Cape Romano-Ten Thousand Islands Aquatic Preserve

SEACAR Habitat Analyses

Last compiled on 08 October, 2025

Contents

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	mˆ-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

Qualifier Source	*Value Qualifier*	*Include*	*Description*
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 $p >= 0.05$). 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-Sep-04.txt*
- *Combined_WQ_WC_NUT_Chlorophyll_a_uncorrected_for_pheophytin-2025-Sep-04.txt*
- *Combined_WQ_WC_NUT_Colored_dissolved_organic_matter_CDOM-2025-Sep-04.txt*
- *Combined_WQ_WC_NUT_Dissolved_Oxygen-2025-Sep-04.txt*
- *Combined_WQ_WC_NUT_Dissolved_Oxygen_Saturation-2025-Sep-04.txt*
- *Combined_WQ_WC_NUT_pH-2025-Sep-04.txt*
- *Combined_WQ_WC_NUT_Salinity-2025-Sep-04.txt*
- *Combined_WQ_WC_NUT_Secchi_Depth-2025-Sep-04.txt*
- *Combined_WQ_WC_NUT_Total_Nitrogen-2025-Sep-04.txt*
- *Combined_WQ_WC_NUT_Total_Phosphorus-2025-Sep-04.txt*
- *Combined_WQ_WC_NUT_Total_Suspended_Solids_TSS-2025-Sep-04.txt*
- *Combined_WQ_WC_NUT_Turbidity-2025-Sep-04.txt*
- *Combined_WQ_WC_NUT_Water_Temperature-2025-Sep-04.txt*

Chlorophyll a, Corrected for Pheophytin - Discrete

Seasonal Kendall-Tau Trend Analysis

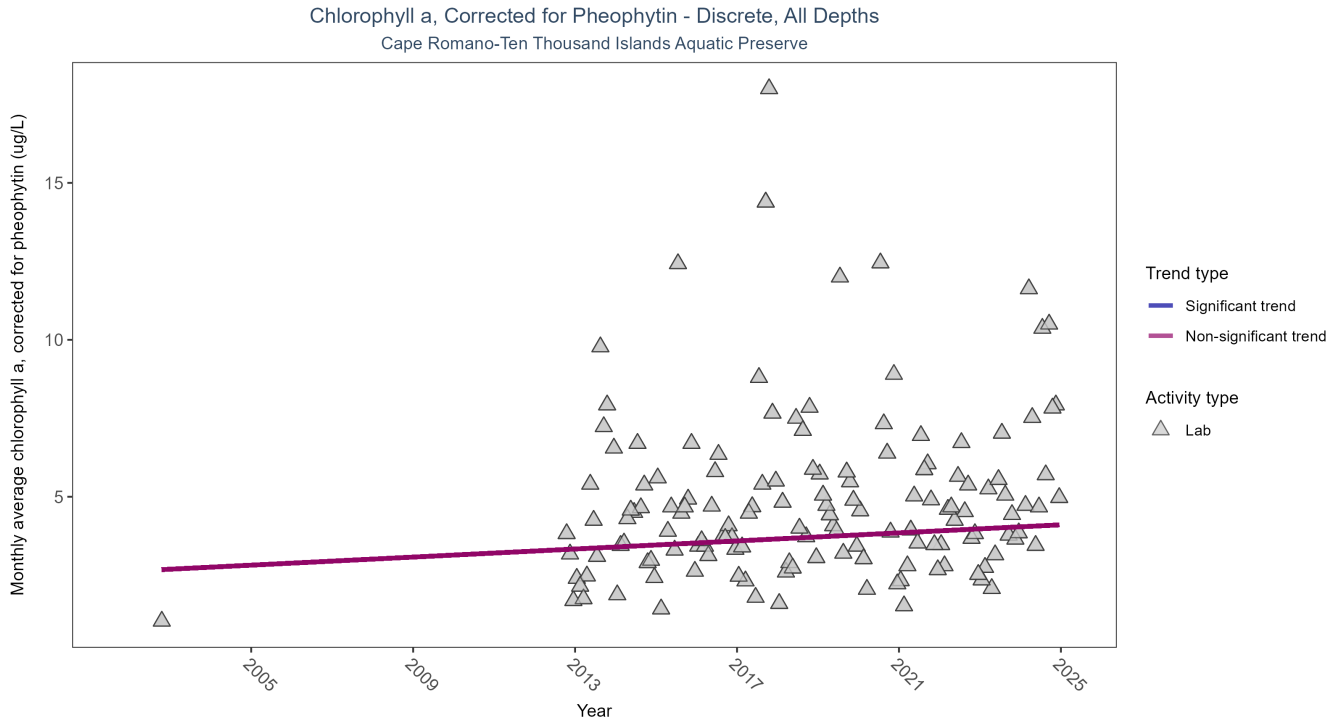

Figure 1: Scatter plot of monthly average levels of chlorophyll a, corrected for pheophytin, over time. If the time series included ten or more years of discrete observations, a significant (blue) or non-significant (magenta) trend line is also shown. Only laboratory-analyzed chlorophyll a (triangles) 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	No significant trend	619	14	2002 - 2024	3.8	0.1213	2.6276	0.0643	0.0596

Chlorophyll a, corrected for pheophytin, showed no detectable trend between 2002 and 2024.

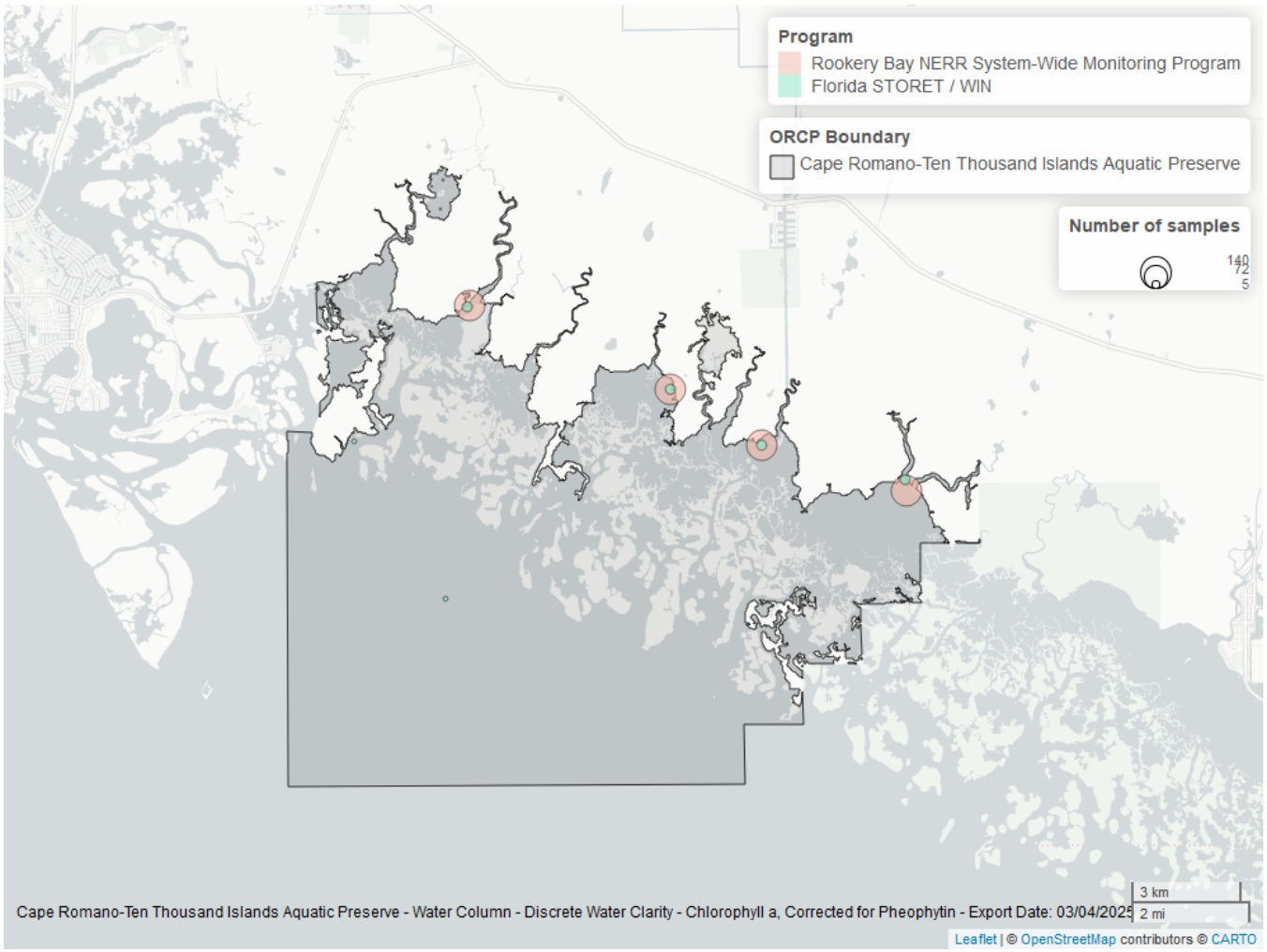

Figure 2: Map showing location of discrete water quality sampling locations within the boundaries of *Cape Romano-Ten Thousand Islands Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

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

ProgramID	*N_Data*	*YearMin*	*YearMax*
354	563	2012	2024
5002	68	2002	2021

Program names:

354 - Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program[1]
5002 - Florida STORET / WIN[2]

Chlorophyll a, Uncorrected for Pheophytin - Discrete

Seasonal Kendall-Tau Trend Analysis

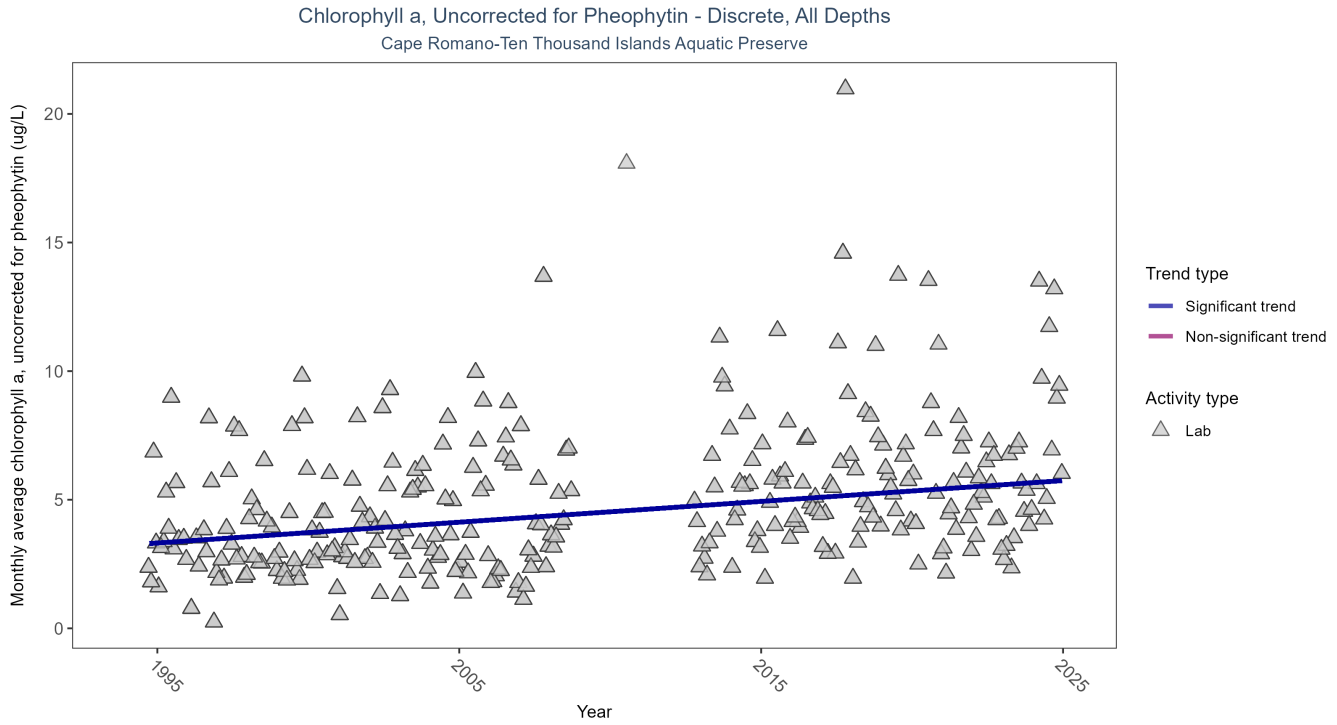

Figure 3: Scatter plot of monthly average levels of chlorophyll a, uncorrected for pheophytin, over time. If the time series included ten or more years of discrete observations, a significant (blue) or non-significant (magenta) trend line is also shown. Only laboratory-analyzed chlorophyll a (triangles) 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	2153	29	1994 - 2024	3.6548	0.2802	3.2365	0.0809	0

Monthly average chlorophyll a, uncorrected for pheophytin, increased by 0.08 µg/L per year, indicating a decrease in water clarity.

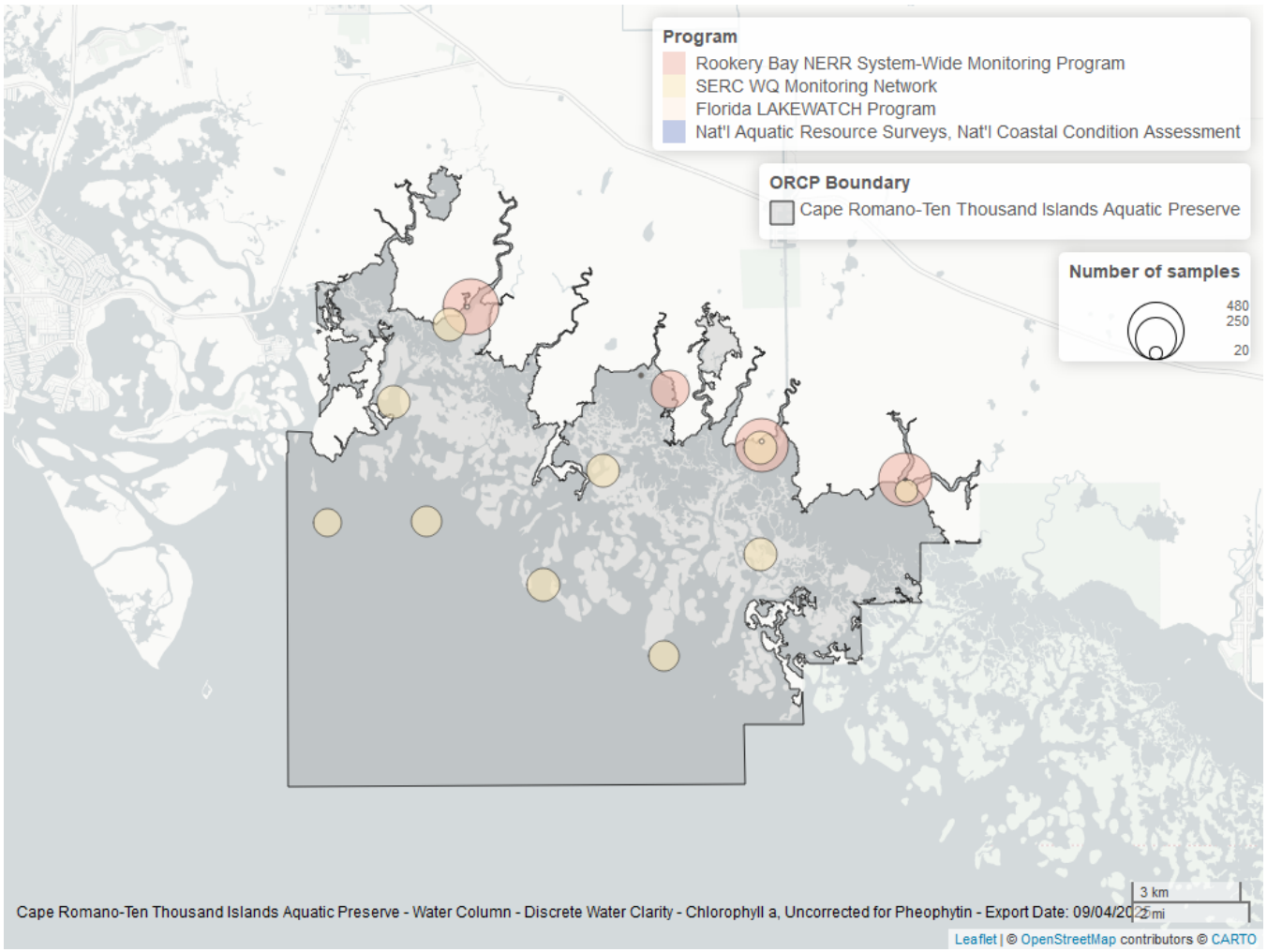

Figure 4: Map showing location of discrete water quality sampling locations within the boundaries of *Cape Romano-Ten Thousand Islands Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

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

ProgramID	*N_Data*	*YearMin*	*YearMax*
354	2750	2002	2024
509	1512	1994	2008
5002	72	2001	2021
514	15	2001	2001
103	1	2015	2015
118	1	2010	2010

Program names:

103 - EPA STOrage and RETrieval Data Warehouse (STORET)/WQX[3]
118 - National Aquatic Resource Surveys, National Coastal Condition Assessment[4]
354 - Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program[1]
509 - SERC Water Quality Monitoring Network[5]
514 - Florida LAKEWATCH Program[6]
5002 - Florida STORET / WIN[2]

Dissolved Oxygen - Discrete

Seasonal Kendall-Tau Trend Analysis

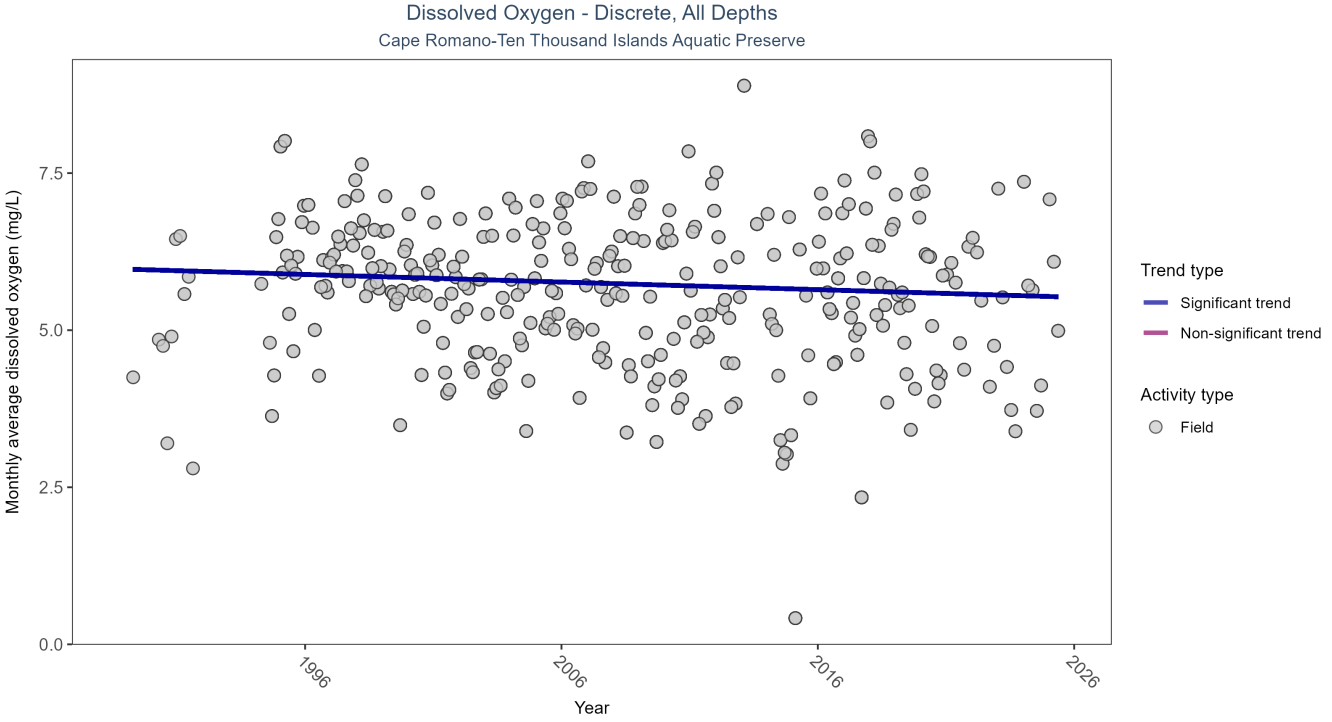

Figure 5: Scatter plot of monthly average dissolved oxygen over time. If the time series included ten or more years of discrete observations, a significant (blue) or non-significant (magenta) trend line is also shown. Only dissolved oxygen values measured in the field (circles) are included in the plot.

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	10661	35	1989 - 2025	5.8	-0.0869	5.9716	-0.0121	0.0258

Monthly average dissolved oxygen decreased by 0.01 mg/L per year.

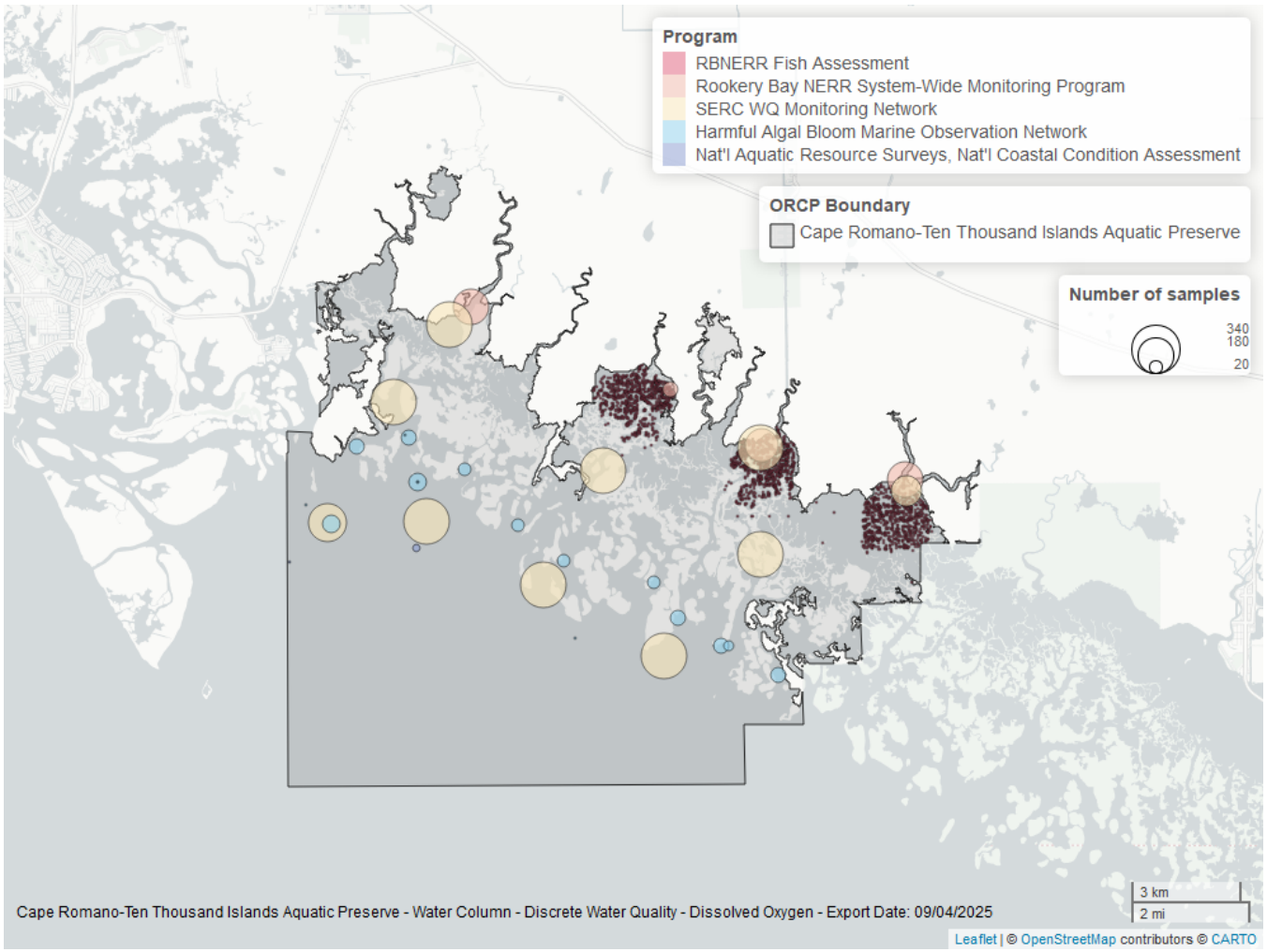

Figure 6: Map showing location of discrete water quality sampling locations within the boundaries of *Cape Romano-Ten Thousand Islands Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Table 11: Programs contributing data for Dissolved Oxygen

ProgramID	*N_Data*	*YearMin*	*YearMax*
5002	4210	1989	2025
509	2974	1994	2008
4043	2493	1999	2020
354	917	2002	2023
95	390	1997	2018
118	10	2015	2021
103	2	2015	2015

Program names:

95 - Harmful Algal Bloom Marine Observation Network[7]
103 - EPA STOrage and RETrieval Data Warehouse (STORET)/WQX[3]
118 - National Aquatic Resource Surveys, National Coastal Condition Assessment[4]
354 - Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program[1]
509 - SERC Water Quality Monitoring Network[5]

4043 - RBNERR Fish Assessment[8]
5002 - Florida STORET / WIN[2]

Dissolved Oxygen Saturation - Discrete

Seasonal Kendall-Tau Trend Analysis

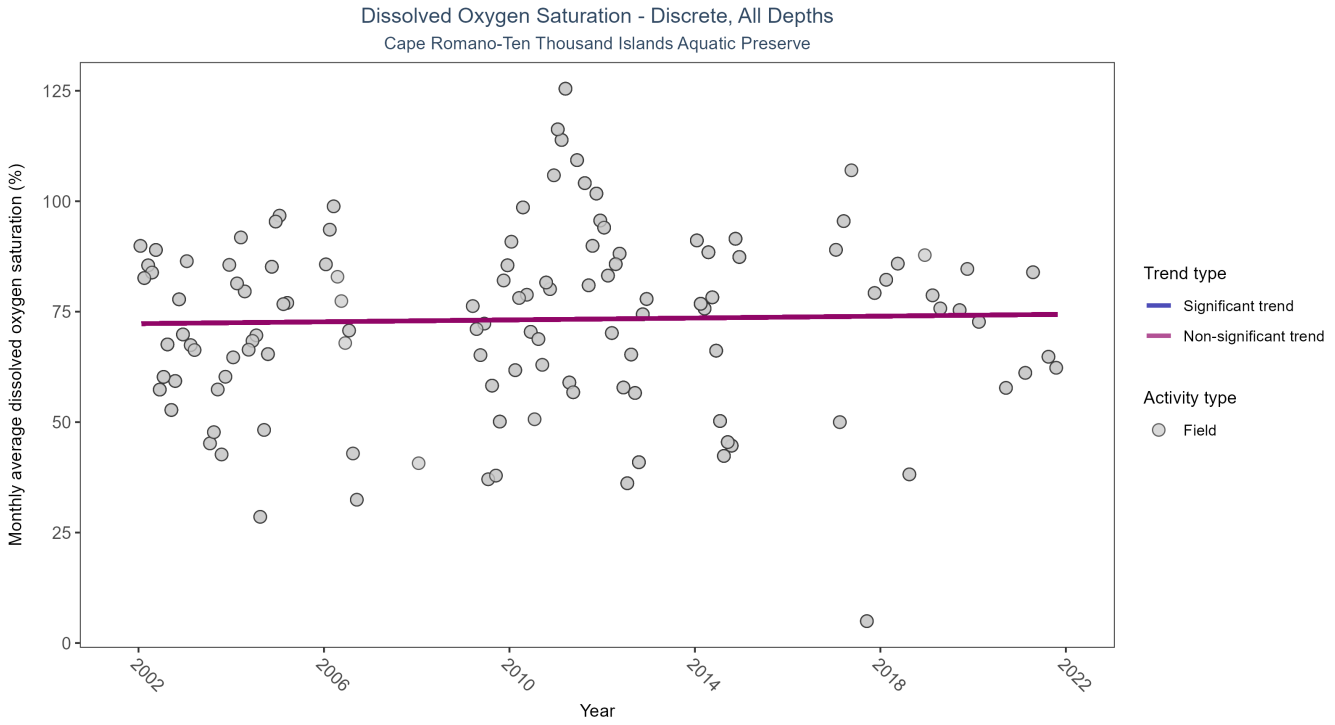

Figure 7: Scatter plot of monthly average dissolved oxygen saturation over time. If the time series included ten or more years of discrete observations, a significant (blue) or non-significant (magenta) trend line is also shown. Only dissolved oxygen saturation values measured in the field (circles) 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	No significant trend	570	16	2002 - 2021	74.75	0.0495	72.2842	0.1062	0.597

Dissolved oxygen saturation showed no detectable trend between 2002 and 2021.

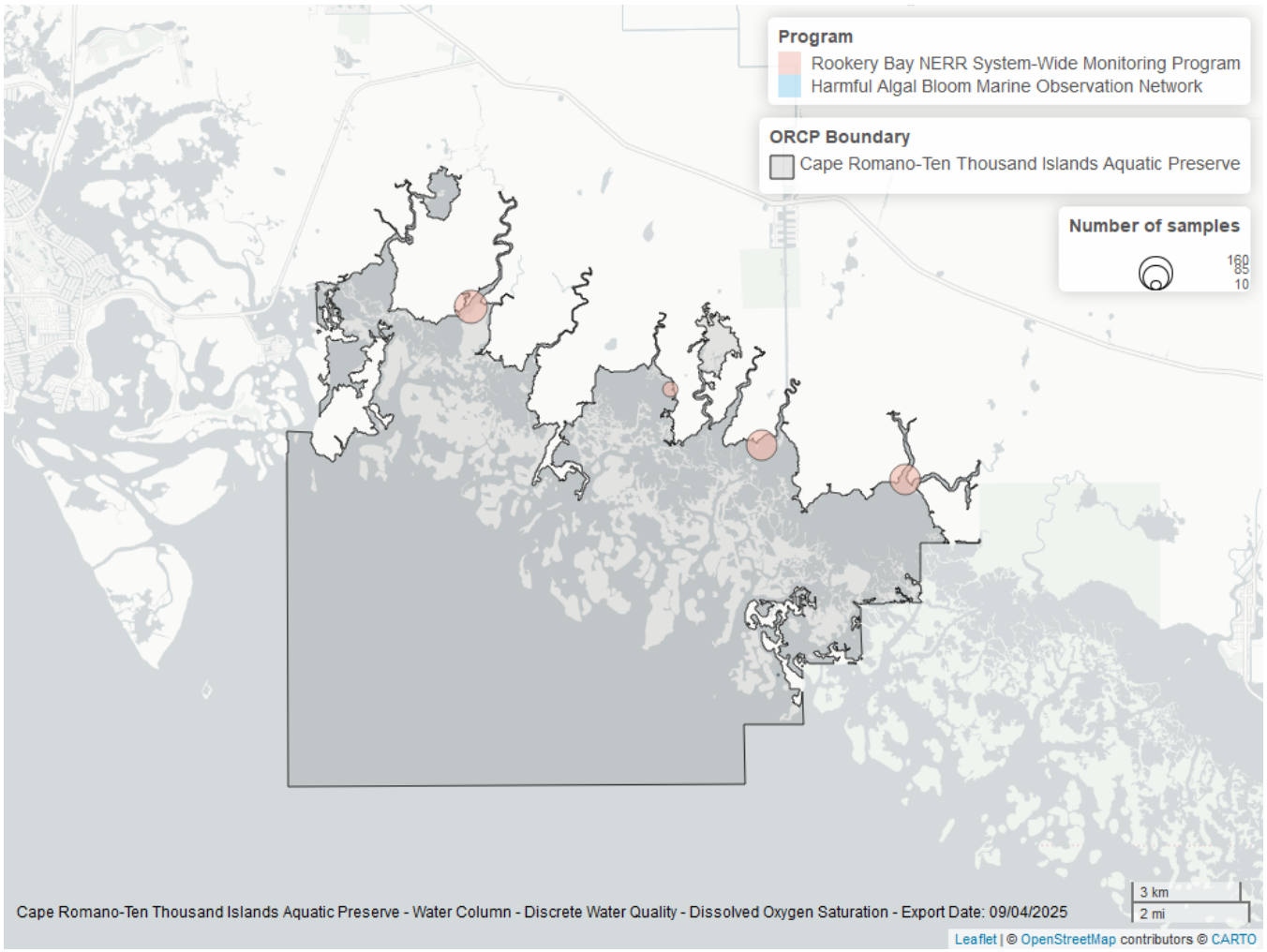

Figure 8: Map showing location of discrete water quality sampling locations within the boundaries of *Cape Romano-Ten Thousand Islands Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Table 13: Programs contributing data for Dissolved Oxygen Saturation

ProgramID	*N_Data*	*YearMin*	*YearMax*
354	899	2002	2024
5002	71	2017	2021
95	1	2008	2008

Program names:

95 - Harmful Algal Bloom Marine Observation Network[7]
354 - Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program[1]
5002 - Florida STORET / WIN[2]

pH - Discrete

Seasonal Kendall-Tau Trend Analysis

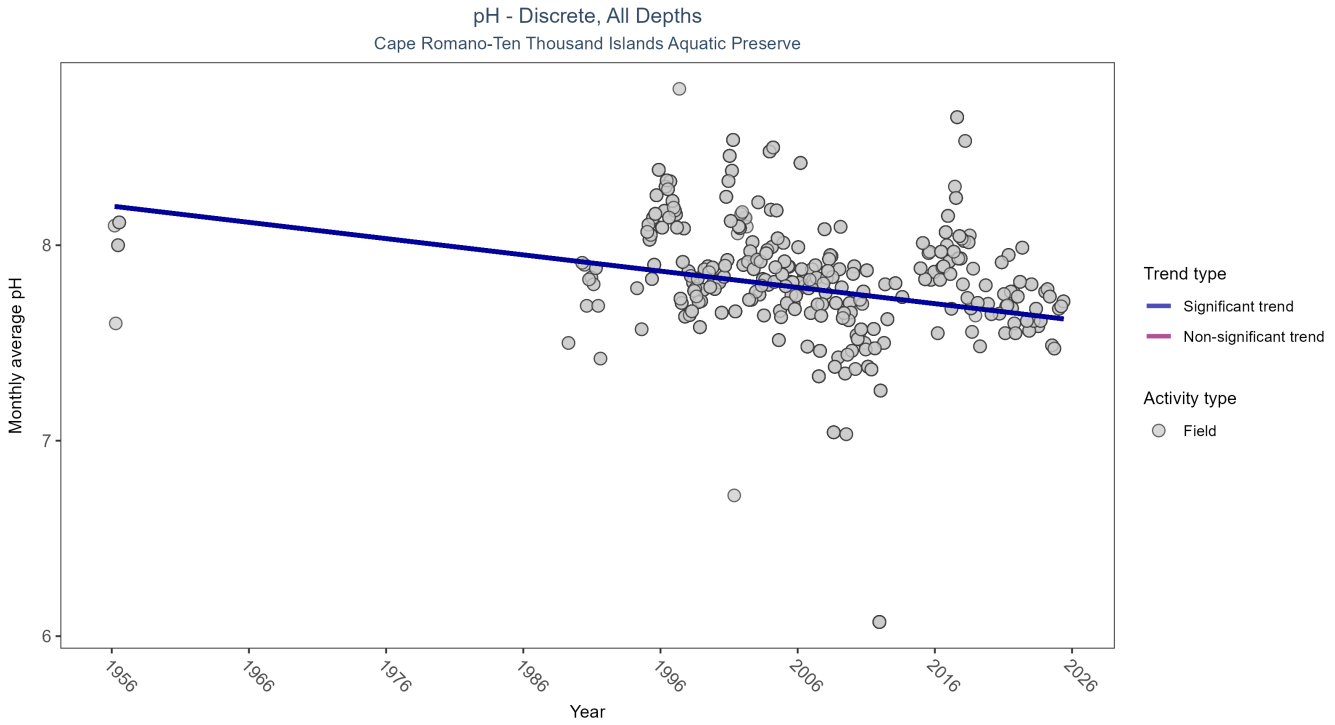

Figure 9: Scatter plot of monthly average pH over time. If the time series included ten or more years of discrete observations, a significant (blue) or non-significant (magenta) trend line is also shown. Only pH values measured in the field (circles) are included in the plot.

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	4573	36	1956 - 2025	7.87	-0.2397	8.2002	-0.0083	0

Monthly average pH decreased by 0.01 pH units per year.

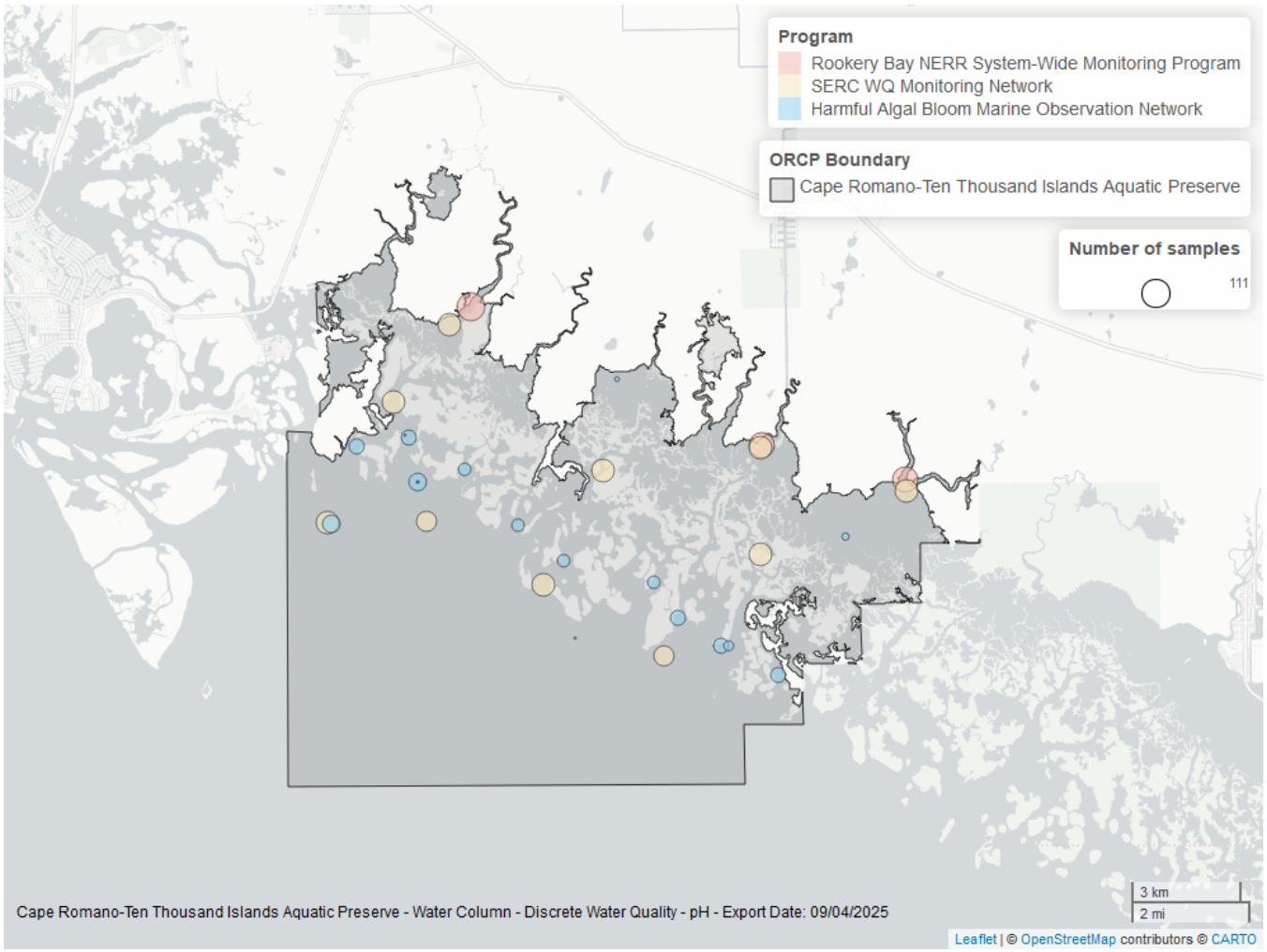

Figure 10: Map showing location of discrete water quality sampling locations within the boundaries of *Cape Romano-Ten Thousand Islands Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Table 15: Programs contributing data for pH

ProgramID	*N_Data*	*YearMin*	*YearMax*
5002	3109	1989	2025
354	756	2002	2024
509	748	2001	2008
95	395	1956	2018
103	4	2015	2015

Program names:

95 - Harmful Algal Bloom Marine Observation Network[7]
103 - EPA STOrage and RETrieval Data Warehouse (STORET)/WQX[3]
354 - Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program[1]
509 - SERC Water Quality Monitoring Network[5]
5002 - Florida STORET / WIN[2]

Salinity - Discrete

Seasonal Kendall-Tau Trend Analysis

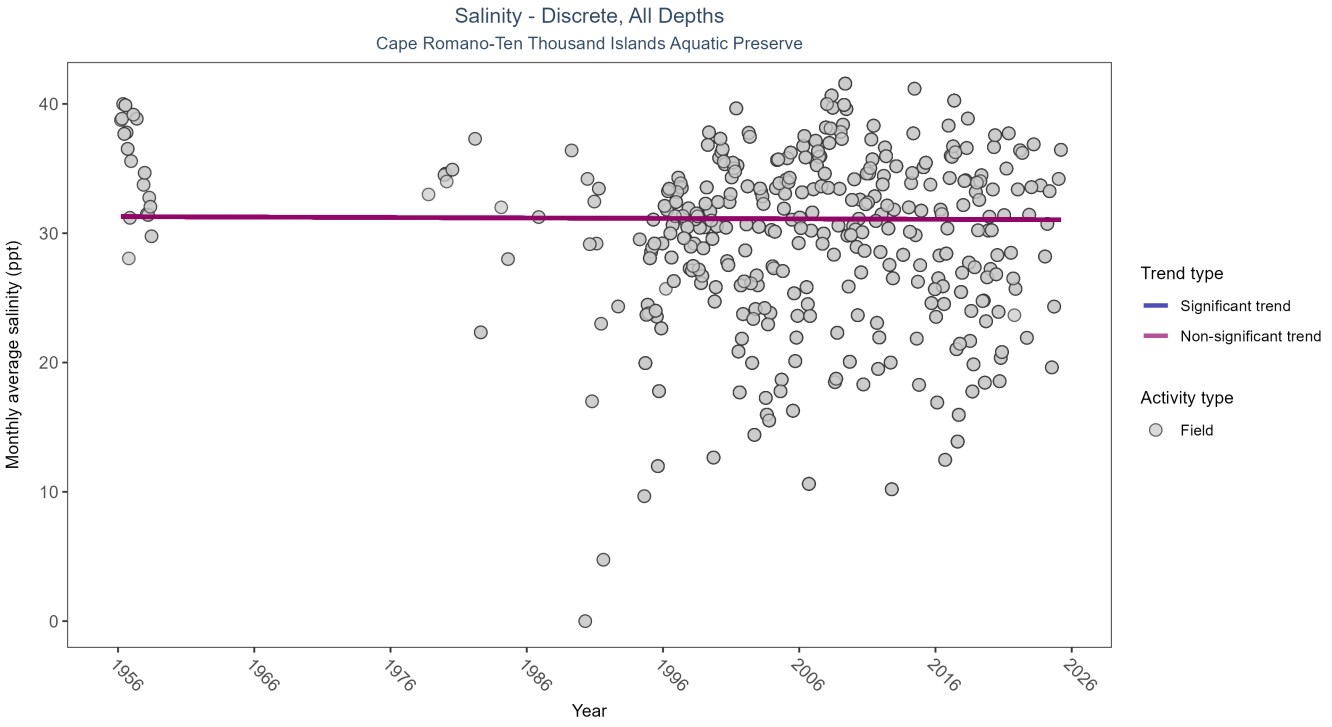

Figure 11: Scatter plot of monthly average salinity over time. If the time series included ten or more years of discrete observations, significant (blue) or non-significant (magenta) trend lines are also shown. Discrete salinity values derived from grab samples analyzed in the field (circles) or the 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	No significant trend	11012	45	1956 - 2025	31.9	-0.0072	31.2837	-0.0035	0.8862

Salinity showed no detectable trend between 1956 and 2025.

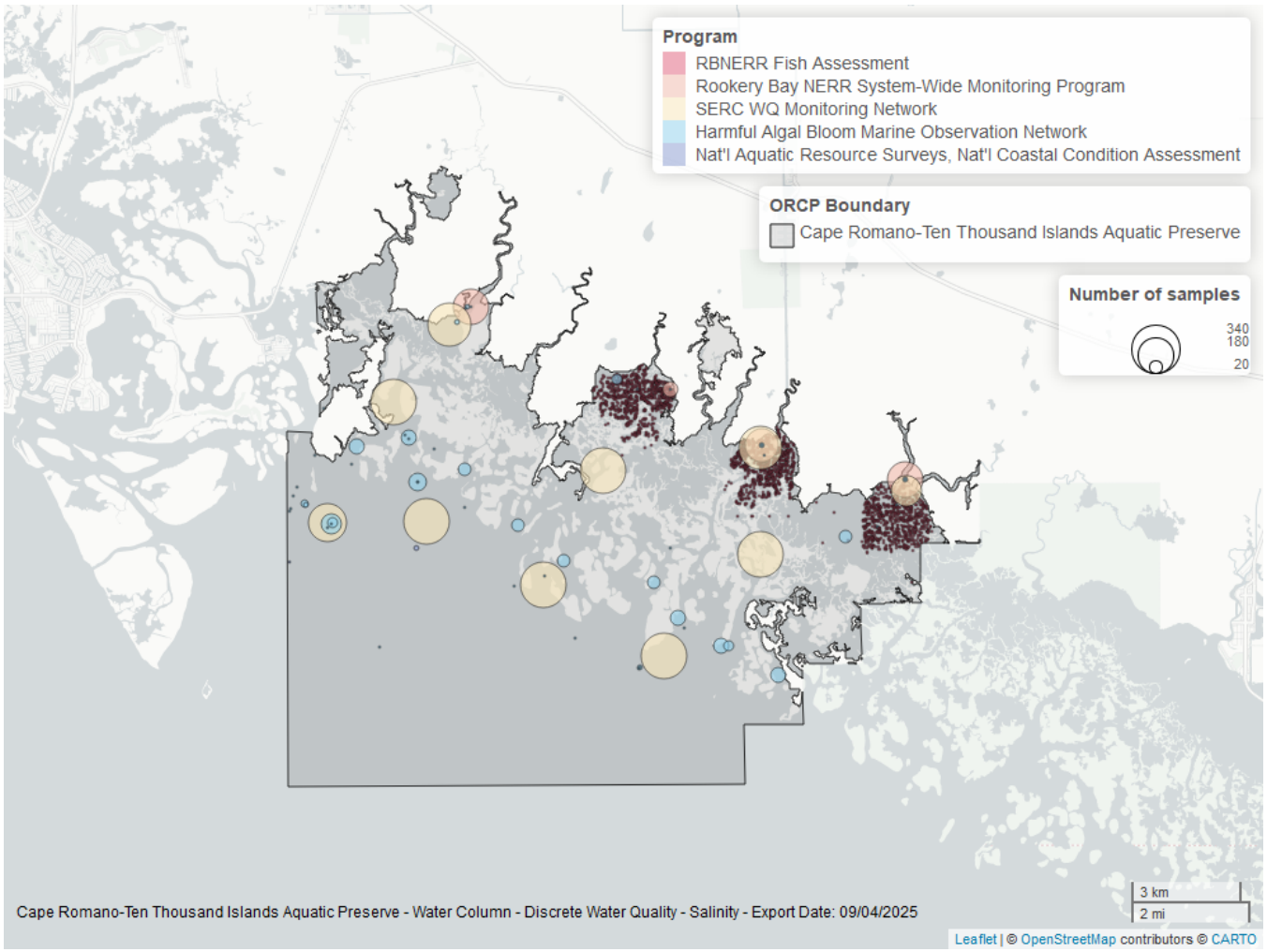

Figure 12: Map showing location of discrete water quality sampling locations within the boundaries of *Cape Romano-Ten Thousand Islands Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Table 17: Programs contributing data for Salinity

ProgramID	*N_Data*	*YearMin*	*YearMax*
5002	4396	1989	2025
509	2948	1994	2008
4043	2555	1999	2020
354	1117	2002	2024
95	532	1956	2018
118	8	2015	2021

Program names:

95 - Harmful Algal Bloom Marine Observation Network[7]
118 - National Aquatic Resource Surveys, National Coastal Condition Assessment[4]
354 - Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program[1]
509 - SERC Water Quality Monitoring Network[5]
4043 - RBNERR Fish Assessment[8]
5002 - Florida STORET / WIN[2]

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 + NO3O2;
2) TN = TKN + NO3 + NO2;
3) TN = ORGN + NH4 + NO3O2;
4) TN = ORGN + NH4 + NO2 + NO3;
5) TN = TKN + NO3;
6) TN = ORGN + NH4 + NO3;

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

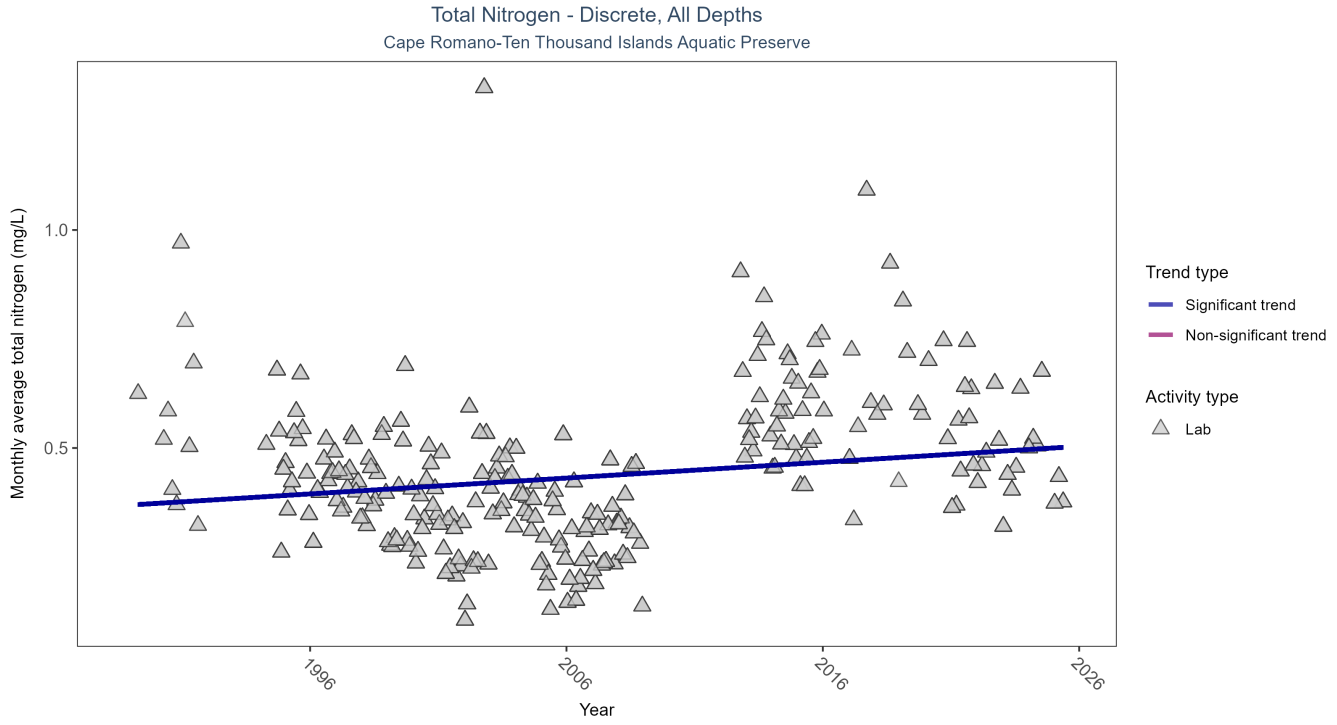

Figure 13: Scatter plot of monthly average total nitrogen over time. If the time series included ten or more years of discrete observations, a significant (blue) or non-significant (magenta) trend line is also shown. Only nitrogen values obtained from laboratory analyses (triangles) are included in the plot.

Table 18: 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 increasing trend	2488	32	1989 - 2025	0.3761	0.1354	0.3693	0.0036	0.0019

Monthly average total nitrogen increased by less than 0.01 mg/L per year.

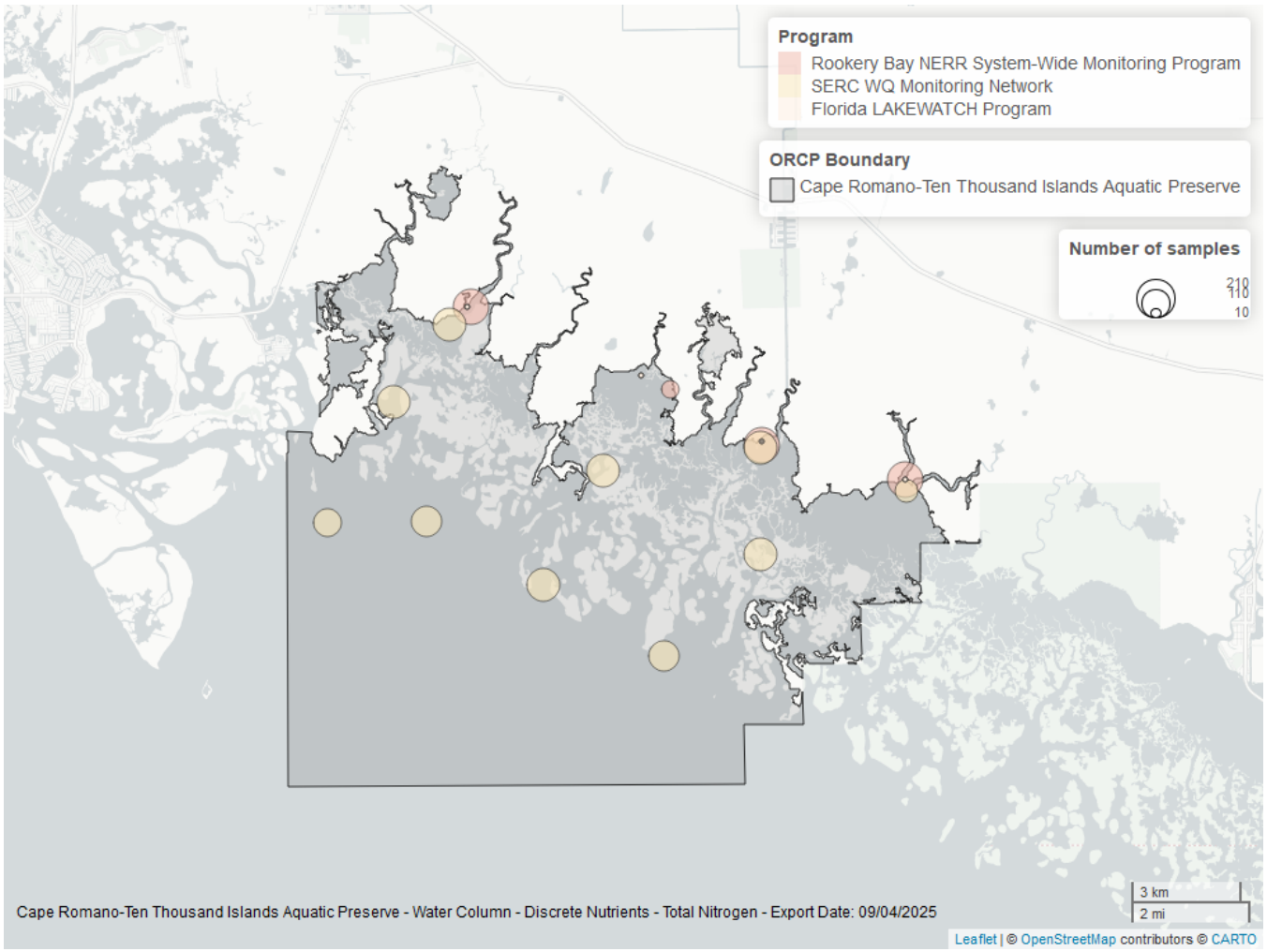

Figure 14: Map showing location of discrete water quality sampling locations within the boundaries of *Cape Romano-Ten Thousand Islands Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Table 19: Programs contributing data for Total Nitrogen

ProgramID	*N_Data*	*YearMin*	*YearMax*
509	1512	1994	2008
354	812	2002	2018
5002	320	1989	2025
514	35	2001	2001

Program names:

354 - Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program[1]
509 - SERC Water Quality Monitoring Network[5]
514 - Florida LAKEWATCH Program[6]
5002 - Florida STORET / WIN[2]

Total Phosphorus - Discrete

Seasonal Kendall-Tau Trend Analysis

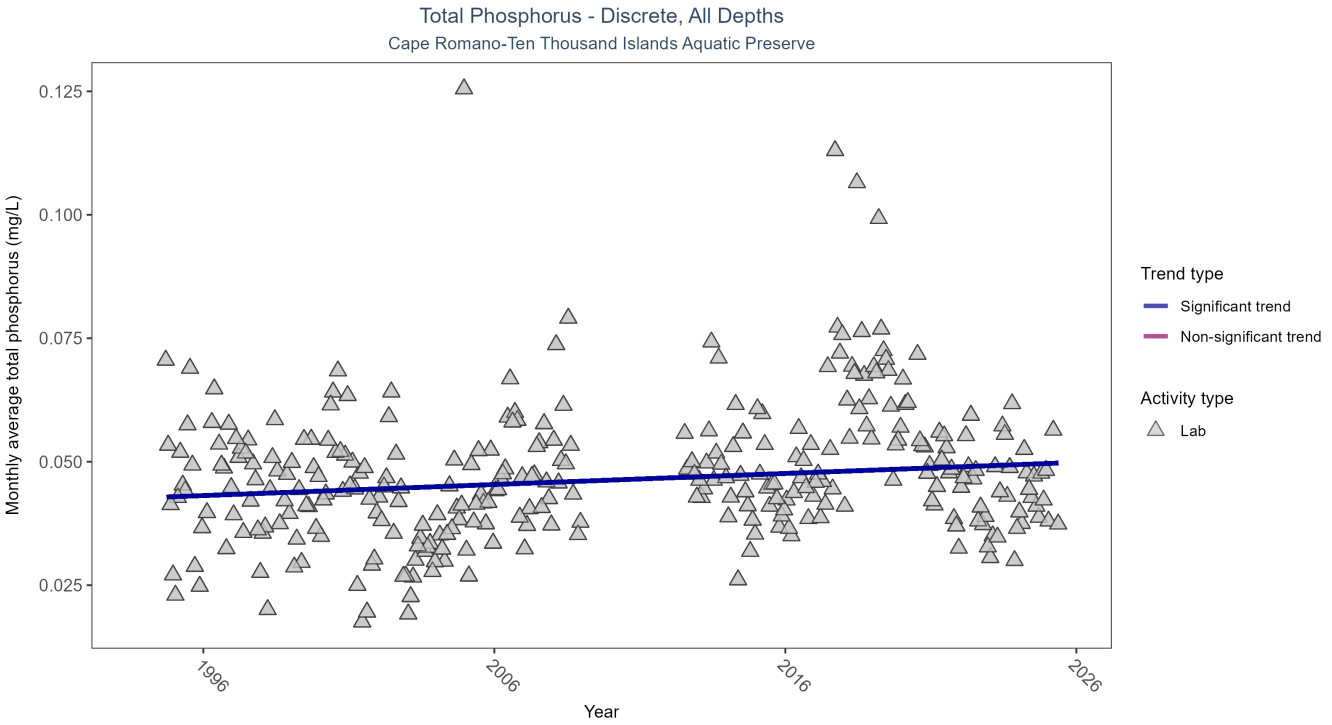

Figure 15: Scatter plot of monthly average total phosphorus over time. If the time series included ten or more years of discrete observations, a significant (blue) or non-significant (magenta) trend line is also shown. Only phosphorus values obtained from laboratory analyses (triangles) are included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

Table 20: 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	Significantly increasing trend	2949	29	1994 - 2025	0.043	0.1364	0.0427	0.0002	0.0007

Monthly average total phosphorus increased by less than 0.01 mg/L per year.

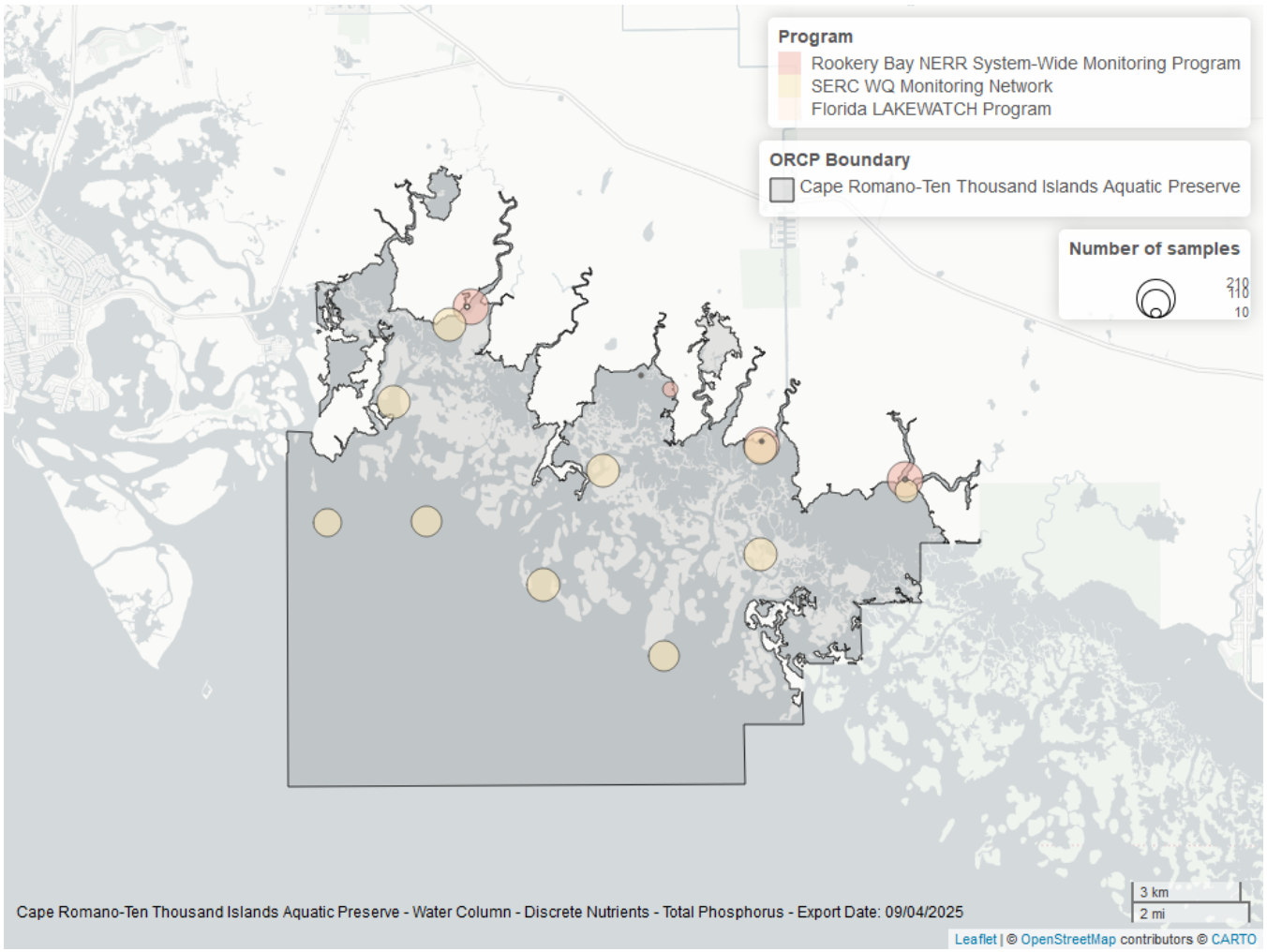

Figure 16: Map showing location of discrete water quality sampling locations within the boundaries of *Cape Romano-Ten Thousand Islands Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Table 21: Programs contributing data for Total Phosphorus

ProgramID	*N_Data*	*YearMin*	*YearMax*
509	1499	1994	2008
354	1182	2002	2024
5002	266	2002	2025
514	31	2001	2001
103	1	2015	2015

Program names:

103 - EPA STOrage and RETrieval Data Warehouse (STORET)/WQX[3]
354 - Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program[1]
509 - SERC Water Quality Monitoring Network[5]
514 - Florida LAKEWATCH Program[6]
5002 - Florida STORET / WIN[2]

Total Suspended Solids - Discrete

Seasonal Kendall-Tau Trend Analysis

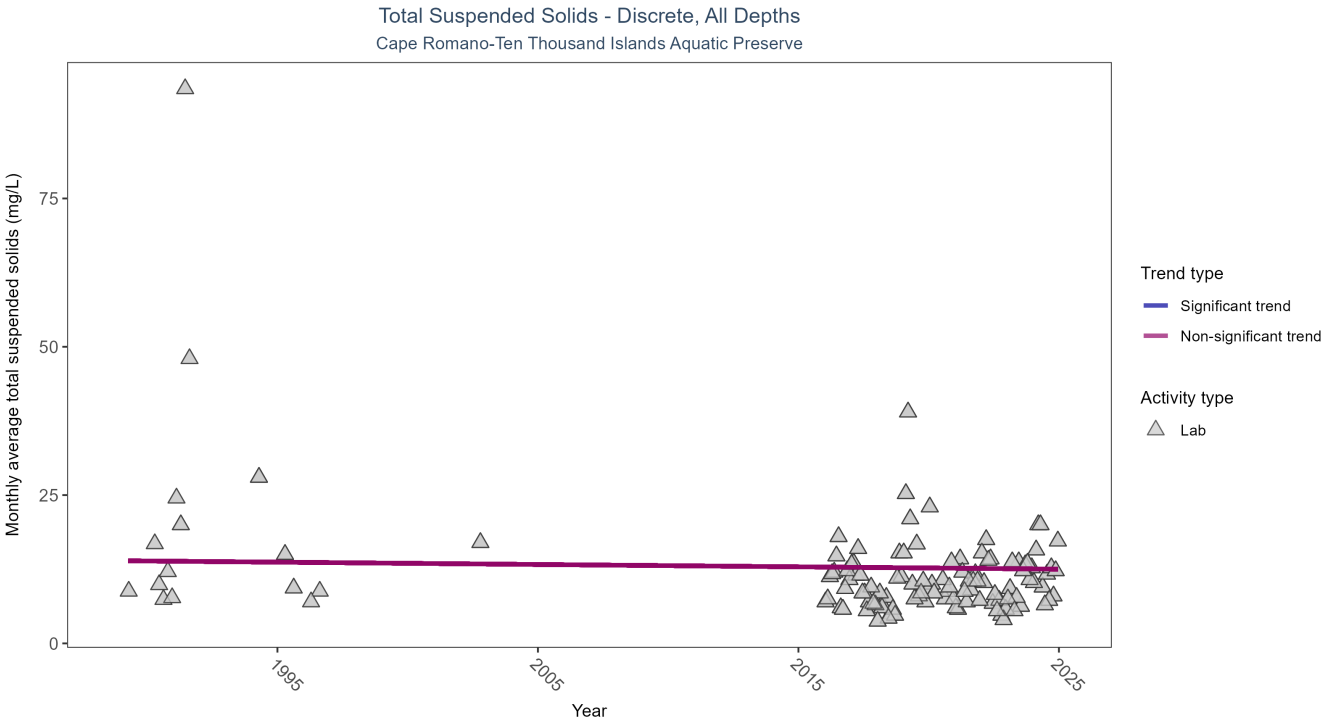

Figure 17: Scatter plot of monthly average total suspended solids (TSS) over time. If the time series included ten or more years of discrete observations, a significant (blue) or non-significant (magenta) trend line is also shown. Only TSS values obtained from laboratory analyses (triangles) are included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

Table 22: 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	No significant trend	464	16	1989 - 2024	10	-0.0252	13.93	-0.0393	0.5894

Total suspended solids showed no detectable trend between 1989 and 2024.

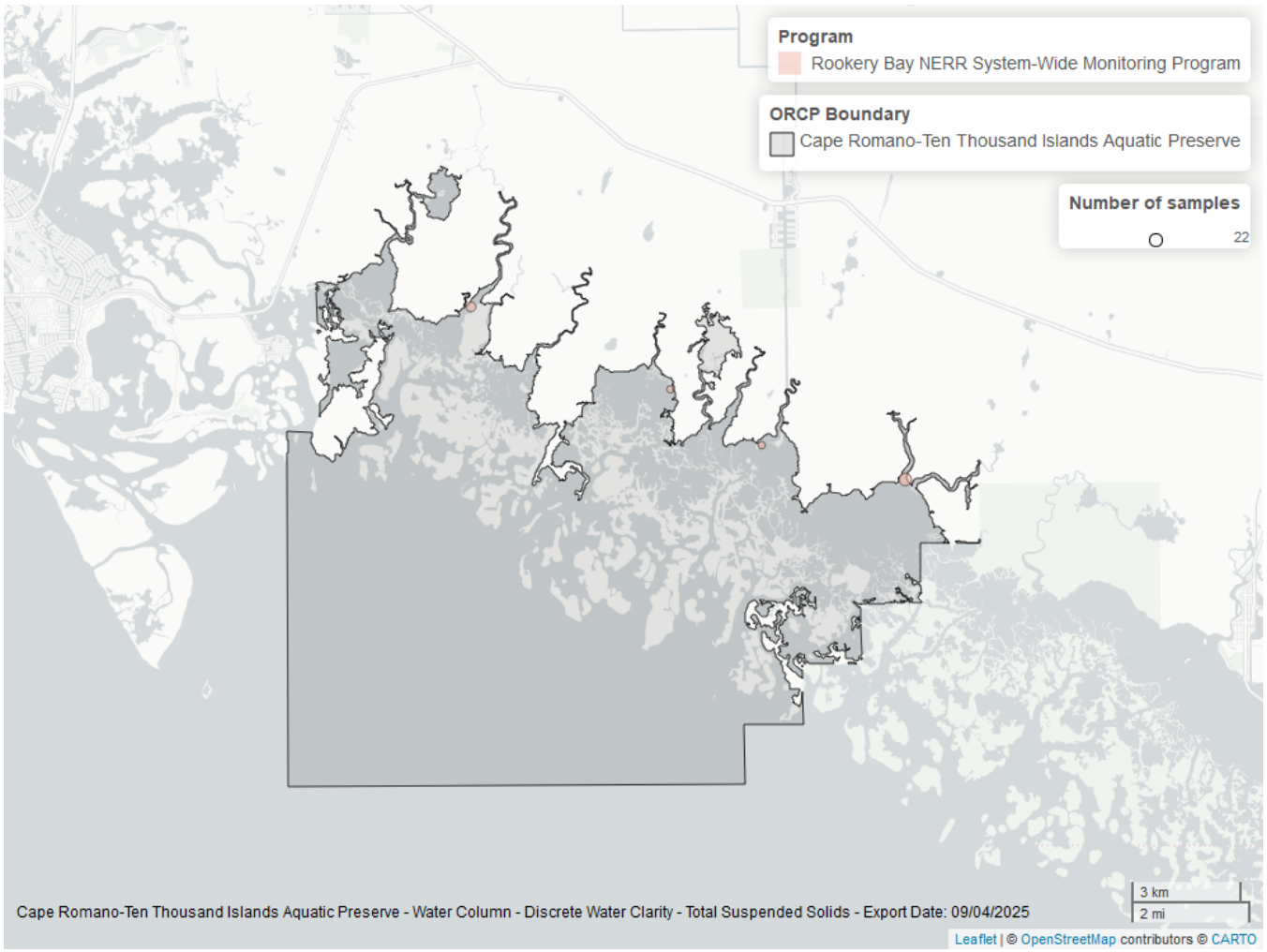

Figure 18: Map showing location of discrete water quality sampling locations within the boundaries of *Cape Romano-Ten Thousand Islands Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Table 23: Programs contributing data for Total Suspended Solids

ProgramID	*N_Data*	*YearMin*	*YearMax*
354	889	2016	2024
5002	46	1989	2017

Program names:

354 - Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program[1]
5002 - Florida STORET / WIN[2]

Turbidity - Discrete

Seasonal Kendall-Tau Trend Analysis

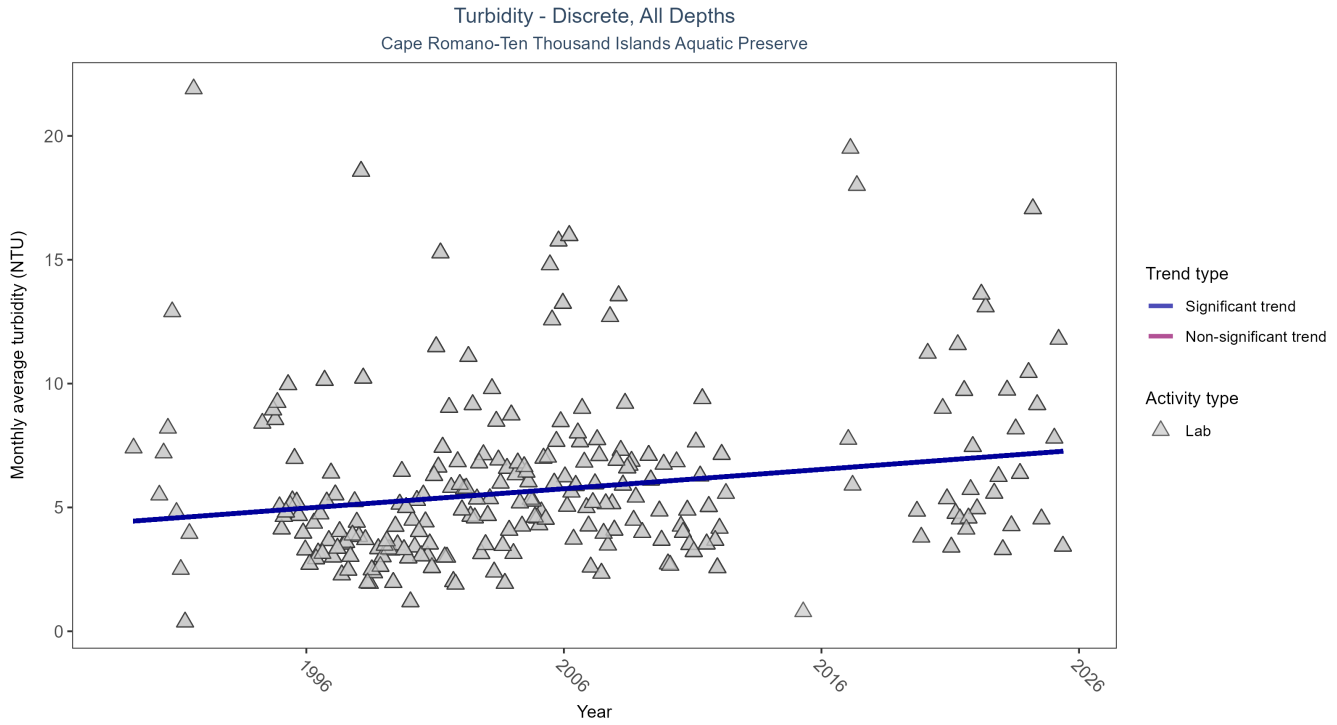

Figure 19: Scatter plot of monthly average turbidity over time. If the time series included ten or more years of discrete observations, a significant (blue) or non-significant (magenta) trend line is also shown. Only turbidity values measured in the laboratory (triangles) are included in the plot.

Table 24: 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 increasing trend	4672	31	1989 - 2025	4	0.1556	4.4264	0.0781	0.0005

Monthly average turbidity increased by 0.08 NTU per year, indicating a decrease in water clarity.

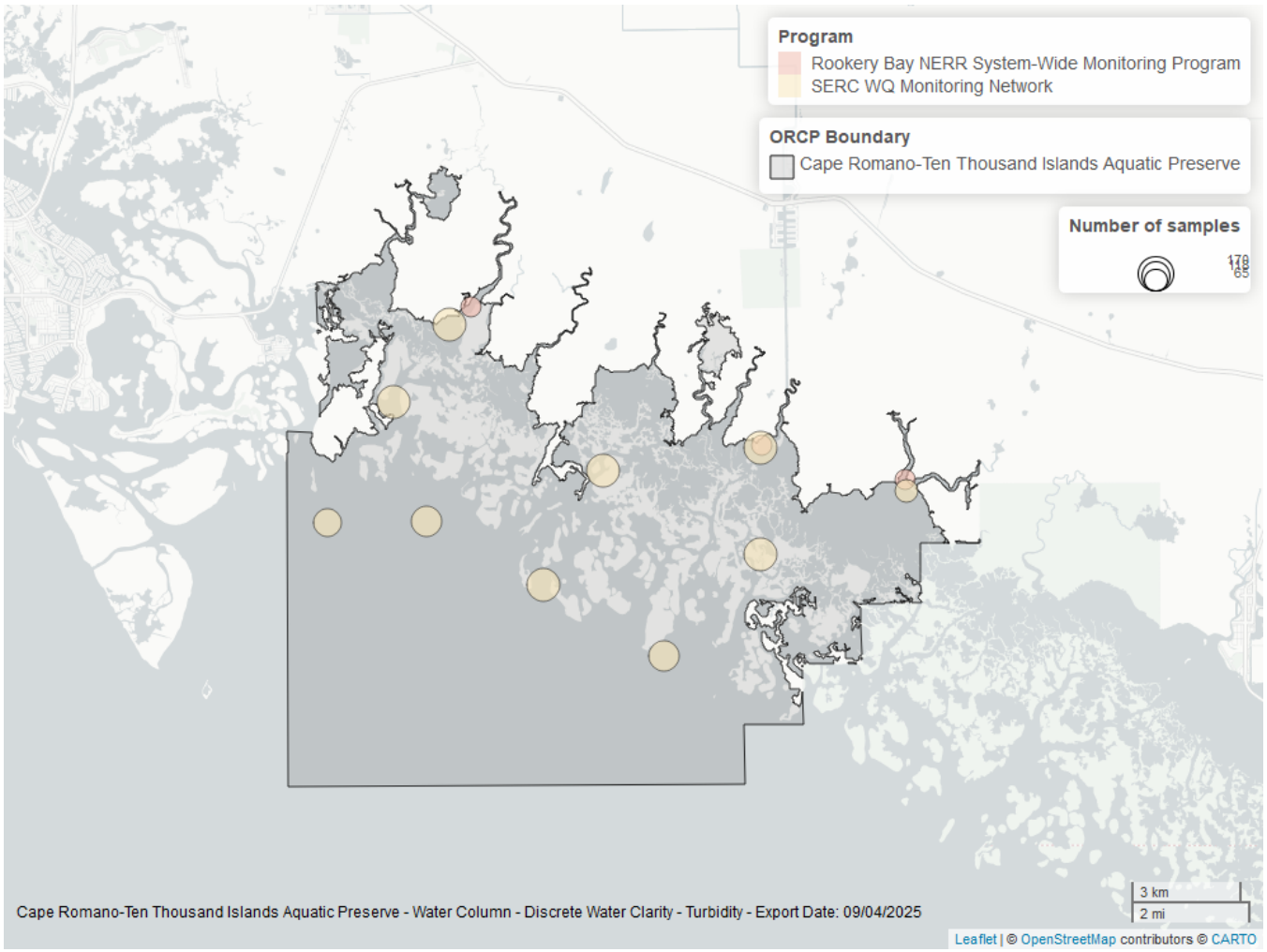

Figure 20: Map showing location of discrete water quality sampling locations within the boundaries of *Cape Romano-Ten Thousand Islands Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Table 25: Programs contributing data for Turbidity

ProgramID	*N_Data*	*YearMin*	*YearMax*
5002	3169	1989	2025
509	1510	1994	2008
354	207	2002	2006

Program names:

354 - Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program[1]
509 - SERC Water Quality Monitoring Network[5]
5002 - Florida STORET / WIN[2]

Water Temperature - Discrete

Seasonal Kendall-Tau Trend Analysis

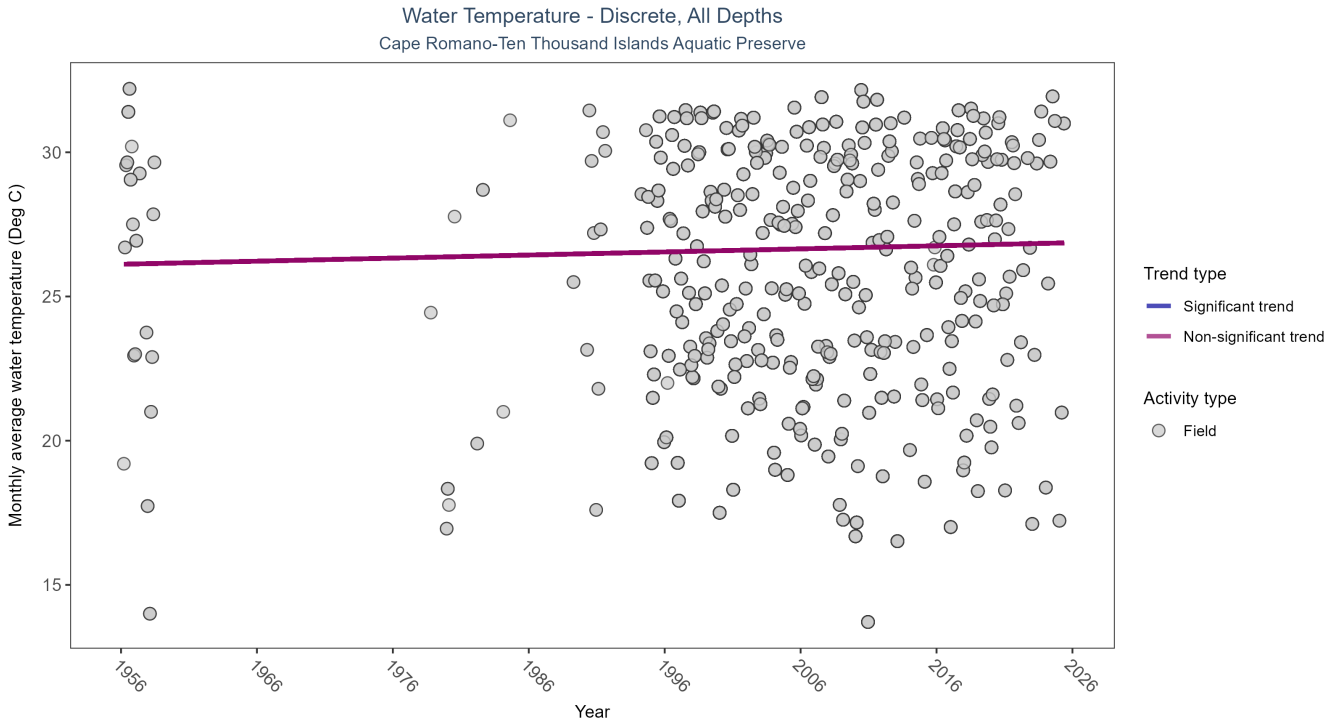

Figure 21: Scatter plot of monthly average water temperature over time. If the time series included ten or more years of discrete observations, a significant (blue) or non-significant (magenta) trend line is also shown. Only water temperature measurements taken in the field (circles) are included in the plot.

Table 26: 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	No significant trend	11167	43	1956 - 2025	26.7	0.0591	26.1169	0.0107	0.1019

Water temperature showed no detectable trend between 1956 and 2025.

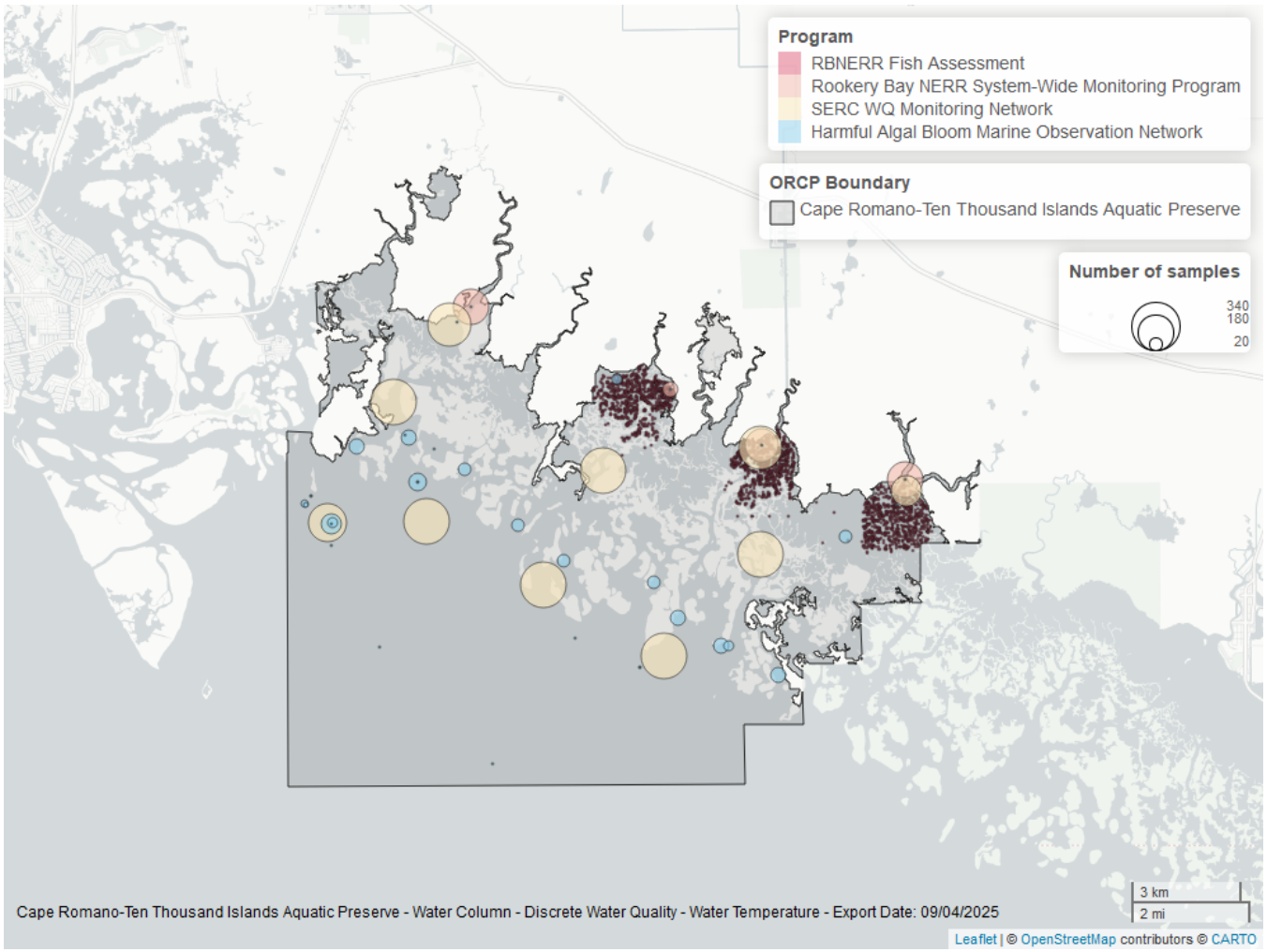

Figure 22: Map showing location of discrete water quality sampling locations within the boundaries of *Cape Romano-Ten Thousand Islands Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Table 27: Programs contributing data for Water Temperature

ProgramID	*N_Data*	*YearMin*	*YearMax*
5002	4608	1989	2025
509	2944	1994	2008
4043	2541	1999	2020
354	1041	2002	2024
95	482	1956	2018

Program names:

95 - Harmful Algal Bloom Marine Observation Network[7]
354 - Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program[1]
509 - SERC Water Quality Monitoring Network[5]
4043 - RBNERR Fish Assessment[8]
5002 - Florida STORET / WIN[2]

Water Quality - Continuous

The following files were used in the continuous analysis:

- *Combined_WQ_WC_NUT_cont_Dissolved_Oxygen_SW-2025-Sep-19.txt*
- *Combined_WQ_WC_NUT_cont_Dissolved_Oxygen_Saturation_SW-2025-Sep-19.txt*
- *Combined_WQ_WC_NUT_cont_pH_SW-2025-Sep-19.txt*
- *Combined_WQ_WC_NUT_cont_Salinity_SW-2025-Sep-19.txt*
- *Combined_WQ_WC_NUT_cont_Turbidity_SW-2025-Sep-19.txt*
- *Combined_WQ_WC_NUT_cont_Water_Temperature_SW-2025-Sep-19.txt*

Continuous monitoring locations in Cape Romano-Ten Thousand Islands Aquatic Preserve

Table 28: Station overview for Continuous parameters by Program

ProgramID	*ProgramLocationID*	*Years of Data*	*Use in Analysis*	*Parameters*
7	255123081321300	11	TRUE	Sal , TempW
7	255138081321701	9	TRUE	Sal , TempW
7	255432081303900	20	TRUE	Sal , TempW
7	255443081314700	5	FALSE	Sal , TempW
7	255532081314300	3	FALSE	Sal , TempW
7	255534081324000	19	TRUE	Sal , TempW
7	255654081350200	19	TRUE	Sal , TempW
7	255732081363700	5	TRUE	Sal , TempW
354	rkbfbwq	24	TRUE	DO , DOS , pH , Sal , Turb , TempW
354	rkbfuwq	24	TRUE	DO , DOS , pH , Sal , Turb , TempW
354	rkbmbwq	26	TRUE	DO , DOS , pH , Sal , Turb , TempW
354	rkbpbwq	10	TRUE	DO , DOS , pH , Sal , Turb , TempW

Program names:

7 - National Water Information System[9]
354 - Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program[1]

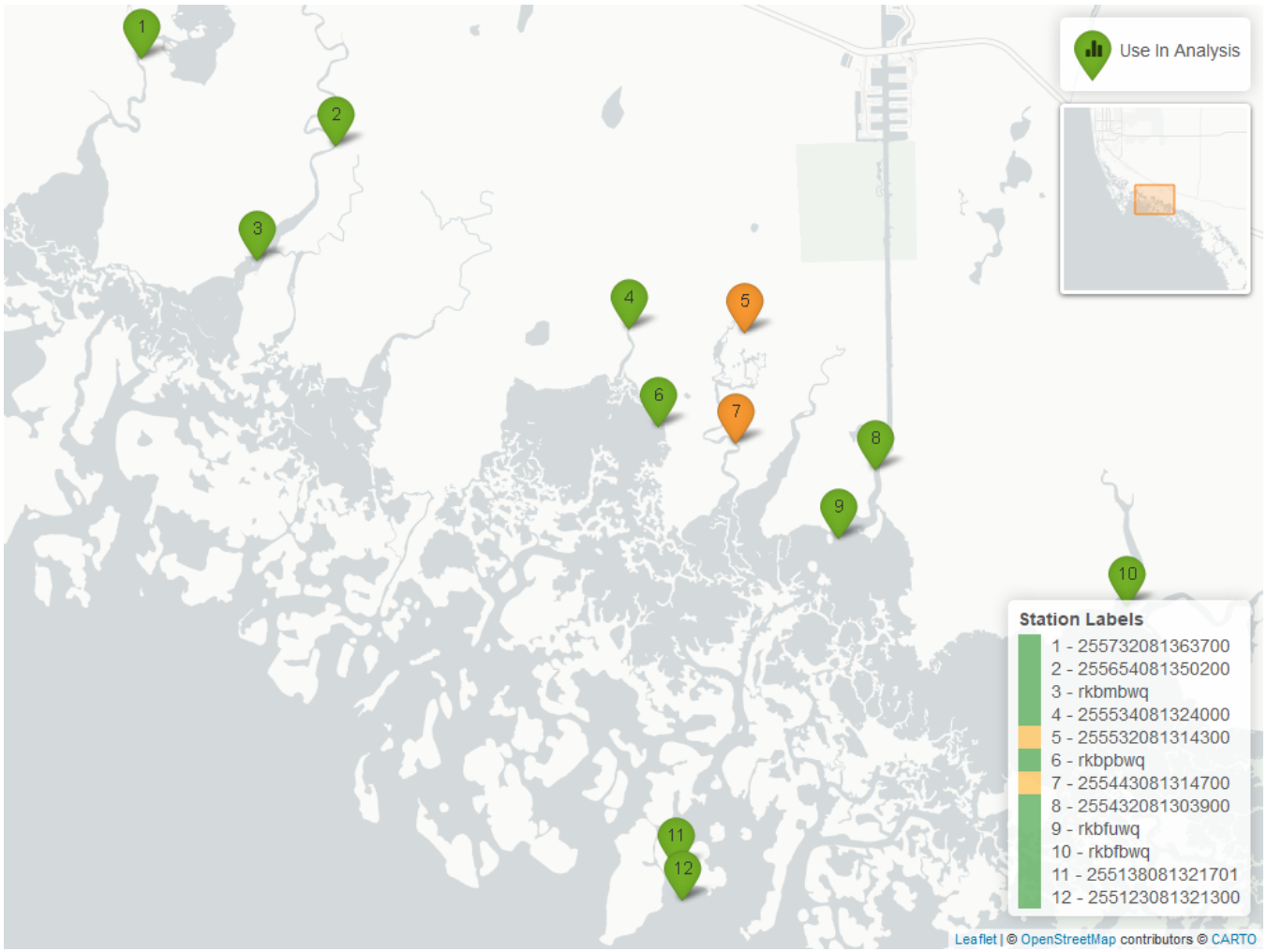

Figure 23: Map showing continuous water quality sampling locations within the boundaries of *Cape Romano-Ten Thousand Islands Aquatic Preserve*. Sites marked as *Use In Analysis* (green) are featured in this report.

Dissolved Oxygen - Continuous

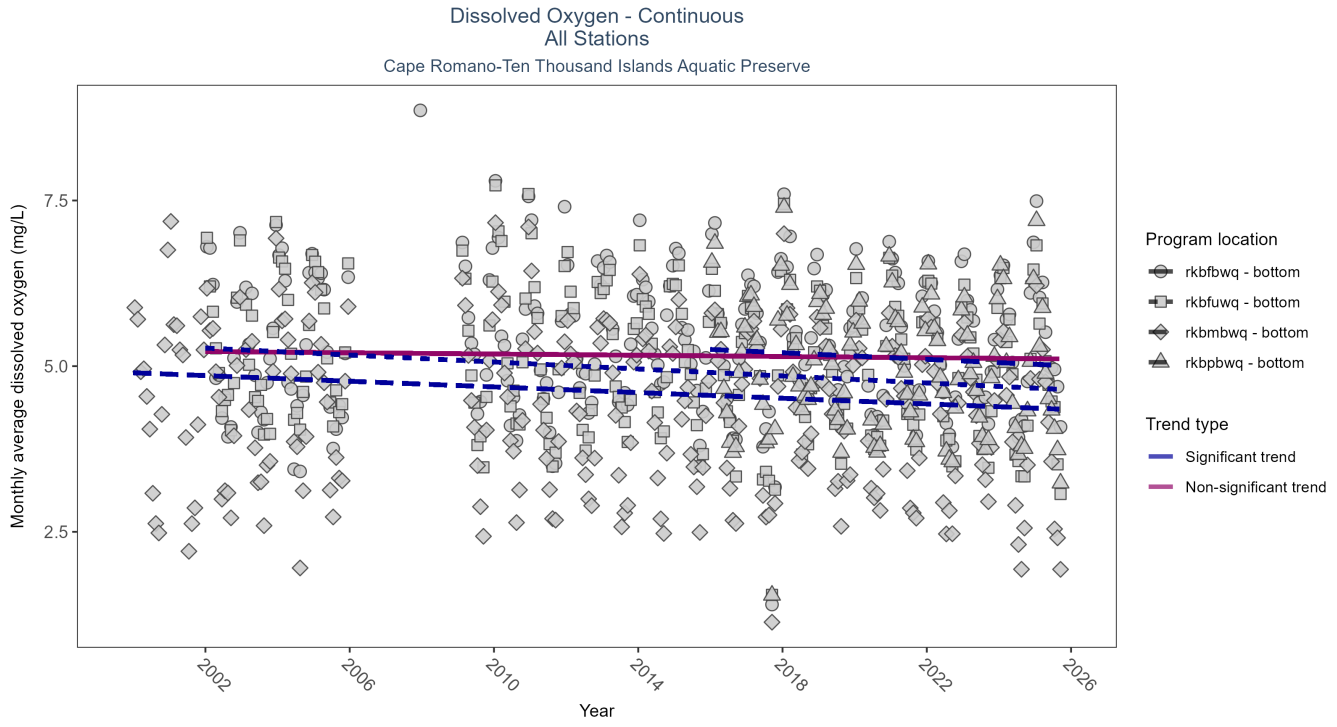

Figure 24: Scatter plot of monthly average dissolved oxygen over time at continuously monitored program locations. Each location is analyzed separately, with significant (blue) or non-significant (magenta) trend lines shown for time series that included five or more years of observations.

Table 29: 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
rkbmbwq	Significantly decreasing trend	644227	23	2000 - 2025	4.4	-0.26	4.90	-0.02	0.00
rkbfbwq	No significant trend	589693	22	2002 - 2025	5.4	-0.04	5.22	0.00	0.41
rkbpbwq	Significantly decreasing trend	320370	10	2016 - 2025	4.9	-0.17	5.25	-0.02	0.02
rkbfuwq	Significantly decreasing trend	621074	21	2002 - 2025	5.1	-0.31	5.27	-0.03	0.00

At three program locations, monthly average dissolved oxygen decreased between 0.02 and 0.03 mg/L per year. No detectable change in monthly average dissolved oxygen was observed at one location.

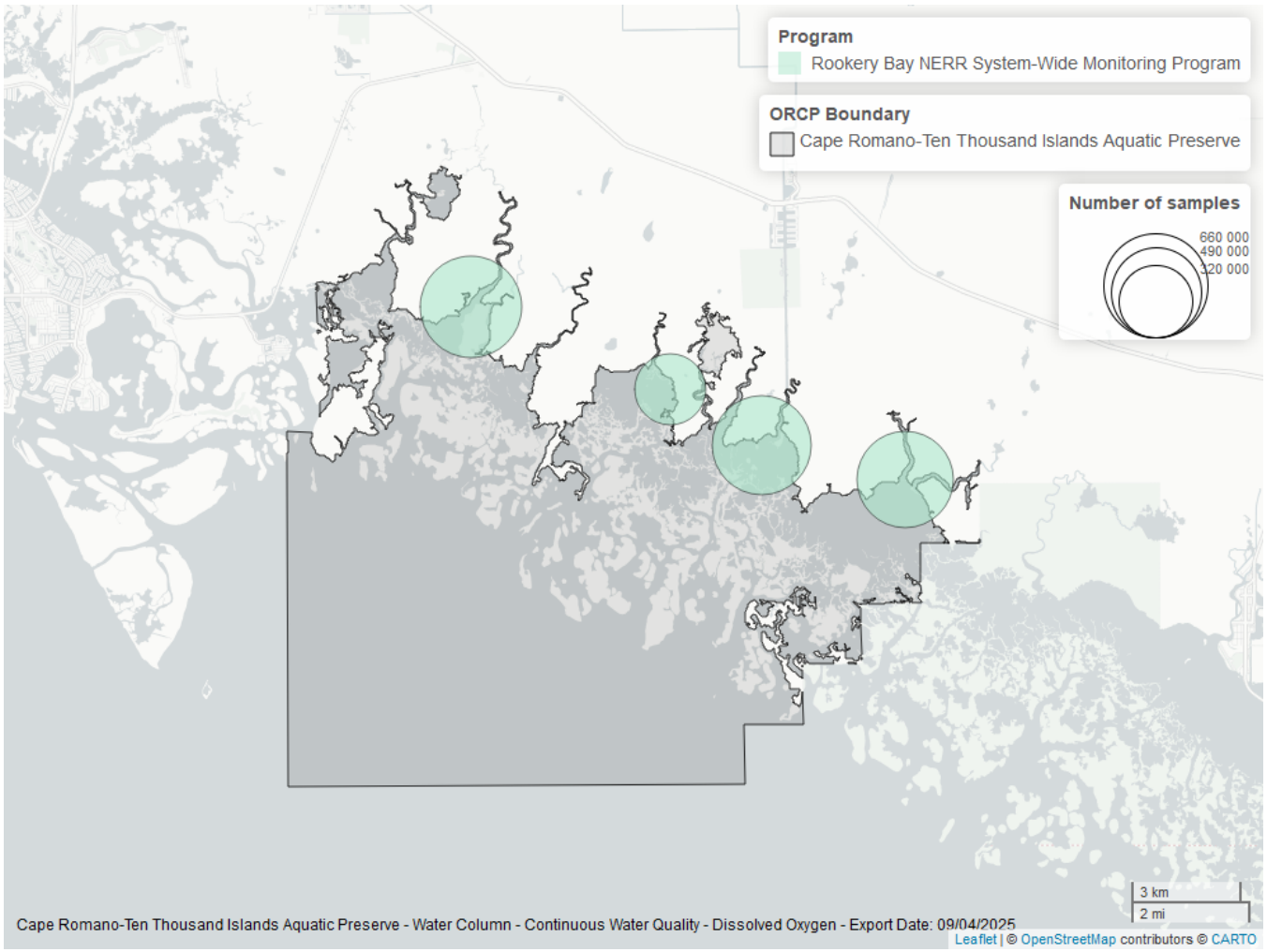

Figure 25: Map showing location of dissolved oxygen continuous water quality sampling locations within the boundaries of *Cape Romano-Ten Thousand Islands Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Dissolved Oxygen Saturation - Continuous

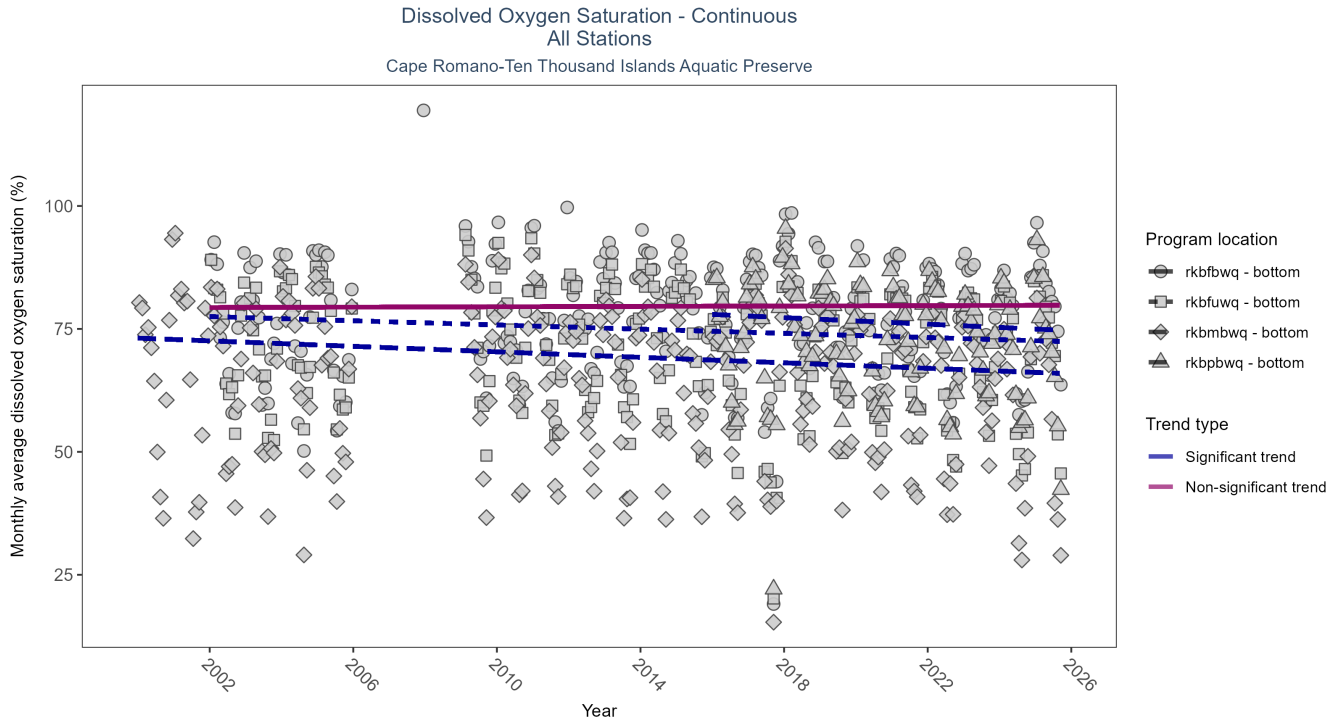

Figure 26: Scatter plot of monthly average dissolved oxygen saturation over time at continuously monitored program locations. Each location is analyzed separately, with significant (blue) or non-significant (magenta) trend lines shown for time series that included five or more years of observations.

Table 30: 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
rkbfbwq	No significant trend	593999	22	2002 - 2025	78.8	0.02	79.35	0.02	0.72
rkbfuwq	Significantly decreasing trend	621333	21	2002 - 2025	72.5	-0.23	77.51	-0.21	0.00
rkbpbwq	Significantly decreasing trend	322002	10	2016 - 2025	72.7	-0.18	77.95	-0.33	0.02
rkbmbwq	Significantly decreasing trend	650551	23	2000 - 2025	65.2	-0.23	73.13	-0.28	0.00

At three program locations, monthly average dissolved oxygen saturation decreased between 0.21 and 0.33% per year. No detectable change in monthly average dissolved oxygen saturation was observed at one location.

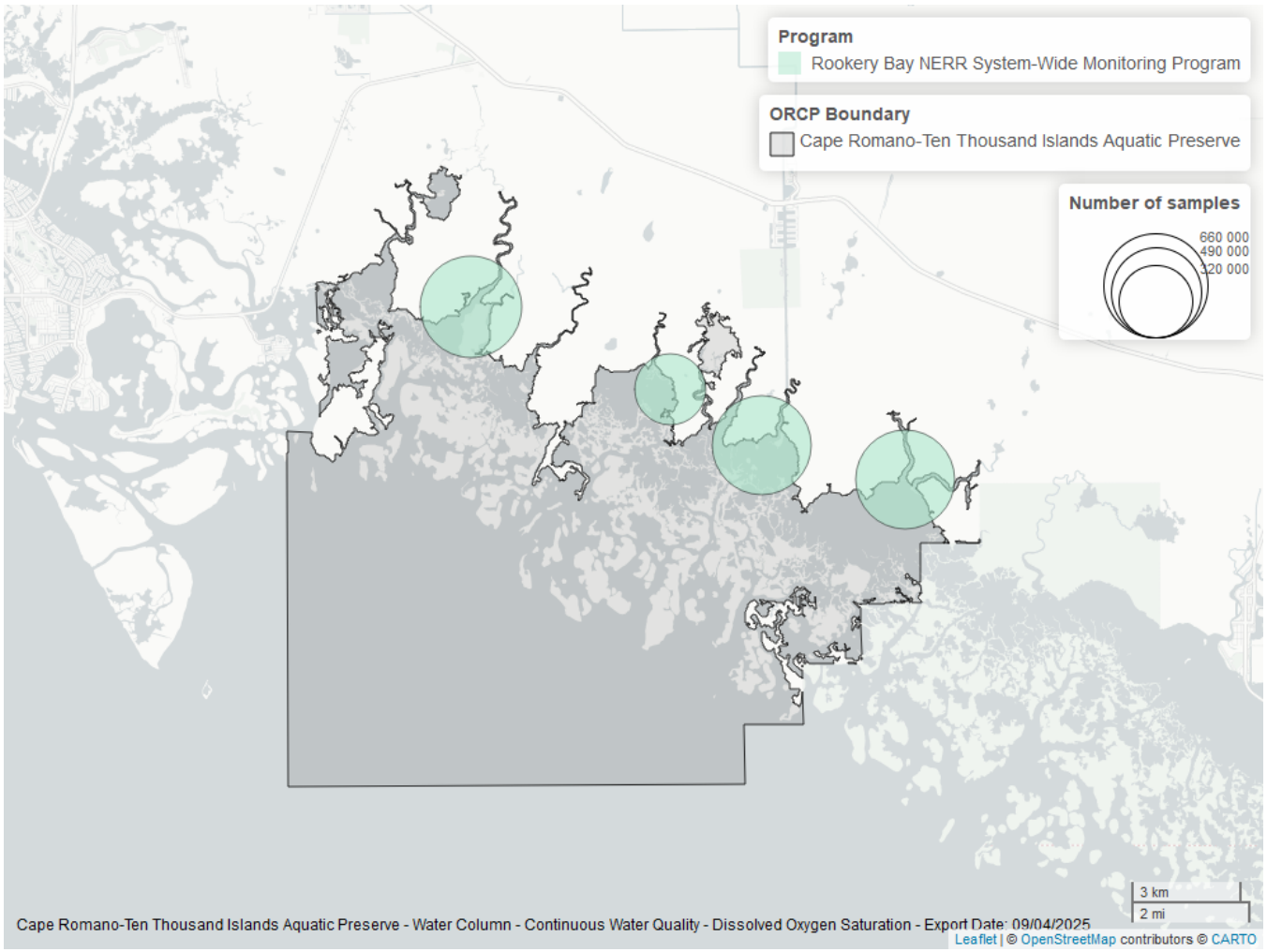

Figure 27: Map showing location of dissolved oxygen saturation continuous water quality sampling locations within the boundaries of *Cape Romano-Ten Thousand Islands Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

pH - Continuous

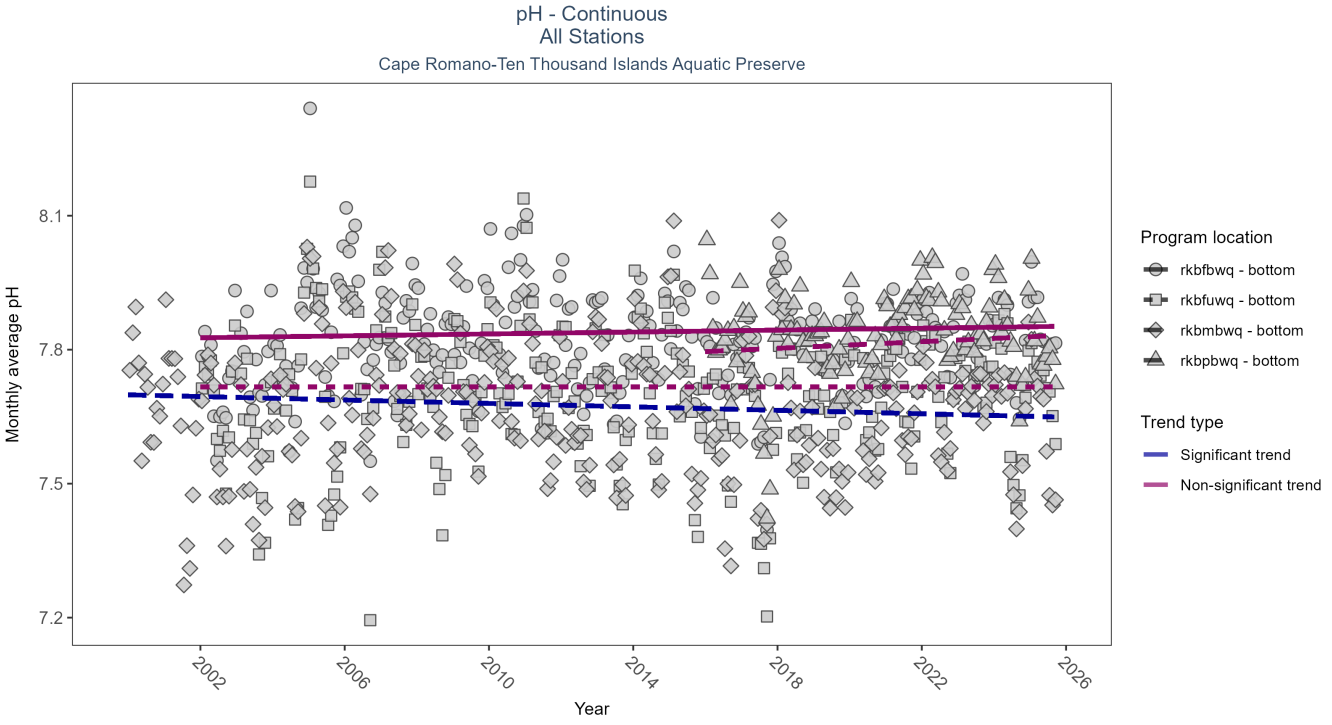

Figure 28: Scatter plot of monthly average pH over time at continuously monitored program locations. Each location is analyzed separately, with significant (blue) or non-significant (magenta) trend lines shown for time series that included five or more years of observations.

Table 31: 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
rkbmbwq	Significantly decreasing trend	714491	26	2000 - 2025	7.7	-0.09	7.70	0	0.02
rkbpbwq	No significant trend	313866	10	2016 - 2025	7.8	0.11	7.80	0	0.15
rkbfuwq	No significant trend	673674	24	2002 - 2025	7.7	0.00	7.72	0	0.98
rkbfbwq	No significant trend	656468	24	2002 - 2025	7.8	0.06	7.83	0	0.15

At one program location, monthly average pH decreased by less than 0.01 pH units per year. No detectable change in monthly average pH was observed at three locations.

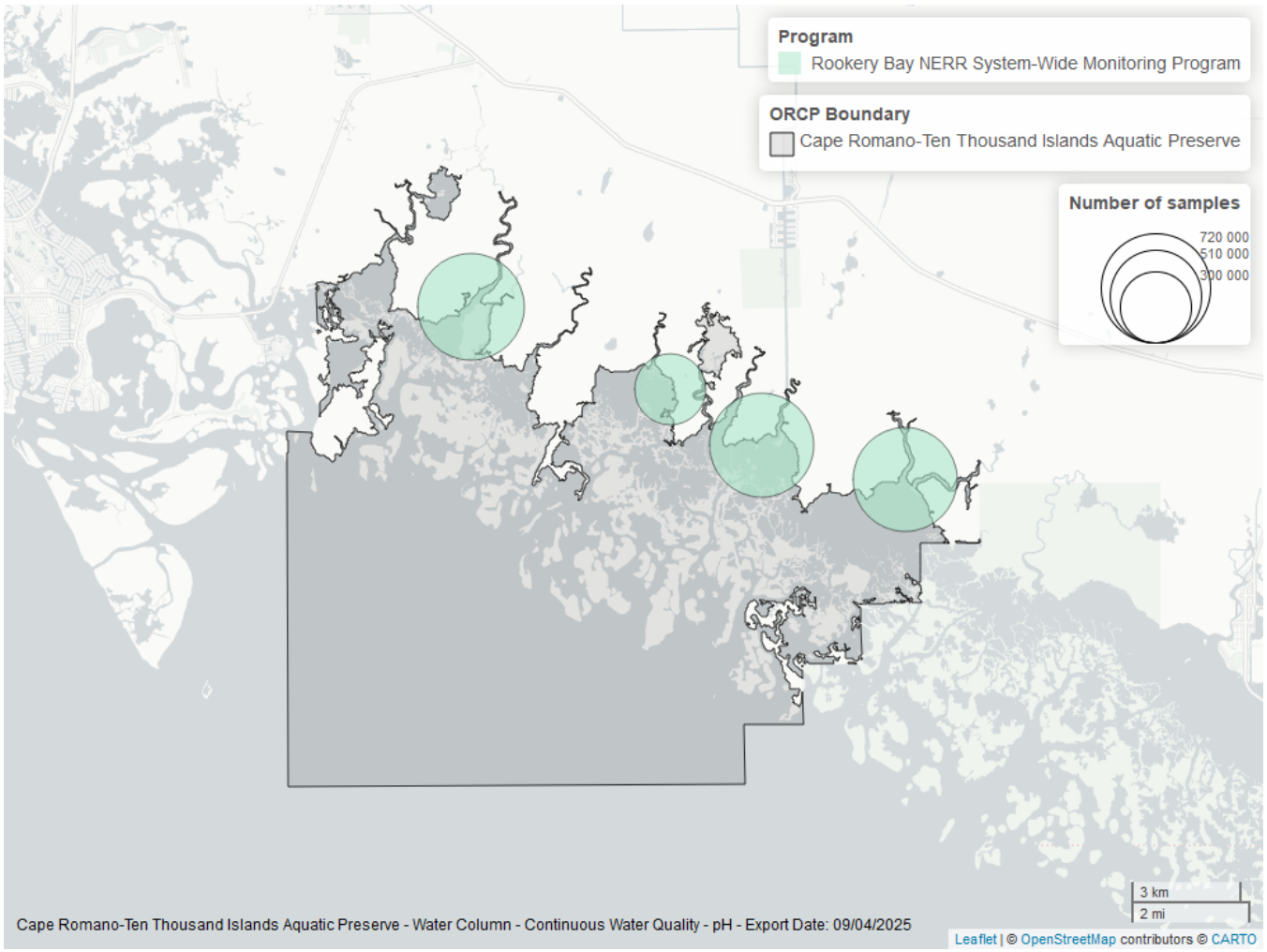

Figure 29: Map showing location of ph continuous water quality sampling locations within the boundaries of *Cape Romano-Ten Thousand Islands Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Salinity - Continuous - Program 7

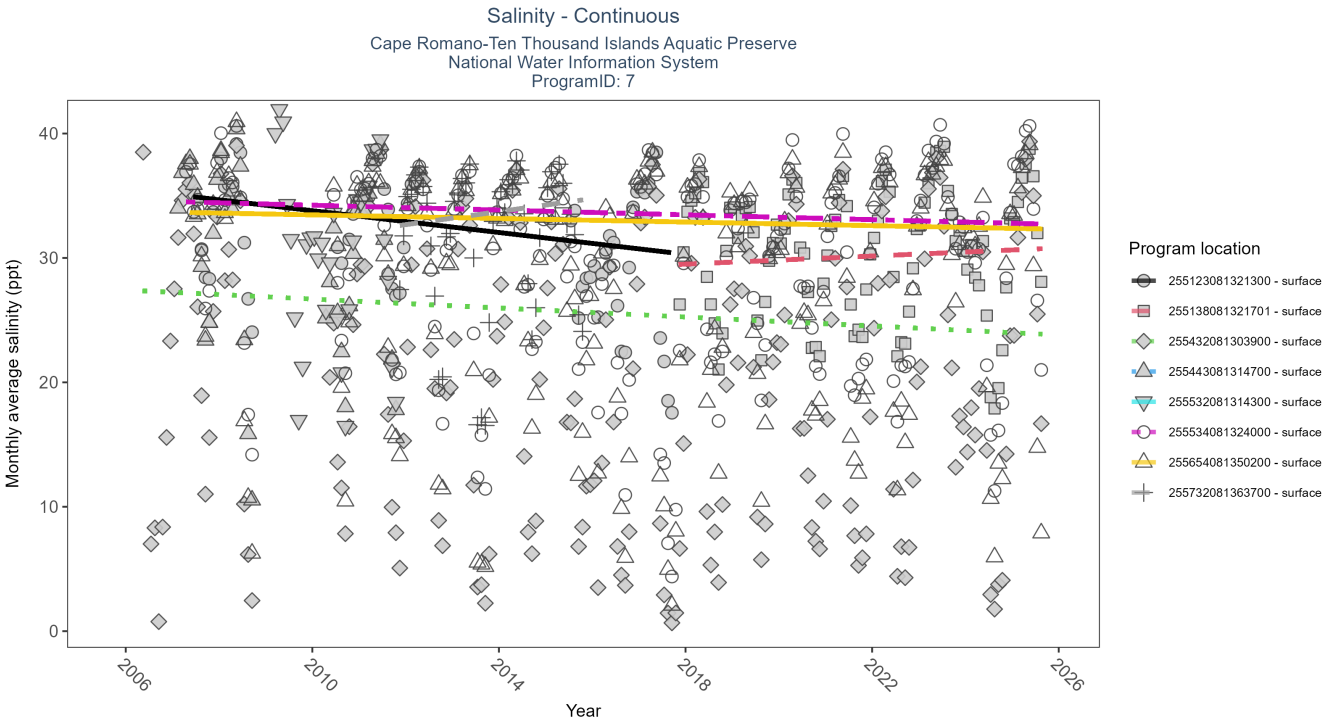

Figure 30: Scatter plot of monthly average salinity over time at continuously monitored program locations. Each location is analyzed separately, with significant (blue) or non-significant (magenta) trend lines shown for time series that included five or more years of observations.

Table 32: Seasonal Kendall-Tau Results for Salinity - Program 7

Station	Statistical Trend	Sample Count	Years with Data	Period of Record	Median	tau	Sen Intercept	Sen Slope	p
255534081324000	No significant trend	5981	18	2007 - 2025	32	-0.08	34.53	-0.1	0.11
255432081303900	Significantly decreasing trend	6288	19	2006 - 2025	22	-0.14	27.42	-0.18	0.01
255123081321300	Significantly decreasing trend	1809	8	2007 - 2017	32	-0.23	35.11	-0.44	0.02
255654081350200	No significant trend	6002	18	2007 - 2025	32	-0.07	33.68	-0.07	0.17
255138081321701	No significant trend	2809	9	2017 - 2025	32	0.09	29.34	0.16	0.32
255732081363700	No significant trend	1434	5	2011 - 2015	34	0.25	32.15	0.52	0.1
255532081314300	Insufficient data to calculate trend	902	3	2009 - 2011	31	-	-	-	-
255443081314700	Insufficient data to calculate trend	1465	4	2007 - 2011	32	-	-	-	-

At three program locations, monthly average salinity decreased between 0.07 and 0.44 ppt per year. No detectable change in monthly average salinity was observed at seven locations. There was insufficient data to fit a model for two locations.

Salinity - Continuous - Program 354

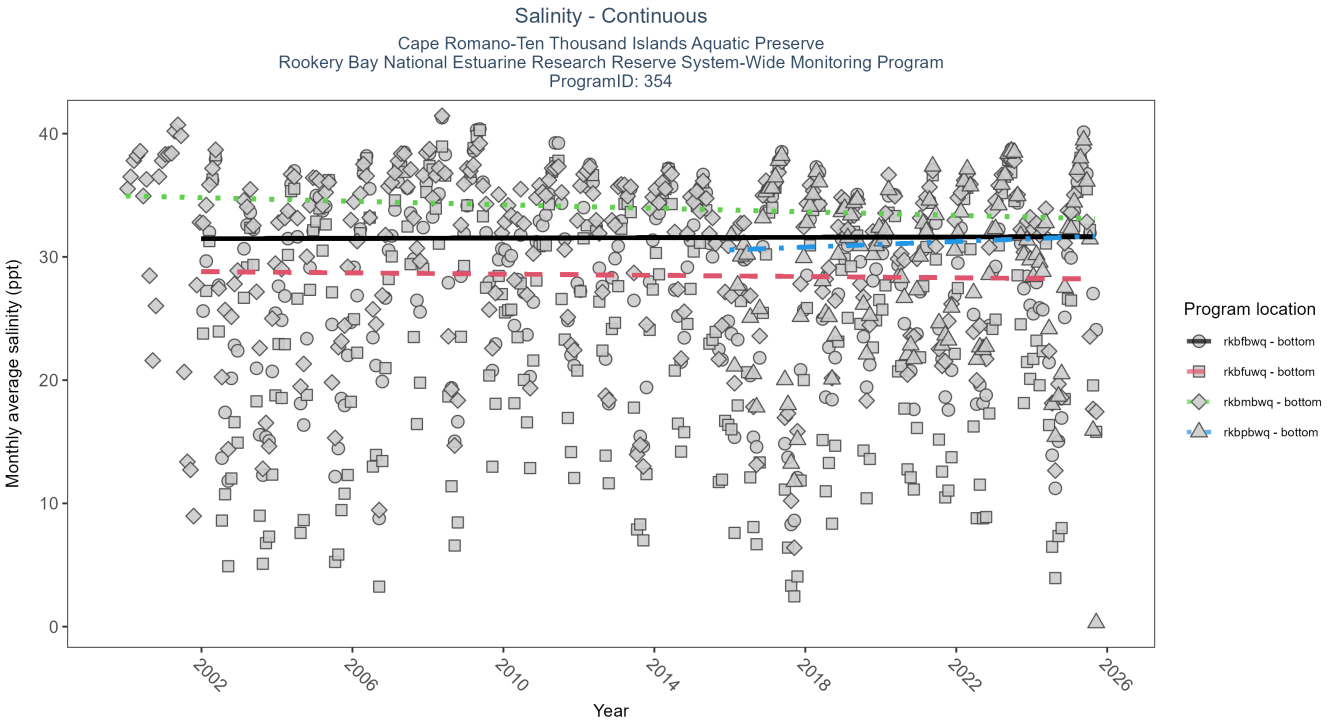

Figure 31: Scatter plot of monthly average salinity over time at continuously monitored program locations. Each location is analyzed separately, with significant (blue) or non-significant (magenta) trend lines shown for time series that included five or more years of observations.

Table 33: Seasonal Kendall-Tau Results for Salinity - Program 354

Station	Statistical Trend	Sample Count	Years with Data	Period of Record	Median	tau	Sen Intercept	Sen Slope	p
rkbfuwq	No significant trend	701628	24	2002 - 2025	26.2	-0.02	28.81	-0.03	0.64
rkbpbwq	No significant trend	320685	10	2016 - 2025	30.5	0.06	30.56	0.11	0.44
rkbfbwq	No significant trend	688966	24	2002 - 2025	29.8	0.01	31.48	0.01	0.83
rkbmbwq	Significantly decreasing trend	725814	26	2000 - 2025	33.3	-0.11	34.95	-0.07	0.01

At three program locations, monthly average salinity decreased between 0.07 and 0.44 ppt per year. No detectable change in monthly average salinity was observed at seven locations. There was insufficient data to fit a model for two locations.

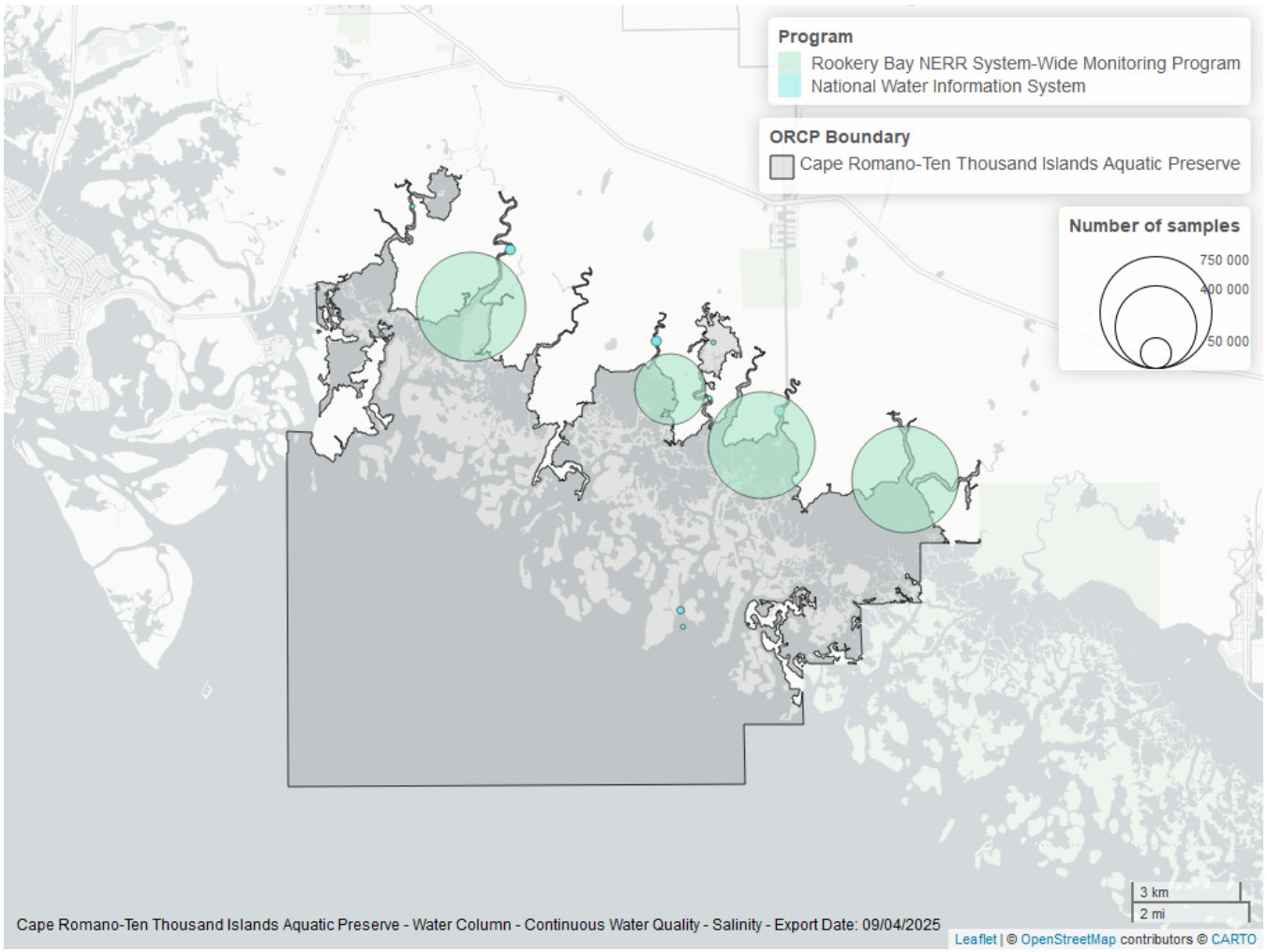

Figure 32: Map showing location of salinity continuous water quality sampling locations within the boundaries of *Cape Romano-Ten Thousand Islands Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Turbidity - Continuous

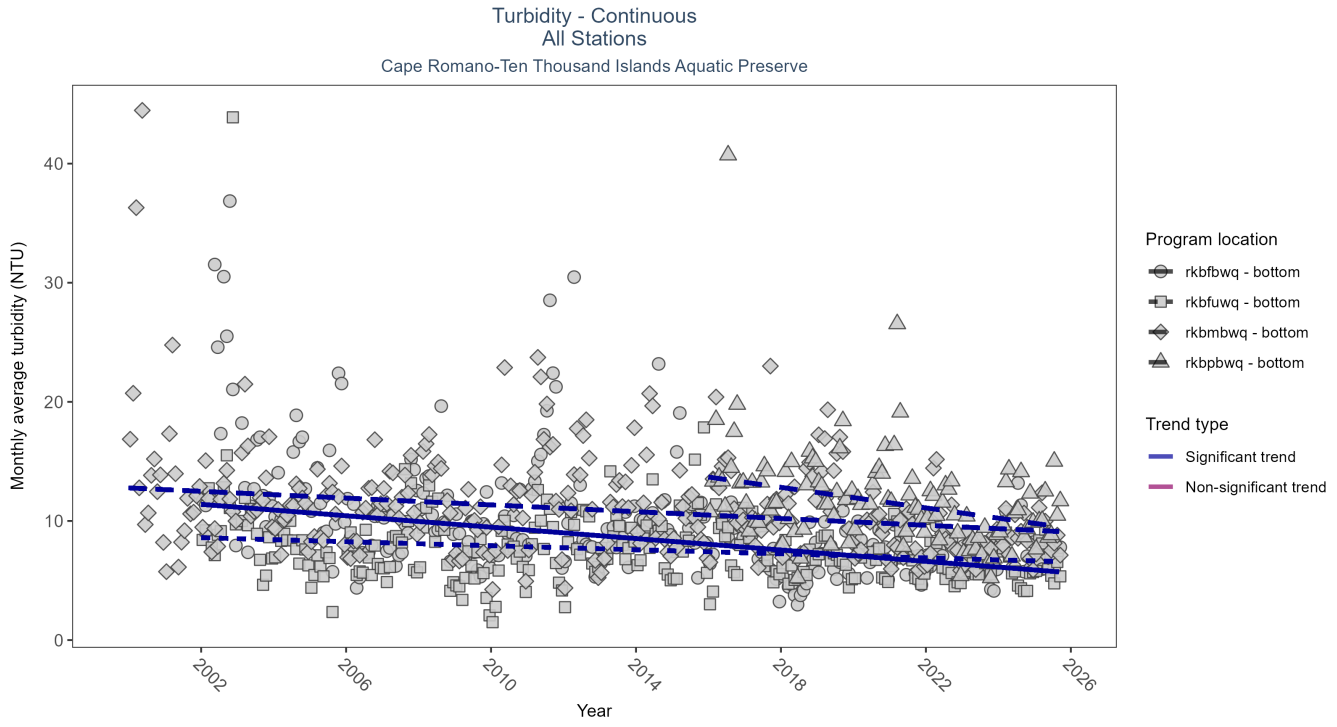

Figure 33: Scatter plot of monthly average turbidity over time at continuously monitored program locations. Each location is analyzed separately, with significant (blue) or non-significant (magenta) trend lines shown for time series that included five or more years of observations.

Table 34: 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
rkbfuwq	Significantly decreasing trend	642336	24	2002 - 2025	6	-0.21	8.60	-0.08	0
rkbpbwq	Significantly decreasing trend	317056	10	2016 - 2025	9	-0.34	13.68	-0.43	0
rkbfbwq	Significantly decreasing trend	668705	24	2002 - 2025	7	-0.40	11.40	-0.24	0
rkbmbwq	Significantly decreasing trend	701426	26	2000 - 2025	9	-0.24	12.78	-0.14	0

At four program locations, monthly average turbidity decreased between 0.08 and 0.43 NTU per year.

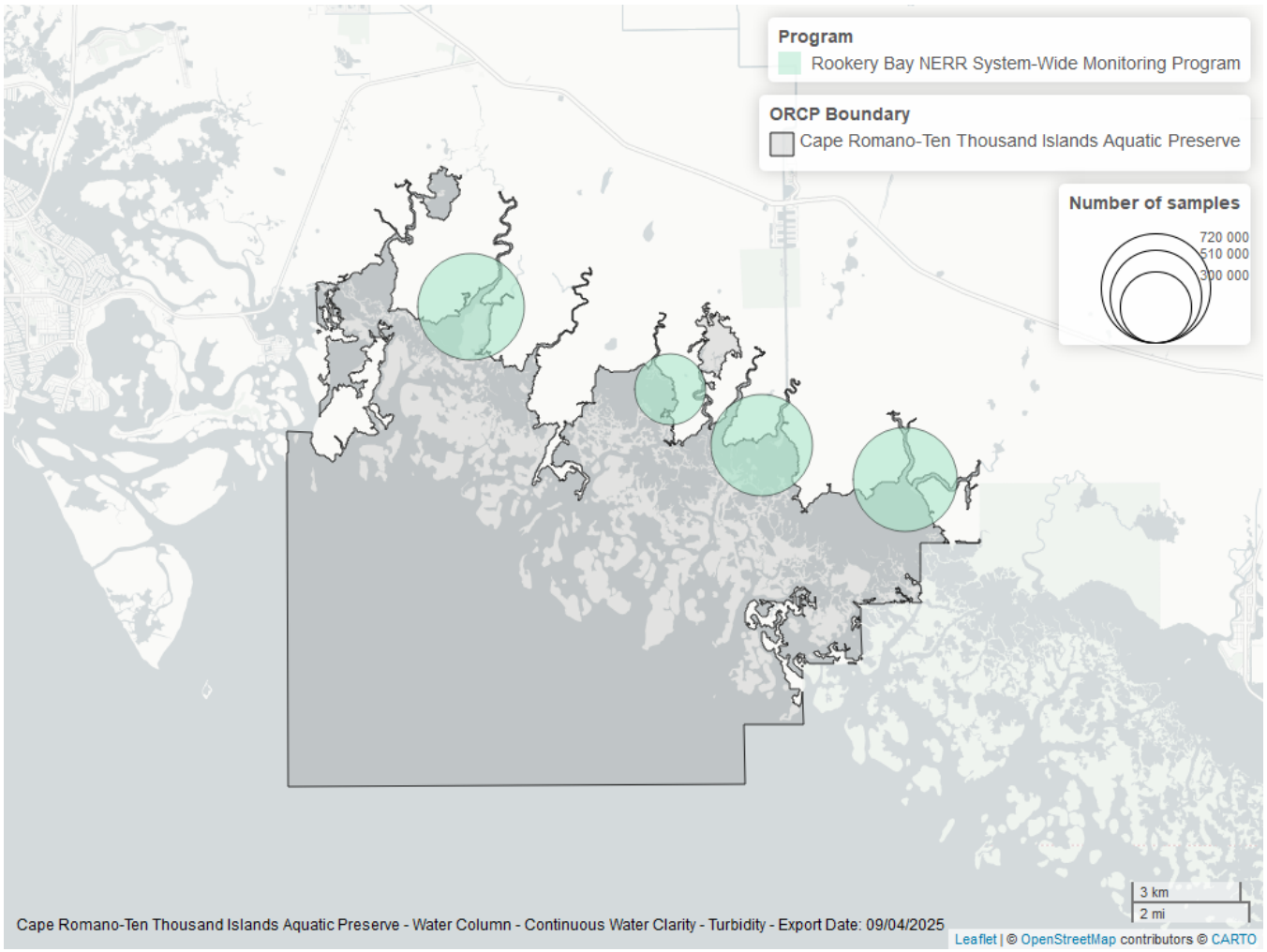

Figure 34: Map showing location of turbidity continuous water quality sampling locations within the boundaries of *Cape Romano-Ten Thousand Islands Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Water Temperature - Continuous - Program 7

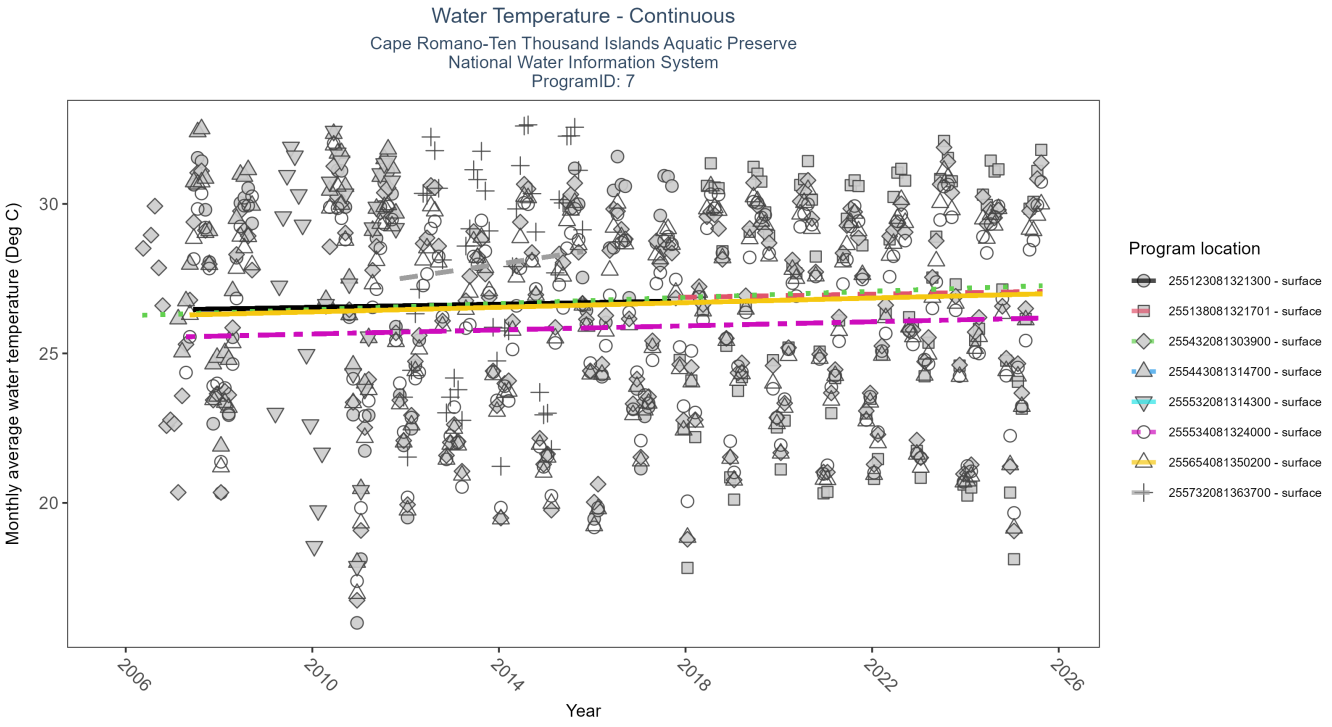

Figure 35: Scatter plot of monthly average water temperature over time at continuously monitored program locations. Each location is analyzed separately, with significant (blue) or non-significant (magenta) trend lines shown for time series that included five or more years of observations.

Table 35: Seasonal Kendall-Tau Results for Water Temperature - Program 7

Station	Statistical Trend	Sample Count	Years with Data	Period of Record	Median	tau	Sen Intercept	Sen Slope	p
255534081324000	Significantly increasing trend	6044	18	2007 - 2025	26.7	0.14	25.55	0.03	0.01
255654081350200	Significantly increasing trend	6041	18	2007 - 2025	26.8	0.13	26.27	0.04	0.01
255138081321701	No significant trend	2827	9	2017 - 2025	27.2	0.06	26.85	0.03	0.49
255432081303900	Significantly increasing trend	6347	19	2006 - 2025	27.0	0.17	26.26	0.05	0
255123081321300	No significant trend	1818	8	2007 - 2017	27.3	0.1	26.46	0.03	0.38
255732081363700	No significant trend	1435	5	2011 - 2015	28.4	0.24	27.3	0.23	0.11
255532081314300	Insufficient data to calculate trend	906	3	2009 - 2011	29.3	-	-	-	-
255443081314700	Insufficient data to calculate trend	2011	4	2007 - 2011	29.3	-	-	-	-

At six program locations, monthly average water temperature increased between 0.03 and 0.07°C per year. No detectable change in monthly average water temperature was observed at four locations. There was insufficient data to fit a model for two locations.

Water Temperature - Continuous - Program 354

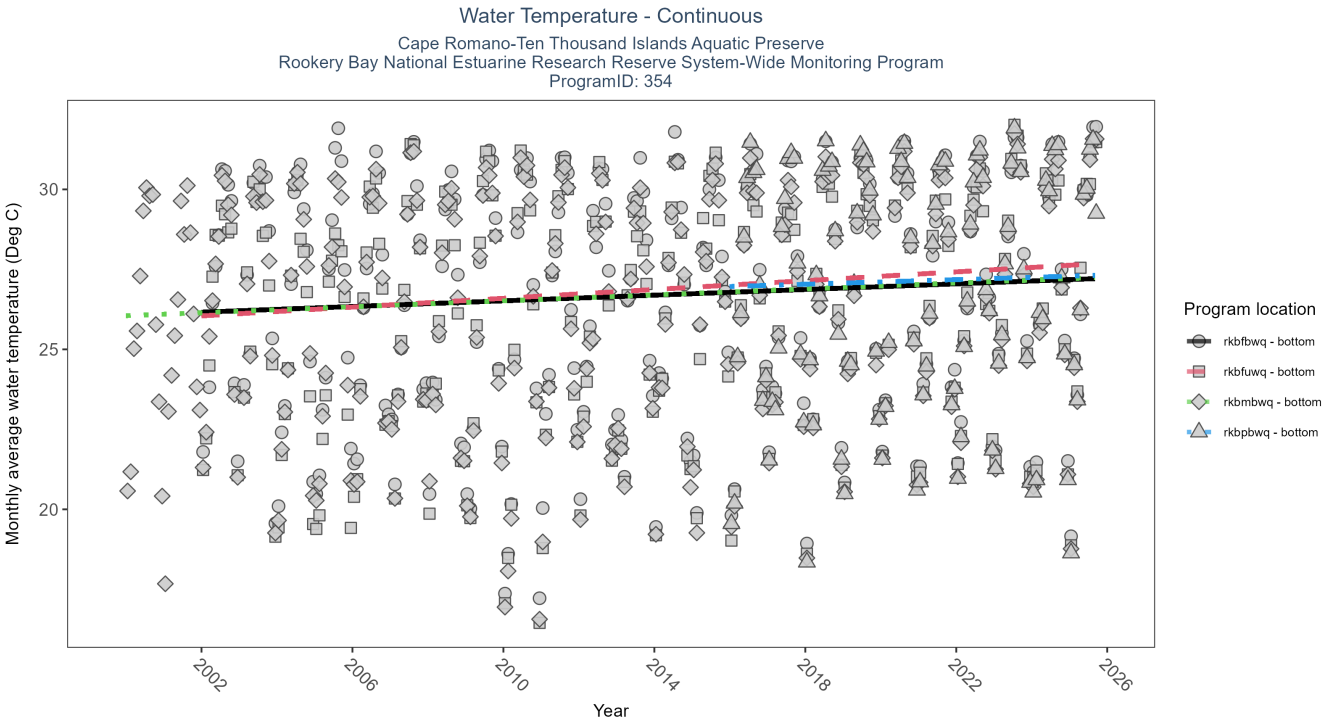

Figure 36: Scatter plot of monthly average water temperature over time at continuously monitored program locations. Each location is analyzed separately, with significant (blue) or non-significant (magenta) trend lines shown for time series that included five or more years of observations.

Table 36: Seasonal Kendall-Tau Results for Water Temperature - Program 354

Station	Statistical Trend	Sample Count	Years with Data	Period of Record	Median	tau	Sen Intercept	Sen Slope	p
rkbfuwq	Significantly increasing trend	712059	24	2002 - 2025	27.0	0.27	26.05	0.07	0.0
rkbpbwq	No significant trend	323585	10	2016 - 2025	27.5	0.08	26.96	0.04	0.3
rkbmbwq	Significantly increasing trend	749141	26	2000 - 2025	26.9	0.26	26.05	0.05	0.0
rkbfbwq	Significantly increasing trend	704805	24	2002 - 2025	27.0	0.24	26.16	0.04	0.0

At six program locations, monthly average water temperature increased between 0.03 and 0.07°C per year. No detectable change in monthly average water temperature was observed at four locations. There was insufficient data to fit a model for two locations.

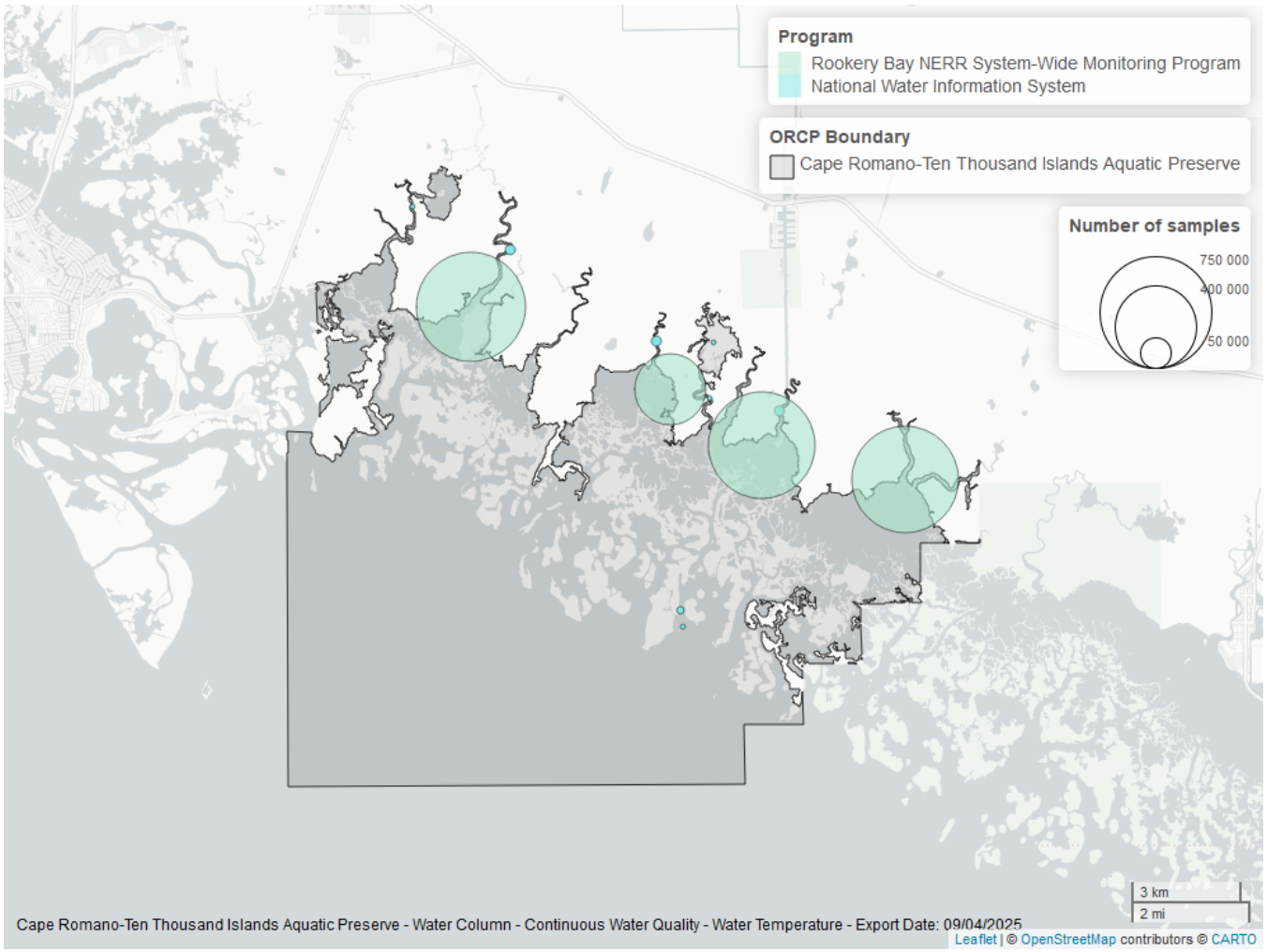

Figure 37: Map showing location of water temperature continuous water quality sampling locations within the boundaries of *Cape Romano-Ten Thousand Islands Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Nekton

The data file used is: **All_NEKTON_Parameters-2025-Sep-04.txt**

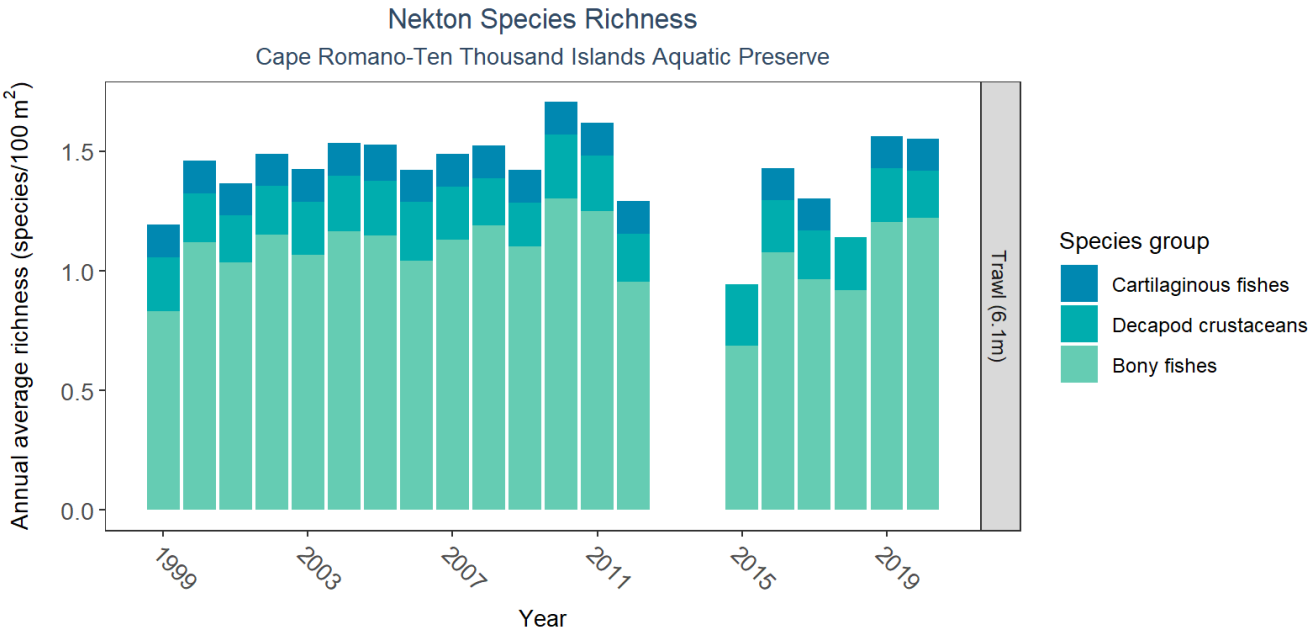

Figure 38: Bar graph(s) of annual average nekton richness over time for species groups occurring in at least 1% of samples. The bar colors represent species groups including bony fishes, cartilaginous fishes, decapod crustaceans (e.g., shrimps, crabs, and lobsters), and cephalopods (e.g., squid). Gear types and sizes are indicated in the panel label.

Table 37: Nekton Species Richness

Gear Type	*Sample Count*	*Number of Years*	*Period of Record*	*Median N of Taxa*	*Mean N of Taxa*
Trawl (6.1)	5002	20	1999 - 2020	0.4	0.67

The median annual number of taxa was 0.40 based on 5,002 observations collected by 6.1-meter trawl between 1999 and 2020.

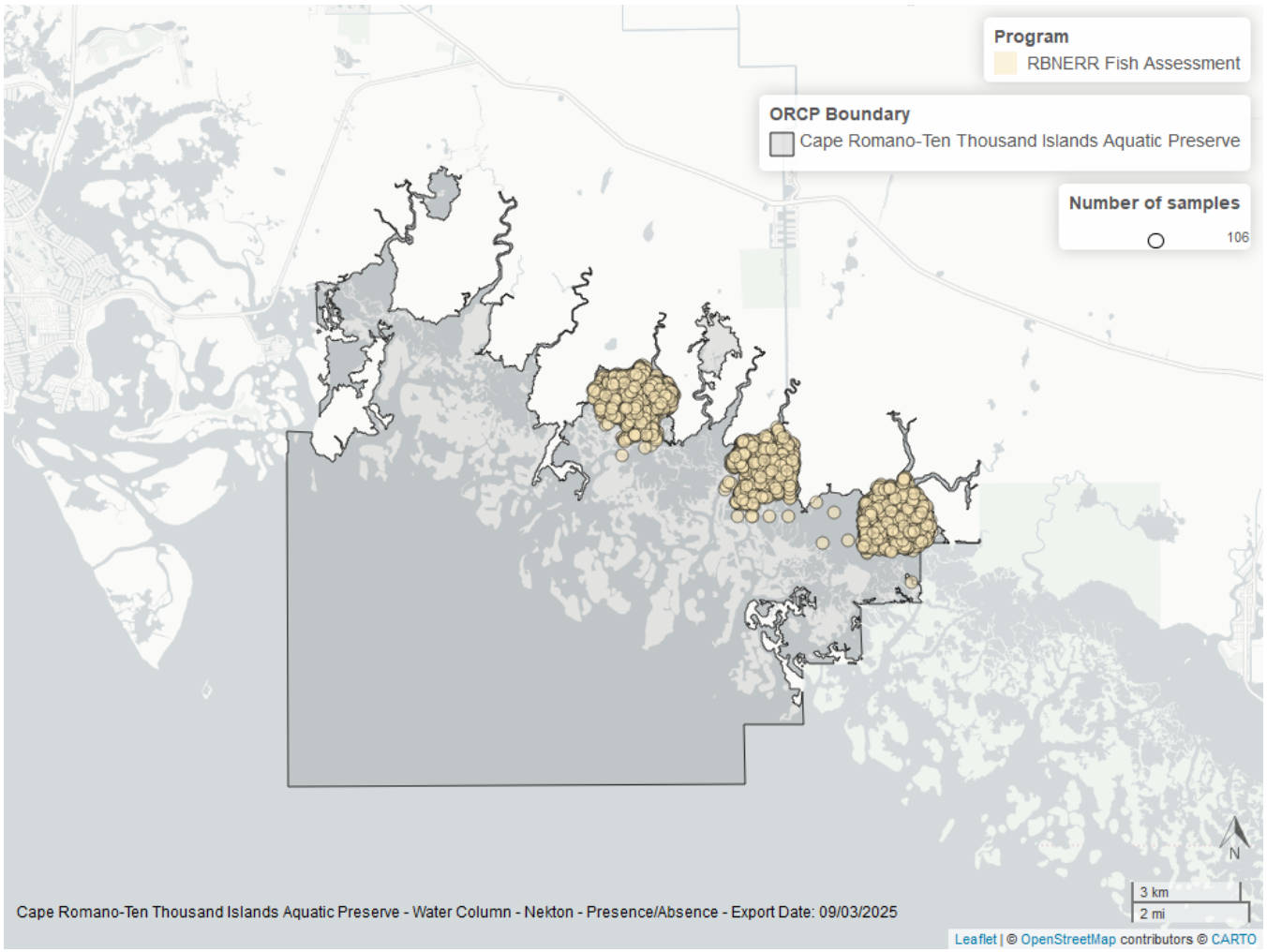

Figure 39: Map showing location of nekton sampling locations within the boundaries of *Cape Romano-Ten Thousand Islands Aquatic Preserve*. The bubble size on the maps above reflect the amount of data available at each sampling site.

Species list

Acanthostracion quadricornis[1]	Etropus crossotus[1]	Mugil cephalus[1]
Achirus lineatus[1]	Eucinostomus spp.[1]	Mugil spp.[1]
Albula vulpes[1]	Eugerres plumieri[1]	Mycteroperca microlepis[1]
Aluterus schoepfii[1]	Floridichthys carpio[1]	Myrophis punctatus[1]
Anarchopterus criniger[1]	Ginglymostoma cirratum[1]	Nicholsina usta[1]
Anchoa spp.[1]	Gobiesox strumosus[1]	Ogcocephalus cubifrons[1]
Ancylopsetta quadrocellata[1]	Gobionellus oceanicus[1]	Ogilbia cayorum[1]
Archosargus probatocephalus[1]	Gobiosoma bosc[1]	Oligoplites saurus[1]
Archosargus rhomboidalis[1]	Gobiosoma robustum[1]	Opisthonema oglinum[1]
Ariopsis felis[1]	Gunterichthys longipenis[1]	Opsanus beta[1]
Bagre marinus[1]	Gymnura micrura[1]	Orthopristis chrysoptera[1]
Bairdiella chrysoura[1]	Harengula jaguana[1]	Paralichthys albigutta[1]
Brevoortia smithi[1]	Hippocampus erectus[1]	Penaeus spp.[1]
Brevoortia spp.[1]	Hippocampus zosterae[1]	Pogonias cromis[1]
Calamus arctifrons[1]	Hoplosternum littorale[1]	Prionotus scitulus[1]
Callinectes sapidus[1]	Hypanus americanus[1]	Prionotus tribulus[1]
Caranx spp.[1]	Hypanus sabinus[1]	Rachycentron canadum[1]
Centropomus undecimalis[1]	Hypostomus plecostomus[1]	Rhinoptera bonasus[1]
Chaetodipterus faber[1]	Hypsoblennius hentz[1]	Sciaenops ocellatus[1]
Chasmodes saburrae[1]	Lagodon rhomboides[1]	Scorpaena brasiliensis[1]
Chilomycterus schoepfii[1]	Leiostomus xanthurus[1]	Selene vomer[1]
Chloroscombrus chrysurus[1]	Lepomis spp.[1]	Serraniculus pumilio[1]
Cichlidae spp.[1]	Leptocephalus larvae[1]	Sphoeroides nephelus[1]
Citharichthys macrops[1]	Lophogobius cyprinoides[1]	Sphoeroides spengleri[1]
Citharichthys spilopterus[1]	Lucania parva[1]	Stephanolepis hispida[1]
Clupeidae[1]	Lutjanus analis[1]	Symphurus plagiusa[1]
Ctenogobius boleosoma[1]	Lutjanus griseus[1]	Syngnathus louisianae[1]
Ctenogobius smaragdus[1]	Lutjanus synagris[1]	Syngnathus scovelli[1]
Cynoscion arenarius[1]	Menippe mercenaria[1]	Synodus foetens[1]
Cynoscion nebulosus[1]	Menticirrhus spp.[1]	Trachinotus falcatus[1]
Diplectrum formosum[1]	Microgobius gulosus[1]	Trinectes maculatus[1]
Echeneis neucratoides[1]	Microgobius thalassinus[1]	Urophycis floridana[1]
Elops saurus[1]	Micropterus salmoides[1]	Acanthostracion quadricornis[1]
Epinephelus itajara[1]	Monacanthus ciliatus[1]	Achirus lineatus[1]

1 - Nekton

References

1. Florida Department of Environmental Protection (DEP); Office of Resilience and Coastal Protection (RCP); Rookery Bay National Estuarine Research Reserve. Rookery Bay National Estuarine Research Reserve System-Wide Monitoring Program. (2024).
2. Florida Department of Environmental Protection (DEP). Florida STORET / WIN. (2024).
3. U.S. Environmental Protection Agency (EPA). EPA STOrage and RETrieval Data Warehouse (STORET)/WQX. (2023).
4. U.S. Environmental Protection Agency (EPA); Office of Water; National Oceanic and Atmospheric Administration (NOAA); U.S. Geological Survey (USGS); U.S. Fish and Wildlife Service (USFWS); National Estuary Program (NEP); coastal states. National Aquatic Resource Surveys, National Coastal Condition Assessment. (2021).
5. Florida International University (FIU); Southeastern Environmental Research Program. SERC Water Quality Monitoring Network. (2008).
6. University of Florida (UF); Institute of Food and Agricultural Sciences. Florida LAKEWATCH Program. (2024).
7. Florida Fish and Wildlife Conservation Commission (FWC); Florida Fish and Wildlife Research Institute (FWRI). Harmful Algal Bloom Marine Observation Network. (2018).
8. Florida Department of Environmental Protection (DEP); Office of Resilience and Coastal Protection (RCP); Rookery Bay National Estuarine Research Reserve. RBNERR Fish Assessment. (2023).
9. U.S. Geological Survey (USGS). National Water Information System. (2024).