2001

The State of Florida Bay Water Quality (1989-2001)

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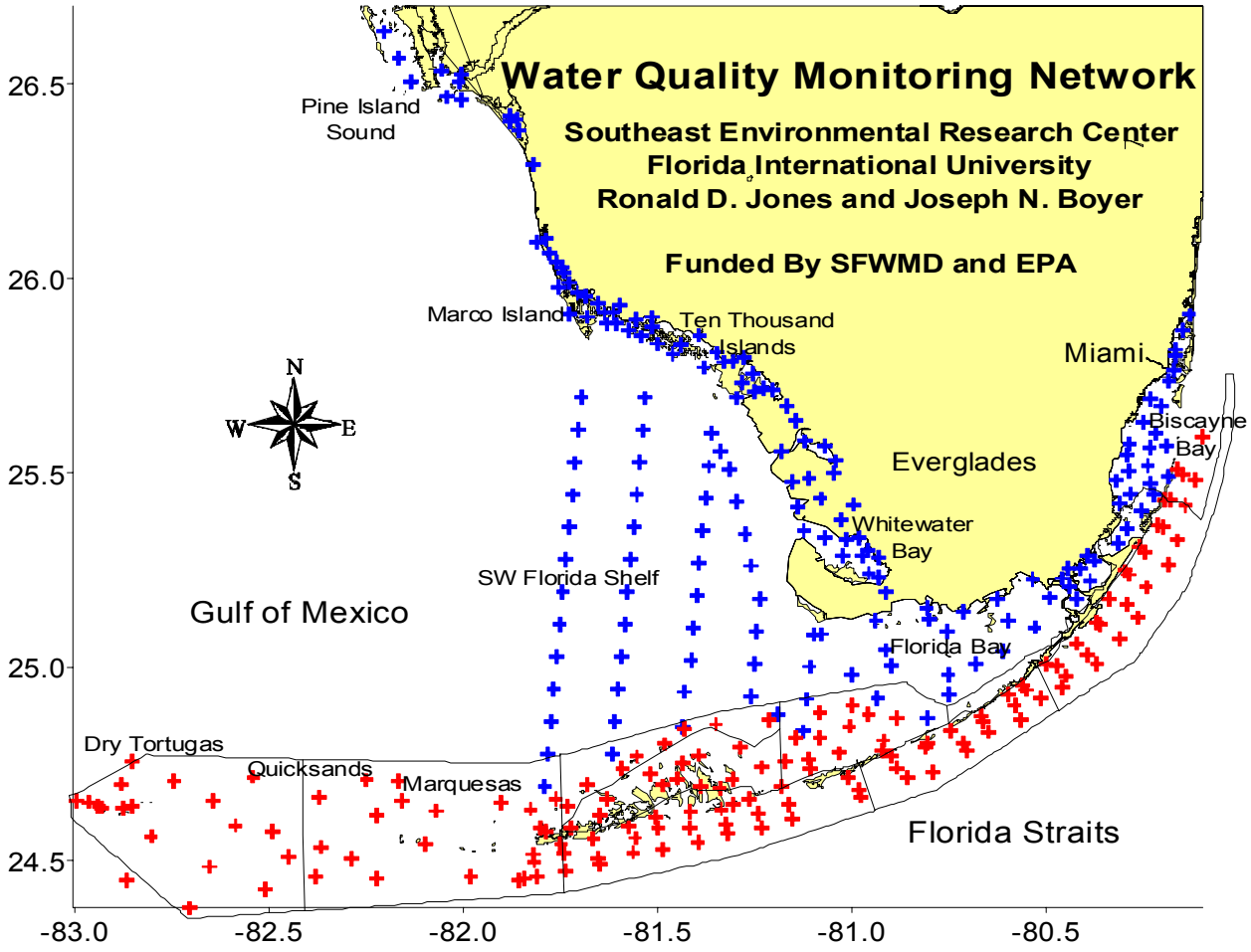

Introduction

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 (and funded by SFWMD in 1991) to explicate both spatial patterns and temporal trends in water quality in an effort to elucidate mechanisms behind the recent ecological change.

Overall Period of Record

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 hydrodymanic forcing 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 9 of the last 12 years (Fig 2.). Early in the record, salinity and total phosphorus (TP) concentrations declined baywide while turbidity (cloudiness of the water) increased dramatically. The salinity decline in Eastern and Central Florida Bay was dramatic early on and has since stabilized into a regular seasonal cycle (Fig. 3). The box-and-whisker plots presented in this and following figures show the range (boxes are quartiles; whiskers include 90% of data) and median (line in box) of the monthly data. 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) during the summer but the extent and duration of the events is much smaller.

Chlorophyll *a* concentrations (CHLA), a proxy for phytoplankton biomass, were particularly dynamic and spatially heterogeneous (Fig. 4). The Eastern Bay generally has the lowest CHLA while the Central Bay is highest. In the Eastern Bay, which makes up roughly half of the surface area of Florida Bay, CHLA has declined by 0.9 $\mu g\ l^{-1}$ or 63%. Most of this decline occurred over a few months in the spring/summer of 1994 and has remained relatively stable. The isolated Central Bay zone underwent a 5-fold increase in CHLA from 1989-94, then rapidly declined to previous levels by 1996. In Western Florida Bay, there was a significant increase in CHLA, yet median concentrations remained modest (2 $\mu g\ l^{-1}$) by most estuarine standards. There were significant blooms in Central and Western Bay immediately following Hurricanes Georges (Nov. 1998) but it was Hurricane Irene's large rainfall input (Oct. 1999) which spiked a large bloom all throughout the bay. It is important to note that these changes in CHLA (and turbidity) happened years after the poorly-understood seagrass die-off in 1987. It is possible that the death and decomposition of large amounts of seagrass biomass might 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.

As mentioned previously, TP concentrations have declined baywide over the 12 year period of record (Fig. 5). As with salinity, most of these declines occurred in the early record. 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 less accessible to plants and algae than inorganic phosphate.

The dissolved inorganic nitrogen pool (DIN) is made up of ammonium (NH_4^+), nitrate (NO_3^-), and nitrate (NO_2^-). The Western Bay is lowest in DIN; phytoplankton in this region may be limited by N availability on a regular basis (Fig. 6). DIN in the Eastern Bay is a little higher and is mostly in the form of NO_3^- while highest levels are found in the Central Bay as NH_4^+.

Turbidity in the Central and Western Bays have increased tremendously since 1991 (Fig. 7). Turbidity in Eastern Bay increased 2-fold from 1991-93, while Central and Western Bays increased by factors of 20 and 4, respectively. 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. 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.

2001 Alone

Most water quality variables during 2001 generally followed typical annual trends but there were a couple exceptions. Unlike some years, all regions of the bay experienced a prolonged period of hypersalinity during the summer months. Most of this was due to the dry year prior which set up the system for this occurrence. The annual pattern in CHLA was unremarkable; no blooms reported. TP values declined from the very high fall 2000 levels and have returned to normal. Western Bay showed elevated DIN during the early part of the year but was not unreasonable compared to other years. Turbidity continues fluctuate at post 1993 levels. Note that the high turbidities observed in the Western Bay during the winter also correlated with elevated TP.

ACKNOWLEDGMENTS

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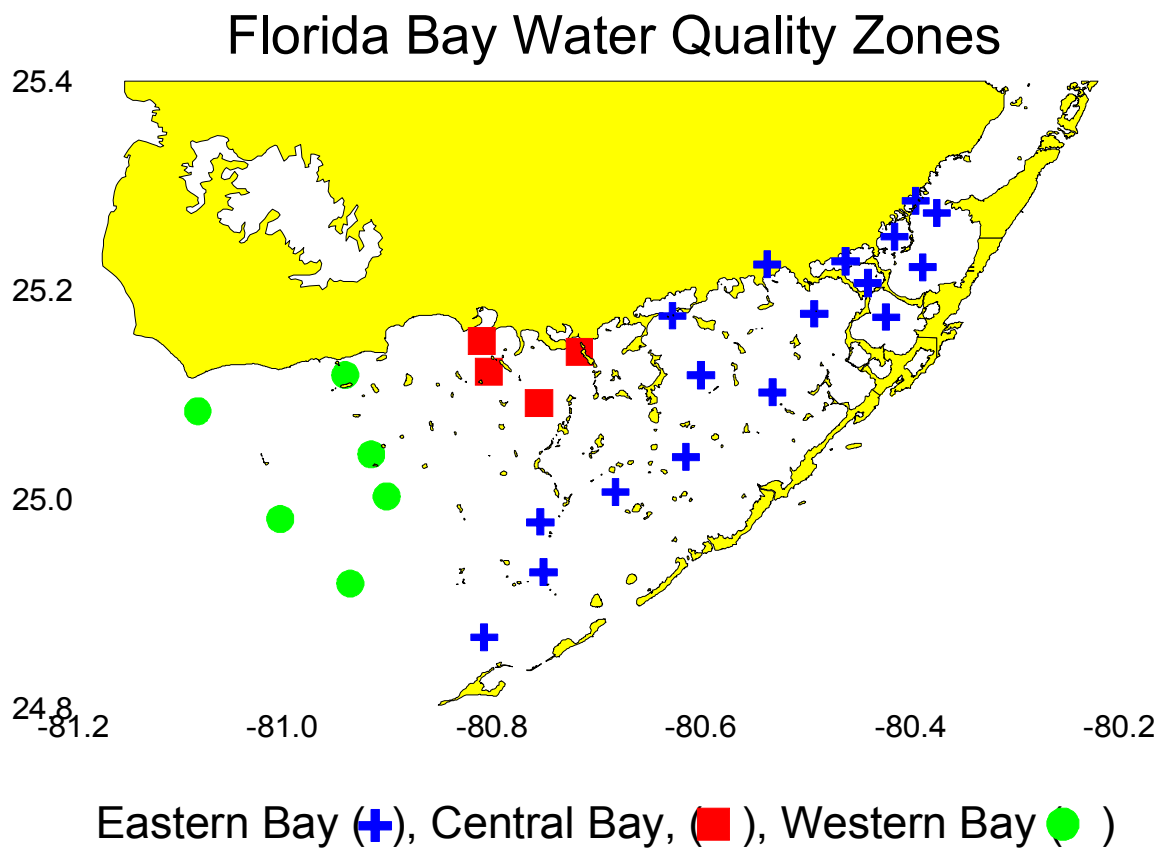

Figure 1. Zones of similar water quality in Florida Bay

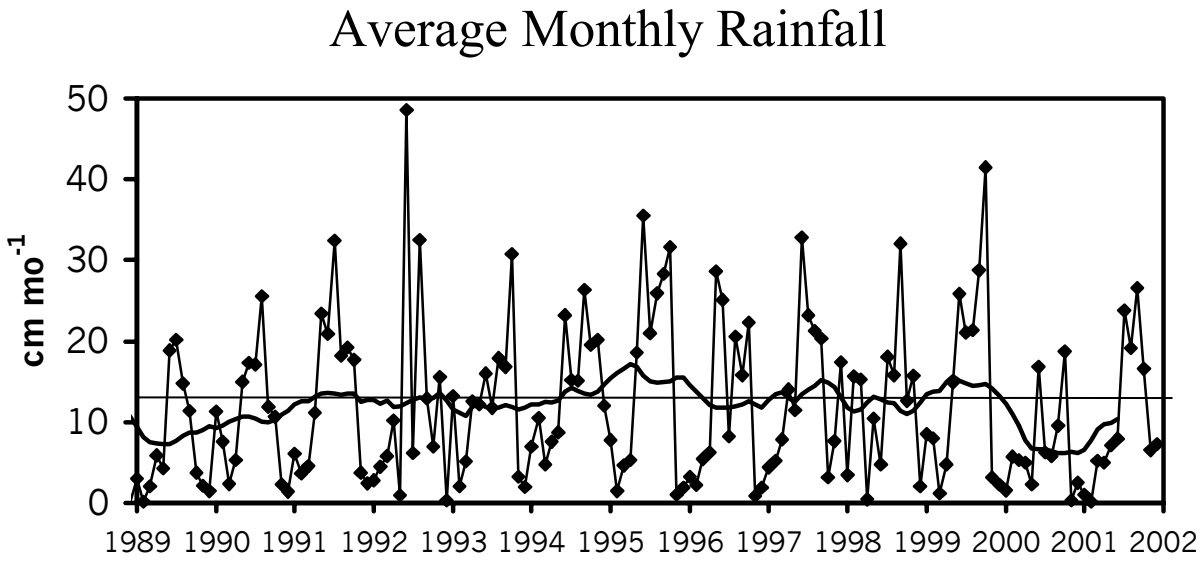

Figure 2. Monthly average rainfall in the Florida Bay area.

Median Salinity

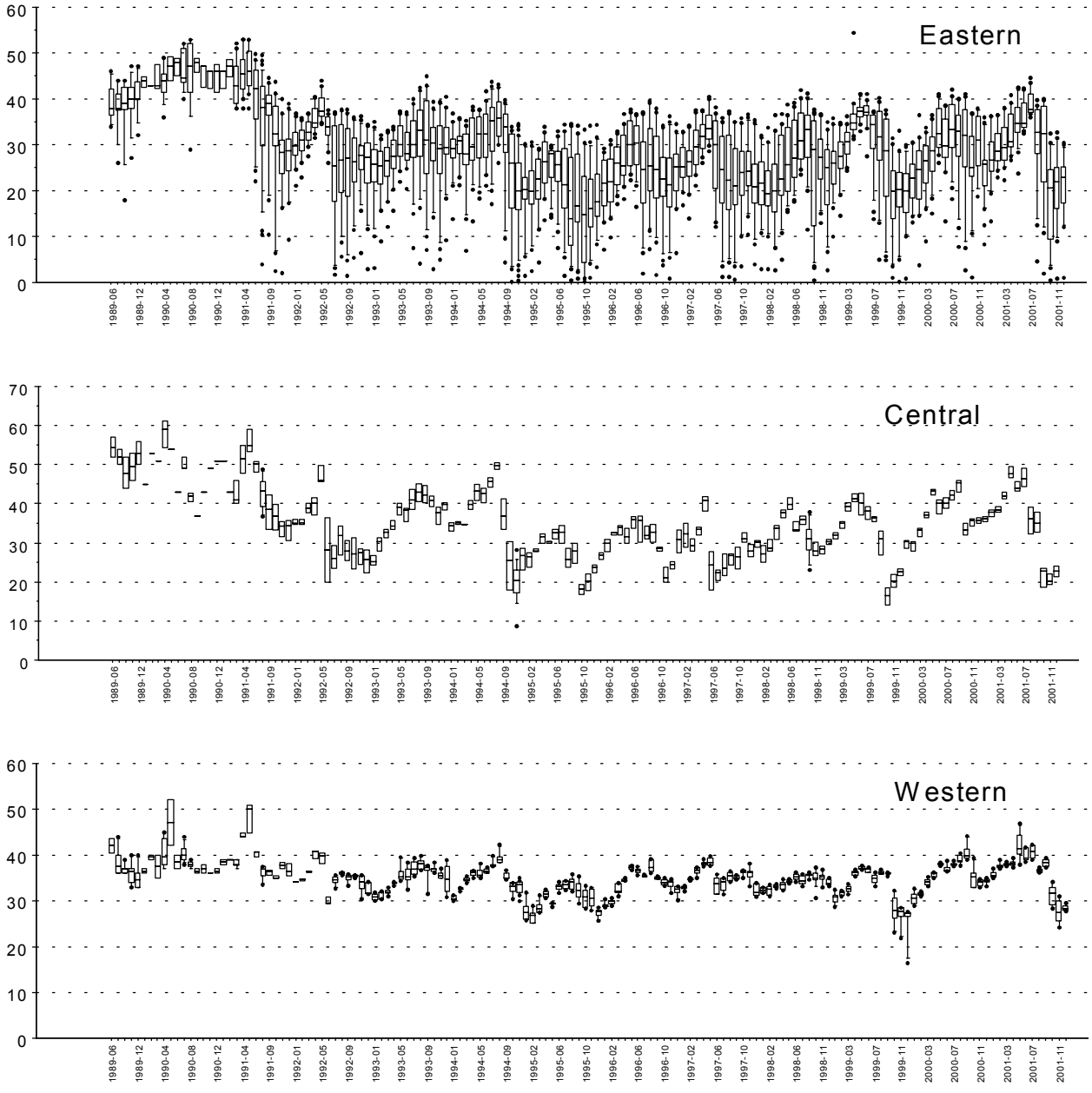

Figure 3. Monthly median salinity in the three Florida Bay zones.

Median Chlorophyll a

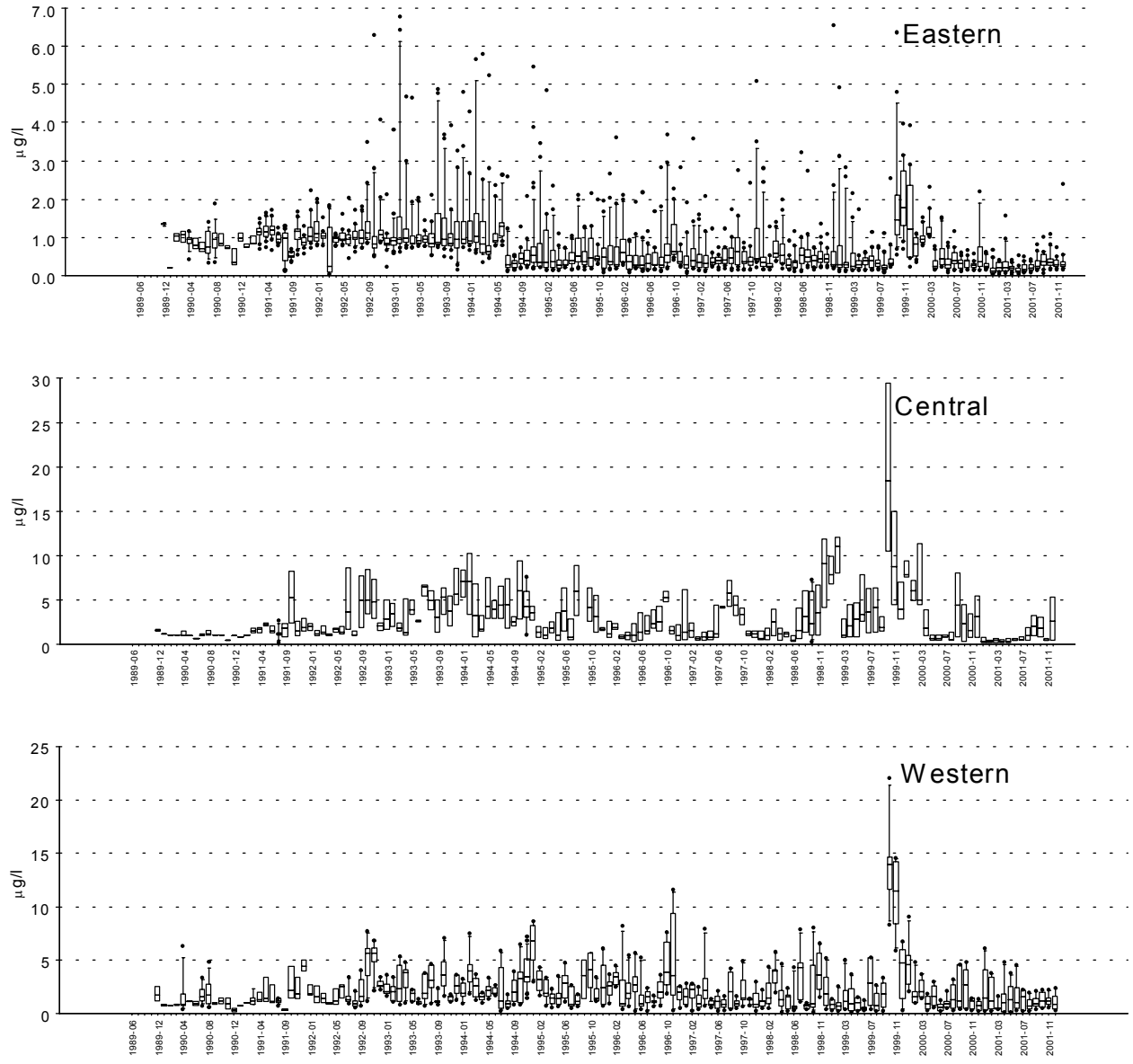

Figure 4. Monthly median CHLA in the three Florida Bay zones.

Median Total Phosphorus

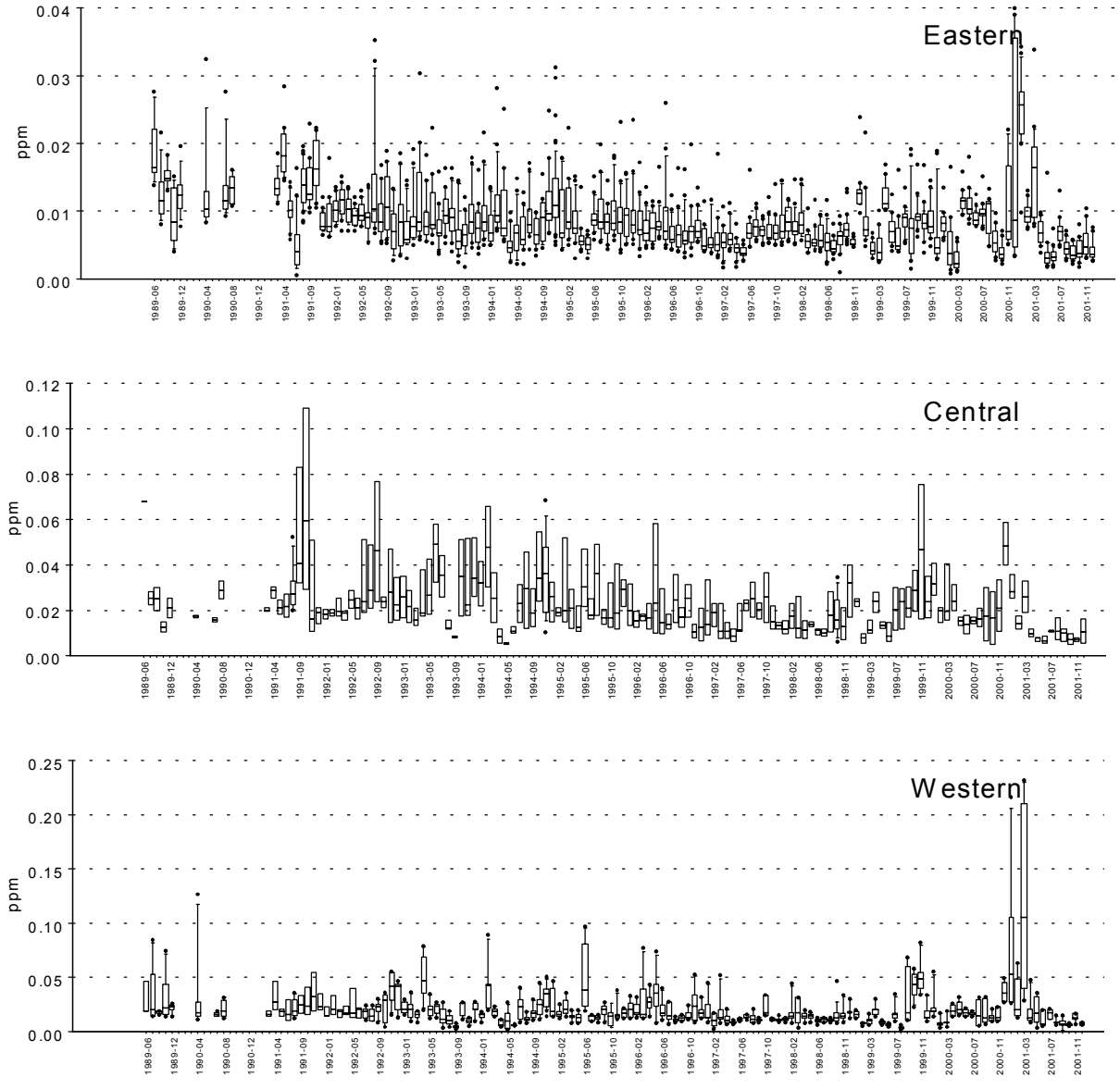

Figure 5. Monthly median TP in the three Florida Bay zones.

Median Dissolved Inorganic Nitrogen

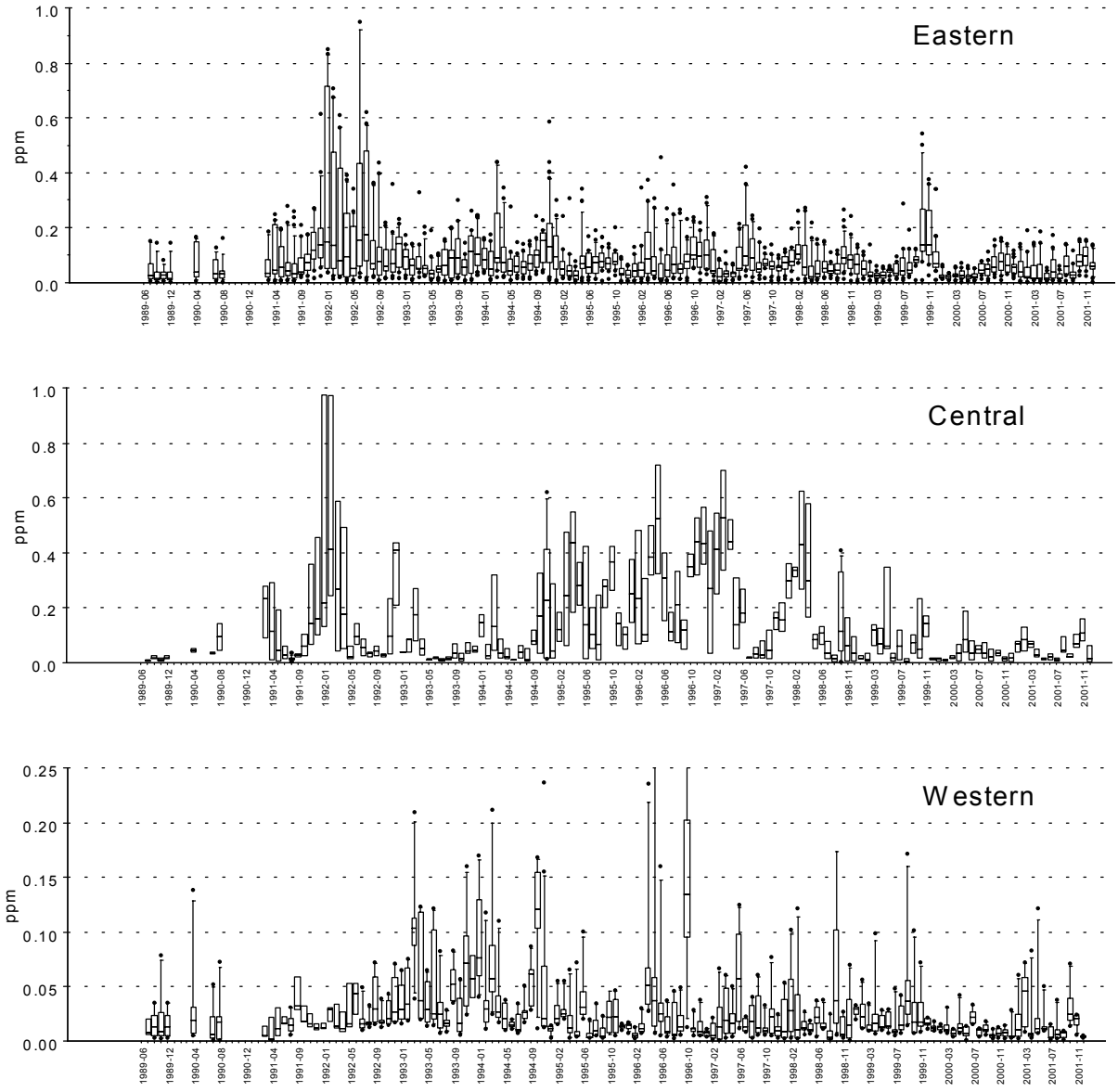

Figure 6. Monthly median DIN in the three Florida Bay zones.

Median Turbidity

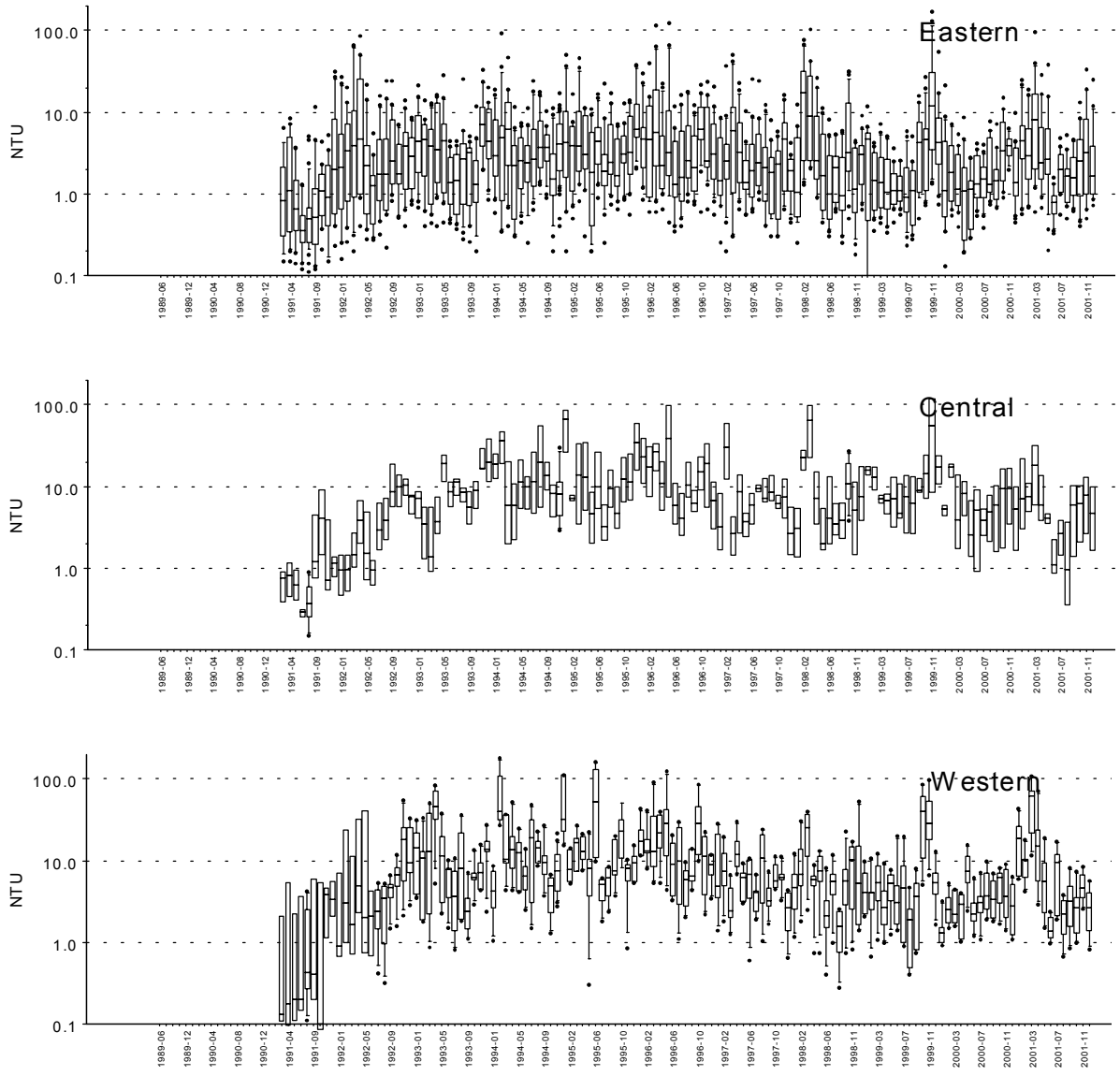

Figure 7. Monthly median turbidity in the three Florida Bay zones.