



**Author:** Cheng (Caroline) Chen **Collaborators:** Rachel Noble, Denene Blackwood, Carly Dinga, Jenna Hynes, Tamara Bennett, Norah Patterson, Thomas Clerkin, Javier Gallard, Mark Ciesielski, Colin Eimers, Ryan Neve

## INTRODUCTION

The **Town of Atlantic Beach** is situated in the coastal plain region of southeastern North Carolina with a relatively small permanent population (1399) that experiences exponential seasonal growth given its proximity to coastal waters and productive tourism industry. Several non-point sources of fecal contamination exist that affect the surface water quality in the surrounding waterbodies of Atlantic Beach:

- Septic system leachate
- Fecal matter from domestic animals and avian species
- Abandoned waste disposal from boats and other vessels
- Cross contamination of stormwater conveyance systems

The **primary objectives** of this research were to :

- 1) Determine the dynamics, magnitude and sources of fecal contaminants in discharge conveyed to highly-used receiving waters using multi-sample, time-paced, temporal-intensive sampling approach over a four-month period;
- 2) Relate **fecal indicator bacteria (FIB)** and **microbial source tracking tools (MST)** marker concentrations to environmental and meteorological parameters such as tidal height, antecedent rainfall, salinity and **total suspended solids (TSS)**;
- 3) Understand rates of water quality exceedances in the context of **king tides** versus non-king tide periods. This research aims to advance the understanding of microbial contaminant delivery patterns in **septic system**-relying residential areas in low-lying coastal systems during king tide events.

## METHODS

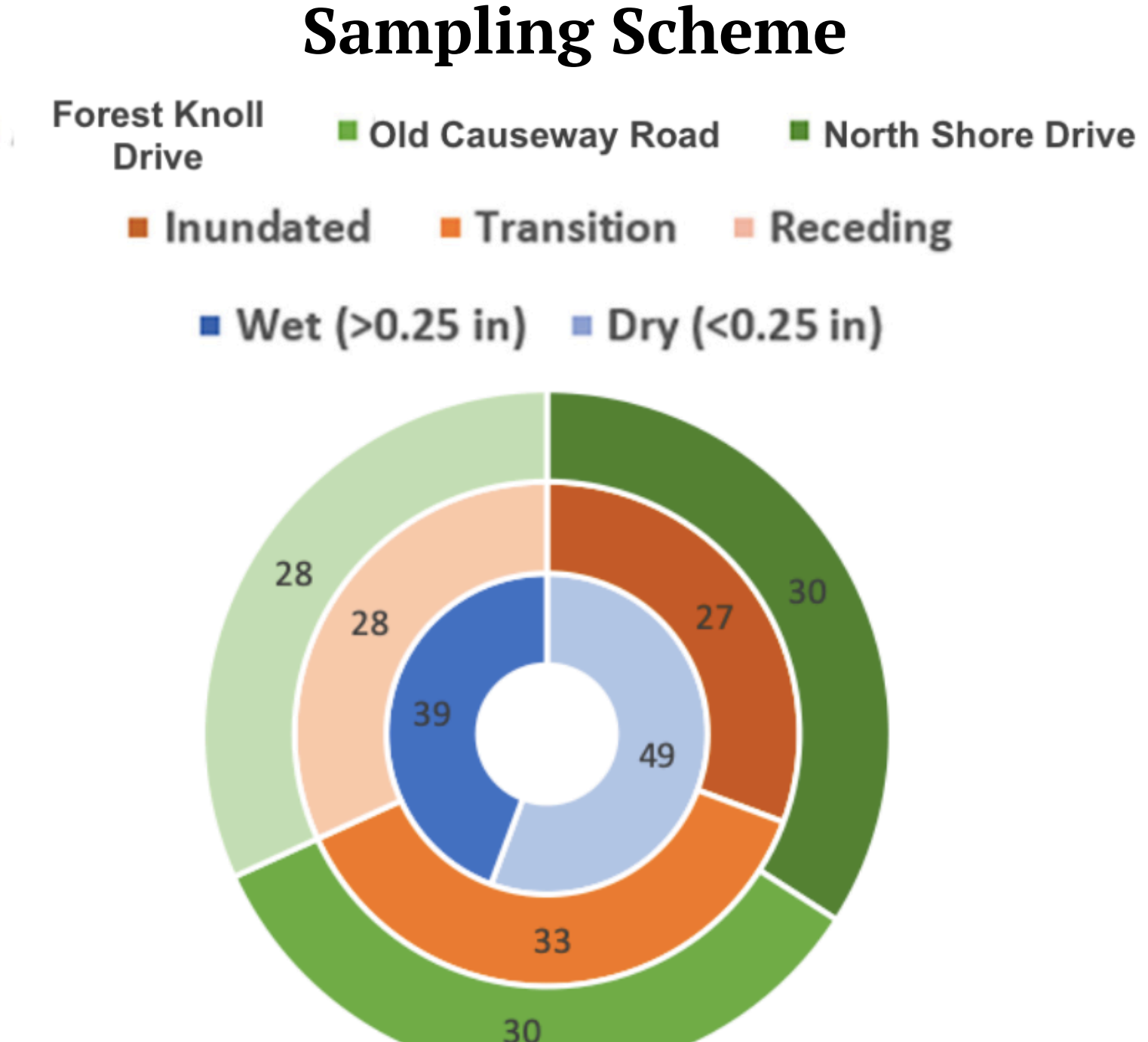
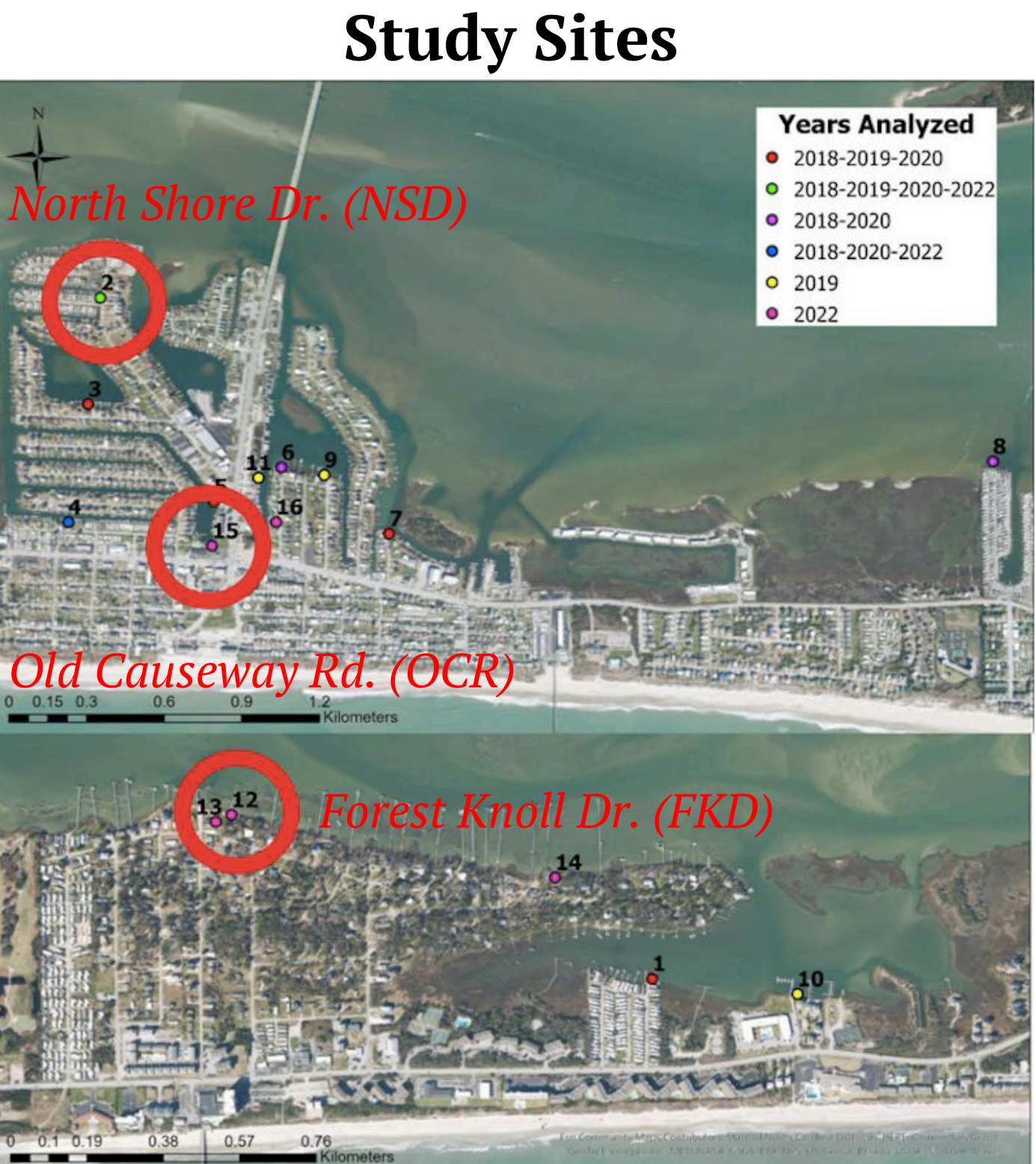
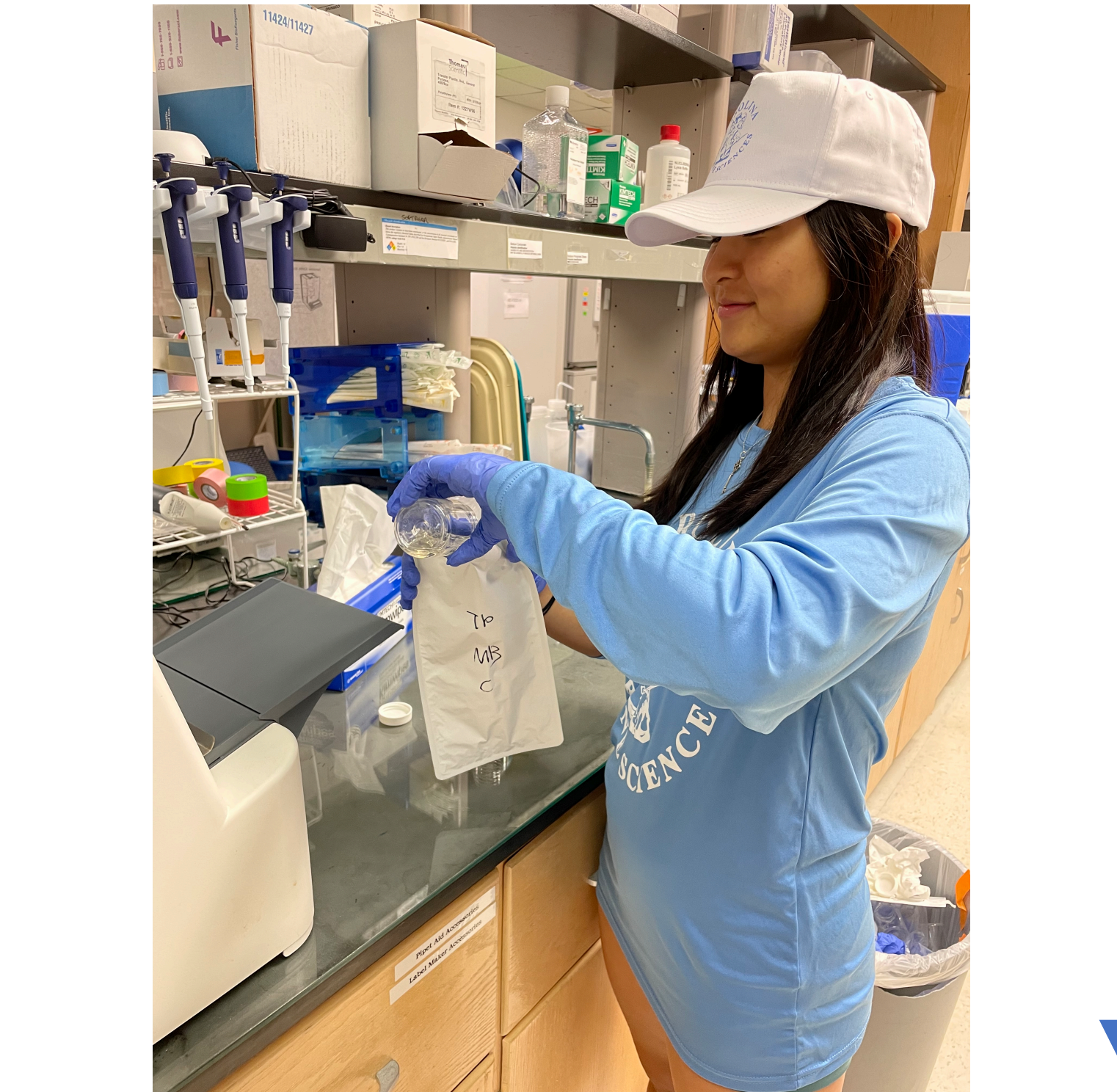


Figure 1. Number of samples collected at each sampling sites.

### Sample Collection



### FIB Enumeration & ddPCR Analyses



## RESULT

The quadrant analysis demonstrates the relationship between *Escherichia coli* (EC) and *Enterococcus sp.* (ENT) concentrations across all samples (Fig. 2). Only 31.8% of samples didn't exceed any standards.

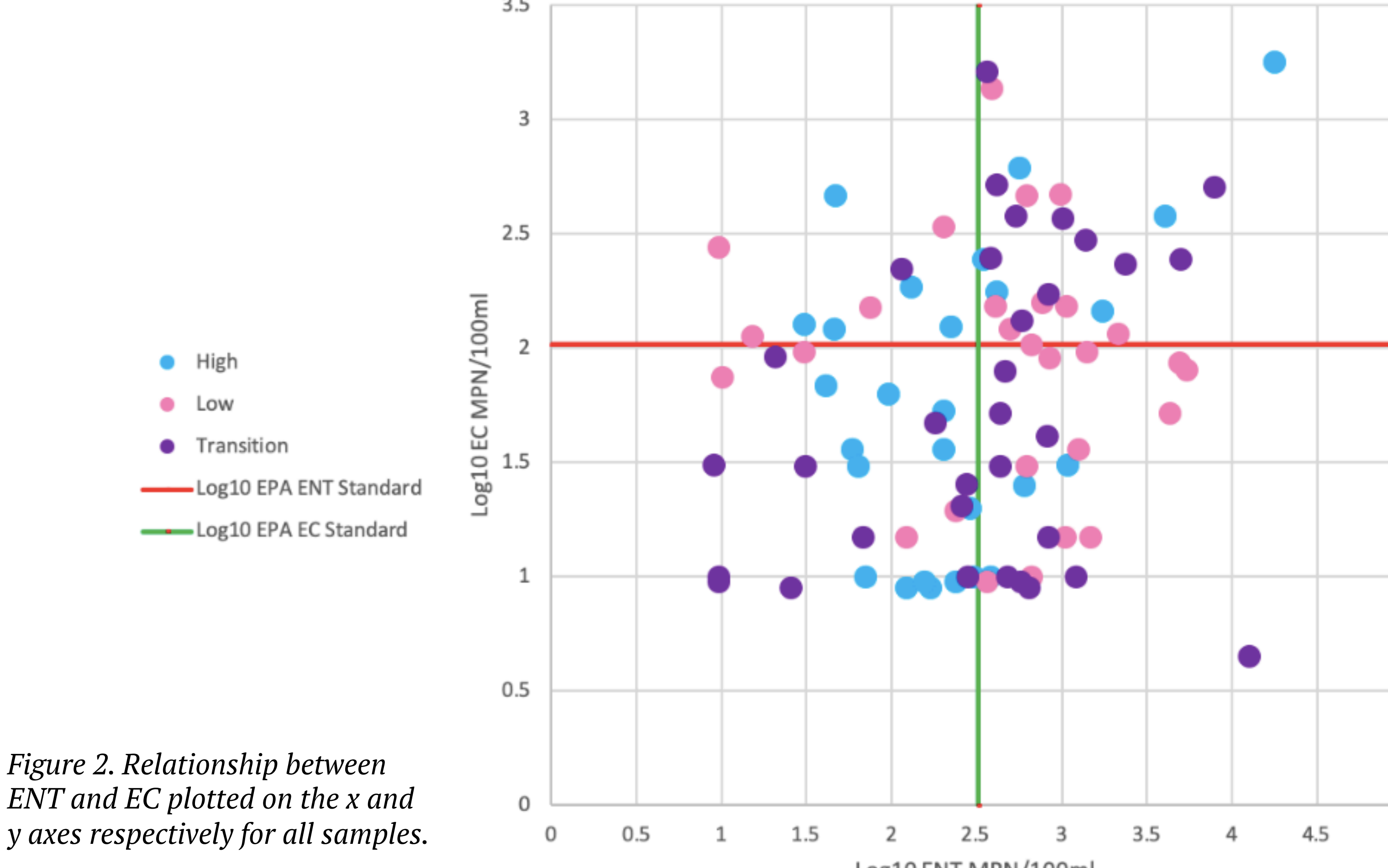


Figure 2. Relationship between ENT and EC plotted on the x and y axes respectively for all samples.

### September King Tides Event

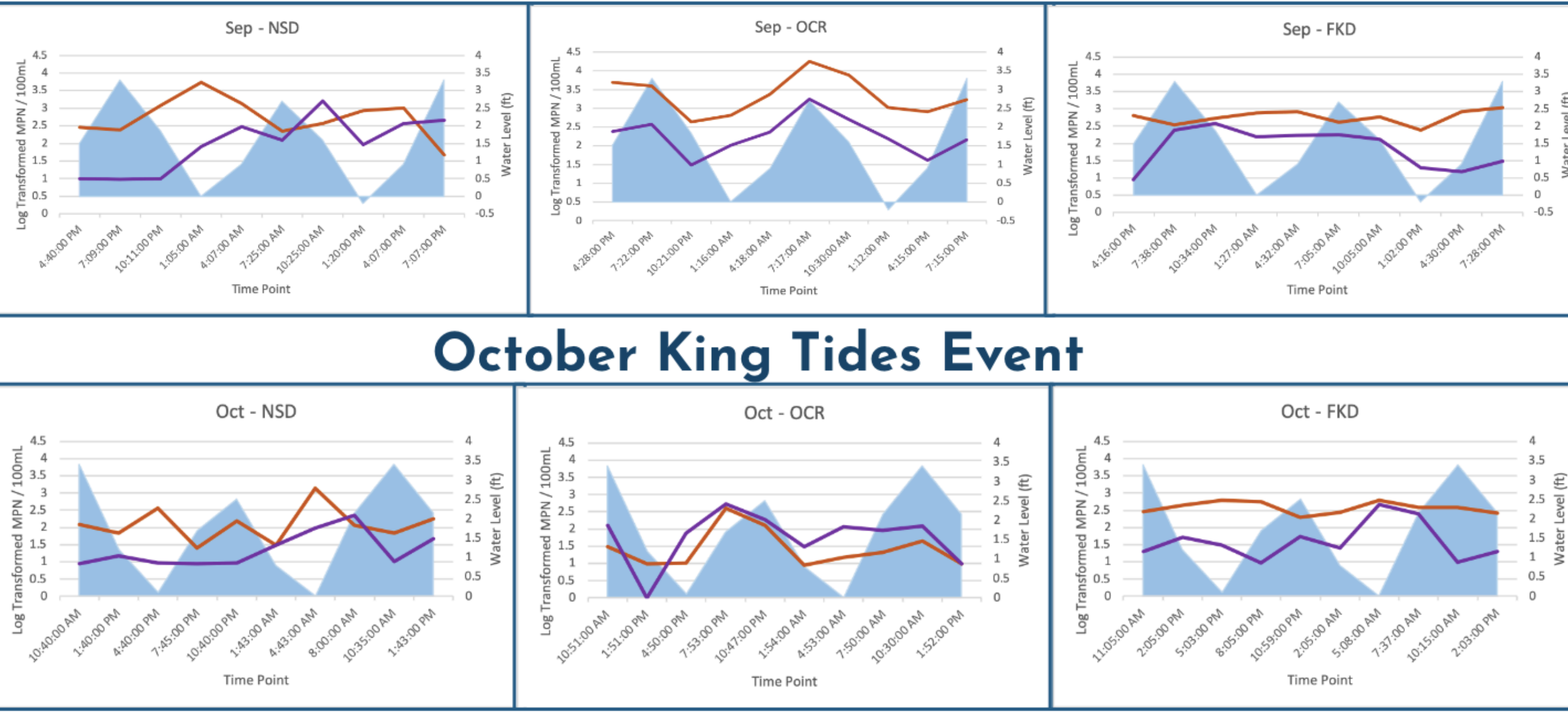


Figure 3. EC and ENT concentrations plotted against the water levels

### September King Tides Event

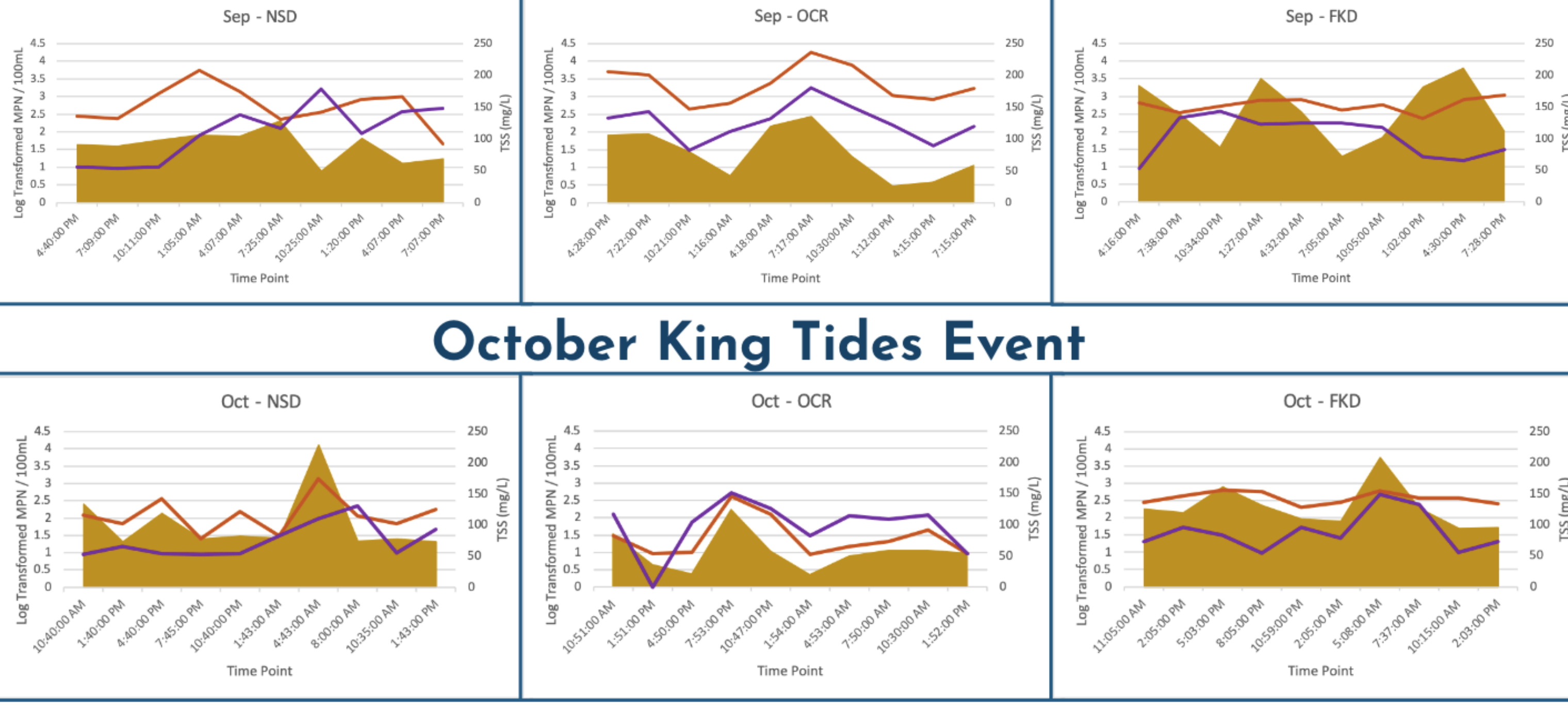
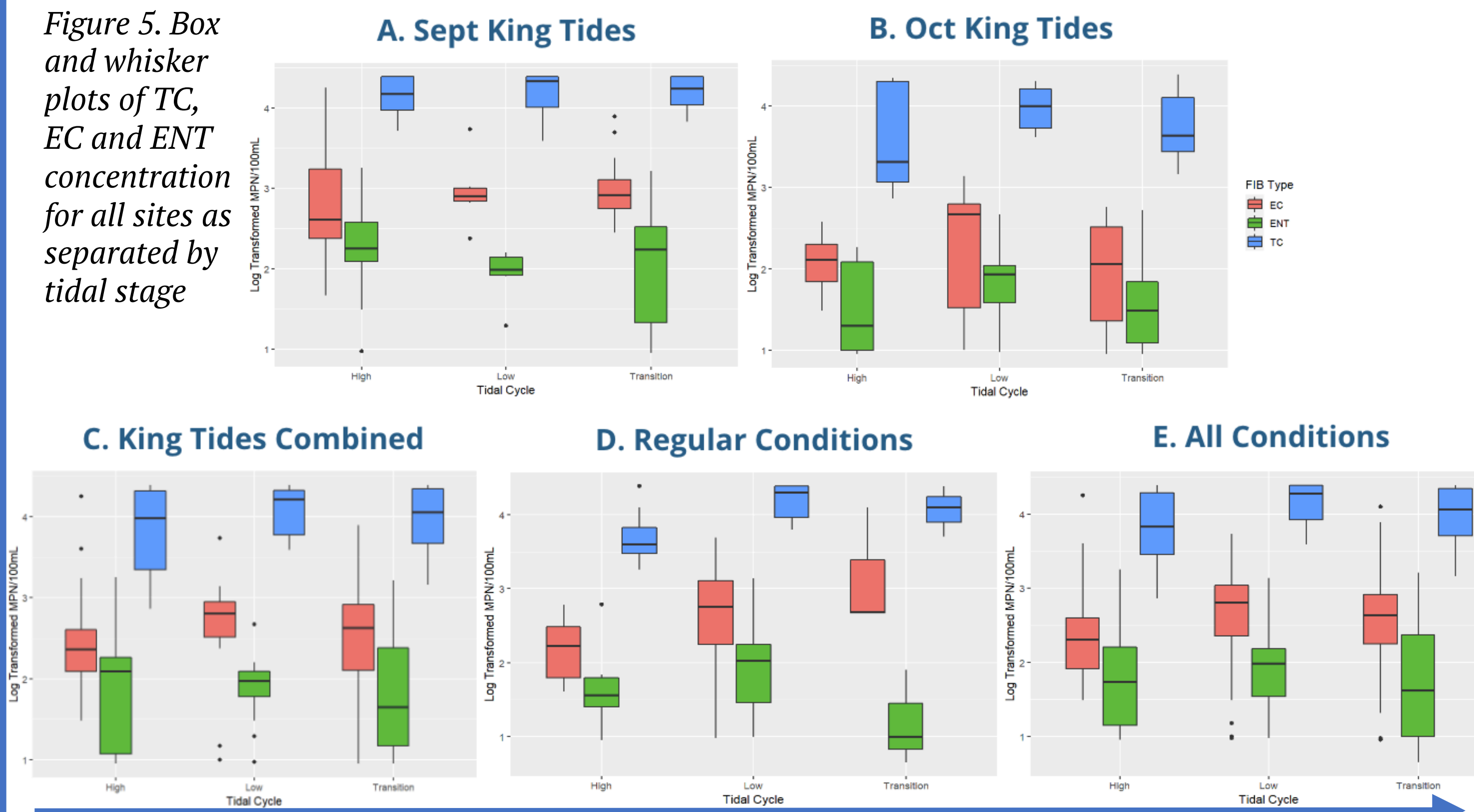


Figure 4. EC and ENT concentrations plotted against TSS levels

Figure 5 demonstrates the comparison of locality, spread and skewness of FIB concentrations between the three tidal stages under different sampling conditions. EC concentrations are generally higher during low and transition tides than during high tides. Both EC and ENT concentrations during the September king tides event are higher than those during the October king tides event, which could be a remnant from the tourist season.



## DISCUSSION

**- Alternative MST Marker**  
In addition to Bacteroides HF183 marker, other human-associated MST markers, i.e. HumM2, crAssphage and pepper mild mottle virus (PMMoV), could be used to, to assess the impact from aging septic systems. To rule out domestic animals and avian species as contributing sources of contamination, animal fecal markers such as canine-associated BacCan and avian-associated GFD could be tested in conjunction. A "toolbox approach" has been proposed to address the limitations of any single MST marker <sup>1</sup>.

**- Novel Tracer**  
There is too much excess water in the system during king tides due to the inundation of the land, thus dilution is causing a depression of the FIB concentration. To evaluate accurate waste load and assimilate capacity models, future studies could potentially incorporate the use of water tracing dye fluorometry <sup>2</sup>. Fluorometric hydrologic measurements could characterize the dilution factor and the contamination magnitude for septic system effluent, based on its ability to simultaneously analyze the transport and fate of instantaneous pollutant discharges and water movement. Rhodamine WT is recommended amongst all tracers because of its ease of application, distinction from most substances found in estuarine water, and conservative nature <sup>3</sup>.

**- Future Monitoring Efforts**  
Wider adoption of sampling under more varied weather and tidal conditions, comparing proximal sites with different stormwater conveyance infrastructures, and assessing relationships between more parameters (e.g. total suspended solids) could create the opportunity for risk modeling and expand the timing and scenarios under which these models can reliably predict threats to public health.

**- Implication for Regulations**  
FIB concentrations during both king tides and regular sampling events exceeded recreational water quality standards **68.2%** of the time, which poses alarming public health risk for a highly utilized recreational area. If there was an effort to categorize more extreme events, including king tides, storm events, and flooding event, the town could potentially develop and benefit from an active water quality monitoring advisory, in order to address instances of FIB levels exceeding the state standard and to update local residents, tourists and primary recreators.