

# **Assessment of Trends in Marathon Coastal Water Nutrient Concentrations and EPA Target Compliance within the Florida Keys National Marine Sanctuary**

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## **Abstract**

The close-to-shore waters of the Florida Keys have been designated as impaired in violation of the Clean Water Act since the 1980's. The EPA has established "Strategic Targets" for nutrient concentrations within the waters of the Florida Keys National Marine Sanctuary (FKNMS) through EPA project SP-47. These Strategic Targets are nutrient concentration values set equal to a 2005 baseline and are required to "promote coral growth and overall ecosystem health." Within the halo zone, the area  $\leq 500$  m from shore, dissolved inorganic nitrogen (DIN) and total phosphorus (TP) concentrations are not to exceed 0.75 and 0.25 micromolar, respectively. Marathon, FL uses 12 shallow sewage wells to dispose of partially treated sewage effluent into the groundwater under the Keys. Because studies have shown problems with shallow sewage wells, Friends of the Lower Keys (FOLKS) requested an analysis of the official FKNMS data concerning Marathon's halo zone water quality. DIN and TP concentrations have been measured at the two stations located in halo zone waters of Marathon through the Southeast Environmental Research Center at Florida International University Water Quality Monitoring Network (SERC-FIU WQMN). From 2012 to 2018, Marathon halo zone waters were not compliant with EPA Strategic Targets 78.2% and 67.9% of the timeseries for DIN and TP concentrations, respectively. Linear regressions of 4-year moving windows of DIN and TP concentrations show consistent time periods of increasing non-compliant nutrient concentrations.

## Introduction

Within the City of Marathon, Florida, wastewater treatment plants dispose of partially treated sewage effluent into 12 shallow sewage wells, with depths ranging from 90-120 feet. Studies have shown shallow sewage well effluent - containing nitrogen, phosphorus, other nutrients, and contaminants - rises rapidly to surface waters (Briceño et al. 2014; Paul et al. 2000; Paul et al. 1997). Maintaining low nutrient concentrations in coastal waters is vital to maintaining ecosystem integrity and preventing further damage to the Florida Keys ecosystem.

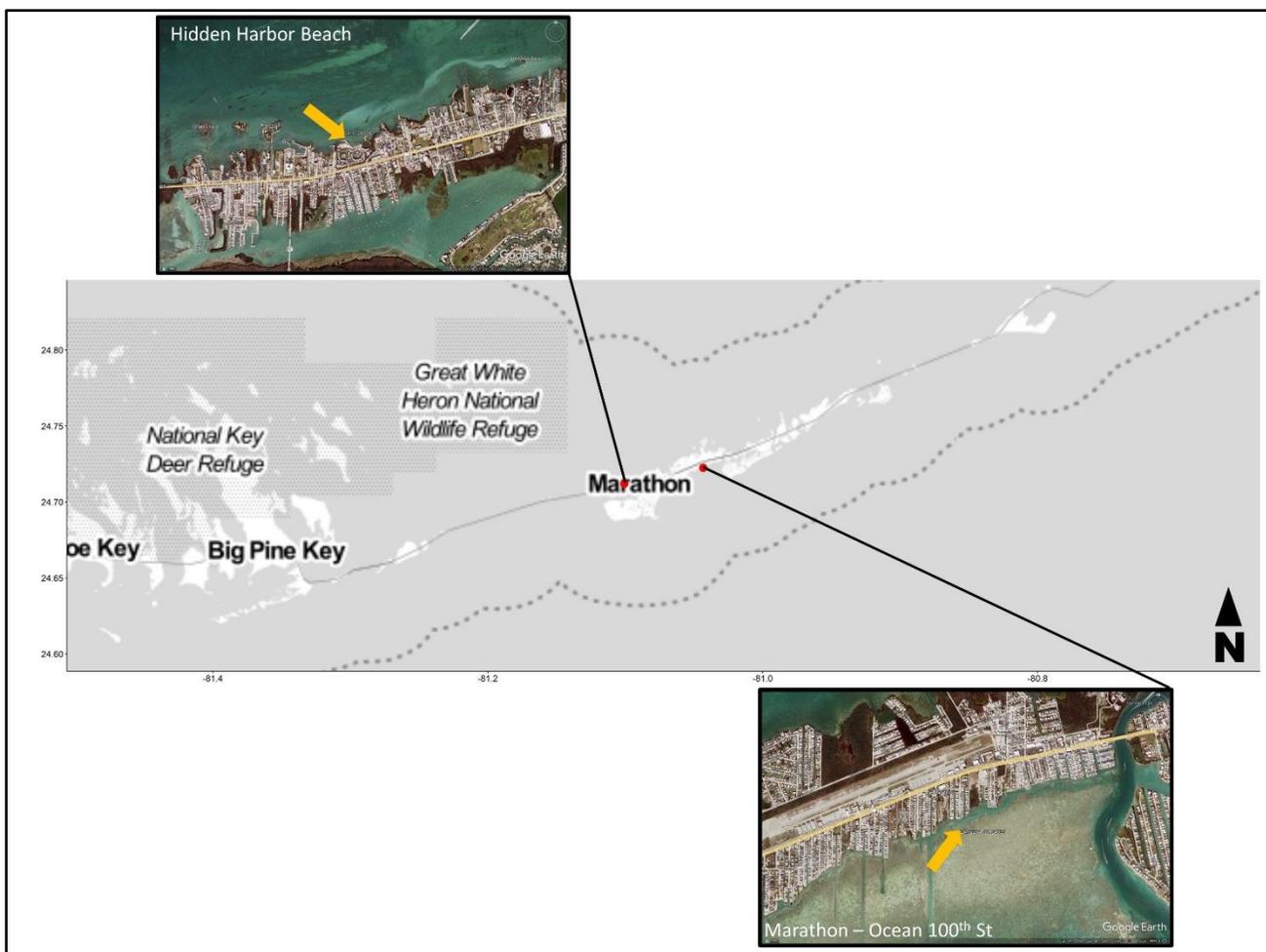
The EPA has established “Strategic Targets” for nutrient concentrations within the waters of FKNMS through EPA project SP-47. These Strategic Targets are nutrient concentration values required to “promote coral growth and overall ecosystem health” and are not to be exceeded. Through SP-47, Strategic Targets for dissolved inorganic nitrogen (DIN) and total phosphorus (TP) have been set at 0.75 micromolar and 0.25 micromolar, respectively. Collectively, the concentrations of these nutrients are a measure of water quality and ecosystem health.

The Southeast Environmental Research Center at Florida International University (SERC-FIU) has deployed and maintained a suite of water quality monitoring stations throughout the Florida Keys National Marine Sanctuary (FKNMS). The SERC-FIU Water Quality Monitoring Network (SERC-FIU WQMN) includes a set of stations within the halo zone, the area  $\leq 500$  m from shore, that collects data on nutrient composition. These halo zone stations, referred to as SHORE stations, can be used to assess water quality trends over time and compliance with EPA Strategic Targets.

The SERC-FIU WQMN SHORE stations span Key Largo to Key West, with 10 sampling stations collecting data from 2011 to present (2021). There are two stations located in Marathon (**Figure 1**). Complete data are available spanning 2012-2018. The goal of the assessment herein is to:

- 1) Evaluate the frequency in which Marathon halo zone waters are compliant with EPA Strategic Targets for DIN and TP using data provided by SERC-FIU WQMN SHORE stations.
- 2) Examine whether data from the SERC-FIU WQMN SHORE stations located in Marathon halo zone waters show temporal trends in EPA Strategic Target compliance.

All data for this assessment are publicly available through the SERC-FIU WQMN data portal at <http://serc.fiu.edu/wqmnetwork/FKNMS-CD/DataDL.htm>. Program details are available at <http://serc.fiu.edu/wqmnetwork/>. Data utilized for this assessment span 2012 through 2018 and have been restricted only to SHORE stations in Marathon halo zone waters. Data from 2011 and 2019 are omitted due to incomplete temporal coverage, and more recent years are not yet publicly available. All visualizations were performed using R version 4.0.0 and executed within RStudio.



**Figure 1.** Map and satellite images of SERC-FIU WQMN SHORE stations located in Marathon halo zone waters. SHORE Stations within satellite images are denoted with a yellow arrow. Satellite imagery was captured at an elevation of 10,000 ft ( $\pm$  10 ft) via Google Earth.

### Assessment of Percent Compliance with EPA Strategic Targets

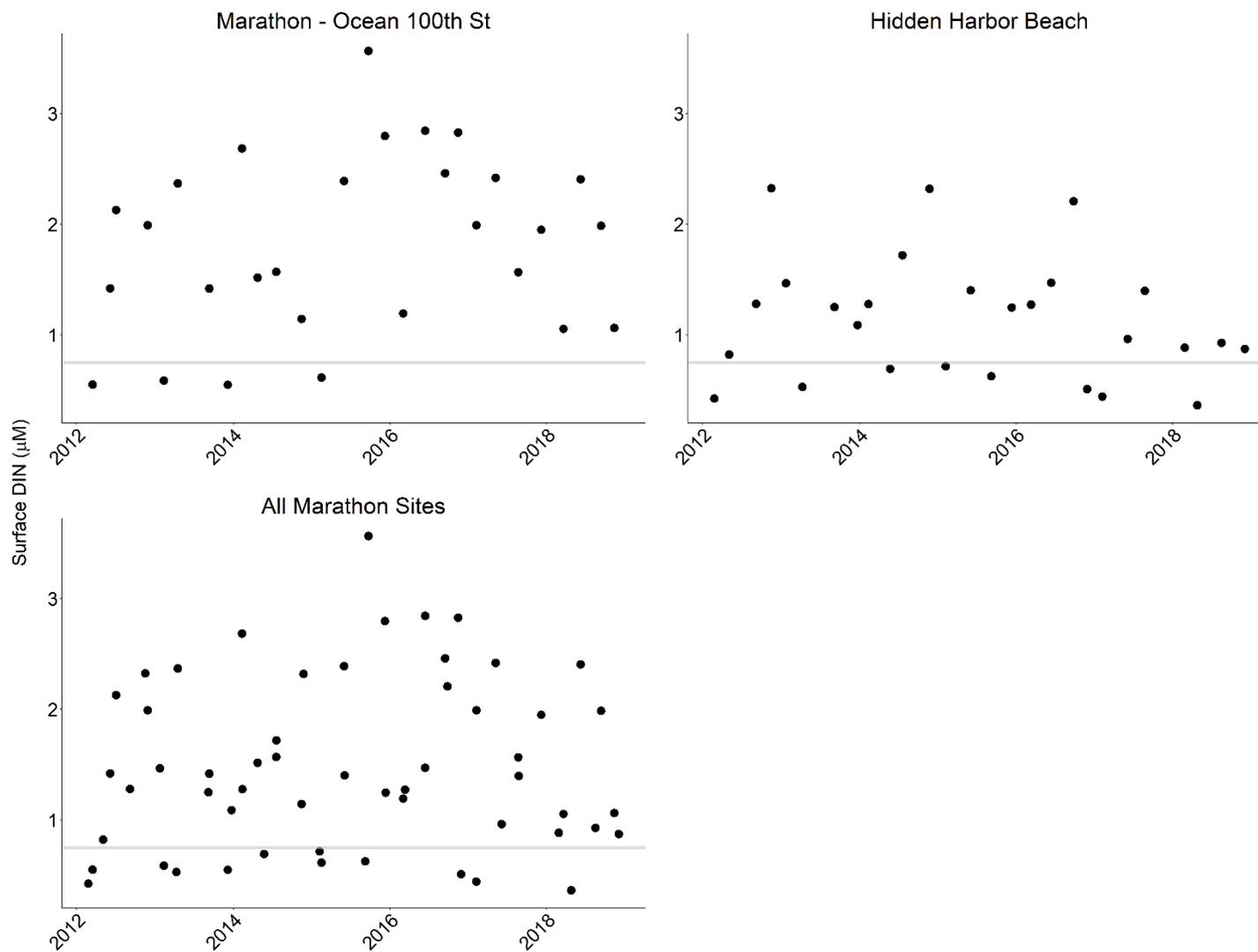
EPA Strategic Targets have been established for dissolved inorganic nitrogen (DIN) and total phosphorus (TP). Values above 0.75 micromolar and 0.25 micromolar, respectively, are non-compliant. Herein, for each of the two EPA Strategic Targets, percent non-compliance at each station over time, percent non-compliance across both Marathon stations in aggregate, and trends in nutrient concentration will be examined. Trends are to be assessed through simple linear regression in order to evaluate changes in nutrient concentration over time. A four-year moving window will be used to reduce the influence of high leverage points within the regression, which can result in lines being fit to the most extreme values. In the linear regression, an upward slope indicates increasing concentrations of the measured parameter, a downward slope indicates decreasing concentrations of the measured parameter, and a horizontal slope indicates static concentrations of the measured parameter.

### DIN

Dissolved inorganic nitrogen concentrations were reported 55 times across the two Marathon stations from 2012 through 2018. A protocol of four samples per year per station was set, though data were not always reported (see 2017). Yearly DIN non-compliance ranged from 62.5% in 2015 to 87.5% in 2014, 2016, and 2018 (**Table 1**). Concentrations across both Marathon stations were non-compliant with the EPA Strategic Target 78.2% of the timeseries, with Marathon – Ocean 100<sup>th</sup> St non-compliant 86% of the timeseries and Hidden Harbor Beach non-compliant 71% of the timeseries (**Figure 2**). A history of measurements taken and of yearly percent non-compliance for each station is given in **Table 2**. Trends for DIN concentration values can be assessed using a 4-year moving window and constructing a simple linear regression (**Figure 3**). Trend lines inclusive of 2012-2015 show an increase in DIN concentration over time. The time period 2013-2016 shows the strongest increase in DIN concentration. The time period 2015-2018 shows the only decrease in DIN concentration. All trend lines show consistent non-compliance.

**Table 1.** Yearly DIN EPA Strategic Target (DIN  $\geq$  0.75 micromolar) compliance/non-compliance summary for the two Marathon stations over the timeseries 2012-2018.

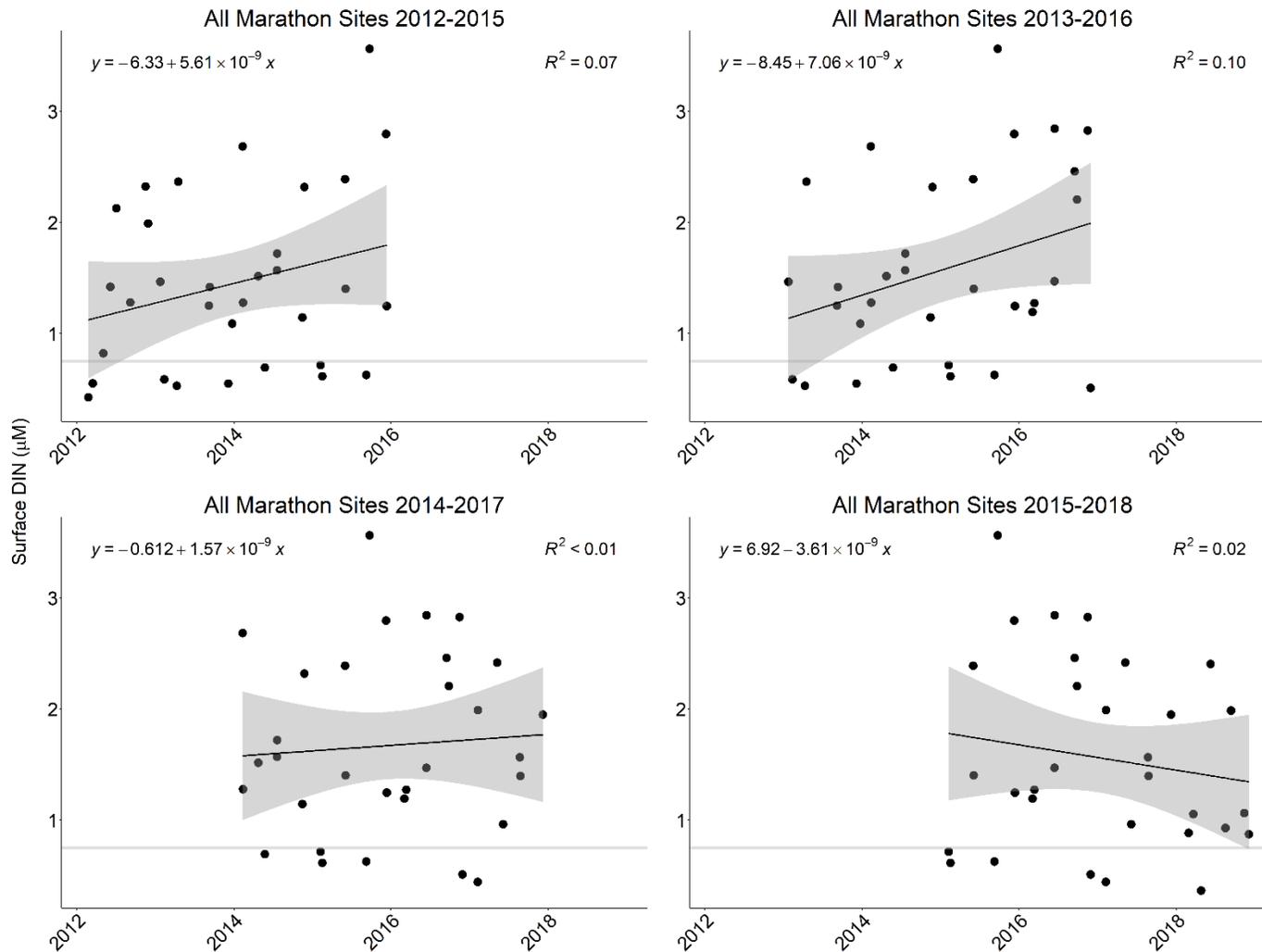
Year	Number of Measurements	Non-Compliant	Compliant	Non-Compliant Percent
2012	8	6	2	75.0%
2013	8	5	3	62.5%
2014	8	7	1	87.5%
2015	8	5	3	62.5%
2016	8	7	1	87.5%
2017	7	6	1	85.7%
2018	8	7	1	87.5%
2012-2018	55	43	12	78.2%



**Figure 2.** Surface DIN concentrations by station and in aggregate for the timeseries 2012-2018. Horizontal gray line represents the EPA Strategic Target value of 0.75 micromolar. Points above the horizontal gray line are non-compliant measurements.

**Table 2.** Yearly DIN EPA Strategic Target (DIN  $\geq$  0.75 micromolar) percent non-compliance for both Marathon monitoring stations for the timeseries 2012-2018.

	<b>Percent Non-Compliance</b>						
<b>Station</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>
Marathon – Ocean 100 <sup>th</sup> St	75	50	100	75	100	100	100
Hidden Harbor Beach	75	75	75	50	75	75	75



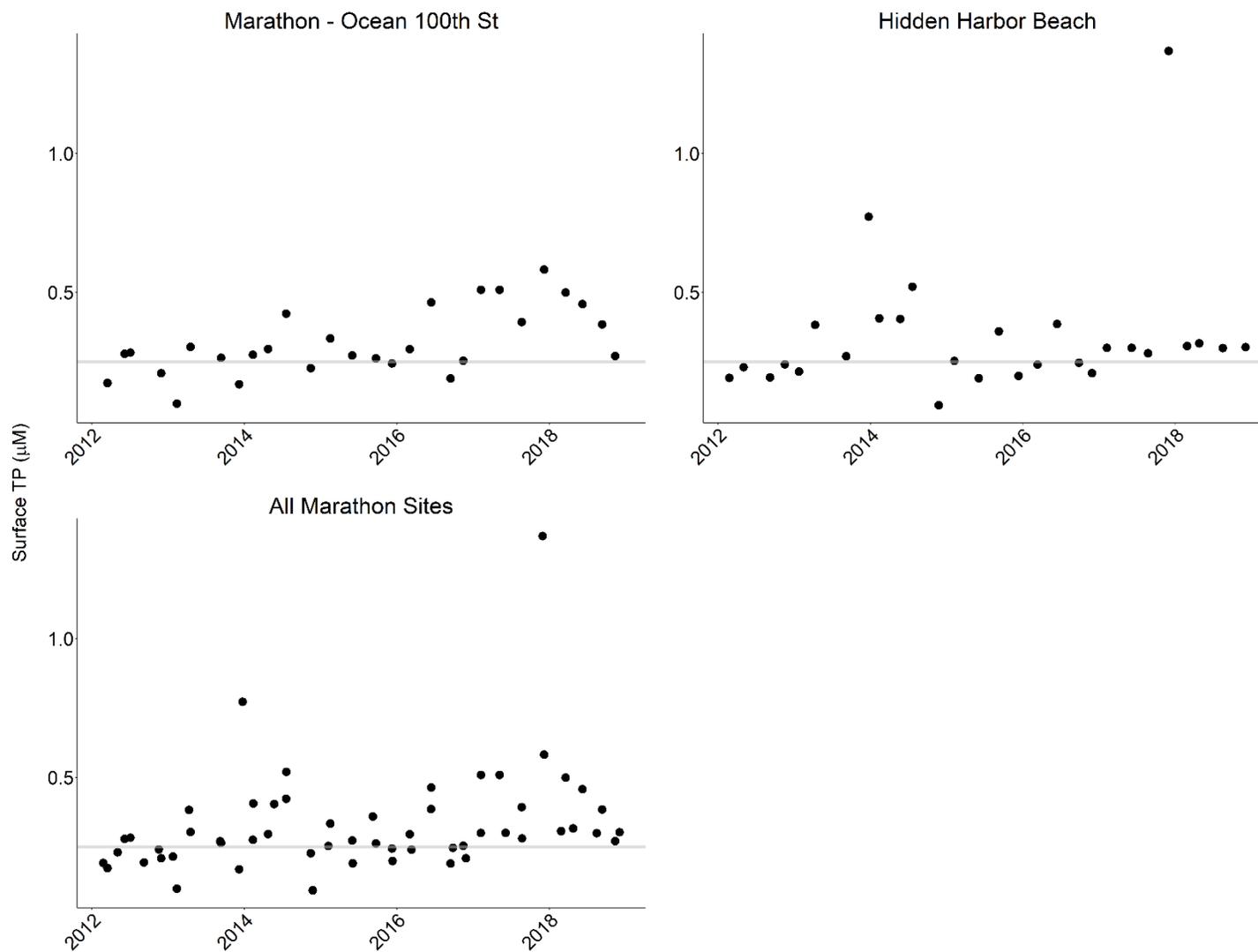
**Figure 3.** Linear regressions of a four-year moving window of DIN concentrations across both stations. Upward slopes indicate increasing concentrations of DIN, while downward slopes indicate decreasing concentrations of DIN. The horizontal gray line represents the EPA Strategic Target DIN concentration of 0.75 micromolar. Points above the horizontal gray line are non-compliant measurements. Gray shading around the regression lines are 95% confidence intervals.

## TP

Total phosphorus concentrations were reported 56 times across the two Marathon stations from 2012 through 2018. A protocol of four samples per year per station was set and achieved. Yearly TP non-compliance ranged from 25% in 2012 to 100% in 2017 and 2018 (**Table 3**). Concentrations across both Marathon stations were non-compliant with the EPA Strategic Target 67.9% of the timeseries, with Marathon – Ocean 100<sup>th</sup> St non-compliant 75% of the timeseries and Hidden Harbor Beach non-compliant 61% of the timeseries (**Figure 4**). A history of measurements taken and of yearly percent non-compliance for each station is given in **Table 4**. Trends for TP concentration values can be assessed using a 4-year moving window and constructing a simple linear regression (**Figure 5**). The trend lines inclusive of 2016-2018 show an increase in TP concentration over time, while 2012-2015 are static in TP concentration. The time period 2014-2017 shows the strongest increase in TP concentration, while 2013-2016 shows the only decrease in TP concentration. All trend lines show consistent non-compliance.

**Table 3.** Yearly TP EPA Strategic Target (TP  $\geq$  0.25 micromolar) compliance/non-compliance summary for the two Marathon stations over the timeseries 2012-2018.

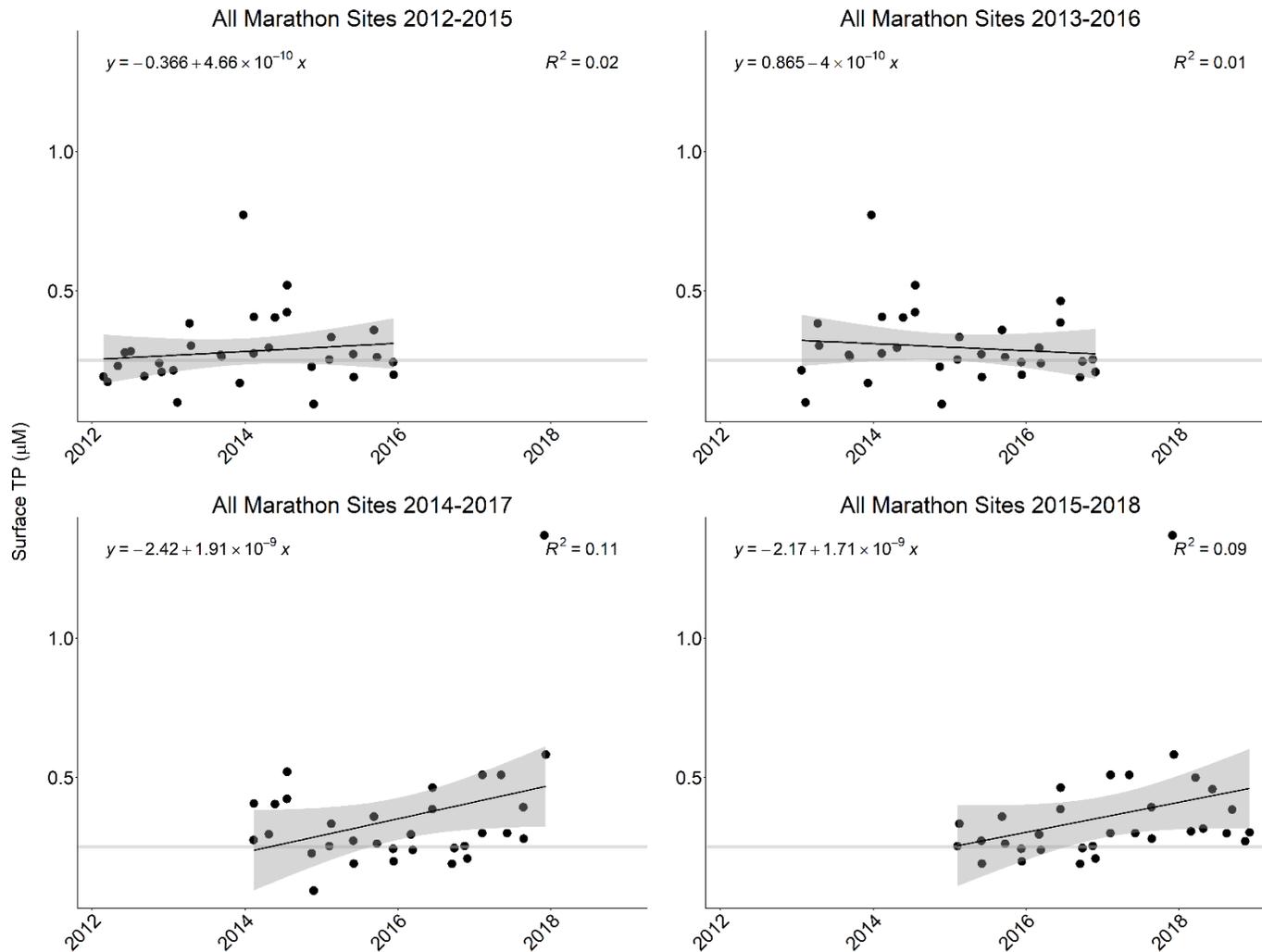
Year	Number of Measurements	Non-Compliant	Compliant	Non-Compliant Percent
2012	8	2	6	25.0%
2013	8	5	3	62.5%
2014	8	6	2	75.0%
2015	8	5	3	62.5%
2016	8	4	4	50.0%
2017	8	8	0	100.0%
2018	8	8	0	100.0%
2012-2018	56	38	18	67.9%



**Figure 4.** Surface TP concentrations by station and in aggregate for the timeseries 2012-2018. Horizontal gray line represents the EPA Strategic Target value of 0.25 micromolar. Points above the horizontal gray line are non-compliant measurements.

**Table 4.** Yearly TP EPA Strategic Target (TP  $\geq$  0.25 micromolar) percent non-compliance for both Marathon monitoring stations for the timeseries 2012-2018.

Station	Percent Non-Compliance						
	2012	2013	2014	2015	2016	2017	2018
Marathon – Ocean 100 <sup>th</sup> St	50	50	75	75	75	100	100
Hidden Harbor Beach	0	75	75	50	25	100	100



**Figure 5.** Linear regressions of a four-year moving window of TP concentrations across both stations. Upward slopes indicate increasing concentrations of TP, while downward slopes indicate decreasing concentrations of TP. The horizontal gray line represents the EPA Strategic Target TP concentration of 0.25 micromolar. Points above the horizontal gray line are non-compliant measurements. Gray shading around the regression lines are 95% confidence intervals.

## References

\*\* Data were provided by the SERC-FIU Water Quality Monitoring Network which is supported by EPA Agreement #X7 00D02412-1 and NOAA Agreement #NA09NOS4260253\*\*

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