



# Shark River Slough – Preliminary Water Quality Analysis

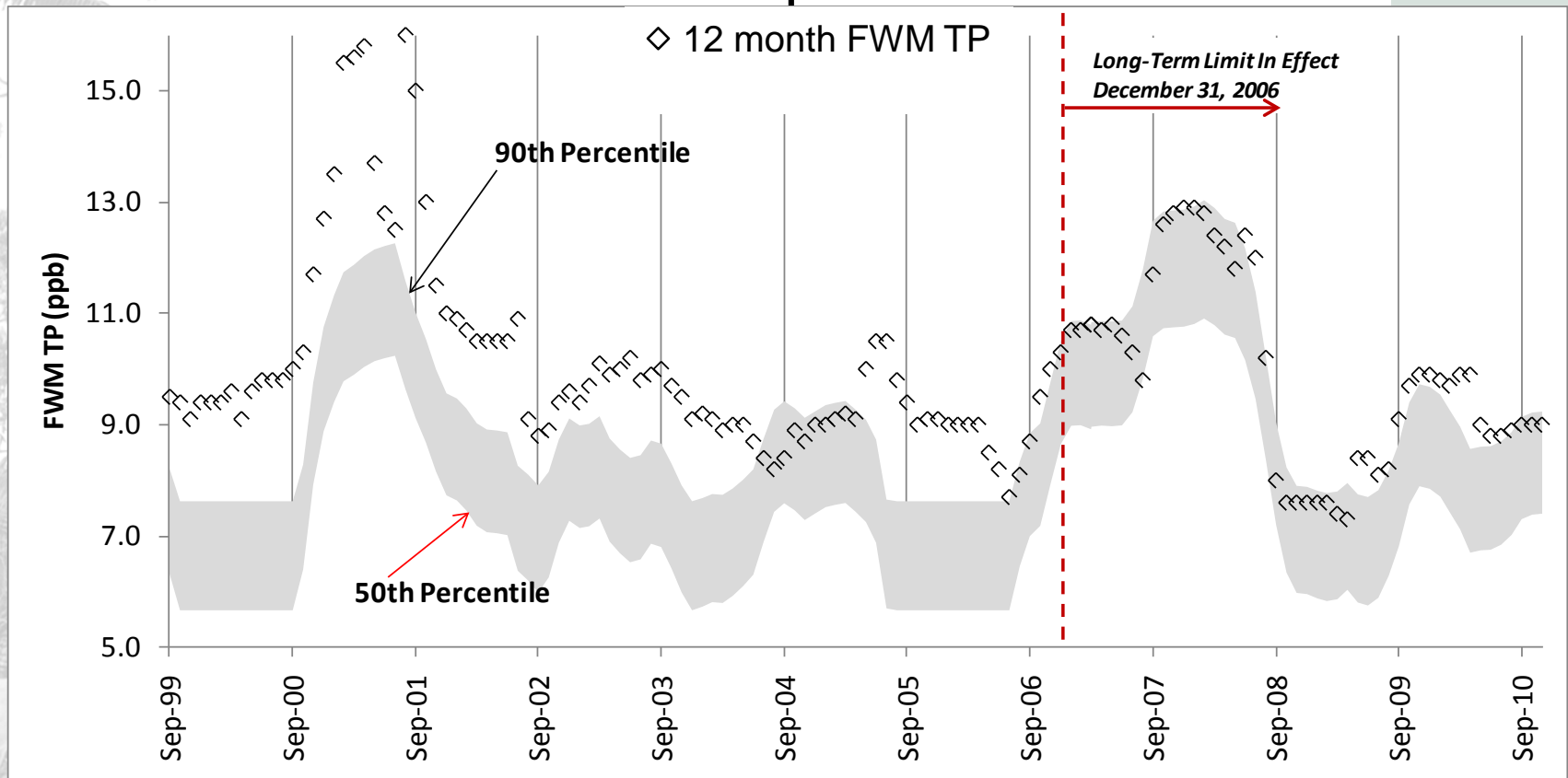
**Technical Oversight Committee Meeting  
May 31, 2011**

Everglades Program Team  
Donatto Surratt, Ecologist  
Everglades National Park

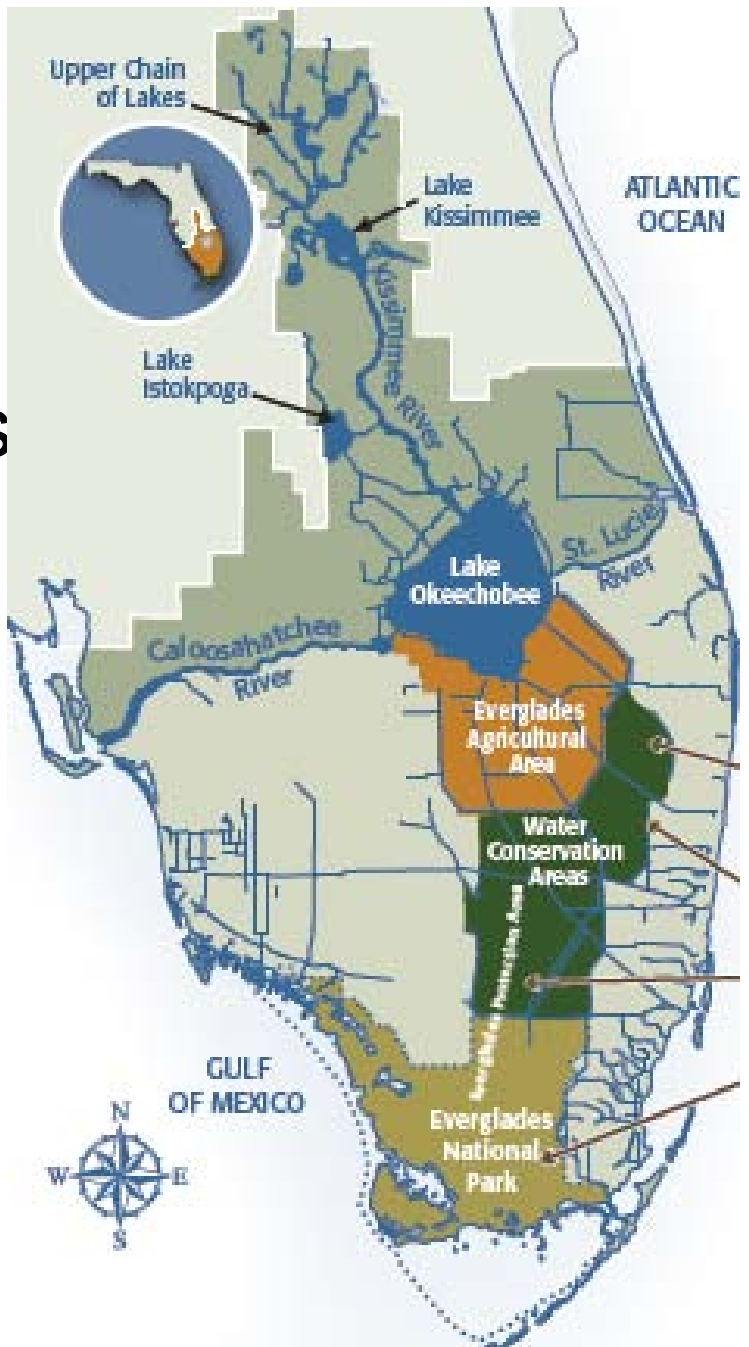


## Problem

- TP hovering at 90<sup>th</sup> percentile - Long-Term Limit
- Should center around 50<sup>th</sup> percentile



# Total Phosphorus Concentrations in the Everglades Protection Area



**Water Years 2005-09  
FWM Inflows  
GM Interior  
TP concentrations  
(parts per billion)**

- Refuge:  
Inflow = 95.0  
Interior = 10.7
- WCA-2A:  
Inflow = 32.0  
Interior = 12.9
- WCA-3A:  
Inflow = 35.3  
Interior = 8.3
- Park:  
Inflow = 9.0  
Interior = 5.6



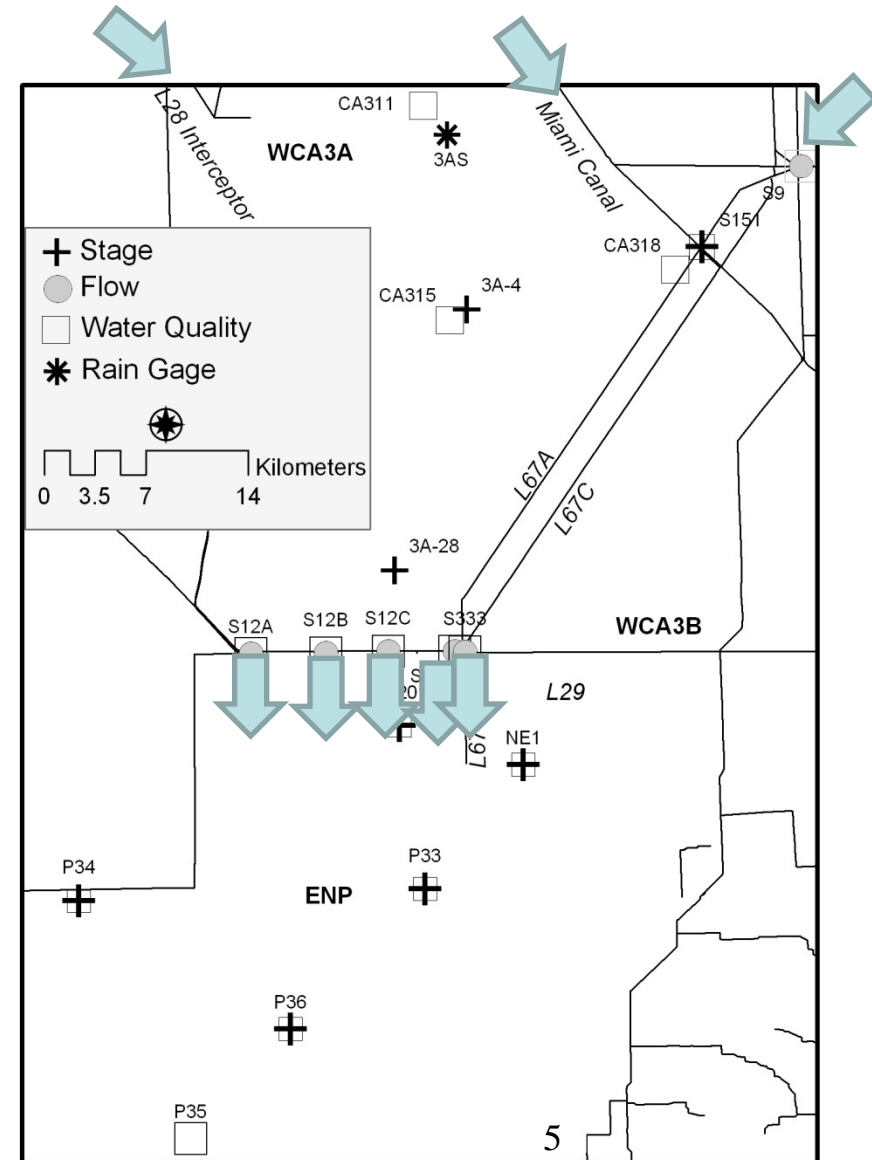
## Water Management Changes

- 1970 – operated under minimum delivery schedule
- 1984 – begin Experimental Program
- 1985 – Rainfall plan (55% east; 45% west)
- 1994 – ENR online
- 1998 – STA-6 Section 1 online
- 1999 – STA-5 Cells 1A, 1B, 2A, 2B online
- 1999 – end Experimental Program
- 1999 – Interim Structure and Operational Plan
- 2000 – STA-1W and STA-2 online
- 2001 – Interim Operation Plan
- 2004 – STA-1E Central and Western Flow-way online
- 2004 – STA-3/4 online



## Methods

- Rain gage
  - 3AS
- Stage gages
  - WCA3A: 3A-3, 3A-4, 3A-28
  - ENP: NE1, NP201, P33, P34, P36
- Flow
  - L29: S12A, S12B, S12C, S12D, S333
- Water quality sites
  - WCA3A: CA311, CA315, CA318, S151
  - ENP: S12s, S333, NE1, NP201, P33, P34, P35, P36





## Methods

- POR: 1987 - 2010
- Water quality parameters
  - TP, Na:Ca
- We focused this analysis on TP because of Consent Decree considerations
- Na:Ca ratio used to assess changes in site impacts from canal water



## Methods

- Data Preparation
  - Outliers → Multi-parameter assessment
  - MDL → ½ MDL
- Statistics and Tools
  - Change-point analysis (Change-Point Analyzer)
    - Used stage, flow, water quality, all sites
    - Positive autocorrelation corrected through aggregations
    - Remaining outliers corrected using ranking
  - Descriptive statistics (XLSTAT)
  - Mann-Whitney (XLSTAT)
  - TP Loads (Excel)
  - TP Trends (XLSTAT)



## Methods

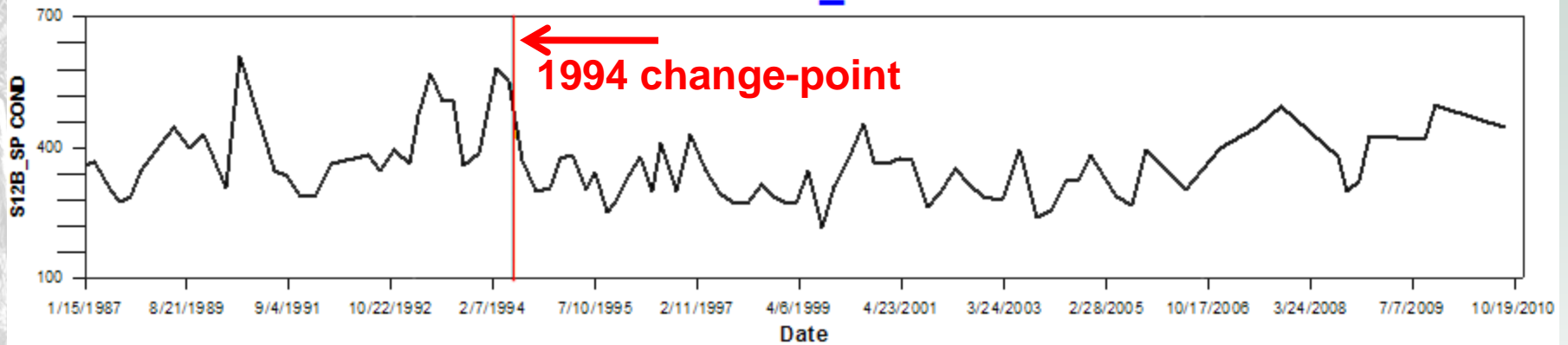
- TP Trends
  - Natural-log transformed
  - Removed seasonality and dealt with autocorrelation:
    - Regressed against: stage, stage rise, Julian date
    - Residual analyzed for changes through time for:
      - 1987-2010
      - 1994-2010
      - 2002-2010



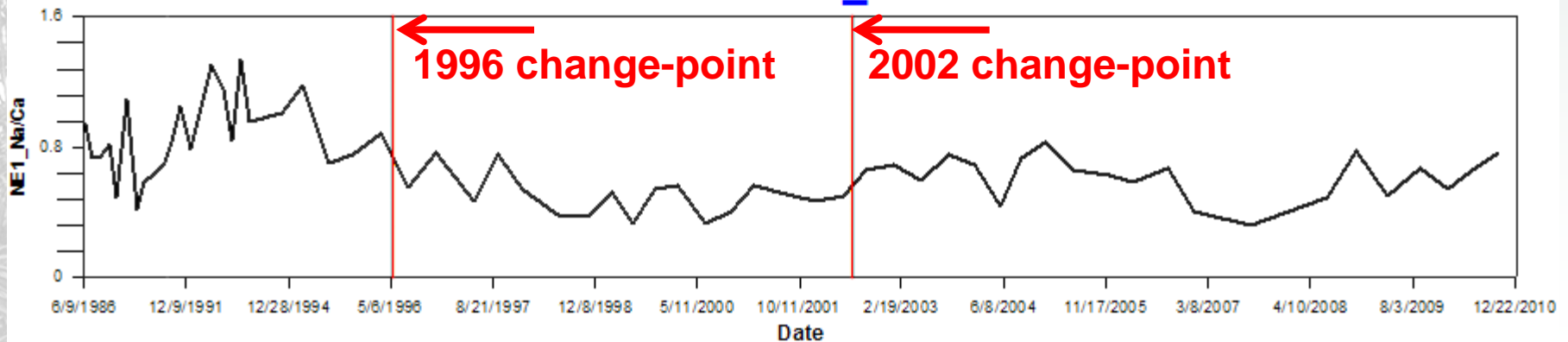


## Examples of Change-Points

Plot of S12B\_SP COND



Plot of NE1\_Na/Ca





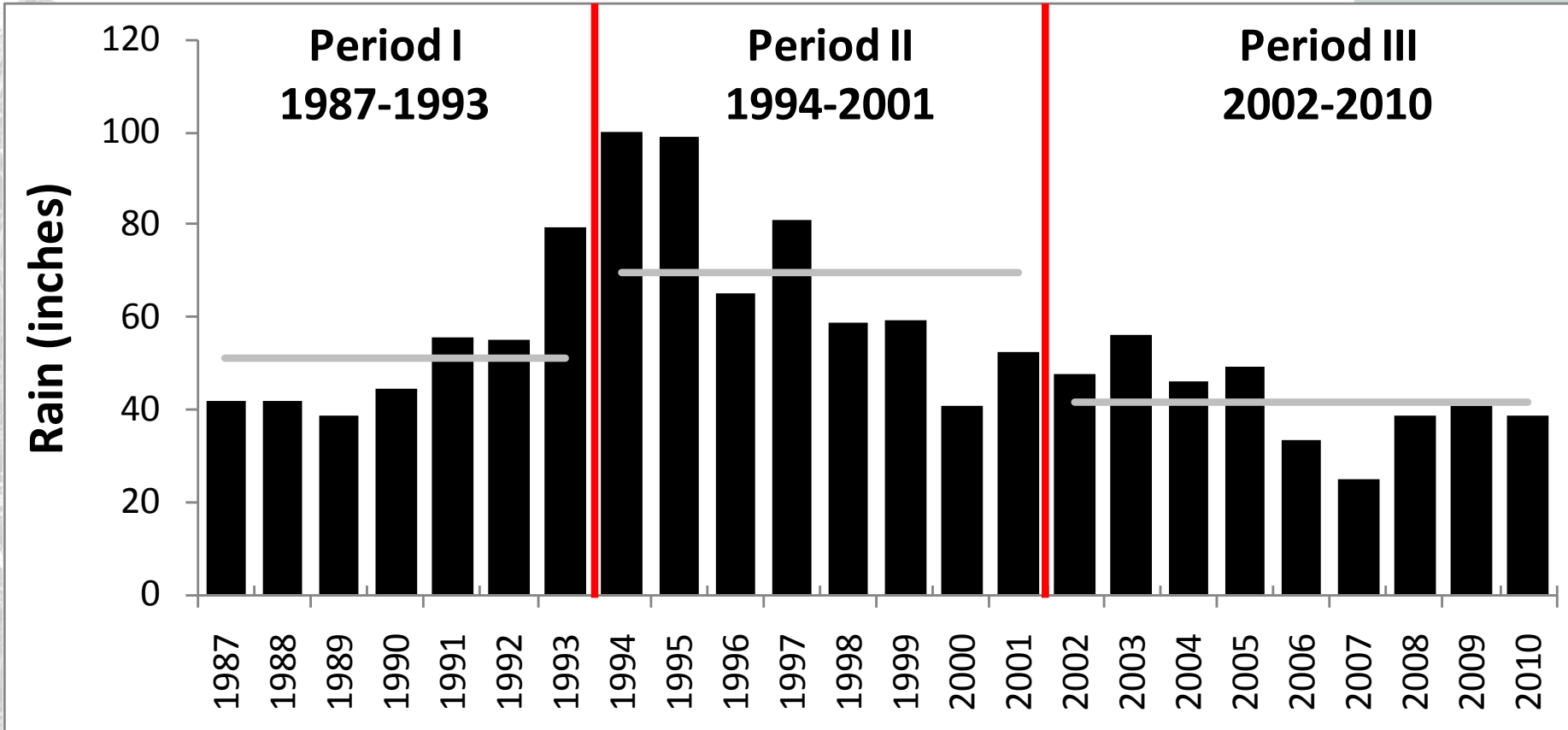
## Analytical Periods

- 3 periods derived from change-point analysis
- Relationships between those 3 periods and water management operations
  - 1987-1993 (Iterations of Experimental Program)
  - 1994-2001 (Iterations of Experimental Program)
  - 2002-2010 (ISOP and IOP)

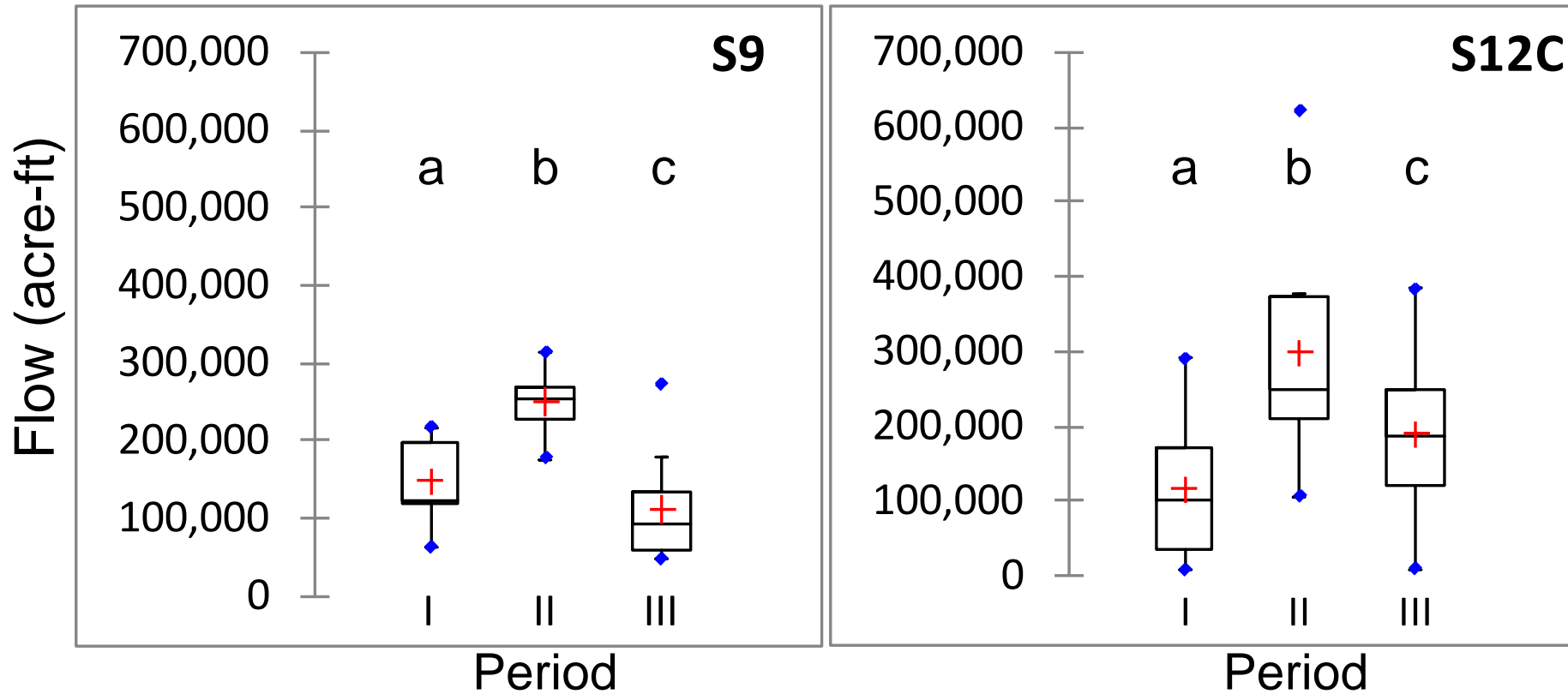


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## Rainfall



# Annual Flow

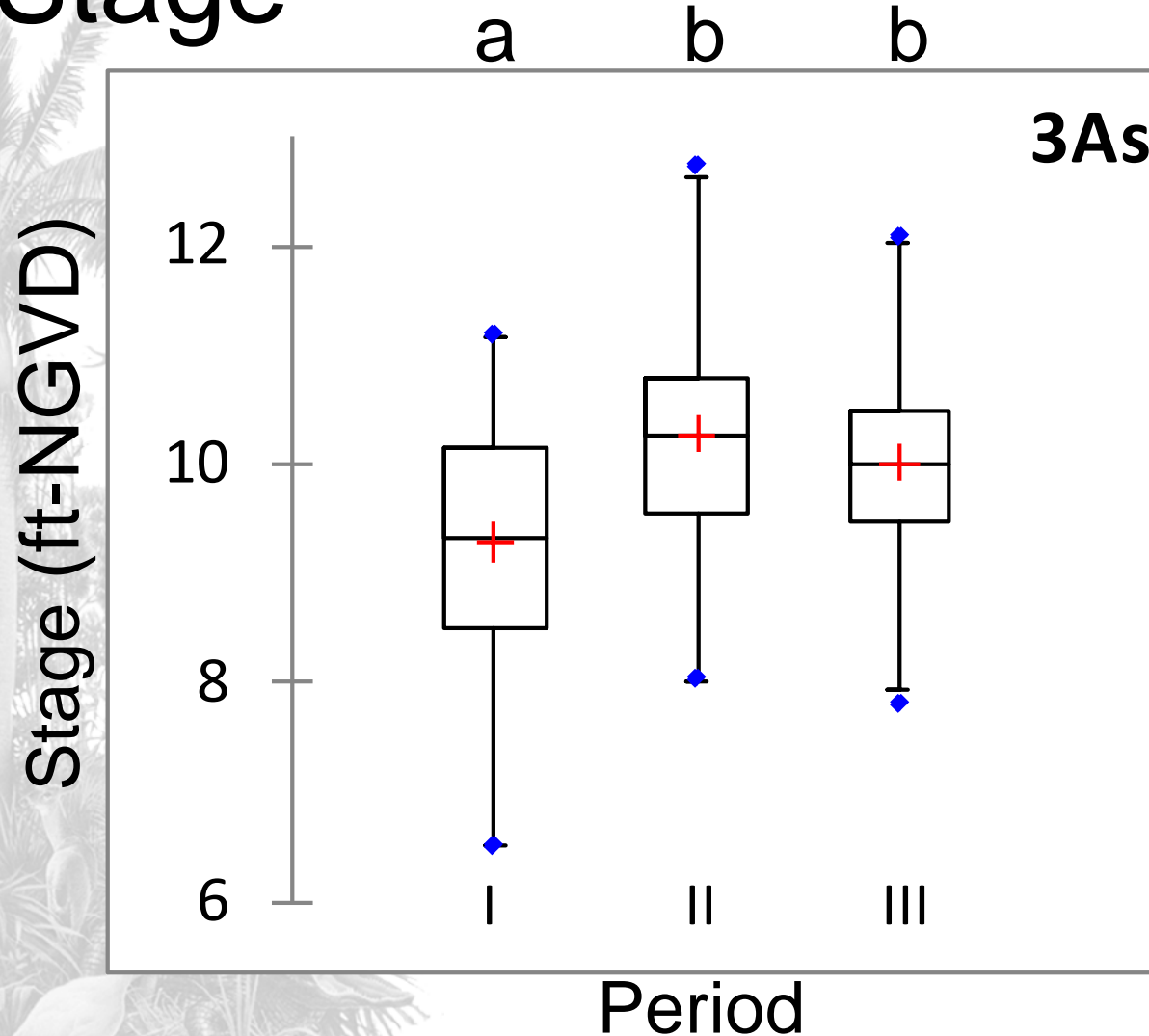


- In Period II, flow increased through S12A-C and decreased through S333
- In Period III, flows through S12A-B decreased because of seasonal closures resulting from ISOP and IOP operations



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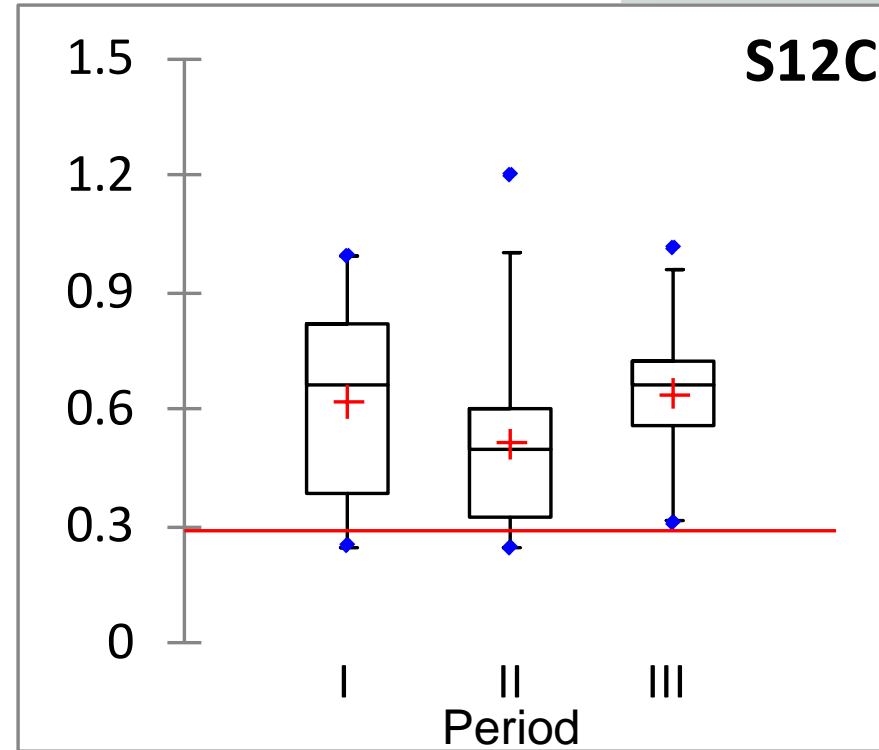
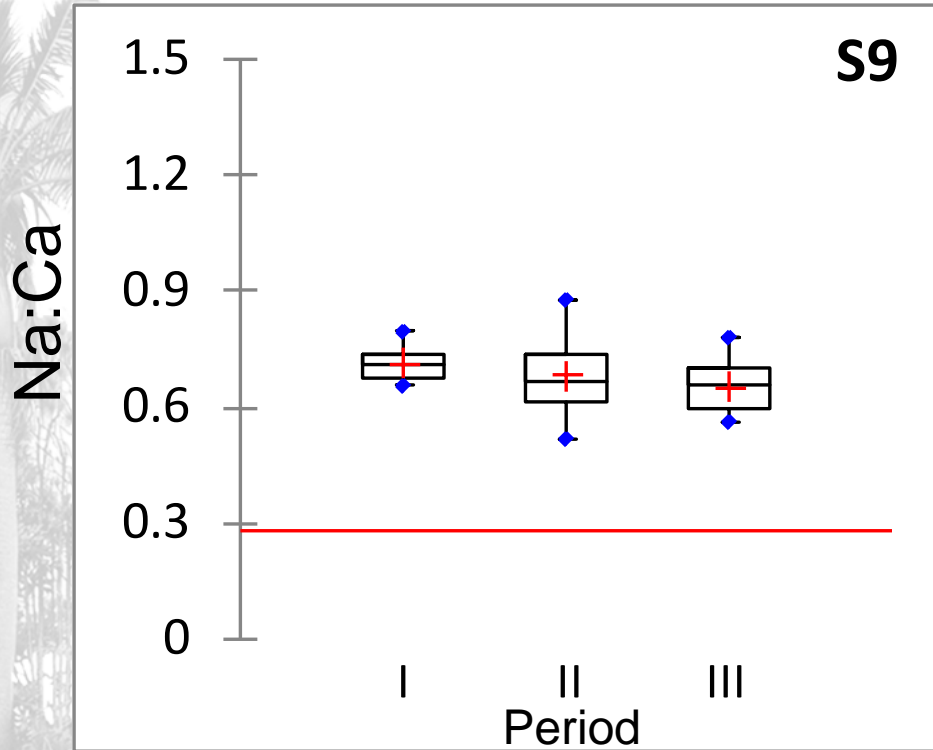
## Stage



3As = Average of  
3A-3, 3A-4,  
3A-28

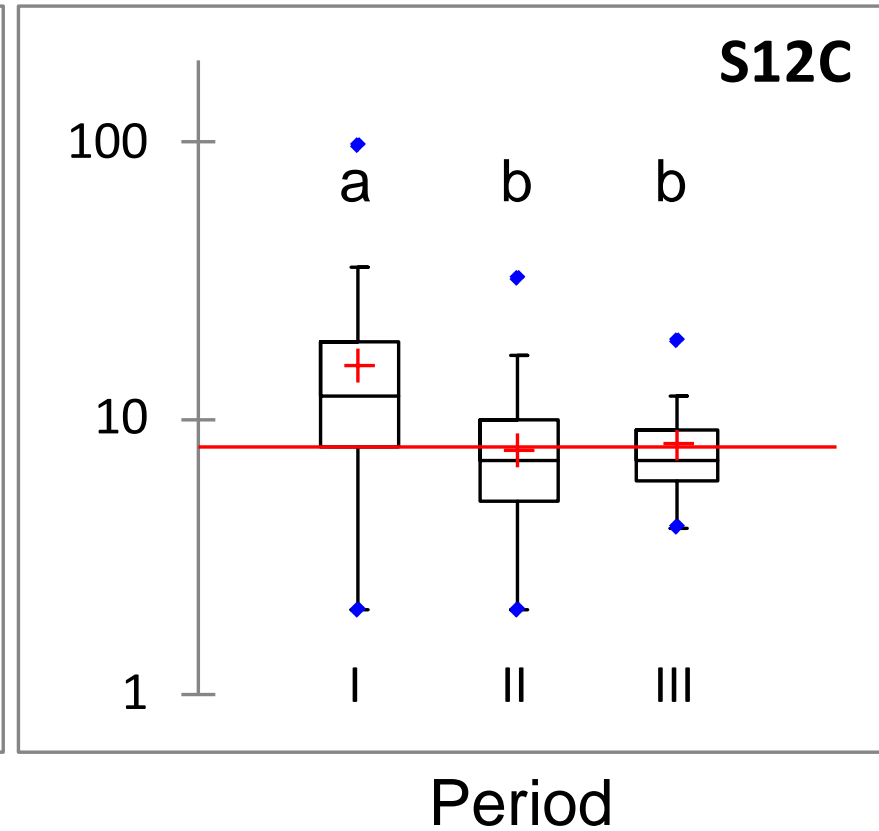
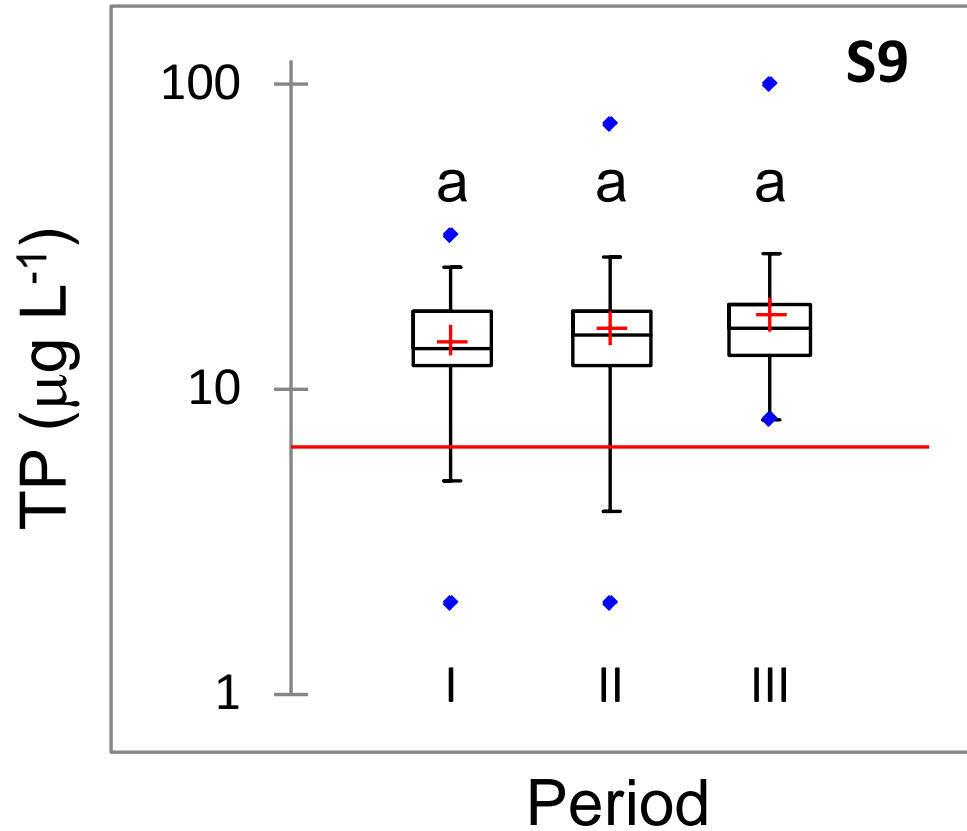


## Canal Na:Ca Ratio



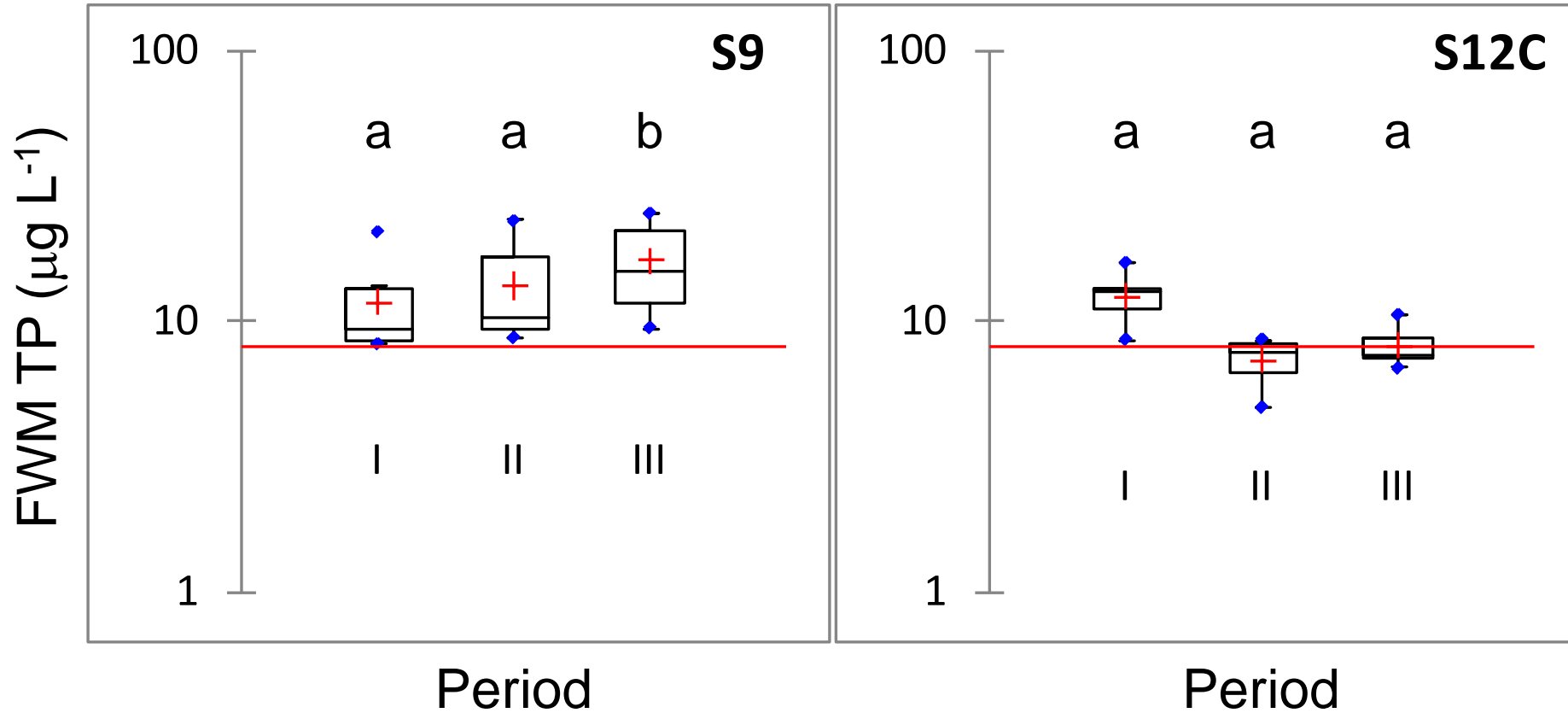
- Na:Ca ratio in Northern Everglades generally greater than 0.6
- Na:Ca ratio in unimpacted Park historically less than 0.34
- Average Na:Ca at S12A declined below 0.34 in Period II (1994-2001)

# Canal TP



- TP when structures were flowing declined after Period II at S12A-C
  - rainfall and stages in WCA3A were higher in Period II
- No declines in TP concentrations were observed in discharges to L29

# FWM TP



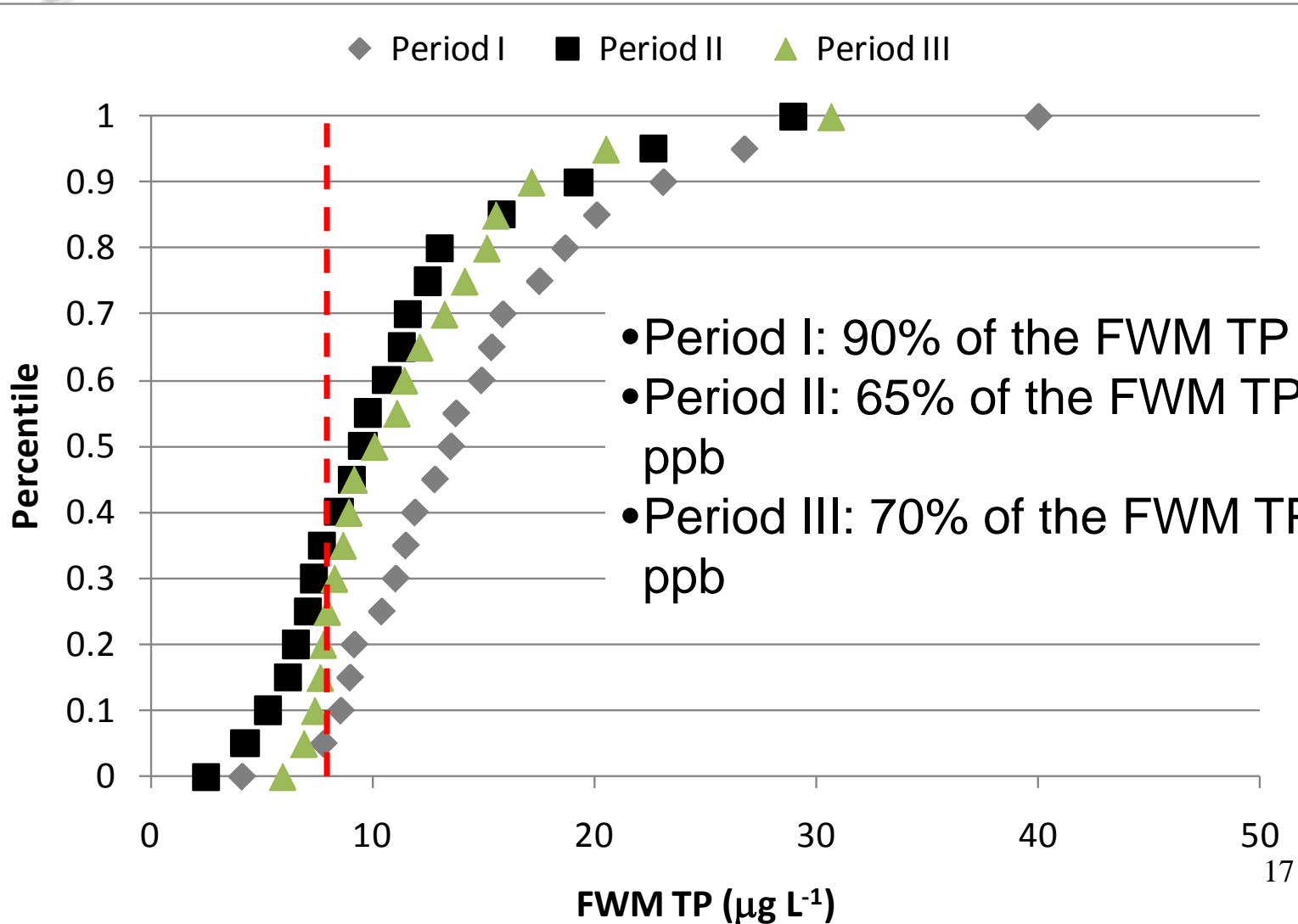
- FWM TP declined after Period II at S12A-C
  - S333 remained similar to the previous periods
- No declines in FWM TP were observed in discharges to L29
  - FWM TP discharged to L29 increased in Period III



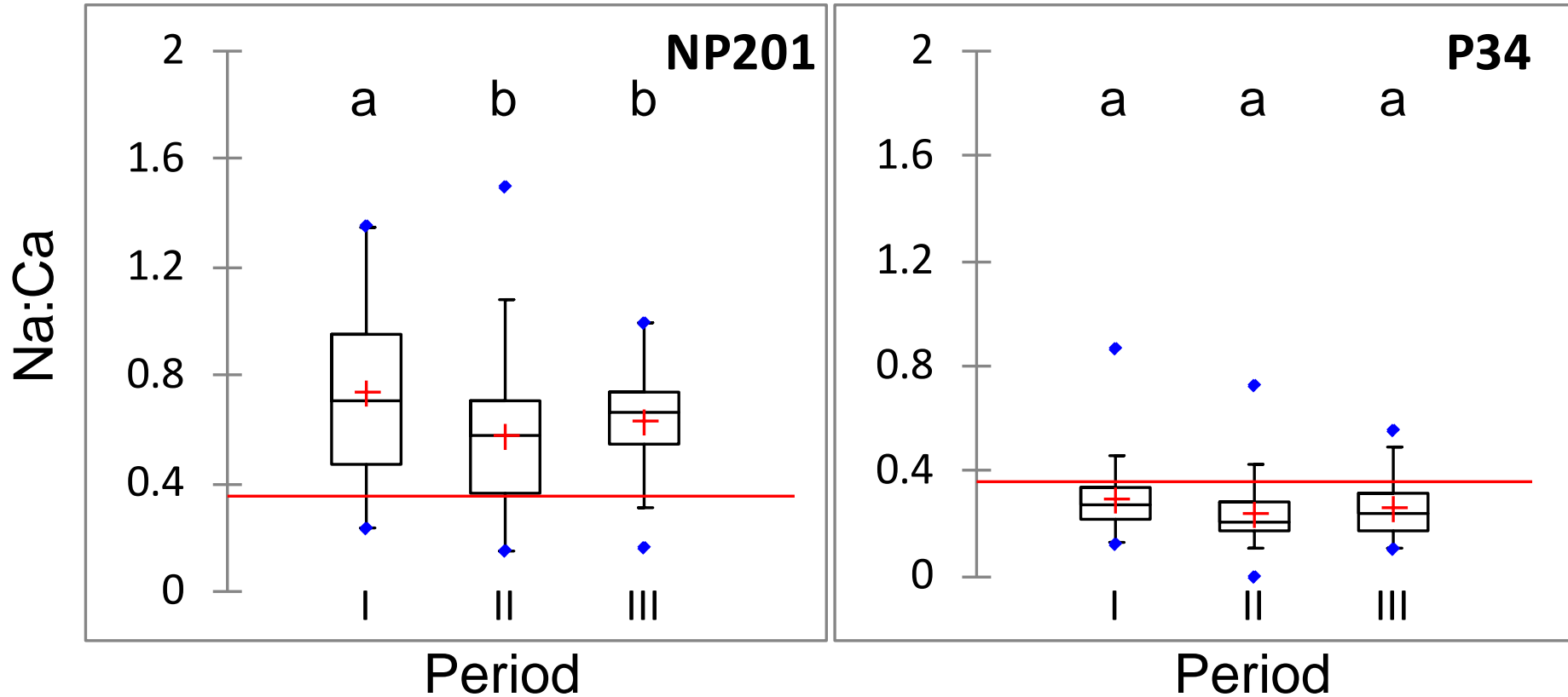


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## S12s + S333 FWM TP Concentrations

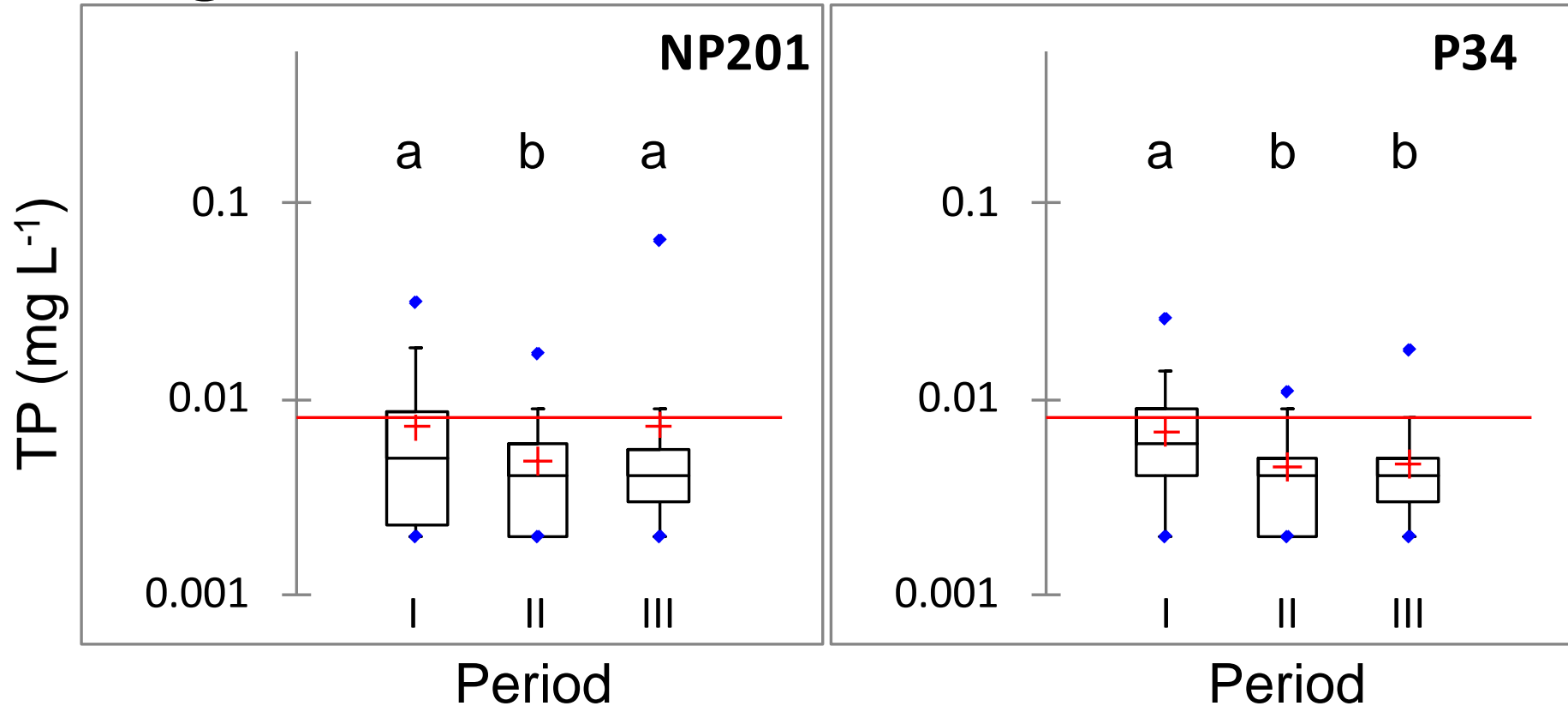


# Slough Na:Ca



- Slough sites were influenced by L29 canal water through all periods with average Na:Ca consistently greater than 0.6
- P34 is least impacted by canal influence with average Na:Ca below 0.34 in all periods

# Slough TP



- TP concentrations in the slough generally declined in Period II
  - TP at sites closest to the canal increased again in Period III
- Spikes above 8 ppb among the slough sites occurred
  - Period I: 30 to 60% of sampling events
  - Period II: 15 to 55% of sampling events
  - Period III: 10 to 35% of sampling events

# TP change per year over entire POR

S151 = -0.73 ppb yr<sup>-1</sup>

S12C = -0.14 ppb yr<sup>-1</sup>

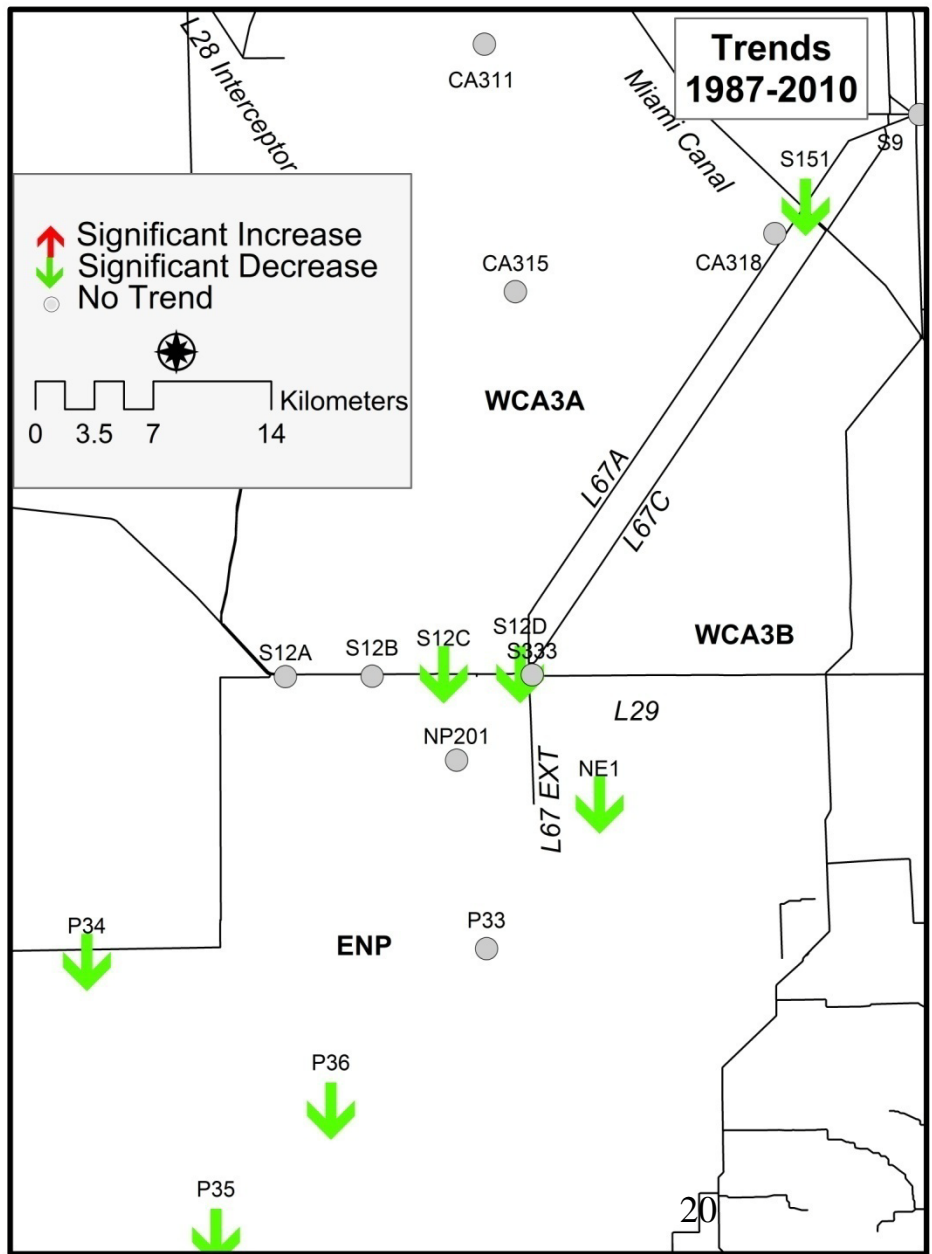
S12D = -0.10 ppb yr<sup>-1</sup>

NE1 = -0.29 ppb yr<sup>-1</sup>

P34 = -0.11 ppb yr<sup>-1</sup>

P36 = -1.1 ppb yr<sup>-1</sup>

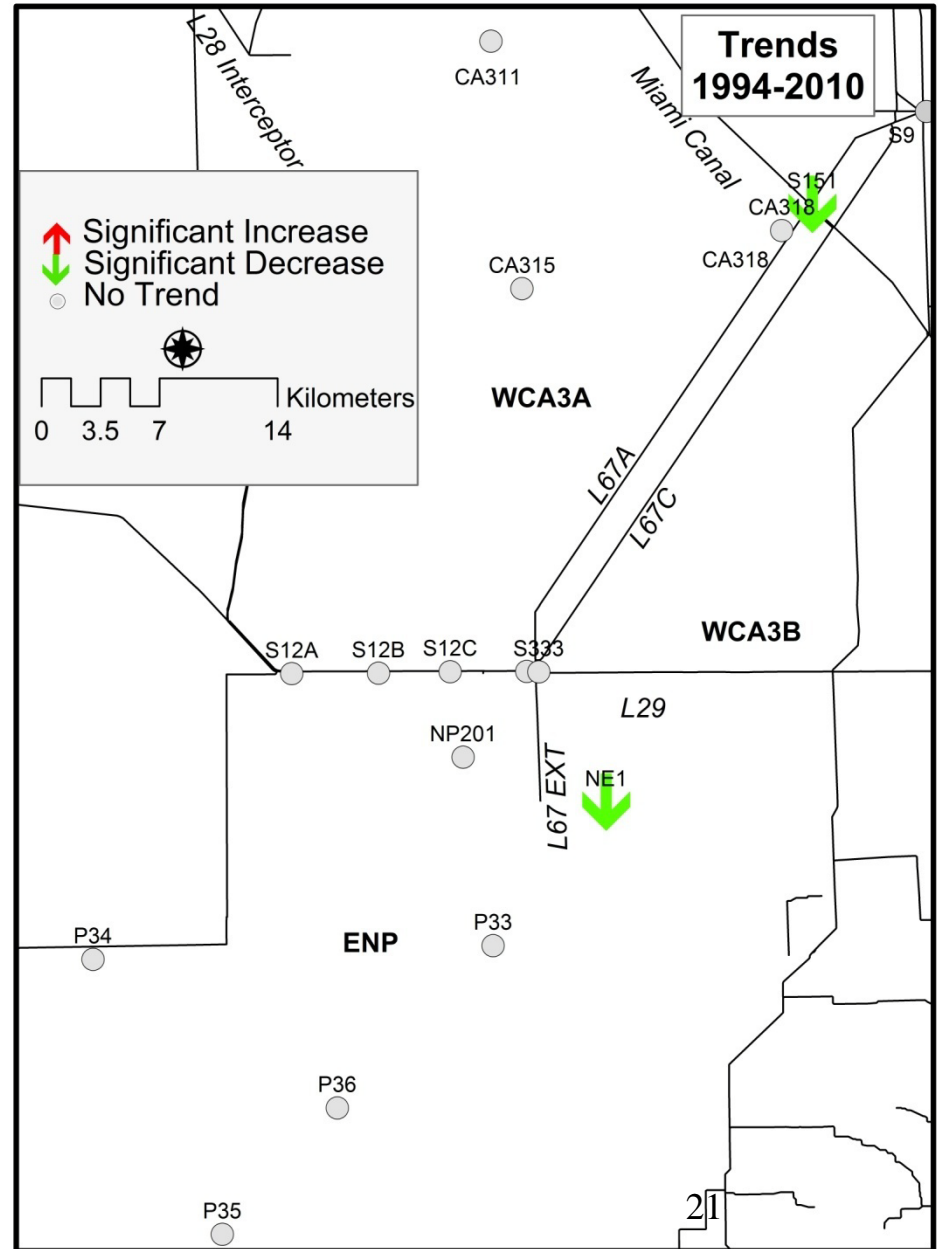
P35 = -0.37 ppb yr<sup>-1</sup>



# TP change per year (1994-2010)

S151 = -0.37 ppb yr<sup>-1</sup>

NE1 = -0.29 ppb yr<sup>-1</sup>



# TP change per year (2002-2010)

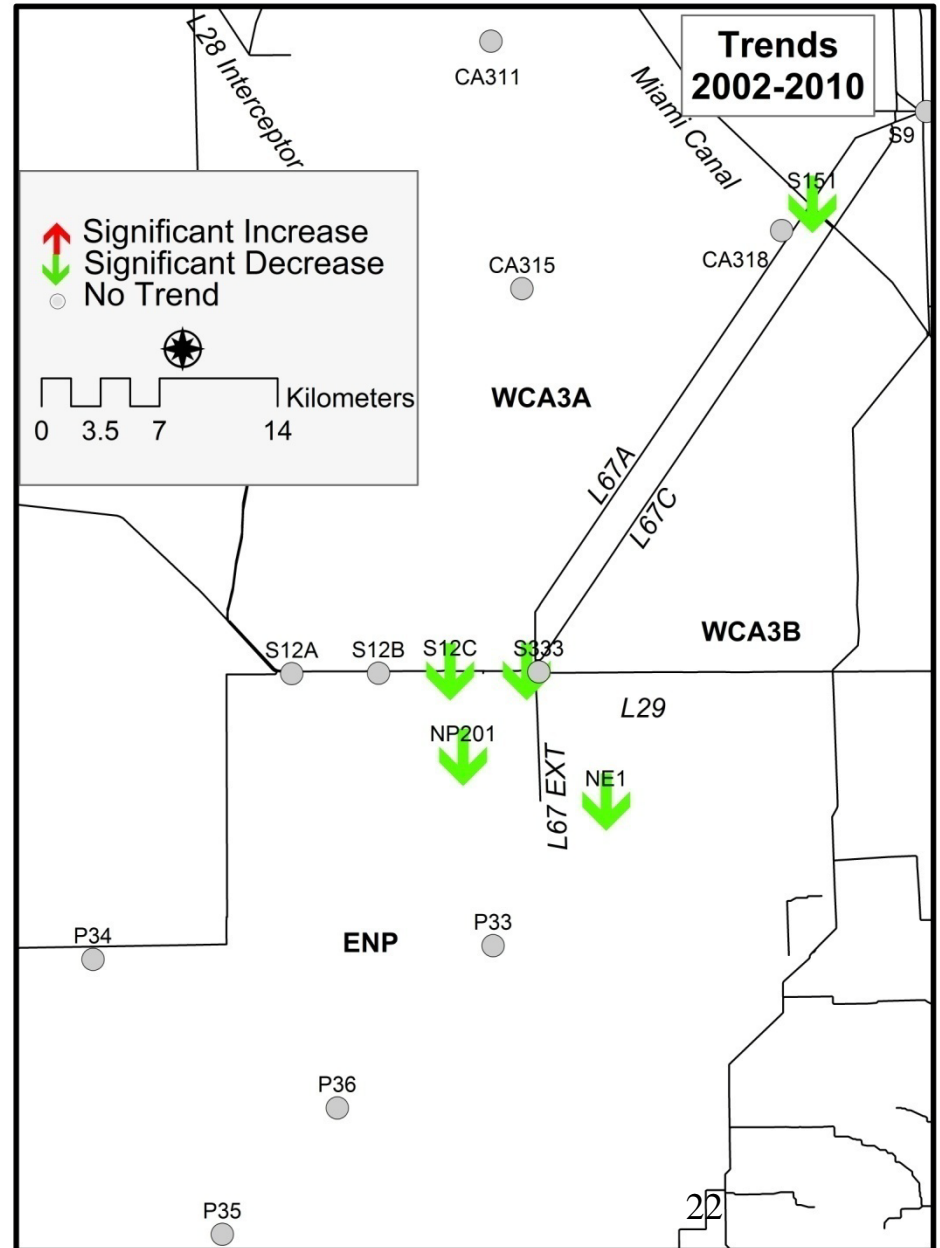
$$S151 = -0.07 \text{ ppb yr}^{-1}$$

$$S12C = -0.36 \text{ ppb yr}^{-1}$$

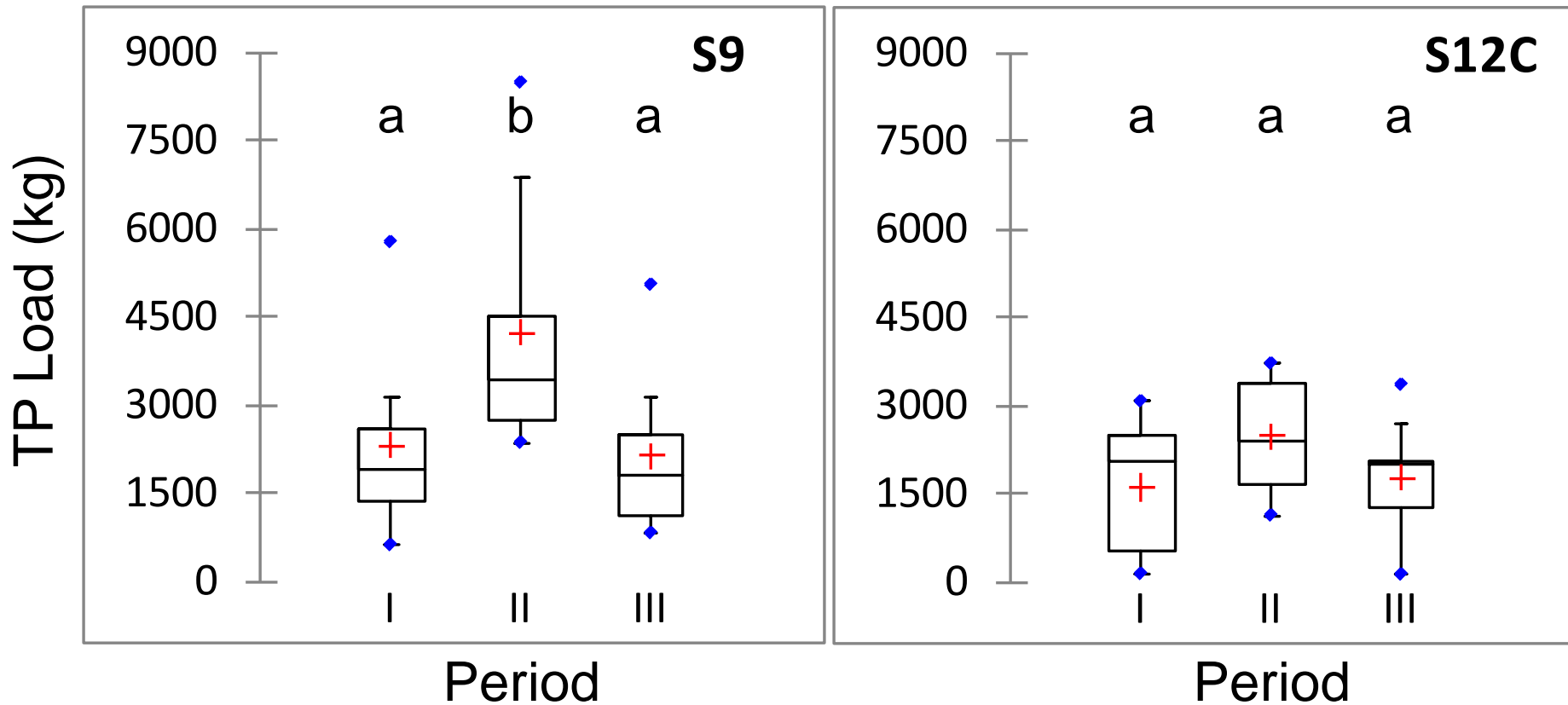
$$S12D = -0.36 \text{ ppb yr}^{-1}$$

$$NP201 = -0.11 \text{ ppb yr}^{-1}$$

$$NE1 = -0.18 \text{ ppb yr}^{-1}$$

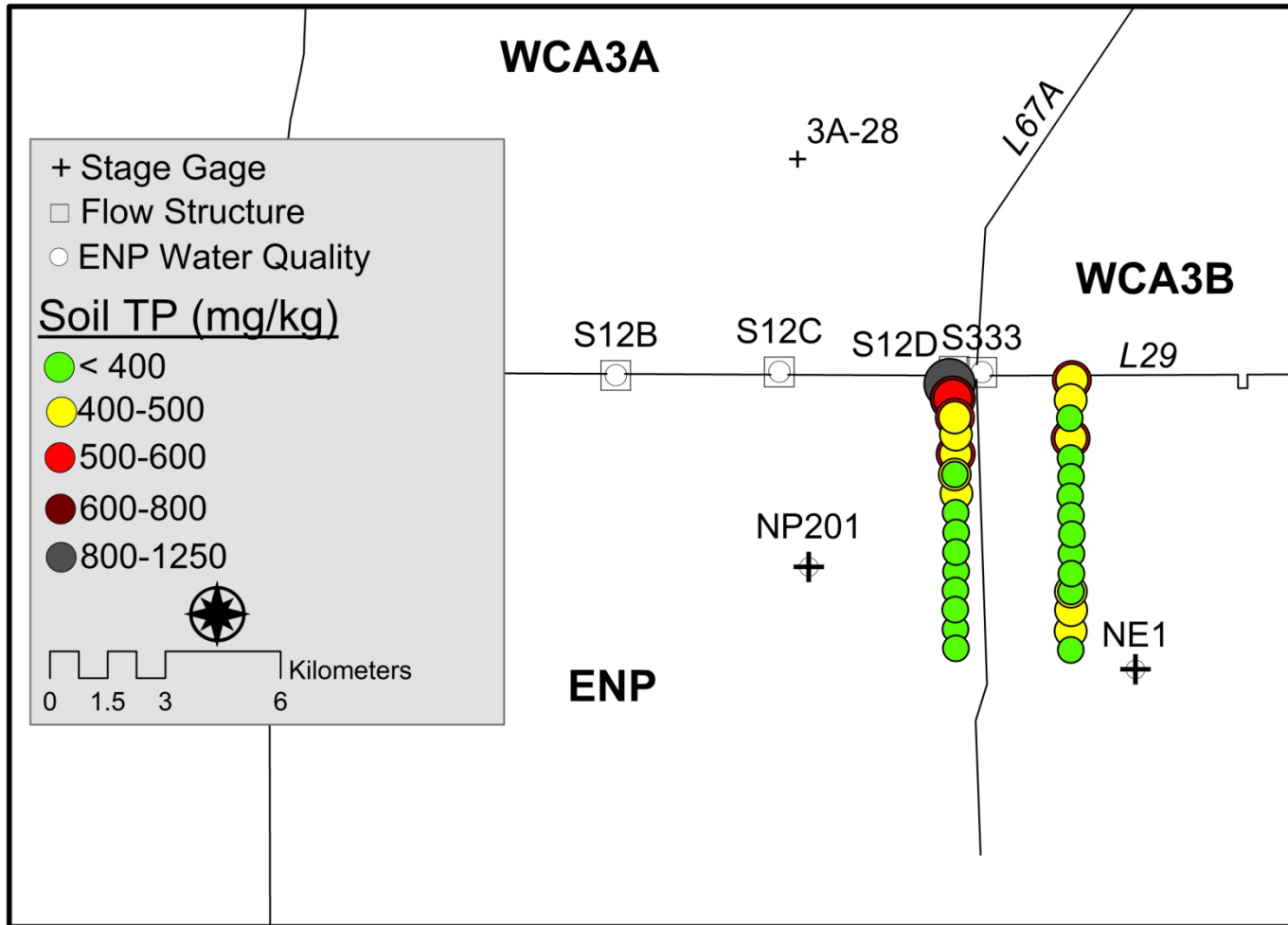


# Annual TP Loads



- Loads delivered to L29 were greatest in Period II
- There were no differences in loads to the Park among the 3 periods from the S12s and S333

# Soil TP 2007



Top 10 cm of soil  
Data collected by University of Florida in 2007





## Discussion

- TP concentrations delivered to both WCA3A and Park are higher than desired
- Higher rainfall and stage in WCA3A during Period II diluted TP concentrations delivered to the Park
- Water dilution of TP was evident in L29 by relatively lower Na:Ca in Period II



## Discussion

- TP concentrations delivered to the Park during Period III were higher than in Period II
  - Rainfall in WCA3A during Period III was lower than Period II
  - WCA3A stages were higher in Period III than Period I
  - Decreasing WCA3A stage below a certain level likely will result in elevated TP delivered to the Park



## Possible Next Steps

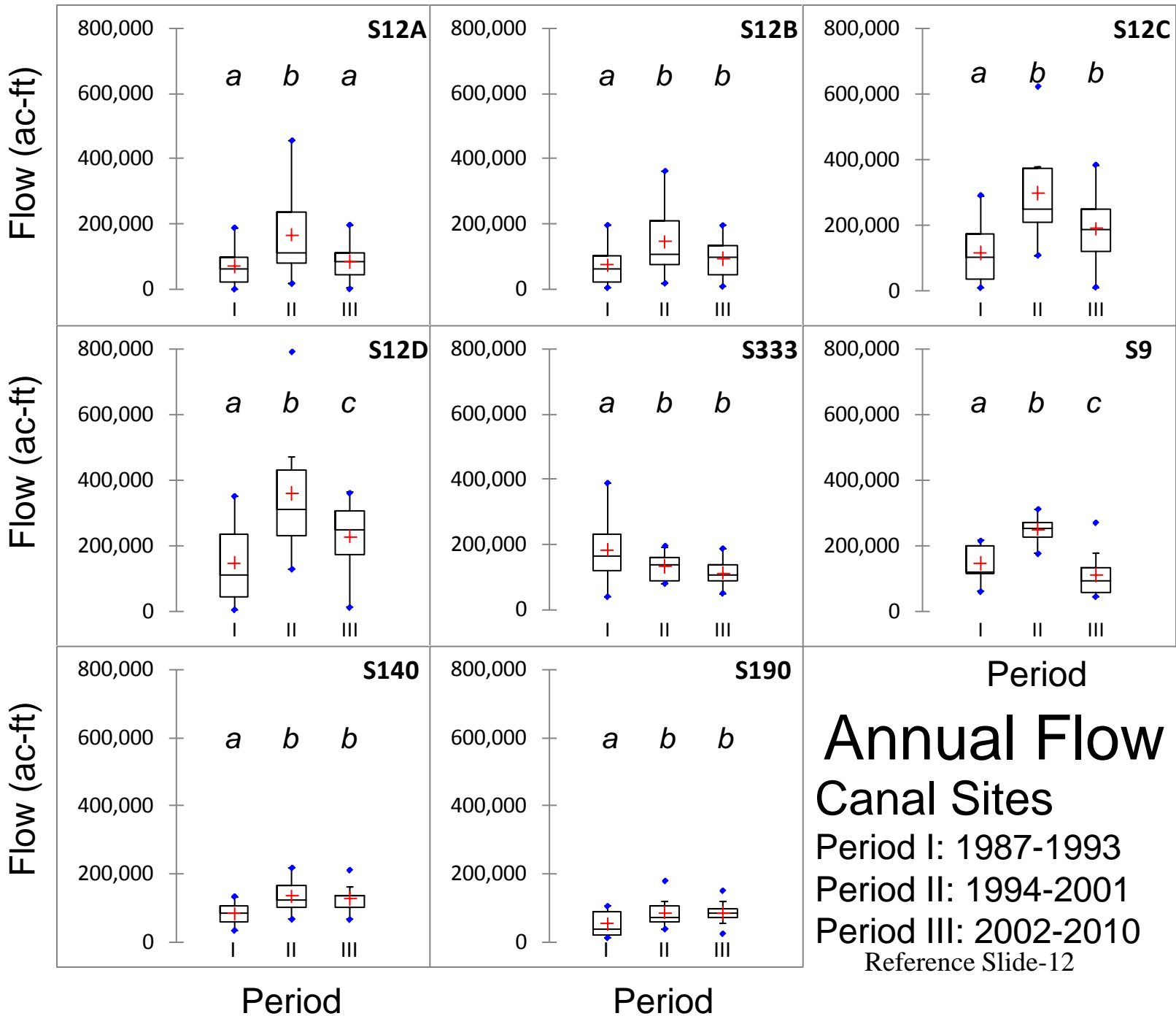
- Include other water quality parameters in the analysis
- Improve understanding of WCA3 dynamics and influence on the Park
  - Track water and nutrient budgets
- Expand the hydrologic analysis
  - Improve understanding of rainfall influence on water deliveries to the Park
  - Investigate ground water influence on surface waters in the Park



## Recommended Monitoring

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- Enhance monitoring to explicitly capture early signs of water quality changes
  - periphyton (composition and tissue TP)
  - soil TP, biogeochemical soil core (baseline)
  - water quality transects from each structure
  - vegetation monitoring

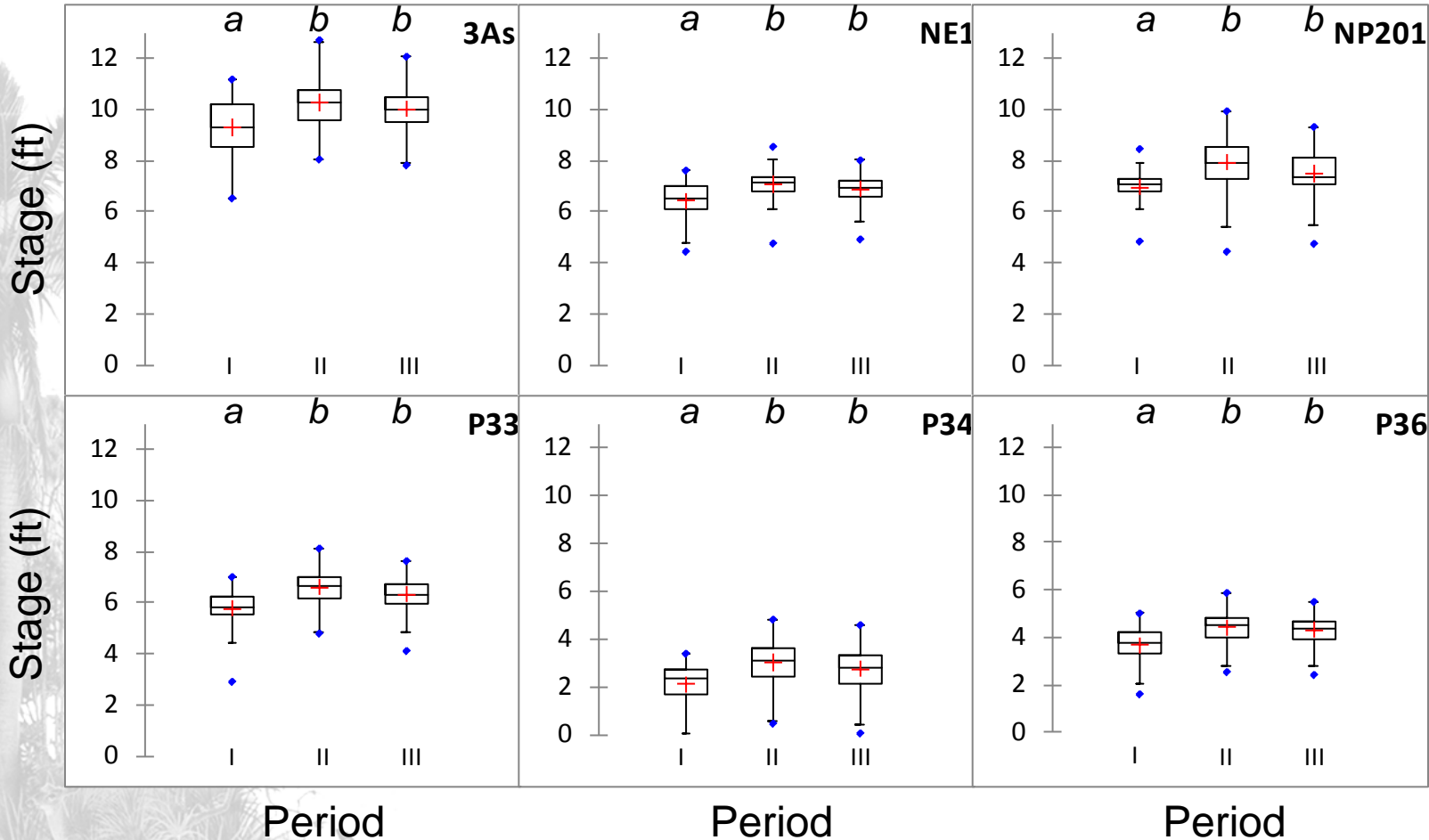


# National Park Service

South Florida Natural Resources Center



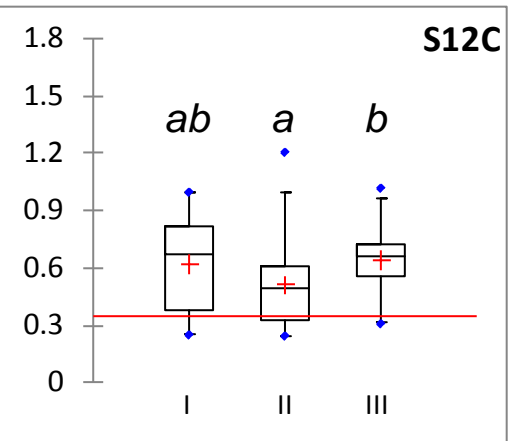
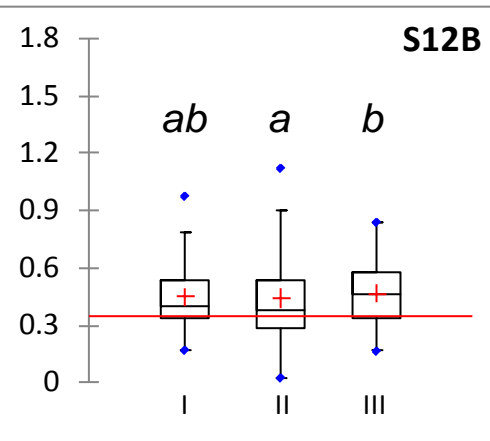
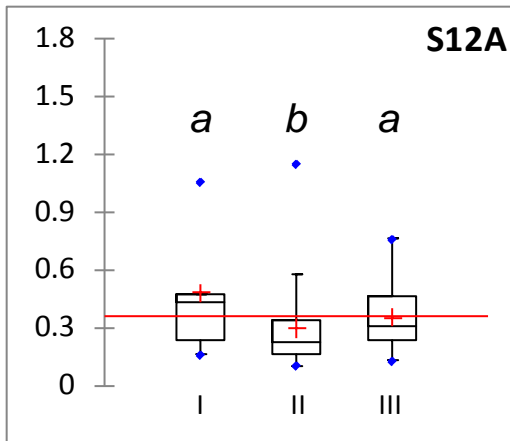
EXPERIENCE  
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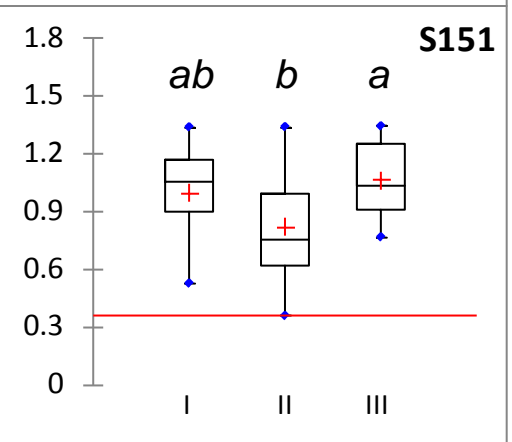
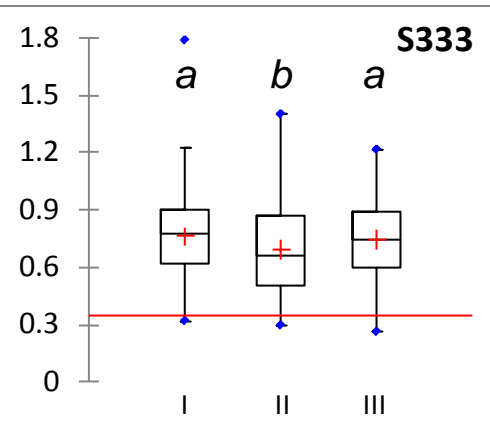
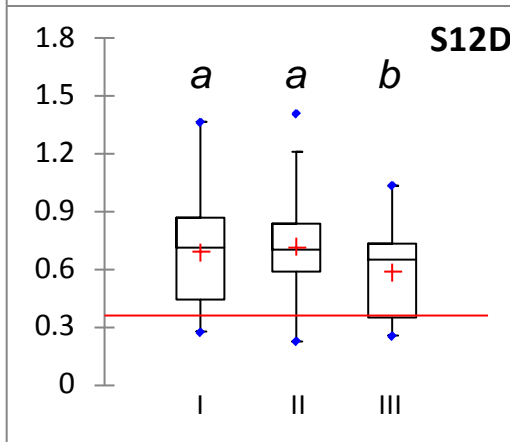
Period I: 1987-1993  
 Period II: 1994-2001  
 Period III: 2002-2010

Reference Slide-13

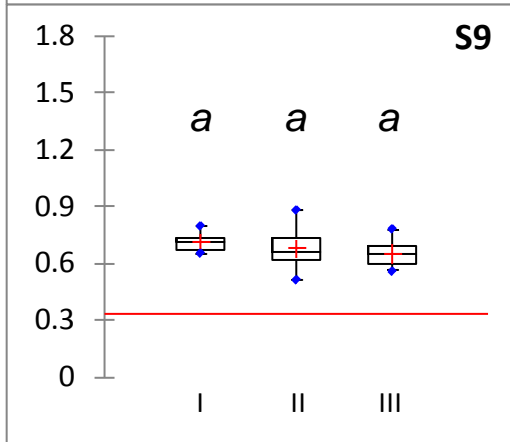
Na:Ca



Na:Ca



Na:Ca



Period

Period

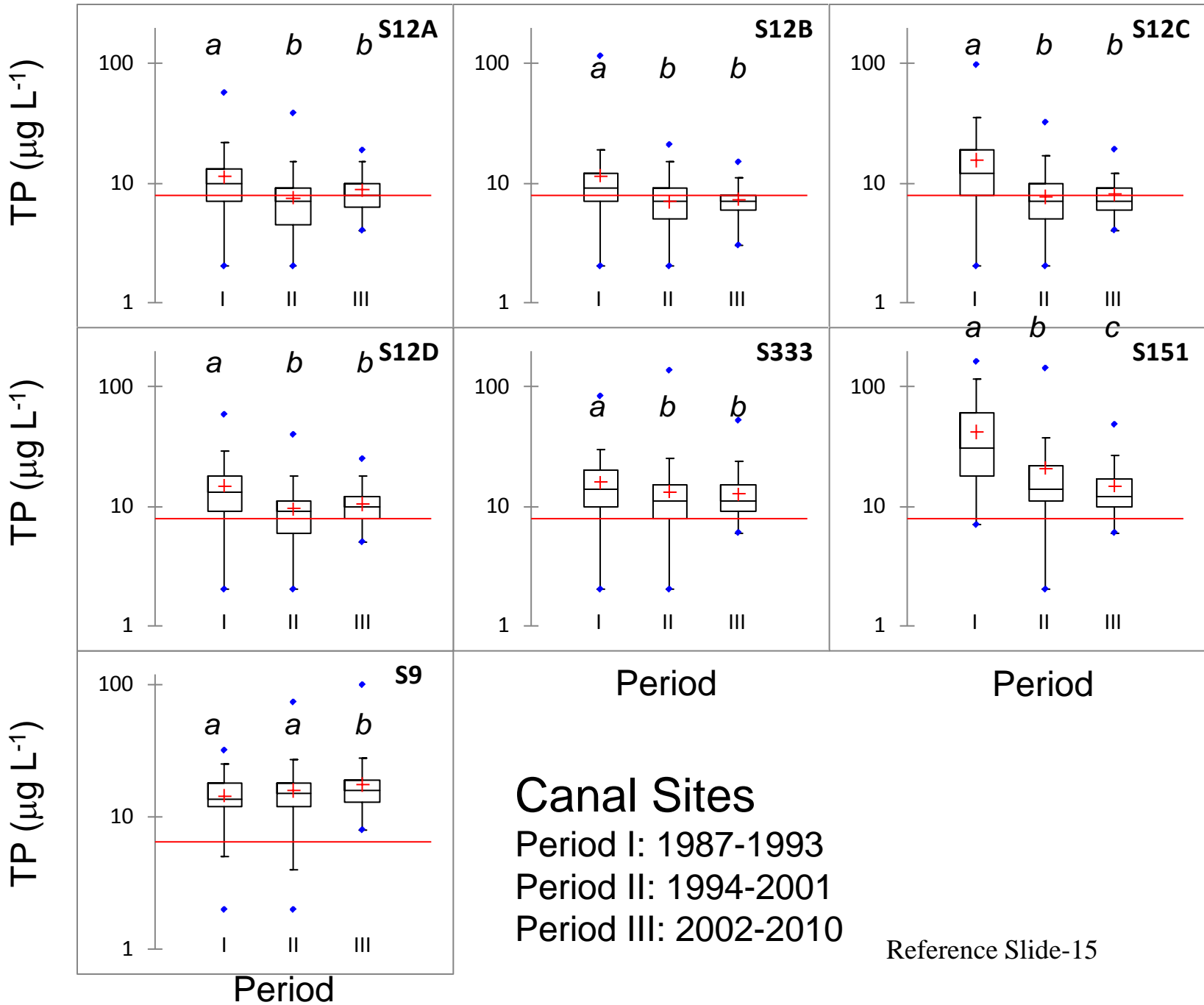
## Canal Sites

Period I: 1987-1993

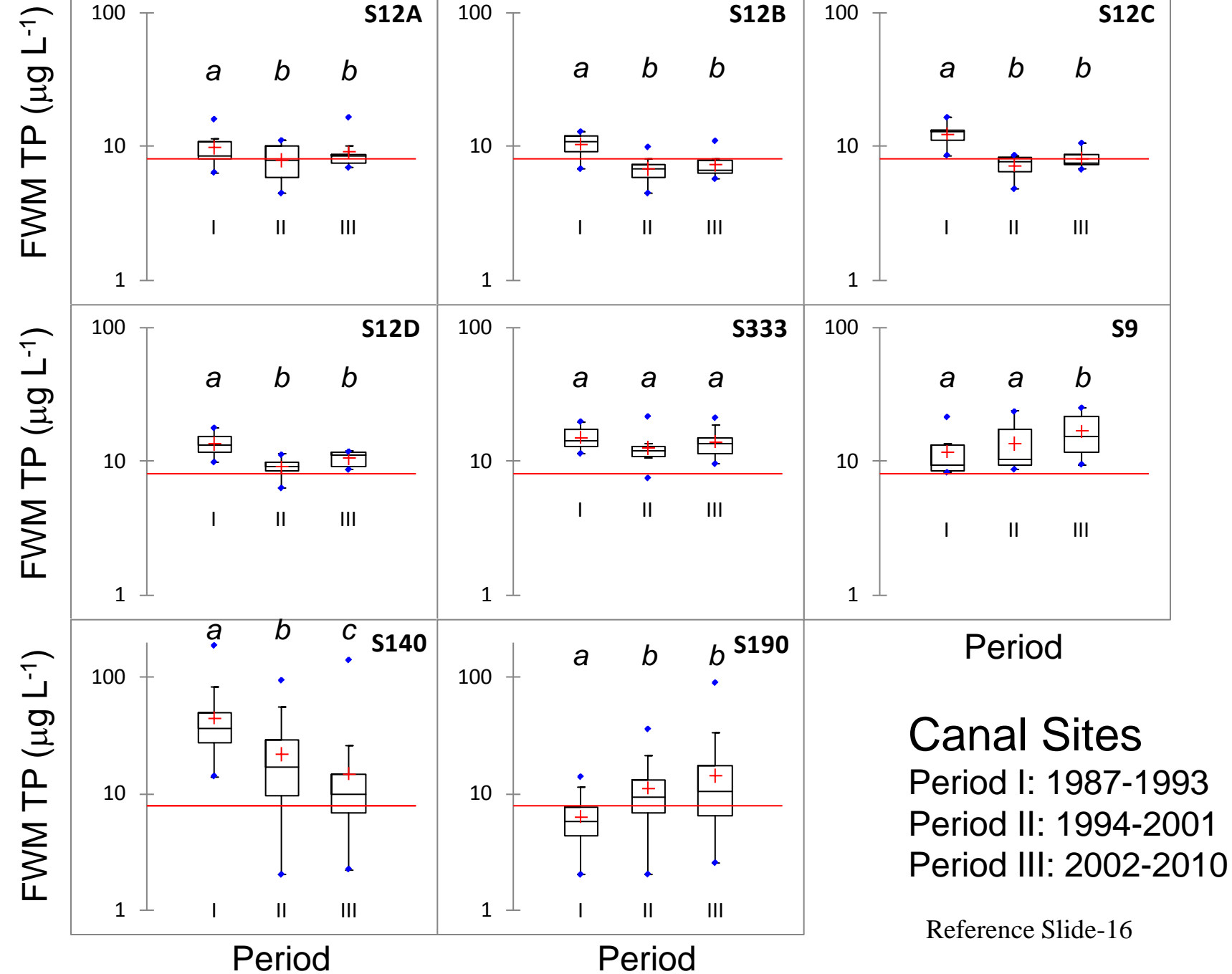
Period II: 1994-2001

Period III: 2002-2010

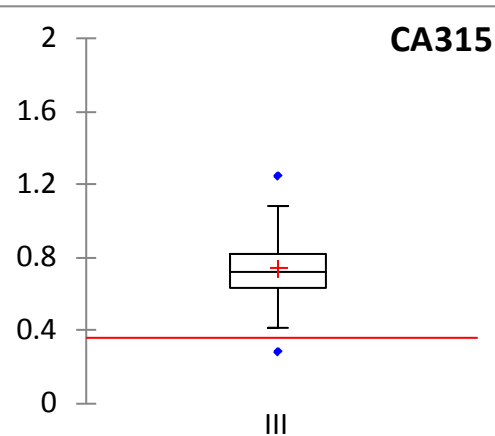
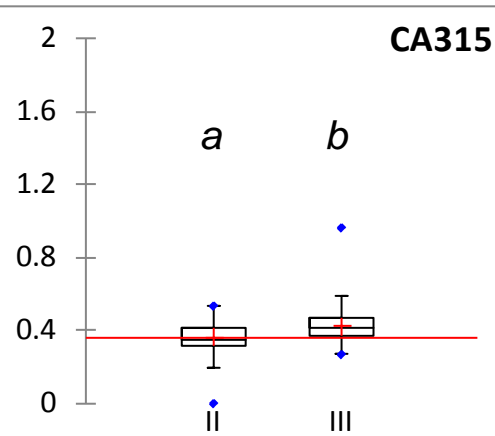
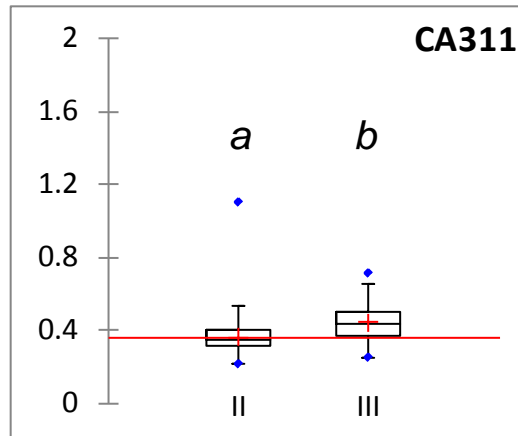
Period



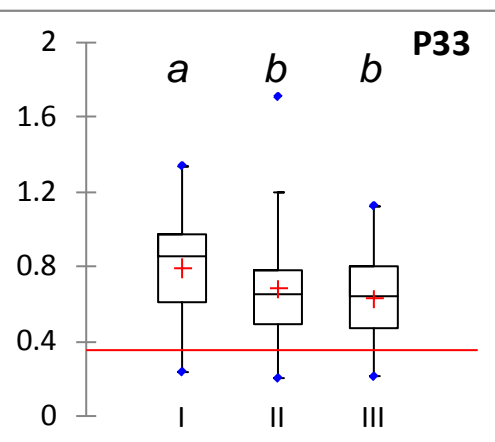
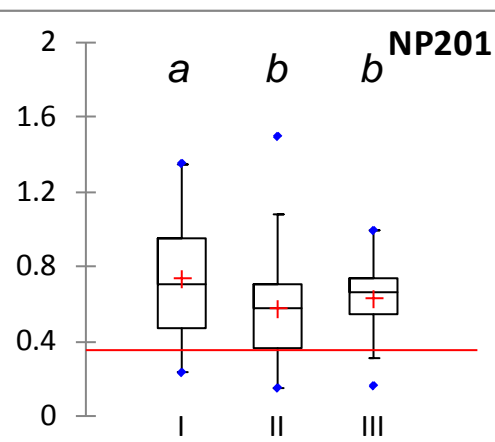
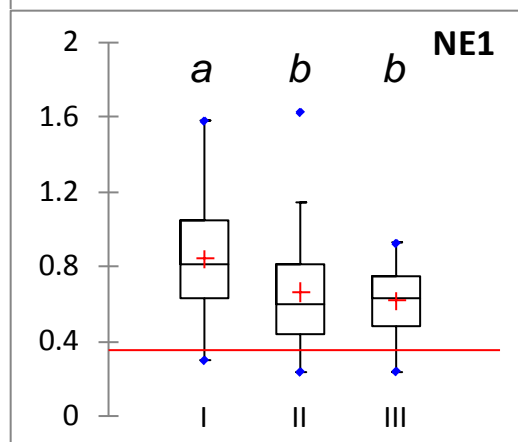




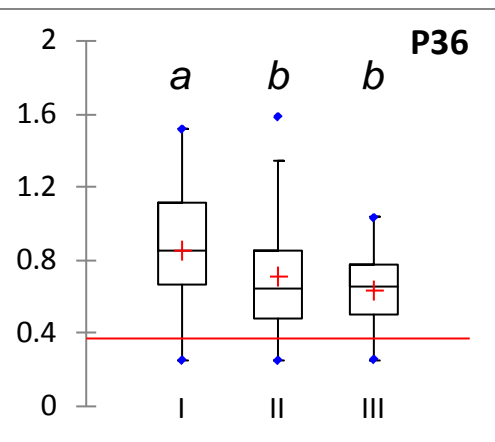
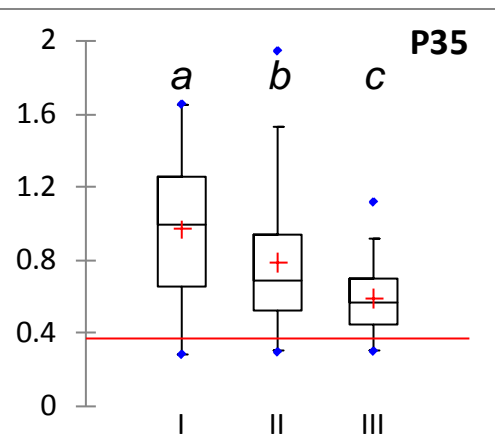
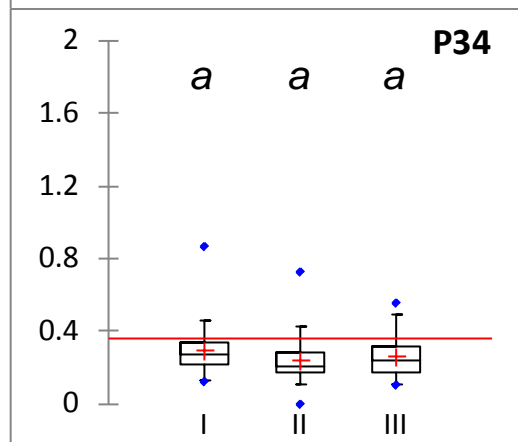
Na:Ca



Na:Ca



Na:Ca

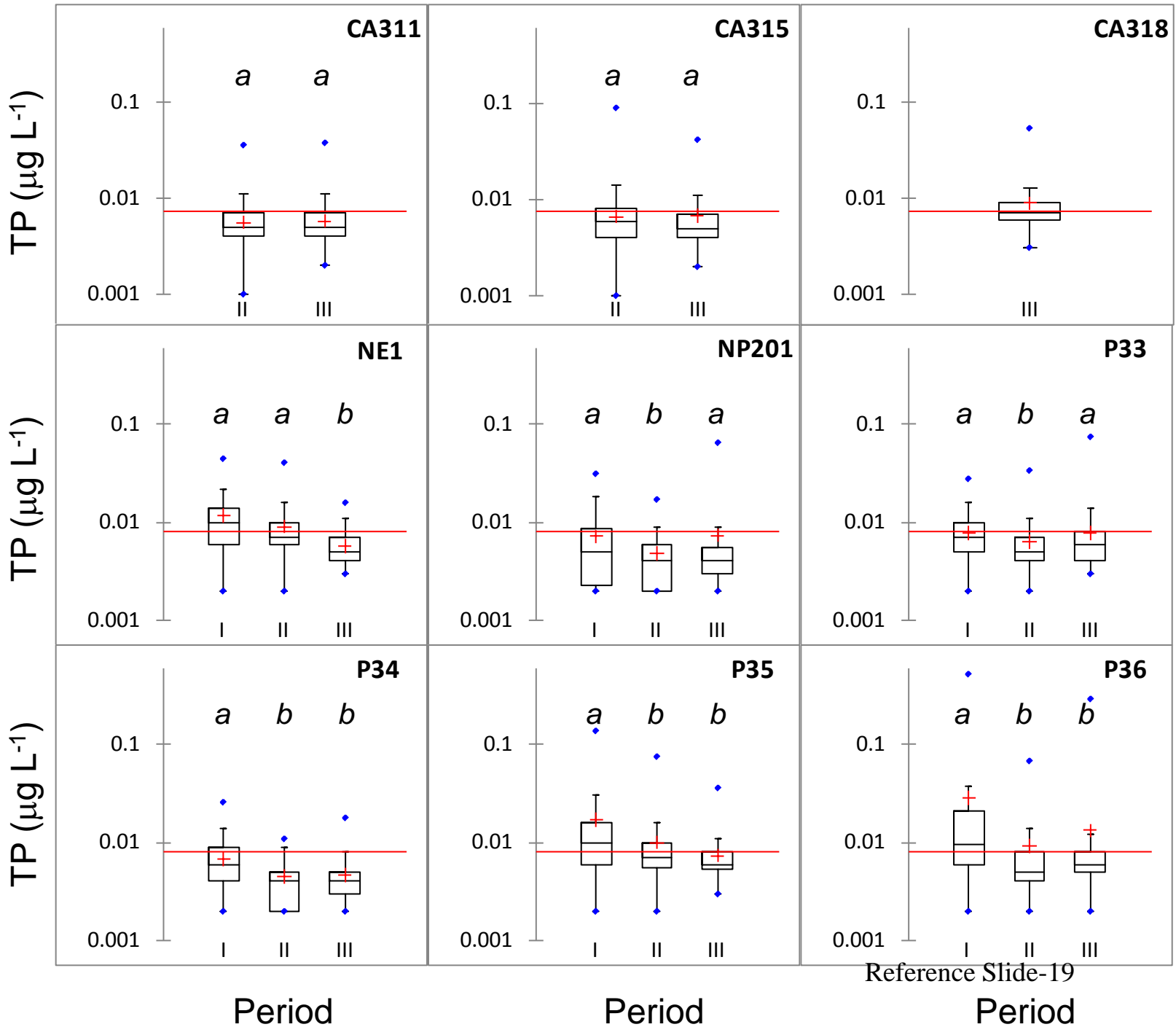


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Period

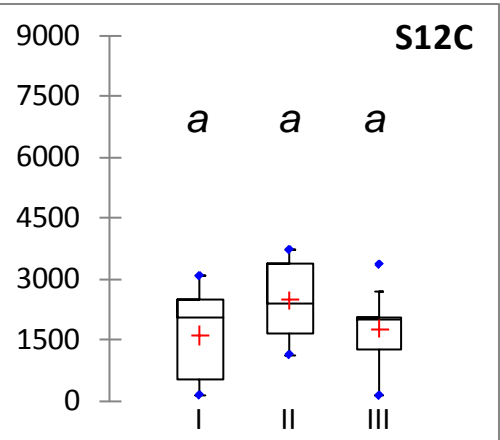
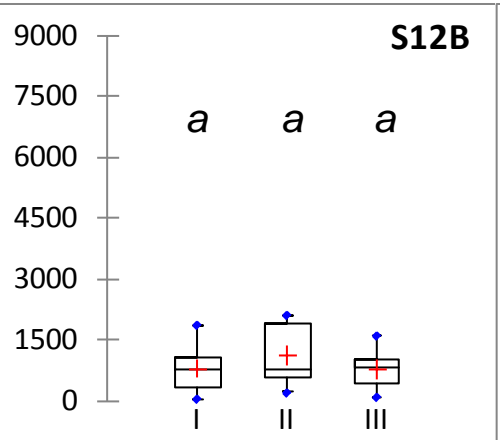
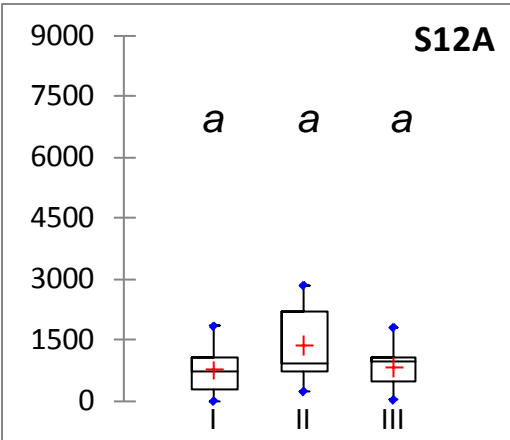
Period

Period

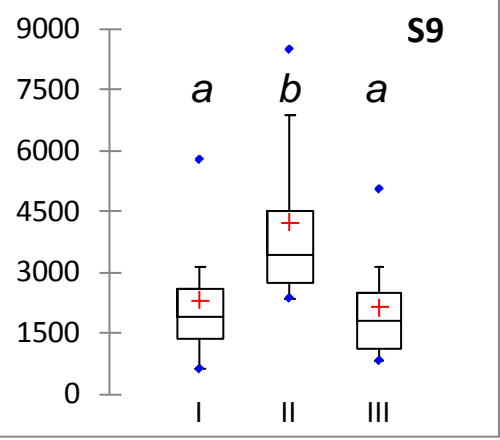
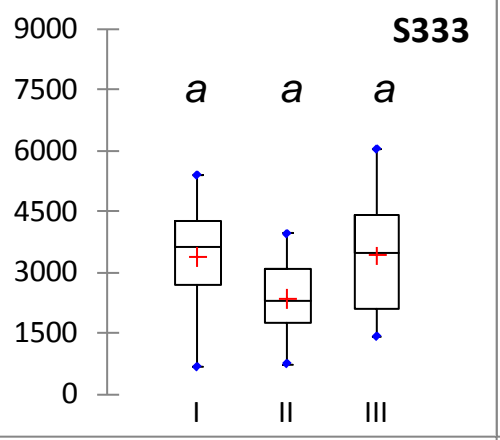
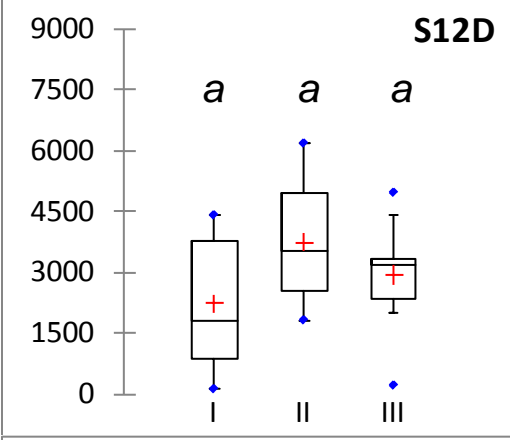


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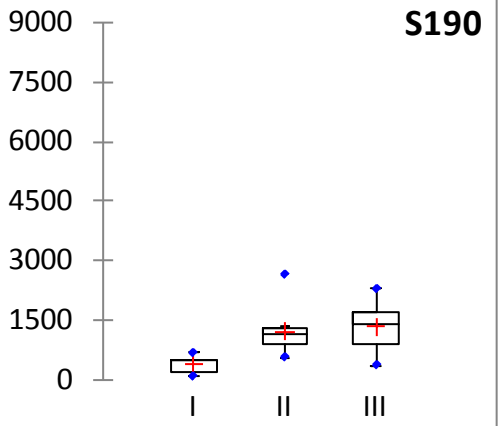
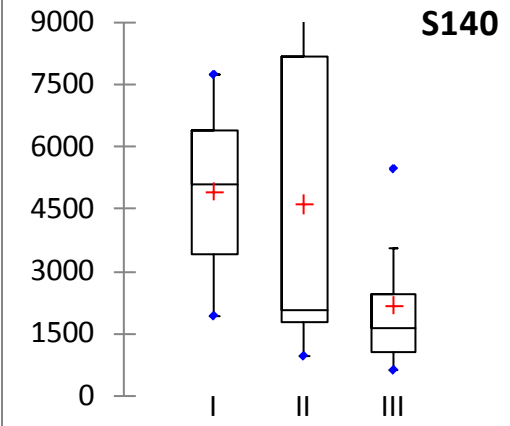
TP Load (kg)



TP Load (kg)



TP Load (kg)



Period

# Canal Sites

Period I: 1987-1993

Period II: 1994-2001

Period III: 2002-2010

Period

Period