

Indian River-Malabar to Vero Beach Aquatic Preserve

SEACAR Habitat Analyses

Last compiled on 22 May, 2025

Contents

Funding & Acknowledgements	2
Threshold Filtering	2
Value Qualifiers	3
Water Column	5
Seasonal Kendall-Tau Analysis	5
Water Quality - Discrete	5
Chlorophyll a, Corrected for Pheophytin - Discrete	6
Chlorophyll a, Uncorrected for Pheophytin - Discrete	7
Dissolved Oxygen - Discrete	10
Dissolved Oxygen Saturation - Discrete	12
pH - Discrete	13
Salinity - Discrete	16
Secchi Depth - Discrete	18
Total Nitrogen - Discrete	20
Total Phosphorus - Discrete	22
Total Suspended Solids - Discrete	24
Turbidity - Discrete	26
Water Temperature - Discrete	29
Water Quality - Continuous	32
Dissolved Oxygen - Continuous	34
Dissolved Oxygen Saturation - Continuous	36
pH - Continuous	38
Salinity - Continuous	40
Turbidity - Continuous	42
Water Temperature - Continuous	44
Submerged Aquatic Vegetation	46
Parameters	46
Species	46
Notes	46
Oyster	52
Density	52
Natural	52
Percent Live	54
Natural	54
Shell Height	56
Natural	56

Funding & Acknowledgements

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Threshold Filtering

Threshold filters, following the guidance of Florida Department of Environmental Protection's (*FDEP*) Division of Environmental Assessment and Restoration (*DEAR*) are used to exclude specific results values from the SEACAR Analysis. Based on the threshold filters, Quality Assurance / Quality Control (*QAQC*) Flags are inserted into the *SEACAR_QAQCFlagCode* and *SEACAR_QAQC_Description* columns of the export data. The *Include* column indicates whether the *QAQC* Flag will also indicate that data are excluded from analysis. No data are excluded from the data export, but the analysis scripts can use the *Include* column to exclude data (1 to include, 0 to exclude).

Table 1: Continuous Water Quality threshold values

Parameter Name	Units	Low Threshold	High Threshold
Dissolved Oxygen	mg/L	-0.000001	50
Dissolved Oxygen Saturation	%	-0.000001	500
Salinity	ppt	-0.000001	70
Turbidity	NTU	-0.000001	4000
Water Temperature	Degrees C	-5.000000	45
pH	None	2.000000	14

Table 2: Discrete Water Quality threshold values

Parameter Name	Units	Low Threshold	High Threshold
Ammonia, Un-ionized (NH3)	mg/L	-	-
Ammonium, Filtered (NH4)	mg/L	-	-
Chlorophyll a, Corrected for Pheophytin	ug/L	-	-
Chlorophyll a, Uncorrected for Pheophytin	ug/L	-	-
Colored Dissolved Organic Matter	PCU	-	-

Parameter Name	Units	Low Threshold	High Threshold
Dissolved Oxygen	mg/L	-0.000001	25
Dissolved Oxygen Saturation	%	-0.000001	310
Fluorescent Dissolved Organic Matter	QSE	-	-
Light Extinction Coefficient	m^-1	-	-
NO2+3, Filtered	mg/L	-	-
Nitrate (NO3)	mg/L	-	-
Nitrite (NO2)	mg/L	-	-
Nitrogen, organic	mg/L	-	-
Phosphate, Filtered (PO4)	mg/L	-	-
Salinity	ppt	-0.000001	70
Secchi Depth	m	0.000001	50
Specific Conductivity	mS/cm	0.005000	100
Total Kjeldahl Nitrogen	mg/L	-	-
Total Nitrogen	mg/L	-	-
Total Nitrogen	mg/L	-	-
Total Phosphorus	mg/L	-	-
Total Suspended Solids	mg/L	-	-
Turbidity	NTU	-	-
Water Temperature	Degrees C	3.000000	40
pH	None	2.000000	13

Table 3: Quality Assurance Flags inserted based on threshold checks listed in Table 1 and 2

SEACAR QAQC Description	Include	SEACAR QAQCFlagCode
Exceeds maximum threshold	0	2Q
Below minimum threshold	0	4Q
Within threshold tolerance	1	6Q
No defined thresholds for this parameter	1	7Q

Value Qualifiers

Value qualifier codes included within the data are used to exclude certain results from the analysis. The data are retained in the data export files, but the analysis uses the *Include* column to filter the results.

STORET and WIN value qualifier codes

Value qualifier codes from *STORET* and *WIN* data are examined with the database and used to populate the *Include* column in data exports.

Table 4: Value Qualifier codes excluded from analysis

Qualifier Source	Value Qualifier	Include	MDL	Description
STORET-WIN	H	0	0	Value based on field kit determination; results may not be accurate
STORET-WIN	J	0	0	Estimated value
STORET-WIN	V	0	0	Analyte was detected at or above method detection limit
STORET-WIN	Y	0	0	Lab analysis from an improperly preserved sample; data may be inaccurate

Discrete Water Quality Value Qualifiers

The following value qualifiers are highlighted in the Discrete Water Quality section of this report. An exception is made for **Program 476 - Charlotte Harbor Estuaries Volunteer Water Quality Monitoring Network** and data flagged with Value Qualifier **H** are included for this program only.

H - Value based on field kit determiniation; results may not be accurate. This code shall be used if a field screening test (e.g., field gas chromatograph data, immunoassay, or vendor-supplied field kit) was used to generate the value and the field kit or method has not been recognized by the Department as equivalent to laboratory methods.

I - The reported value is greater than or equal to the laboratory method detection limit but less than the laboratory practical quantitation limit.

Q - Sample held beyond the accepted holding time. This code shall be used if the value is derived from a sample that was prepared or analyzed after the approved holding time restrictions for sample preparation or analysis.

S - Secchi disk visible to bottom of waterbody. The value reported is the depth of the waterbody at the location of the Secchi disk measurement.

U - Indicates that the compound was analyzed for but not detected. This symbol shall be used to indicate that the specified component was not detected. The value associated with the qualifier shall be the laboratory method detection limit. Unless requested by the client, less than the method detection limit values shall not be reported

Systemwide Monitoring Program (SWMP) value qualifier codes

Value qualifier codes from the *SWMP* continuous program are examined with the database and used to populate the *Include* column in data exports. *SWMP* Qualifier Codes are indicated by *QualifierSource=SWMP*.

Table 5: SWMP Value Qualifier codes

<i>Qualifier Source</i>	<i>Value Qualifier</i>	<i>Include</i>	<i>Description</i>
SWMP	-1	1	Optional parameter not collected
SWMP	-2	0	Missing data
SWMP	-3	0	Data rejected due to QA/QC
SWMP	-4	0	Outside low sensor range
SWMP	-5	0	Outside high sensor range
SWMP	0	1	Passed initial QA/QC checks
SWMP	1	0	Suspect data
SWMP	2	1	Reserved for future use
SWMP	3	1	Calculated data: non-vented depth/level sensor correction for changes in barometric pressure
SWMP	4	1	Historical: Pre-auto QA/QC
SWMP	5	1	Corrected data

Water Column

The water column habitat extends from the water's surface to the bottom sediments, and it's where fish, dolphins, crabs and people swim! So much life makes its home in the water column that the health of marine and coastal ecosystems, as well as human economies, depend on the condition of this vulnerable habitat. Local patterns of rainfall, temperature, winds and currents can rapidly change the condition of the water column, while global influences such as [El Niño/La Niña](#), large-scale fluctuation in sea temperatures and climate change can have long-term effects. Inputs from the prosperity of our day-to-day lives including farming, mining and forestry, and emissions from power generation, automobiles and water treatment can also alter the health of the water column. Acting alone or together, each input can have complex and lasting effects on habitats and ecosystems.

SEACAR evaluates water column health with several essential parameters. These include nutrient surveys of nitrogen and phosphorus, and water quality assessments of salinity, dissolved oxygen, pH, and water temperature. Water clarity is evaluated with Secchi depth, turbidity, levels of chlorophyll a, total suspended solids, and colored dissolved organic matter. Additionally, the richness of nekton is indicated by the abundance of free-swimming fishes and macroinvertebrates like crabs and shrimps.

Seasonal Kendall-Tau Analysis

Indicators must have a minimum of five to ten years, depending on the habitat, of data within the geographic range of the analysis to be included in the analysis. Ten years of data are required for discrete parameters, and five years of data are required for continuous parameters. If there are insufficient years of data, the number of years of data available will be noted and labeled as "insufficient data to conduct analysis". Further, for the preferred Seasonal Kendall-Tau test, there must be data from at least two months in common across at least two consecutive years within the RCP managed area being analyzed. Values that pass both of these tests will be included in the analysis and be labeled as *Use_In_Analysis = TRUE*. Any that fail either test will be excluded from the analyses and labeled as *Use_In_Analysis = FALSE*. The points for all Water Column plots displayed in this section are monthly averages. Trend significance will be denoted as "Significant Trend" (when $p < 0.05$), or "Non-significant Trend" (when $p \geq 0.05$). Any parameters with insufficient data to perform Seasonal Kendall-Tau test will have their monthly averages plotted without a corresponding trend line.

Water Quality - Discrete

The following files were used in the discrete analysis:

- *Combined_WQ_WC_NUT_Chlorophyll_a_corrected_for_pheophytin-2025-Mar-06.txt*
- *Combined_WQ_WC_NUT_Chlorophyll_a_uncorrected_for_pheophytin-2025-Mar-06.txt*
- *Combined_WQ_WC_NUT_Colored_dissolved_organic_matter_CDOM-2025-Mar-06.txt*
- *Combined_WQ_WC_NUT_Dissolved_Oxygen-2025-Mar-06.txt*
- *Combined_WQ_WC_NUT_Dissolved_Oxygen_Saturation-2025-Mar-06.txt*
- *Combined_WQ_WC_NUT_pH-2025-Mar-06.txt*
- *Combined_WQ_WC_NUT_Salinity-2025-Mar-06.txt*
- *Combined_WQ_WC_NUT_Secchi_Depth-2025-Mar-06.txt*
- *Combined_WQ_WC_NUT_Total_Nitrogen-2025-Mar-06.txt*
- *Combined_WQ_WC_NUT_Total_Phosphorus-2025-Mar-06.txt*
- *Combined_WQ_WC_NUT_Total_Suspended_Solids_TSS-2025-Mar-06.txt*
- *Combined_WQ_WC_NUT_Turbidity-2025-Mar-06.txt*
- *Combined_WQ_WC_NUT_Water_Temperature-2025-Mar-06.txt*

Chlorophyll a, Corrected for Pheophytin - Discrete

Seasonal Kendall-Tau Trend Analysis

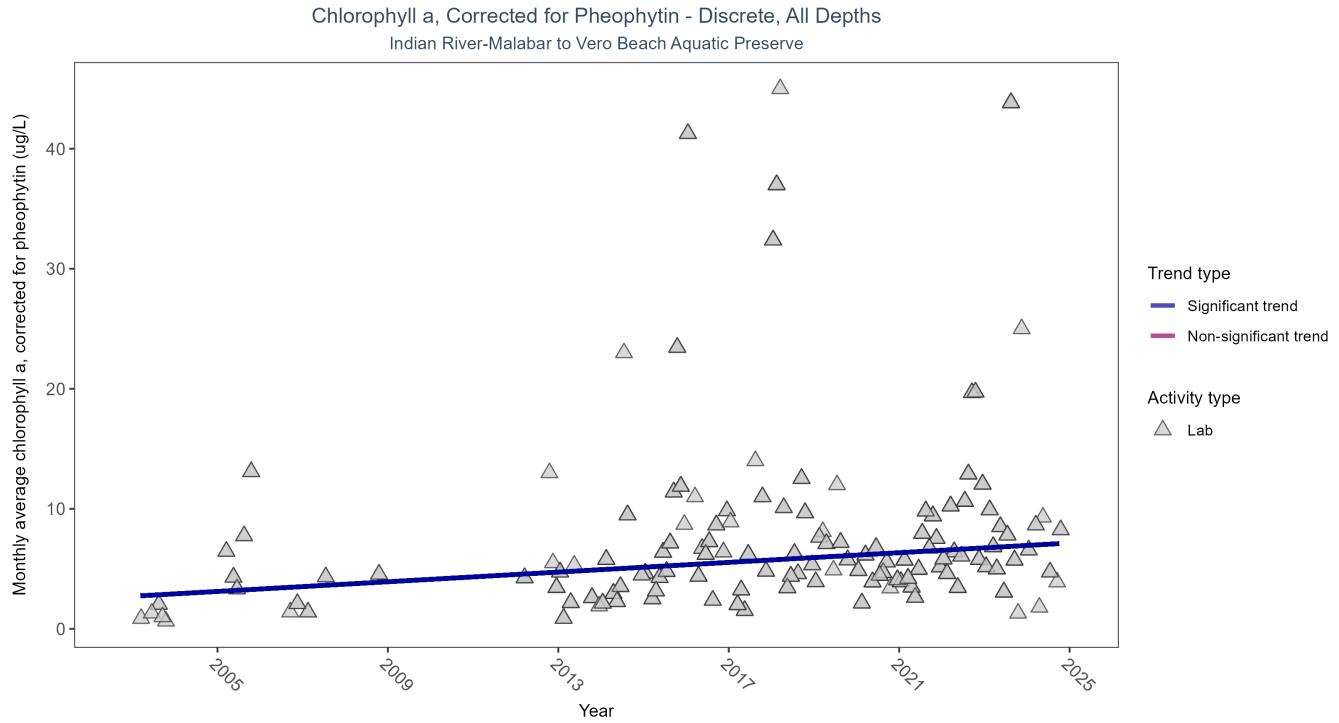


Figure 1: Scatter plot of monthly average levels of chlorophyll a, corrected for pheophytin, over time. If the time series included ten or more years of discrete observations, a significant (blue) or non-significant (magenta) trend line is also shown. Only laboratory-analyzed chlorophyll a (triangles) is included in the plot.

Table 6: Seasonal Kendall-Tau Trend Analysis for Chlorophyll a, Corrected for Pheophytin

Activity Type	Statistical Trend	Sample Count	Years with Data	Period of Record	Median	tau	Sen Intercept	Sen Slope	p
Lab	Significantly increasing trend	725	18	2003 - 2024	4.6	0.2145	2.7115	0.2017	0.0032

Monthly average chlorophyll a, corrected for pheophytin, increased by 0.2 $\mu\text{g}/\text{L}$ per year, indicating a decrease in water clarity.

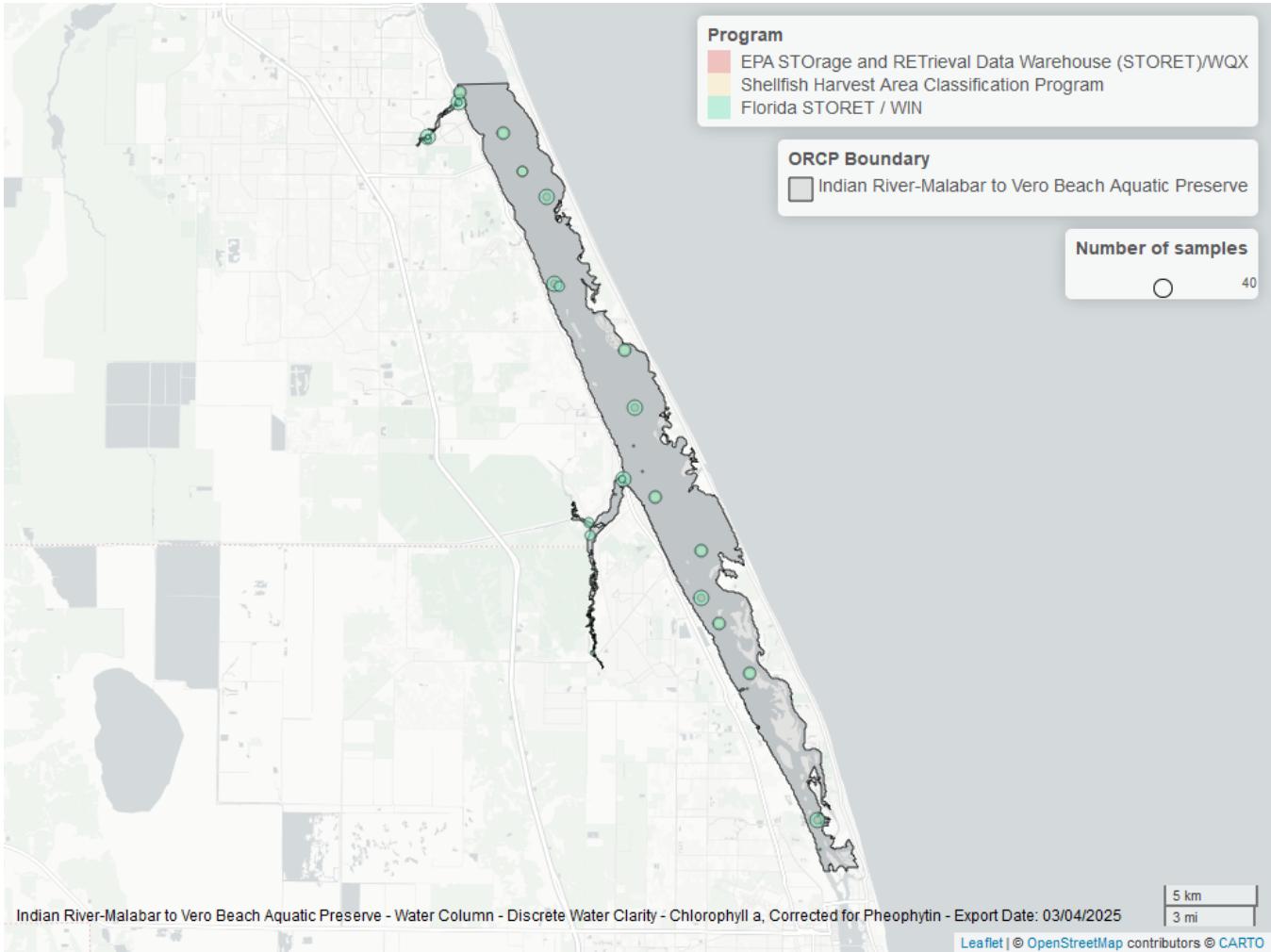


Figure 2: Map showing location of discrete water quality sampling locations within the boundaries of *Indian River-Malabar to Vero Beach Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Table 7: Programs contributing data for Chlorophyll a, Corrected for Pheophytin

ProgramID	N_Data	YearMin	YearMax
5002	589	2003	2024
540	127	2016	2020
103	35	2020	2021

Program names:

103 - EPA STOrage and RETrieval Data Warehouse (STORET)/WQX¹

540 - Shellfish Harvest Area Classification Program²

5002 - Florida STORET / WIN³

Chlorophyll a, Uncorrected for Pheophytin - Discrete

Seasonal Kendall-Tau Trend Analysis

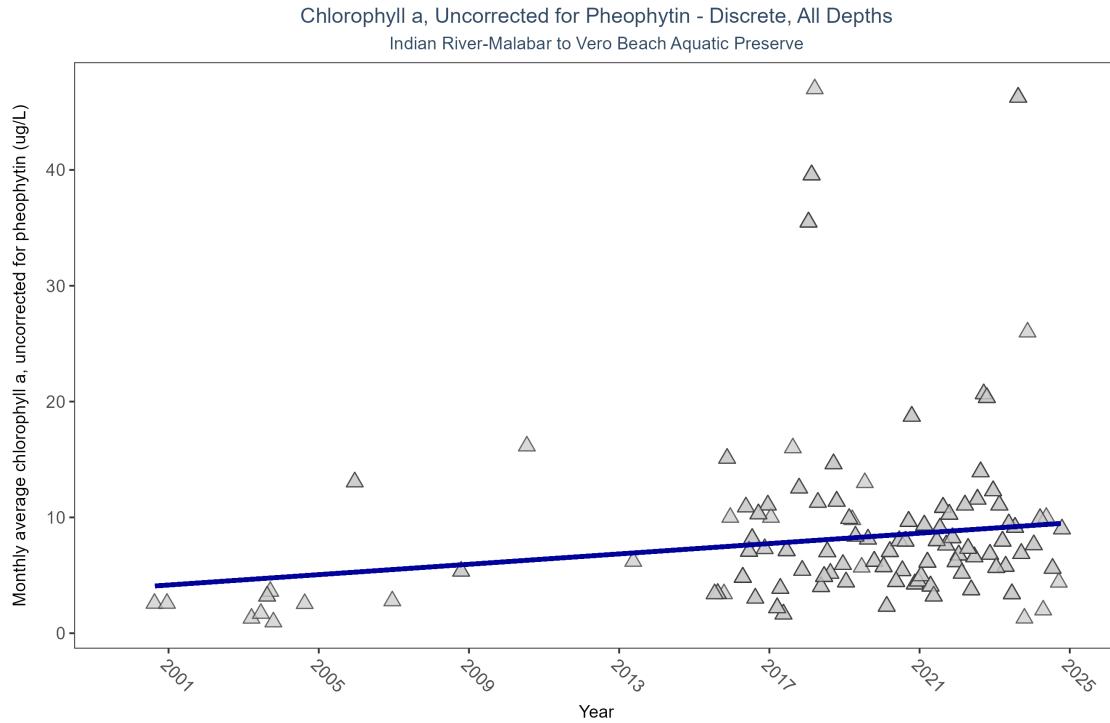


Figure 3: Scatter plot of monthly average levels of chlorophyll a, uncorrected for pheophytin, over time. If the time series included ten or more years of discrete observations, a significant (blue) or non-significant (magenta) trend line is also shown. Only laboratory-analyzed chlorophyll a (triangles) is included in the plot.

Table 8: Seasonal Kendall-Tau Trend Analysis for Chlorophyll a, Uncorrected for Pheophytin

Activity Type	Statistical Trend	Sample Count	Years with Data	Period of Record	Median	tau	Sen Intercept	Sen Slope	p
Lab	Significantly increasing trend	565	18	2000 - 2024	6	0.1353	3.9385	0.2237	0.0263

Monthly average chlorophyll a, uncorrected for pheophytin, increased by 0.22 $\mu\text{g}/\text{L}$ per year, indicating a decrease in water clarity.

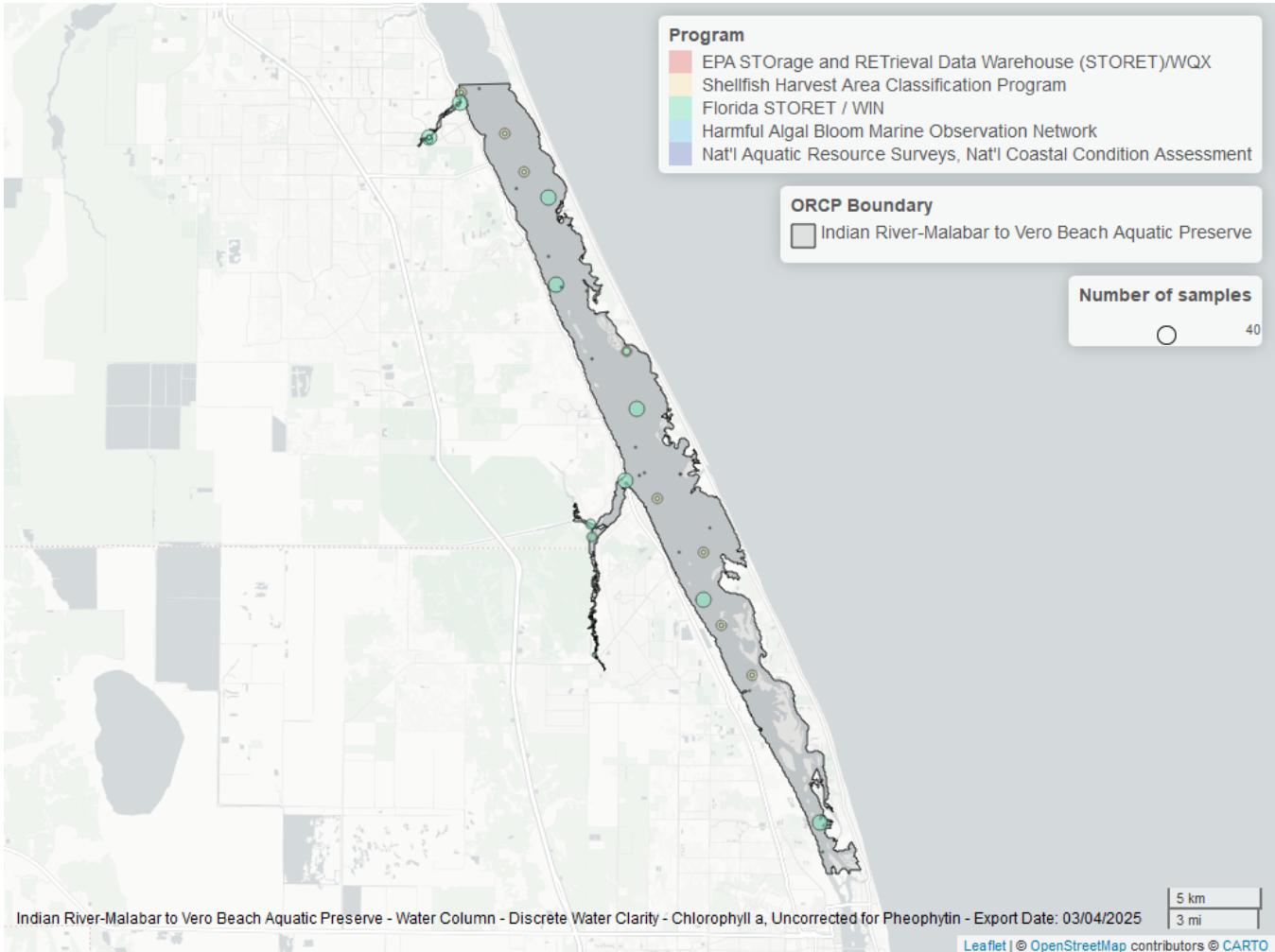


Figure 4: Map showing location of discrete water quality sampling locations within the boundaries of *Indian River-Malabar to Vero Beach Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Table 9: Programs contributing data for Chlorophyll a, Uncorrected for Pheophytin

<i>ProgramID</i>	<i>N_Data</i>	<i>YearMin</i>	<i>YearMax</i>
5002	430	2003	2024
540	131	2016	2020
103	14	2000	2021
118	5	2000	2010
95	3	2018	2018

Program names:

95 - Harmful Algal Bloom Marine Observation Network⁴

103 - EPA STOrage and RETrieval Data Warehouse (STORET)/WQX¹

118 - National Aquatic Resource Surveys, National Coastal Condition Assessment⁵

540 - Shellfish Harvest Area Classification Program²

5002 - Florida STORET / WIN³

Dissolved Oxygen - Discrete

Seasonal Kendall-Tau Trend Analysis

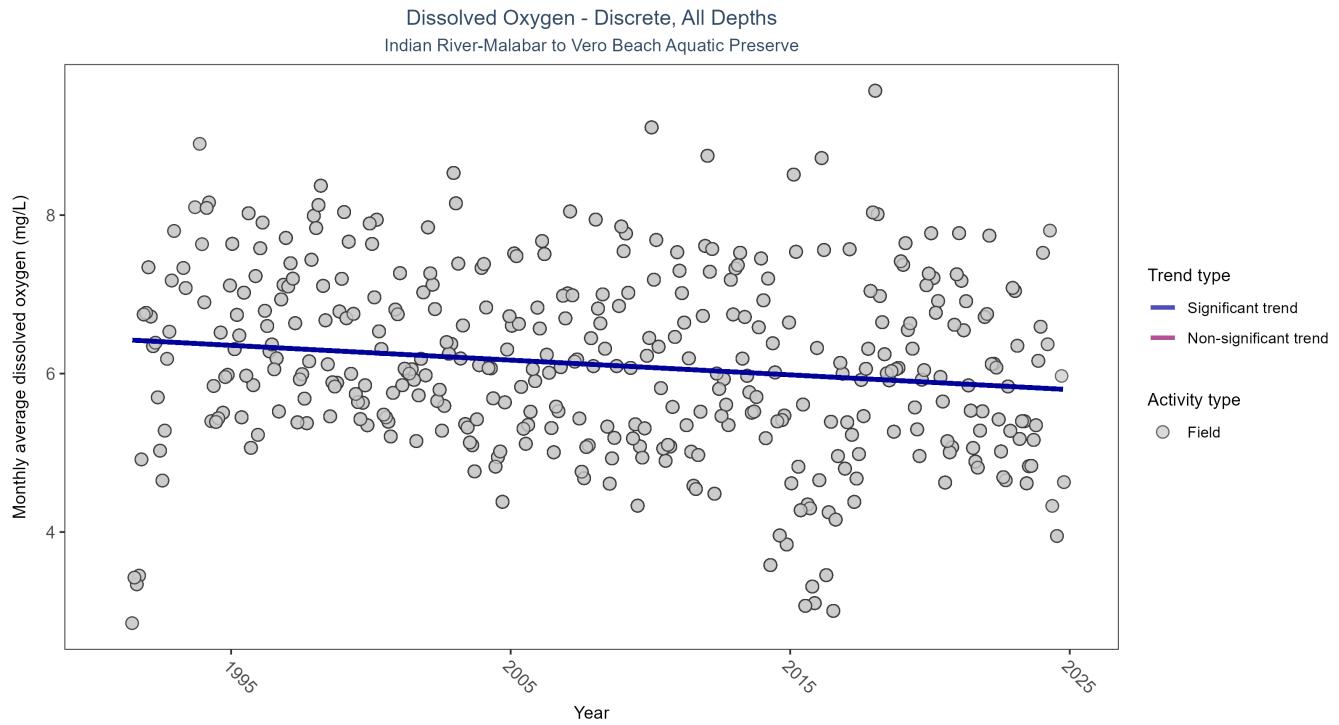


Figure 5: Scatter plot of monthly average dissolved oxygen over time. If the time series included ten or more years of discrete observations, a significant (blue) or non-significant (magenta) trend line is also shown. Only dissolved oxygen values measured in the field (circles) are included in the plot.

Table 10: Seasonal Kendall-Tau Trend Analysis for Dissolved Oxygen

Activity Type	Statistical Trend	Sample Count	Years with Data	Period of Record	Median	tau	Sen Intercept	Sen Slope	p
Field	Significantly decreasing trend	56820	34	1991 - 2024	6.2	-0.1702	6.4308	-0.0186	0

Monthly average dissolved oxygen decreased by 0.02 mg/L per year.

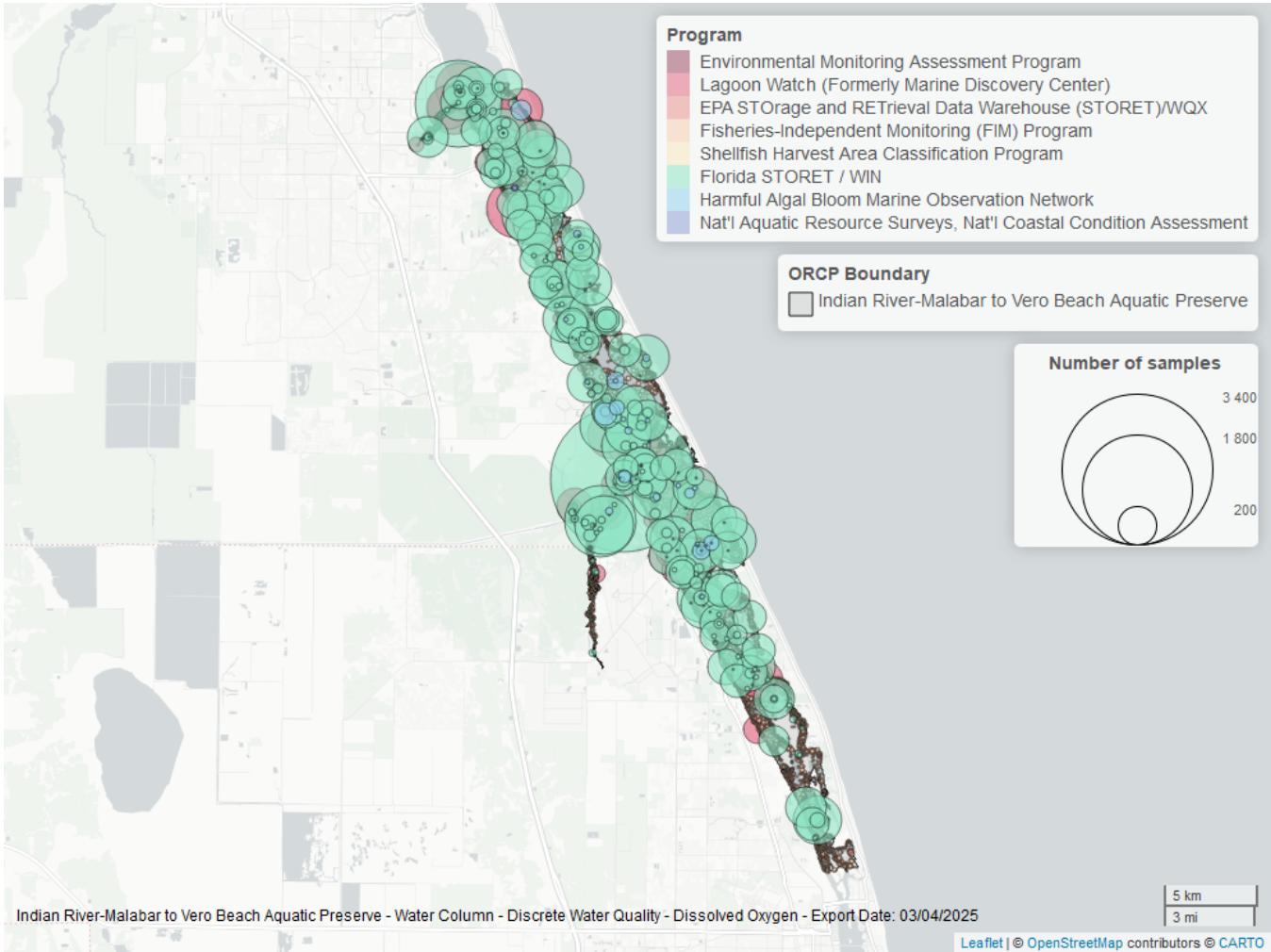


Figure 6: Map showing location of discrete water quality sampling locations within the boundaries of *Indian River-Malabar to Vero Beach Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Table 11: Programs contributing data for Dissolved Oxygen

<i>ProgramID</i>	<i>N_Data</i>	<i>YearMin</i>	<i>YearMax</i>
5002	29588	1991	2024
69	19356	1991	2022
3001	6309	1991	2023
3013	1107	2003	2023
95	494	1996	2018
540	127	2016	2020
103	63	2004	2021
115	28	1994	1995
118	15	2000	2021

Program names:

69 - Fisheries-Independent Monitoring (FIM) Program⁶

95 - Harmful Algal Bloom Marine Observation Network⁴

103 - EPA STOrage and RETrieval Data Warehouse (STORET)/WQX¹

115 - Environmental Monitoring Assessment Program⁷

118 - National Aquatic Resource Surveys, National Coastal Condition Assessment⁵

540 - Shellfish Harvest Area Classification Program²

3001 - Lagoon Watch (Formerly Marine Discovery Center)⁸

3013 - Seagrass (SJRWMD)⁹

5002 - Florida STORET / WIN³

Dissolved Oxygen Saturation - Discrete

Seasonal Kendall-Tau Trend Analysis

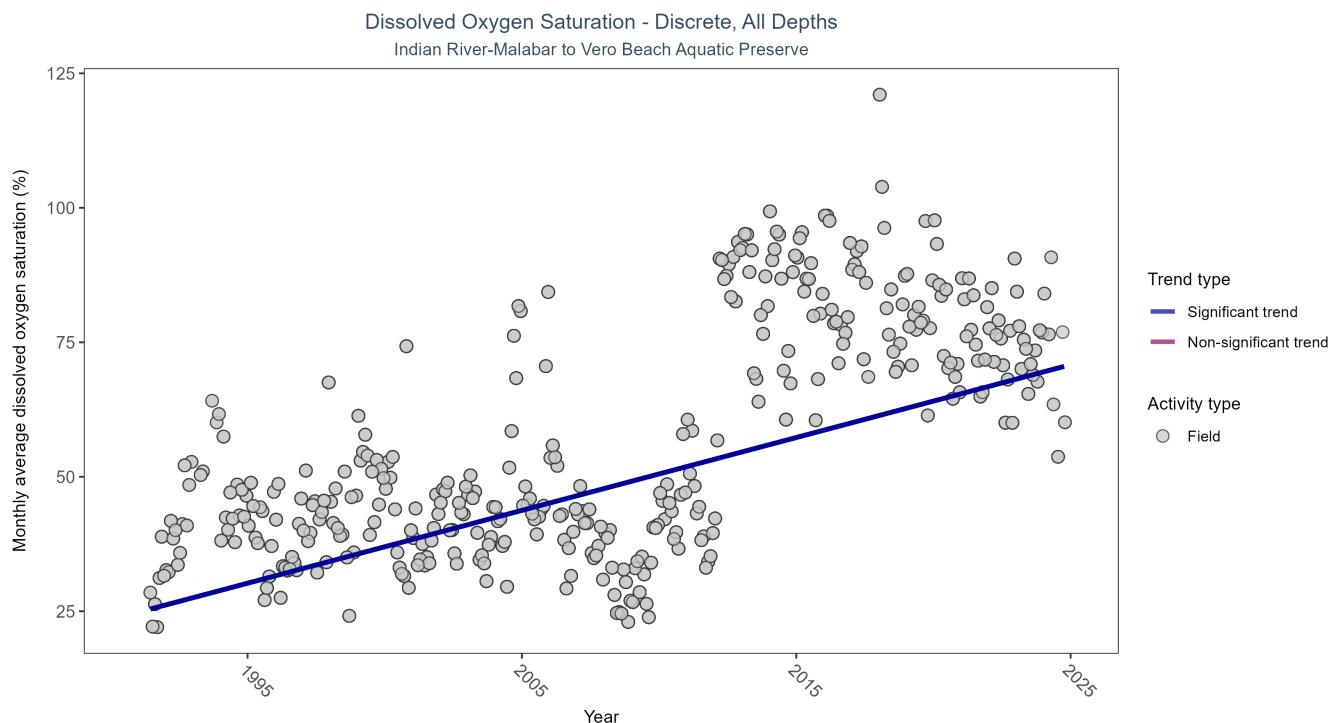


Figure 7: Scatter plot of monthly average dissolved oxygen saturation over time. If the time series included ten or more years of discrete observations, a significant (blue) or non-significant (magenta) trend line is also shown. Only dissolved oxygen saturation values measured in the field (circles) are included in the plot.

Table 12: Seasonal Kendall-Tau Trend Analysis for Dissolved Oxygen Saturation

Activity Type	Statistical Trend	Sample Count	Years with Data	Period of Record	Median	tau	Sen Intercept	Sen Slope	p
Field	Significantly increasing trend	13193	34	1991 - 2024	68.845	0.4107	24.7959	1.3543	0

Monthly average dissolved oxygen saturation increased by 1.35% per year.

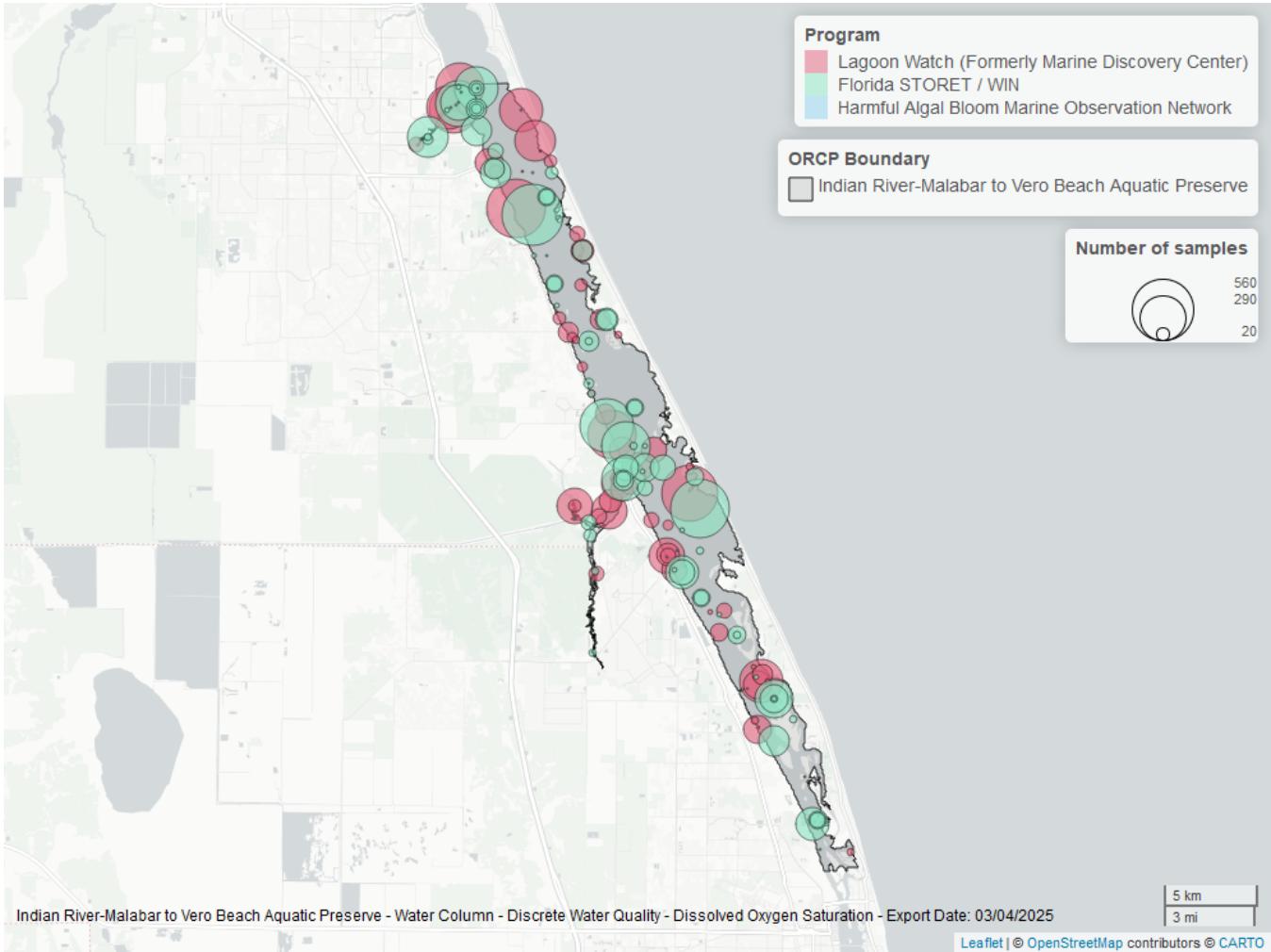


Figure 8: Map showing location of discrete water quality sampling locations within the boundaries of *Indian River-Malabar to Vero Beach Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Table 13: Programs contributing data for Dissolved Oxygen Saturation

ProgramID	N_Data	YearMin	YearMax
3001	6321	1991	2023
5002	6306	1991	2024
3013	570	2012	2023
95	5	2016	2018

Program names:

- 95 - Harmful Algal Bloom Marine Observation Network⁴
- 3001 - Lagoon Watch (Formerly Marine Discovery Center)⁸
- 3013 - Seagrass (SJRWMD)⁹
- 5002 - Florida STORET / WIN³

pH - Discrete

Seasonal Kendall-Tau Trend Analysis

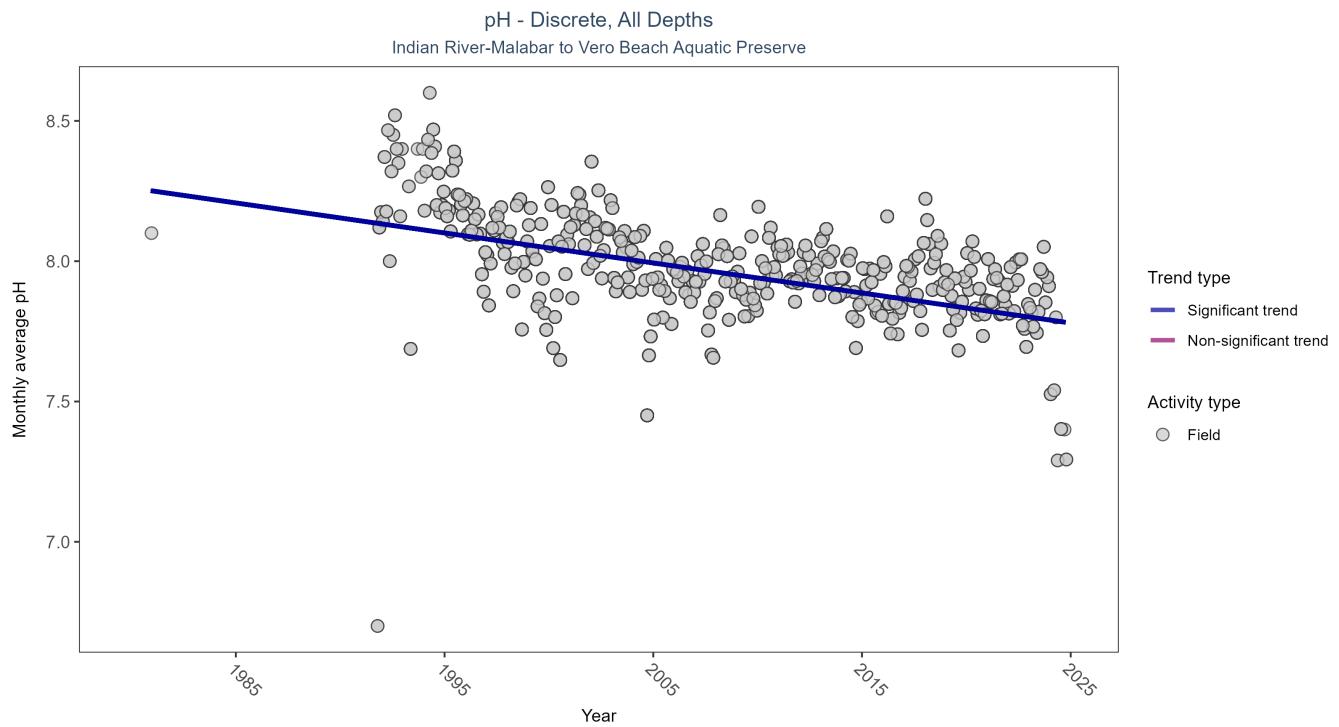


Figure 9: Scatter plot of monthly average pH over time. If the time series included ten or more years of discrete observations, a significant (blue) or non-significant (magenta) trend line is also shown. Only pH values measured in the field (circles) are included in the plot.

Table 14: Seasonal Kendall-Tau Trend Analysis for pH

Activity Type	Statistical Trend	Sample Count	Years with Data	Period of Record	Median	tau	Sen Intercept	Sen Slope	p
Field	Significantly decreasing trend	47826	35	1980 - 2024	8	-0.4406	8.2612	-0.0107	0

Monthly average pH decreased by 0.01 pH units per year.

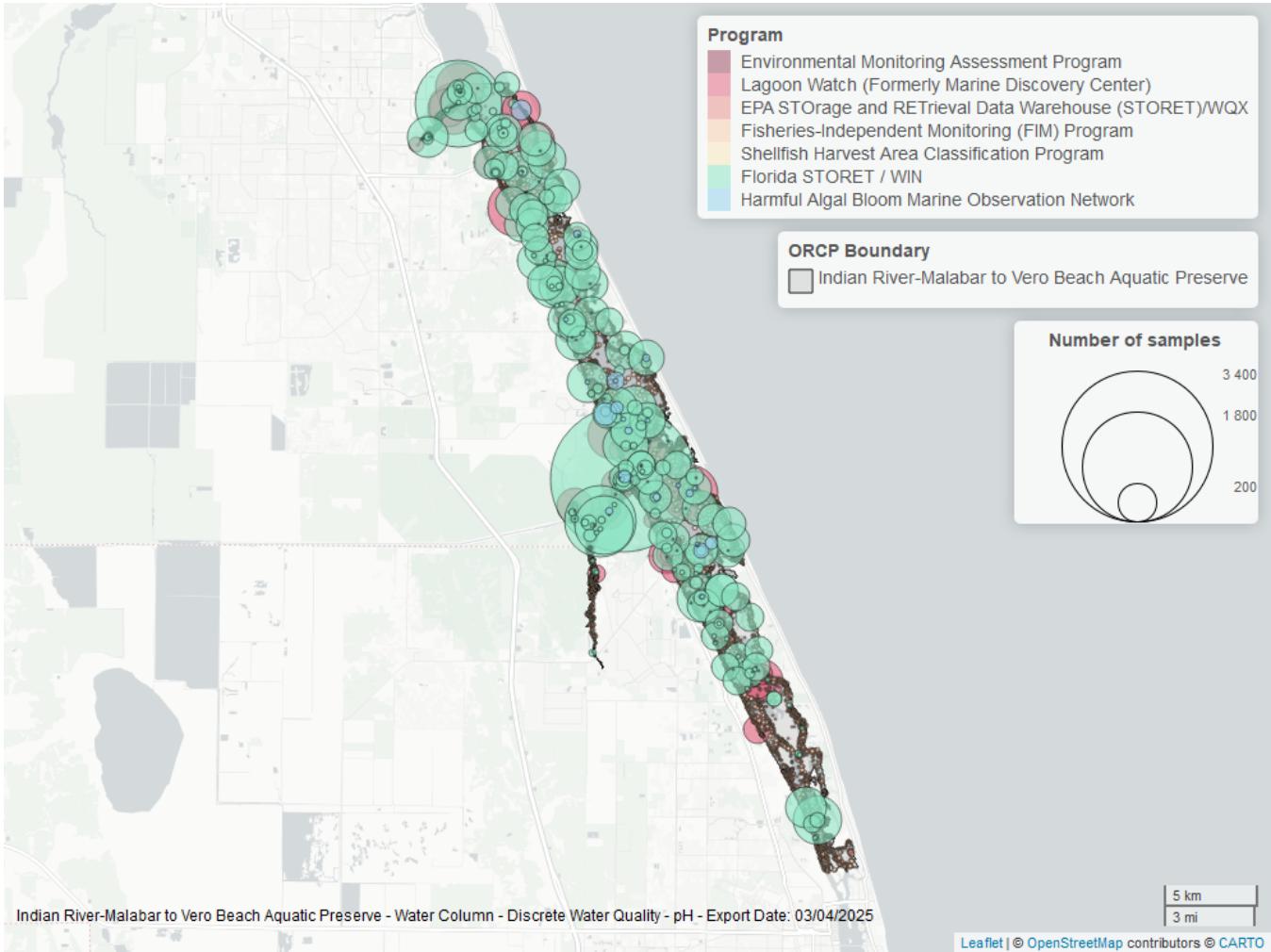


Figure 10: Map showing location of discrete water quality sampling locations within the boundaries of *Indian River-Malabar to Vero Beach Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Table 15: Programs contributing data for pH

ProgramID	N_Data	YearMin	YearMax
5002	22022	1995	2024
69	19360	1991	2022
3001	5913	1991	2023
3013	1119	2003	2023
95	454	1980	2018
540	119	2016	2020
103	62	2004	2021
115	22	1994	1995

Program names:

- 69 - Fisheries-Independent Monitoring (FIM) Program⁶
- 95 - Harmful Algal Bloom Marine Observation Network⁴
- 103 - EPA STOrage and RETrieval Data Warehouse (STORET)/WQX¹
- 115 - Environmental Monitoring Assessment Program⁷

- 540 - Shellfish Harvest Area Classification Program²
 3001 - Lagoon Watch (Formerly Marine Discovery Center)⁸
 3013 - Seagrass (SJRWMD)⁹
 5002 - Florida STORET / WIN³

Salinity - Discrete

Seasonal Kendall-Tau Trend Analysis

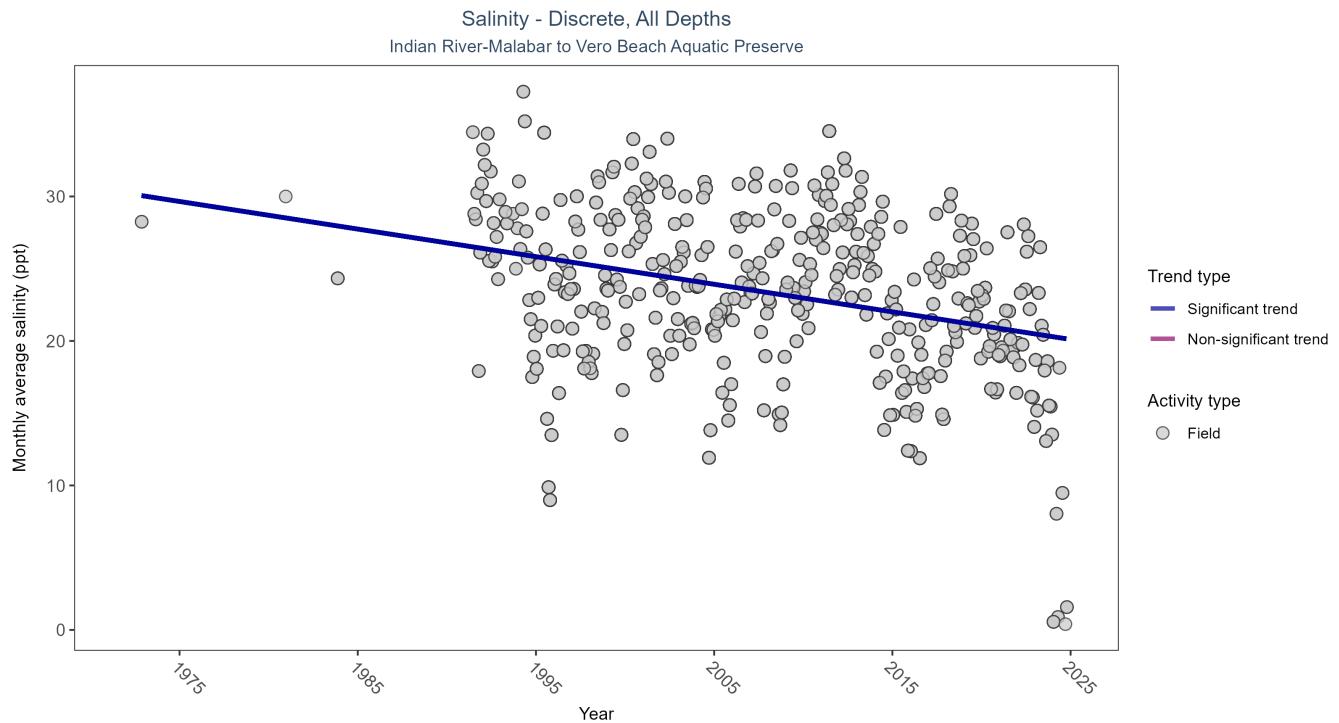


Figure 11: Scatter plot of monthly average salinity over time. If the time series included ten or more years of discrete observations, significant (blue) or non-significant (magenta) trend lines are also shown. Discrete salinity values derived from grab samples analyzed in the field (circles) or the laboratory (triangles) are both included in the plot.

Table 16: Seasonal Kendall-Tau Trend Analysis for Salinity

Activity Type	Statistical Trend	Sample Count	Years with Data	Period of Record	Median	tau	Sen Intercept	Sen Slope	p
All	Significantly decreasing trend	59747	37	1972 - 2024	26.09	-0.2613	30.2261	-0.191	0

Monthly average salinity decreased by 0.19 ppt per year.

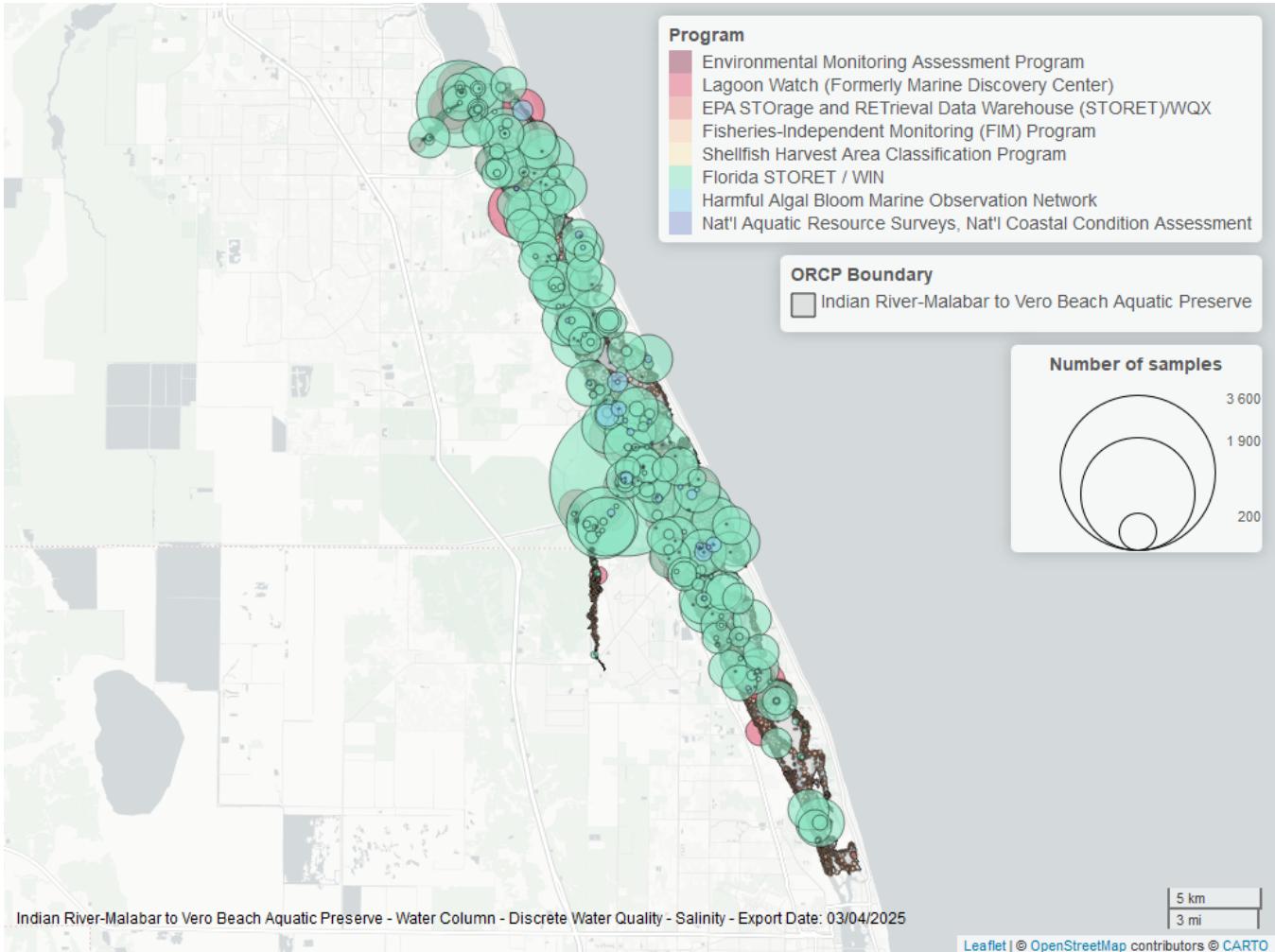


Figure 12: Map showing location of discrete water quality sampling locations within the boundaries of *Indian River-Malabar to Vero Beach Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Table 17: Programs contributing data for Salinity

ProgramID	N_Data	YearMin	YearMax
5002	32339	1991	2024
69	19425	1991	2022
3001	6272	1991	2023
3013	1123	2003	2023
95	527	1972	2018
540	127	2016	2020
115	25	1994	1995
118	10	2015	2021
103	2	2004	2004

Program names:

69 - Fisheries-Independent Monitoring (FIM) Program⁶

95 - Harmful Algal Bloom Marine Observation Network⁴

103 - EPA STOrage and RETrieval Data Warehouse (STORET)/WQX¹

115 - Environmental Monitoring Assessment Program⁷

118 - National Aquatic Resource Surveys, National Coastal Condition Assessment⁵

540 - Shellfish Harvest Area Classification Program²

3001 - Lagoon Watch (Formerly Marine Discovery Center)⁸

3013 - Seagrass (SJRWM)⁹

5002 - Florida STORET / WIN³

Secchi Depth - Discrete

Seasonal Kendall-Tau Trend Analysis

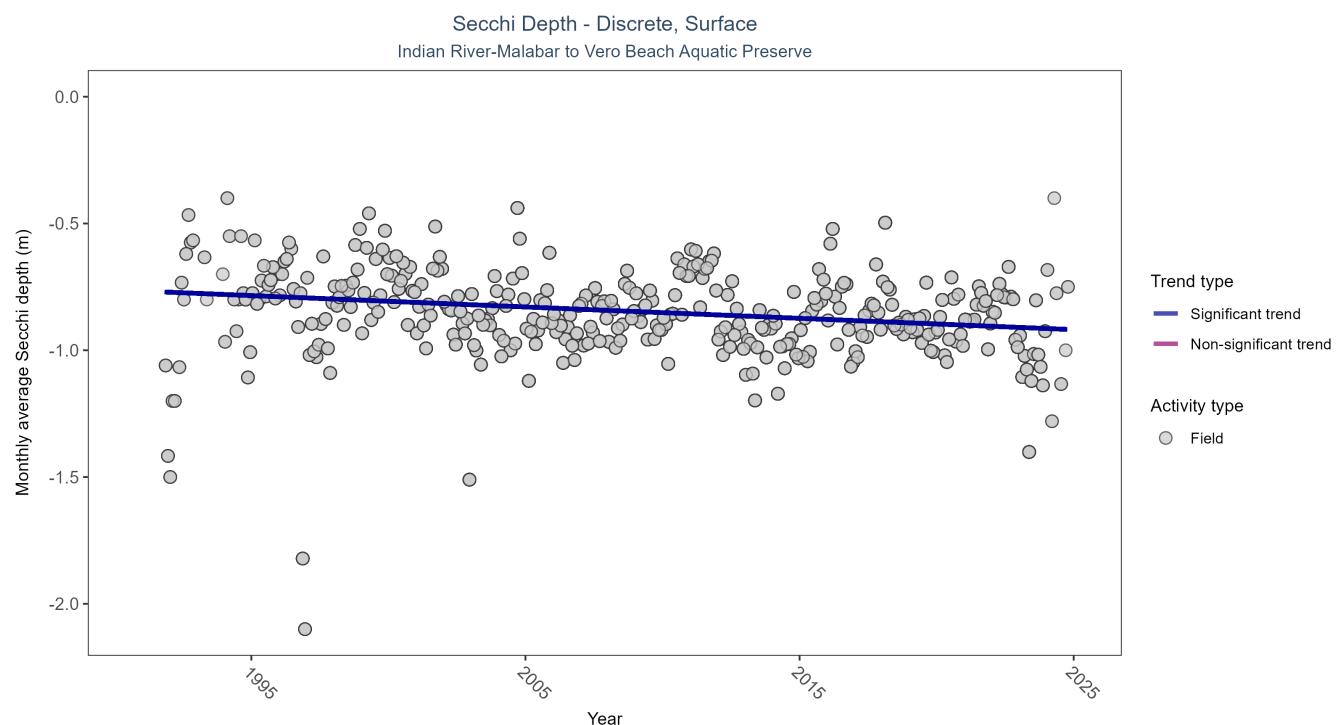


Figure 13: Scatter plot of monthly average Secchi depth over time. If the time series included ten or more years of discrete observations, a significant (blue) or non-significant (magenta) trend line is also shown. Secchi depth is only measured in the field (circles).

Table 18: Seasonal Kendall-Tau Trend Analysis for Secchi Depth

Activity Type	Statistical Trend	Sample Count	Years with Data	Period of Record	Median	tau	Sen Intercept	Sen Slope	p
Field	Significantly decreasing trend	27011	34	1991 - 2024	-0.8	-0.1782	-0.7666	-0.0045	0

Monthly average Secchi depth became deeper by less than 0.01 m per year, indicating an increase in water clarity.

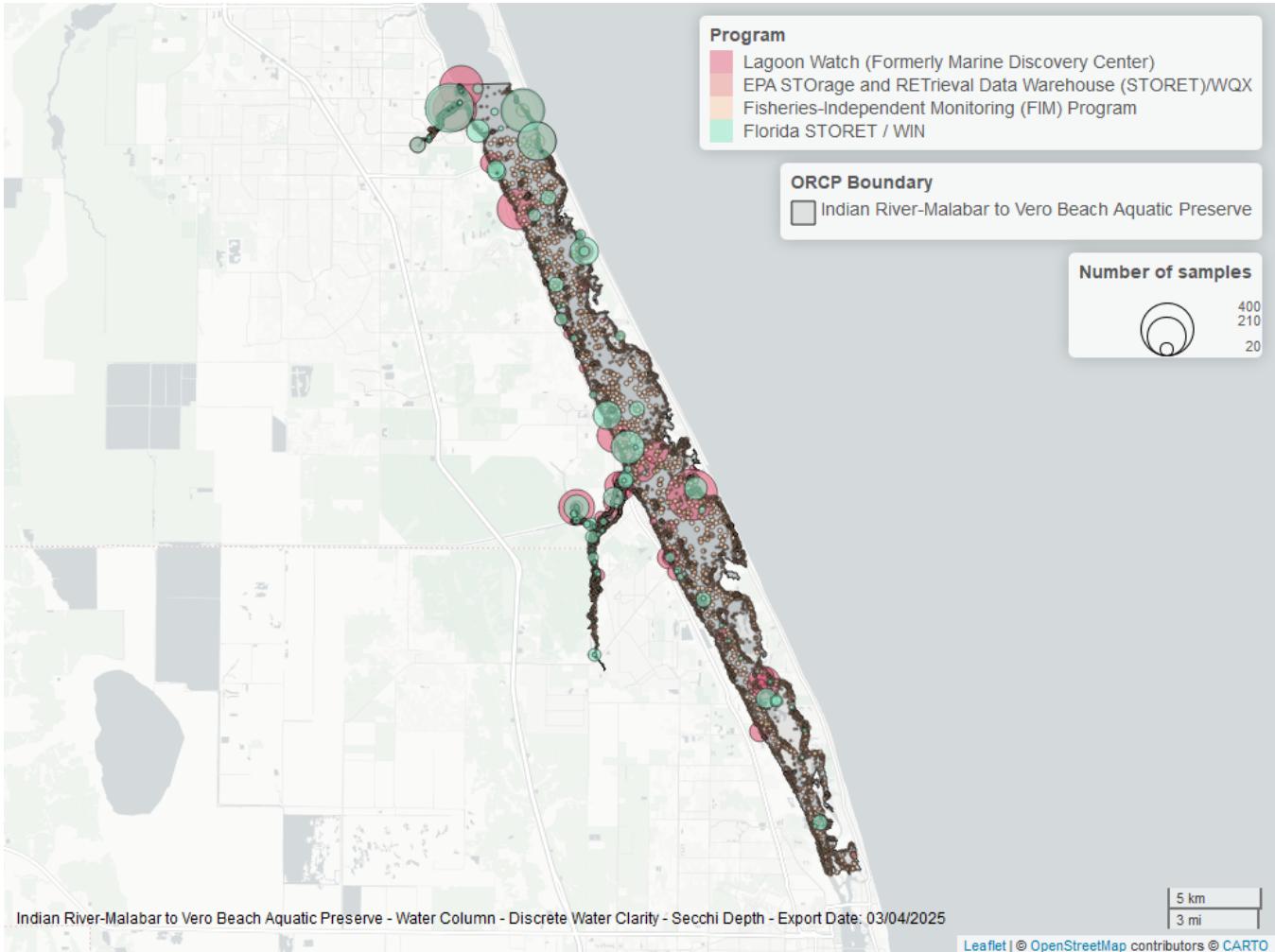


Figure 14: Map showing location of discrete water quality sampling locations within the boundaries of *Indian River-Malabar to Vero Beach Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Table 19: Programs contributing data for Secchi Depth

ProgramID	N_Data	YearMin	YearMax
69	19263	1995	2022
3001	4033	1991	2023
5002	2635	2005	2024
3013	1129	2003	2023
103	148	2020	2021

Program names:

- 69 - Fisheries-Independent Monitoring (FIM) Program⁶
- 103 - EPA STOrage and RETrieval Data Warehouse (STORET)/WQX¹
- 3001 - Lagoon Watch (Formerly Marine Discovery Center)⁸
- 3013 - Seagrass (SJRWMD)⁹
- 5002 - Florida STORET / WIN³

Total Nitrogen - Discrete

Total Nitrogen Calculation:

The logic for calculated Total Nitrogen was provided by Kevin O'Donnell and colleagues at FDEP (with the help of Jay Silvanima, Watershed Monitoring Section). The following logic is used, in this order, based on the availability of specific nitrogen components.

- 1) $TN = TKN + NO_3O_2;$
- 2) $TN = TKN + NO_3 + NO_2;$
- 3) $TN = ORGN + NH_4 + NO_3O_2;$
- 4) $TN = ORGN + NH_4 + NO_2 + NO_3;$
- 5) $TN = TKN + NO_3;$
- 6) $TN = ORGN + NH_4 + NO_3;$

Additional Information:

- Rules for use of sample fraction:
 - Florida Department of Environmental Protection (FDEP) report that if both “Total” and “Dissolved” components are reported, only “Total” is used. If the total is not reported, then the dissolved components are used as a best available replacement.
 - Total nitrogen calculations are done using nitrogen components with the same sample fraction, nitrogen components with mixed total/dissolved sample fractions are not used. In other words, total nitrogen can be calculated when TKN and NO₃O₂ are both total sample fractions, or when both are dissolved sample fractions. *Future calculations of total nitrogen values may be based on components with mixed sample fractions.*
- Values inserted into data:
 - ParameterName = “Total Nitrogen”
 - SEACAR_QAQCFlagCode = “1Q”
 - SEACAR_QAQC_Description = “SEACAR Calculated”

Seasonal Kendall-Tau Trend Analysis

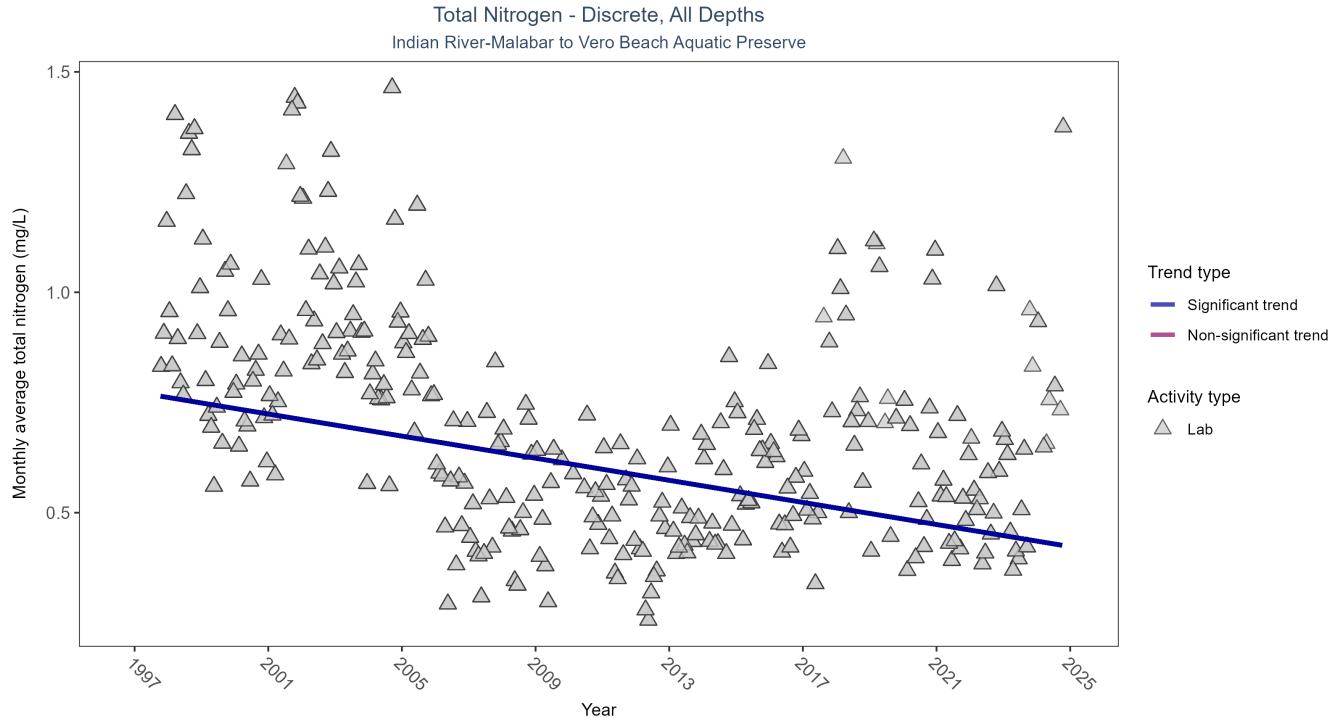


Figure 15: Scatter plot of monthly average total nitrogen over time. If the time series included ten or more years of discrete observations, a significant (blue) or non-significant (magenta) trend line is also shown. Only nitrogen values obtained from laboratory analyses (triangles) are included in the plot.

Table 20: Seasonal Kendall-Tau Trend Analysis for Total Nitrogen

Activity Type	Statistical Trend	Sample Count	Years with Data	Period of Record	Median	tau	Sen Intercept	Sen Slope	p
Lab	Significantly decreasing trend	3136	28	1997 - 2024	0.6552	-0.2846	0.774	-0.0125	0

Monthly average total nitrogen decreased by 0.01 mg/L per year.

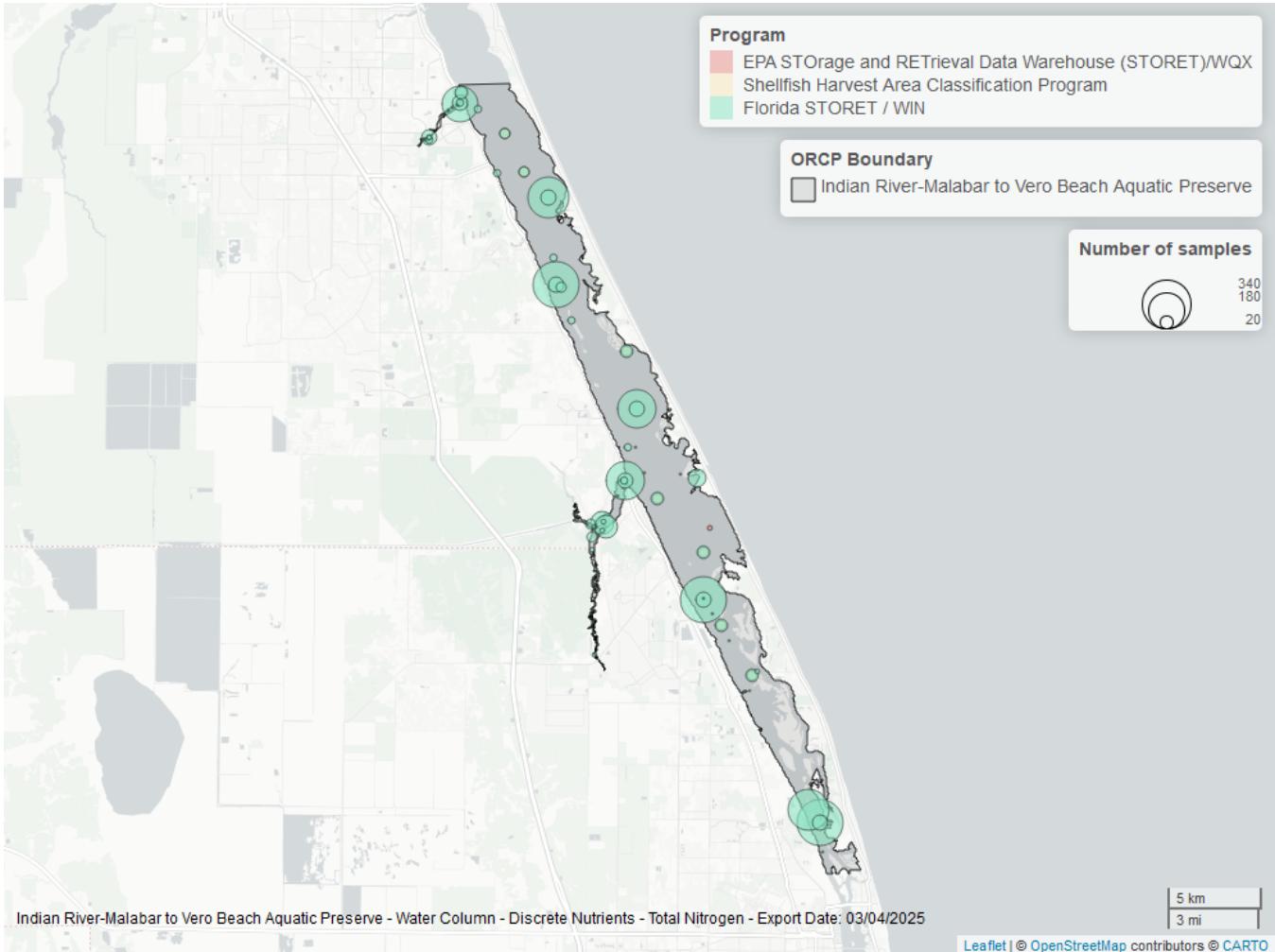


Figure 16: Map showing location of discrete water quality sampling locations within the boundaries of *Indian River-Malabar to Vero Beach Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Table 21: Programs contributing data for Total Nitrogen

ProgramID	N_Data	YearMin	YearMax
5002	3010	1997	2024
540	122	2016	2020
103	4	2000	2004

Program names:

103 - EPA STOrage and RETrieval Data Warehouse (STORET)/WQX¹

540 - Shellfish Harvest Area Classification Program²

5002 - Florida STORET / WIN³

Total Phosphorus - Discrete

Seasonal Kendall-Tau Trend Analysis

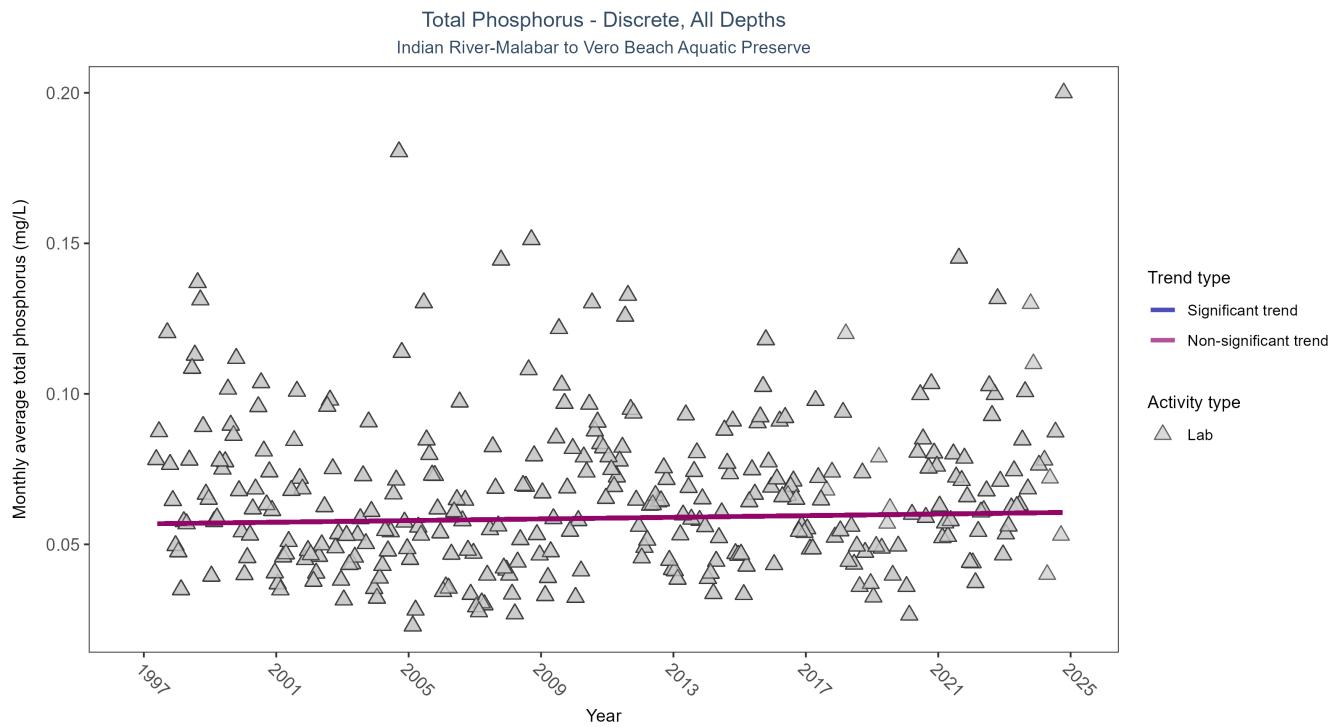


Figure 17: Scatter plot of monthly average total phosphorus over time. If the time series included ten or more years of discrete observations, a significant (blue) or non-significant (magenta) trend line is also shown. Only phosphorus values obtained from laboratory analyses (triangles) are included in the plot.

Table 22: Seasonal Kendall-Tau Trend Analysis for Total Phosphorus

Activity Type	Statistical Trend	Sample Count	Years with Data	Period of Record	Median	tau	Sen Intercept	Sen Slope	p
Lab	No significant trend	6414	28	1997 - 2024	0.054	0.0449	0.0568	0.0001	0.2546

Total phosphorus showed no detectable trend between 1997 and 2024.

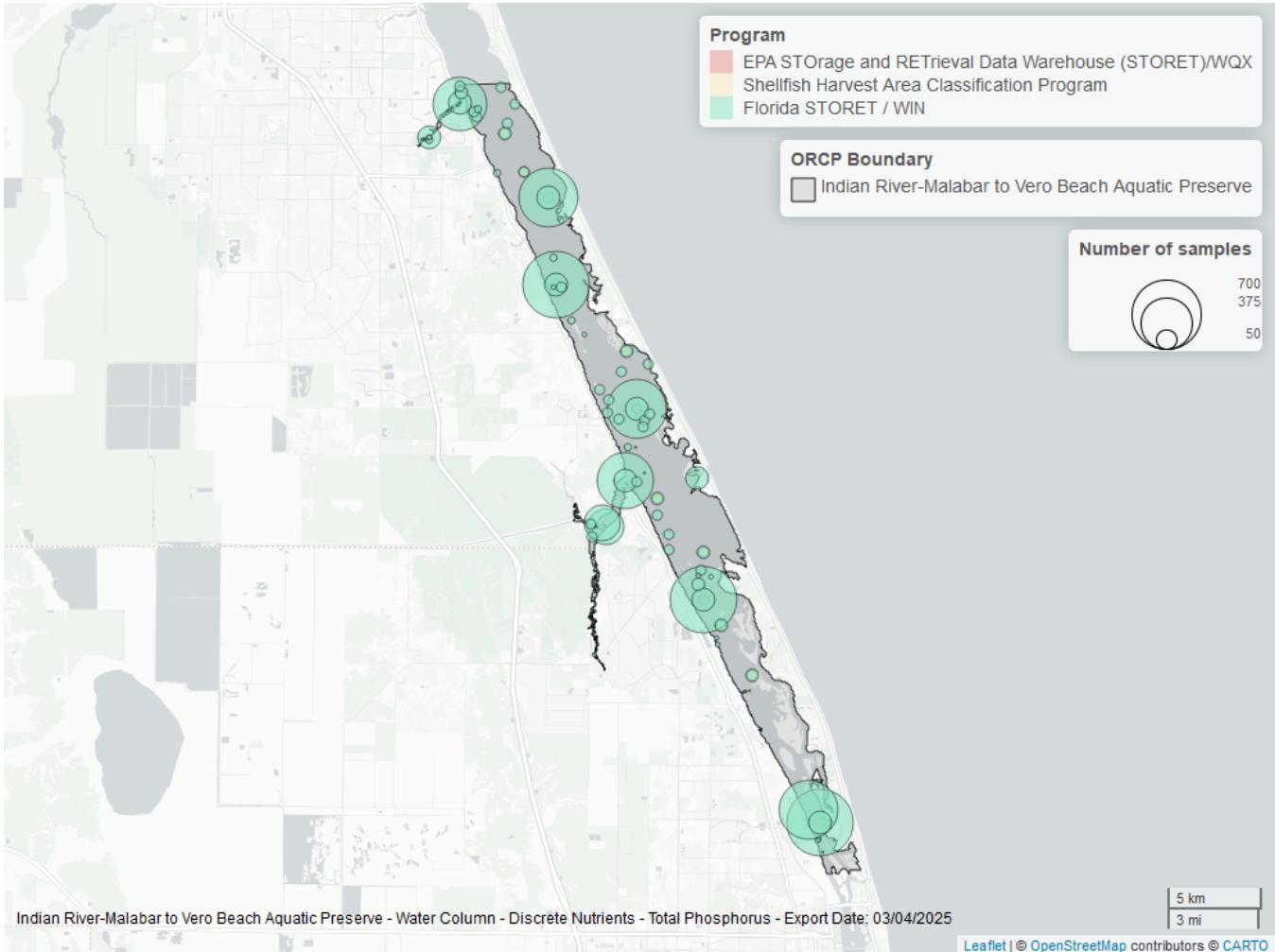


Figure 18: Map showing location of discrete water quality sampling locations within the boundaries of *Indian River-Malabar to Vero Beach Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Table 23: Programs contributing data for Total Phosphorus

<i>ProgramID</i>	<i>N_Data</i>	<i>YearMin</i>	<i>YearMax</i>
5002	6319	1997	2024
540	126	2016	2020
103	76	2020	2021

Program names:

103 - EPA STOrage and RETrieval Data Warehouse (STORET)/WQX¹

540 - Shellfish Harvest Area Classification Program²

5002 - Florida STORET / WIN³

Total Suspended Solids - Discrete

Seasonal Kendall-Tau Trend Analysis

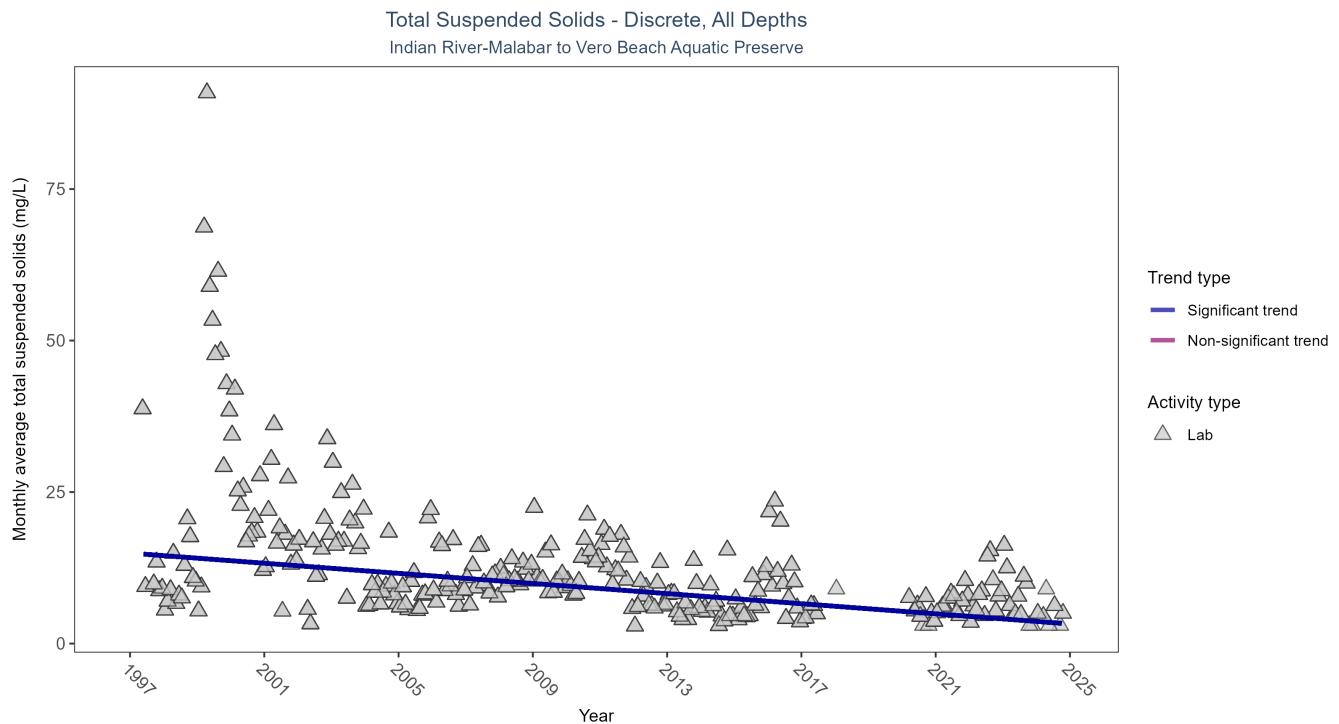


Figure 19: Scatter plot of monthly average total suspended solids (TSS) over time. If the time series included ten or more years of discrete observations, a significant (blue) or non-significant (magenta) trend line is also shown. Only TSS values obtained from laboratory analyses (triangles) are included in the plot.

Table 24: Seasonal Kendall-Tau Trend Analysis for Total Suspended Solids

Activity Type	Statistical Trend	Sample Count	Years with Data	Period of Record	Median	tau	Sen Intercept	Sen Slope	p
Lab	Significantly decreasing trend	3251	27	1997 - 2024	9	-0.4094	14.9248	-0.4175	0

Monthly average total suspended solids decreased by 0.42 mg/L per year, indicating an increase in water clarity.

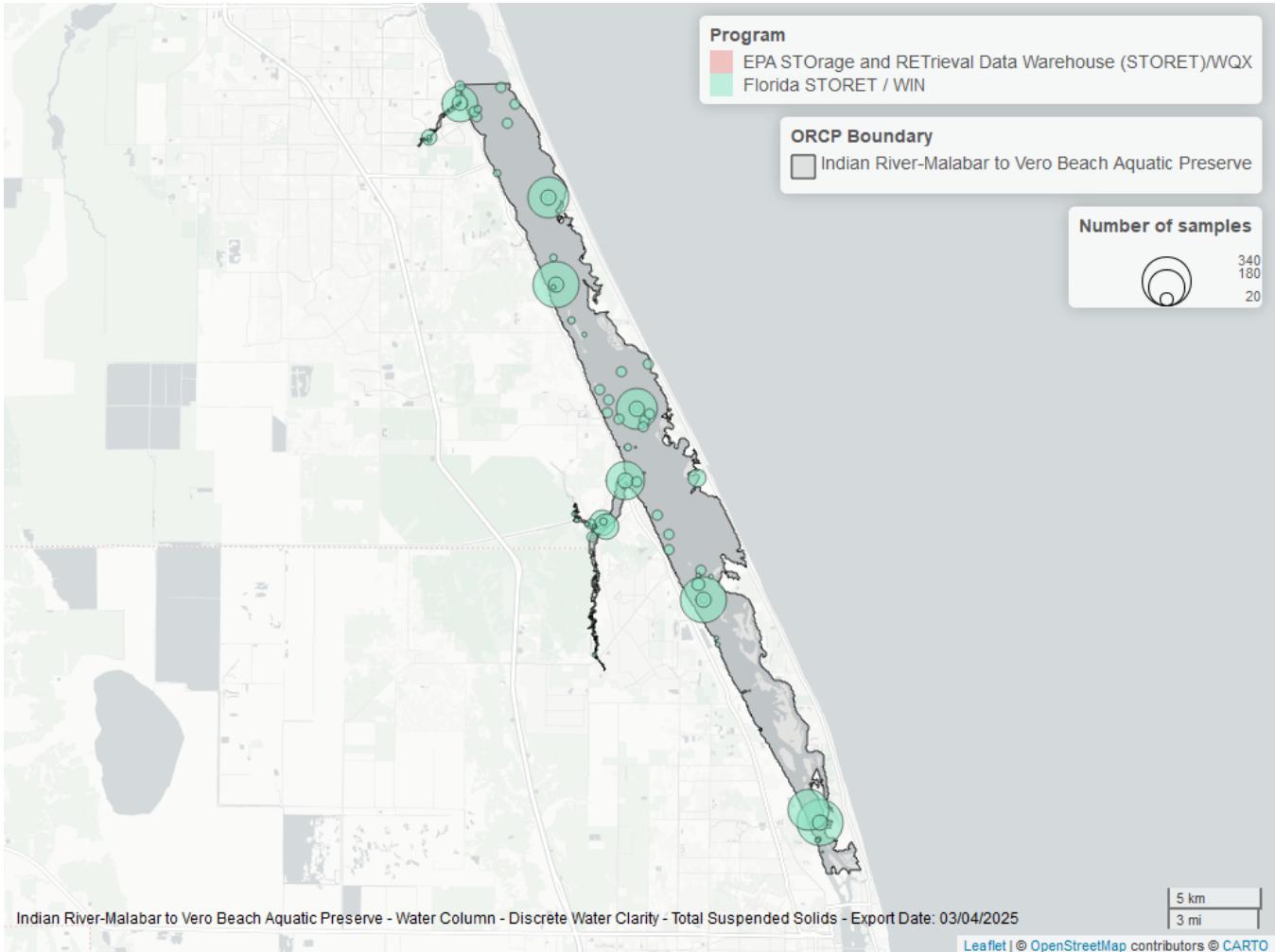


Figure 20: Map showing location of discrete water quality sampling locations within the boundaries of *Indian River-Malabar to Vero Beach Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Table 25: Programs contributing data for Total Suspended Solids

ProgramID	N_Data	YearMin	YearMax
5002	3305	1997	2024
103	41	2020	2021

Program names:

103 - EPA STOrage and RETrieval Data Warehouse (STORET)/WQX¹
 5002 - Florida STORET / WIN³

Turbidity - Discrete

Seasonal Kendall-Tau Trend Analysis

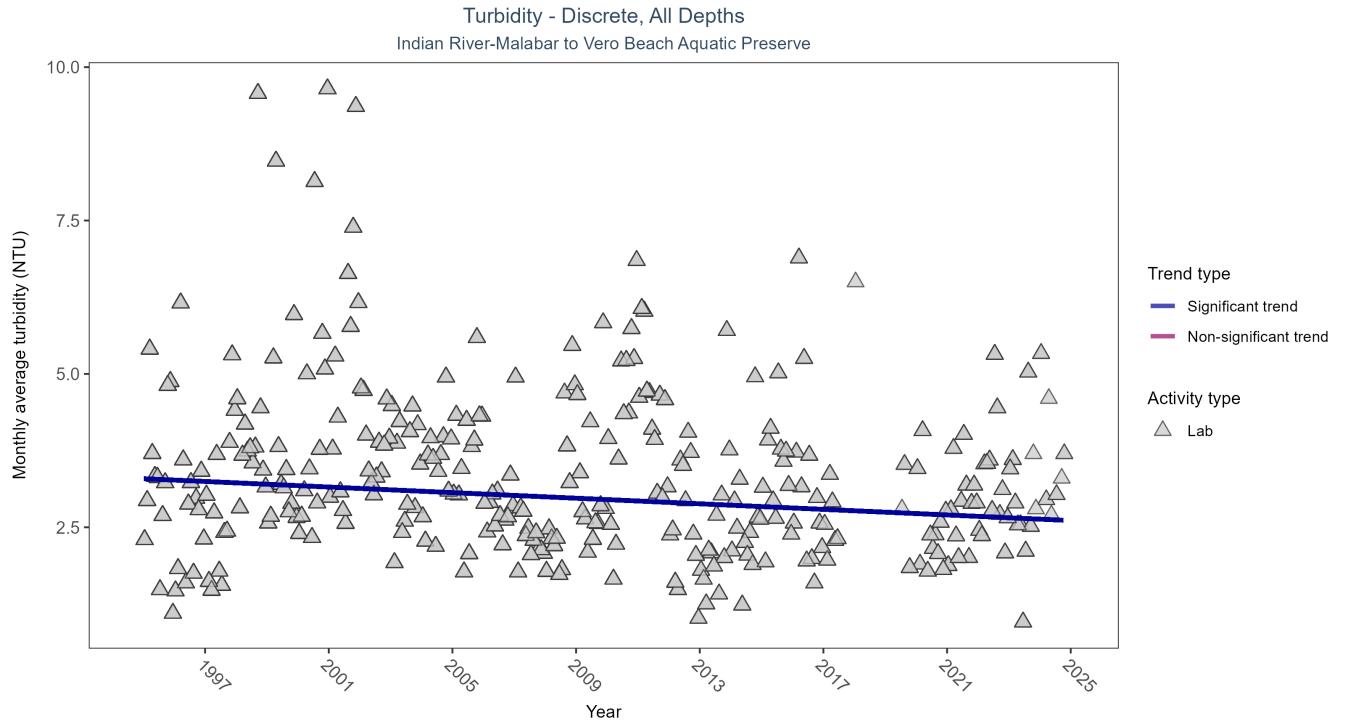


Figure 21: Scatter plot of monthly average turbidity over time. If the time series included ten or more years of discrete observations, a significant (blue) or non-significant (magenta) trend line is also shown. Only turbidity values measured in the laboratory (triangles) are included in the plot.

Table 26: Seasonal Kendall-Tau Trend Analysis for Turbidity

Activity Type	Statistical Trend	Sample Count	Years with Data	Period of Record	Median	tau	Sen Intercept	Sen Slope	p
Lab	Significantly decreasing trend	14396	30	1995 - 2024	2.8	-0.1248	3.2923	-0.0227	0.0019

Monthly average turbidity decreased by 0.02 NTU per year, indicating an increase in water clarity.

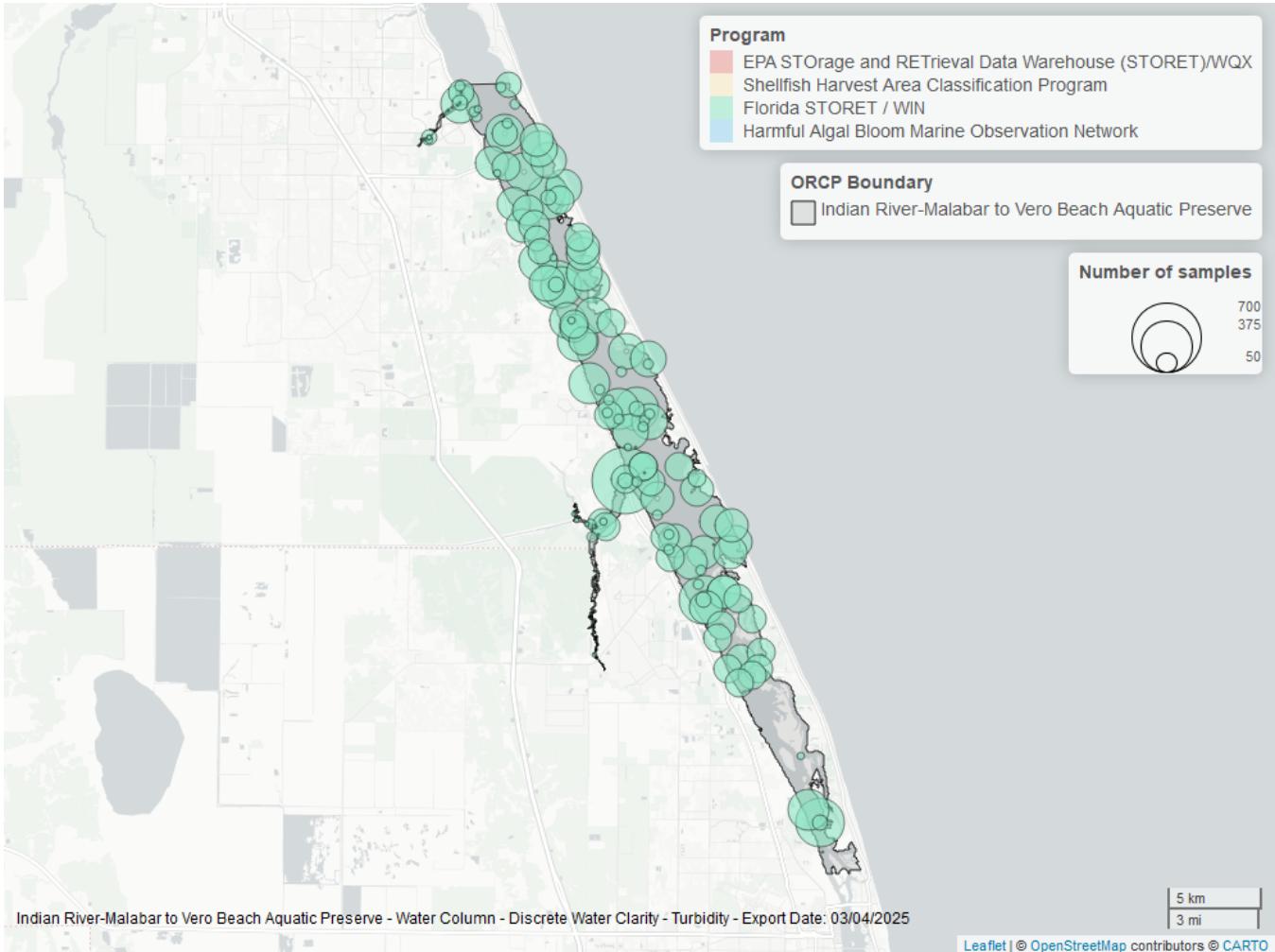


Figure 22: Map showing location of discrete water quality sampling locations within the boundaries of *Indian River-Malabar to Vero Beach Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Table 27: Programs contributing data for Turbidity

ProgramID	N_Data	YearMin	YearMax
5002	14967	1995	2024
3013	938	2004	2019
103	40	2020	2021
540	29	2019	2020
95	1	2008	2008

Program names:

- 95 - Harmful Algal Bloom Marine Observation Network⁴
- 103 - EPA STOrage and RETrieval Data Warehouse (STORET)/WQX¹
- 540 - Shellfish Harvest Area Classification Program²
- 3013 - Seagrass (SJRWM)⁹
- 5002 - Florida STORET / WIN³

Water Temperature - Discrete

Seasonal Kendall-Tau Trend Analysis

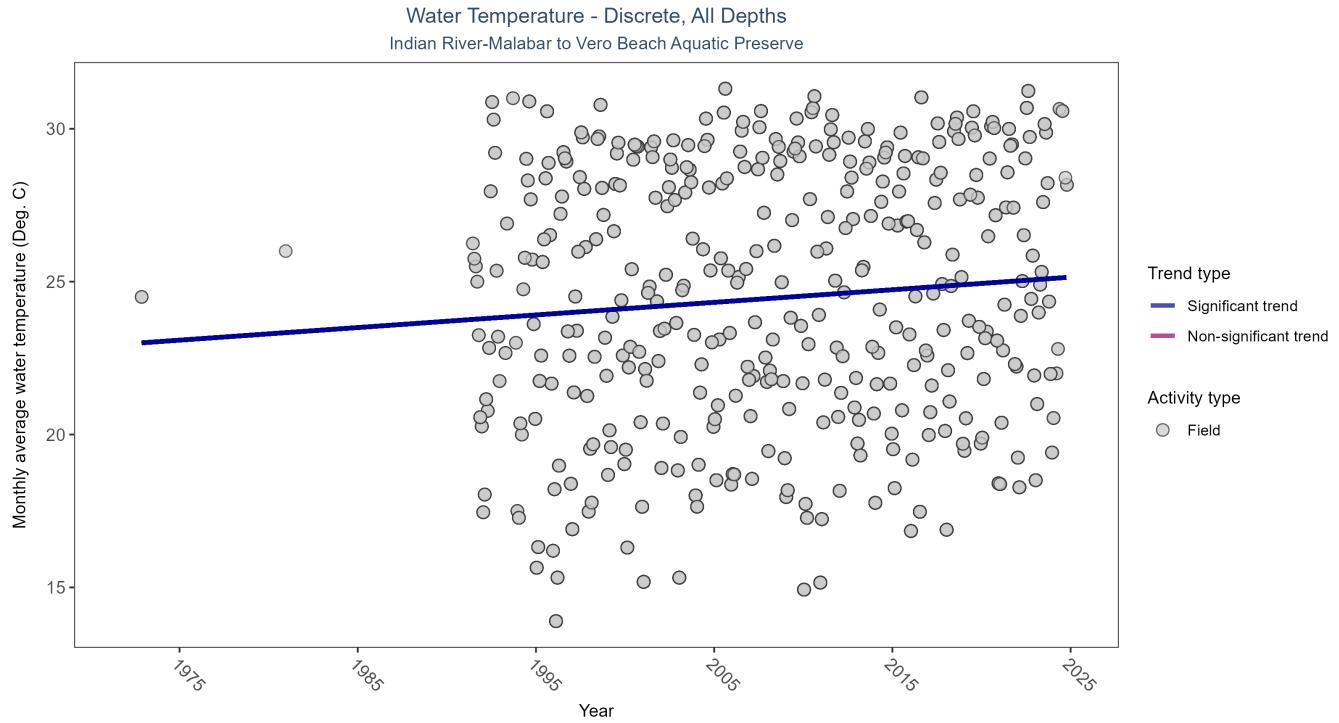


Figure 23: Scatter plot of monthly average water temperature over time. If the time series included ten or more years of discrete observations, a significant (blue) or non-significant (magenta) trend line is also shown. Only water temperature measurements taken in the field (circles) are included in the plot.

Table 28: Seasonal Kendall-Tau Trend Analysis for Water Temperature

Activity Type	Statistical Trend	Sample Count	Years with Data	Period of Record	Median	tau	Sen Intercept	Sen Slope	p
Field	Significantly increasing trend	58894	36	1972 - 2024	25.5	0.2209	22.9629	0.0412	0

Monthly average water temperature increased by 0.04°C per year.

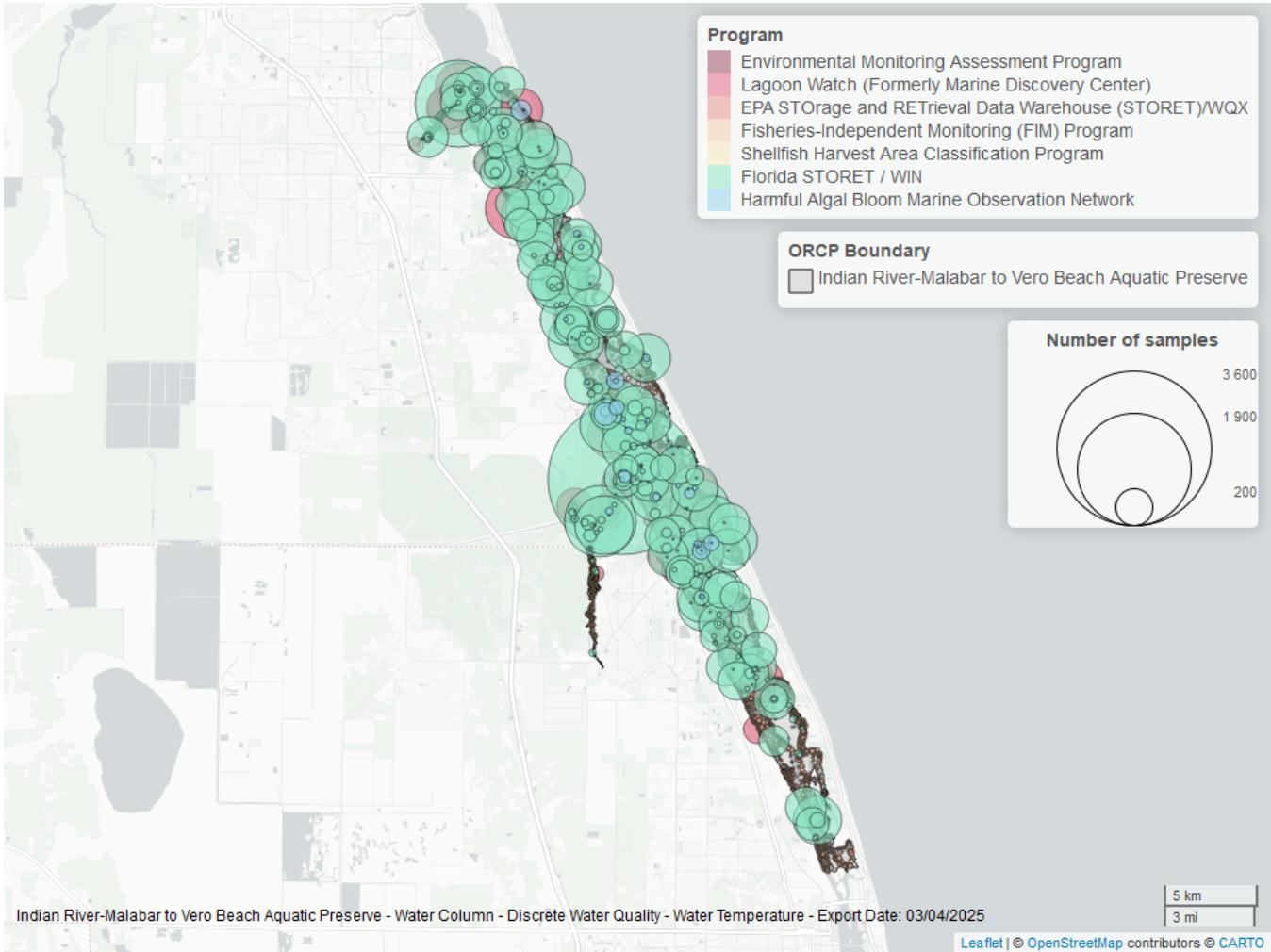


Figure 24: Map showing location of discrete water quality sampling locations within the boundaries of *Indian River-Malabar to Vero Beach Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Table 29: Programs contributing data for Water Temperature

ProgramID	N_Data	YearMin	YearMax
5002	32812	1991	2024
69	19428	1991	2022
3001	6298	1991	2023
3013	1115	2003	2023
95	509	1972	2018
540	127	2016	2020
103	62	2004	2021
115	25	1994	1995

Program names:

- 69 - Fisheries-Independent Monitoring (FIM) Program⁶
- 95 - Harmful Algal Bloom Marine Observation Network⁴
- 103 - EPA STOrage and RETrieval Data Warehouse (STORET)/WQX¹
- 115 - Environmental Monitoring Assessment Program⁷

540 - Shellfish Harvest Area Classification Program²

3001 - Lagoon Watch (Formerly Marine Discovery Center)⁸

3013 - Seagrass (SJRWMD)⁹

5002 - Florida STORET / WIN³

Water Quality - Continuous

The following files were used in the continuous analysis:

- *Combined_WQ_WC_NUT_cont_Dissolved_Oxygen_NE-2025-Mar-06.txt*
- *Combined_WQ_WC_NUT_cont_Dissolved_Oxygen_Saturation_NE-2025-Mar-06.txt*
- *Combined_WQ_WC_NUT_cont_pH_NE-2025-Mar-06.txt*
- *Combined_WQ_WC_NUT_cont_Salinity_NE-2025-Mar-06.txt*
- *Combined_WQ_WC_NUT_cont_Turbidity_NE-2025-Mar-06.txt*
- *Combined_WQ_WC_NUT_cont_Water_Temperature_NE-2025-Mar-06.txt*

Continuous monitoring locations in Indian River-Malabar to Vero Beach Aquatic Preserve

Table 30: Station overview for Continuous parameters by Program

<i>ProgramID</i>	<i>ProgramLocationID</i>	<i>Years of Data</i>	<i>Use in Analysis</i>	<i>Parameters</i>
5005	IRDM	5	TRUE	DO , DOS , pH , Sal , Turb , TempW

Program names:

5005 - Indian River Lagoon Aquatic Preserves Continuous Water Quality Monitoring¹⁰

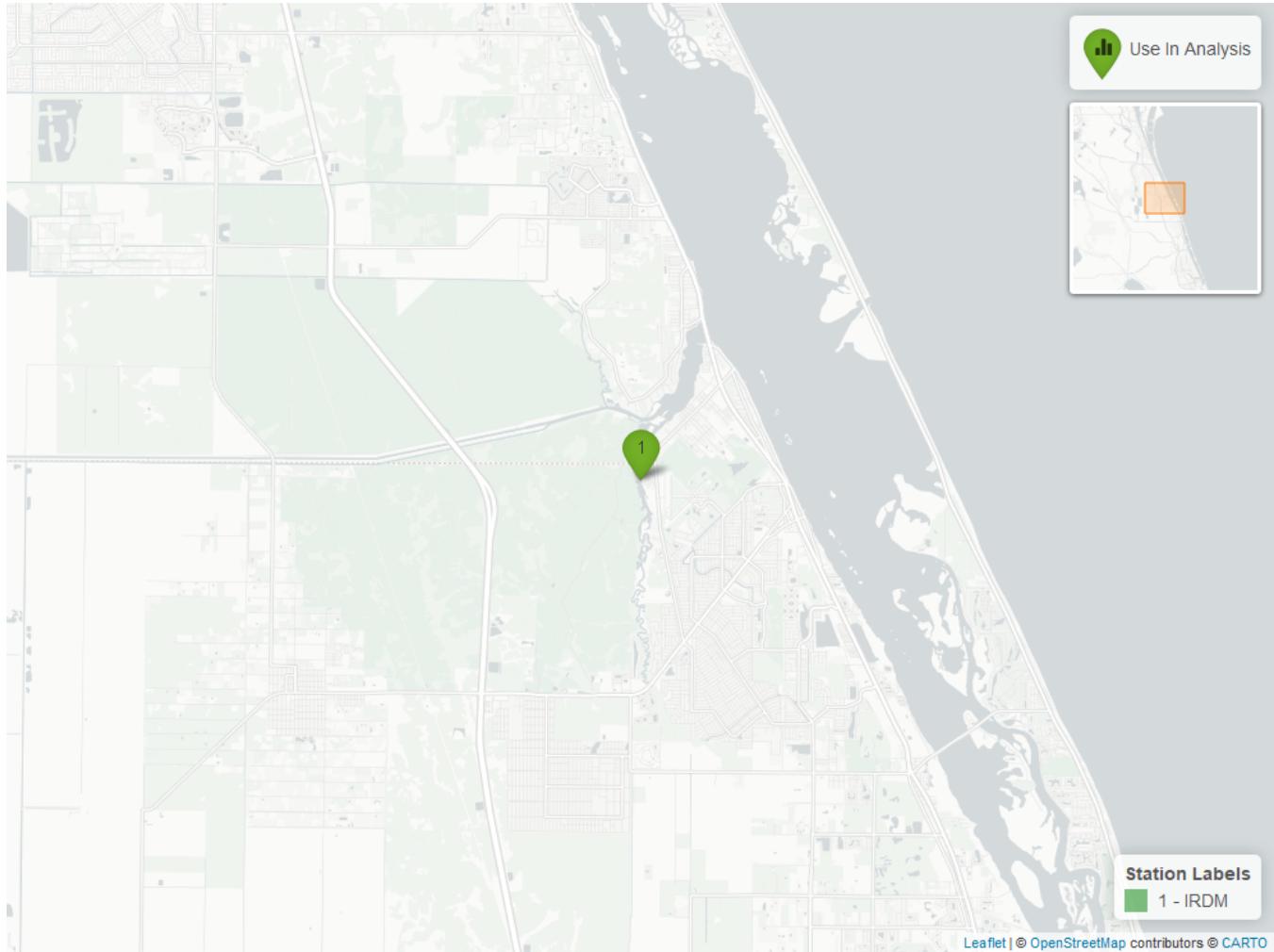


Figure 25: Map showing continuous water quality sampling locations within the boundaries of *Indian River-Malabar to Vero Beach Aquatic Preserve*. Sites marked as *Use In Analysis* (green) are featured in this report.

Dissolved Oxygen - Continuous

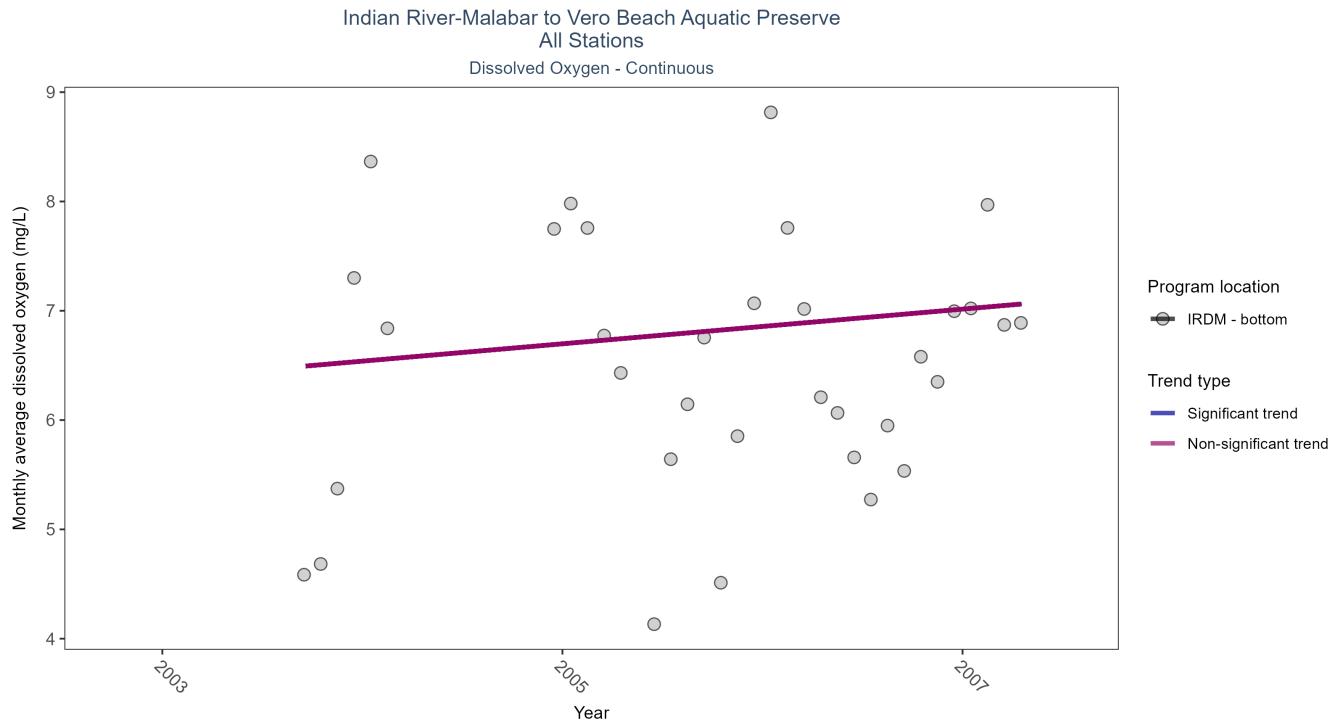


Figure 26: Scatter plot of monthly average dissolved oxygen over time at continuously monitored program locations. Each location is analyzed separately, with significant (blue) or non-significant (magenta) trend lines shown for time series that included five or more years of observations.

Table 31: Seasonal Kendall-Tau Results for Dissolved Oxygen - All Stations

Station	Statistical Trend	Sample Count	Years with Data	Period of Record	Median	tau	Sen Intercept	Sen Slope	p
IRDM	No significant trend	39746	5	2003 - 2007	6.5	0.15	6.38	0.16	0.47

No detectable change in monthly average dissolved oxygen was observed at one location.

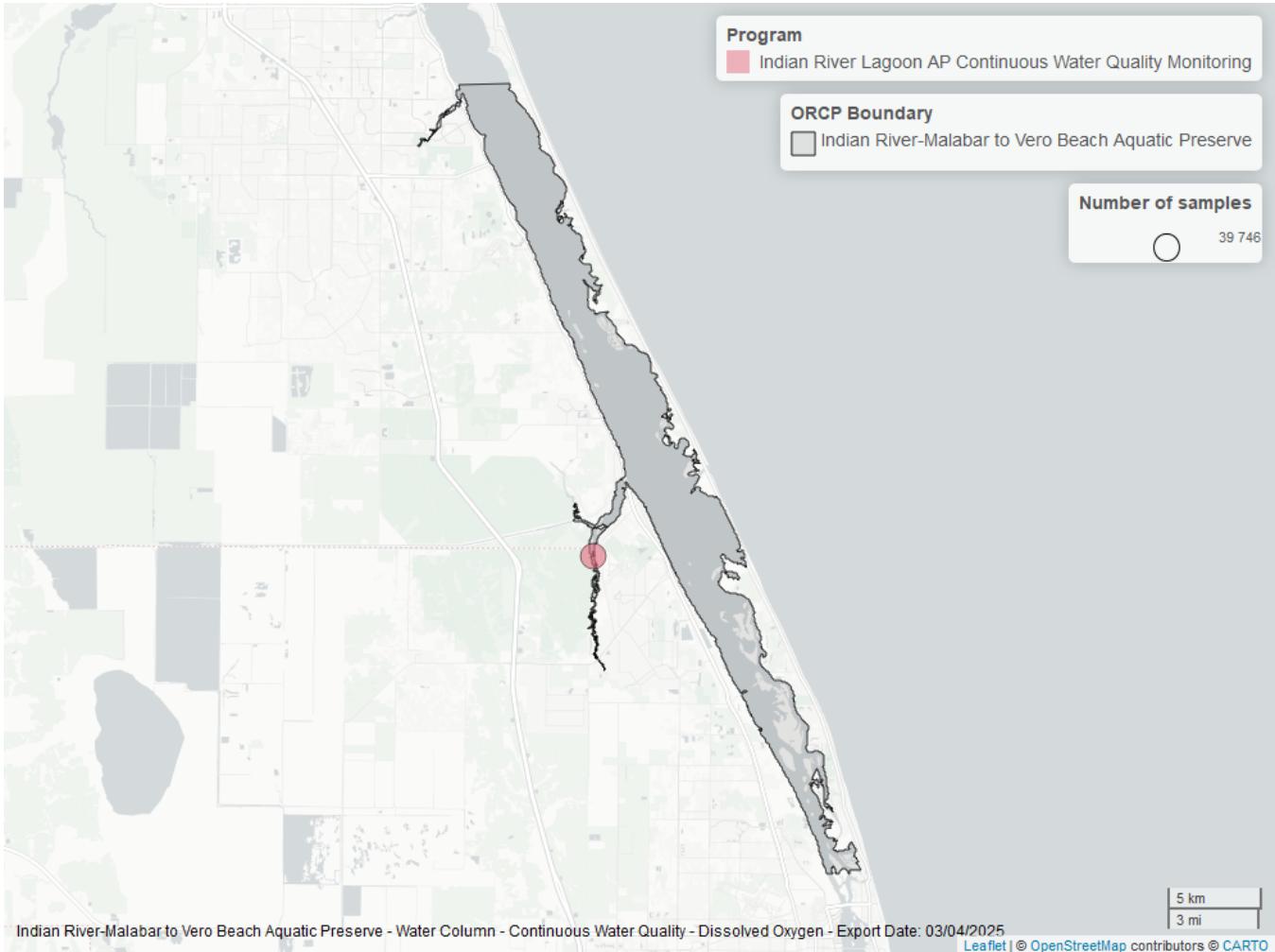


Figure 27: Map showing location of dissolved oxygen continuous water quality sampling locations within the boundaries of *Indian River-Malabar to Vero Beach Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Dissolved Oxygen Saturation - Continuous

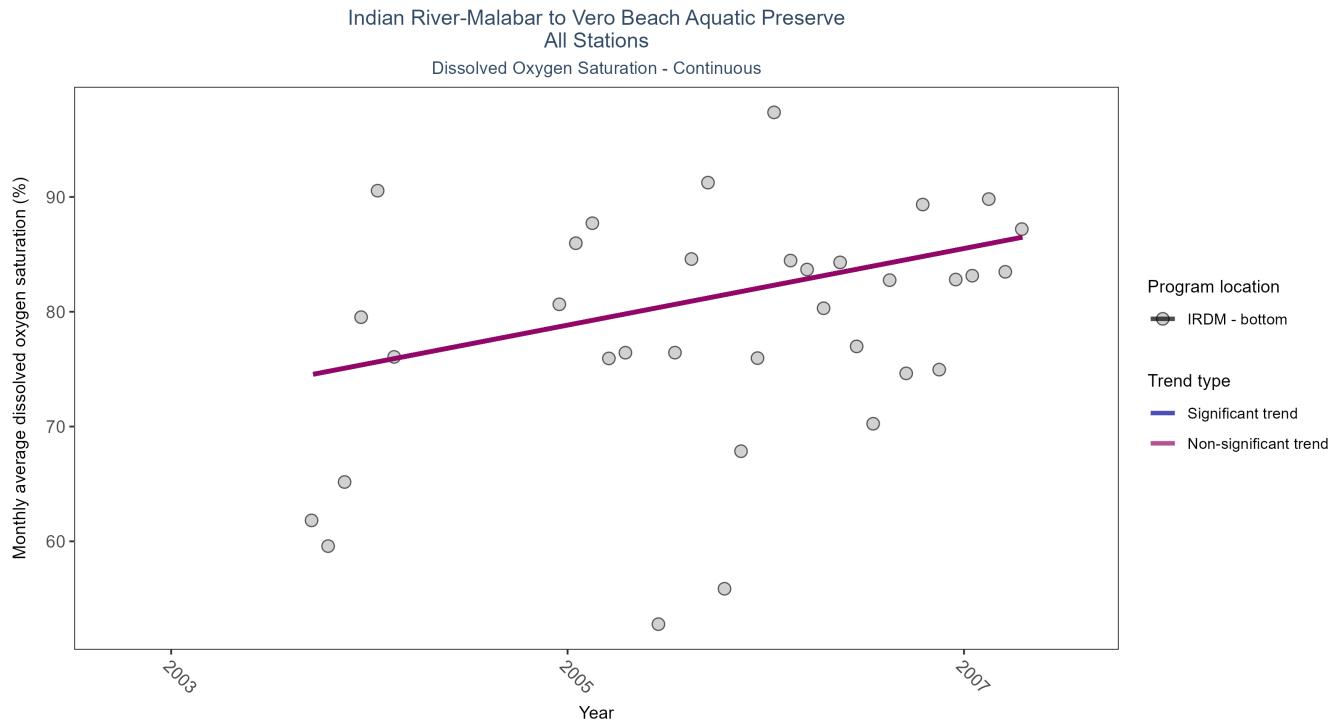


Figure 28: Scatter plot of monthly average dissolved oxygen saturation over time at continuously monitored program locations. Each location is analyzed separately, with significant (blue) or non-significant (magenta) trend lines shown for time series that included five or more years of observations.

Table 32: Seasonal Kendall-Tau Results for Dissolved Oxygen Saturation - All Stations

Station	Statistical Trend	Sample Count	Years with Data	Period of Record	Median	tau	Sen Intercept	Sen Slope	p
IRDM	No significant trend	39746	5	2003 - 2007	77.7	0.29	72.16	3.34	0.11

No detectable change in monthly average dissolved oxygen saturation was observed at one location.

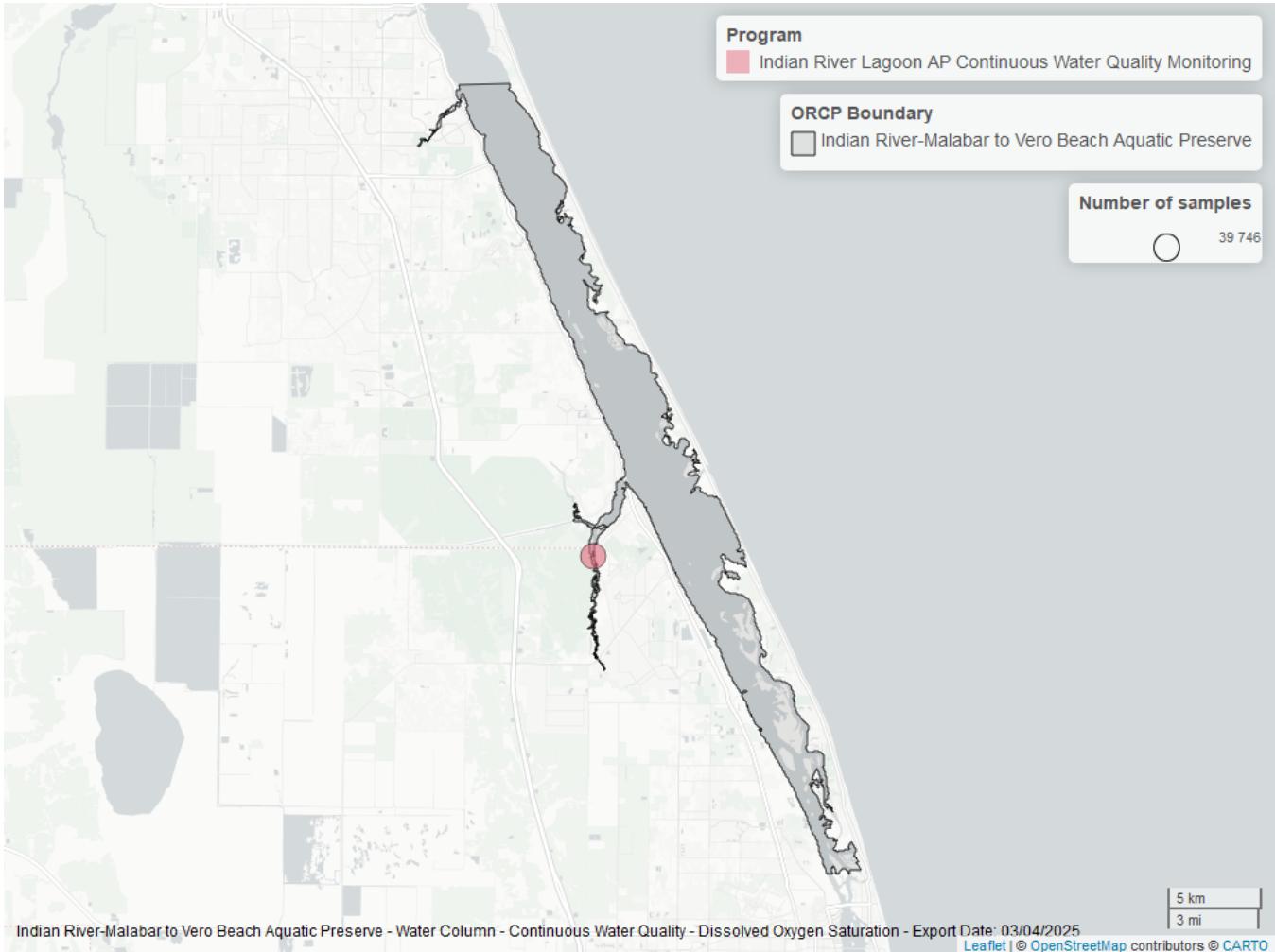


Figure 29: Map showing location of dissolved oxygen saturation continuous water quality sampling locations within the boundaries of *Indian River-Malabar to Vero Beach Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

pH - Continuous

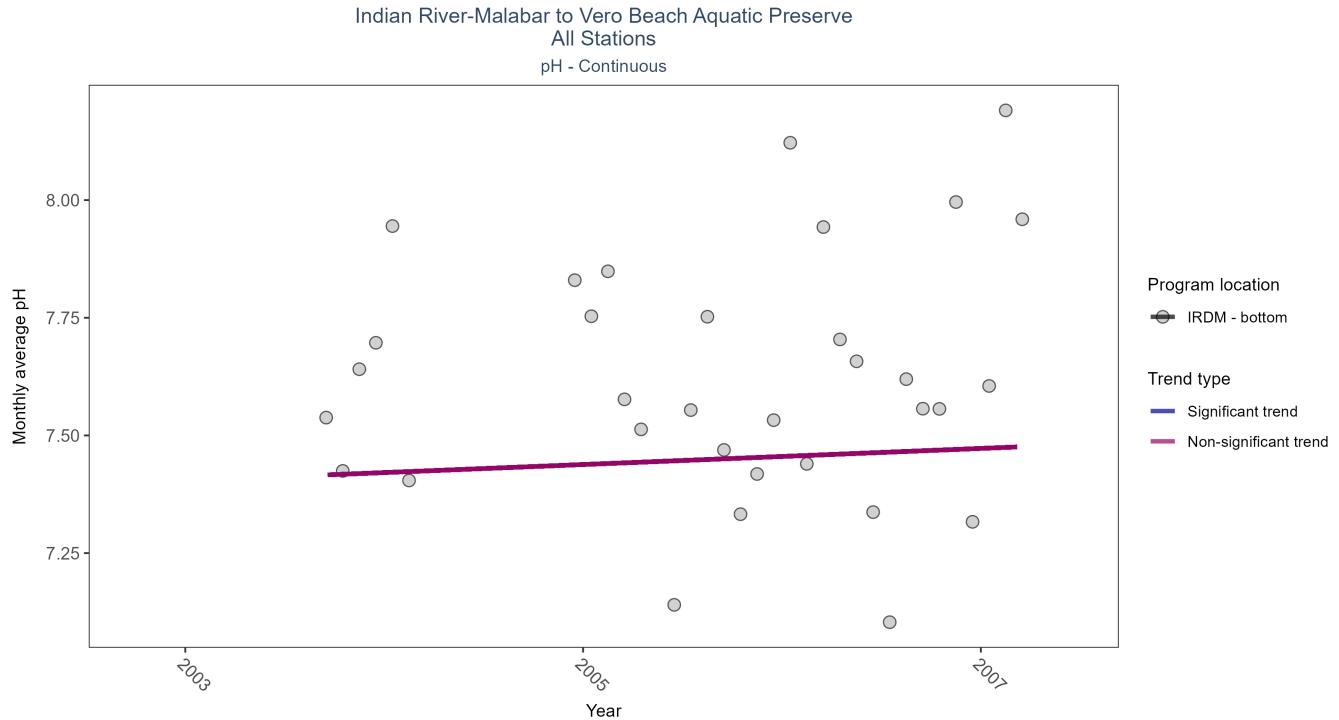


Figure 30: Scatter plot of monthly average pH over time at continuously monitored program locations. Each location is analyzed separately, with significant (blue) or non-significant (magenta) trend lines shown for time series that included five or more years of observations.

Table 33: Seasonal Kendall-Tau Results for pH - All Stations

Station	Statistical Trend	Sample Count	Years with Data	Period of Record	Median	tau	Sen Intercept	Sen Slope	p
IRDM	No significant trend	38184	5	2003 - 2007	7.6	0.15	7.4	0.02	0.65

No detectable change in monthly average pH was observed at one location.

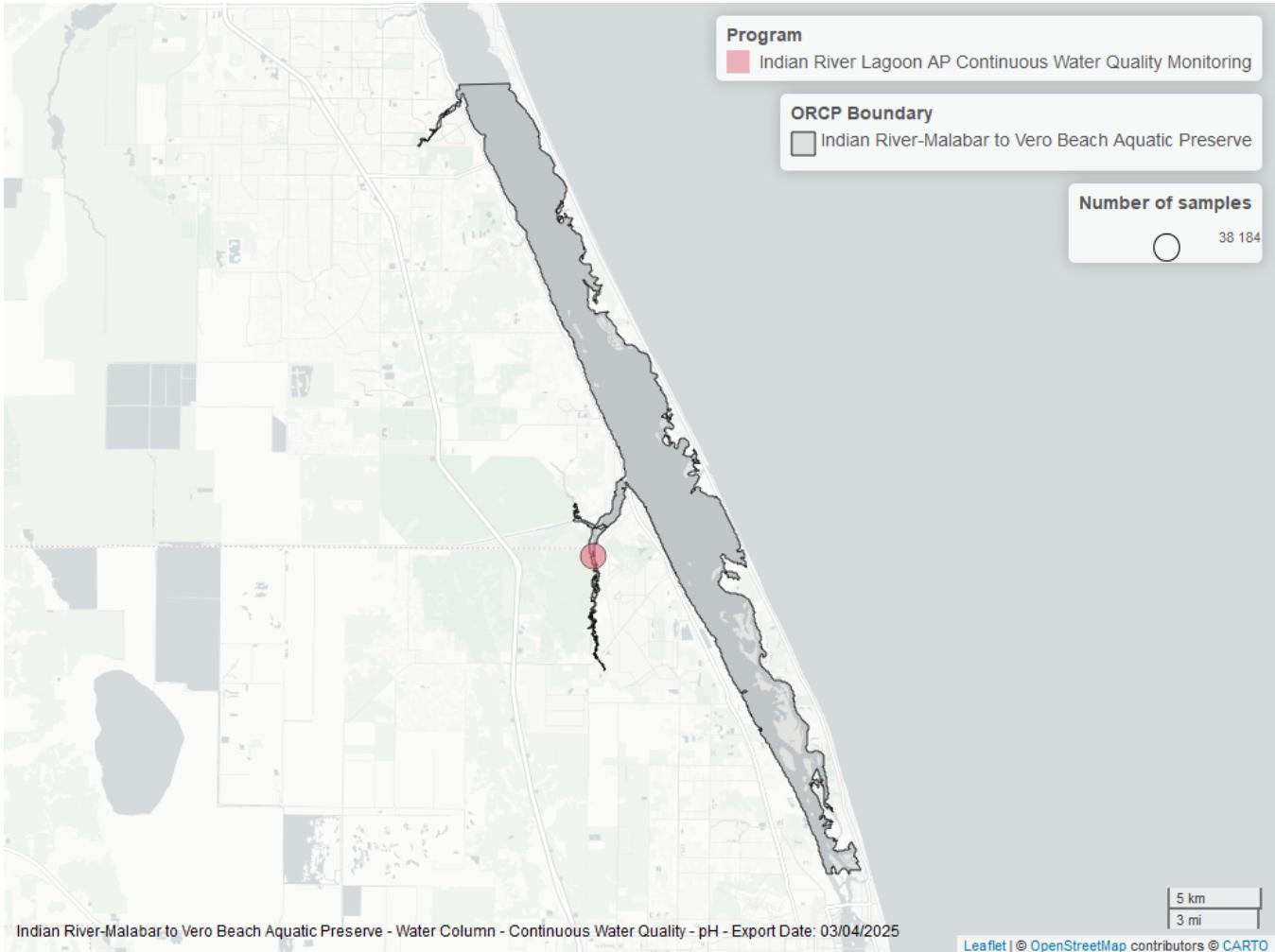


Figure 31: Map showing location of ph continuous water quality sampling locations within the boundaries of *Indian River-Malabar to Vero Beach Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Salinity - Continuous

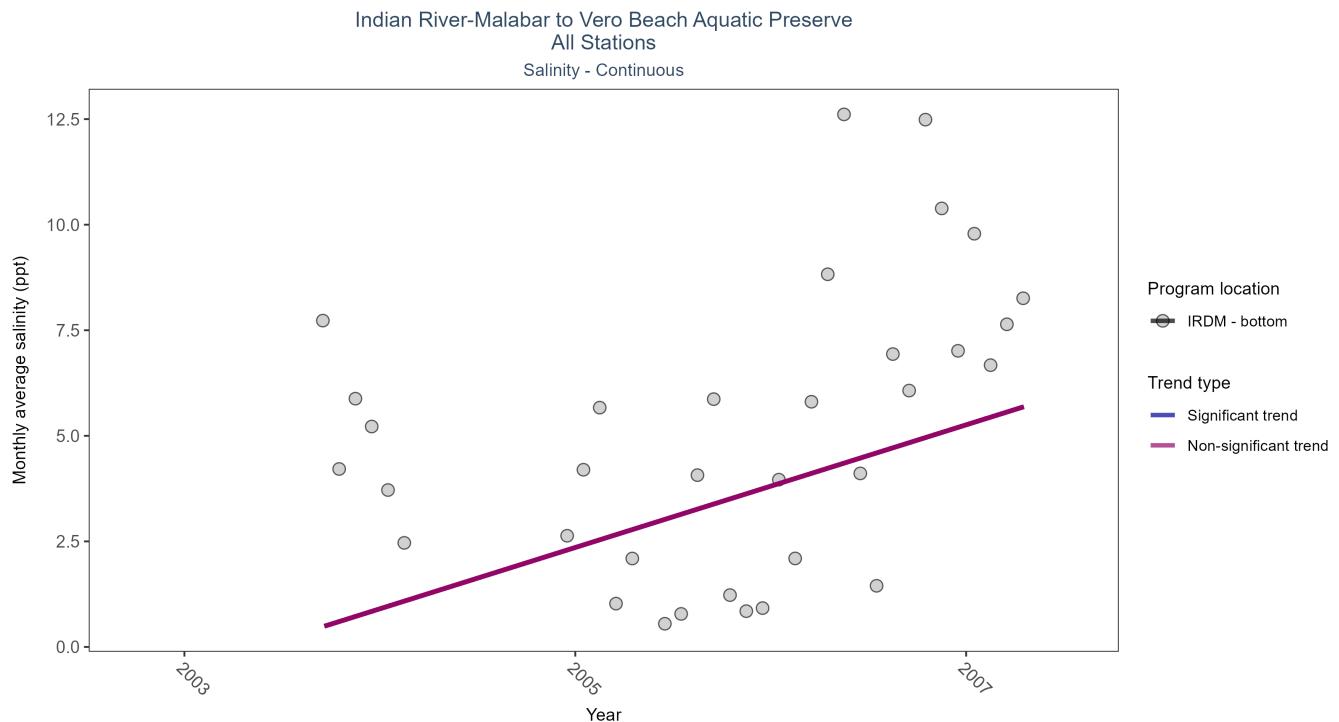


Figure 32: Scatter plot of monthly average salinity over time at continuously monitored program locations. Each location is analyzed separately, with significant (blue) or non-significant (magenta) trend lines shown for time series that included five or more years of observations.

Table 34: Seasonal Kendall-Tau Results for Salinity - All Stations

Station	Statistical Trend	Sample Count	Years with Data	Period of Record	Median	tau	Sen Intercept	Sen Slope	p
IRDM	No significant trend	43791	5	2003 - 2007	3.9	0.45	-0.55	1.45	0.06

No detectable change in monthly average salinity was observed at one location.

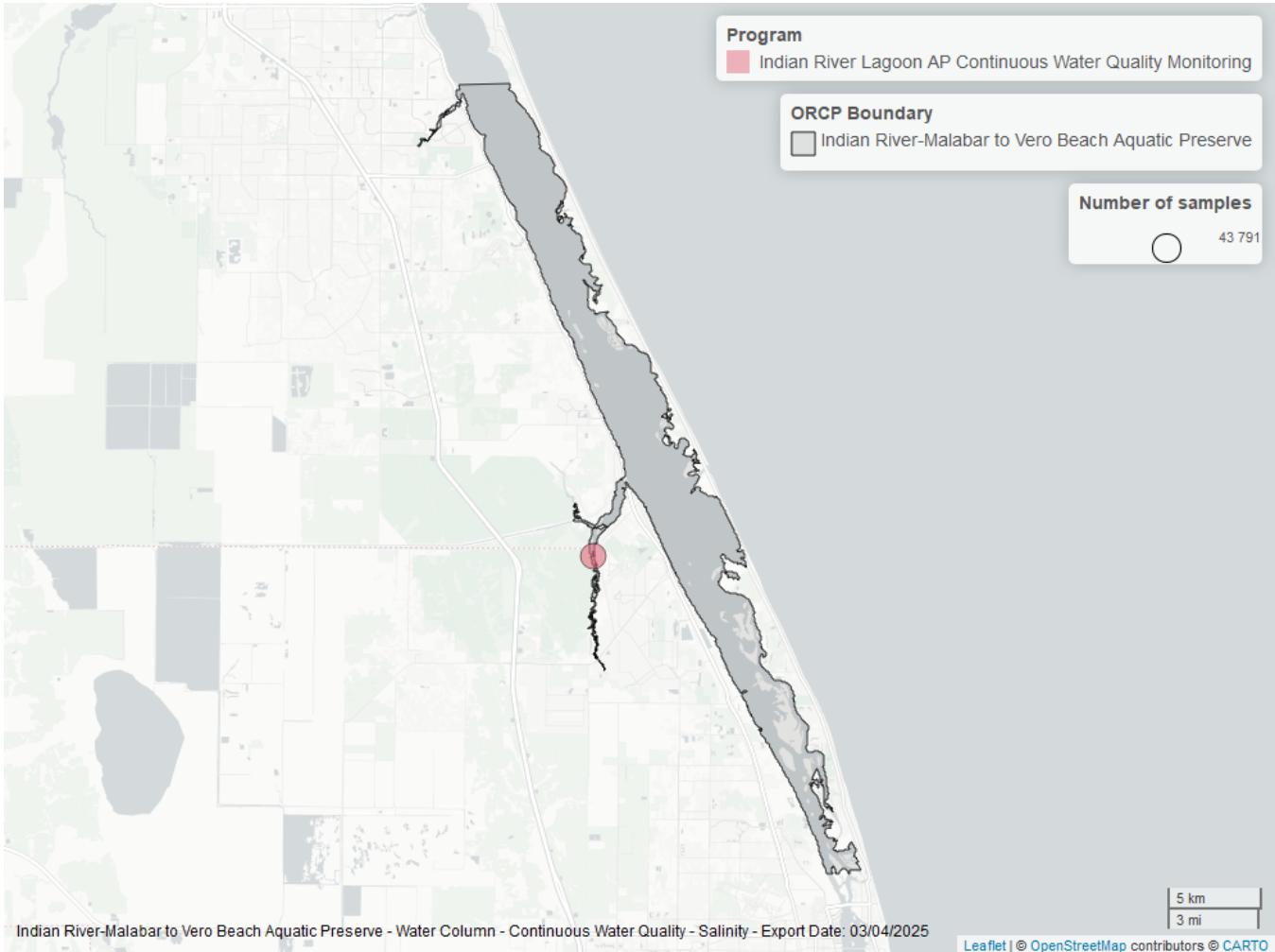


Figure 33: Map showing location of salinity continuous water quality sampling locations within the boundaries of *Indian River-Malabar to Vero Beach Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Turbidity - Continuous

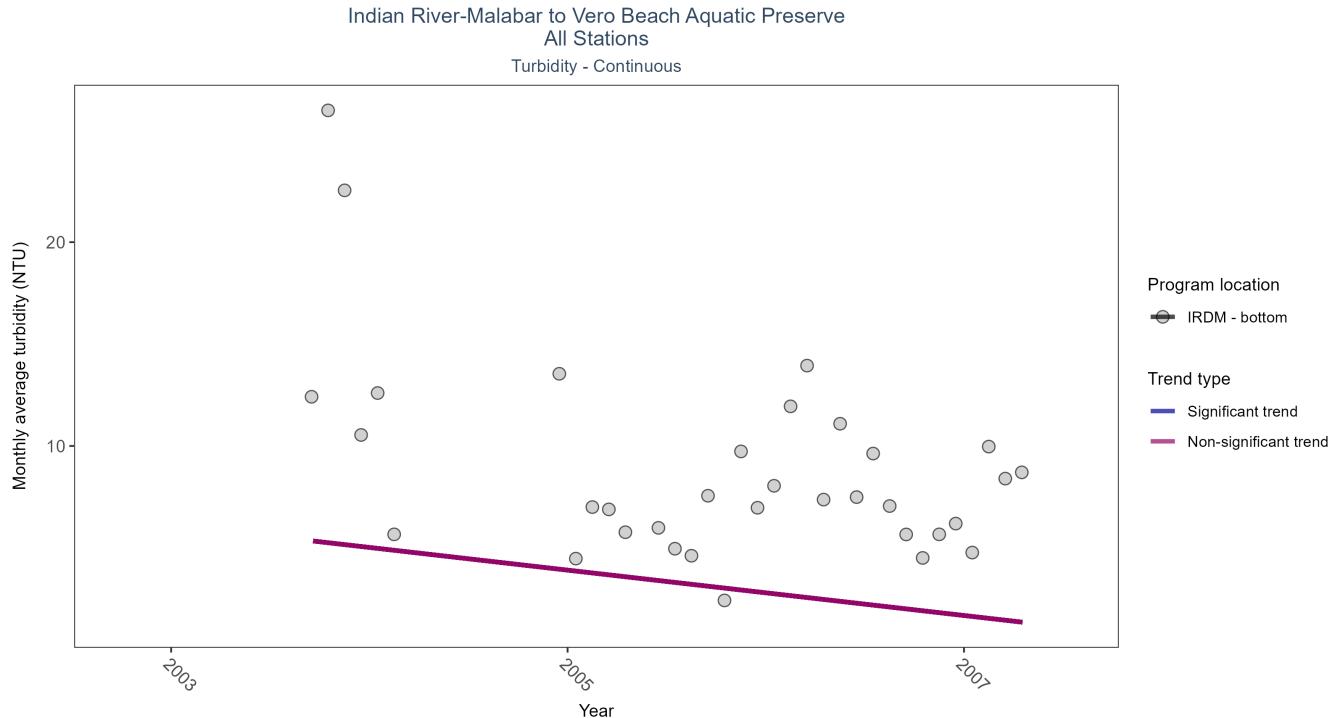


Figure 34: Scatter plot of monthly average turbidity over time at continuously monitored program locations. Each location is analyzed separately, with significant (blue) or non-significant (magenta) trend lines shown for time series that included five or more years of observations.

Table 35: Seasonal Kendall-Tau Results for Turbidity - All Stations

Station	Statistical Trend	Sample Count	Years with Data	Period of Record	Median	tau	Sen Intercept	Sen Slope	p
IRDM	No significant trend	39124	5	2003 - 2007	5	0.05	6.13	-1.11	0.88

No detectable change in monthly average turbidity was observed at one location.

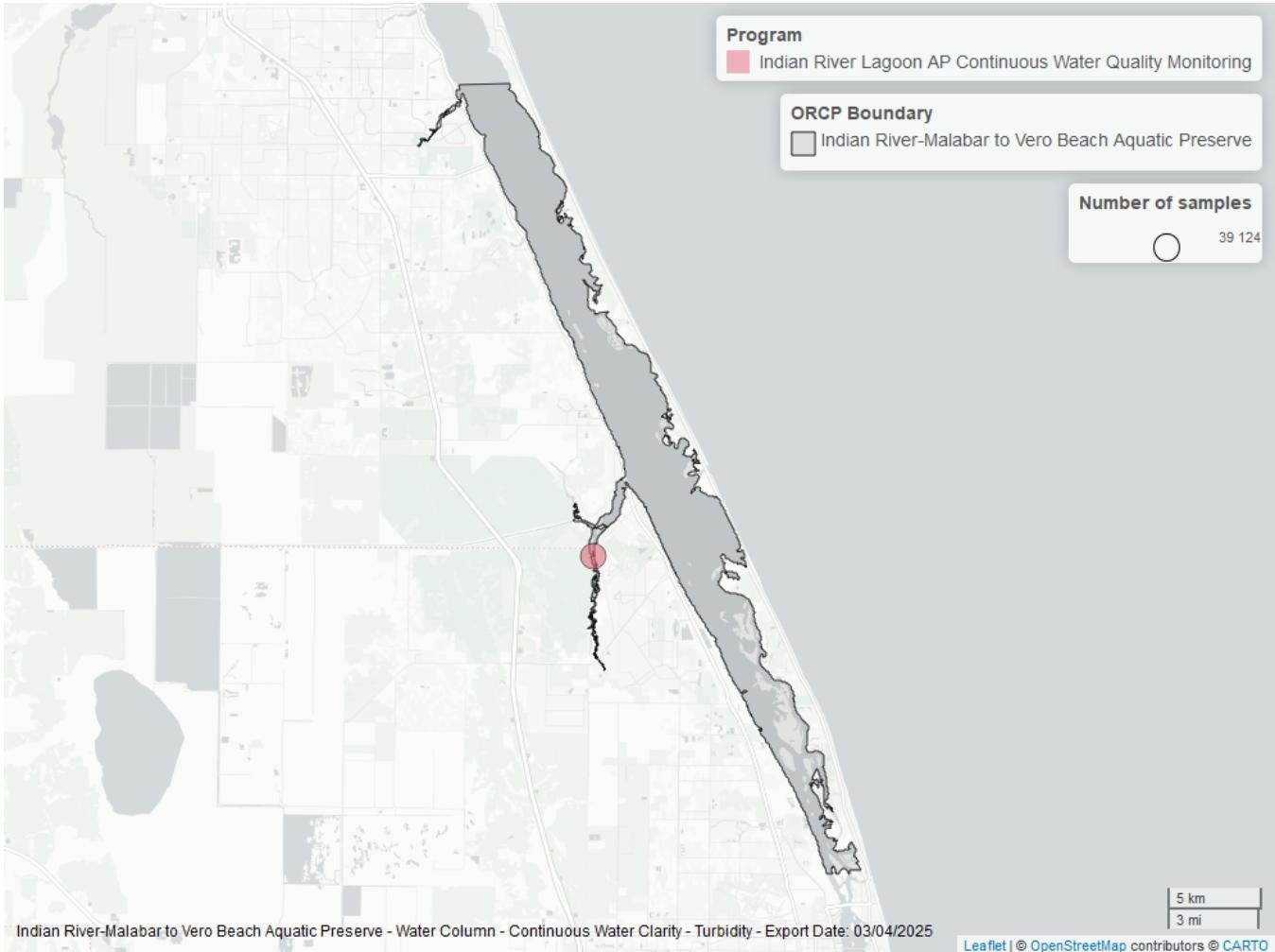


Figure 35: Map showing location of turbidity continuous water quality sampling locations within the boundaries of *Indian River-Malabar to Vero Beach Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Water Temperature - Continuous

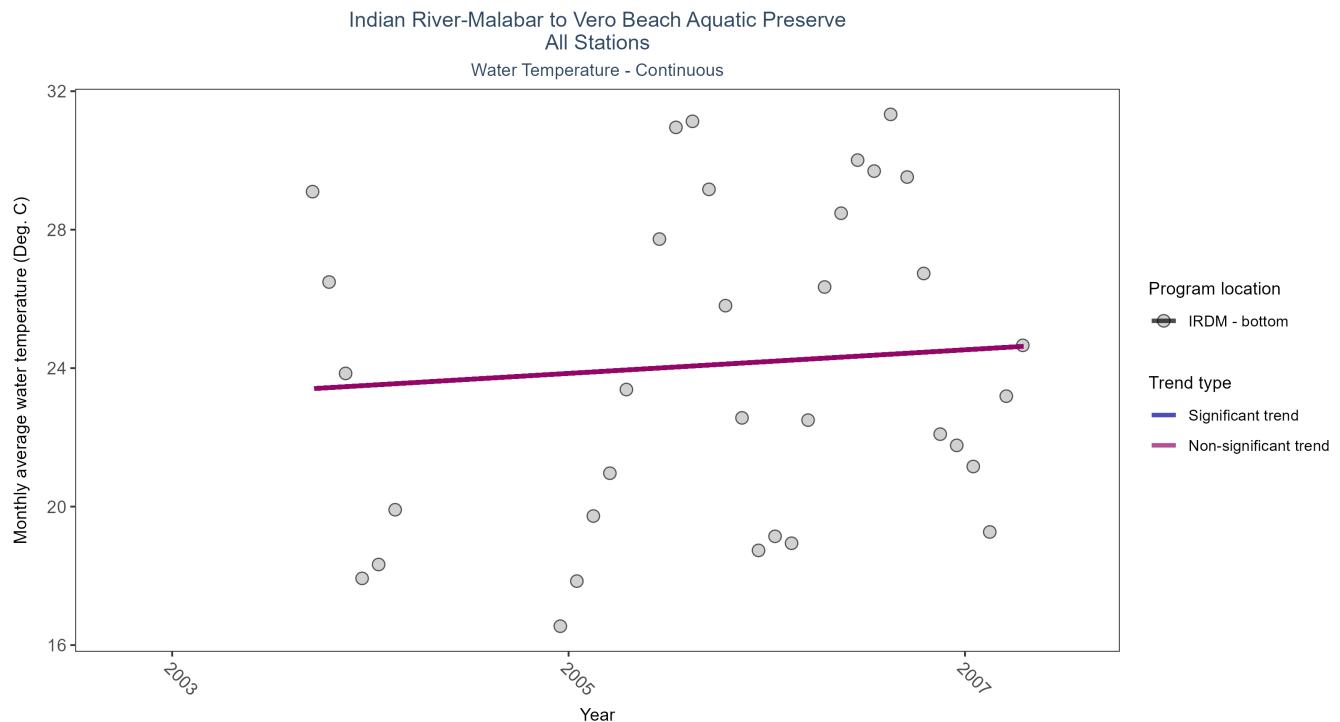


Figure 36: Scatter plot of monthly average water temperature over time at continuously monitored program locations. Each location is analyzed separately, with significant (blue) or non-significant (magenta) trend lines shown for time series that included five or more years of observations.

Table 36: Seasonal Kendall-Tau Results for Water Temperature - All Stations

Station	Statistical Trend	Sample Count	Years with Data	Period of Record	Median	tau	Sen Intercept	Sen Slope	p
IRDM	No significant trend	43791	5	2003 - 2007	23.5	0.29	23.17	0.34	0.19

No detectable change in monthly average water temperature was observed at one location.

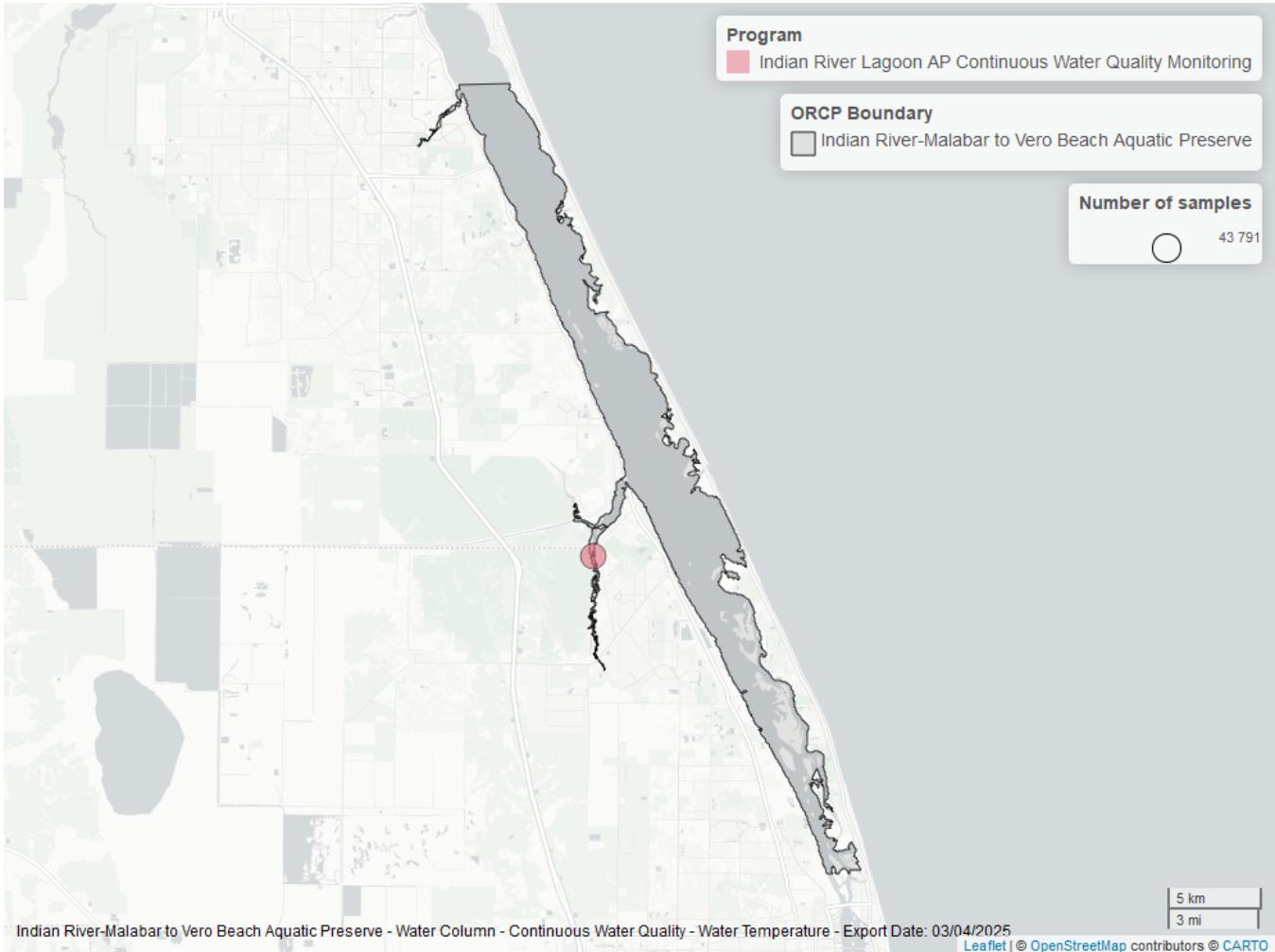


Figure 37: Map showing location of water temperature continuous water quality sampling locations within the boundaries of *Indian River-Malabar to Vero Beach Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Submerged Aquatic Vegetation

The data file used is: All_SAV_Parameters-2025-Mar-06.txt

Submerged aquatic vegetation (SAV) refers to plants and plant-like macroalgae species that live entirely underwater. The two primary categories of SAV inhabiting Florida estuaries are *benthic macroalgae* and *seagrasses*. They often grow together in dense beds or meadows that carpet the seafloor. *Macroalgae* include multicellular species of green, red and brown algae that often live attached to the substrate by a holdfast. They tend to grow quickly and can tolerate relatively high nutrient levels, making them a threat to seagrasses and other benthic habitats in areas with poor water quality. In contrast, *seagrasses* are grass-like, vascular, flowering plants that are attached to the seafloor by extensive root systems. *Seagrasses* occur throughout the coastal areas of Florida, including protected bays and lagoons as well as deeper offshore waters on the continental shelf. *Seagrasses* have taken advantage of the broad, shallow shelf and clear water to produce two of the most extensive seagrass beds anywhere in continental North America.

Parameters

Percent Cover measures the fraction of an area of seafloor that is covered by SAV, usually estimated by evaluating multiple small areas of seafloor. Percent cover is often estimated for total SAV, individual types of vegetation (seagrass, attached algae, drift algae) and individual species.

Frequency of Occurrence was calculated as the number of times a taxon was observed in a year divided by the number of sampling events, multiplied by 100. Analysis is conducted at the quadrat level and is inclusive of all quadrats (i.e., quadrats evaluated using Braun-Blanquet, modified Braun-Blanquet, and percent cover.)

Species

Turtle grass (*Thalassia testudinum*) is the largest of the Florida seagrasses, with longer, thicker blades and deeper root structures than any of the other seagrasses. It is considered a climax seagrass species.

Shoal grass (*Halodule wrightii*) is an early colonizer of vegetated areas and usually grows in water too shallow for other species except *widgeon grass*. It can often tolerate larger salinity ranges than other seagrass species. *Shoal grass* is characterized by thin, flat blades, that are narrower than *turtle grass* blades.

Manatee grass (*Syringodium filiforme*) is easily recognizable because its leaves are thin and cylindrical instead of the flat, ribbon-like form shared by many other seagrass species. The leaves can grow up to half a meter in length. *Manatee grass* is usually found in mixed seagrass beds or small, dense monospecific patches.

Widgeon grass (*Ruppia maritima*) grows in both fresh and salt water and is widely distributed throughout Florida's estuaries in less saline areas, particularly in inlets along the east coast. This species resembles *shoal grass* in certain environments but can be identified by the pointed tips of its leaves.

Three species of *Halophila spp.* are found in Florida - **Star grass** (*Halophila engelmannii*), **Paddle grass** (*Halophila decipiens*), and **Johnson's seagrass** (*Halophila johnsonii*). These are smaller, more fragile seagrasses than other Florida species and are considered ephemeral. They grow along a single long rhizome, with short blades. These species are not well-studied, although surveys are underway to define their ecological roles.

Notes

Star grass, *Paddle grass*, and *Johnson's seagrass* will be grouped together and listed as **Halophila spp.** in the following managed areas. This is because several surveys did not specify to the species level:

- Banana River Aquatic Preserve
- Indian River-Malabar to Vero Beach Aquatic Preserve
- Indian River-Vero Beach to Ft. Pierce Aquatic Preserve
- Jensen Beach to Jupiter Inlet Aquatic Preserve
- Loxahatchee River-Lake Worth Creek Aquatic Preserve
- Mosquito Lagoon Aquatic Preserve

- Biscayne Bay Aquatic Preserve
- Florida Keys National Marine Sanctuary

Indian River-Malabar to Vero Beach Aquatic Preserve
SAV Percent Cover - Sample Locations

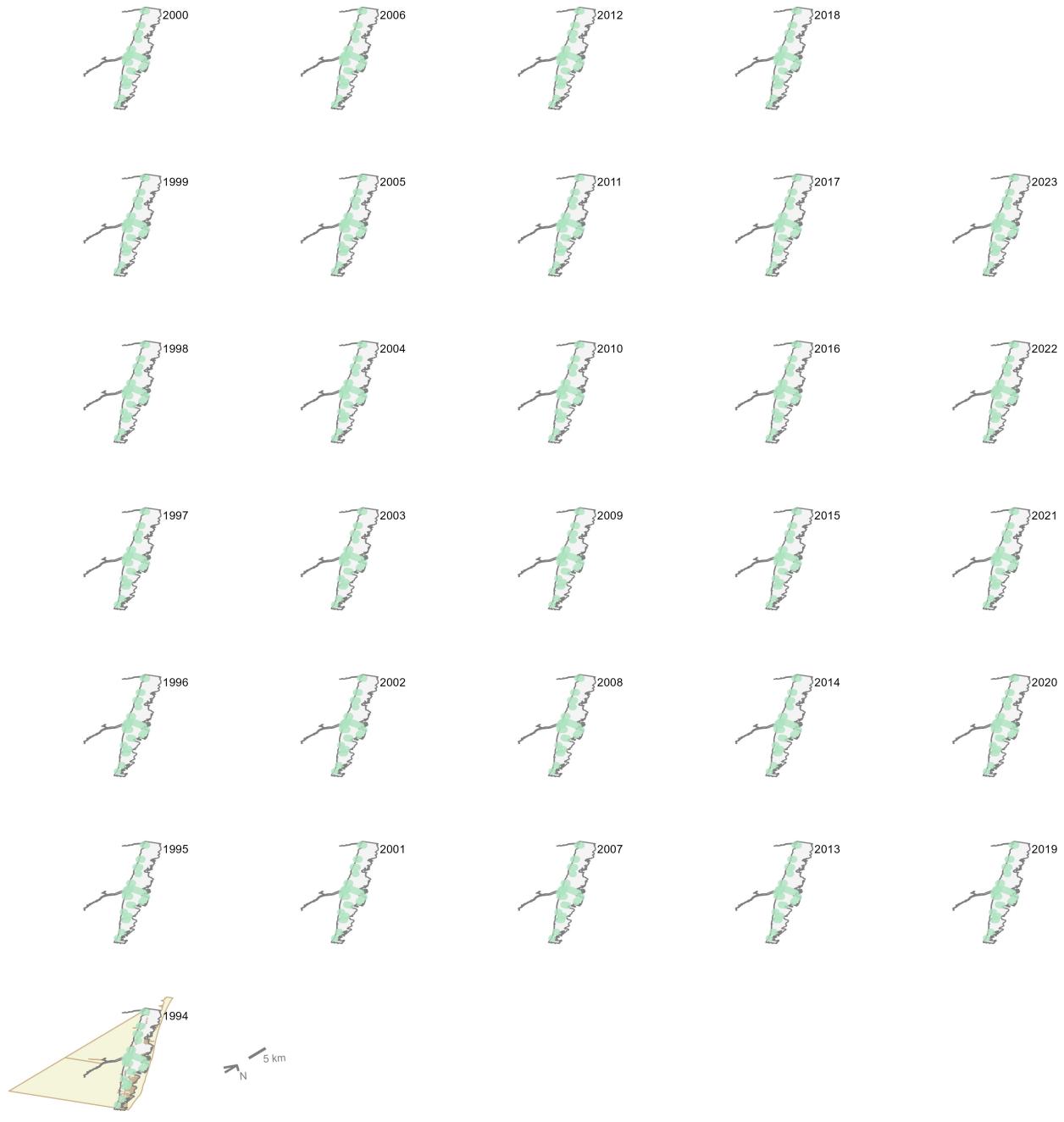


Figure 38: Maps showing the temporal scope of SAV sampling sites within the boundaries of *Indian River-Malabar to Vero Beach Aquatic Preserve* by Program name.

Click [here](#) to view spatio-temporal plots on GitHub.

Sampling locations by Program:

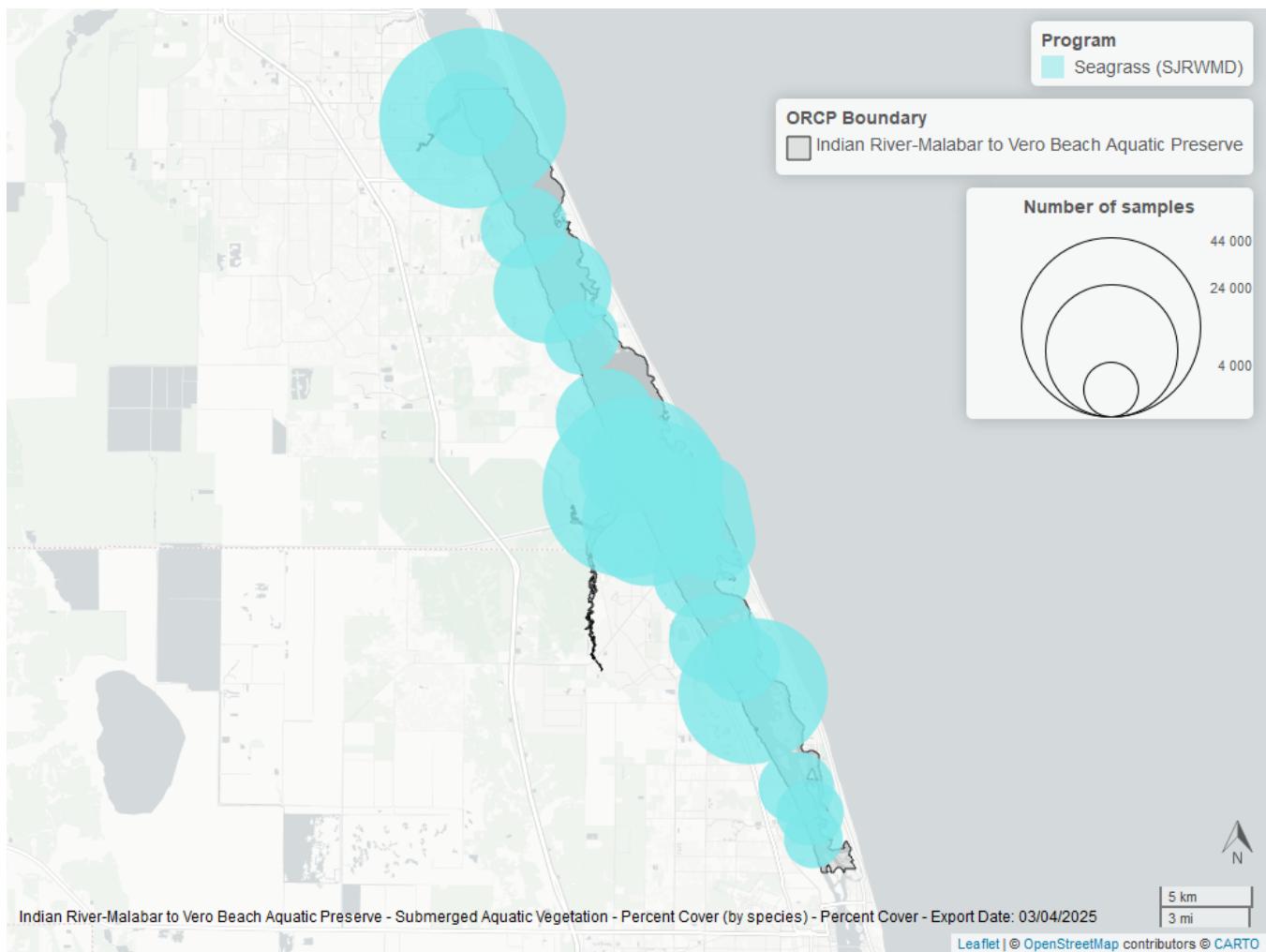


Figure 39: Map showing SAV sampling sites within the boundaries of *Indian River-Malabar to Vero Beach Aquatic Preserve*. The point size reflects the number of samples at a given sampling site.

Table 37: Program Information for Submerged Aquatic Vegetation

ProgramID	N-Data	YearMin	YearMax	method	Sample Locations
3013	123999	1994	2023	Percent Cover	19
3013	146527	1994	2023	Percent Occurrence	19

Program names:

- 3013 - Seagrass (SJRWMD)⁹
3013 - Seagrass (SJRWMD)⁹

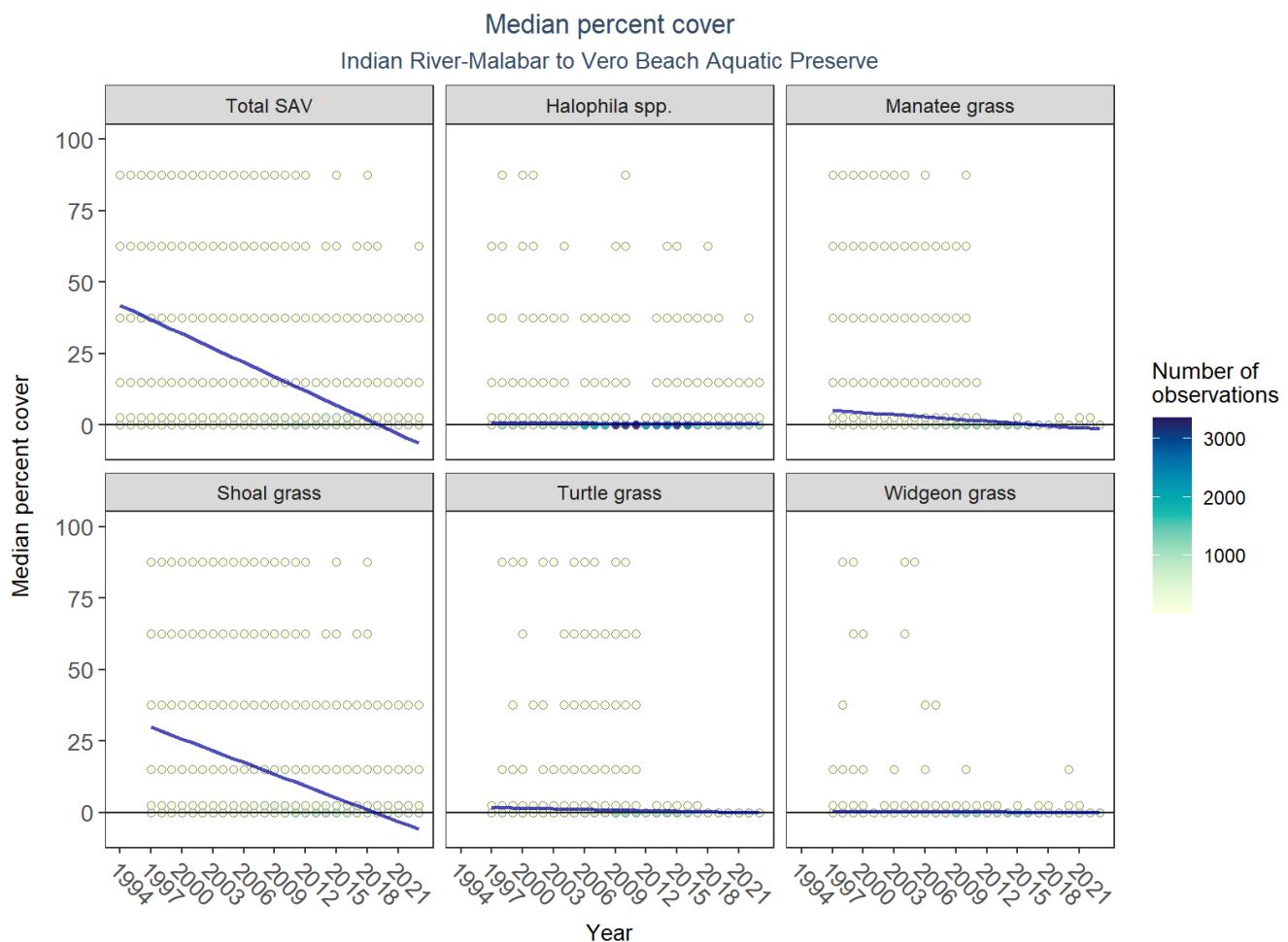


Figure 40: Scatter plots of median percent cover of submerged aquatic vegetation over time by group. Plots for time series that included five or more years of observations show the estimated trend as a blue line.

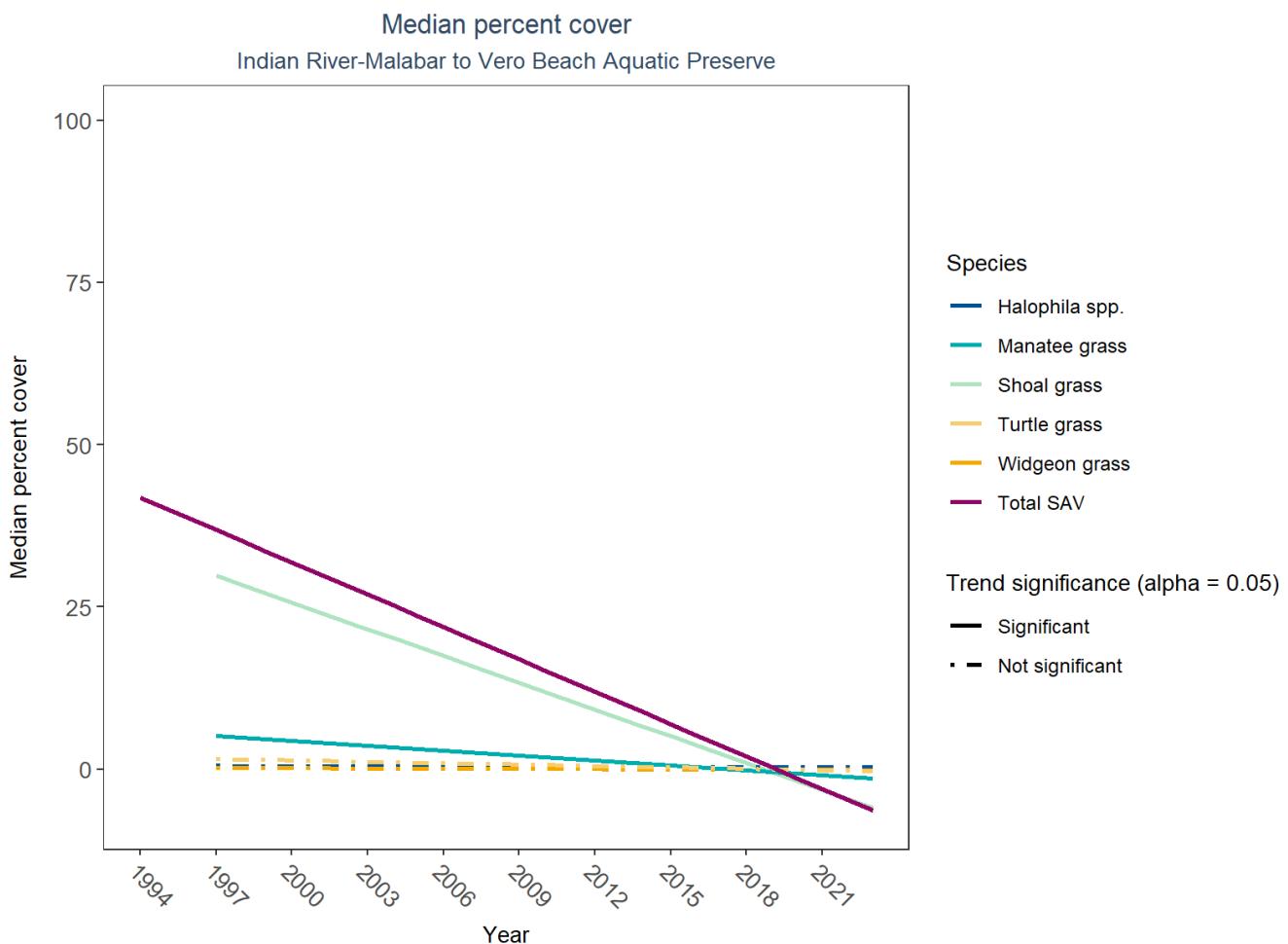


Figure 41: Trends in median percent cover for various seagrass species in Indian River-Malabar to Vero Beach Aquatic Preserve - simplified

Table 38: Percent Cover Trend Analysis for Indian River-Malabar to Vero Beach Aquatic Preserve

Common Name	Trend Significance (0.05)	Period of Record	LME-Intercept	LME-Slope	p
Drift algae	Insufficient data to calculate trend	-	-	-	-
Shoal grass	Significantly decreasing trend	1997 - 2023	33.9584135	-1.3749485	0.0000000
Halophila spp.	No significant trend	1997 - 2023	0.5666968	-0.0076418	0.3586450
Widgeon grass	No significant trend	1997 - 2023	0.2581593	-0.0123387	0.1027931
Manatee grass	Significantly decreasing trend	1997 - 2023	5.9003807	-0.2543566	0.0044713
Turtle grass	No significant trend	1997 - 2023	1.8113108	-0.0714913	0.0978987
Total SAV	Significantly decreasing trend	1994 - 2023	41.8891869	-1.6639276	0.0000000
Total seagrass	Insufficient data to calculate trend	-	-	-	-

Annual decreases in percent cover were observed for total SAV (-1.7%), manatee grass (-0.2%), and shoal grass (-1.4%). *Halophila* spp., turtle grass, and widgeon grass showed no detectable change in percent cover. Trends in percent cover could not be evaluated for total seagrass and drift algae due to insufficient data.

Frequency of occurrence
 Indian River-Malabar to Vero Beach Aquatic Preserve

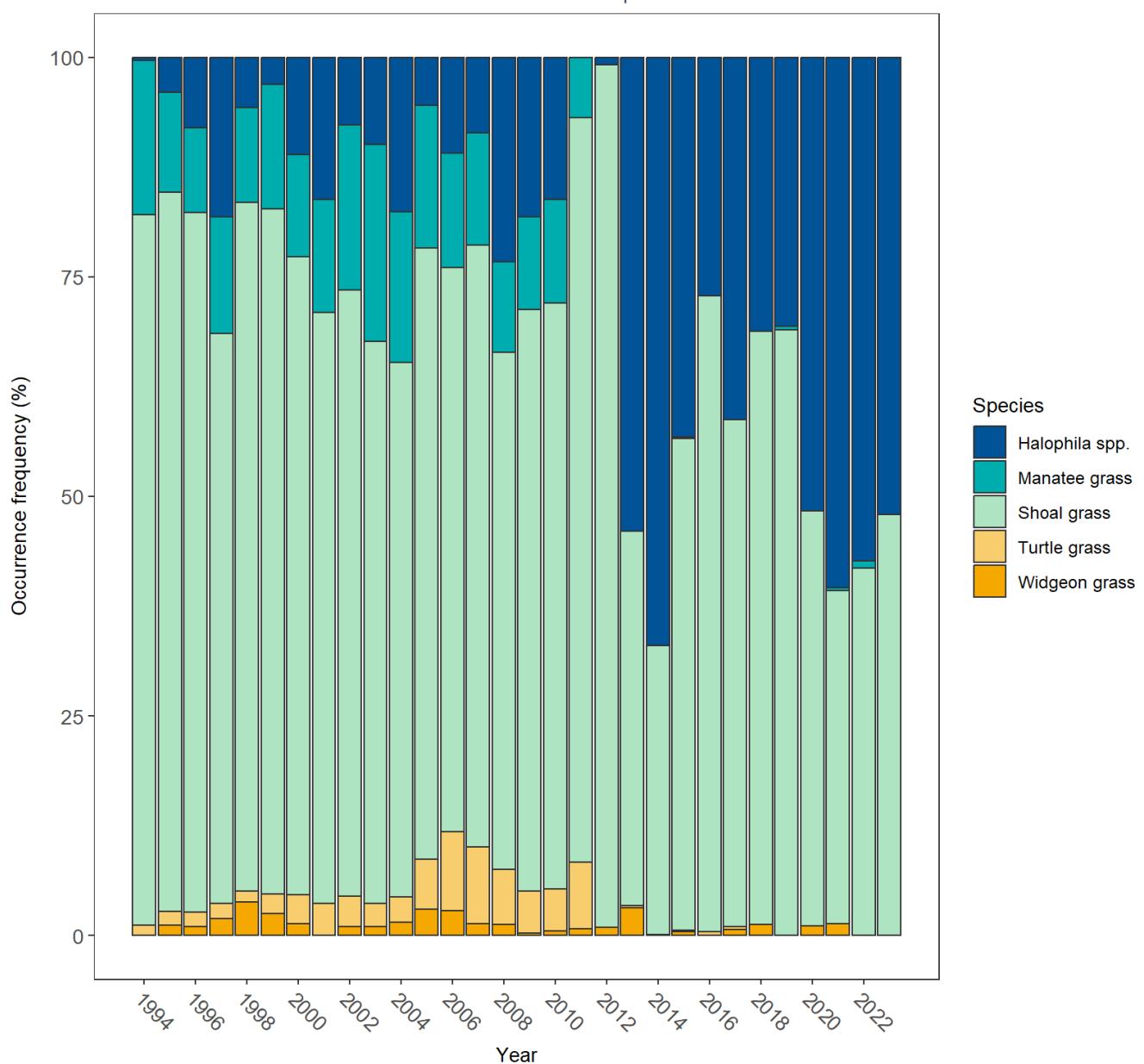


Figure 42: Frequency of occurrence for various seagrass species in Indian River-Malabar to Vero Beach Aquatic Preserve

Oyster

The data file used is: All_OYSTER_Parameters-2025-Apr-24.txt

Density

Natural

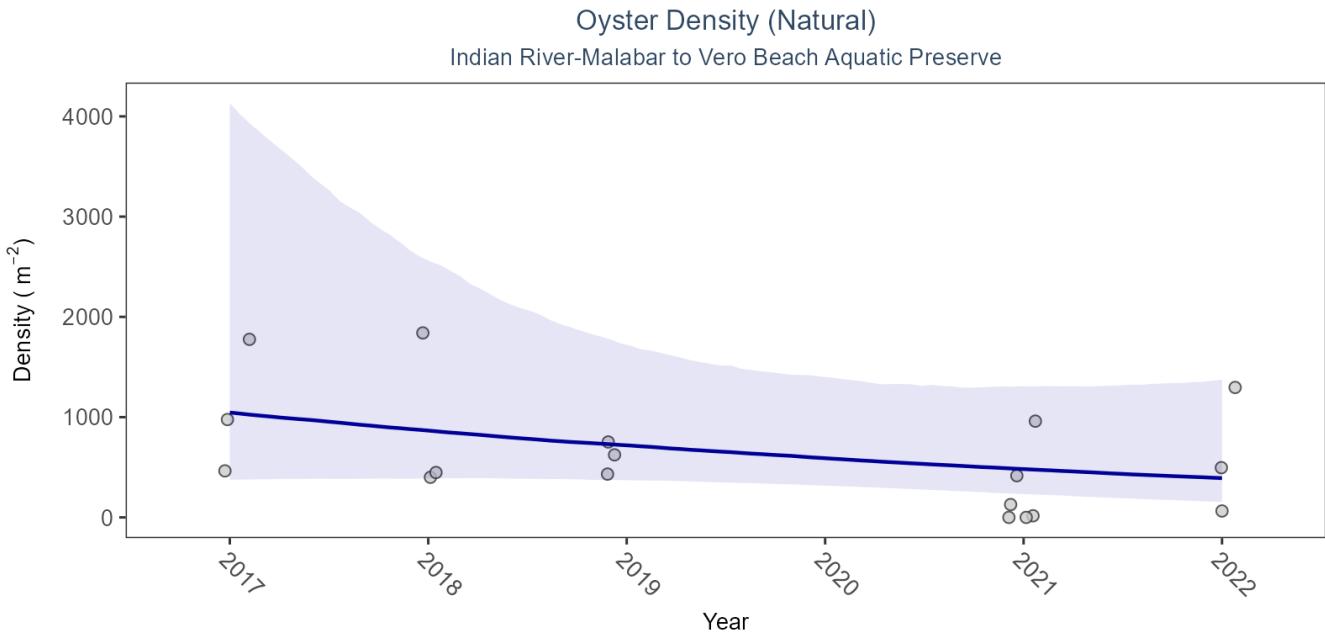


Figure 43: Scatter plot of oyster density over time. If the time series included five or more years with observations, an estimated trend (blue line) and a 95% credible interval (purple band) may also be plotted. Data points are jittered horizontally to reduce overlap.

Table 39: Model results for Oyster Density - Natural

Shell Type	Habitat Type	Trend Status	Estimate	Standard Error	Credible Interval
Live Oysters	Natural	Significantly decreasing trend	-130.86	278.08	-44.24 to -551.55

For natural reefs, density decreased by an average of 130.86 oysters per square meter per year.

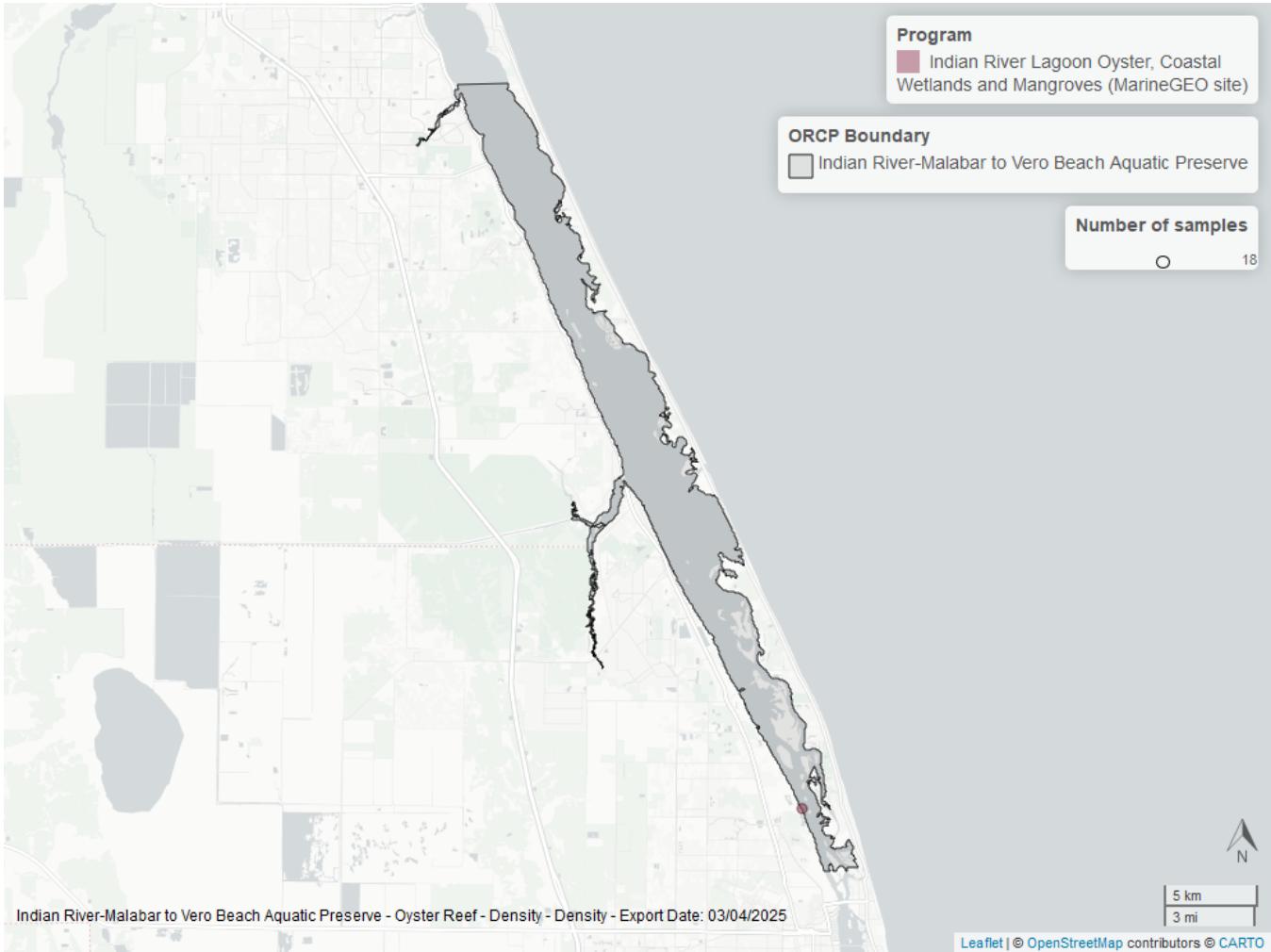


Figure 44: Map showing location of oyster density sampling locations within the boundaries of *Indian River-Malabar to Vero Beach Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Percent Live

Natural

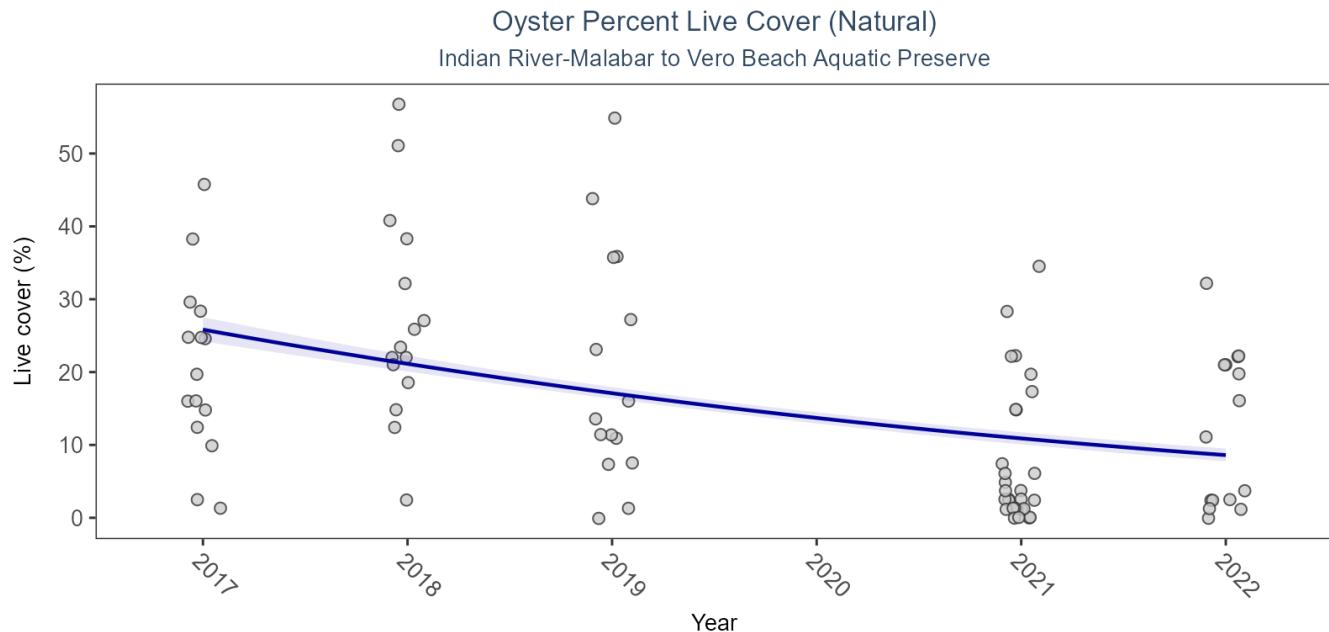


Figure 45: Scatter plot of percent live oysters over time. If the time series included five or more years with observations, an estimated trend (blue line) and a 95% credible interval (purple band) may also be plotted. Data points are jittered horizontally to reduce overlap.

Table 40: Model results for Oyster Percent Live - Natural

<i>Shell Type</i>	<i>Habitat Type</i>	<i>Trend Status</i>	<i>Estimate</i>	<i>Standard Error</i>	<i>Credible Interval</i>
Live Oysters	Natural	Significantly decreasing trend	-3.45	0.48	-3.29 to -3.61

For natural reefs, percent live cover decreased by an average of 3.45% per year.

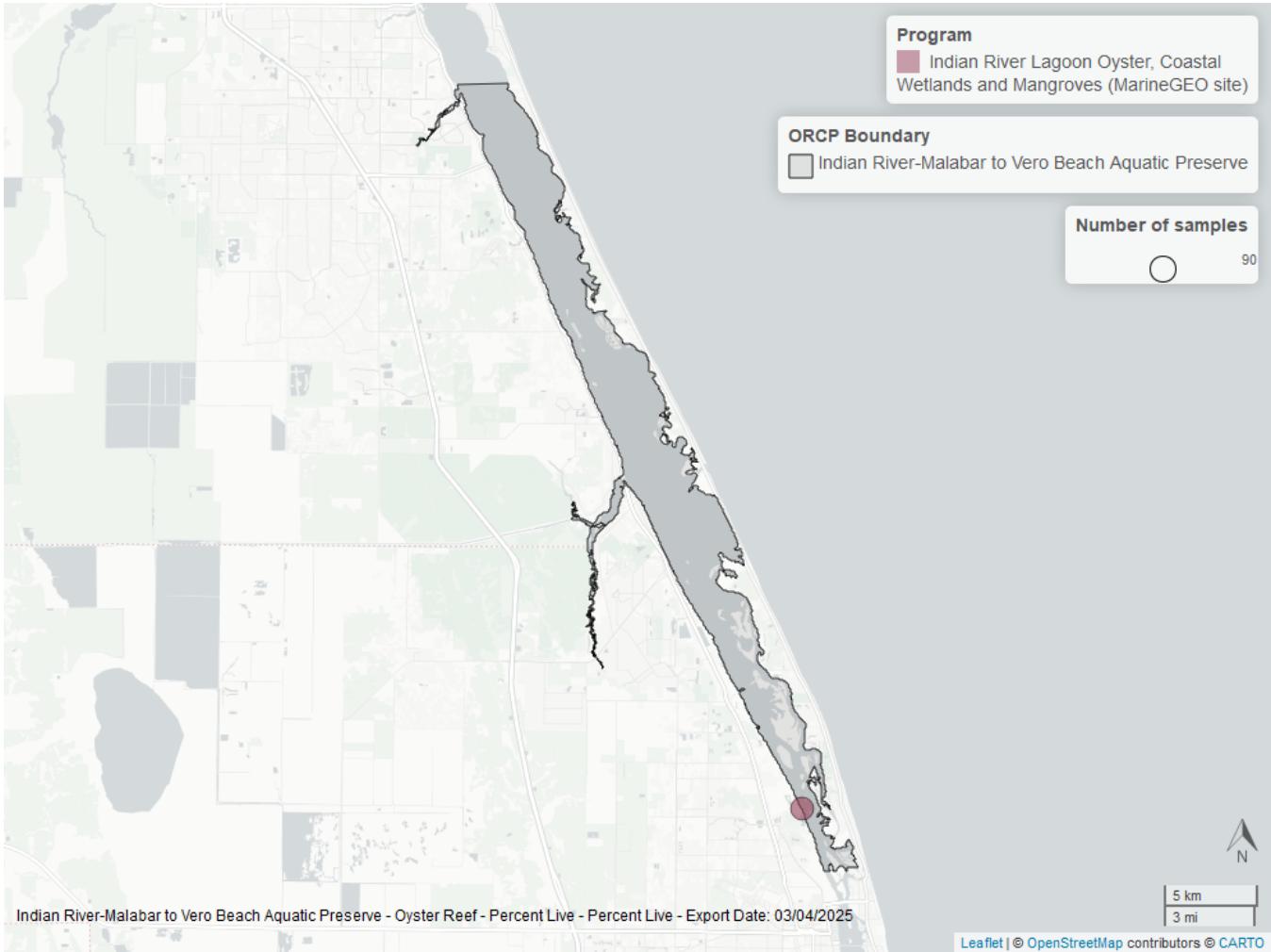


Figure 46: Map showing location of oyster percent live sampling locations within the boundaries of *Indian River-Malabar to Vero Beach Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Shell Height

Natural

Oyster Size Class (Natural)
Indian River-Malabar to Vero Beach Aquatic Preserve

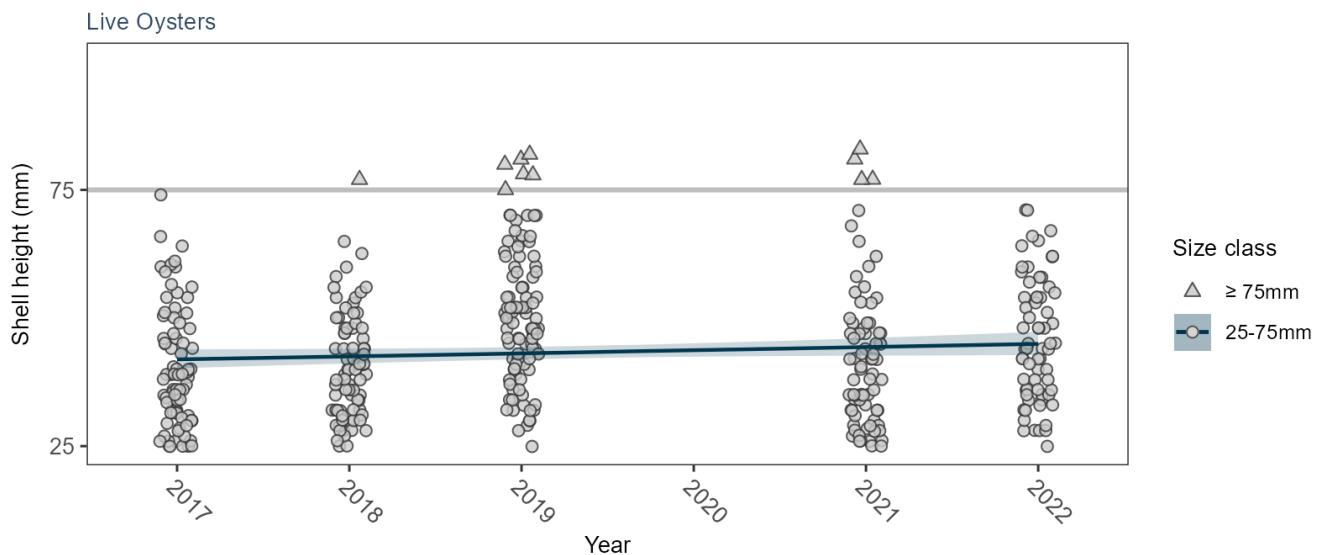


Table 41: Model results for Oyster Shell Height - Natural

Shell Type	Size Class	Habitat Type	Trend Status	Estimate	Standard Error	Credible Interval
Dead Oyster Shells		Natural	-	-	-	-
Live Oysters	>75mm	Natural	-	-	-	-
Live Oysters	25-75mm	Natural	No significant change	1.52	0.95	-0.16 to 3.54
Live Oysters		Natural	-	-	-	-

For natural reefs, annual average live oyster shell height in the 25-75mm size class increased by 1.52mm per year, and there was insufficient data to calculate a trend for live oysters in the $\geq 75\text{mm}$ size class.

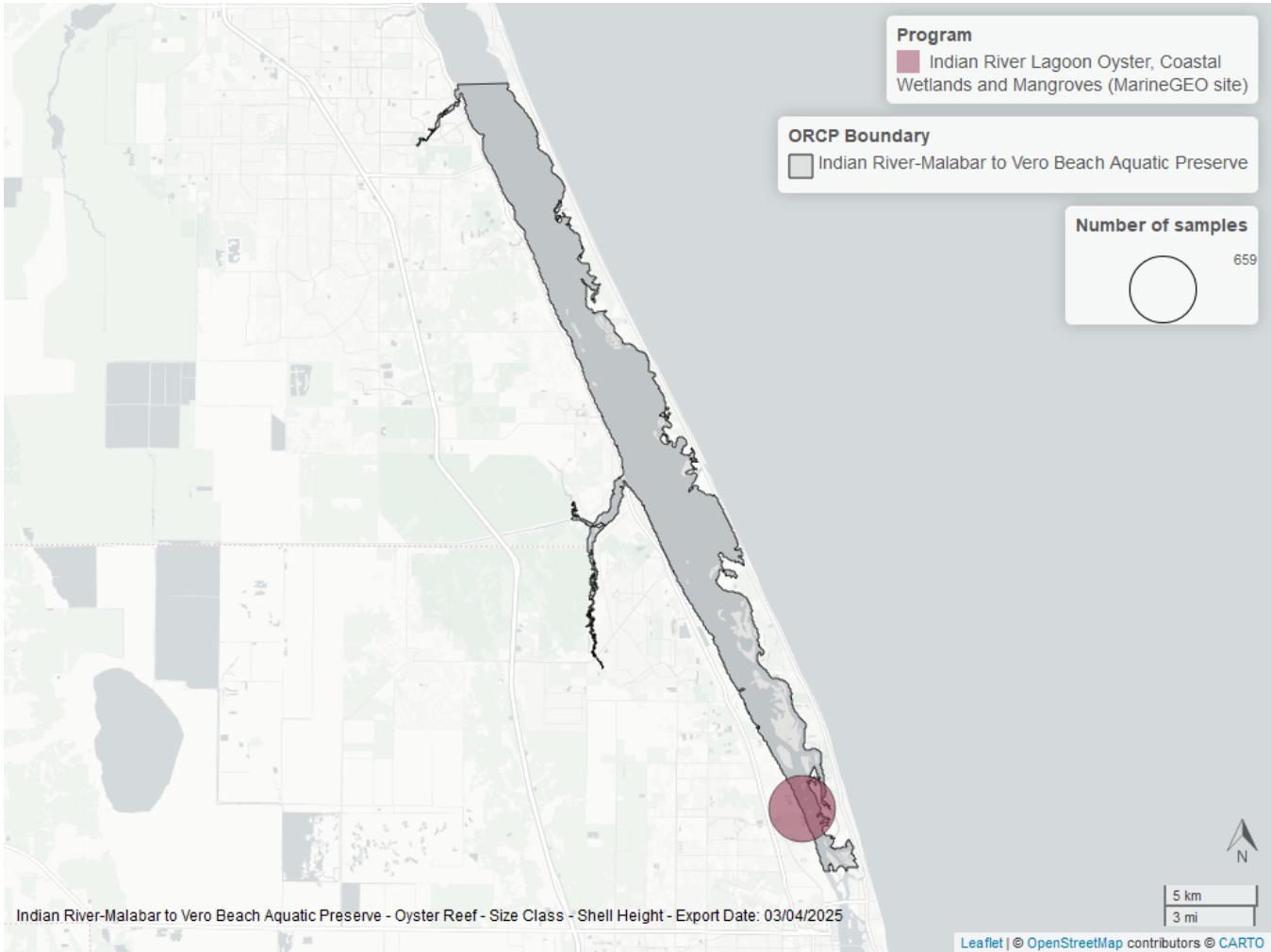


Figure 47: Map showing location of oyster shell height sampling locations within the boundaries of *Indian River-Malabar to Vero Beach Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

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