Long-term trends in the water quality of Florida Bay (1989-98)

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One of the primary purposes for conducting long-term monitoring projects is to be able to detect trends in the measured variables over time. These programs are usually initiated as a response to public perception (and possibly some scientific data) that "the river-bay-prairie-forest-etc. is dying". In the case of Florida Bay during 1987, the impetus was the combination of a seagrass die-off, increased phytoplankton abundance, sponge mortality, and a perceived decline in fisheries. In response to these phenomena, a network of water quality monitoring stations was established in 1989 to explicate both spatial patterns and temporal trends in water quality in an effort to elucidate mechanisms behind the recent ecological change.

A spatial analysis of data from our monitoring program resulted in the delineation of 3 groups of stations which have robust similarities in water quality (Fig. 1). We have argued that these spatially contiguous groups of stations are the result of similar loading and processing of materials, hence we call them "zones of similar influence". The Eastern Bay zone acts most like a "conventional" estuary in that it has a quasi-longitudinal salinity gradient caused by the mixing of freshwater runoff with seawater. In contrast, the Central Bay is a hydrographically isolated area with low and infrequent terrestrial freshwater input, a long water residence time, and high evaporative potential. The Western Bay zone is the most influenced by the Gulf of Mexico tides and is also isolated from direct overland freshwater sources.

Climactic changes occurring over the data collection period of record had major effects on the health of the bay. Precipitation rebounded from the drought during the late 80's being greater than the long term average (9.2 cm mo^{-1}) for the last 7 of 10 years (Fig. 2). The heavy line in Fig. 2 and others is a 12 month moving average which shows interannual trends and oscillations. Over this period, salinity and total phosphorus (TP) concentrations declined baywide while turbidity (cloudiness of the water) increased dramatically. The salinity decline in Eastern, Central and Western Florida Bay was 13.6, 11.6, and 5.6 ppt, respectively (Fig. 3). Some of this decrease in Eastern Bay could be accounted for by increased freshwater flows from the Everglades but declines in other areas point to the climactic effect of increased rainfall during this period. The Central Bay continues to experience hypersaline conditions (>35 ppt) during the summer but the extent and duration of the events is much smaller.

As mentioned previously, TP concentrations have declined baywide over the 10 year period. The Eastern Bay has the lowest concentrations while the Central Bay is highest (Fig. 4). Unlike most other estuaries, increased terrestrial runoff may have been partially responsible for the decrease in TP concentrations in the Eastern Bay. This is because the TP concentrations of the runoff are at or below ambient levels in the bay. The elevated TP in the Central Bay is mostly due to concentration effect of high evaporation. It is important to understand that almost all the phosphorus measured as TP is in the form of organic matter which is much less accessible to plants and algae than inorganic phosphate (fertilizer).

Turbidity in Eastern Bay increased 2-fold from 1991-98, while Central and Western Bays increased by factors of 20 and 4, respectively (Fig. 5). Generally, the Eastern Bay has the clearest water which is due to a combination of factors such as high seagrass cover, more protected basins, low tidal energy, and shallow sediment coverage. Turbidity in the Central and Western Bays have increased tremendously since 1991. We are unsure as to the cause but the loss of seagrass coverage may have destabilized the bottom so that it is more easily disturbed by wind events.

Chlorophyll *a* concentrations, a proxy for phytoplankton biomass, were particularly dynamic and spatially heterogeneous. In the Eastern Bay, which makes up roughly half of the surface area of Florida Bay, chlorophyll *a* declined by 0.9 $\mu g\ l^{-1}$ or 63% (Fig. 6). The isolated Central Bay zone underwent a 5-fold increase in chlorophyll *a* from 1989-94, then rapidly declined to previous levels by 1996. In Western Florida Bay, there was a significant increase in chlorophyll *a*, yet median concentrations of chlorophyll *a* in the water column remained modest (~2 $\mu g\ l^{-1}$) by most estuarine standards.

Ammonium (NH_4^+) levels displayed large variability over the period of record and was much higher in the Central Bay than anywhere else (Fig. 7). Only in Central Bay did the NH_4^+ pool increase substantially over time (3-6 fold). Trends in nitrate (NO_3^-) concentrations (Fig. 8) mirrored those of NH_4^+ and were mostly due to the biological conversion of NH_4^+ to NO_3^- (nitrification) under aerobic conditions.

It is important to note that these changes in turbidity and chlorophyll *a* happened after the poorly-understood seagrass die-off in 1987. It is likely that the death and decomposition of large amounts of seagrass biomass can at least partially explain some of the changes in water quality of Florida Bay but the connections are temporally disjoint and the processes indirect and not well understood.

ACKNOWLEDGMENTS

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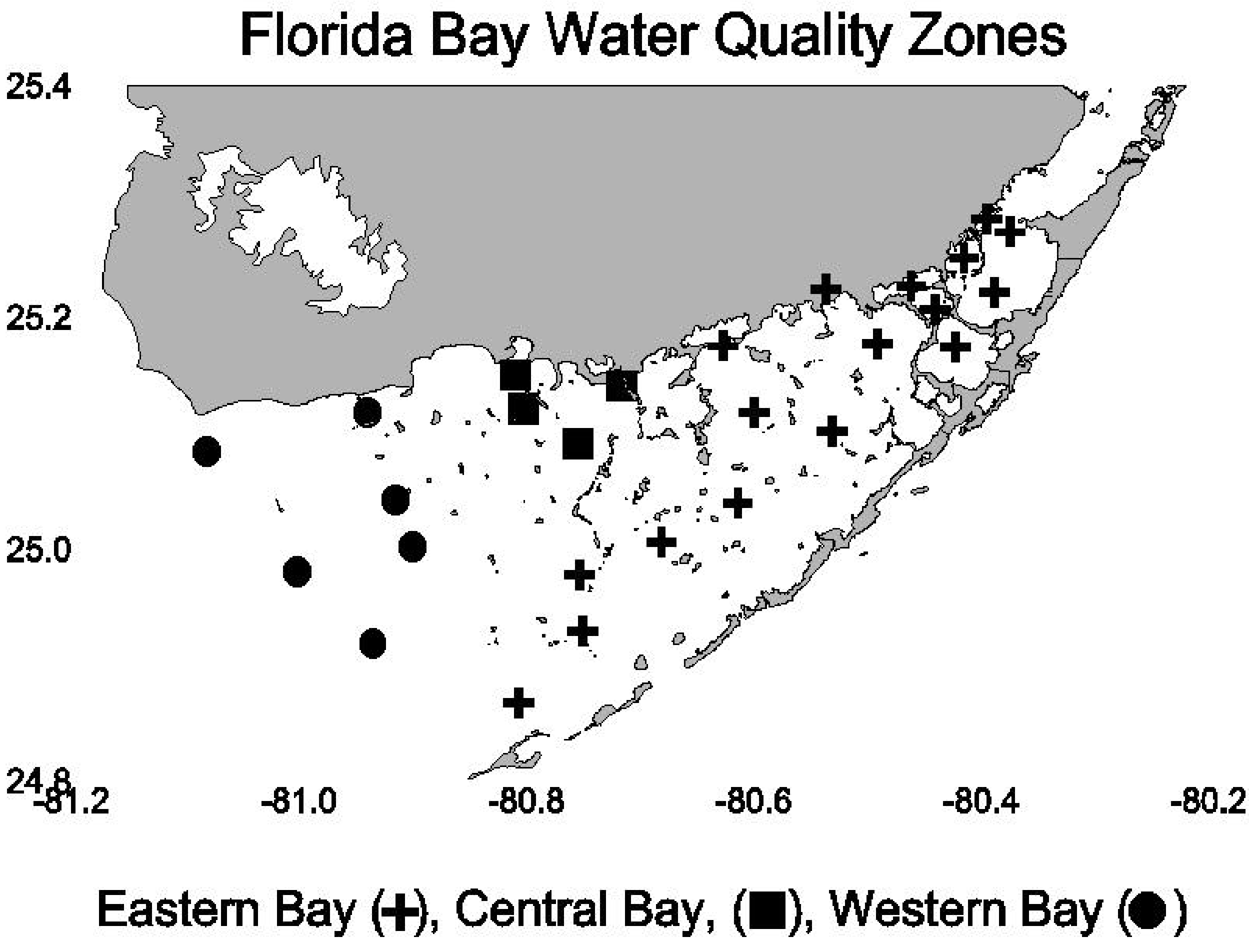


Figure 1

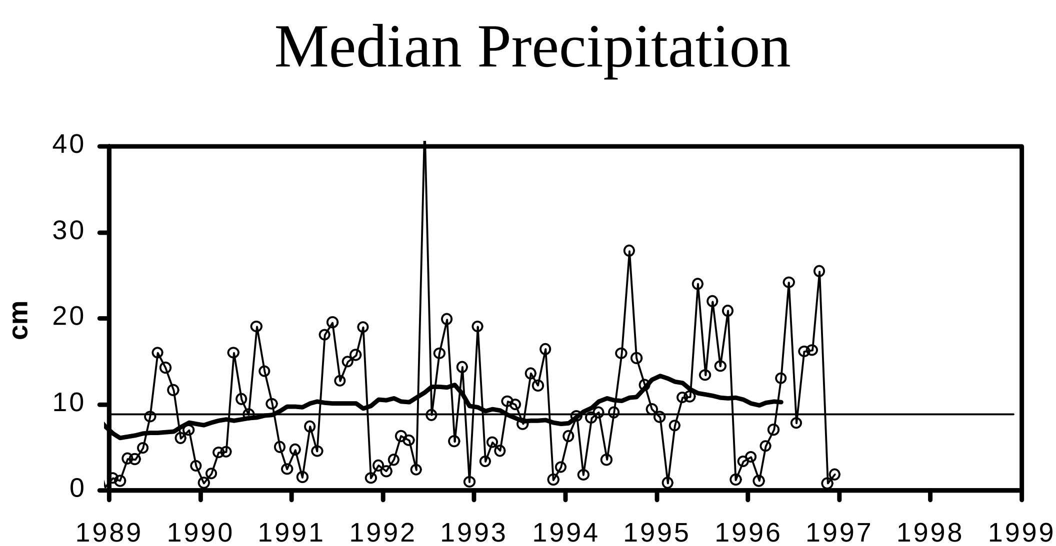
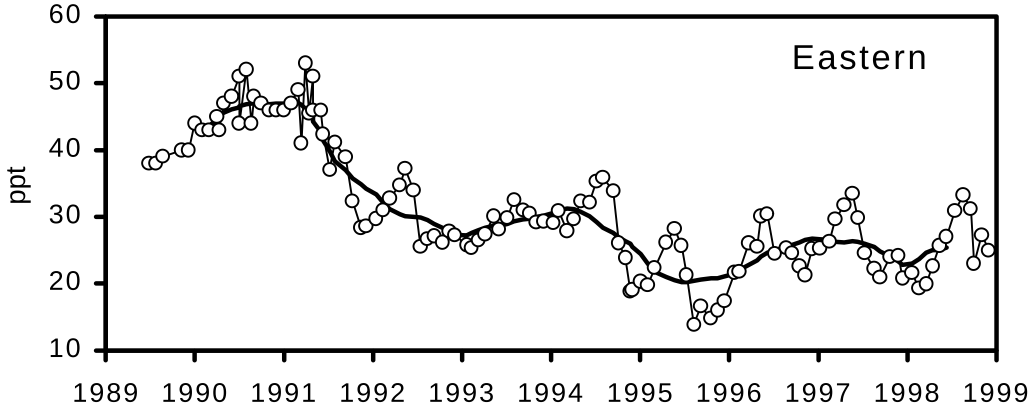
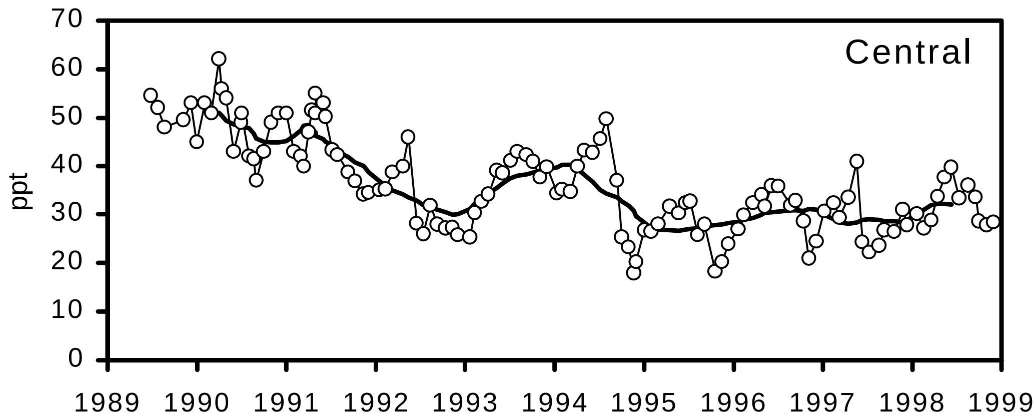


Figure 2

Median Salinity





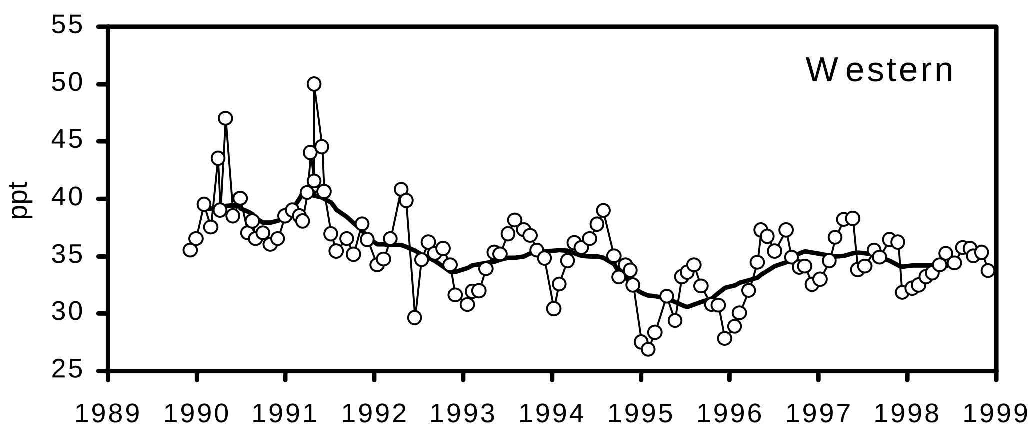


Figure 3

Median Total Phosphorus

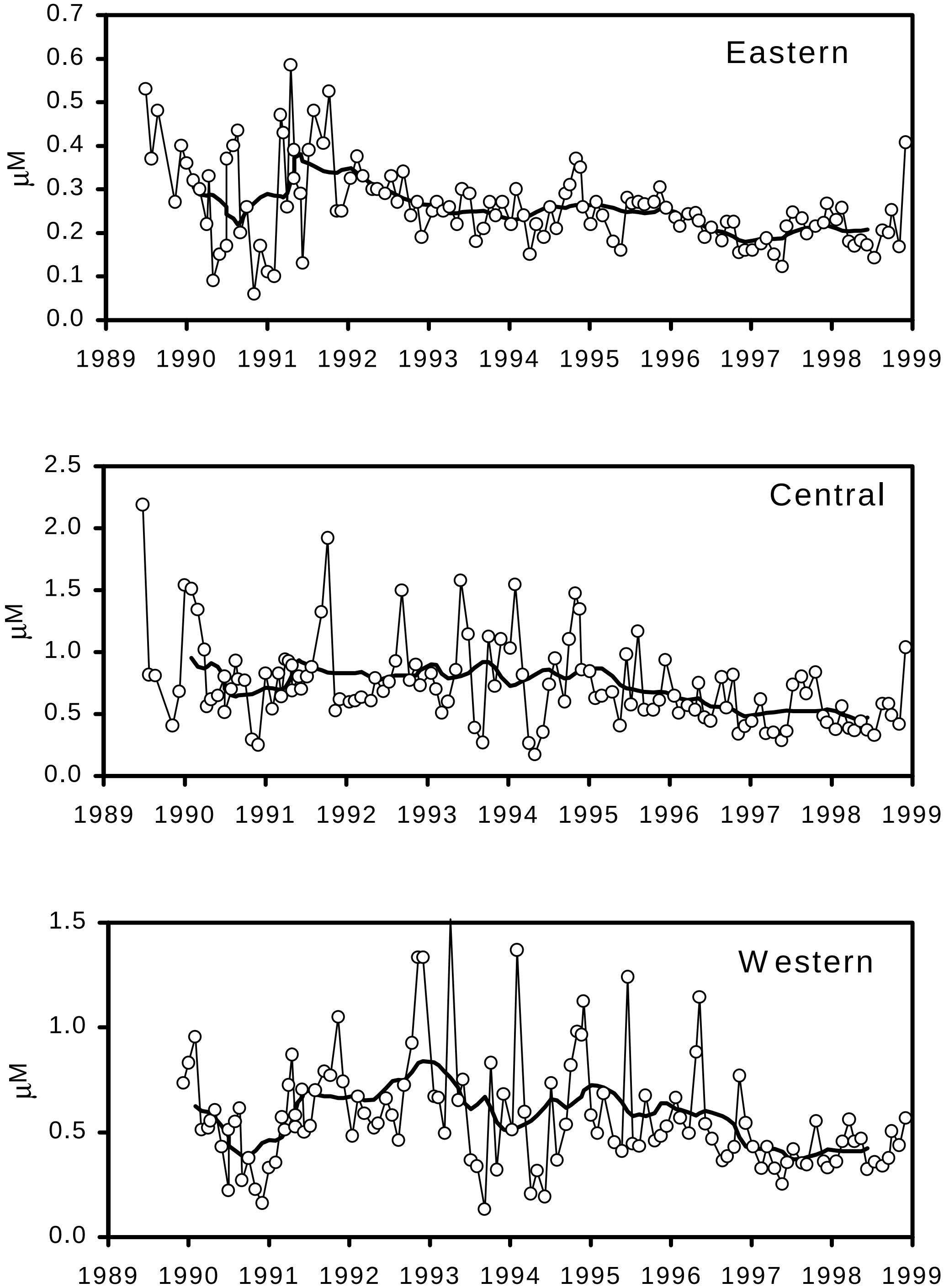


Figure 4

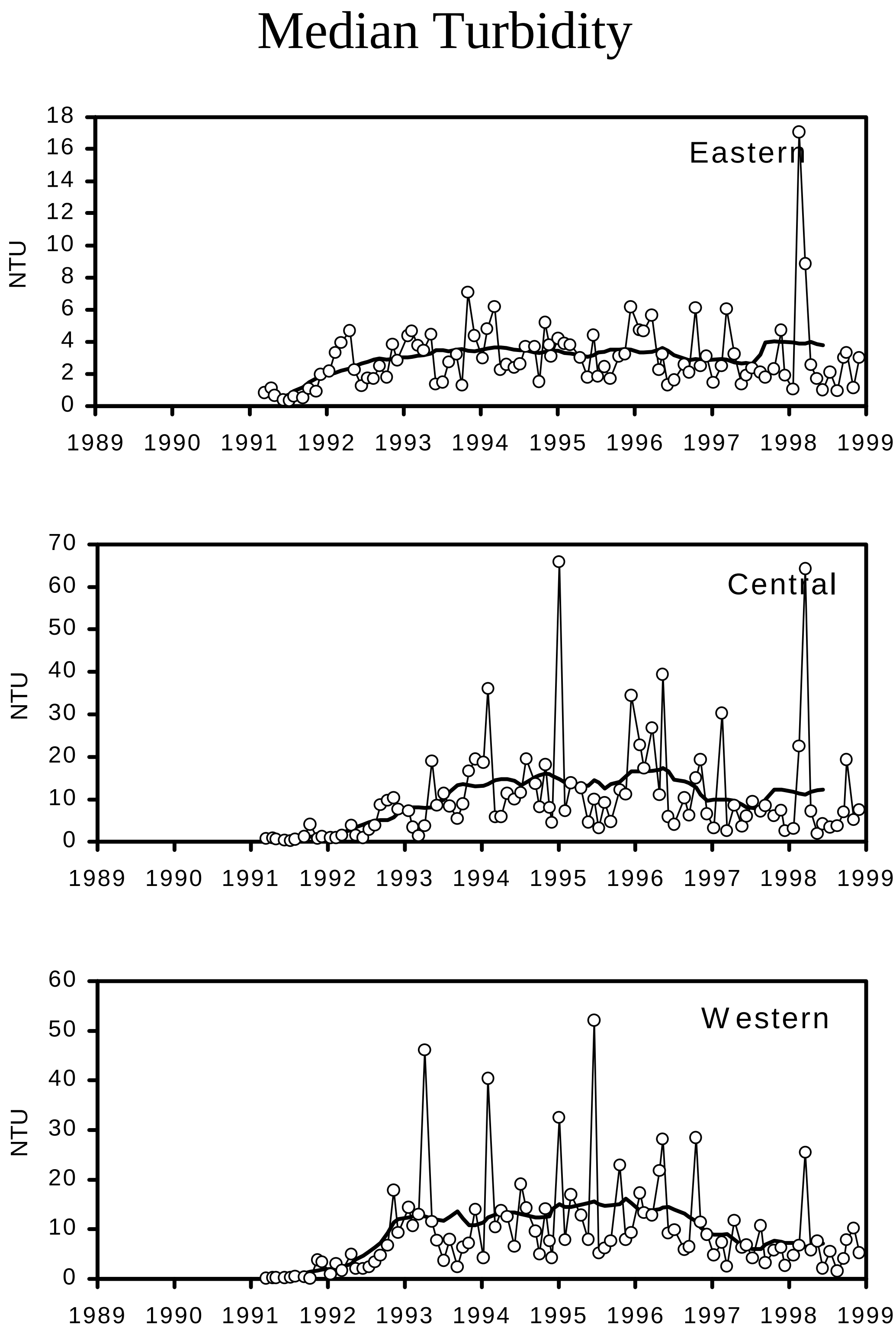

Median Turbidity
Eastern
Central
Western
NTU
0
2
4
6
8
10
12
14
16
18
20
30
40
50
60
70
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999

Figure 5

Median Chlorophyll *a*

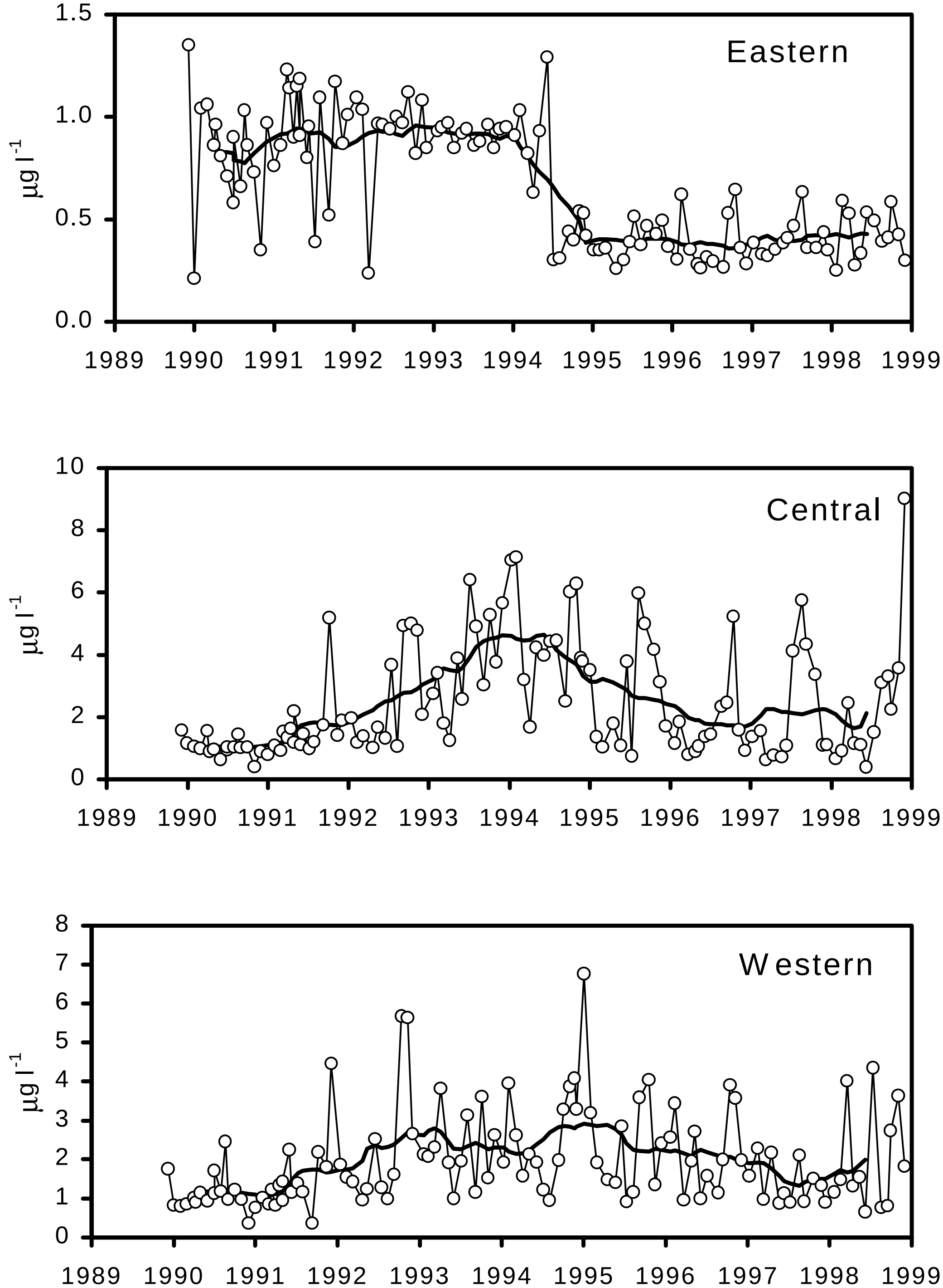


Figure 6

Median Ammonium (NH_4^+)

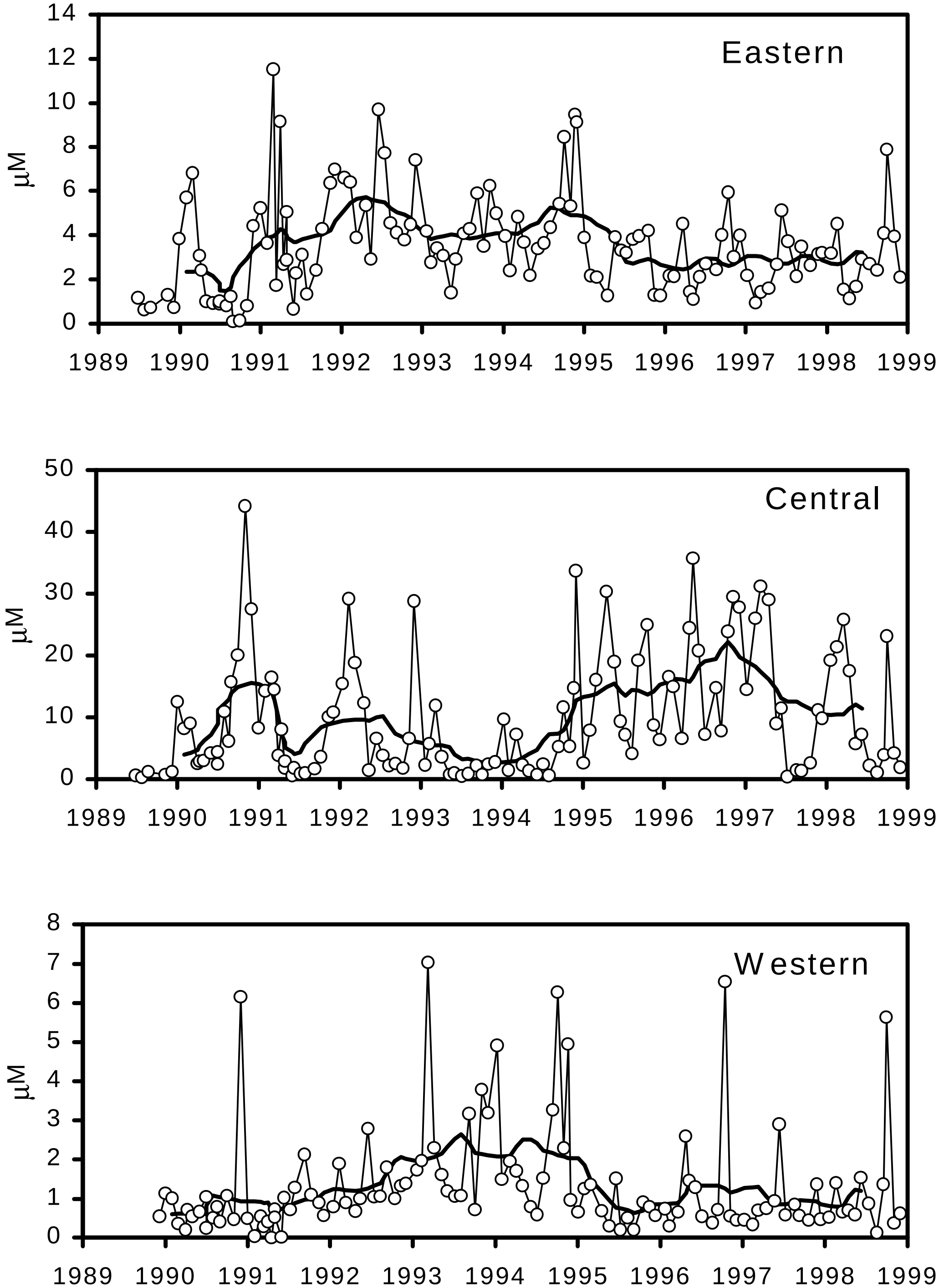


Figure 7

Median Nitrate (NO_3^-)

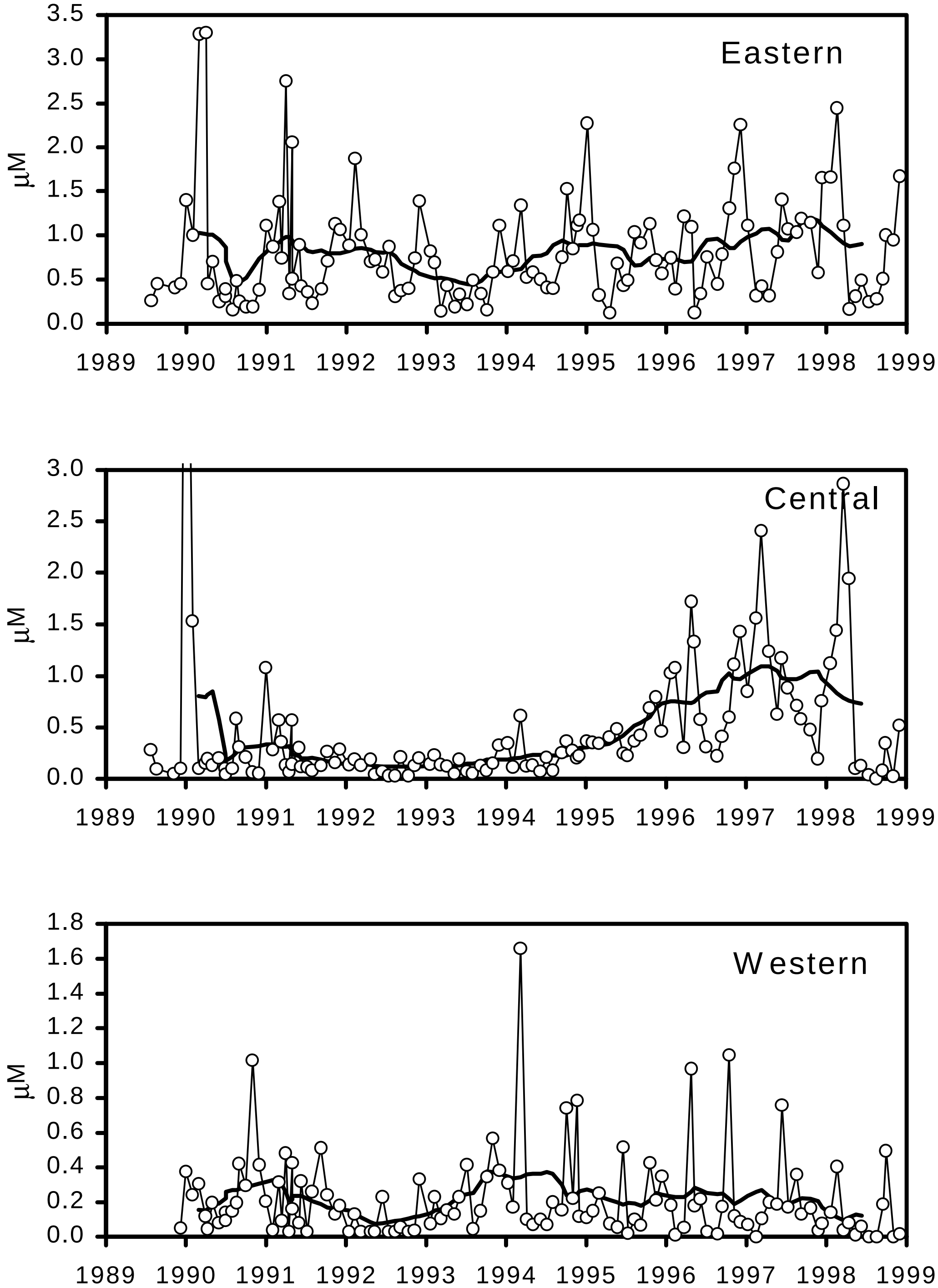


Figure 8