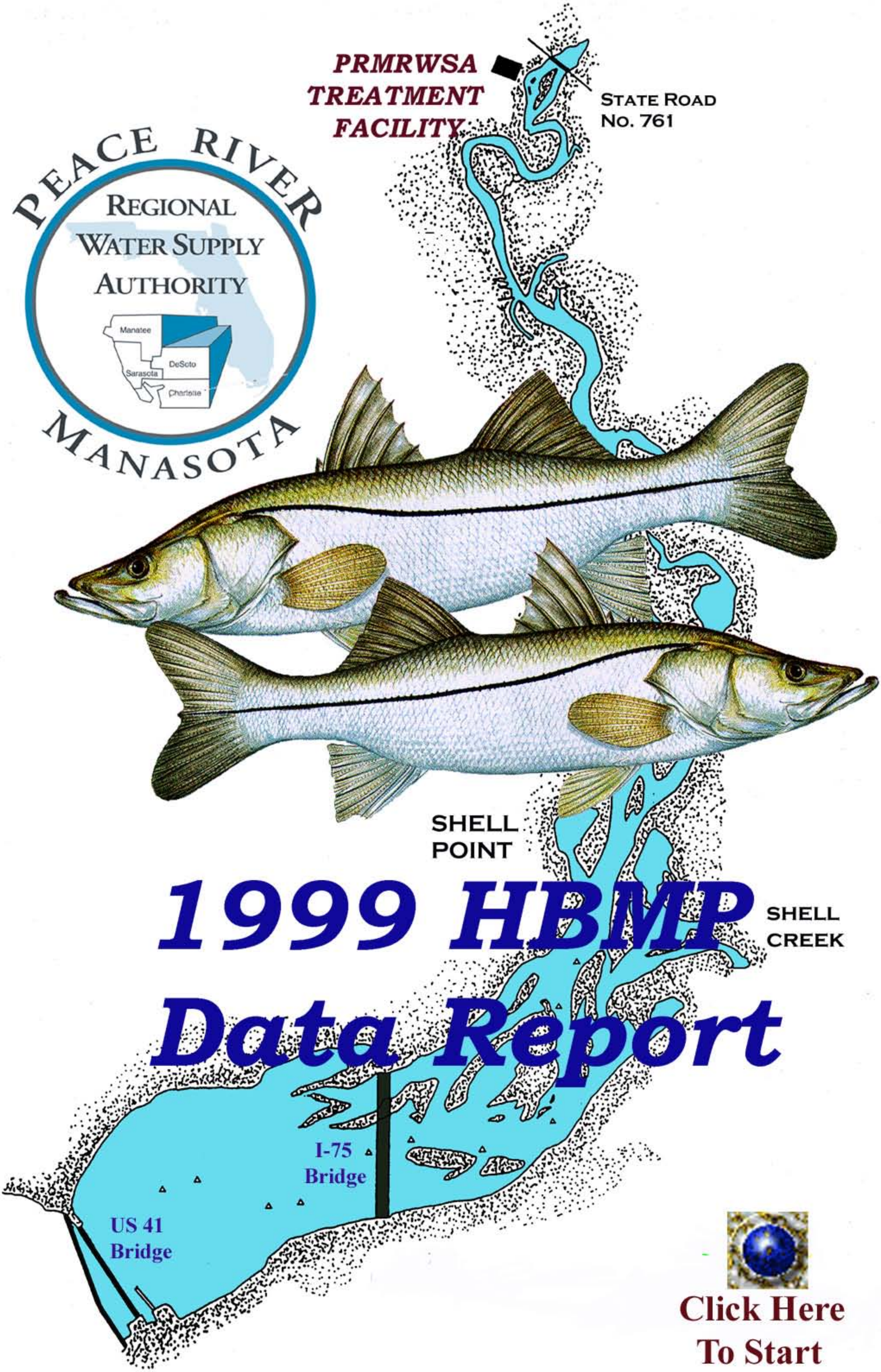
PEACE RIVER
REGIONAL
WATER SUPPLY
AUTHORITY
MANASOTA

1999 HBMP Data Report



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ACKNOWLEDGMENTS

- **Janicki Environmental** – provided technical assistance in the development of the statistical data bases, graphics, and preparation of the document.

The raw data, as well as the methods sections, presented in this report for the calendar year 1999, were provided by each of the contractors responsible for conducting specific elements of the Hydrobiological Monitoring Program.

- **Environmental Quality Laboratory** - conducted the moving, isohaline station physical and chemical water quality measurements, as well as the phytoplankton carbon uptake and biomass measurements.

- **Florida Environmental** - was responsible for all work associated with the long-term studies of riparian vegetation.

- **U.S. Geological Survey** - conducted all physical and chemical water quality measurements taken along the river transect series of fixed station locations. In addition, they were responsible for all data collected by the three tide gauges and the associated measurements of surface and bottom conductivity. Information regarding U.S.G.S. methods and procedures contained within this report were taken in part, or whole, from the "Peace River Monitoring Project Quality Assurance Plan / Project FL459600105" provided by the U.S.G.S. Tampa office (Yvonne Stoker, personal communication).

- **U.S. Geological Survey (Tampa Office)** – provided all flow data used in this study.

    1. Peace River at Arcadia
    2. Horse Creek near Arcadia
    3. Joshua Creek near Nocatee
    4. Shell Creek near Punta Gorda

- **Peace River/Manasota Regional Water Supply Authority** - provided daily measurements of daily withdrawals by the facility.

- **Dr. Susan Jensen** - conducted all phytoplankton taxonomic identifications.

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Chapter I

Introduction / Summary

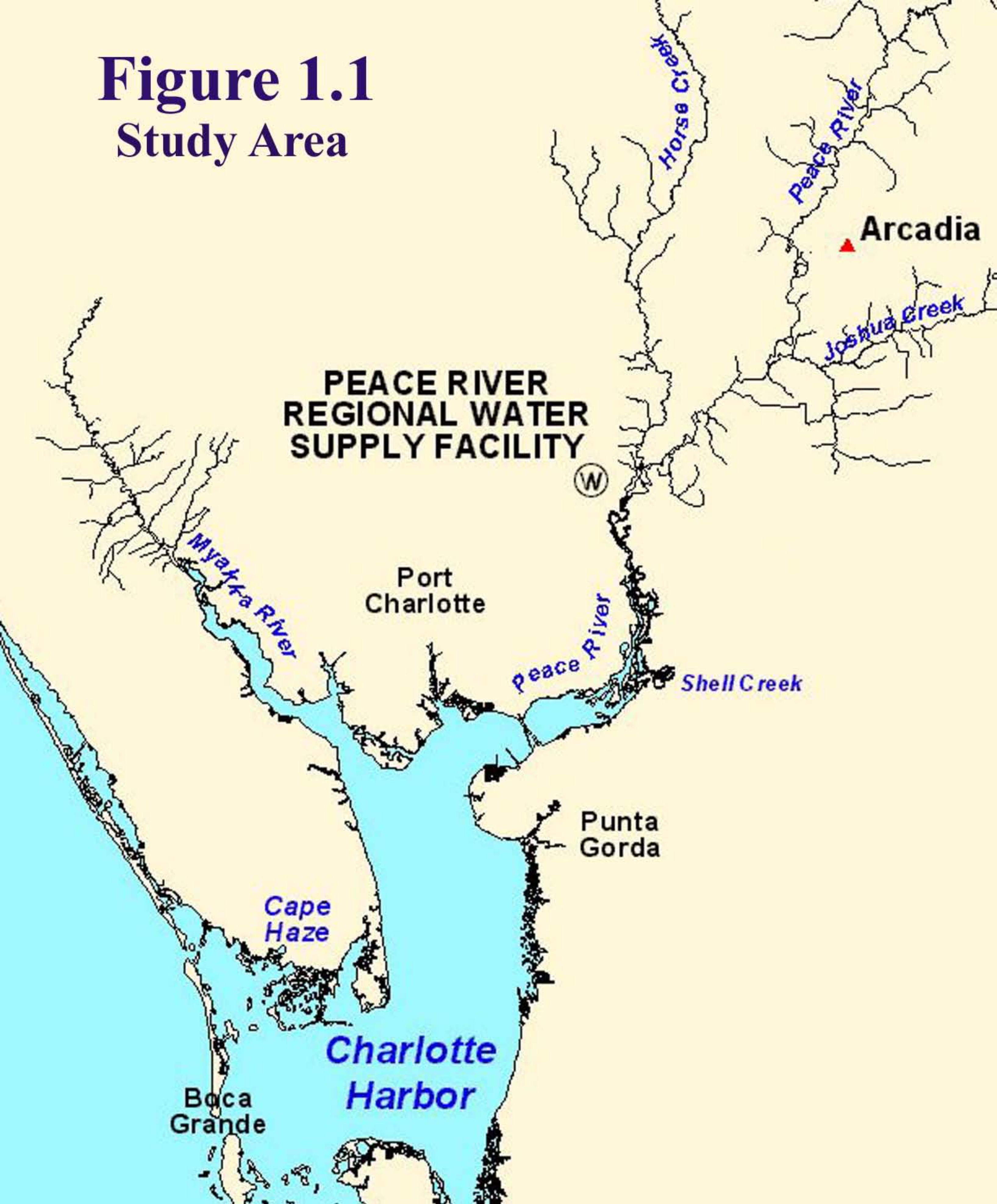
1.1 Previous Studies and Reports

On December 10, 1975, the consumptive use permit #7500016 for the Peace River Regional Water Supply Facility was signed between General Development Utilities, Inc. and the Southwest Florida Water Management District (SWFWMD). In conjunction with this agreement, a comprehensive Hydrobiological Monitoring Program (HBMP), was set forth to assess the responses of various physical, chemical and biological characteristics of the Charlotte Harbor estuary to changes in Peace River flow. The program was designed to evaluate the impacts and significance of natural salinity changes on the aquatic fauna and flora in upper Charlotte Harbor, and to determine if freshwater withdrawals by the Peace River Regional Water Supply Facility could be shown to alter these patterns. The area of study is shown in **Figure 1.1**.

A series of twenty-one previous reports have been filed (February 1979, December 1980, July 1981, August 1982, September 1983, August 1984, July 1985, August 1986, August 1987, September 1989, December 1990, August 1991, August 1992, December 1992, July 1993, August 1994, July 1995, September 1997, December 1997, December 1998, and November 1999) with the SWFWMD, documenting the results of the HBMP during the period from January 1976 through December 1998. These reports include summarizations (findings) of data collected during the first four years of baseline monitoring, prior to the start of freshwater withdrawals, as well as comparisons of these data to the results obtained from the HBMP during subsequent years of water treatment plant operation. The period covered within this Annual Data Report follows directly upon that contained within the preceding data report submitted in November, 1999 and includes unreported data collected from January through December 1999. This represents the tenth year of data collection for the Peace River/Manasota Regional Water Supply Authority, owner/operator of the Peace River Regional Water Supply Facility.

The initial HBMP was designed in 1976 to provide answers to specific questions dealing with possible salinity changes in Charlotte Harbor raised by SWFWMD staff during the original permitting process. Analysis of data from pre and post water treatment plant operation, presented in the August 1982 Summary Report, indicated the need to revise the monitoring program in order to better evaluate possible changes in the Charlotte Harbor system due to natural variations in freshwater inflows. Further modifications of the HBMP were made in 1985 and again in conjunction with the renewal of the consumptive use permit in November 1988. Under the 1988 permit, data reports were submitted for the first through fifth years of the monitoring program. In addition two expanded, Comprehensive Summary Reports were

Figure 1.1
Study Area



submitted which included various comparative analyses of the data reported over the preceding periods of data. The first of these Comprehensive Summary Reports was finalized in December

1993 and included analyses of long-term data collected between 1983 and 1991. The next Comprehensive Summary Report was filed in draft form in 1994, and as a final report in April 1995. This second summary report statistically summarized and evaluated the results of the HBMP elements conducted between 1976 and 1993. In this document it was stated that, "To date, no observed short-term seasonal or long-term trends in any of the physical/chemical or biological parameters measured in this extensive investigation of the Upper Charlotte Harbor estuary have shown any influence by current water withdrawals by the Peace River Regional Water Facility".

1.2 Current Hydrobiological Monitoring Program

Based on the results of these summary reports, and additional analyses requested by District staff during the permit renewal process, an expanded HBMP was approved by the District in March 1996 as a part of WUP#2010420.03 for implementation in 1996 and subsequent years. This 20 year Water Use Permit continues to require the submission of both Annual Data Reports as well as Comprehensive Summary Documents after data collection for the 3rd and 5th years of each five year period. Specific conditions within the permit include major expansions of both the physical and biological elements of the Hydrobiological Monitoring Program.

1.2.1 Ongoing HBMP Program Study Elements

An explicit element of the updated HBMP was the development of standardized station descriptors to be applied across all program elements. As part of the required morphometric study (see description below), the "mouth" of the Peace River was defined using USGS standardized protocols as an imaginary line extending from Punta Gorda Point to Hog Island (**Figure 1.2**). Table 1.1 provides a summary of the locations of all of the ongoing long-term fixed study elements, and provides a cross-reference to previous station identifications. The following briefly outlines each of the current HBMP study elements.

1.2.2 Continuous Recorders

The primary goal of this element of the HBMP was to develop an extensive database of short-term (daily or more frequent) changes in surface and near bottom salinity in the lower Peace River. These data, combined with corresponding gage height, freshwater flows and withdrawals would then be used to develop detailed spatial and temporal relationships. A secondary goal was to assess potential long-term changes in river salinity, which might be explained by predicted increases in sea level.

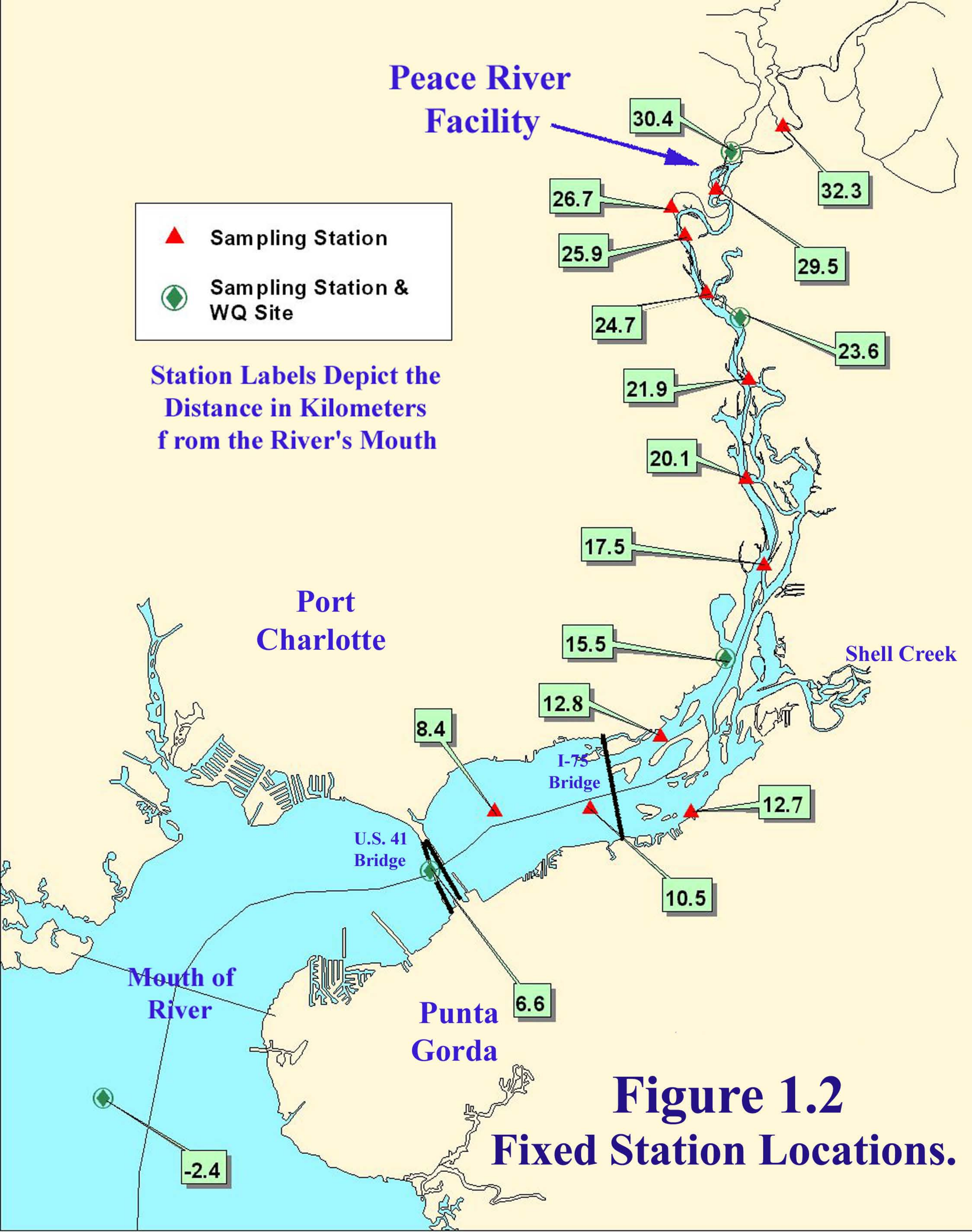


Figure 1.2
Fixed Station Locations.

Table 1.1 HBMP Fixed Sampling Locations

USGS River Mile	USGS Location Number	Previous EQL Station Number	Additional Sampling	New River Kilometer designation based on Morphometric Study
Current *In Situ* Water Column Profile Sampling				
CH6	265355082075500	9	Water Quality	**-2.4**
RM3.95	265640082033500	10	Water Quality	**6.6**
RM4.88	265724082024400	21		**8.4**
RM6.25	265727082012800	11		**10.5**
RM8.61	265711081595500	Shell Creek 9		**12.7**
RM8.6B	265819082003200	22		**12.8**
RM10.2	2297460	12	Water Quality/Tide Gage/Conductivity	**15.5**
RM11.2	270022081591000	23		**17.5**
RM 12.55	270124081592500	13		**20.1**
RM13.95	270235081592400	24		**21.9**
RM14.82	270318081593100	14	Water Quality	**23.6**
RM15.45	270337081595800	25		**24.7**
RM16.29	270418082001600	15		**25.9**
N/A	2297350	N/A	Tide Gage/ Conductivity	**26.7**
RM18.25	270451081595100	17		**29.5**
RM18.95	2297330	18	Water Quality	**30.4**
RM19.5	270537081585800	19		**32.3**
Vegetation Transect Locations				
N/A	N/A	I		**15.6**
N/A	N/A	II		**22.3**
N/A	N/A	III		**20.4**
Previous EQL Water Column and Chemistry Sampling Sites				
N/A	N/A	16		**27.1**
N/A	N/A	20		**34.1**

In 1996 the U.S. Geological Survey (USGS) installed automated 15-minute interval water level recorders at two locations:

- At Boca Grande which is the estuary's largest opening to the Gulf of Mexico; and
- Approximately 15.5 kilometers upstream of the river's mouth at Harbour Heights. The gaging station at Harbour Heights also measures surface and bottom conductivity at 15-minute intervals.

In November 1997 a third gage was installed at approximately river kilometer (RK) 26.7 just downstream of the Peace River Facility. This gage also measures both water level as well as surface and bottom conductivity at 15-minute intervals. The relative locations of each of these three USGS gages are depicted in **Figure 3.1a**.

1.2.3 Water Chemistry and Water Column Physical Profiles

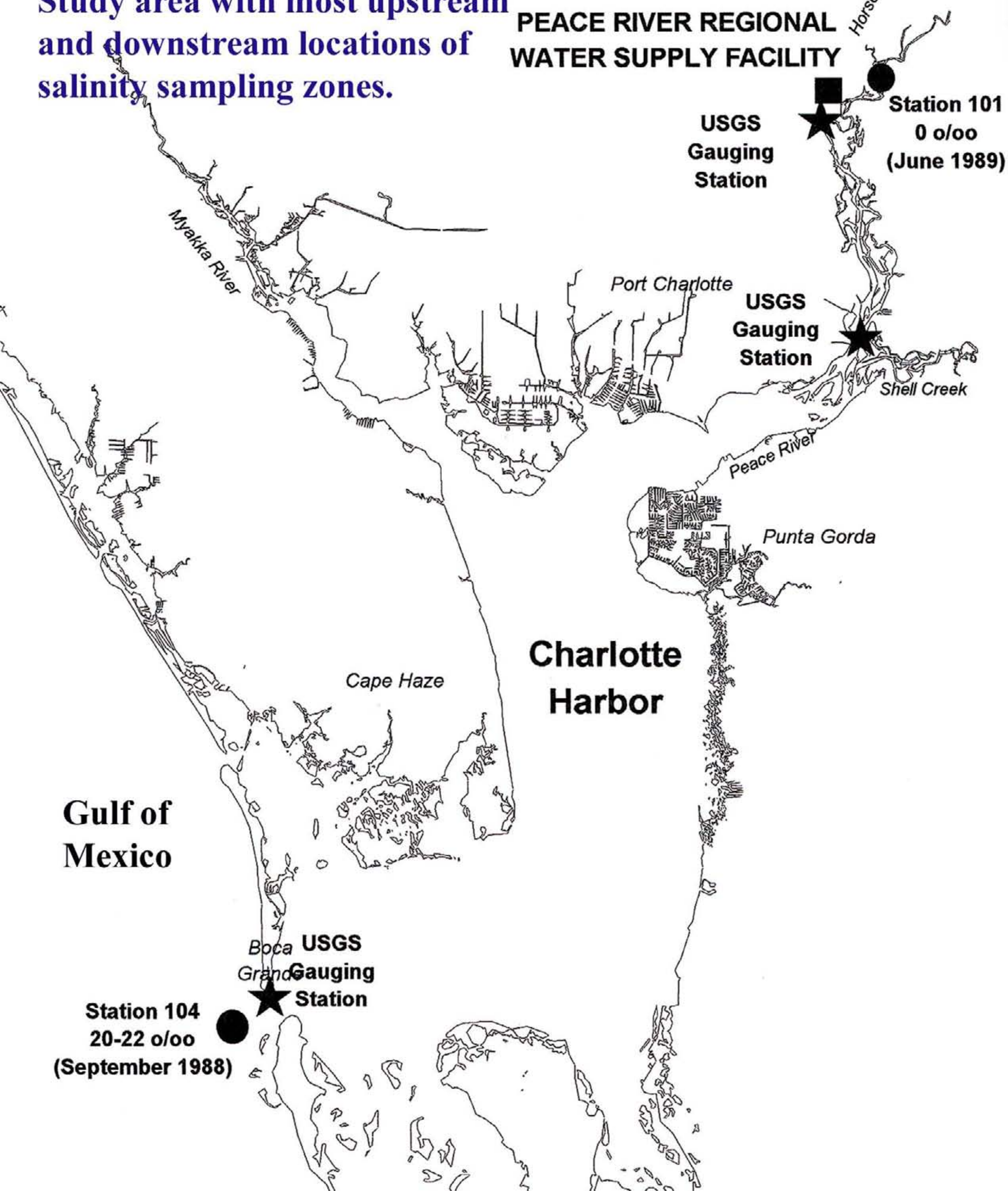
There are a number of goals associated with the study elements in which physical and chemical water quality are measured. On an overall "Health of the Harbor" level, a primary goal is to collect sufficient long-term data to statistically describe spatial and seasonal variability in the water quality characteristics of the Lower Peace River/Upper Charlotte Harbor estuary, and test for significant changes over time (trends). A second goal is to determine if significant relationships exist between freshwater inflows and the seasonal/spatial variability of these water quality parameters. If such relationships can be shown, then the ultimate goal is to determine the potential magnitude of change that might result from permitted withdrawals, and compare such predictions with the range of observed natural variability.

Physical and chemical water quality parameters are measured within the Lower Peace River/Upper Charlotte Harbor estuary under two different HBMP study elements. The first is the monthly "fixed" station water quality characterization study being conducted by the USGS. Additional water quality measurements are also conducted in conjunction with the monthly "moving" isohaline station phytoplankton/primary production study being conducted by Environmental Quality Laboratory (EQL). Physical *in situ* water column profile measurement of water quality characteristics (temperature, dissolved oxygen, pH, conductivity and salinity) are made at 0.5 meter intervals during both of these study elements. In addition both HBMP study elements measure the penetration of photosynthetically active radiation (PAR) to determine ambient extinction coefficients at each sampling location. Both studies also include the analyses of an extensive list of chemical water quality parameters (Table 1.2). The only difference is that at the "fixed" stations sampled by the USGS, both sub-surface and near-bottom samples are collected at each site, while EQL only collects sub-surface samples as part of it's phytoplankton/primary production study.

"Fixed" Station Locations - This study element requires the USGS to conduct monthly water column physical profiles near high tide at sixteen locations along a transect running from just below the river's mouth upstream to a point just above the Peace River Facility (see **Figure 1.2**

Figure 3.1a

Study area with most upstream and downstream locations of salinity sampling zones.



and Table 1.1). Sub-surface and near-bottom samples are also collected at five of these locations for the measurement of selected chemical parameters.

"Moving" Salinity Based Stations – EQL staff conduct physical water column profiles and take sub-surface water chemistry samples monthly within two hours of noon at four salinity based isohalines (0, 6, 12 and 20 ppt) along an imaginary center line running down the Peace River from above its junction with Horse Creek to Boca Grande Pass. The relative monthly location of each sampling is based on the first occurrence of each isohaline.

Table 1.2 HBMP Chemical Water Quality Measurements

Salinity	Nitrate + Nitrite Nitrogen	Inorganic Carbon
Chloride	Ammonia/Ammonium Nitrogen	Total Organic Carbon
Color	Total Kjeldahl Nitrogen	Dissolved Organic Carbon
Turbidity	Total Nitrogen	Chlorophyll *a*
Alkalinity	Ortho-Phosphorus	both total and by size fraction
Suspended Solids	Total Phosphorus	1) > 20 *u*
Volatile Solids	Silica	2) 5 to 20 *u* 3) 5 > *u*

1.2.4 HBMP Study of Long-Term Changes in Vegetation

Identification of potential adverse effects to emergent vegetation and riverine wetlands caused by freshwater withdrawals initially requires determining the magnitude of the spatial and temporal responses of these vegetative communities to the natural variation resulting from extended periods of drought and flood. This step involves developing methodologies that allow differentiating between long-term natural changes in riverine vegetative patterns and withdrawal induced changes. The vegetative monitoring elements of the HBMP provide information for determining relationships between vegetation patterns and freshwater flows by observing the positions of the freshwater and salt-tolerant plant communities, especially in the salinity transitional zone of the river. A permanent shift of more salt-tolerant plants upriver could be an indication that withdrawals were impacting the river corridor wetlands, as long as natural variability (drought) or man-made causes could be eliminated. All vegetation elements of the HBMP studies are currently being done by Florida Environmental, Inc.

Photointerpretation - This long-term element of the HBMP initially began in 1976. Initially aerial infra-red photography was taken yearly of the vegetative communities along the lower Peace River, starting at the US 41 Bridge (river kilometer 6.6) and extending upstream above the Peace River Facility to near the area where Horse Creek enters the river (river kilometer 39.5). Under the 1996 HBMP permit modifications, such aerial surveys continue to be conducted at two years intervals. All post-1996 aerial photography are taken in a corrected, GIS compatible format, thus allowing for accurate quantification of any observed changes. Photointerpretation of these images, in conjunction with field observations, will periodically be used to develop maps of the river's vegetation associations. Both qualitative and quantitative data is being used to assess potential changes associated with extended natural periods of both low and high freshwater inflows.

First and Last Occurrence of Indicator Plant Species – Since 1976, at approximately two year intervals, the first and last occurrence of a large number of indicator plant species has been recorded along the banks of the Peace River downstream of the Peace River Facility. As part of the vegetation study element of the HBMP, detailed maps using the standardized river kilometer scale are made, identifying the first and last occurrences of individual and substantial populations of key indicator species. The current permit requires a detailed photographic record be compiled in conjunction with this effort. These data is used in conjunction with the aerial photography to assess the influences of long-term natural variations in river flow.

Vegetation Transition Sites – Under the current permit, this portion of the HBMP study extends and expands the detailed monitoring begun in 1979 of plant communities along the river's banks at fixed locations. The vegetative communities at three permanent transects sites (see **Figure 1.3** and Table 1.1) are sampled at two year intervals. At each monitoring location, three transects from the top of the bank to the water's edge are surveyed. The vegetation one meter to each side of the transects is identified, and the location and density recorded. These long-term data can be used to further assess the response of the riverine vegetative communities to natural variations in freshwater flows.

1.2.5 Phytoplankton Studies

Environmental Quality Laboratory, Inc is conducting these HBMP investigations. Sub-surface samples are being collected in conjunction with the moving station physical and chemical water quality data described above.

Carbon Uptake - Since 1983, monthly *in situ* measurements have been conducted within 2 hours of noon at each of the four "moving" isohalines (0, 6, 12, 20 ppt salinity). Replicate (5) rates of carbon uptake are determined for each of three separate phytoplankton size fractions: 1) greater than 20 microns; 2) less than 20 microns and greater than 5 microns; and 3) those cells less than 5 microns.

Chlorophyll *a* Biomass - corresponding values for sub-surface concentrations are determined for each of the above size fractions.

Species Composition - Since 1989, monthly sub-surface samples have been collected, preserved and identified to the lowest practical taxon in conjunction with the carbon uptake measurements at each of the four isohalines. Dr. Susan Jensen has made all taxonomic identifications.

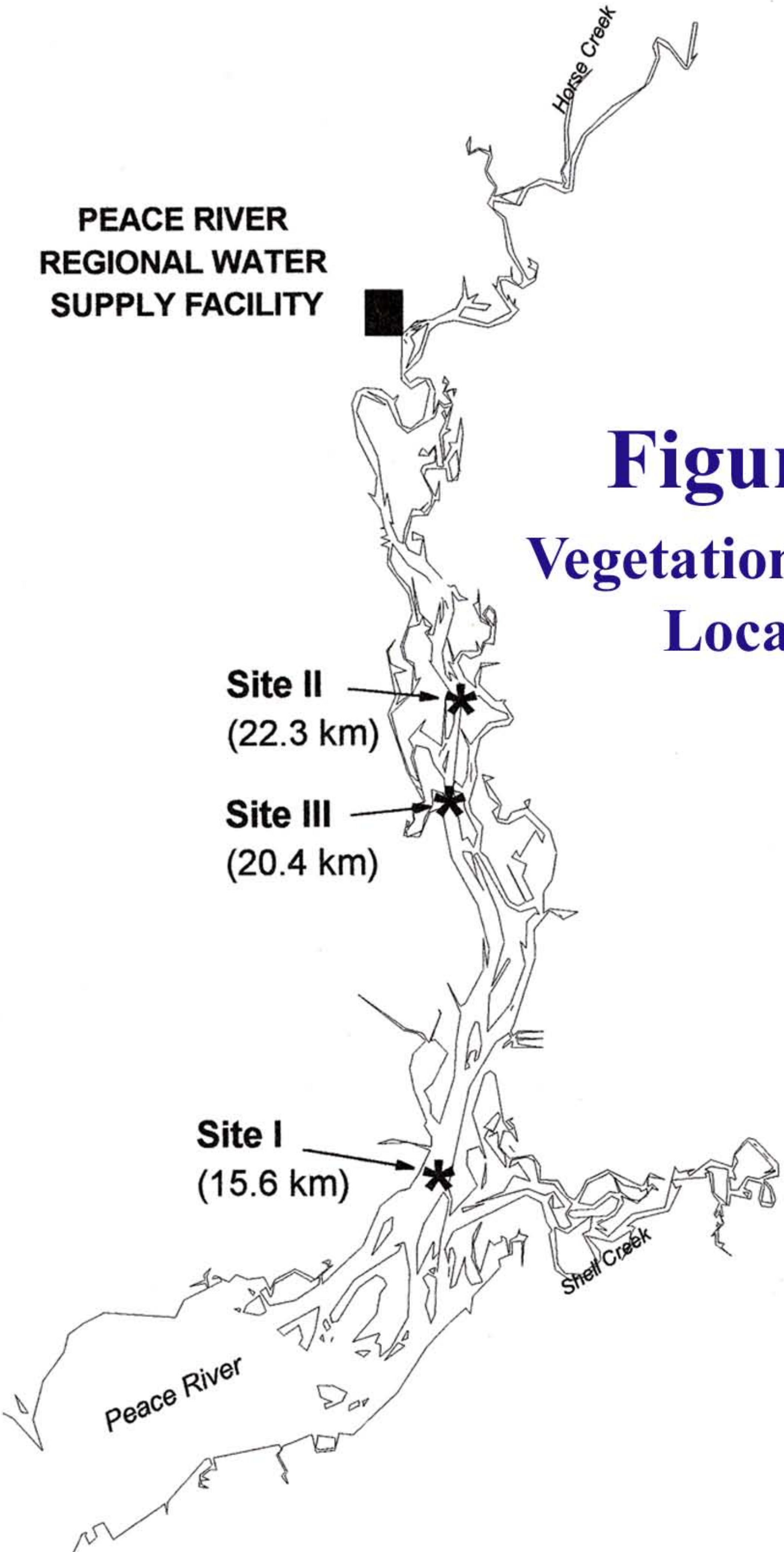


Figure 1.3
Vegetation Transect Locations

1.3 Special Studies Associated with the HBMP

In addition to the current, ongoing elements of the HBMP outlined above, the revised HBMP program implemented in 1996 also required the Authority to conduct and/or contribute to a number of duration-limited studies designed to answer specific research questions. The following outlines the major goals of each of these special studies. Each of these special investigations will result in a stand-alone report to be submitted to the District. Where applicable, all pertinent data collected during these specific research studies will be incorporated into other study elements of the HBMP.

1.3.1 Morphometric Investigation

The goal of this effort, conducted by PBS&J, was to develop maps and tabular files indicating: typical cross-sections; open-water area; water volume; shoreline length; and areas/types of adjacent wetland habitat. All such determinations and metrics were determined corresponding to 0.5 kilometer interval segmentss along a developed centerline extending from the mouth of the Peace River near Punta Gorda to a point well upstream of the Water Peace River Facility. In addition, a summary table was developed indicating the locations of both current and previous fixed water quality and vegetation sampling locations in relation to the new centerline kilometer distance scale developed during the morphometeric analysis. The results of the morphometeric study have been submitted to the District as a separate report. Table 1.1 and **Figure 1.2** indicate the permanent river kilometer distances that will be used in all future HBMP documents, in relation to both USGS river miles and EQL station locations.

1.3.2 Benthic Macroinvertebrate and Mollusc Study

This special study element of the HBMP is being conducted by Mote Marine Laboratory, and a separate report summarizing the findings is expected early in 2001. The primary objectives of the two investigations being conducted as part of this effort are to:

- Describe the distribution of major macroinvertebrate habitats and communities in the lower Peace River.

- Determine whether benthic organisms and/or their community structure can be used to assess natural variations in freshwater inflows and, measure potential influences caused by the diversions of the Peace River Facility.

The approach of these studies has been to characterize the tidal area of the river downstream of the Peace River Facility based on a series of criteria, including: 1) the magnitude of tidal influence, 2) dominant shoreline habitats, and 3) observed gradients in physical and/or chemical characteristics, or other features found to be significant. Important riverine characteristics of significance to the distribution of benthic invertebrate communities would include physical/chemical parameters such as the sediment granulometry of the riverbed, as well as spatial differences with depth, salinity and dissolved oxygen.

Macroinvertebrates – The design of this sampling effort incorporated dividing the lower Peace River into four "salinity segments" based on historic gradients from data gathered as part of the HBMP.

- < 0.5 ppt
- > 0.5 & < 8 ppt
- > 8 & < 16 ppt
- > 16 ppt

Core samples, the colonization of artificial substrates, and sweep nets were used to characterize the benthic invertebrate communities from two depths: 1) the intertidal zone; and 2) from Mean Low Low Water down to a depth of 3.7 meters; within each of the four identified salinity zones.

Mollusc Study - A second corollary investigation has been undertaken of the distribution of benthic, hard-shell mollusc communities, examining both live and dead shells to delineate ecological zones in the estuary and attempting to relate the observed patterns to recent seasonal patterns in flows and observed variations in near bottom salinity. This investigation has incorporated intensive sampling at 0.5 km intervals along the lower river.

1.3.3 Fish Nursery Study

The University of South Florida is undertaking this special short-term program. A two-year study is being funded by the Authority and the Water Management District to define seasonal and spatial patterns of fish nursery use within the Lower Peace River/Upper Charlotte Harbor Estuary to determine the influences/relationships freshwater inflows have on such patterns. Stratified estimates of the relative distribution and abundance of fishes and selected invertebrate taxa will be made from two randomly selected, five minute, three-step (bottom-midwater-surface) oblique tows collected during night, flood tide conditions using a weighted, flowmeter-equipped plankton net. Monthly samples have been collected at seven zones within the lower Peace River. A separate Summary Report is expected to be finished early in 2001.

1.4 Summary of 1999 Results

The following text and tables compare data collected during 1999 with similar average values for key parameters previously compiled during various elements of the ongoing long-term monitoring programs. Such key elements, include:

1. Peace River freshwater inflows and facility withdrawals.
2. Physical measurements such as water temperature, color and extinction coefficients.
3. Water quality characteristics such as nitrate/nitrite, ortho-phosphorus, nitrogen to phosphorus ratios, and silicon.

4. Biological measurements of phytoplankton production and biomass - carbon uptake, and chlorophyll *a*.

In making comparisons of the 1999 data with averages of similar data collected over the proceeding 16 year period (1983-1998), it should be noted that the relatively dry 1999 La Niña directly followed the very wet winter/spring El Niño of 1997/1998 (see **Figure 2.6**).

- **Flow** - Peace River average daily flow at the Arcadia gauge during 1999 was approximately 65% of the average daily flow for the long-term preceding period 1976-1998 (**Table 1.3**). The sum of average daily flows from the gauges at Peace River at Arcadia, Horse Creek, Joshua Creek, and Shell Creek indicate that flows for 1998 were approximately 76% of the sum of average daily flows for the interval 1976-1998. The total withdrawals during 1999 were approximately 1.15% of the combined daily flows of the Peace River, Horse Creek, Joshua Creek, and Shell Creek. In comparison, withdrawals during the period 1980-1998 averaged approximately 0.58% of these same combined daily flows.

- **Temperature** - Average water temperatures in 1999 were just slightly higher than the long-term averages. The slightly higher average water temperatures during 1998 probably resulted from mild winters during 1998 and 1999 (see **Table 1.4** for comparisons between 1999 and long-term averages of this and the following parameters).

- **Water Color –** Average water color at each of the four salinities monitored as part of the moving isohaline study declined in 1999 from very high levels observed during the 1997/1998 El Niño event. However, median water color during 1999 was still greater than the preceding long-term averages.

- **Extinction Coefficient –** The rates of measured light attenuation at each of the four isohaline salinities showed relative patterns very similar to those for color.

- **Nitrite/Nitrate Nitrogen**- During 1999, the average concentrations of this major inorganic form of nitrogen were very similar to the long-term averages at each of the four measured salinities. A comparison among the isohalines indicates that a strong inorganic nitrogen gradient exists in the upper estuary. Concentrations typically decrease rapidly with increasing salinity. Seasonally, ambient inorganic nitrogen concentrations decline to their lowest levels during the late spring dry season, as phytoplankton populations respond to increasing water temperatures and light.

- **Ortho-Phosphorus** - Average inorganic phosphorus concentrations during 1999 were slightly lower than the long-term averages at each of the four isohalines for the preceding period 1983-1998. These observations probably reflect the marked decline in phosphorus concentrations that began in the Peace River in the early 1980's.

Table 1.3 Long-Term Yearly Mean Measurements of Peace River Flows and Facility Withdrawals

Year	Means (in cubic ft/sec)			Withdrawal as Percent of Gaged Flow at:	
	Flow at Peace Facility Arcadia	Peace Arcadia + Horse Creek + Joshua Creek + Shell Creek	Withdrawal	Arcadia	US 41 Bridge
1976	703.3	959.6	No Withdrawals Until 1980		
1977	478.7	731.9			
1978	997.2	1525.8			
1979	1171.4	2080.5			
1980	495.2	726.3	3.93	0.66	0.45
1981	288.4	629.6	5.10	1.77	0.81
1982	1610.5	2746.9	5.91	0.37	0.21
1983	1371.3	2319.9	5.11	0.37	0.22
1984	567.0	1102.7	4.07	0.72	0.37
1985	368.9	680.7	7.24	1.96	1.06
1986	548.9	1013.6	7.50	1.37	0.74
1987	802.7	1357.8	7.59	0.95	0.56
1988	1054.0	1738.4	9.48	0.90	0.55
1989	373.6	699.0	9.60	2.57	1.37
1990	402.4	741.4	8.72	2.17	1.18
1991	771.1	1567.6	10.38	1.35	0.66
1992	784.6	1543.6	9.41	1.20	0.61
1993	698.5	1249.3	12.02	1.72	0.96
1994	1365.9	2359.0	11.65	0.85	0.52
1995	1708.1	3071.6	12.23	0.72	0.40
1996	598.2	928.8	12.46	2.08	1.34
1997	1059.9	1777.6	12.12	1.14	0.68
1998	1915.9	2921.3	15.43	0.81	0.53
1999	565.2	1142.5	12.8	2.26	1.15

Table 1.4 Mean Values for Key Physical, Chemical and Biological Measurements by Isohaline

Isohaline	TEMP	COLOR	N23	OP	NP	SI	EXC	CHLA	P3
Summary of data from current year – 1999									
0 o/oo Salinity	25.0	173	0.499	0.637	0.9	2.85	3.33	11.0	0.32
6 o/oo Salinity	25.5	131	0.213	0.444	0.7	2.31	2.95	25.5	3.56
12 o/oo Salinity	25.5	91	0.080	0.306	0.5	1.57	2.47	24.6	3.89
20 o/oo Salinity	25.1	49	0.032	0.160	0.6	1.02	1.67	13.4	1.26
Summary of data from preceding period 1983-1998									
0 o/oo Salinity	24.7	140	0.493	0.743	0.8	2.60	3.18	9.8	8.85
6 o/oo Salinity	25.0	111	0.216	0.534	0.5	2.16	2.81	23.2	20.52
12 o/oo Salinity	25.0	81	0.098	0.372	0.4	1.67	2.27	23.0	21.87
20 o/oo Salinity	24.6	45	0.036	0.215	0.4	0.97	1.59	12.3	17.24

Temp = Temperature
Color = Color
N23 = Nitrate/Nitrite Nitrogen
OP = Ortho-phosphorus
NP = Atomic Inorganic Nitrogen to Phosphorus Ratio
SI = Reactive Silica
EXC = Extinction Coefficient
CHLA = Chlorophyll *a*
P3 = Rate of Carbon Uptake

- **Nitrogen to Phosphorus Atomic ratios –** Calculated atomic inorganic nitrogen to phosphorus ratios for ambient measured concentrations in 1999, as indicated by the long-term averages, show that nitrogen is always the limiting macronutrient at each of the four isohalines.

- **Silica** - Mean concentrations during 1999 at each of the four salinities were very similar to the ranges and seasonal pattern previously observed.

- **Carbon Uptake –** The relative differences during 1999 among measured rates at each of the four isohalines was similar to the historic pattern, with measured rates being generally much higher at the two intermediate salinities. However, overall measured uptake rates were only a small fraction of the historic norm and failed to show the characteristic seasonal patterns that have always been observed during the preceding period (1983-1998). Based on a complete and thorough review of all results and procedures (software and hardware), the probable answer seems to have resulted from either: 1) contamination and loss of radioactivity in the standard C14 stock solution added during the *in situ* incubations; or 2) damage and loss of calibration of the liquid scintillation counter. Based on this finding, all 1999 carbon uptake measurements should be eliminated from the HBMP data base.

- **Chlorophyll *a* –** Concentrations measured at each of the four salinities were very similar to the long-term averages. The somewhat higher than normal levels at the two intermediate salinities (6 and 12 o/oo) during January and February probably reflect both the mild winter and the continued influence of the strong 1997/1998 El Niño event.

1.5 Conclusions

This document represents the fourth Annual Data Report submitted under the expanded Hydrobiological Monitoring Program (HBMP) initiated in January 1996 in compliance with Water Use Permit (WUP) 2010420.03. The graphical and summary analyzes presented in this document do not indicate any substantial changes, or atypical events, in either the physical or biological data collected during 1999. These "limited" analyzes also do not suggest there to have been any long-term changes resulting from either current or historic water withdrawals by the Peace River Regional Water Supply Facility.

1.6 Permanent Data

All historic water quality and in situ data collected during the fixed and moving station elements of the HBMP used in the preparation of this document are provided on the Year Three Annual Data Report CD in the directory labeled 1999 Data Sets, as either ASCII files and/or SAS format. Table 1.5 provides a summary and links to descriptions of the variables within each of the SAS data sets.

Table 1.5 Description of Data Sets		
Data Set Name	**Time Period**	**Brief Description**
flows99.sd2	1931-1999	Historic daily flow data for: Peace at Arcadia; Horse Creek near Arcadia; Joshua Creek near Nocatee; and Shell Creek near Punta Gorda. Historic daily Peace River Facility withdrawals. All values in cfs.
Mov8399.sd2	1983-1999	Water quality, and phytoplankton biomass and uptake measurements from monthly surface samples collected at each of the four moving isohalines. Relative locations reflect distances from the river mouth in kilometers.
Eqlhy99.sd2	1983-1999	Monthly hydrolab *in situ* water quality measurements taken at 0.5 meter intervals at each of the four moving isohalines. Relative locations reflect distances from the river mouth in kilometers.
Field99.sd2	1996-1999	Monthly *in situ* hydrolab water column profile data taken at 0.5 meter intervals from fixed sample locations from near the river's mouth to just upstream of the Treatment Facility.
Chem99.sd2	1996-1999	Monthly surface and bottom chemical water quality samples taken at five intervals from fixed sample locations from near the river's mouth to just upstream of the Treatment Facility.
Boca99.sd2	1996-1999	Water level at 15-minute intervals from the continuous recording gage near Boca Grande.
Phh9699.sd2	1996-1999	Water Level, and surface and bottom conductivity and temperature at 15-minute intervals from the continuous recording gage on the Peace River near Harbor Heights (River Kilometer 15.5).
pr9799.sd2	1997-1999	Water Level, and surface and bottom conductivity and temperature at 15-minute intervals from the continuous recording gage on the Peace River near Peace River Heights (River Kilometer 26.7).

** **Note:** Click on the data set name to review a comprehensive listing of the data set contents.

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Chapter II

Peace River Gaged Flows and Regional Water Supply Facility Withdrawals

Daily discharges (in cubic feet per second) at the USGS gauging station at Arcadia, Florida, for January through December 1999, are depicted in Figure 2.1. Daily Peace River flows between 1976, the beginning of the HBMP, and 1999 are shown in Figure 2.2. This long-term period of river flow is further presented as mean monthly values (Figure 2.3) and as the 3-month moving averages (Figure 2.4). Plots similar to those above for total gauged flow entering Charlotte Harbor from the Peace River (Peace River at Arcadia + Horse Creek + Joshua Creek + Shell Creek) are shown in Figures 2.5 through 2.8.

Table 2.1 Comparisons of Freshwater Inflows during 1999 and the Period 1976-1999.

Figure	Description
Figure 2.1	Daily Peace River Flow at Arcadia (1999)
Figure 2.2	Daily Peace River Flow at Arcadia (1976-1999)
Figure 2.3	Monthly Mean Peace River Flow at Arcadia (1976-1999)
Figure 2.4	3-Month Moving Average Peace River Flow at Arcadia (1976-1999).
Figure 2.5	Daily Peace River Flow at Arcadia + (Horse + Joshua + Shell) Creeks (1999)
Figure 2.6	Daily Peace River Flow at Arcadia + (Horse + Joshua + Shell) Creeks (1976-1999)
Figure 2.7	Monthly Mean Peace River Flow at Arcadia + (Horse + Joshua + Shell) Creeks (1976-1999)
Figure 2.8	3-Month Moving Average Peace River Flow at Arcadia + (Horse + Joshua + Shell) Creeks (1976-1999)

Daily withdrawals from the Peace River (in cubic feet per second) during 1999 by the Treatment Facility are presented in Figure 2.9. Daily withdrawals since plant startup are shown from 1980-1999 in Figure 2.10. Plots of the monthly means and 3-month moving averages of withdrawals over this period are depicted in Figures 2.11 and 2.12. Various relationships between Peace River flows as measured at Arcadia and Water Supply Facility withdrawals are depicted in Figures 2.13 through 2.16.

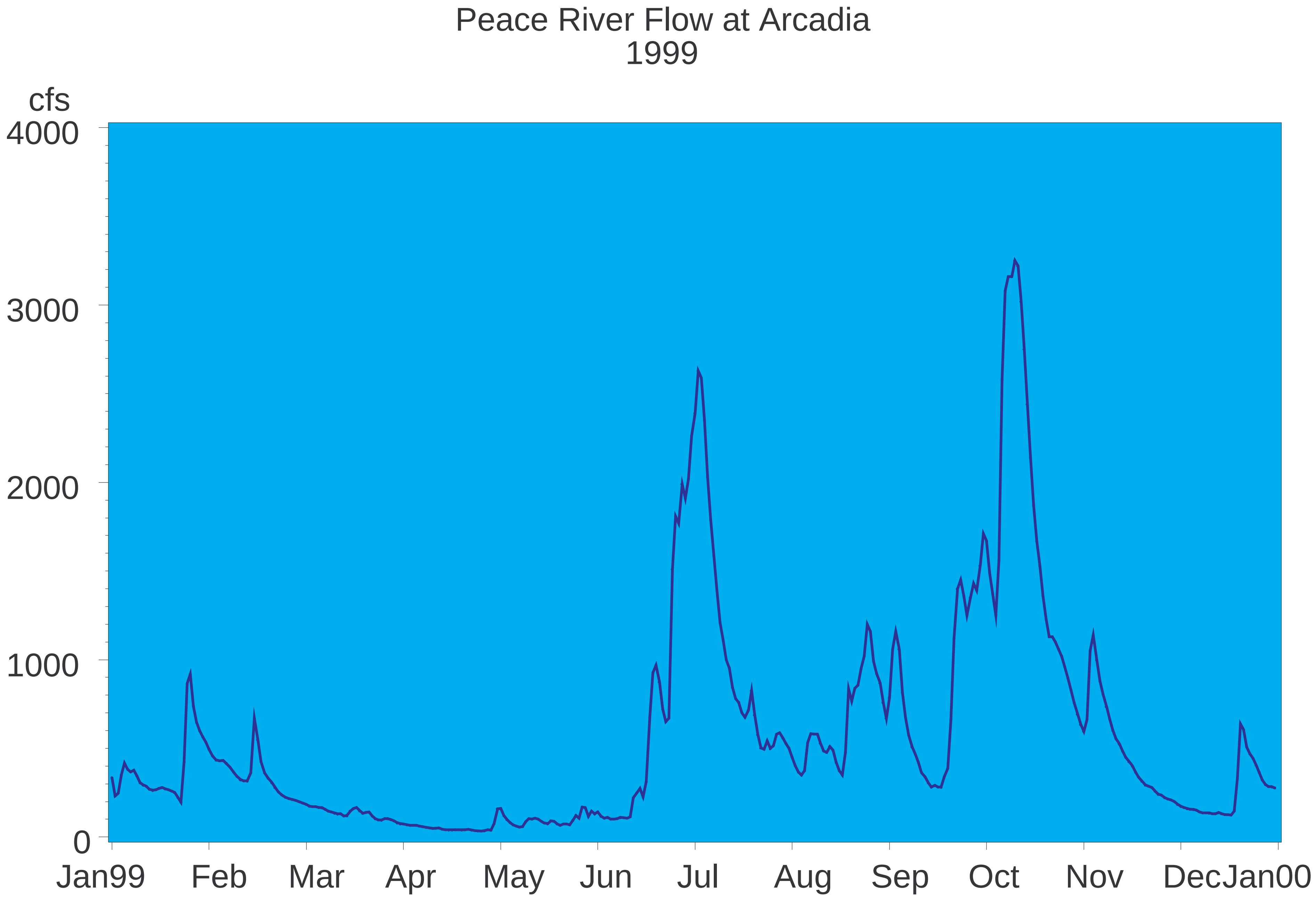

Figure 2.1 Daily Peace River Flow at Arcadia (1999).

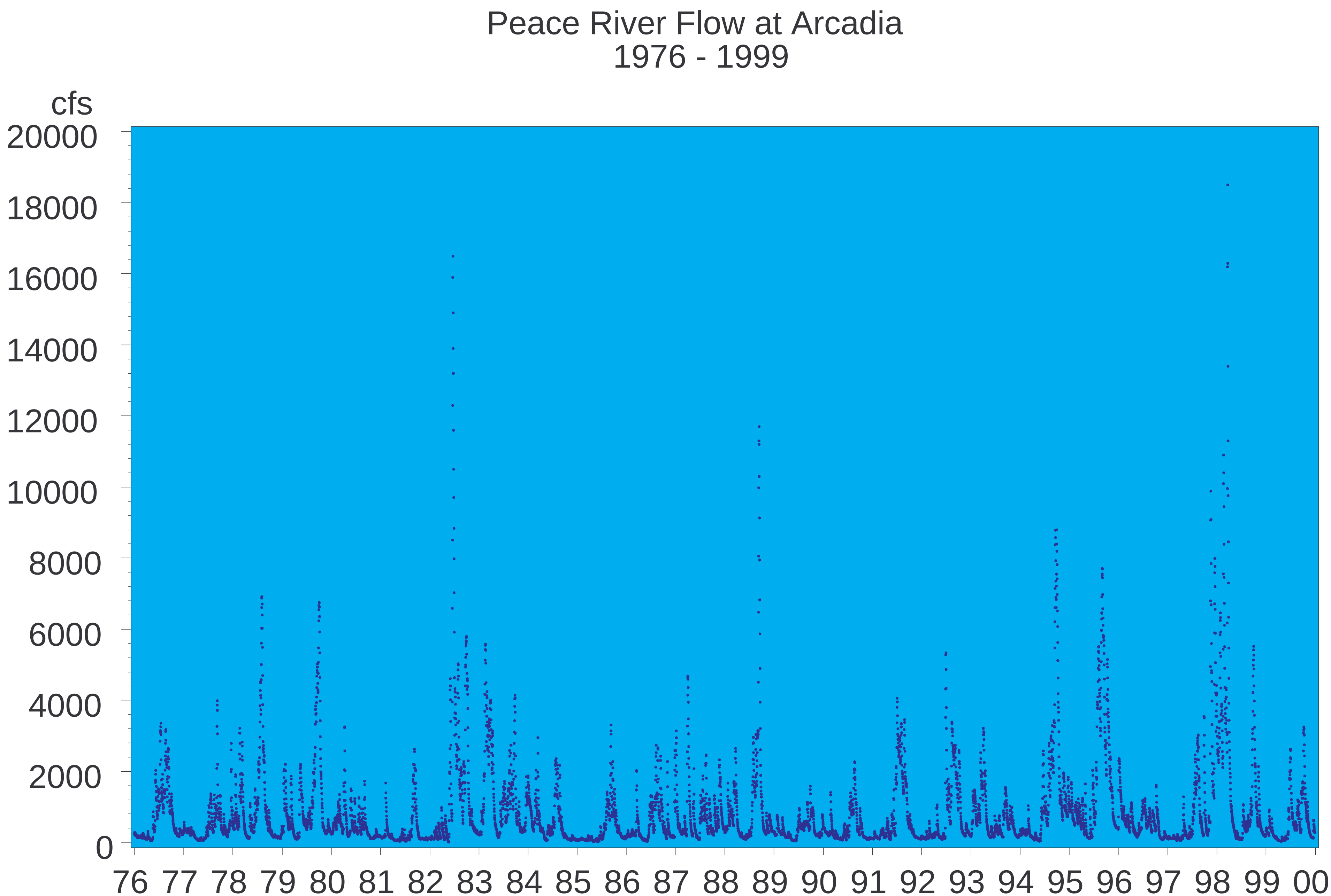

Figure 2.2 Daily Peace River Flow at Arcadia (1976-1999).

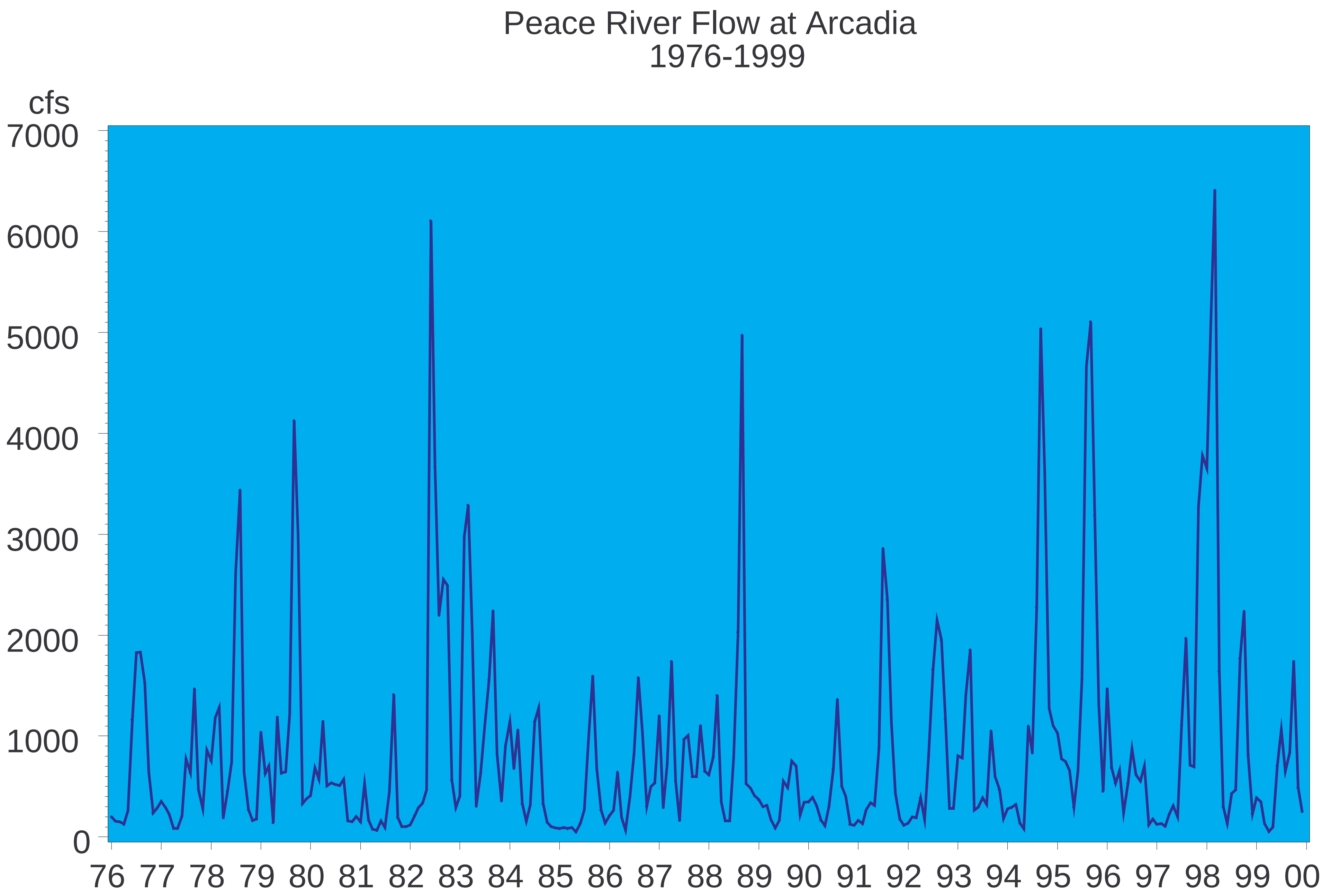

Figure 2.3 Monthly Mean Peace River Flow at Arcadia (1976-1999).

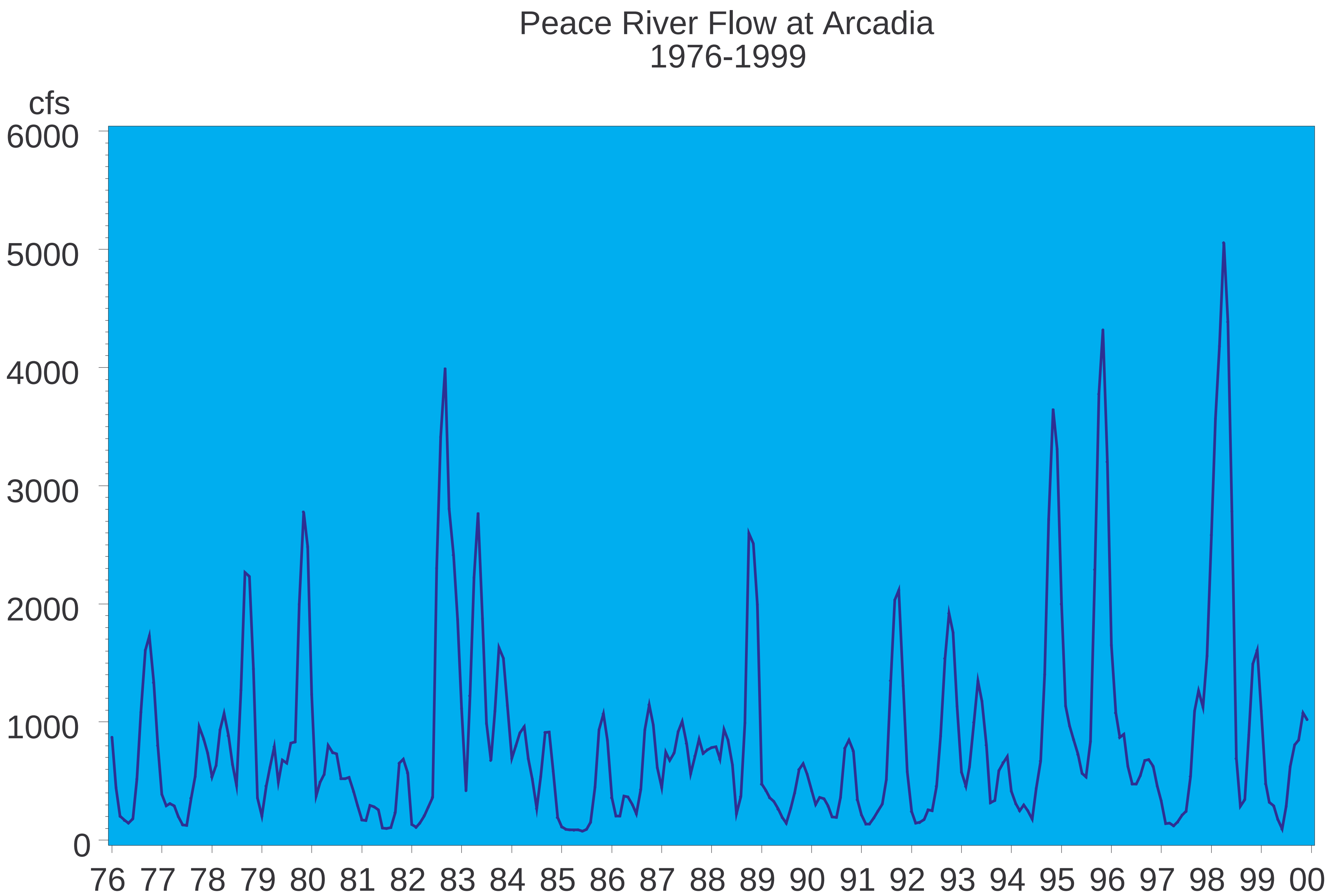

Figure 2.4 3-Month Moving Average Peace River Flow at Arcadia (1976-1999).

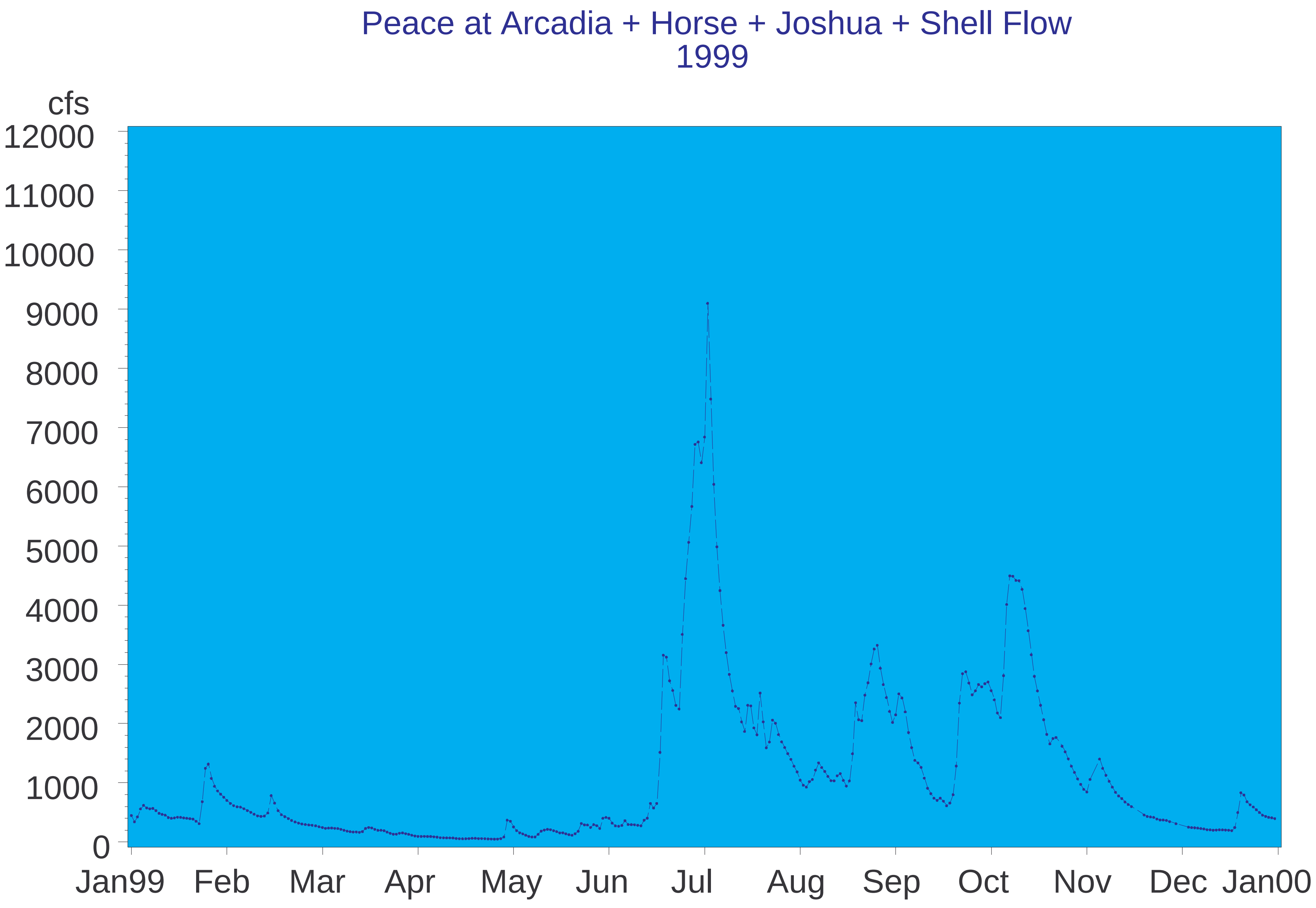

Figure 2.5 Daily Peace at Arcadia + Horse + Joshua + Shell (1999).

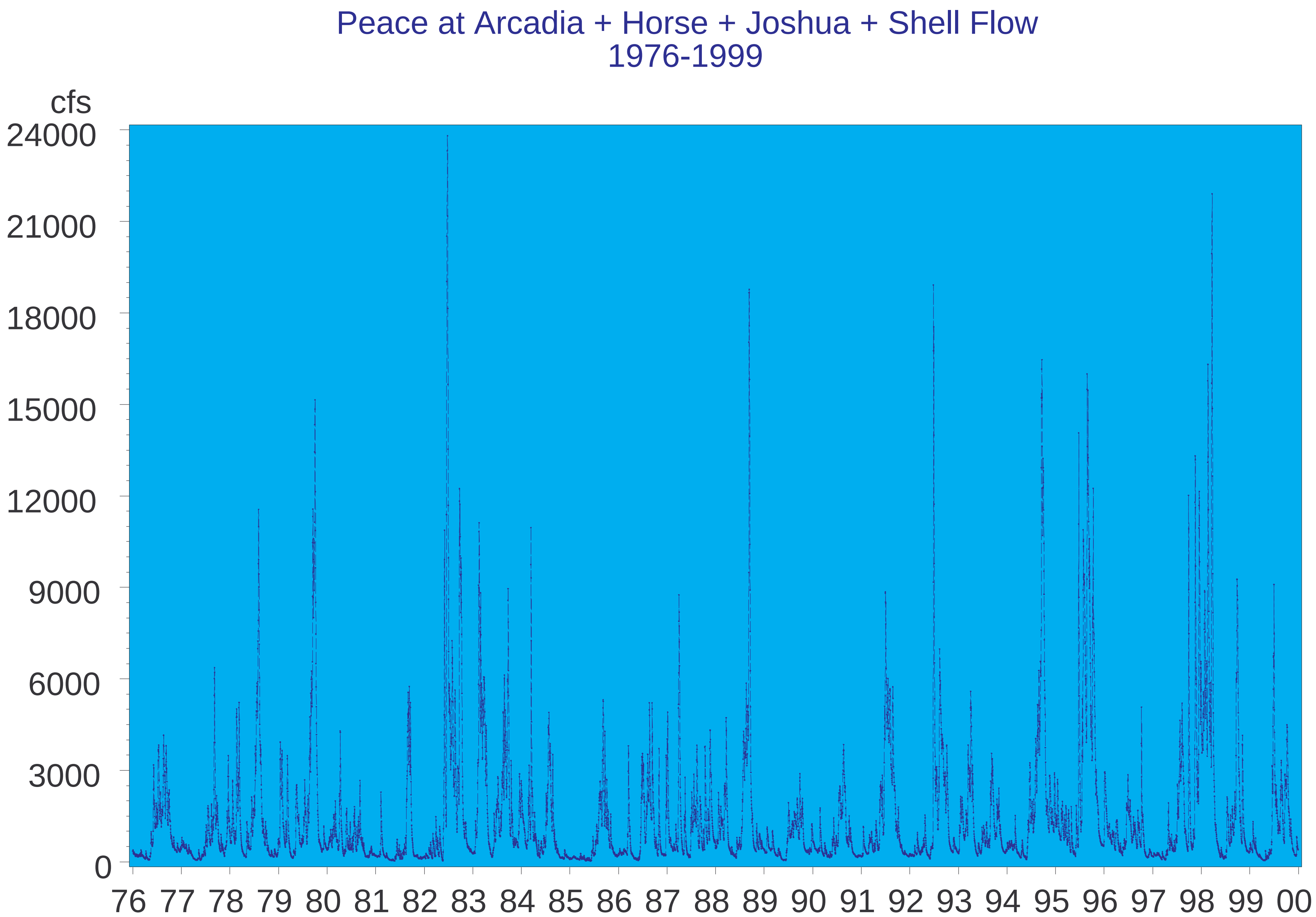

Figure 2.6 Daily Peace at Arcadia + Horse + Joshua + Shell (1976-1999).

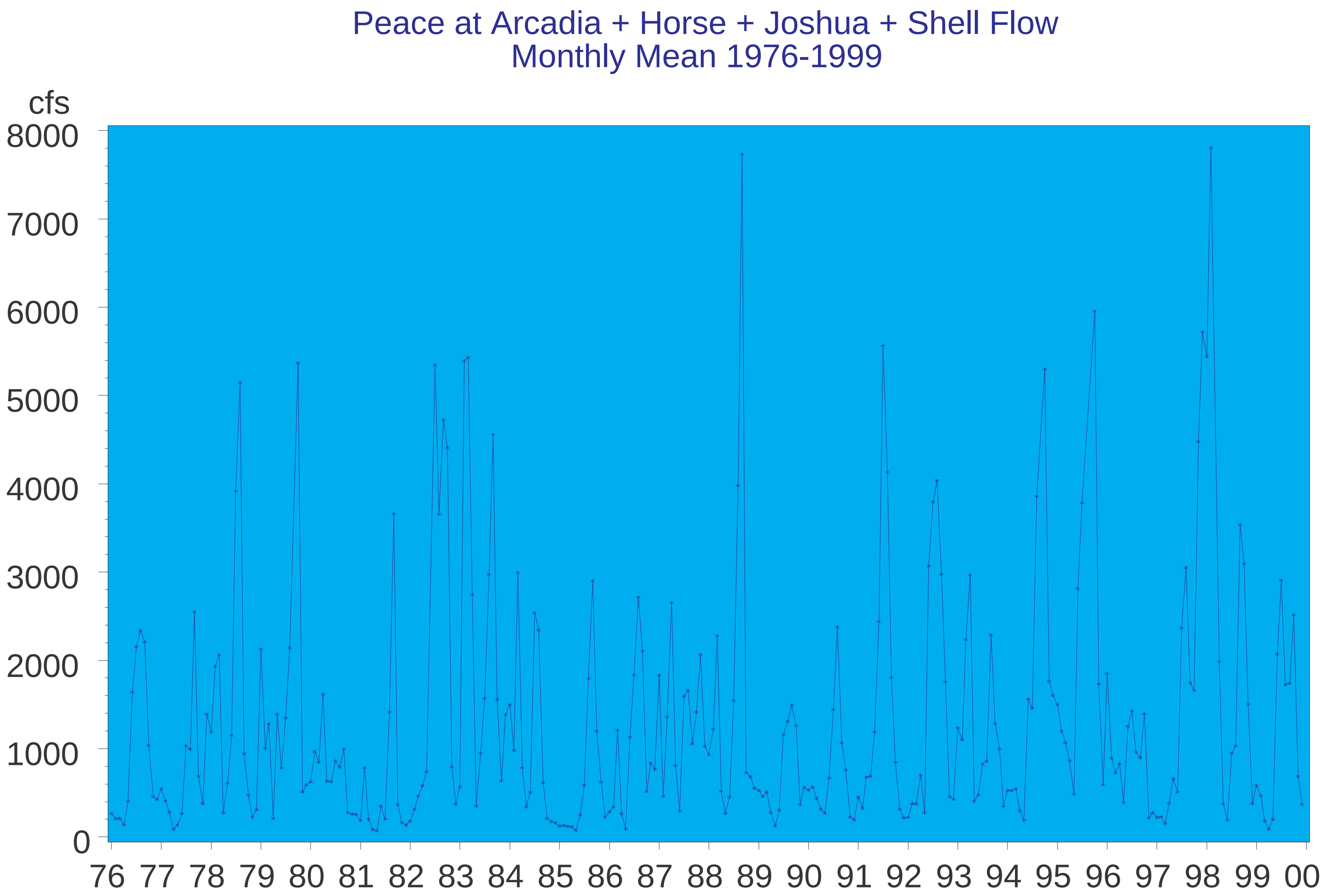

Figure 2.7 Monthly Mean Peace at Arcadia + Horse + Joshua + Shell (1976-1999).

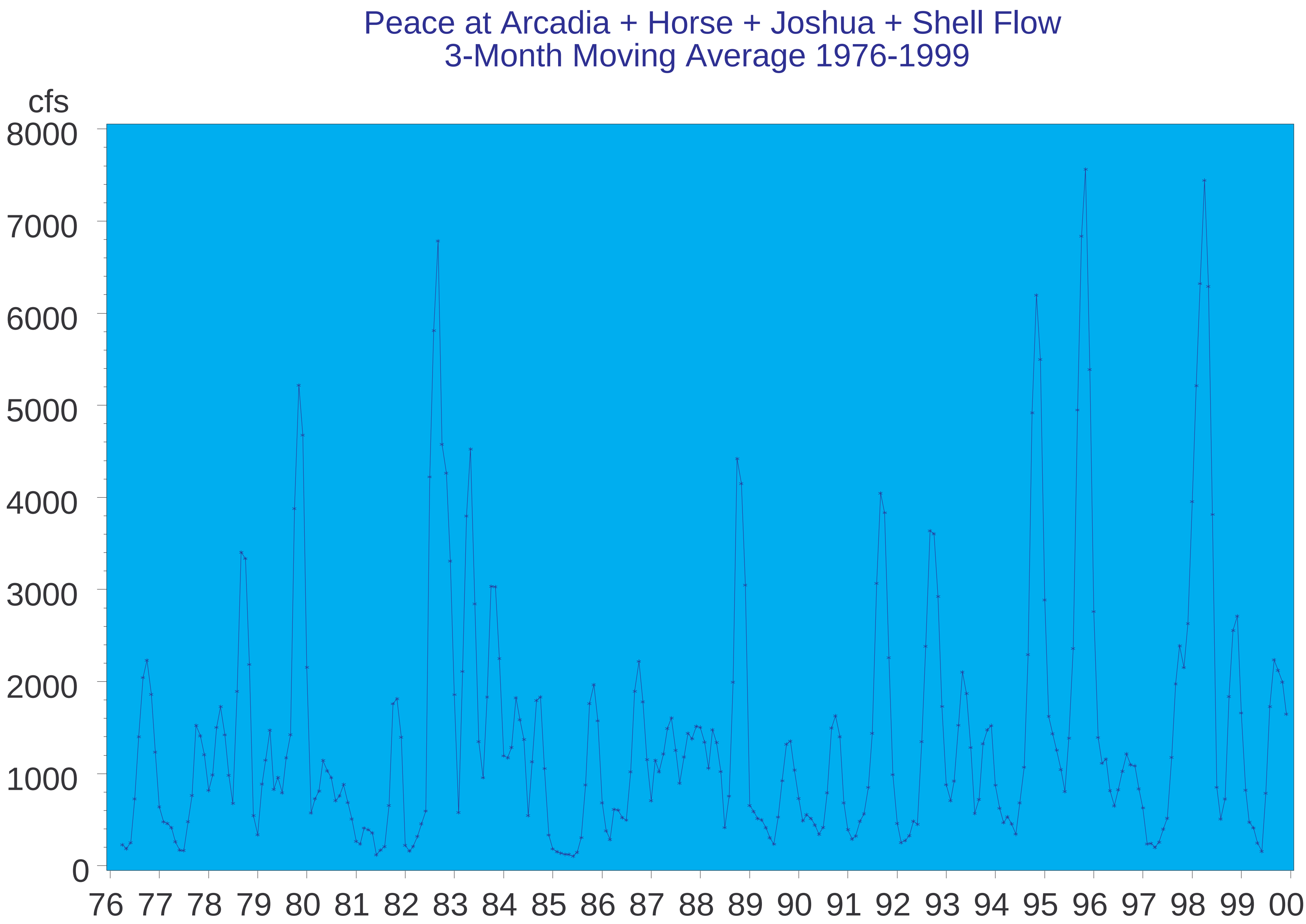

Figure 2.8 3-Month Moving Average Peace at Arcadia + Horse + Joshua + Shell (1976-1999).

Table 2.2 Comparisons of Facility Withdrawals and Freshwater Inflows during 1999 and the Period 1976-1999.

Figure	Description
Figure 2.9	Daily Water Treatment Facility Withdrawals (1999)
Figure 2.10	Daily Water Treatment Facility Withdrawals (1980-1999)
Figure 2.11	Monthly Mean Water Treatment Facility Withdrawals (1980-1999)
Figure 2.12	3-Month Moving Average Water Treatment Facility Withdrawals (1980-1999)
Figure 2.13	Peace River Flows at Arcadia and Water Treatment Facility Withdrawals (1999)
Figure 2.14	Peace at Arcadia + Horse + Joshua + Shell Flows and Water Treatment Facility Withdrawals (1999)
Figure 2.15	Peace River Flows at Arcadia vs. Water Treatment Facility Withdrawals (1999)
Figure 2.16	Peace River Flows at Arcadia vs. % Water Treatment Facility Withdrawals (1999)

Comparison of the data displayed in Figures 2.1 and 2.2 shows that Peace River average daily flow at Arcadia for 1999 was approximately 65% of the average daily flow from 1976-1998. The data displayed in Figures 2.5 and 2.6 for the sum of average daily flows from the Peace River at Arcadia, Horse Creek, Joshua Creek, and Shell Creek indicate that flows for 1999 were roughly 76% of the average daily flows for the long-term preceding time period 1976-1998.

Withdrawals from the river by the Treatment Facility during 1999 reached the maximum allowable levels during 13% of the days of the year. As indicated in Figure 2.16, withdrawals exceeded the permitted maximum of 10% of the preceding daily flow at the Arcadia gage a number of times during 1999. Such instances resulted from two causes:

1. The Authority receives and calculates preceding day flows from the water level recorder at the USGS gaging station on the Peace River at Arcadia. However, after the fact, the USGS checks and evaluates the data from the stage recorder and river cross section a number of times each year. Thus the daily values used by the Authority are only "provisional" and are often changed by the USGS weeks or even months after-the-fact. Thus, it is not uncommon for subsequent determinations of percent withdrawals, based on revised USGS calculations of daily flows, to sometimes indicated that daily withdrawals, based on provisional flow information, to exceed 10%.

2. A second problem was discovered during 1999. The Authority was using rating curve information provided by USGS to directly convert average daily stage levels into estimated flows. However, at some point, USGS changed rating curves without informing the Authority. As a result, there was a period when there were substantial differences between the flows being used by USGS and the Authority. This problem has been corrected and should never occur again, since the Authority now obtains provisional information directly from the USGS Tampa Office's Web Site.

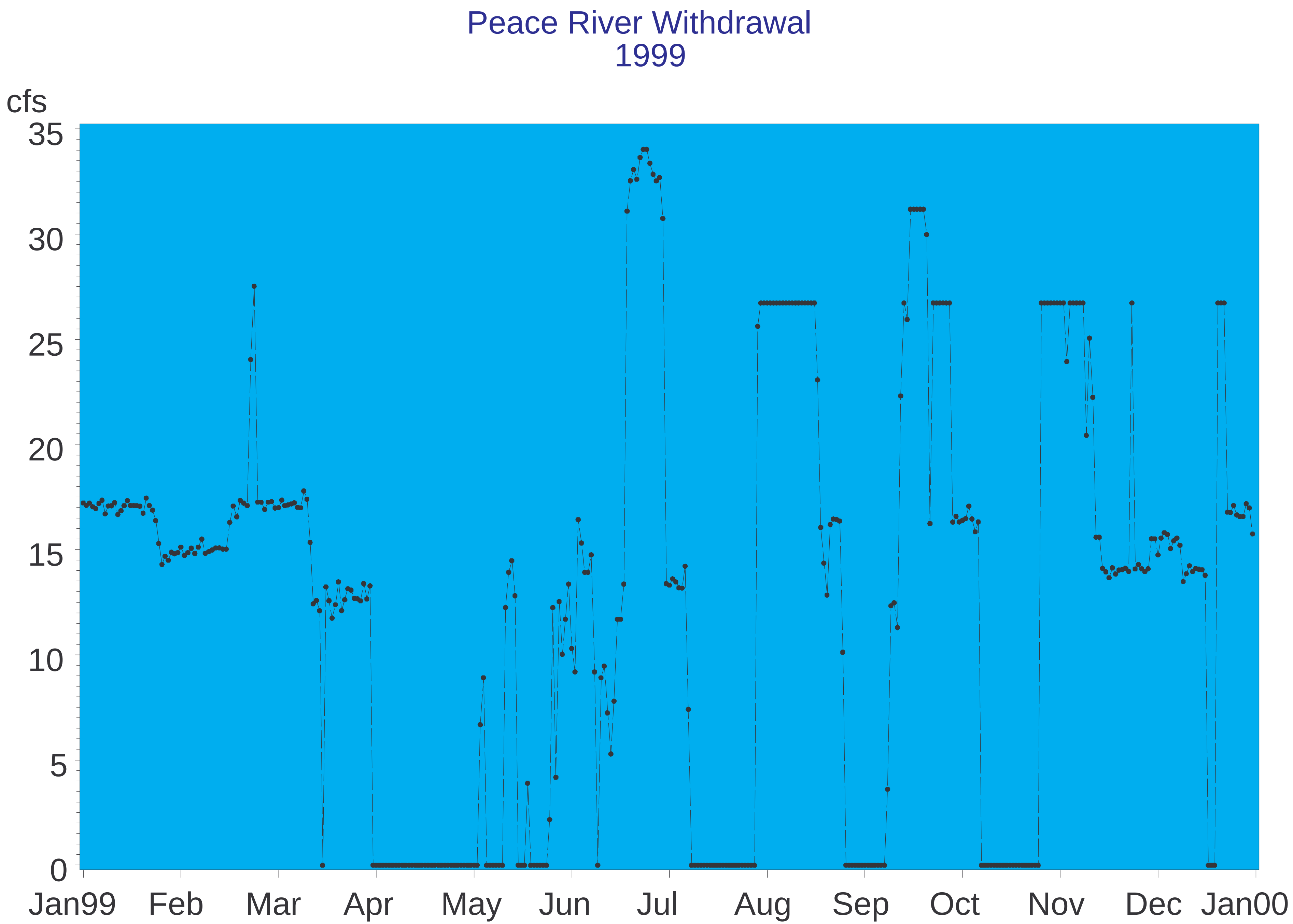

Figure 2.9 Daily Water Treatment Facility Withdrawals (1999)

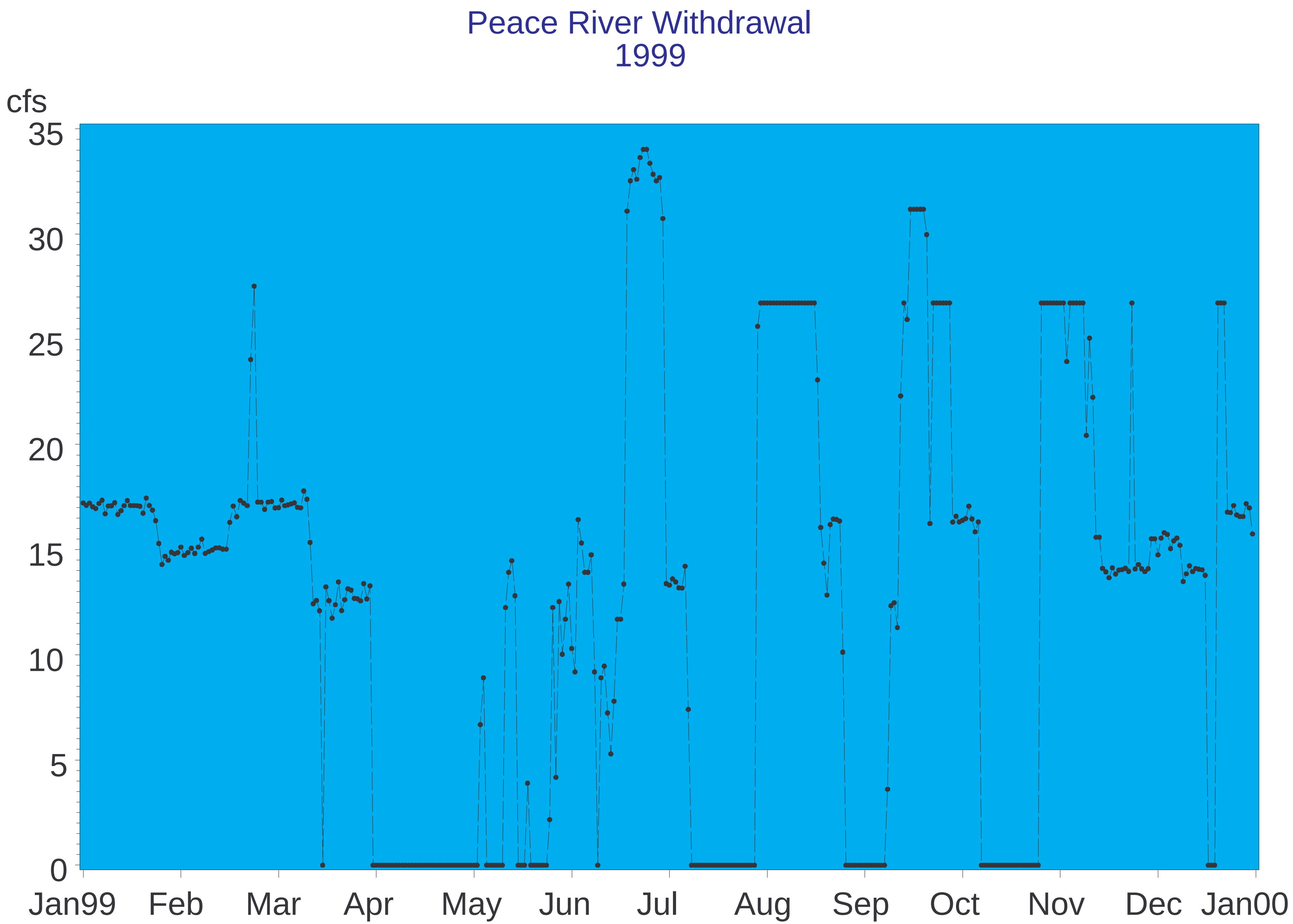

Figure 2.9 Daily Water Treatment Facility Withdrawals (1999)

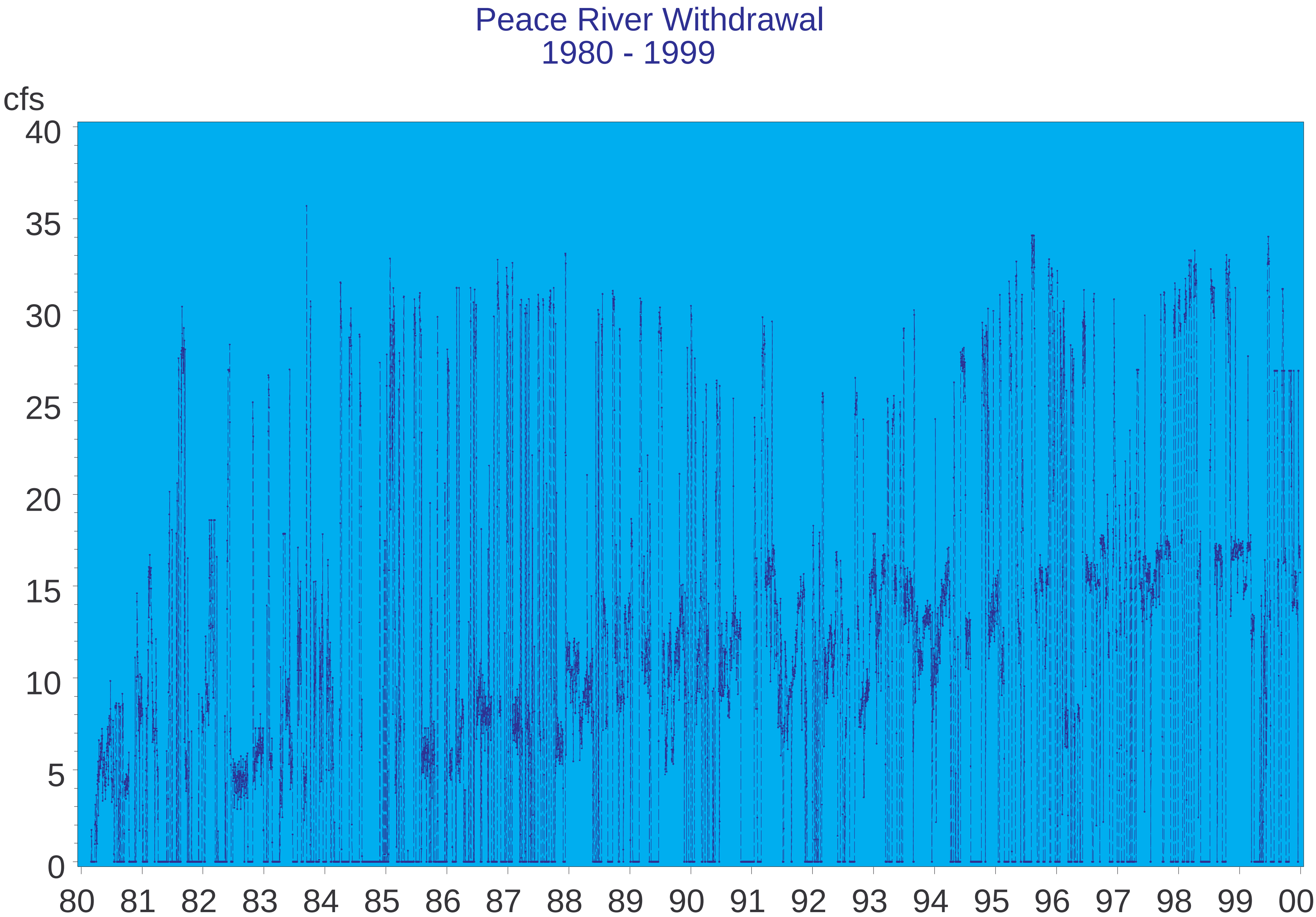

Figure 2.10 Daily Water Treatment Facility Withdrawals (1980-1999)

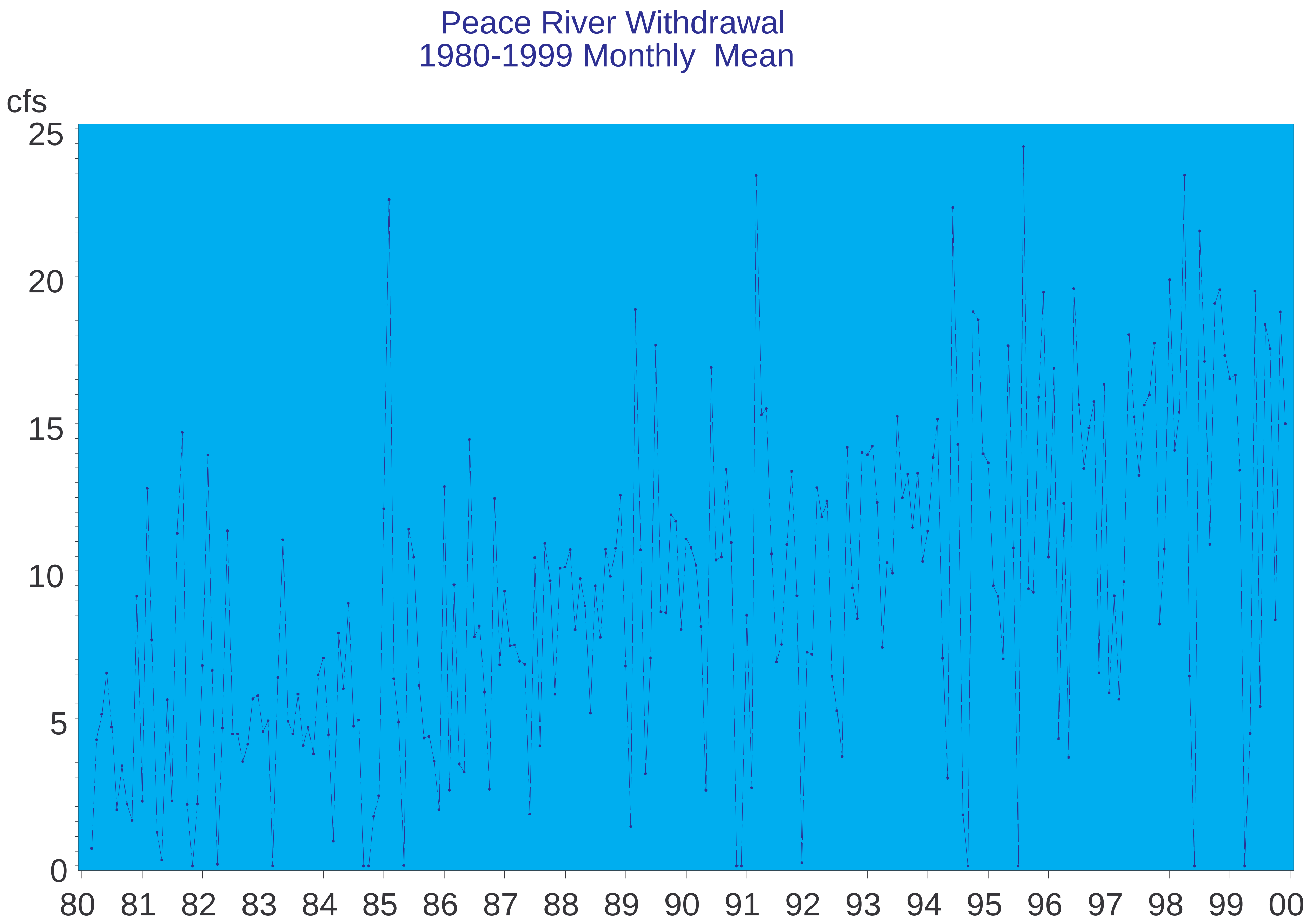

Figure 2.11 Monthly Mean Water Treatment Facility Withdrawals (1980-1999)

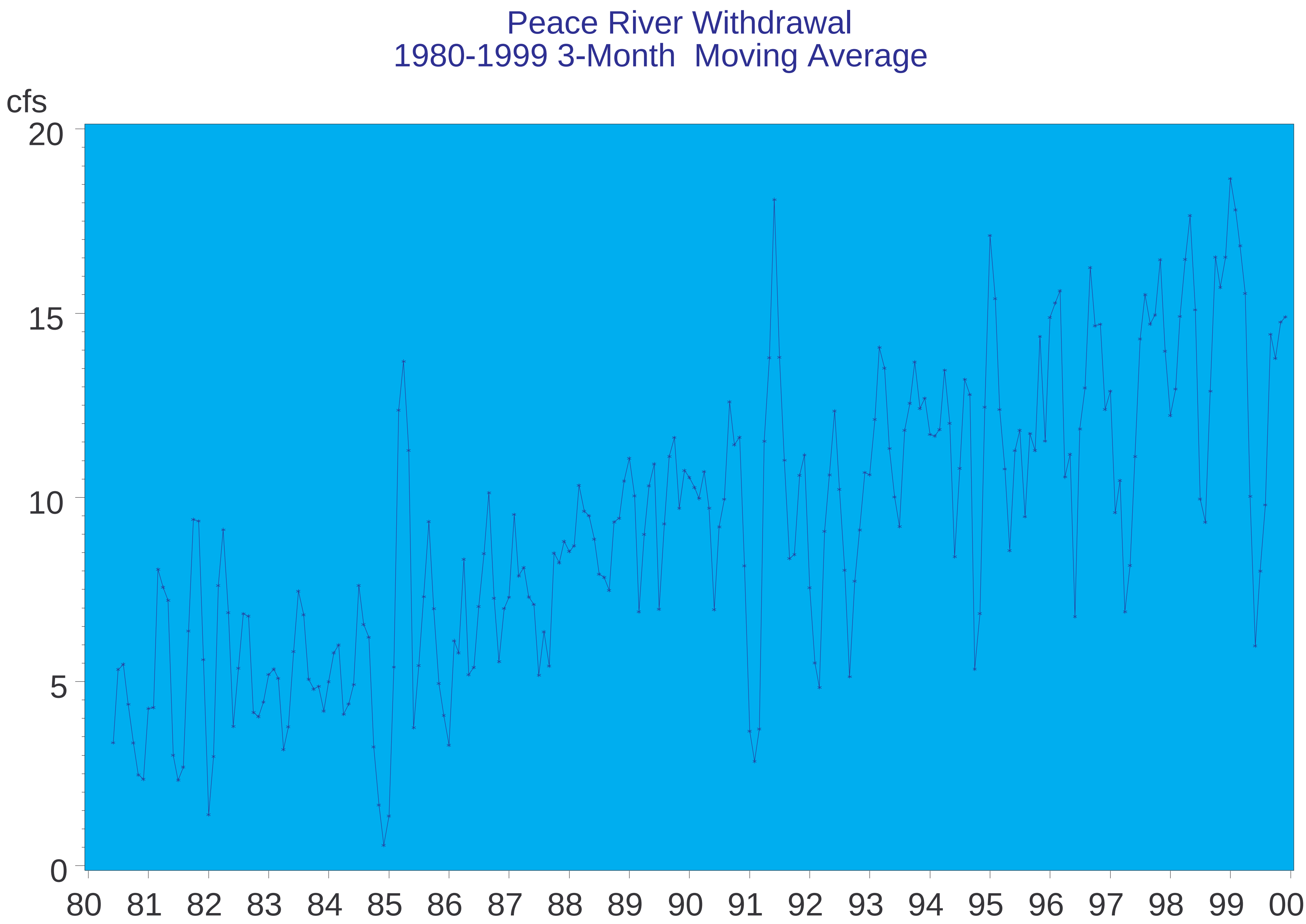

Figure 2.12 3-Month Moving Average Water Treatment Facility Withdrawals (1980-1999)

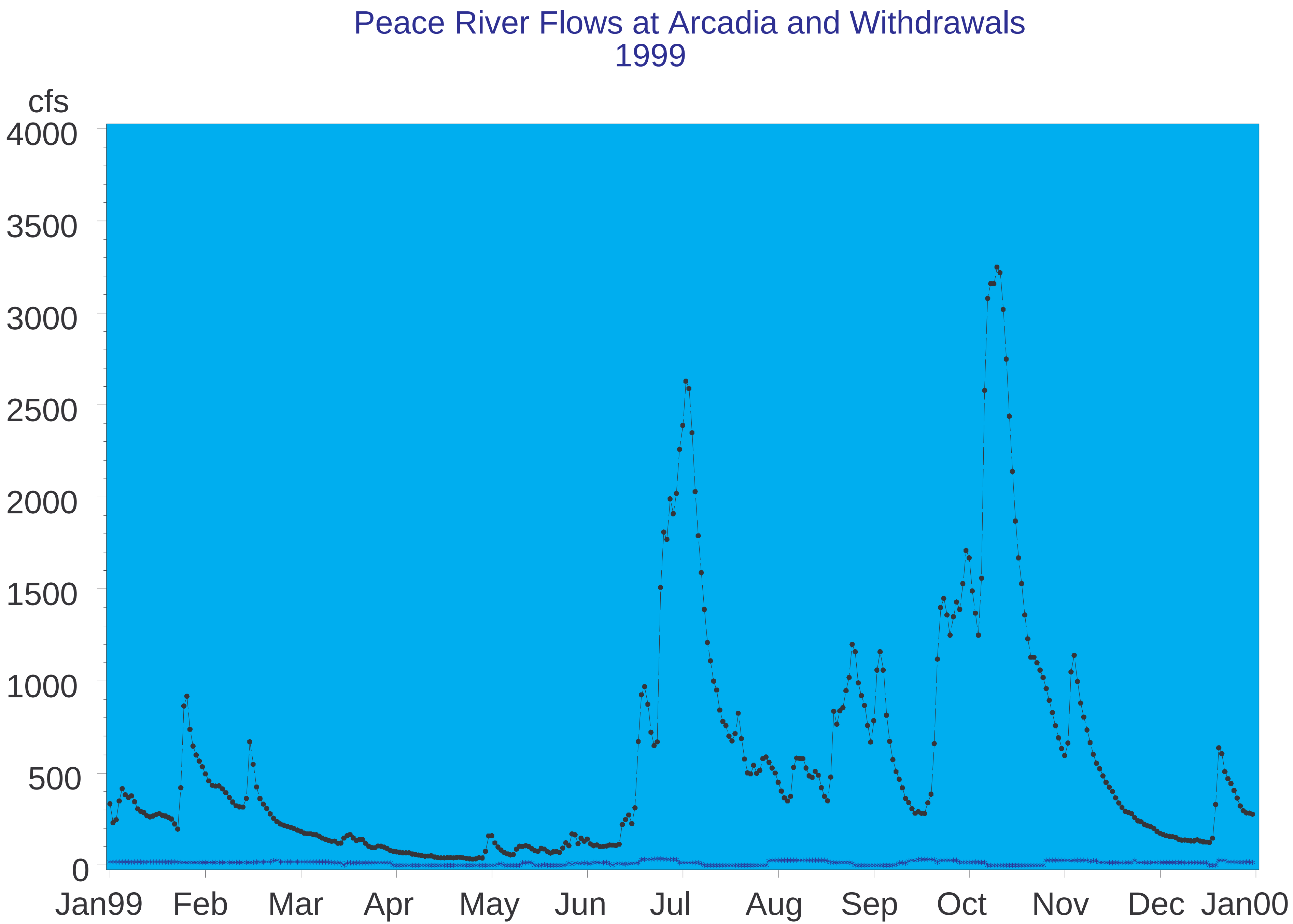

Figure 2.13 Peace River Flows at Arcadia and Water Treatment Facility Withdrawals (1999)

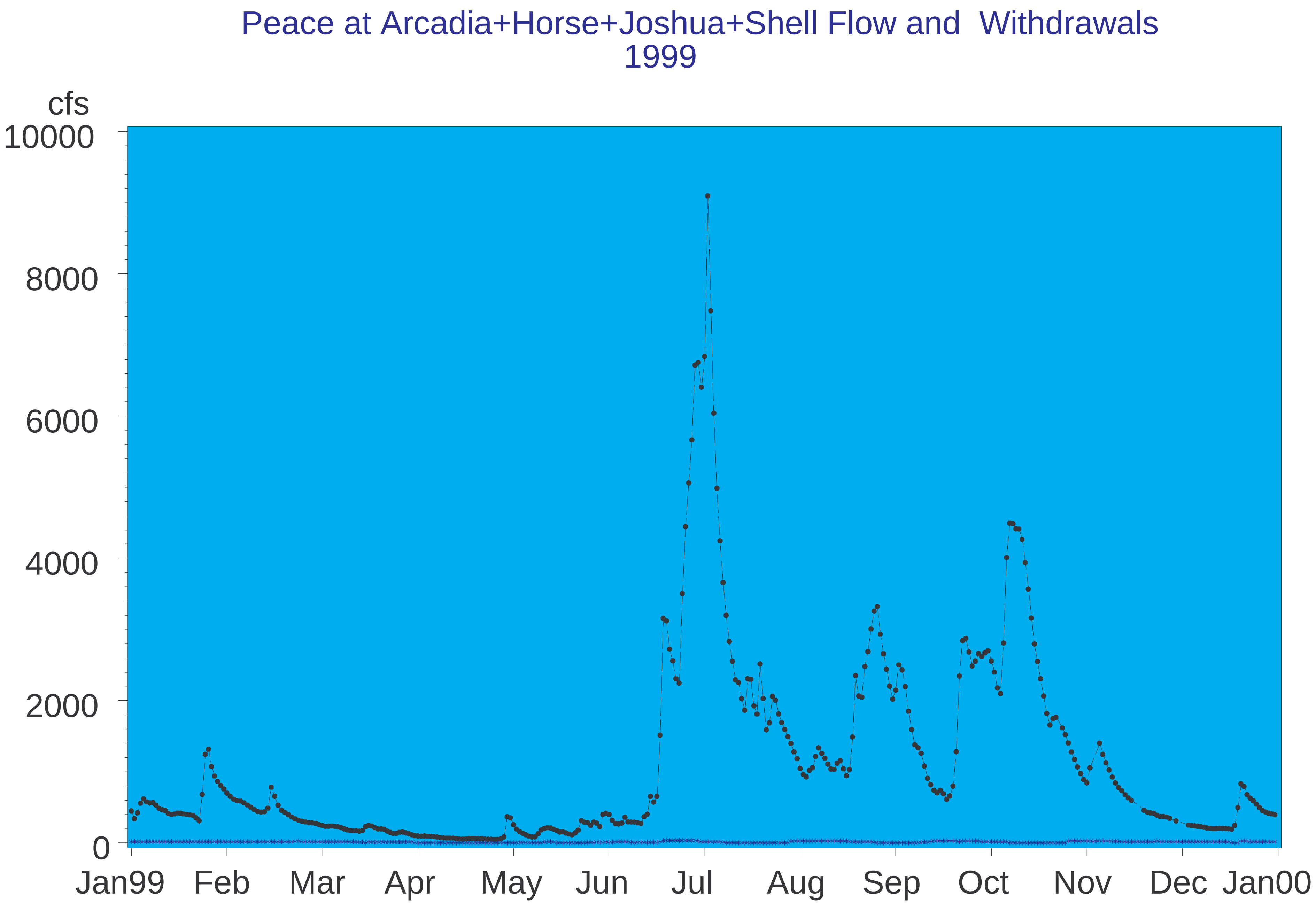

Figure 2.14 Peace River at Arcadia + Horse + Joshua + Shell Flow and Water Treatment Facility Withdrawals (1999)

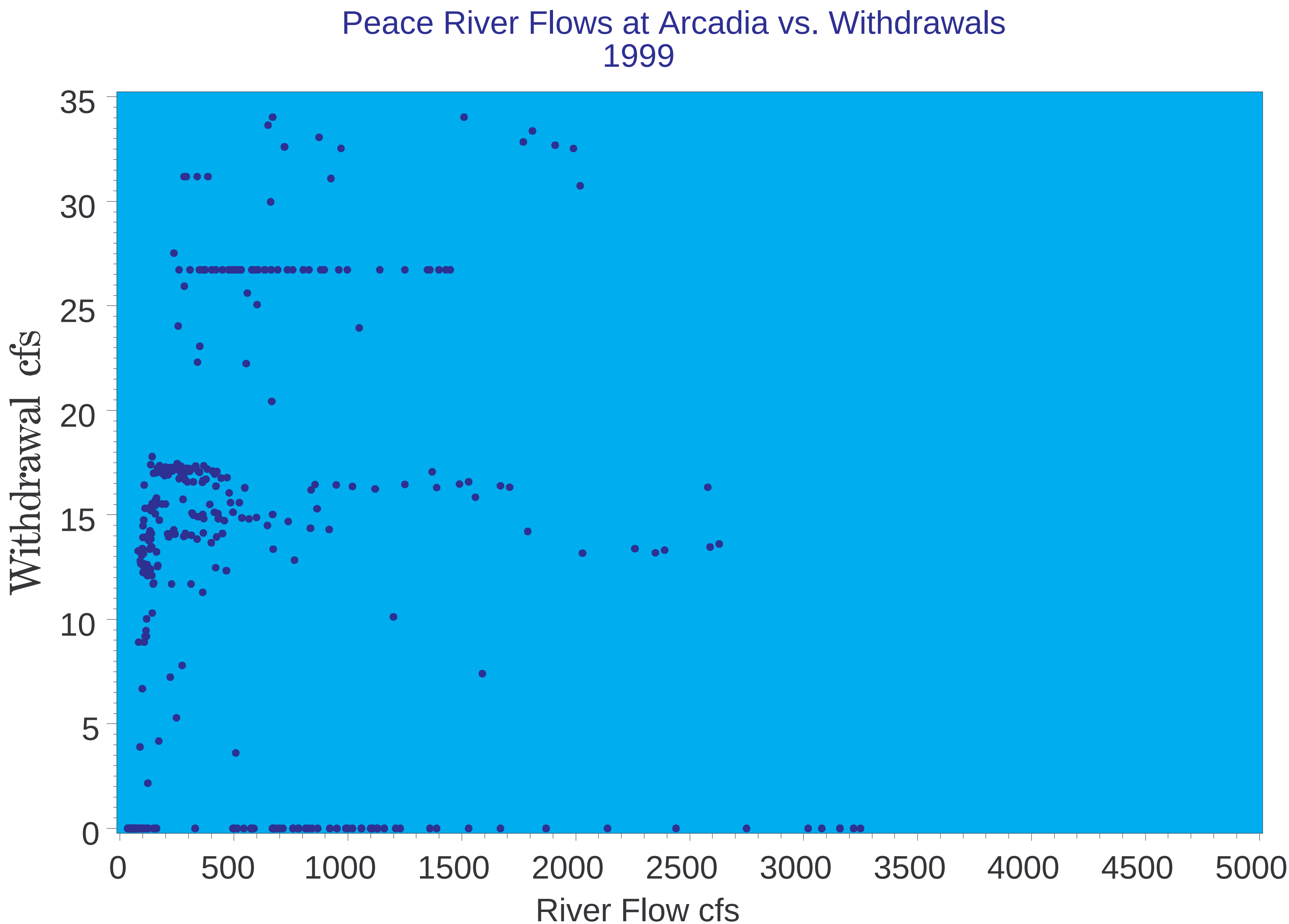

Figure 2.15 Peace River Flows at Arcadia vs. Water Treatment Facility Withdrawals (1999)

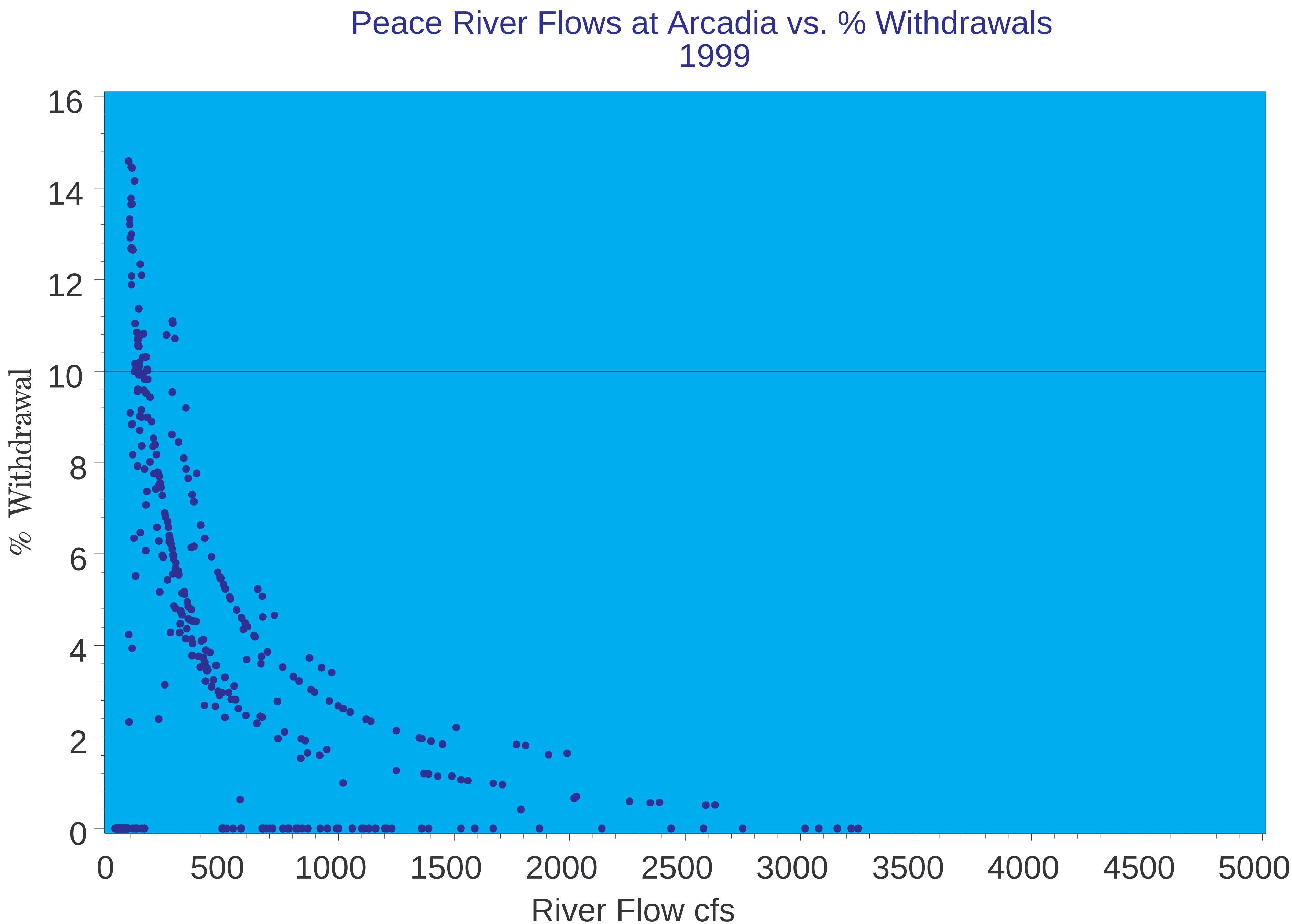

Figure 2.16 Peace River Flows at Arcadia vs. % Water Treatment Facility Withdrawals (1999)

Average daily withdrawal for 1999 was approximately 1.15% of the combined average daily flows of the Peace River, Horse Creek, Joshua Creek, and Shell Creek. During the preceding period 1980-1998, average daily withdrawals were approximately 0.58% of the combined average daily flows of the Peace River, Horse Creek, Joshua Creek, and Shell Creek.

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Chapter III

Primary Productivity and Water Chemistry

3.1 Introduction

The development of a comprehensive understanding of primary production and the related structure of the phytoplankton communities within the Charlotte Harbor system is fundamental to the development of knowledge about other interrelated systems and processes within the estuary, such as secondary production and nutrient cycling. A thorough understanding of those processes controlling phytoplankton primary production within Charlotte Harbor is necessary to quantify the estuary's immediate and long-term responses to various external inputs. A thorough long-term investigation of that portion of the upper Harbor's production attributable to phytoplankton assemblages meets the previous cited criteria by providing both: 1) measurement of populations which act as sensitive barometers of external change at a short (daily to weekly) temporal scale; and 2) insight into basic processes not only affecting water quality but having secondary widespread interrelations and effects upon other estuarine system components. Phytoplankton production generally represents an immediately available food resource, unlike other estuarine production such as that associated with seagrass, mangrove and saltmarsh habitats, where much of the resource becomes available through secondary processes. Of the various inputs into the Charlotte Harbor estuarine system, phytoplankton production represents both the largest single component of primary production and a food source directly accessible to many filter and detrital feeding organisms. Phytoplankton production and composition, due to the short generation times involved, have also been shown to be effective in demonstrating ephemeral, seasonal and long-term changes in water quality. Phytoplankton production represents a highly integrated estuarine component and can be used to provide information on both direct and predictive secondary impacts of external influences.

3.1.1 Current Long-Term Studies of Primary Production

The current studies of primary production in Upper Charlotte Harbor, conducted as part of the Peace River Regional Water Supply facility's ongoing SWFWMD HBMP, are designed to develop the needed long-term base of data necessary to evaluate both short and long-term cycles in phytoplankton production in the upper estuarine system. Statistically comparable levels of phytoplankton ^{14}C fixation rates have been determined monthly at four salinity-based stations since June 1983. These investigations have included determinations of phytoplankton population structure, related physical parameters, water column light profiles and analysis of the major chemical constituents associated with phytoplankton growth. The four sampling locations in this study represent non-fixed surface salinity zones, such that the monthly location of each station is dependent upon the preceding amount of freshwater inflow from the Peace River. The four salinity sampling zones are:

- Station 101 = 0 o/oo
- Station 102 = 5_7 o/oo
- Station 103 = 11_13 o/oo
- Station 104 = 20_22 o/oo

Table 3.1 Summary Statistics of the Four Isohaline Locations (Kilometers) from the Peace River's Mouth for the Period 1983-1999.

Isohaline	Minimum	Maximum	Mean	Median
0 o/oo	3.4	33.8	20.5	19.8
6 o/oo	-16.3	26.4	11.9	11.8
12 o/oo	-30.3	21.7	6.6	8.0
20 o/oo	-36.3	14.2	-1.2	2.0

To date, the most upstream occurrence of Station 101 (salinity = 0 o/oo) has been approximately one-half mile below Horse Creek (June 1989), and the most downstream occurrence of Station 104 (salinity = 20_22 o/oo) station has been in the Gulf of Mexico just off Boca Grande (September 1988) (see Figure 3.1a).

The relative location of each of these four isohalines during 1999 is shown in Figure 3.1b, while long-term patterns for the period 1983-1999 are presented in Figures 3.1c and 3.1d.

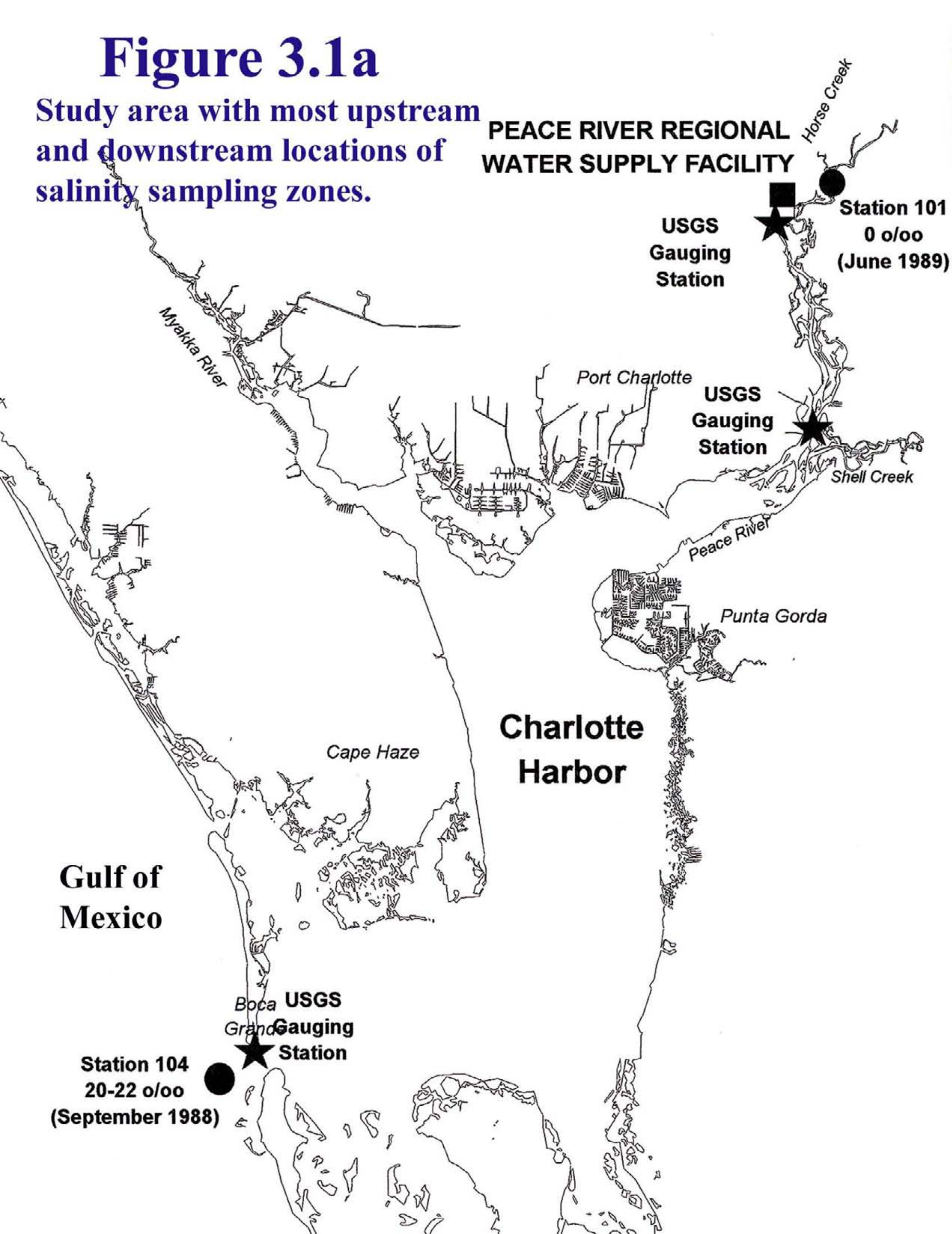
Table 3.2 Comparisons of Isohaline Locations during 1999 and the Period 1983-1999.

Figure	Description
Figure 3.1a	Study area with most upstream and downstream locations of salinity sampling zones
Figure 3.1b	Relative distance (km) from the Mouth of the River – 1999
Figure 3.1c	Relative distance from the Mouth of the River of 0 and 6 ppt salinity sampling zones (1983-1999)
Figure 3.1d	Relative distance from the Mouth of the River of 12 and 20 ppt salinity sampling zones (1983-1999
Figure 3.1e	Box & Whiskers of relative distance (km) from the Mouth of the River- 1999 & 1983-1999

This report presents data collected during the seventeenth year (1999) of this unique long-term study of the relationships between phytoplankton productivity and Peace River flow into Upper Charlotte Harbor. Under the newest SWFWMD Water Use Permit, phytoplankton studies is intended to continue, in order to continue development of a data

Figure 3.1a

Study area with most upstream and downstream locations of salinity sampling zones.



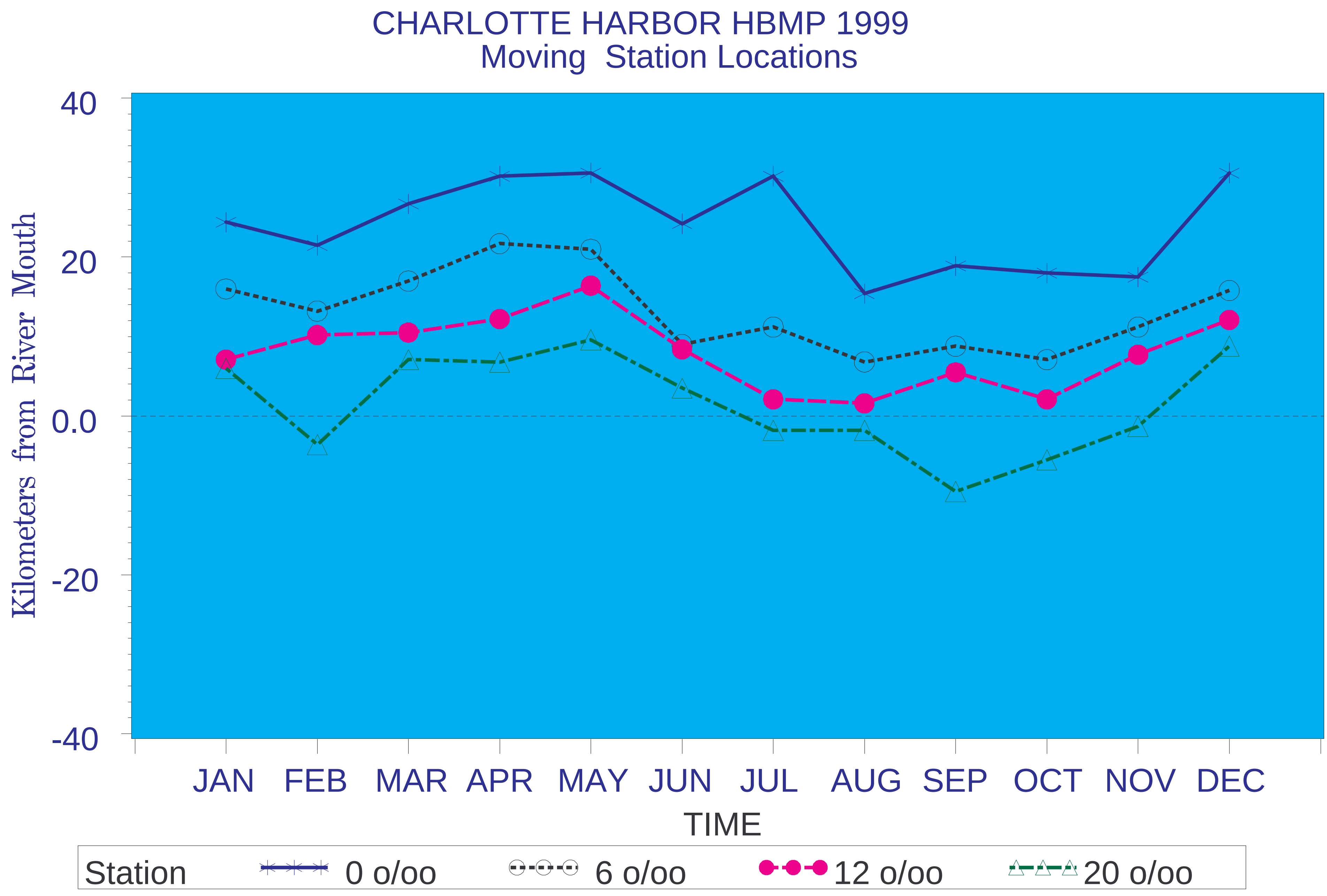


Figure 3.1(b) Relative distance (km) from the Mouth of the River -1999.

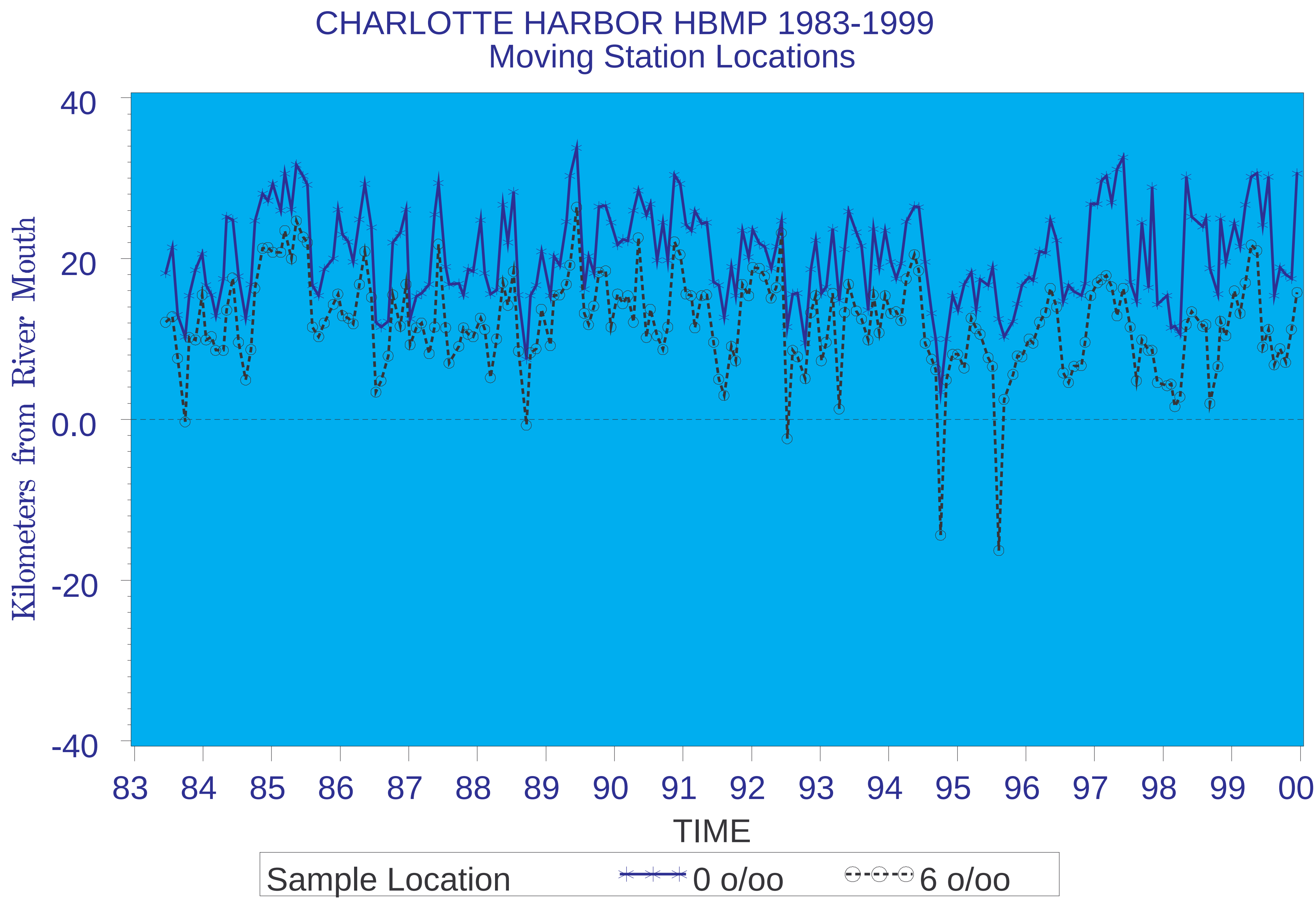


Figure 3.1(c) Relative distance (km) from the Mouth of the River of 0 and 6 ppt salinity sampling zones (1983-1999).

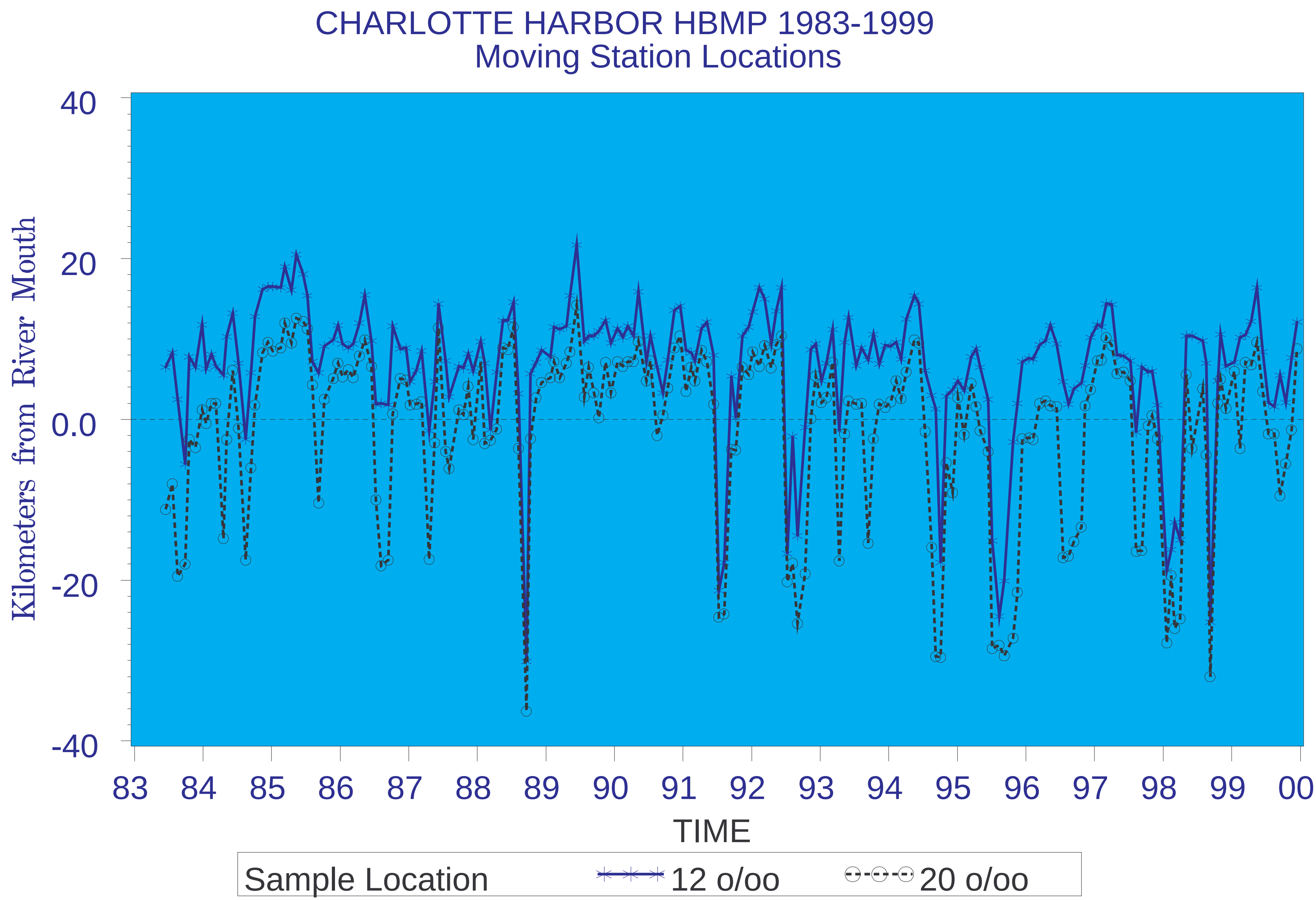


Figure 3.1(d) Relative distance (km) from the Mouth of the River of 12 and 20 ppt salinity sampling zones (1983-1999).

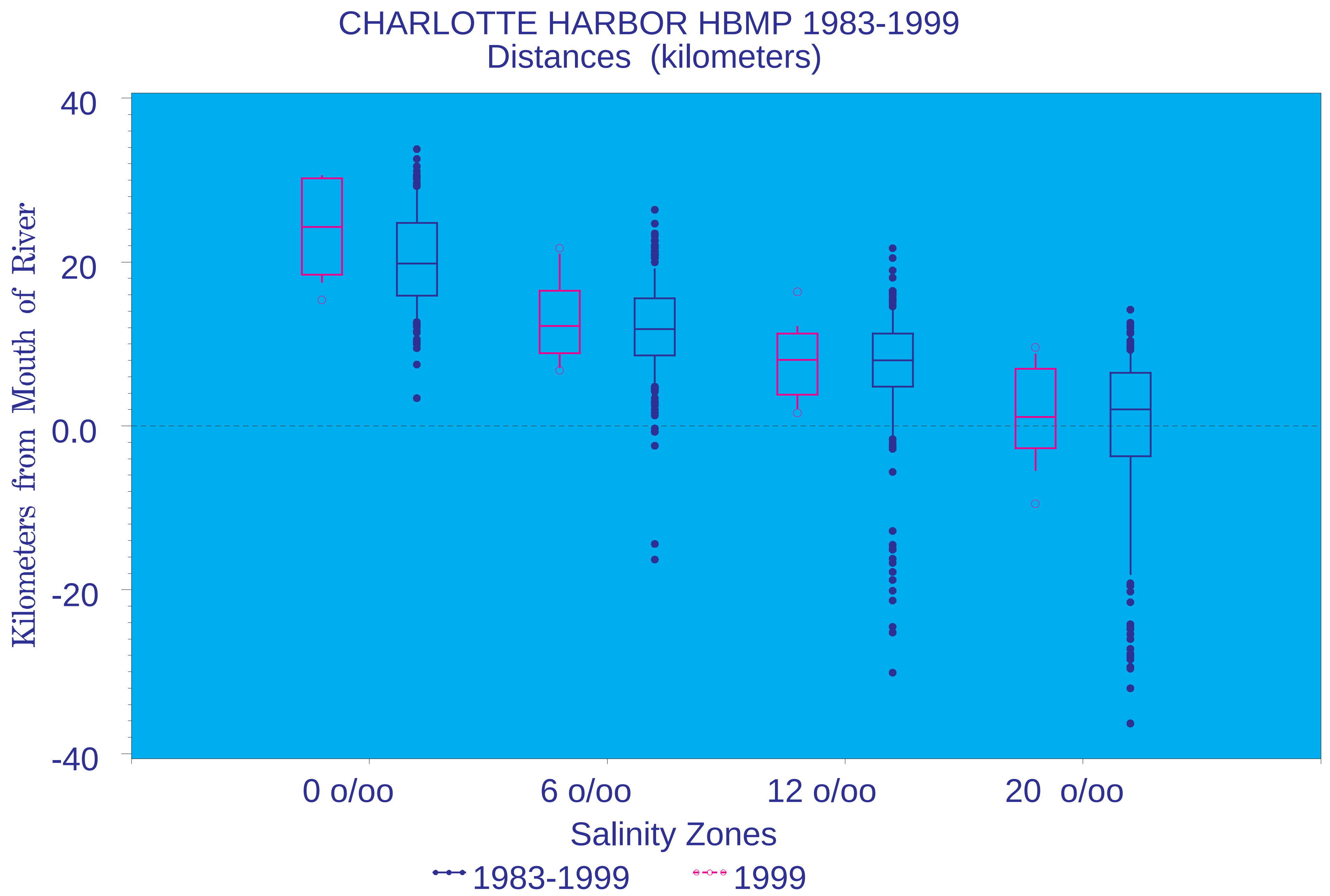


Figure 3.1(e) Box & Whiskers of relative distance (km) from the Mouth of the River.

base sufficiently large that current statistical evaluation of trends and developed predictive models can be enhanced. In addition, the permit continues the collection and thorough taxonomic evaluation of the seasonal abundance and dominance of observed phytoplankton species. This portion of the study seeks to quantify the specific responses of major phytoplankton taxonomic groups to variations in the periodicity of freshwater inflow, and assess potential influences of Peace River Water Facility diversions.

3.2 Primary Productivity Methods

The methodologies used to measure and evaluate the physical, chemical, and biological parameters encompassed within this investigation are outlined and described within the following sections.

3.2.1 *In Situ* Measurements of Physical Parameters

Depth, temperature, dissolved oxygen, conductivity, and pH were measured *in situ* with a Hydrolab Surveyor Model II or YSI Model system. Profiles were made from the surface to the bottom in 0.5m increments at each sampling station location. Depth measurements were determined both on the basis of pre-measured marks on the unit's cable and the units depth sensor.

Pre-sampling instrument calibrations were conducted within 6 hours prior of use. Temperature was measured with a linear resistance thermistor, factory calibrated and accurate to within ±0.2 ^{o}C. Dissolved oxygen (DO) was measured with a temperature-compensated, passive, polarographic cell, which measures the partial pressure of oxygen as parts per million (ppm or mg/l) of oxygen, ±0.2 ppm. The probe is calibrated using the oxygen tension of water-saturated air (temperature corrected) as a standard.

The conductivity probes are six electrode cells and were calibrated against a KCl solution of known conductivity. Probe response was then tested with a solution of known, low conductivity to ensure that the reading is within ±1.0% of the range selected. The probes are automatically temperature compensated to provide conductivity at 25 ^{o}C.

The Hydrolab pH probes are glass, KCl filled with silver/silver chloride reference electrodes and refillable junctions. They are automatically temperature compensated. Two buffer solutions of 7.0 and 10.0 pH (± 0.1 units) were used to calibrate the accuracy of the probe.

Oxidation-reduction potential (ORP) was measured using a platinum-tipped glass ORP probe and standard pH/ORP silver/silver chloride reference probe. Conversion of these ORP values to those of a standard hydrogen electrode can be approximated by adding 300 mV to the results from the silver/silver chloride electrode.

3.2.2 Light Profile

Light intensity profiles utilized both to determine the 50% light depth and calculate the water column extinction coefficient were conducted at each station. A LI-COR (model LI-185B) quantum/radiometer/photometer equipped with an underwater LI-1925B quantum sensor was used to measure photosynthetically active radiation (400-700 nanometers). Light intensities (microeinsteins/m^2/sec) were measured in the air just above the water surface, again just below the surface, and at six selected depths (20, 40, 60, 80, and 100 cm).

3.2.3 Primary Productivity Measurements

Five subsurface water samples were collected at each of the salinity-based station locations. These were randomly collected to account for phytoplankton patchiness. The subsurface samples were placed in five replicate "light" and two (black plastic dipped) "dark" acid-rinsed, 450ml glass incubation bottles. Each bottle was then inoculated with 10 microcuries of trace metal-free ^{14}C (to obtain counts of approximately ten thousand counts per minute or CPM, depending on phytoplankton levels). The bottles were quickly placed on an adjustable rack (**Figure 3.2**) and incubated *in situ* at the depth where, during the light profile determination, 50% of incident surface radiation was found to remain.

All incubations were conducted within two hours of apparent noon to standardize for known patterns of diurnal periodicity in phytoplankton production. Cumulative light levels during the incubation periods were recorded using a LI-COR integrating quantum photometer. After incubation all samples were placed in the dark, in cool ice chests and quickly returned to the laboratory and prepared for scintillation counting.

3.2.4 Determinations of Rates of Radioactive Carbon Uptake

The following procedures were undertaken to determine both the overall rates of ^{14}C fixation, as well as those proportions attributable to the net- (> 20 microns), nano- (5 - 20 microns), and pico- (< 5 microns) size fractions. Three separate subsamples were taken from each of the "light" sample bottles and processed as follows:

1. 50 ml was filtered through a 2.4 cm Whatman GF/C glass fiber filter using low vacuum (less than 2 PSI). The wet fiber filter was then placed in a scintillation vial and frozen until ready for analysis.
2. A second subsample was prepared in the same manner as the first, except prior to filtering, the 50 ml subsample was passed through 20 micron Nitex screening.
3. The third subsample was prepared in a likewise manner, but passed through 5 micron Nitex screening prior to filtering.

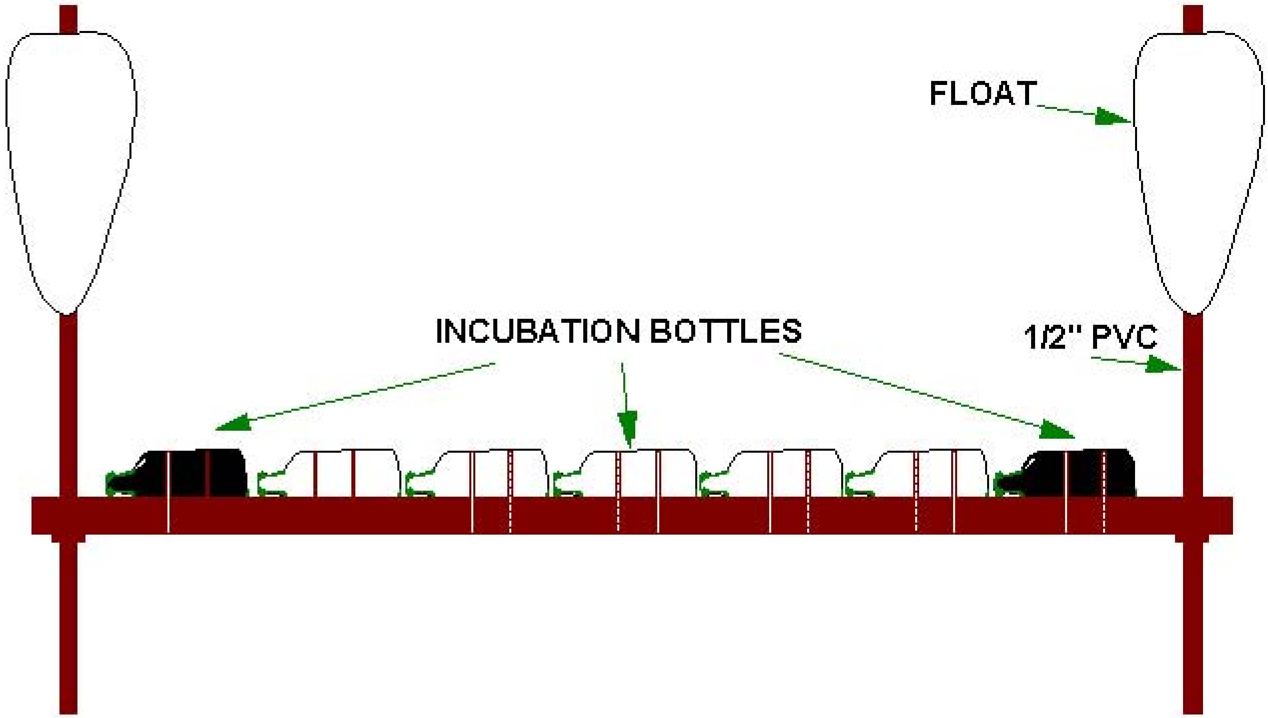


Figure 3.2 *In Situ* Incubation Racks

4. 50 ml sub-samples from each of the two dark bottles incubated at each station were filtered as in (1) above. Three corresponding filter blanks for each station were prepared by adding ten microcuries ^{14}C to a 450 ml ice stored water sample taken at the same station, and then immediately taking three 50 ml subsamples. These were also filtered as in (1) above.
5. To begin analysis 0.5 ml of 0.1 NHC1 was added to each vial and the vials were then allowed to stand for 3 hours before the addition of 10.0 ml of scintillation fluor. The vials were then placed in the liquid scintillation counter and allowed to dark adapt for at least 24 hours before being counted.
6. Background and known ^{14}C standards were run to check and validate the performance of the laboratory's Packard liquid scintillation system. Verification of the activity of the ^{14}C inoculation solution was also conducted monthly.
7. Each sample vial was counted for 30 minutes, or until the CPM in spectral region A had a standard deviation of less than 0.2%. Counts per minute were then converted to disintegrations per minute using the filter standardization channels ratio method.

3.2.5 Chlorophyll *a*

Ambient chlorophyll *a* levels are widely used to estimate phytoplankton biomass. For these investigations, chlorophyll *a* concentrations were determined both fluorometrically and spectrometrically for the: 1) greater than 20 microns; 2) 5 to 20 microns; and 3) less than 5 microns size fractions, from samples collected simultaneously with those for primary productivity estimates. Chlorophyll *a* levels were determined for each of the three size fractions, both uncorrected and corrected for pheophytin, using the same filtering procedures as described above for the determination of ^{14}C incorporation. Comparable estimates were thus made for comparison of both phytoplankton biomass and productivity rates for each of three measured phytoplankton size fractions.

3.2.6 Water Chemistry

Surface water samples were collected for analysis at each salinity-based station in pre-labeled, one-liter polyethylene containers. The containers were rinsed with sample water, filled and immediately placed in the dark on ice until returned to the laboratory following standard chain of custody and quality assurance procedures. Specific methods of analyses are listed in Table 3.3.

Table 3.3 Water Chemistry Methods			
Parameter		***Method***	***Detection Limit***
Color		**EPA 110.2**	**1.0 Co_Pt Units**
Chloride		**EPA 325.2**	**0.4 mg/l**
Turbidity		**EPA 180.1**	**0.1mg/l**
Alkalinity		**EPA 310.1**	**0.1 mg/l**
NO2+NO3 Nitrogen		**EPA 353.2**	**0.002 mg/l**
NH3+NH4 Nitrogen		**EPA 350.1**	**0.002 mg/l**
Total Kjeldahl		**EPA 351.2**	**0.1 mg/l**
Ortho-Phosphorus		**EPA 365.2**	**0.002 mg/l**
Total Phosphorus		**EPA 365.4**	**0.002 mg/l**
Silica		**EPA 370.1**	**0.05 mg/l**
Inorganic Carbon		**SM 5310 B**	**1.0 mg/l**
Total Organic Carbon		**EPA 415.1**	**1.0 mg/l**
Dissolved Organic Carbon		**SM 5310 B**	**1.0 mg/l**
Iron		**EPA 236.1**	**0.04 mg/l**
Chlorophyll *a*		**Flurometeric SM 10200H.3** **Spectrophotometric Sm10200.H2**	**0.25 mg/l** **2.0 mg/l**

3.2.7 Population Structure

Surface water samples were collected for taxonomic analysis at each salinity-based station in conjunction with primary productivity measurements. Samples for microscopic investigation were placed in one-liter polyethylene containers and immediately fixed with 4 ml of Lugol's solution, which is the preferred preservative for samples that may include significant numbers of flagellates. The samples were placed on ice in the dark for transportation back to the lab, where they were held in a refrigerator at 4 ^oC until prepared for counting. Extensive work has been completed in preparing a thorough photographic taxonomic inventory of the phytoplankton taxa seasonally present at the four salinity zones. To date over 500 taxa have been identified from samples collected. Samples were prepared for observation using a Zeiss inverted microscope utilizing the following settling procedures:

1. Samples were removed from the refrigerator and gently shaken to assure resuspension of all material.

2. Randomly selected subsamples totaling 5-200 ml (depending on the concentration of the material in the samples) were withdrawn and placed in 50 ml conical glass centrifuge tubes.
3. The tubes were then spun at approximately 50 x gravity for 45 minutes. Three to four drops of iodine solution were then added at the top of the tubes, which were then allowed to stand for at least 24 hrs.
4. At the end of the first settling period, the settled material in the bottom 2.5 ml and any cells adhering to the surface tension of each centrifuge tube was drawn off and placed in a 10 ml Zeiss inverted microscope settling chamber.
5. Two drops of iodine solution were again added to promote settling, and the composite samples were again allowed to stand undisturbed for 24 hrs.

Once the samples were prepared, the counting chambers were placed on a Zeiss inverted microscope for phytoplankton identification. Taxonomic determinations to the lowest practical taxonomy level were conducted from random fields using a modified strip method. To determine community structure, a standardized number of cells are identified (500). The majority of the taxonomic work was conducted using a 100X objective and 16X wide field oculars. As each observation was made, assigned genus and species codes are recorded. After having recorded the taxonomic determinations of 500 cells, additional notes on each sample were compiled using a combination of low and high power objectives. Determinations of the number of cells per unit volume were conducted on the same samples using a 10X ocular grid and 100X objective. The total number of cells in randomly selected fields, taken in a modified strip method, were recorded on a data sheet and appropriate dilution calculations made.

3.2.8 Taxonomic Determinations of Phytoplankton Community Structure

In 1989 the collection of monthly samples for the analysis of phytoplankton community structure was begun in conjunction with the long-term study of physical/chemical water quality and primary production at the four monitored salinity zones. Phytoplankton community structure has long been used in other studies as a tool in assessing both temporal and long-term changes in water quality in estuarine systems. A complete presentation of all the phytoplankton taxonomic data collected during 1999, listing: 1) the taxonomic structure; 2) percent composition of the major taxonomic groups; and 3) species diversity and evenness indices, are presented by salinity zone, month and year in Appendix C.

Microscopic survey of phytoplankton samples collected concurrently with carbon uptake productivity and chlorophyll a biomass estimates generally indicate the relative dominance of the following groups. At the stations characterized by intermediate and higher salinities, the smallest phytoplankton size fraction (<5 microns) was often dominated by Cryptophyceae species (Chroomanas spp. and Cryptomonas spp.). Small Bacillariphyceae (Thalossiosira spp., Nitzschia spp., Navicula spp.) were also significant portions of the nano-plankton components at these salinities. At the higher salinity stations, which are under greater influences from Gulf waters, chain-forming and larger diatoms frequently dominated the net-plankton size fraction. Seasonally important diatoms at these locations were Skeletonema costatum, Asterionella glacialis, Odentella sinensis, Corethron criophilum, Coscinodiscus centralis, and Coscinodiscus eccentricus, as well as species of Chaetoceros and Rizosolenia. Dinophyceae (Ceratium spp. and Peridinium spp.) were often seasonally common in the largest size fraction during the summer months at some of the higher salinity stations. At intermediate salinities, blooms of Skeleton*ema costatum* were commonly associated with relative increases in carbon uptake and chlorophyll *a* within the largest size fraction. In certain instances, however, dinoflagellates (*Prorocentrum micans*, *P. minimum*, *Gymnodinium* spp. and *Gyrodinium* spp.) were also major components of the largest size fraction. Specifically, at 6 and 12 o/oo salinity at the mouth of the Peace River, the larger size fractions were seasonally dominated by blooms of *Gyrodinium splendens*.

The picoplankton size fraction (< 5 microns), at the lower salinity stations, often contained significant numbers of non-flagellated, smooth, circular to ovoid, green cells. Taxonomically, such cells probably include both Cyanophyceae (*Synechoccus* spp., *Chroococcus* spp., *Anacystis* spp.) as well as Chlorophyceae (*Nannochloris* spp., *Chlorella* spp.). Small phytoflagellates (*Chlamydomonas* spp., *Carteria* spp., *Chroomonas* spp., *Cryptomonas* spp.) were also common components of the picoplankton at the lowest salinities. The larger size fractions in the riverine portions of the estuary are generally characterized by mixtures of both Chlorophyceae (*Ankistrodesmus* spp., *Coelastrum* spp., *Crucigenia* spp., *Pediastrum* spp., *Scenedesmus* spp., *Tetraedron* spp.), Bacillariophyceae (*Cyclotella* spp., *Nitschia* spp., *Navicula* spp., *Fragillaria* spp.) and Cyanophyceae (*Anabaena* spp., *Anacystis* spp.).

3.3 Water Chemistry Data Collected in Conjunction With Primary Production Data

Data collected during the primary productivity studies in 1999 are presented and summarized in the following tables and figures. Tables 3.4 through 3.8 summarize the determinations of a number of the key physical, chemical and biological measurements. Seasonal representations of selected parameters are further graphically presented in Figures 3.3 through 3.16. Complete *in situ* physical water column profiles at each of the four salinity zones by month are present in Table 3.4. Surface water chemistry results at each salinity zone during each month are presented in Appendix D.

Table 3.9 Summary Tables and Graphics of Key Physical and Chemical Measurements for Data Collected in 1999 at the Four Isohaline Locations.

Table/Figure	Description
Table 3.4	Physical and Chemical Parameters (January – December 1999)
Table 3.5	Ambient Solar Radiation and Water Column Extinction (January - December 1999)
Table 3.6	Measured Rates of Primary Production (January - December 1999)
Table 3.7	Determination of Carbon Uptake by Size Fraction (January - December 1999)
Table 3.8	Determination of Chlorophyll *a* by Size Fraction (January - December 1999)
Figure 3.3	1999 Temperature at salinity sampling zones
Figure 3.4	1999 Color at salinity sampling zones
Figure 3.5	1999 Extinction Coefficient at salinity sampling zones
Figure 3.6	1999 Nitrite/Nitrate at salinity sampling zones
Figure 3.7	1999 Ortho-Phosphorus at salinity sampling zones
Figure 3.8	1999 Atomic N/P Ratio at salinity sampling zones
Figure 3.9	1999 Silica at salinity sampling zones
Figure 3.10	1999 Carbon Uptake (mgC/m^3/hr) at salinity sampling zones
Figure 3.11	1999 Carbon Uptake (mgC/m^3/Einstein) at salinity sampling zones
Figure 3.12	1999 Chlorophyll *a* (mg/m^3) at salinity sampling zones
Figure 3.13	1999 Percent Carbon Uptake Among Size Fractions
Figure 3.14	1999 Carbon Uptake (mgC/m^3/Einstein) Among Size Fractions
Figure 3.15	1999 Chlorophyll *a* (mg/m^3) Among Size Fractions
Figure 3.16	1999 Percent Chlorophyll *a* Among Size Fractions

Relationships of the 1999 data to those data collected during previous years are shown for selected physical, chemical and biological measurements in Figures 3.17 through 3.26. Further comparisons of these parameters are presented as box and whisker plots by salinity for both 1999 and long-term data collected between 1983-1999 in Figures 3.27 through 3.36. The box and whisker plots display a detailed distribution of the data, showing the median (50th percentile) at the center of the box and the 25th and 75th percentiles at the bottom and top of the box, respectively. The whiskers are lines that extend from the 25th percentile to the 10th percentile and 75th percentile to the 90th percentile. Extreme values (outside the 10th-90th percentiles) are represented by dots at the ends of the whiskers.

Table 3.10 Summary Graphics of Key Physical and Chemical Measurements for Data Collected during the Period 1983-1999 at the Four Isohaline Locations.

Figure	Description
Figure 3.17	1983-1999 Temperature at salinity sampling zones
Figure 3.18	1983-1999 Color at salinity sampling zones
Figure 3.19	1983-1999 Extinction Coefficient at salinity sampling zones
Figure 3.20	1983-1999 Nitrite/Nitrate at salinity sampling zones
Figure 3.21	1983-1999 Ortho-Phosphorus at salinity sampling zones
Figure 3.22	1983-1999 Atomic Nitrogen/Phosphorus Ratio at salinity sampling zones
Figure 3.23	1983-1999 Silica at salinity sampling zones
Figure 3.24	1983-1999 Carbon Uptake ($mgC/m^3/hr$) at salinity sampling zones
Figure 3.25	1983-1999 Carbon Uptake (mgC/m^3/Einstein) at salinity sampling zones
Figure 3.26	1983-1999 Chlorophyll *a* (mg/m^3) at salinity sampling zones
Figure 3.27	Box and Whisker Plots of Temperature at salinity sampling zones (1999) & (1983-1999)
Figure 3.28	Box and Whisker Plots of Color at salinity sampling zones(1999) & (1983-1999)
Figure 3.29	Box and Whisker Plots of Extinction Coefficient at salinity sampling zones (1999) & (1983-1999)
Figure 3.30	Box and Whisker Plots of Nitrite/Nitrate at salinity sampling zones 1999) & (1983-1999)
Figure 3.31	Box and Whisker Plots of Ortho-Phosphorus at salinity sampling zones (1999) & (1983-1999)
Figure 3.32	Box and Whisker Plots of Atomic N/P Ratio at salinity sampling zones (1999) & (1983-1999)
Figure 3.33	Box and Whisker Plots of Silica at salinity sampling zones (1999) & (1983-1999)
Figure 3.34	Box and Whisker Plots of Carbon Uptake ($mgC/m^3/hr$) at salinity sampling zones (1999) & (1983-1999).
Figure 3.35	Box and Whisker Plots of Carbon Uptake (mgC/m^3/Einstein) at salinity sampling zones ((1999) & (1983-1999)
Figure 3.36	Box and Whisker Plots of Chlorophyll *a* (mg/m^3) at salinity sampling Zones (1999) & (1983-1999)

3.4 Summary

In summary, the data collected during 1999 indicate:

- **Temperature** - Average water temperatures in 1999 were just slightly higher than the long-term averages. The slightly higher average water temperatures during 1999 probably resulted from mild winters during 1998 and 1999 (see **Table 1.4** for comparisons between 1999 and long-term averages of this and the following parameters).

- **Water Color** – Average water color at each of the four salinities monitored as part of the moving isohaline study declined in 1999 from very high levels observed during the 1997/1998 El Niño event. However, median water color during 1999 was still greater than the preceding long-term averages.

- **Extinction Coefficient –** The rates of measured light attenuation at each of the four isohaline salinities showed relative patterns very similar to those for color.

- **Nitrite/Nitrate Nitrogen**- During 1999, the average concentrations of this major inorganic form of nitrogen were very similar to the long-term averages at each of the four measured salinities. A comparison among the isohalines indicates that a strong gradient exists in inorganic nitrogen in the upper estuary. Concentrations typically decrease rapidly with increasing salinity. Seasonally, ambient inorganic nitrogen concentrations decline to their lowest levels during the late spring dry season, as phytoplankton populations respond to increasing water temperatures and light.

- **Ortho-Phosphorus** - Average inorganic phosphorus concentrations during 1999 were slightly lower than the long-term averages at each of the four isohalines for the preceding period 1983-1998. These observations probably reflect the marked decline in phosphorus concentrations that began in the Peace River in the early 1980's.

- **Nitrogen to Phosphorus Atomic ratios –** Calculated atomic inorganic nitrogen to phosphorus ratios for ambient measured concentrations in 1999, as indicated by the long-term averages, show that nitrogen to always be the limiting macronutrient at each of the four isohalines.

- **Silica** - Mean concentrations during 1999 at each of the four salinities were very similar to the ranges and seasonal pattern previously observed.

- **Carbon Uptake –** The relative differences during 1999 among measured rates at each of the four isohalines was similar to the historic pattern, with measured rates being generally much higher at the two intermediate salinities. However, overall measured uptake rates were only a small fraction of the historic norm and failed to show the characteristic seasonal patterns that have always been observed during the preceding period (1983-1998). Based on a complete and thorough review of all results and procedures (software and hardware), the probable answer seems to have resulted from either: 1) contamination and loss of radioactivity in the standard C14 stock solution added during the *in situ* incubations; or 2) damage and loss of calibration of the liquid scintillation counter. Based on this finding, all 1999 carbon uptake measurements should be extremely suspect, and should not be used in any long-term analyses or comparisons. It is suggested that to prevent future potential confusion they should be eliminated from the HBMP data base.

- **Chlorophyll *a* –** Concentrations measured at each of the four salinities were very similar to the long-term averages. The somewhat higher than normal levels at the two intermediate salinities (6 and 12 o/oo) during January and February probably reflect the mild winter.

Complete analysis of water column profile light levels is contained within Appendix A, while thorough analysis of carbon uptake and chlorophyll *a* determinations are presented in Appendix B. Complete water chemistry and *in situ* Hydrolab data are presented in Appendices D and E, respectively.

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Table 3.4 Physical and Chemical Parameters (January - December 1999)

Atomic Year	Month	Sample Location	Temperature (C)	Color (CPU)	Ammonia/ Ammonium (mg/l)	Nitrite/ Nitrate (mg/l)	Orthophosphorus (mg/l)	Available Silica (mg/l)	N/P Ratio
1999	JAN	0 o/oo	17.0	80	0.031	0.759	0.584	2.53	3.1
1999	JAN	6 o/oo	17.7	65	0.010	0.365	0.468	2.40	1.8
1999	JAN	12 o/oo	17.3	55	0.010	0.053	0.289	2.00	0.5
1999	JAN	20 o/oo	17.0	45	0.010	0.002	0.153	1.21	0.2
1999	FEB	0 o/oo	23.1	120	0.020	0.505	0.697	2.97	1.7
1999	FEB	6 o/oo	23.4	100	0.010	0.129	0.450	1.71	0.7
1999	FEB	12 o/oo	24.3	60	0.010	0.015	0.272	0.51	0.2
1999	FEB	20 o/oo	23.5	38	0.010	0.002	0.123	0.27	0.2
1999	MAR	0 o/oo	20.6	70	0.051	0.433	0.660	1.31	1.7
1999	MAR	6 o/oo	20.6	70	0.017	0.090	0.413	1.04	0.6
1999	MAR	12 o/oo	20.2	48	0.014	0.002	0.266	0.17	0.1
1999	MAR	20 o/oo	20.1	28	0.018	0.002	0.132	0.11	0.3
1999	APR	0 o/oo	27.5	45	0.018	0.056	0.797	0.97	0.2
1999	APR	6 o/oo	26.7	55	0.046	0.004	0.562	1.15	0.2
1999	APR	12 o/oo	26.6	60	0.018	0.004	0.380	1.16	0.1
1999	APR	20 o/oo	25.8	60	0.019	0.002	0.200	0.70	0.2
1999	MAY	0 o/oo	27.0	55	0.060	0.521	0.598	1.69	2.2
1999	MAY	6 o/oo	27.4	65	0.028	0.130	0.601	1.67	0.6
1999	MAY	12 o/oo	28.0	55	0.013	0.002	0.484	1.18	0.1
1999	MAY	20 o/oo	27.6	37	0.016	0.002	0.263	0.40	0.2
1999	JUN	0 o/oo	27.3	249	0.086	1.190	0.491	3.40	5.9
1999	JUN	6 o/oo	28.7	174	0.149	0.565	0.354	2.51	4.6
1999	JUN	12 o/oo	29.5	137	0.130	0.342	0.269	2.24	4.0
1999	JUN	20 o/oo	28.6	77	0.057	0.180	0.181	1.41	3.0
1999	JUL	0 o/oo	29.7	316	0.073	0.434	0.721	3.85	1.6
1999	JUL	6 o/oo	30.7	235	0.078	0.152	0.475	3.16	1.1
1999	JUL	12 o/oo	31.1	131	0.010	0.004	0.265	0.61	0.1
1999	JUL	20 o/oo	30.2	48	0.038	0.004	0.105	0.65	0.9
1999	AUG	0 o/oo	31.0	260	0.010	0.123	0.578	2.77	0.5
1999	AUG	6 o/oo	31.1	160	0.086	0.095	0.387	2.78	1.1
1999	AUG	12 o/oo	29.6	110	0.140	0.050	0.281	2.45	1.5
1999	AUG	20 o/oo	29.9	45	0.089	0.006	0.131	1.71	1.7
1999	SEP	0 o/oo	29.0	280	0.035	0.286	0.648	4.19	1.1
1999	SEP	6 o/oo	29.2	180	0.038	0.192	0.335	3.52	1.6
1999	SEP	12 o/oo	29.8	140	0.205	0.091	0.290	3.16	2.3
1999	SEP	20 o/oo	29.6	70	0.146	0.015	0.167	2.36	2.2
1999	OCT	0 o/oo	26.4	320	0.032	0.202	0.655	3.55	0.8
1999	OCT	6 o/oo	27.4	220	0.113	0.166	0.387	2.92	1.6
1999	OCT	12 o/oo	27.3	150	0.156	0.134	0.313	2.55	2.1
1999	OCT	20 o/oo	27.6	60	0.145	0.034	0.132	1.87	3.1
1999	NOV	0 o/oo	21.6	180	0.050	0.504	0.526	3.74	2.4
1999	NOV	6 o/oo	21.8	170	0.036	0.194	0.325	2.10	1.6
1999	NOV	12 o/oo	21.6	95	0.035	0.019	0.225	0.94	0.5
1999	NOV	20 o/oo	21.3	37	0.031	0.009	0.110	0.44	0.8
1999	DEC	0 o/oo	19.4	95	0.033	0.972	0.691	3.18	3.3
1999	DEC	6 o/oo	20.8	80	0.077	0.476	0.566	2.72	2.2
1999	DEC	12 o/oo	20.3	55	0.116	0.243	0.336	1.89	2.4
1999	DEC	20 o/oo	20.3	40	0.088	0.122	0.220	1.05	2.2

Table 3.5 Ambient Solar Radiation and Water Column Extinction January - December 1999)

Year	Month	Sample Location	Light Extinction Coefficient	Depth 1% of Surface Light Remains (m)	Depth 10% of Surface Light Remains (m)	Depth 50% of Surface Light Remains (m)
1999	JAN	0 o/oo	2.01	2.30	1.15	0.34
1999	JAN	6 o/oo	3.22	1.40	0.72	0.22
1999	JAN	12 o/oo	2.26	2.00	1.02	0.31
1999	JAN	20 o/oo	1.15	4.00	1.99	0.60
1999	FEB	0 o/oo	3.03	1.50	0.76	0.23
1999	FEB	6 o/oo	2.79	1.60	0.82	0.25
1999	FEB	12 o/oo	1.76	2.60	1.31	0.39
1999	FEB	20 o/oo	1.00	4.60	2.30	0.69
1999	MAR	0 o/oo	1.70	2.70	1.36	0.41
1999	MAR	6 o/oo	2.01	2.30	1.15	0.34
1999	MAR	12 o/oo	2.45	1.90	0.94	0.28
1999	MAR	20 o/oo	2.29	2.00	1.01	0.30
1999	APR	0 o/oo	1.54	3.00	1.50	0.45
1999	APR	6 o/oo	1.62	2.80	1.42	0.43
1999	APR	12 o/oo	1.54	3.00	1.50	0.45
1999	APR	20 o/oo	1.36	3.40	1.69	0.51
1999	MAY	0 o/oo	1.73	2.70	1.33	0.40
1999	MAY	6 o/oo	1.70	2.70	1.35	0.41
1999	MAY	12 o/oo	2.03	2.30	1.13	0.34
1999	MAY	20 o/oo	1.22	3.80	1.89	0.57
1999	JUN	0 o/oo	3.48	1.30	0.66	0.20
1999	JUN	6 o/oo	2.31	2.00	1.00	0.30
1999	JUN	12 o/oo	1.97	2.30	1.17	0.35
1999	JUN	20 o/oo	1.97	2.30	1.17	0.35
1999	JUL	0 o/oo	5.45	0.80	0.42	0.13
1999	JUL	6 o/oo	5.00	0.90	0.46	0.14
1999	JUL	12 o/oo	3.06	1.50	0.75	0.23
1999	JUL	20 o/oo	1.69	2.70	1.36	0.41
1999	AUG	0 o/oo	4.71	1.00	0.49	0.15
1999	AUG	6 o/oo	2.89	1.60	0.80	0.24
1999	AUG	12 o/oo	1.89	2.40	1.22	0.37
1999	AUG	20 o/oo	1.25	3.70	1.84	0.55
1999	SEP	0 o/oo	4.81	1.00	0.48	0.14
1999	SEP	6 o/oo	2.96	1.60	0.78	0.23
1999	SEP	12 o/oo	2.76	1.70	0.83	0.25
1999	SEP	20 o/oo	1.95	2.40	1.18	0.36
1999	OCT	0 o/oo	4.33	1.10	0.53	0.16
1999	OCT	6 o/oo	3.67	1.30	0.63	0.19
1999	OCT	12 o/oo	2.64	1.70	0.87	0.26
1999	OCT	20 o/oo	2.38	1.90	0.97	0.29
1999	NOV	0 o/oo	4.55	1.00	0.51	0.15
1999	NOV	6 o/oo	3.72	1.20	0.62	0.19
1999	NOV	12 o/oo	4.30	1.10	0.54	0.16
1999	NOV	20 o/oo	2.07	2.20	1.11	0.34
1999	DEC	0 o/oo	2.66	1.70	0.87	0.26
1999	DEC	6 o/oo	3.51	1.30	0.66	0.20
1999	DEC	12 o/oo	2.80	1.60	0.82	0.25
1999	DEC	20 o/oo	1.76	2.60	1.31	0.39

Table 3.6 Measured Rates of Primary Production (January - December 1999)

Year	Month	Sample Location	Carbon Uptake (mg Carbon/m3/E)	Carbon Uptake (mg Carbon/m3/ E/Chla)	Carbon Uptake (mg Carbon/ m3/hr)	Carbon Uptake (mg Carbon/m3/ hr/Chla)
1999	JAN	0 o/oo	0.44	0.16	1.69	0.60
1999	JAN	6 o/oo	4.73	0.04	17.43	0.16
1999	JAN	12 o/oo	4.92	0.10	17.65	0.37
1999	JAN	20 o/oo	0.97	0.19	3.34	0.67
1999	FEB	0 o/oo	0.31	0.06	1.27	0.23
1999	FEB	6 o/oo	3.37	0.07	14.06	0.27
1999	FEB	12 o/oo	4.15	0.19	17.09	0.77
1999	FEB	20 o/oo	0.72	0.10	2.90	0.41
1999	MAR	0 o/oo	0.40	0.15	2.01	0.74
1999	MAR	6 o/oo	3.53	0.16	17.36	0.79
1999	MAR	12 o/oo	3.42	0.22	16.75	1.05
1999	MAR	20 o/oo	0.74	0.06	3.54	0.27
1999	APR	0 o/oo	0.52	0.06	2.60	0.28
1999	APR	6 o/oo	4.12	0.35	20.58	1.77
1999	APR	12 o/oo	3.74	0.31	20.35	1.70
1999	APR	20 o/oo	0.72	0.06	4.03	0.33
1999	MAY	0 o/oo	0.41	0.06	1.92	0.27
1999	MAY	6 o/oo	4.02	0.28	18.32	1.29
1999	MAY	12 o/oo	3.84	0.36	17.88	1.69
1999	MAY	20 o/oo	0.85	0.08	3.99	0.36
1999	JUN	0 o/oo	0.23	0.23	1.15	1.15
1999	JUN	6 o/oo	3.19	0.66	15.47	3.22
1999	JUN	12 o/oo	3.39	0.45	17.09	2.28
1999	JUN	20 o/oo	0.76	0.09	3.64	0.42
1999	JUL	0 o/oo	0.20	0.01	0.93	0.03
1999	JUL	6 o/oo	2.85	0.57	13.42	2.68
1999	JUL	12 o/oo	3.24	0.05	14.39	0.21
1999	JUL	20 o/oo	0.71	0.04	3.05	0.18
1999	AUG	0 o/oo	0.28	0.01	1.31	0.03
1999	AUG	6 o/oo	3.86	0.51	17.77	2.34
1999	AUG	12 o/oo	4.05	0.94	17.54	4.08
1999	AUG	20 o/oo	0.83	0.09	3.64	0.40
1999	SEP	0 o/oo	0.21	0.01	0.92	0.06
1999	SEP	6 o/oo	2.79	0.31	12.36	1.36
1999	SEP	12 o/oo	2.86	0.24	12.37	1.02
1999	SEP	20 o/oo	0.61	0.02	2.61	0.09
1999	OCT	0 o/oo	0.16	0.08	0.62	0.31
1999	OCT	6 o/oo	4.67	0.90	18.53	3.56
1999	OCT	12 o/oo	3.78	0.14	14.73	0.56
1999	OCT	20 o/oo	1.19	0.08	4.62	0.30
1999	NOV	0 o/oo	0.31	0.04	1.09	0.13
1999	NOV	6 o/oo	3.85	0.08	13.61	0.27
1999	NOV	12 o/oo	3.99	0.07	14.28	0.25
1999	NOV	20 o/oo	0.88	0.06	2.99	0.20
1999	DEC	0 o/oo	0.35	0.06	1.18	0.19
1999	DEC	6 o/oo	1.71	0.13	5.73	0.42
1999	DEC	12 o/oo	5.31	0.51	17.88	1.70
1999	DEC	20 o/oo	6.13	0.36	19.38	1.13

TABLE 3.7 Determination of Carbon Uptake By Size Fraction (January - December 1999)

Year	Month	Sample Location	Uptake >20 um Fraction (mg Carbon/m3/E)	Uptake 20><5 um Fract. (mg Carbon/m3/E)	Uptake 5> um Fraction (mg Carbon/m3/E)	% Carbon Uptake >20 um Size Fraction	% Carbon Uptake 20><5 um Size Fraction	% Carbon Uptake 5> um Size Fraction
1999	JAN	0 o/oo	0.00	0.11	0.35	0.0	23.8	78.1
1999	JAN	6 o/oo	0.39	0.76	3.58	8.2	16.0	75.8
1999	JAN	12 o/oo	0.70	0.40	3.82	14.2	8.1	77.6
1999	JAN	20 o/oo	0.11	0.08	0.78	11.2	8.6	80.2
1999	FEB	0 o/oo	0.00	0.07	0.24	0.2	22.5	77.3
1999	FEB	6 o/oo	0.30	0.54	2.53	8.8	16.2	75.0
1999	FEB	12 o/oo	0.59	0.34	3.22	14.2	8.1	77.6
1999	FEB	20 o/oo	0.11	0.09	0.52	15.2	12.6	72.3
1999	MAR	0 o/oo	0.02	0.08	0.30	5.2	19.4	75.4
1999	MAR	6 o/oo	0.21	0.61	2.70	6.0	17.3	76.6
1999	MAR	12 o/oo	0.48	0.30	2.65	13.9	8.7	77.3
1999	MAR	20 o/oo	0.08	0.06	0.59	11.2	8.6	80.2
1999	APR	0 o/oo	0.02	0.11	0.40	3.7	20.4	76.0
1999	APR	6 o/oo	0.36	0.66	3.09	8.8	16.2	75.0
1999	APR	12 o/oo	0.52	0.33	2.90	13.9	8.7	77.3
1999	APR	20 o/oo	0.08	0.06	0.58	11.2	8.6	80.2
1999	MAY	0 o/oo	0.02	0.08	0.32	3.9	18.2	77.9
1999	MAY	6 o/oo	0.32	0.67	3.03	7.9	16.7	75.4
1999	MAY	12 o/oo	0.55	0.31	2.98	14.2	8.1	77.6
1999	MAY	20 o/oo	0.10	0.07	0.68	11.2	8.6	80.2
1999	JUN	0 o/oo	0.02	0.03	0.18	9.2	12.3	78.5
1999	JUN	6 o/oo	0.28	0.52	2.39	8.8	16.2	75.0
1999	JUN	12 o/oo	0.48	0.28	2.63	14.2	8.1	77.6
1999	JUN	20 o/oo	0.08	0.06	0.61	11.2	8.6	80.2
1999	JUL	0 o/oo	0.01	0.04	0.15	5.2	19.4	75.4
1999	JUL	6 o/oo	0.25	0.46	2.14	8.8	16.2	75.0
1999	JUL	12 o/oo	0.45	0.28	2.50	13.9	8.7	77.3
1999	JUL	20 o/oo	0.08	0.06	0.57	11.2	8.6	80.2
1999	AUG	0 o/oo	0.01	0.06	0.21	5.2	19.4	75.4
1999	AUG	6 o/oo	0.34	0.62	2.90	8.8	16.2	75.0
1999	AUG	12 o/oo	0.61	0.26	3.18	15.1	6.4	78.5
1999	AUG	20 o/oo	0.09	0.07	0.66	11.2	8.6	80.2
1999	SEP	0 o/oo	0.01	0.04	0.16	5.2	19.4	75.4
1999	SEP	6 o/oo	0.25	0.45	2.09	8.8	16.2	75.0
1999	SEP	12 o/oo	0.43	0.18	2.25	15.1	6.4	78.5
1999	SEP	20 o/oo	0.07	0.05	0.49	11.2	8.6	80.2
1999	OCT	0 o/oo	0.01	0.03	0.12	5.2	19.4	75.4
1999	OCT	6 o/oo	0.43	0.72	3.52	9.1	15.5	75.4
1999	OCT	12 o/oo	0.54	0.31	2.93	14.2	8.1	77.6
1999	OCT	20 o/oo	0.15	0.09	0.95	12.5	7.7	79.8
1999	NOV	0 o/oo	0.02	0.06	0.23	5.2	19.4	75.4
1999	NOV	6 o/oo	0.30	0.64	2.90	7.9	16.7	75.4
1999	NOV	12 o/oo	0.56	0.35	3.08	13.9	8.7	77.3
1999	NOV	20 o/oo	0.10	0.08	0.70	11.2	8.6	80.2
1999	DEC	0 o/oo	0.02	0.05	0.29	4.8	13.6	81.6
1999	DEC	6 o/oo	0.24	0.28	1.19	14.3	16.2	69.6
1999	DEC	12 o/oo	0.75	1.45	3.12	14.1	27.2	58.7
1999	DEC	20 o/oo	3.29	0.77	2.08	53.6	12.5	33.9

TABLE 3.8 Determination of Chlorophyll a by Size Class Fraction (January - December 1999)

Year	Month	Sample Location	Chlorophyll a >20 um Fraction (mg/m3)	Chlorophyll a 20><5 um Fraction (mg/m3)	Chlorophyll a 5> um Fraction (mg/m3)	% Chlorophyll a >20 um Size Fraction	% Chlorophyll a 20><5 um Size Fraction	% Chlorophyll a 5> um Size Fraction
1999	JAN	0 o/oo	0.0	0.8	2.2	0.0	21.4	78.6
1999	JAN	6 o/oo	25.5	35.1	51.2	22.8	31.4	45.8
1999	JAN	12 o/oo	15.9	13.6	18.8	32.9	28.2	38.9
1999	JAN	20 o/oo	1.1	0.6	3.3	22.0	12.0	66.0
1999	FEB	0 o/oo	0.4	0.5	4.6	7.3	9.1	83.6
1999	FEB	6 o/oo	2.0	10.9	38.5	3.9	21.2	74.9
1999	FEB	12 o/oo	16.0	0.6	5.7	71.7	2.7	25.6
1999	FEB	20 o/oo	4.5	0.3	2.3	63.4	4.2	32.4
1999	MAR	0 o/oo	0.0	0.5	2.3	0.0	18.5	85.2
1999	MAR	6 o/oo	2.8	4.1	15.1	12.7	18.6	68.6
1999	MAR	12 o/oo	6.3	1.2	8.4	39.6	7.5	52.8
1999	MAR	20 o/oo	5.4	0.0	8.3	37.1	0.0	62.9
1999	APR	0 o/oo	0.5	0.0	8.9	3.3	0.0	96.7
1999	APR	6 o/oo	0.2	5.0	6.4	1.7	43.1	55.2
1999	APR	12 o/oo	2.8	4.0	5.2	23.3	33.3	43.3
1999	APR	20 o/oo	0.2	2.5	9.6	1.6	20.3	78.0
1999	MAY	0 o/oo	1.0	0.9	5.1	14.3	12.9	72.9
1999	MAY	6 o/oo	2.0	2.5	9.7	14.1	17.6	68.3
1999	MAY	12 o/oo	0.7	1.5	8.4	6.6	14.2	79.2
1999	MAY	20 o/oo	4.3	0.5	6.4	38.4	4.5	57.1
1999	JUN	0 o/oo	0.0	0.2	0.8	0.0	20.0	80.0
1999	JUN	6 o/oo	0.1	0.4	4.3	2.1	8.3	89.6
1999	JUN	12 o/oo	0.7	0.7	6.1	9.3	9.3	81.3
1999	JUN	20 o/oo	2.0	1.0	5.7	23.0	11.5	65.5
1999	JUL	0 o/oo	9.9	3.7	15.4	34.1	12.8	53.1
1999	JUL	6 o/oo	0.0	0.7	4.5	0.0	10.0	90.0
1999	JUL	12 o/oo	40.4	6.5	22.7	58.0	9.3	32.6
1999	JUL	20 o/oo	6.3	3.8	7.2	36.4	22.0	41.6
1999	AUG	0 o/oo	3.9	28.3	10.7	9.1	66.0	24.9
1999	AUG	6 o/oo	0.0	3.4	6.2	0.0	18.4	81.6
1999	AUG	12 o/oo	0.5	0.4	3.4	11.6	9.3	79.1
1999	AUG	20 o/oo	4.8	0.8	3.6	52.2	8.7	39.1
1999	SEP	0 o/oo	0.0	9.3	7.3	0.0	59.6	46.8
1999	SEP	6 o/oo	0.8	0.2	8.1	8.8	2.2	89.0
1999	SEP	12 o/oo	4.8	0.9	6.4	39.7	7.4	52.9
1999	SEP	20 o/oo	12.6	0.0	20.6	42.4	0.0	69.4
1999	OCT	0 o/oo	0.2	0.0	1.8	10.0	0.0	90.0
1999	OCT	6 o/oo	0.7	0.6	3.9	13.5	11.5	75.0
1999	OCT	12 o/oo	14.3	5.6	6.3	54.6	21.4	24.0
1999	OCT	20 o/oo	4.6	2.9	7.8	30.1	19.0	51.0
1999	NOV	0 o/oo	2.2	2.1	4.1	26.2	25.0	48.8
1999	NOV	6 o/oo	11.5	24.4	14.2	23.0	48.7	28.3
1999	NOV	12 o/oo	16.0	28.5	11.9	28.4	50.5	21.1
1999	NOV	20 o/oo	1.0	2.3	11.6	6.7	15.4	77.9
1999	DEC	0 o/oo	1.2	0.0	7.9	13.1	0.0	96.9
1999	DEC	6 o/oo	1.9	3.2	8.5	14.0	23.5	62.5
1999	DEC	12 o/oo	2.0	2.3	6.2	19.0	21.9	59.0
1999	DEC	20 o/oo	10.1	2.0	5.0	59.1	11.7	29.2

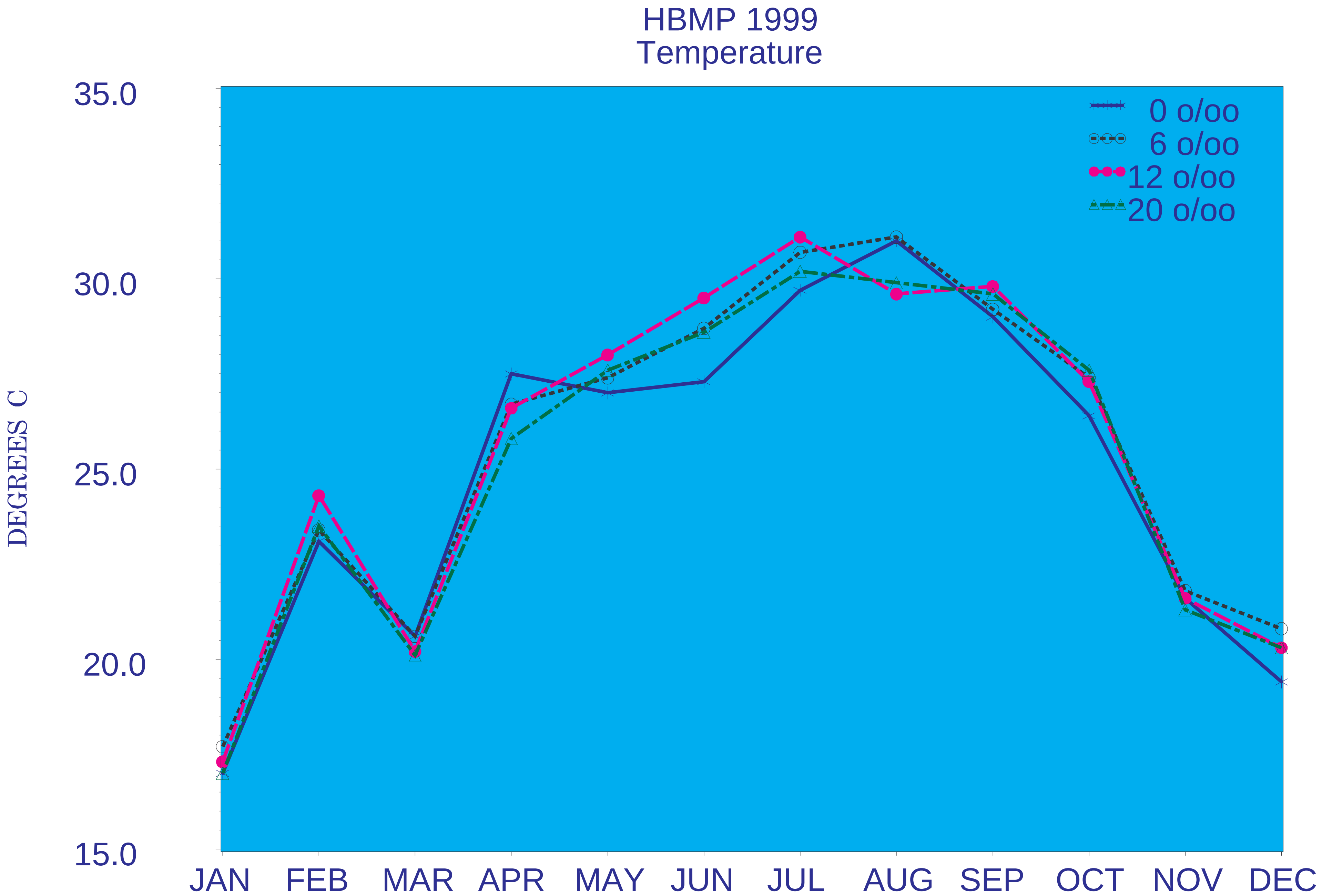

Figure 3.3 1999 Temperature at salinity sampling zones.

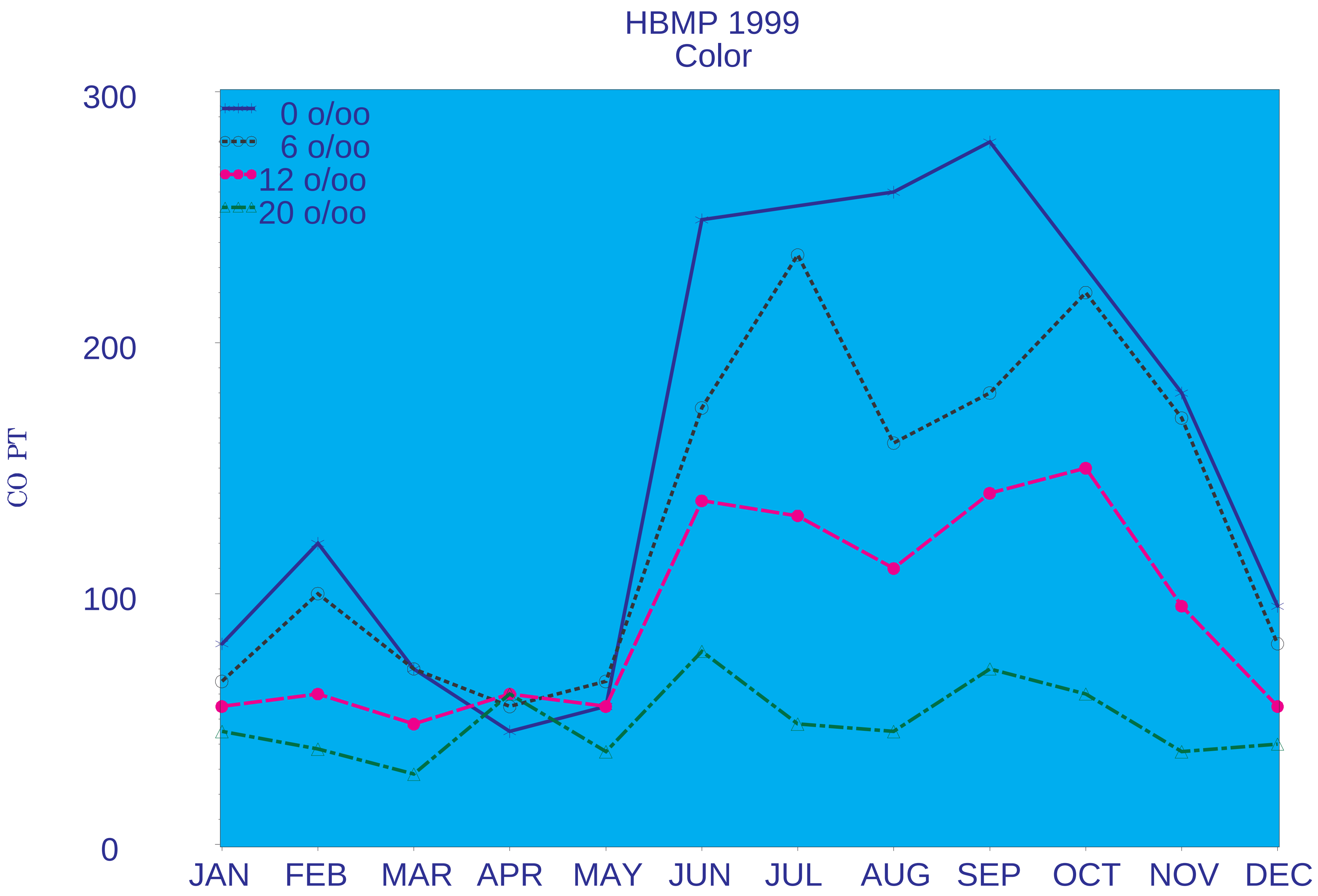

Figure 3.4 1999 Color at salinity sampling zones.

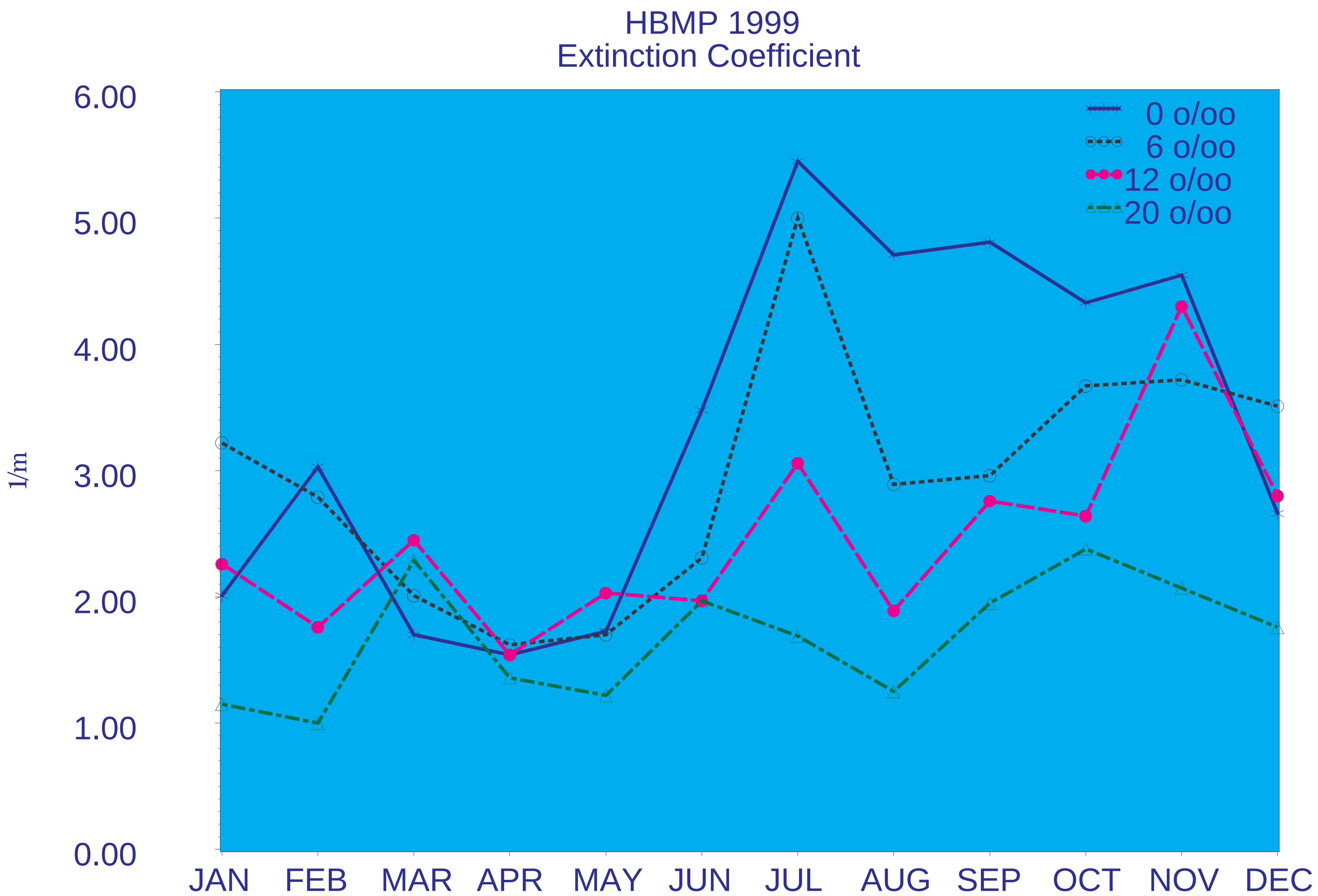

Figure 3.5 1999 Extinction Coefficient at salinity sampling zones.

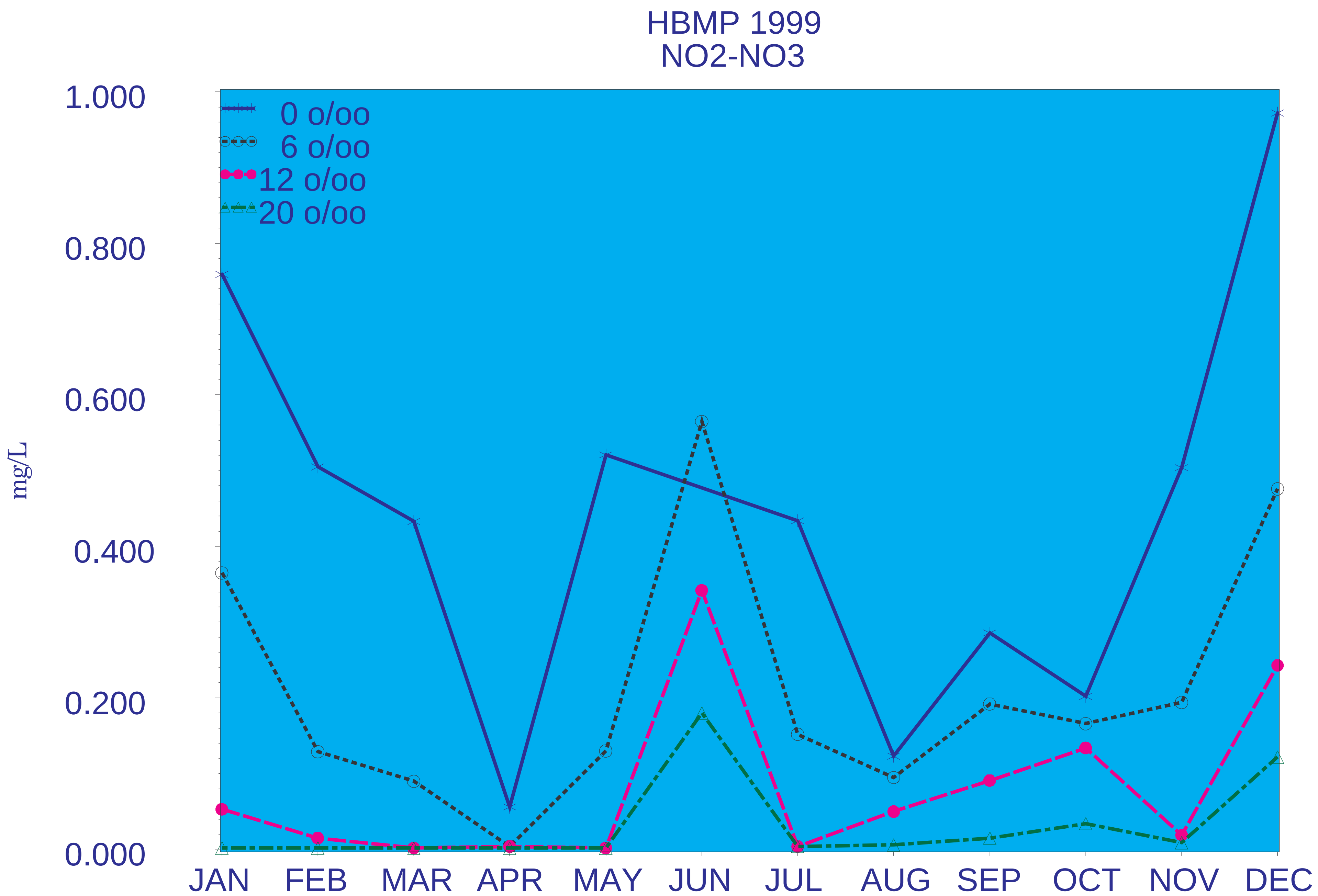

Figure 3.6 1999 Nitrite/Nitrate at salinity sampling zones.

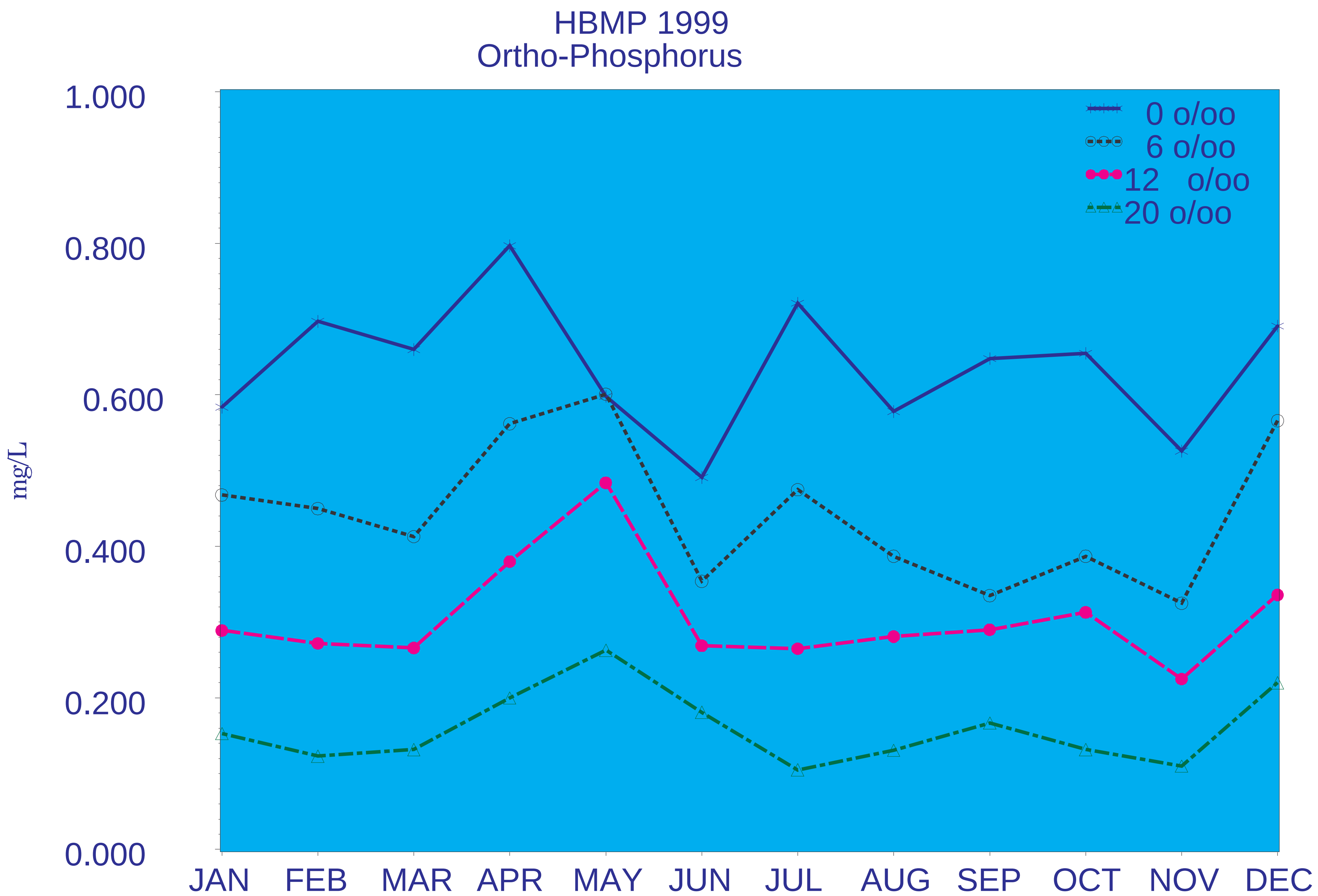

Figure 3.7 1999 Ortho-phosphorus at salinity sampling zones.

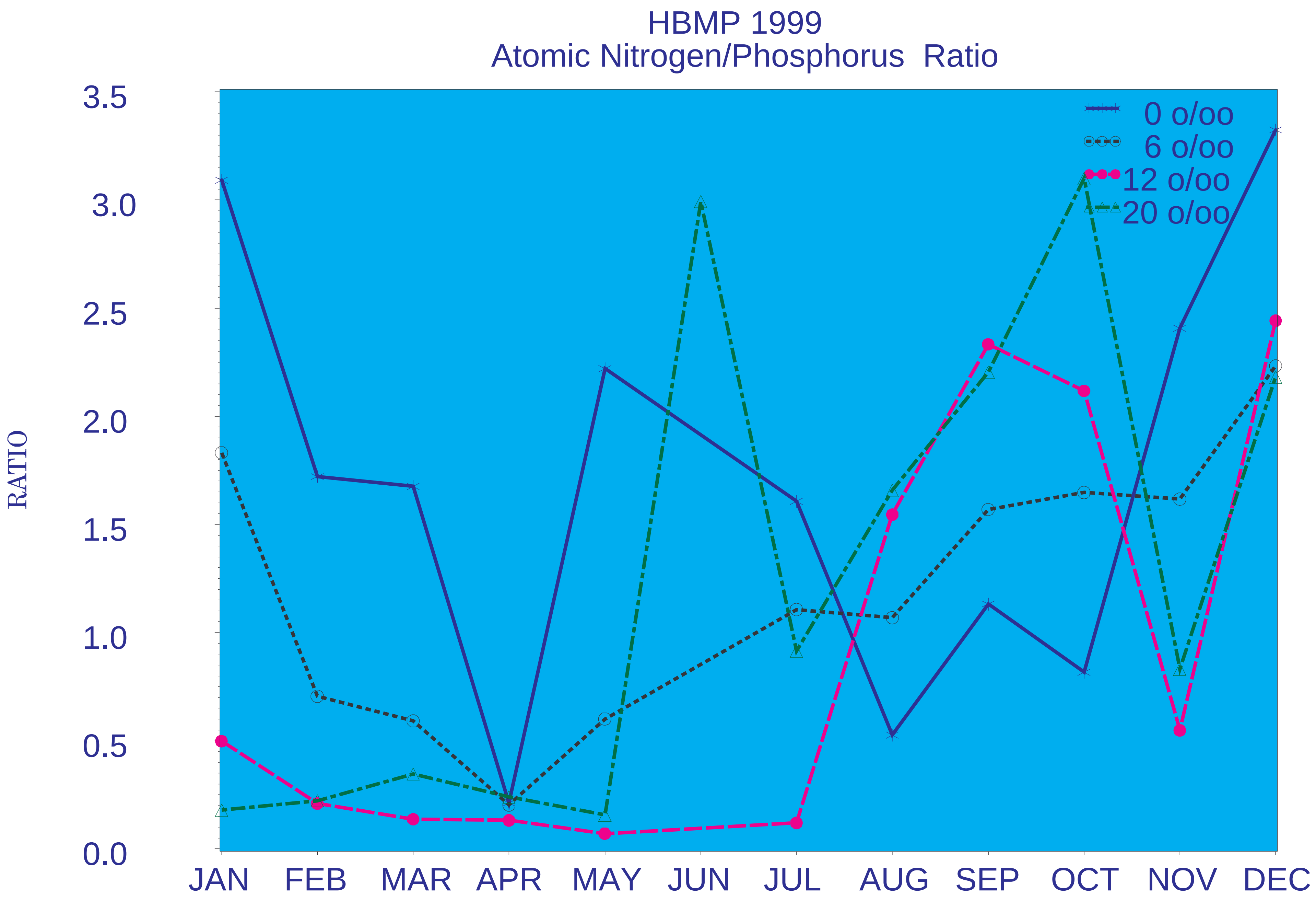

Figure 3.8 1999 Atomic N/P Ratio at salinity sampling zones.

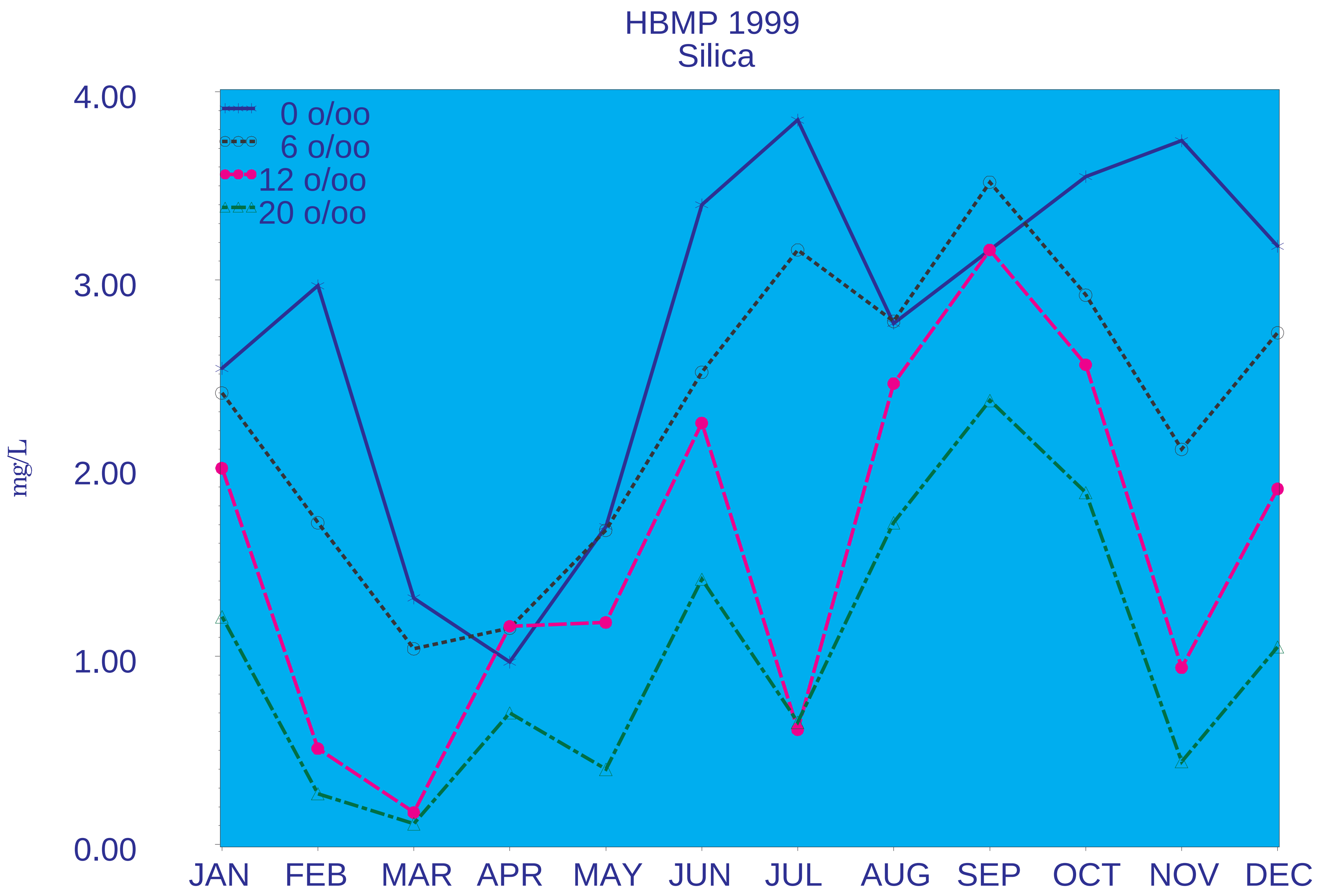

Figure 3.9 1999 Silica at salinity sampling zones.

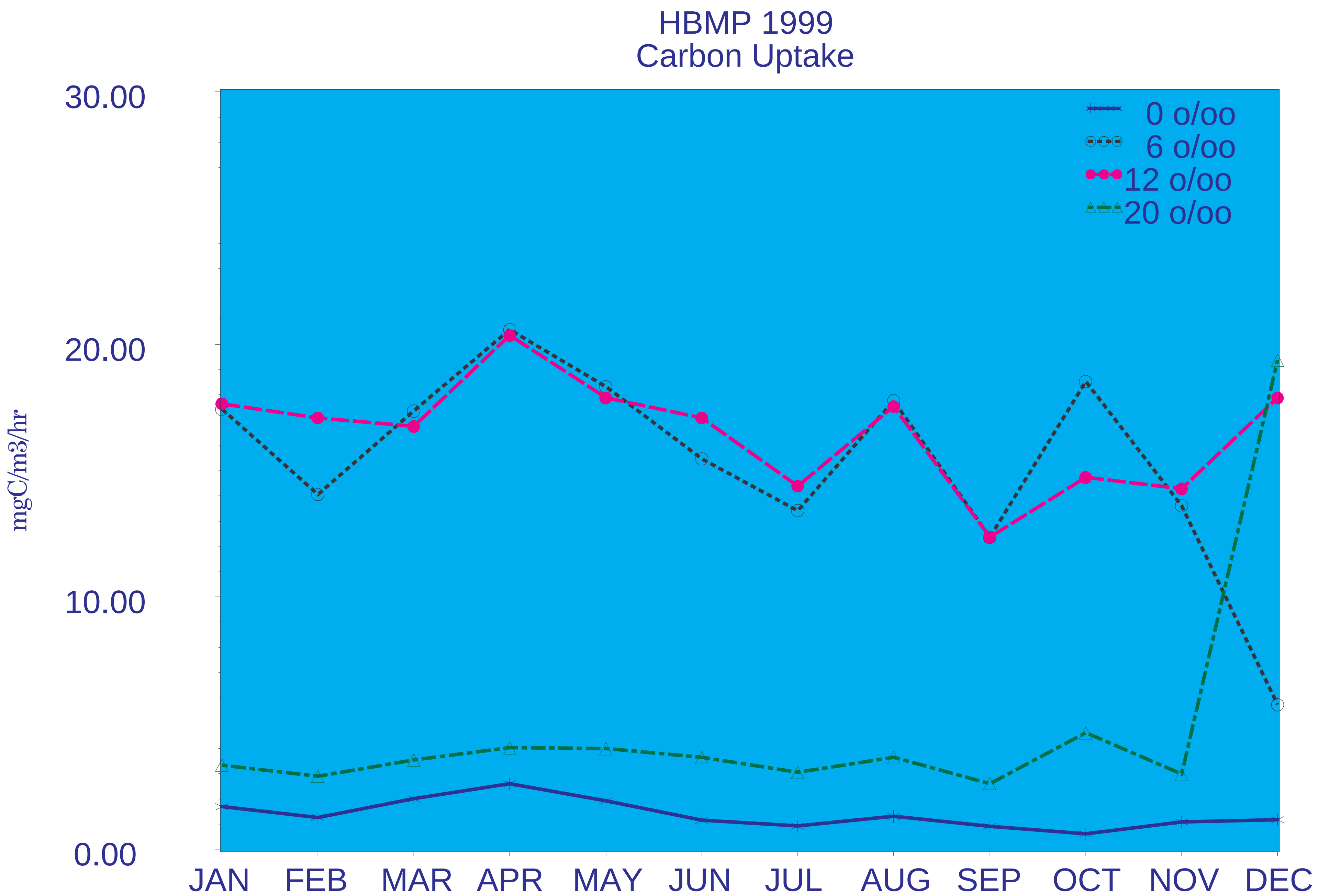

Figure 3.10 1999 Carbon Uptake (mgC/m3/hr) at salinity sampling zones.

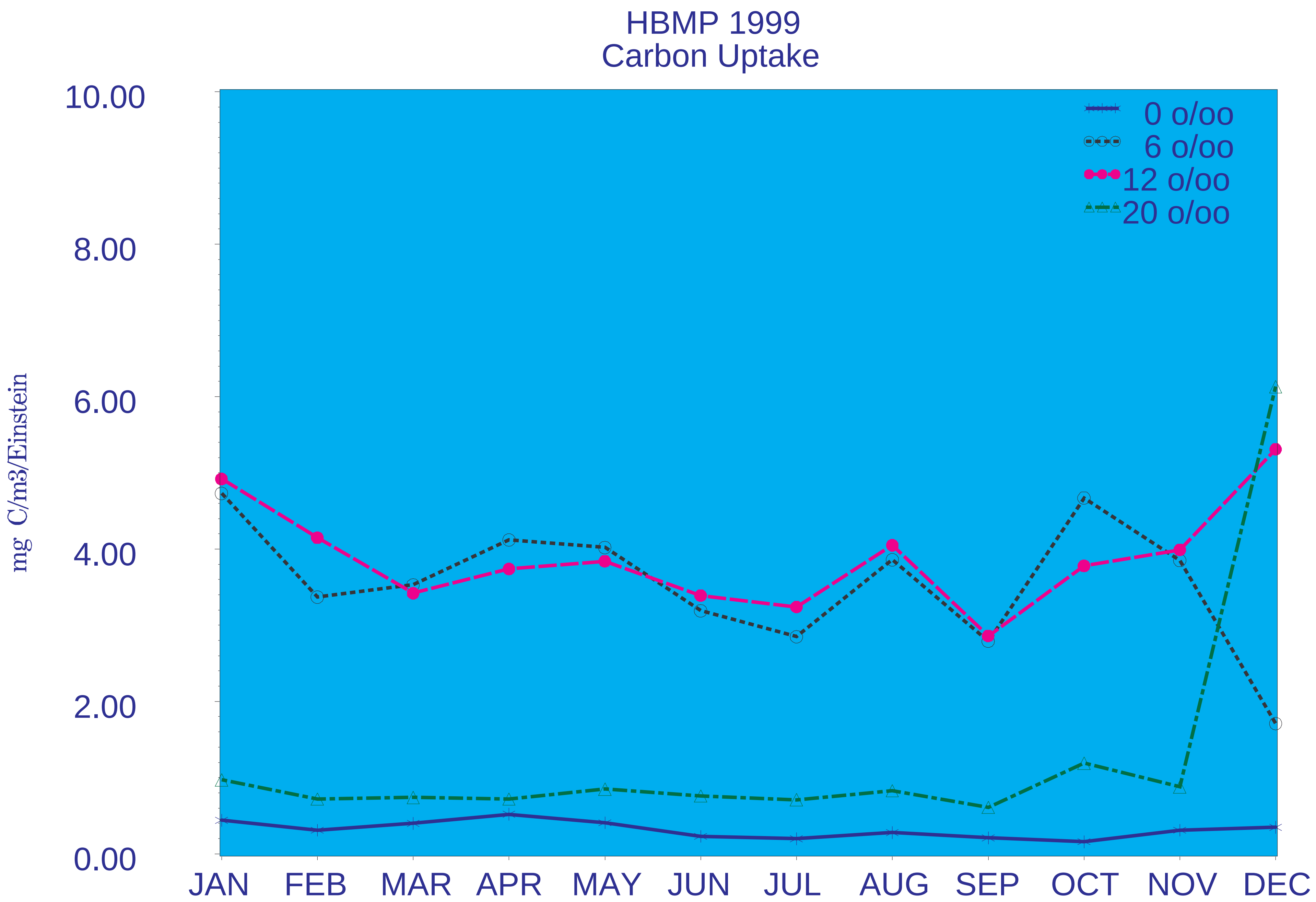

Figure 3.11 1999 Carbon Uptake (mgC/m3/Einstein) at salinity sampling zones.

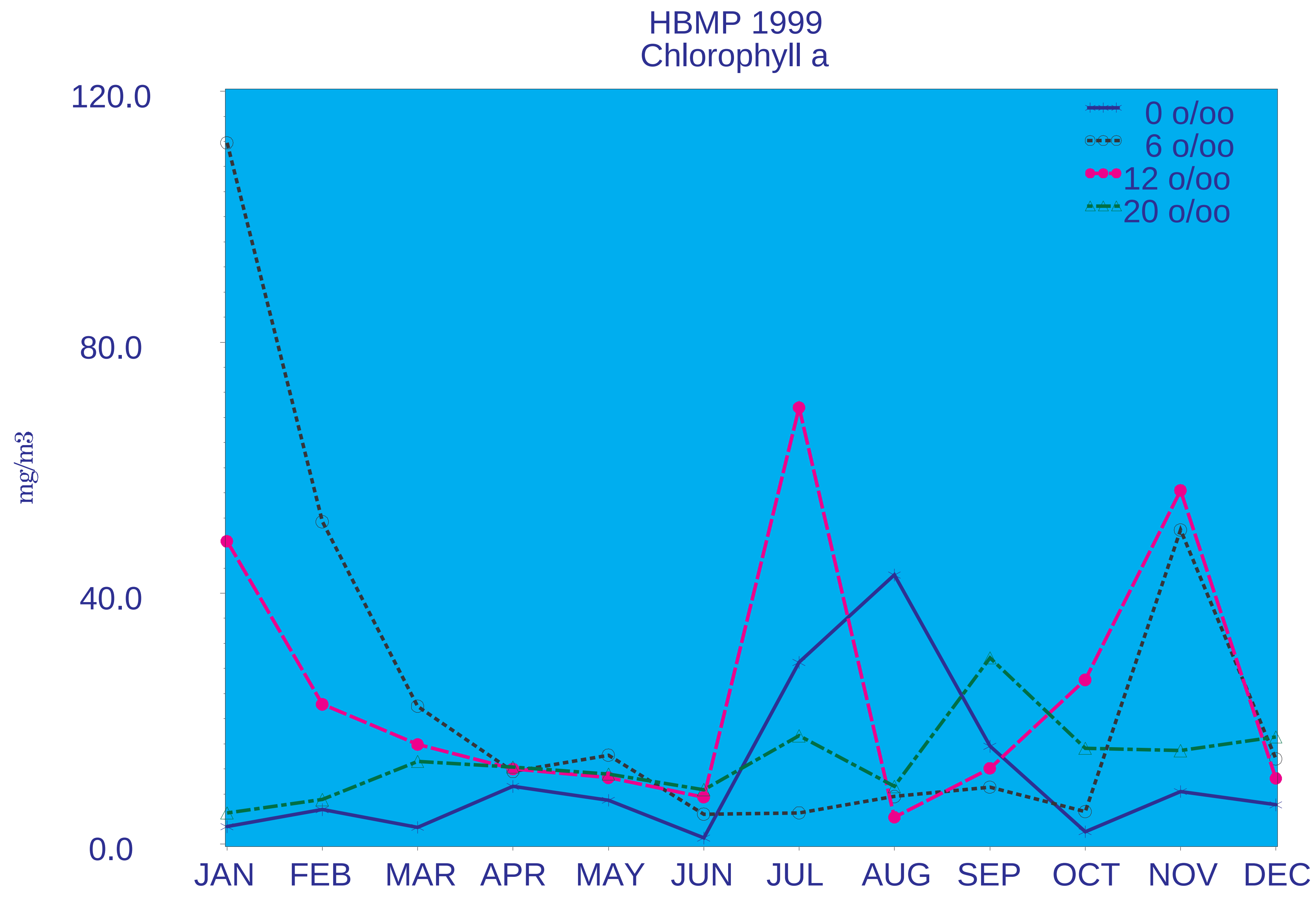

Figure 3.12 1999 Chlorophyll a (mg/m3) at salinity sampling zones.

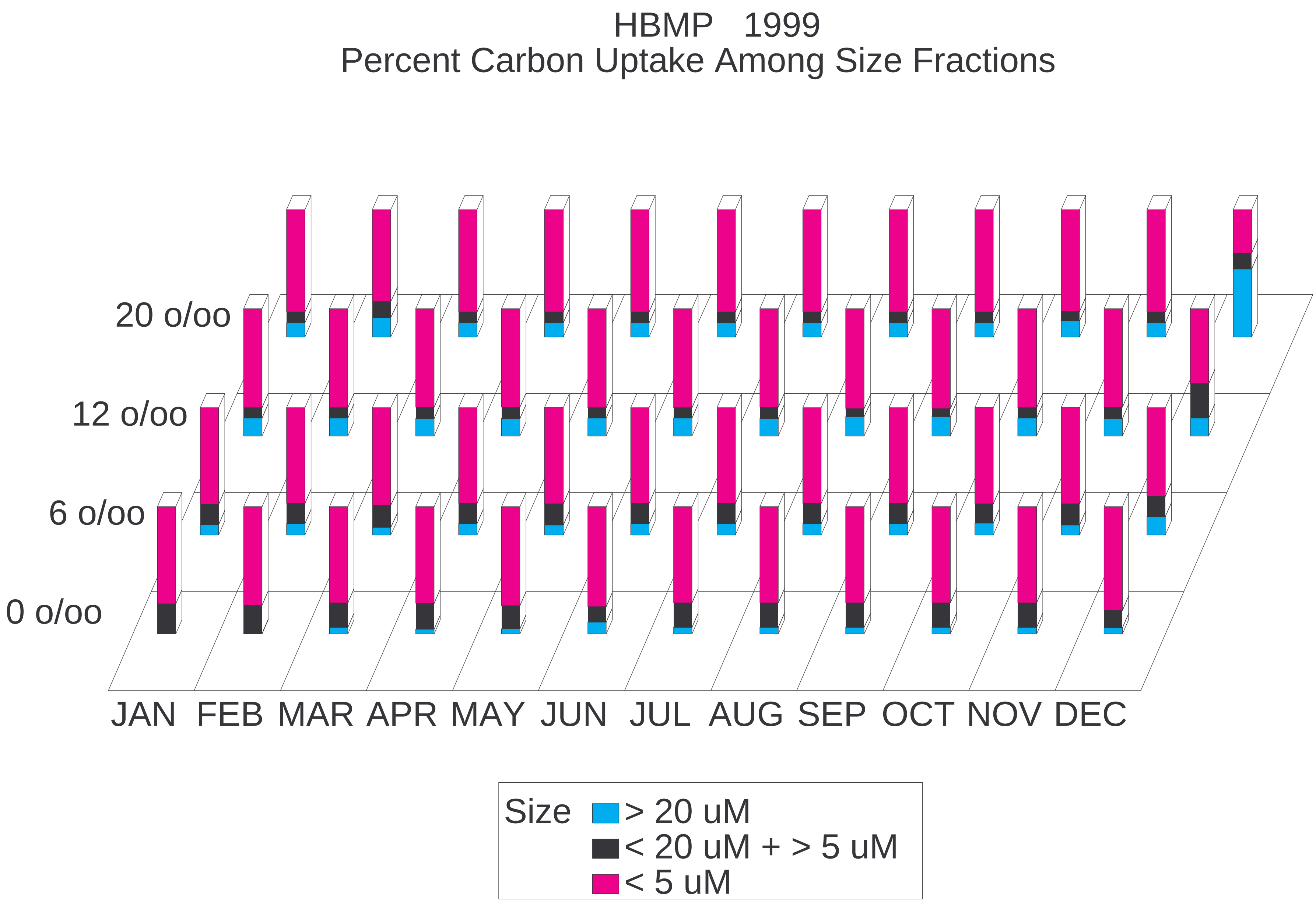

Figure 3.13 Percent Carbon Uptake Among Size Fractions

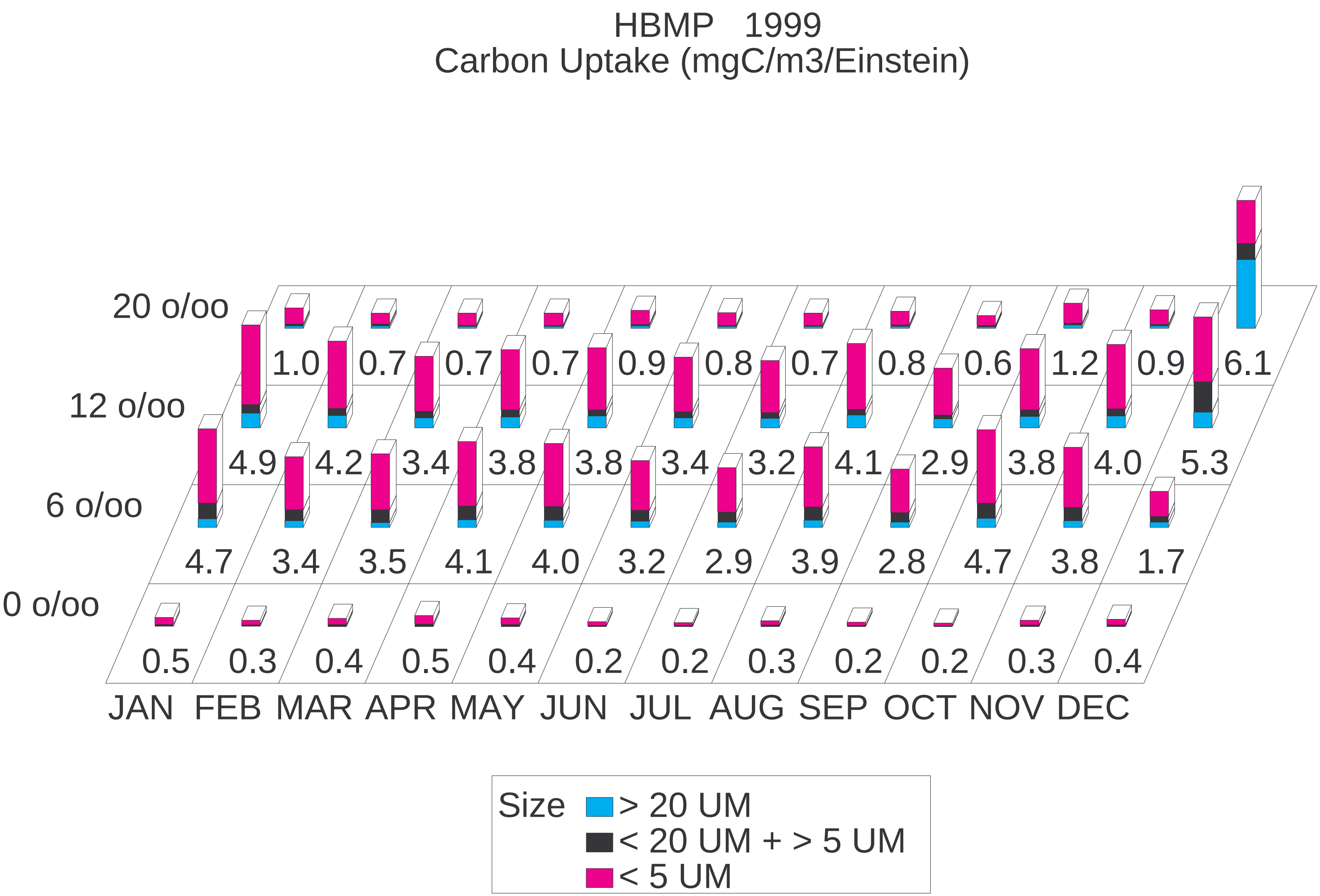

Figure 3.14 Carbon Uptake (mgC/m3/Einstein) Among Size Fractions

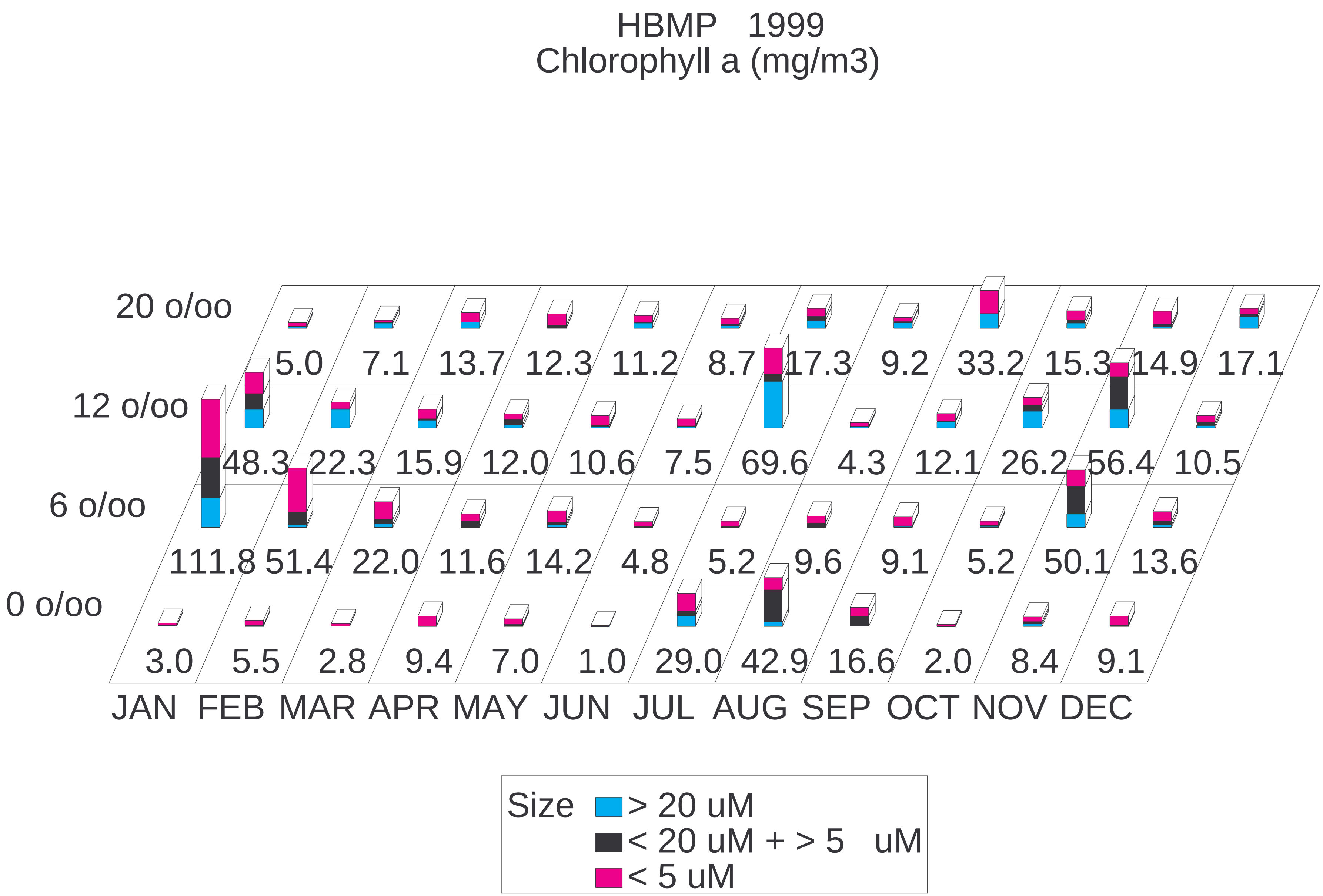

Figure 3.15 Chlorophyll a (mg/m3) Among Size Fractions

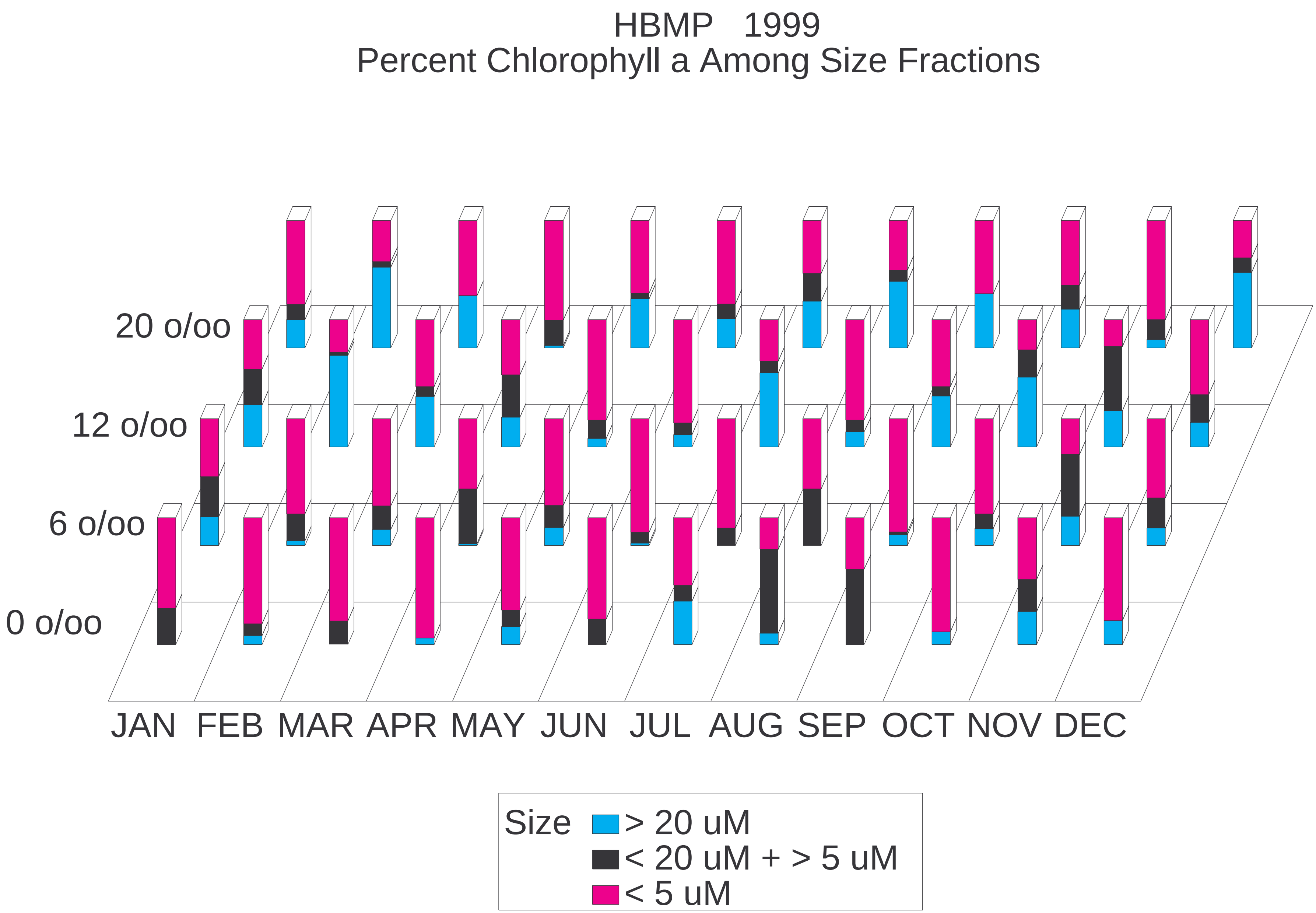

Figure 3.16 Percent Chlorophyll a Among Size Fractions

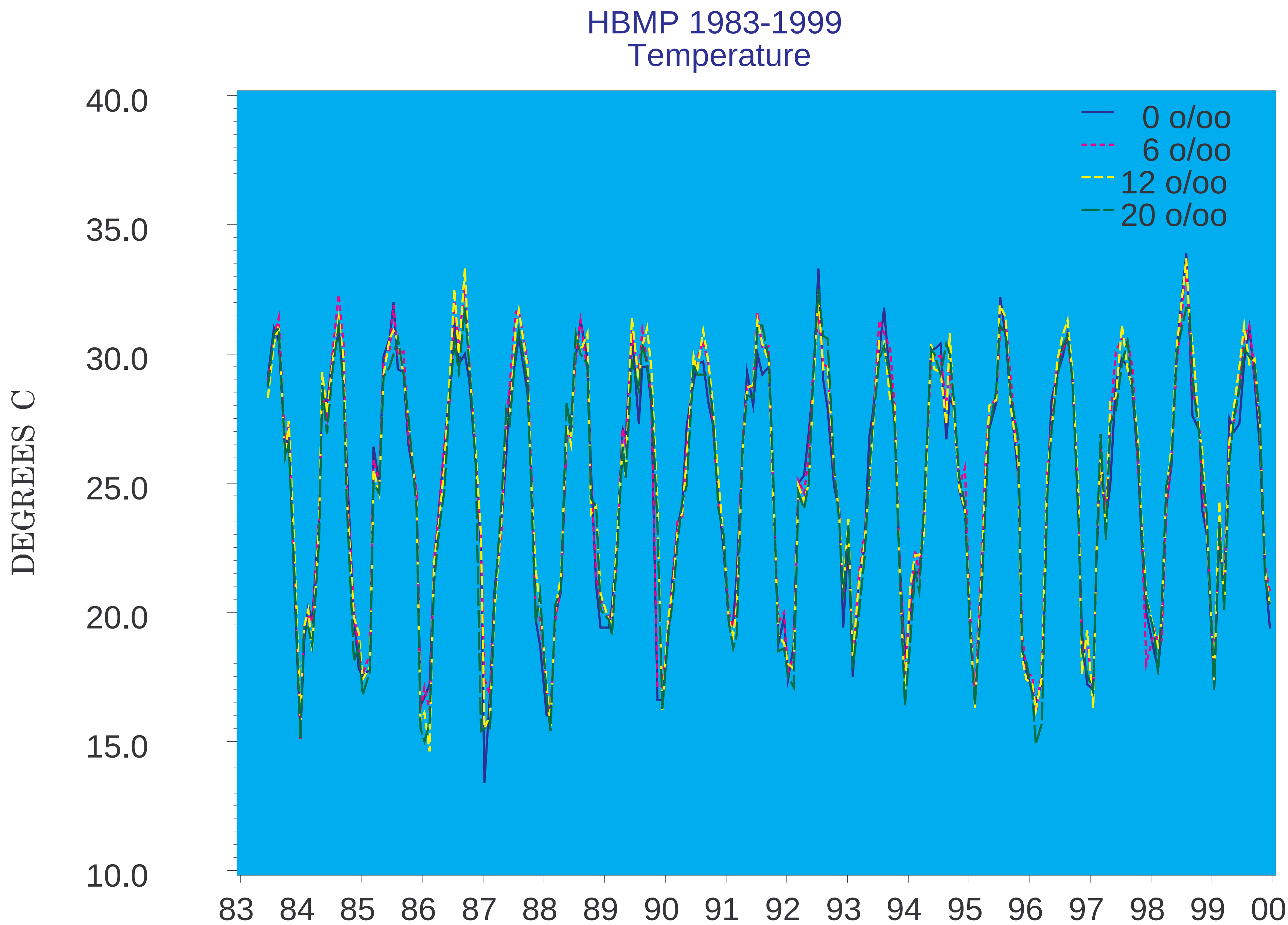

Figure 3.17 1983-1999 Temperature at salinity sampling zones.

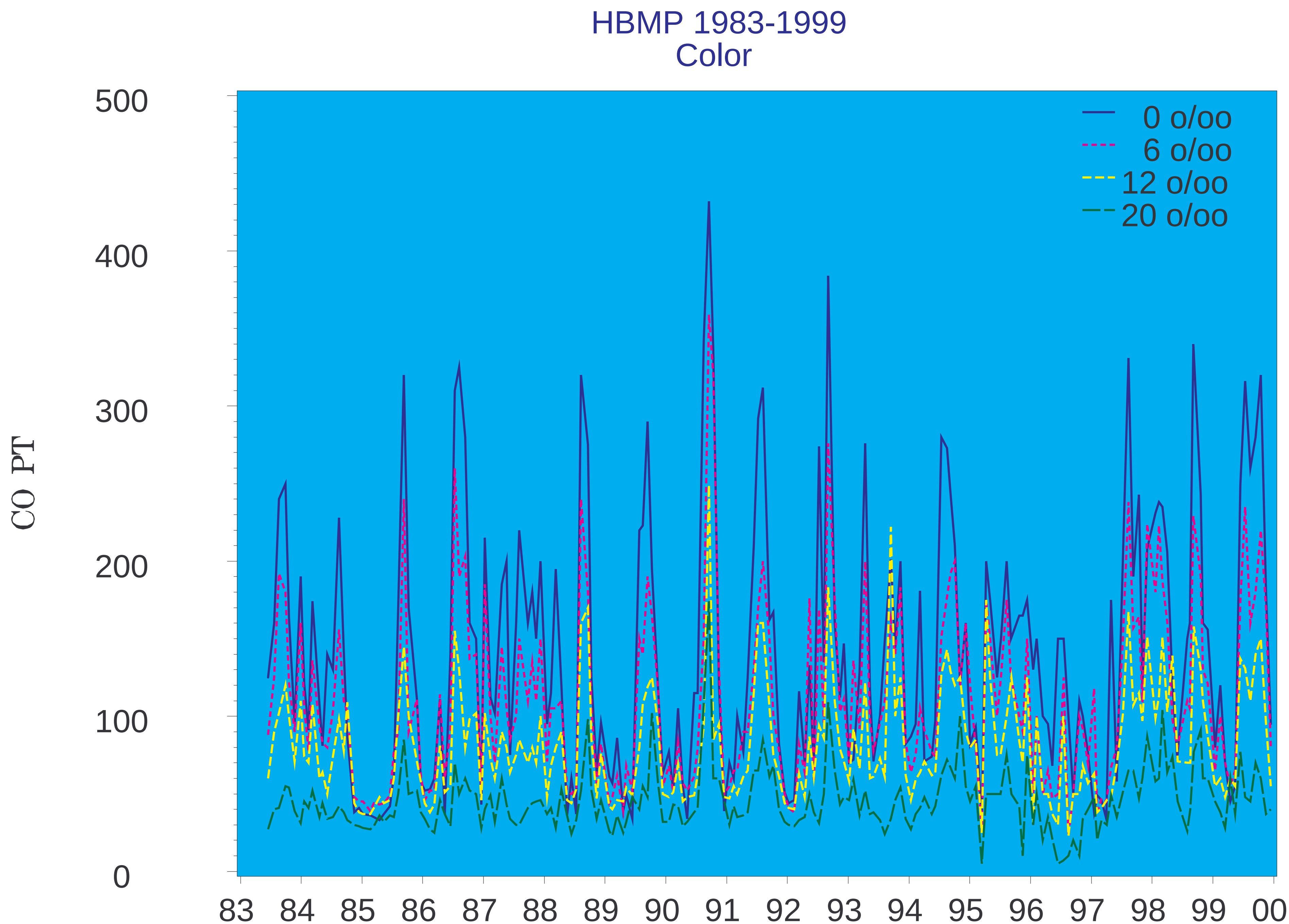

Figure 3.18 1983-1999 Color at salinity sampling zones.

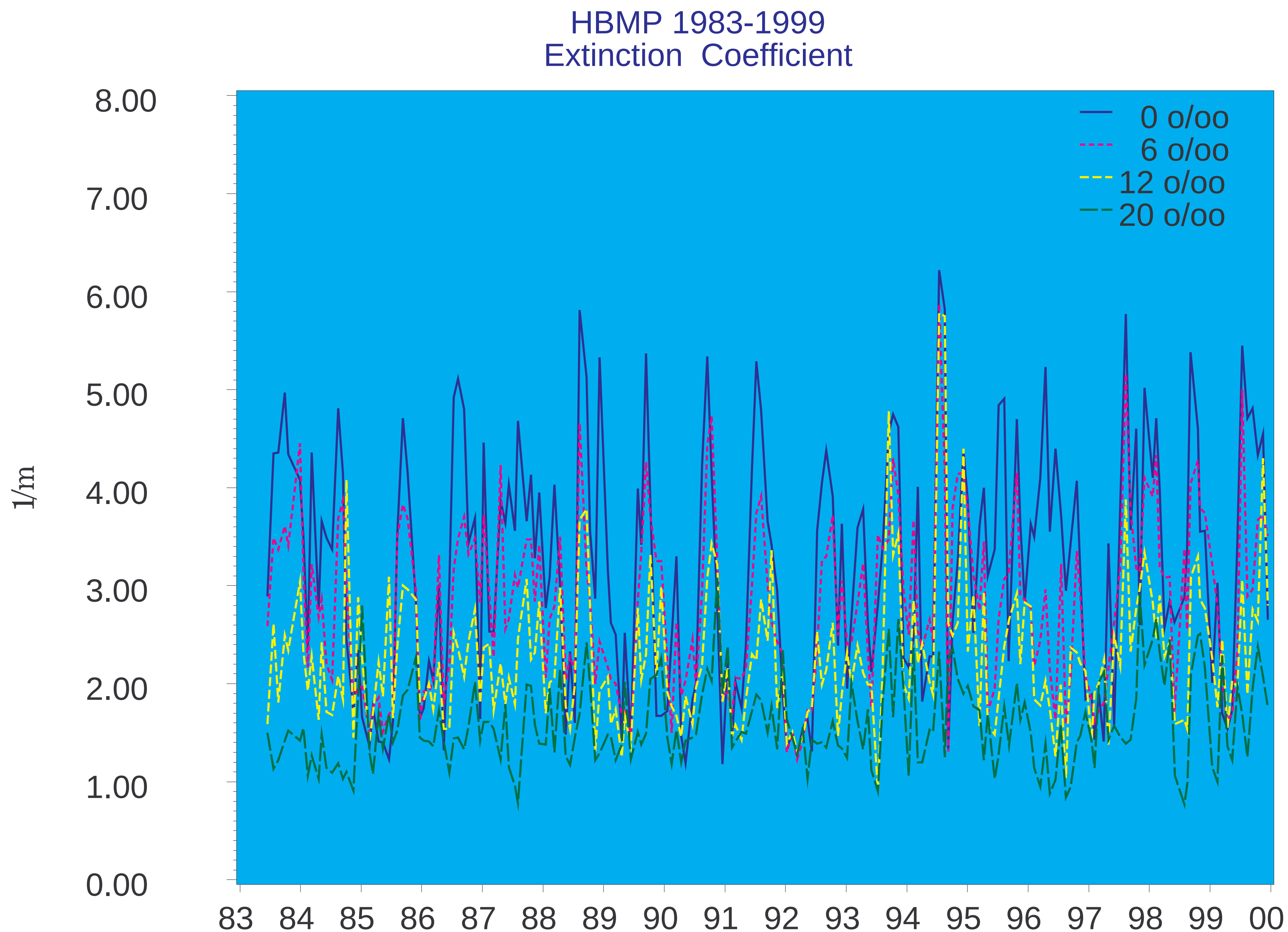

Figure 3.19 1983-1999 Extinction Coefficient at salinity sampling zones.

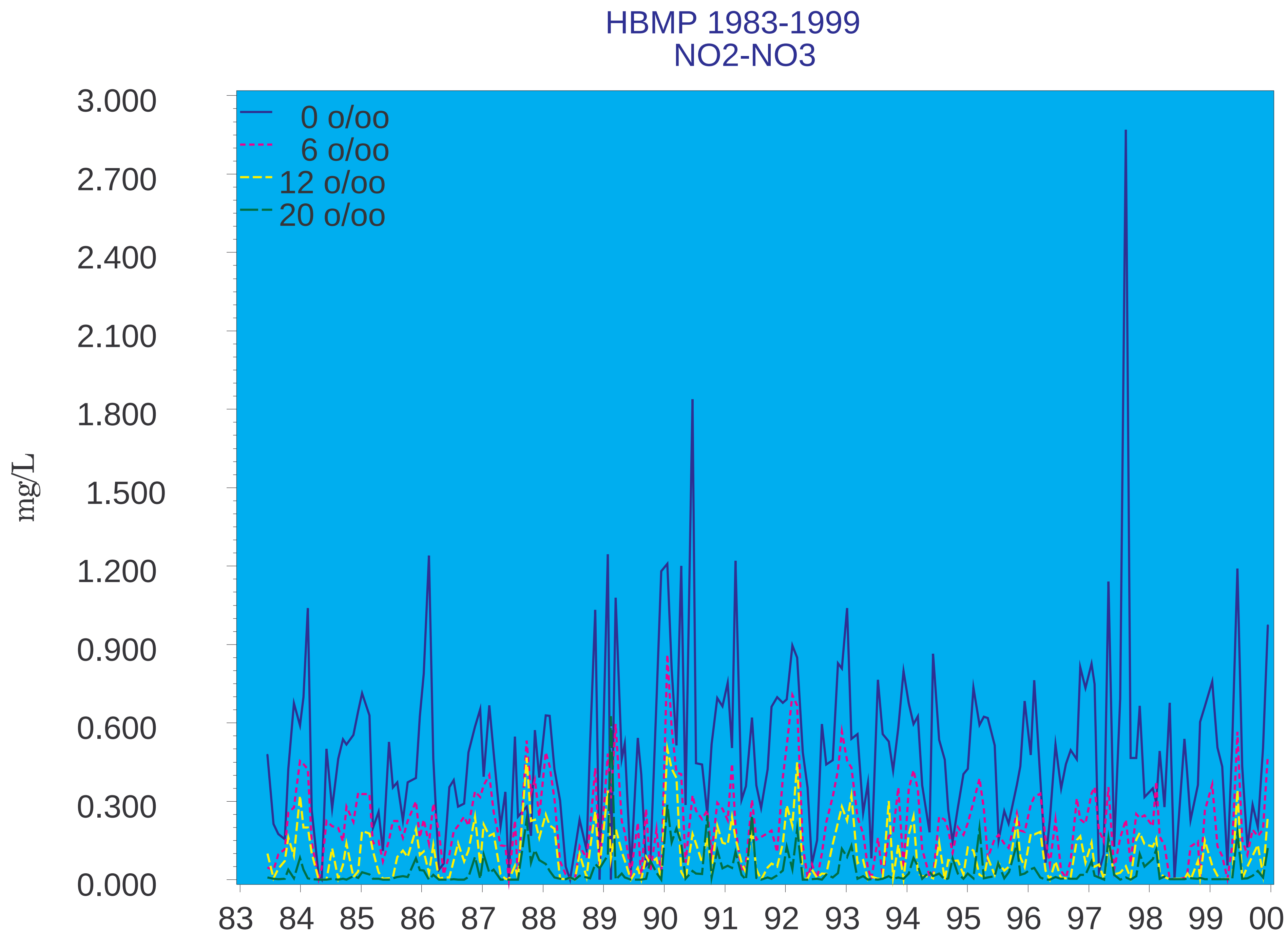

Figure 3.20 1983-1999 Nitrate/Nitrite at salinity sampling zones.

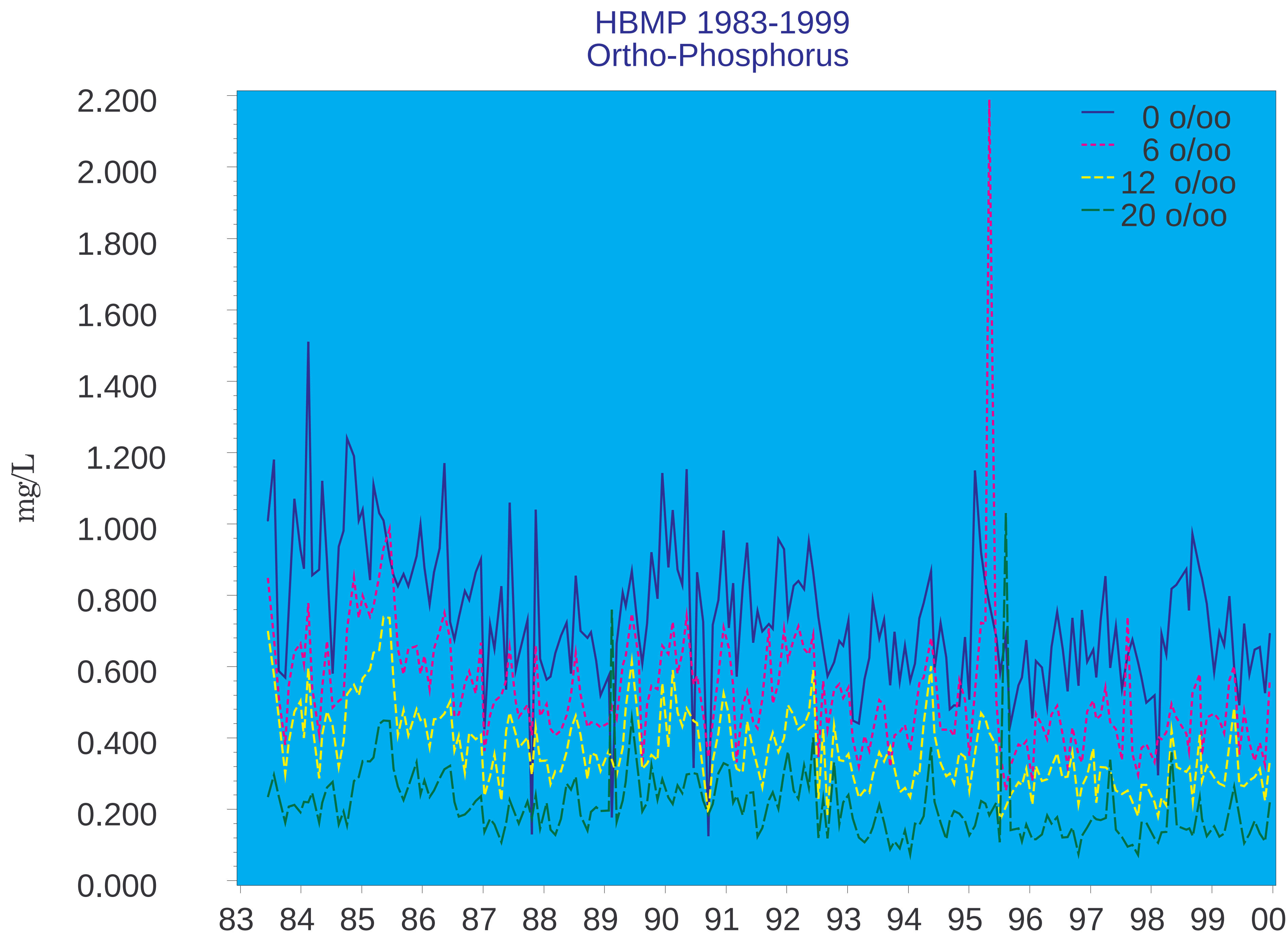

Figure 3.21 1983-1999 Ortho-Phosphorus at salinity sampling zones.

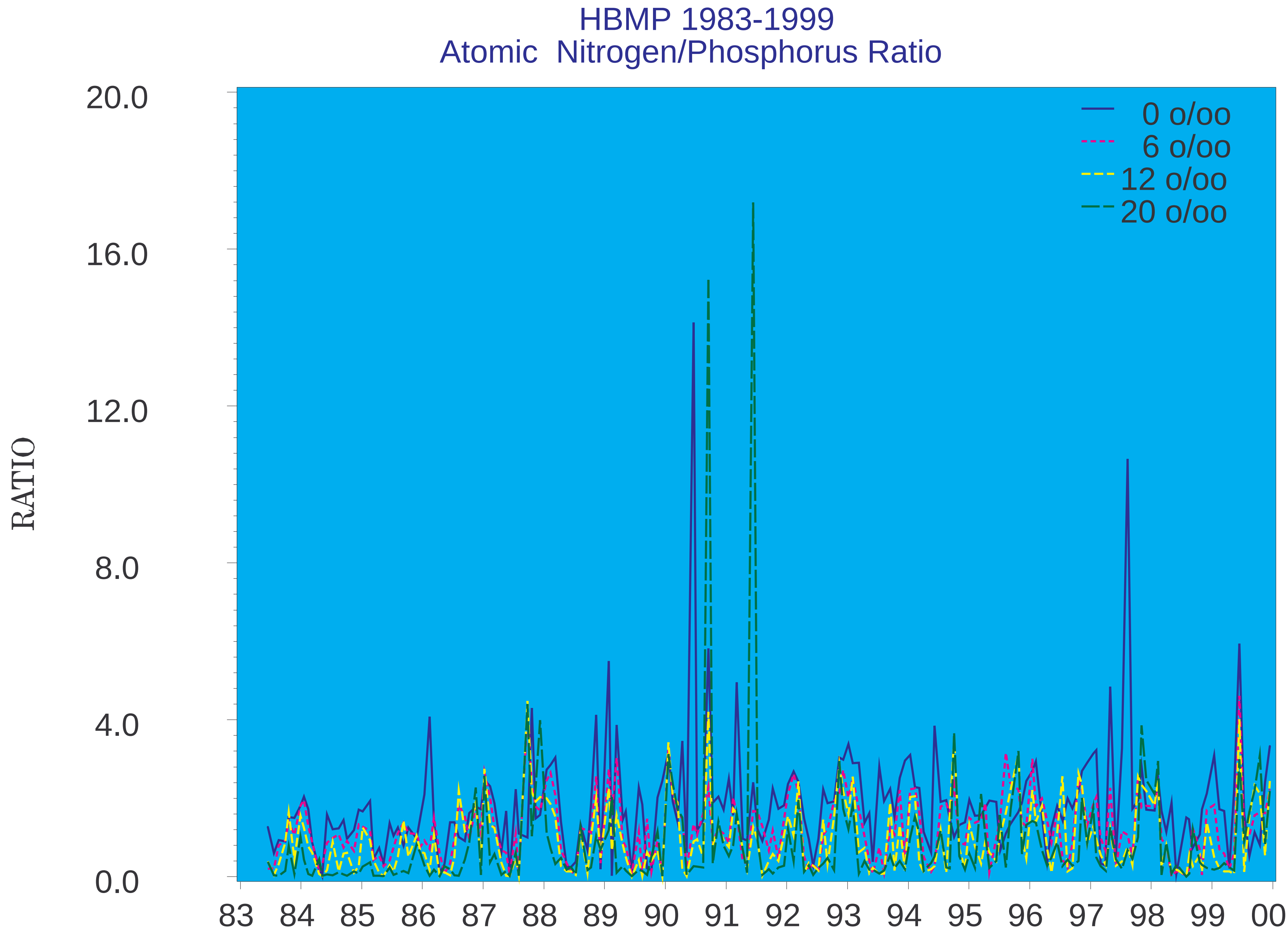

Figure 3.22 1983-1999 Atomic Nitrogen/Phosphorus Ratio at salinity sampling zones.

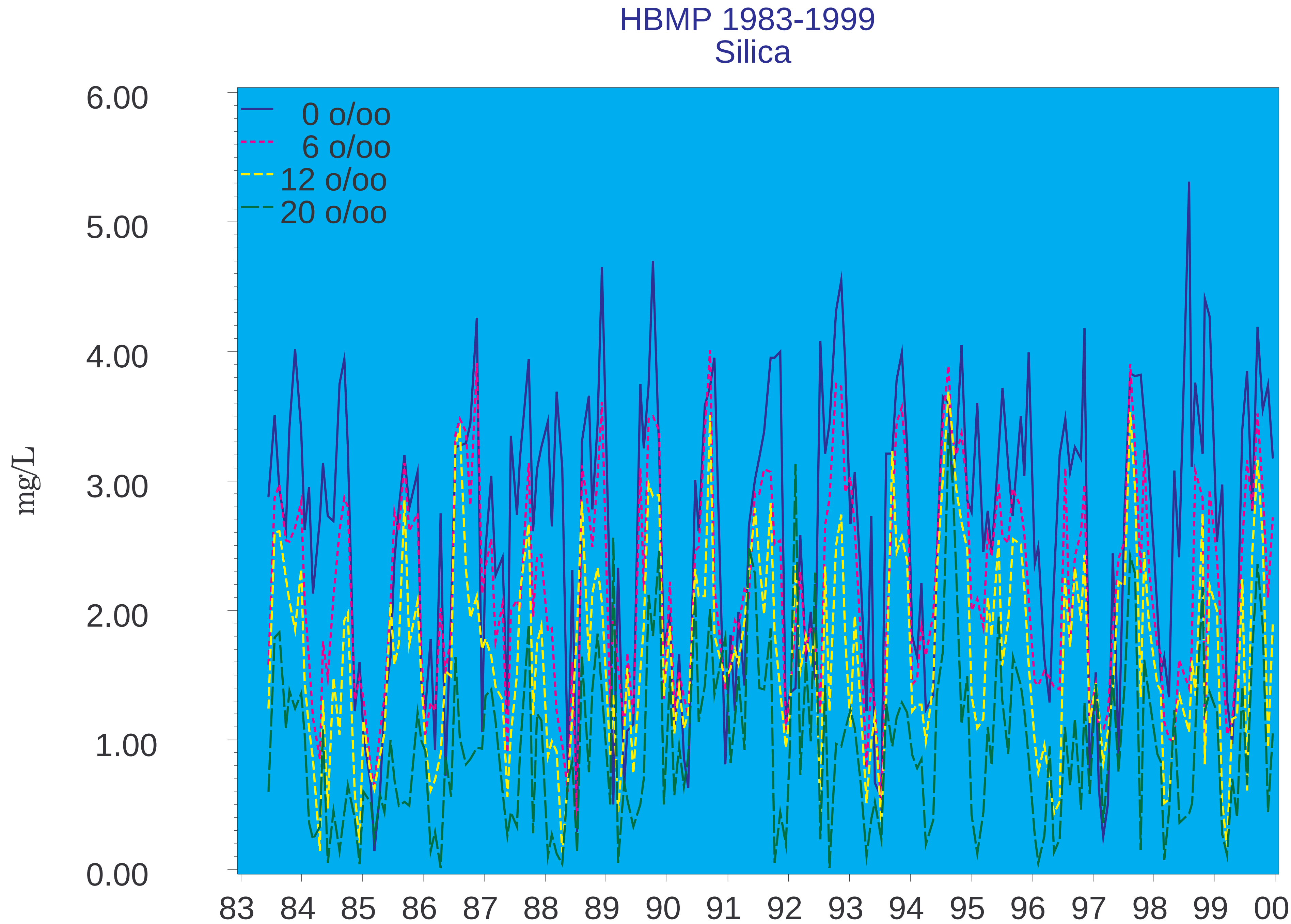

Figure 3.23 1983-1999 Silica at salinity sampling zones.

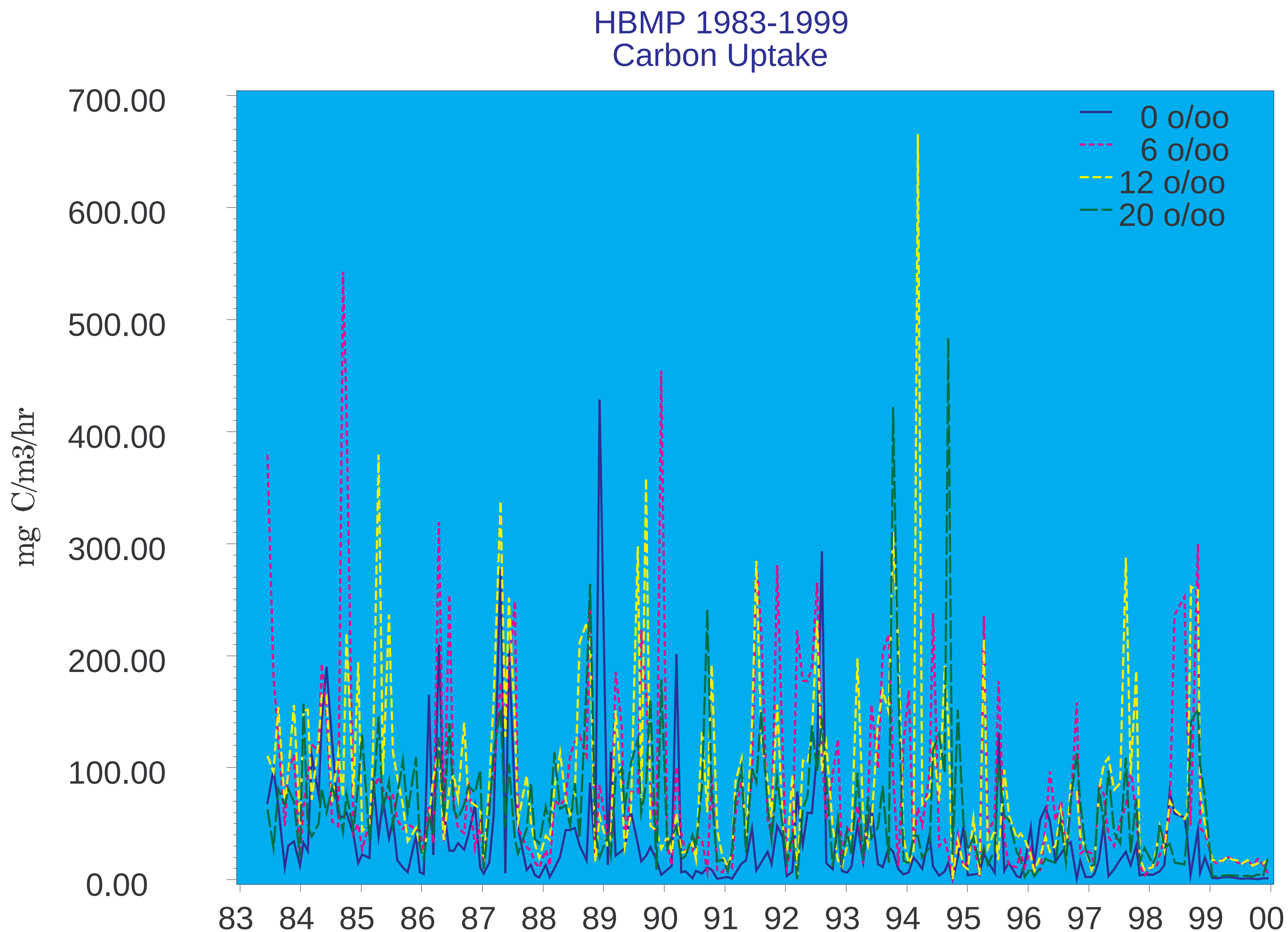

Figure 3.24 1983-1999 Carbon Uptake (mg C/m3/hr) at salinity sampling zones.

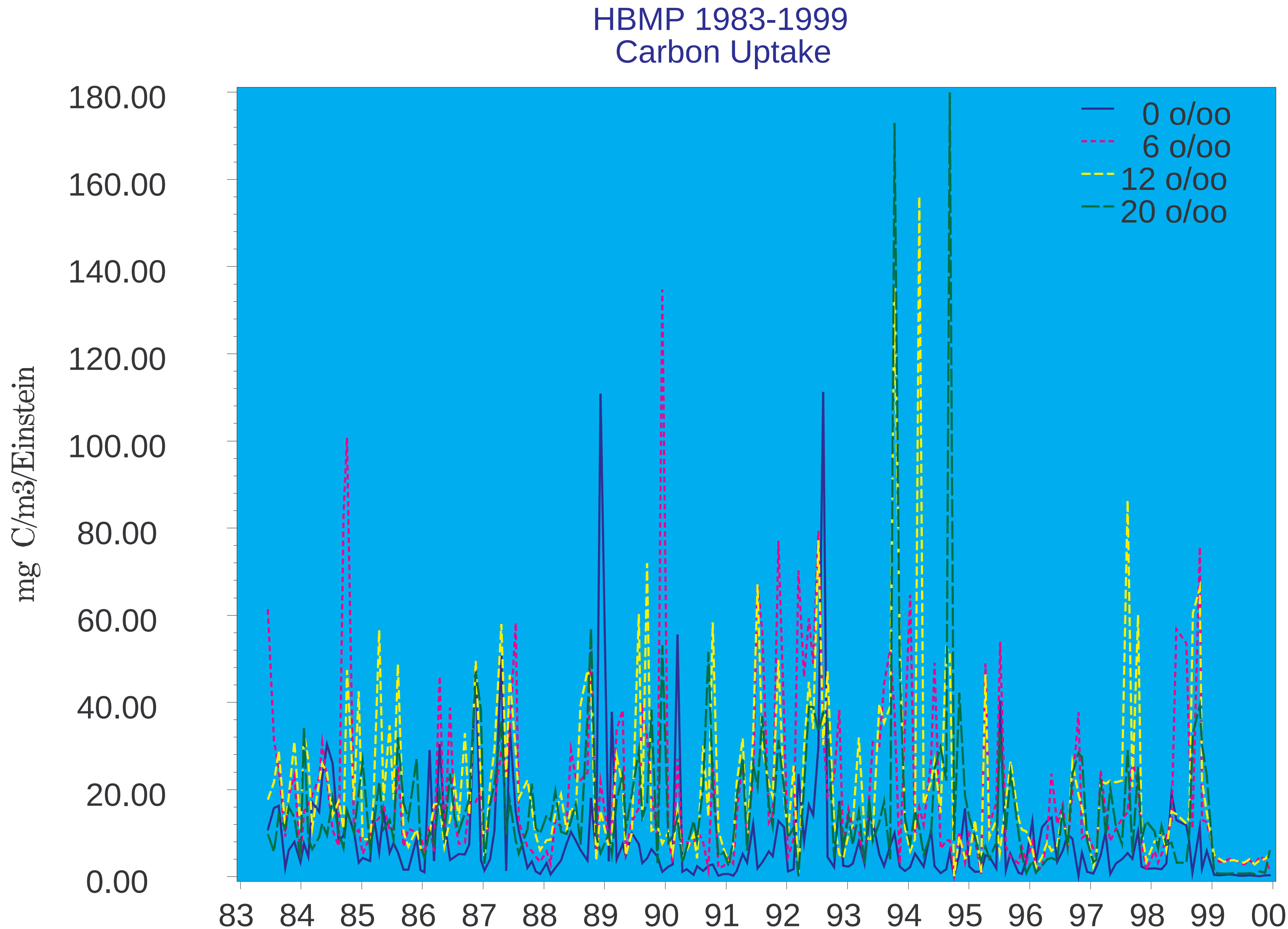

Figure 3.25 1983-1999 Carbon Uptake (mg C/m3/Einstein) at salinity sampling zones.

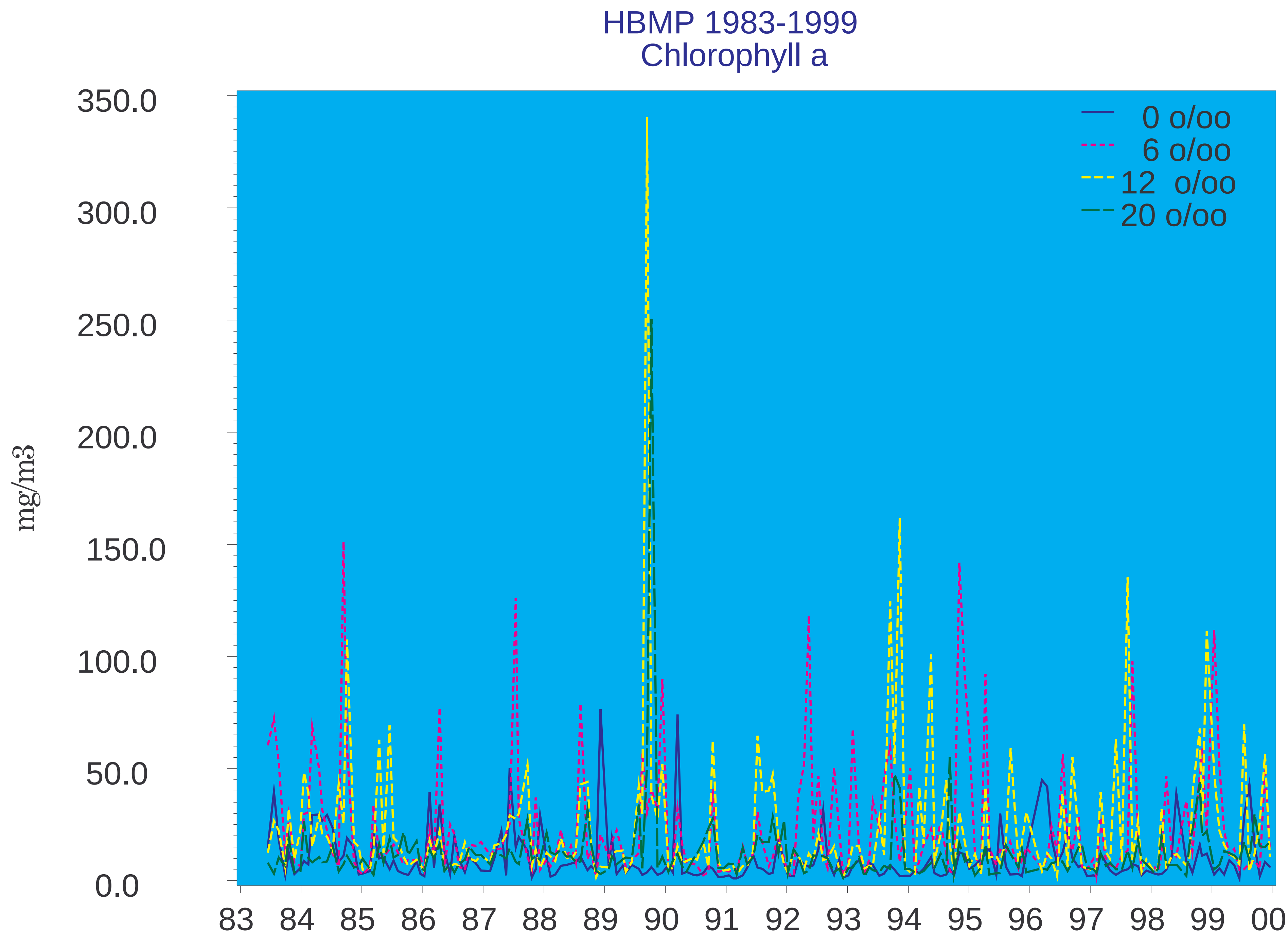

Figure 3.26 1983-1999 Chlorophyll a (mg/m3) at salinity sampling zones.

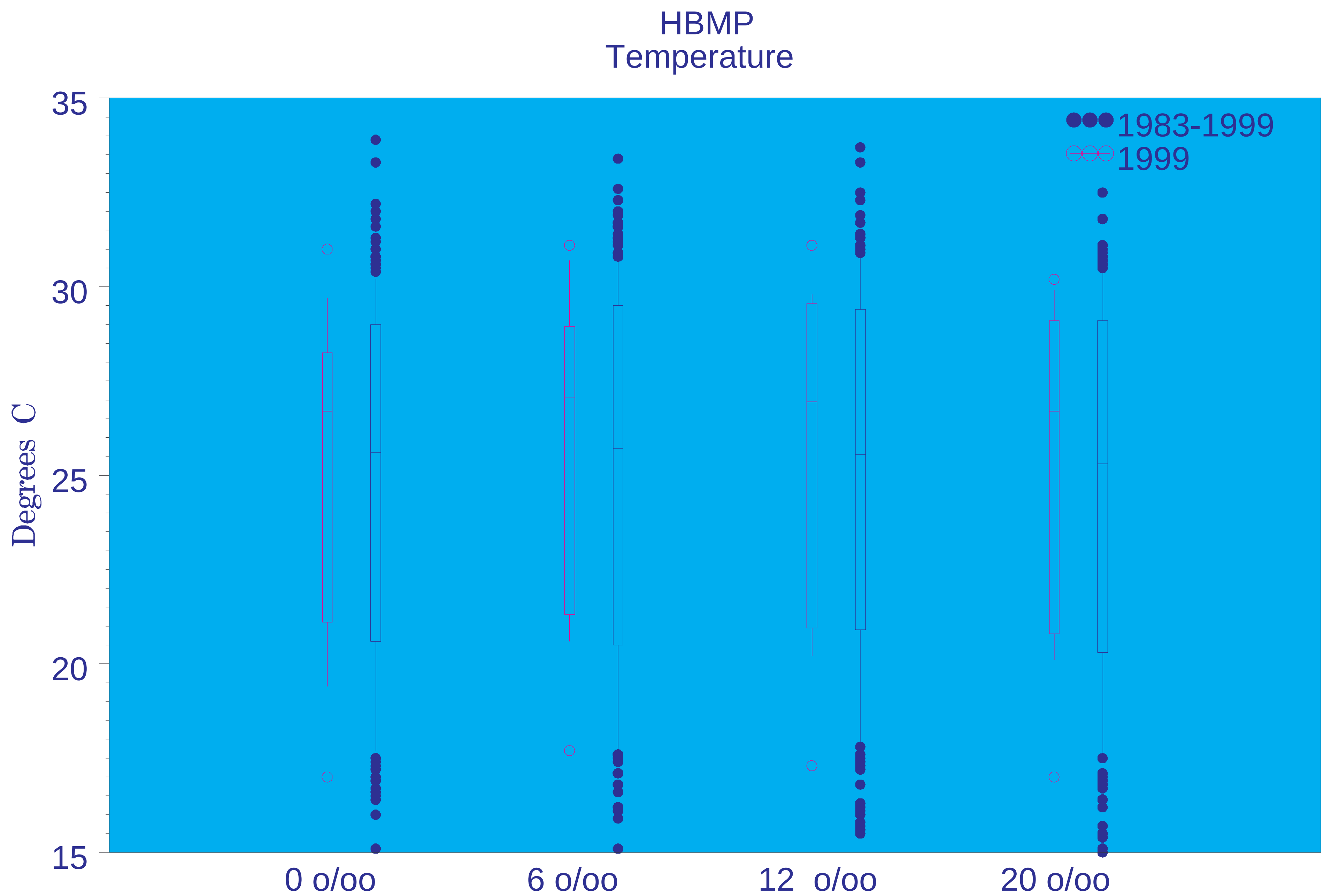

Figure 3.27 Box and Whisker Plots of Temperature at salinity sampling zones (1999) & (1983-1999).

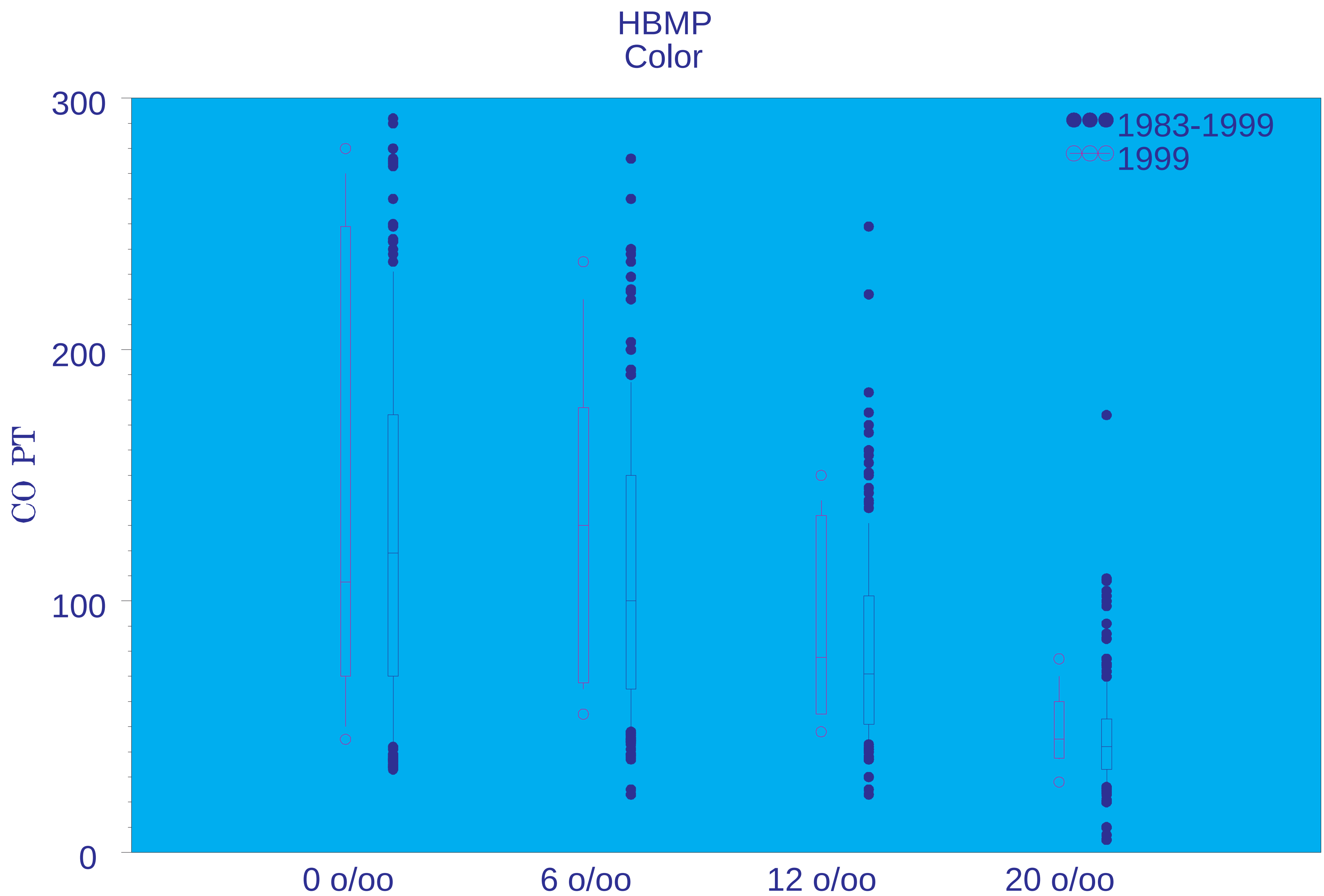

Figure 3.28 Box and Whisker Plots of Color at salinity sampling zones (1999) & (1983-1999).

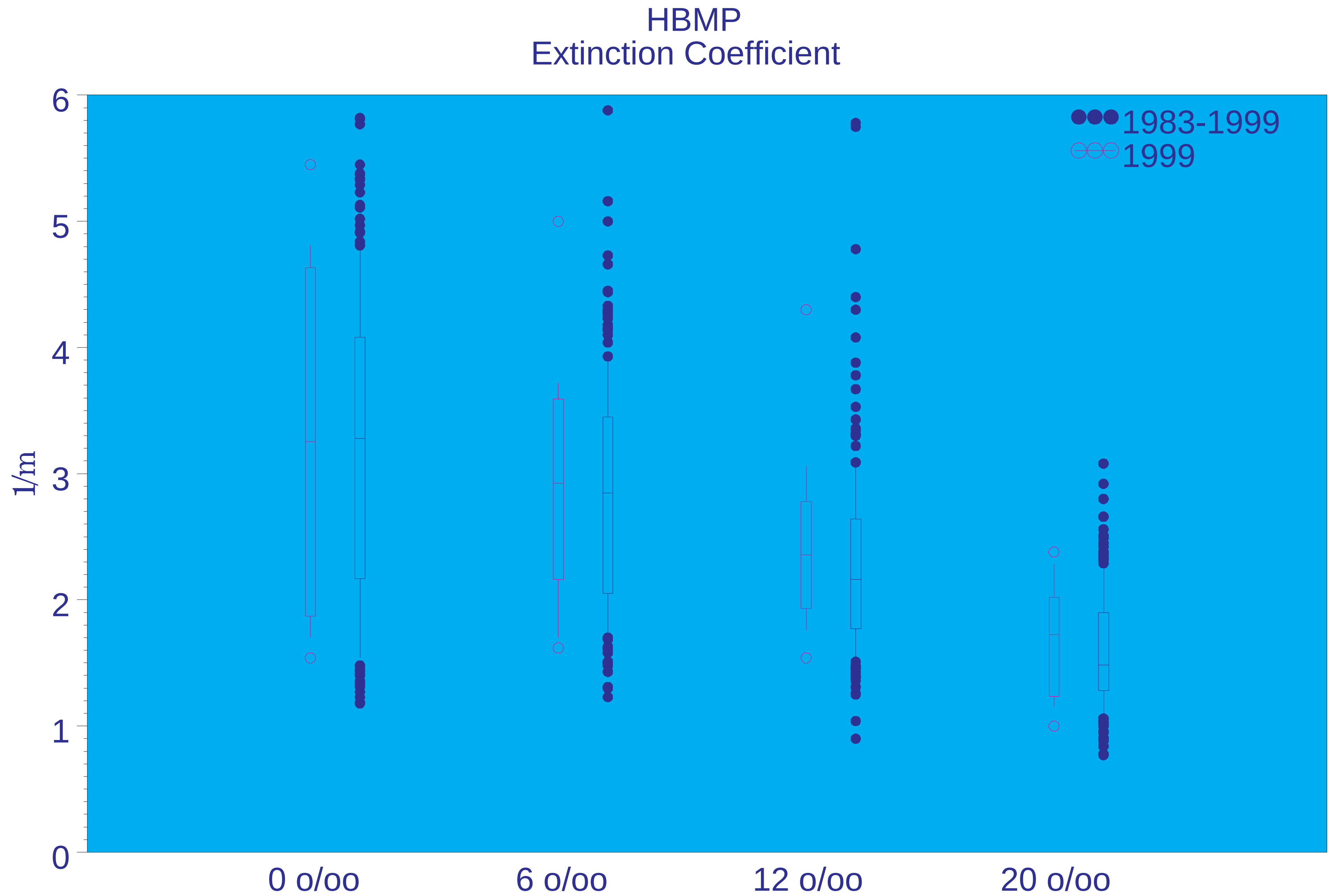

Figure 3.29 Box and Whisker Plots of Extinction Coefficient at salinity sampling zones
(1999) & (1983-1999).

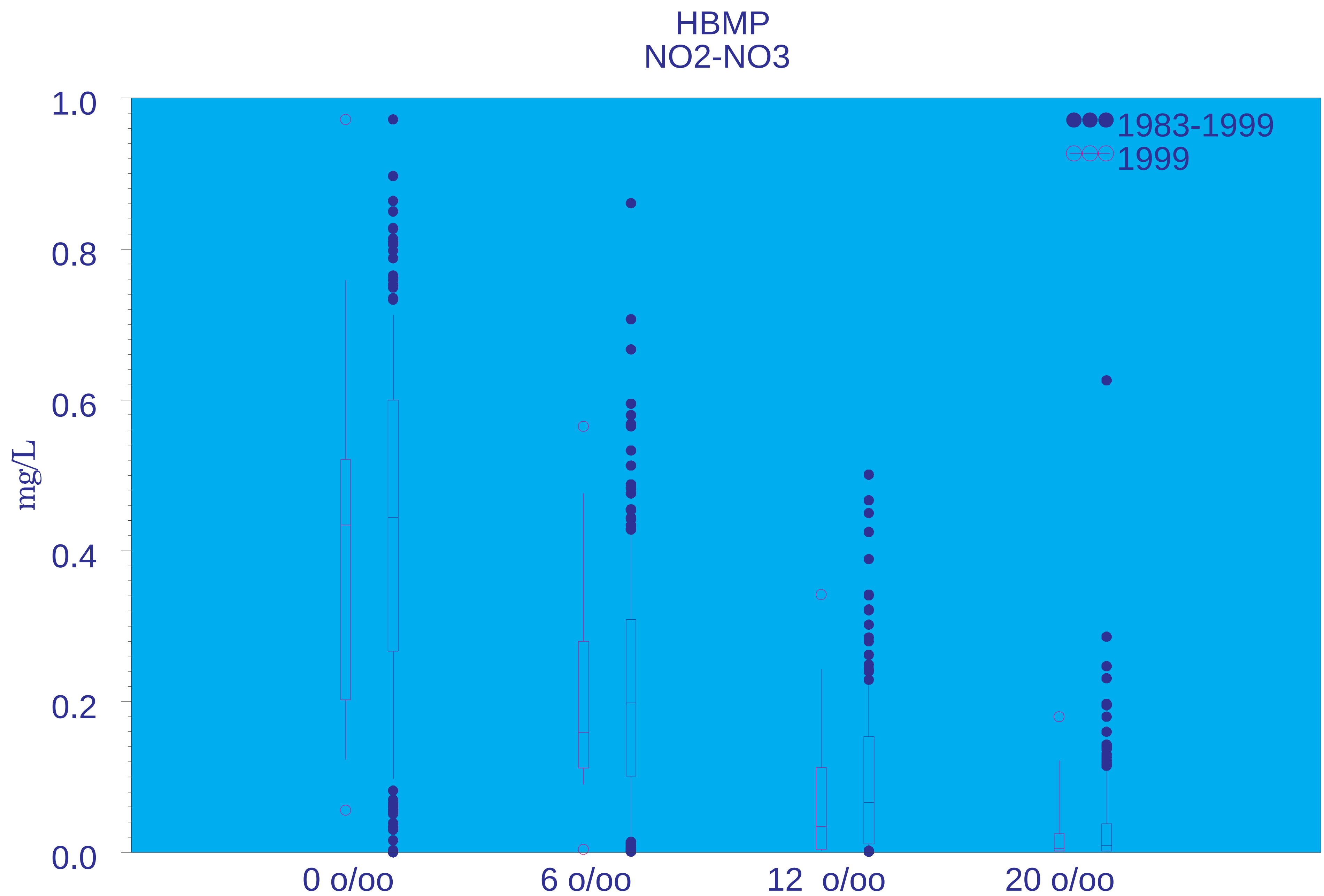

Figure 3.30 Box and Whisker Plots of Nitrite/Nitrate at salinity sampling zones (1999) & (1983-1999).

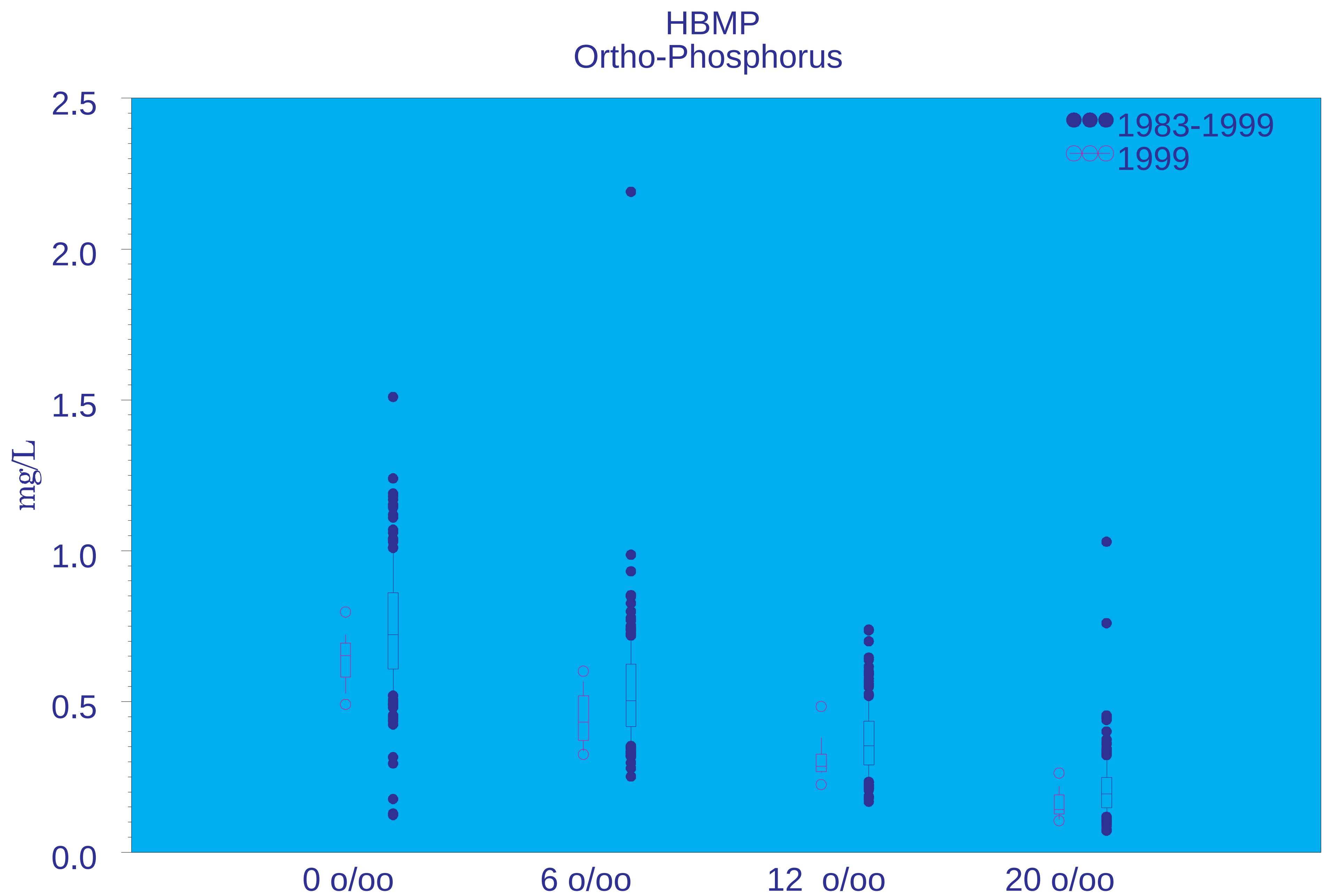

Figure 3.31 Box and Whisker Plots of Ortho-phosphorus at salinity sampling zones (1999) & (1983-1999).

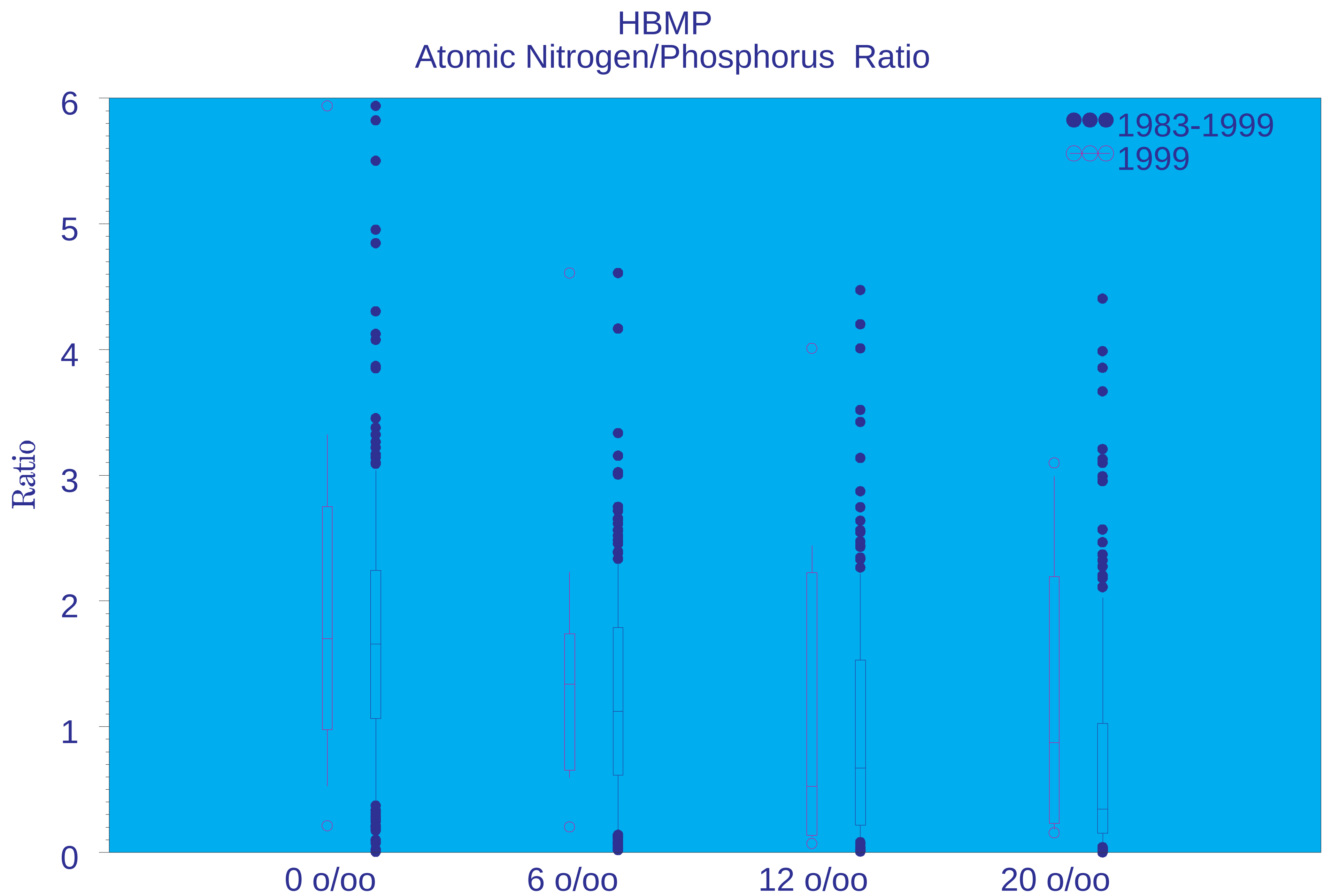

Figure 3.32 Box and Whisker Plots of Atomic N/P Ratio at salinity sampling zones (1999) & (1983-1999).

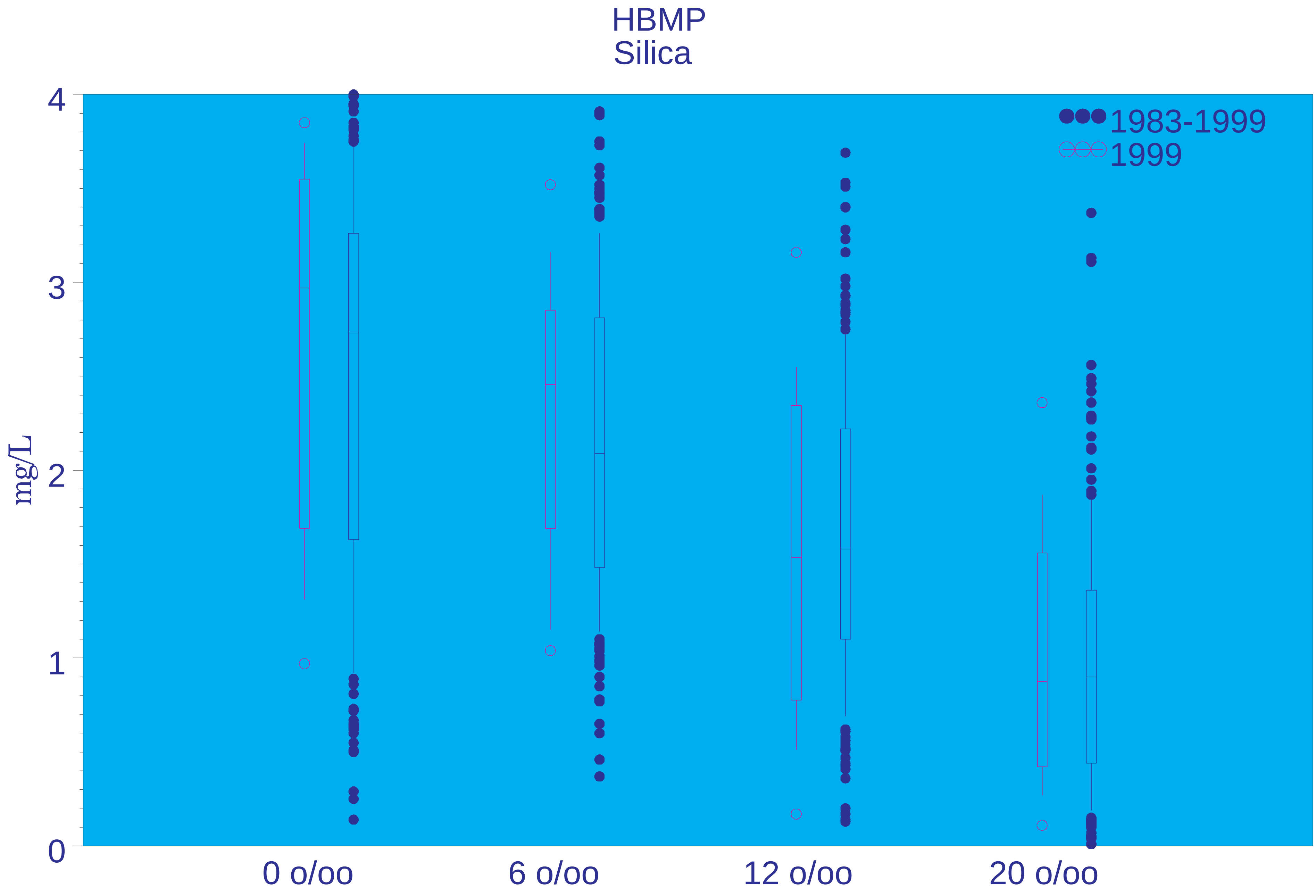

Figure 3.33 Box and Whisker Plots of Silica at salinity sampling zones (1999) & (1983-1999).

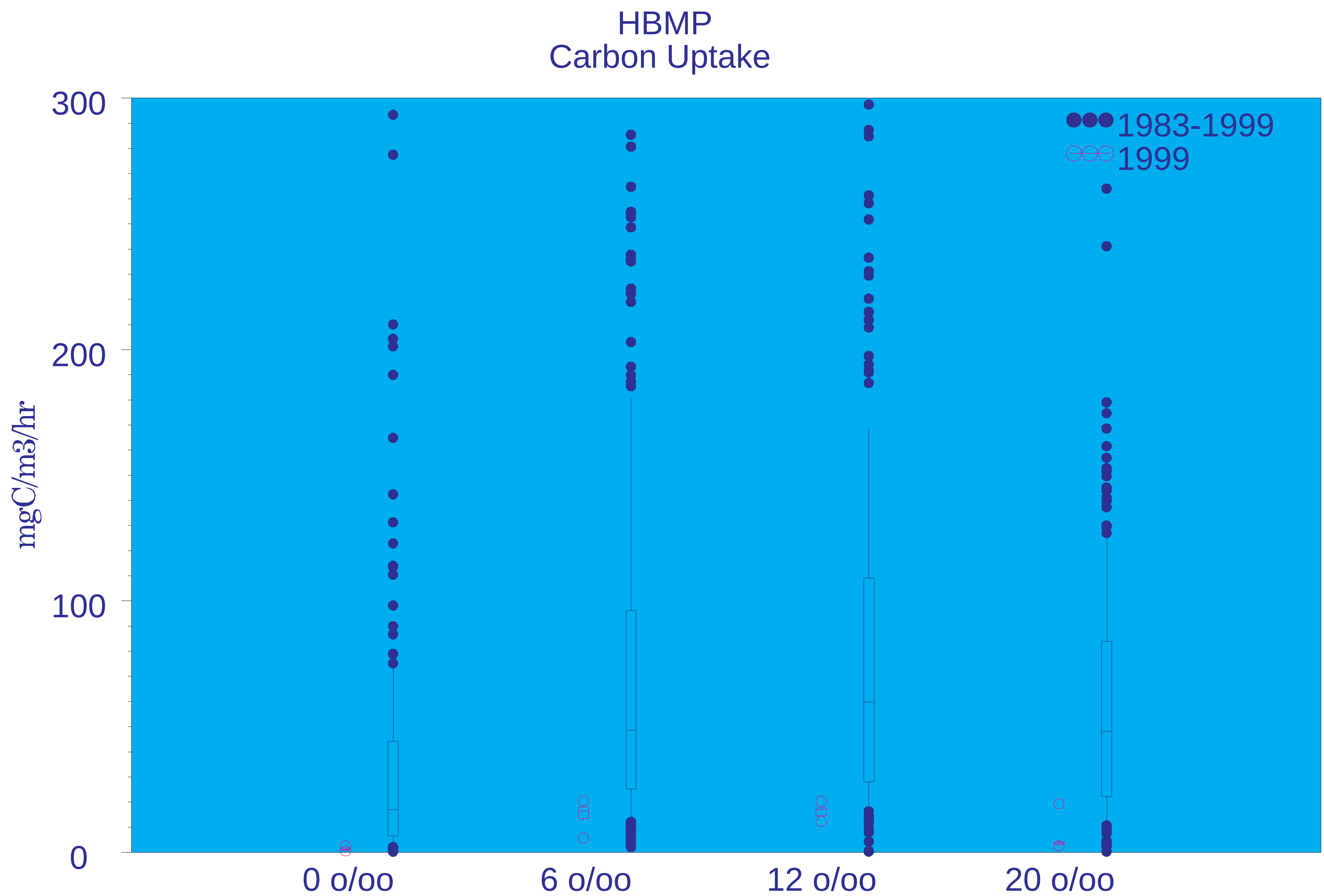

Figure 3.34 Box and Whisker Plots of Carbon Uptake (mgC/m3/hr) at salinity sampling zones (1999) & (1983-1999).

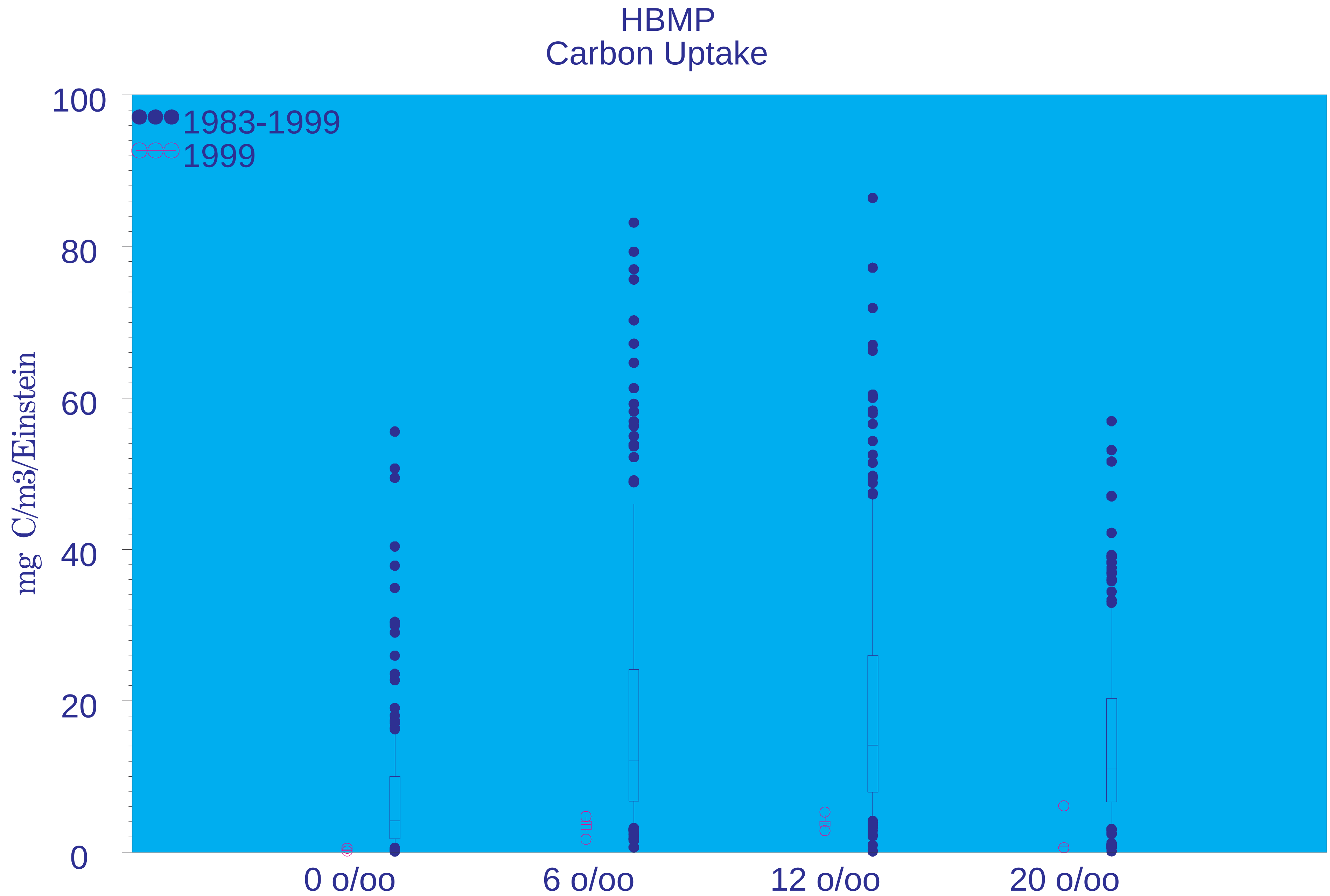

Figure 3.35 Box and Whisker Plots of Carbon Uptake (mgC/m3/Ein.) at salinity sampling zones (1999) & (1983-1999).

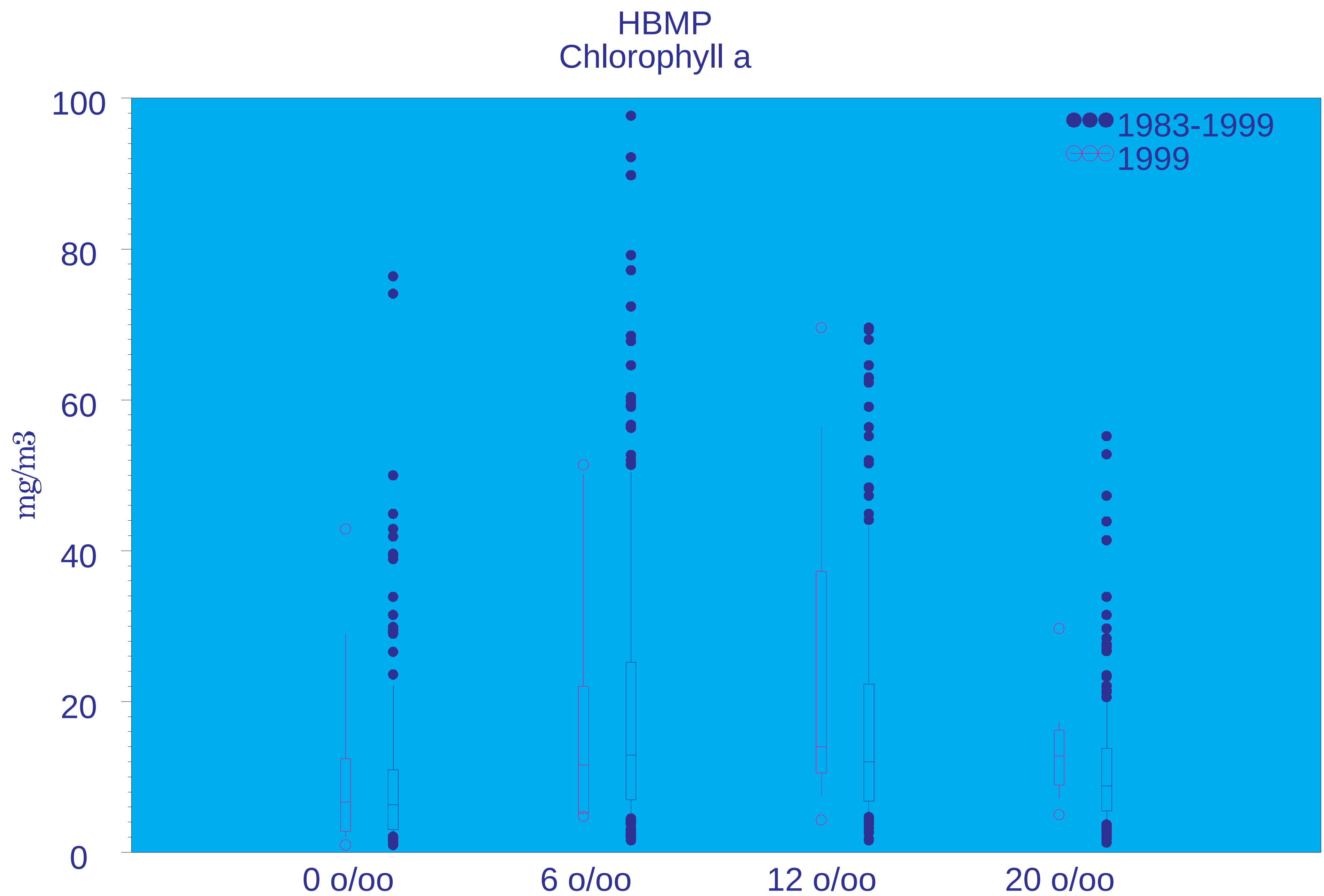

Figure 3.36 Box and Whisker Plots of Chlorophyll a (mg/m3) at salinity sampling zones (1999) & (1983-1999).

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Chapter IV

Water Chemistry Data Collected at Fixed Station Locations

4.1 Introduction

A number of the HBMP elements prior to 1996 had included collections of water quality data. However, the majority of these data were *in situ* physical measurements of water column characteristics. Such in *situ* water column profile data were collected during:

1. The monthly HBMP night trawl fish study conducted between 1976-1986.
2. The sea star and benthic invertebrate studies carried out between 1976 and 1984.
3. The long-term monthly fixed station study of water column characteristics undertaken between 1976 and 1986 at numerous fixed sites in the Lower Peace River and Upper Charlotte Harbor.

In addition both water column profiles as well as surface water chemistry samples have been collected monthly since 1983 at four moving isohaline locations in conjunction with the ongoing HBMP study of phytoplankton primary production.

Under the 1996 expansion of the monitoring program, water chemistry data collections began at five fixed sampling locations from near the mouth of the river to upstream of the Treatment Facility. In addition, *in situ* physical water column profile sampling was instigated at 10 additional fixed sampling locations, as well as the five water chemistry stations. This water sampling and *in situ* water column investigation was initiated using sampling sites formerly (1975-1990) utilized by EQL for similar long-term background monitoring. Beginning in 1998, an additional fixed monthly sampling site was added to corresponding to the location of the third tide gage that was installed in 1997 at river kilometer 26.7. The relative locations of these fixed sampling locations are shown in **Figure 4.1**, while Table 1.1 provides currently used river kilometers as well as previously used EQL station numbers and USGS river mile designations. During 1999, the U.S. Geological Survey (USGS) collected all fixed station water quality data under contract with the Authority.

4.2 Fixed Station Data Collection

The U.S. Geological Survey (USGS) began a cooperative water quality data collection program with the Peace/Manasota Regional Water Supply Authority (PMRWSA) in

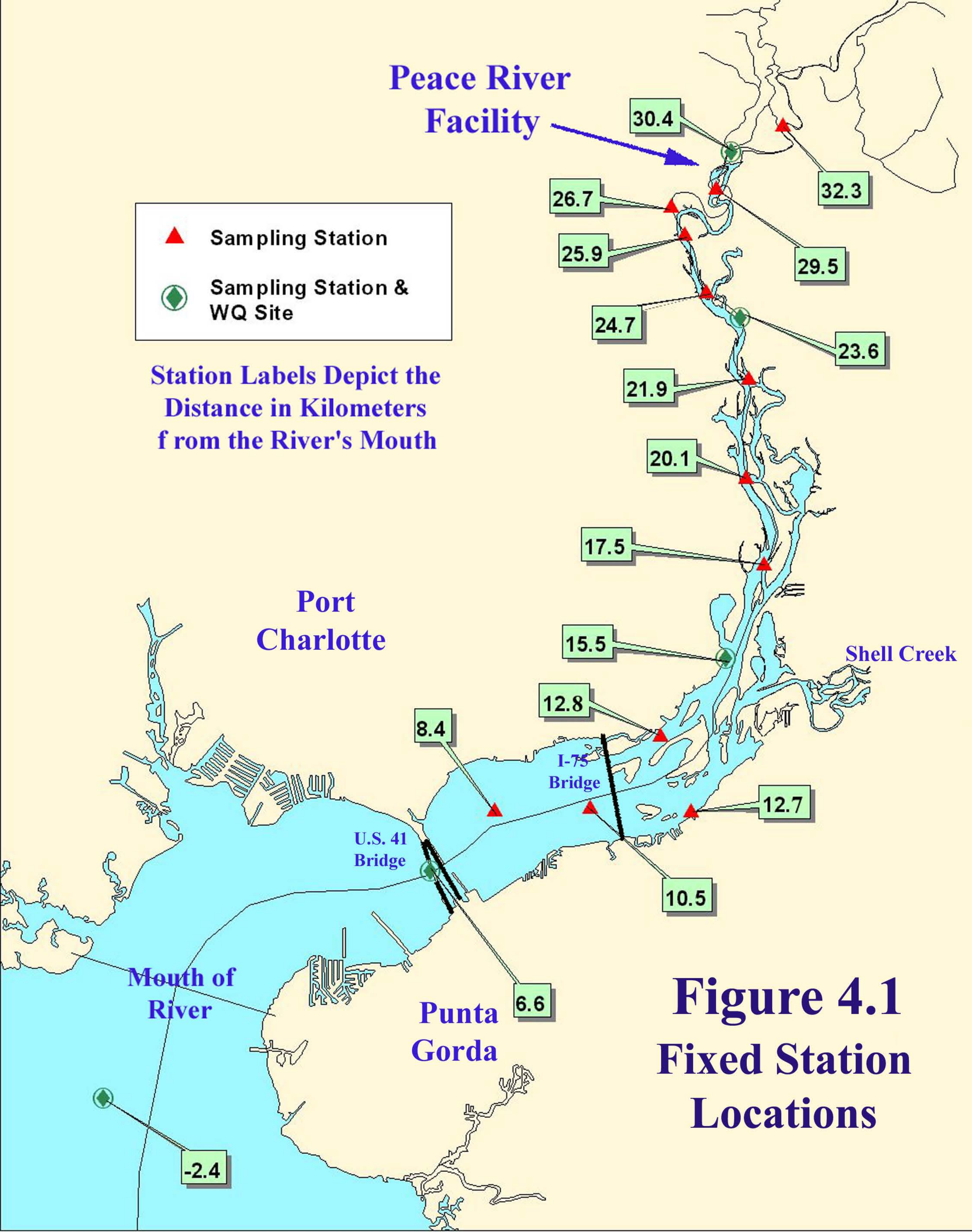

Figure 4.1 Fixed Station Locations

August 1996. As part of this program, the USGS initiated continuous (15 minute intervals) monitoring of:

1. Water level, as well as surface and bottom specific conductance and temperature at Harbour Heights on the Peace River. The USGS designates this site as 2297460, and it is located at river kilometer 15.5.
2. Water level near Boca Grande at the USGS designated site 2643120821530000.
3. Monthly physical and chemical water quality sampling at selected sites in the Peace River and Upper Charlotte Harbor **(Figure 4.1**).

In November 1997 the USGS added a third gauging station designated by USGS as site 2297350 (Peace River Heights) located at river kilometer 26.7. Measurements taken at this upstream location include both water level, and surface and bottom specific conductance and temperature.

4.3 Description

The following description provides an overview and summary of the procedures and methods used by USGS during the fixed station elements of the HBMP.

The fixed station water quality monitoring projects consists of three categories of data collection:
1. Continuous monitoring of selected parameters at three locations.
2. Monthly physical water column *in situ* water quality measurements at 16 fixed sampling sites.
3. Monthly surface and bottom chemical water quality samples collected at five locations, spaced along a transect between near the river's mouth and just upstream of the Treatment Facility.

Water levels are recorded at all three continuous recording sites. In addition, temperature and specific conductance (surface and bottom) are recorded at the two Peace River sites. Monthly water quality measurements are generally scheduled as a two-day sampling event during the last two weeks of the calendar month. The first day generally consists of the collection of water quality samples and field measurements at six sites. The second day consists of *in situ* water column profile measurements at 16 sites, including those sampled the previous day. All sampling and field measurement sites are reached by boat. Each site is located in the main channel of the river.

Near surface and near bottom samples collected at the six monthly water quality sites are analyzed for color, turbidity, alkalinity, total nutrients (ammonia nitrogen, ammonia plus organic nitrogen, nitrate plus nitrite nitrogen, nitrite nitrogen, orthophosphorus, phosphorus), total organic carbon, total inorganic carbon, dissolved organic carbon, dissolved silica, dissolved chloride, total suspended solids, volatile suspended solids, salinity (estimated from specific conductance), and chlorophyll *a*.

Field measurements made in conjunction with sampling at the six water quality sites include depth, pH, temperature, dissolved oxygen, specific conductance, and light characteristics. Field measurements are made at 0.5 meter (m) intervals, beginning at the surface and ending near the river bottom. Light characteristics are measured in the air and at 5 depths: just below the water surface; at the depth where 1 percent (%) of the surface light is remaining; and at 3 evenly spaced points between the surface and 1% depth readings.

Field measurements made on the second day at the 16 field measurement sites include depth, pH, temperature, dissolved oxygen, and specific conductance. Field measurements are made at 0.5 m intervals, beginning at the surface and ending near the bottom.

4.3.1 Responsibility

The water quality monitoring program described above is the responsibility of the USGS Environmental Studies Section (ESS) located in Tampa, Florida. Maintenance of gages, collection and processing of water quality samples, processing and review of the data, and implementation of the quality assurance plan for this project are the responsibility of the ESS.

The USGS Quality of Water Service Unit (QWSU) in Ocala, Florida performs all water quality analyses for the project except chlorophyll a analyses. Established quality assurance practices for the laboratory are described in a Comprehensive Quality Assurance Plan (#910161G), approved by the Florida Department of Environmental Protection. This plan is updated annually.

4.4 Data Collection and Analyses

Data collection protocols are derived from standard USGS techniques described in Ward and Harr (1990), Britton and Greeson (1989), Horowitz and others (1994), and numerous USGS Office of Water Quality Technical Memoranda. The specific procedures used for data collection and analyses are described below.

4.4.1 Field Activities Continuous Record Sites

Three recording gages have been established as part of this project. Water level is measured at each site (stations 264312082153000, 02297460 and 02297350) using a float sensor in a PVC stilling well (Rantz and others, 1982) and is recorded at 15-minute intervals using a Campbell Scientific CR-10 electronic data logger. Near surface and near bottom specific conductance and temperature are measured in the Peace River at stations 02297460 and 02297350 using USGS combination temperature and specific conductance probes. Readings are averaged over a two-minute interval and are recorded at 15-minute intervals.

Near surface sensors are suspended 1 ft below the surface using a float in a stilling well. The near bottom sensors are suspended about 1 ft from the bottom in the same stilling well as the near surface sensor.

Data are retrieved at approximately monthly intervals or more often as needed. Once data are retrieved, the calibration stability of the specific conductance and temperature sensors is checked using a field thermometer and specific conductance standards with values that bracket the range of expected values in the Peace River. The sensors are cleaned, inspected, and rechecked with the thermometer and specific conductance standards. If needed, the sensor readings are adjusted to the standard values. The sensors are considered calibrated if the temperature is within 0.5 C and the specific conductance is within 5% of the standard values. Calibrations are recorded on calibration forms and these records are maintained by the USGS in Tampa, FL.

4.4.2 Monthly Water Quality Sampling

Specific field sampling protocols utilized are:

1. Check the calibration of the multiparameter meter the day of sampling, prior to the collection of field data. Adjust the meter if needed and record calibration notes.
2. Measure the temperature, specific conductance, dissolved oxygen, and pH just below the water surface and at 0.5 m intervals from the surface to the bottom of the water column. Record the data on the field measurement form. Temperature is recorded in degrees Celsius, specific conductance in microsiemens per centimeter at 25 degrees Celsius; dissolved oxygen in milligrams per liter, corrected for salinity effects; and pH in pH units. Depth is recorded in meters from the surface.
3. Measure the incident light in air and record on the field measurement form. Light is recorded in microeinsteins per meter squared per second. Measure light in the water just below the water surface and record. Determine the depth where 1% of the surface light remains and record. Once this depth is determined, measure light at 3 additional depths, evenly spaced between the surface and the 1% depth. Record depths in meters.
4. While wearing a clean pair of non-powdered, disposable vinyl gloves, collect water near the surface using the Kemmerer point water sampler. Discharge some of the sample water through the Kemmerer spigot to rinse and place the remaining water in the churn splitter marked "TOP". Do not remove the inner bag around the churn. Tear a small hole in the bag for the churn spigot. Rinse the churn splitter with sample water and discharge about 50-100ml through the churn spigot. Discard the rinse water and repeat. When the churn splitter is not being held, wrap churn splitter in the outer plastic bag.
5. Collect 6 liters of water near the surface using the Kemmerer point sampler and place in the churn splitter. The plastic bags covering the churn splitter should be opened only long enough to transfer water to the churn to avoid contamination of the sample.
6. Place pre-cleaned silicon tubing in the peristaltic pump. Place a 0.45 μm silver filter in the stainless steel filtration unit. Fill the Kemmerer sampler near the surface. Fill the bottles for total inorganic carbon and total organic carbon directly from the Kemmerer spigot. Cap the bottles and place on ice. Fill the stainless steel filtration

unit with water from the Kemmerer sampler. Attach the tubing from the peristaltic pump and apply air pressure to the filtration unit. Collect the dissolved organic carbon sample from the filtrate. Cap the bottle and place on ice.

7. All whole water samples are collected from the churn before filtered samples are collected. Mix the sample water in the churn using a churning rate of 9 inches per second, taking care not to break the water surface with the churn paddle. Rinse the bottles and caps used for samples of total nutrients, alkalinity, color, turbidity, specific conductance, and suspended solids twice using sample water and discard water. Maintain the churning rate during withdrawal of any sample water. Fill each bottle and seal. Place the bottles for total nutrients, suspended solids, and color on ice.
8. Attach one end of clean silicon tubing to a disposable 0.45 μm capsule filter and pump 1 liter of deionized (DI) water through the tubing and filter to rinse. Pump out all the DI water from the tubing and capsule filter. Place the intake end of the tubing in the sample water in the churn splitter and pump sample water through the tubing and filter. Rinse the sample bottle and caps used for dissolved silica and chloride twice with filtrate. Fill each bottle with filtered water and seal. Preserve the dissolved silica sample with 1mL of concentrated nitric acid.
9. Repeat steps 4-8 for the near bottom sample. Use the churn splitter marked "BOTTOM" for this sample.
10. Chlorophyll sample protocols: Chlorophyll samples were processed and analyzed by the USGS for samples collected August through December 1996. Starting in 1997, chlorophyll samples have been collected by USGS and analyzed by EQL. For the near surface chlorophyll samples, collect one gallon of water at a depth of about 1 foot (ft) from the surface and store in a dark cooler. For the near bottom chlorophyll sample, remove one liter of bottom sample water from the churn splitter while the water is being mixed and store the sample in the dark cooler.
11. Clean the outside and inside of the Kemmerer sampler, "TOP" and "BOTTOM" churn splitters, and stainless steel filtration unit using two rinses with DI water. Discharge a portion of the rinse water through the sampler and churn spigots. Rinse the stainless steel filtration unit with carbon-free water after the DI rinses. Place a new 0.45 μm silver filter in the stainless steel filtration unit and wrap the unit in aluminum foil. Place the churn splitters in clean plastic bags and close bags. Place each churn and bag in another plastic bag and enclose. Wrap the Kemmerer sampler in a clean plastic bag.

4.4.3 Analytical Procedures

The laboratory method, concentration range, precision, accuracy, and method reporting limit of the analytes measured for this project are listed in **Tables 4.1** and **4.2**.

4.4.4 Water Quality Instruments

A LiCor model 1000 photometer and LiCor spherical quantum light sensors are used to measure ambient light in air and at selected depths at the water quality sampling sites.

Table 4.1 Water Quality Parameters

Lab Code[1]	Watstore Number[2]	Parameter Name	Method Number
0020	00080(A)	color	I-1250-85[3]
0049	00535(A)	residue, volatile non-filterable	I-3767-85[3]
0050	00076(A)	turbidity	I-3860-85[3]
0069	90095(A)	specific conductance	I-2781-84[3]
0070	90410(A)	alkalinity, total as $CaCO_3$	I-2030-85[3]
0113	00681(0)	carbon, organic, dissolved	SM5310B[4]
0114	00680(0)	carbon, organic, total	EPA-415.1[5]
0019	00685(A)	carbon, inorganic, total	O-0004-78[6]
0169	00530(B)	residue, total non-filterable at 105°C	I-3765-84[3]
0292	00940(F)	chloride, dissolved	I-2057-84[3]
0667	00955(D)	silica, dissolved	I-1472-87[3]
1984	00665(D)	phosphorus, as P total	I-4600-84[3]
1986	00625(D)	nitrogen, NH_3+organic-N, total	I-4552-84[3]
3071	00610(F)	nitrogen, NH_3-N, total	I-4522-85[3]
3072	00615(B)	nitrogen, NO_2-N, total	I-4540-84[3]
3073	00630(E)	nitrogen, NO_2+NO_3-N, total	I-4545-84[3]
3074	70507(H)	phosphorus, PO_4-P, total	I-4601-84[3]

[1] The lab code refers to a specific analysis method
[2] The Watstore code refers to a unique code associated with the data stored in the water quality database.
[3] The method is described in Fishman and Friedman, 1989.
[4] The method is described in American Public Health Association, 1992.
[5] U.S. Environmental Protection published method
[6] The method is described in Wershaw and others, 1987.

Table 4.2 Methods, Precision and Accuracy Limits

Analytes, concentration ranges, precision, accuracy, and method reporting limits of the analytes measured for the Peace River water-quality monitoring project
[% is percent; RSD is relative standard deviation; N is nitrogen; L is low; M is medium; mg/L is milligrams per liter; µS/cm is microsiemens per centimeter at 25 °C; NTU is nephelometric turbidity units; PCU is platinum-cobalt units]

Analyte	Range	Precision (% RSD)	Accuracy (% Recovery)	Method Reporting Limit
Ammonia nitrogen as N, total	L	9.1	91.4 - 114.2	0.01 mg/L
	M	4.3	95.6 - 103.9	
Ammonia + Organic nitrogen as N, total	L	10.1	83.6 - 115	0.2 mg/L
	M	5.4	90.9 - 111.8	
Nitrate + Nitrite nitrogen as N, total	L	9.8	88.5 - 108.2	0.02 mg/L
	M	5.6	97 - 102.8	
Nitrite nitrogen as N, total	L	12.5	88.5 - 110	0.01 mg/L
	M	6.6	94.9 - 104.2	
Orthophosphate as P, total	L	11	83.3 - 107.7	0.01 mg/L
	M	3.4	95.5 - 103.3	
Phosphorus as P, total	L	13.2	79 - 121	0.02 mg/L
	M	3.4	93 - 104.8	
Carbon, Organic, dissolved	L	15	84 - 120	0.1 mg/L
	M	2.3	96 - 102	
Carbon, Organic, total	L	16	83 - 121	0.1 mg/L
	M	2.7	93.2 - 107.2	
Alkalinity as CaCO3	L	8.9	92 - 115	1 mg/L
	M	3.1	98.5 - 101	
Chloride	L	9.5	89 - 109	0.1 mg/L
	M	2.8	97.7 - 104.5	
Silica	L	8.9	86.9 - 118	0.01 mg/L
	M	3.1	94.9 - 109	
Residue, non-filterable at 105 °C	L	16.7	75 - 120	1 mg/L
	M	5.9	92 - 112	
Chlorophyll *a*	L	23	88 - 109	0.1 mg/L
	M	8.9	93 - 105	
Specific Conductance	L	9.8	96.2 - 105.5	1 µS/cm
	M	1.8	97.5 - 102.2	
pH	L	2.3	93.4 - 108	0.1 pH unit
	M	0.9	95.2 - 105	
Turbidity	L	12.2	81 - 118	1 NTU
	M	3.5	90.4 - 105	
Color	L	9.8	75 - 125	5 PCU units
	M	2.3	87.5 - 114.3	

The light sensors are calibrated by LiCor according to manufacturing specifications (every 2 years) or more often if needed.

A Hydrolab H20 multiparameter probe combined with a Hydrolab Surveyor 3 or a Hydrolab MiniSonde combined with a Surveyor 4 data logger is used to measure temperature, pH, dissolved oxygen, specific conductance, and depth. Field instruments are calibrated in the office prior to each field trip. Instrument calibration is rechecked in the field prior to the first measurement of the day and after the last measurement of the day to document calibration stability. Calibrations may be necessary during the day if the range in values measured exceeds the calibration range, if instrument maintenance is required, or other conditions warrant a recalibration. Calibrations are recorded and stored in the instrument calibration book. Calibration procedures for specific measurements are described below.

- **Dissolved oxygen**: A water-saturated air calibration is done in accordance with manufacturer's instructions. A 100% water saturated air environment is created by placing tap water in the calibration chamber to a depth just below the dissolved oxygen membrane. The membrane is blotted dry with a soft paper towel and a loose fitting cap is place over the calibration chamber. The probe and water-saturated air are allowed to equilibrate before any adjustment is made. After equilibration has occurred, the meter is set to the appropriate value, based on the chamber temperature and the current atmospheric temperature. Once calibrated, the minimum dissolved oxygen that can be read by the meter is checked in an oxygen-free solution of sodium sulfite. A reading of 0.5 mg/L or less is acceptable.

- **Temperature**: A two-point calibration check of the temperature thermistor is made at least once annually. A thermometer traceable to NIST is used to check the meter. One calibration point is in an ice-water bath and the other calibration point is in a hot water bath. The certified thermometer and the meter thermistor are compared after equilibration (about 20 minutes). The meter is considered calibrated if the temperature reads within 0.5 C.

4.5 Results and Conclusions

The results for the period January through December 1999 of the *in situ* hydrolab water column profiles at the seventeen fixed stations are presented in Appendix F. These data are presented graphically in Figure 4.2 through Figure 4.6 (see Table 4.3).

The water chemistry data for the fixed water quality stations are presented in Appendix G. The water chemistry data are presented in Figure 4.7 through Figure 4.17 (see Table 4.4).

Table 4.3 Summary Graphics of Physical *In Situ* Water Quality Measurements for Data Collected during 1999 at the Fixed Sampling Locations.

Figure	Description
Figure 4.2a	1999 Temperature at 4 of 17 fixed sampling stations
Figure 4.2b	1999 Temperature at 4 of 17 fixed sampling stations
Figure 4.2c	1999 Temperature at 4 of 17 fixed sampling stations
Figure 4.2d	1999 Temperature at 5 of 17 fixed sampling stations
Figure 4.3a	1999 Dissolved Oxygen at 4 of 17 at fixed sampling stations
Figure 4.3b	1999 Dissolved Oxygen at 4 of 17 at fixed sampling stations
Figure 4.3c	1999 Dissolved Oxygen at 4 of 17 at fixed sampling stations
Figure 4.3d	1999 Dissolved Oxygen at 5 of 17 at fixed sampling stations
Figure 4.4a	1999 pH at 4 of 17 fixed sampling stations
Figure 4.4b	1999 pH at 4 of 17 fixed sampling stations
Figure 4.4c	1999 pH at 4 of 17 fixed sampling stations
Figure 4.4d	1999 pH at 5 of 17 fixed sampling stations
Figure 4.5a	1999 Light Depth at 4 of 17 fixed sampling stations
Figure 4.5b	1999 Light Depth at 4 of 17 fixed sampling stations
Figure 4.5c	1999 Light Depth at 4 of 17 fixed sampling stations
Figure 4.5d	1999 Light Depth at 5 of 17 fixed sampling stations
Figure 4.6a	1999 Specific Conductance at 4 of 17 fixed sampling stations
Figure 4.6b	1999 Specific Conductance at 4 of 17 fixed sampling stations
Figure 4.6c	1999 Specific Conductance at 4 of 17 fixed sampling stations
Figure 4.6d	1999 Specific Conductance at 5 of 17 fixed sampling stations

Table 4.4 Summary Graphics of Chemical Water Quality Measurements for Data Collected during 1999 at the Fixed Sampling Locations.

Figure	Description
Figure 4.7	1999 Turbidity at fixed sampling stations
Figure 4.8	1999 Color at fixed sampling stations
Figure 4.9	1999 Total Suspended Solids at fixed sampling stations
Figure 4.10	1999 Nitrite/Nitrate at fixed sampling stations
Figure 4.11	1999 Dissolved Chloride at fixed sampling stations
Figure 4.12	1999 Silica at fixed sampling stations
Figure 4.13	1999 Ortho-Phosphorus at fixed sampling stations
Figure 4.14	1999 Specific Conductance at fixed sampling stations
Figure 4.15	1999 Alkalinity at fixed sampling stations
Figure 4.16	1999 Surface chlorophyll *a* at fixed sampling stations
Figure 4.17	1999 Bottom chlorophyll *a* at fixed sampling stations

Gage height, as well as surface and bottom, conductivity and temperature collected at 15-minute intervals at Harbour Height on Peace River (USGS Station 02297460, river kilometer 15.5) are presented in Figures 4.18 through 4.22. Similar plots are shown in Figures 4.23 through 4.27 for the continuous gage at Peace River Heights on the Peace River (USGS Station 02297350, river kilometer 26.7). Gage height data are depicted in Figure 4.28 for the 15-minute interval data collected during 1999 by the USGS at the Boca Grande Station (264312082153000). These graphics are summarized in Table 4.5.

Table 4.5 Summary Graphics of Data from USGS Continuous Recorders.

Figure	Description
Figure 4.18	Gage Height (15-minute intervals) for Peace River fixed station 02297460 (River Kilometer 15.5)
Figure 4.19	Surface conductivity (15-minute intervals) for Peace River fixed Station 02297460 (River kilometer)
Figure 4.20	Bottom conductivity (15-minute intervals) for Peace River fixed station 02297460 (River Kilometer 15.5)
Figure 4.21	Surface temperature (15-minute intervals) for Peace River fixed station 02297460 (River Kilometer 15.5)
Figure 4.22	Bottom temperature (15-minute intervals) for Peace River fixed station 02297460 (River Kilometer)
Figure 4.23	Gage Height (15-minute intervals) for Peace River fixed station 02297350 (River Kilometer 26.7)
Figure 4.24	Surface conductivity (15-minute intervals) for Peace River fixed station 02297350 (River Kilometer 26.7)
Figure 4.25	Bottom conductivity (15-minute intervals) for Peace River fixed station 02297350 (River Kilometer 26.7)
Figure 4.26	Surface temperature (15-minute intervals) for Peace River fixed station 02297350 (River Kilometer 26.7)
Figure 4.27	Bottom temperature (15-minute intervals) for Peace River fixed station 02297350 (River Kilometer 26.7)
Figure 4.28a	Gage Height (15-minute intervals) for Boca Grande
Figure 4.28b	Gage Height (15-minute intervals) for Boca Grande

Comparisons of gage heights and both surface and bottom conductivity measurements at the two Peace River gage locations, Harbour Heights (river kilometer 15.5) and Peace River Heights (river kilometer 26.7), are presented in Figures 4.29 through 4.40 for the last two weeks in May 1999 (dry-season) and the last two weeks in August1999 (wet-season). An overview of these graphics is presented in Table 4.6.

Table 4.5 Summary Graphics of Comparisons of Stage Height and Surface and Bottom Conductivity at the Continuous Recorders.

Figure	Description
Figure 4.29	Surface Conductivity and Stage Height in May - Station 02297460 (River Kilometer 15.5)
Figure 4.30	Bottom Conductivity and Stage Height in May – Station 02297460 (River Kilometer 15.5)
Figure 4.31	Surface & Bottom Conductivity in May - Station 02297460 (River Kilometer 15.5)
Figure 4.32	Surface Conductivity and Stage Height in August -Station 02297460 River Kilometer 15.5)
Figure 4.33	Bottom Conductivity and Stage Height in August – Station 02297460 (River Kilometer 15.5)
Figure 4.34	Surface & Bottom Conductivity in August – Station 02297460(River Kilometer 15.5)
Figure 4.35	Surface Conductivity and Stage Height in May - Station 02297350 (River Kilometer 26.7)
Figure 4.36	Bottom Conductivity and Stage Height in May - Station 02297350 (River Kilometer 26.7)
Figure 4.37	Surface & Bottom Conductivity in May – Station 02297350 (River Kilometer 26.7).
Figure 4.38	Surface Conductivity and Stage Height in August - Station 02297350 (River Kilometer 26.7)
Figure 4.39	Bottom Conductivity and Stage Height in August - Station 02297350 (River Kilometer 26.7)
Figure 4.40	Surface & Bottom Conductivity in August - Station 02297350 (River Kilometer 26.7)

As indicated in comparing the series of figures, both surface and bottom conductivities at the downstream Harbour Heights site (river kilometer 15.5) are strongly influences by tide. During May, in the dry-season, it was not uncommon for surface conductivities to vary 5000 to 10000 uS/cm (roughly 3 to 6 ppt salinity) over a tidal cycle. The amount of tidal variability in conductivity near the bottom was even greater. During August, in the wet-season, this area of the Peace River was characteristically far fresher and daily tidal influences were greatly reduced.

Upstream, the conductivity data collected during May 1999 at the continuous gage at Peace River Heights (river kilometer 26.7) showed tidal variations in conductivity (5000 to 10000 uS/cm) similar in magnitude to those downstream. However, conductivity rapidly declined in this region of the river in response to a relatively small increase in flow. During the wet-season (August), conductivities were extremely low and observed variations showed little tidal influence.

Back to Start

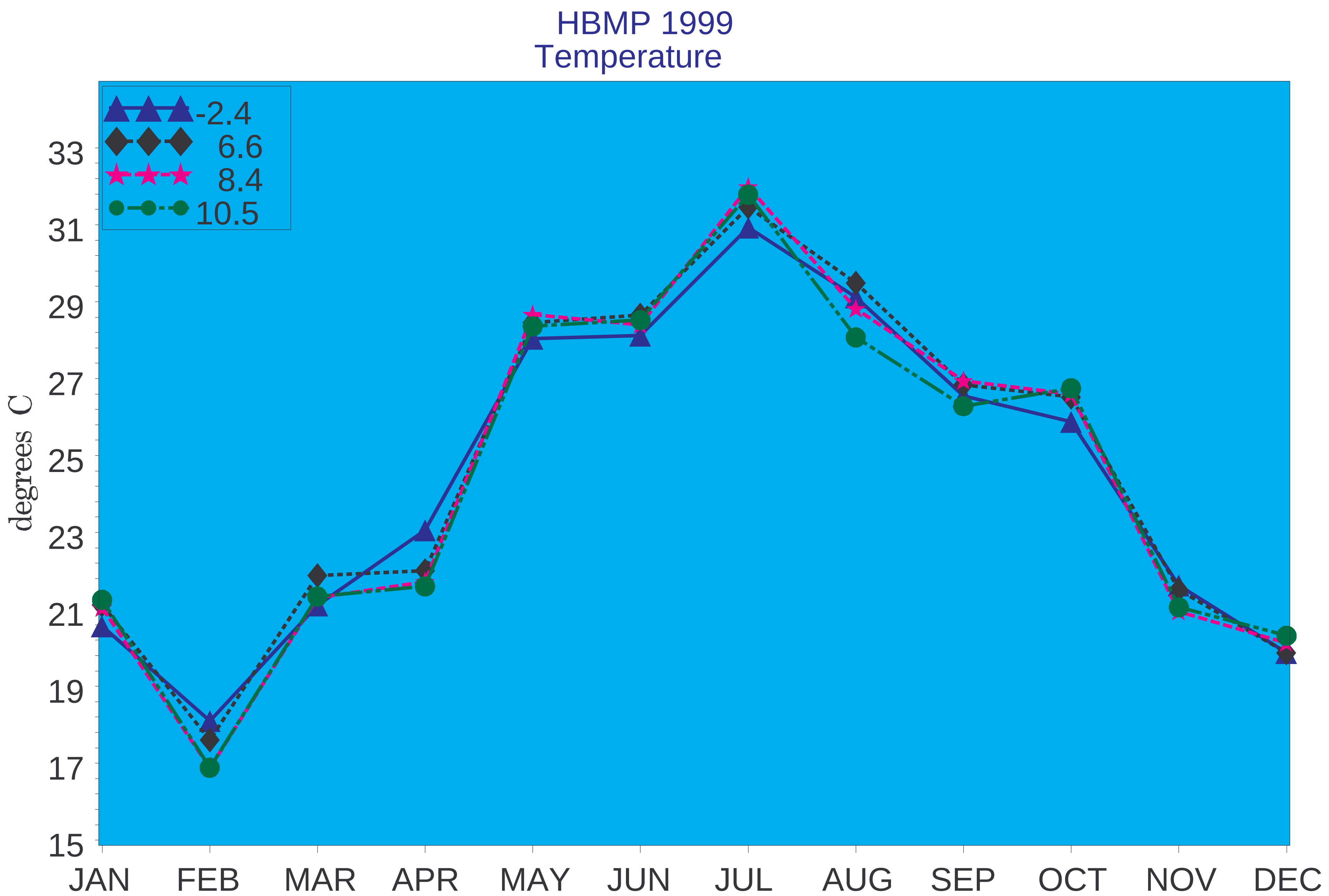

Figure 4.2a 1999 Temperature at 4 of the 17 fixed sampling stations.

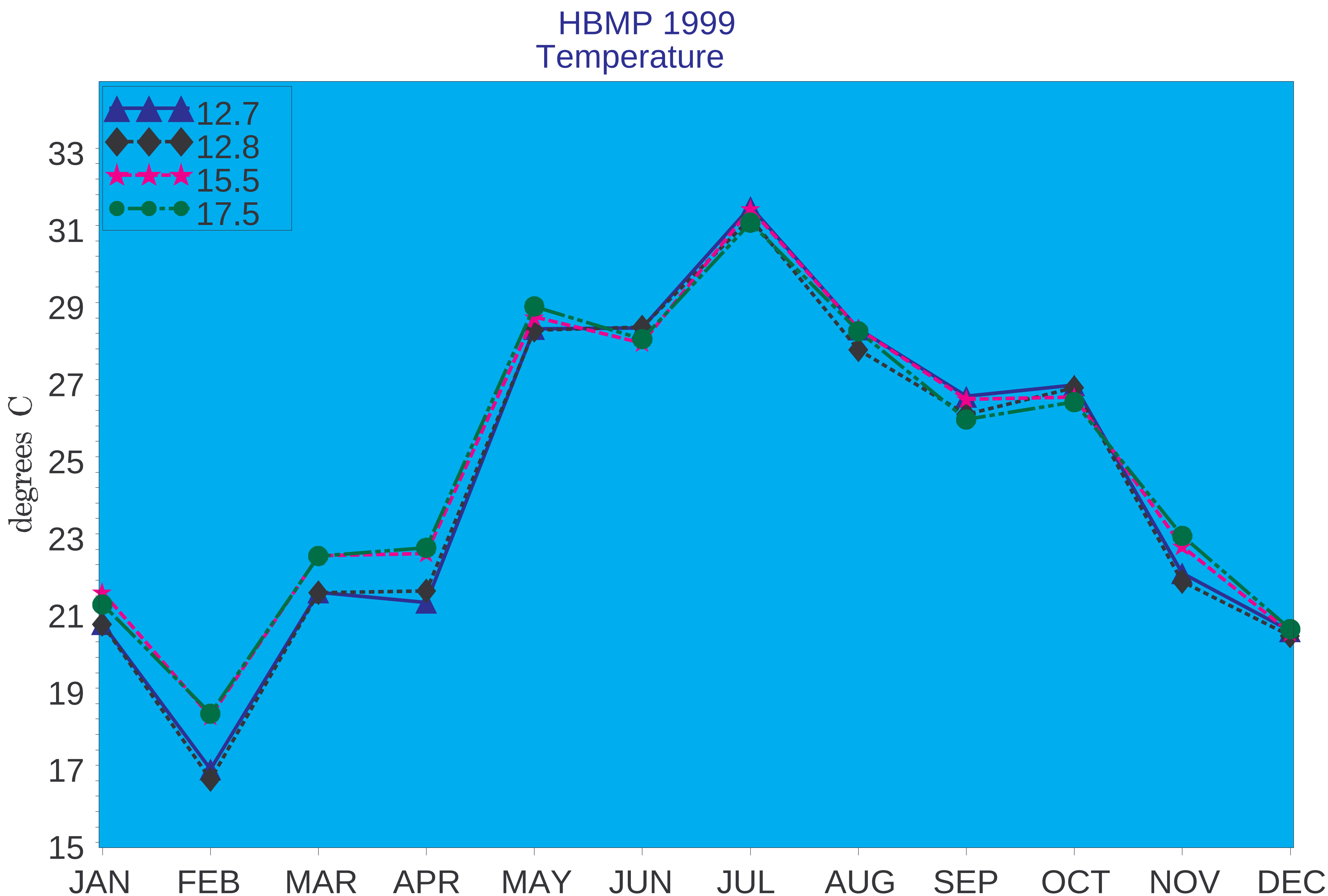

Figure 4.2b 1999 Temperature at 4 of the 17 fixed sampling stations.

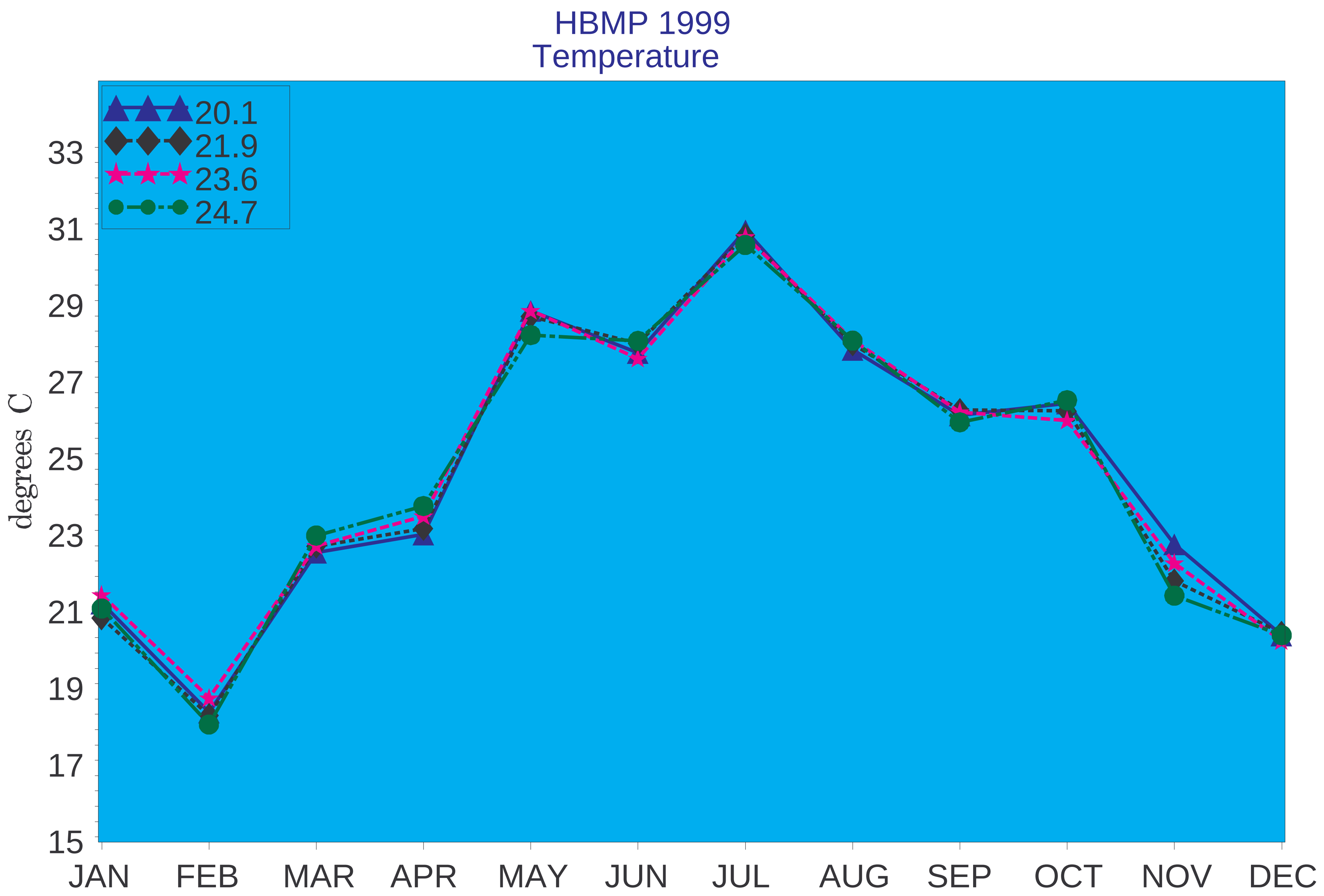

Figure 4.2c 1999 Temperature at 4 of the 17 fixed sampling stations.

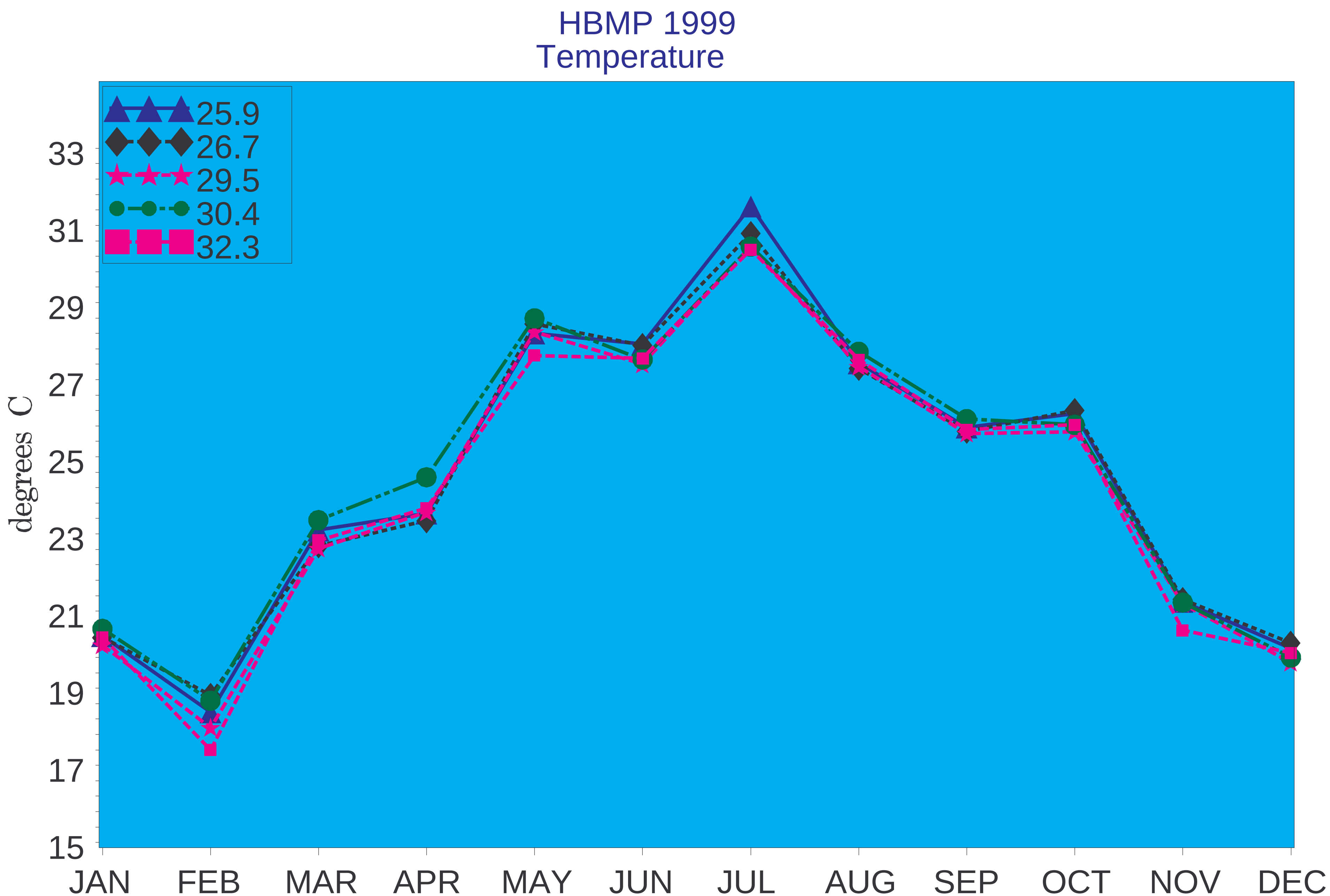

Figure 4.2d 1999 Temperature at 5 of the 17 fixed sampling stations.

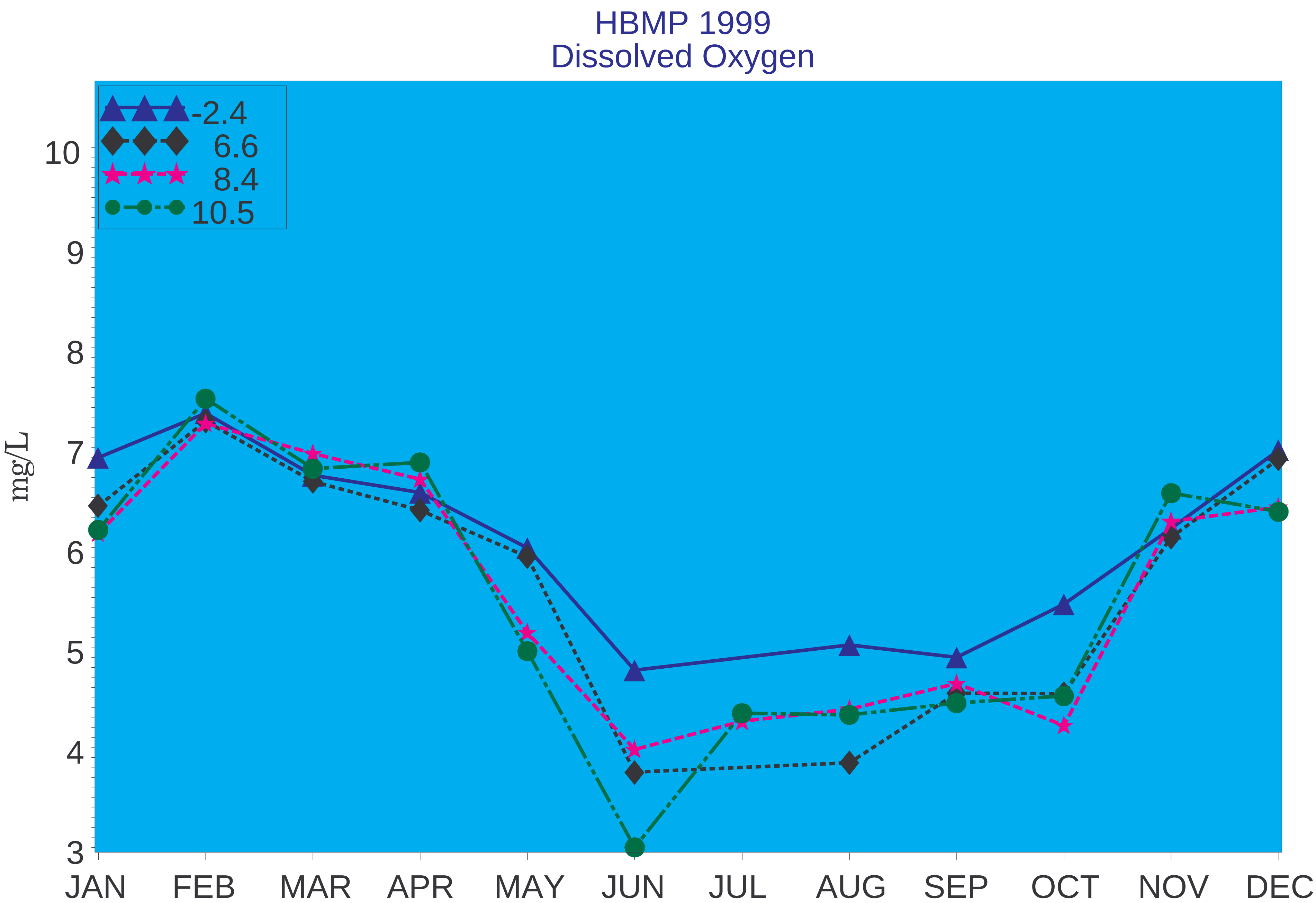

Figure 4.3a 1999 Dissolved Oxygen at 4 of the 17 fixed sampling stations.

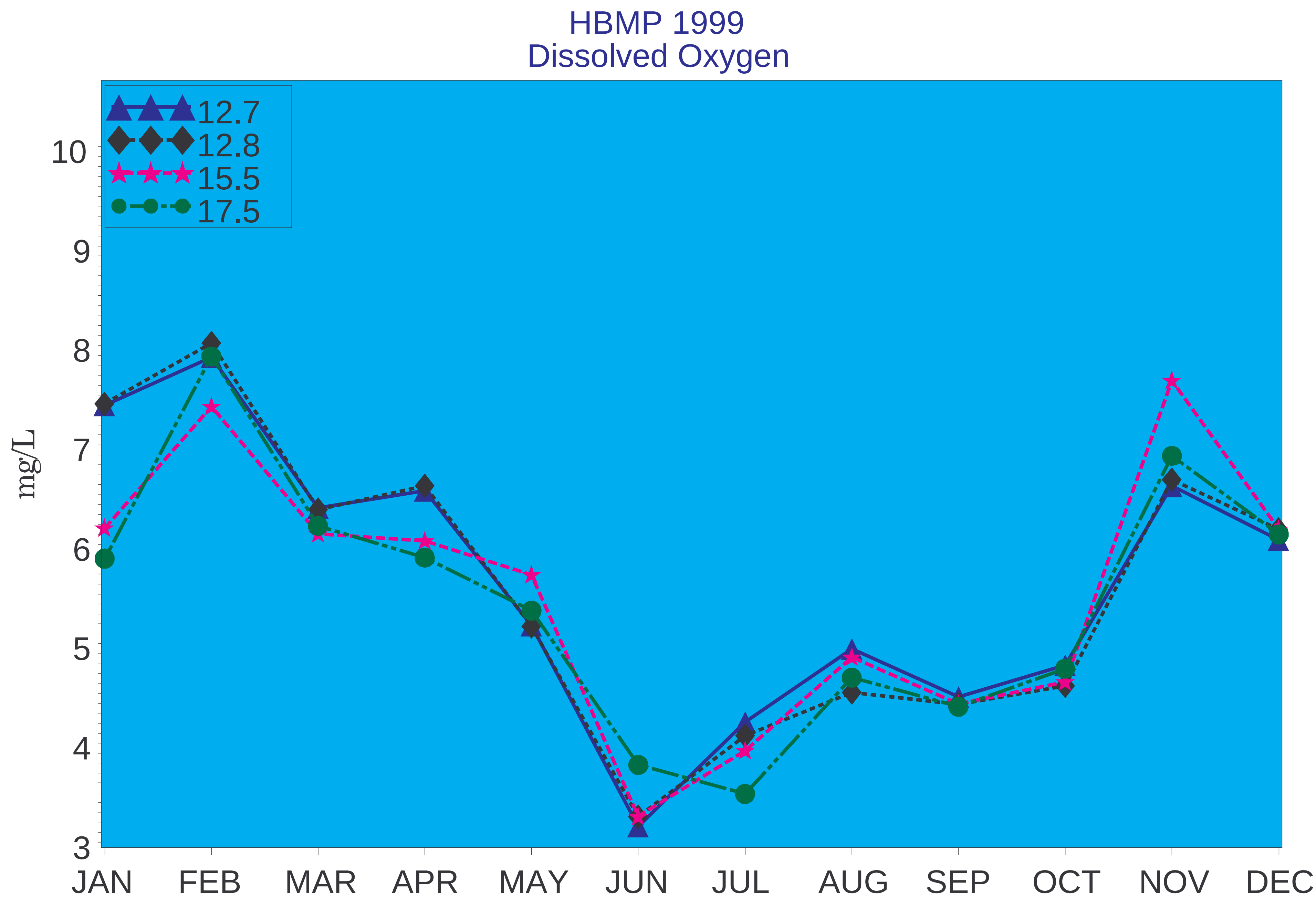

Figure 4.3b 1999 Dissolved Oxygen at 4 of the 17 fixed sampling stations.

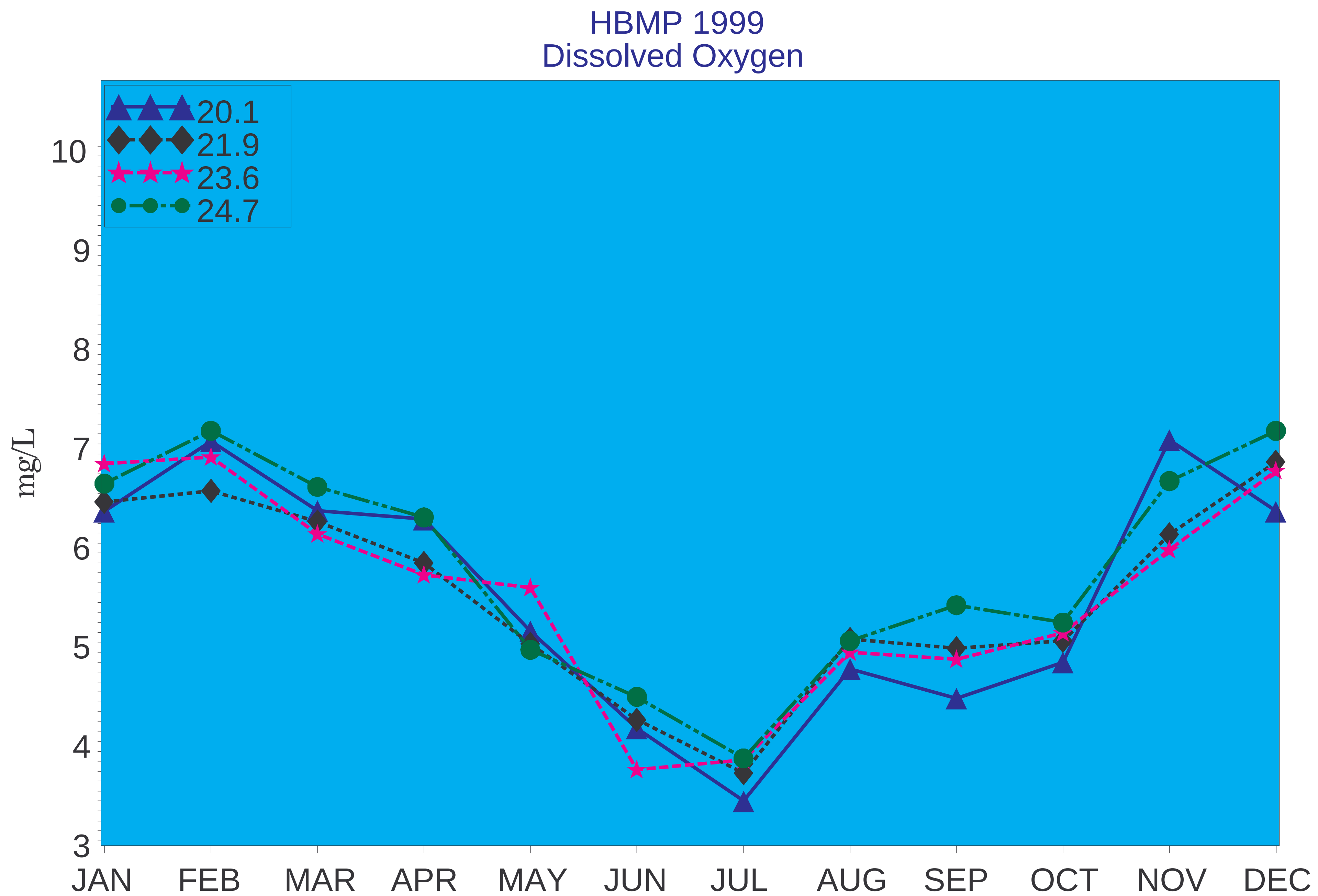

Figure 4.3c 1999 Dissolved Oxygen at 4 of the 17 fixed sampling stations.

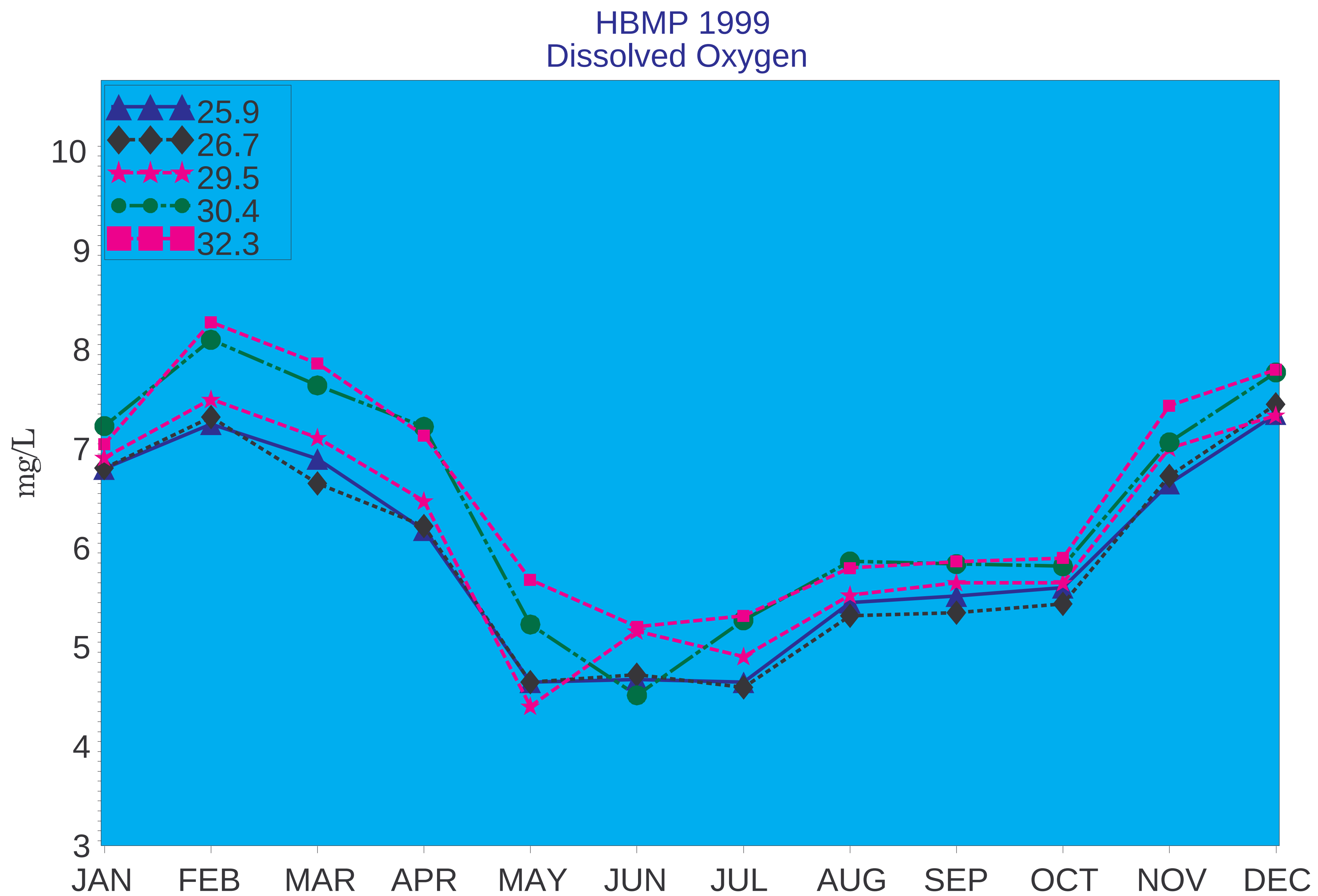

Figure 4.3d 1999 Dissolved Oxygen at 5 of the 17 fixed sampling stations.

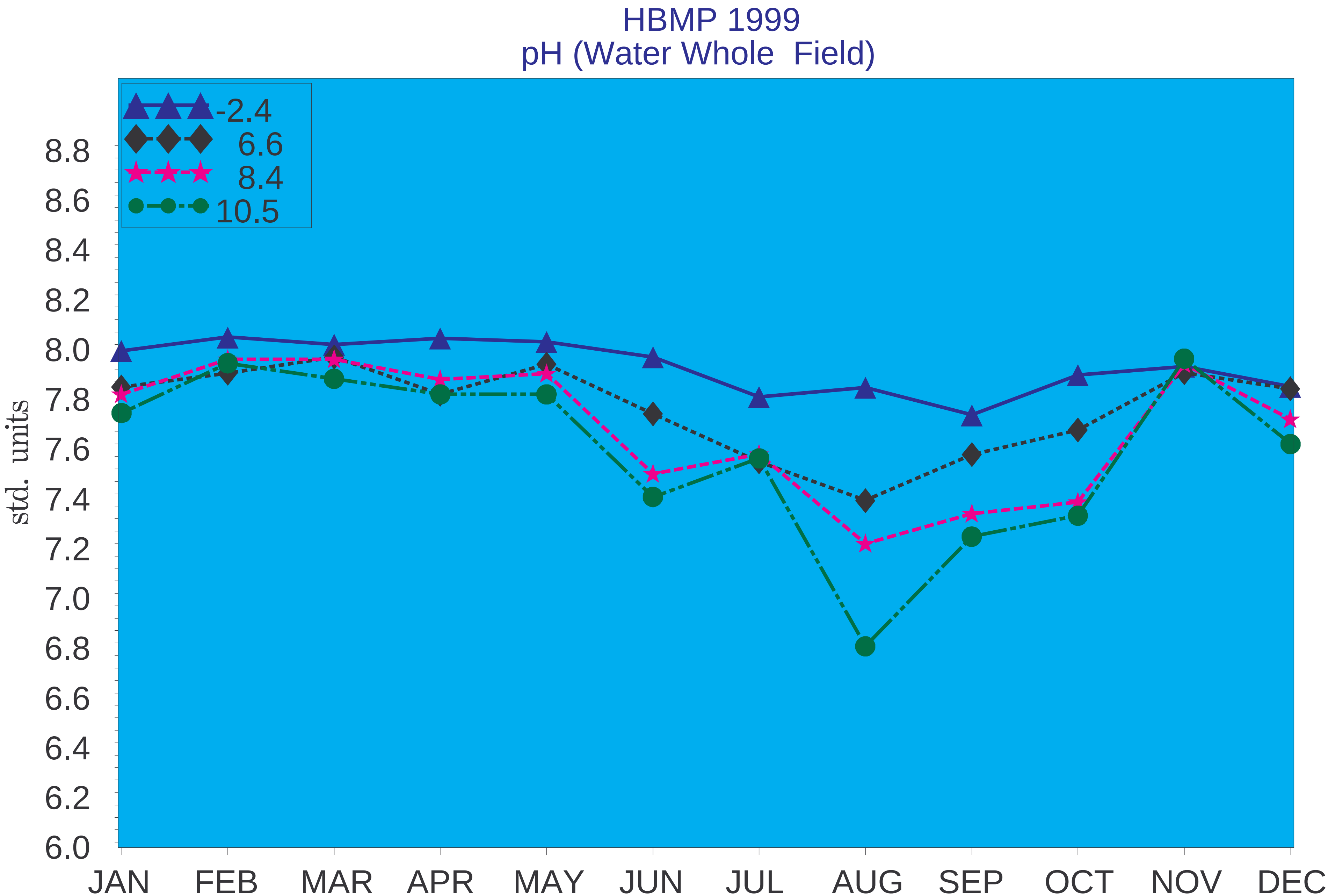

Figure 4.4a 1999 pH at 4 of the 17 fixed sampling stations.

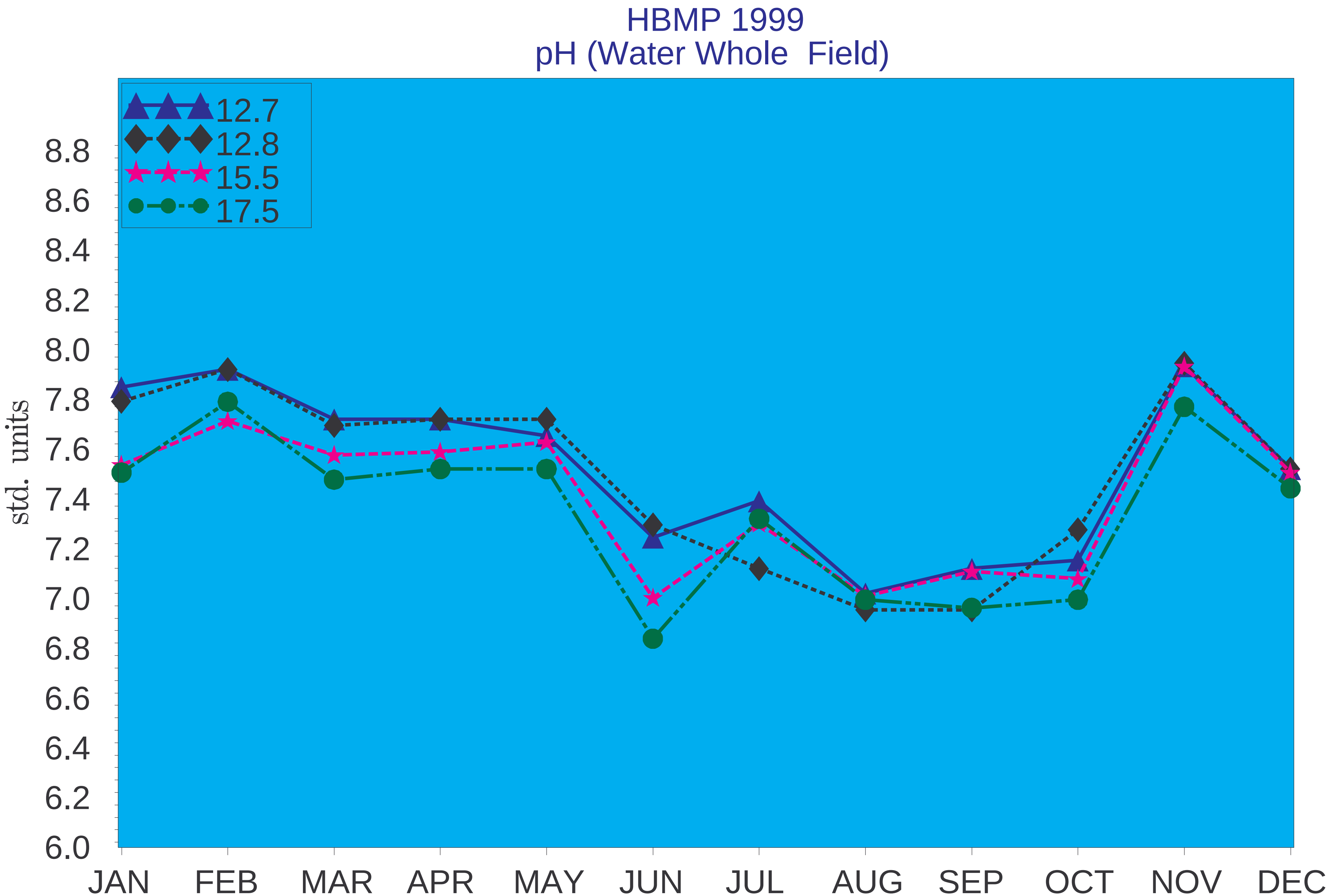

Figure 4.4b 1999 pH at 4 of the 17 fixed sampling stations.

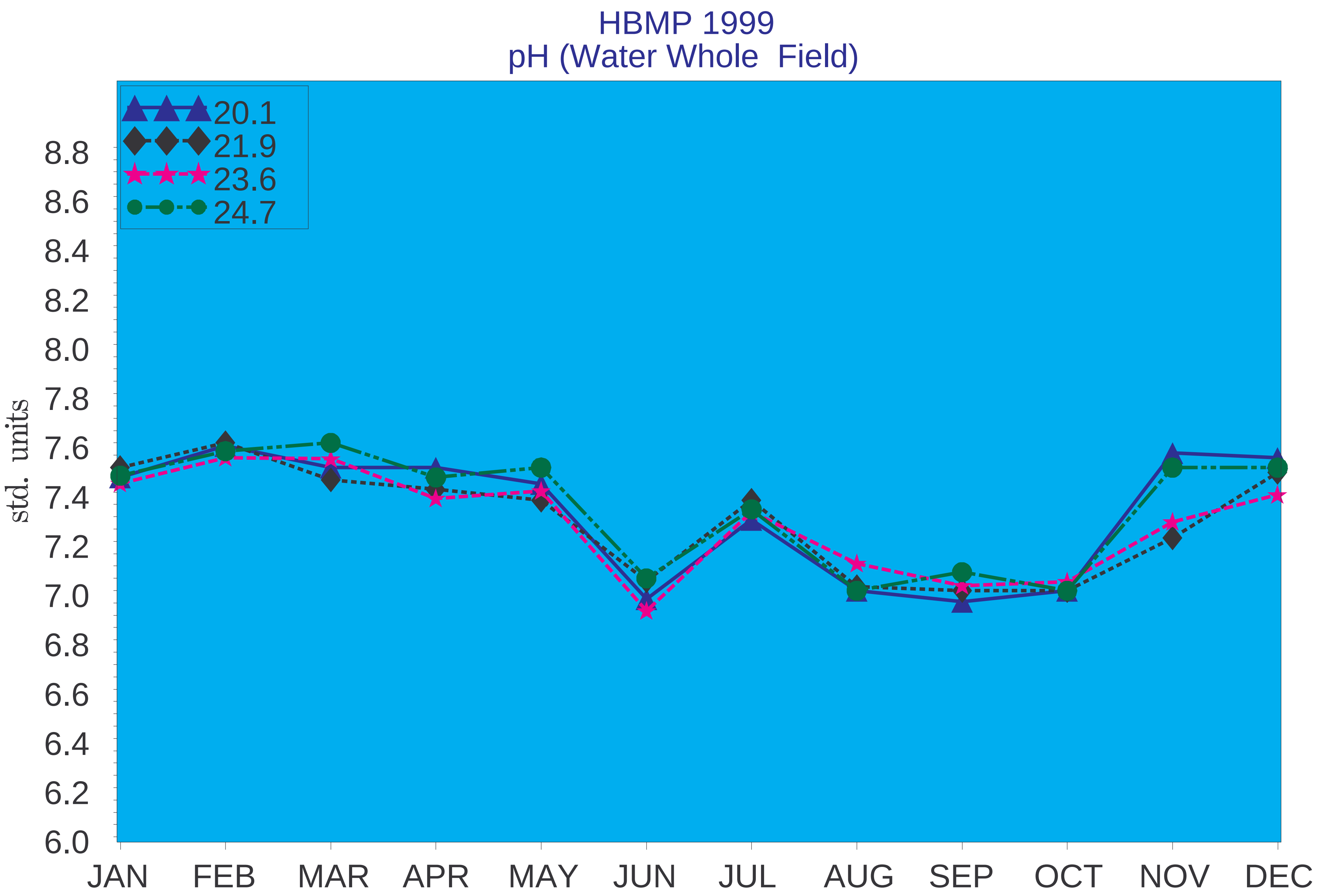

Figure 4.4c 1999 pH at 4 of the 17 fixed sampling stations.

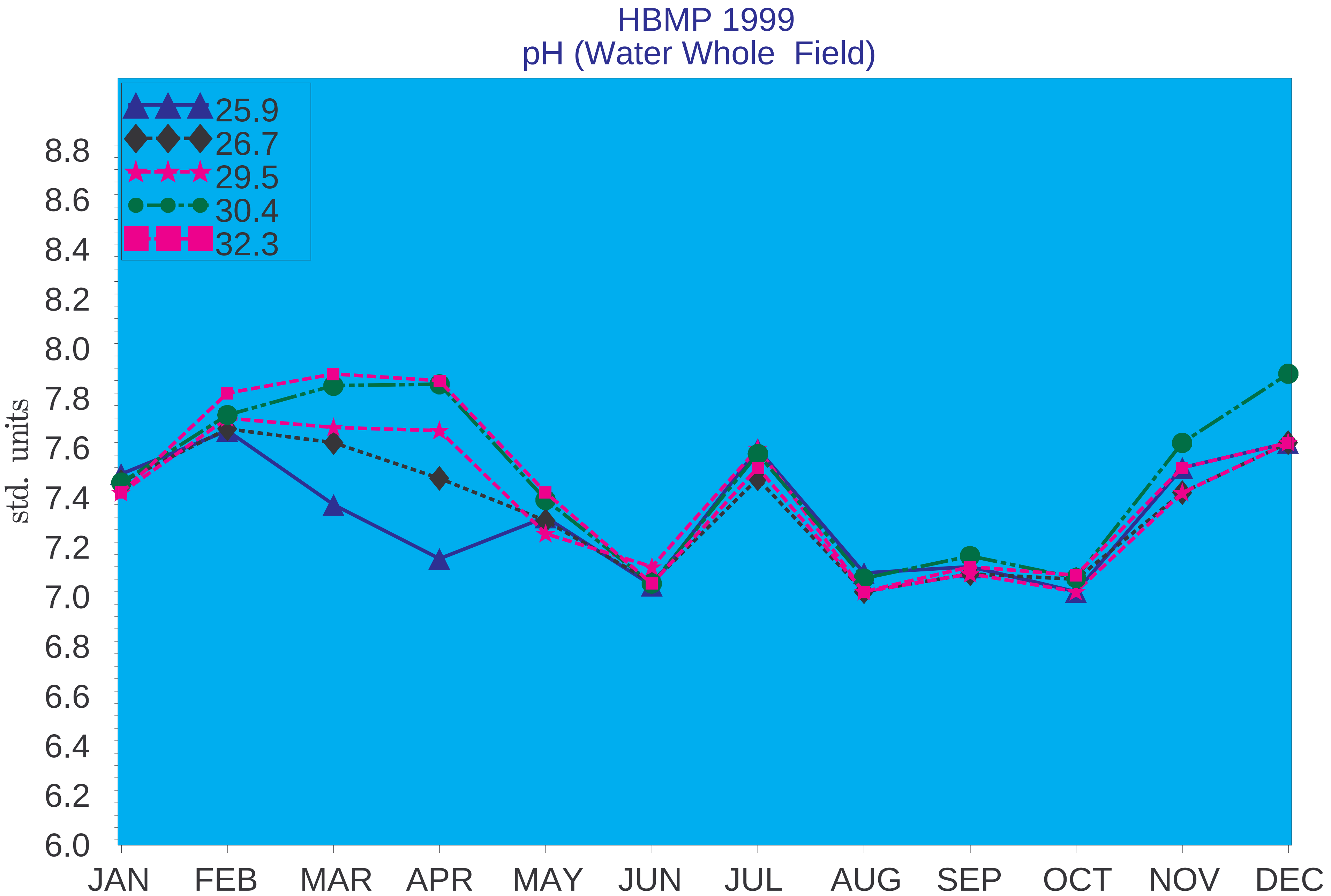

Figure 4.4d 1999 pH at 5 of the 17 fixed sampling stations.

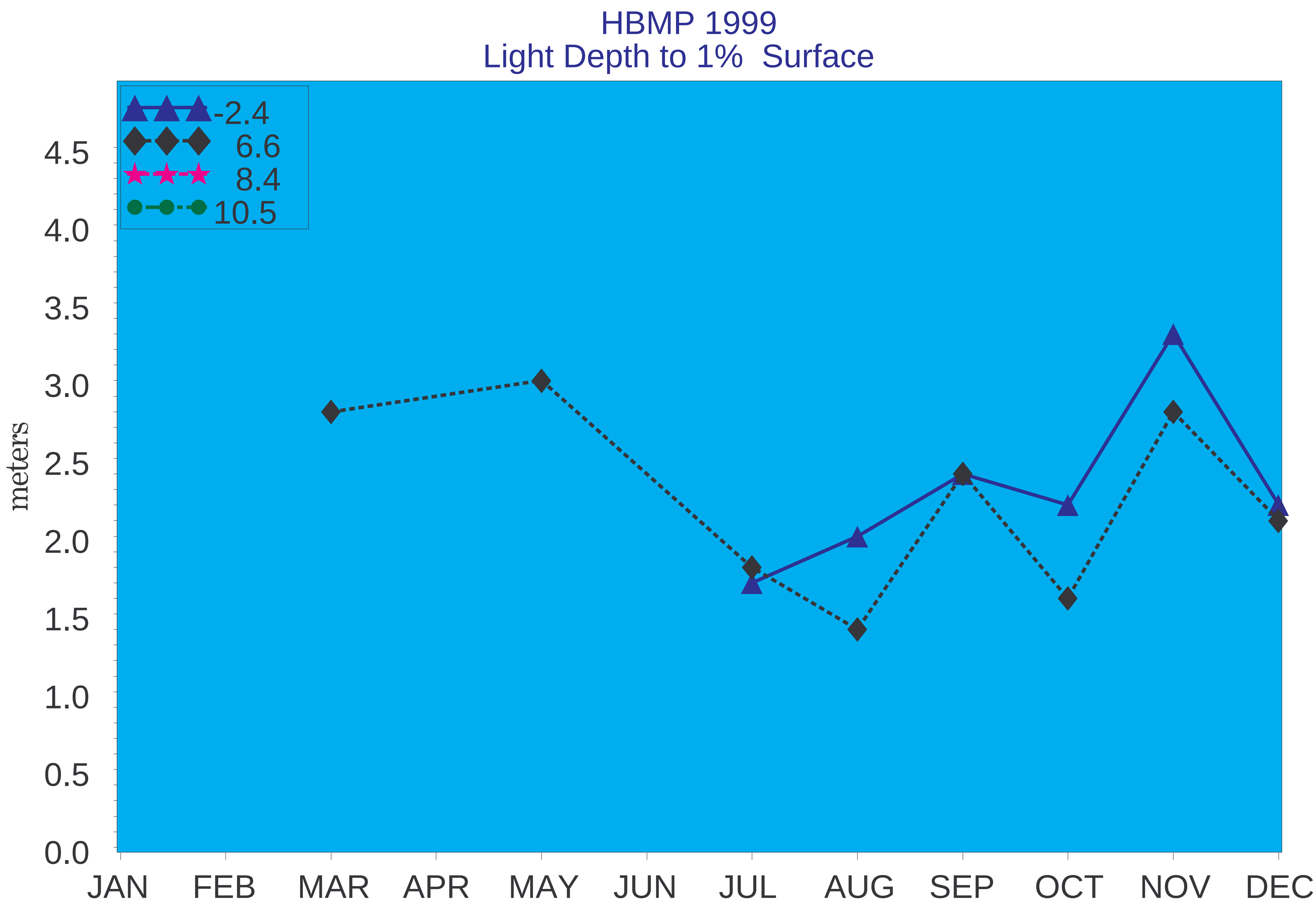

Figure 4.5a 1999 Light Depth at 4 of the 17 fixed sampling stations.

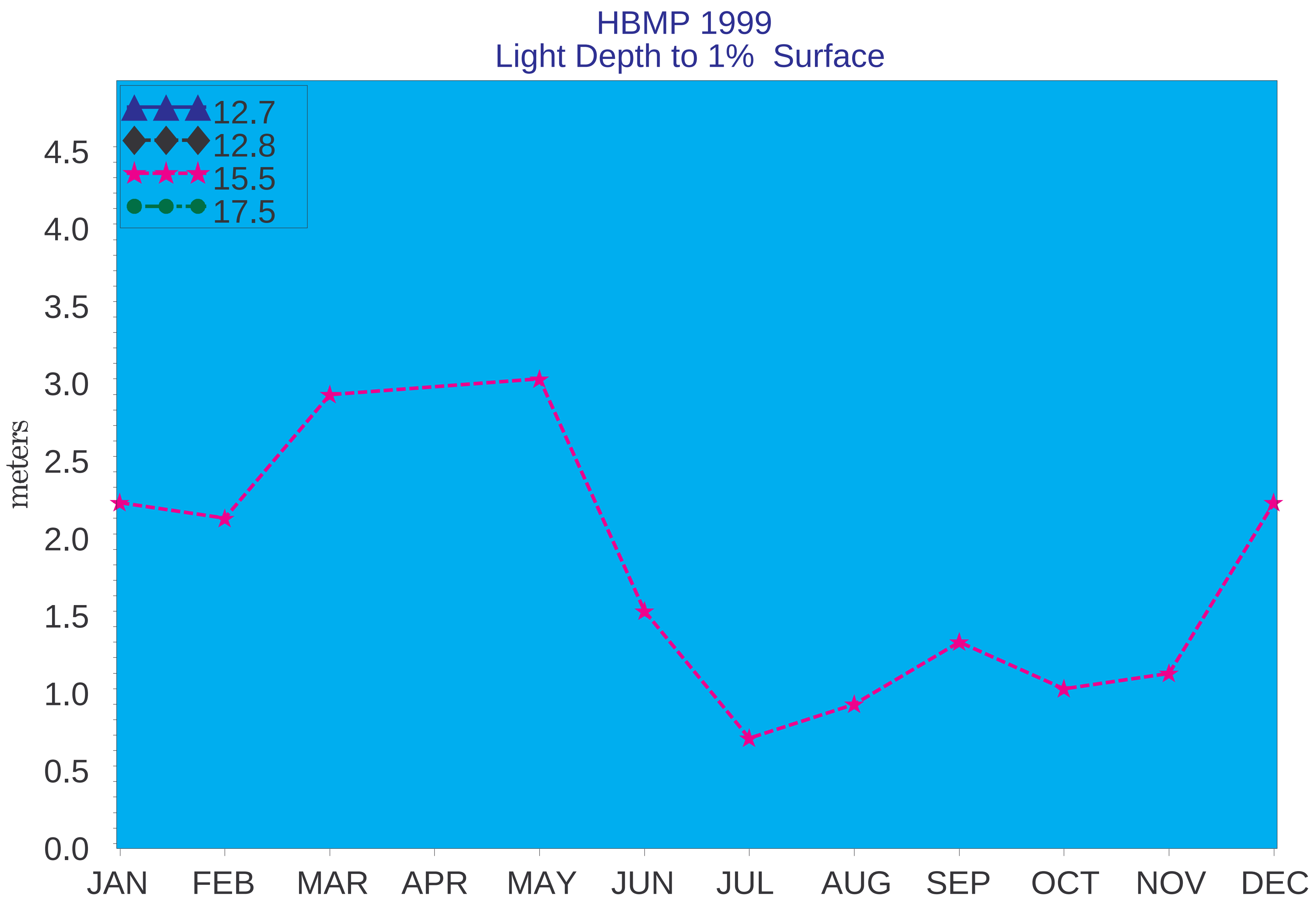

Figure 4.5b 1999 Light Depth at 4 of the 17 fixed sampling stations.

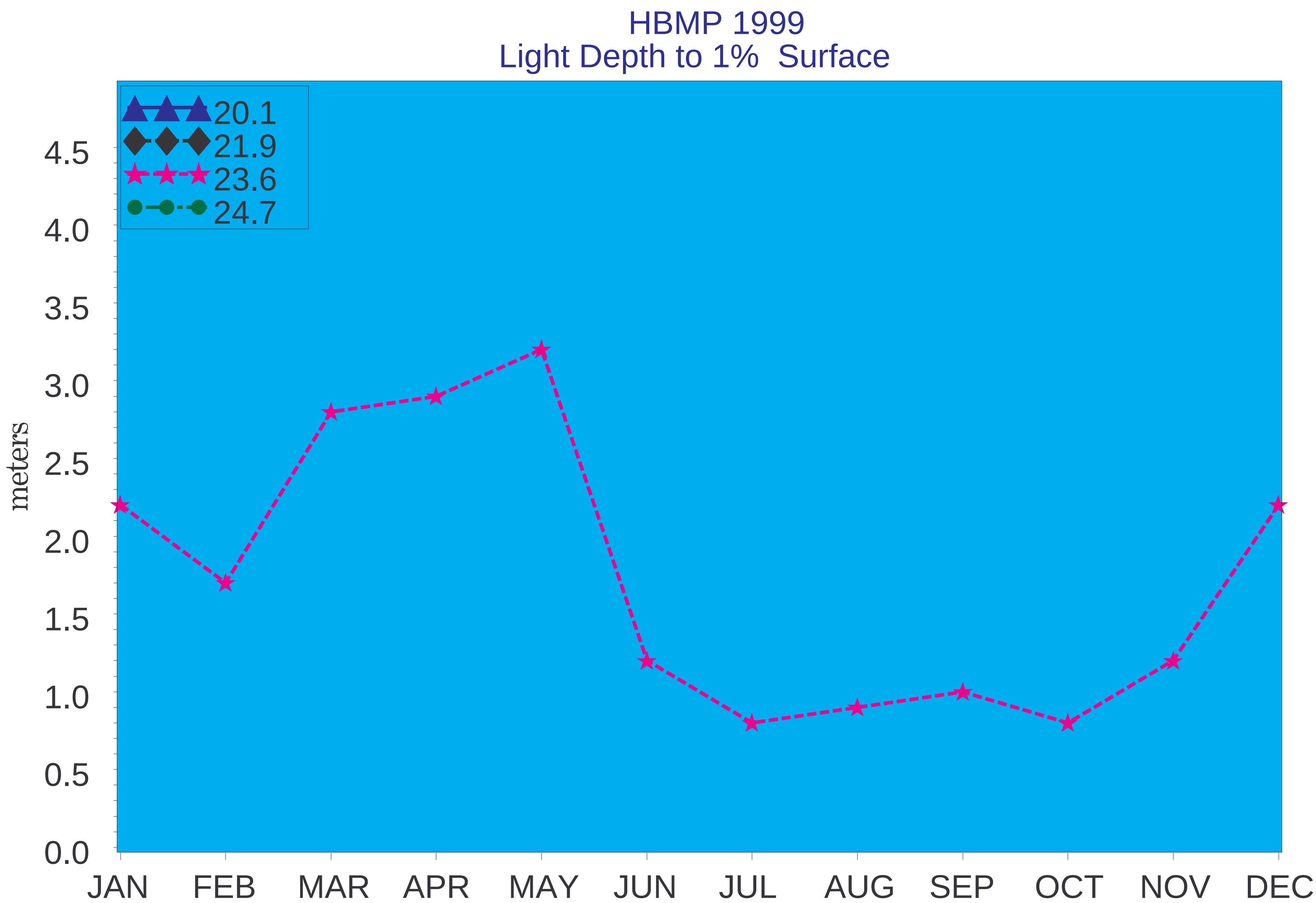

Figure 4.5c 1999 Light Depth at 4 of the 17 fixed sampling stations.

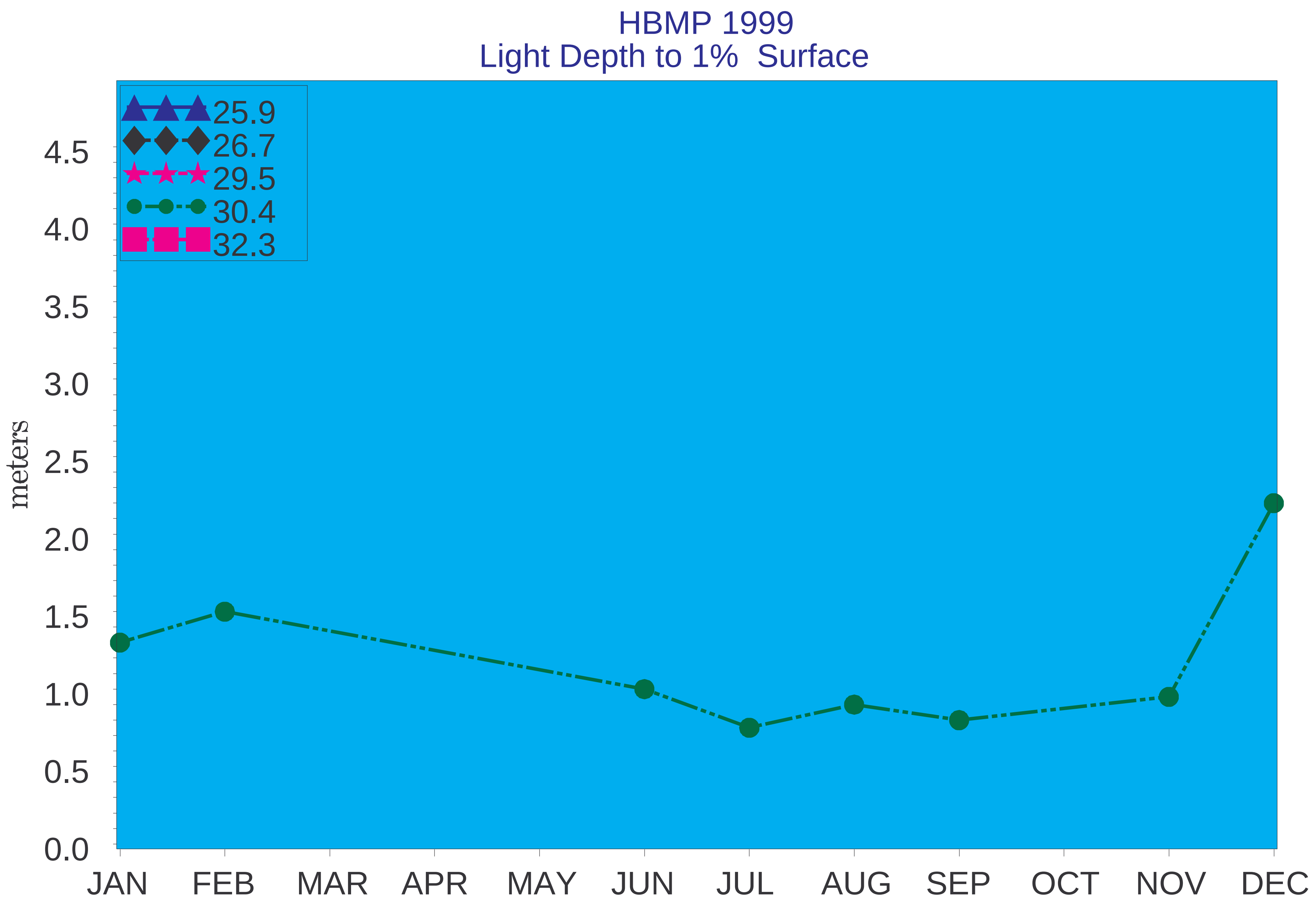

Figure 4.5d 1999 Light Depth at 5 of the 17 fixed sampling stations.

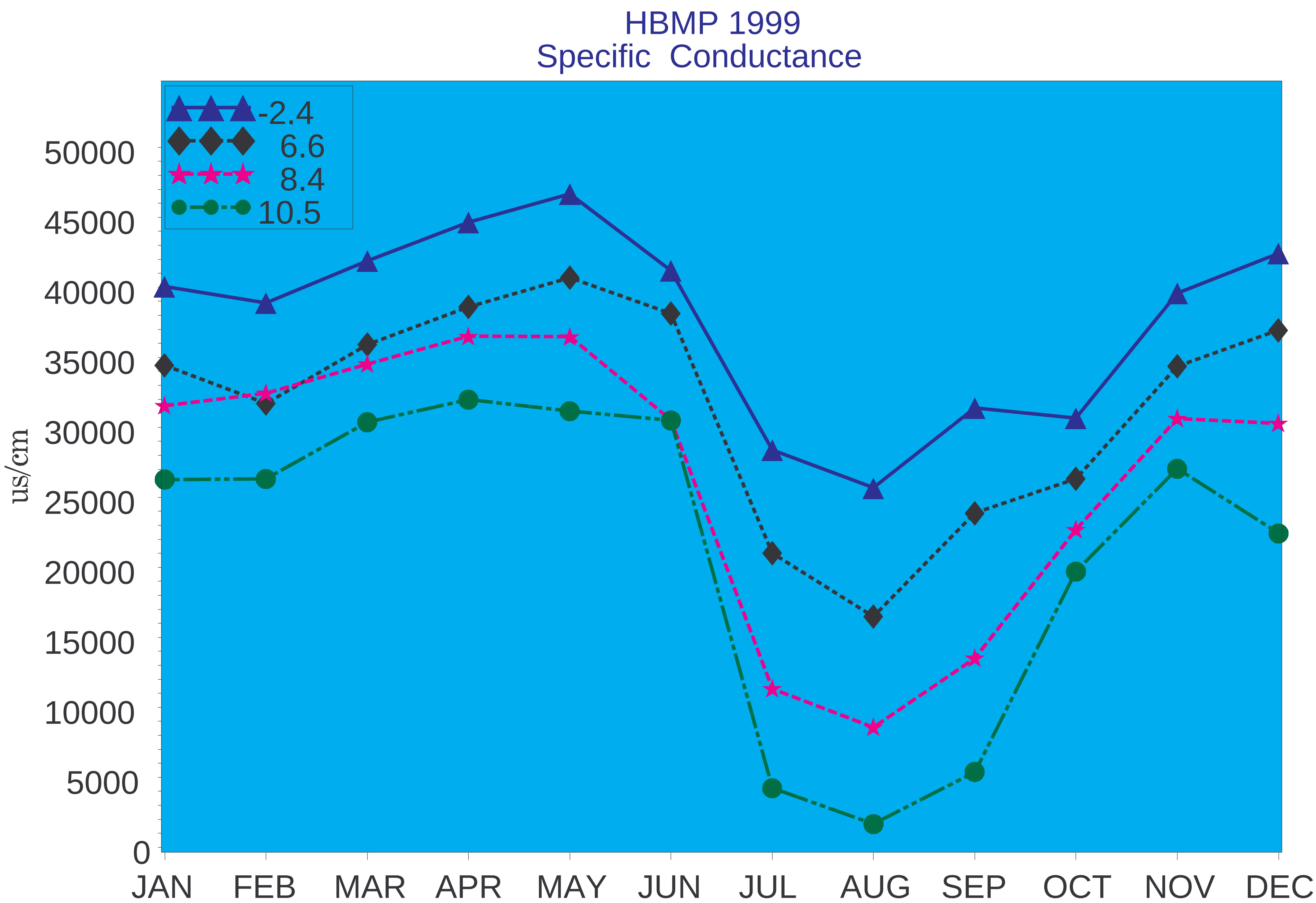

Figure 4.6a 1999 Specific Conductance at 4 of the 17 fixed sampling stations.

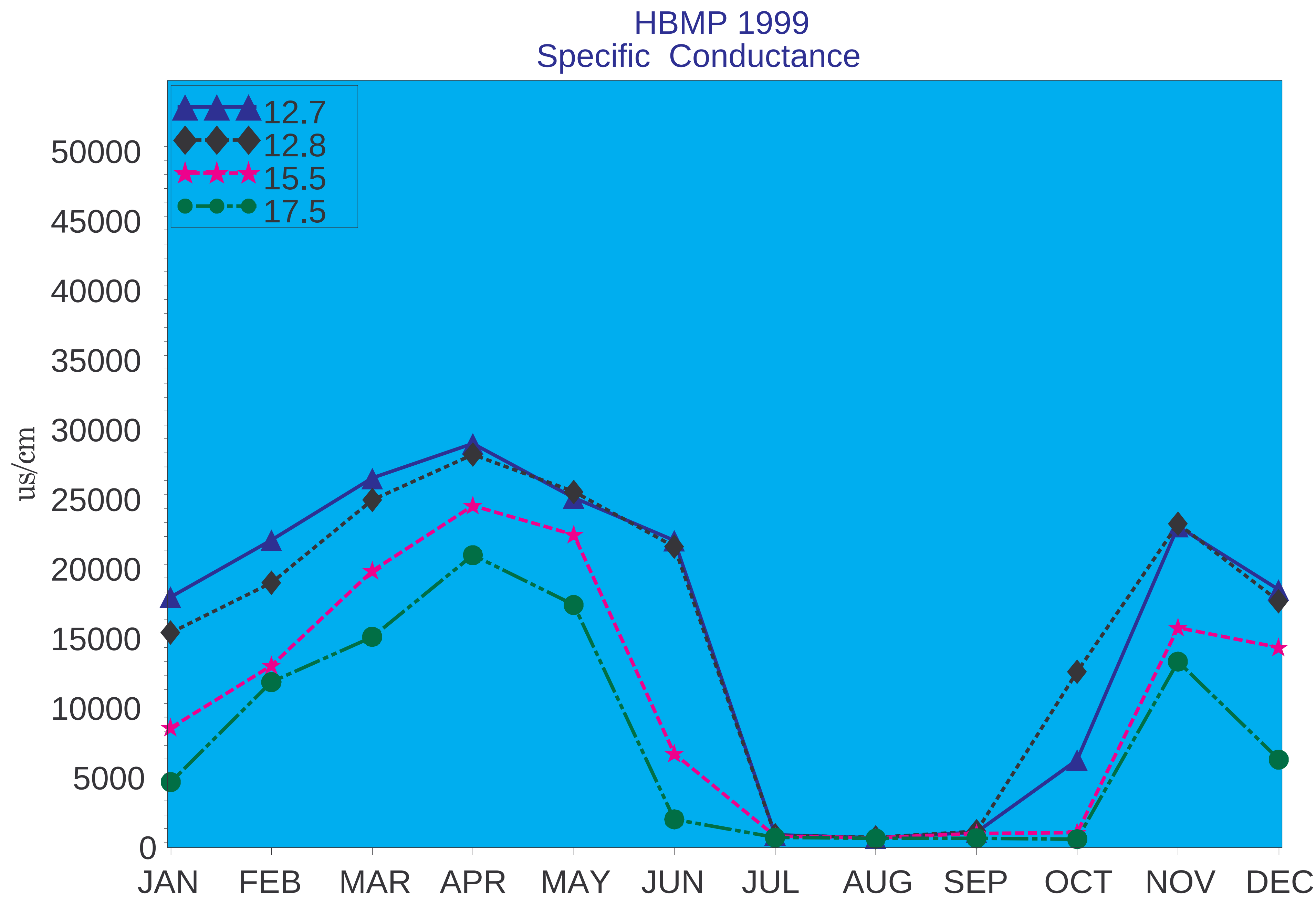

Figure 4.6b 1999 Specific Conductance at 4 of the 17 fixed sampling stations.

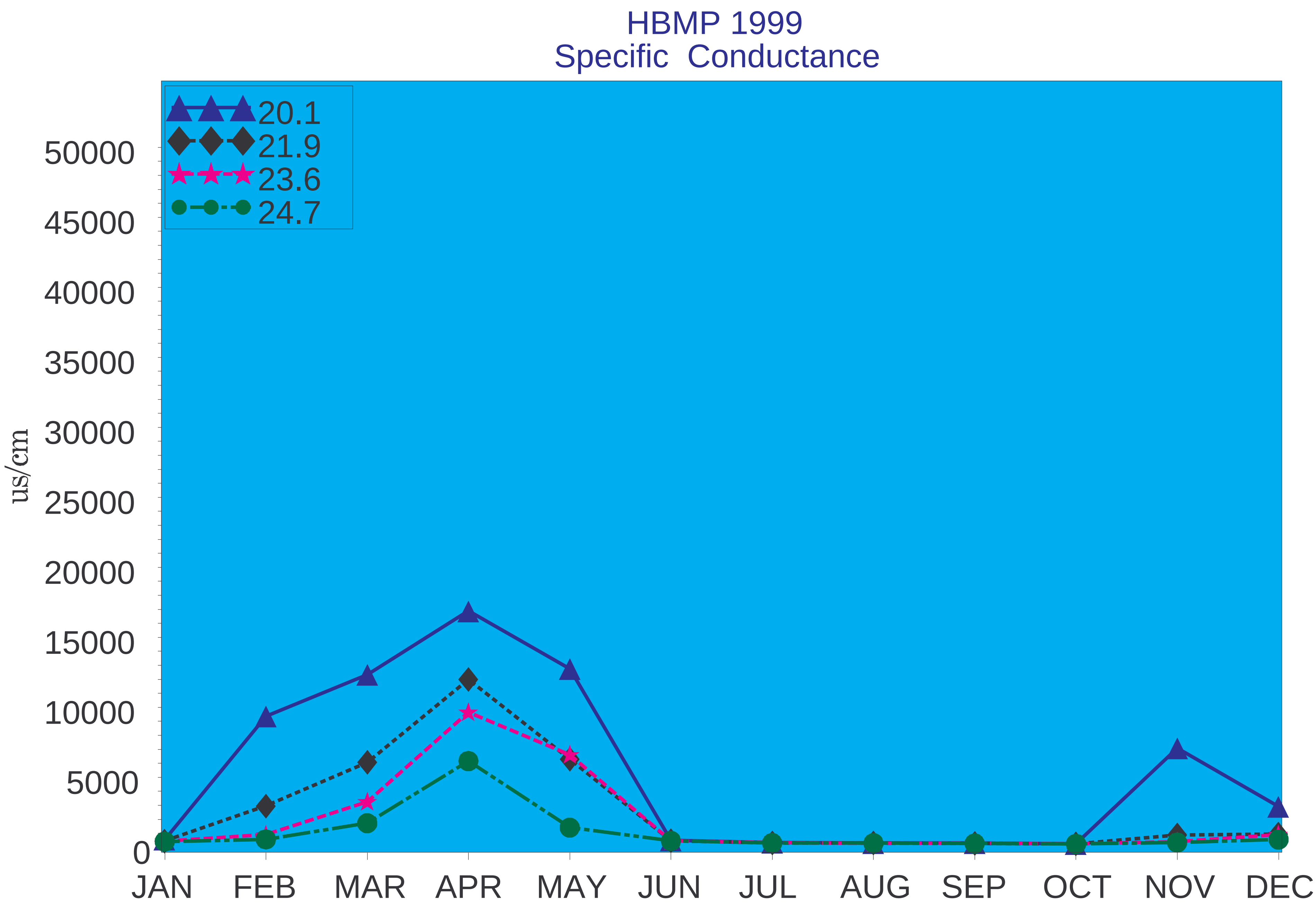

Figure 4.6c 1999 Specific Conductance at 4 of the 17 fixed sampling stations.

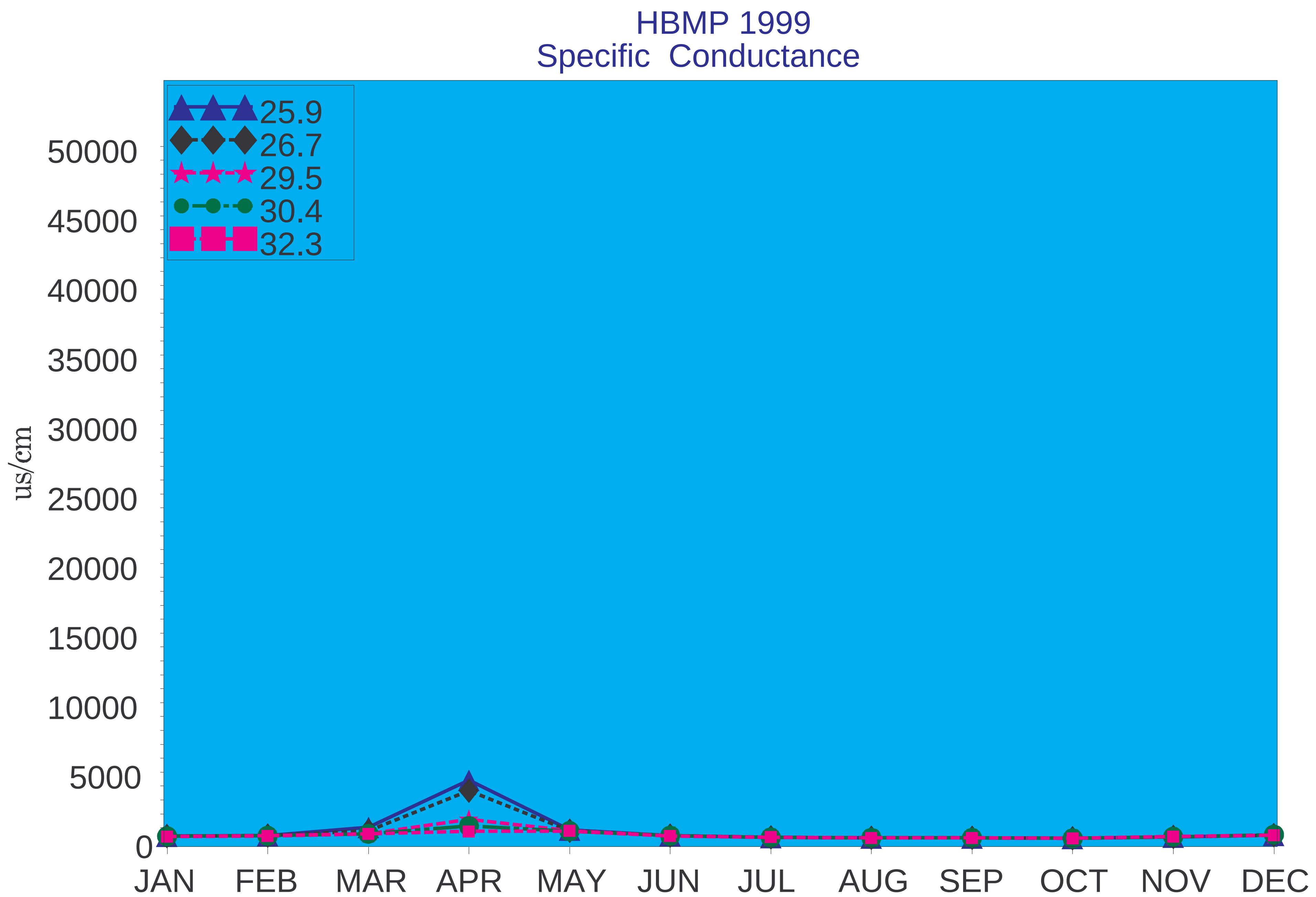

Figure 4.6d 1999 Specific Conductance at 5 of the 17 fixed sampling stations.

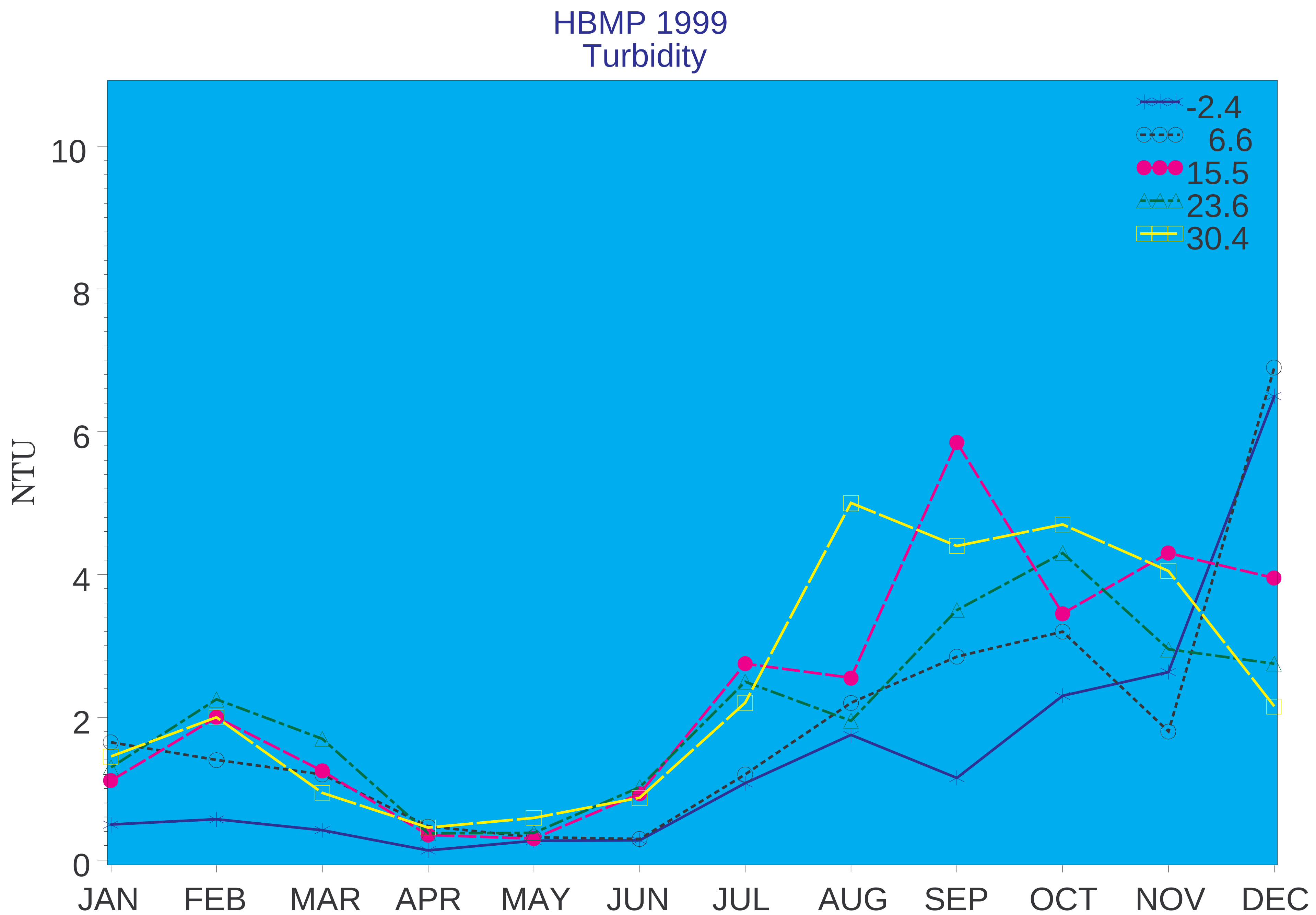

Figure 4.7 1999 Turbidity at fixed sampling stations.

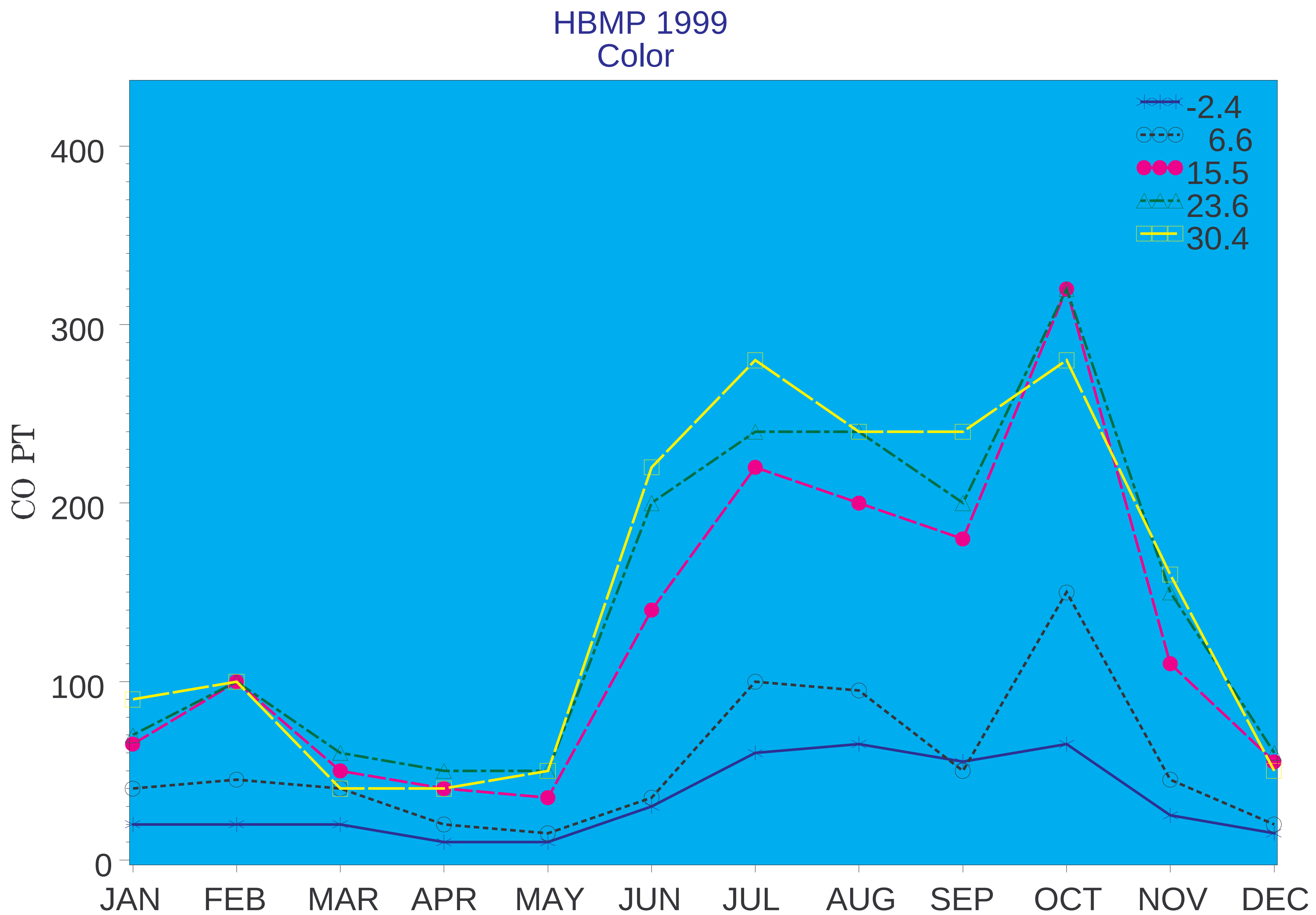

Figure 4.8 1999 Color at fixed sampling stations.

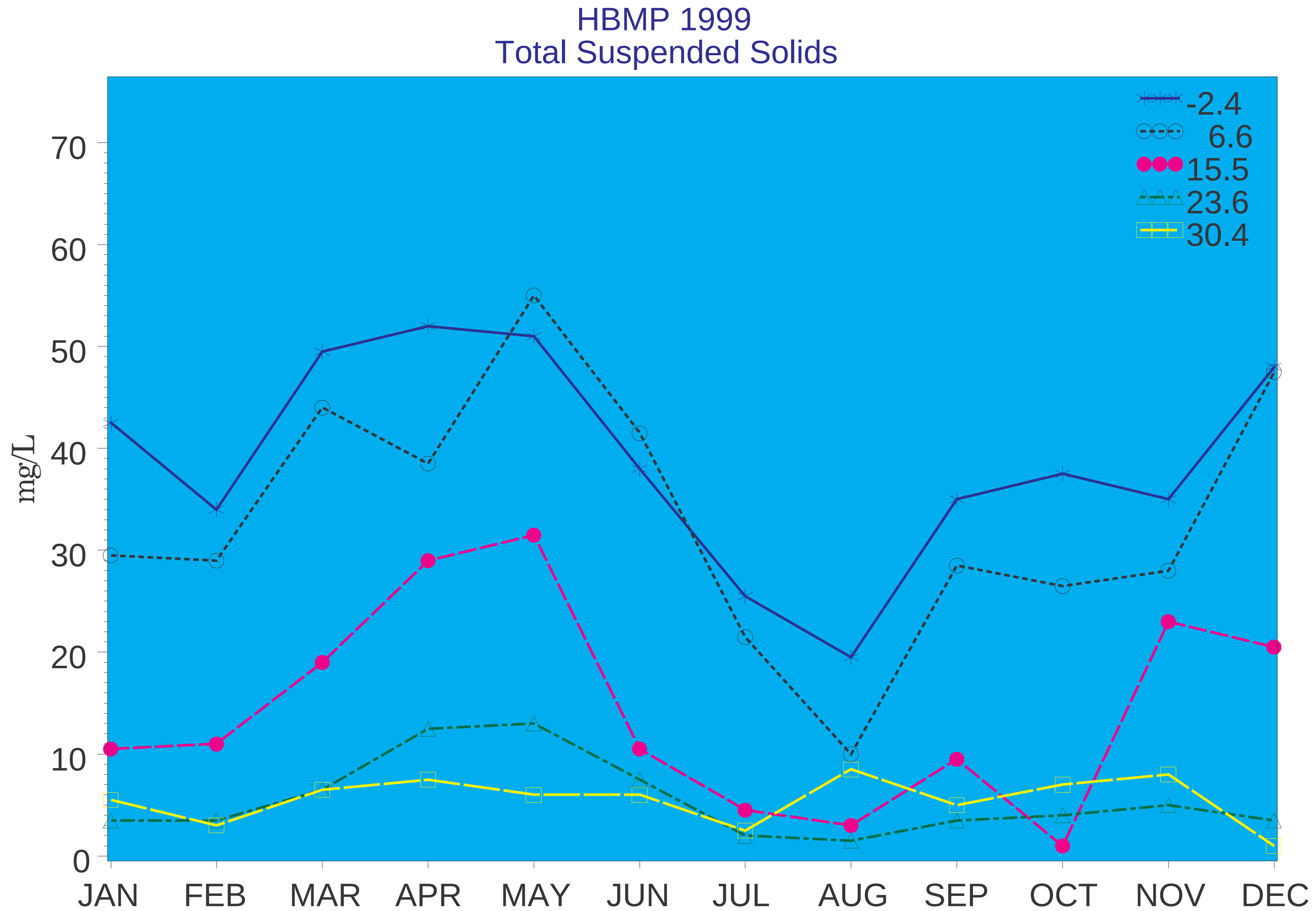

Figure 4.9 1999 Total Suspended Solids at fixed sampling stations.

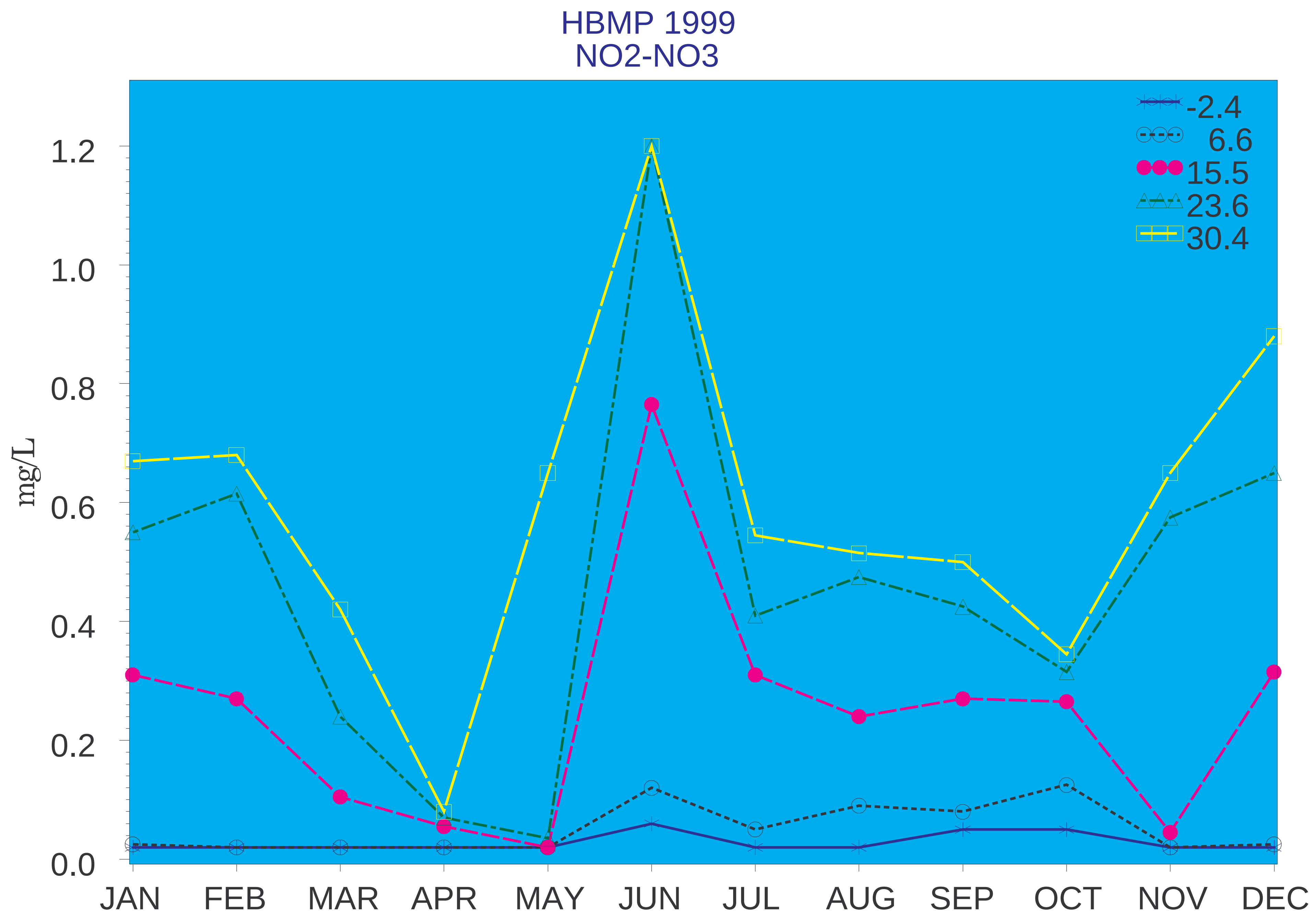

Figure 4.10 1999 Nitrite/Nitrate at fixed sampling stations.

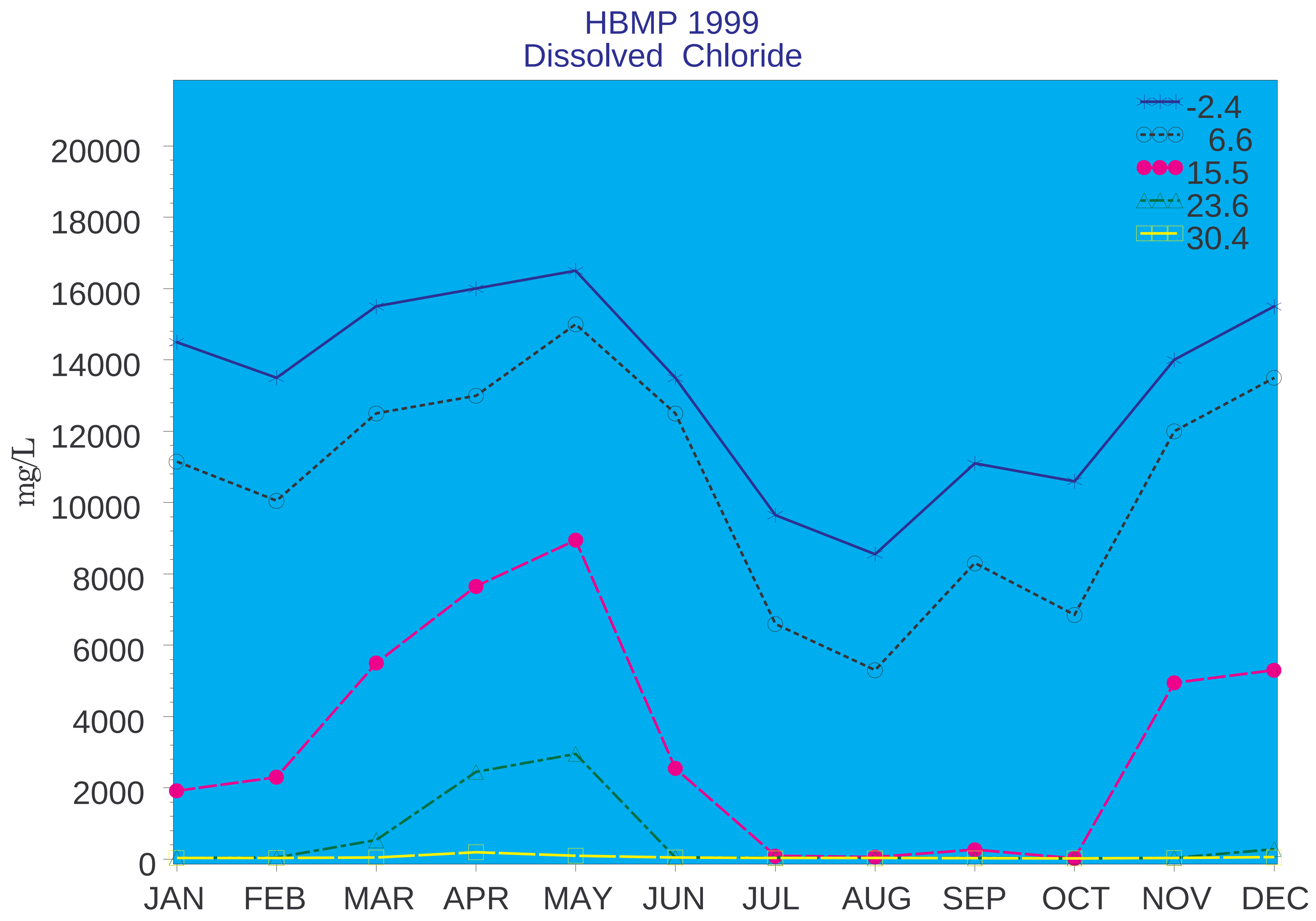

Figure 4.11 1999 Dissolved Chloride at fixed sampling stations.

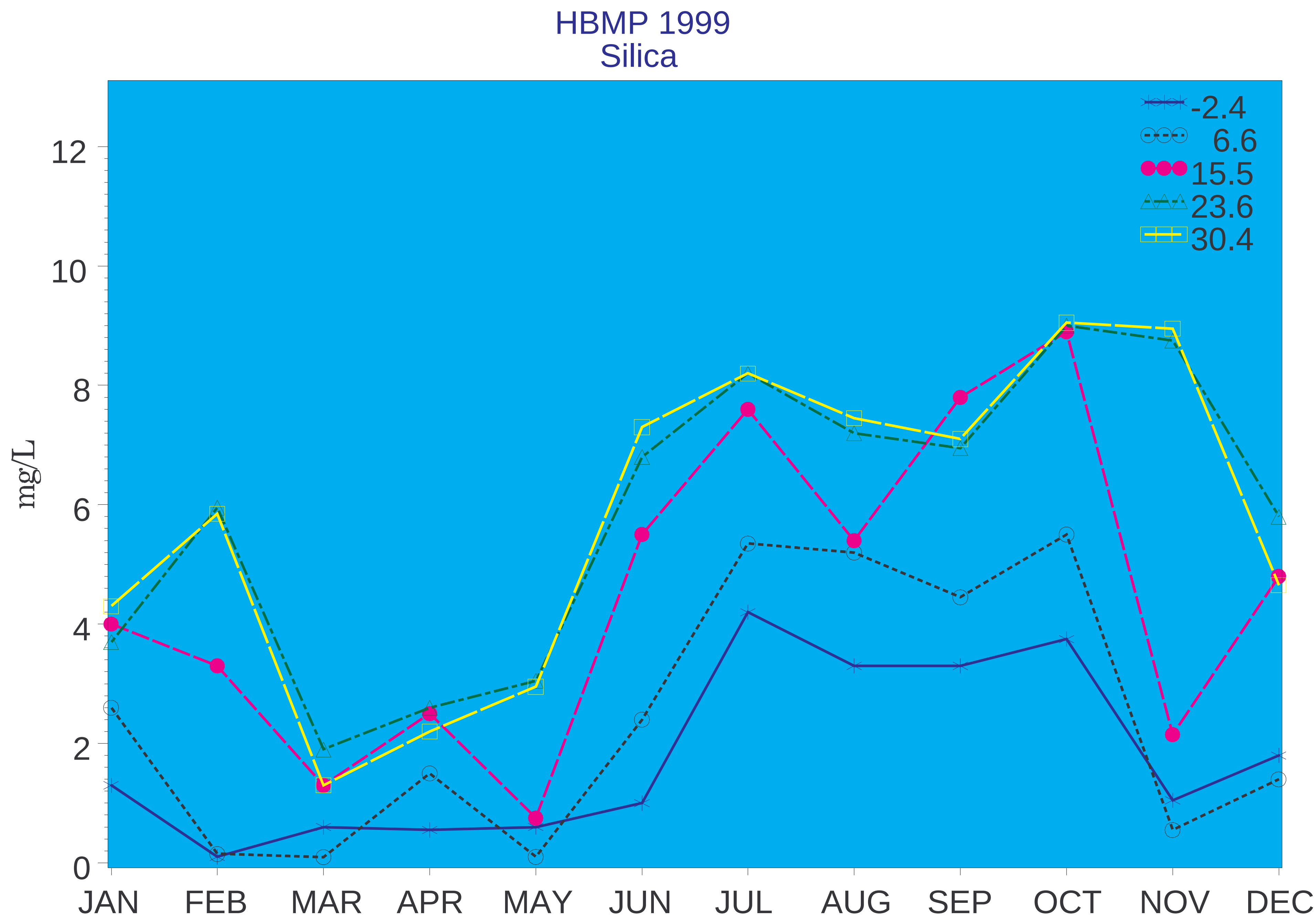

Figure 4.12 1999 Silica at fixed sampling stations.

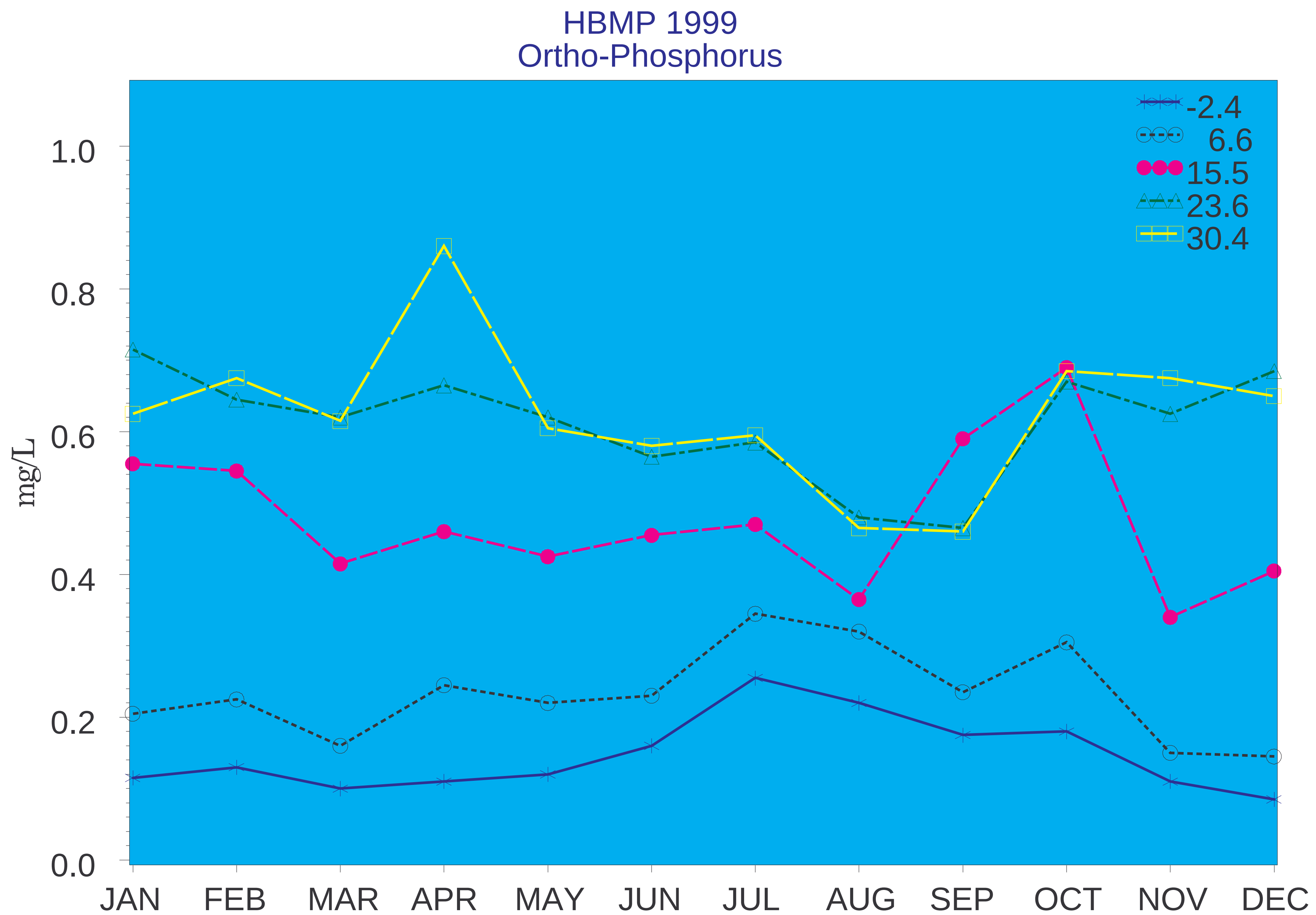

Figure 4.13 1999 Ortho-phosphorus at fixed sampling stations.

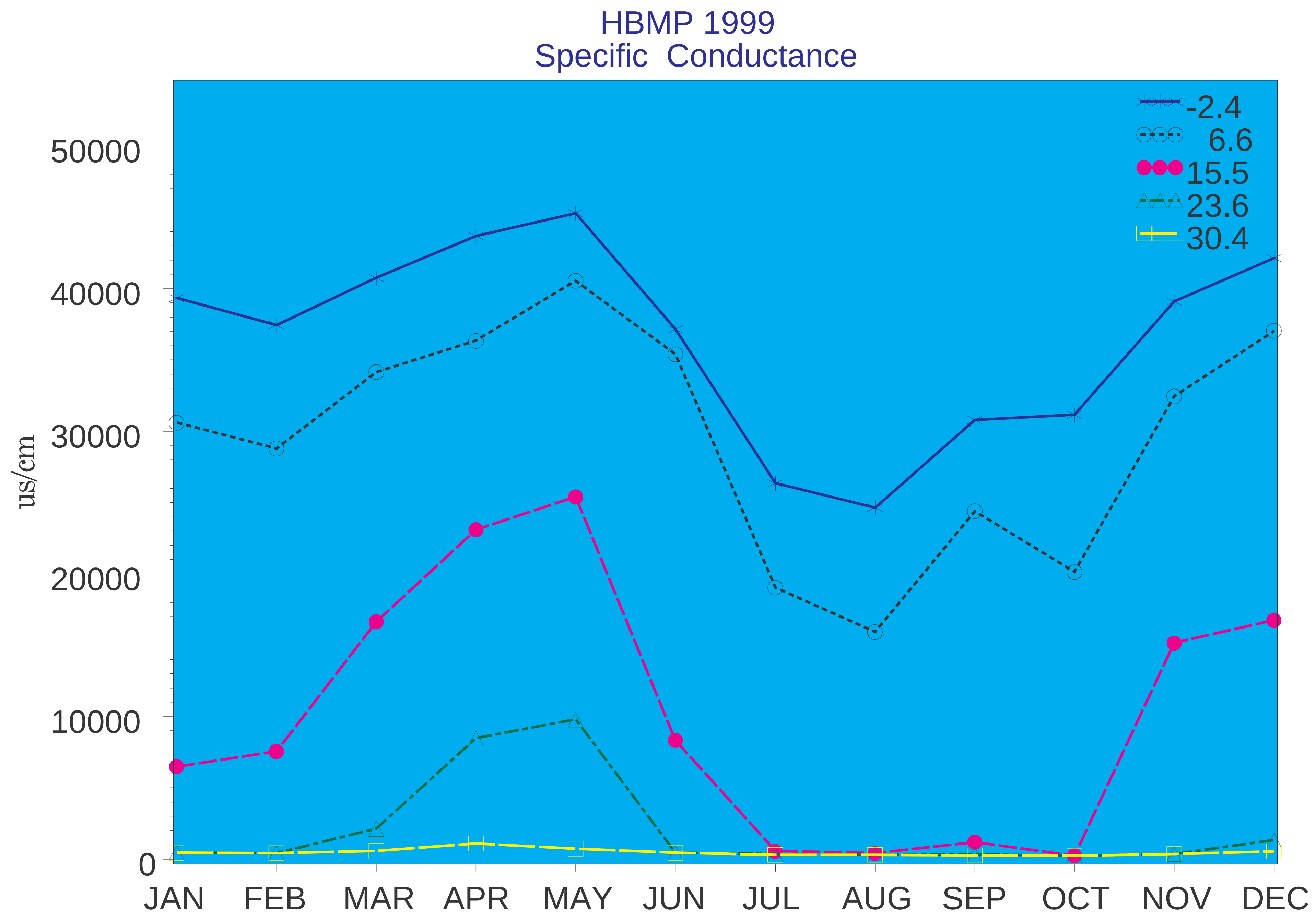

Figure 4.14 1999 Specific Conductance at fixed sampling stations.

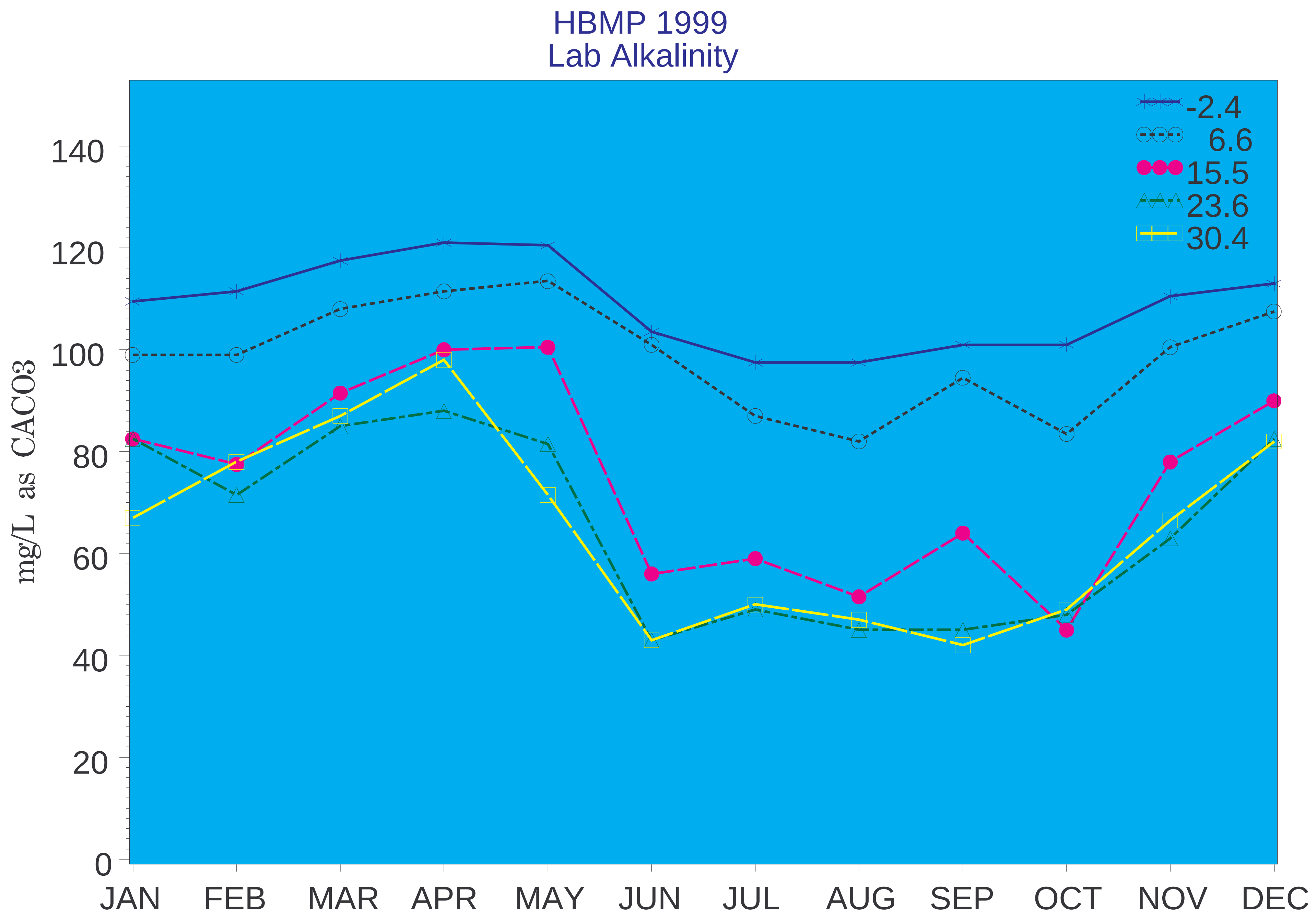

Figure 4.15 1999 Alkalinity at fixed sampling stations.

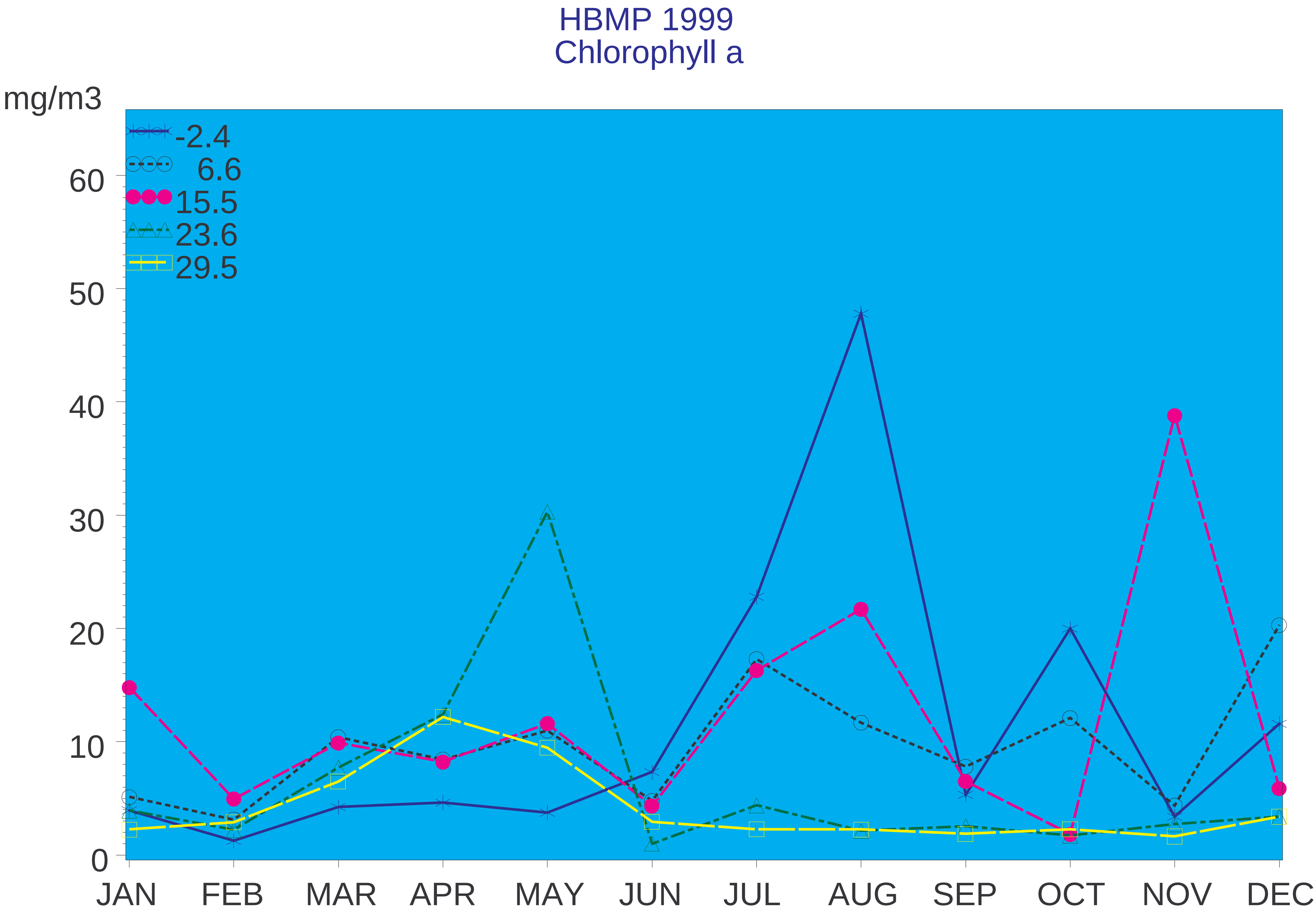

Figure 4.16 1999 Surface chlorophyll a (mg/m3) at fixed stations.

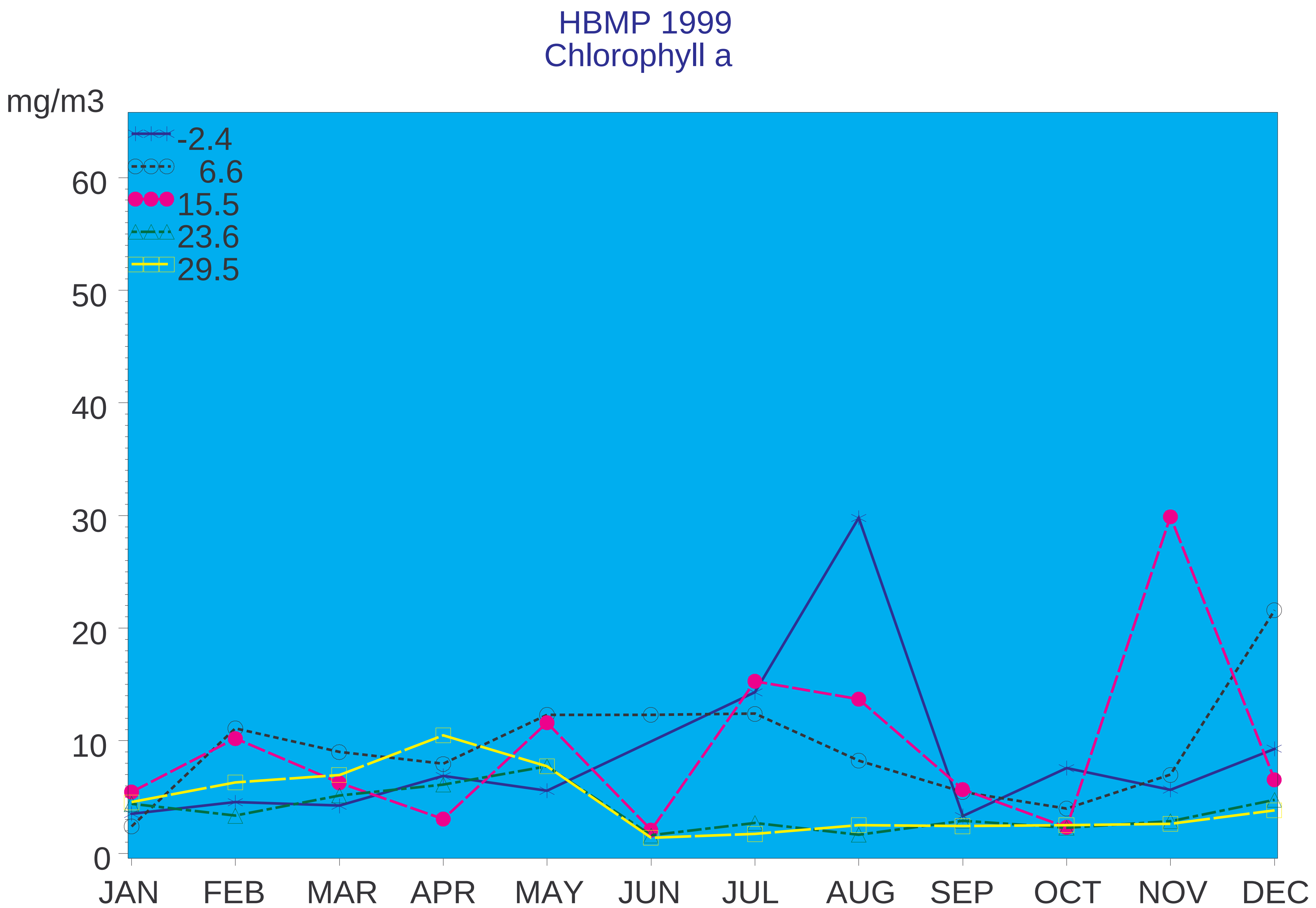

Figure 4.17 1999 Bottom chlorophyll a (mg/m3) at fixed stations.

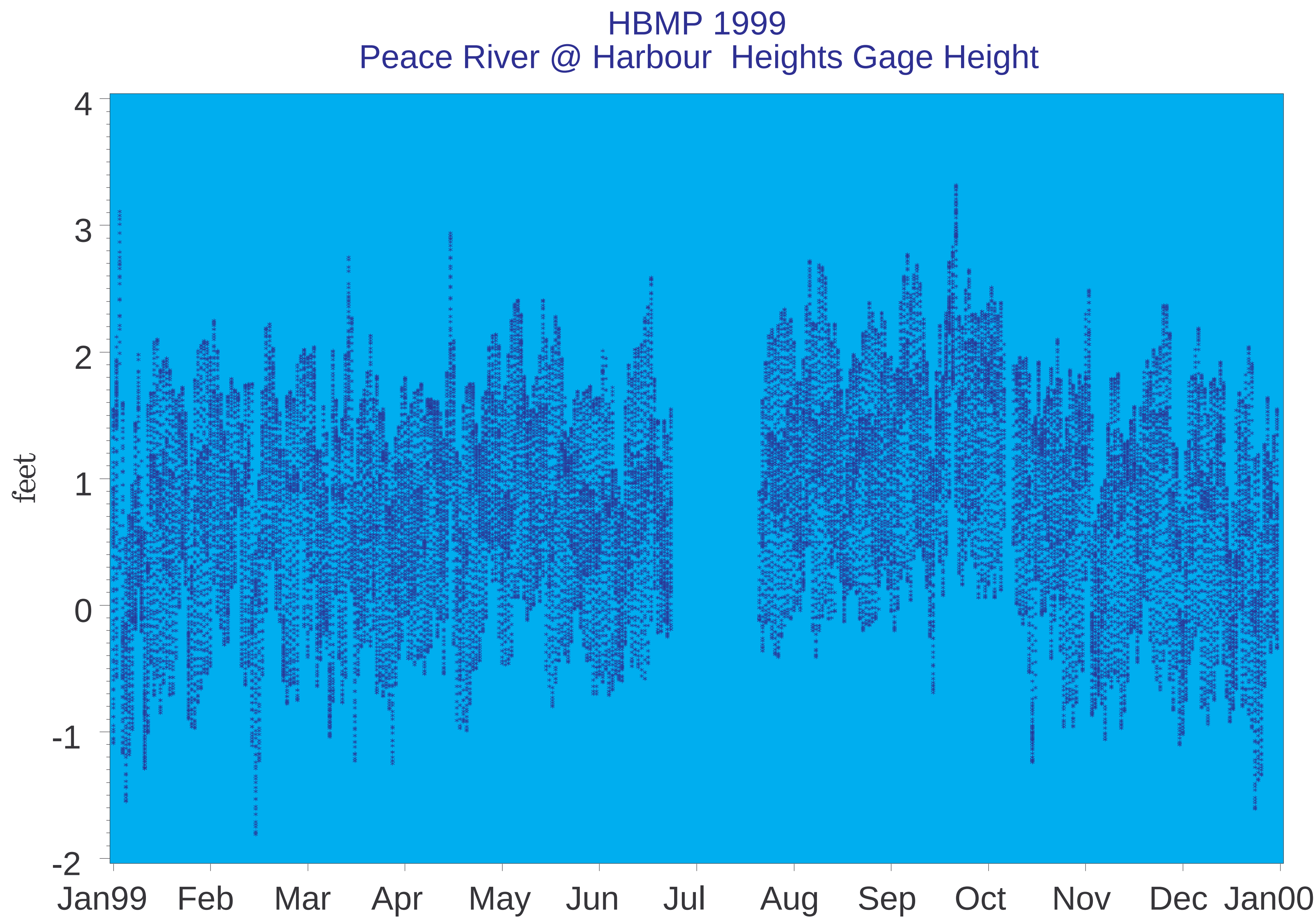

Figure 4.18 Gage height (15-min intervals) for Peace River fixed station 02297460 (River Kilometer=15.5).

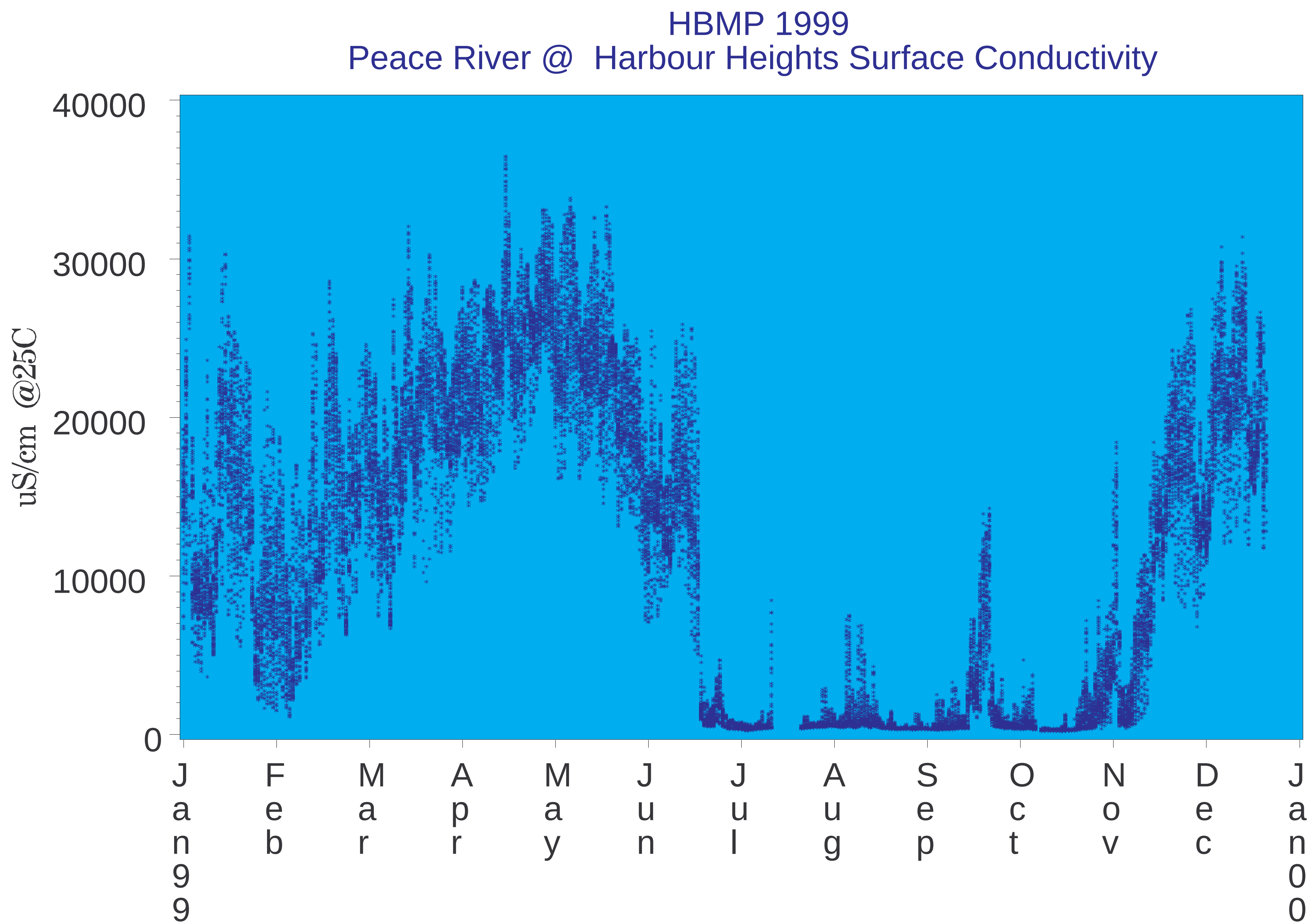

Figure 4.19 Surface conductivity (15-min intervals) for Peace River fixed station 02297460 (River Kilometer=15.5).

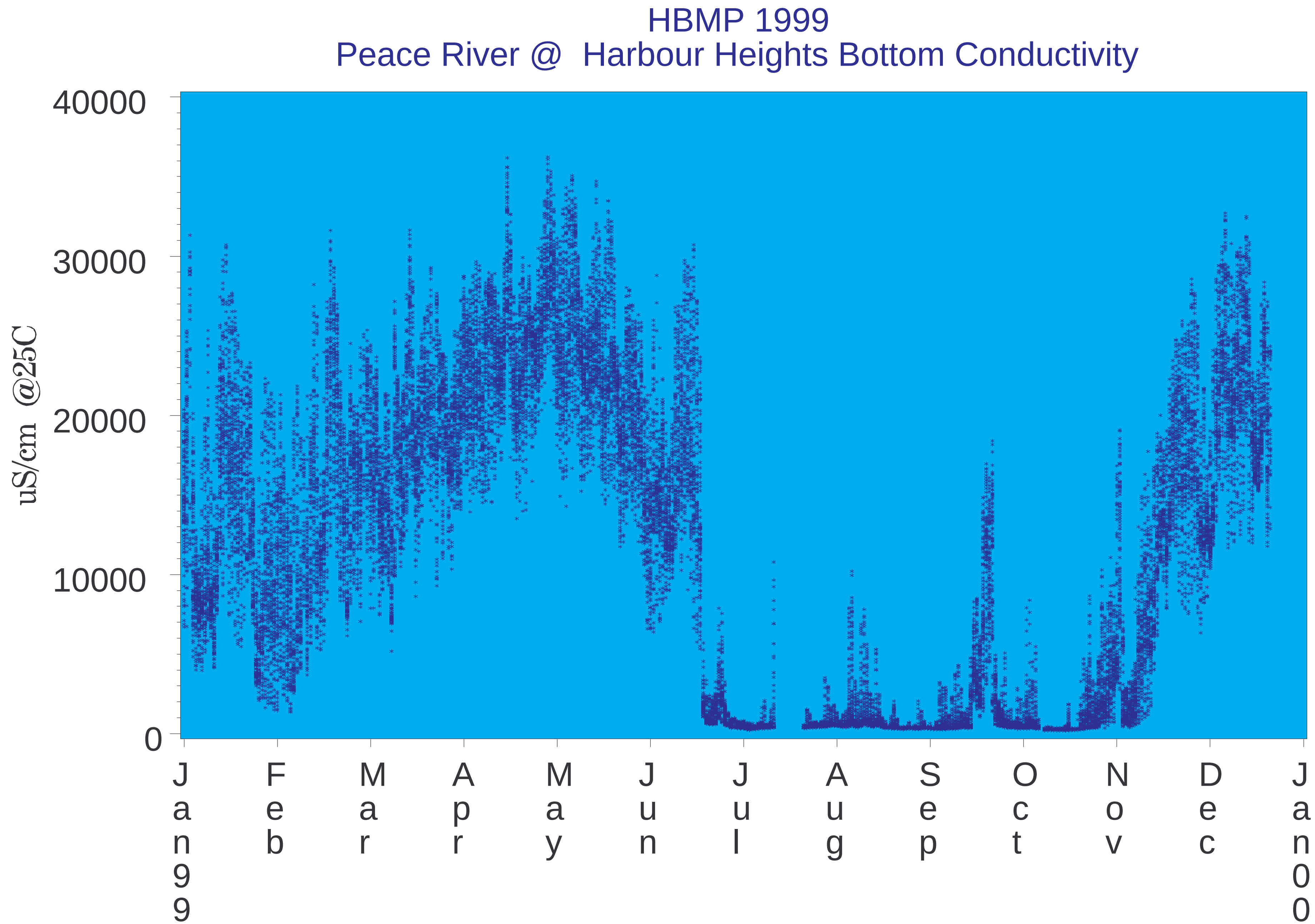

Figure 4.20 Bottom conductivity (15-min intervals) for Peace River fixed station 02297460 (River Kilometer=15.5).

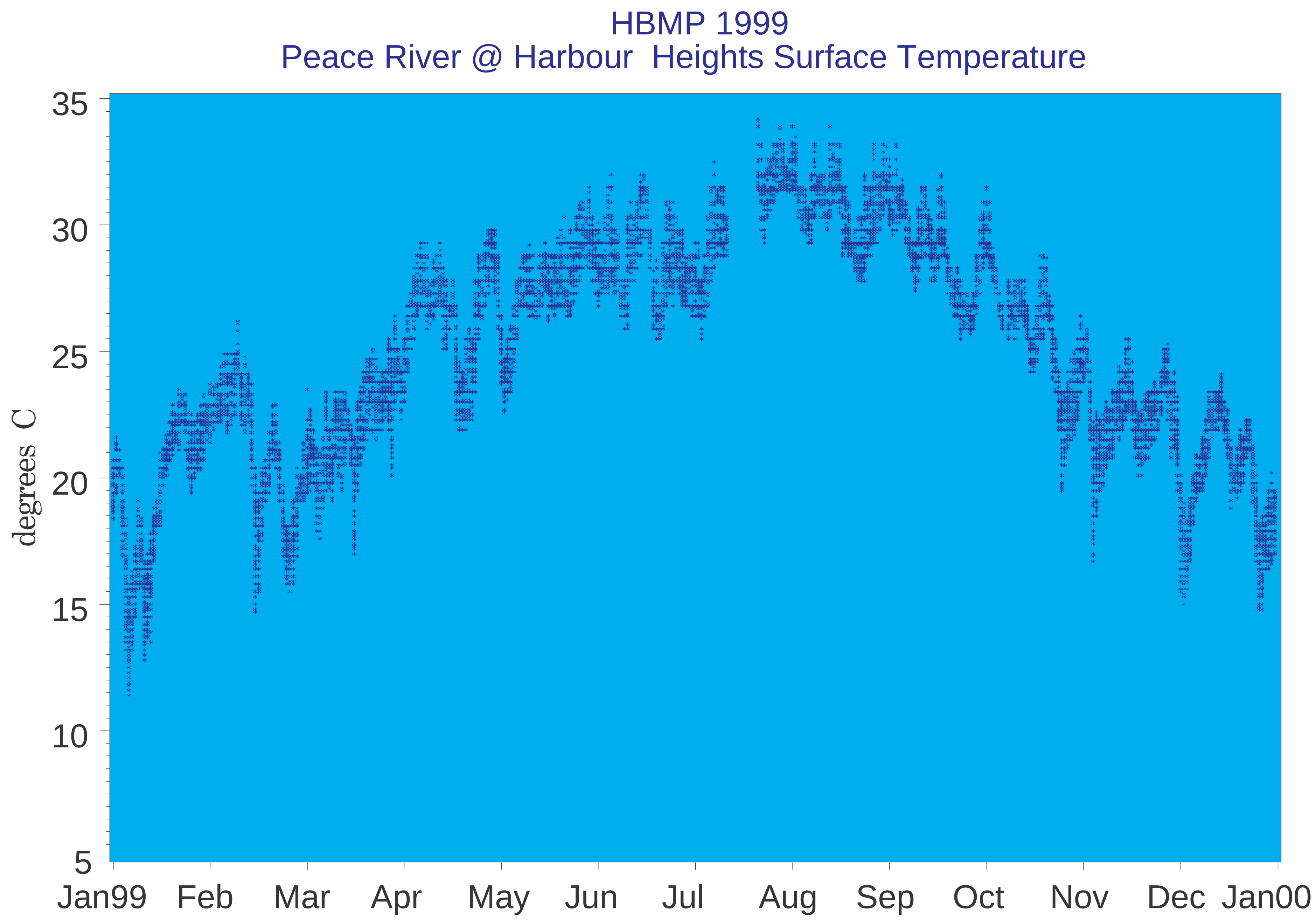

Figure 4.21 Surface temperature (15-min intervals) for Peace River fixed station 02297460 (River Kilometer=15.5).

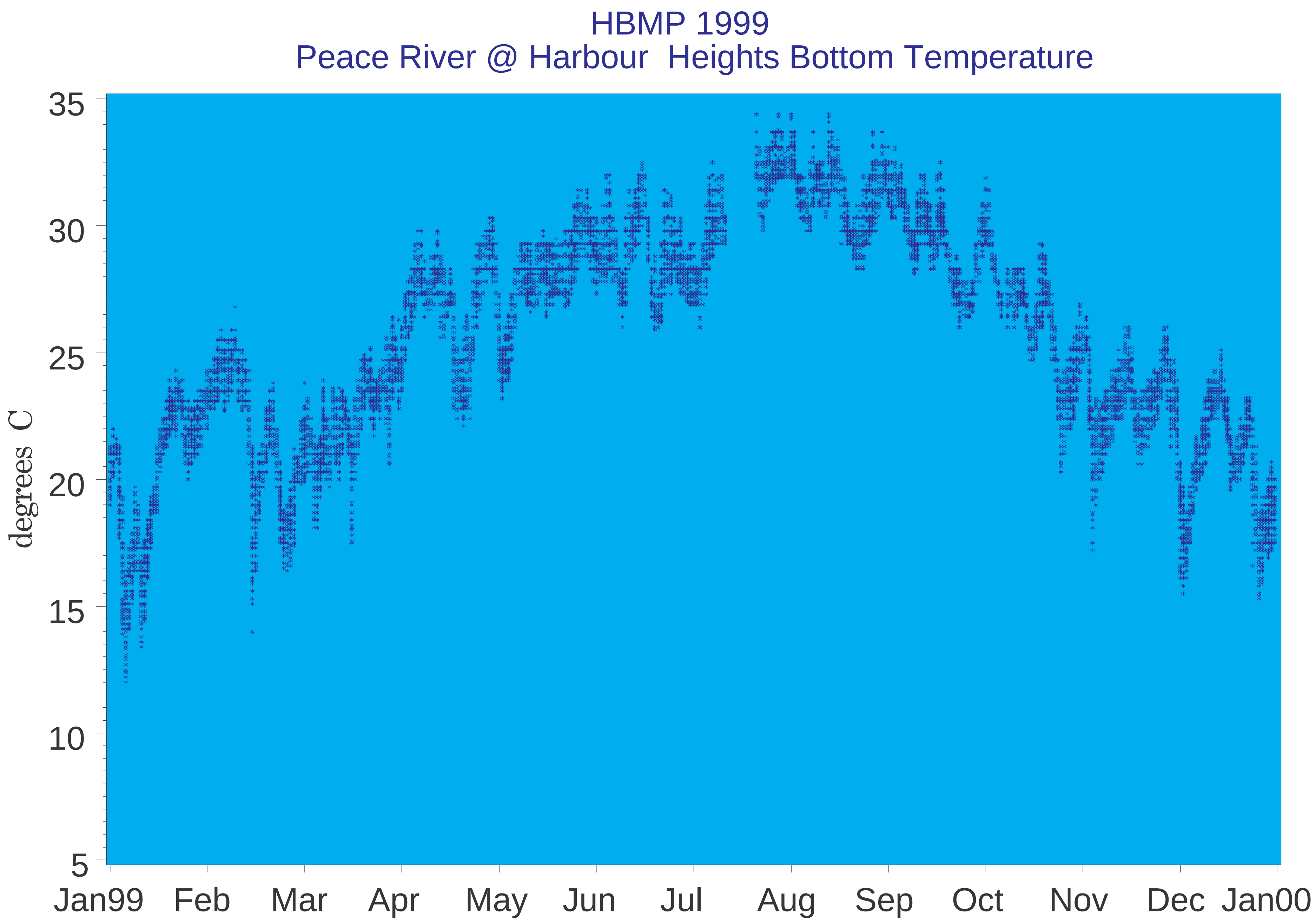

Figure 4.22 Bottom temperature (15-min intervals) for Peace River fixed station 02297460 (River Kilometer=15.5).

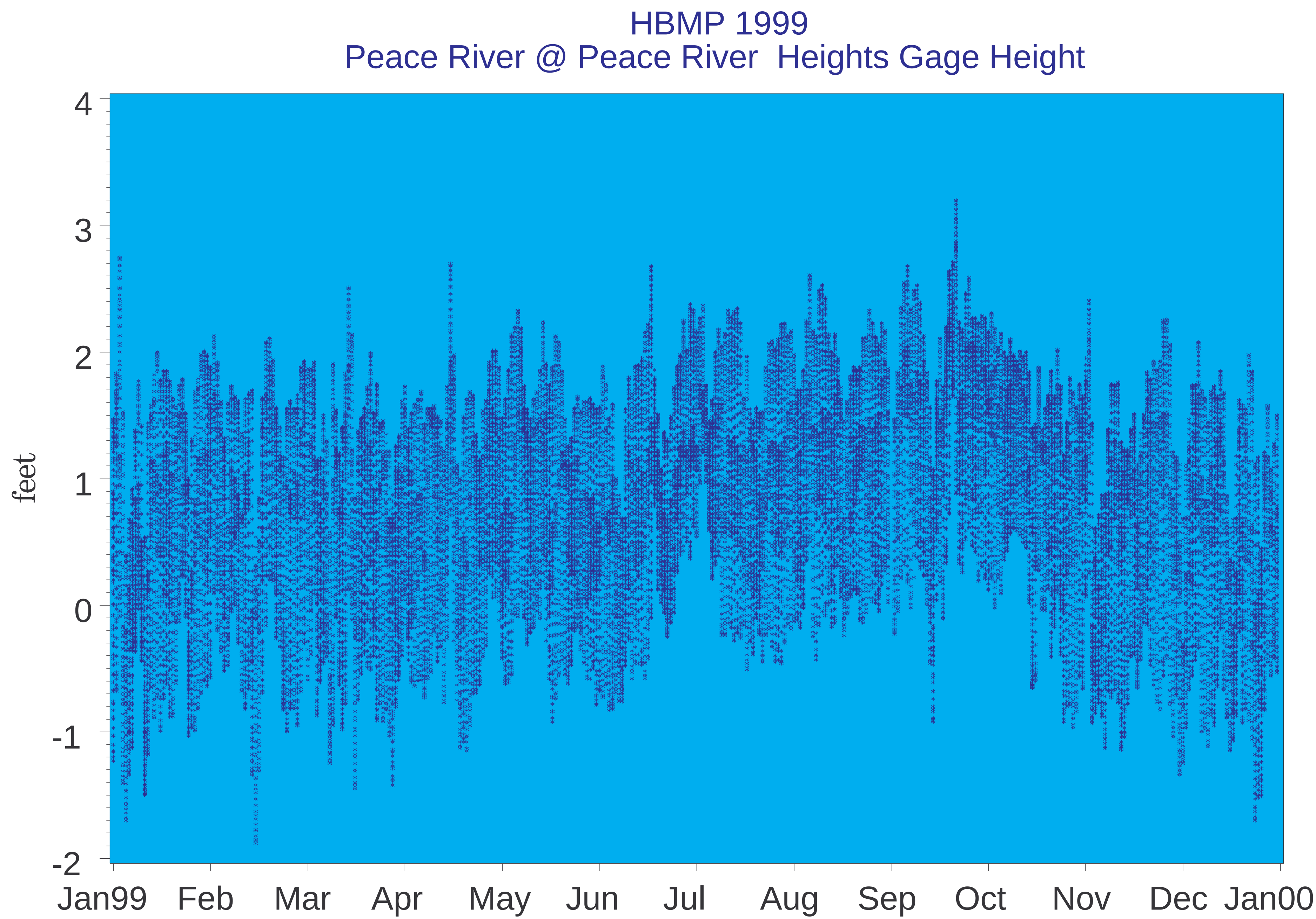

Figure 4.23 Gage height (15-min intervals) for Peace River fixed station 02297350 (River Kilometer=26.7).

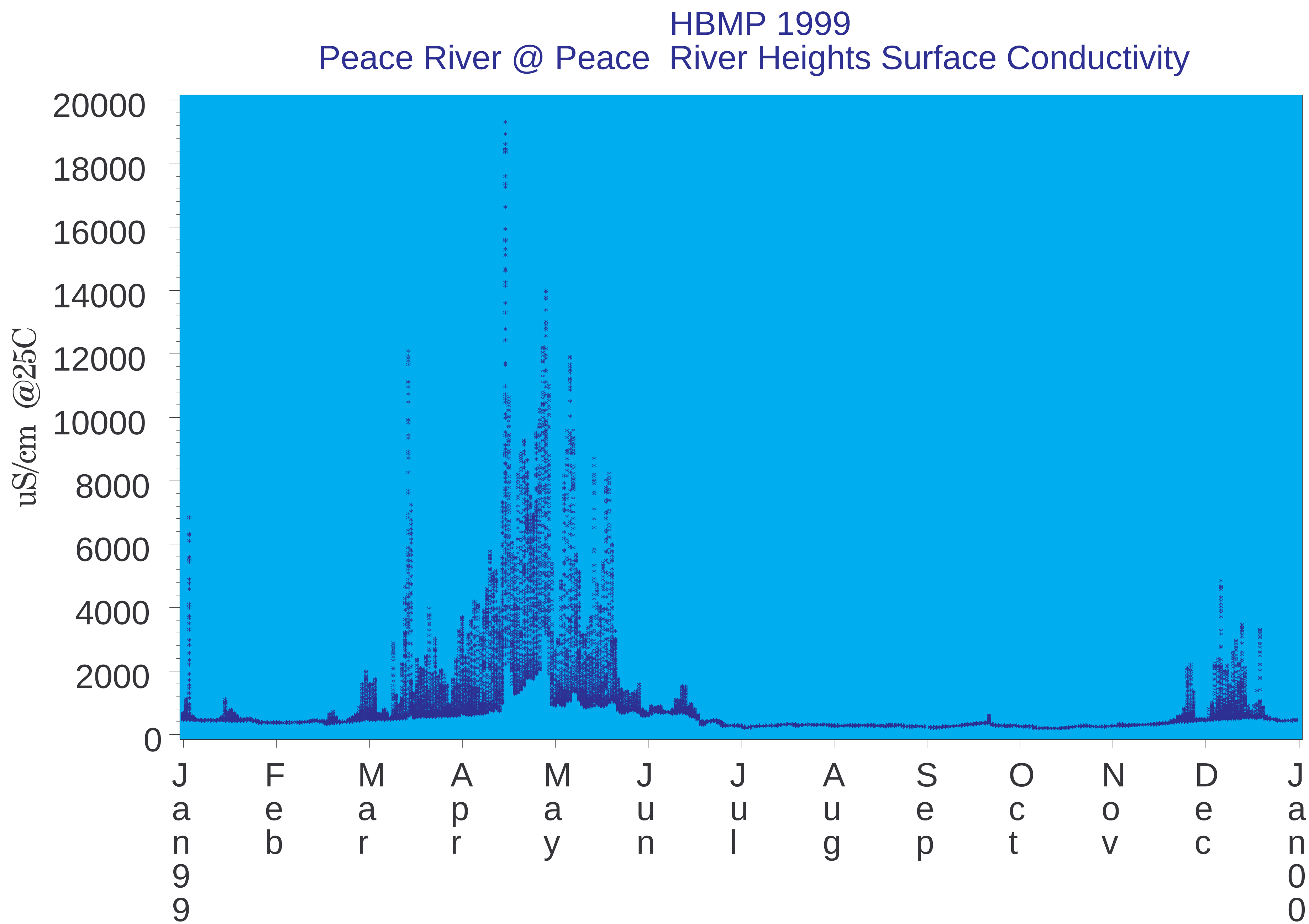

Figure 4.24 Surface conductivity (15-min intervals) for Peace River fixed station 02297350 (River Kilometer=26.7).

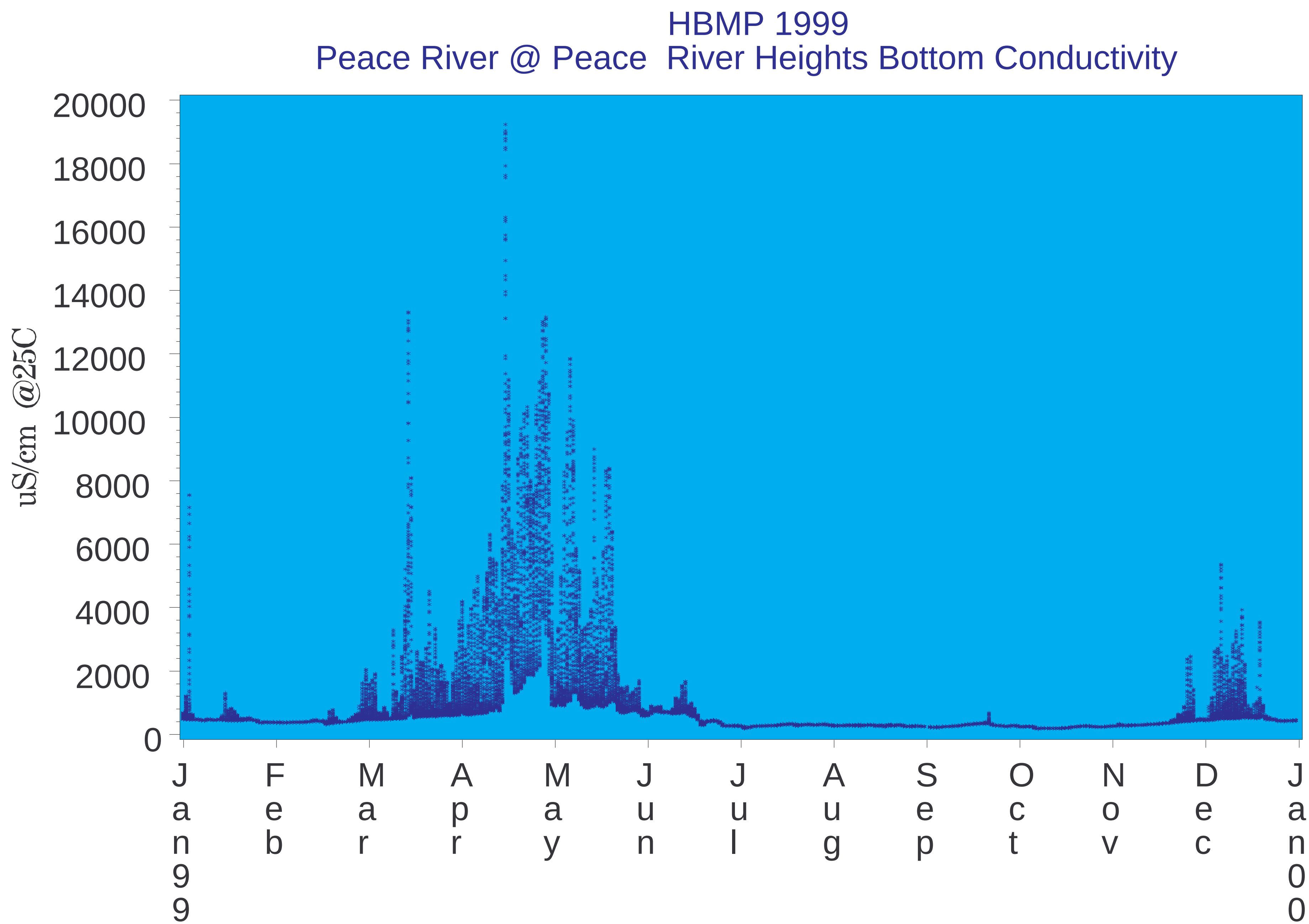

Figure 4.25 Bottom conductivity (15-min intervals) for Peace River fixed station 02297350 (River Kilometer=26.7).

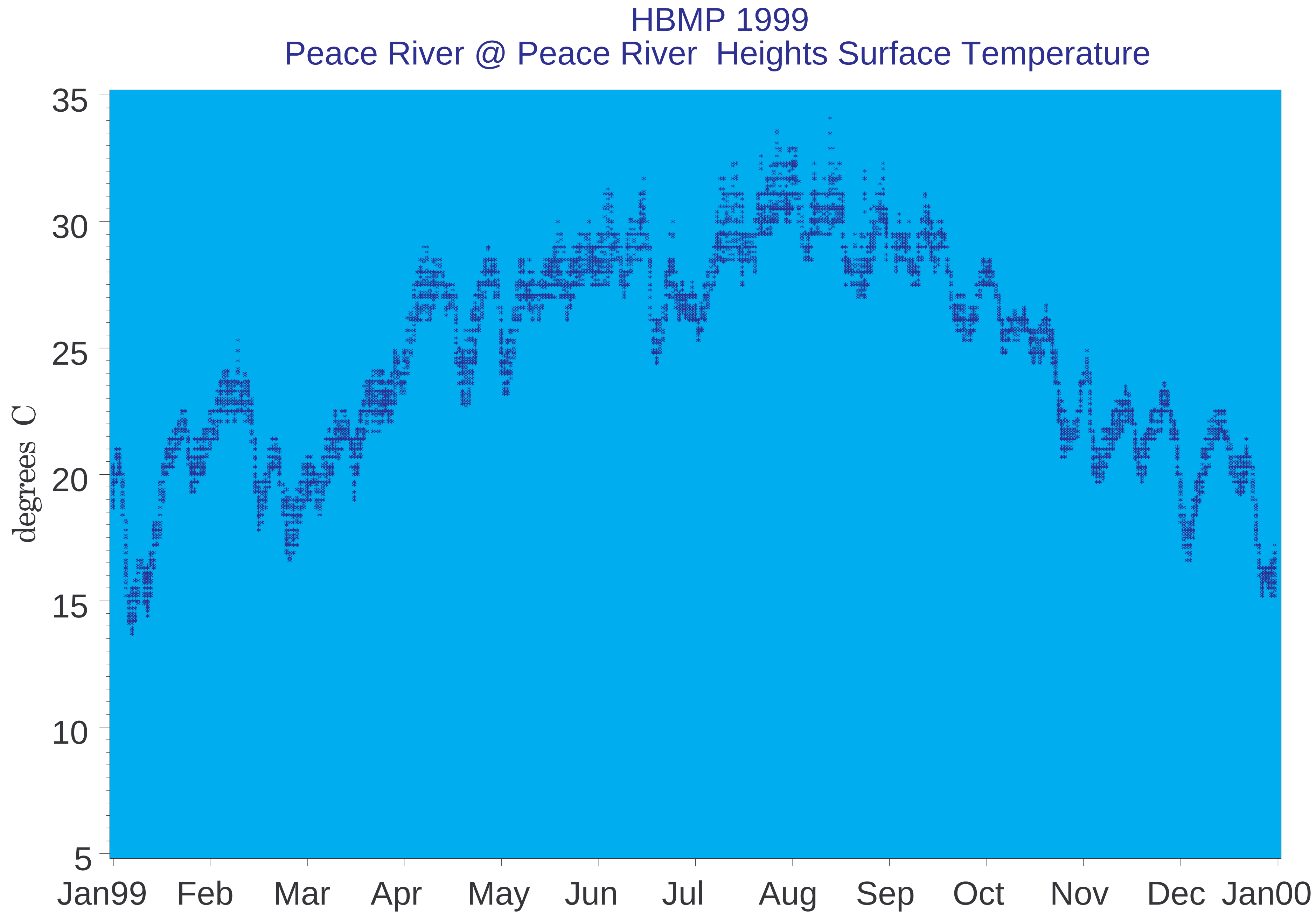

Figure 4.26 Surface temperature (15-min intervals) for Peace River fixed station 02297350 (River Kilometer=26.7).

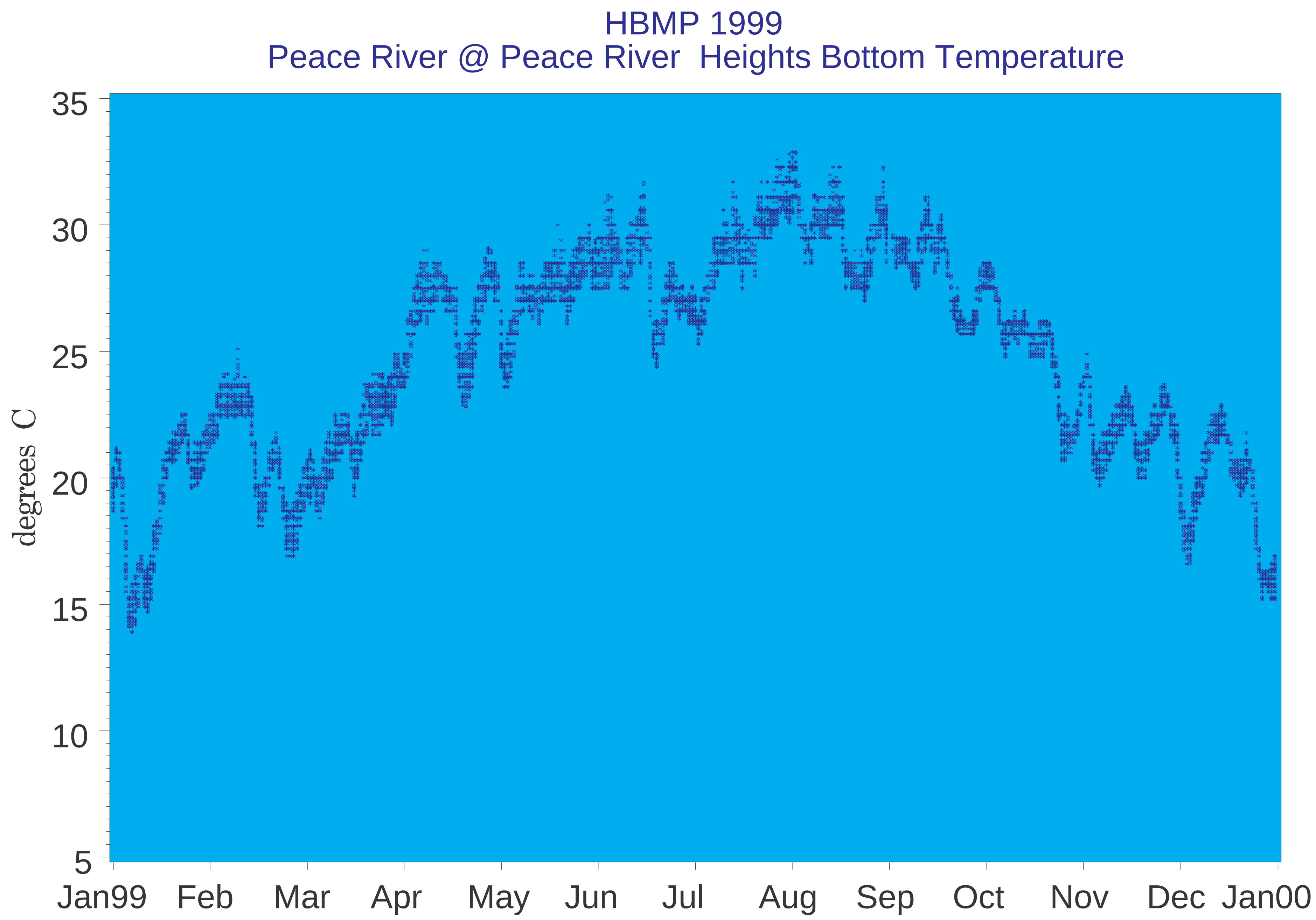

Figure 4.27 Bottom temperature (15-min intervals) for Peace River fixed station 02297350 (River Kilometer=26.7).

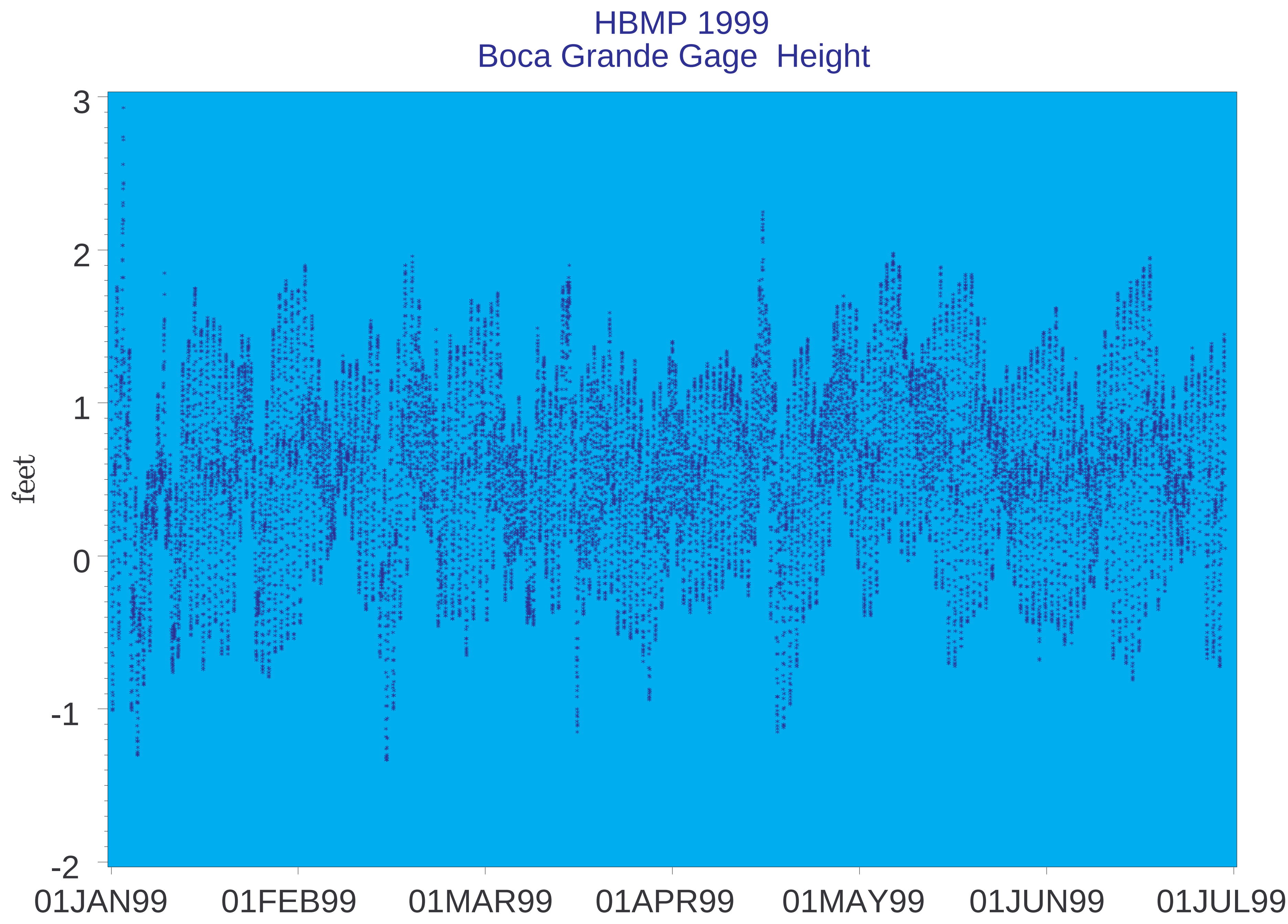

Figure 4.28a Gage Height (15-minute intervals) for Boca Grande.

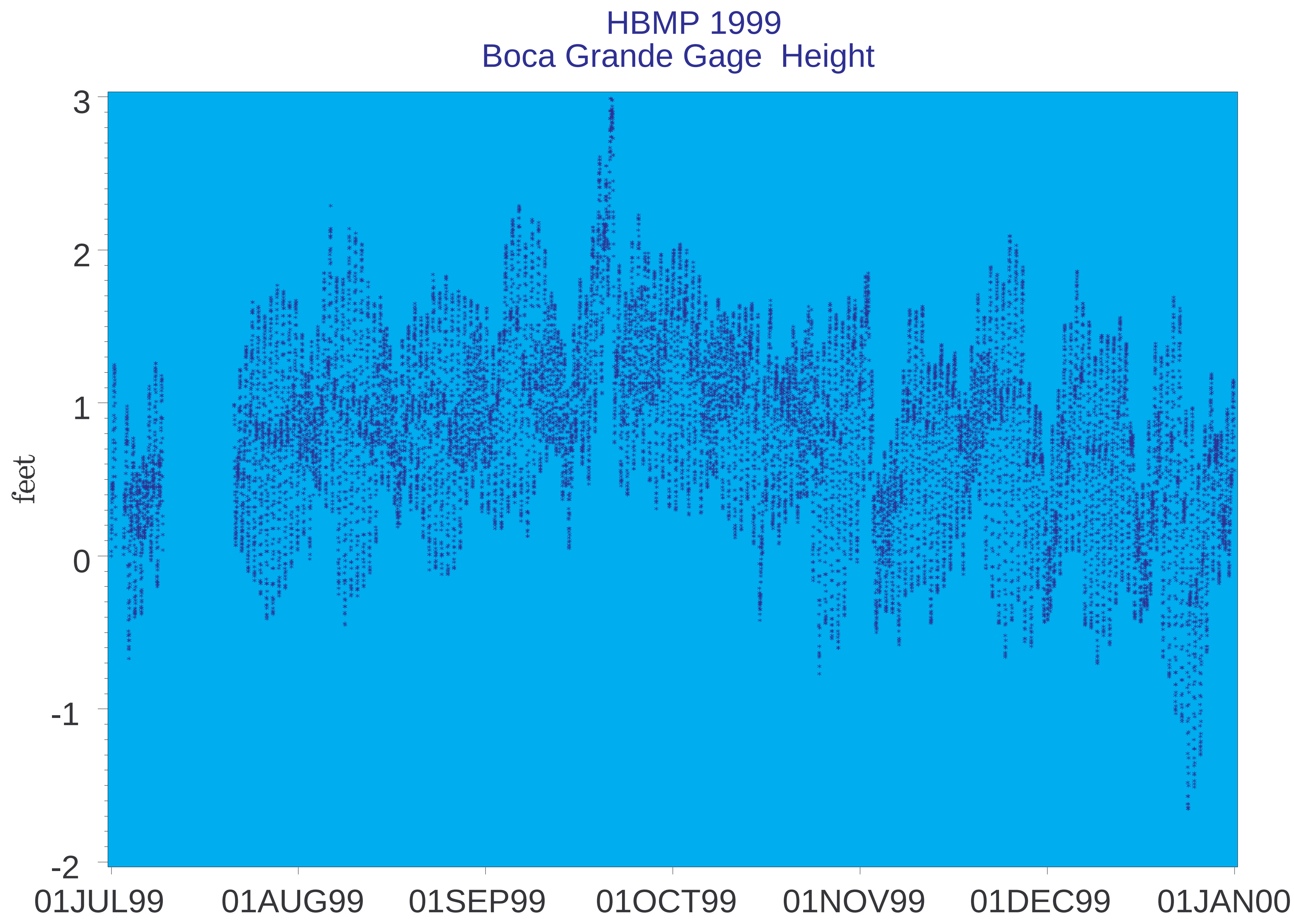

Figure 4.28b Gage Height (15-minute intervals) for Boca Grande.

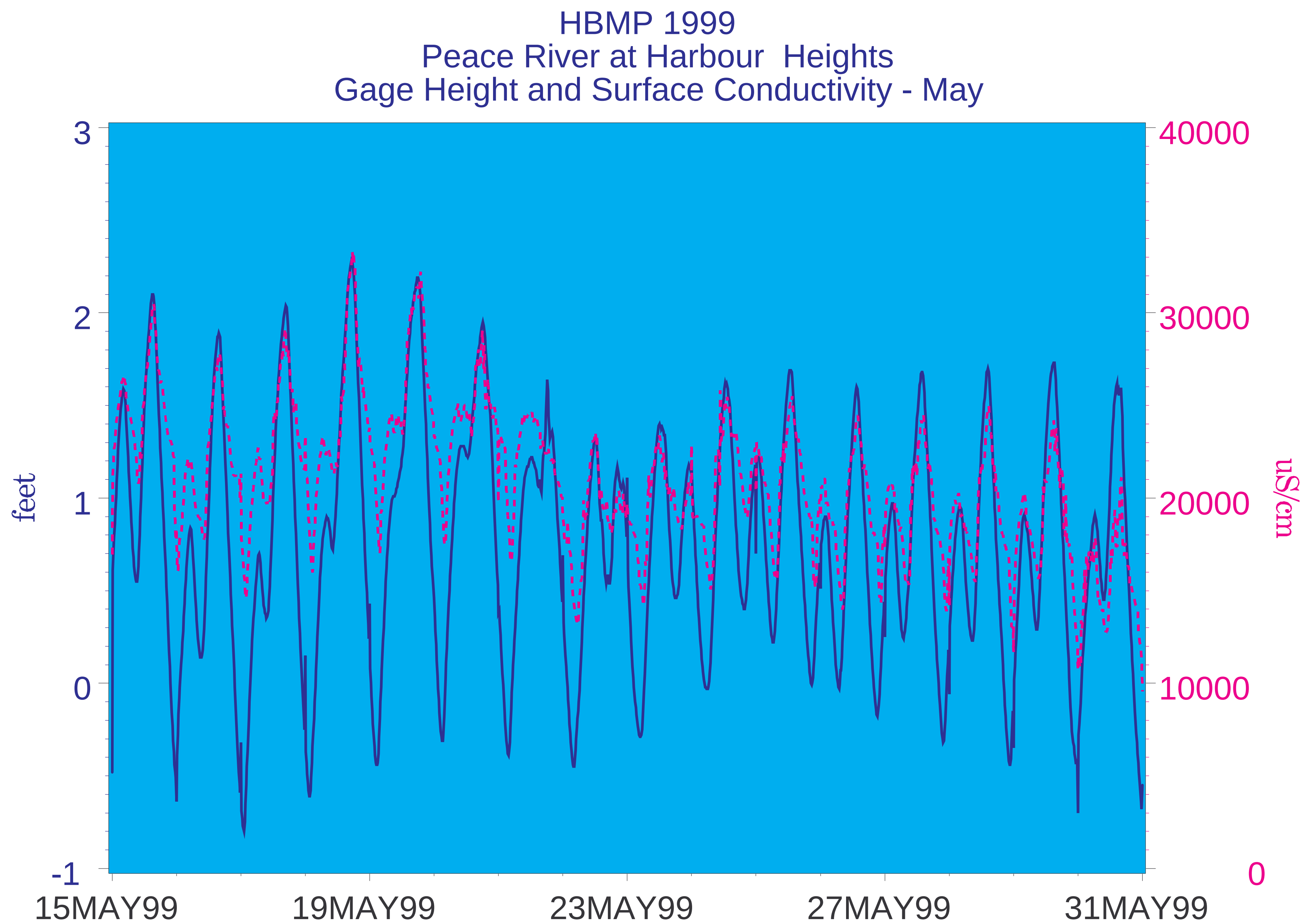

Figure 4.29 Surface in May- Station 02297460 (River Kilometer 15.5)

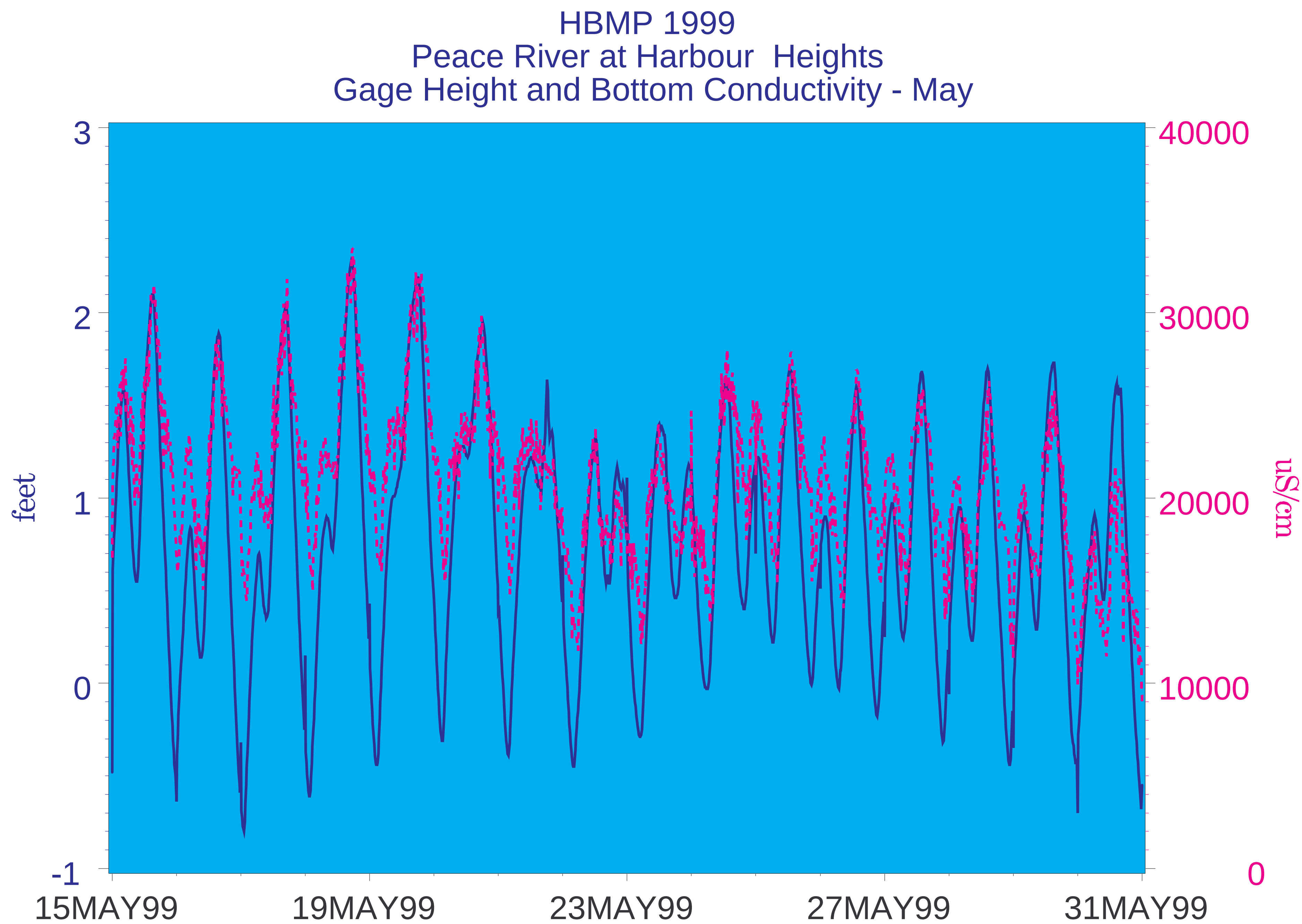

Figure 4.30 Bottom in May - Station 02297460 (River Kilometer 15.5)

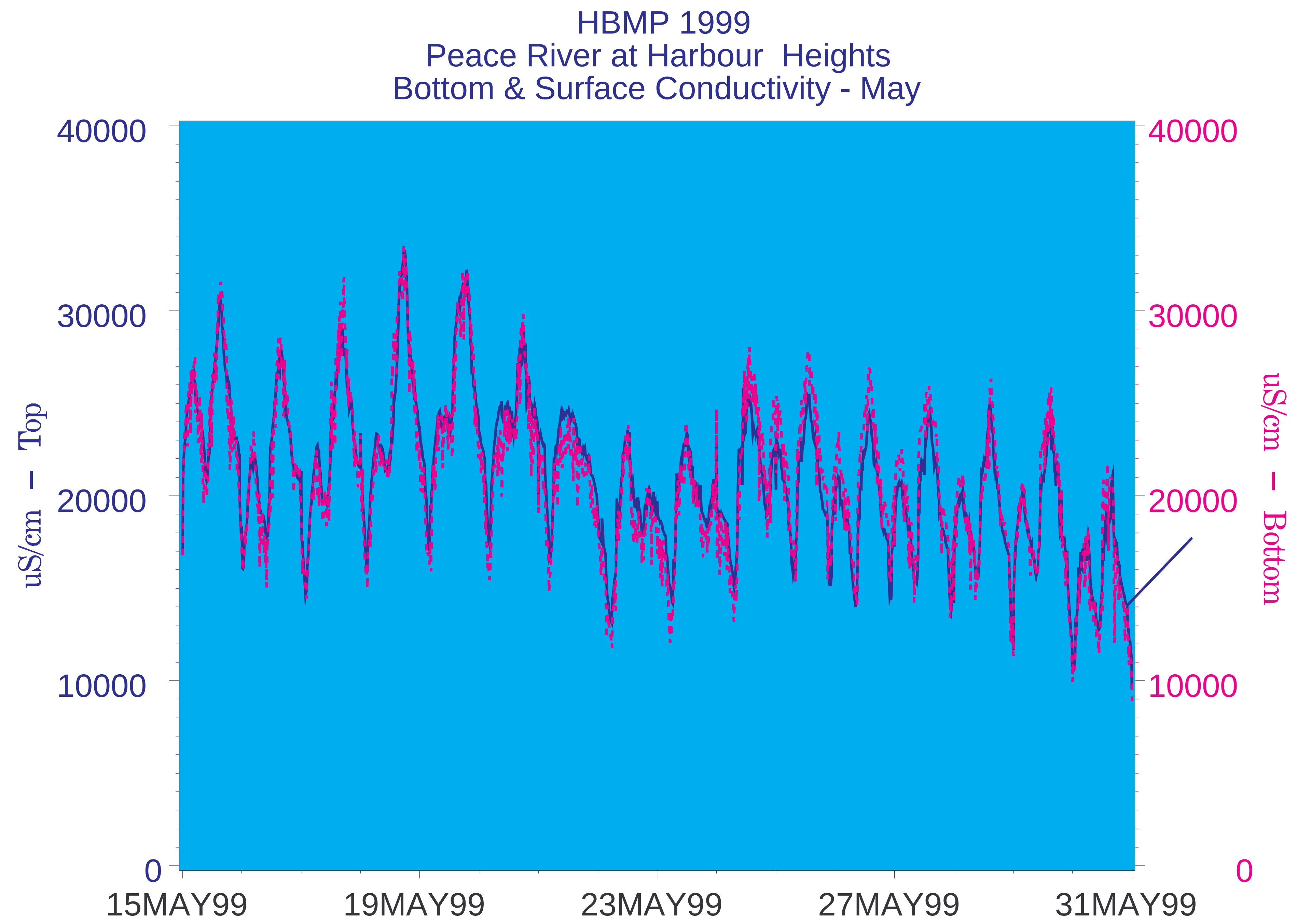

Figure 4.31 Surface & Bottom Conductivity in May - Station 02297460 (River Kilometer 15.5)

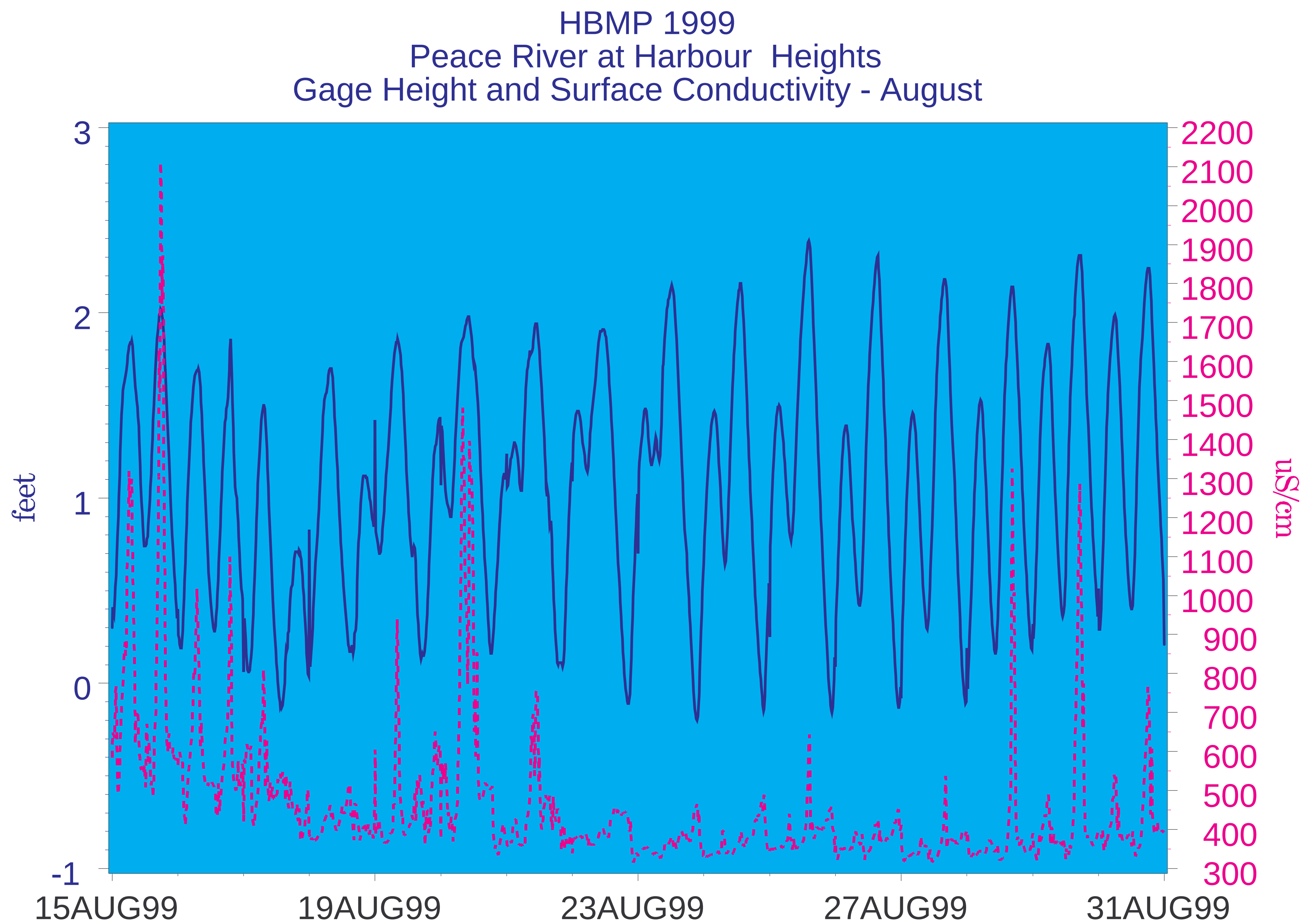

Figure 4.32 Surface in August - Station 02297460 (River Kilometer 15.5)

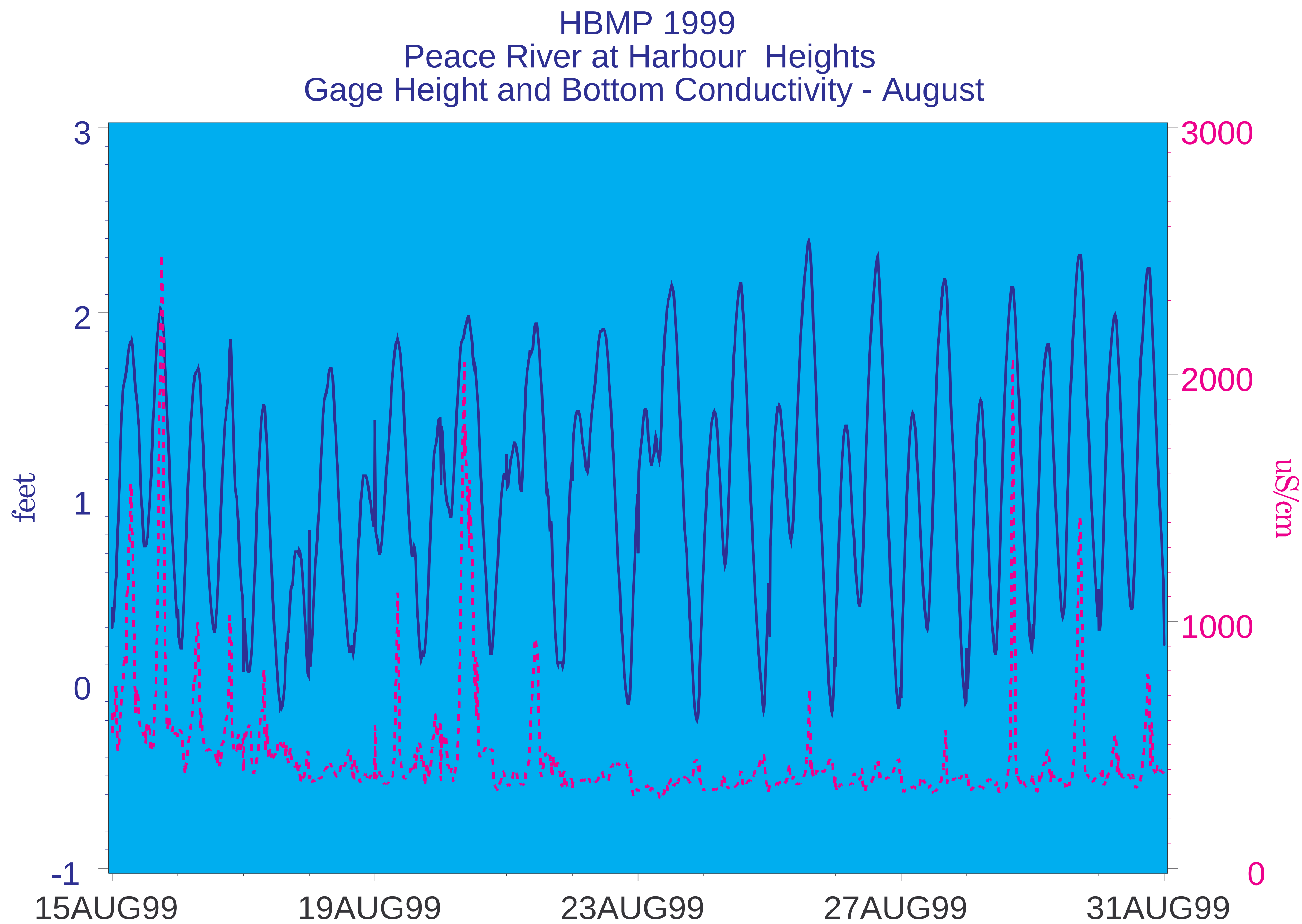

Figure 4.33 Bottom in August - Station 02297460 (River Kilometer 15.5)

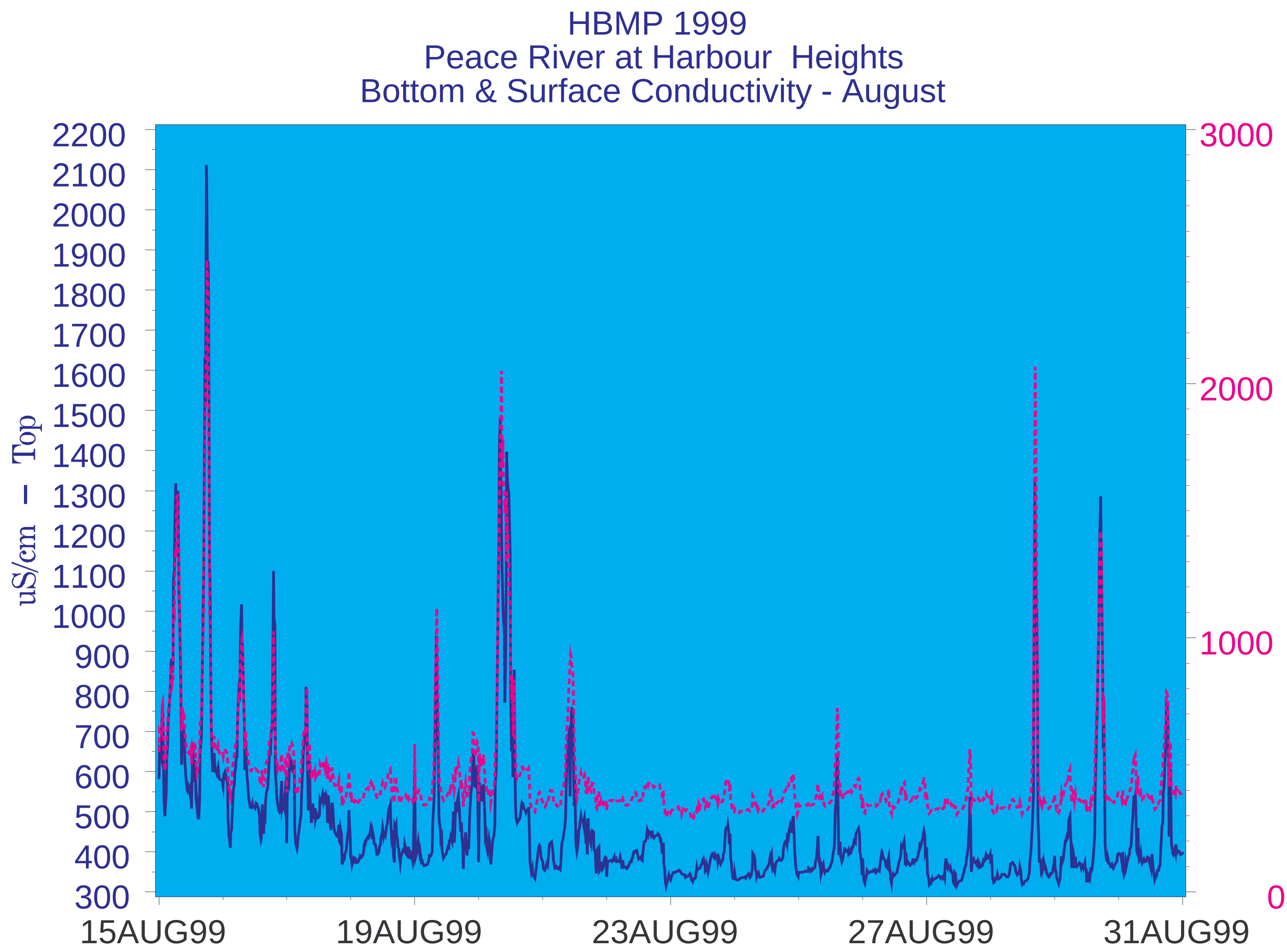

Figure 4.34 Surface & Bottom Conductivity in August - Station 02297460 (River Kilometer 15.5)

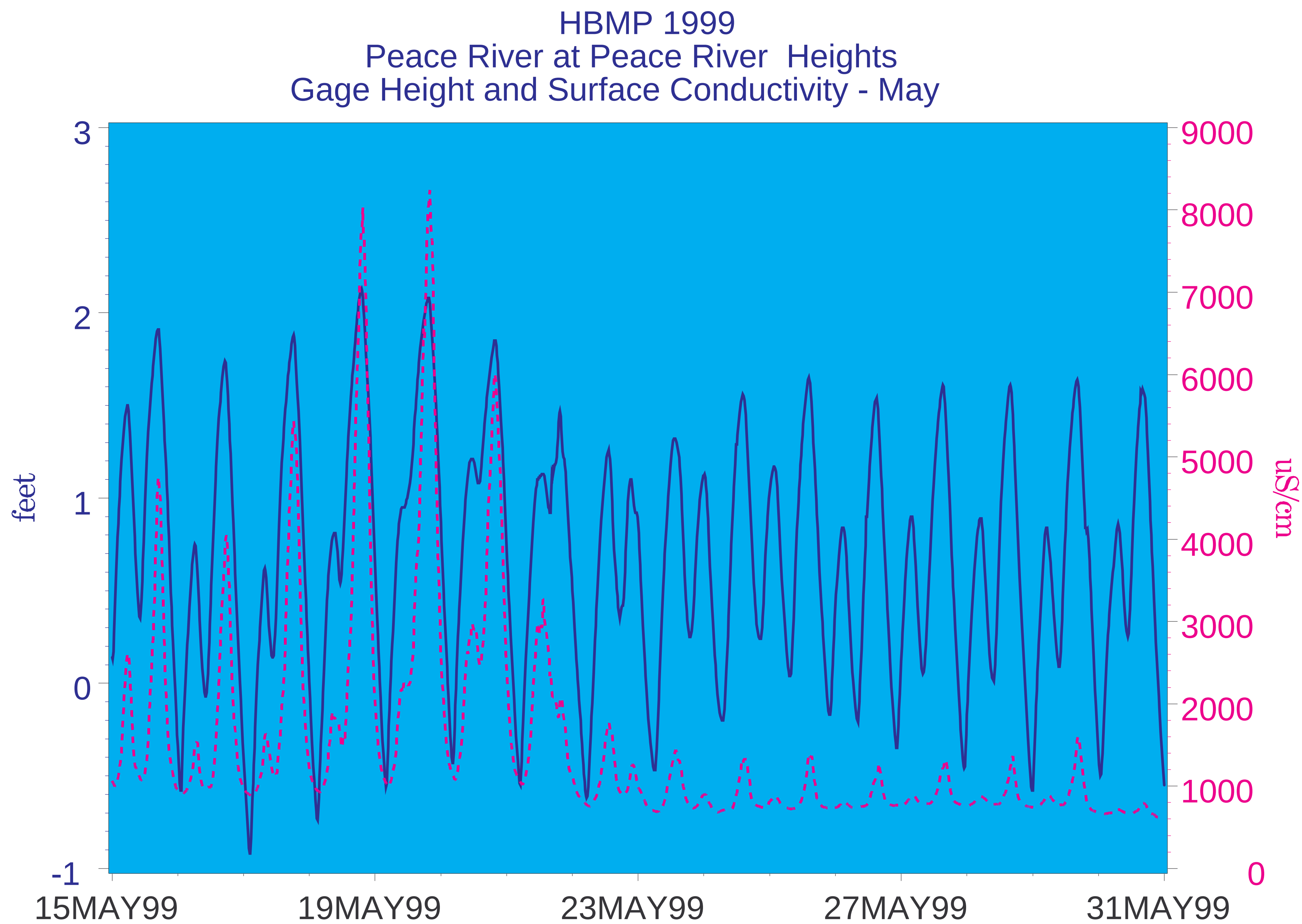

Figure 4.35 Surface in May - Station 02297350 (River Kilometer 26.7)

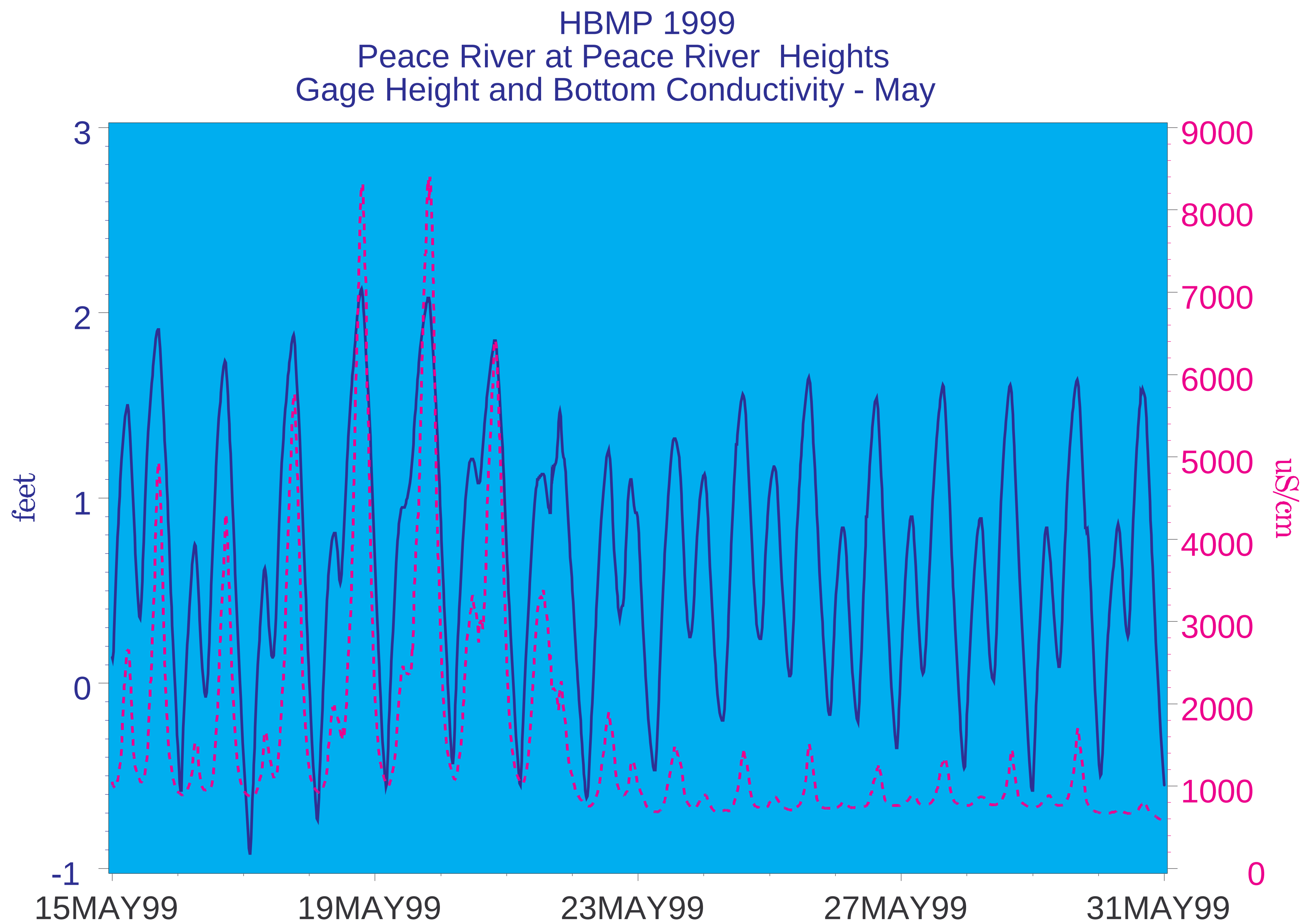

Figure 4.36 Bottom in May - Station 02297350 (River Kilometer 26.7)

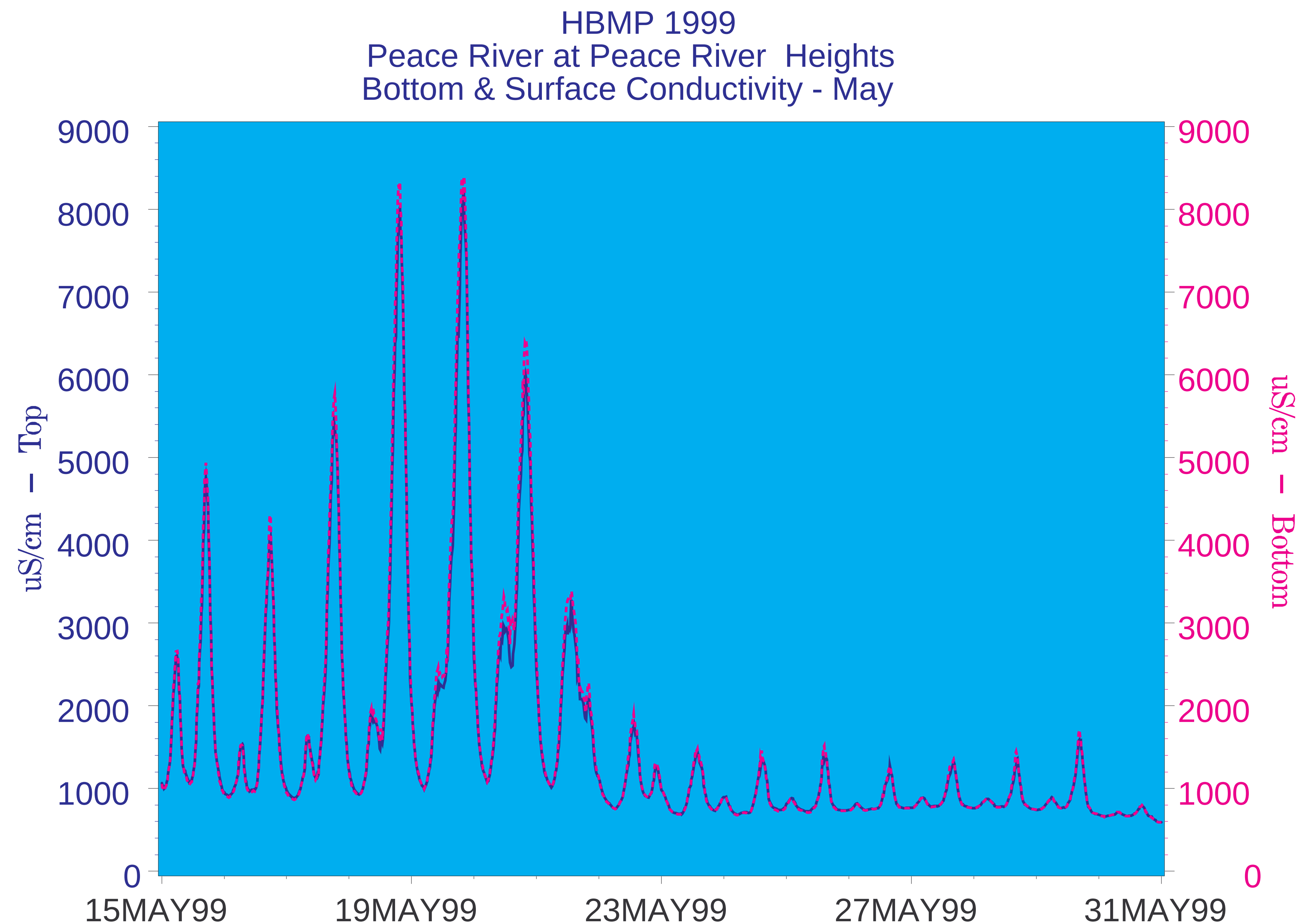

Figure 4.37 Surface & Bottom Conductivity in May - Station 02297350 (River Kilometer 26.7)

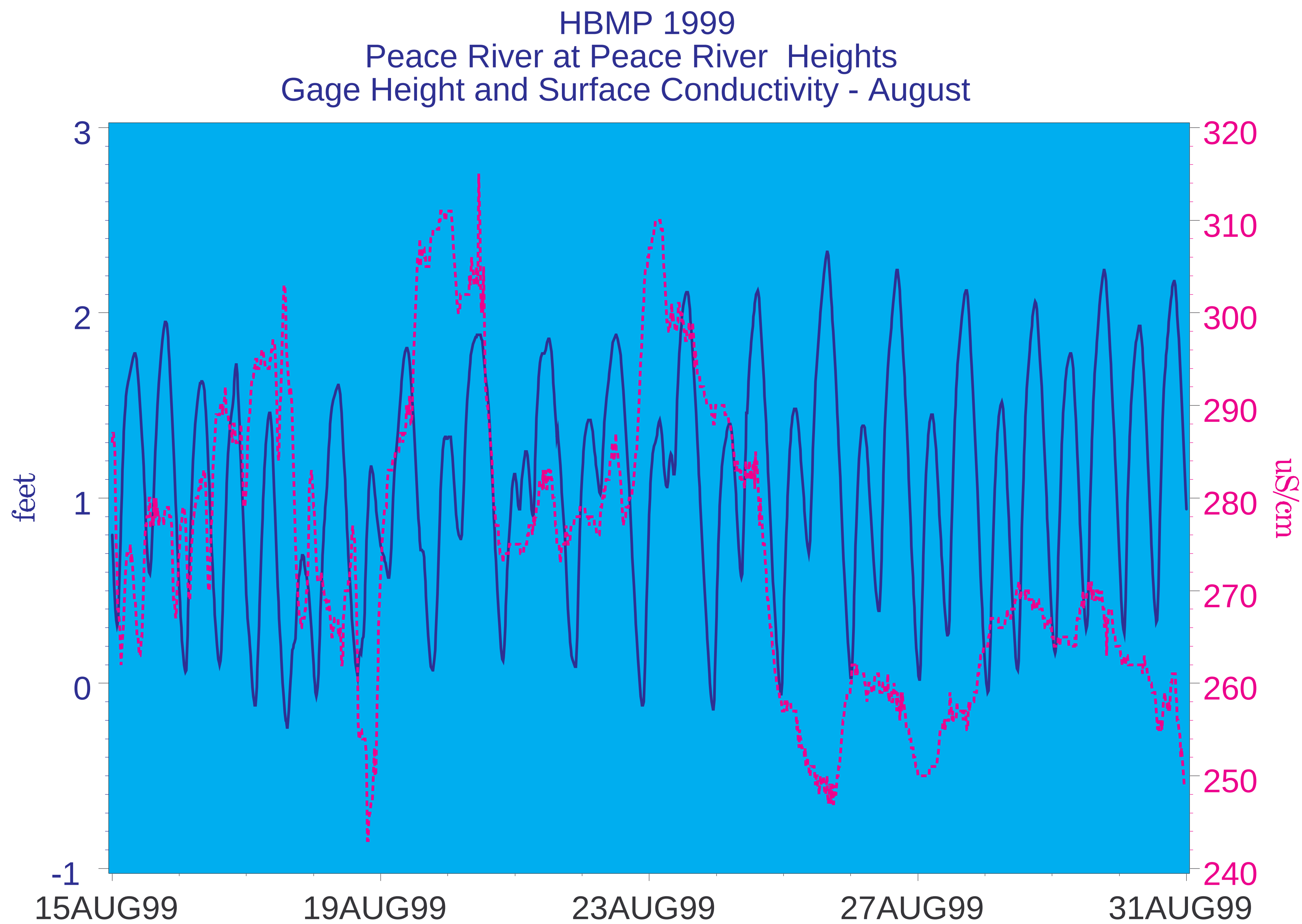

Figure 4.38 Surface in August - Station 02297350 (River Kilometer 26.7)

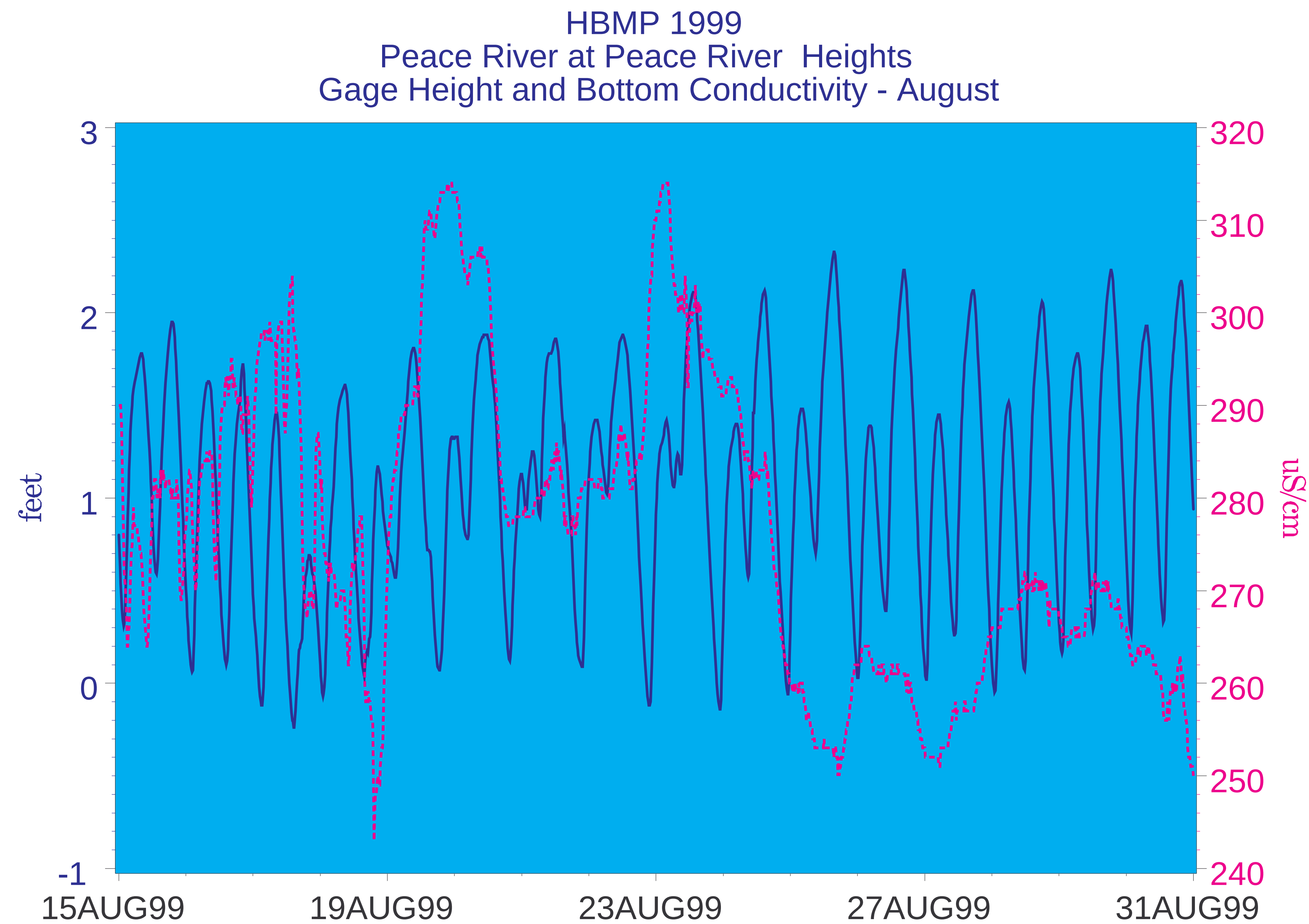

Figure 4.39 Bottom in August - Station 02297350 (River Kilometer 26.7)

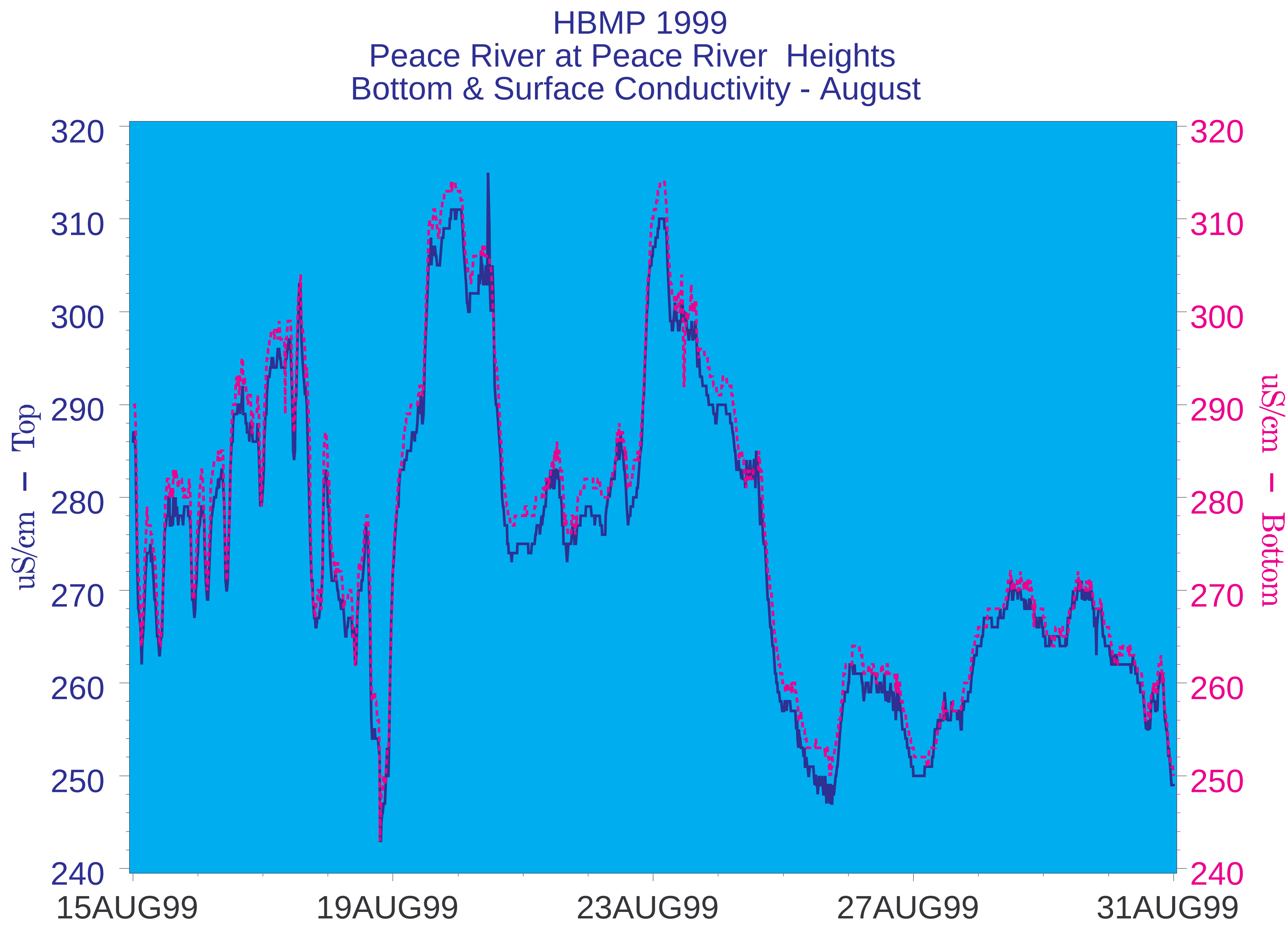

Figure 4.40 Surface & Bottom Conductivity in August - Station 02297350 (River Kilometer 26.7)

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