7.0 NUTRIENT CONDITIONS

7.1 Introduction

Historically, the Everglades ecosystem was nutrient poor, with phosphorus concentrations less than 10 ppb over large areas of the ecosystem (Davis and Ogden 1994). The hydrology of the marsh was predominantly precipitation driven, with lateral overland flows supplying a large proportion of the water to the southern half of the marsh. There were no canals in the Everglades region prior to the early part of the twentieth century.

Significant land use changes have occurred in the Everglades since the early1900s. Over 50% of the original marsh has been converted to agricultural, urban, and residential uses (Davis and Ogden 1994). The EAA for example, is located below Lake Okeechobee in areas that historically were freshwater Everglades marsh. To facilitate the conversion of marsh for agricultural production, a network of canals was constructed to drain the Everglades marsh, making these areas suitable for agricultural production and urban and residential development. Nutrient loading from the EAA and urban areas has significantly increased nutrient concentrations, particularly TP, in the downstream WCAs and ENP (Scheidt et al. 1989, Walker 1991, Walker 1995). This resulted in major eutrophic impacts to downstream wetland systems (Nearhoof 1992). Increased soil phosphorus content (Doren et al. 1996, DeBusk et al. 1994), altered periphyton communities (Raschke 1993, McCormick et al. 1996), loss of water column DO and changed aquatic community metabolism (Belanger et al. 1989, McCormick et al. 1998), conversion of wet prairie and sawgrass plant communities to cattail (Davis 1994, Jensen et al. 1995), and subsequent loss of important wading bird foraging habitat (Fleming et al. 1994, Hoffman et al. 1994) are examples of the progressive eutrophic impacts observed in the Everglades. These collective changes are systemic and impact the structure and function of the aquatic ecosystem (Belanger et al. 1989, Nearhoof 1992, McCormick et al. 1998). Increased nutrient concentrations, particularly TP concentrations, have also been hypothesized as being one of several variables that influences Hg methylation processes in the Everglades ecosystem (see Chapter 10.0 for hypotheses regarding TP and Hg methylation).

From 1994 through 1996, TP control strategies were implemented in the EAA through a combination of agricultural BMPs and construction of about 10% of the approximately 43,000 acres of constructed wetlands, known as STAs. The Everglades Nutrient Removal Project (ENR), which is the initial STA totaling 3,700 acres adjacent to the northwest corner of LNWR (Figure 1.1), began discharging in August 1994. A recent study of Everglades water quality trends documents that TP entering ENP from 1993 to 1996 was lower than concentrations recorded from 1984 to 1992 (Walker 1997), and the data from this study show that marsh median TP concentrations were lower in 1996 than in 1995 (Figure 7.1). However, whether the lower observed concentrations are due to changing water management practices, the initiation of phosphorus control efforts, the specific hydrologic conditions that occurred during a particular sampling event, or some combination of these factors, is unclear.

Initial results from the ENR indicate that TP loads from the EAA can be reduced. For example, the mean flow-weighted TP concentration at the ENR inflow and outflow for the first 2 years are as follows: August 1994 to November 1995, 124 μg/L and 21 μg/L; December 1995 to November 1996, 107 μg/L and 24 μg/L. (SFWMD 1998).

Agricultural BMPs were phased in over several years, with 1996 being the first year during which all lands within the EAA had fully implemented BMPs. Annual EAA basin phosphorus load reductions attributed to the BMP program were as follows: water year 1993, 44%; 1994, 17%; 1995, 31%; and 1996, 68%. Even with these reductions, the TP concentration discharged from the EAA basin was still about 100 μg/L for each of these years, (SFWMD 1997c) much higher than natural Everglades concentrations. However, caution should be used in predicting long-term annual BMP and STA TP control performance under the varied hydrologic conditions in South Florida based on the initial 2 or 3 years of implementation.

Because multiple Everglades restoration issues and several hypotheses regarding Hg methylation in the Everglades are linked to nutrient concentrations, an extensive spatial characterization of nutrients in the Everglades ecosystem, was initiated as part of this project. Water and sediment samples were collected from the canals from September 1993 through May 1995 and analyzed for TP and for other indicators of nutrient enrichment. Similarly, water and soil samples were collected from the marsh from April 1995 through September 1996, and along four transects within the marsh during the dry season in April 1994. These transects, previously sampled by Doren et al. (1996) and Raschke (1993), originated at the canals and extended into the marsh. These transects were placed along known nutrient gradients and are of varying distances, with a maximum distance of over 10 km from the canal. Numerous statistical analyses were completed on these data to identify the magnitude, extent, and spatial patterns in four indicators of eutrophication: TP, chlorophyll *a*, APA, and TN. Statistical analyses and graphical presentations of both marsh and canal data included: univariate and multivariate descriptive statistics, ANOVA and covariance, distributional tests, kriging, box and whisker plots, and spatial displays. These results were evaluated to identify the dominant and consistent patterns in the data collected in the marsh and in the canals. Relationships among TP concentrations in water and soils and plant community dominance or composition and periphyton occurrences were also investigated to identify possible correlations between nutrient enrichment and habitat changes in the Everglades ecosystem and relationship(s) to MeHg contamination in the Everglades.

7.2 Results

The results for the canal, marsh, and transect sampling are presented separately in this section. A synthesis section integrates these results to provide an overall perspective of eutrophication during the 1993 through 1996 sampling period.

7.2.1 Canals

7.2.1.1 Canal Surface Water

Several consistent patterns were observed in the canal water quality data that provide a picture of the potential sources of, and transport mechanisms for, TP in the Everglades ecosystem. From 1993 to 1995, the canal sampling period, TP concentrations consistently were found to be highest in the canals north of Alligator Alley (Figure 7.2). Table 7.1 shows geometric mean TP concentrations in canal water throughout the South Florida Everglades ecosystem. TP concentrations in water collected from canals located above Alligator Alley are significantly higher ($P<0.05$) than TP concentrations in canals located between Alligator Alley and Tamiami Trail, and in canals located below Tamiami Trail; and TP concentrations in canals between

Alligator Alley and Tamiami Trail are significantly higher (P<0.05) than in canals below Tamiami Trail.

Table 7.1 Annual comparison of TP concentrations in water (μg/L) in Everglades canals and marsh. Data presented are the geometric means for the lognormally distributed data and sample size in parentheses. (> or < is statistically significant, P<0.05)

Total Phosphorus in Water (μg/L)					
	SUBAREA				
	North of Alligator Alley		**Alligator Alley to Tamiami Trail**		**South of Tamiami Trail**
Canal	**79 (113)**	>	**24 (63)**	>	**14 (18)**
Marsh	**18 (146)**	>	**12 (157)**	=	**10 (138)**

The highest TP concentrations are found in the EAA canals. Approximately 80% of the canal miles in the EAA and north of Alligator Alley had TP concentrations greater than the Phase I STA design target of 50 μg/L. The percentage of canal miles exceeding the 50 μg/L TP design target drops rapidly from 80% to 15% for canals in the area between Alligator Alley and Tamiami Trail, and further to 1% for canals in the area south of Tamiami Trail (Figure 7.3). Box and whisker plots of TP concentrations within the EAA, WCAs, ENP, and BCNP (Figure 7.4) show that the median TP concentrations in the EAA are significantly different (P<0.05) from TP concentrations in the WCAs, ENP, and BCNP. Furthermore, TP concentrations in surface water in the canal within the WCAs are significantly higher (P<0.05) than TP concentrations in the ENP canals.

TP concentrations in the canals decrease with increasing distance from the EAA or with decreasing latitude (Figures 7.2 and 7.5). This north to south concentration gradient corresponds to the direction of flow from the EAA south through the Everglades ecosystem to ENP or Florida Bay. Geometric mean concentration of TP in canal water north of Alligator Alley was approximately 3 times higher than the geometric mean TP concentration in canal water in the area between Alligator Alley and Tamiami Trail, and over 5 times higher than in the canals south of Tamiami Trail (Table 7.1).

TP concentrations in canal water were slightly higher during the dry season through the Everglades with the exception of the EAA, where TP concentrations in the canal water were higher in the wet season than the dry season. The increases observed during the dry season, however, were not significant. Overall, little seasonal differences were observed in TP concentrations in canal water between wet and dry seasons. The presence of a north to south gradient in TP was the same between the dry and wet seasons.

Although not as pronounced as TP concentration patterns, similar patterns exist for chlorophyll *a* and APA in the canal water during the 1995 dry season (Table 7.2). Higher chlorophyll *a* concentrations were found in the EAA compared to concentration in the WCAs, BCNP, and the ENP. In general, APA throughout the canals exhibited an inverse relationship with TP in water (Figures 7.2 and 7.6). The lowest APA was observed in the EAA where TP concentrations in canal water were highest. The highest APA was found in the ENP where TP concentrations in canal water were lowest. Table 7.2 shows a comparison of mean TP concentrations, APA, and chlorophyll *a* concentrations during May 1995, which is the only cycle when all three constituents were sampled.

Table 7.2 Comparison of geometric mean of TP, APA, and chlorophyll *a* concentrations in canal water by subarea during the May 1995 sampling cycle. Sample size *n* is shown in parentheses. (> or < is statistically significant, $P<0.05$)

Parameter	Geographic Subarea						
	EAA		WCAs		ENP		BCNP
TP (μg/L)	73.30 (14)	>	44.20 (19)	>	14.20 (5)	<	28.70 (7)
APA (μMol/hr)	0.12 (14)	<	0.32 (20)	=	0.65 (8)	=	0.36 (8)
Chlorophyll *a* (μg/L)	8.43 (14)	>	4.54 (20)	>	1.52 (8)	<	4.67 (8)

7.2.1.2 Canal Sediment Data

No spatial or temporal relationships were observed in TP concentrations in canal sediments throughout the study. Table 7.3 and Figure 7.7 provide the results of TP concentrations in canal sediments by geographic subarea. Figures 7.8 and 7.9 provide the results of the TP sediment analyses in canals in the three latitudinal subareas in the Everglades and by cycle. Some higher concentrations were noted in BCNP when the data were parsed by longitude (Figure 7.10). TP concentrations in canal sediments in BCNP were significantly higher and in ENP were significantly lower compared with TP canal sediment concentrations in the other geographic subareas (Table 7.3).

Table 7.3 Geometric mean of TP concentrations (μg/kg) in canal sediments by four geographic subarea within the Everglades. (> or < is statistically significant, $P<0.05$)

Total Phosphorus in Canal Sediments (μg/kg)				
	Geographic Subarea			
	EAA	**WCAs**	**ENP**	**BCNP**
Geometric Mean (*n*)	829.9 (71)	= 727.8 (67)	> 495.4 (29)	< 1,603.2 (29)
Minimum	17.5	103.3	77.7	94.6
Maximum	9,099.7	3,834.8	4,165.0	7,907.4

7.2.2 Transects

Figure 7.11 shows the locations of the 4 transects that were established within the marsh to evaluate contributions of the canals to TP concentrations in the marsh. These 4 transects originate at the edge of the canal and extend into the marsh for varying distances. Two of these transects, the LNWR and the WCA2 transects, are located in close proximity to the EAA north of Alligator Alley. The remaining 2 transects, the WCA3 and ENP transects, are located perpendicular to Tamiami Trail at S-12C.

TP concentrations in water, plotted as a function of distance from the canal, show that TP concentrations were of greater magnitude and spatial extent for the two transects located in close proximity to the EAA than for those along Tamiami Trail. A rapid decline in TP concentrations was observed as distance from the canal increased within these two transects. This decline approaches an exponential decline in TP concentrations. The TP concentrations in WCA3 and ENP adjacent to Tamiami Trail were lower both in magnitude and spatial extent than concentrations observed in the transects north of Alligator Alley. Although concentrations entering the marsh from the canals were lower at these two transects than the transects near the EAA, the transect data show that TP concentrations in the marsh are highest at locations closest to the canal (Figure 7.12) supporting the hypothesis that phosphorus is being delivered to the marshes via the canals. The delivery of TP to the marsh is highest in the WCAs north of Alligator Alley.

Similar to the patterns observed for TP in water along the transects, TP in soil samples collected within these transects show decreasing concentrations with distance from the canal (Figure 7.13). The pattern of elevated TP soil concentration near the canal that decreases with distance from the canal, was more pronounced in the soil data than in the water data. Other investigators have documented this phosphorus water and soil gradient within WCA2A (Walker 1995; Urban et al. 1993; Doren et al. 1986).

7.2.3 Marsh

TP concentrations in water in the marsh from 1995 to 1996 show important patterns relative to proposed ecosystem restoration objectives. Figure 7.1 shows that overall, median TP concentrations in the Everglades were lower in 1996 compared to 1995 and that TP concentrations generally were lower during the wet season.

Although TP patterns are quite different in the marsh between the 1995 and 1996 sampling years (Figure 7.1) and between the wet and dry seasons (Figure 7.14), several noticeable patterns appear to support the hypothesis that TP is transported to the marsh from the canals. Data from 1996, which was approaching normal precipitation, showed that during the dry season, approximately 85% of the marsh had TP concentrations below the 50 μg/L design target for the STAs (Figure 7.15). Furthermore, approximately 85% of the marsh had concentrations greater than 10 μg/L during the dry season in 1996. During the wet season of 1996, TP concentrations were greater than 10 μg/L in LNWR, WCA2, the northernmost portion of WCA3, and only one location in the marsh near the Miami Canal in WCA3 (Figure 7.14). A more extensive “front” of elevated TP concentrations (i.e., TP concentrations greater than the 10 ppb natural TP concentration) in the marsh was observed during the wet season in 1995 when precipitation and flows in the canals were above normal. Over 60% of the marsh had TP concentrations in water greater than 10 μg/L during the wet season in 1995 (Figure 7.15).

The percentage of the marsh area sampled with concentrations greater than the Phase I STA design target of 50 μg/L was quite small. Only approximately 8% of the marsh area above Alligator Alley had a concentration greater than 50 μg/L. Only approximately 5% to 2% of the marsh area sampled below Alligator Alley and Tamiami Trail had TP concentrations in surface water greater than the 50 μg/L STA design target. Approximately 92 to 98% of the marsh had surface water TP concentrations less than or equal to 50 μg/L (Figure 7.16). Geometric mean TP concentrations in surface water in the marsh were approximately two times higher above Alligator Alley than concentrations south of Tamiami Trail (Table 7.1).

During the 1995 and 1996 dry seasons (Figure 7.14), a few locations in WCA2 and ENP near the canals had TP concentrations greater than 50 μg/L. These TP "hot spots" were not as prevalent during the wet season when more dilution from increased precipitation and surface flow occurred.

Under more normal rainfall conditions and water depths, TP concentrations were higher in marsh during the 1996 dry season than the 1996 wet season (Figure 7.14). The seasonal differences in TP concentrations in water in the marsh were more pronounced below Alligator Alley than north of Alligator Alley, which is adjacent to the EAA (Table 7.4 and Figure 7.17). When the data for each subarea were evaluated by season, TP concentrations in marsh water were lower during the wet seasons than during the dry seasons (Figures 7.17 through 7.19). Little change was observed in the overall pattern of TP concentrations in marsh water by subarea, when evaluated on a seasonal basis (Figures 7.18 and 7.19). TP concentrations in marsh water were highest in WCA2, and lowest in ENP and BCNP, regardless of the seasonal differences in TP concentrations in marsh water (Figures 7.18 and 7.19).

Patterns of APA in marsh water were inverse to TP patterns (Figure 7.20). Lowest APA occurred in areas where TP concentrations were highest. For example, during the 1996 wet season when TP concentrations were highest above Alligator Alley, APA activity was lowest (Figure 7.21). The interior marsh within LNWR always had high APA indicative of a low phosphorus, rain driven marsh system (Newman et al. 1997, Browder et al. 1994).

Table 7.4 Seasonal comparison of canal and marsh TP geometric mean concentrations (μg/L) in water by latitudinal subarea. Sample size *n* is shown in parentheses. (> or < is statistically significant, P<0.05)

	North of Alligator Alley		Alligator Alley to Tamiami Trail		South of Tamiami Trail
Canal					
Wet	101 (56)	>	18 (35)	=	10 (8)
Dry	62 (57)	>	36 (28)	>	19 (10)
Marsh					
Wet	15 (84)	>	8 (81)	=	8 (77)
Dry	25 (62)	>	20 (76)	=	16 (61)

Summaries of TN concentrations in marsh water are shown on Table 7.5 and Figures 7.22 and 7.23. The pattern of TN concentrations is very similar to that for TP in water with higher concentrations occurring in WCA2 and concentrations decreasing in WCA3, ENP, and BCNP. Dry season concentrations were higher than wet season concentrations. The box and whisker plots indicate that TN concentrations in WCA2 are consistently significantly (P<0.05) greater than those in WCA3 and ENP. TN concentrations in WCA2 are also significantly (P<0.05) different from those in BCNP. It is uncertain wether or not the higher TN concentrations measured in BCNP during the dry season are representative, because there were only five measurements during this sampling cycle.

Table 7.5 Geometric mean TN (mg/L) in water in the Marsh. Number in parenthesis is sample size for both sampling cycles.

Total Nitrogen (mg/L)	
Subarea	**Geometric Mean (*n*)**
LNWR	1.6 (22)
WCA2	1.8 (18)
WCA3	1.4 (86)
BCNP	1.2 (17)
ENP	1.2 (62)

TP concentrations in marsh soils showed similar patterns as TP concentrations in water. Highest soil TP concentrations were found above Alligator Alley (Figures 7.24 and 7.25). Generally, median TP concentrations in marsh soil were significantly higher in WCA2 and WCA3 than in LNWR or ENP and BCNP except during the wet seasons (Figure 7.26). Maximum TP concentrations in marsh soils (i.e., marsh soils hot spots), were located in WCA2, WCA3, and the ENP. Strong correlation between TP hot spots in marsh soils and marsh water was observed (Figure 7.27).

7.2.4 Vegetation and Periphyton Relationships

A comparison of TP concentrations in marsh soils with presence of cattails (*Typha domingiensis*) throughout the marsh (Figure 7.28) showed a strong correlation between TP concentrations in soils and presence of cattails. A weak relationship was observed between TP in water and the presence of cattails. Similar analyses of TP in water and presence of floating periphyton mats suggest that as TP concentrations in water increased, the presence of floating periphyton mats in the marsh decreased.

7.3 Synthesis

Consistent patterns exist in TP concentrations in water and soil in the Everglades ecosystem to describe the spatial distribution of TP within the Everglades and allow inferences on the sources and potential ecosystem changes associated with TP enrichment. Data collected for other indicators of nutrient enrichment (i.e., APA and chlorophyll *a*) further support the patterns in TP observed and the following conclusions.

The canal and the marsh water quality data collected during this assessment support the hypotheses in the original 1993 conceptual model (Stober et al. 1993) that the EAA is the primary source of phosphorus enrichment in the Everglades, and that the canals are the major mechanism for transport of TP from the EAA to the marsh ecosystem. Identifiable gradients in TP concentrations in marsh water and soils were observed, with highest concentrations consistently found above Alligator Alley. Canal data collected over two very different years with respect to precipitation, consistently showed highest concentrations of TP in the EAA and decreasing TP concentrations in water with increasing distance from the EAA. Transect data showed an increase in TP in soils and water in the marsh at locations closest to the canals, thereby, indicating that the canals are likely to be a major source of TP in the marsh.

The data show that certain localized areas within the Everglades marsh, particularly in WCA2 and WCA3 and in the ENP, have TP concentrations in water and soil that are higher than background concentrations found in the marsh at similar latitudes or within each of the subareas. Maximum concentrations or TP hot spots in water in ENP, where TP concentrations typically are lowest, were observed in locations near or at the end of the major canals in ENP. TP concentrations in the ENP during the dry season likely represented the transport of TP to ENP via the L67 canal. These data combined, with the canal and the transect data, support the hypothesis that the canals are a major transport mechanism for TP to the marsh.

Evaluation of seasonal patterns of TP concentrations in marsh water showed that seasonal differences in TP concentrations were more pronounced south of Alligator Alley than north of Alligator Alley adjacent to the EAA. These data suggest that there is more continuous input of TP to LNWR, WCA2, and the northern portion of WCA3 during both dry and wet seasons. The higher TP concentrations observed were south of Alligator Alley during the dry season expected as a result of evapoconcentration in this precipitation driven marsh system.

TP concentrations in the WCAs and the ENP also appeared to correlate well with plant community composition and the presence of floating periphyton mats. The data showed a high correlation between the presence of cattails and increased TP concentrations in marsh soils. This association between high elevated soil phosphorus and cattail presence was also independently observed by Doren et al. (1996) in LNWR, WCA2A, WCA3A and ENP, and in WCA2A by DeBusk et al. (1994) and Urban et al. (1993). North of Alligator Alley the plant community was largely sawgrass (*Cladium jamaicense*) dominated, but both the presence of cattails within this community and the frequency of cattail dominated plant communities was higher north of Alligator Alley where TP concentrations were highest in water and soil. Although high TP concentrations in water and soil were not likely the sole factor for the presence of cattails or the higher frequency of cattail dominated communities north of Alligator Alley, it is likely that the shift in plant community composition and increased cattail dominated communities as described in

Chapter 5.0 was a response to high TP concentrations in the soils and water in the marsh north of Alligator Alley. Preliminary field observations of increased height and density of marsh vegetation (i.e., sawgrass and cattails) in northern WCA3A near the EAA and at locations along the canal compared to similar vegetation throughout the marsh also support this conclusion. Studies by Urban et al. (1993) and Davis (1991) indicate that cattails effectively outcompeted other plant species, thereby reducing plant community diversity when soil TP concentrations increased above background concentrations. The periphyton data from this study also support this conclusion. In those areas in the northern portion of Alligator Alley where sawgrass was the dominant plant community, where the presence of cattails was the highest, and where the frequency of cattail dominated communities was highest, the presence of periphyton mats were lowest. As documented by McCormick et al. (1998), the presence of floating periphyton mats was well correlated with the presence of wet prairie or slough dominated communities. Consequently, as shifts in the dominant plant communities occurred and plant biomass increased as a response to increased TP concentrations in the marsh, periphyton productivity and the ability of the habitats to support higher trophic levels (i.e., fish) decreased.

The nutrient data collected in this study also provides a baseline for evaluating proposed ecosystem restoration measures in the Florida Everglades. As part of the Everglades restoration project, approximately 43,000 acres (175 km^2) of constructed wetlands are to be built to reduce TP concentrations discharged from the EAA into the Everglades ecosystem. The STAs are designed to reduce TP concentrations in water to 50 μg/L. The 1993 through 1996 Everglades marsh and canal phosphorus conditions described by the present study represent the phase-in period for the EAA BMP program and implementation of about 10% of the Phase I STA program treatment area. This assessment indicates that from 1993 to 1995 75% of canal miles had TP concentrations in water greater than 50 μg/L north of Alligator Alley while less than 15% had TP greater than 50 μg/L south of Alligator Alley. Approximately 4% of the marsh area sampled from 1995 to 1996 had TP concentrations in water greater than 50 μg/L. If the Phase I TP target became the criterion, the marsh would continue to eutrophy. In fact, 55 to 62% of the marsh already has concentrations less than 10 μg/L.

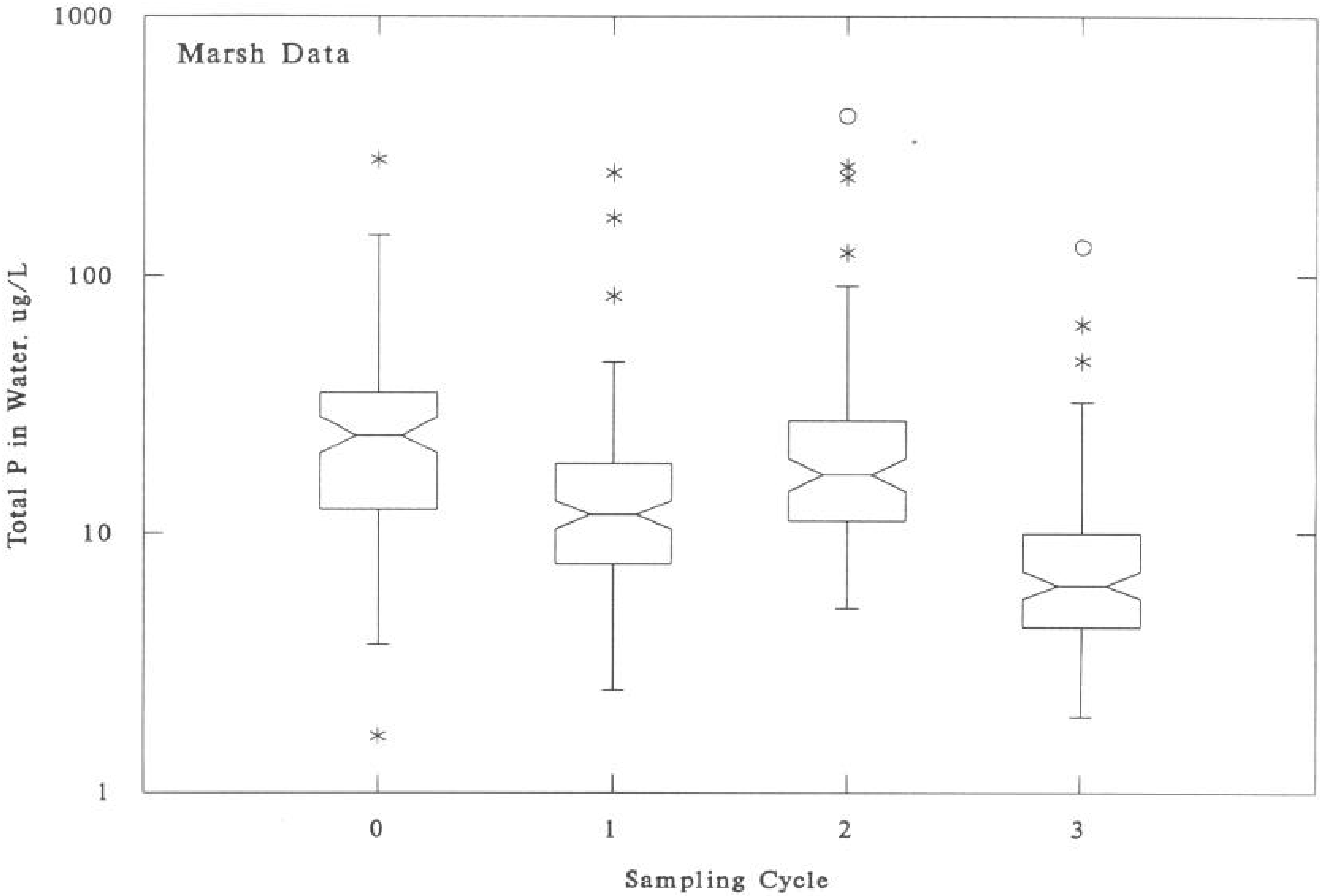

Figure 7.1 TP concentrations in surface water in the Everglades marsh were lower in 1996 than 1995 and during the wet season.

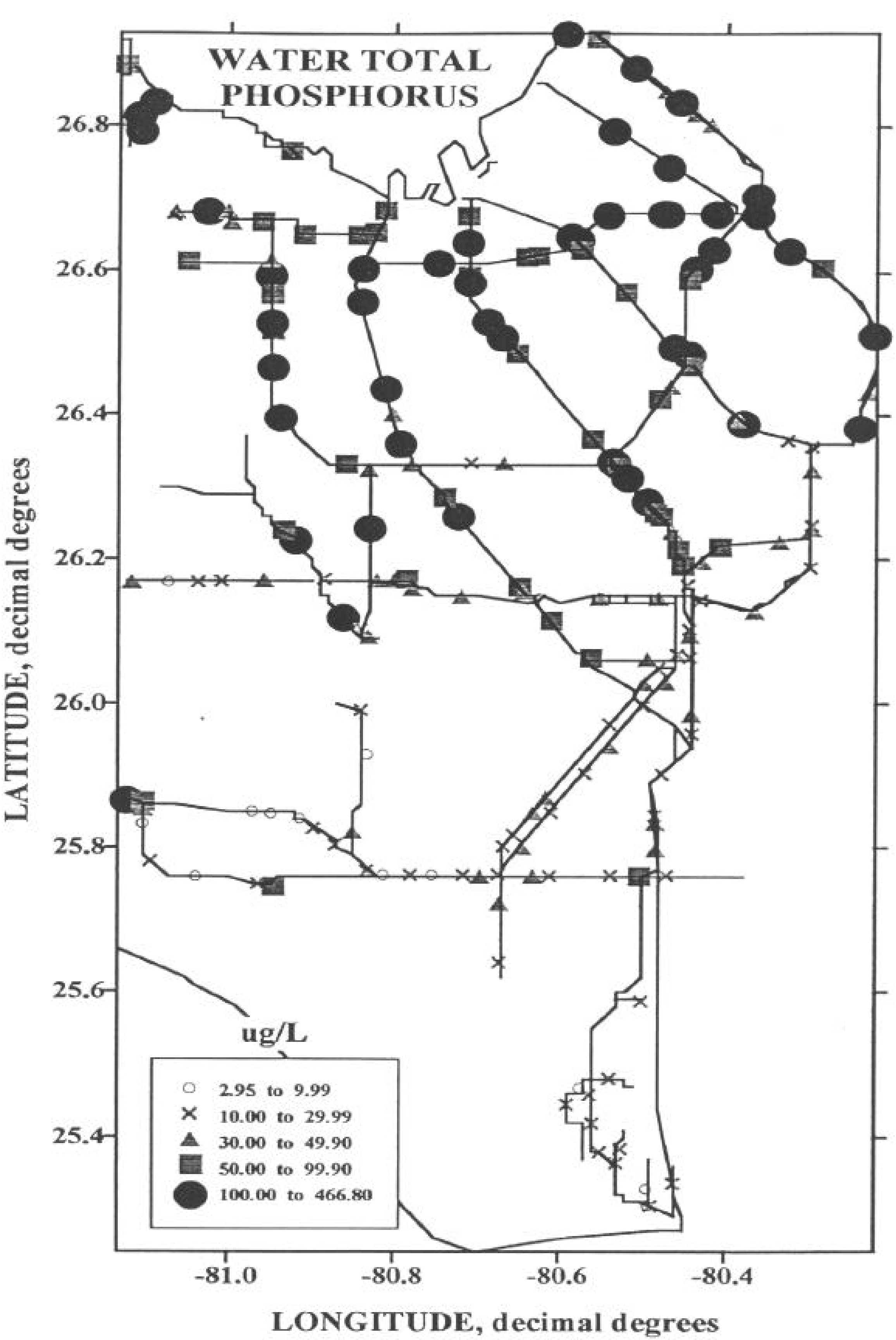

Figure 7.2 TP concentrations in canals are highest in canals north of Alligator Alley.

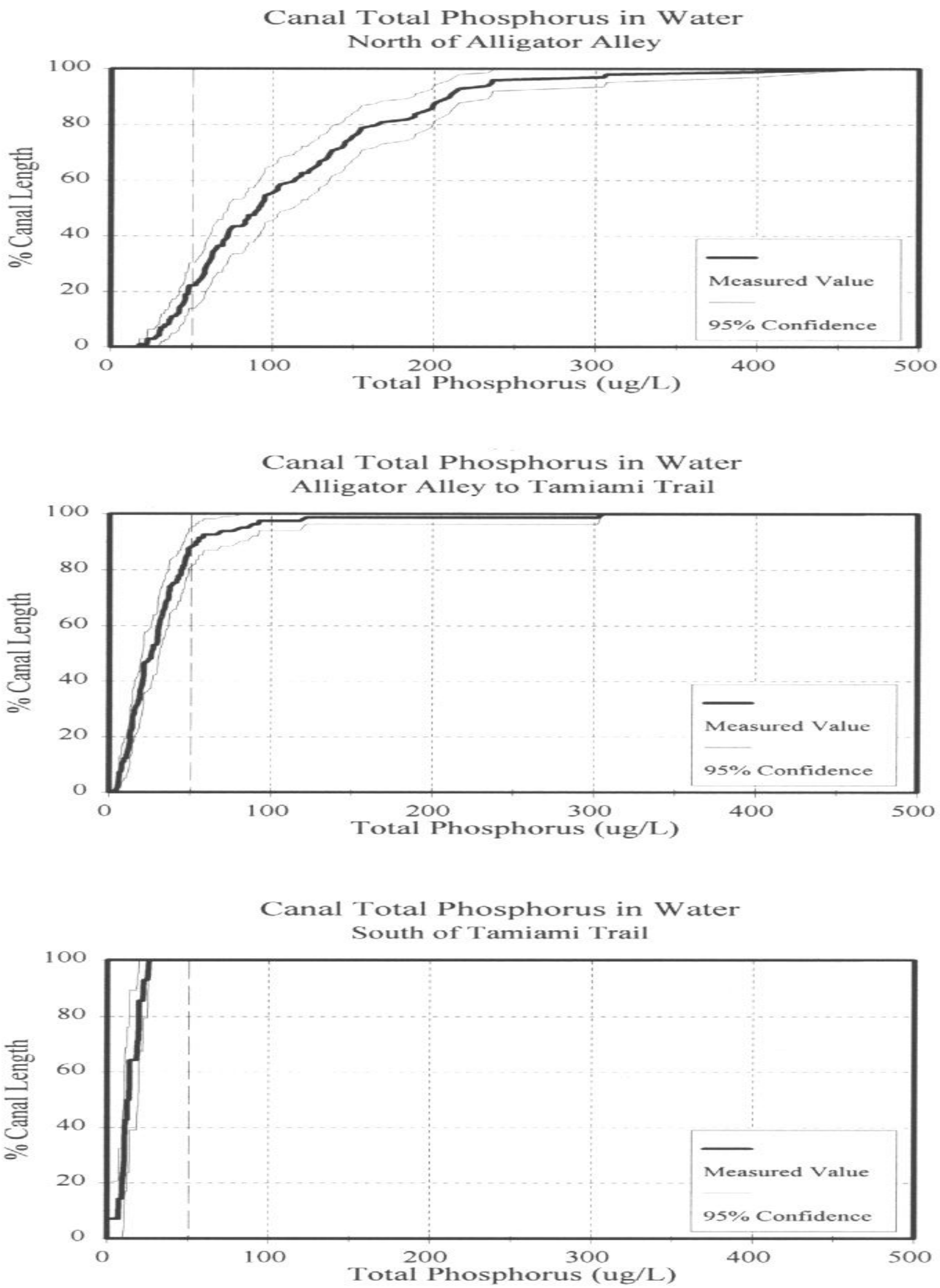

Figure 7.3 Cumulative distributions of canal TP in subareas. % canal length refers to the population estimate, where each sample represents a specific portion of the population.

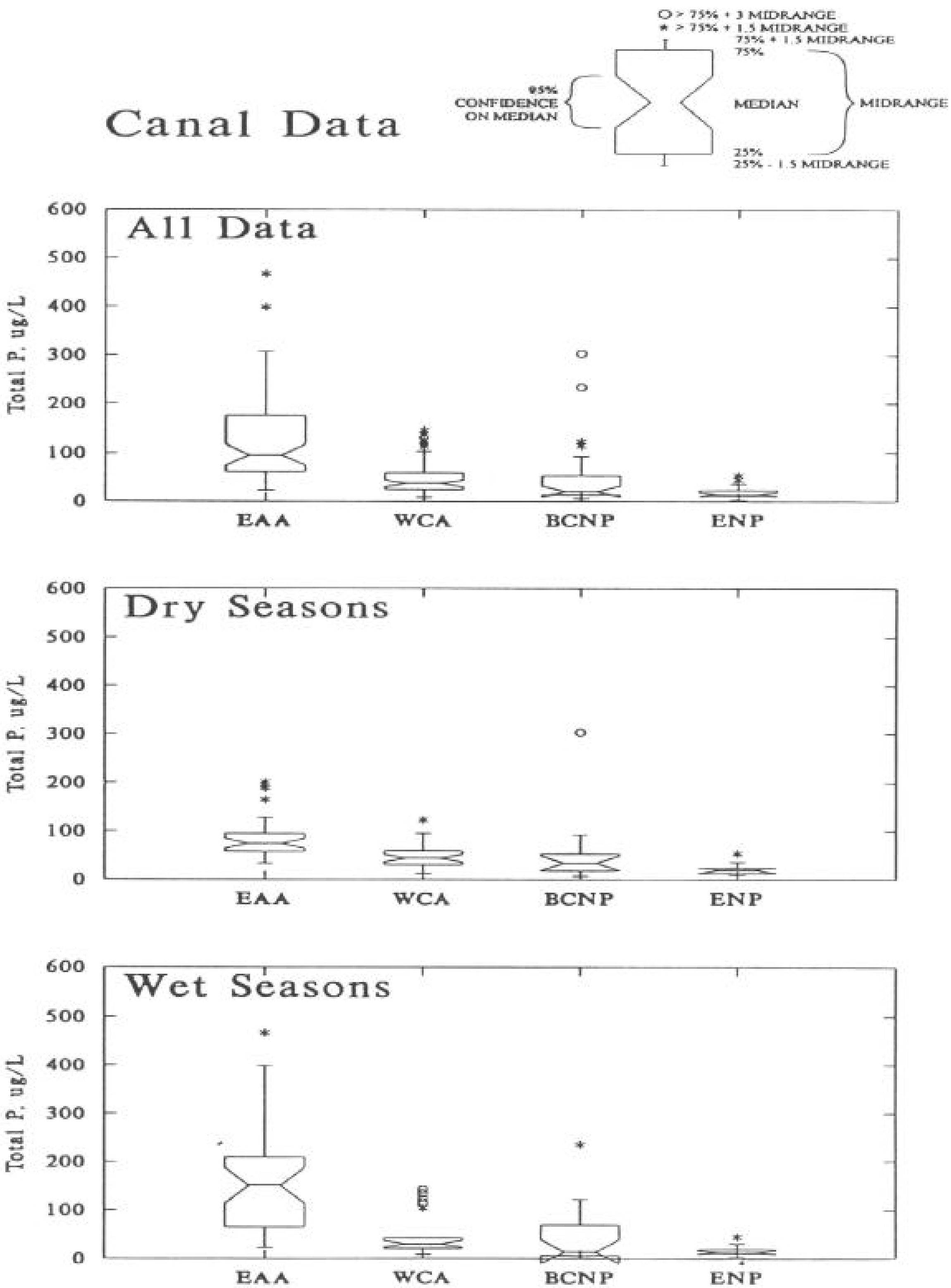

Figure 7.4 Notched box and whisker plots of canal TP in each of the subareas.

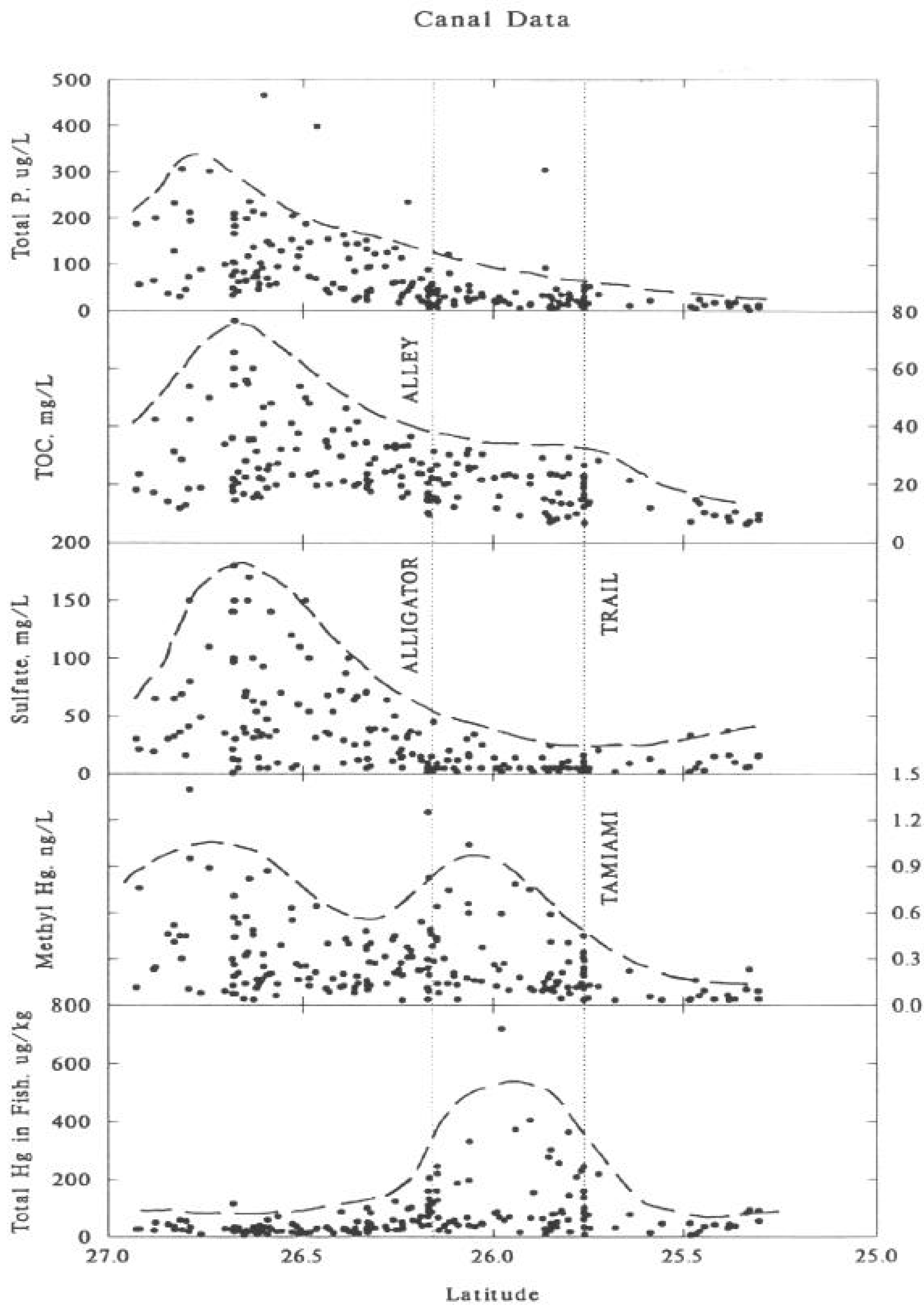

Figure 7.5 Plot of selected constituents showing latitudinal gradients in canals.

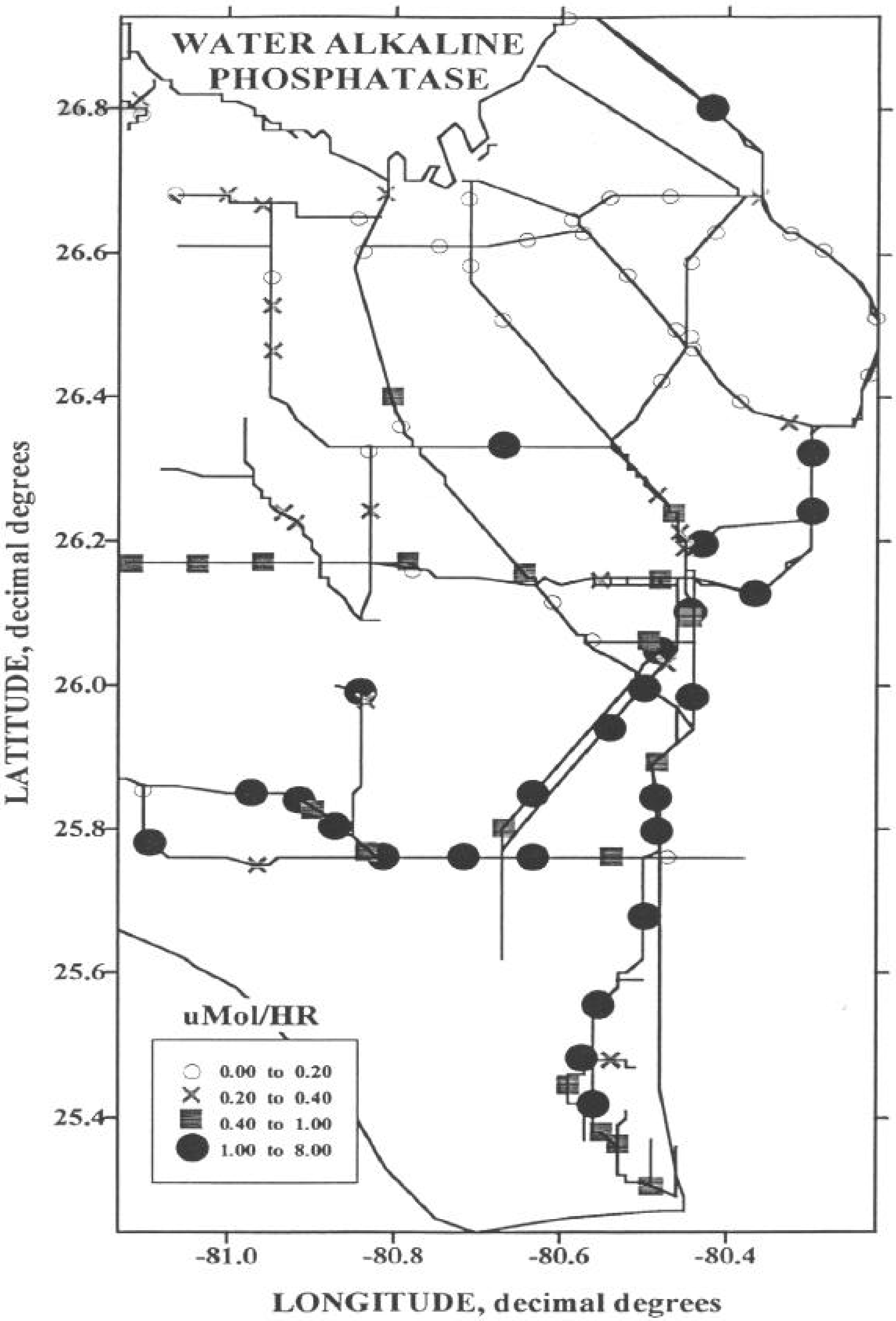

Figure 7.6 APA in canals is highest in areas where TP concentrations are lowest.

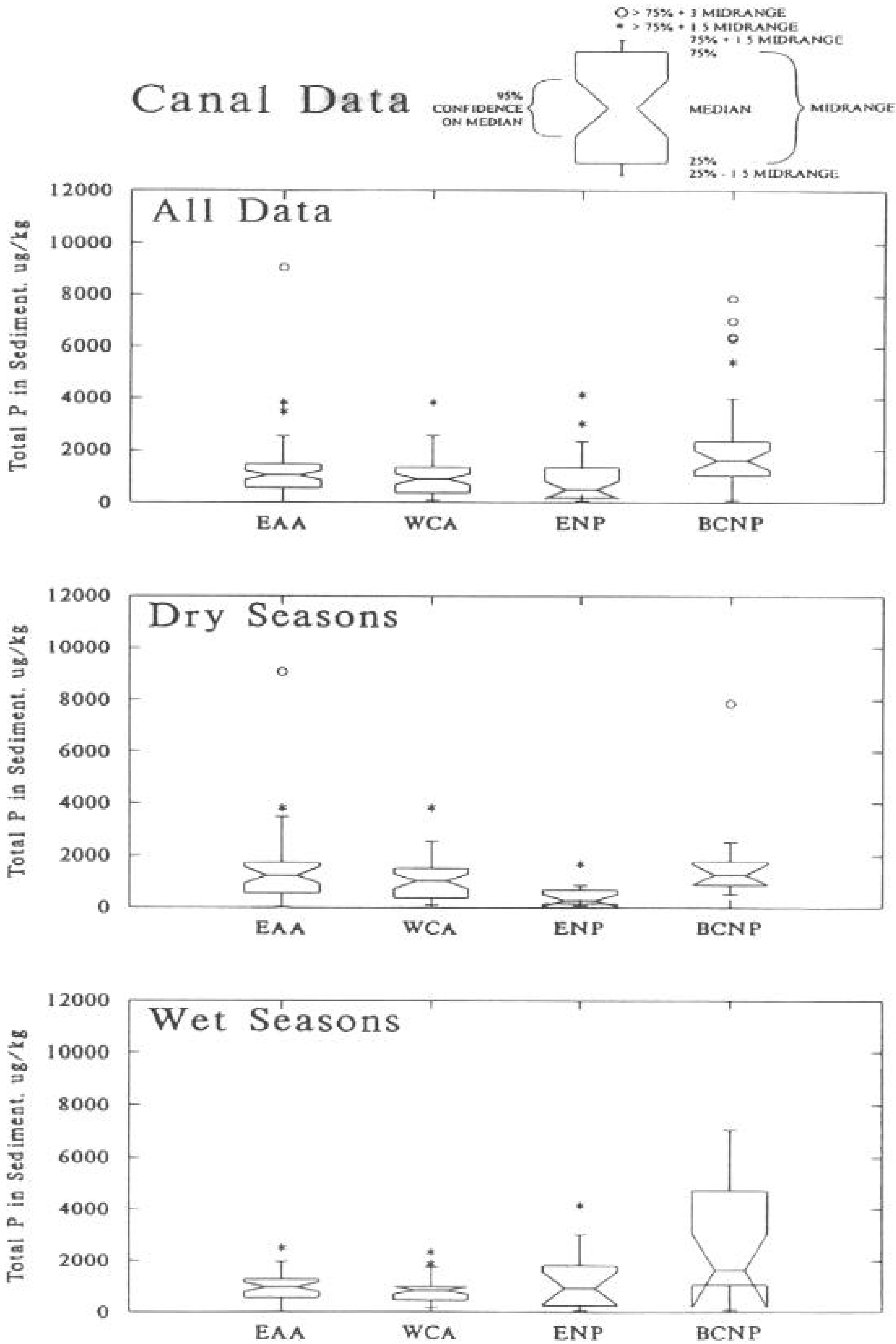

Figure 7.7 TP concentrations in canal sediments by geographic subarea show no spatial patterns.

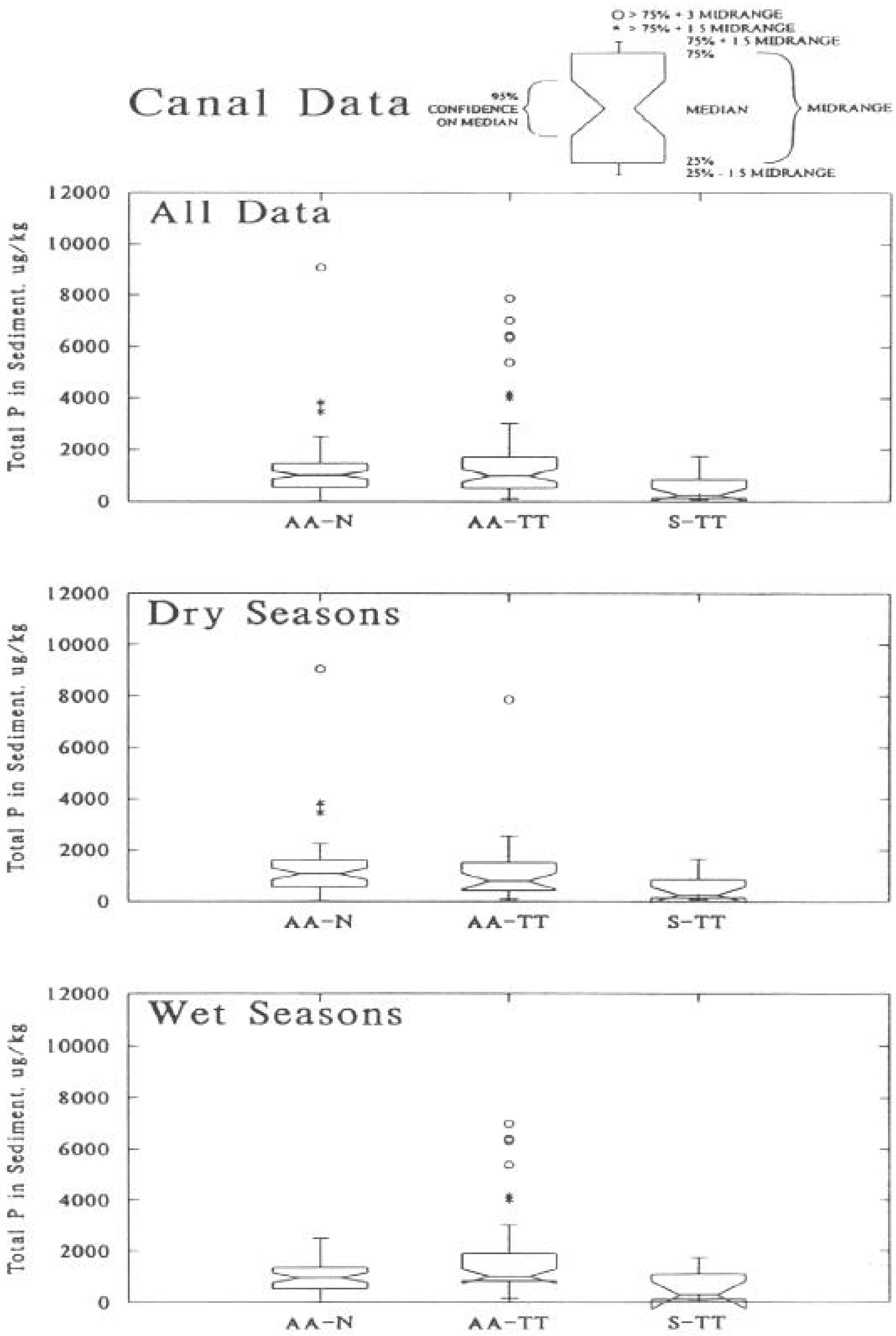

Figure 7.8 TP concentrations in canal sediments by latitudinal subarea show no spatial patterns.

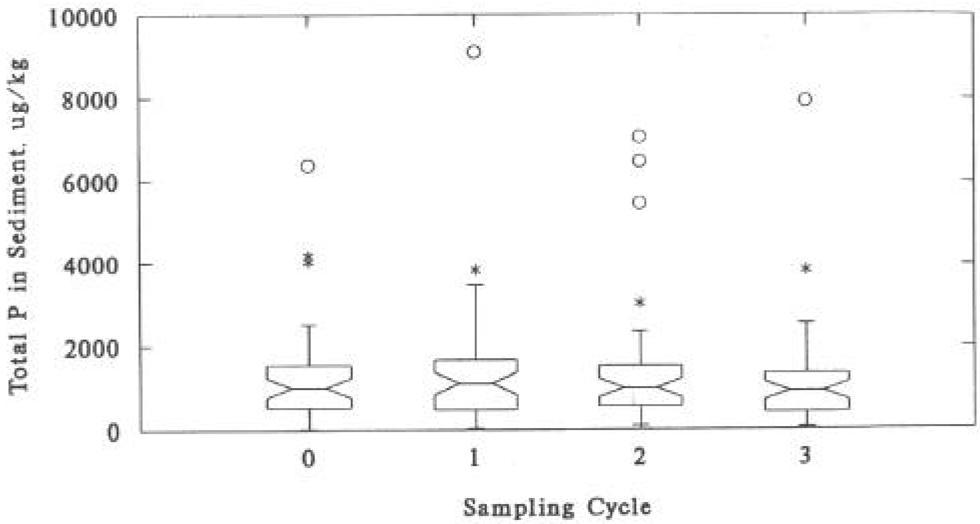

Figure 7.9 TP concentrations in canal sediments by cycle show no temporal patterns.

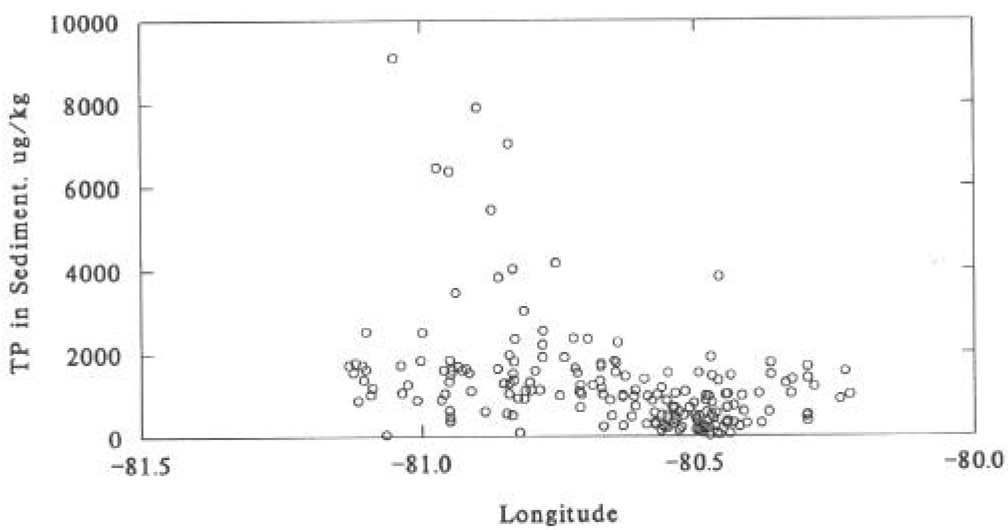

Figure 7.10 TP concentrations in canal sediments by longitude for all cycles combined.

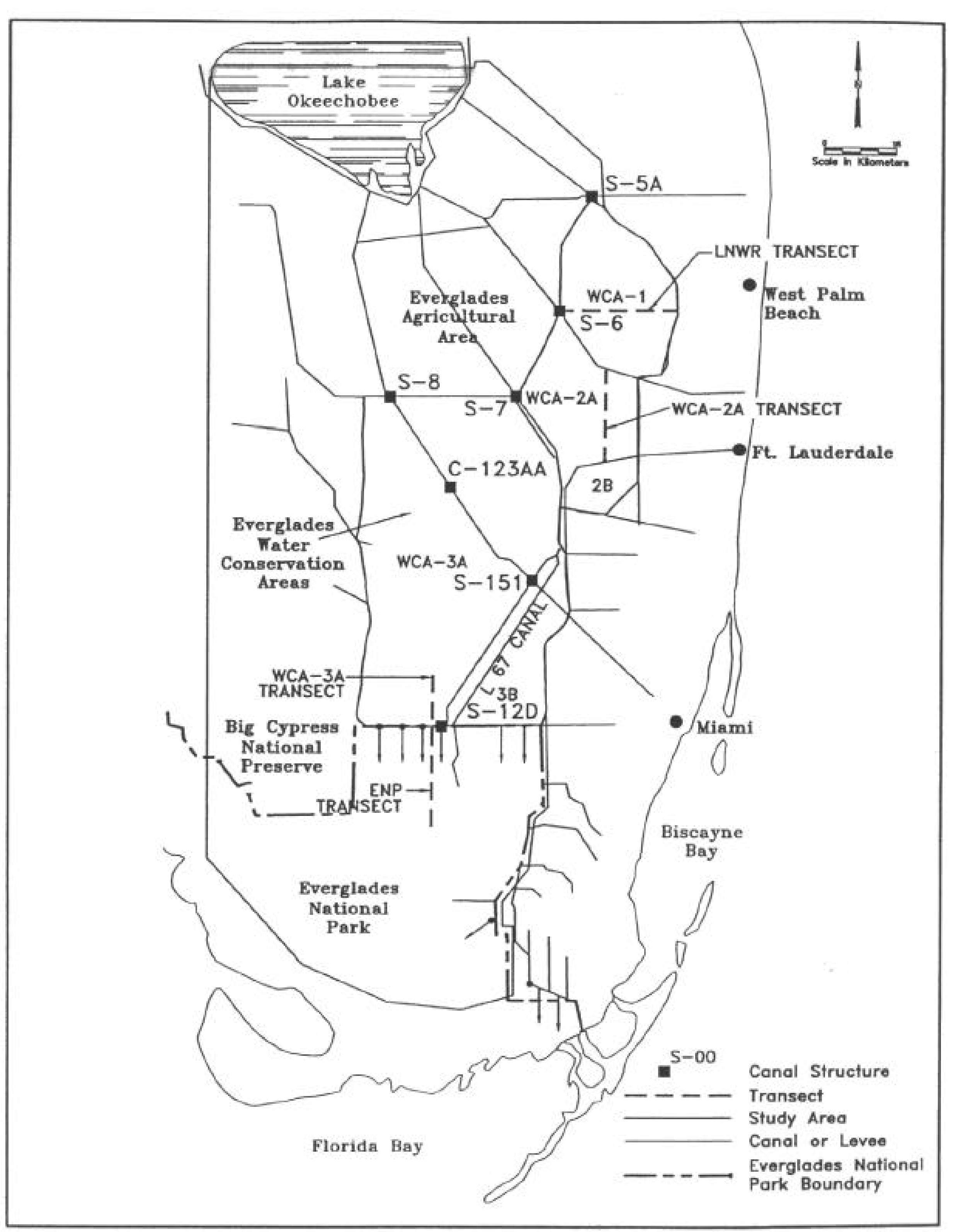

Figure 7.11 Location of four April 1994 marsh transects and canal water control structures sampled on a biweekly basis.

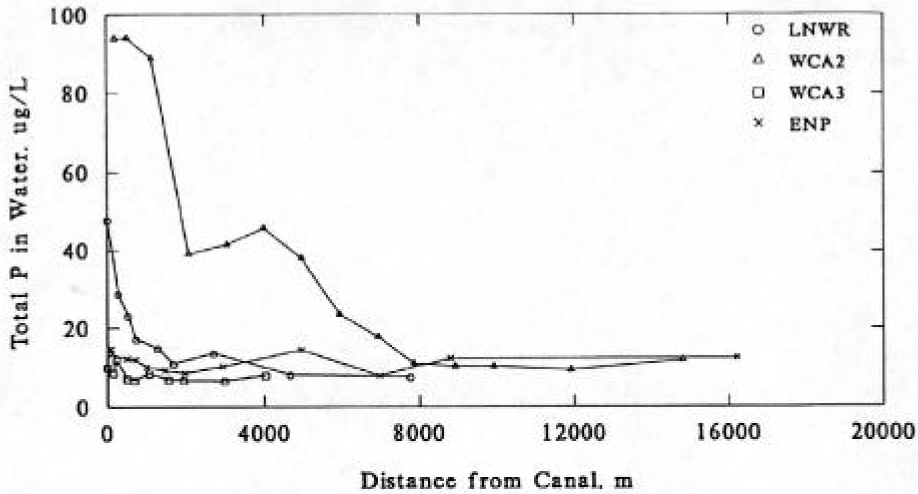

Figure 7.12 TP in water along transects decreases with distance from the canals.

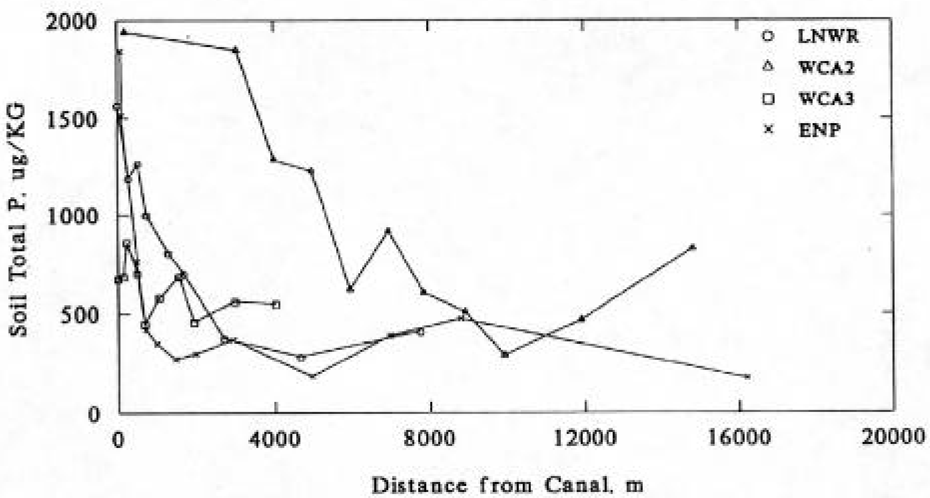

Figure 7.13 TP in soil along transects decreases with distance from the canals.

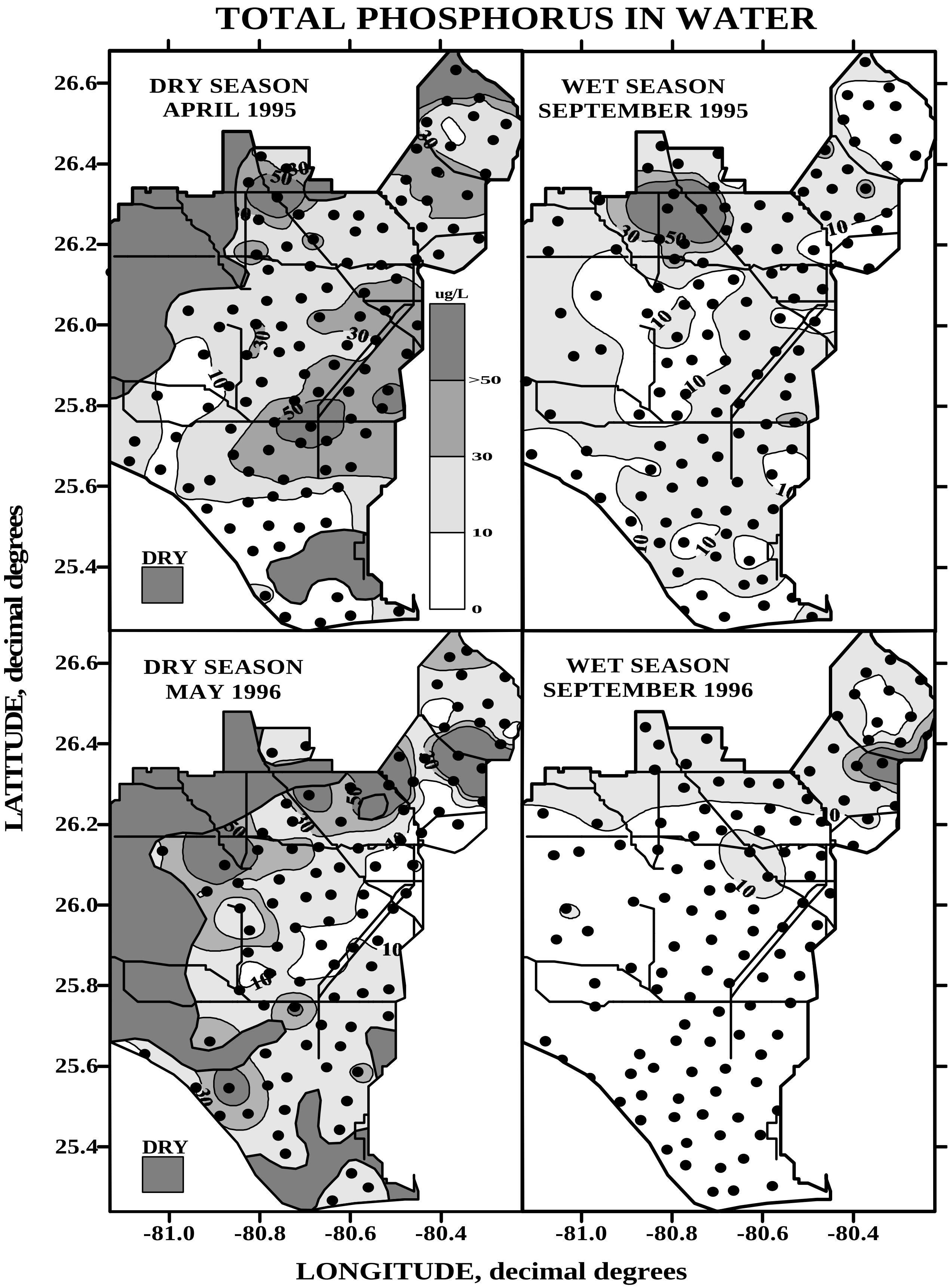

Figure 7.14 Kriged surfaces showing TP in the marsh for each sampling cycle based on sampling data.

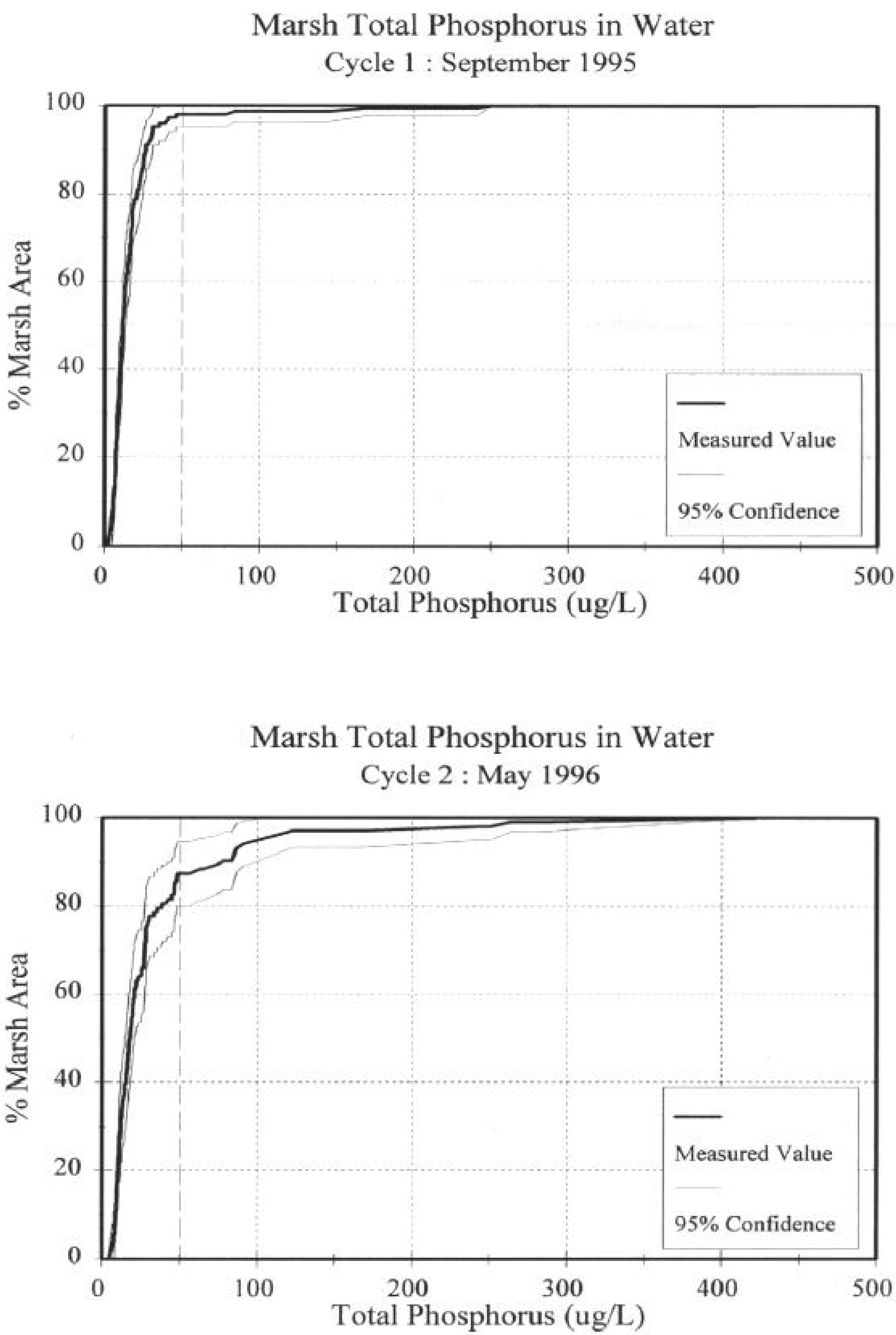

Figure 7.15 Cumulative distributions of TP concentrations in the marsh for selected cycles.

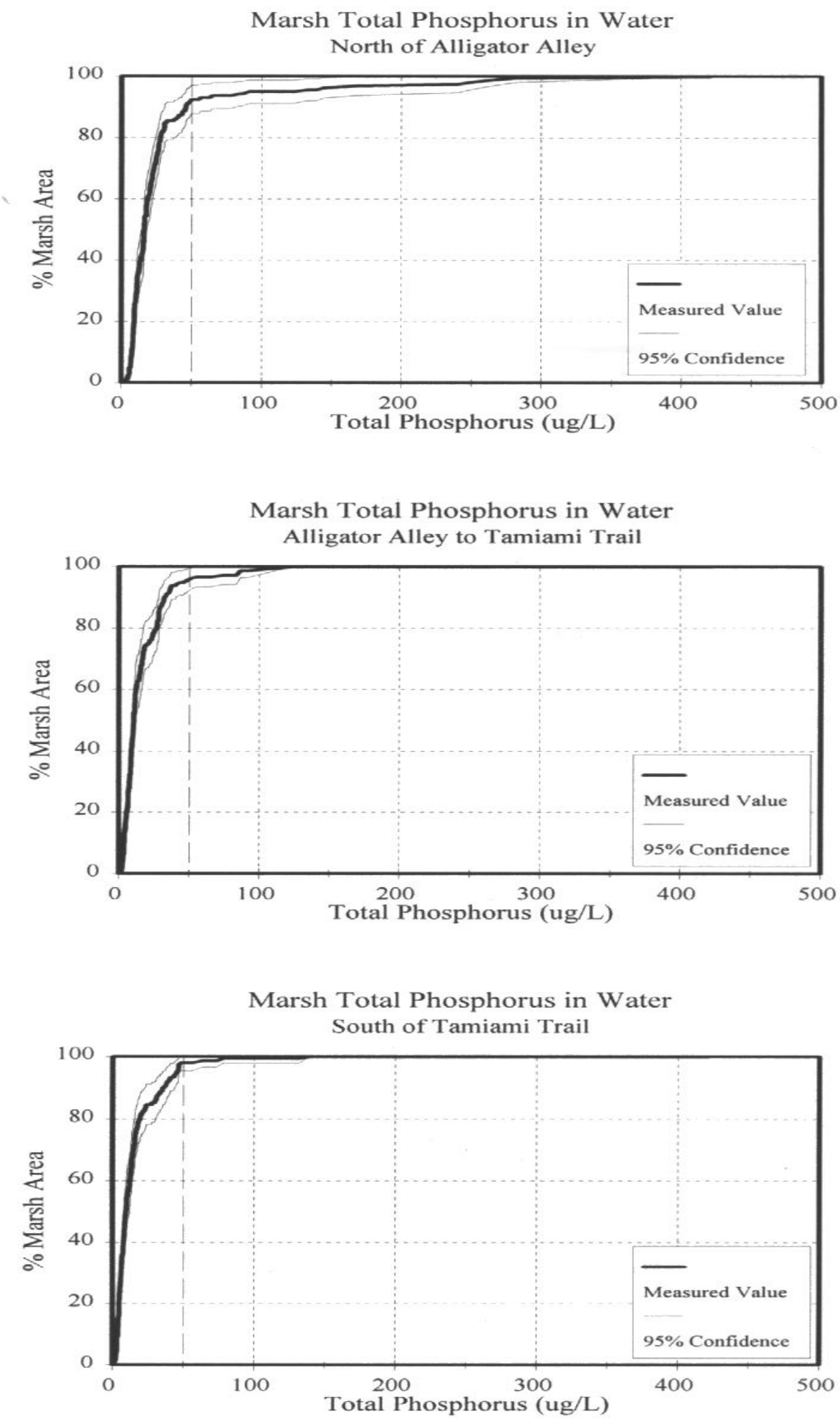

Figure 7.16 Cumulative distributions of TP concentrations in the marsh subareas.

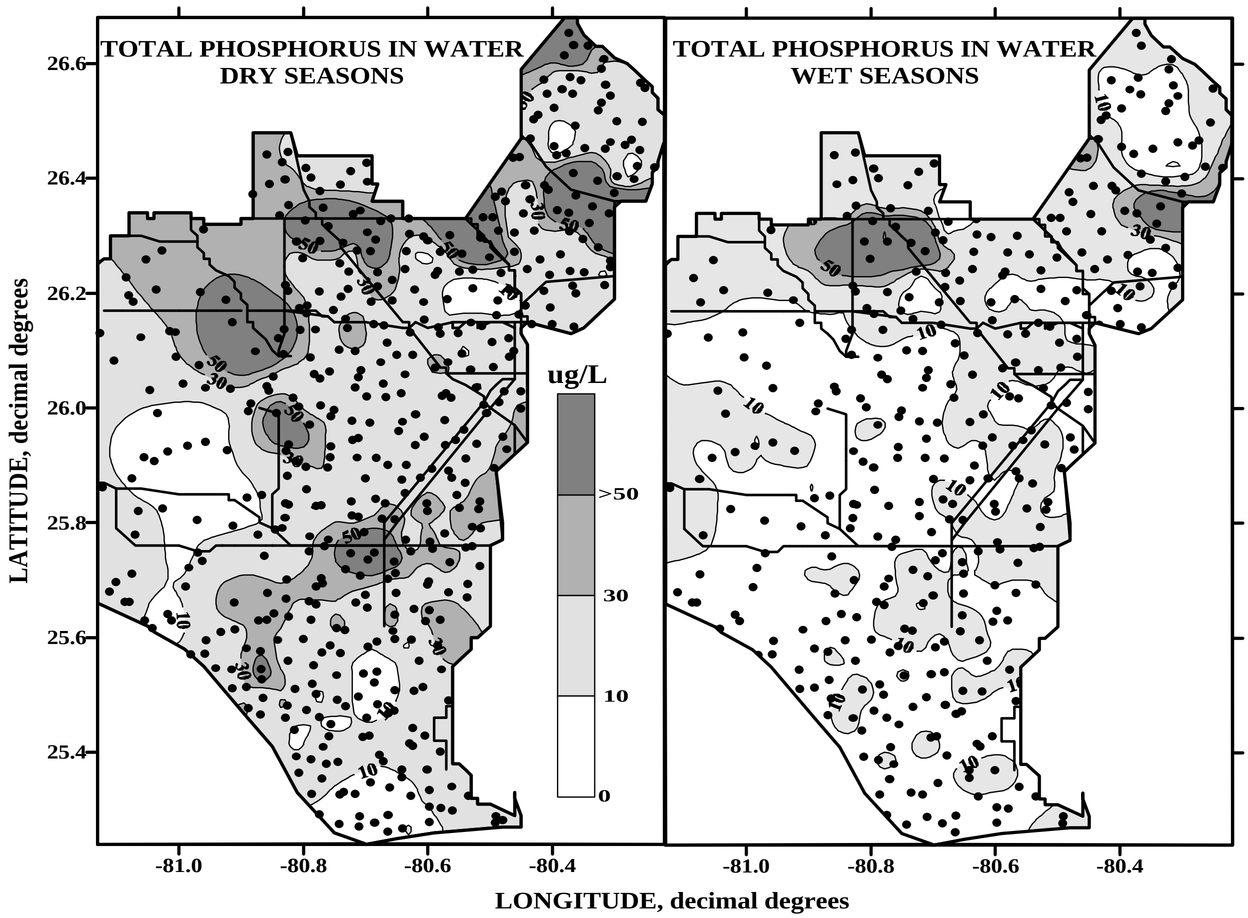

Figure 7.17 Kriged surfaces showing TP concentrations in the marsh using dry and wet season data.

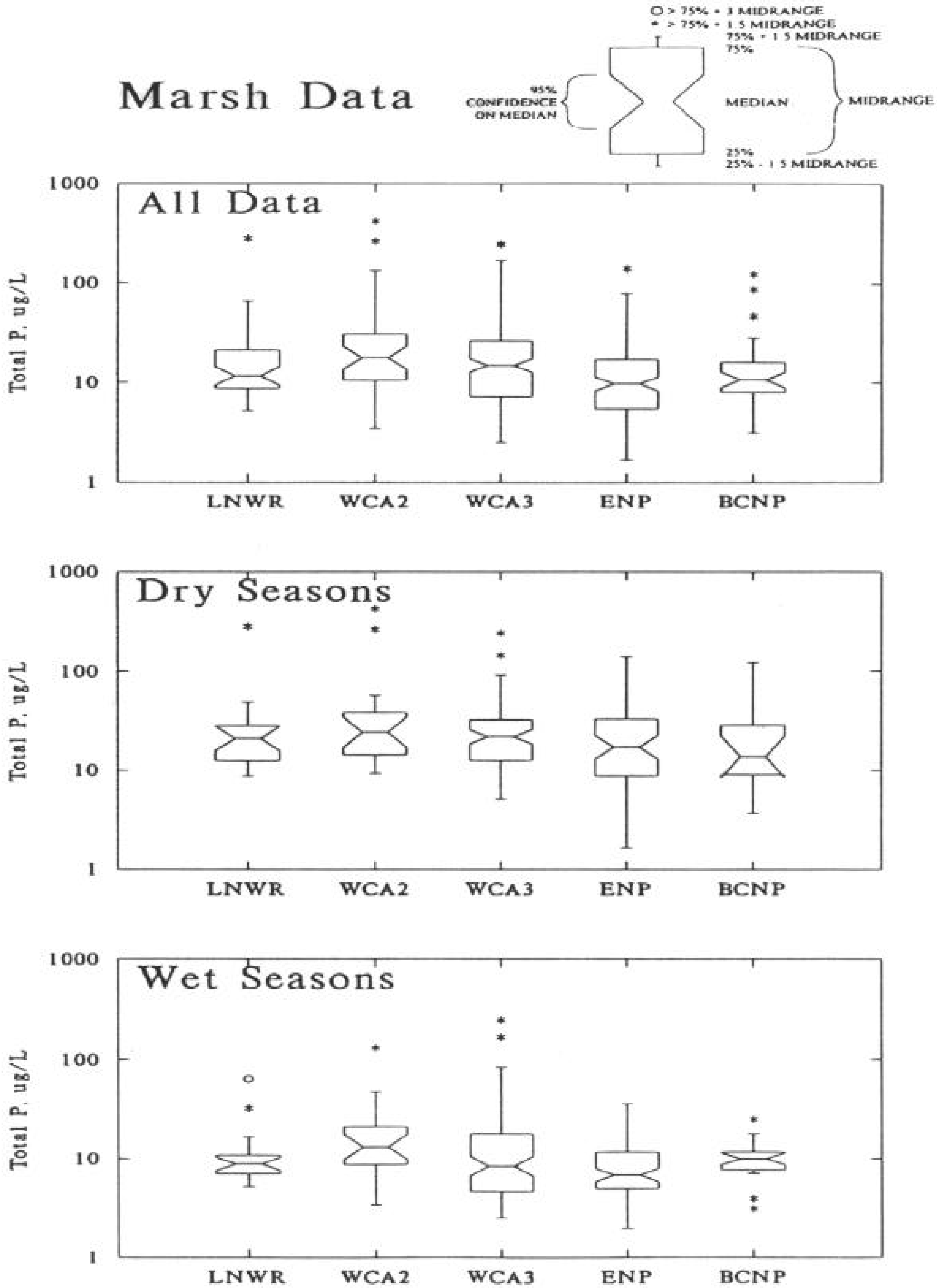

Figure 7.18 Notched box and whisker plots comparing marsh TP in subareas during dry and wet seasons.

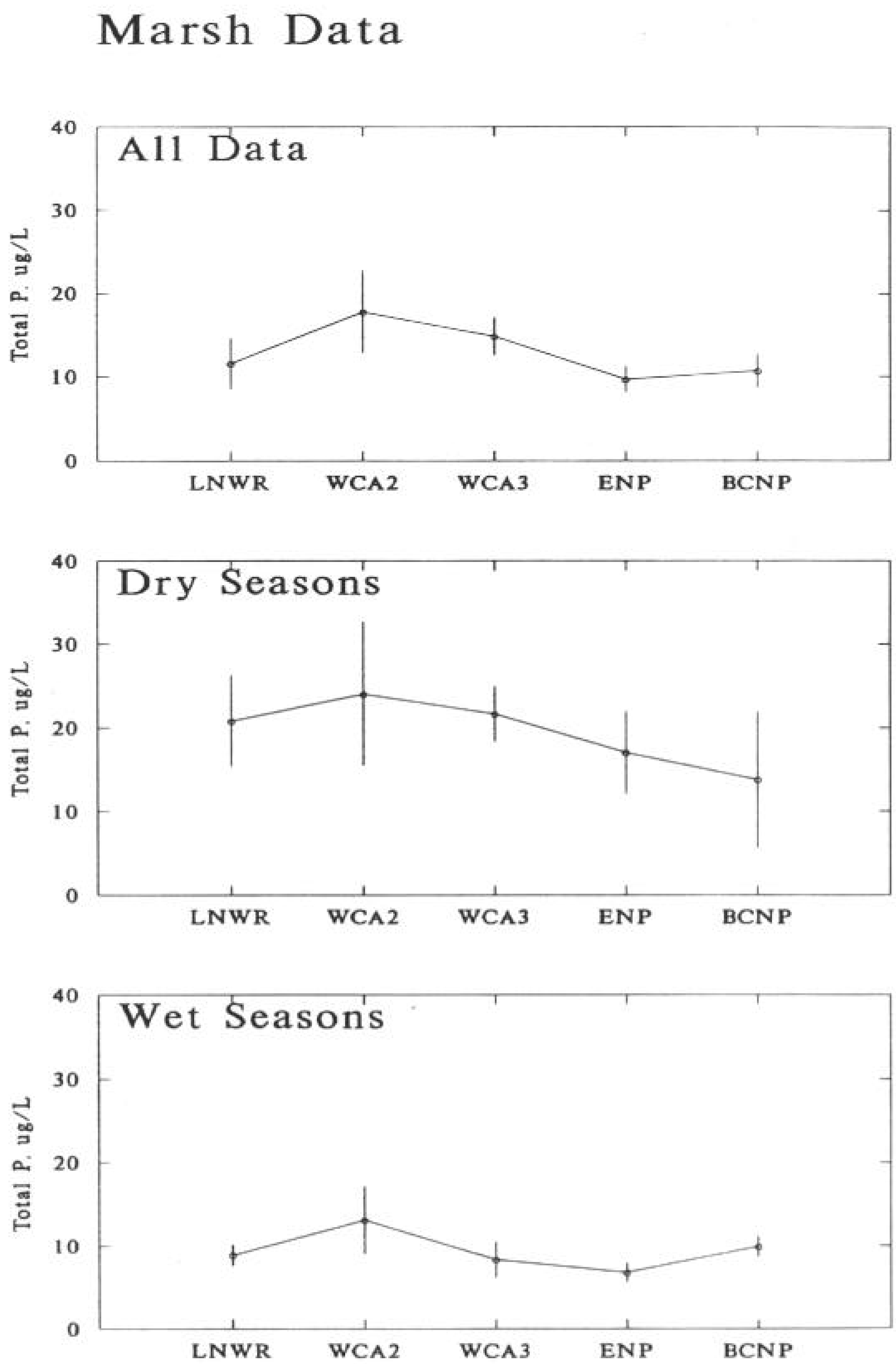

Figure 7.19 Plots of the medians of marsh TP measurements in each of the subareas with a vertical line indicating the 95% confidence interval about each median.

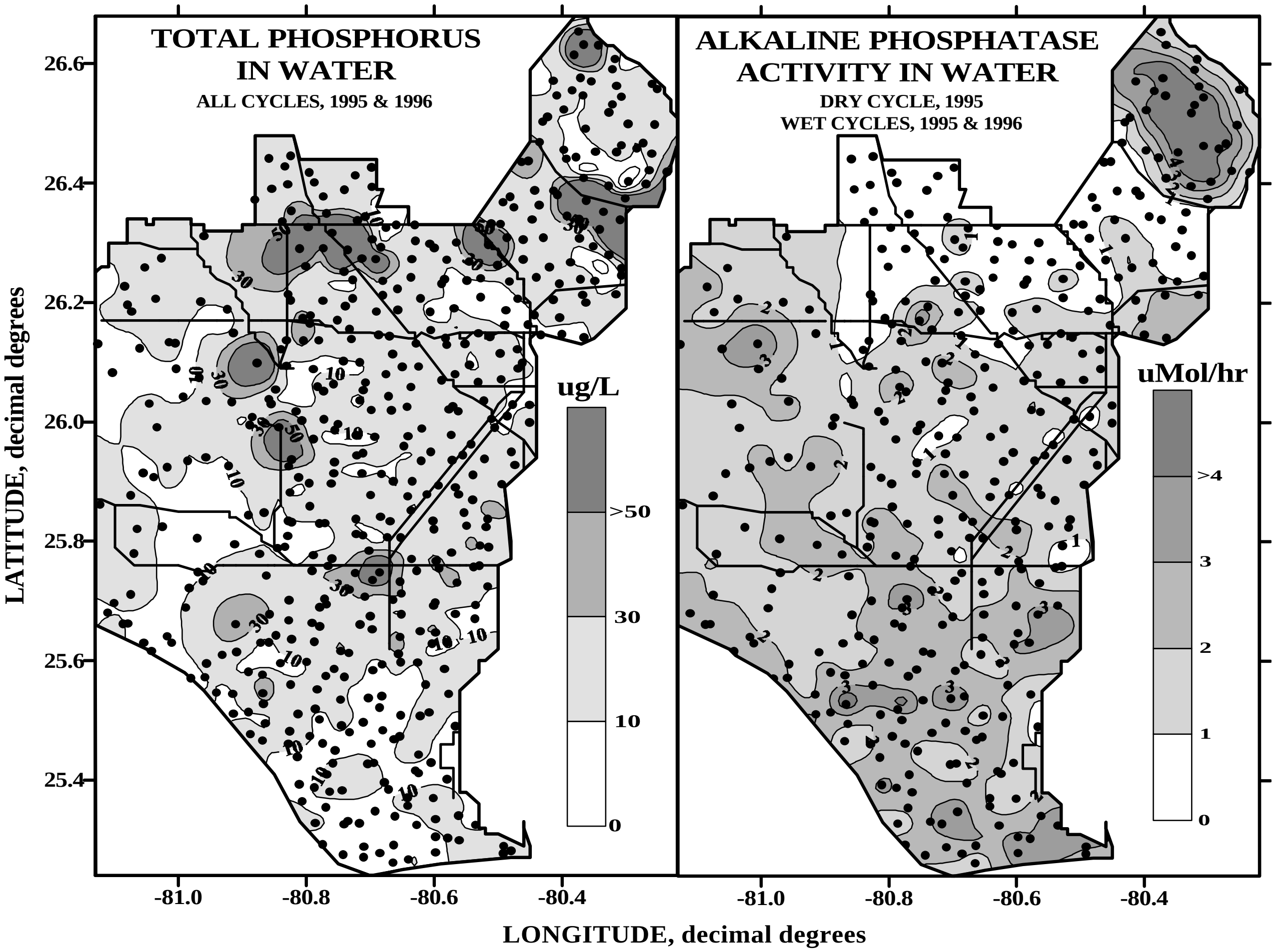

Figure 7.20 Kriged surfaces showing patterns of TP and APA in the marsh.

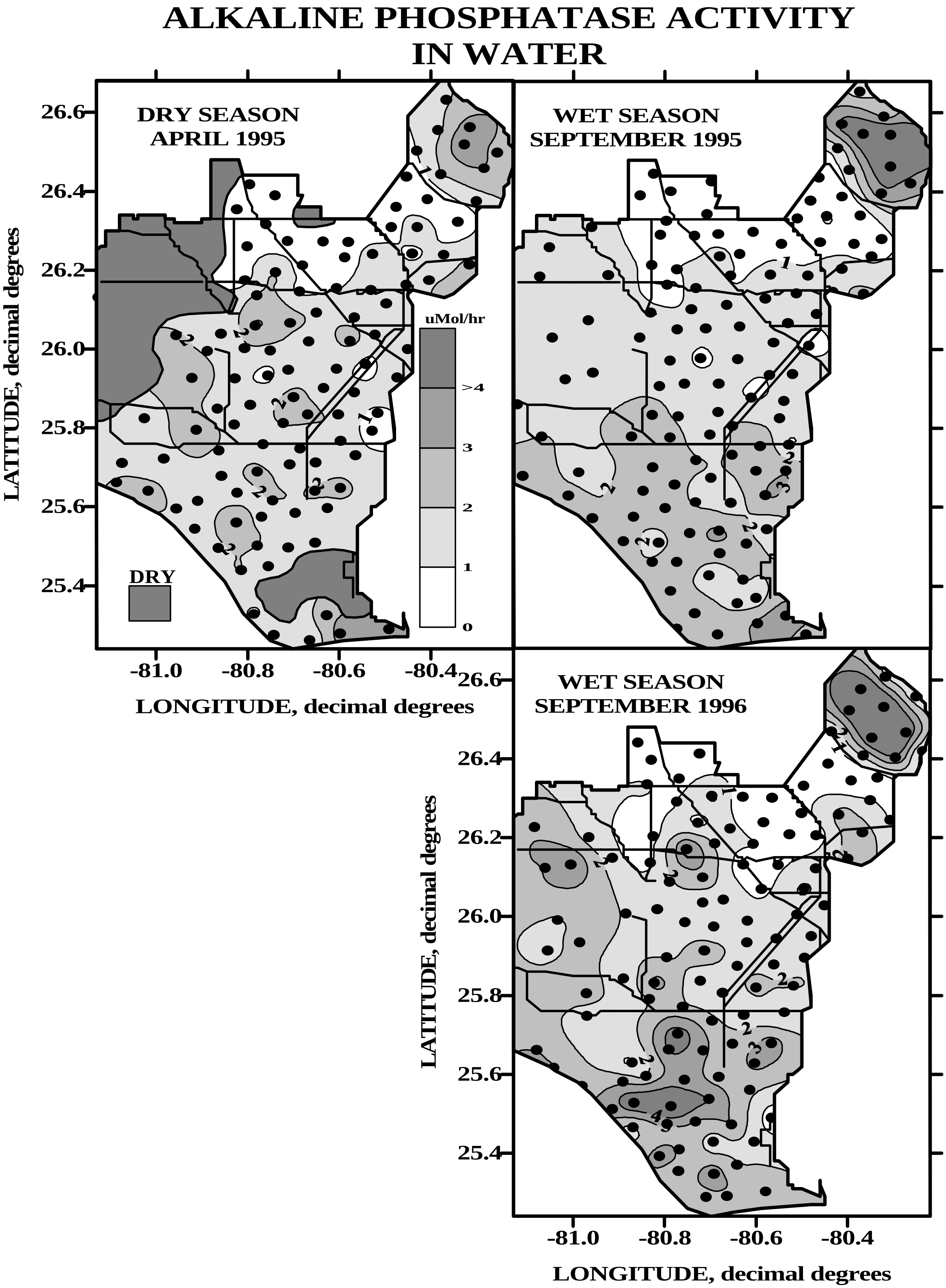

Figure 7.21 Kriged surfaces showing APA in the marsh for each sampling cycle.

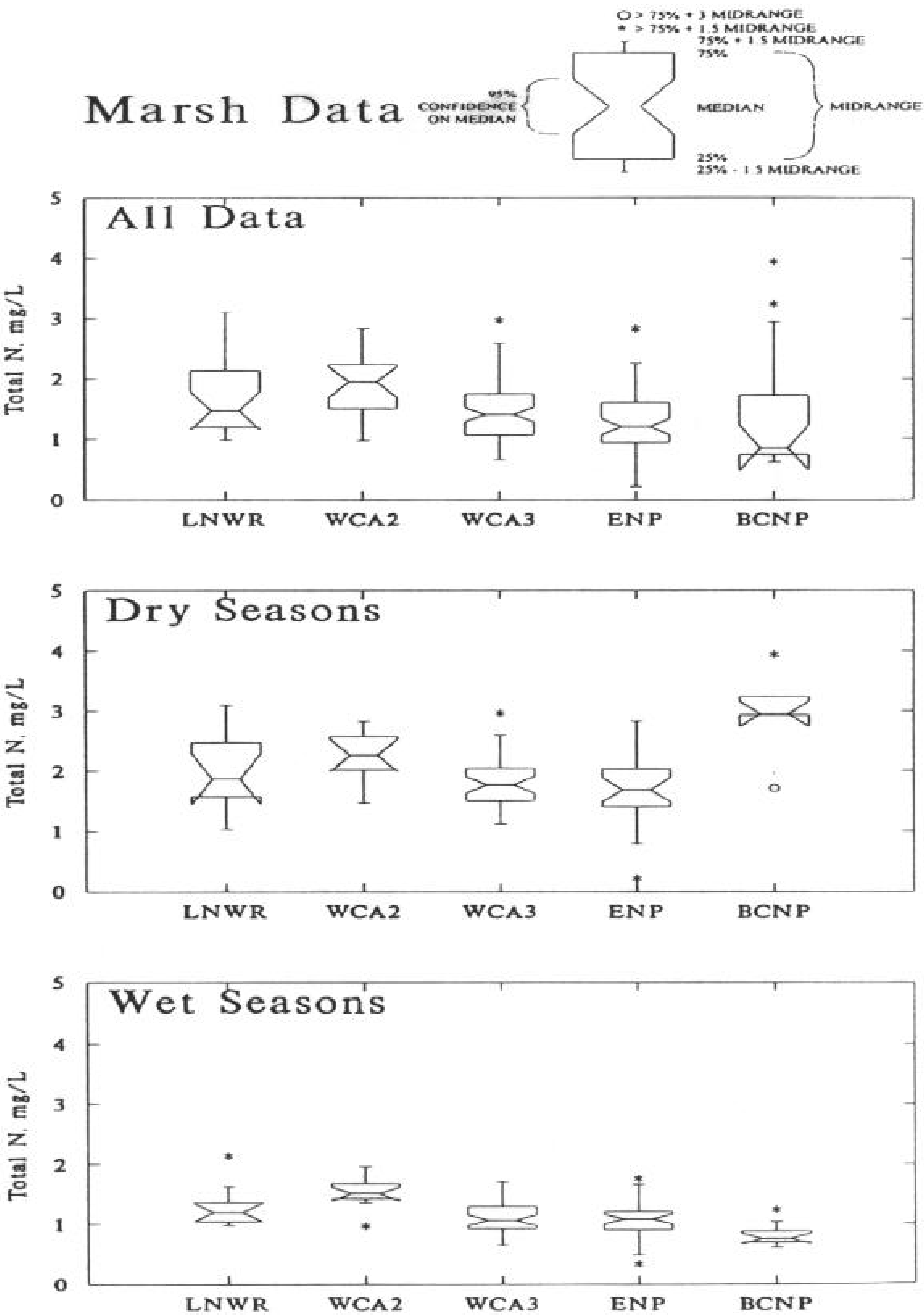

Figure 7.22 Notched box and whisker plots comparing marsh TN in subareas during dry and wet seasons.

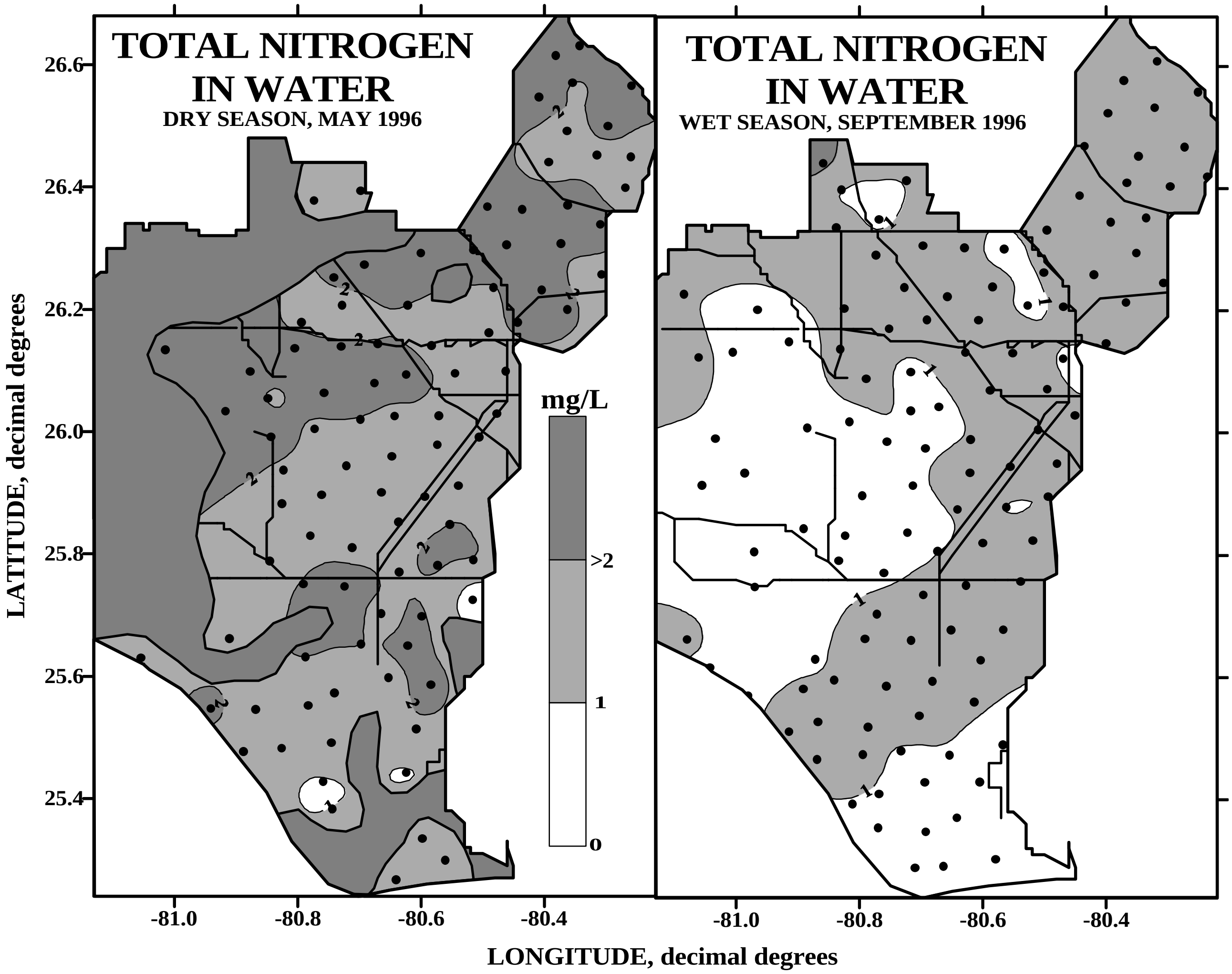

Figure 7.23 Kriged surface showing marsh TN concentrations in water during the May and September 1996 cycles.

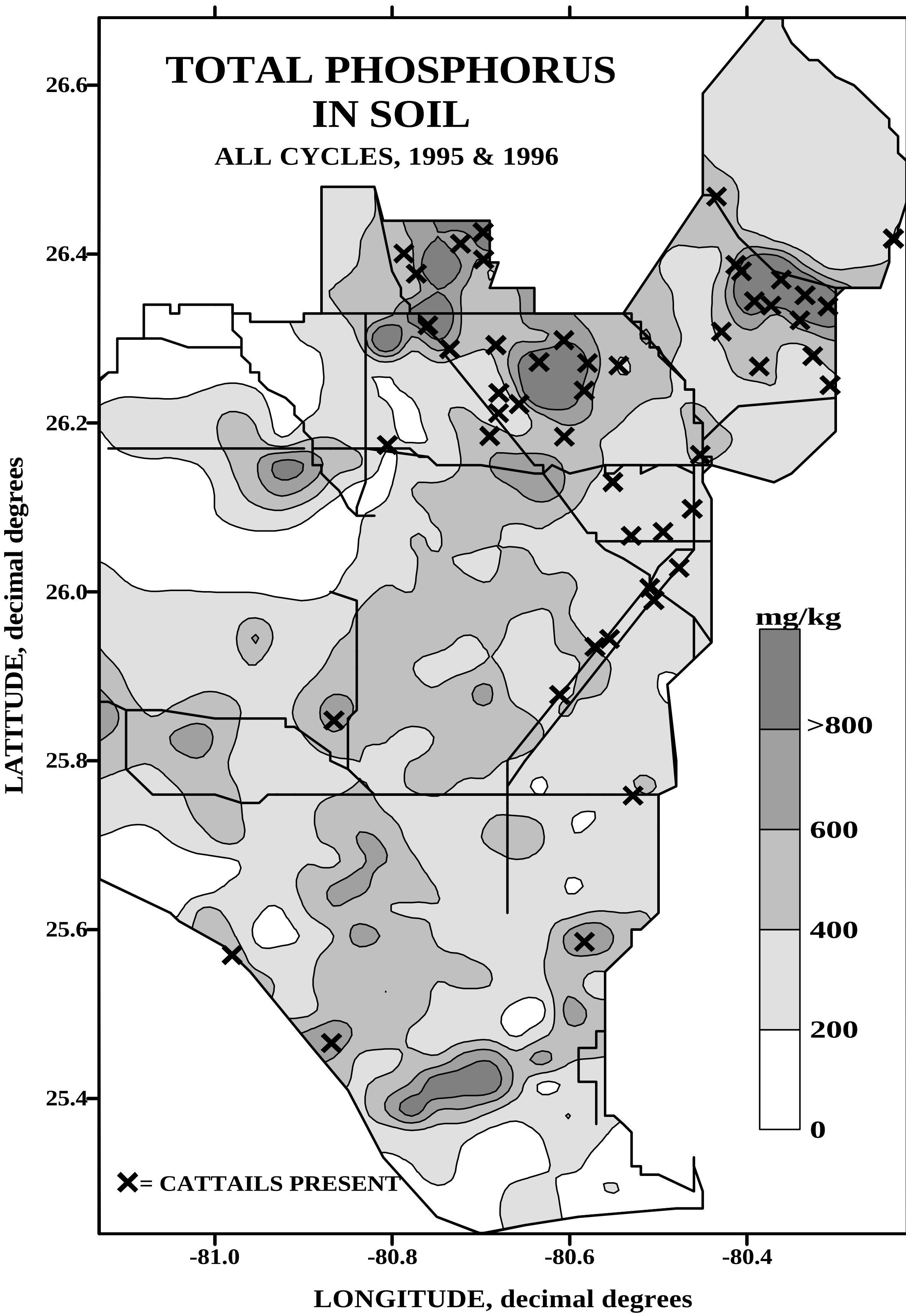

Figure 7.24 Kriged surface showing marsh soil TP concentrations over the study period.

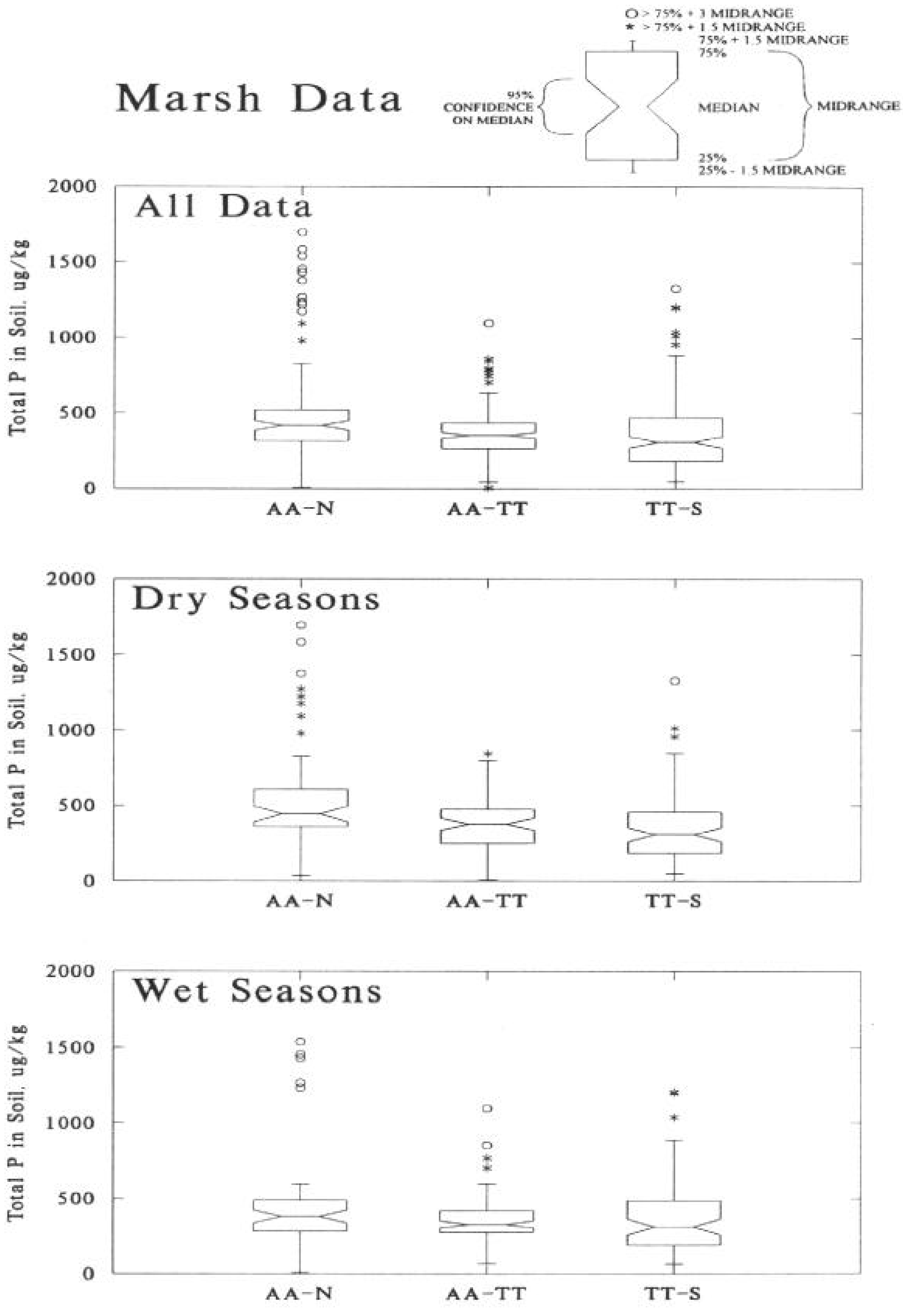

Figure 7.25 Notched box and whisker plots comparing marsh soil TP in latitudinal subareas during dry and wet seasons.

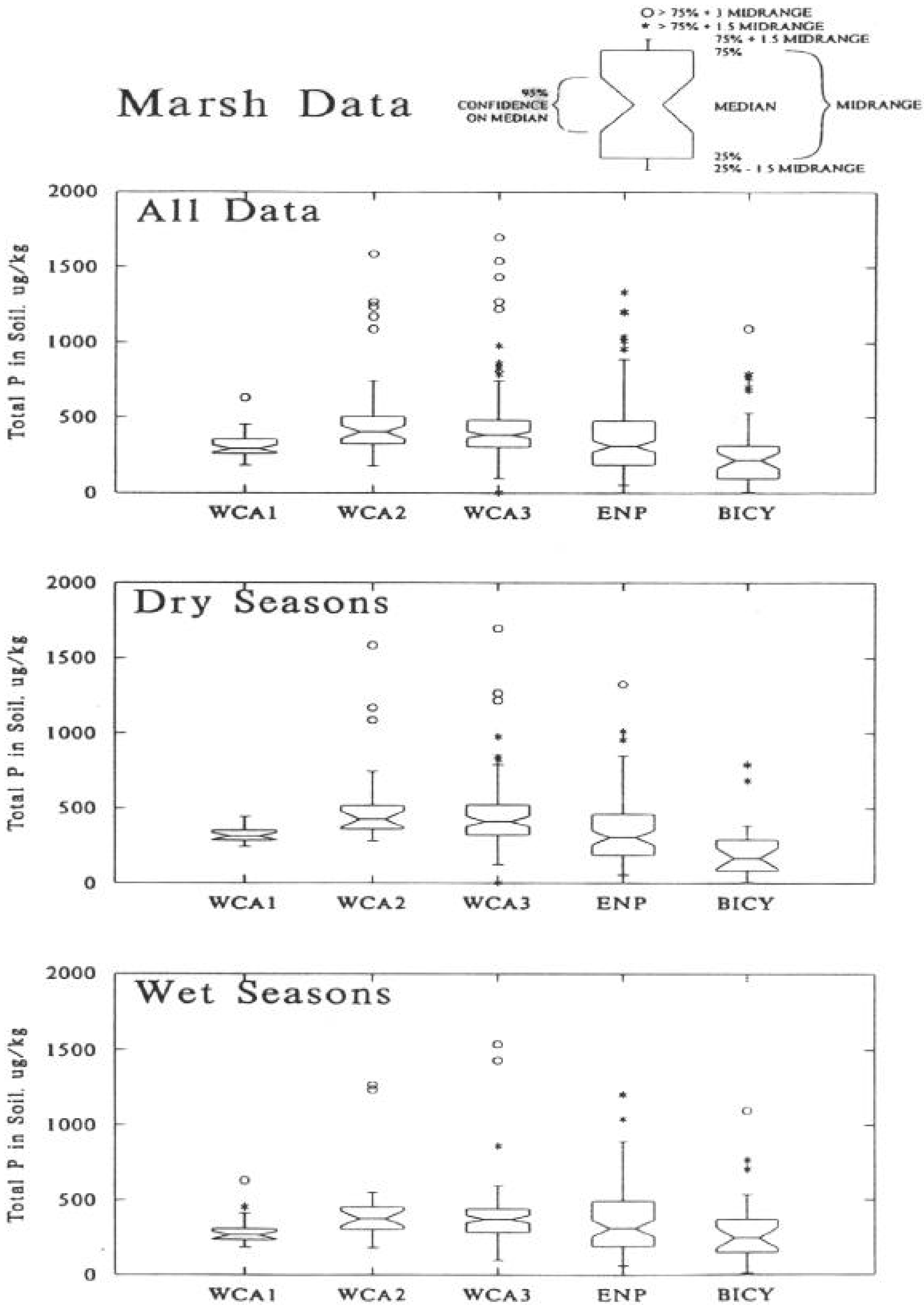

Figure 7.26 Notched box and whisker plots comparing marsh soil TP in geographic subareas during dry and wet seasons.

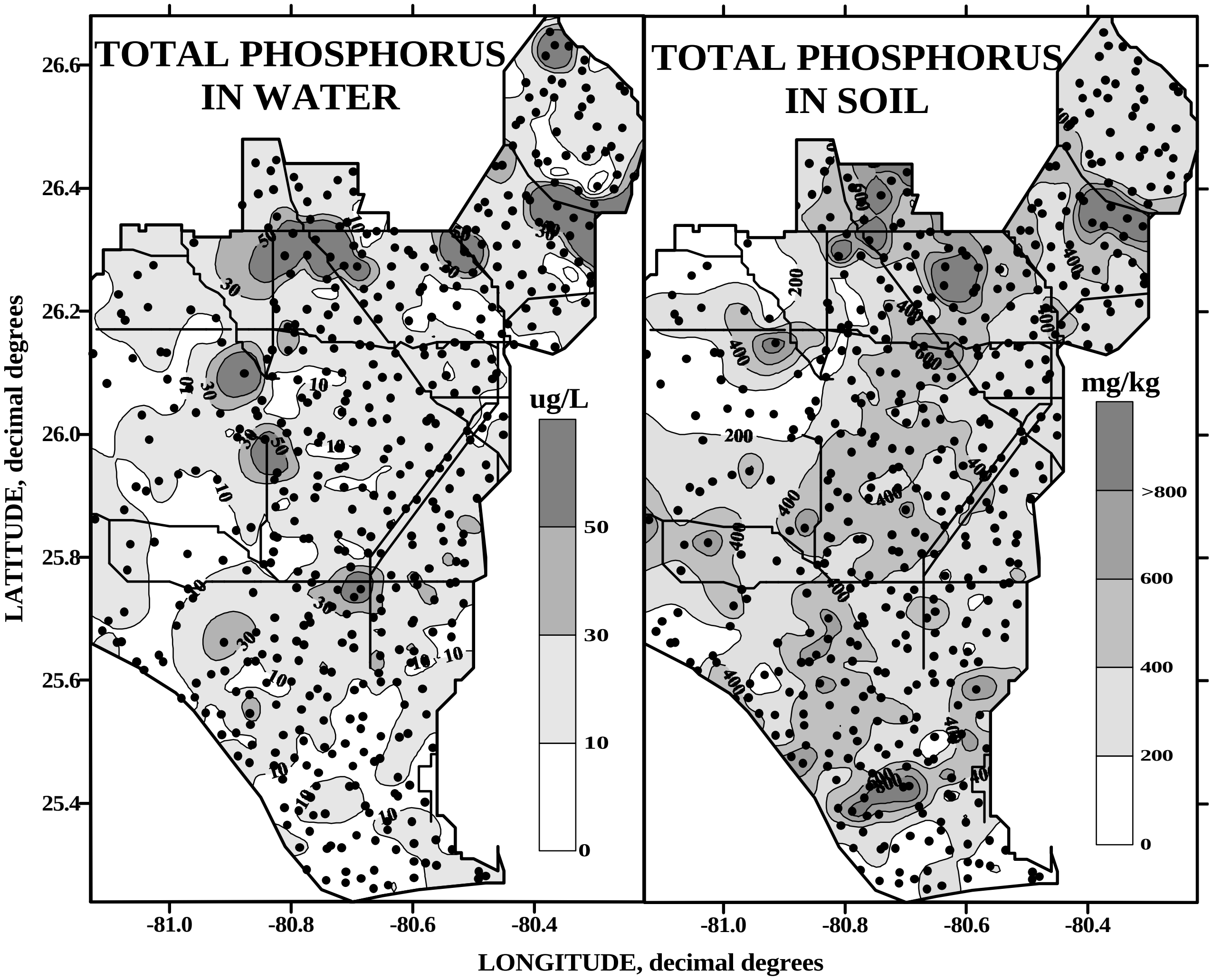

Figure 7.27 Kriged surfaces showing TP concentrations in marsh water and soil during study period.

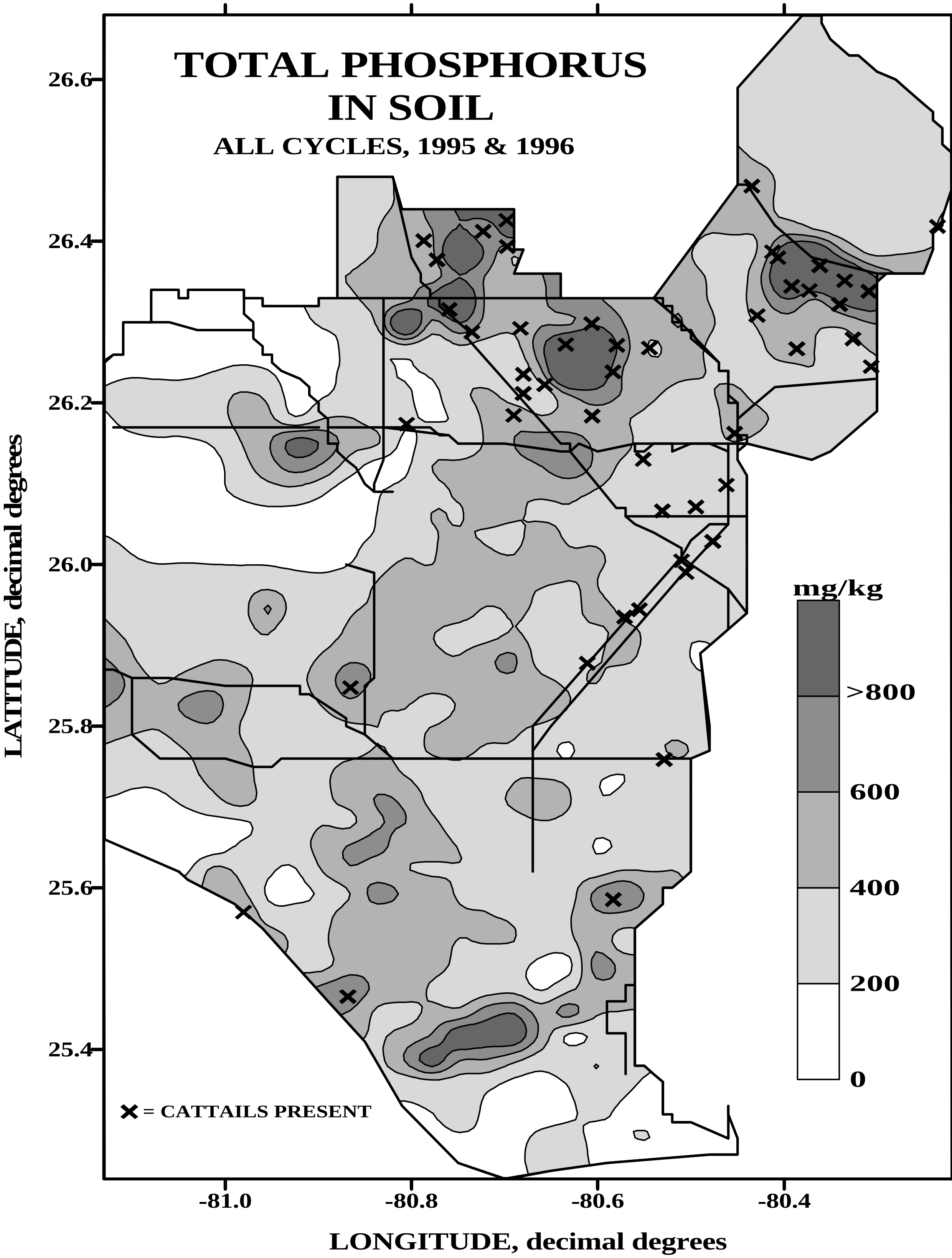

Figure 7.28 Kriged surface of TP in marsh soils with sampling stations where cattails were present.