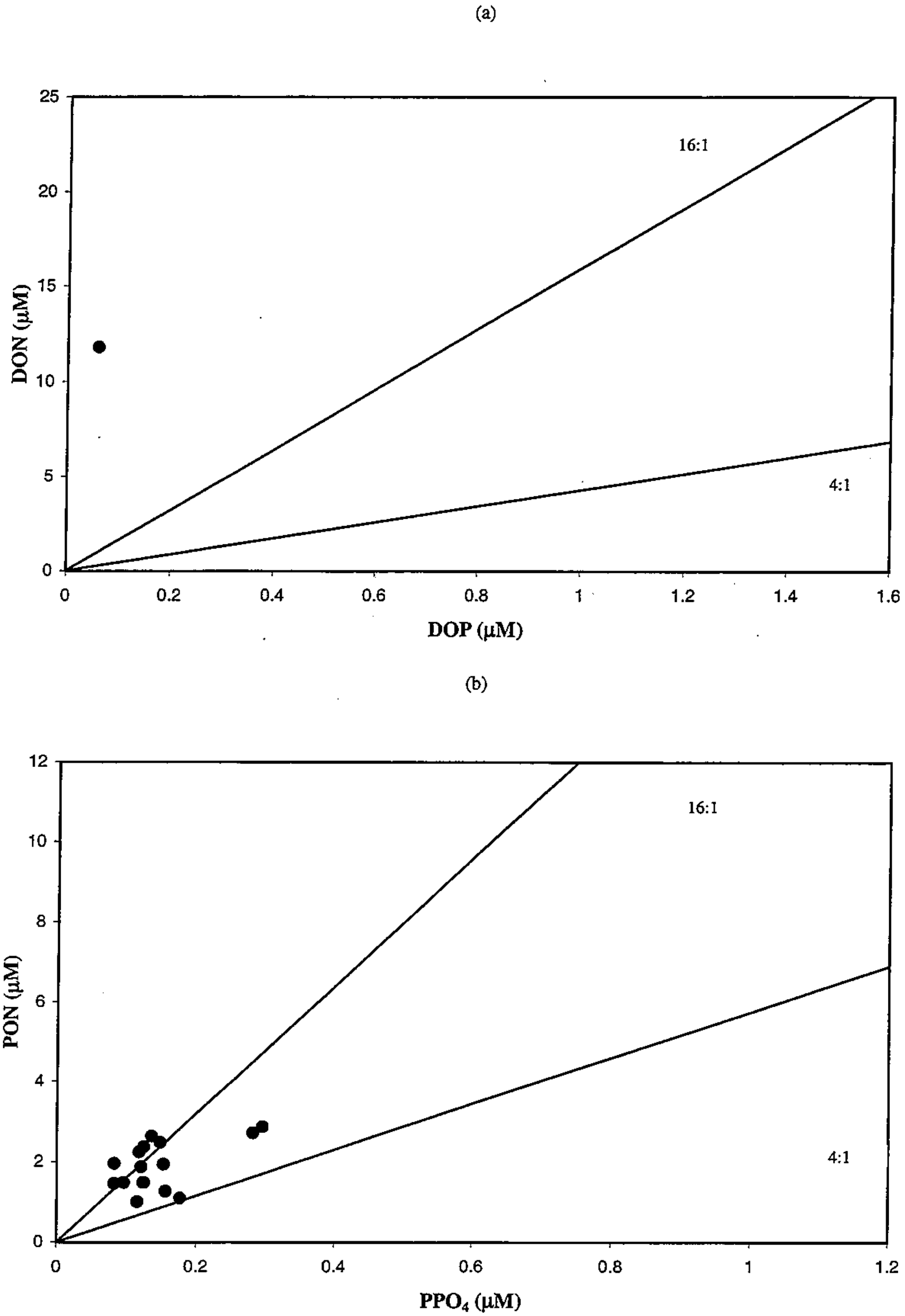


FIGURE 4-84

Nutrient vs. nutrient plots for nearfield survey W9715, (Oct 97)

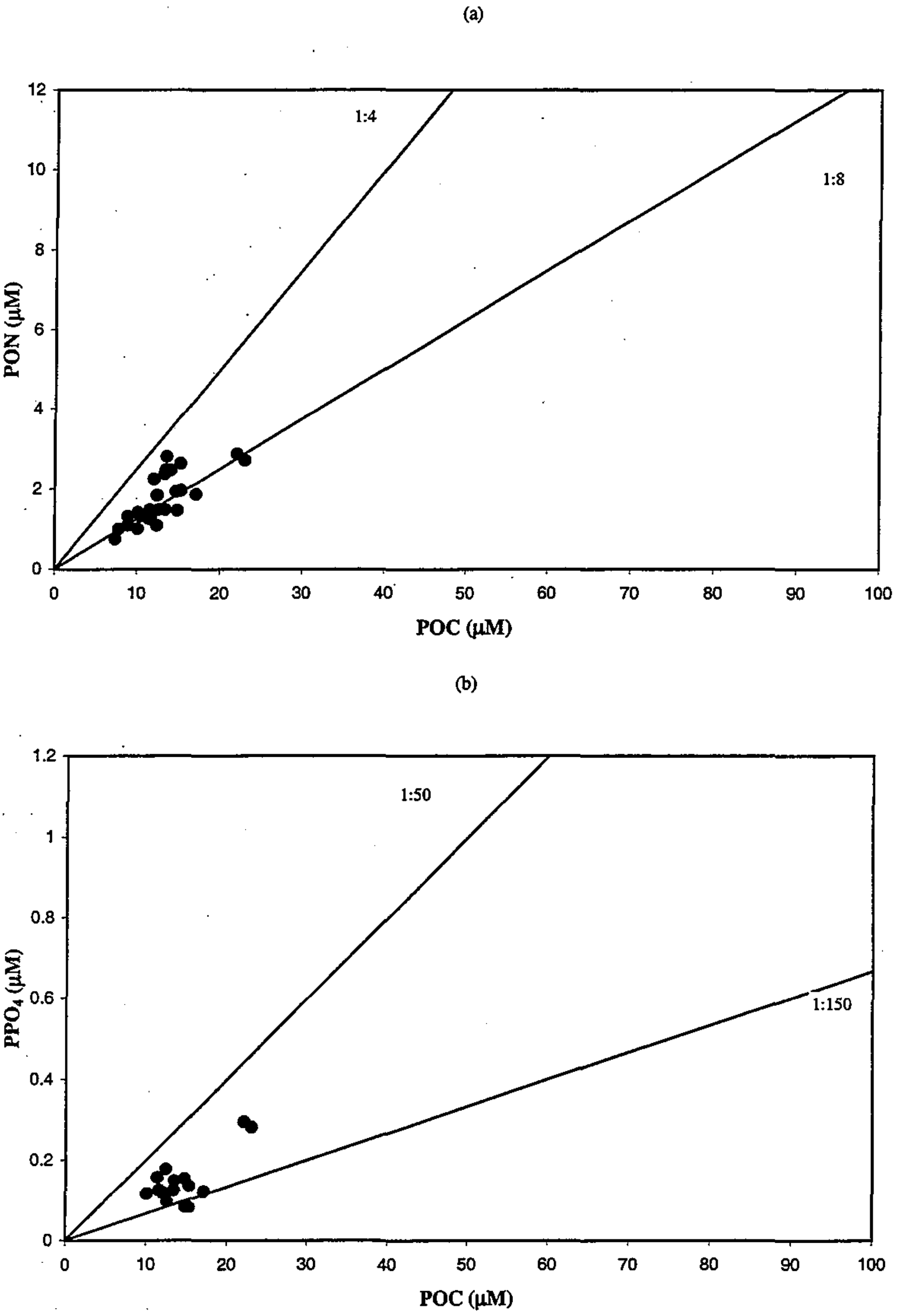
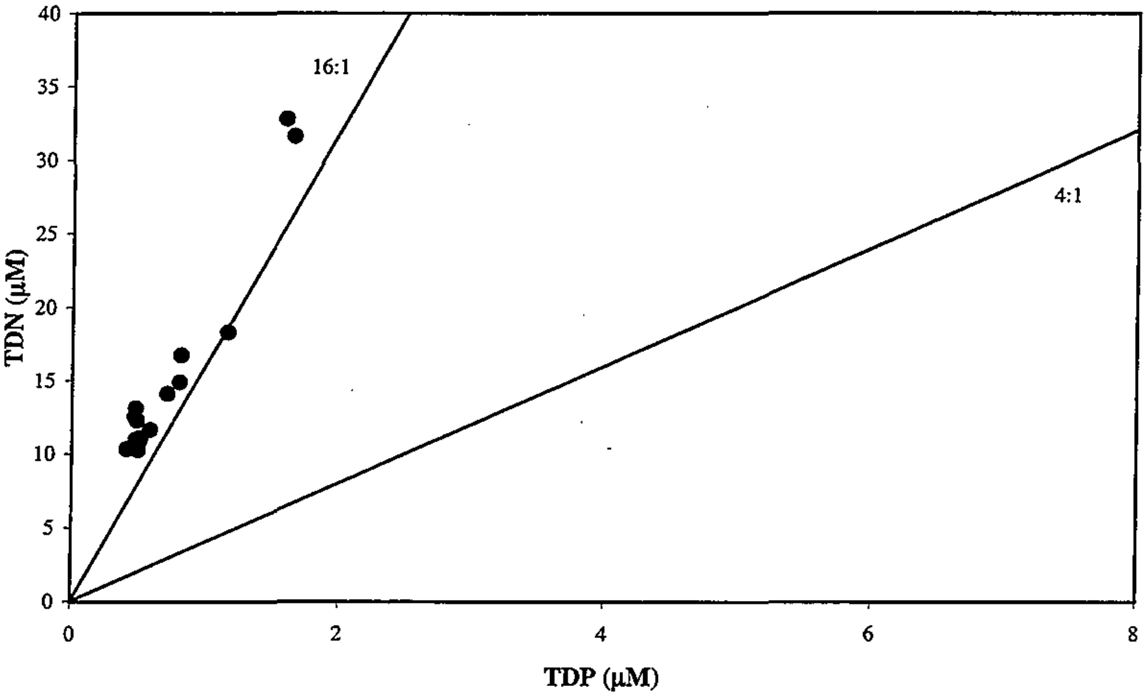


FIGURE 4-85
Nutrient vs. nutrient plots for nearfield survey W9715, (Oct 97)

(a)



(b)

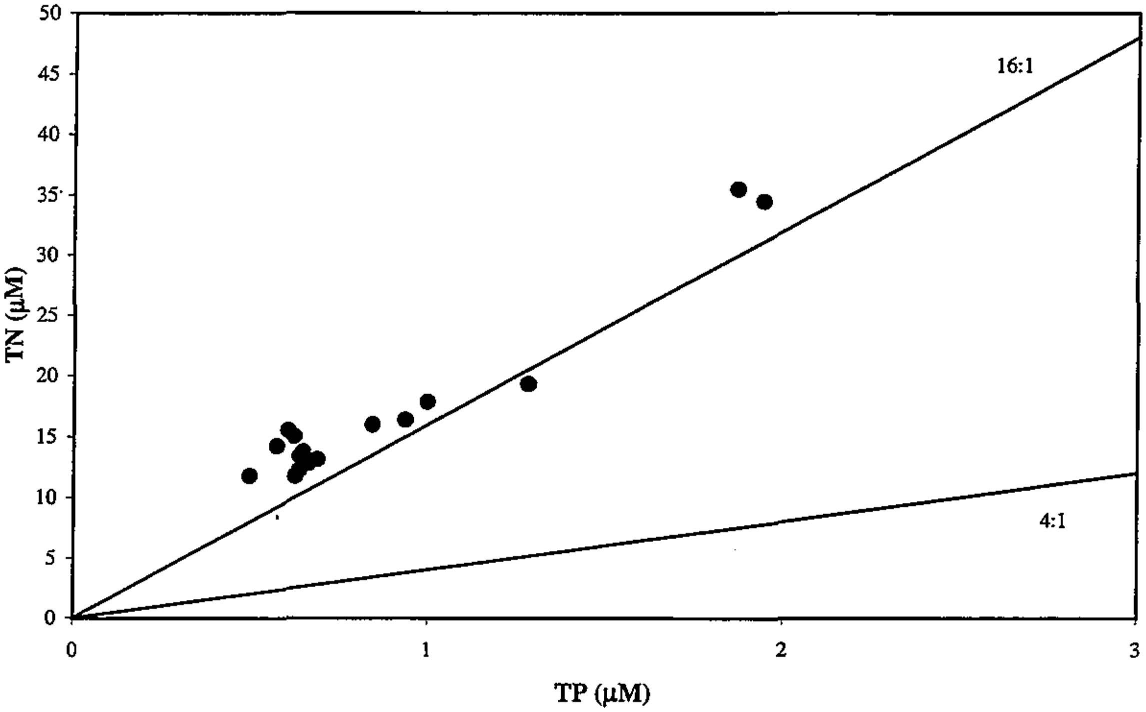


FIGURE 4-86

Nutrient vs. nutrient plots for nearfield survey W9715, (Oct 97)

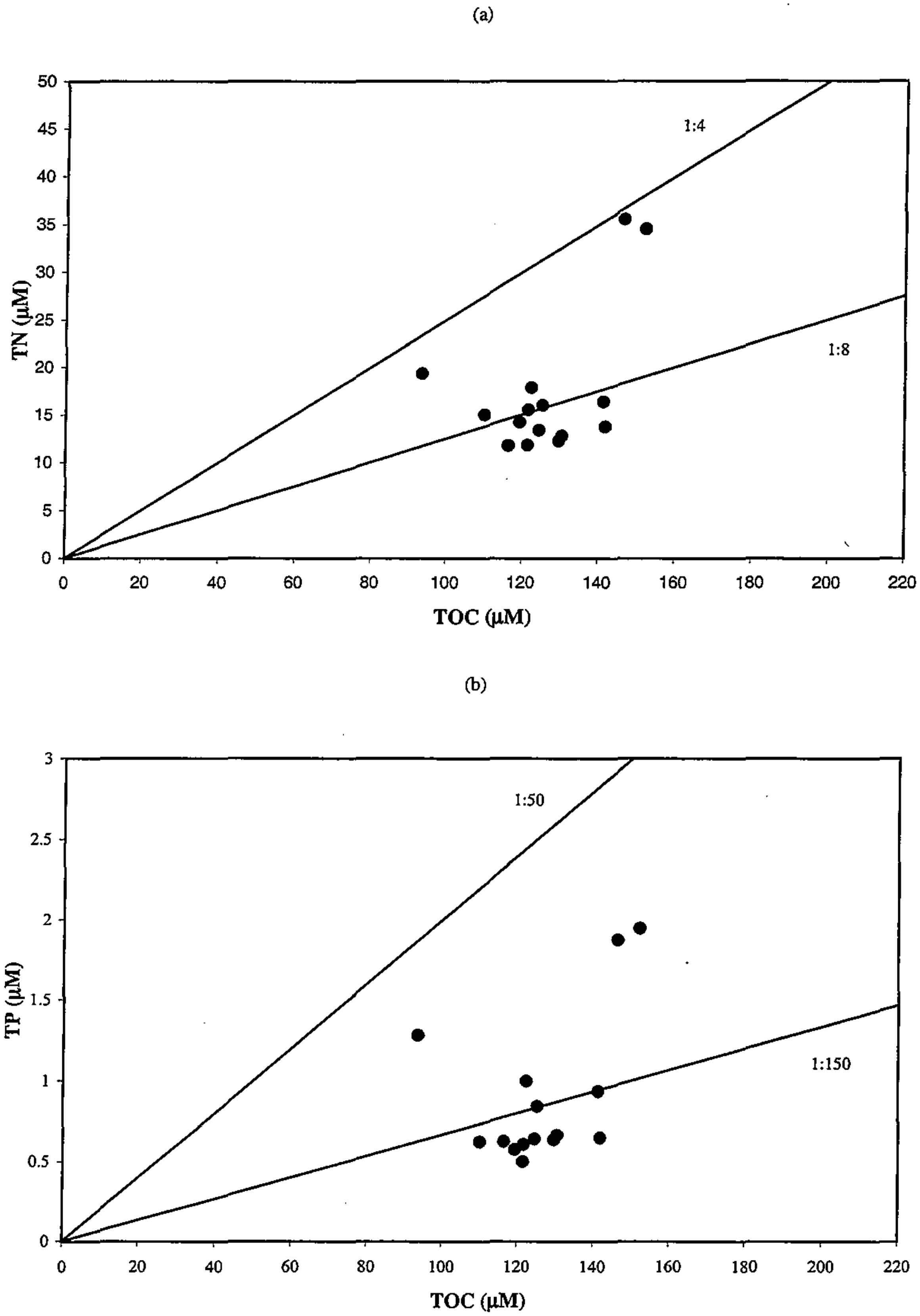


FIGURE 4-87

Nutrient vs. nutrient plots for nearfield survey W9715, (Oct 97)

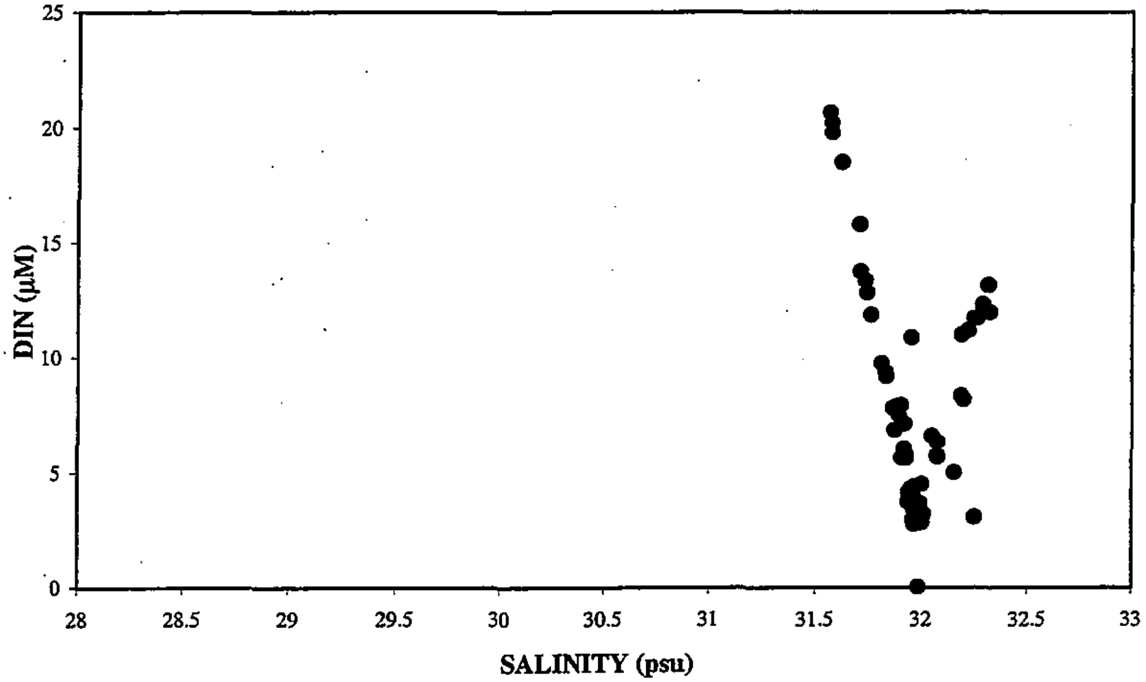


FIGURE 4-88

Nutrient vs. salinity plots for nearfield survey W9715, (Oct 97)

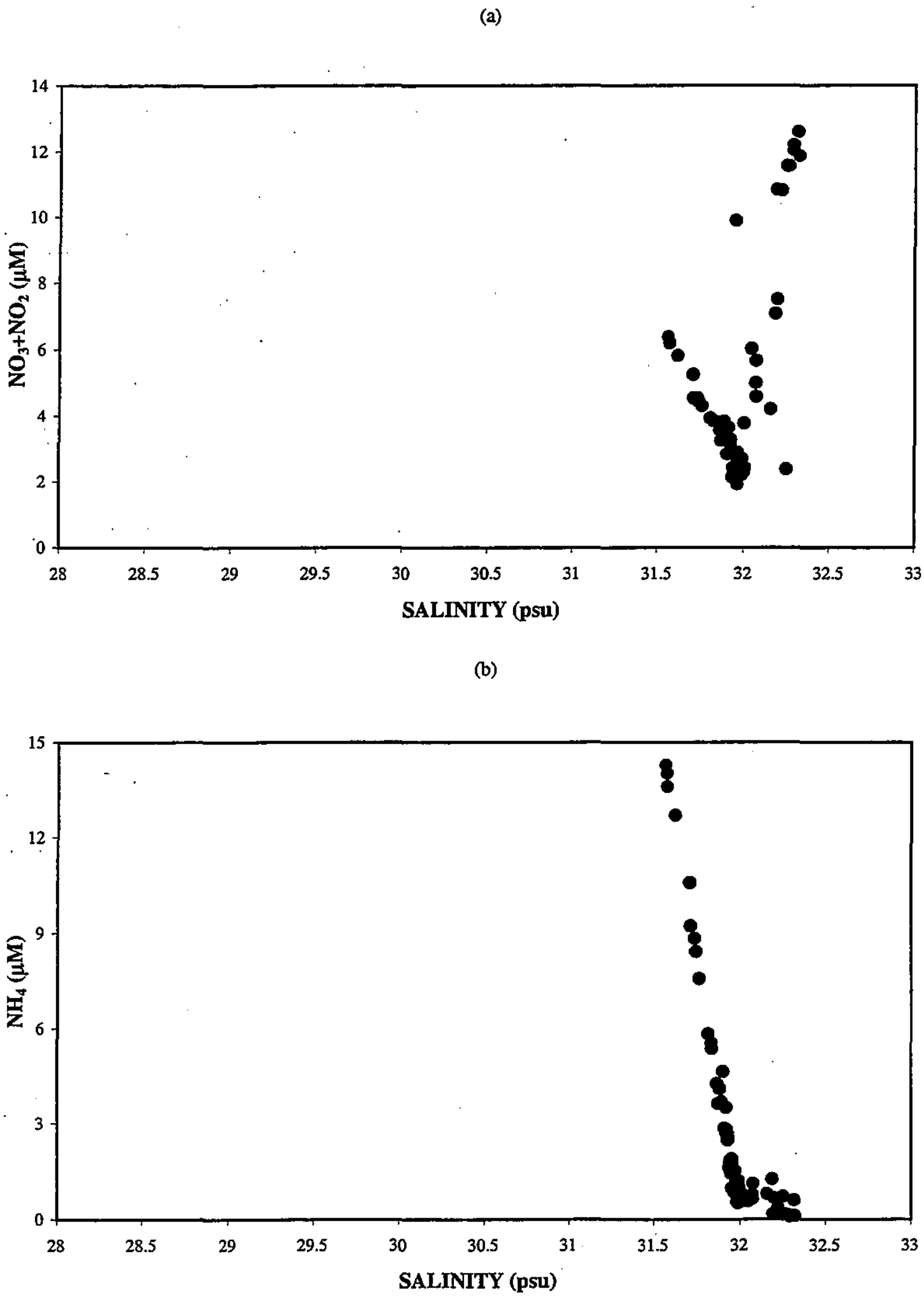
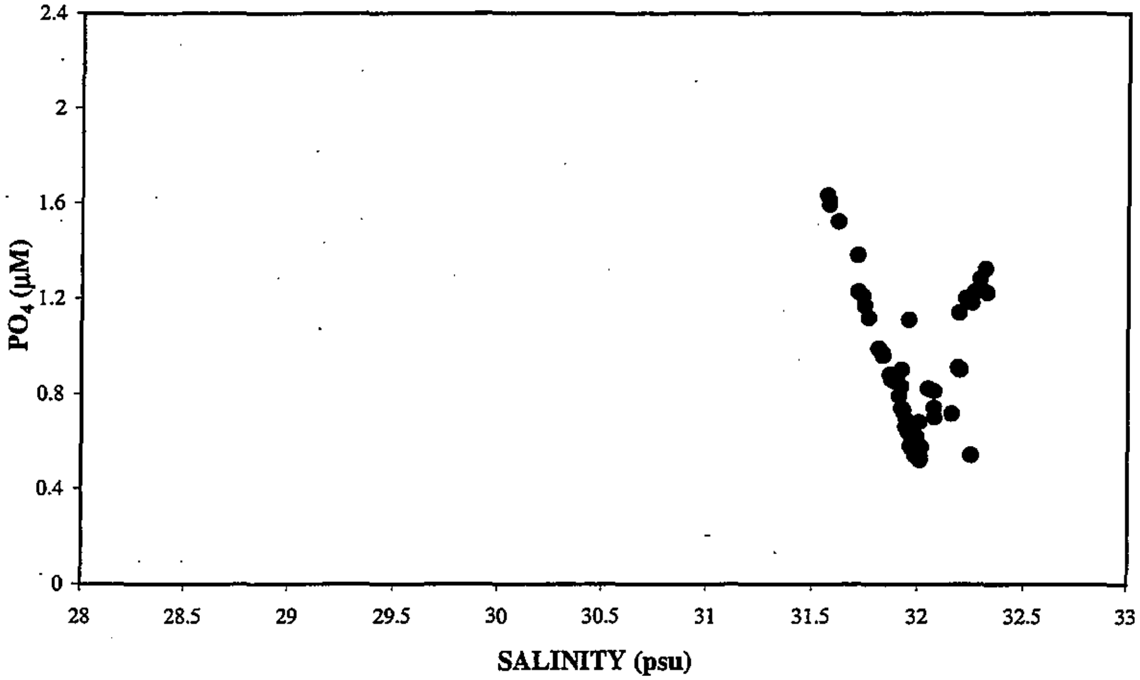


FIGURE 4-89

Nutrient vs. salinity plots for nearfield survey W9715, (Oct 97)

(a)



(b)

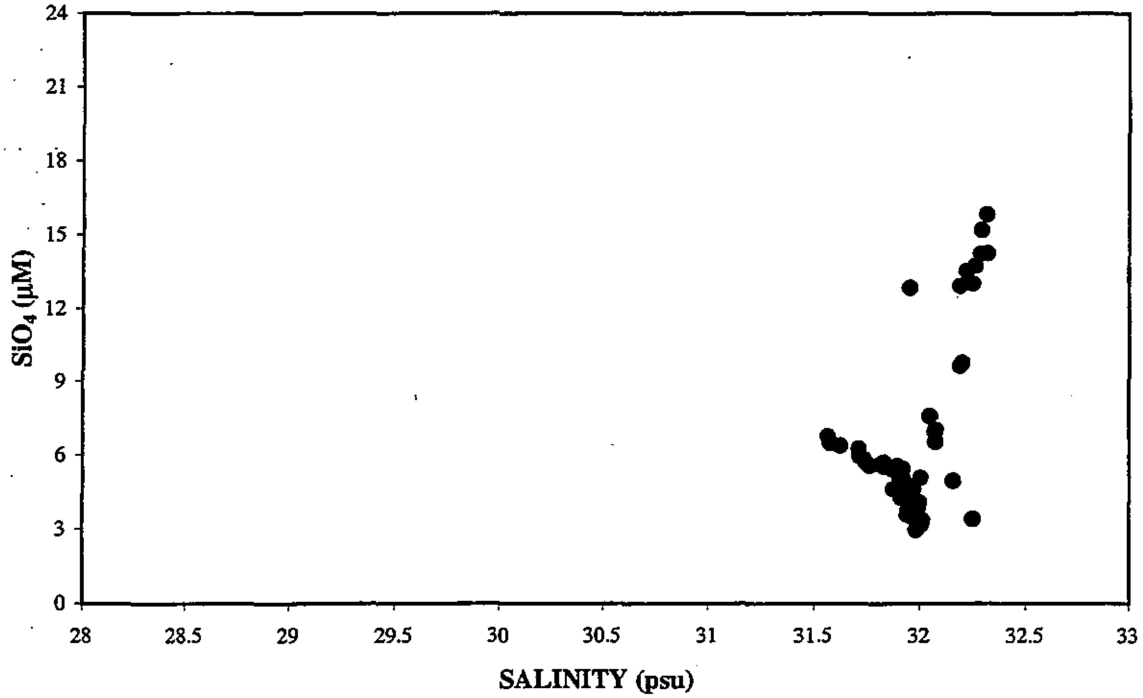


FIGURE 4-90

Nutrient vs. salinity plots for nearfield survey W9715, (Oct 97)

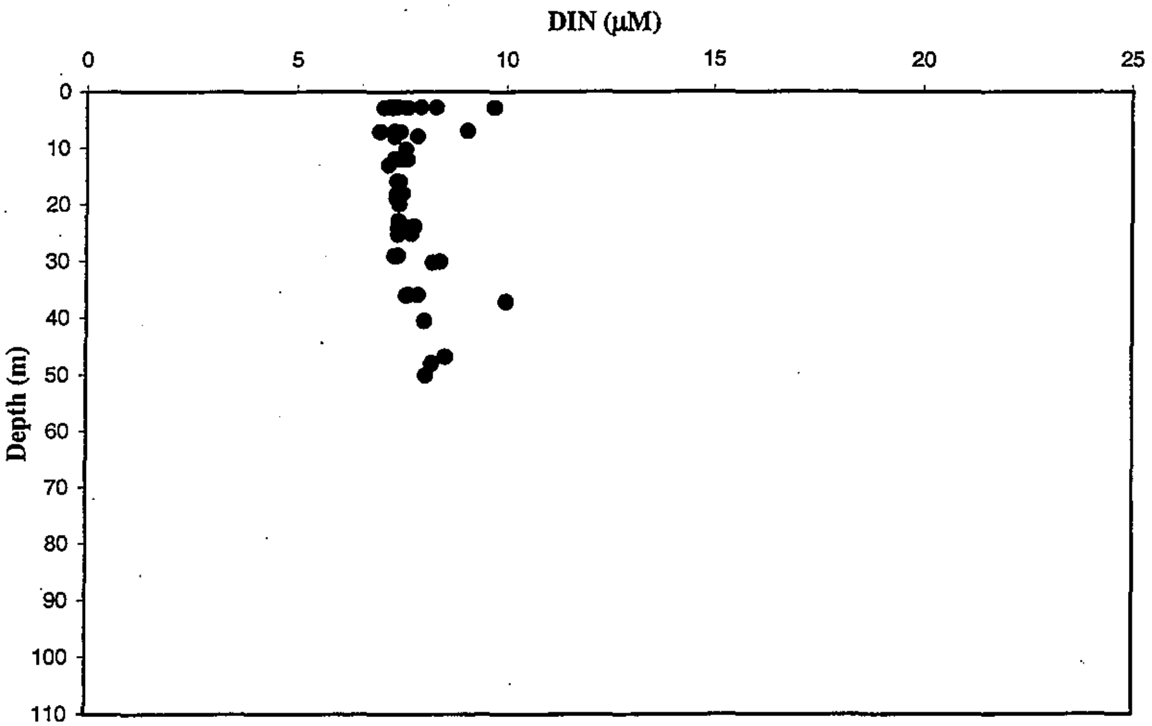


FIGURE 4-91
Depth vs. nutrient plots for nearfield survey W9716, (Nov/Dec 97)

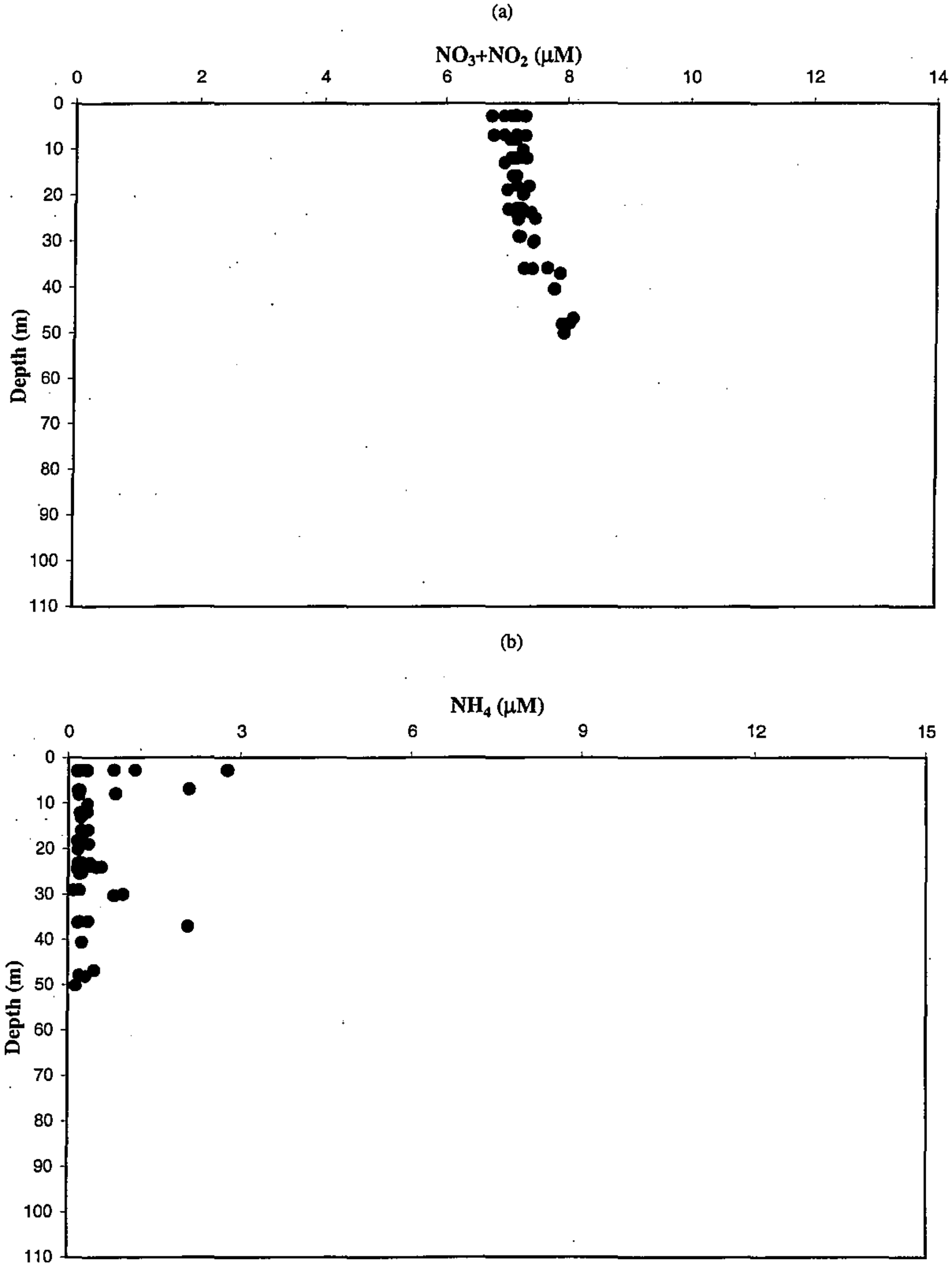
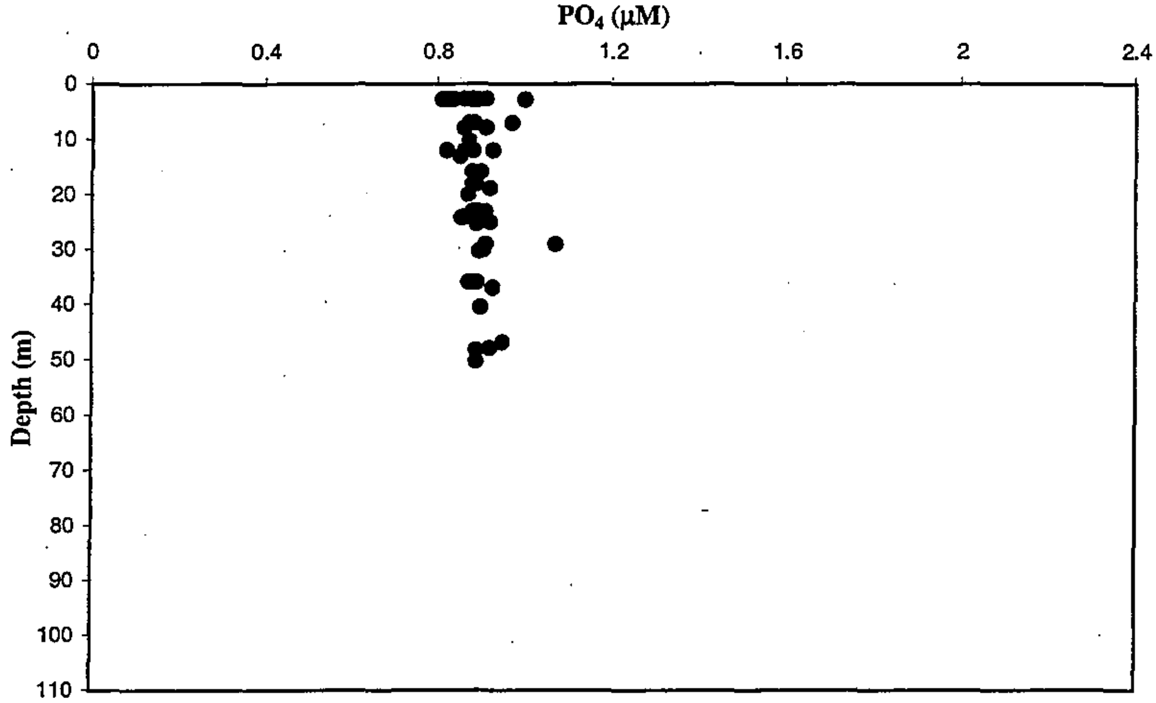


FIGURE 4-92
Depth vs. nutrient plots for nearfield survey W9716, (Nov/Dec 97)

(a)



(b)

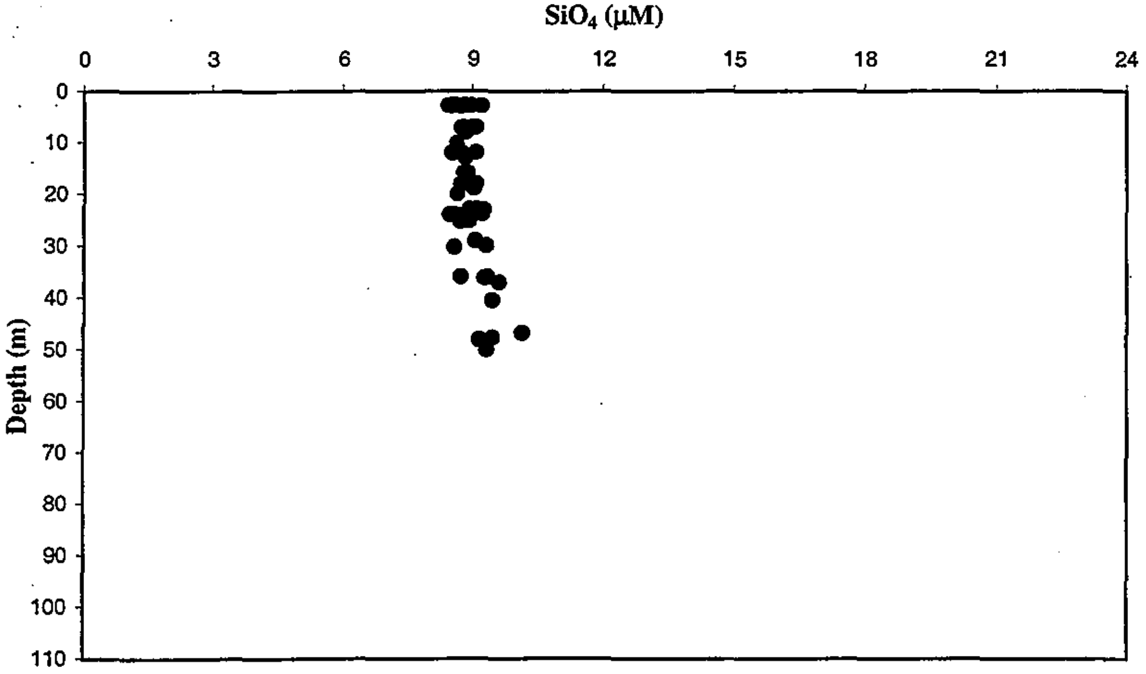
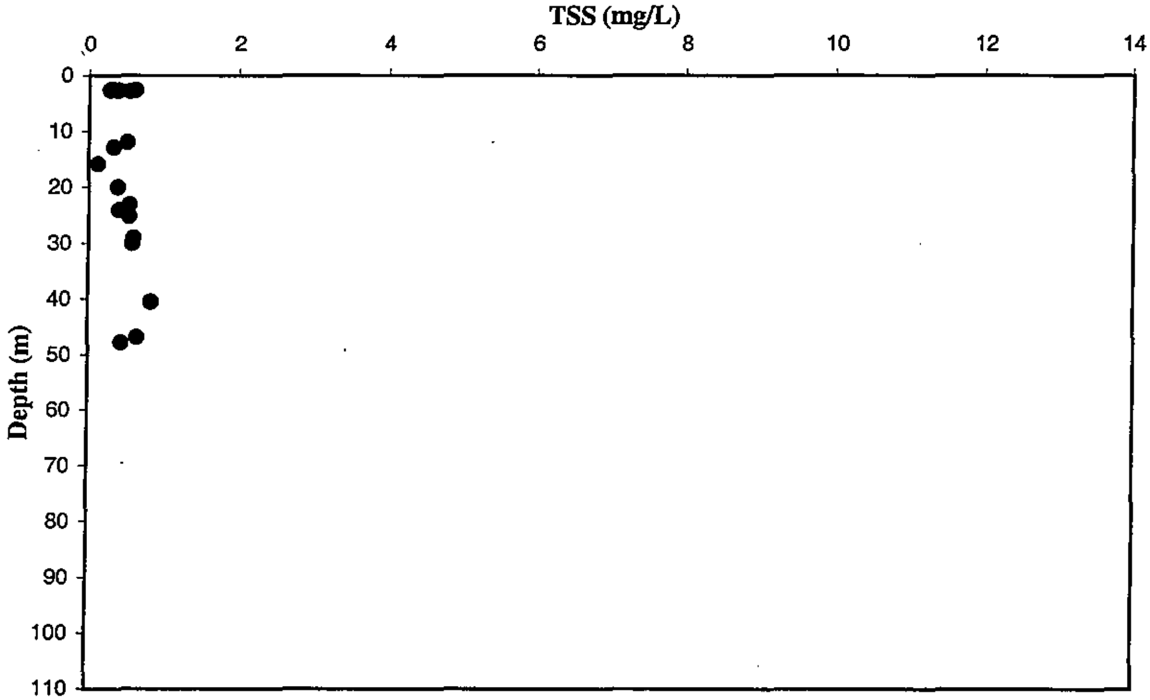


FIGURE 4-93

Depth vs. nutrient plots for nearfield survey W9716, (Nov/Dec 97)

(a)



(b)

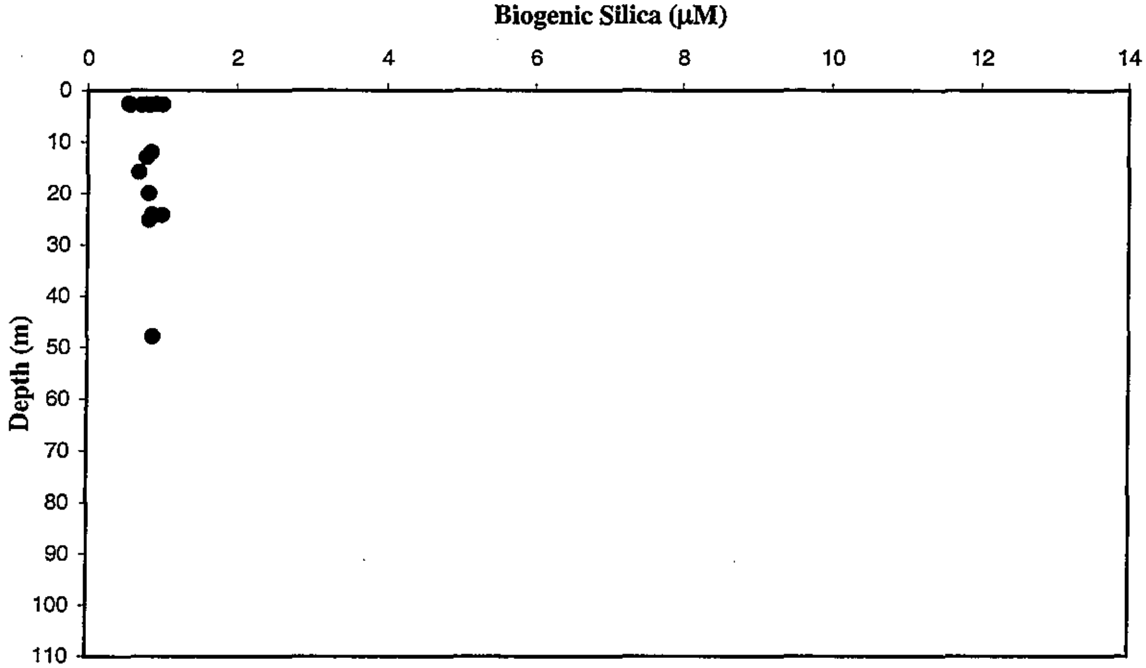


FIGURE 4-94

Depth vs. nutrient plots for nearfield survey W9716, (Nov/Dec 97)

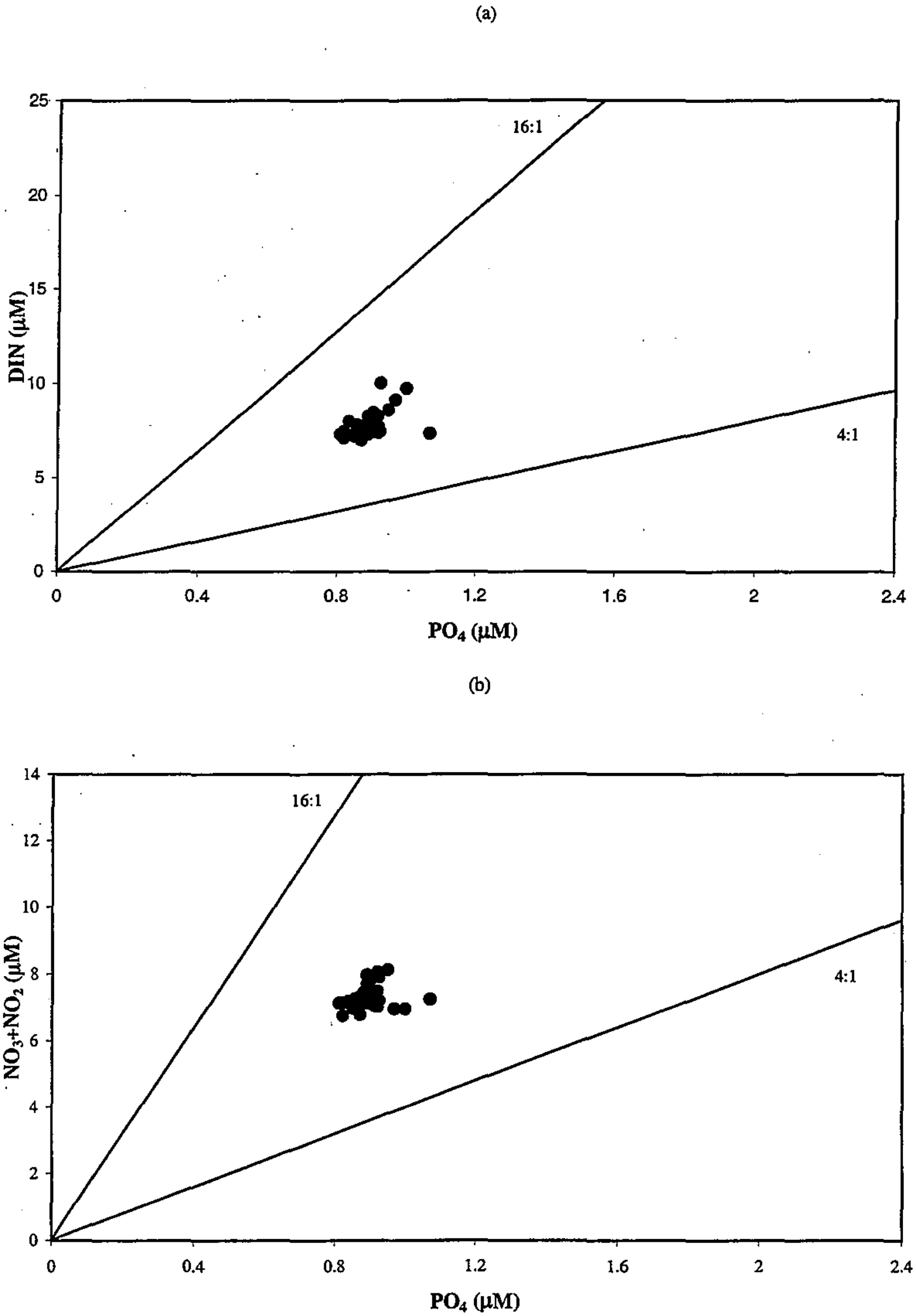


FIGURE 4-95

Nutrient vs. nutrient plots for nearfield survey W9716, (Nov/Dec 97)

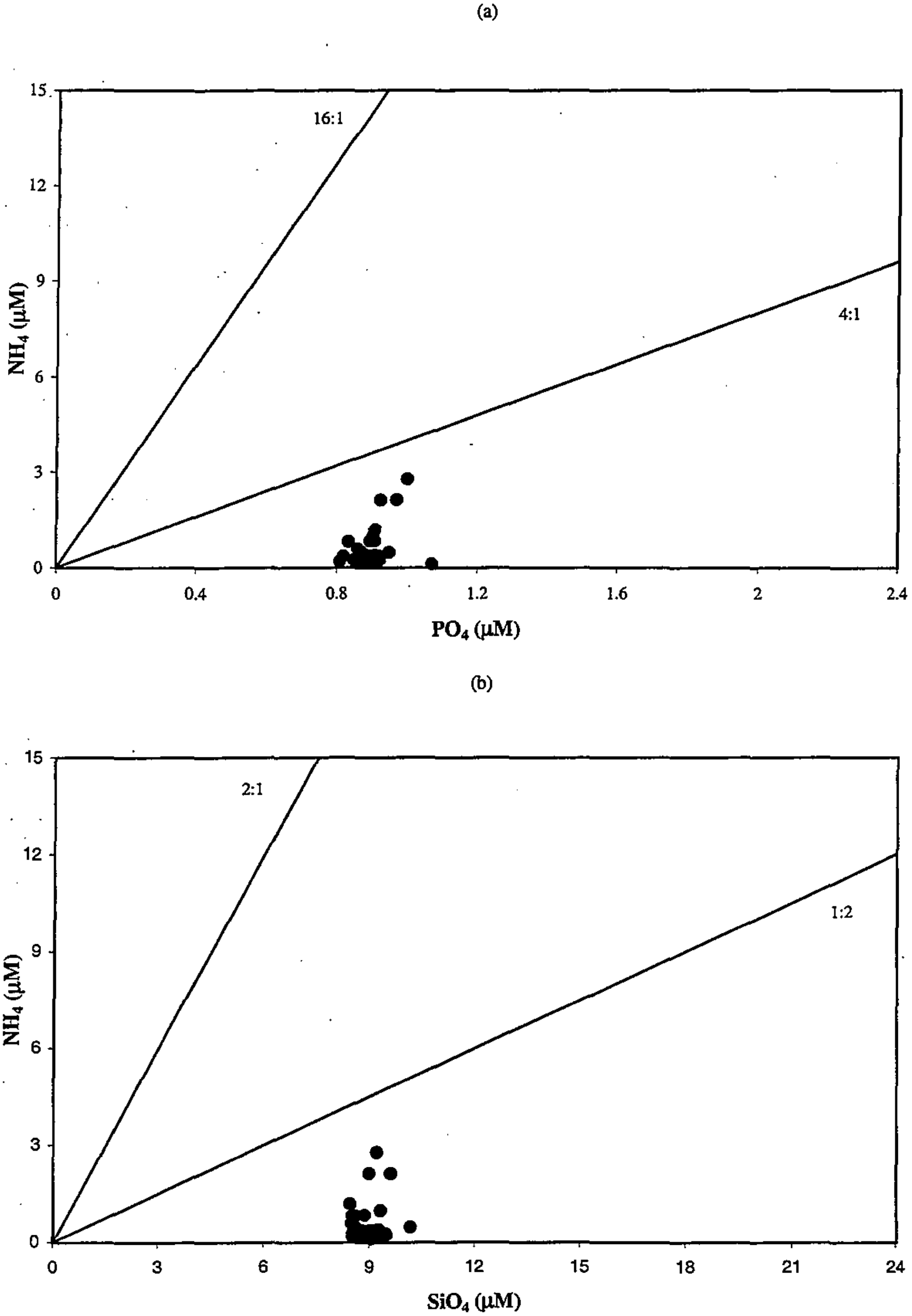


FIGURE 4-96
Nutrient vs. nutrient plots for nearfield survey W9716, (Nov/Dec 97)

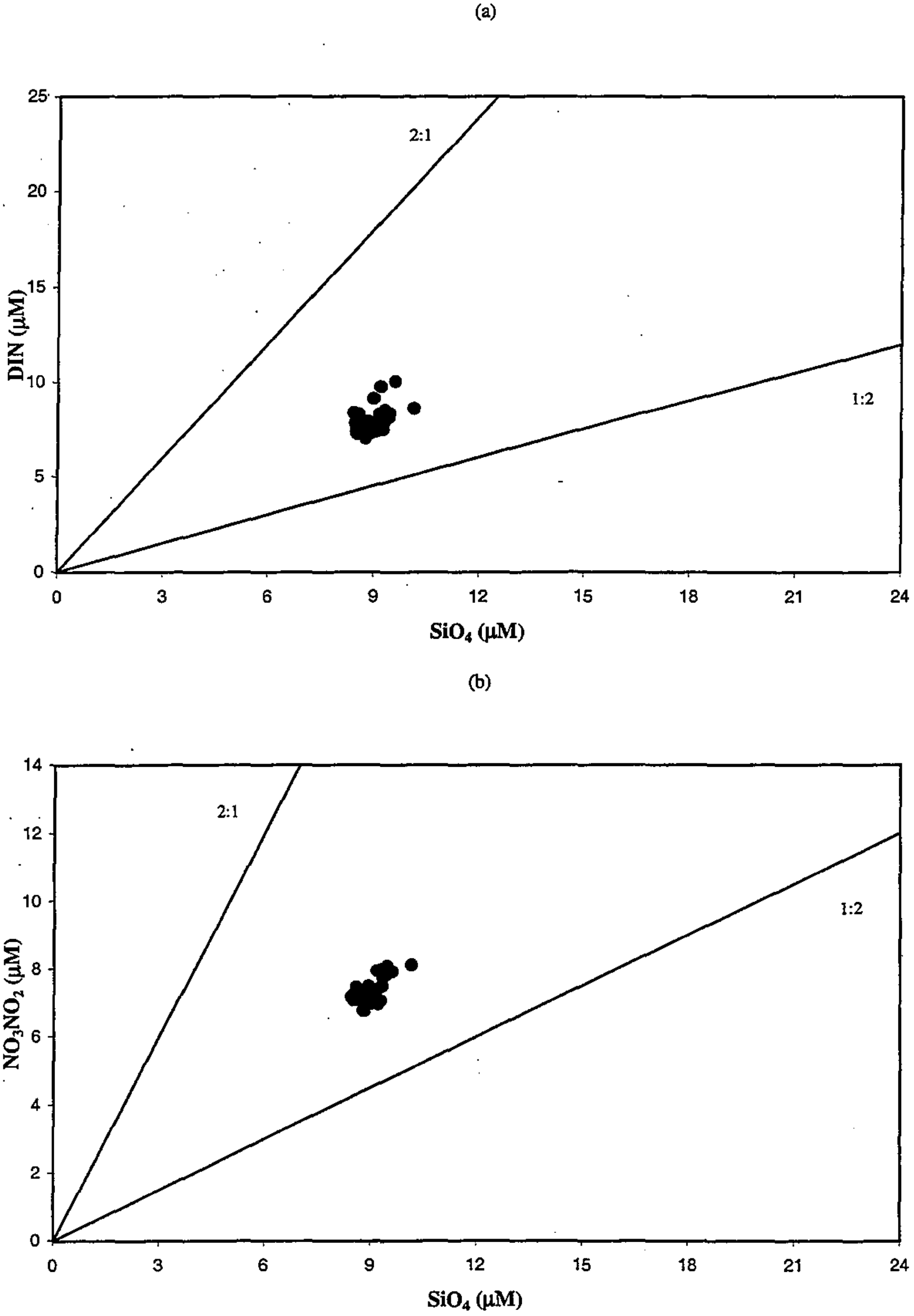
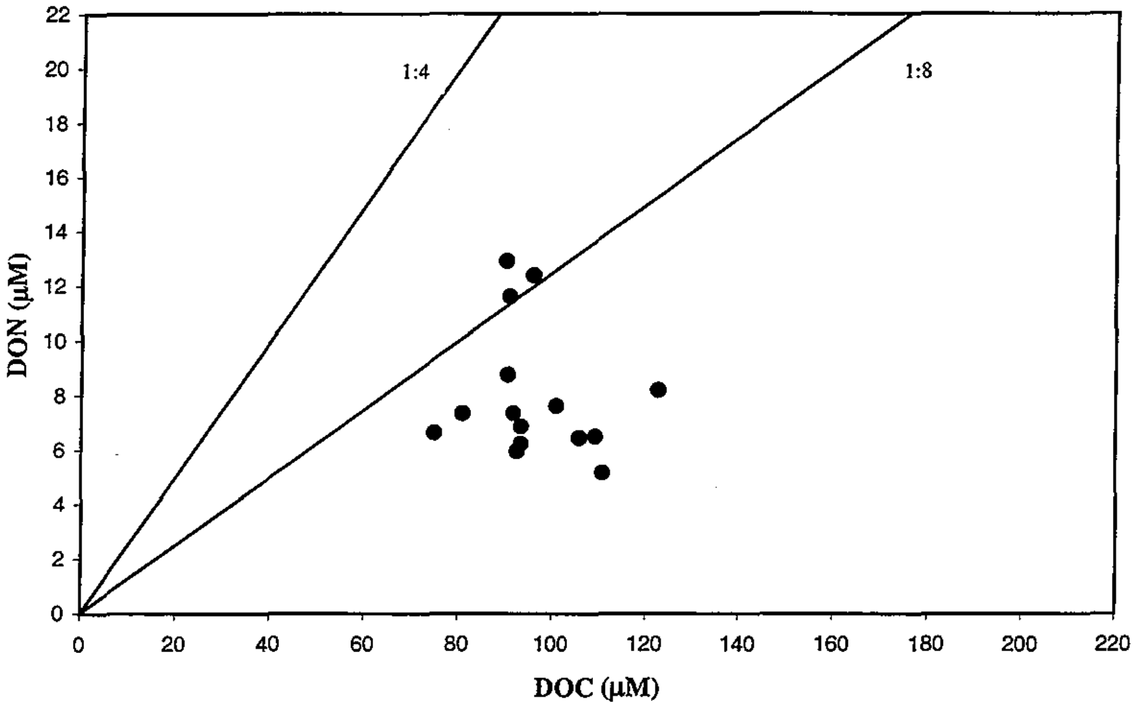


FIGURE 4-97

Nutrient vs. nutrient plots for nearfield survey W9716, (Nov/Dec 97)

(a)



(b)

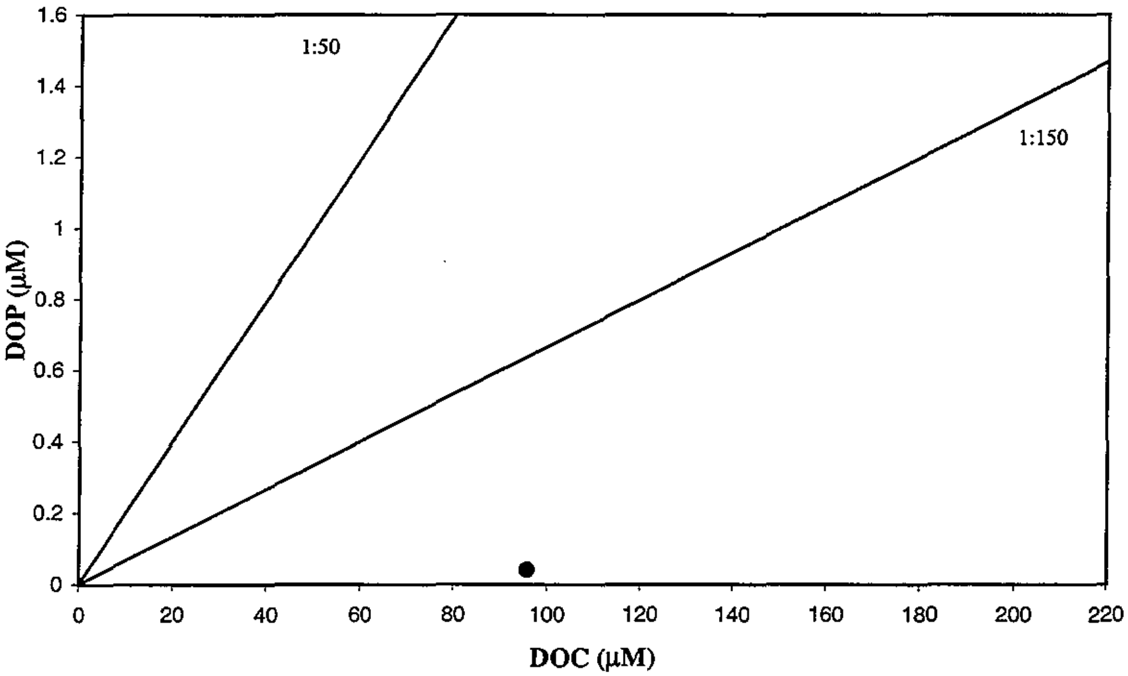


FIGURE 4-98

Nutrient vs. nutrient plots for nearfield survey W9716, (Nov/Dec 97)

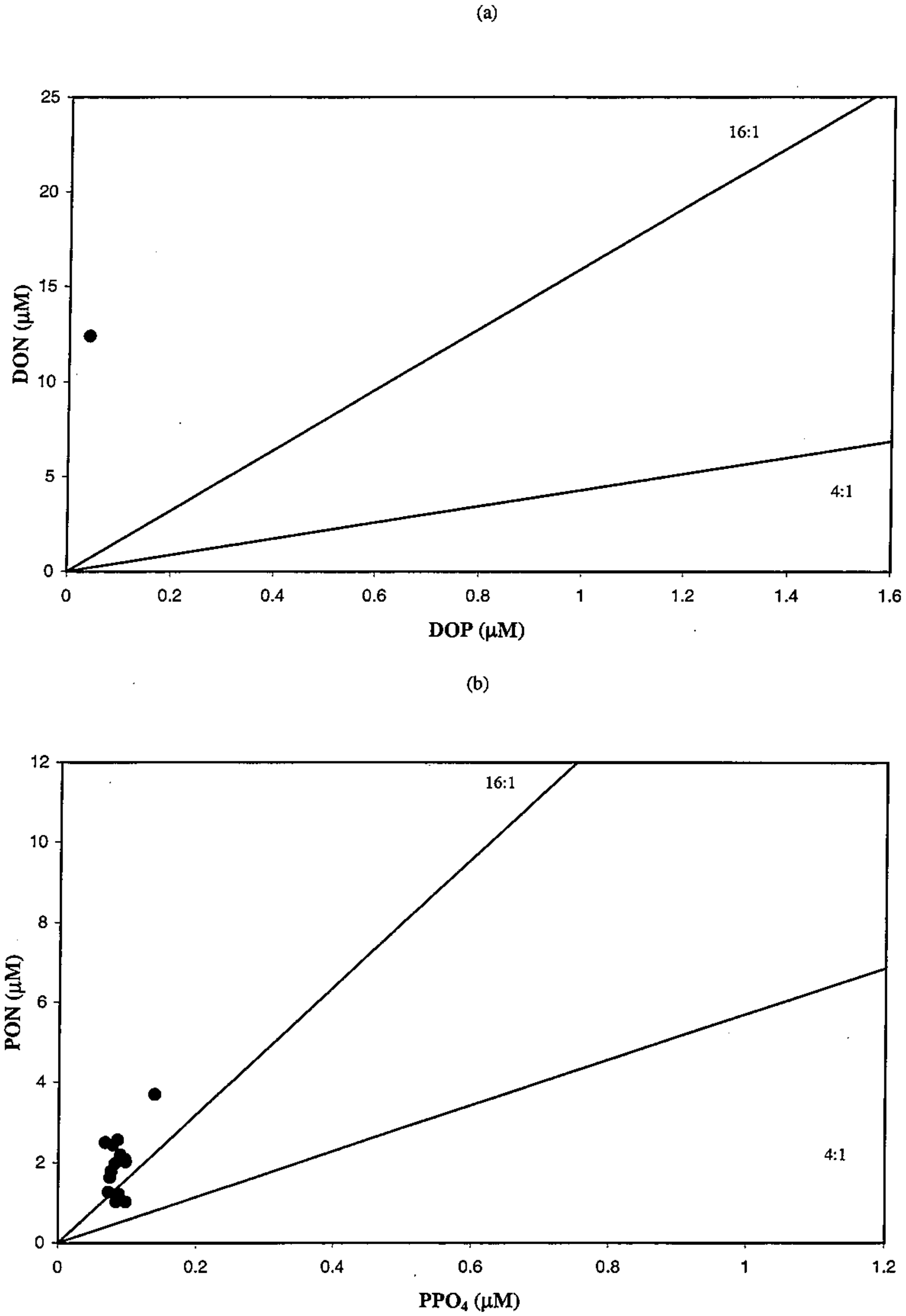
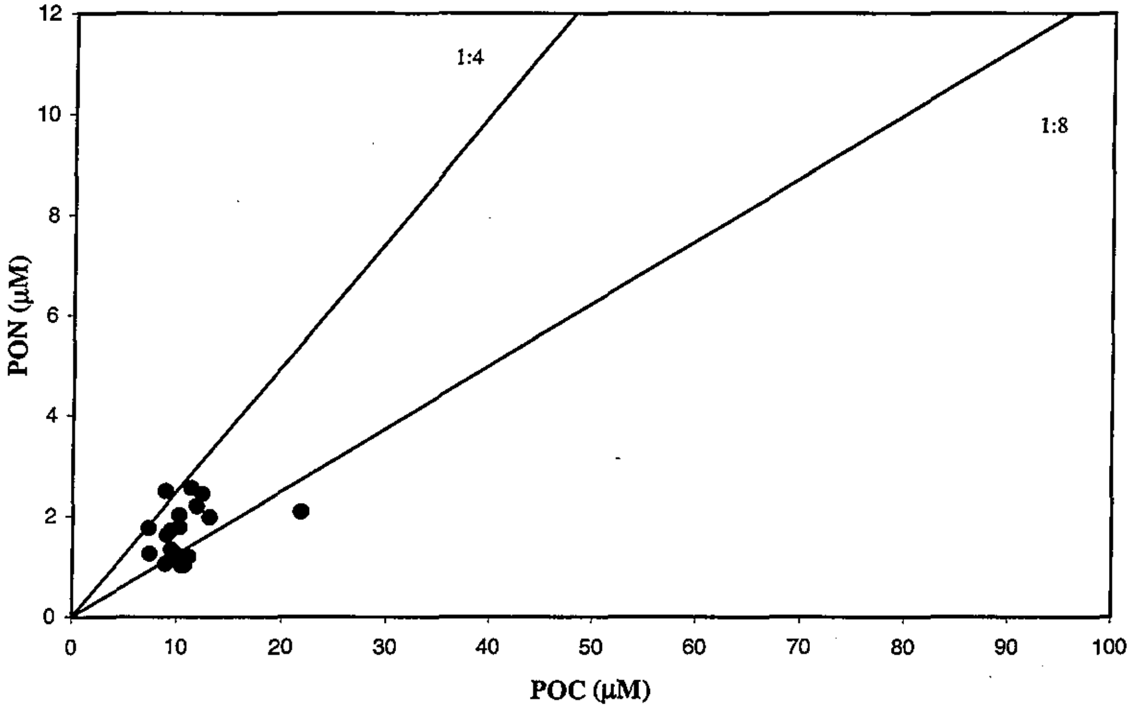


FIGURE 4-99
Nutrient vs. nutrient plots for nearfield survey W9716, (Nov/Dec 97)

(a)



(b)

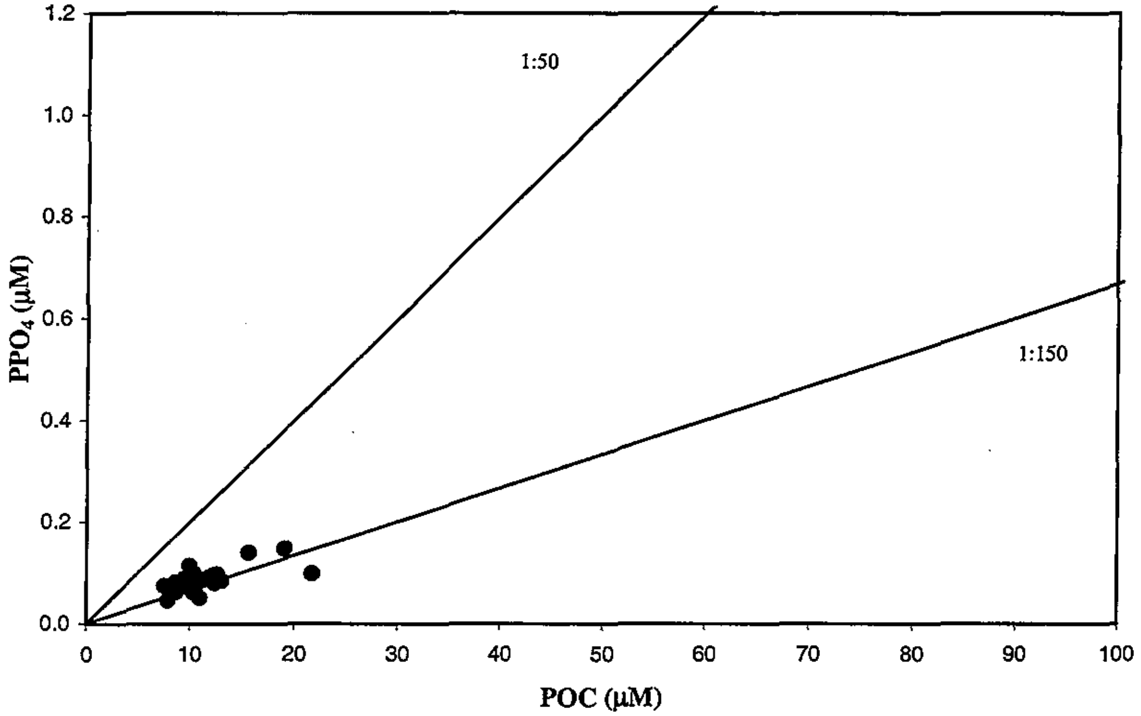


FIGURE 4-100

Nutrient vs. nutrient plots for nearfield survey W9716, (Nov/Dec 97)

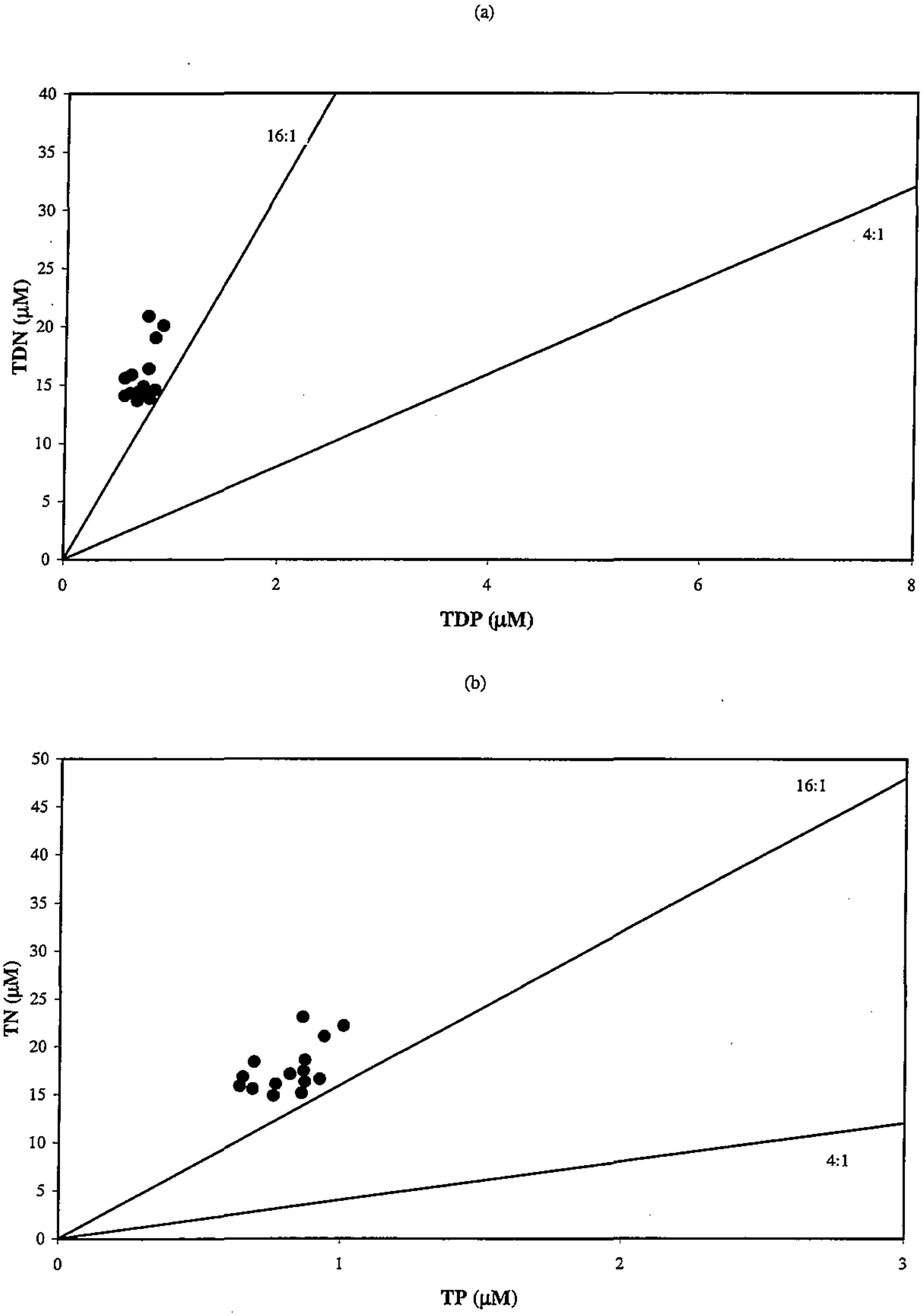


FIGURE 4-101

Nutrient vs. nutrient plots for nearfield survey W9716, (Nov/Dec 97)

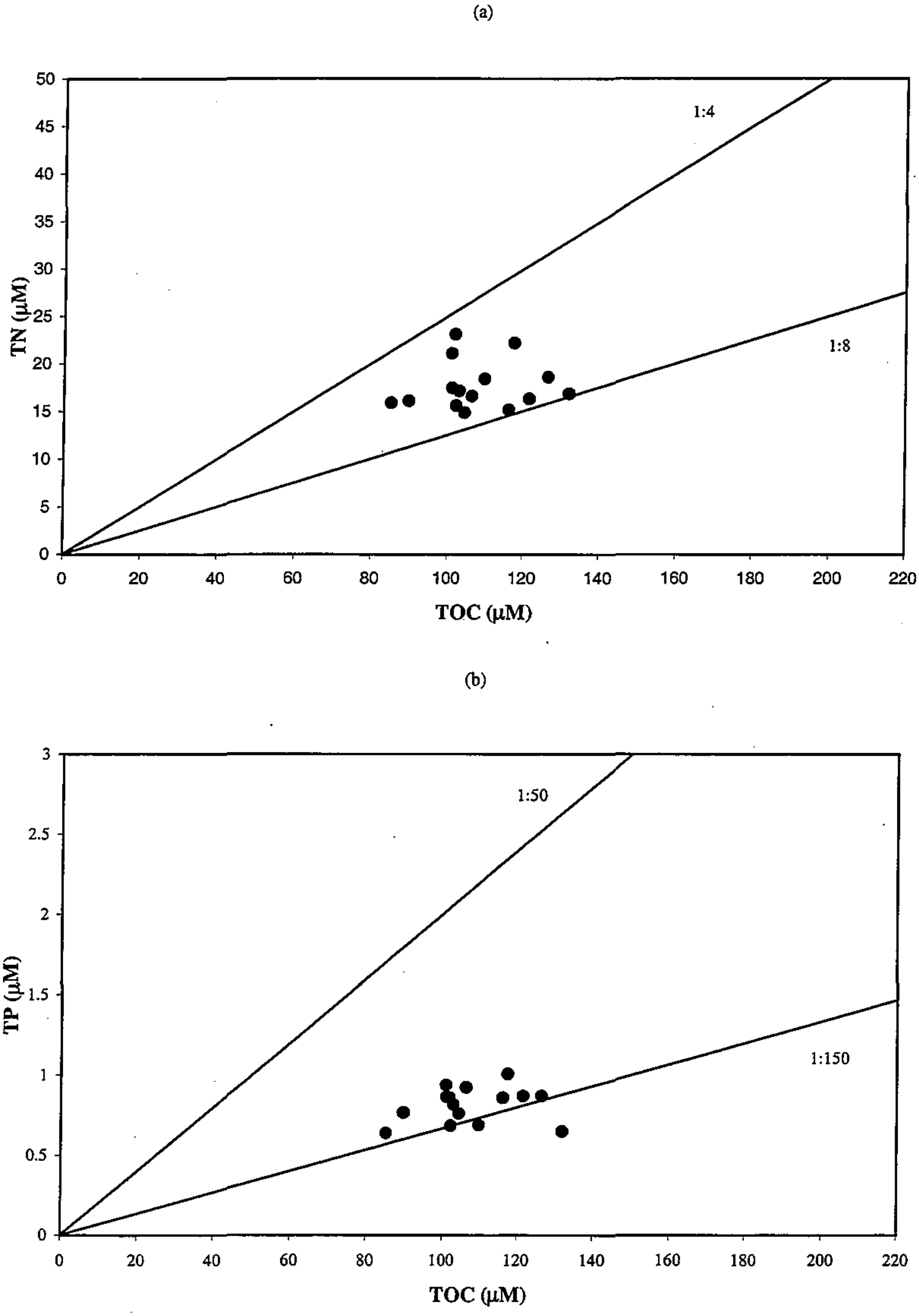


FIGURE 4-102

Nutrient vs. nutrient plots for nearfield survey W9716, (Nov/Dec 97)

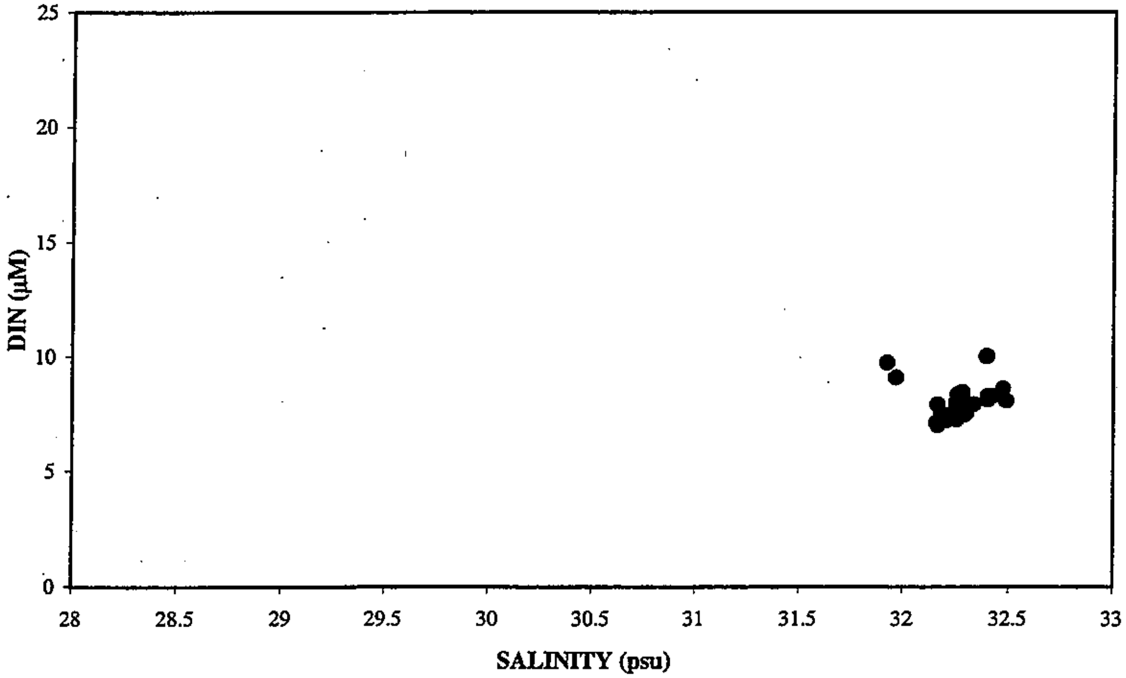


FIGURE 4-103

Nutrient vs. salinity plots for nearfield survey W9716, (Nov/Dec 97)

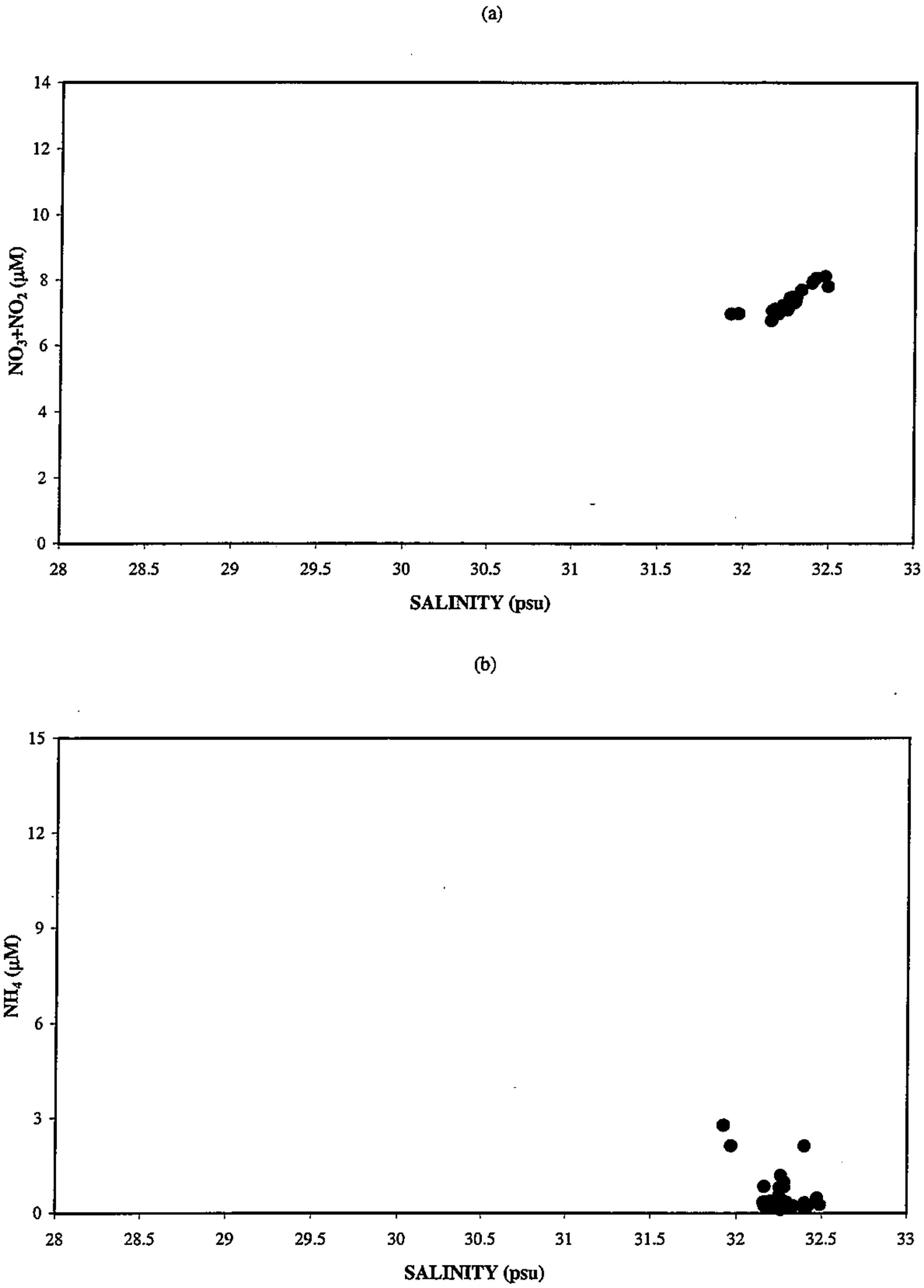
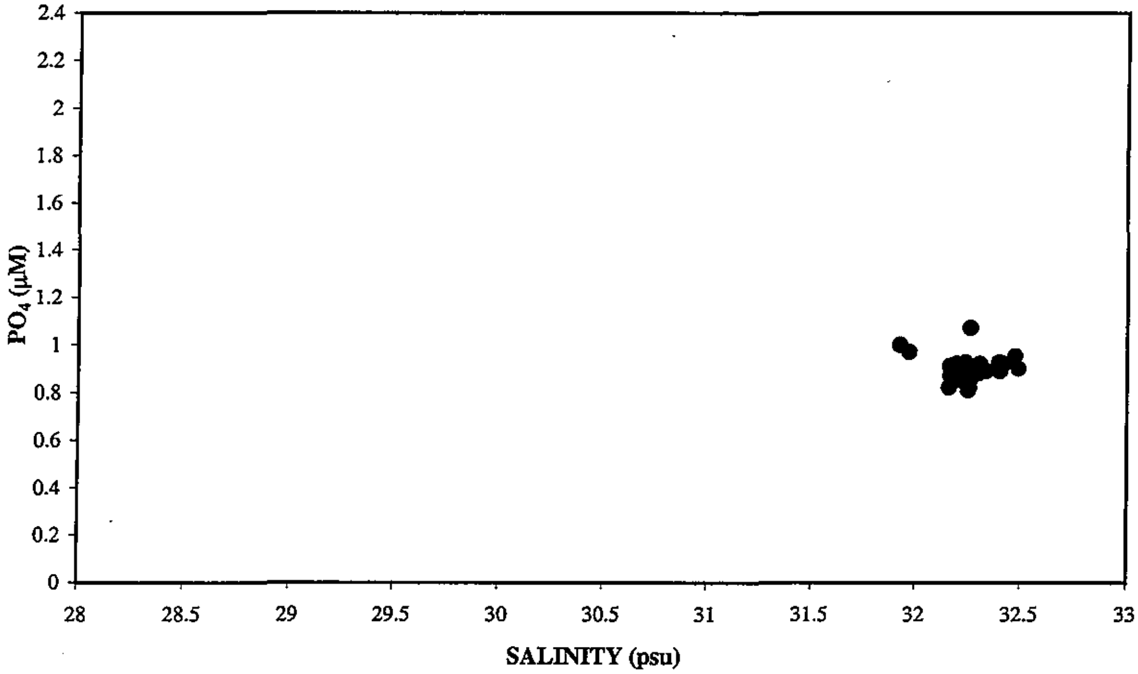


FIGURE 4-104

Nutrient vs. salinity plots for nearfield survey W9716, (Nov/Dec 97)

(a)



(b)

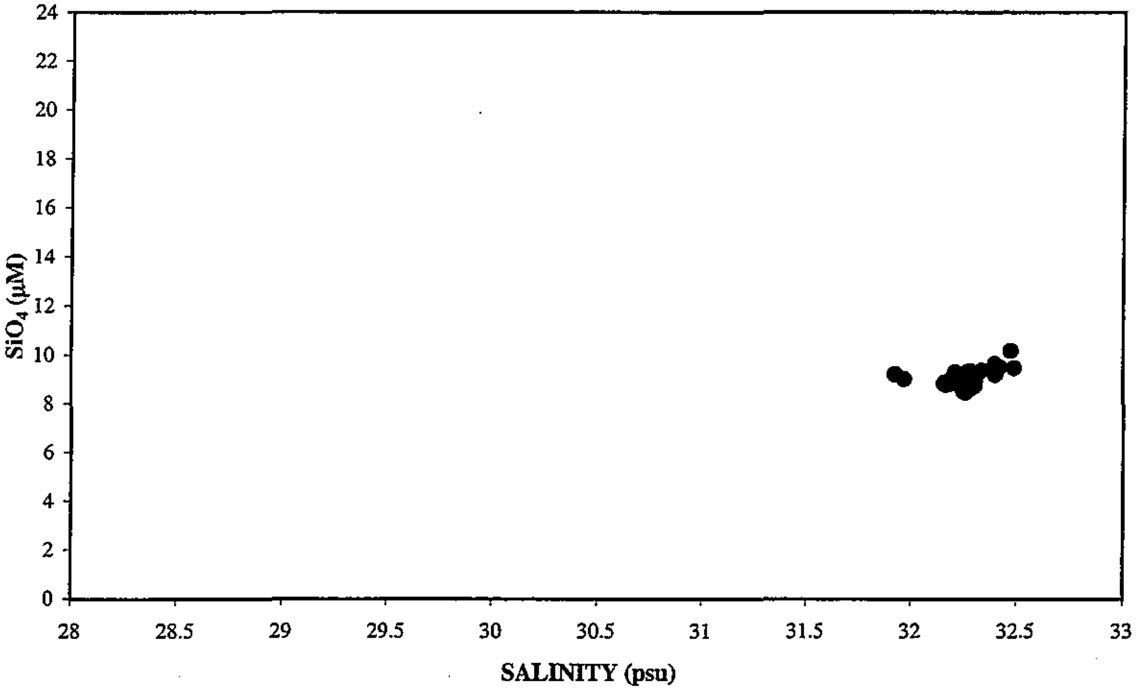


FIGURE 4-105

Nutrient vs. salinity plots for nearfield survey W9716, (Nov/Dec 97)

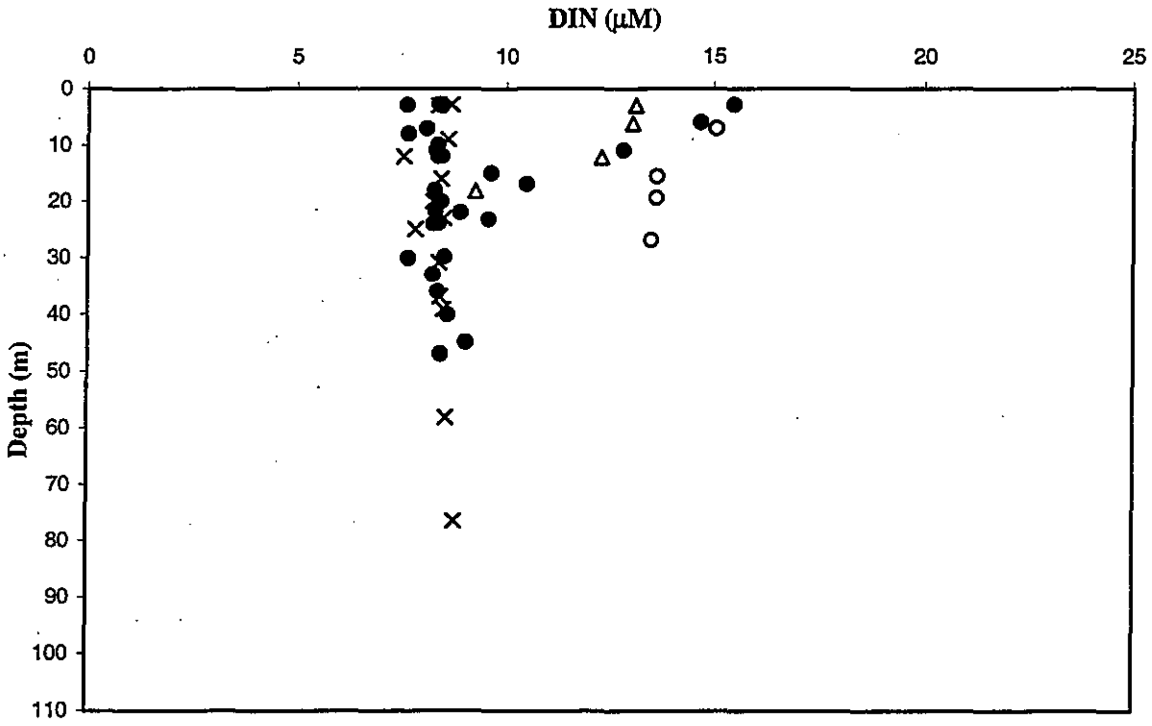


FIGURE 4-106

Depth vs. nutrient plots for nearfield survey W9717, (Dec 97)

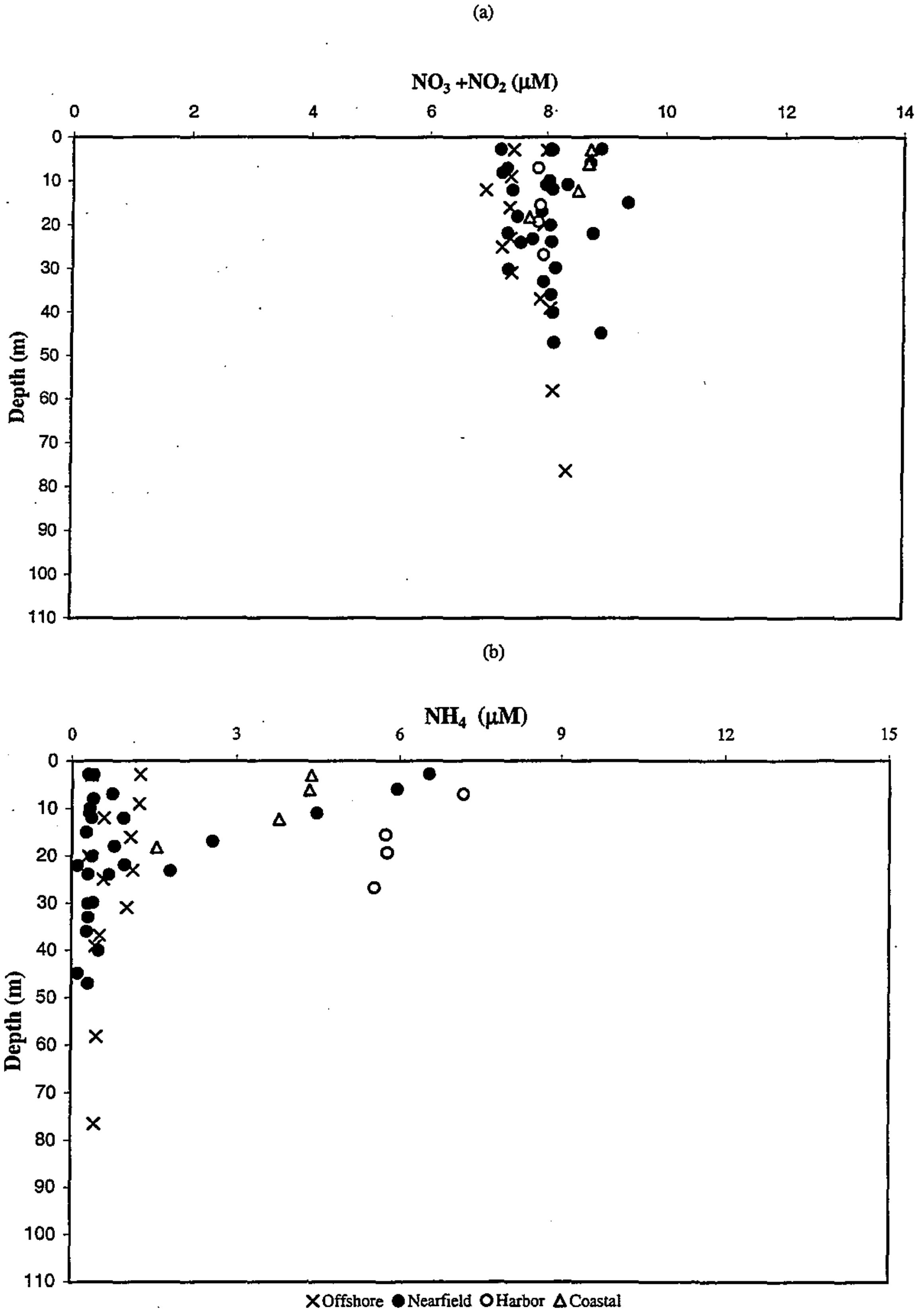


FIGURE 4-107
Depth vs. nutrient plots for nearfield survey W9717, (Dec 97)

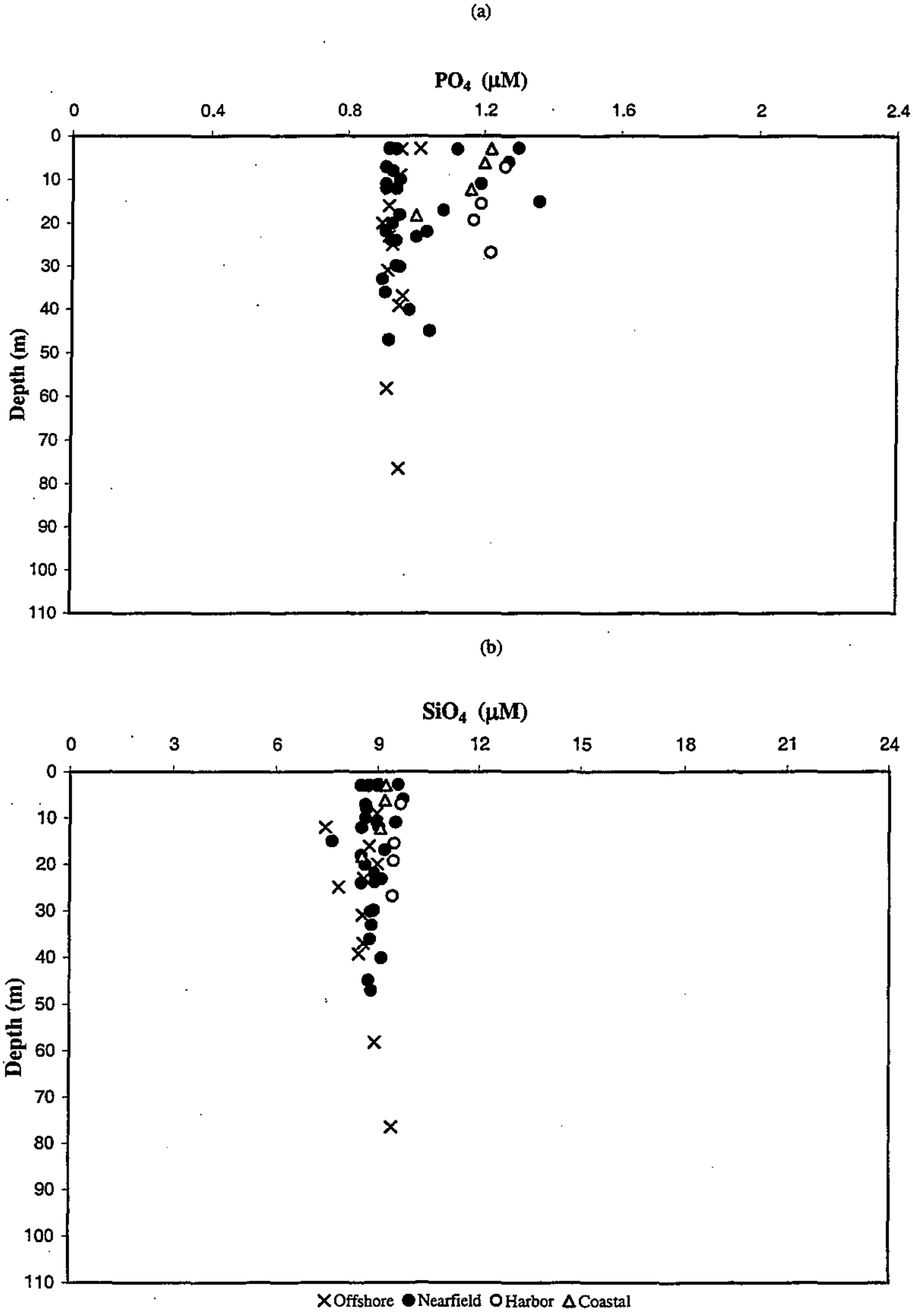


FIGURE 4-108

Depth vs. nutrient plots for nearfield survey W9717, (Dec 97)

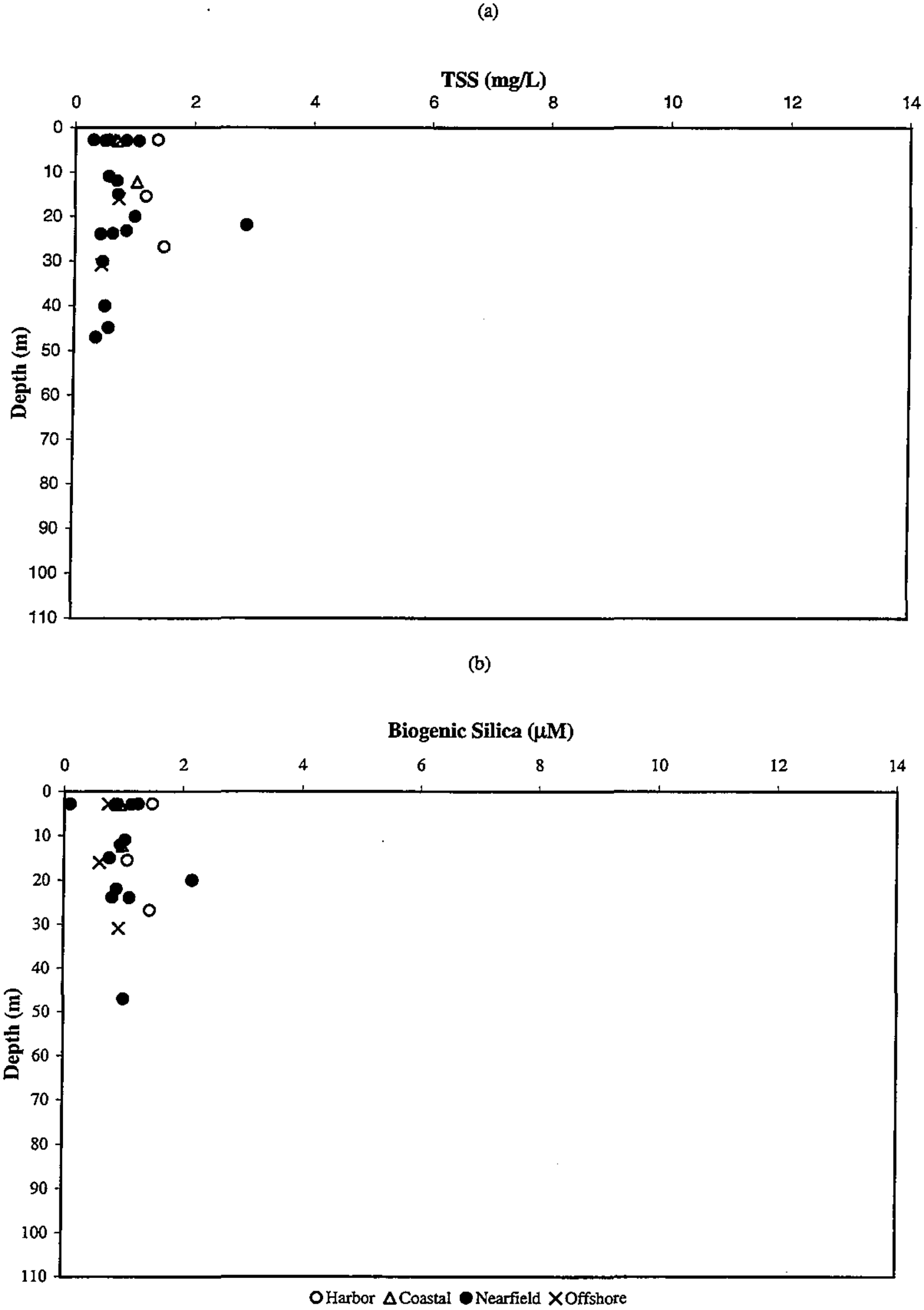
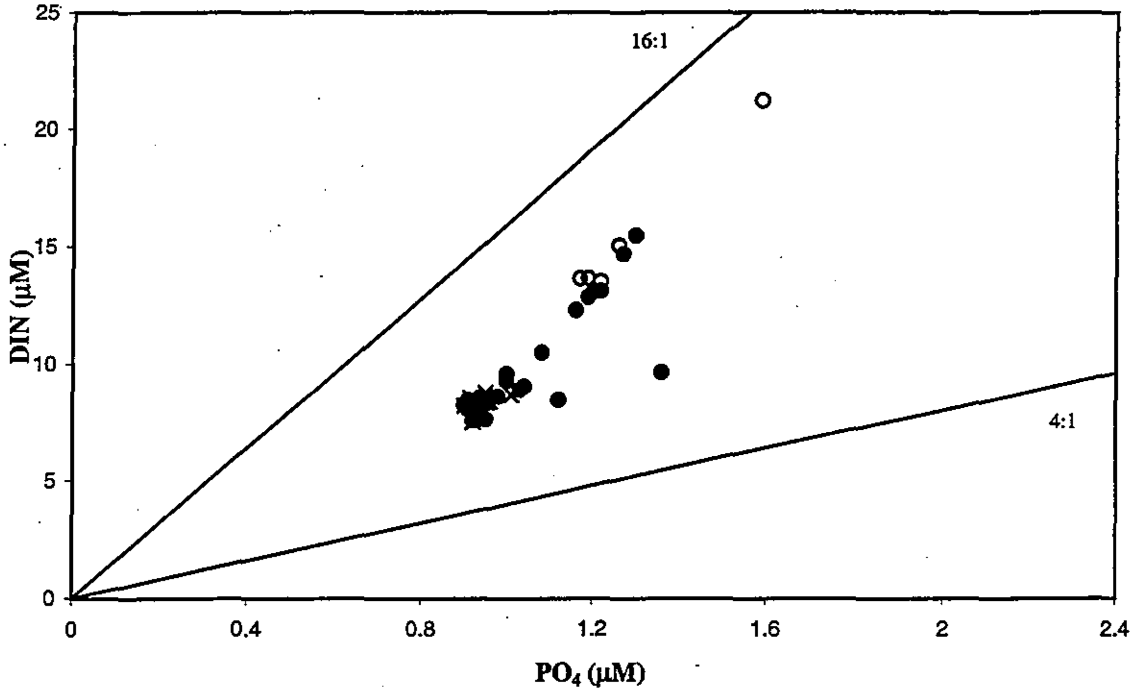


FIGURE 4-109

Depth vs. nutrient plots for nearfield survey W9717, (Dec 97)

(a)



(b)

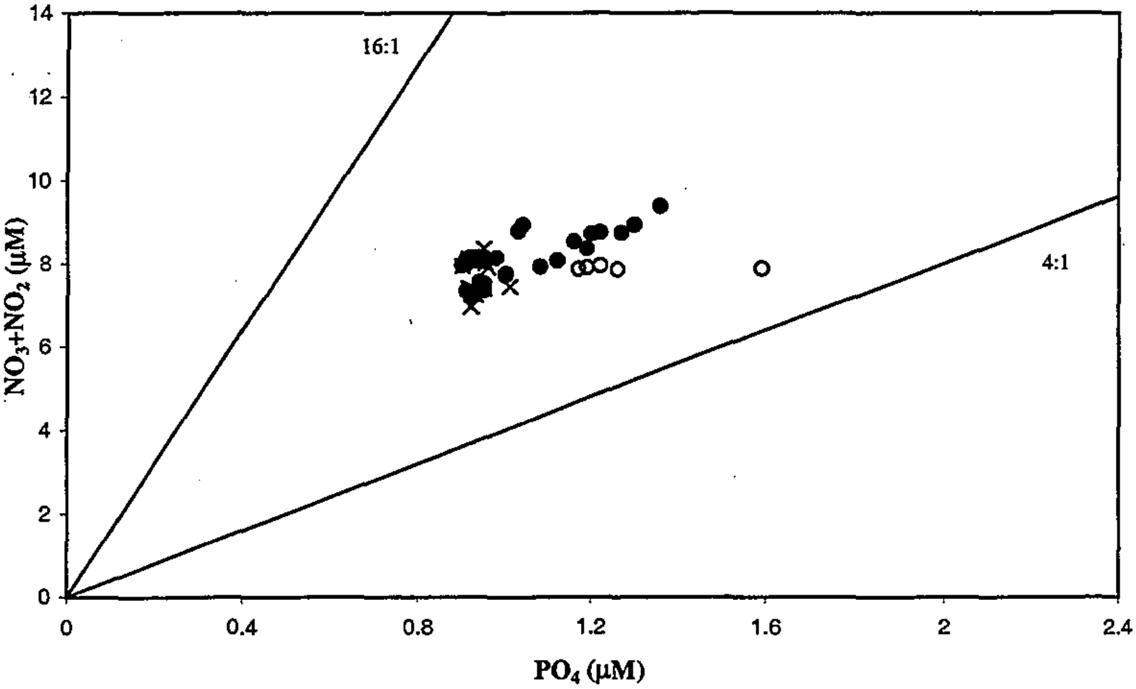


FIGURE 4-110

Nutrient vs. nutrient plots for nearfield survey W9717, (Dec 97)

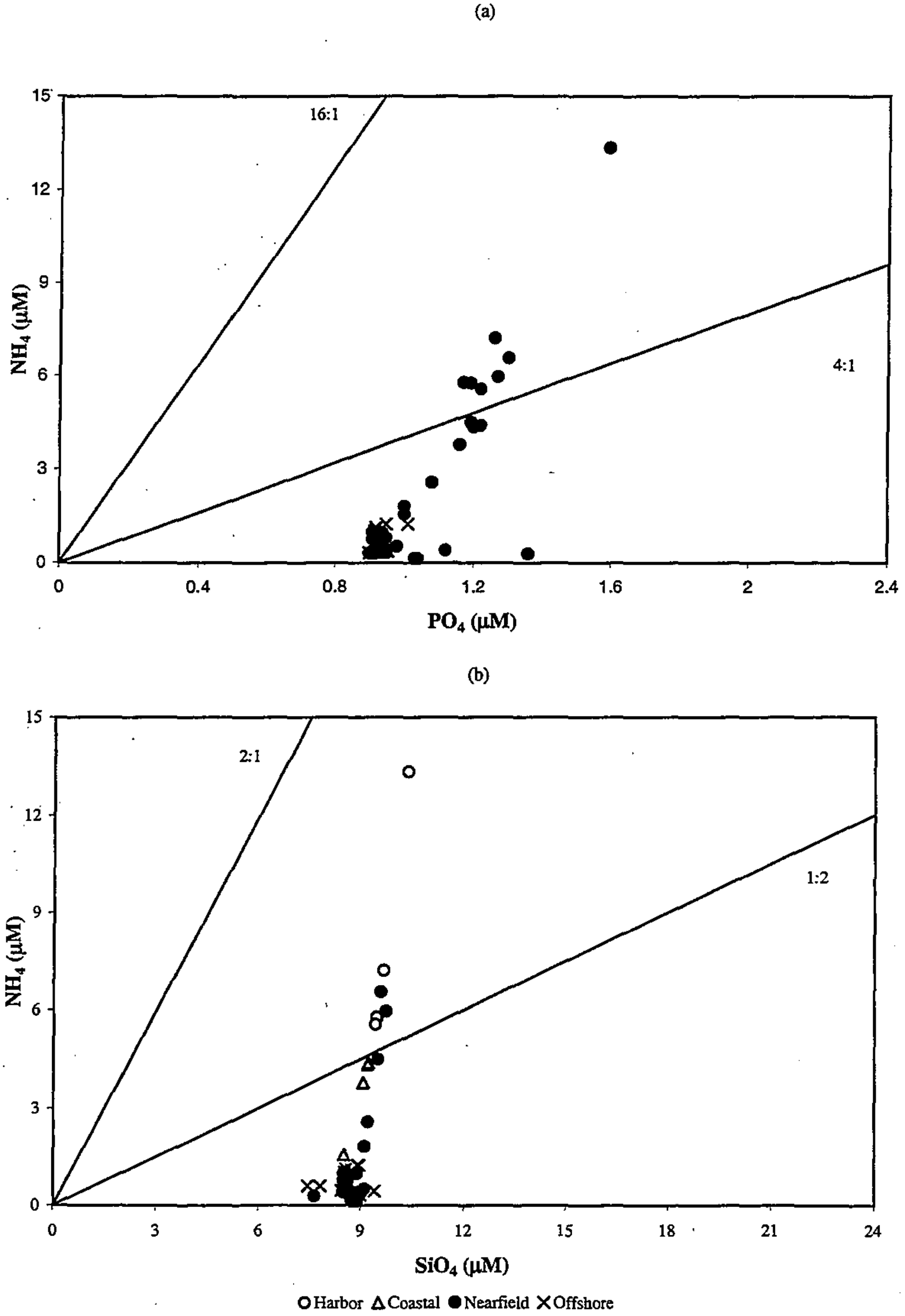


FIGURE 4-111

Nutrient vs. nutrient plots for nearfield survey W9717, (Dec 97)

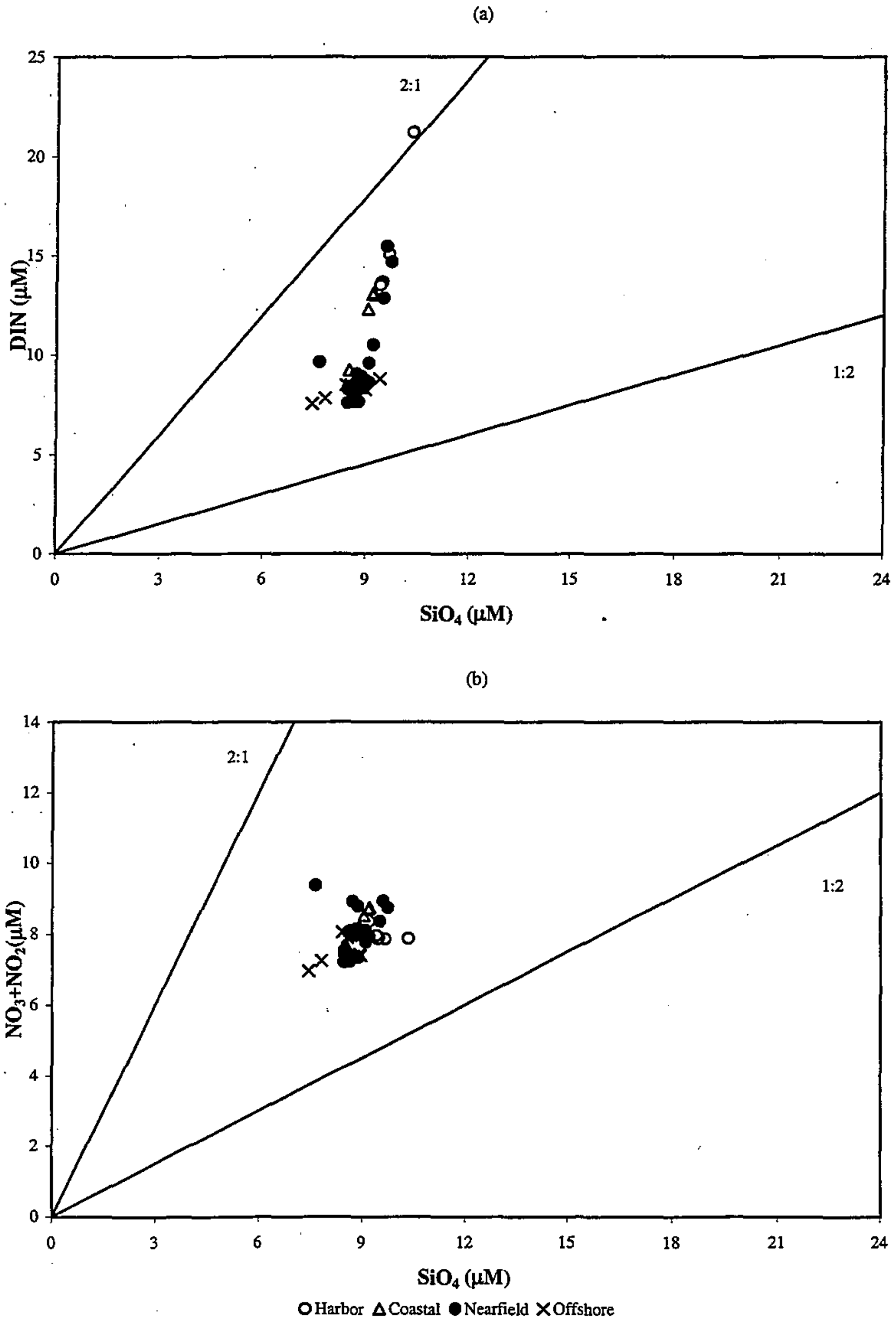
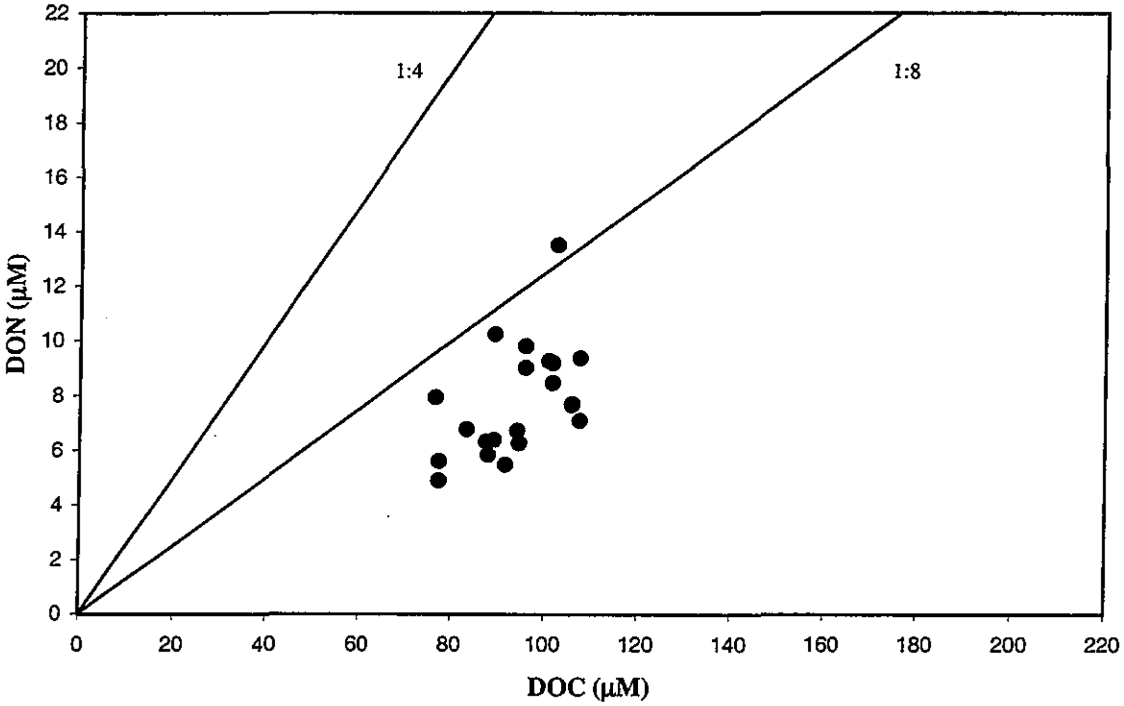


FIGURE 4-112

Nutrient vs. nutrient plots for nearfield survey W9717, (Dec 97)

(a)



(b)

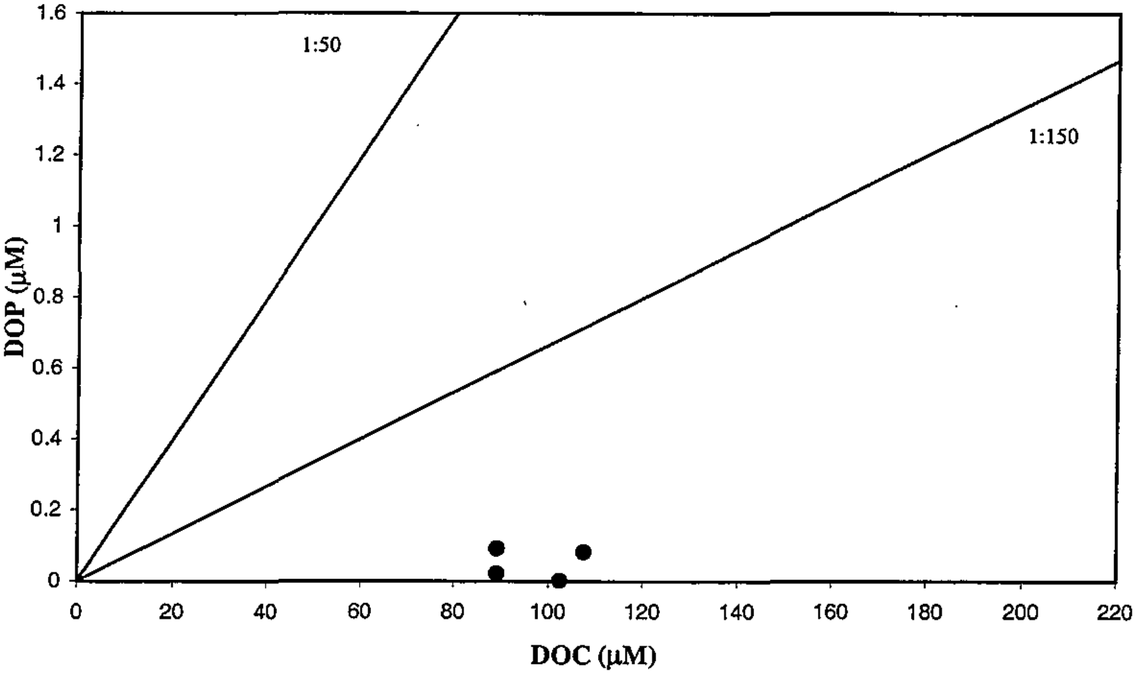


FIGURE 4-113

Nutrient vs. nutrient plots for nearfield survey W9717, (Dec 97)

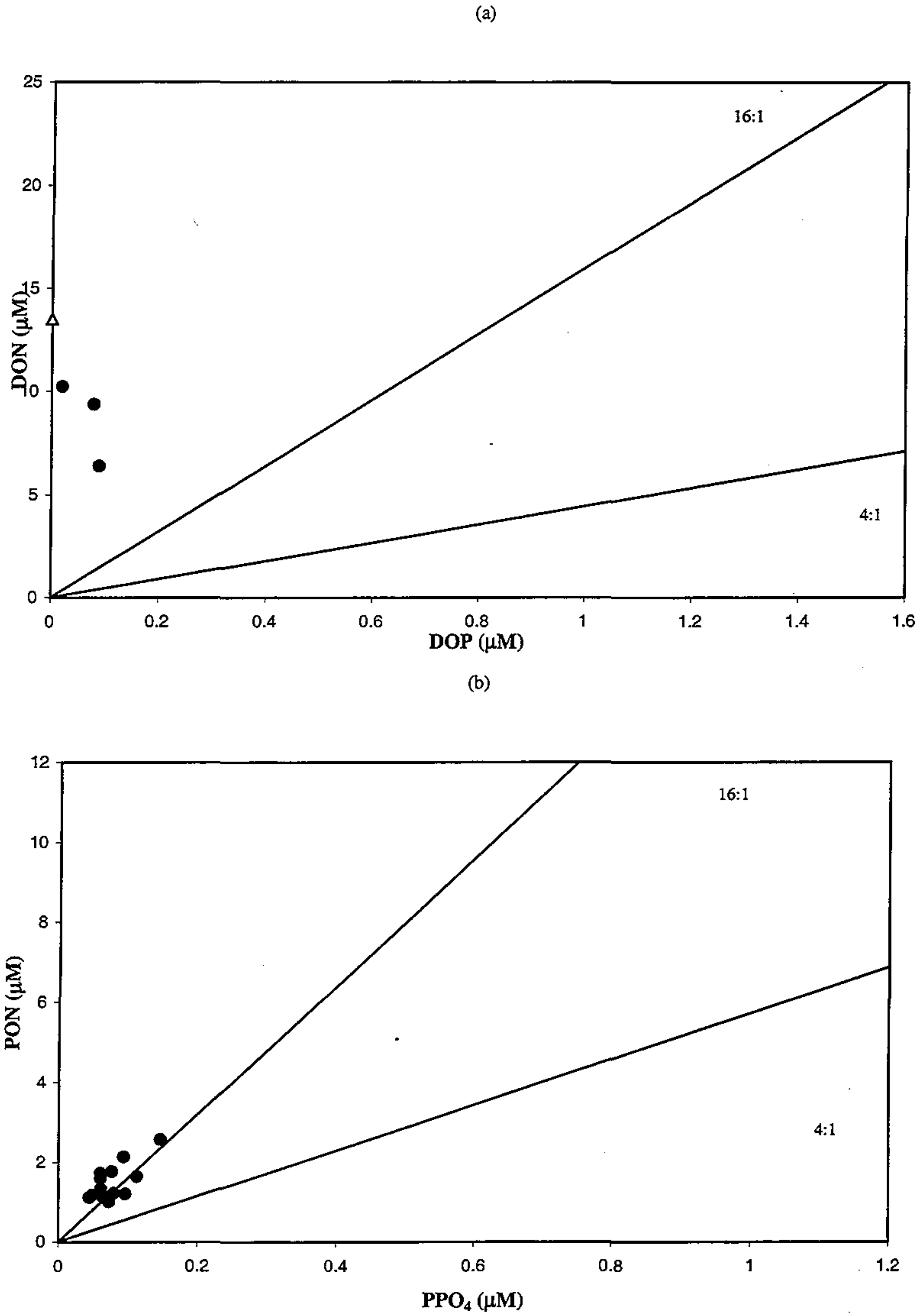
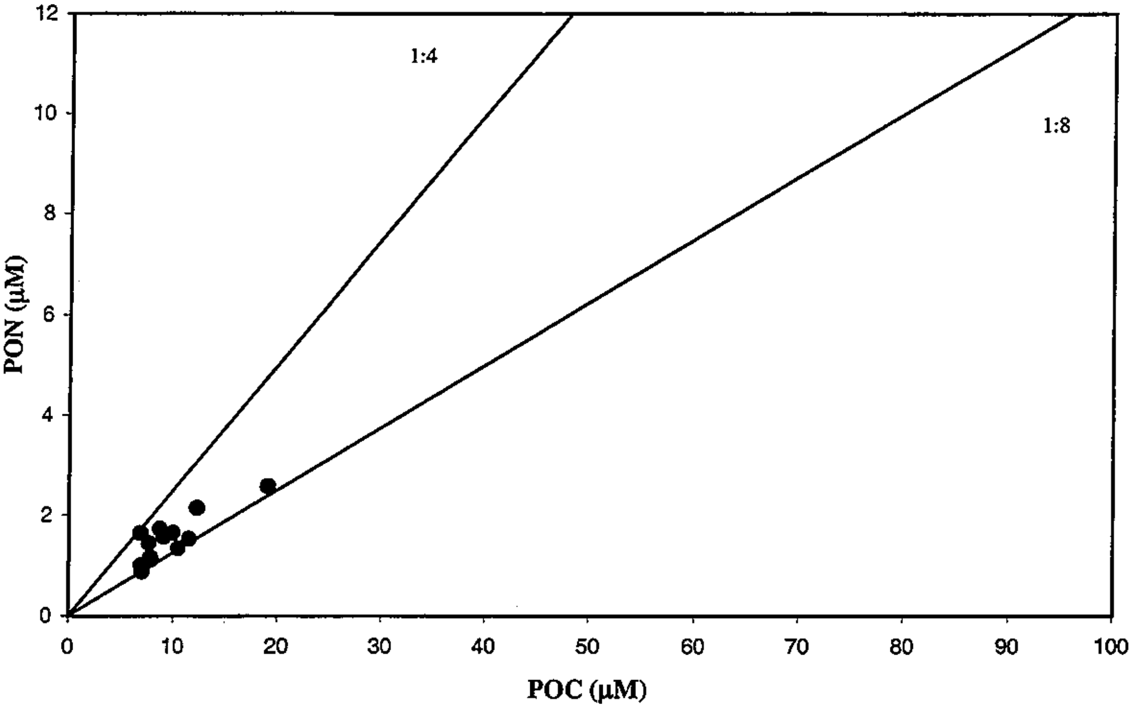


FIGURE 4-114

Nutrient vs. nutrient plots for nearfield survey W9717, (Dec 97)

(a)



(b)

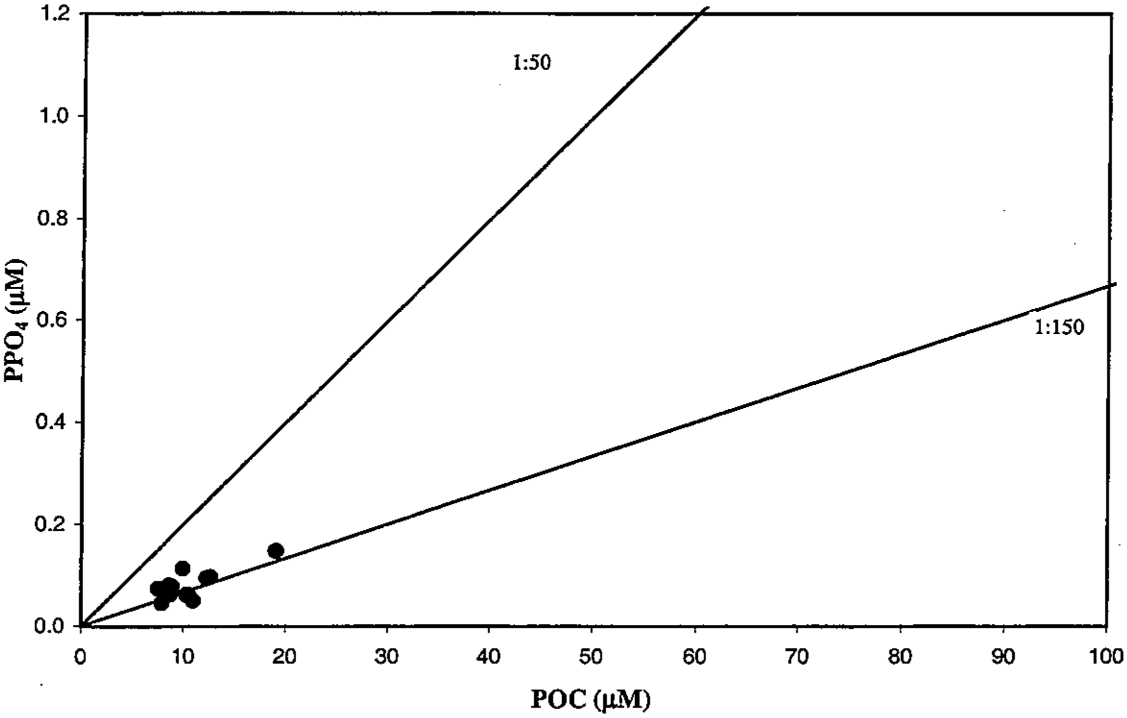


FIGURE 4-115

Nutrient vs. nutrient plots for nearfield survey W9717, (Dec 97)

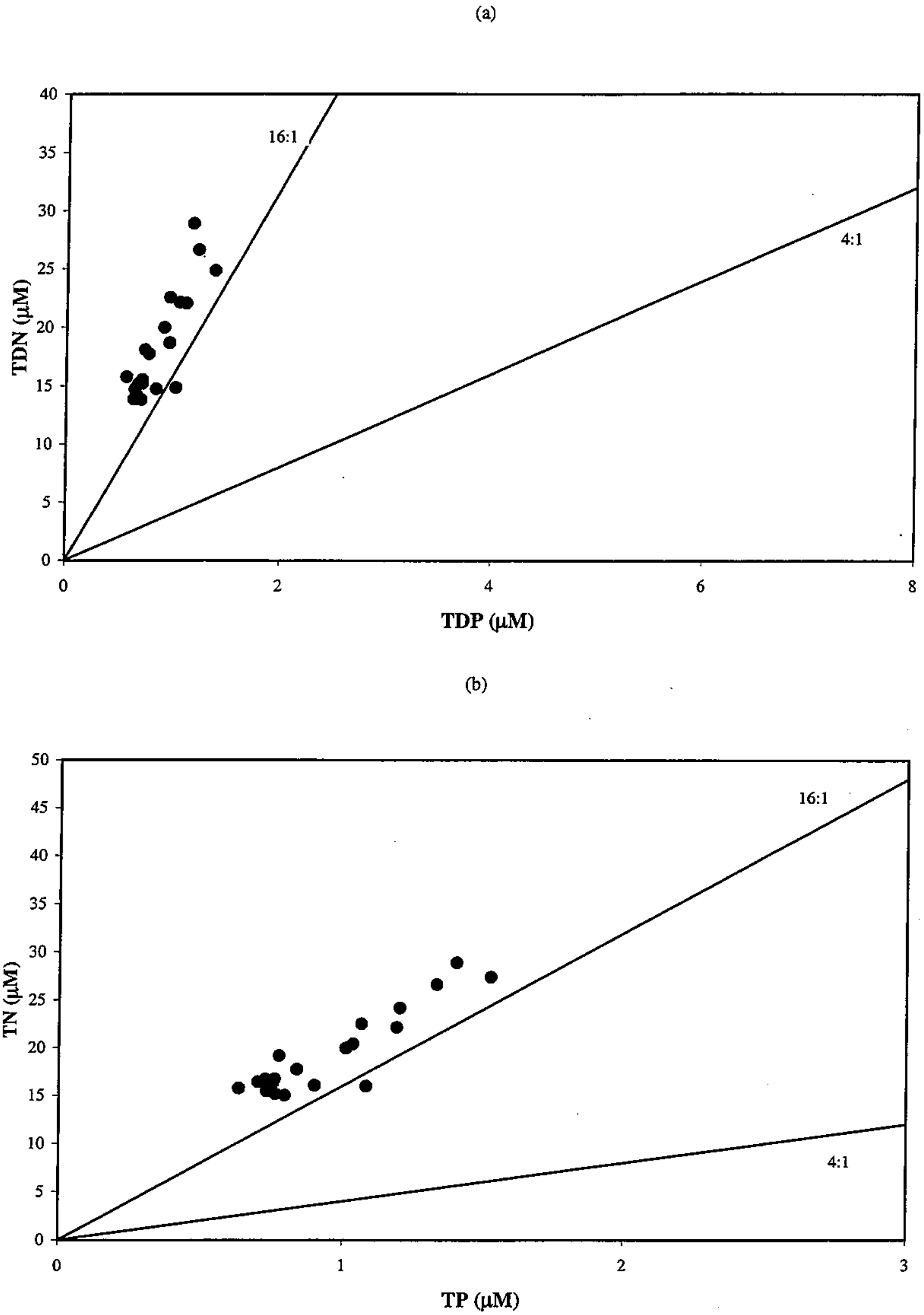
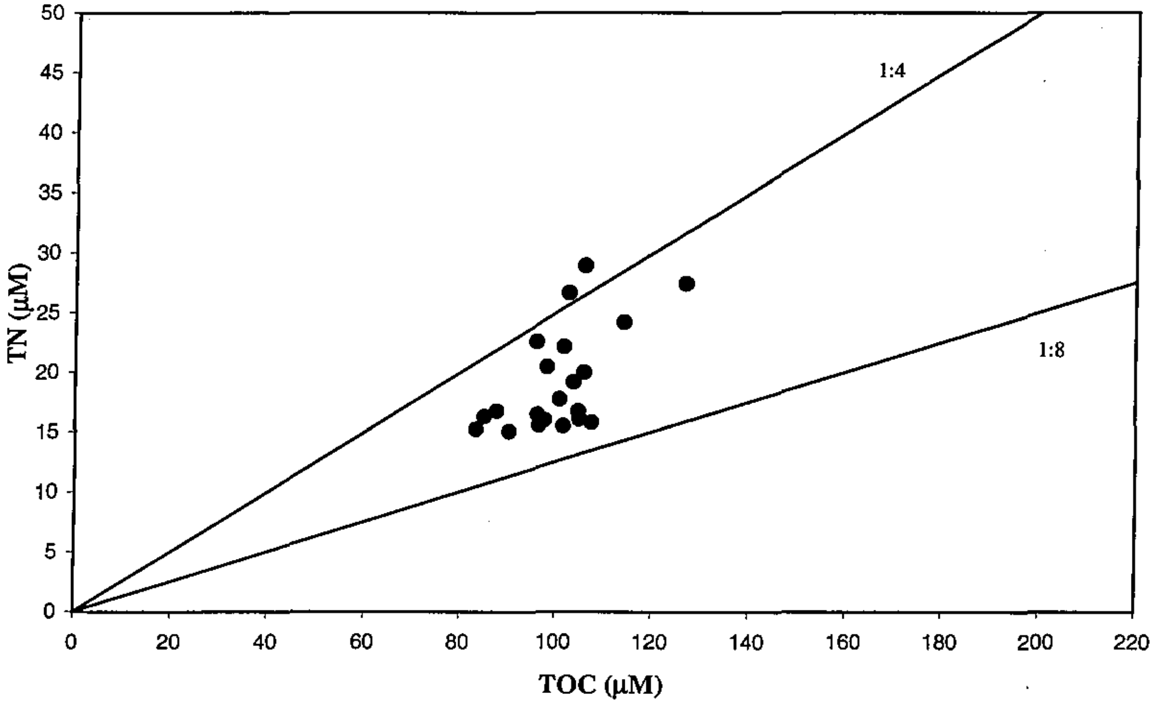


FIGURE 4-116
Nutrient vs. nutrient plots for nearfield survey W9717, (Dec 97)

(a)



(b)

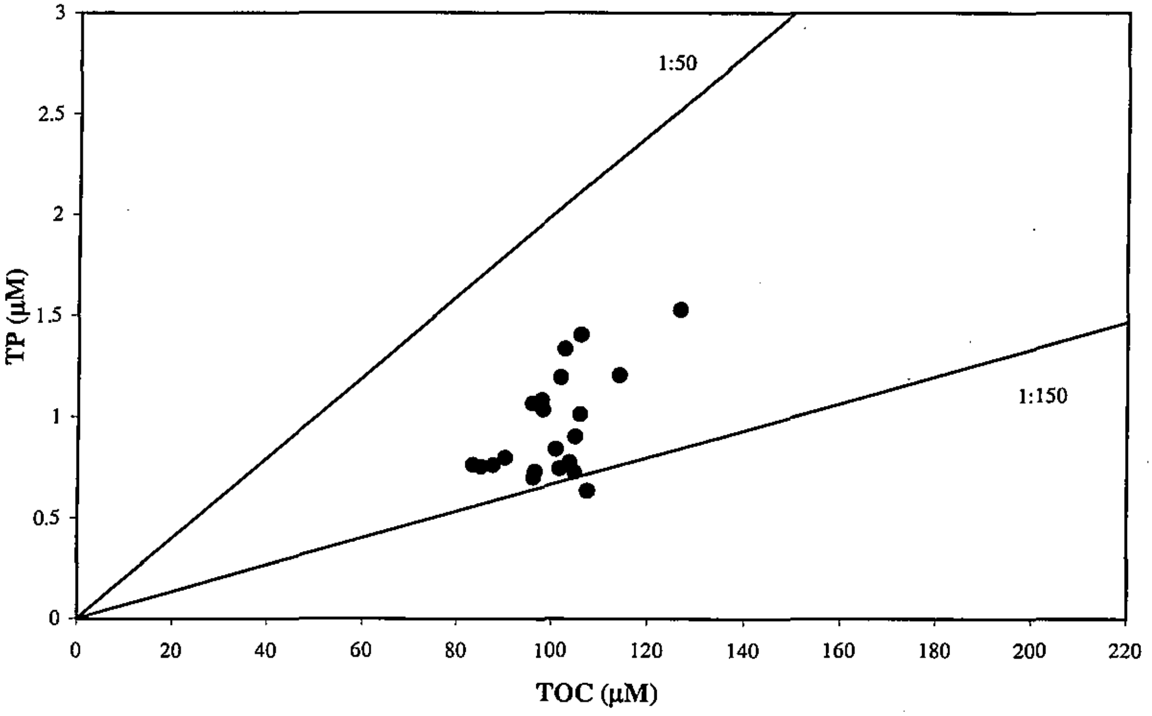


FIGURE 4-117

Nutrient vs. nutrient plots for nearfield survey W9717, (Dec 97)

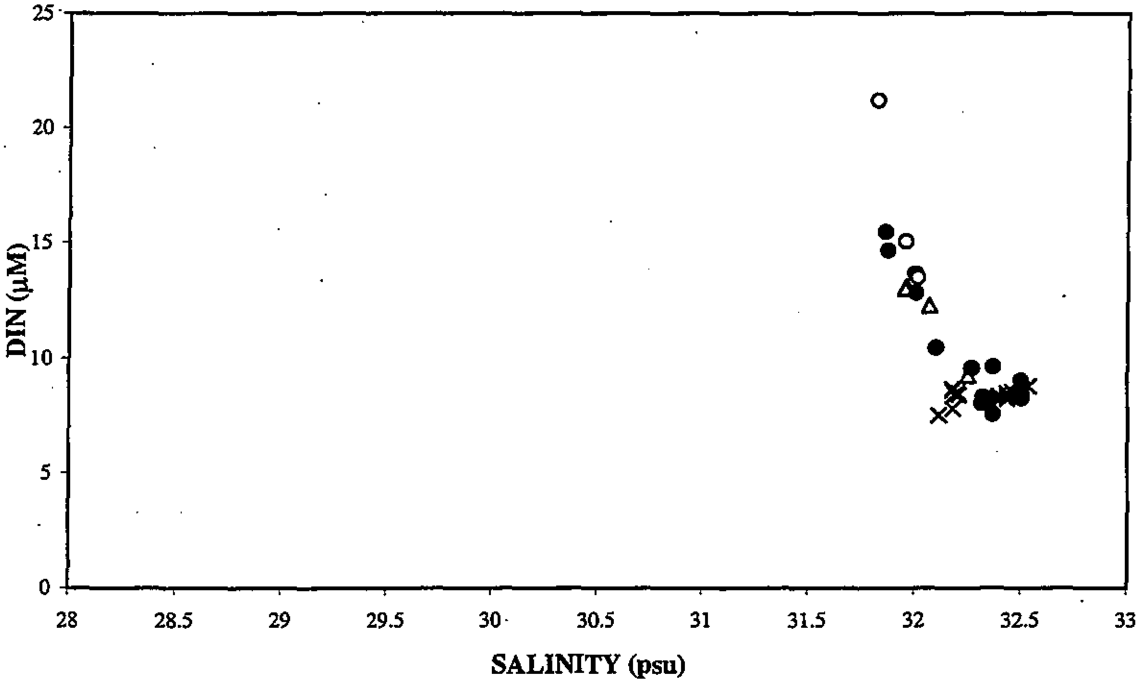


FIGURE 4-118

Nutrient vs. salinity plots for nearfield survey W9717, (Dec 97)

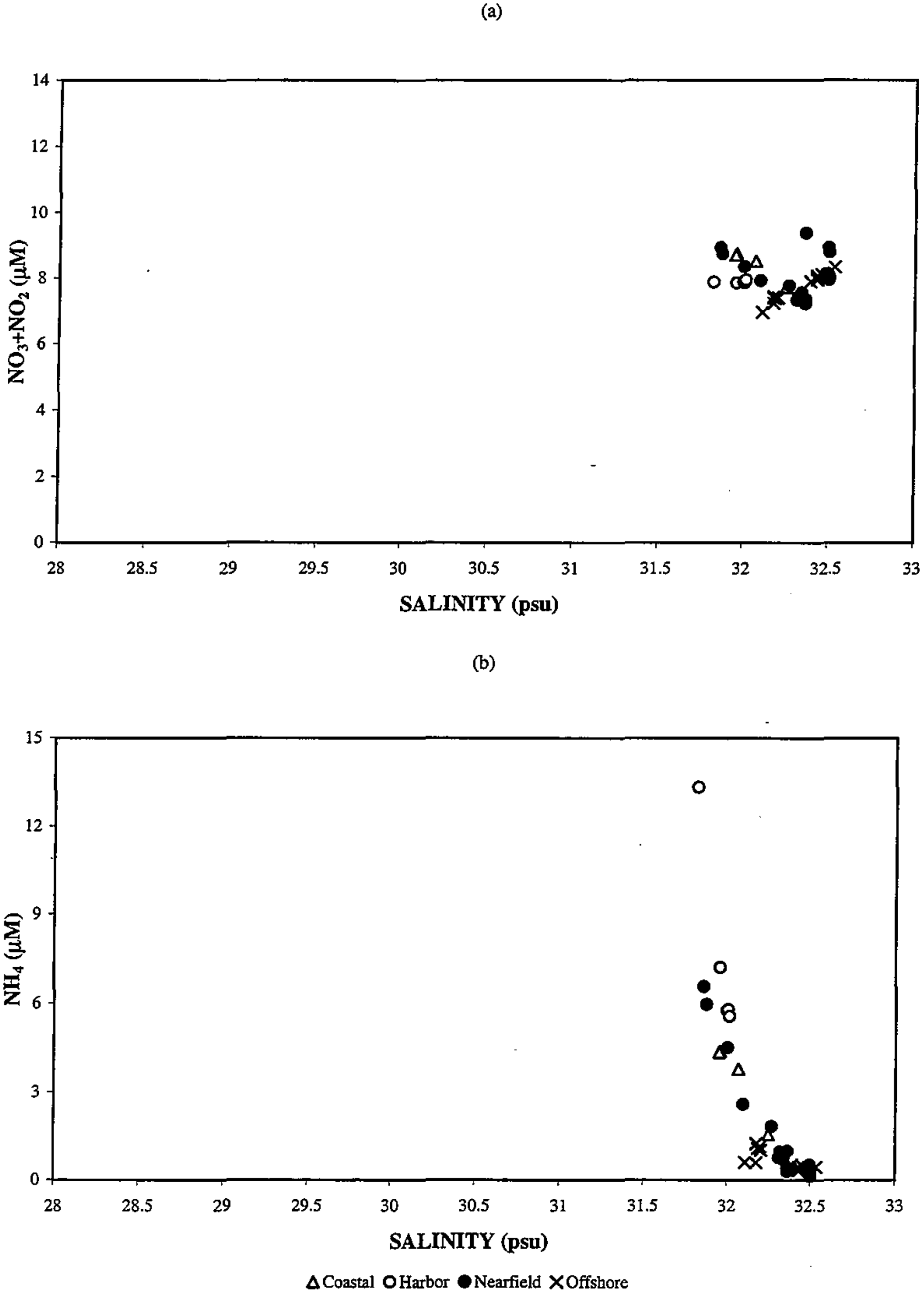


FIGURE 4-119

Nutrient vs. salinity plots for nearfield survey W9717, (Dec 97)

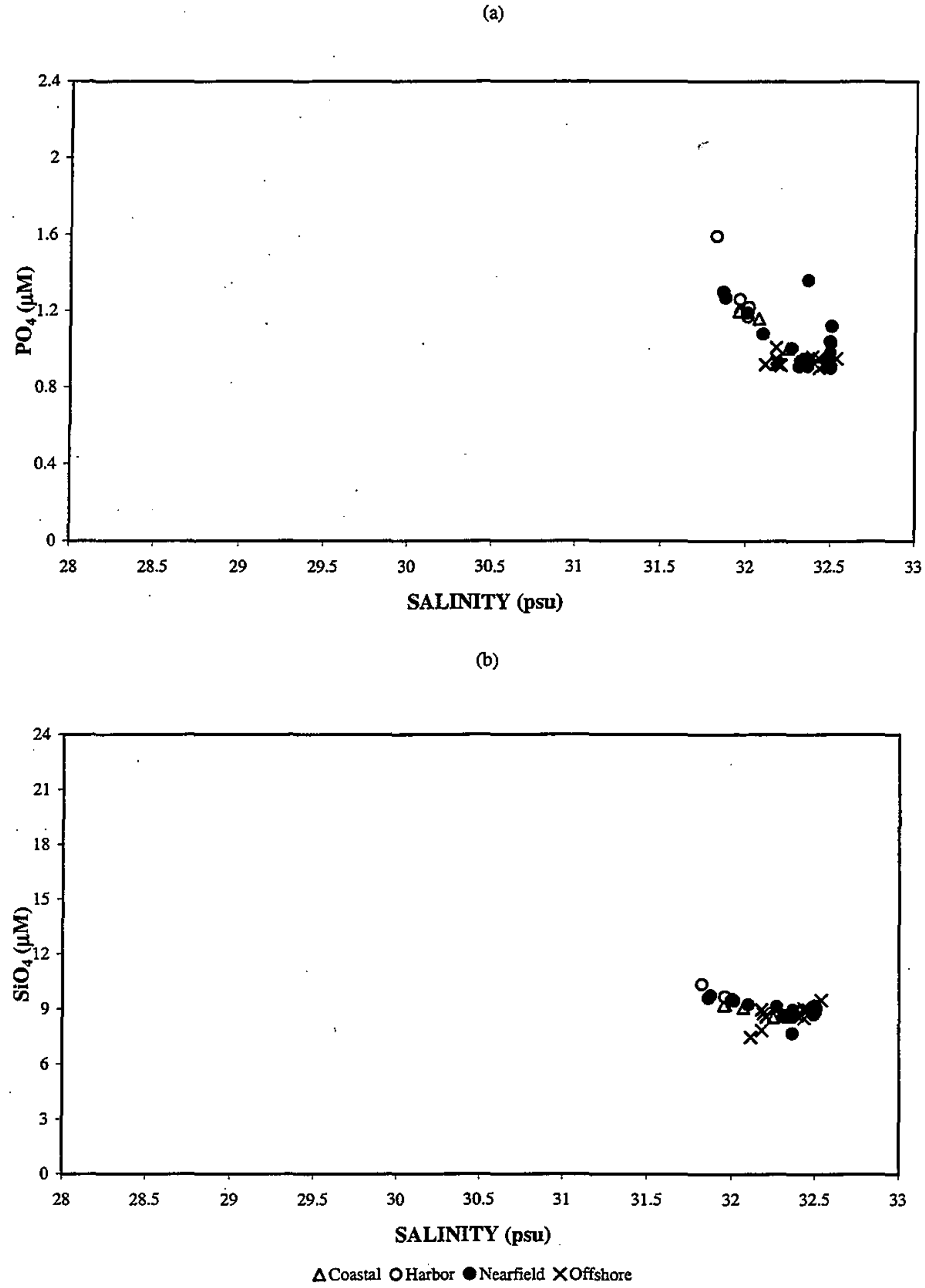


FIGURE 4-120

Nutrient vs. salinity plots for nearfield survey W9717, (Dec 97)

APPENDIX D

PHOTOSYNTHESIS – IRRADIANCE (P-I) CURVES

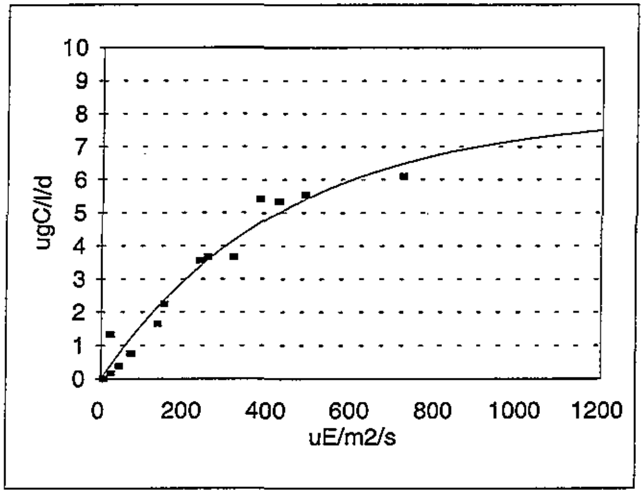
APPENDIX D

Photosynthesis-Irradiance (P-I) Curves

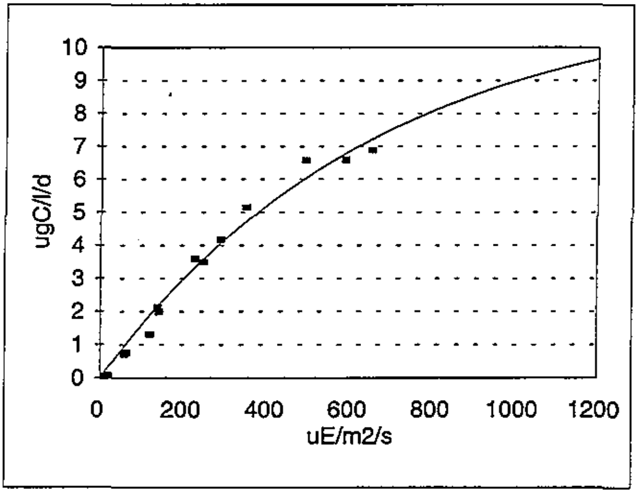
Productivity calculations utilized light attenuation data from a CTD-mounted 4π sensor and incident light time-series data from an on-deck 2π irradiance sensor (Combined Work/Quality Assurance Project Plan for Water Quality Monitoring, ENSR, 1996). After collection of the productivity samples, they were incubated in a temperature-controlled incubator. The resulting photosynthesis (mgC/m^3/h) versus light irradiance (μE/m^2/s, P-I) curves are comprehensively presented in this appendix. These data were used to determine hourly production at intervals throughout the day for each sampling depth.

W9710 Station N18

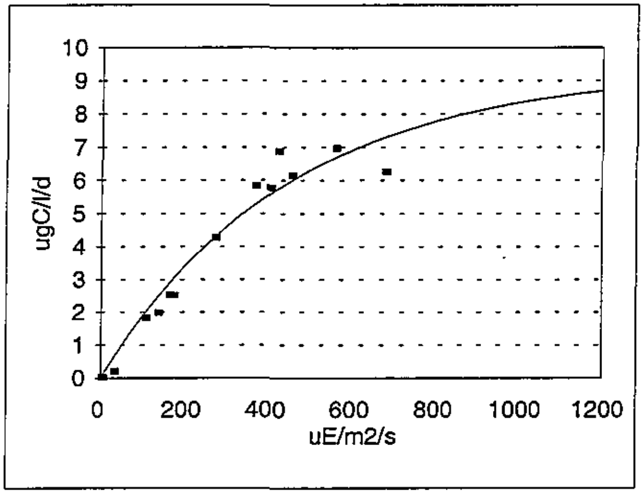
Surface



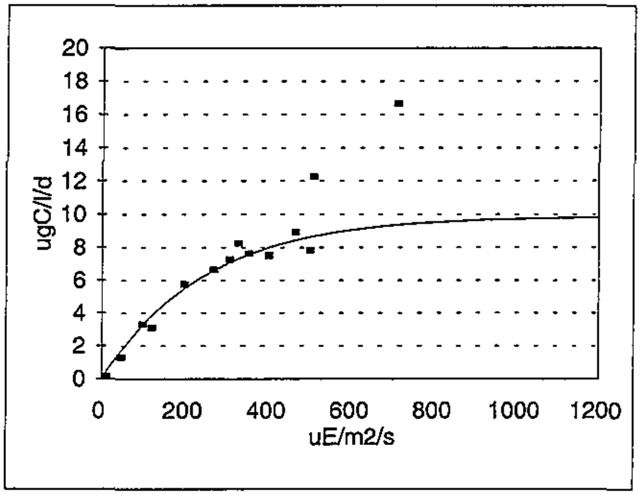
Mid-Surface



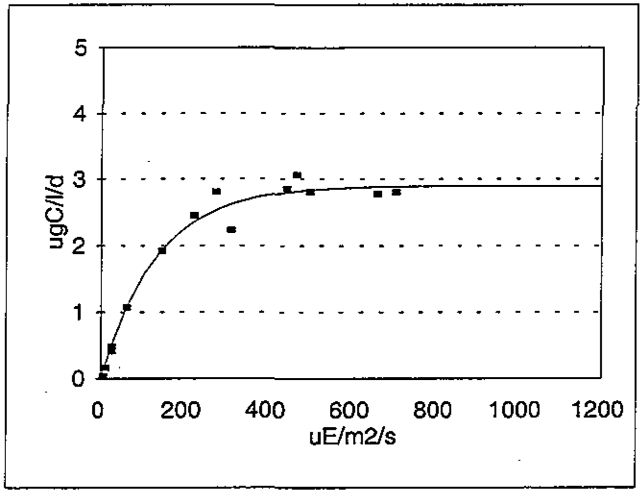
Middle



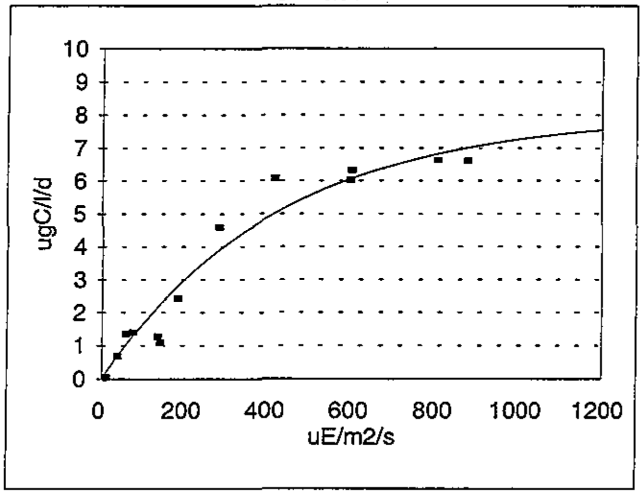
Mid-Bottom



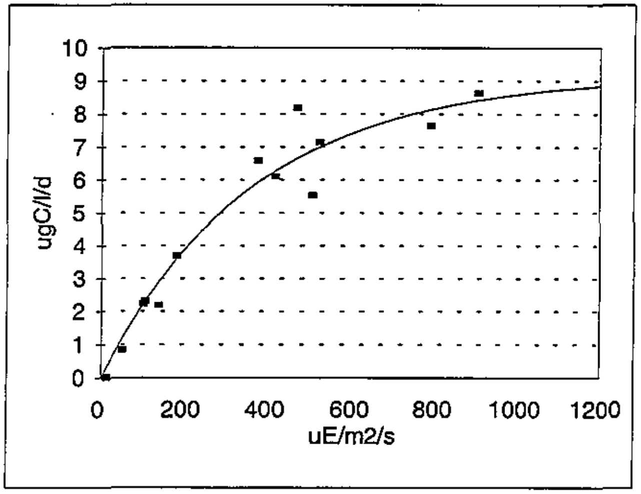
Bottom



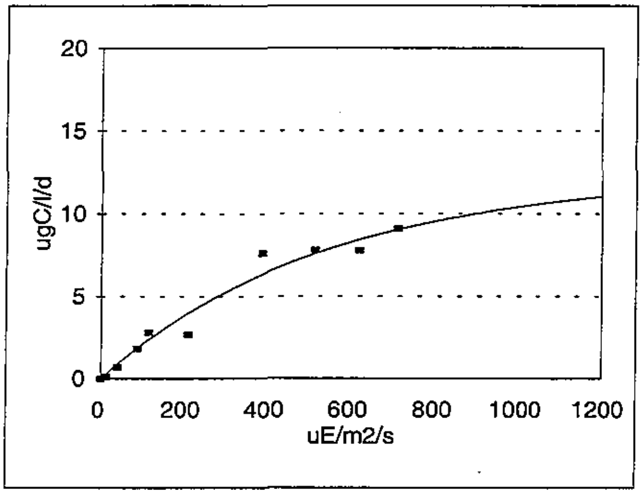
W9710 Station N04



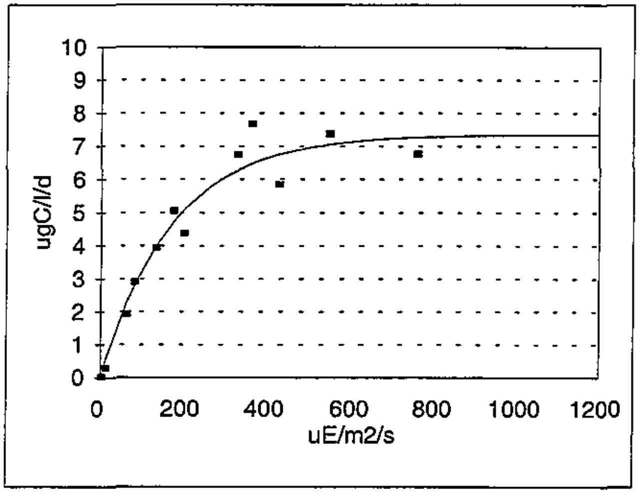
Surface



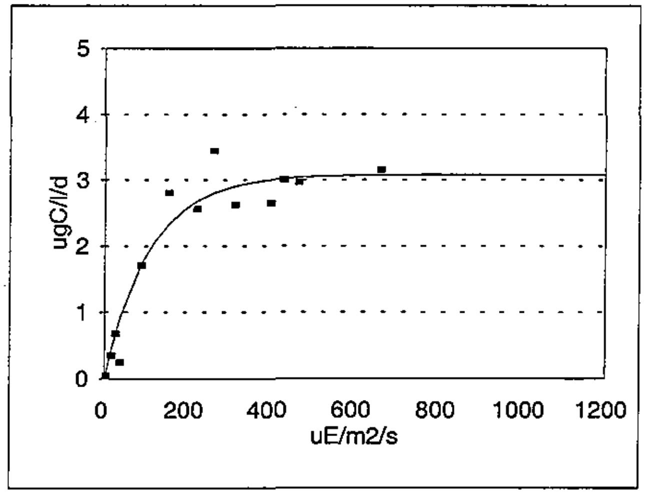
Mid-Surface



Middle



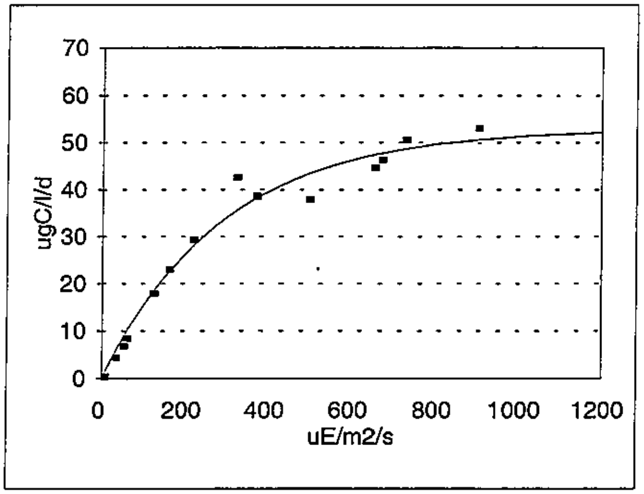
Mid-Bottom



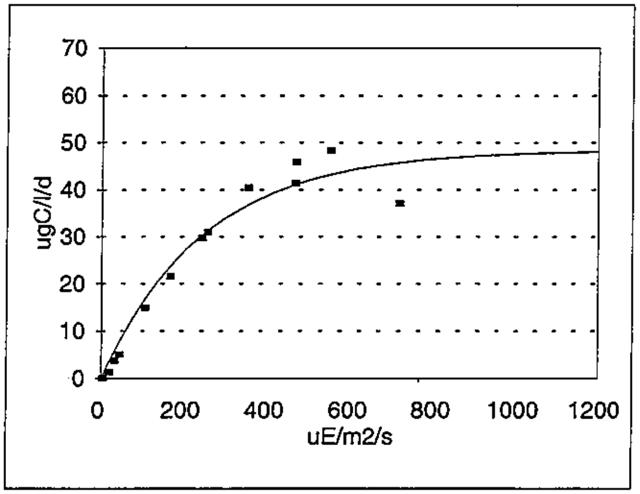
Bottom

W9711b Station F23

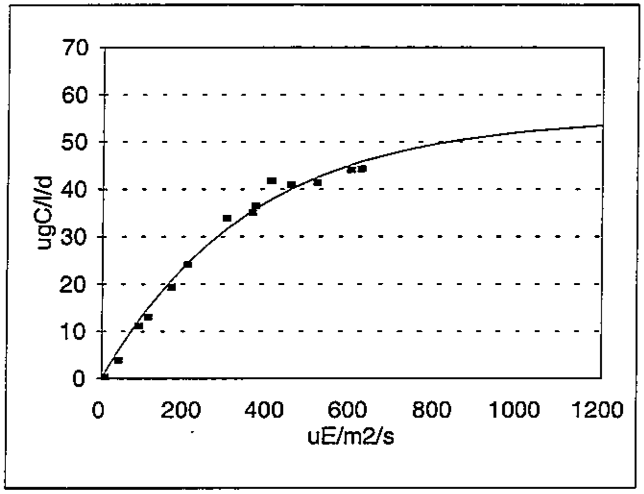
Surface



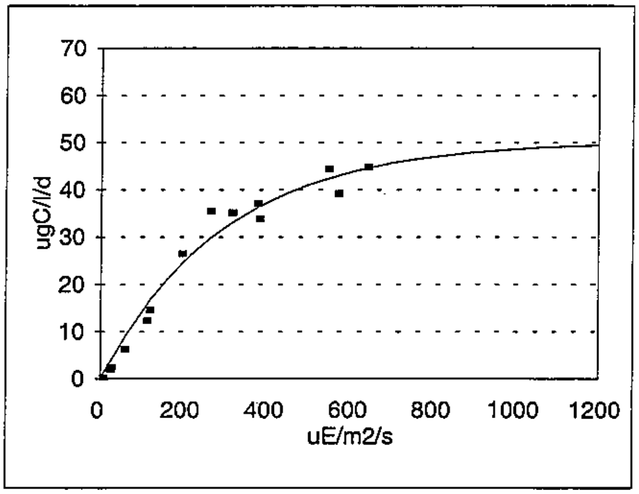
Mid-Surface



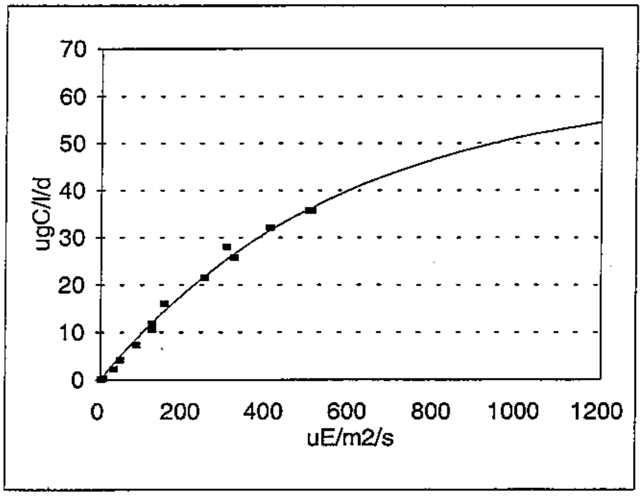
Middle



Mid-Bottom

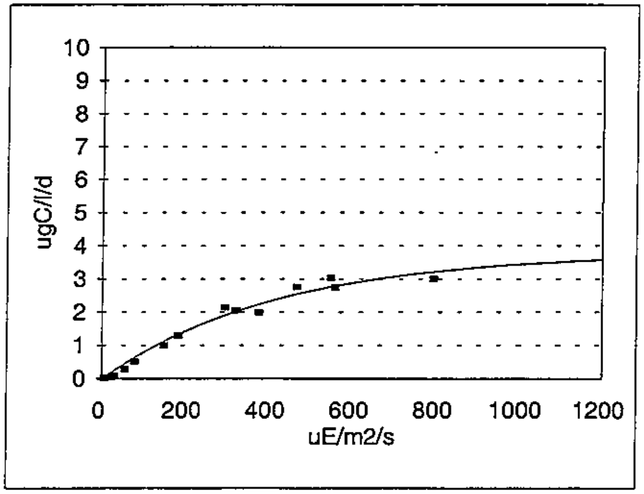


Bottom

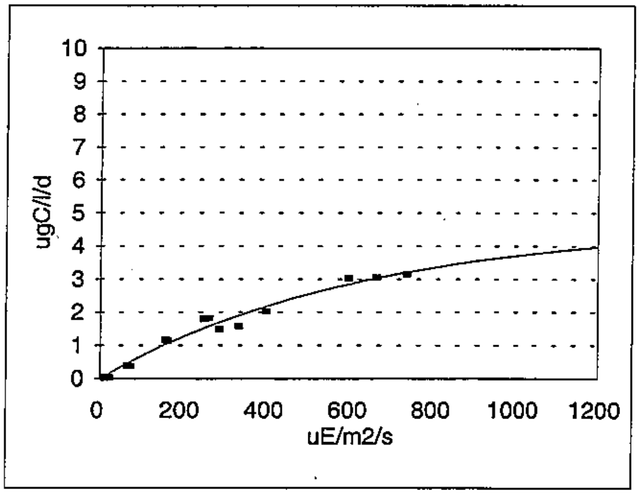


W9711a Station N18

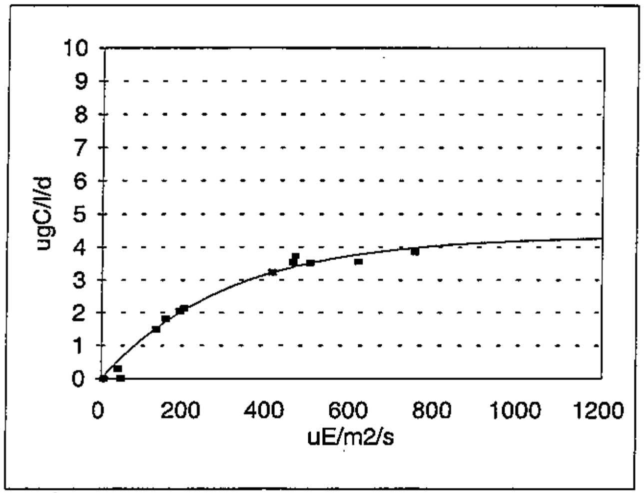
Surface



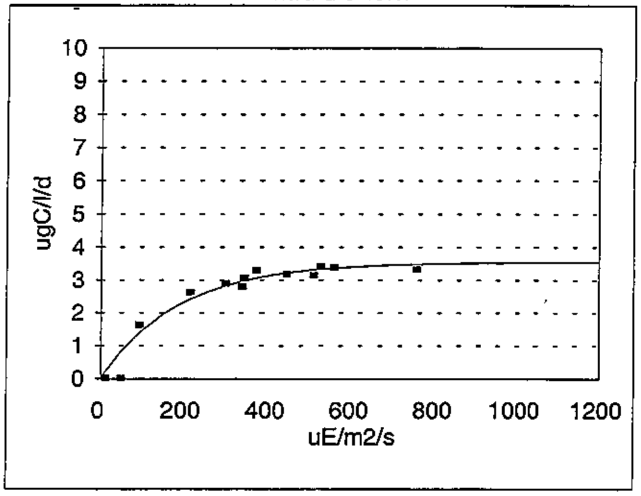
Mid-Surface



Middle



Mid-Bottom



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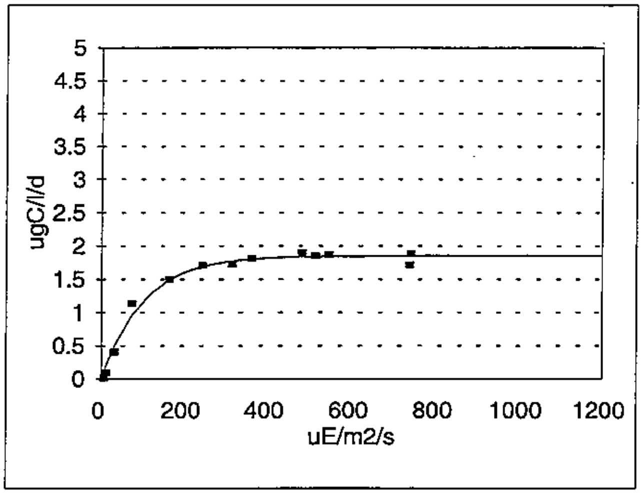
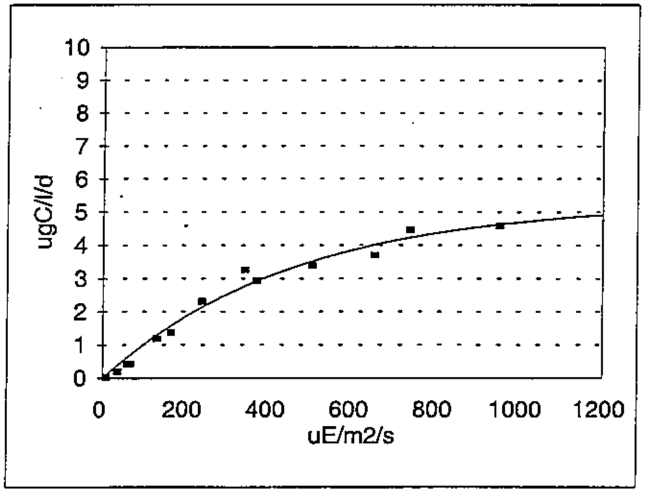


W9711a Station N04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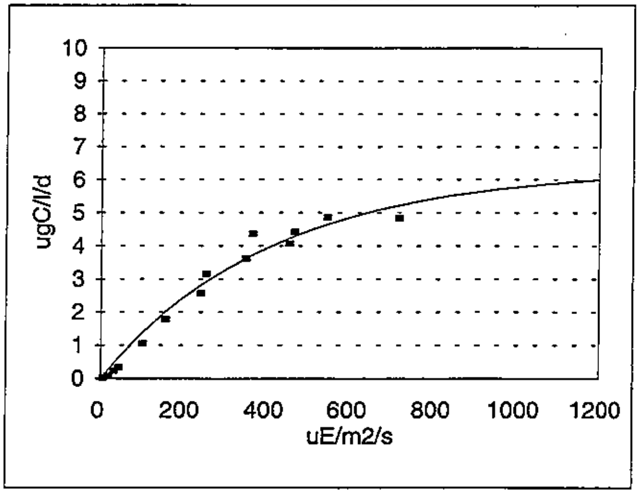
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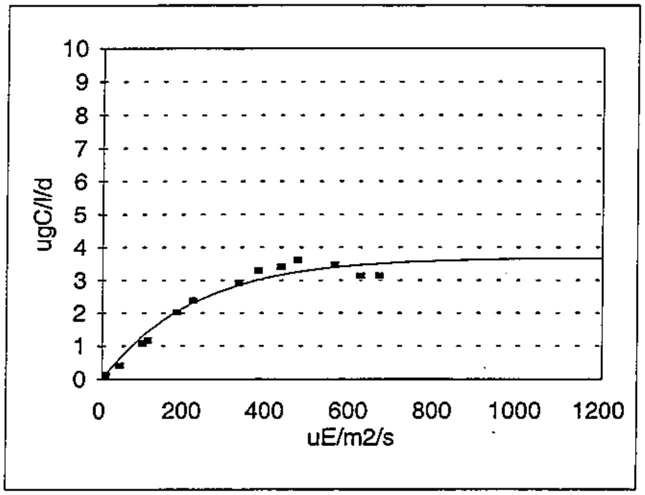
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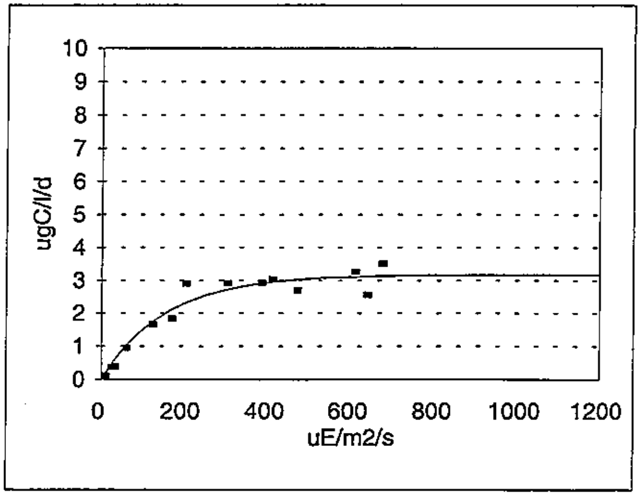
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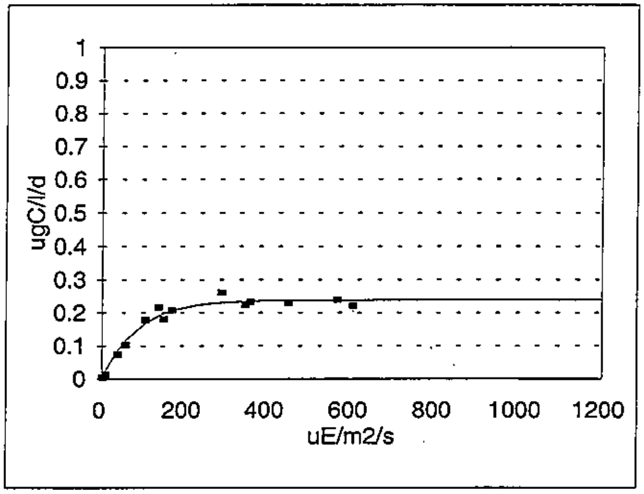
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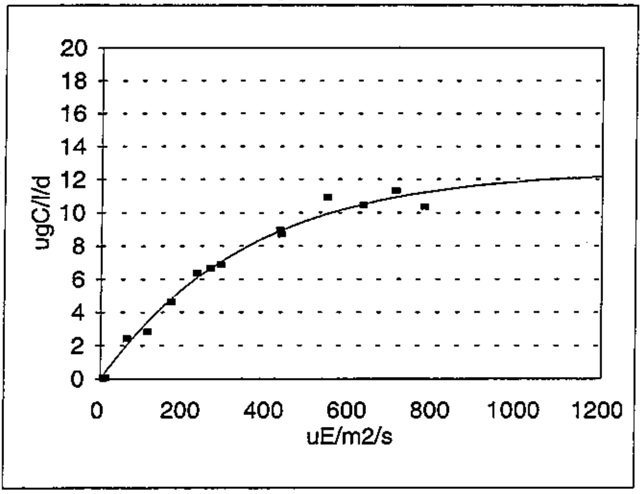
W9712 Station N18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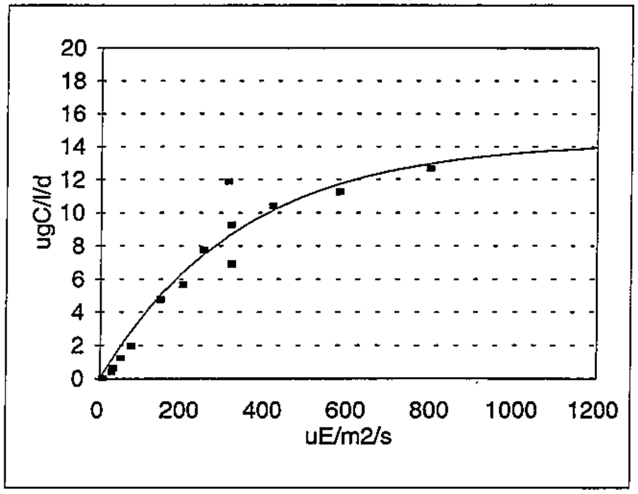
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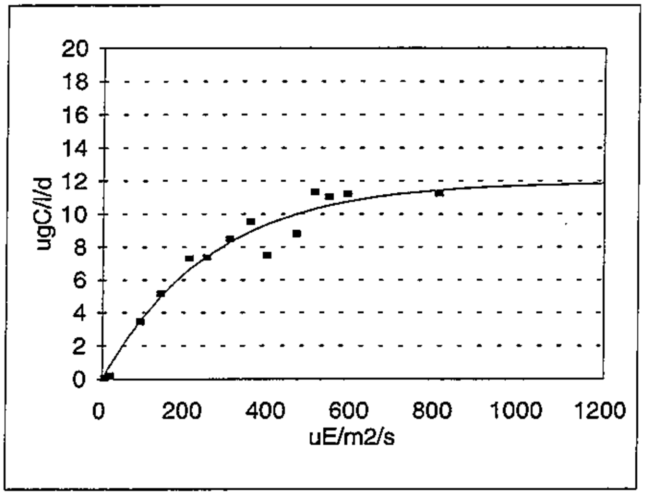
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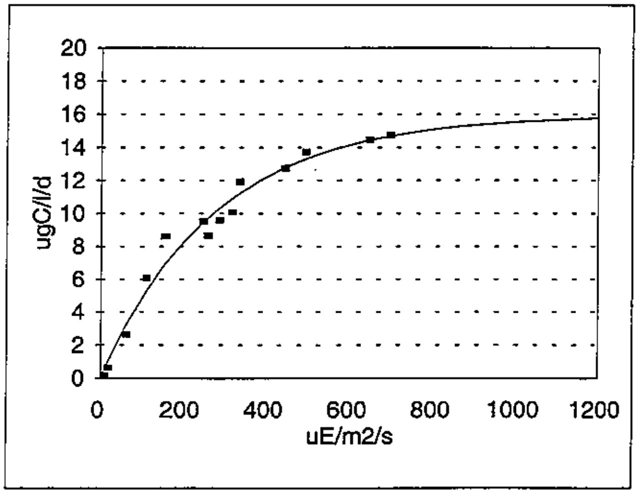
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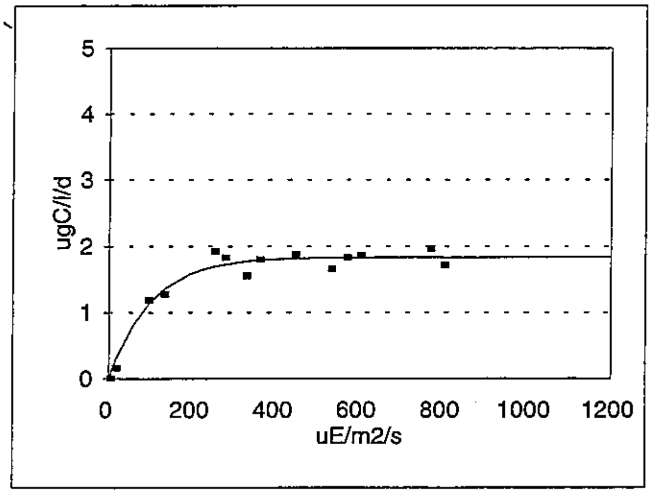
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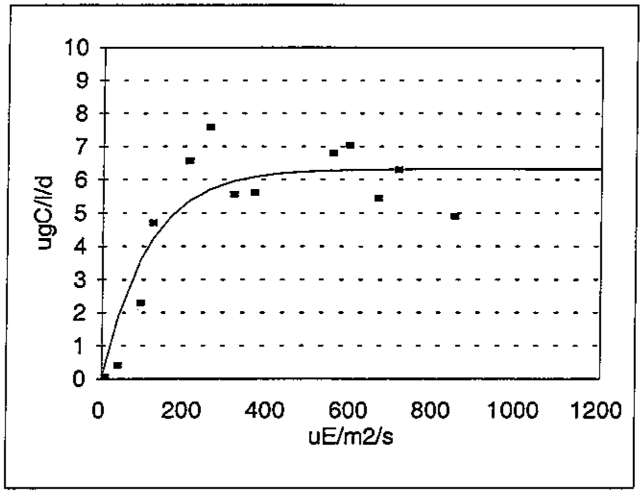
W9712 Station N04

Surface



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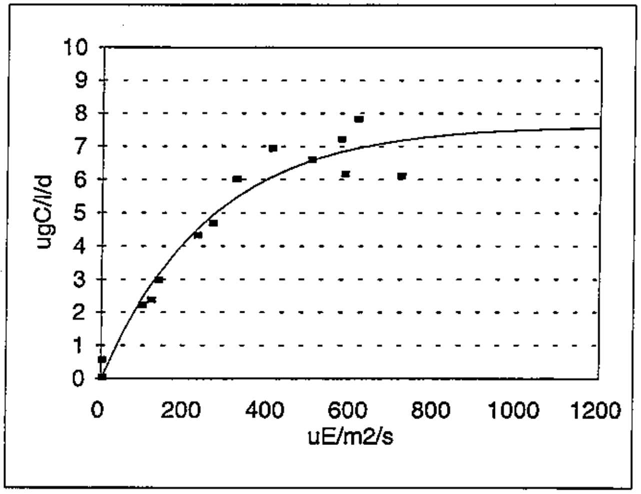

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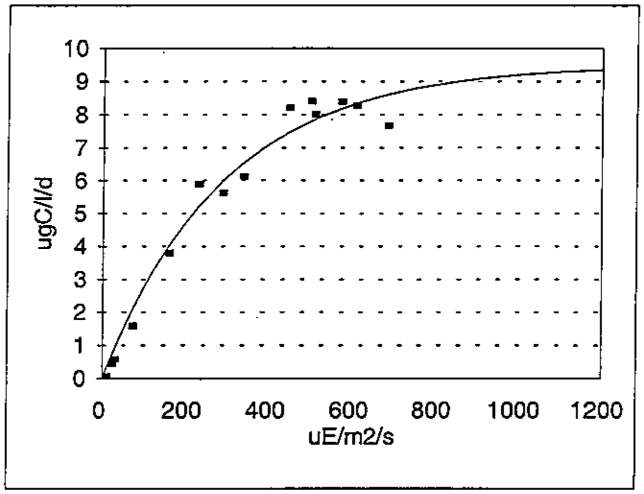

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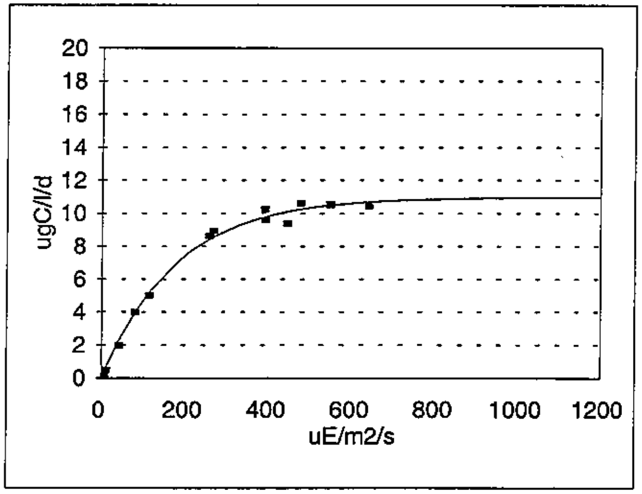

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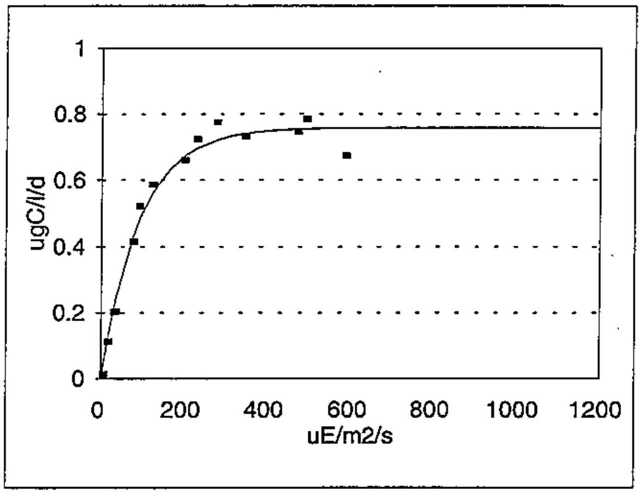
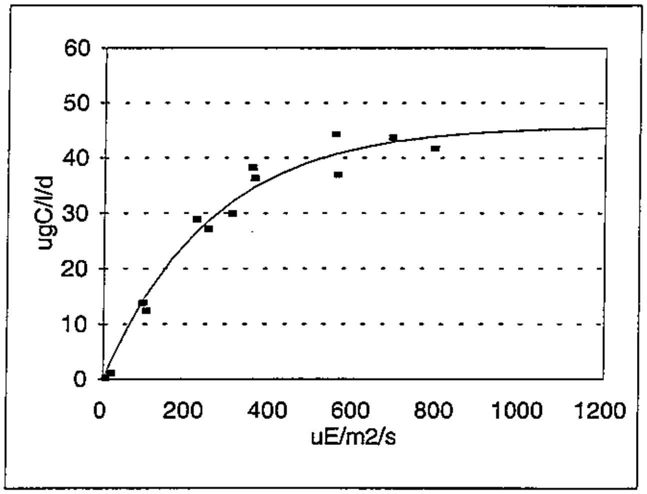


W9713 Station N18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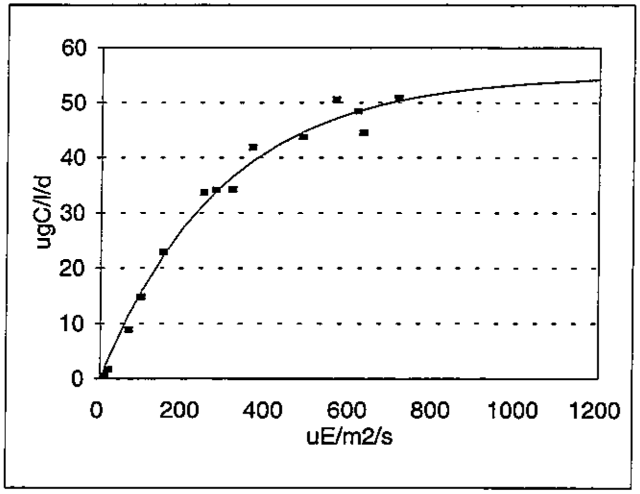
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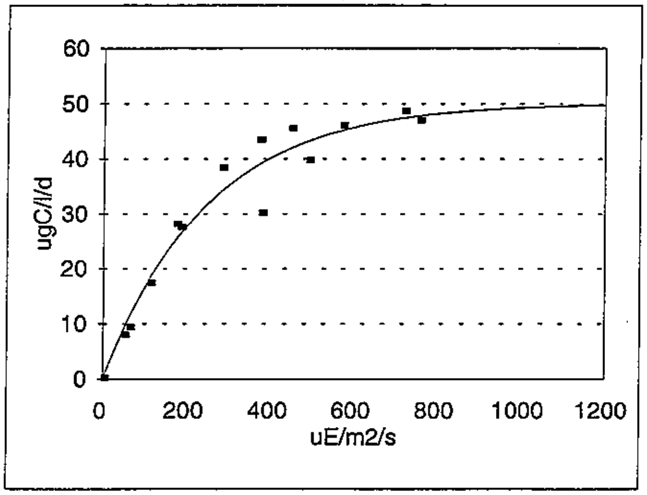
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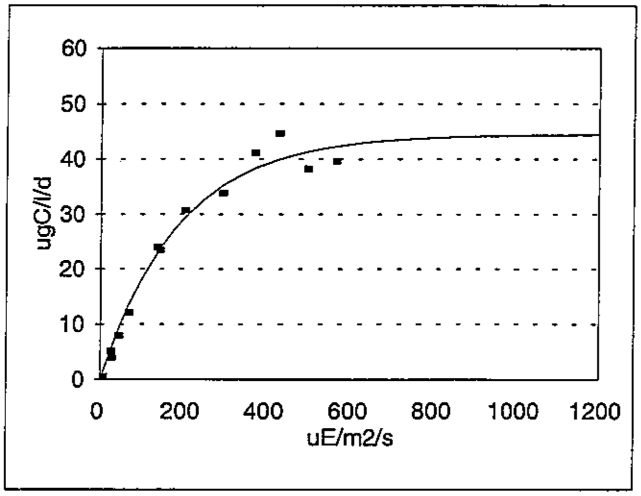
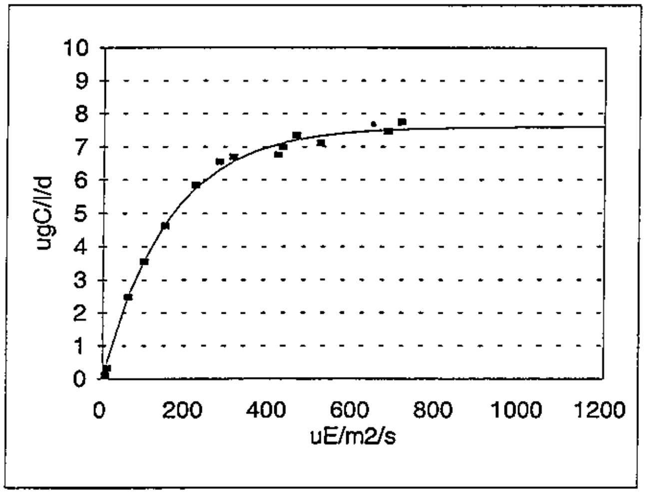

Mid-Bottom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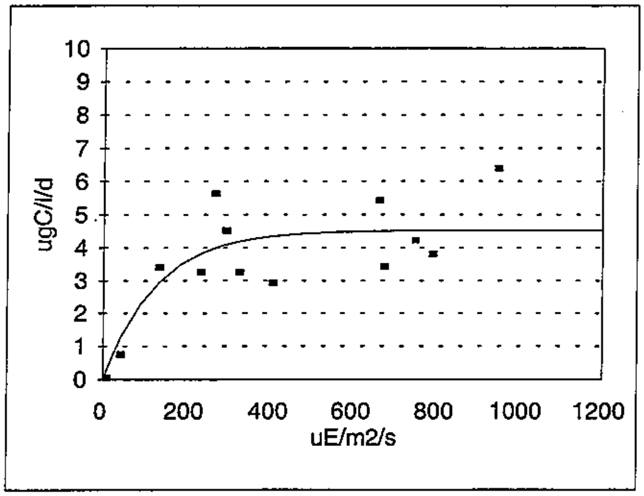
W9713 Station N04

Surface



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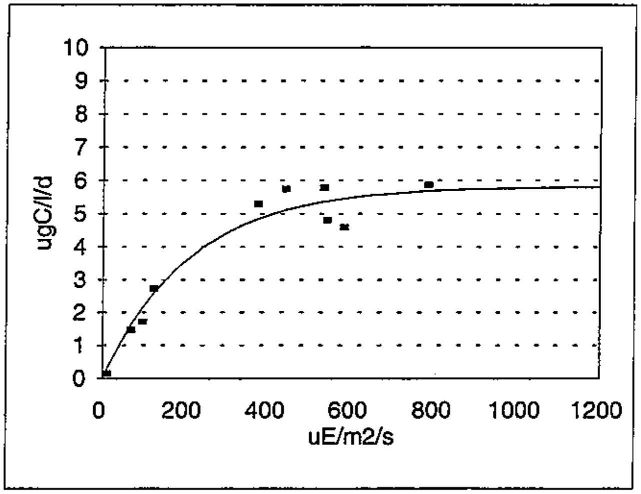

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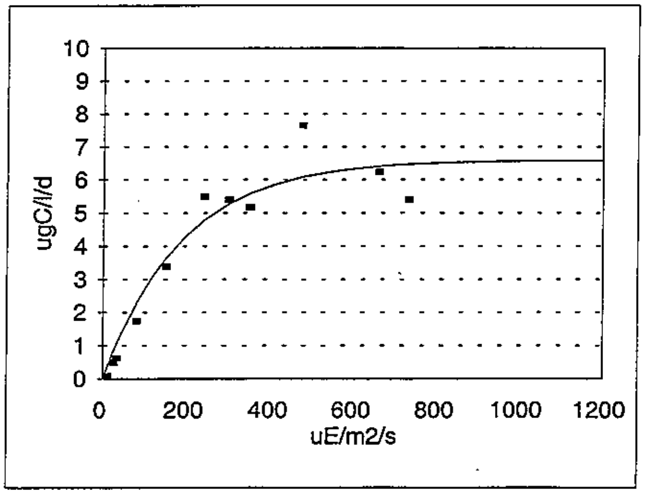
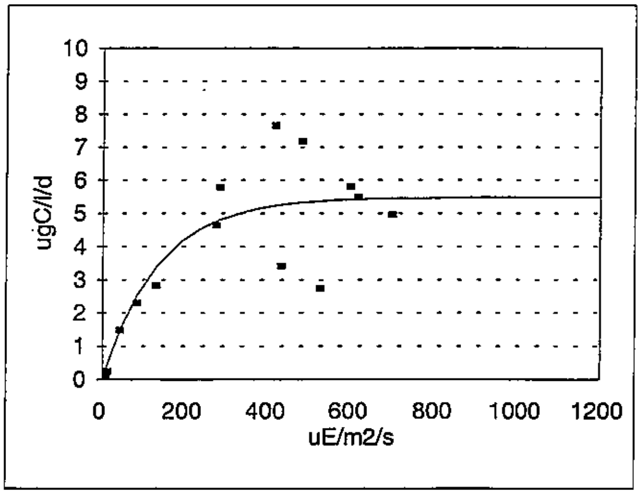
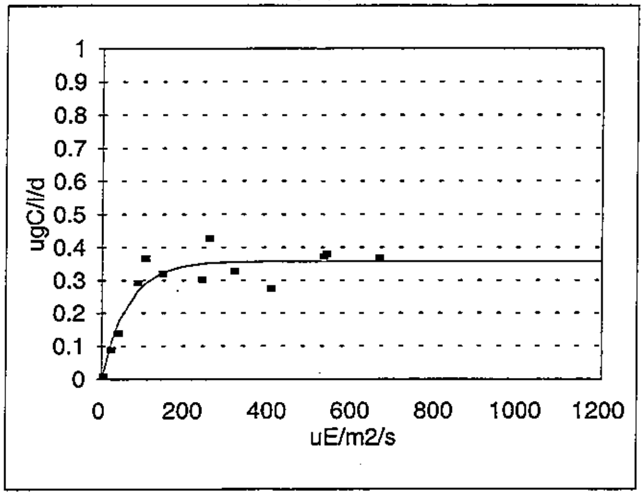


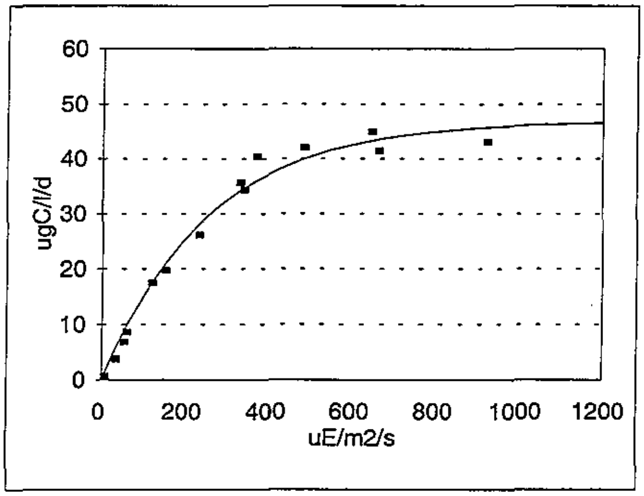
Mid-Bottom



Bottom



W9714 Station F23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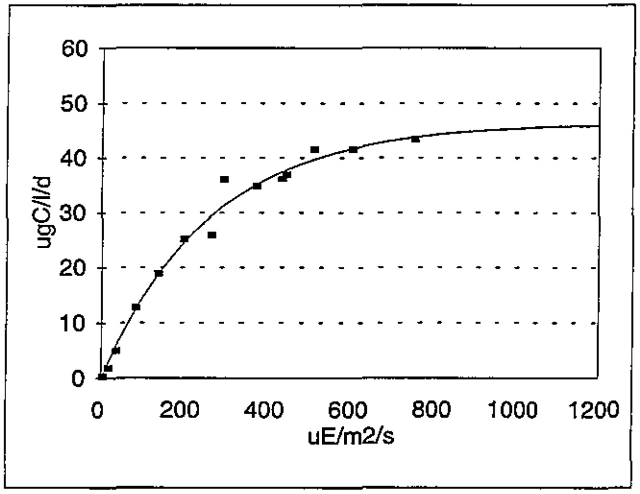
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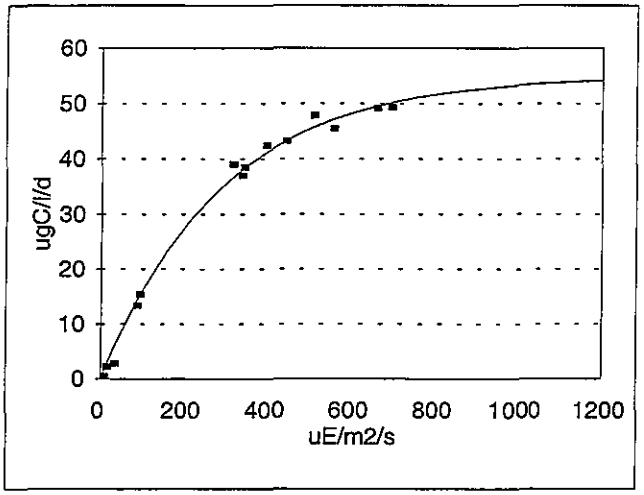
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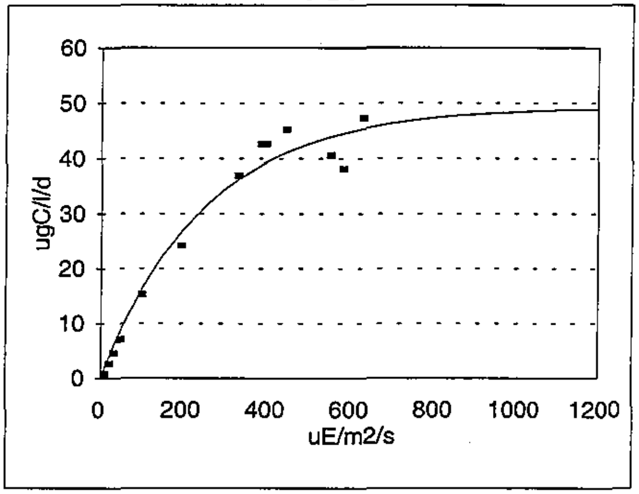
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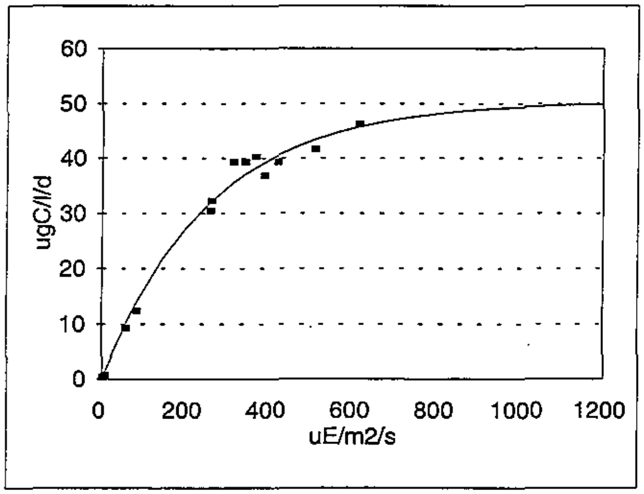
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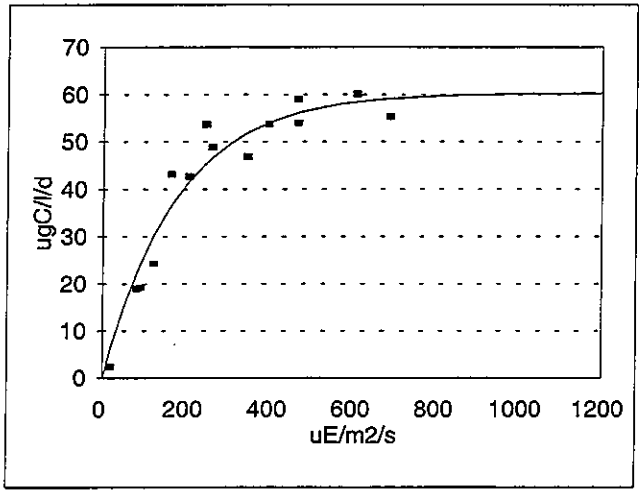
W9714 Station N18

Surface



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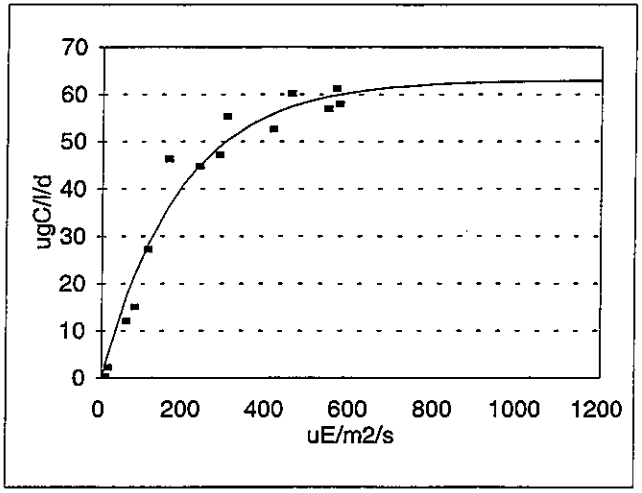

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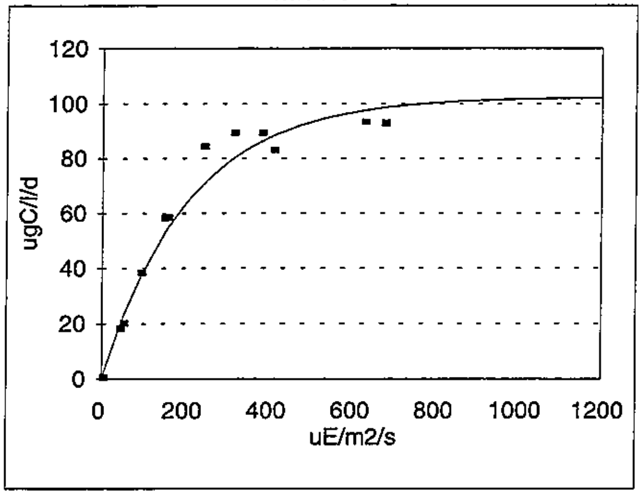
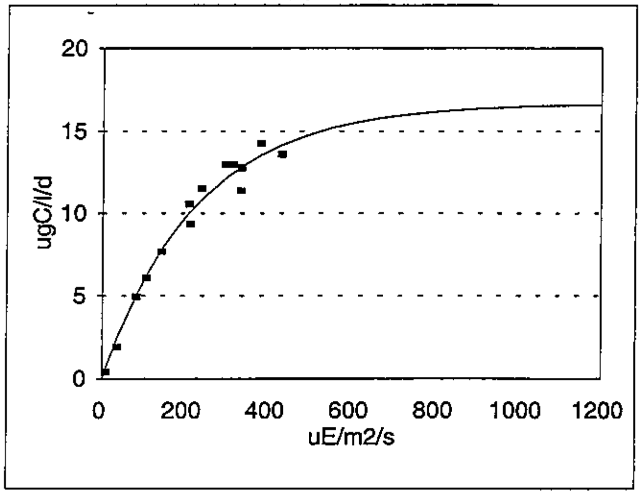


Mid-Bottom



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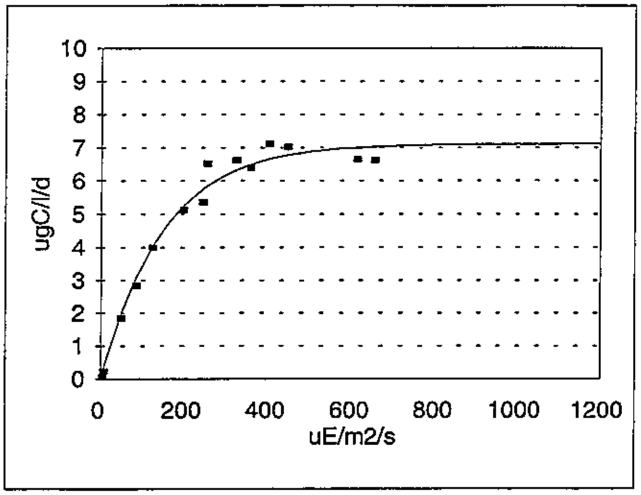
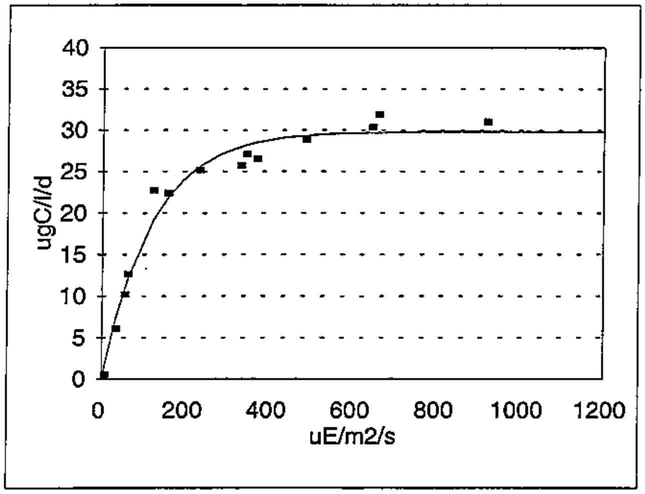


W9714 Station N04

Surface



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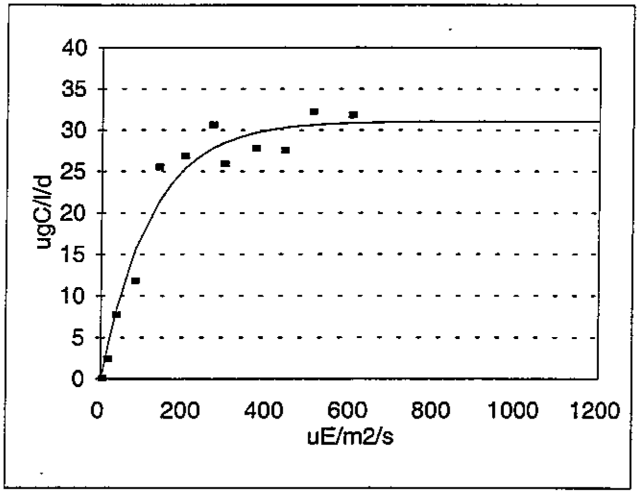

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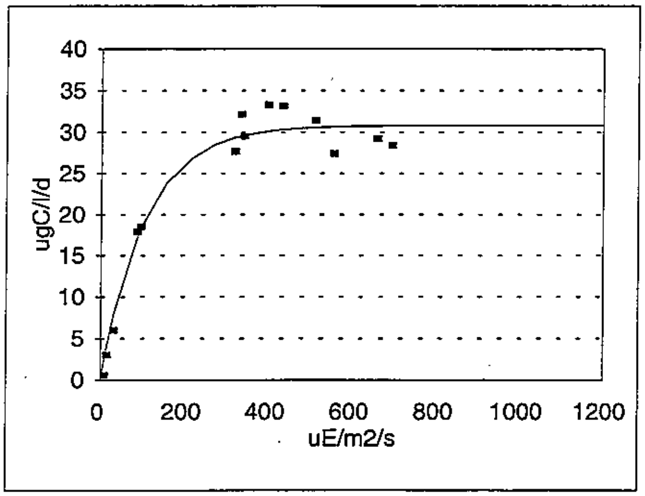

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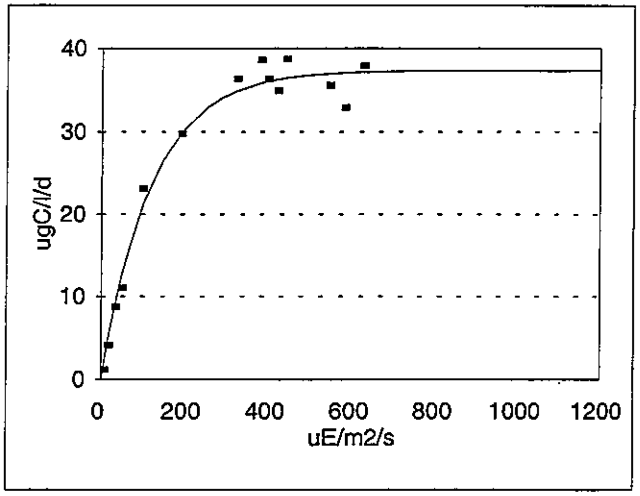

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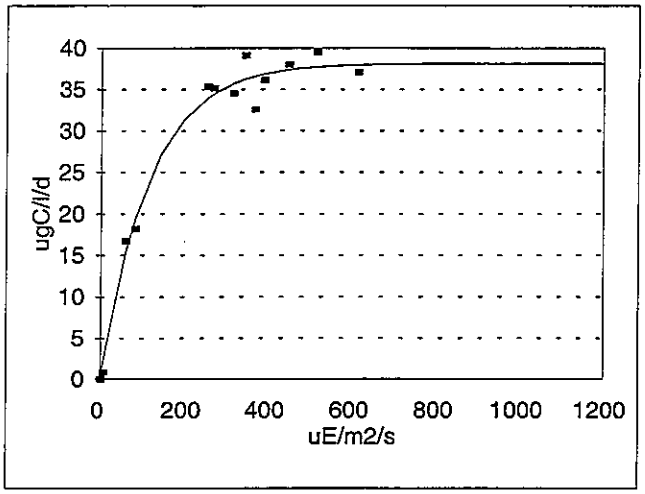
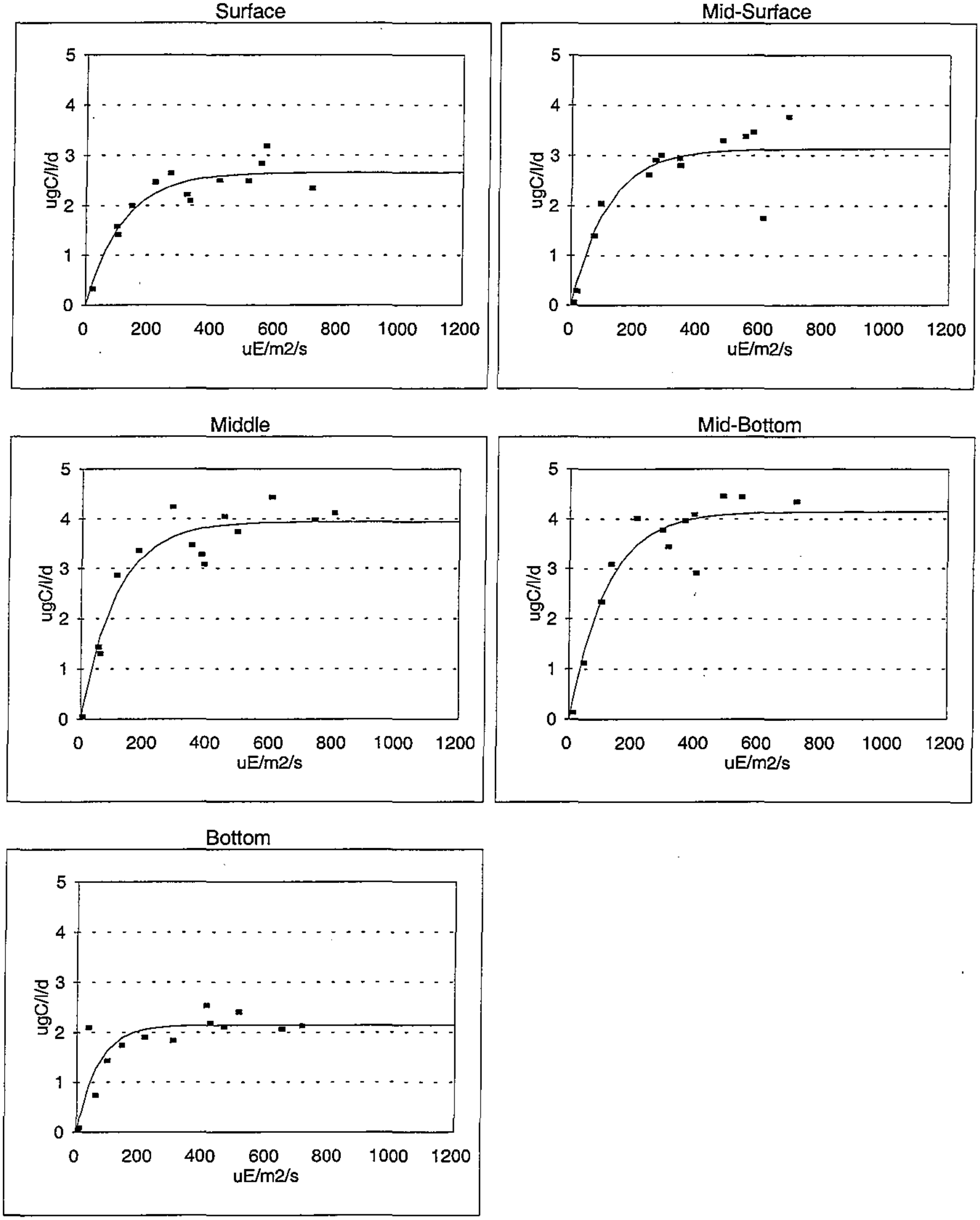


W9715 Station N18


Surface

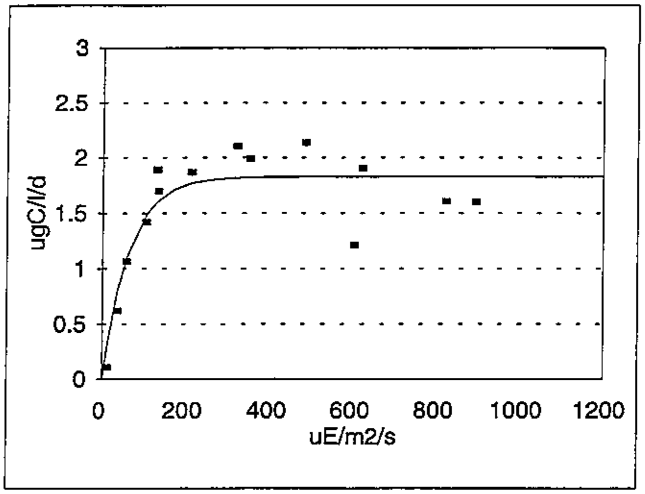
Mid-Surface

Middle

Mid-Bottom

Bottom

W9715 Station N04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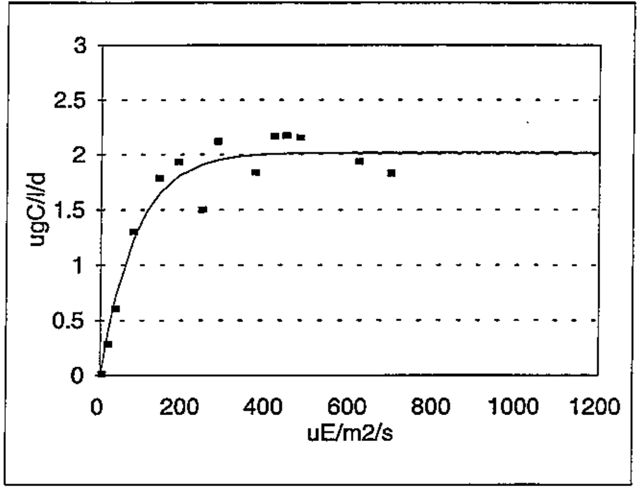
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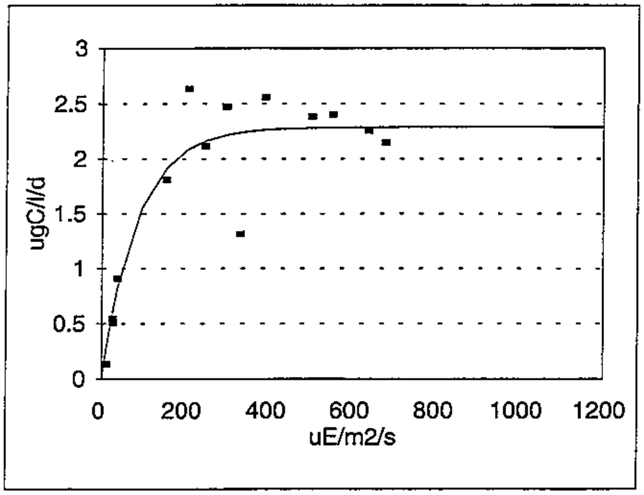
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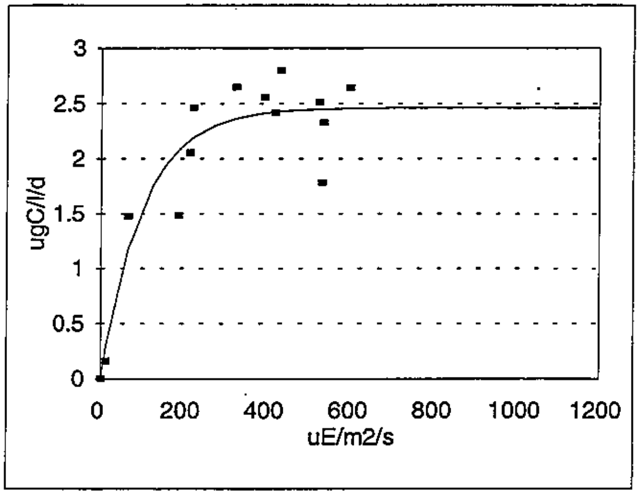
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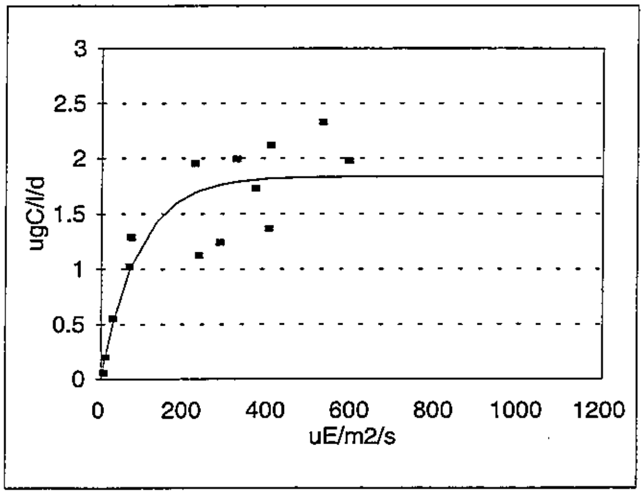
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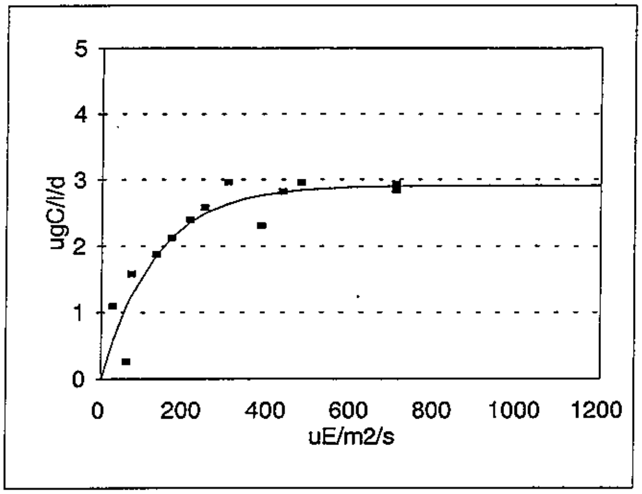
W9716 Station N18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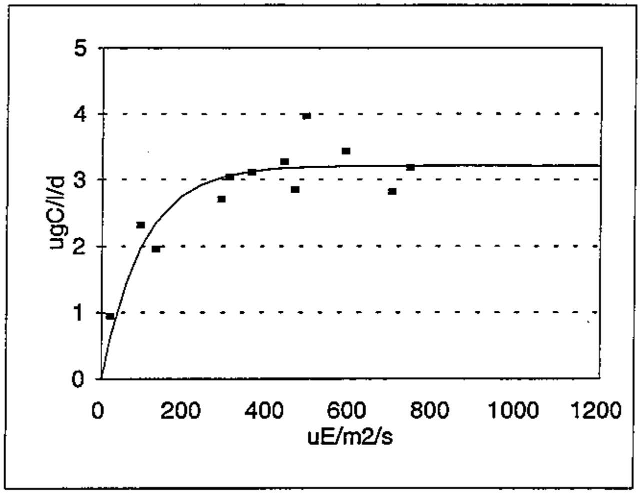
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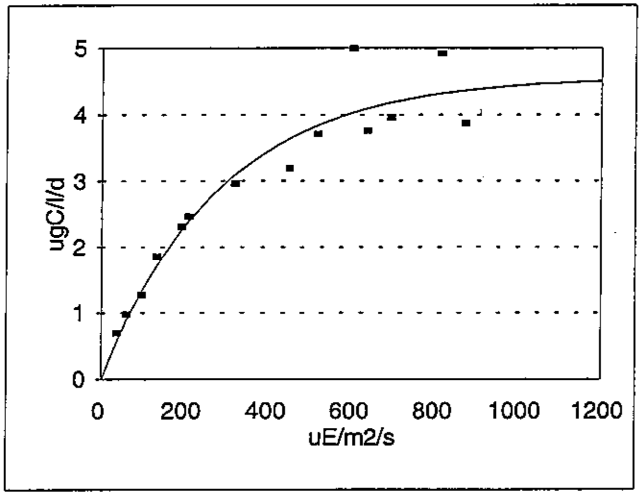
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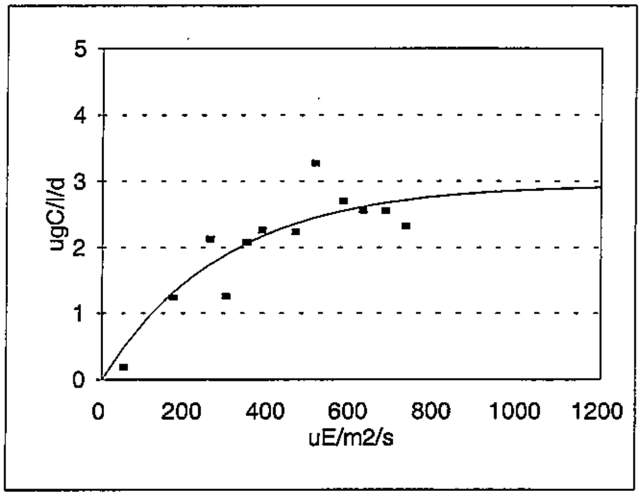
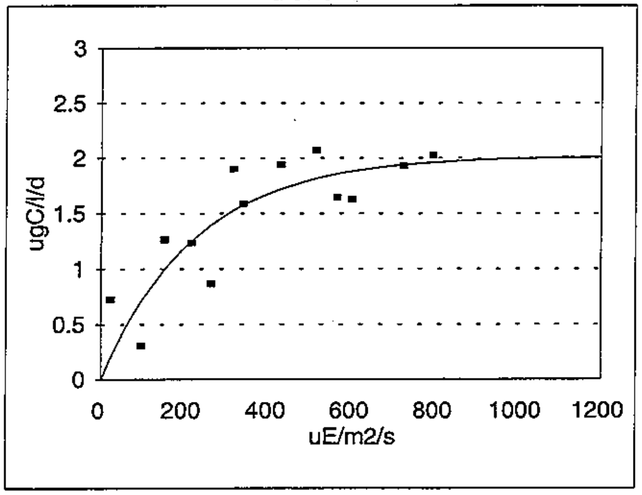
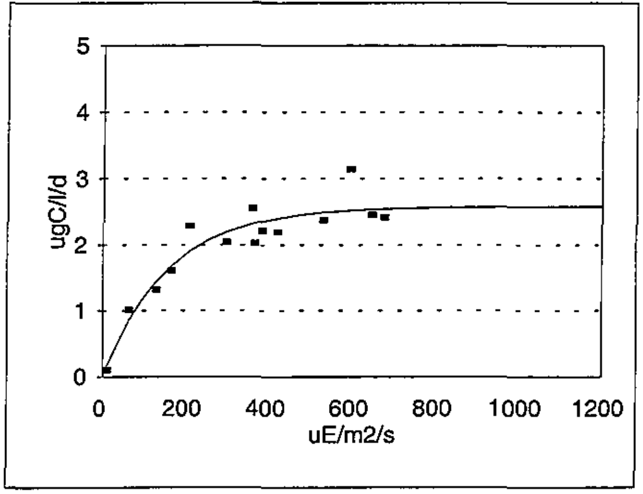

Mid-Bottom

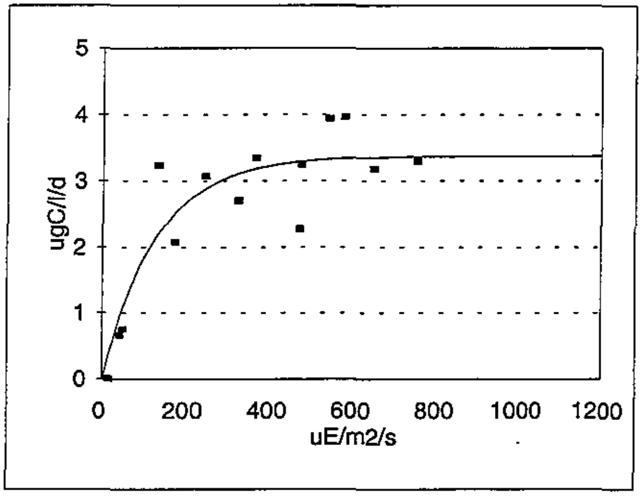

Bottom

W9716 Station N04

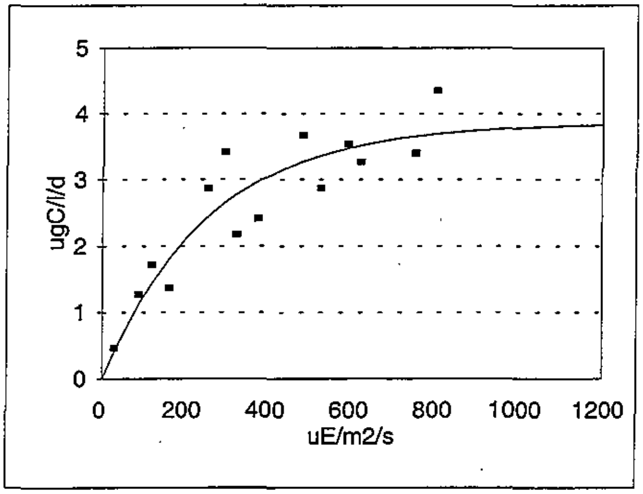
Surface



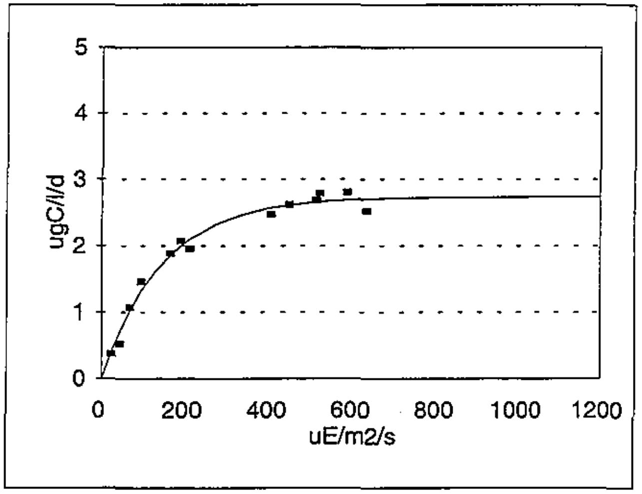
Mid-Surface



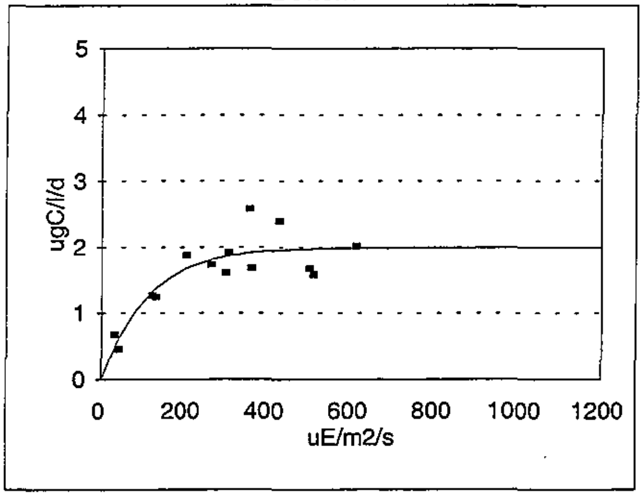
Middle



Mid-Bottom

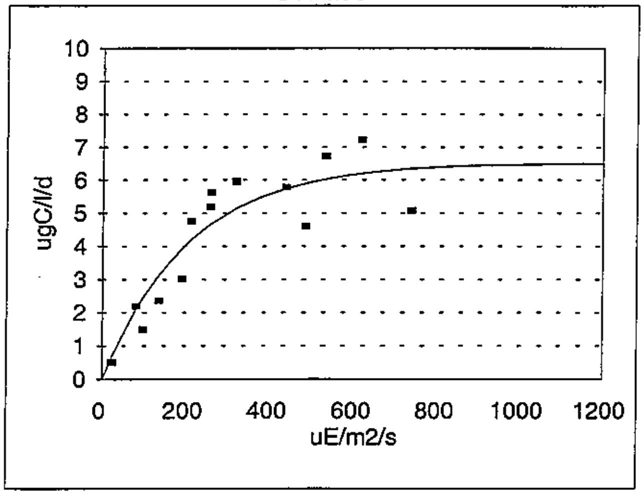


Bottom



W9717 Station N18

Surface



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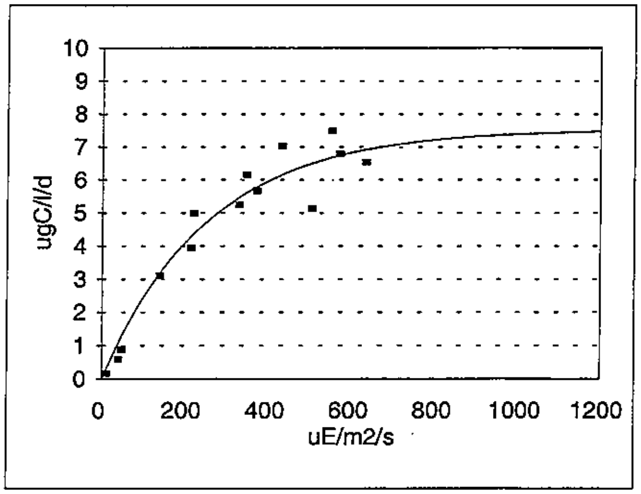
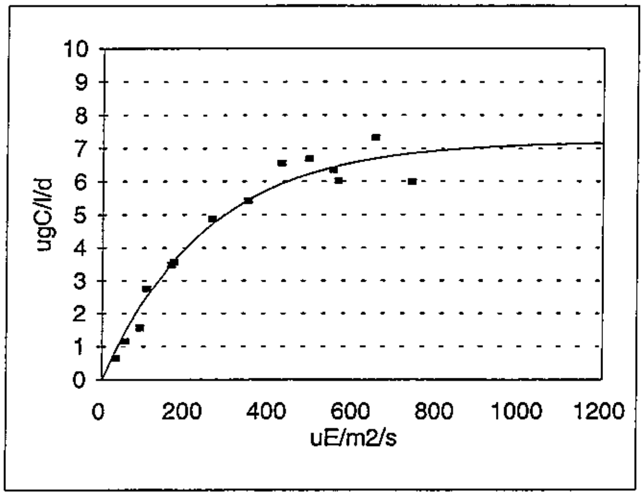
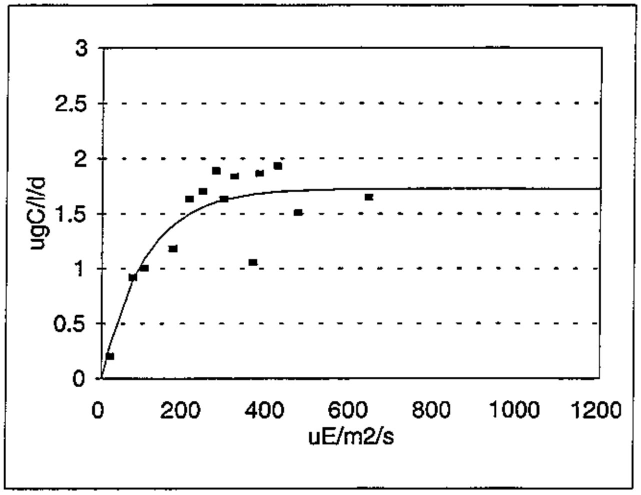


Middle



Mid-Bottom



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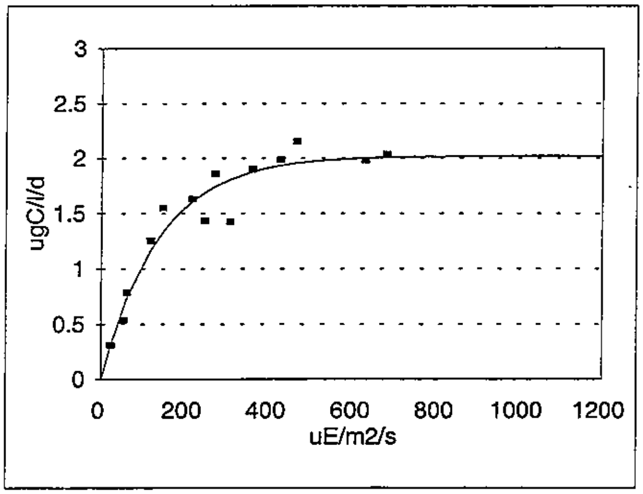
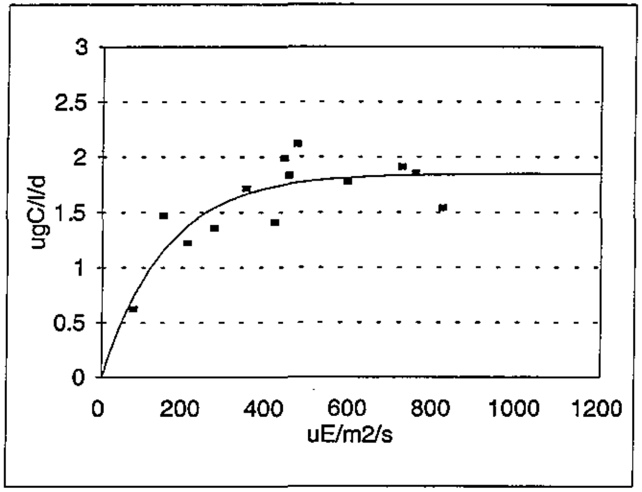
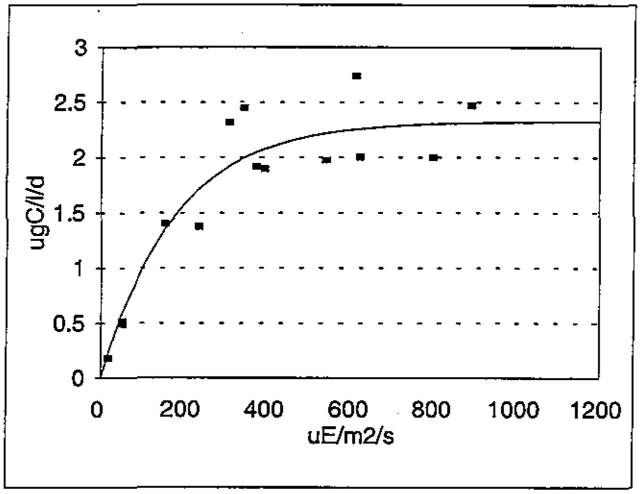


W9717 Station N04


Surface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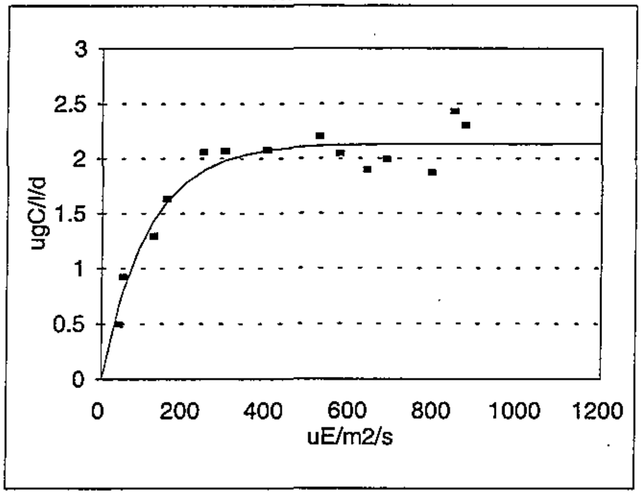
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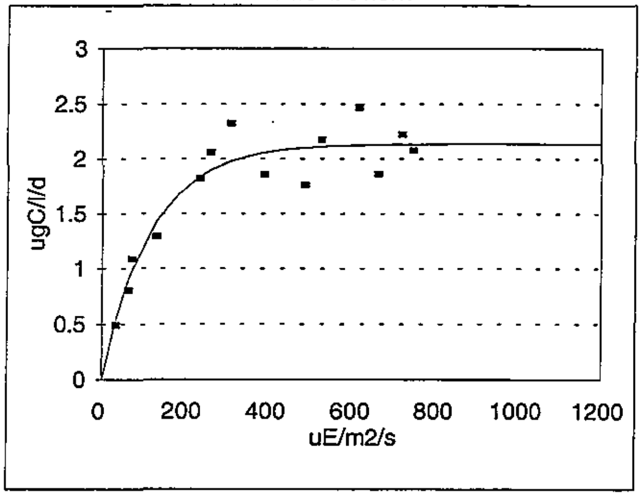
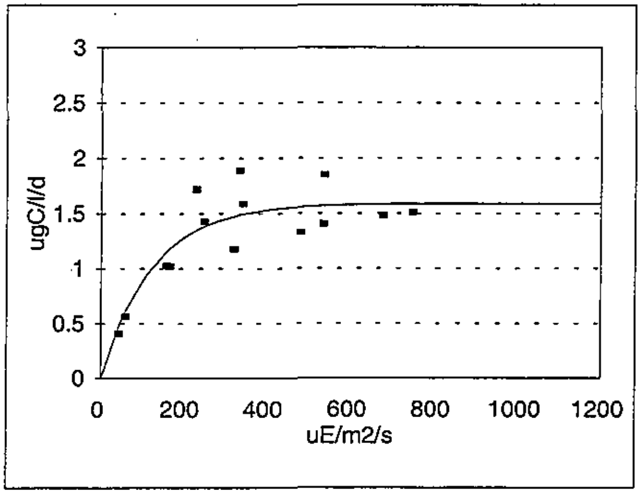

Mid-Bottom


Bottom

APPENDIX E-1

ABUNDANCE OF PREVALENT SPECIES IN WHOLE WATER SURFACE SAMPLES

Abundance of Prevalent Species (> 5% Total Count) in Surface Sample
Whole Water Phytoplankton, Survey W9710
August 5, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	10^6cells/L	0.11	0.04
		%	10	7
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	10^6cells/L	0.12	0.05
		%	11	9
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	10^6cells/L	0.71	0.47
		%	64	77
Group Definitions:	CD	Centric Diatom		
	DF	Dinoflagellate		
	MF	Microflagellate		
	HP	Haptophyte		
	CR	Cryptophyte		
	PD	Pennate Diatom		

Abundance of Prevalent Species (> 5% Total Count) in Surface Sample
Whole Water Phytoplankton, Survey W9711
August 18 - 20, 1997

Species	Group	Parameter	Station Cast												
			F01	F02	F06	F13	F23	F24	F25	F27	F30	F31	N04	N16	N18
ASTERIONELLA GLACIALIS	PD	10^6cells/L						0.45			0.46				
		%						14			13				
CHAETOCEROS SP#1 DIAM <10 MICRONS	CD	10^6cells/L										0.16			
		%										5			
CRYPTOMONAS SP#1 LENGTH <10 MICRONS	CR	10^6cells/L									0.24	0.37			
		%									7	12			
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	10^6cells/L				0.16	0.34		0.21		0.24	0.29			
		%				7	6		7		7	9			
CYCLOTELLA SP#1 DIAM <10 MICRONS	CD	10^6cells/L			0.12										
		%			6										
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	10^6cells/L			0.12	0.33				0.07			0.09	0.09	0.09
		%			6	14				9			19	18	12
RHIZOSOLENIA FRAGILISSIMA	CD	10^6cells/L	1.64	0.73	0.32	0.17									
		%	45	21	17	7									
SKELETONEMA COSTATUM GREV+CLEVE	CD	10^6cells/L	0.20	0.60	0.27	0.14	1.67	0.44	0.96		0.41	0.30			
		%	6	17	14	6	31	14	32		12	10			
THALASSIONEMA NITZSCHIOIDES	PD	10^6cells/L	0.19												
		%	5												
UNID. CENTRIC DIATOM DIAM <10 MICRONS	CD	10^6cells/L				0.14									
		%				6									
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	10^6cells/L	0.82	1.02	0.54	0.84	1.57	1.04	0.91	0.70	1.12	1.39	0.29	0.35	0.57
		%	23	30	28	35	29	32	31	80	32	44	60	70	73

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Abundance of Prevalent Species (> 5% Total Count) in Surface Sample
Whole Water Phytoplankton, Survey W9712
September 3, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	10^6cells/L	0.13	0.18
		%	9	9
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	10^6cells/L	0.18	0.15
		%	13	8
RHIZOSOLENIA FRAGILISSIMA	CD	10^6cells/L		0.10
		%		5
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	10^6cells/L	0.94	1.33
		%	68	68

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Abundance of Prevalent Species (> 5% Total Count) in Surface Sample
Whole Water Phytoplankton, Survey W9713
September 23, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	10^6cells/L		0.17
		%		5
CYCLOTELLA SP#1 DIAM <10 MICRONS	CD	10^6cells/L		0.37
		%		11
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	10^6cells/L	0.12	0.18
		%	6	5
THALASSIONEMA NITZSCHIOIDES	PD	10^6cells/L		0.26
		%		8
UNID. CENTRIC DIATOM DIAM 10-30 MICRONS	CD	10^6cells/L		0.31
		%		9
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	10^6cells/L	1.63	1.32
		%	83	40
Group Definitions:	CD	Centric Diatom		
	DF	Dinoflagellate		
	MF	Microflagellate		
	HP	Haptophyte		
	CR	Cryptophyte		
	PD	Pennate Diatom		

Abundance of Prevalent Species (> 5% Total Count) in Surface Sample
Whole Water Phytoplankton, Survey W9714
October 6 - 8, 1997

Species	Group	Parameter	Station Cast												
			F01	F02	F06	F13	F23	F24	F25	F27	F30	F31	N04	N16	N18
ASTERIONELLA GLACIALIS	PD	10^6cells/L					0.51	0.64	0.48		0.49	0.39		0.86	
		%					15	17	9		14	10		6	
CERATAULINA PELAGICA	CD	10^6cells/L			0.17										
		%			6										
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	10^6cells/L							0.31		0.35	0.23			
		%							6		10	6			
CYCLOTELLA SP#1 DIAM <10 MICRONS	CD	10^6cells/L	0.33		0.61	0.55			0.79	0.10		0.29	0.77	0.94	1.43
		%	12		19	14			16	6		8	11	7	12
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	10^6cells/L	0.16							0.10					
		%	6							6					
LEPTOCYLINDRUS DANICUS	CD	10^6cells/L					0.46	0.47	0.43		0.35	0.27			
		%					14	13	9		10	7			
LEPTOCYLINDRUS MINIMUS	CD	10^6cells/L					0.25	0.44	0.32		0.31	0.21			
		%					7	12	6		9	6			
PYRAMIMONAS SPP.	PR	10^6cells/L							0.25						
		%							5						
RHIZOSOLENIA FRAGILISSIMA	CD	10^6cells/L												0.69	
		%												5	
SKELETONEMA COSTATUM GREV+CLEVE	CD	10^6cells/L	0.33	0.75	0.16										
		%	11	24	5										
THALASSIONEMA NITZSCHIOIDES	PD	10^6cells/L						0.22			0.17	0.19			
		%						6			5	5			
THALASSIOSIRA SP#1 DIAM <20 MICRONS	CD	10^6cells/L												4.05	4.71
		%												30	38
UNID. CENTRIC DIATOM DIAM <10 MICRONS	CD	10^6cells/L				0.22			0.48	0.21		0.50	2.83		
		%				5			9	13		13	42		
UNID. CENTRIC DIATOM DIAM 10-30 MICRONS	CD	10^6cells/L	0.33	0.28	0.45	0.68									
		%	11	9	14	17									
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	10^6cells/L	1.24	1.44	1.05	1.74	1.10	1.06	1.00	1.04	1.17	0.97	1.18	1.76	1.68
		%	43	47	33	43	33	29	20	62	35	26	17	13	14
UNID. PENNATE DIATOM <10 MICRONS LENGTH	PD	10^6cells/L											0.65	1.93	1.52
		%											10	14	12

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Abundance of Prevalent Species (> 5% Total Count) in Surface Sample
Whole Water Phytoplankton, Survey W9715
October 28, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CRYPTOMONAS SP#1 LENGTH <10 MICRONS	CR	10^6cells/L	0.16	0.20
		%	12	14
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	10^6cells/L		0.12
		%		9
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	10^6cells/L	1.02	0.98
		%	75	69
Group Definitions:	CD	Centric Diatom		
	DF	Dinoflagellate		
	MF	Microflagellate		
	HP	Haptophyte		
	CR	Cryptophyte		
	PD	Pennate Diatom		

Abundance of Prevalent Species (> 5% Total Count) in Surface Sample
Whole Water Phytoplankton, Survey W9716
November 25, 1997

Species	Group	Parameter	Station Cast N04	Station Cast N18
CRYPTOMONAS SP#1 LENGTH <10 MICRONS	CR	10^6cells/L	0.12	0.12
		%	12	25
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	10^6cells/L		0.05
		%		11
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	10^6cells/L		0.03
		%		6
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	10^6cells/L	0.73	0.24
		%	75	50

Group Definitions:

CD	Centric Diatom
DF	Dinoflagellate
MF	Microflagellate
HP	Haptophyte
CR	Cryptophyte
PD	Pennate Diatom

Abundance of Prevalent Species (> 5% Total Count) in Surface Sample
Whole Water Phytoplankton, Survey W9717
December 16, 1997

Species	Group	Parameter	Station Cast N04	Station Cast N18
CRYPTOMONAS SP#1 LENGTH <10 MICRONS	CR	10^6cells/L	0.07	0.07
		%	13	10
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	10^6cells/L		0.04
		%		7
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	10^6cells/L	0.03	
		%	5	
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	10^6cells/L	0.38	0.47
		%	71	72
Group Definitions:	CD	Centric Diatom		
	DF	Dinoflagellate		
	MF	Microflagellate		
	HP	Haptophyte		
	CR	Cryptophyte		
	PD	Pennate Diatom		

APPENDIX E-2

ABUNDANCE OF PREVALENT SPECIES IN WHOLE WATER CHLOROPHYLL *a* MAXIMUM SAMPLES

Abundance of Prevalent Species (> 5% Total Count) in Chlorophyll *a* Maximum Sample
Whole Water Phytoplankton, Survey W9710
August 5, 1997

Species	Group	Parameter	Station Cast N04	Station Cast N18
CRYPTOMONAS SP#1 LENGTH <10 MICRONS	CR	10^6 cells/L	0.06	0.08
		%	7	8
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	10^6 cells/L	0.10	0.08
		%	12	9
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	10^6 cells/L	0.06	0.15
		%	7	16
PYRAMIMONAS SPP.	PR	10^6 cells/L		0.05
		%		6
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	10^6 cells/L	0.56	0.49
		%	66	54

Group Definitions:		
	CD	Centric Diatom
	CR	Cryptophyte
	DF	Dinoflagellate
	MF	Microflagellate
	PD	Pennate Diatom
	PR	Prasinophyte
	O	Other

Abundance of Prevalent Species (> 5% Total Count) in Chlorophyll *a* Maximum Sample
Whole Water Phytoplankton, Survey W9711
August 18 - 20, 1997

Species	Group	Parameter	Station Cast												
			F01	F02	F06	F13	F23	F24	F25	F27	F30	F31	N04	N16	N18
ASTERIONELLA GLACIALIS	PD	10^6 cells/L				0.17		0.06			0.46				
		%				9		6			16				
CHAETOCEROS SP#1 DIAM <10 MICRONS	CD	10^6 cells/L					0.25								
		%					5								
CRYPTOMONAS SP#1 LENGTH <10 MICRONS	CR	10^6 cells/L								0.20	0.15	0.29			
		%								11	5	8			
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	10^6 cells/L							0.23	0.33	0.14	0.20		0.10	0.03
		%							5	19	5	6		11	6
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	10^6 cells/L		0.17	0.07	0.15		0.08					0.03	0.12	0.12
		%		9	7	8		7					6	14	23
KATODINIUM ROTUNDATUM	DF	10^6 cells/L												0.16	
		%												19	
LEPTOCYLINDRUS MINIMUS	CD	10^6 cells/L						0.09							
		%						8							
RHIZOSOLENIA FRAGILISSIMA	CD	10^6 cells/L	1.76	0.24	0.09	0.12									
		%	35	13	9	6									
SKELETONEMA COSTATUM GREV+CLEVE	CD	10^6 cells/L	1.17	0.25	0.07	0.11	1.48	0.17	1.78		0.16	0.48			
		%	23	14	7	5	32	16	41		6	13			
UNID. CENTRIC DIATOM DIAM <10 MICRONS	CD	10^6 cells/L				0.12									
		%				6									
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	10^6 cells/L	1.04	0.71	0.54	0.71	1.45	0.33	1.17	1.12	1.13	1.87	0.47	0.40	0.28
		%	21	38	53	36	31	30	27	64	40	52	82	47	52

Group Definitions:	CD	Centric Diatom
	CR	Cryptophyte
	DF	Dinoflagellate
	MF	Microflagellate
	PD	Pennate Diatom
	PR	Prasinophyte
	O	Other

Abundance of Prevalent Species (> 5% Total Count) in Chlorophyll *a* Maximum Sample
Whole Water Phytoplankton, Survey W9712
September 3, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CRYPTOMONAS SP#1 LENGTH <10 MICRONS	CR	10^6 cells/L	0.16	0.20
		%	7	7
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	10^6 cells/L	0.19	0.20
		%	8	7
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	10^6 cells/L	0.15	0.30
		%	7	10
RHIZOSOLENIA FRAGILISSIMA	CD	10^6 cells/L		0.15
		%		5
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	10^6 cells/L	1.52	1.85
		%	69	63
Group Definitions:	CD	Centric Diatom		
	CR	Cryptophyte		
	DF	Dinoflagellate		
	MF	Microflagellate		
	PD	Pennate Diatom		
	PR	Prasinophyte		
	O	Other		

Abundance of Prevalent Species (> 5% Total Count) in Chlorophyll *a* Maximum Sample
Whole Water Phytoplankton, Survey W9713
September 23, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
ASTERIONELLA GLACIALIS	PD	10^6 cells/L		0.36
		%		10
CERATAULINA PELAGICA	CD	10^6 cells/L	0.02	
		%	11	
CRYPTOMONAS SP#1 LENGTH <10 MICRONS	CR	10^6 cells/L	0.04	
		%	17	
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	10^6 cells/L	0.02	
		%	9	
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	10^6 cells/L	0.03	
		%	16	
RHIZOSOLENIA FRAGILISSIMA	CD	10^6 cells/L		0.22
		%		6
THALASSIONEMA NITZSCHIOIDES	PD	10^6 cells/L		0.21
		%		6
UNID. CENTRIC DIATOM DIAM <10 MICRONS	CD	10^6 cells/L		0.32
		%		9
UNID. CENTRIC DIATOM DIAM 10-30 MICRONS	CD	10^6 cells/L		0.31
		%		9
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	10^6 cells/L	0.06	1.33
		%	28	37

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	O	Other
	PD	Pennate Diatom

Abundance of Prevalent Species (> 5% Total Count) in Chlorophyll *a* Maximum Sample
Whole Water Phytoplankton, Survey W9714
October 6 - 8, 1997

Species	Group	Parameter	Station Cast F01	F02	F06	F13	F23	F24	F25	F27	F30	F31	N04	N16	N18
ASTERIONELLA GLACIALIS	PD	10^6 cells/L					0.84	1.41	0.40		0.61	0.32	0.48	0.71	
		%					26	30	7		18	11	6	7	
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	10^6 cells/L									0.19	0.24			
		%									6	8			
CYCLOTELLA SP#1 DIAM <10 MICRONS	CD	10^6 cells/L	0.25		0.71	0.59			1.70			0.32	0.92	0.53	0.98
		%	9		17	30			29			11	12	5	7
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	10^6 cells/L								0.02					
		%								9					
LEPTOCYLINDRUS DANICUS	CD	10^6 cells/L					0.41	0.53	0.40		0.46	0.24			
		%					13	11	7		13	8			
LEPTOCYLINDRUS MINIMUS	CD	10^6 cells/L					0.30	0.41			0.36	0.16			
		%					9	9			10	5			
RHIZOSOLENIA DELICATULA	CD	10^6 cells/L												0.53	
		%												5	
RHIZOSOLENIA FRAGILISSIMA	CD	10^6 cells/L											0.43		0.91
		%											5		7
SKELETONEMA COSTATUM GREV+CLEVE	CD	10^6 cells/L	0.65	0.57	0.45	0.14									
		%	23	24	11	7									
THALASSIONEMA NITZSCHIOIDES	PD	10^6 cells/L						0.25							
		%						5							
THALASSIOSIRA SP#1 DIAM <20 MICRONS	CD	10^6 cells/L											3.27	3.13	7.66
		%											42	33	57
UNID. CENTRIC DIATOM DIAM <10 MICRONS	CD	10^6 cells/L	0.14	0.27	0.81	0.25		0.38	0.88		0.24				
		%	5	12	20	13		8	15		7				
UNID. CENTRIC DIATOM DIAM 10-30 MICRONS	CD	10^6 cells/L	0.27	0.12											
		%	10	5											
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	10^6 cells/L	1.18	1.04	1.19	0.63	0.86	1.02	1.14	0.14	0.97	1.12	0.71	1.27	
		%	42	44	29	32	27	22	19	78	28	37	9	13	
UNID. PENNATE DIATOM <10 MICRONS LENGTH	PD	10^6 cells/L											0.57	1.63	1.25
		%											7	17	9

Group Definitions:		
	CD	Centric Diatom
	CR	Cryptophyte
	DF	Dinoflagellate
	MF	Microflagellate
	PD	Pennate Diatom
	PR	Prasinophyte
	O	Other

Abundance of Prevalent Species (> 5% Total Count) in Chlorophyll *a* Maximum Sample
Whole Water Phytoplankton, Survey W9715
October 28, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CRYPTOMONAS SP#1 LENGTH <10 MICRONS	CR	10^6 cells/L	0.15	0.15
		%	16	17
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	10^6 cells/L	0.08	0.07
		%	8	9
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	10^6 cells/L	0.08	
		%	9	
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	10^6 cells/L	0.57	0.48
		%	61	58

Group Definitions:		
	CD	Centric Diatom
	CR	Cryptophyte
	DF	Dinoflagellate
	MF	Microflagellate
	PD	Pennate Diatom
	PR	Prasinophyte
	O	Other

Abundance of Prevalent Species (> 5% Total Count) in Chlorophyll *a* Maximum Sample
Whole Water Phytoplankton, Survey W9716
November 25, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CRYPTOMONAS SP#1 LENGTH <10 MICRONS	CR	10^6 cells/L	0.13	0.13
		%	26	24
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	10^6 cells/L	0.04	0.03
		%	7	6
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	10^6 cells/L	0.03	
		%	6	
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	10^6 cells/L	0.28	0.34
		%	55	61

Group Definitions:		
	CD	Centric Diatom
	CR	Cryptophyte
	DF	Dinoflagellate
	MF	Microflagellate
	PD	Pennate Diatom
	PR	Prasinophyte
	O	Other

Abundance of Prevalent Species (> 5% Total Count) in Chlorophyll *a* Maximum Sample
Whole Water Phytoplankton, Survey W9717
December 16, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CRYPTOMONAS SP#1 LENGTH <10 MICRONS	CR	10^6 cells/L	0.09	0.09
		%	16	17
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	10^6 cells/L		0.06
		%		10
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	10^6 cells/L	0.03	
		%	6	
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	10^6 cells/L	0.39	0.32
		%	68	58

Group Definitions:		
	CD	Centric Diatom
	CR	Cryptophyte
	DF	Dinoflagellate
	MF	Microflagellate
	PD	Pennate Diatom
	PR	Prasinophyte
	O	Other

APPENDIX F-1

ABUNDANCE OF PREVALENT SPECIES IN SCREENED SURFACE SAMPLES

Abundance of Prevalent Species (> 5% Total Count) in Surface Sample
Screened Phytoplankton, Survey W9710
August 5, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM FUSUS	DF	10^6 cells/L		1.23E-05
		%		7
CERATIUM LONGIPES	DF	10^6 cells/L	1.68E-03	1.20E-04
		%	93	71
CERATIUM TRIPOS	DF	10^6 cells/L		3.00E-05
		%		18

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Abundance of Prevalent Species (> 5% Total Count) in Surface Sample
Screened Phytoplankton, Survey W9711
August 18 - 20, 1997

Species	Group	Parameter	Station Cast												
			F01	F02	F06	F13	F23	F24	F25	F27	F30	F31	N04	N16	N18
CERATIUM FUSUS	DF	10^6 cells/L		7.60E-05		1.48E-04	1.77E-05	4.56E-05	1.40E-05	1.72E-05	1.31E-05	1.10E-05	8.10E-05	3.06E-05	1.54E-05
		%		5		19	12	8	5	16	24	9	33	28	22
CERATIUM LONGIPES	DF	10^6 cells/L				6.70E-05	7.28E-05	2.23E-04	2.16E-04	2.81E-05	1.77E-05	8.14E-05	9.99E-05	4.55E-05	2.44E-05
		%				9	48	37	84	27	33	67	41	41	35
CERATIUM TRIPOS	DF	10^6 cells/L				9.11E-05	1.43E-05		2.41E-05	5.23E-05	6.16E-06	1.47E-05	4.46E-05	2.99E-05	1.93E-05
		%				12	9		9	50	11	12	18	27	27
DIPLOPSALIS SPP.	DF	10^6 cells/L				1.17E-04	2.18E-05				1.08E-05	8.93E-06			
		%				15	14				20	7			
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	10^6 cells/L	3.43E-04												
		%	6												
GYMNODINIUM SP.#2 21-40UM W 21-50UM L	DF	10^6 cells/L				4.15E-05									
		%				5									
NITZSCHIA PUNGENS	PD	10^6 cells/L	2.22E-03	1.01E-03	3.08E-03										
		%	41	72	60										
NITZSCHIA SERIATA	PD	10^6 cells/L	2.45E-03	1.88E-04	1.79E-03										
		%	46	13	35										
PROTOPERIDINIUM MINUTUM	DF	10^6 cells/L						5.16E-05							
		%						9							
PROTOPERIDINIUM SP.#1 10-30W 10-40L	DF	10^6 cells/L				2.27E-04		2.27E-04							
		%				29		38							
PROTOPERIDINIUM SP.#2 31-75W 41-80L	DF	10^6 cells/L					8.84E-06								
		%					6								
SCRIPPSIELLA TROCHOIDEA	DF	10^6 cells/L													4.48E-06
		%													6

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Abundance of Prevalent Species (> 5% Total Count) in Surface Sample
Screened Phytoplankton, Survey W9712
September 3, 1997

Species	Group	Parameter	Station Cast N04	Station Cast N18
CERATIUM FUSUS	DF	10^6 cells/L	2.22E-05	1.32E-05
		%	8	12
CERATIUM LONGIPES	DF	10^6 cells/L	3.99E-05	7.92E-06
		%	14	7
CERATIUM TRIPOS	DF	10^6 cells/L	2.15E-04	8.91E-05
		%	77	79

Group Definitions:	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Abundance of Prevalent Species (> 5% Total Count) in Surface Sample
Screened Phytoplankton, Survey W9713
September 23, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM FUSUS	DF	10^6 cells/L	1.33E-05	
		%	25	
CERATIUM LONGIPES	DF	10^6 cells/L	1.33E-05	4.80E-05
		%	25	10
CERATIUM TRIPOS	DF	10^6 cells/L	2.55E-05	3.93E-04
		%	48	82

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Abundance of Prevalent Species (> 5% Total Count) in Surface Sample
Screened Phytoplankton, Survey W9714
October 6 - 8, 1997

Species	Group	Parameter	Station Cast												
			F01	F02	F06	F13	F23	F24	F25	F27	F30	F31	N04	N16	N18
CERATIUM LONGIPES	DF	10^6 cells/L			2.74E-05		1.78E-05	1.49E-05	7.88E-05	8.70E-06	6.00E-06	4.50E-06	1.98E-05	3.87E-05	1.32E-05
		%			5		54	30	47	55	27	26	12	33	20
CERATIUM TRIPOS	DF	10^6 cells/L					1.14E-05	3.34E-05	7.46E-05	5.80E-06	1.15E-05	1.13E-05	1.33E-04	7.40E-05	4.64E-05
		%					35	66	45	37	51	65	80	63	71
DINOPHYSIS NORVEGICA	DF	10^6 cells/L					2.50E-06								
		%					8								
DINOPHYSIS PUNCTATA	DF	10^6 cells/L									1.50E-06				
		%									7				
NITZSCHIA PUNGENS	PD	10^6 cells/L	1.19E-03	2.23E-04	4.10E-04	7.25E-04									
		%	91	56	77	96									
NITZSCHIA SERIATA	PD	10^6 cells/L	9.43E-05	1.40E-04	5.98E-05										
		%	7	35	11										
PROTOPERIDINIUM SP.#1 10-30W 10-40L	DF	10^6 cells/L									2.00E-06				
		%									9				
Group Definitions:	CD	Centric Diatom													
	DF	Dinoflagellate													
	MF	Microflagellate													
	HP	Haptophyte													
	CR	Cryptophyte													
	PD	Pennate Diatom													

Abundance of Prevalent Species (> 5% Total Count) in Surface Sample
Screened Phytoplankton, Survey W9715
October 28, 1997

Species	Group	Parameter	Station Cast N04	Station Cast N18
CERATIUM FUSUS	DF	10^6 cells/L	3.00E-05	2.13E-05
		%	13	10
CERATIUM LONGIPES	DF	10^6 cells/L	1.15E-05	1.85E-05
		%	5	9
CERATIUM TRIPOS	DF	10^6 cells/L	1.74E-04	1.60E-04
		%	77	76

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Abundance of Prevalent Species (> 5% Total Count) in Surface Sample
Screened Phytoplankton, Survey W9716
November 25, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM FUSUS	DF	10^6 cells/L	6.69E-05	6.13E-05
		%	42	43
CERATIUM LONGIPES	DF	10^6 cells/L	1.38E-05	8.00E-06
		%	9	6
CERATIUM TRIPOS	DF	10^6 cells/L	7.52E-05	6.73E-05
		%	47	48

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Abundance of Prevalent Species (> 5% Total Count) in Surface Sample
Screened Phytoplankton, Survey W9717
December 16, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM FUSUS	DF	10^6 cells/L	3.85E-05	1.20E-05
		%	30	31
CERATIUM LONGIPES	DF	10^6 cells/L	1.60E-05	4.70E-06
		%	12	12
CERATIUM TRIPOS	DF	10^6 cells/L	6.38E-05	1.82E-05
		%	49	47
Group Definitions:	CD	Centric Diatom		
	DF	Dinoflagellate		
	MF	Microflagellate		
	HP	Haptophyte		
	CR	Cryptophyte		
	PD	Pennate Diatom		

APPENDIX F-2

ABUNDANCE OF PREVALENT SPECIES IN SCREENED CHLOROPHYLL *a* MAXIMUM SAMPLES

Abundance of Prevalent Species (> 5% Total Count) in Chlorophyll *a* Maximum Sample
Screened Phytoplankton, Survey W9710
August 5, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM FUSUS	DF	10^6 cells/L		1.04E-05
		%		7
CERATIUM LONGIPES	DF	10^6 cells/L	3.23E-03	1.25E-04
		%	98	79
CERATIUM TRIPOS	DF	10^6 cells/L		1.85E-05
		%		12
Group Definitions:	CD	Centric Diatom		
	DF	Dinoflagellate		
	MF	Microflagellate		
	PD	Pennate Diatom		

Abundance of Prevalent Species (> 5% Total Count) in Chlorophyll *a* Maximum Sample
Screened Phytoplankton, Survey W9711
August 18 - 20, 1997

Species	Group	Parameter	Station Cast												
			F01	F02	F06	F13	F23	F24	F25	F27	F30	F31	N04	N16	N18
CERATIUM FUSUS	DF	10^6 cells/L				4.48E-05	2.72E-05	1.58E-05	1.93E-05		6.55E-06	8.40E-06			1.02E-04
		%				10	10	7	14		7	11			33
CERATIUM LONGIPES	DF	10^6 cells/L		8.82E-05	3.31E-04	1.69E-04	1.65E-04	1.93E-04	6.78E-05	6.63E-05	3.85E-05	5.36E-05	1.81E-04	1.99E-04	1.22E-04
		%		5	16	38	58	83	51	44	43	69	93	93	40
CERATIUM TRIPOS	DF	10^6 cells/L				4.33E-05	1.84E-05	1.96E-05	1.44E-05	8.03E-05	4.91E-06	7.20E-06			4.12E-05
		%				10	7	8	11	53	6	9			13
DIPLOPSALIS SPP.	DF	10^6 cells/L				3.50E-05	3.28E-05		7.92E-06						
		%				8	12		6						
NITZSCHIA PUNGENS	PD	10^6 cells/L	2.49E-03		1.07E-03	2.36E-05									
		%	48		53	5									
NITZSCHIA SERIATA	PD	10^6 cells/L	1.97E-03	1.34E-03	5.59E-04										
		%	38	83	27										
PROTOPERIDINIUM PYRIFORME	DF	10^6 cells/L													1.92E-05
		%													6
PROTOPERIDINIUM SP.#1 10-30W 10-40L	DF	10^6 cells/L				3.34E-05	2.16E-05		1.29E-05		1.06E-05				
		%				7	8		10		12				
PROTOPERIDINIUM SP.#2 31-75W 41-80L	DF	10^6 cells/L									1.47E-05				
		%									17				
SCRIPPSIELLA TROCHOIDEA	DF	10^6 cells/L									4.91E-06				
		%									6				

Group Definitions:	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	PD	Pennate Diatom

Abundance of Prevalent Species (> 5% Total Count) in Chlorophyll *a* Maximum Sample
Screened Phytoplankton, Survey W9712
September 3, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM FUSUS	DF	10^6 cells/L		1.71E-05
		%		12
CERATIUM LONGIPES	DF	10^6 cells/L	1.17E-04	2.92E-05
		%	38	20
CERATIUM TRIPOS	DF	10^6 cells/L	1.70E-04	9.46E-05
		%	56	66

Group Definitions:	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	PD	Pennate Diatom

Abundance of Prevalent Species (> 5% Total Count) in Chlorophyll *a* Maximum Sample
Screened Phytoplankton, Survey W9713
September 23, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM LONGIPES	DF	10^6 cells/L	1.14E-04	2.70E-05
		%	10	16
CERATIUM TRIPOS	DF	10^6 cells/L	9.85E-04	1.30E-04
		%	87	77

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	PD	Pennate Diatom

Abundance of Prevalent Species (> 5% Total Count) in Chlorophyll *a* Maximum Sample
Screened Phytoplankton, Survey W9714
October 6 - 8, 1997

Species	Group	Parameter	Station Cast												
			F01	F02	F06	F13	F23	F24	F25	F27	F30	F31	N04	N16	N18
CERATIUM FUSUS	DF	10^6 cells/L											2.05E-05		
		%											6		
CERATIUM LONGIPES	DF	10^6 cells/L	1.11E-04				5.70E-06	1.29E-05	2.91E-05	7.00E-06	2.90E-06	1.02E-04	5.20E-05	3.74E-05	2.00E-05
		%	8				36	38	23	34	26	49	15	41	11
CERATIUM TRIPOS	DF	10^6 cells/L	1.08E-04		5.48E-05	6.72E-05	8.60E-06	2.07E-05	8.66E-05	1.02E-05	6.20E-06	1.00E-04	2.61E-04	5.25E-05	1.44E-04
		%	8		5	88	54	61	69	49	56	48	76	57	78
DINOPHYSIS OVUM	DF	10^6 cells/L									1.00E-06				
		%									9				
NITZSCHIA PUNGENS	PD	10^6 cells/L	9.99E-04	8.13E-04	7.20E-04										
		%	76	76	71										
NITZSCHIA SERIATA	PD	10^6 cells/L	8.10E-05	2.14E-04	1.68E-04										
		%	6	20	17										
PROTOPERIDINIUM DEPRESSUM	DF	10^6 cells/L								1.60E-06					
		%								8					
Group Definitions:	CD	Centric Diatom													
	DF	Dinoflagellate													
	MF	Microflagellate													
	PD	Pennate Diatom													

Abundance of Prevalent Species (> 5% Total Count) in Chlorophyll *a* Maximum Sample
Screened Phytoplankton, Survey W9715
October 28, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM FUSUS	DF	10^6 cells/L	2.24E-05	3.64E-05
		%	12	15
CERATIUM LONGIPES	DF	10^6 cells/L	1.59E-05	
		%	9	
CERATIUM TRIPOS	DF	10^6 cells/L	1.40E-04	1.88E-04
		%	76	76
Group Definitions:	CD	Centric Diatom		
	DF	Dinoflagellate		
	MF	Microflagellate		
	PD	Pennate Diatom		

Abundance of Prevalent Species (> 5% Total Count) in Chlorophyll *a* Maximum Sample
Screened Phytoplankton, Survey W9716
November 25, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM FUSUS	DF	10^6 cells/L	6.45E-05	4.70E-05
		%	39	41
CERATIUM LONGIPES	DF	10^6 cells/L	1.10E-05	8.60E-06
		%	7	7
CERATIUM TRIPOS	DF	10^6 cells/L	8.25E-05	5.44E-05
		%	50	47

Group Definitions:	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	PD	Pennate Diatom

Abundance of Prevalent Species (> 5% Total Count) in Chlorophyll *a* Maximum Sample
Screened Phytoplankton, Survey W9717
December 16, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM FUSUS	DF	10^6 cells/L	3.45E-05	1.78E-05
		%	35	38
CERATIUM LONGIPES	DF	10^6 cells/L	5.70E-06	2.50E-06
		%	6	5
CERATIUM TRIPOS	DF	10^6 cells/L	4.92E-05	2.28E-05
		%	50	48
PROROCENTRUM GRACILE	DF	10^6 cells/L	5.10E-06	
		%	5	

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	PD	Pennate Diatom

APPENDIX G

ZOOPLANKTON SPECIES DATA

Abundance of Prevalent Species (> 5% Total Count)
Zooplankton, Survey W9710
August 5, 1997

Species		Life Stage	Group	Parameter	Station Cast N04	Station Cast N18
BIVALVIA SPP.		L	OZ	ind/m3	7279.64	2954.01
				%	16	9
COPEPOD SPP.		N	C	ind/m3	17184.72	8862.03
				%	37	27
OITHONA SIMILIS	CLAUS	C	C	ind/m3	10143.76	7851.45
				%	22	24
OITHONA SIMILIS	CLAUS	F	C	ind/m3	3222.14	2254.38
				%	7	7
PSEUDOCALANUS NEWMANI		C	C	ind/m3	3460.81	1943.43
				%	8	6
PSEUDOCALANUS NEWMANI		F	C	ind/m3		4664.23
				%		14

Life Stage Definitions:

C	Copepodite stages I-V
F	Copepoda adult female
L	Larva
M	Copepoda adult male
N	Nauplii
T	Trochophore (larval stage of polychaete)
Y	Cypris Larva of Barnacle

Abundance of Prevalent Species (> 5% Total Count)
Zooplankton, Survey W9711
August 18 - 20, 1997

Species	Life Stage	Group	Parameter	Station Cast												
				F01	F02	F06	F13	F23	F24	F25	F27	F30	F31	N04	N16	N18
ACARTIA TONSA	C	C	ind/m3					26871.92		12323.63		36133.06	5428.27			
			%					22		13		25	15			
ACARTIA TONSA	F	C	ind/m3							5436.89						
			%							6						
ACARTIA TONSA	M	C	ind/m3					7328.71		7974.11			2714.14			
			%					6		8			8			
BIVALVIA SPP.	L	OZ	ind/m3	8446.35	3137.33	6836.87	25355.53	7817.29	13211.59	14135.92		7339.53	7599.58			4949.03
			%	9	6	12	26	6	15	15		5	21			18
CIRRIPEDE SPP.	N	B	ind/m3											979.55		
			%											6		
COPEPOD SPP.	N	C	ind/m3	22298.37	18375.79	18231.65	28708.32	40552.18	28146.43	23922.33	18724.19	58151.65	7056.75	5877.30	19412.66	8733.57
			%	23	33	31	29	33	32	25	30	41	20	35	35	31
MICROSETELLA NORVEGICA	nul	C	ind/m3			3581.22								897.92		
			%			6								5		
OIKOPLEURA DIOICA	nul	OZ	ind/m3	9459.91	4257.80											
			%	10	8											
OITHONA SIMILIS CLAUS	C	C	ind/m3	18919.83	10980.65	11720.35	7334.24	6840.13	11775.55		18298.64		2714.14	2612.13	20232.91	5458.48
			%	20	19	20	7	6	13		29		8	15	37	20
OITHONA SIMILIS CLAUS	F	C	ind/m3	5067.81	3137.33				8041.84		5106.60			897.92	3007.59	1528.38
			%	5	6				9		8			5	5	6
POLYCHAETE SPP.	L	OZ	ind/m3									10162.42				
			%									7				
PSEUDOCALANUS NEWMANI	C	C	ind/m3		3137.33	6674.09					3829.95			2612.13		1892.27
			%		6	11					6			15		7

Life Stage Definitions:

C	Copepodite stages I-V
F	Copepoda adult female
L	Larva
M	Copepoda adult male
N	Nauplii
T	Trochophore (larval stage of polychaete)
Y	Cypris Larva of Barnacle

Abundance of Prevalent Species (> 5% Total Count)
Zooplankton, Survey W9712
September 3, 1997

Species	Life Stage	Group	Parameter	Station Cast N04	Station Cast N18
COPEPOD SPP.	N	C	ind/m3	19665.63	12075.71
			%	31	17
OITHONA SIMILIS CLAUS	C	C	ind/m3	26783.86	35356.81
			%	42	50
OITHONA SIMILIS CLAUS	F	C	ind/m3	3740.09	5657.09
			%	6	8
PSEUDOCALANUS NEWMANI	C	C	ind/m3	3257.50	
			%	5	

Life Stage Definitions:

C	Copepodite stages I-V
F	Copepoda adult female
L	Larva
M	Copepoda adult male
N	Nauplii
T	Trochophore (larval stage of polychaete)
Y	Cypris Larva of Barnacle

Abundance of Prevalent Species (> 5% Total Count)
Zooplankton, Survey W9713
September 23, 1997

Species		Life Stage	Group	Parameter	Station Cast	
					N04	N18
BIVALVIA SPP.		L	OZ	ind/m3	2505.45	
				%	6	
COPEPOD SPP.		N	C	ind/m3	11324.64	5977.95
				%	27	21
OITHONA SIMILIS	CLAUS	C	C	ind/m3	18440.12	9033.34
				%	45	32
TEMORA LONGICORNIS		M	C	ind/m3		1992.65
				%		7

Life Stage Definitions:	C	Copepodite stages I-V
	F	Copepoda adult female
	L	Larva
	M	Copepoda adult male
	N	Nauplii
	T	Trochophore (larval stage of polychaete)
	Y	Cypris Larva of Barnacle

Abundance of Prevalent Species (> 5% Total Count)
Zooplankton, Survey W9714
October 6 - 8, 1997

Species	Life Stage	Group	Parameter	Station Cast												
				F01	F02	F06	F13	F23	F24	F25	F27	F30	F31	N04	N16	N18
ACARTIA TONSA	C	C	ind/m3									6204.57				
			%									17				
BIVALVIA SPP.	L	OZ	ind/m3			5906.84	6280.48	2062.73	12039.60				2260.04		6474.13	2439.00
			%			13	22	5	12				5		15	8
COPEPOD SPP.	N	C	ind/m3	5734.55	364.44	13542.51	5865.73	19853.81	46574.26	20564.94	1039.49	14850.29	19587.04	22639.56	20393.51	16707.12
			%	30	10	29	20	50	47	41	9	40	45	46	46	56
GASTROPODA;MOLLUSCA	L	OZ	ind/m3				2310.74			2765.03		2441.14				
			%				8			6		7				
OITHONA SIMILIS CLAUS	C	C	ind/m3	8247.45	1676.44	15559.48	7702.47	3480.86	10138.61	6394.14	6742.61	2339.43	7232.14	11637.16	6555.06	3658.49
			%	43	44	34	26	9	10	13	58	6	17	24	15	12
OITHONA SIMILIS CLAUS	F	C	ind/m3								674.26			2644.81		
			%								6			5		
POLYCHAETE SPP.	L	OZ	ind/m3									3560.00				
			%									10				
SALPA SPP.		OZ	ind/m3	1385.31	937.84						1179.96					
			%	7	25						10					
TEMORA LONGICORNIS	C	C	ind/m3					2836.26								
			%					7								
UNIDENTIFIED LARVAE	L	OZ	ind/m3		204.09											
			%		5											

Life Stage Definitions:

C	Copepodite stages I-V
F	Copepoda adult female
L	Larva
M	Copepoda adult male
N	Nauplii
T	Trochophore (larval stage of polychaete)
Y	Cypris Larva of Barnacle

Abundance of Prevalent Species (> 5% Total Count)
Zooplankton, Survey W9715
October 28, 1997

Species		Life Stage	Group	Parameter	Station Cast	
					N04	N18
BIVALVIA SPP.		L	OZ	ind/m3	22842.49	42352.39
				%	45	29
CENTROPAGES SPP.		C	C	ind/m3	2772.79	14329.76
				%	5	10
COPEPOD SPP.		N	C	ind/m3	9770.78	39168.00
				%	19	27
GASTROPODA;MOLLUSCA		L	OZ	ind/m3	6865.95	21972.29
				%	14	15
OITHONA SIMILIS	CLAUS	C	C	ind/m3	3829.09	18787.90
				%	8	13

Life Stage Definitions:		
	C	Copepodite stages I-V
	F	Copepoda adult female
	L	Larva
	M	Copepoda adult male
	N	Nauplii
	T	Trochophore (larval stage of polychaete)
	Y	Cypris Larva of Barnacle

Abundance of Prevalent Species (> 5% Total Count)
Zooplankton, Survey W9716
November 25, 1997

Species		Life Stage	Group	Parameter	Station Cast N04	Station Cast N18
BIVALVIA SPP.		L	OZ	ind/m3	2582.63	
				%	10	
CENTROPAGES SPP.		C	C	ind/m3		2678.39
				%		6
COPEPOD SPP.		N	C	ind/m3	9535.87	19722.72
				%	38	47
OITHONA SIMILIS	CLAUS	C	C	ind/m3	7151.91	10591.83
				%	29	25
PSEUDOCALANUS NEWMANI		C	C	ind/m3		3895.85
				%		9

Life Stage Definitions:

C	Copepodite stages I-V
F	Copepoda adult female
L	Larva
M	Copepoda adult male
N	Nauplii
T	Trochophore (larval stage of polychaete)
Y	Cypris Larva of Barnacle

Abundance of Prevalent Species (> 5% Total Count)
Zooplankton, Survey W9717
December 16, 1997

Species		Life Stage	Group	Parameter	Station Cast N04	Station Cast N18
BIVALVIA SPP.		L	OZ	ind/m3	2966.08	1985.87
				%	11	10
COPEPOD SPP.		N	C	ind/m3	9421.67	6415.88
				%	35	33
OITHONA SIMILIS	CLAUS	C	C	ind/m3	8287.58	6721.40
				%	31	35
OITHONA SIMILIS	CLAUS	F	C	ind/m3	1657.52	
				%	6	

Life Stage Definitions:

C	Copepodite stages I-V
F	Copepoda adult female
L	Larva
M	Copepoda adult male
N	Nauplii
T	Trochophore (larval stage of polychaete)
Y	Cypris Larva of Barnacle

APPENDIX H-1

ORGANIC CARBON CONTENT OF PREVALENT SPECIES IN WHOLE WATER SURFACE SAMPLES

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Surface Sample
Whole Water Phytoplankton, Survey W9710
August 5, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM LONGIPES	DF	ug/L	13.24	
		%	19	
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	ug/L	4.65	1.76
		%	7	8
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	ug/L	12.77	5.66
		%	19	25
PROTOPERIDINIUM SP.#1 10-30W 10-40L	DF	ug/L		1.48
		%		6
RHIZOSOLENIA FRAGILISSIMA	CD	ug/L	16.99	1.56
		%	25	7
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	ug/L	14.85	9.77
		%	22	42
UNID. MICRO-PHYTOFLAG LENGTH >10 MICRONS	MF	ug/L		1.92
		%		8

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Surface Sample
Whole Water Phytoplankton, Survey W9711
August 18 - 20, 1997

Species	Group	Parameter	Station Cast												
			F01	F02	F06	F13	F23	F24	F25	F27	F30	F31	N04	N16	N18
ASTERIONELLA GLACIALIS	PD	ug/L					18.08	32.72	10.33		33.41	6.89			
		%					6	16	6		18	5			
CERATAULINA PELAGICA	CD	ug/L											20.21		
		%											42		
CERATIUM LONGIPES	DF	ug/L		38.62					23.17					4.63	
		%		9					13					17	
CHAETOCEROS SP#2 DIAM 10-30 MICRONS	CD	ug/L		34.63	11.19	12.79	27.97	19.98	11.99		10.39	11.99			
		%		8	5	6	10	10	7		6	9			
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	ug/L								1.59	9.92	11.88			
		%								6	5	9			
CYCLOTELLA SP#2 DIAM 10-30 MICRONS	CD	ug/L			10.77		20.95	12.77							
		%			5		7	6							
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	ug/L			12.39	35.74		11.13		7.99	10.37		10.11	9.61	9.99
		%			6	18		5		30	6		21	35	28
LEPTOCYLINDRUS DANICUS	CD	ug/L				10.74									
		%				5									
LITHODESMIUM UNDULATUM	CD	ug/L					19.33								
		%					7								
PROTOPERIDINIUM SP.#2 31-75W 41-80L	DF	ug/L				13.03									2.61
		%				7									7
RHIZOSOLENIA DELICATULA	CD	ug/L					14.66	16.52	9.59		9.59	7.99			
		%					5	8	5		5	6			
RHIZOSOLENIA FRAGILISSIMA	CD	ug/L	543.77	242.55	107.45	57.90	39.12	26.60	28.17		25.82	11.74	6.89		4.69
		%	82	57	52	29	14	13	16		14	9	14		13
SKELETONEMA COSTATUM GREV+CLEVE	CD	ug/L					31.98		18.29						
		%					11		10						
THALASSIOSIRA GRAVIDA	CD	ug/L					20.51	11.93	11.19		13.42	13.42			
		%					7	6	6		7	10			
UNID. CENTRIC DIATOM DIAM 10-30 MICRONS	CD	ug/L										7.75			
		%										6			
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	ug/L		21.32	11.29	17.54	32.57	21.57	19.03	14.47	23.35	28.93	6.03	7.36	11.80
		%		5	5	9	12	10	11	54	13	21	12	27	33

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Surface Sample
Whole Water Phytoplankton, Survey W9712
September 3, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM LONGIPES	DF	ug/L	4.63	
		%	8	
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	ug/L	5.29	7.51
		%	10	7
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	ug/L	19.38	16.44
		%	35	16
RHIZOSOLENIA FRAGILISSIMA	CD	ug/L		34.34
		%		33
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	ug/L	19.54	27.66
		%	35	26

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Surface Sample
Whole Water Phytoplankton, Survey W9713
September 23, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	ug/L	3.77	
		%	6	
CYCLOTELLA SP#2 DIAM 10-30 MICRONS	CD	ug/L		10.37
		%		5
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	ug/L	12.81	19.47
		%	21	10
RHIZOSOLENIA DELICATULA	CD	ug/L		14.39
		%		7
RHIZOSOLENIA FRAGILISSIMA	CD	ug/L	4.38	18.00
		%	7	9
THALASSIONEMA NITZSCHIOIDES	PD	ug/L		10.75
		%		6
UNID. CENTRIC DIATOM DIAM 10-30 MICRONS	CD	ug/L		44.36
		%		23
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	ug/L	34.01	27.41
		%	55	14
Group Definitions:	CD	Centric Diatom		
	DF	Dinoflagellate		
	MF	Microflagellate		
	HP	Haptophyte		
	CR	Cryptophyte		
	PD	Pennate Diatom		

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Surface Sample
Whole Water Phytoplankton, Survey W9714
October 6 - 8, 1997

Species	Group	Parameter	Station Cast												
			F01	F02	F06	F13	F23	F24	F25	F27	F30	F31	N04	N16	N18
ASTERIONELLA GLACIALIS	PD	ug/L					37.02	46.49	34.87		35.73	28.84	18.29	62.59	
		%					15	16	12		16	11	8	7	
CERATAULINA PELAGICA	CD	ug/L	8.42		207.75	25.27	32.75	21.06			22.46	14.04	20.27		
		%	6		65	10	13	7			10	6	9		
CHAETOCEROS SP#2 DIAM 10-30 MICRONS	CD	ug/L										13.99			
		%										6			
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	ug/L									14.49				
		%									6				
CYCLOTELLA SP#2 DIAM 10-30 MICRONS	CD	ug/L		14.76	23.94	22.35									
		%		12	6	9									
EUCAMPIA ZODIACUS	CD	ug/L							18.22		31.23	15.62	22.55	65.50	
		%							6		14	6	10	7	
GUINARDIA FLACCIDA	CD	ug/L										26.98			
		%										11			
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	ug/L	17.19	9.36		17.45				10.62			21.90		
		%	12	7		7				20			9		
LEPTOCYLINDRUS DANICUS	CD	ug/L					83.78	85.93	78.41		63.59	49.41		45.05	42.05
		%					34	29	27		28	19		5	6
RHIZOSOLENIA DELICATULA	CD	ug/L												78.23	
		%												9	
RHIZOSOLENIA FRAGILISSIMA	CD	ug/L						19.56					39.54	229.69	202.35
		%						7					17	26	27
SKELETONEMA COSTATUM GREV+CLEVE	CD	ug/L		14.33											
		%		11											
THALASSIOSIRA GRAVIDA	CD	ug/L							14.91						
		%							5						
THALASSIOSIRA SP#1 DIAM <20 MICRONS	CD	ug/L												214.75	249.67
		%												24	33
UNID. CENTRIC DIATOM DIAM <10 MICRONS	CD	ug/L											23.50		
		%											10		
UNID. CENTRIC DIATOM DIAM 10-30 MICRONS	CD	ug/L	47.17	39.42	64.69	97.71		16.85	24.43	7.41					
		%	33	31	17	39		6	8	14					
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	ug/L	25.89	29.95	21.83	36.29	22.96	22.07	20.89	21.57	24.43	20.14	24.52		
		%	18	24	6	15	9	8	7	40	11	8	10		

Group Definitions:	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Surface Sample
Whole Water Phytoplankton, Survey W9715
October 28, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
AMPHIDINIUM SPP.	DF	ug/L		2.39
		%		6
AMPHIDINIUM SPP. SYN. PHALACROMA SPP.	DF	ug/L		2.39
		%		6
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	ug/L	2.27	5.19
		%	7	14
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	ug/L	4.13	6.07
		%	13	16
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	ug/L	21.20	20.44
		%	67	54
Group Definitions:	CD	Centric Diatom		
	DF	Dinoflagellate		
	MF	Microflagellate		
	HP	Haptophyte		
	CR	Cryptophyte		
	PD	Pennate Diatom		

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Surface Sample
Whole Water Phytoplankton, Survey W9716
November 25, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM TRIPOS	DF	ug/L		7.37
		%		30
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	ug/L	1.58	2.18
		%	7	9
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	ug/L	2.90	3.34
		%	13	14
PLEUROSIGMA ANGULATUM	PD	ug/L		1.89
		%		8
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	ug/L	15.17	4.98
		%	68	20

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Surface Sample
Whole Water Phytoplankton, Survey W9717
December 16, 1997

Species	Group	Parameter	Station Cast N04	Station Cast N18
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	ug/L		1.82
		%		10
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	ug/L	2.96	2.52
		%	15	14
GYMNODINIUM SP.#2 21-40UM W 21-50UM L	DF	ug/L	1.61	
		%	8	
RHIZOSOLENIA STOLTERFOTHII	CD	ug/L	3.91	
		%	20	
THALASSIOSIRA SP#2 DIAM >20 MICRONS	CD	ug/L		1.07
		%		6
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	ug/L	7.87	9.71
		%	41	55
Group Definitions:	CD	Centric Diatom		
	DF	Dinoflagellate		
	MF	Microflagellate		
	HP	Haptophyte		
	CR	Cryptophyte		
	PD	Pennate Diatom		

APPENDIX H-2

ORGANIC CARBON CONTENT OF PREVALANT SPECIES IN WHOLE WATER CHLOROPHYLL *a* MAXIMUM SAMPLES

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Chlorophyll *a* Maximum Sample
Whole Water Phytoplankton, Survey W9710
August 5, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM LONGIPES	DF	ug/L	18.54	4.63
		%	42	10
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	ug/L	4.26	3.45
		%	10	7
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	ug/L	6.00	15.68
		%	14	32
RHIZOSOLENIA FRAGILISSIMA	CD	ug/L		8
		%		16
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	ug/L	11.67	10.28
		%	26	21
Group Definitions:	CD	Centric Diatom		
	DF	Dinoflagellate		
	MF	Microflagellate		
	HP	Haptophyte		
	CR	Cryptophyte		
	PD	Pennate Diatom		

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Chlorophyll *a* Maximum Sample
Whole Water Phytoplankton, Survey W9711
August 18 - 20, 1997

Species	Group	Parameter	Station Cast												
			F01	F02	F06	F13	F23	F24	F25	F27	F30	F31	N04	N16	N18
ASTERIONELLA GLACIALIS	PD	ug/L					15.50		12.40		33.75	7.92			
		%					7		7		20	5			
CERATIUM LONGIPES	DF	ug/L				23.17		34.75		4.63				4.63	
		%				8		32		9				12	
CHAETOCEROS SP#2 DIAM 10-30 MICRONS	CD	ug/L					21.98	7.59							
		%					10	7							
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	ug/L							9.59	13.70		8	1	4	
		%							6	28		5	6	10	
CYCLOTELLA SP#2 DIAM 10-30 MICRONS	CD	ug/L					13.97								
		%					6								
CYLINDROTHECA CLOSTERIUM	PD	ug/L		11.17	4.32										
		%		7	6										
GUINARDIA FLACCIDA	CD	ug/L			5.40										
		%			7										
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	ug/L		18	7.59	16.18		8.34	11.63				3	13	13
		%		11	10	6		8	7				20	32	34
KATODINIUM ROTUNDATUM	DF	ug/L												3.45	
		%												9	
LEPTOCYLINDRUS DANICUS	CD	ug/L						6.66							
		%						6							
LITHODESMIUM UNDULATUM	CD	ug/L				15.46									
		%				5									
PROTOPERIDINIUM SP.#1 10-30W 10-40L	DF	ug/L									14.77				
		%									9				
PROTOPERIDINIUM SP.#2 31-75W 41-80L	DF	ug/L				78.18						26.06			2.61
		%				27						17			7
RHIZOSOLENIA DELICATULA	CD	ug/L				16.52					20.79	8.53			
		%				6					12	5			
RHIZOSOLENIA FRAGILISSIMA	CD	ug/L	582.89	78.24	29.34	41.47	35.21	17.21	28.17		21.91	15.65			2.66
		%	79	49	40	14	16	16	17		13	10			7
SKELETONEMA COSTATUM GREV+CLEVE	CD	ug/L					28.38		34.01			9.19			
		%					13		20			6			
THALASSIOSIRA GRAVIDA	CD	ug/L				31.32									7.46
		%				11									19
UNID. CENTRIC DIATOM DIAM 10-30 MICRONS	CD	ug/L							9.43						
		%							6						
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	ug/L		14.72	11.17	14.72	30.14	6.77	24.43	23.22	23.60	38.83	9.77	8.38	5.84
		%		9	15	5	14	6	14	47	14	25	59	21	15

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Chlorophyll *a* Maximum Sample
Whole Water Phytoplankton, Survey W9712
September 3, 1997

Species	Group	Parameter	Station Cast N04	Station Cast N18
CERATIUM LONGIPES	DF	ug/L	9.27	
		%	12	
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	ug/L	7.73	8.22
		%	10	5
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	ug/L	16.01	32.62
		%	21	21
RHIZOSOLENIA FRAGILISSIMA	CD	ug/L		50
		%		33
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	ug/L	31.72	38.58
		%	41	25

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Chlorophyll *a* Maximum Sample
Whole Water Phytoplankton, Survey W9713
September 23, 1997

Species	Group	Parameter	Station Cast N04	Station Cast N18
ASTERIONELLA GLACIALIS	PD	ug/L		26.17
		%		10
CERATAULINA PELAGICA	CD	ug/L	26.96	
		%	78	
CYCLOTELLA SP#2 DIAM 10-30 MICRONS	CD	ug/L		14.76
		%		5
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	ug/L	4	14
		%	10	5
RHIZOSOLENIA DELICATULA	CD	ug/L		28.78
		%		11
RHIZOSOLENIA FRAGILISSIMA	CD	ug/L		72.76
		%		27
UNID. CENTRIC DIATOM DIAM 10-30 MICRONS	CD	ug/L		44.36
		%		16
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	ug/L		27.66
		%		10
Group Definitions:	CD	Centric Diatom		
	DF	Dinoflagellate		
	MF	Microflagellate		
	HP	Haptophyte		
	CR	Cryptophyte		
	PD	Pennate Diatom		

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Chlorophyll *a* Maximum Sample
Whole Water Phytoplankton, Survey W9714
October 6 - 8, 1997

Species	Group	Parameter	Station Cast F01	F02	F06	F13	F23	F24	F25	F27	F30	F31	N04	N16	N18
ASTERIONELLA GLACIALIS	PD	ug/L					61.42	103.32	29.27		44.66	23.48	35.15	51.76	
		%					26	31	10		17	11	7	8	
CERATAULINA PELAGICA	CD	ug/L			196.52		16.85		21.06		26.74				
		%			59		7		7		10				
CYCLOTELLA SP#1 DIAM <10 MICRONS	CD	ug/L				7.21			20.76						
		%				11			7						
CYCLOTELLA SP#2 DIAM 10-30 MICRONS	CD	ug/L		6		4.79						13			
		%		8		7						6			
EUCAMPIA ZODIACUS	CD	ug/L									27.27	10.41	32.02	43.66	
		%									11	5	6	7	
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	ug/L	11.88	8.34		7.08				1.77			28.28		
		%	10	11		11				25			5		
LEPTOCYLINDRUS DANICUS	CD	ug/L					73.90	96.67	73.04	0.43	83.78	42.97			
		%					31	29	26	6	32	21			
PROROCENTRUM COMPRESSUM	DF	ug/L				3.33									
		%				5									
RHIZOSOLENIA DELICATULA	CD	ug/L												119.21	
		%												18	
RHIZOSOLENIA FRAGILISSIMA	CD	ug/L										17.21	142.19	87.50	301.66
		%										8	27	13	31
RHIZOSOLENIA SPP.	CD	ug/L												76.71	
		%												12	
SKELETONEMA COSTATUM GREV+CLEVE	CD	ug/L	12	11											
		%	11	14											
THALASSIOSIRA GRAVIDA	CD	ug/L						16.78							
		%						5							
THALASSIOSIRA SP#1 DIAM <20 MICRONS	CD	ug/L											173.20	165.86	406.04
		%											33	25	41
UNID. CENTRIC DIATOM DIAM 10-30 MICRONS	CD	ug/L	39.08	17.86	17.69	12.13			16.85						
		%	35	24	5	18			6						
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	ug/L	25	22	24.75	13.03	17.98	21.24	23.79	3.00	20.09	23.35			
		%	22	29	7	20	8	6	8	42	8	11			
UNID. MICRO-PHYTOFLAG LENGTH >10 MICRONS	MF	ug/L								0.70					
		%								10					

Group Definitions:	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Chlorophyll *a* Maximum Sample
Whole Water Phytoplankton, Survey W9715
October 28, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
AMPHIDINIUM SPP.	DF	ug/L		2.39
		%		5
AMPHIDINIUM SPP. SYN. PHALACROMA SPP.	DF	ug/L		2.39
		%		5
CERATIUM TRIPOS	DF	ug/L	7.68	14.74
		%	19	33
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	ug/L	3	3
		%	8	7
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	ug/L	8.80	3.55
		%	22	8
GYRODINIUM SP#2 21-40UM W 21-50UM L	DF	ug/L	2.01	5.78
		%	5	13
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	ug/L	11.88	10.09
		%	30	22
Group Definitions:	CD	Centric Diatom		
	DF	Dinoflagellate		
	MF	Microflagellate		
	HP	Haptophyte		
	CR	Cryptophyte		
	PD	Pennate Diatom		

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Chlorophyll *a* Maximum Sample
Whole Water Phytoplankton, Survey W9716
November 25, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CRYPTOMONAS SP#1 LENGTH <10 MICRONS	CR	ug/L	0.85	0.84
		%	5	6
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	ug/L	1.54	1.29
		%	9	10
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	ug/L	3.03	2.61
		%	19	19
RHIZOSOLENIA SHRUBSOLEII	CD	ug/L	2	
		%	14	
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	ug/L	5.88	7.03
		%	36	53
Group Definitions:	CD	Centric Diatom		
	DF	Dinoflagellate		
	MF	Microflagellate		
	HP	Haptophyte		
	CR	Cryptophyte		
	PD	Pennate Diatom		

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Chlorophyll *a* Maximum Sample
Whole Water Phytoplankton, Survey W9717
December 16, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CORETHRON CRIOPHILUM	CD	ug/L		2.97
		%		12
CRYPTOMONAS SP#2 LENGTH >10 MICRONS	CR	ug/L	1.01	2.34
		%	6	10
GYMNODINIUM SP.#1 5-20UM W 10-20UM L	DF	ug/L	3.65	2.19
		%	22	9
GYMNODINIUM SP.#2 21-40UM W 21-50UM L	DF	ug/L		4
		%		16
GYRODINIUM SP#2 21-40UM W 21-50UM L	DF	ug/L	1.61	
		%	10	
PLEUROSIGMA ANGULATUM	PD	ug/L		1.89
		%		8
UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	MF	ug/L	8.07	6.56
		%	49	28
UNID. MICRO-PHYTOFLAG LENGTH >10 MICRONS	MF	ug/L		2
		%		7
Group Definitions:	CD	Centric Diatom		
	DF	Dinoflagellate		
	MF	Microflagellate		
	HP	Haptophyte		
	CR	Cryptophyte		
	PD	Pennate Diatom		

APPENDIX I-1

ORGANIC CARBON CONTENT OF PREVALENT SPECIES IN SCREENED SURFACE SAMPLES

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Surface Sample
Screened Phytoplankton, Survey W9710
August 5, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM LONGIPES	DF	ug/L	16.50	1.18
		%	94	82
CERATIUM TRIPOS	DF	ug/L		0.23
		%		16

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Surface Sample
Screened Phytoplankton, Survey W9711
August 18 - 20, 1997

Species	Group	Parameter	Station Cast												
			F01	F02	F06	F13	F23	F24	F25	F27	F30	F31	N04	N16	N18
CERATIUM FUSUS	DF	ug/L		0.22	0.10	0.44	0.05			0.05	0.04		0.24	0.09	0.05
		%		24	6	18	5			7	14		15	12	10
CERATIUM LONGIPES	DF	ug/L	0.18	0.24	0.50	0.66	0.72	2.19	2.13	0.28	0.17	0.80	0.98	0.45	0.24
		%	9	25	29	26	70	72	88	36	64	76	60	58	54
CERATIUM TRIPOS	DF	ug/L	0.54	0.37	0.43	0.69	0.11	0.17	0.18	0.40	0.05	0.11	0.34	0.23	0.15
		%	28	39	24	28	11	6	8	52	17	11	21	29	33
NITZSCHIA PUNGENS	PD	ug/L	0.11	0.05	0.15										
		%	6	5	9										
NITZSCHIA SERIATA	PD	ug/L	0.18		0.13										
		%	9		8										
PROTOPERIDINIUM CONICUM	DF	ug/L	0.20		0.18										
		%	10		11										
PROTOPERIDINIUM DEPRESSUM	DF	ug/L	0.26		0.15		0.07	0.16							
		%	14		9		6	5							
PROTOPERIDINIUM SP.#1 10-30W 10-40L	DF	ug/L				0.18		0.18							
		%				7		6							
PROTOPERIDINIUM SP.#2 31-75W 41-80L	DF	ug/L	0.10			0.15									
		%	5			6									
PROTOPERIDINIUM SP.#3 76-150W 81-150L	DF	ug/L				0.13									
		%				5									

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Surface Sample
Screened Phytoplankton, Survey W9712
September 3, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM LONGIPES	DF	ug/L	0.39	0.08
		%	19	10
CERATIUM TRIPOS	DF	ug/L	1.63	0.68
		%	77	85

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Surface Sample
Screened Phytoplankton, Survey W9713
September 23, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM FUSUS	DF	ug/L	0.04	
		%	11	
CERATIUM LONGIPES	DF	ug/L	0.13	0.47
		%	36	13
CERATIUM TRIPOS	DF	ug/L	0.19	2.98
		%	53	83

Group Definitions:

CD	Centric Diatom
DF	Dinoflagellate
MF	Microflagellate
HP	Haptophyte
CR	Cryptophyte
PD	Pennate Diatom

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Surface Sample
Screened Phytoplankton, Survey W9714
October 6 - 8, 1997

Species	Group	Parameter	Station Cast												
			F01	F02	F06	F13	F23	F24	F25	F27	F30	F31	N04	N16	N18
CERATIUM LONGIPES	DF	ug/L	0.09	0.17	0.27	0.08	0.18	0.15	0.77	0.09	0.06	0.04	0.19	0.38	0.13
		%	30	67	55	28	66	36	54	66	39	34	16	39	25
CERATIUM TRIPOS	DF	ug/L	0.13	0.06	0.17	0.18	0.09	0.25	0.57	0.04	0.09	0.09	1.01	0.56	0.35
		%	44	23	34	60	33	63	40	34	68	65	81	58	68
NITZSCHIA PUNGENS	PD	ug/L	0.06			0.04									
		%	20			12									
Group Definitions:	CD	Centric Diatom													
	DF	Dinoflagellate													
	MF	Microflagellate													
	HP	Haptophyte													
	CR	Cryptophyte													
	PD	Pennate Diatom													

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Surface Sample
Screened Phytoplankton, Survey W9715
October 28, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM FUSUS	DF	ug/L	0.09	
		%	6	
CERATIUM LONGIPES	DF	ug/L	0.11	0.18
		%	7	11
CERATIUM TRIPOS	DF	ug/L	1.32	1.21
		%	82	74
PROTOPERIDINIUM DEPRESSUM	DF	ug/L		0.10
		%		6

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Surface Sample
Screened Phytoplankton, Survey W9716
November 25, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM FUSUS	DF	ug/L	0.20	0.18
		%	21	23
CERATIUM LONGIPES	DF	ug/L	0.14	0.08
		%	14	10
CERATIUM TRIPOS	DF	ug/L	0.57	0.51
		%	61	65

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Surface Sample
Screened Phytoplankton, Survey W9717
December 16, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM FUSUS	DF	ug/L	0.11	0.04
		%	14	14
CERATIUM LONGIPES	DF	ug/L	0.16	0.05
		%	19	19
CERATIUM TRIPOS	DF	ug/L	0.48	0.14
		%	58	56
PROTOPERIDINIUM DEPRESSUM	DF	ug/L		0.03
		%		10
PROTOPERIDINIUM SP.#3 76-150W 81-150L	DF	ug/L	0.06	
		%	7	

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

APPENDIX I-2

ORGANIC CARBON CONTENT OF PREVALENT SPECIES IN SCREENED CHLOROPHYLL *a* MAXIMUM SAMPLES

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Chlorophyll *a* Maximum Sample
Screened Phytoplankton, Survey W9710
August 5, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM LONGIPES	DF	ug/L	31.80	1.23
		%	96	86
CERATIUM TRIPOS	DF	ug/L		0.14
		%		10
Group Definitions:	CD	Centric Diatom		
	DF	Dinoflagellate		
	MF	Microflagellate		
	HP	Haptophyte		
	CR	Cryptophyte		
	PD	Pennate Diatom		

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Chlorophyll *a* Maximum Sample
Screened Phytoplankton, Survey W9711
August 18 - 20, 1997

Species	Group	Parameter	Station Cast												
			F01	F02	F06	F13	F23	F24	F25	F27	F30	F31	N04	N16	N18
CERATIUM FUSUS	DF	ug/L	0.48	0.13					0.06						0.30
		%	28	9					6						16
CERATIUM LONGIPES	DF	ug/L	0.26	0.87	3.26	1.66	1.62	1.90	0.67	0.65	0.38	0.53	1.78	1.95	1.20
		%	15	63	84	60	84	88	74	50	56	83	93	93	62
CERATIUM TRIPOS	DF	ug/L	0.11	0.18	0.28	0.33	0.14	0.15	0.11	0.61	0.04	0.05			0.31
		%	6	13	7	12	7	7	12	47	6	9			16
NITZSCHIA PUNGENS	PD	ug/L	0.13												
		%	7												
NITZSCHIA SERIATA	PD	ug/L	0.15	0.10											
		%	8	7											
PROTOPERIDINIUM DEPRESSUM	DF	ug/L	0.23			0.33					0.08				
		%	13			12					12				
PROTOPERIDINIUM SP.#2 31-75W 41-80L	DF	ug/L	0.17								0.08				
		%	10								12				
PROTOPERIDINIUM SP.#3 76-150W 81-150L	DF	ug/L									0.07				
		%									10				

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Chlorophyll *a* Maximum Sample
Screened Phytoplankton, Survey W9712
September 3, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM LONGIPES	DF	ug/L	1.15	0.29
		%	46	27
CERATIUM TRIPOS	DF	ug/L	1.29	0.72
		%	51	68
Group Definitions:	CD	Centric Diatom		
	DF	Dinoflagellate		
	MF	Microflagellate		
	HP	Haptophyte		
	CR	Cryptophyte		
	PD	Pennate Diatom		

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Chlorophyll *a* Maximum Sample
Screened Phytoplankton, Survey W9713
September 23, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM LONGIPES	DF	ug/L	1.12	0.27
		%	12	20
CERATIUM TRIPOS	DF	ug/L	7.47	0.99
		%	80	75
PROTOPERIDINIUM DEPRESSUM	DF	ug/L	0.59	
		%	6	

Group Definitions:		
	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Chlorophyll *a* Maximum Sample
Screened Phytoplankton, Survey W9714
October 6 - 8, 1997

Species	Group	Parameter	Station Cast												
			F01	F02	F06	F13	F23	F24	F25	F27	F30	F31	N04	N16	N18
CERATIUM FUSUS	DF	ug/L			0.07										
		%			7										
CERATIUM LONGIPES	DF	ug/L	1.09	0.20	0.38	0.03	0.06	0.13	0.29	0.07	0.03	1.00	0.51	0.37	0.20
		%	52	52	39	6	40	44	29	30	35	55	19	48	14
CERATIUM TRIPOS	DF	ug/L	0.82	0.11	0.42	0.51	0.07	0.16	0.66	0.08	0.05	0.76	1.98	0.40	1.09
		%	39	29	43	91	46	55	66	34	58	42	75	52	78
NITZSCHIA PUNGENS	PD	ug/L		0.04											
		%		11											
PROTOPERIDINIUM DEPRESSUM	DF	ug/L					0.02			0.08					
		%					12			34					
Group Definitions:	CD	Centric Diatom													
	DF	Dinoflagellate													
	MF	Microflagellate													
	HP	Haptophyte													
	CR	Cryptophyte													
	PD	Pennate Diatom													

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Chlorophyll *a* Maximum Sample
Screened Phytoplankton, Survey W9715
October 28, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM FUSUS	DF	ug/L		0.11
		%		6
CERATIUM LONGIPES	DF	ug/L	0.16	0.12
		%	12	7
CERATIUM TRIPOS	DF	ug/L	1.07	1.43
		%	80	82

Group Definitions:	CD	Centric Diatom
	DF	Dinoflagellate
	MF	Microflagellate
	HP	Haptophyte
	CR	Cryptophyte
	PD	Pennate Diatom

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Chlorophyll *a* Maximum Sample
Screened Phytoplankton, Survey W9716
November 25, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM FUSUS	DF	ug/L	0.19	0.14
		%	20	21
CERATIUM LONGIPES	DF	ug/L	0.11	0.09
		%	11	13
CERATIUM TRIPOS	DF	ug/L	0.63	0.41
		%	64	61
Group Definitions:	CD	Centric Diatom		
	DF	Dinoflagellate		
	MF	Microflagellate		
	HP	Haptophyte		
	CR	Cryptophyte		
	PD	Pennate Diatom		

Organic Carbon Content of Prevalent Species (> 5% Total Carbon) in Chlorophyll *a* Maximum Sample
Screened Phytoplankton, Survey W9717
December 16, 1997

Species	Group	Parameter	Station Cast	
			N04	N18
CERATIUM FUSUS	DF	ug/L	0.10	0.05
		%	18	19
CERATIUM LONGIPES	DF	ug/L	0.06	0.02
		%	10	8
CERATIUM TRIPOS	DF	ug/L	0.37	0.17
		%	67	61
PROTOPERIDINIUM DEPRESSUM	DF	ug/L		0.02
		%		8
Group Definitions:	CD	Centric Diatom		
	DF	Dinoflagellate		
	MF	Microflagellate		
	HP	Haptophyte		
	CR	Cryptophyte		
	PD	Pennate Diatom		

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