# Ocean Research & Conservation Association

## Pollution Mapping Citizen Science Project Findings to Date Report

**May 2025**

# ORCA's Pollution Mapping Citizen Science Project Findings to Date Report

**The goal of the Pollution Mapping Citizen Science (PMCS) Project is to identify pollution sinks and hotspots by evaluating the accumulation of nutrients and toxins in both sediment and water throughout the Indian River Lagoon (IRL).** Since its inception in February 2020 with three sites in Indian River County, the project has expanded to 23 sites spanning four counties—Brevard, Indian River, St. Lucie, and Martin—as of May 2025.

**Ocean Research & Conservation Association (ORCA)** scientists provide rigorous training to citizen scientist volunteers in standardized field and laboratory protocols essential to the project's success. Volunteers conduct quarterly sampling in February, May, August, and November. Fieldwork includes in situ water quality measurements, as well as collection of water column and sediment samples. In the laboratory, ORCA supervises volunteers as they process and analyze samples, including water column and pore water nutrient concentrations, sediment compositing, particle characterization, and more.

A subset of samples is archived for in-house analyses, such as DNA extractions, glyphosate, microcystin, relative toxicity, and caffeine. Annual heavy metal analyses are outsourced to a certified contract laboratory and performed on samples collected in November. ORCA also collaborates with external partners, including Clemson University and the University of Florida, to analyze samples for acetaminophen, sucralose, and per- and polyfluoroalkyl substances (PFAS, or "forever chemicals").

Currently, approximately 110 trained citizen scientists contribute to field sampling and/or laboratory analysis.

This biannual report is intended to inform citizen scientist volunteers and the broader community about the ongoing findings from the PMCS Project. The present report focuses on a subset of analytes, including heavy metals, water column nutrients, glyphosate, sucralose, acetaminophen, and PFAS.

## Heavy Metals

Some trace amounts of heavy metals are essential for biological processes and are naturally available in the environment; however, high concentrations or accumulation of those same heavy metals become toxic to humans and other organisms. Rocks and sediments naturally contain some of these heavy metals, but human activities contribute to heavy metal pollution in the environment.

On an annual basis, ORCA's PMCS project collects sediments for analysis of heavy metals (lead, mercury, and copper) by a contract laboratory. The Environmental Protection Agency (EPA) has established sediment quality benchmarks for individual heavy metals that ORCA tests to evaluate the severity of heavy metal pollution in the IRL (MacDonald, 1994). The Threshold Effect Level (TEL) is the lower benchmark, representing the concentration below which adverse biological effects are unlikely and occur rarely. The Probable Effect Level (PEL) is the upper benchmark, representing the concentration above which adverse biological effects are expected to occur frequently. Each of these heavy metals are compared between years to determine if concentrations of heavy metals are changing at the same site over time. An increase in heavy metals over time could indicate new or consistent inputs of metals, contributing to pollution in that area. A decrease in heavy metals over time could indicate dredging or movement of sediments to a new location, possibly via a large storm event.

Human sources of **lead** include lead-based paint, industrial emissions, mining processes, and deterioration of older plumbing systems (Wani *et al.*, 2015). Lead can affect many human bodily systems, especially the nervous system, in addition to affecting the physiological and biochemical functioning of aquatic organisms (Assi *et al.*, 2016). In November 2024, only one site (Shepard Park I in Martin County) exceeded the TEL (30.2 mg/kg) and no sites exceeded the PEL (112 mg/kg; Figure 1). One site that was above the TEL in November 2023, now falls below it, indicating a slight improvement in sediment quality at De La Bahia in Martin County. Lead concentrations in sediment were also compared between years (Figure 2). Data were excluded for sites that were not measured during both years of the paired statistical testing. We considered results statistically significant at $p < 0.05$. We found no significant difference between years using paired samples t-tests ($p > 0.05$), suggesting that lead levels in sediment are not changing over time on a large scale in the IRL.

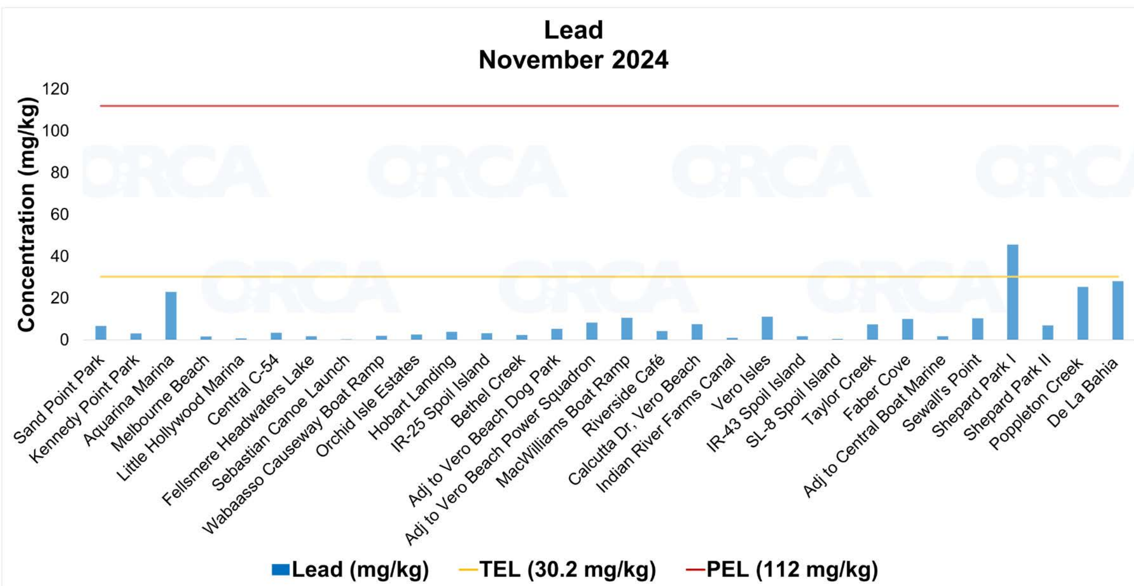


*Figure 1: Lead concentration (mg/kg) in sediment for November 2024 across 30 sites. Sites are listed north to south.*

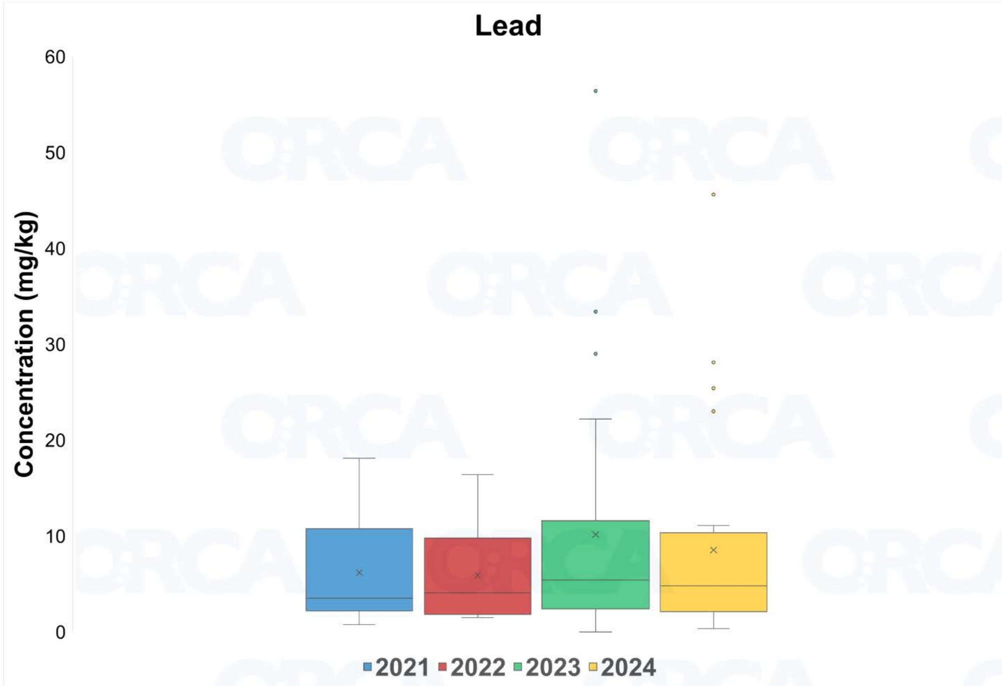


*Figure 2: Lead concentration (mg/kg) in sediment samples distribution by year. The line in the box indicates the median of data that year and the x indicates the mean of data that year.*

Some anthropogenic inputs of **copper** can occur from antifouling paints used on boats, chromated copper arsenate treated timbers docks and dock pilings, and pesticides and herbicides (Environmental Protection Agency, 2024). Copper can be toxic to fish and many aquatic invertebrates, especially larval stages, affecting survival, growth, reproduction, and metabolism (Brix *et al.*, 2022; Qiu *et al.*, 2005). Eight sites exceeded the TEL (18.7 mg/kg) for copper and three of those additionally exceeded the PEL (108 mg/kg; Figure 3). Sediment copper concentrations were compared between years using paired samples t-tests, but no significant differences were found between years ($p > 0.05$) using only sites that had measured copper in all years being compared (Figure 4). Our results suggest no ongoing or new inputs of copper into the IRL at these sites.

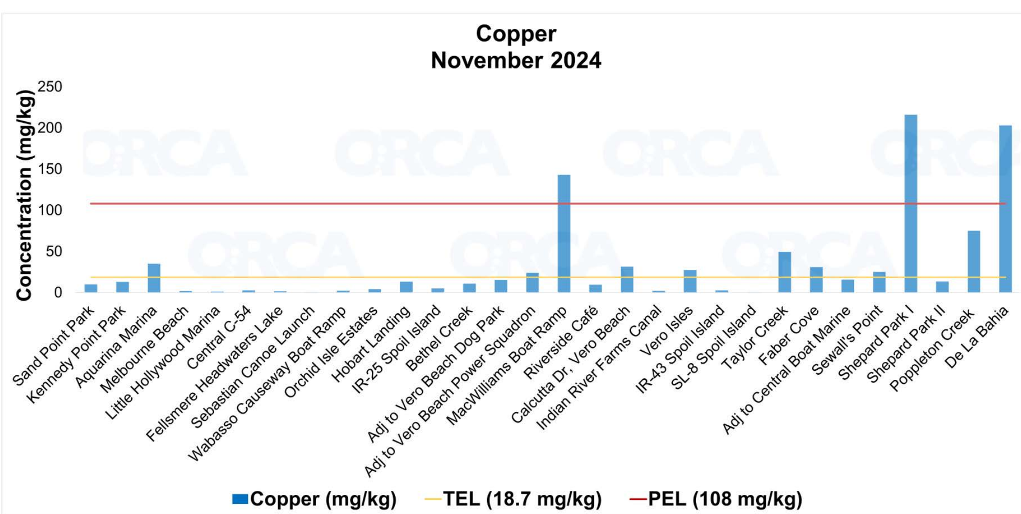


*Figure 3: Copper concentration (mg/kg) in sediment for November 2024. Sites are listed north to south.*

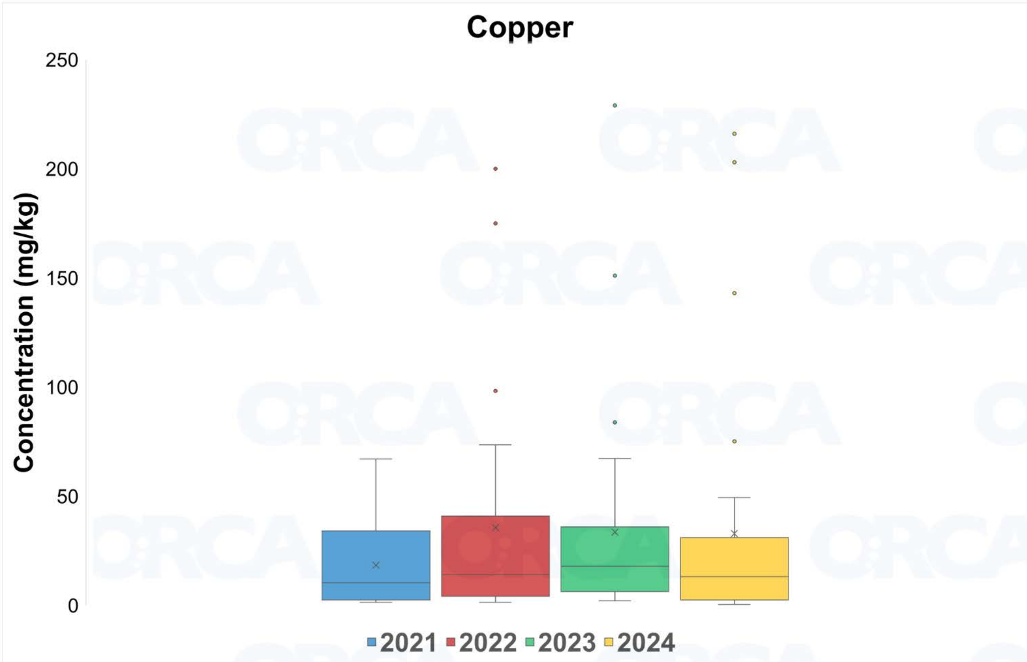


*Figure 4: Copper concentration (mg/kg) in sediment samples distribution by year. The line in the box indicates the median of data that year and the x indicates the mean of data that year.*

Mercury can be released into the environment through mining, atmospheric deposition from burning fossil fuels, and disposal of products containing mercury (Wuana & Okieimen, 2011). At high concentrations, mercury is a potent neurotoxin for fish, wildlife, and humans (Boening, 2000; Rice *et al.*, 2014). In November 2024, three sites in Martin County exceeded the TEL (0.13 mg/kg) for mercury, while no sites exceeded the PEL (0.7 mg/kg; Figure 5). Mercury was compared between years for sites that had sampled mercury for both comparison years using paired samples t-tests (Figure 6). Mercury sediment concentrations increased significantly between 2021 and 2022 ($p < 0.001$), had no significant change between 2022 and 2023 ($p > 0.05$), and then decreased significantly between 2023 and 2024 ($p = 0.002$). While this test indicates changes in sediment mercury concentration across multiple PMCS sites between years, the actual magnitude of change is relatively small. These data emphasize the importance of monitoring sites longitudinally, like in PMCS, to determine if pollutants are consistent over time, revert back to a baseline, or show long-term trends in change.

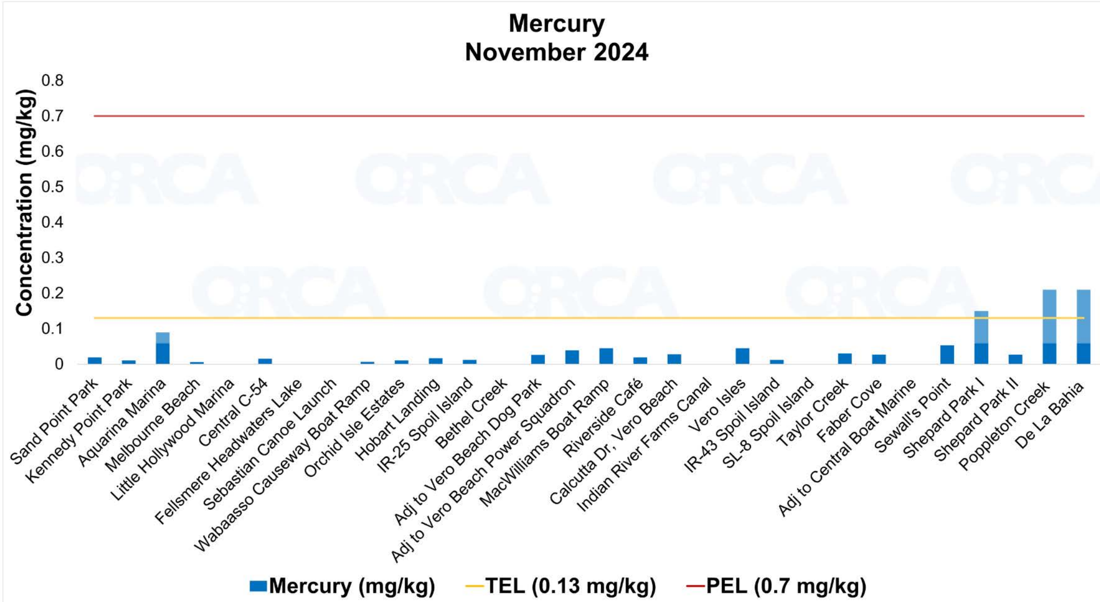


*Figure 5: Mercury concentration (mg/kg) in sediment for November 2024. Sites are shown from north to south.*

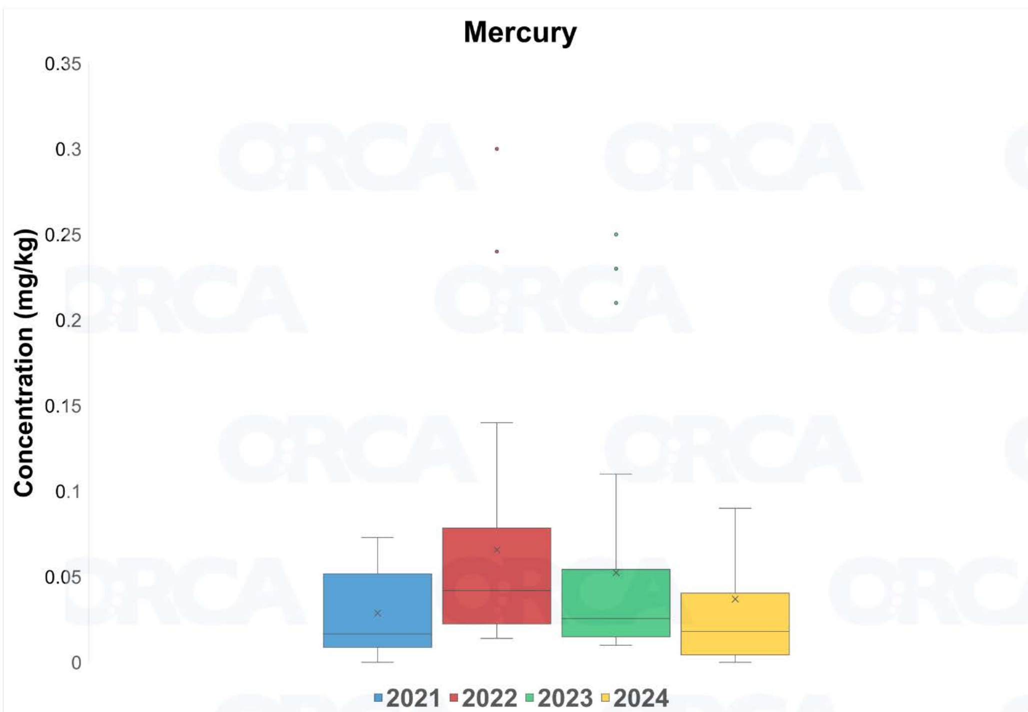


*Figure 6: Mercury concentration (mg/kg) in sediment sample distribution by year. The line in the box indicates the median of data that year and the x indicates the mean of data that year.*

## Water Column Nutrients

While nutrients, such as nitrogen and phosphorus, occur naturally in the environment and are essential for the growth of aquatic plants. In excess, however, they can cause numerous ecological and public health concerns.

For each PMCS cycle (February, May, August, and November), water column samples are collected for analysis of nutrients (nitrate/nitrite, ammonia, and phosphate) and analyzed by trained citizen scientists. There are numerous sources of nutrients in the IRL including, but not limited to, groundwater seepage, atmospheric deposition, effluent from wastewater treatment plants, biosludge spread on agricultural land, internal cycling from suspended sediments, irrigation, fertilizers, precipitation, and agricultural and urban runoff (Sigua & Tweedale, 2003; Martin *et al.*, 2002; Morris, 1991; Buell & Peters, 1988; Reddy *et al.*, 2001; Chand *et al.* 2011). The concentrations of **nitrate/nitrite, ammonia, and phosphate** in the water column are compared by site, cycle, and between years to determine if nutrient loads are changing at the same site over time.

**Nitrate/nitrite ($NO_3$/$NO_2$)** is readily used by algae and bacteria in water bodies, but when nitrate is reduced to nitrite it can be toxic to fish and cause serious human health concerns (Hand, 2004; Chand *et al.*, 2011). PMCS concentrations for nitrate/nitrite ranged from 0 to 0.09 mg/L in February 2025.

**Ammonia ($NH_3$)** input into water bodies can occur from sewage, fertilizers, industrial waste, and pet waste, all of which may cause accelerated eutrophication and harmful algal blooms (Eddy, 2005; Castro *et al.*, 2003). Fish, especially at larval and juvenile stages, are more likely to suffer from increased ammonia exposure and suffer impaired behavior and activity levels (Eddy, 2005). Ammonia concentrations at PMCS sites ranged from 0 to 0.20 mg/L in February 2025. Sand Point Park in Brevard County recorded the highest ammonia concentration (0.20 mg/L) among all sites sampled by ORCA across the Indian River Lagoon during that month.

**Phosphate** (**$PO_4$**) can be released into the environment via effluent from wastewater treatment plants, groundwater seepage, agricultural runoff, and through sediment and water column exchange (Sigua & Tweedale, 2003; Badamasi *et al.*, 2019). Too much phosphate can lead to excessive algal growth, which in turn depletes oxygen levels in the water, causing massive die-offs of fish and other aquatic organisms., as well as downstream effects to human health from toxins released by harmful algae blooms (Badamasi *et al.,* 2019). Phosphate concentrations ranged from 0 to 1.15 mg/L in February 2025 across all sites. The three sites with the highest phosphate concentrations were De La Bahia (Martin County; 1.15 mg/L), Poppleton Creek (Martin County; 0.68 mg/L), and Sebastian Canoe Launch (Indian River County; 0.47 mg/L; Figure 7). Increases in nutrient loads over time at these sites may indicate stored nutrients in sediment leaching into the water or ongoing/new anthropogenic inputs from local sources, such as failing septic systems or increased urbanization.Even low concentrations of phosphate, seen at sites like Central C-54 in Indian River County (0.05 mg/L), can have significant impacts on water quality (Hand, 2004).

ORCA compares water column phosphate concentrations at all PMCS sites to nutrient benchmarks established by the Florida Department of Environmental Protection (FDEP) (Hand, 2004). FDEP developed the 50th and 90th percentile benchmarks for phosphate using estuarine samples collected across the state of Florida. The 50th percentile (0.02 mg/L) represents the concentration at which 50% of samples fall at or below that value, generally indicating sites with lower nutrient influx. The 90th percentile (0.21 mg/L) represents the concentration below which 90% of samples fall; sites exceeding this threshold may warrant further investigation to determine if they pose a level of concern that requires mitigation. All 27 PMCS sites fall on or above the 50th percentile while 12 sites fall above the 90th percentile (Figure 8). All of our sites in Martin County exceed both percentiles, indicating accelerated eutrophication at these sites. Because nutrient percentiles or benchmarks specific to the Indian River Lagoon are not currently available, ORCA uses the Florida-wide benchmarks developed by the Florida Department of Environmental Protection. PMCS data suggest that nutrient concentrations in the IRL may be higher than those observed statewide. ORCA is actively working to establish reference values for each nutrient specific to the IRL based on our ongoing sampling efforts.

Phosphate concentrations across PMCS sampling cycles were analyzed using pairwise t-tests with Bonferroni correction to assess temporal differences. A recurring seasonal pattern was observed, characterized by increasing phosphate concentrations from February to August, with peak values consistently recorded in August for the years 2022, 2023, and 2024 (Figure 9). The increases between February and August were statistically significant in 2023 ($p = 0.03$) and 2024 ($p = 0.02$), potentially reflecting elevated precipitation or temperature during these periods. Following the August peak, phosphate concentrations declined through February across all three years. This reduction may be attributable to decreased surface runoff, lower ambient temperatures, or enhanced biological uptake by primary producers such as phytoplankton.

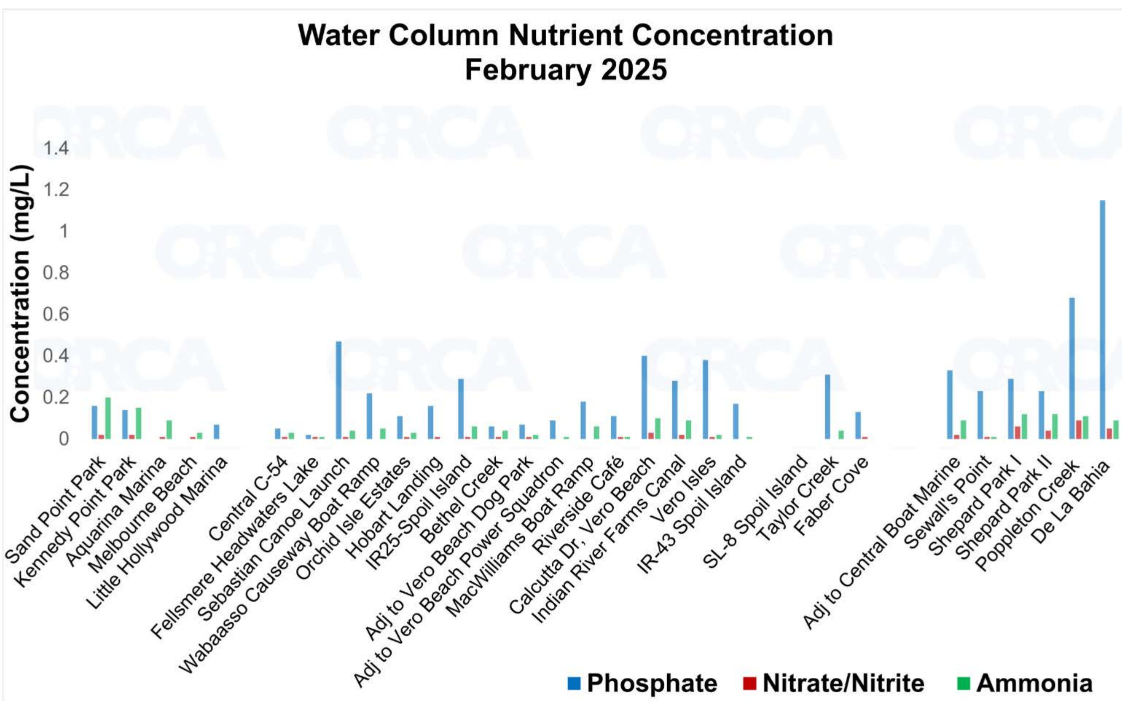


*Figure 7: Nutrient concentration (mg/L) in water column samples across all PMCS sites in February 2025. Sites are arranged from north to south (left to right) on the x-axis and are clustered by county (Brevard, Indian River, St Lucie, Martin)..*

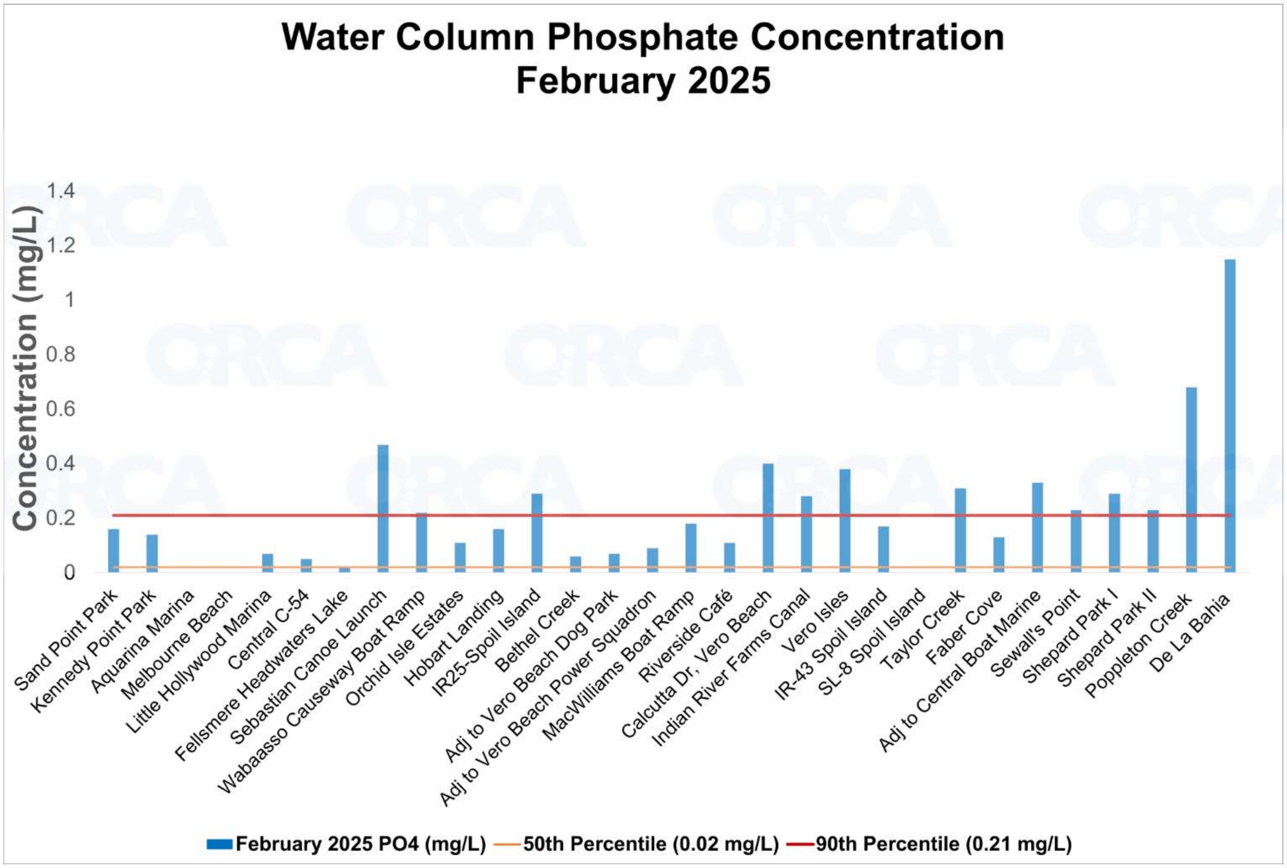


*Figure 8: Phosphate concentration (mg/L) in water column samples, per site, for February 2025.*

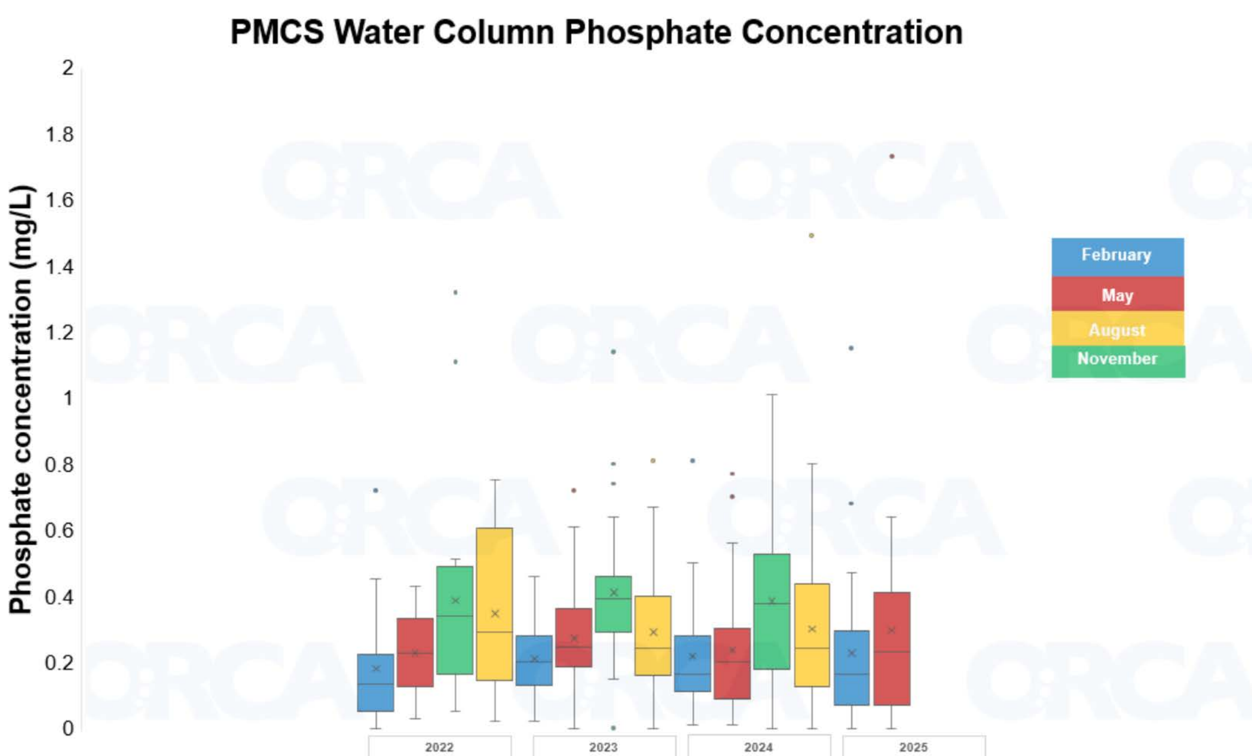


*Figure 9: Phosphate concentration (mg/L) in water column samples across multiple years and Pollution Mapping Citizen Science cycles (February 2022- February 2025).*

## Glyphosate

Each cycle, ORCA analyzes water column samples for **glyphosate**, a contaminant of emerging concern. Glyphosate is one of the most commonly used herbicides worldwide, especially in agricultural settings (Annett *et al.*, 2014). There is quite a bit of controversy and debate on the consequences or lack thereof of glyphosate on human and environmental health. While the Environmental Protection Agency (EPA) ruled that glyphosate is not toxic to the nervous or immune systems of aquatic biota or mammals (Environmental Protection Agency, 2020), the International Agency for Research on Cancer (IARC) classified glyphosate as probably carcinogenic to humans (International Agency for Research on Cancer, 2015). Glyphosate has been reported to have negative biological effects including neurotoxicity, oxidative stress, and impaired physiological functioning on some aquatic species in high concentrations (Huang *et al.*, 2024). Glyphosate can bind to soil and may persist for several days, months or even buildup long-term, depending on site-specific factors (Szekacs and Darvas, 2012; Myers *et al.*, 2016). ORCA's data suggests that glyphosate and its constituents are persistent in the IRL, with detectable concentrations being found in the water column, sediment, and fish fillets. The PMCS glyphosate dataset is unique to the IRL and provides valuable longitudinal data to advance understanding of glyphosate's presence, concentrations, and potential seasonal variations across the IRL.

The PMCS project has been monitoring and comparing glyphosate water column concentrations between years since November 2021. To determine if input loads into the IRL are significantly changing over time, we use a paired Wilcoxon signed-rank test with Bonferroni correction (Figure 10). There was a large spike in glyphosate concentration in 2022, where it significantly increased from February to May ($p < 0.01$), peaked in May, and significantly decreased from May to August ($p = 0.007$). As this was ORCA's first year sampling glyphosate, it was not yet clear if 2022 was an anomaly or if this significant increase would occur annually. In 2023, there was not an obvious spike in glyphosate concentrations, but the increase from February to May was still significant ($p = 0.013$)- peaking in August for most sites, followed by a significant decrease from August to November ($p < 0.01$). Most sites in 2023 peaked in August. In 2024, the significant increase in glyphosate did not occur until May into August ($p = 0.017$) and a significant decrease still happened from August to November ($p < 0.01$). ORCA hypothesizes that the spike in glyphosate concentrations starting in February 2022 and 2023 may be from people applying glyphosate prior to the wet season as a preventative measure for weed growth. In comparison to 2022 and 2023, the application of glyphosate across the IRL in 2024 could have varied or been delayed. There are several other theories that might explain the shifts over the years. Changes in precipitation, warmer temperatures affecting its breakdown, and differences in usage and application may cause varying levels of glyphosate to enter the lagoon at different times of the year. In the near future, we will be looking at comparing glyphosate concentrations with precipitation trends each cycle.

Testing for nutrient and pollutant concentrations in the water column only represents the short-term trends of water quality (Murray *et al.*, 2006). ORCA also tests for glyphosate concentrations in sediment pore water (or the water that is embedded within sediment). Pore water serves as a proxy for nutrient and pollutant concentrations in the sediment and for some benthic organisms it can be an exposure route to these contaminants of concern (Chapman *et al.*, 2002). There were no statistically significant differences in pore water glyphosate concentrations over time (Paired Wilcoxon signed-rank test with Bonferroni correction; $p > 0.05$) and there was no distinct pattern or trend across cycles. We expected that pore water glyphosate would have higher concentrations than the water column, given that sediment can act as a sink and have a higher affinity to bind to nutrients and pollutants (Murray *et al.*, 2006). Surprisingly, pore water concentrations were not consistently higher than in the water column which suggests that glyphosate is degrading over time in the sediment due to factors like temperature, sunlight, or microbial activity. But, as noted above, glyphosate persistence can be site-specific and the sites with higher pore water concentrations compared to the water column were those categorized as mainly silt.

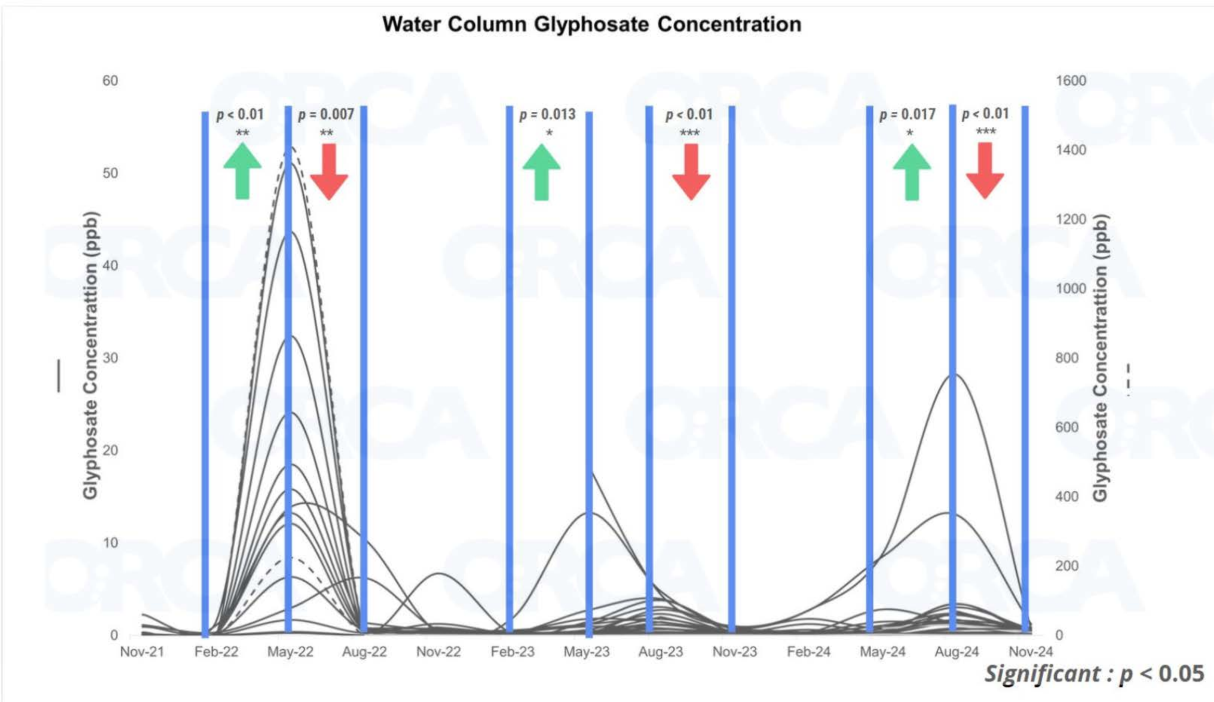


*Figure 10. Glyphosate concentration (ppb) in water column samples across multiple years and Pollution Mapping Citizen Science cycles (November 2021- November 2024).*

## Sucralose and Acetaminophen

ORCA examines several anthropogenic tracers in the environment that can indicate pollution from humans. Important characteristics of human tracers include prevalent use, linkage only to humans (not animals), and only partial metabolism (Currens *et al.*, 2019). The half-life or decay rate of tracers can give an idea of the timeframe of contamination and the presence of co-analytes or their ratio may be used to indicate sources of the contamination. ORCA and PMCS has measured **sucralose** and **acetaminophen** and is starting to examine caffeine. ORCA sends water column samples to a partner at Clemson University for analysis of sucralose and acetaminophen.

Sucralose is an artificial sweetener found in many products that is fairly resistant to wastewater treatment and has negative effects on microbial communities and some fish species in high concentrations (Sang *et al.*, 2014; Westmoreland *et al.*, 2024; Saucedo-Vence *et al.*, 2017). Wastewater treatment can reduce sucralose concentrations but sucralose is still fairly common in the environment after treatment, persistent, and can be added to the environment from sources that have already been treated, like reuse water.

Acetaminophen is a pharmaceutical that is present in over 600 drugs. It should be almost completely removed through effective, efficient wastewater treatment and is therefore found in the environment much less frequently and in lower concentrations than sucralose (Blough & Wu *et al.*, 2011). Acetaminophen in high environmental concentrations can impact fish development and reproduction.

ORCA sent samples from PMCS sites in Indian River County to be analyzed for both sucralose and acetaminophen from August 2022 through November 2023 and half of the samples from February 2024 (96 total). As expected, sucralose was detectable at the majority of sites (91.7%), but these concentrations (max: 1,696.2 ng/L) were much lower than those documented for wastewater treatment plant influent (mean: 40,000 - 48,000 ng/L) and maximum concentrations in the environment in other studies (max: 12,000 - 36,666 ng/L; Cantwell *et al.*, 2018; Currens *et al.*, 2019; Henderson *et al.*, 2020; Seal *et al.*, 2016). Acetaminophen was detected at fewer sites (18.8%). Mean acetaminophen concentrations in wastewater treatment plant influent in previous studies have an average of 78,000 - 122,000 ng/L. ORCA's maximum acetaminophen concentration (55.3 ng/L) falls above one literature source for the environment (11 ng/L), but below several other sources (~380 ng/L) and the mean was comparatively low (Currens *et al.*, 2019; Henderson *et al.*, 2020; Seal *et al.*, 2016; Silvanima *et al.*, 2018). It is important to note that PMCS water column concentrations are much lower than may be expected from a sewage leak.

A map below shows one of the ways that ORCA uses to visualize pollutants over a geographical area, illuminating patterns or pollutants moving downstream (Figure 11). The color scale goes from blue (lower concentration) to red (higher concentration) of acetaminophen or sucralose. Keep in mind that even though the red indicates higher concentrations in ORCA's dataset, these concentrations are still relatively low compared to the literature.

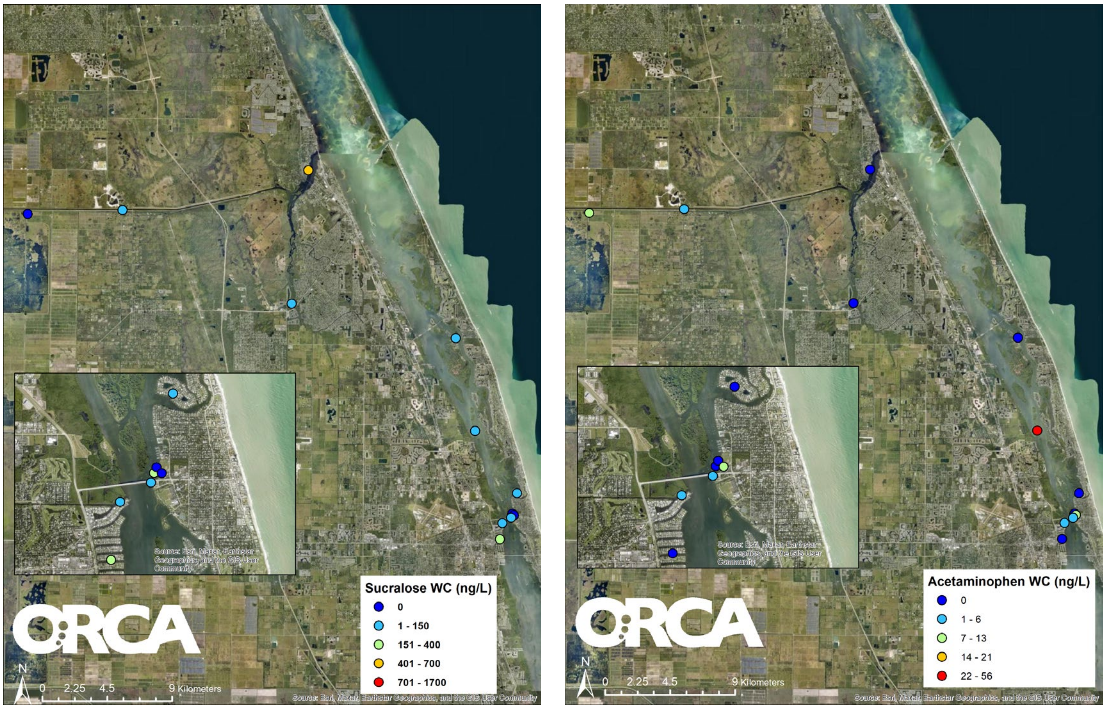


*Figure 11: Water column sucralose and acetaminophen concentrations (parts per trillion; ng/L) at PMCS sites in Indian River County in August 2022.*

There was no clear seasonal trend for sucralose or acetaminophen across sites (Figure 12). Sites with higher concentrations of sucralose include PM2 (Adj to Vero Beach Dog Park), PM8 (Indian River Farms Canal), PM9 (Riverside Café), PM14 (C-54 Canal), PM15 (Little Hollywood Marina), PM16 (Sebastian River Canoe Launch), and PM26 (Calcutta Dr).

The sites that had more than one detectable concentration of acetaminophen were PM1 (Adjacent to Power Squadron), PM8 (Indian River Farms Canal), PM13 (Fellesmere Headwaters), PM14 (C-54), and PM17 (IR-25 Spoil Island).

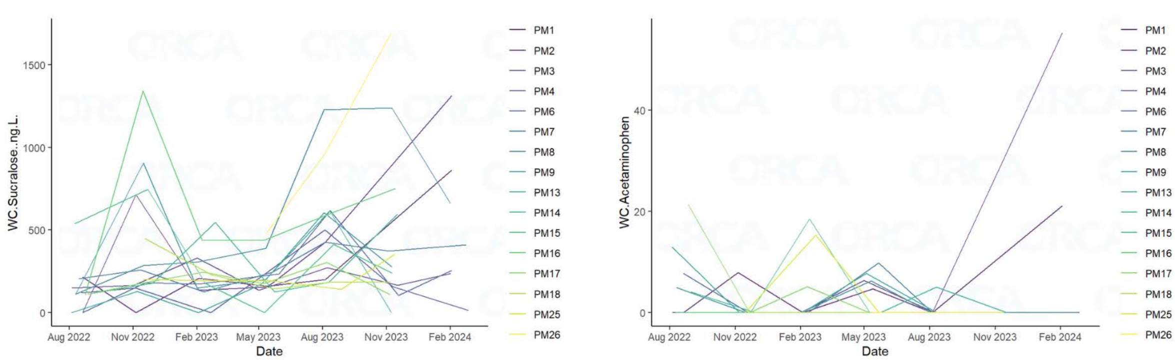


*Figure 12: Water column concentrations of sucralose and acetaminophen at Indian River County sites over time.*

The acetaminophen to sucralose ratio documented in wastewater influent was greater than or equal to 2.5 while the average ratio for acetaminophen to sucralose in effluent, when there was a detectable amount of acetaminophen, was only 0.009 (Henderson *et al.*, 2020). This ratio continues to decrease over time as acetaminophen degrades in the environment accelerated by high temperatures and increased microbial activity. There were only 15 samples in ORCA's dataset where acetaminophen and sucralose coexisted. The maximum ratio value was 0.19 and the mean was 0.05. All of these ratios fall between the values found in the literature. This suggests that water may not have been fully treated or may be from a source that would not get treated but is not very recent, such as dumping from boat tanks.

## PFAS (Forever Chemicals)

**Per- and poly-fluoroalkyl substances,** also known as **PFAS** and 'forever chemicals', are increasingly in the public eye. They are called 'forever chemicals' due to their persistence in the environment and resistance to degradation. PFAS are used in manufacturing processes, dry cleaning chemicals, nonstick coating for pans, firefighting foam, food packaging, and more (Fenton *et al.*, 2021). Regulating PFAS has been difficult since as some are banned or limited, new PFAS can be developed or adapted for the same purpose. There are over 9,000 compounds classified as PFAS which may have differing effects on human health, including cancer, kidney disease, reproductive effects, and liver disease (Pulster *et al.*, 2022). The EPA has now established legally enforceable levels for six PFAS and a Hazard Index for PFAS mixtures of four specific substances in drinking water (Environmental Protection Agency, 2025). FDEP has developed provisional (nonenforceable) screening levels for two prominent PFAS in surface water and cleanup target levels in sediment (Florida Department of Environmental Protection, 2022). While those PFAS being regulated are the most prominently used, there are many more that are unregulated. Additionally, the interactions and effects from mixtures of PFAS are largely unknown. There is currently no federal mandate for acceptable concentrations of PFAS in food. In the Indian River Lagoon, PFAS have been measured by ORCA in the water, sediment, and fish as well as by other organizations in water, sediment, manatees, and alligators (Palmer *et al.*, 2019; Bangma *et al.*, 2017; Griffin *et al.*, 2022).

In November 2022, ORCA sent water and sediment samples from all PMCS sites to a collaborator at University of Florida for analysis. The results from that testing can be found on our website or in our previous Findings to Date presentations and a subset of that data is presented here. After getting an initial baseline for PFAS at all sites, ORCA focused on fewer sites of interest to allow quarterly sampling instead of annual to examine possible seasonal shifts. Water and sediment samples for ten sites from November 2023 through November 2024 (50 samples) were collected and analyzed. Of the ten sites sampled from 2023 to 2024, three sites were added after the sampling in 2022 and therefore are not represented in the 2022 data.

Water and sediment samples represent different residency periods of PFAS. Water samples show a snapshot of what is currently occurring at a site. However, water is transient, constantly moving so it only shows the current conditions. Due to pollutants settling from the water and binding to sediment particles, concentrations in sediments represent a longer, indeterminant time period. This difference can help interpret if PFAS are from a recent input, legacy pollution, or a more continuous source.

Of ORCA's 50 water column samples, all of them had detectable concentrations of PFAS, ranging from 2.66 to 83.72 ppt (parts per trillion) with an average of 28.90 ppt. Another study sampling surface water across Florida for PFAS measured a mean sum PFAS of 29 ppt with a maximum of 3048 ppt (Camacho *et* *al.*, 2024). ORCA's average sum of PFAS compounds in water is comparable, although our maximum concentration is much lower. 29 of our 50 samples fell above the EPA Maximum Contaminant Level for PFOA in drinking water (4 ppt) and 45 samples fell above the EPA Maximum Contaminant Level for PFOS in drinking water (4 ppt; Environmental Protection Agency, 2025). All of ORCA's samples fell well below FDEP's provisional surface water screening levels (Florida Department of Environmental Protection, 2022).

Of ORCA's 50 sediment samples, three had nondetectable levels of PFAS (all at Sebastian Canoe Launch) while an additional nine samples had PFAS detected at concentrations too low to reliably quantify. The samples where PFAS were quantifiable ranged from 84.01 to 3283.73 ppt with a mean of 1321.29 ppt. A study in Tampa Bay observed PFAS concentrations ranging from 36.8 to 2990 ppt with all of their samples having detectable concentrations (Pulster *et al.*, 2022). The ranges of PFAS concentrations detected within PMCS water column and sediment data are comparable with other measurements throughout Florida. When PFAS concentration of sediment samples were high enough to be quantified, sediment samples had much higher concentrations of PFAS than in the water column sampled at the same site and cycle.

PFOS, a specific, ubiquitous PFAS compound, was detected in most samples and composed a large portion of the total PFAS concentration for each sample. In sediment, when PFAS was quantifiable, PFOS on average accounted for almost 76% of total PFAS per sample. In the water column, PFOS on average accounted for almost 47% of total PFAS in each sample.

For the following statistical analyses, substitutions were made for samples where specific PFAS were not detected or below the level of quantification before calculating the sum of PFAS. For more detail on how this was done, reach out to Team ORCA.

Water column and sediment PFAS were compared across years using a repeated measures ANOVA, utilizing the November sampling cycle for each year (Figure 13). While ten sites were analyzed for both 2023 and 2024, only seven of those sites had been sampled in 2022. For both matrices, there was no significant change in PFAS across years ($p > 0.05$). This suggests that PFAS inputs are balanced with movement of the water and sediment containing PFAS out of the area or uptake of PFAS from water and sediment into other organisms.

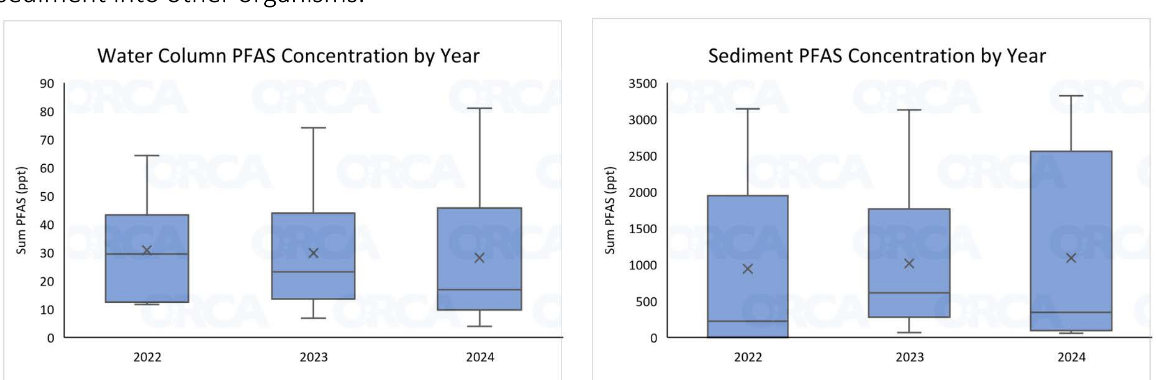


*Figure 13: PFAS concentrations for water column and sediment samples by year (2022-2024).*

Water column and sediment PFAS were compared over time across five cycles to determine if there were seasonal patterns in PFAS concentration, which would indicate seasonal increases in introduction of PFAS or in the cycling and uptake of PFAS within the environment (Figure 14). Very little exploration has been done on seasonal patterns of PFAS to this point. While there was some variation in the range of PFAS concentration over time, a repeated measures ANOVA indicated no significant differences ($p > 0.05$) in seasonal PFAS concentration for either water or sediment samples.

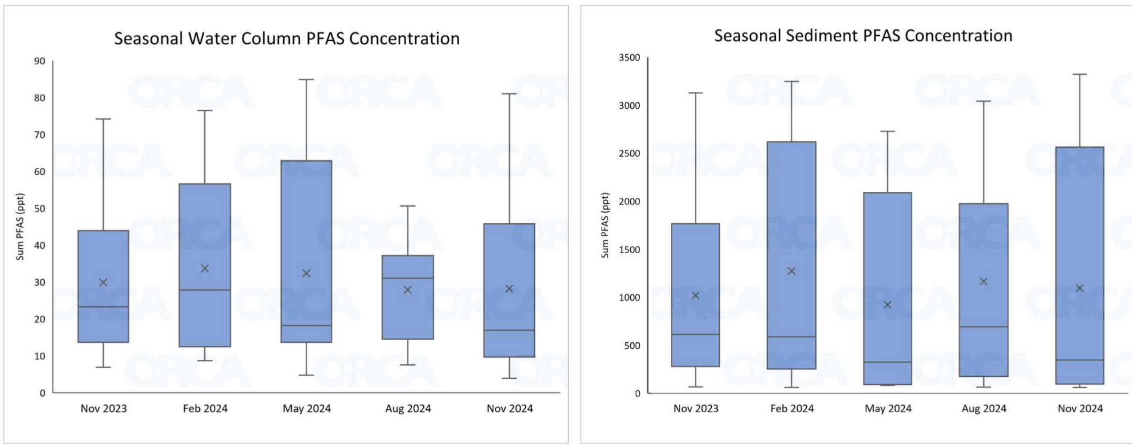


*Figure 14: Seasonal PFAS concentrations for water column and sediment samples (November 2023 - November 2024) .*

Similar to previous research, PFAS concentrations in sediment are positively correlated with the percent of silt in sediment, pore water phosphate, and heavy metals (iron, copper, mercury, and lead). Specific PMCS sites that were highest in sediment PFAS tended to be the more silty or mucky sites, which is supported by the correlations in our data. PFAS in water was not associated with nutrients, metals in sediment, or sediment composition. Sites that were higher in water column PFAS were not always high in sediment PFAS. This mismatch between the water and sediment concentrations happened particularly for sites that have coarser (sandy) sediments, fast-moving water, and possible upstream inputs of PFAS.

ORCA's PFAS analysis supports previous PFAS research in addition to expanding on this cutting-edge subject. The longitudinal and seasonal sampling of ORCA's PMCS Project have provided novel data on PFAS, particularly within the IRL, an extremely important ecosystem.

## Moving Forward

ORCA is constantly evaluating our research programs to make sure that they are running efficiently, adding analyses of contaminants of emerging concern, and discontinuing analyses that did not provide sufficient information or where enough data was collected for the outlined goals. After a recent thorough project evaluation for PMCS, taking into account collected data, proximity to other sites, and regular, sustainable funding for each site, we made the decision to cut several sites moving forward. The cost of monitoring each site has increased with increases in costs of supplies, analysis kits, and contract laboratory fees. ORCA is continuously seeking funding sources for this project and will continue to expand the sites and analyses as we are able to support more.

As part of streamlining the PMCS project and based on the results presented above, ORCA is pausing analysis for pore water glyphosate, sucralose, acetaminophen,and PFAS. ORCA is looking forward to sharing data on microcystin, the biotoxin produced by harmful cyanobacteria algal blooms, and caffeine, an anthropogenic indicator at our next findings to date report. We are also utilizing data from other ORCA projects and from other sources to make new and exciting comparisons with our data. Our focus is to be constantly evolving to learn more about the Indian River Lagoon, its health, and the species it sustains.

We would like to thank our funders for PMCS that make it possible to create this unique longitudinal and comprehensive dataset. Additionally, ORCA wants to thank the many volunteers who donate their time in the field and in the laboratory to collect and process so many samples. It would not be possible without their hard work and dedication. We appreciate all of you and your contributions to helping the Indian River Lagoon.

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**Pictures of ORCA Citizen Scientists in Action**


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Pollution Mapping Citizen Science Project Findings to Date Report

**May 2025**

*Appendix: Pollution Mapping Citizen Science Sites*

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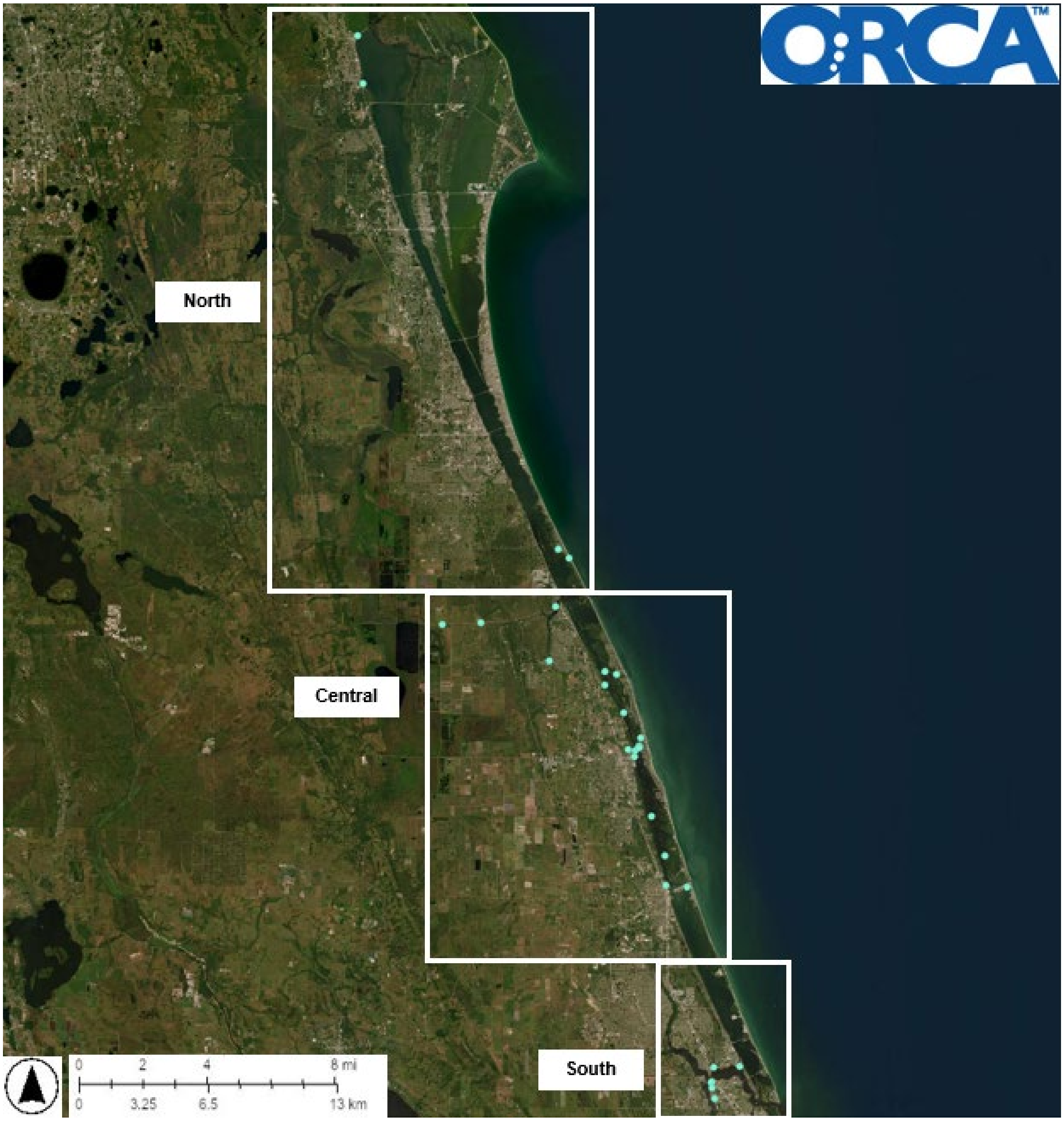
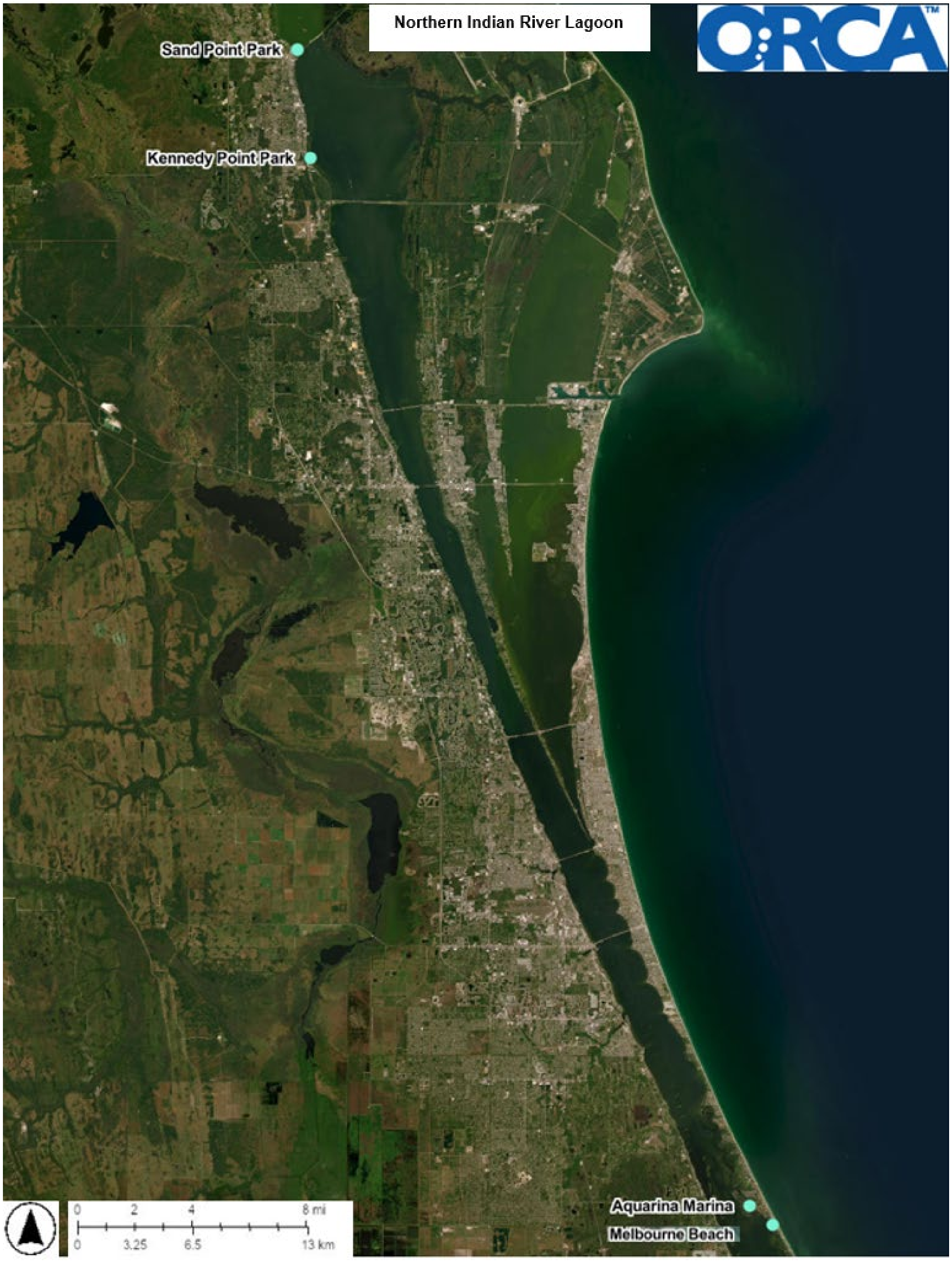
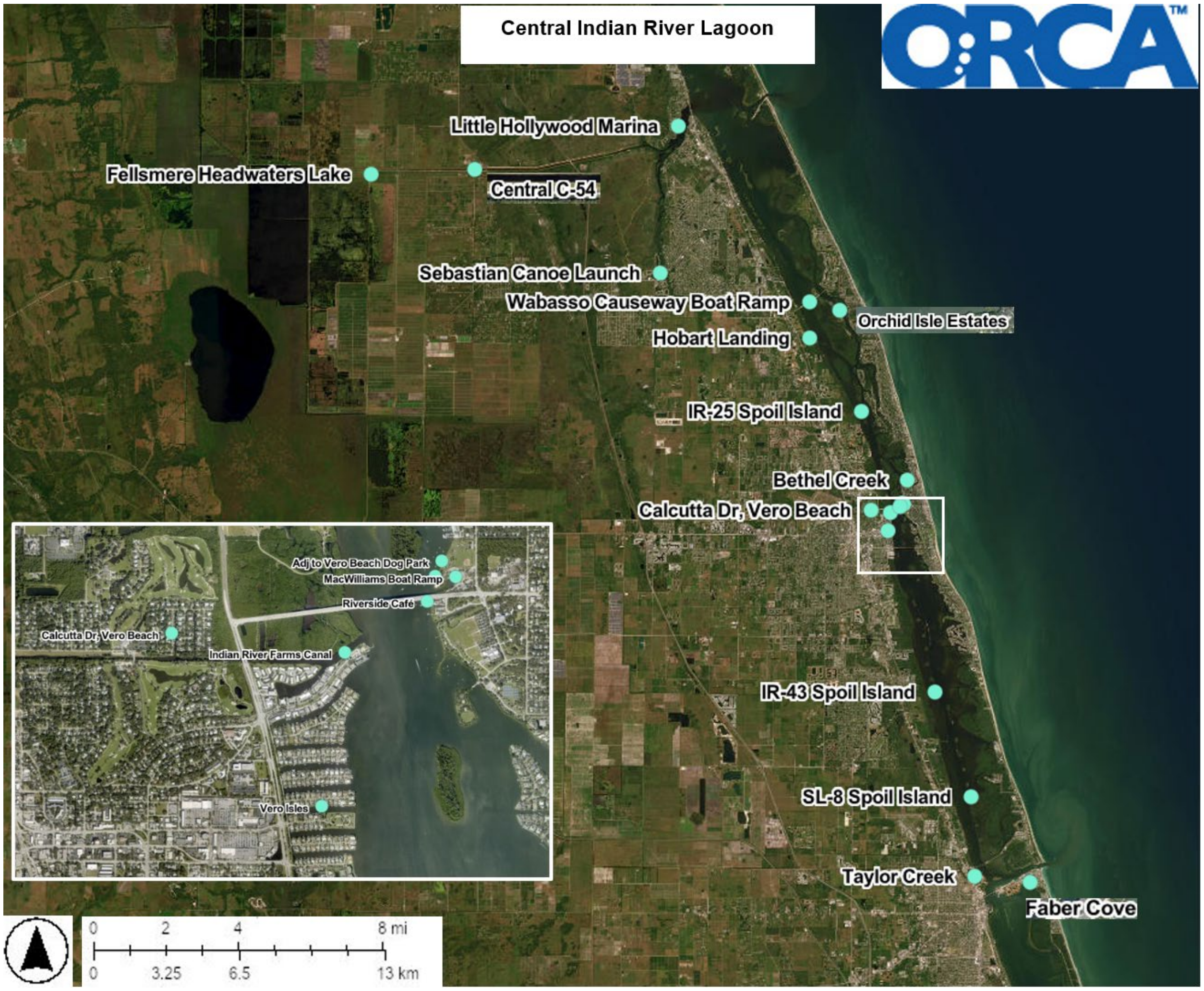


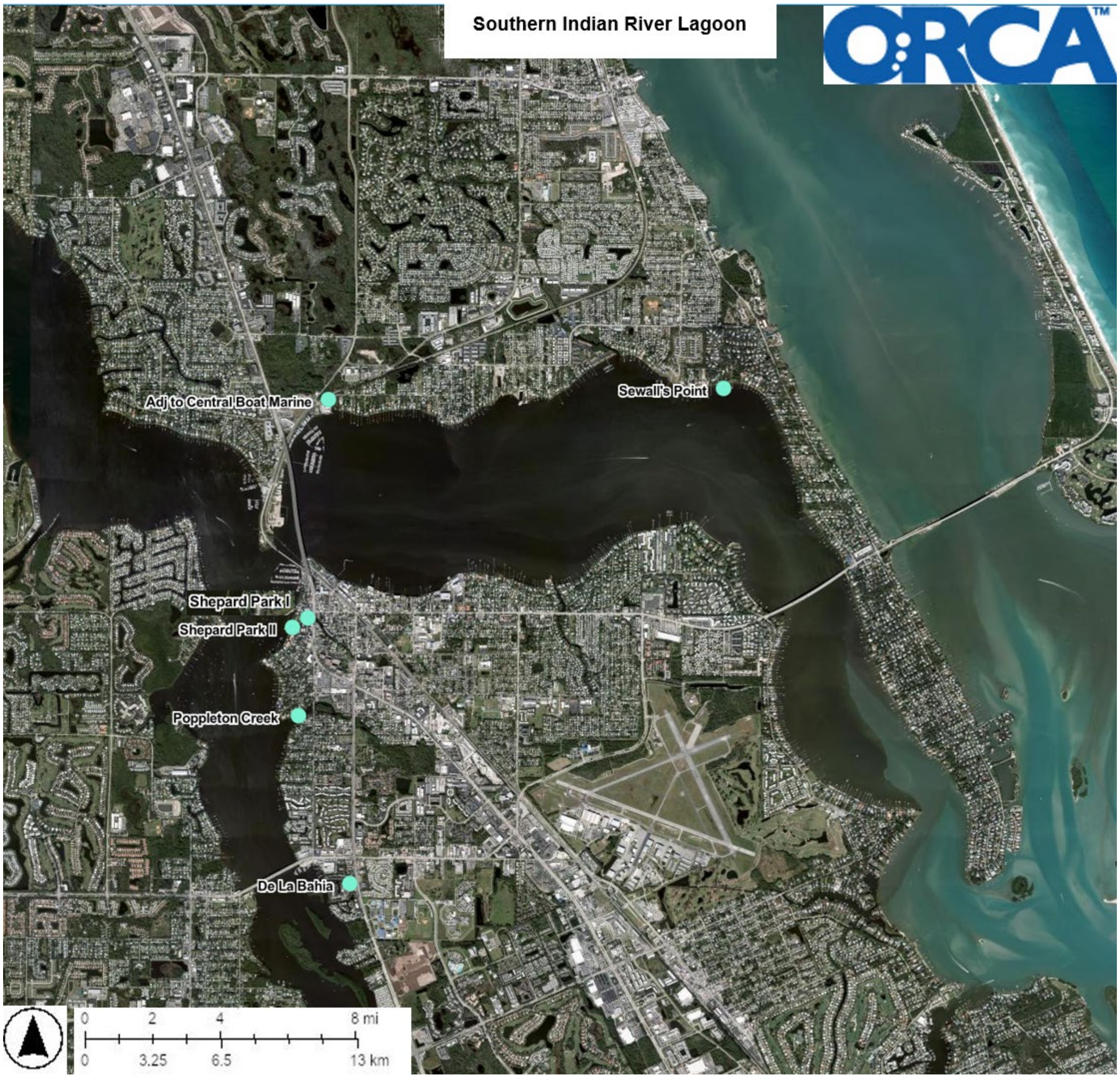

**Appendix Figure 1.** All ORCA Pollution Mapping Citizen Science sites located across the Indian River Lagoon and spanning four counties (Brevard, Indian River, St. Lucie, and Martin).




**Appendix Figure 2.** All ORCA Pollution Mapping Citizen Science sites located in the Northern Indian River Lagoon, which starts at the Ponce de Leon Inlet (Volusia County) and ends at the Sebastian Inlet (Southern Brevard County).




**Appendix Figure 3.** All ORCA Pollution Mapping Citizen Science sites located in the Central Indian River Lagoon, which starts South of Sebastian Inlet (Indian River County) and ends at the St. Lucie Inlet (Martin County).




**Appendix Figure 4.** All ORCA Pollution Mapping Citizen Science sites located in the Southern Indian River Lagoon, which starts South of St. Lucie Inlet (Southern Martin) and ends at the Jupiter Inlet (northern Palm Beach).