Water Residence Time and Water Quality in Taylor Slough

Everglades National Park, Fl, USA

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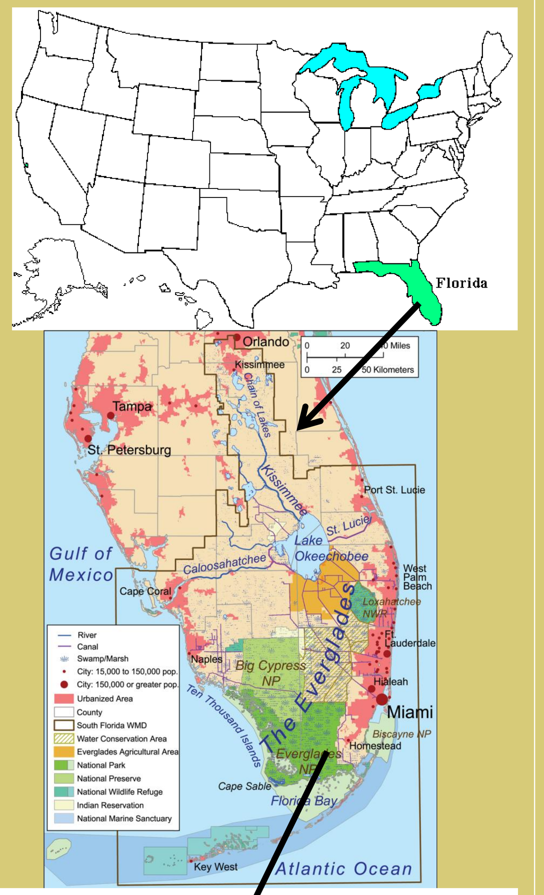
Abstract

One of the main efforts of the Comprehensive Everglades Restoration Plan (CERP) includes increasing freshwater flow to Florida Bay via Taylor Slough. A way to gain insight into the success of these restoration projects is by analyzing hydrological and geochemical conditions in Taylor Slough. The goals of this project was to determine water residence times (T_r) in Taylor Slough and then to correlate the T_r with surface water chemistry. From 2002 to 2010, Tr in Taylor Slough ranged from 5 to 90 days. The T_r varied seasonally with the shorter values occurring in April-June coinciding with the highest rates of evapotranspiration (ET) and lowest surface water volumes in the slough. The highest T_r values occurred in November-December when surface water volumes were high and ET was low. Surface water chemistry was negatively correlated with T_r, with higher ion concentrations observed in April-June. High rates of ET between April and June were most likely responsible for the low T_r values, and the increase in ion concentrations in the surface water.

Introduction

The Everglades is a subtropical wetland that is contained within a larger watershed with an extent of 160 km beginning with the Kissimmee River basin, located in central Florida, through Lake Okeechobee to the southeastern Florida Bay (Harvey and McCormick, 2009). The area experiences a wet (June-October) and a dry (November-May) season. Taylor Slough (TS) is the smaller of two water flow-ways in Everglades National Park (ENP) (**Fig. 1**). The Everglades has experienced many alterations to its natural state due to urbanization and water management practices. The alterations have caused an increase in groundwater – surface water interactions, groundwater seepage outside of the Everglades, peat subsidence, and loss of tree islands to name a few. Efforts to improve the current state of the Everglades include the Comprehensive Everglades Restoration Plan (CERP), the largest restoration effort ongoing in the Everglades. CERP restoration projects began with the completion of the raising and lengthening of the Taylor Slough Bridge in 2001 and are ongoing today.



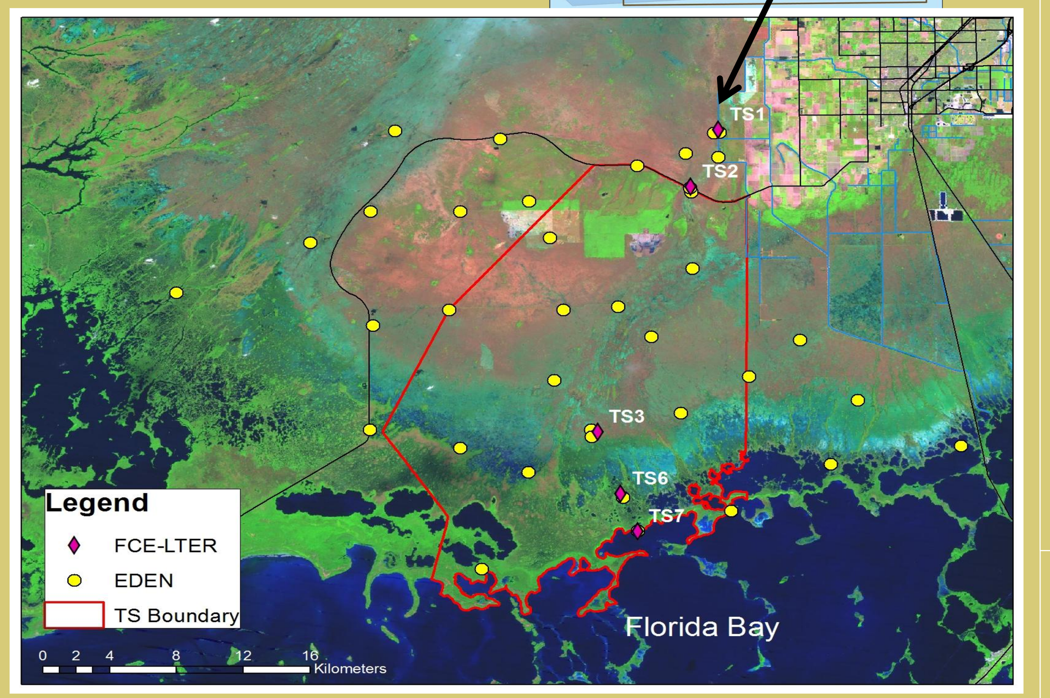


Figure 1: Taylor Slough

Objectives

The purpose of this research is to investigate the effects of restoration on the water balance, residence time, and water chemistry of TS. Specific objectives of this research include:

- Determine water residence time (Tr) of TS from 2002 – 2010.
- Correlate the estimated water Tr with surface water chemistry of TS.

Hypotheses

- Increasing surface water flow due to changes in water management practices will result in a decrease in the water residence time of TS.
- Major ion concentrations will have a positive correlation with the water Tr.

Methods

Calculation of Water Residence Times (T_r)

Using the water budget equation (Zapata-Rios, 2009), the major water budget parameters were solved on a monthly time step from 2002 – 2010 using each parameter's monthly total.

$$P + Q_{in} = ET + Q_{out} + S \pm R$$

P = Precipitation, Q_{in} = Surface water inflow, ET = Evapotranspiration, Q_{out} = Surface water outflow, S = Change in storage, R = Residual

Data sources for each of the terms included:

- Everglades Depth Estimation Network (EDEN) gauging stations (**Fig.1**): P, ET, Water Level data
- ENP TS station: Q_{in}
- South Florda Water Management District (SFWMD)TR, MCC, MC stations: Q_{out}
- GIS Spatial Analyst (Kriging of EDEN Water Level data): S, V
- R: calculated from the other variables with negative values = water leaving the system, positive values = water entering the system.

Water residence Times (Tr) were calculated according to the equation: $\mathbf{T_r = V/Q_{Tout}}$

V = Volume, Q_{Tout} = Total Outflow (ET + Q_{out} + -R)

Water Chemistry

Surface water samples were collected along Taylor Slough at five (5) Florida Coastal Everglades - Long Term Ecological Research (FCE-LTER) sites, TS/Ph-1 (TS1), TS/Ph-2 (TS2), TS/Ph-3 (TS3), TS/Ph-6 (TS6), and TS/Ph-7 (TS7) (**Fig.1**) using an automated ISCO full-size portable sampler (**Fig. 2**). Discrete surface and ground water samples were also collected at TSB and TS3 sites. Samples sent to the Hydrogeology Laboratory at FIU were analyzed for major cations (Ca^{2+}, Mg^{2+}, Na^+, K^+) and anions (Cl^- and SO_4^{2-}) respectively.

Figure 2. ISCO sampler at TS3

Results

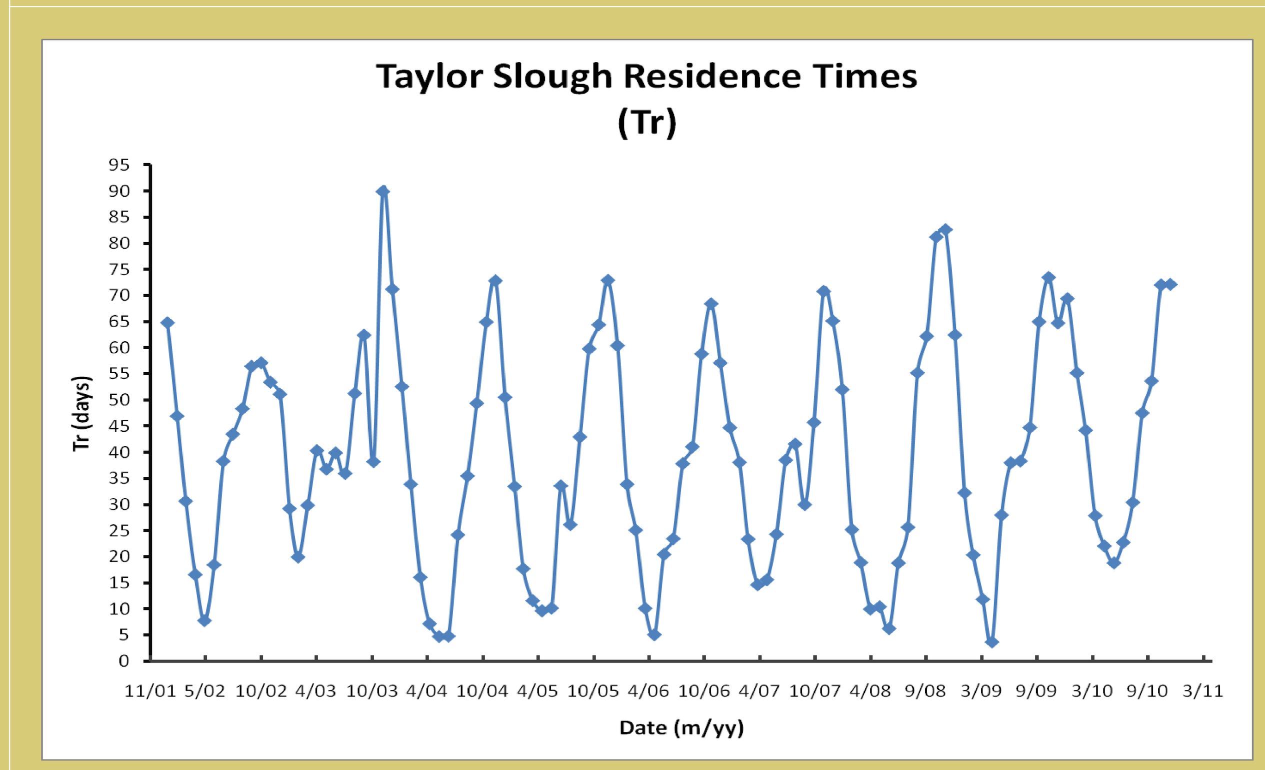


Figure 3. Taylor Slough T_r from 2002-2010.

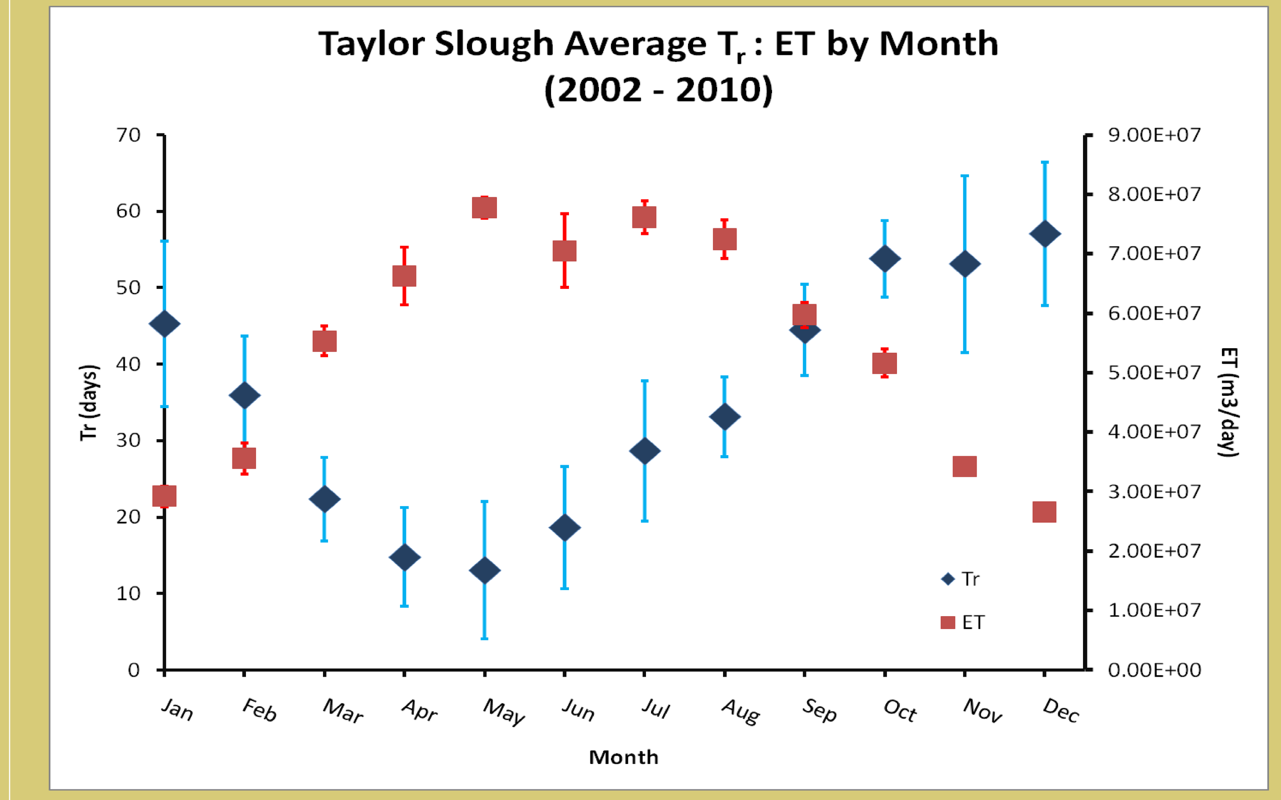


Figure 4. Average monthly T_r and ET were negatively correlated (error bars: 95% confidence intervals).

Figure 5. TS3

- From 2002 – 2010, T_r in TS ranged from 5 to 90 days with values increase during the wet season, peaking in December (**Fig.3**). The T_r decreased throughout the dry season, reaching the shortest times in April-May.
- Average monthly ET values were negatively correlated with monthly average T_r, with maximum ET values in May, and lowest ET values in December (**Fig.4**) .
- Surface water chloride (Cl^-) concentrations (meq/L) at the freshwater site, TS3 (**Fig.5**), were negatively correlated with T_r (**Fig. 6**).
- Surface water Cl^- concentrations for the coastal sites (**Fig.7**) were also negatively correlated with T_r (**Fig. 8**).

Figure 7. Coastal TS near TS7

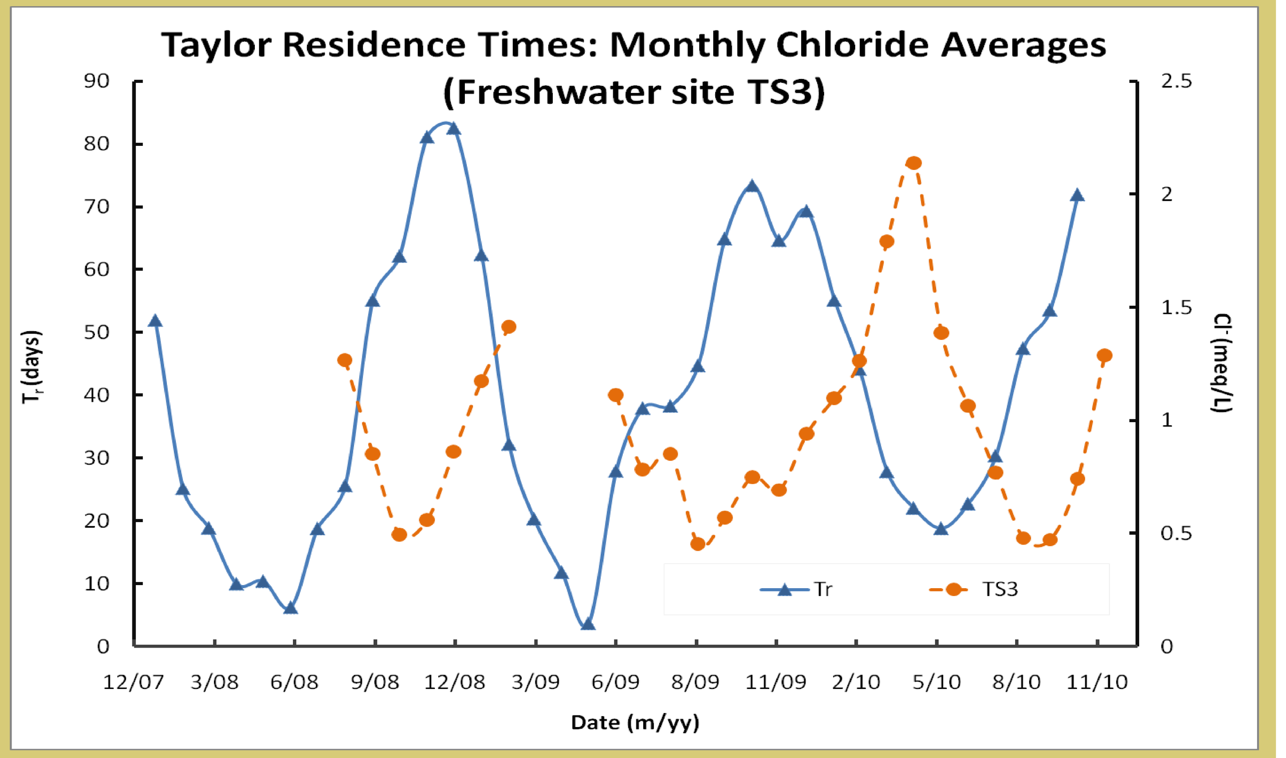


Figure 6. Taylor Slough T_r and monthly Cl^- for freshwater site TS3.

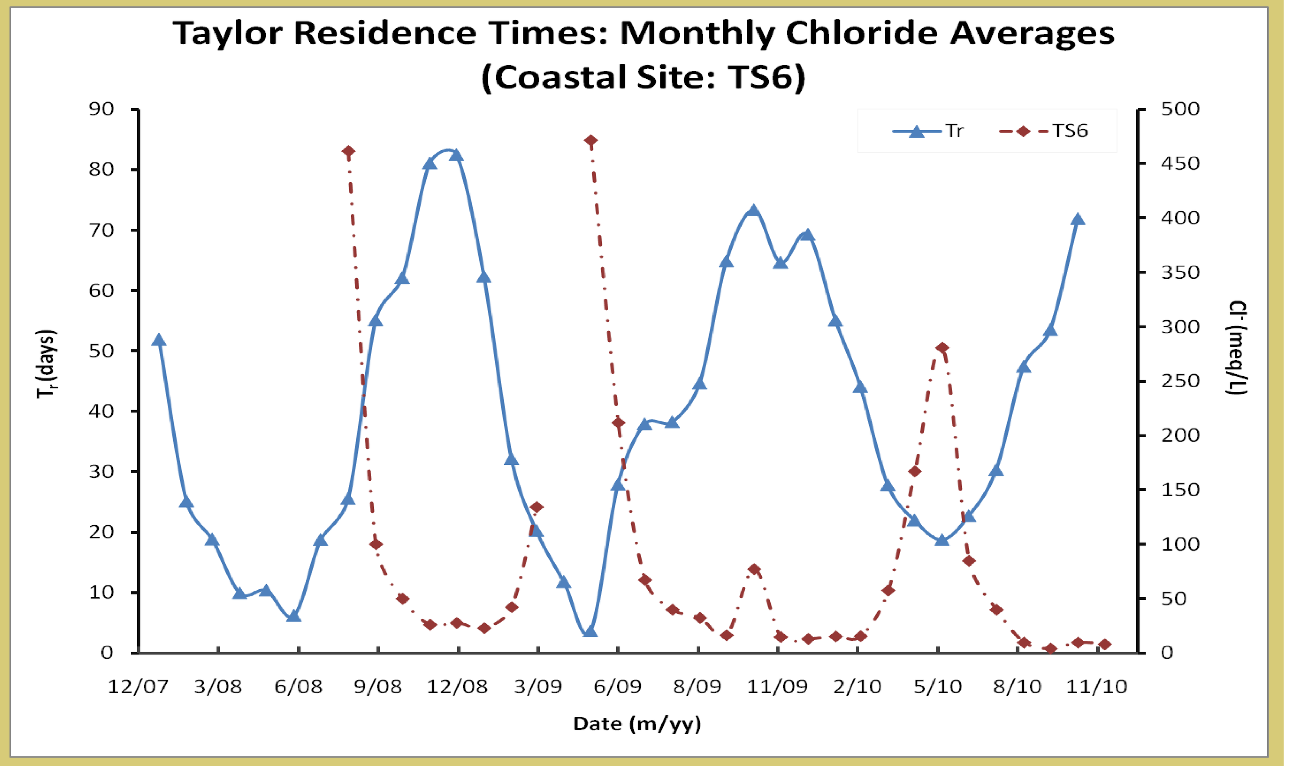


Figure 8. Taylor Slough T_r and monthly Cl^- for coastal site TS6.

Discussion

- The greatest loss of water from TS is via ET (Zapata-Rios, 2008). The highest T_r usually observed in December occurs when ET and Q_{Tout} are low (**Fig.4**). The drop in ET causes T_r to increase as water is remaining longer in the system.
- The lowest T_r are usually observed in May **(Fig.4),** which is right before the beginning of the wet season. Calculated V values are typically lowest in May, while ET is at its highest (**Fig. 4**). The small V value and high Q_{Tout} value leads to the short T_r typically observed in May. The smaller volume of surface water available in the system has a shorter T_r as it quickly exits the system via ET.
- The negative correlation between the T_r of TS and the Cl^- concentrations observed at both the freshwater (**Fig.6**) and coastal (**Fig.8**) is related to both V and ET. When ET is highest, in May, there is less surface water available as V is low. The remnant surface water has higher ion concentrations. The lower Cl^- concentrations with increasing T_r during the wet season and peaking in December is explained by an increase of V in the system mostly by rainfall that dilutes the ion concentrations coinciding with a drop in ET.

Conclusions

- In TS, Tr is lowest at the end of the dry season (May) and then increases through the wet season peaking in December.
- Contrary to the hypothesis of a positive correlation between T_r and major ion concentrations, a negative correlation was observed. Increasing T_r results in decreasing ion concentrations and vice versa due to the availability of surface water in the system (V).

Figure 9. Manatee in the coastal TS area.

Acknowledgements

I would like to thank David Lagomasino and Pamela Sullivan for their support in the field, lab, and data analysis. Thanks to Nicole Neira for helping me process and run the samples in the lab. A special thanks to the Southeast Everglades Research Center technicians Adam Hines and Olga Sanchez for going out and collecting the ISCO samples for Taylor Slough. Thanks to the FCE-LTER, USGS, EDEN,SFWMD, and ENP for the datasets they have made available and were used for this project. Funding for this project was provided by the NSF FCE-LTER program.

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