FSUCML Real-time and Continuous Seawater Monitoring System: Annual Report 2023 – 2024

1. Executive Summary

a) Background and Purpose:

The Florida State University Coastal and Marine Laboratory (FSUCML) has developed a Real-time and Continuous Seawater Monitoring System to track coastal water quality at three stations in the northeastern Gulf of Mexico in Florida's Panhandle: Seawater Intake (SI), Alligator Harbor (AH), and Oyster Bay (OB). Operational since May 2023, this high-frequency network records temperature, salinity, pH, dissolved oxygen, and turbidity every 15 minutes. The system supports research, aquaculture, and environmental decision-making in a dynamic coastal zone increasingly affected by storms, sea-level rise, and development.

b) Monitoring Network Overview:

The network integrates YSI EXO3 multiparameter sondes with Campbell dataloggers and cellular telemetry for near real-time data transmission. All sensors are calibrated before deployment following FSUCML and manufacturer protocols. To maintain continuity and minimize data gaps, instruments are rotated on a 5– to 6–week schedule. Stations are installed on PVC pilings with solar-powered platforms and guarded housing to protect sondes from fouling and damage.

c) Research Objectives and Applications:

This monitoring system enables FSUCML to study estuarine and coastal processes affected by tides, rainfall, and anthropogenic pressures. Its data are actively used to:

- Detect storm-driven anomalies (e.g., Hurricane Idalia in August 2023),
- Support aquaculture, oyster hatchery operations, and coastal habitat restoration,
- Enable inter-network comparisons (e.g., with ANERR).
- Provide actionable insights into aquaculture and resource management.

d) Data Quality Assurance and Workflow Overview:

A rigorous three-tiered QAQC workflow ensures data reliability:

1. Primary QAQC is automated through the NERRS CDMO platform.
2. Secondary QAQC is conducted manually by FSUCML staff using CDMO Excel macros (NOAA Centralized Data Management Office, n.d.) and metadata review.
3. Tertiary QAQC is completed by FSUCML staff before public release.

e) Notable findings from the 2023-2024 monitoring year include:

- Storm events caused major shifts in water quality, with turbidity peaking at 478 NTU and salinity dropping to 16.3 psu at the SI during heavy rain and tidal surges.
- Low pH episodes (< 7.5) occur frequently, especially during cold fronts and tropical systems, with the lowest values (pH 7.3) at SI and OB, signaling potential stress conditions for shellfish and other pH-sensitive organisms.
- Hypoxic conditions (DO < 2 mg/L) were detected at all stations, with a minimum of 0.4 mg/L at SI, emphasizing the need for continuous oxygen monitoring during summer stratification.
- Network uptime exceeded 90%, with AH showing the highest reliability (~95%). OB faced occasional downtime due to tidal exposure, but performance improved with adjustments.

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2. Project Overview

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b) Sensor calibration:

Calibration Procedures
The FSUCML YSI monitoring program began on April 26, 2023, with the installation of the Seawater Intake (SI) station. The other two sites, Alligator Harbor (AH) and Oyster Bay (OB), were deployed shortly thereafter. All stations use YSI EXO3 multiparameter sondes mounted near the water surface and connected to a Campbell CR310 or DL310 datalogger that transmits data via cellular uplink every 15 minutes.

Before each deployment, sondes are calibrated according to the YSI operating manual and the FSUCML Xylem EXO3 Multi-Parameter Water Quality Monitoring Procedure SOP, Version 1 (Mejia-Mercado, 2023). Calibrations are performed in the lab using certified standards:

- Conductivity: One-point calibration with 50 mS/cm YSI standard.
- pH: Two-point calibration with pH 7 and pH 10 buffers.
- Dissolved Oxygen: Optical sensor calibrated in air-saturated water.
- Turbidity: Two-point calibration with deionized water (0 NTU) and YSI 124 NTU standard.
- Depth: Set using barometric pressure measurements from a Kestrel 4000 pocket weather tracker and offset tables from the Water Quality SOP.
- Temperature: Verified based on internal thermistor; no manual calibration required.

Once calibrated, a plastic mesh guard is attached to the datalogger housing. Mesh is placed at both the bottom and outer shell of the guard to reduce biological fouling and protect the sensors from damage caused by aquatic organisms.

Transport and Handling
Following calibration, each sonde is placed in a 5-gallon bucket with water and allowed to rest overnight to stabilize. The morning of deployment, the sondes are checked for proper function.
During transport to and from the field:

- The sonde is wrapped in a wet white towel to maintain humidity.
- It is carried inside a large, vented cooler cushioned with styrofoam to prevent physical shock and overheating.
- These handling procedures help maintain calibration integrity and protect sondes during transport to and from the field.

Deployment Routine
On deployment day, sondes are programmed to begin recording at exactly 07:00 AM Eastern Time (no daylight saving applied). Each unit is mounted on a PVC deployment tube with large holes near the probe region to ensure adequate water circulation.

Field personnel also collect manual water quality measurements at each site using a handheld YSI ProDSS. These measurements (DO, salinity, temperature, turbidity, and pH) are used to verify sonde performance at the time of deployment and retrieval.

Sondes remain deployed for approximately five to six weeks. At the end of each deployment cycle:

- Instruments are retrieved, cleaned, inspected, and recalibrated.
- Freshly calibrated sondes are deployed immediately, minimizing or eliminating data gaps in the 15-minute sampling interval.

Each sonde is connected to a Campbell datalogger, which logs and transmits readings in real-time to the Xylem cloud platform: https://cloud.xylem.com. Once received, data undergoes the primary QAQC process as described in Section 5, before progressing through secondary and tertiary quality control for long-term data validation.

c) QAQC Workflow:

The QAQC process for the FSUCML Seawater Monitoring data involves three sequential stages—Primary, Secondary, and Tertiary QAQC—each designed to ensure the accuracy and reliability of environmental datasets.

Raw sensor data are first uploaded from the YSI EXO3 data logger to a personal computer in the lab. Using KOR Software, the data are then exported as comma-separated value (.csv) files for processing and quality control.

Primary QAQC is conducted automatically by the Centralized Data Management Office (CDMO) after data are exported from KOR Software in .csv format and uploaded. At this stage:

- All pre- and post-deployment records are removed.
- The system flags any missing values or readings outside of sensor operating ranges using codes such as -5 (above range), -4 (below range), and -2 (missing data).

Once the automated review is complete, the dataset is sent back to FSUCML for ***Secondary QAQC***, which is performed manually by the FSUCML information manager. Using Microsoft Excel and the CDMO QAQC macro tool (NOAA Centralized Data Management Office, n.d.), staff:

- Insert station-specific codes and create metadata worksheets.
- Review summary statistics and graphical plots generated by the macro.
- Apply additional QAQC flags such as 1 (suspect), -3 (rejected), and 5 (corrected).
- Remove overlapping deployment periods and append approved datasets.

The cleaned dataset that is marked as "provisional plus" data is revised one more time by the FSUCML information manager for the final step—***Tertiary QAQC***. In this stage:

- FSUCML staff conduct a final validation check for consistency and accuracy.
- The approved dataset is then used to generate the annual report and remains accessible to researchers, resource managers, and the public through the FSUCML website (https://marinelab.fsu.edu/research/seawater-monitoring-system/).

For detailed information on QAQC flags and metadata codes used during this process, see Section 5 of this report.

d) Application in Research:

- **Grubbs Lab at FSUCML**
  Focus Area: Long-term monitoring of fish community structure and its environmental drivers in the Apalachicola Bay – St. George Sound region.
  Use of FSUCML Data: Continuous measurements of temperature, salinity, dissolved oxygen, turbidity,

and phytoplankton dynamics are integrated into ongoing research on bony fishes and sharks that frequent the FSUCML area.
Expected Impact or Outcome: The data will help refine predictive models of fish community structure and strengthen future proposals by identifying how abiotic and biotic variables influence marine populations over time.

- **Breithaupt Lab at FSUCML**
  Focus Area: Biogeochemical cycling of carbon, nitrogen, and phosphorus in intertidal and coastal systems.
  Use of FSUCML Data: Water quality data, including pH, turbidity, and nutrient-related parameters, provide a critical baseline for evaluating stocks and fluxes across intertidal zones and the influence of upland habitats on nearshore processes.
  Expected Impact or Outcome: The high-frequency dataset complements monthly ISCO auto sampling and supports expanded investigations of carbon cycling in barrier islands and tidal creeks, enhancing the lab's capacity to secure future funding.

- **Huettel Lab at FSU–EOAS**
  Focus Area: Coastal biogeochemical processes and the role of hydrodynamics in carbon and nutrient cycling.
  Use of FSUCML Data: The new data stream extends a historical monitoring transect (terminated in 2011) by providing updated measurements of salinity, oxygen, temperature, and chlorophyll along the northeastern Gulf of Mexico shelf.
  Expected Impact or Outcome: Comparing the current dataset with legacy records enables the lab to assess long-term shifts in chemical and physical conditions and contributes to ongoing Northern Gulf Institute research on benthic processes.

- **Burgess Lab at FSU–Biology**
  Focus Area: Environmental variability and its influence on organismal fitness in seagrass and oyster/marsh habitats.
  Use of FSUCML Data: Real-time monitoring of pH, nutrients, and phytoplankton abundance supports spectral analyses of environmental predictability and facilitates controlled experiments on suspension-feeding animals in flow-through systems.
  Expected Impact or Outcome: The system allows early detection of harmful water quality conditions that impact lab organisms, enabling timely adjustments and strengthening the infrastructure supporting NSF-funded research on phenotypic adaptation.

- **Apalachicola Bay System Initiative (ABSI)**
  Focus Area: Oyster biology, restoration, and hatchery operations in Apalachicola Bay and surrounding estuaries.
  Use of FSUCML Data: The monitoring system supports hatchery infrastructure by providing dependable, high-resolution seawater quality data for managing water intake and assessing environmental suitability for oyster growth.
  Expected Impact or Outcome: The system addresses critical gaps in ABSI's broader monitoring program and enhances the resilience of hatchery operations. Its integration ensures sustained, high-quality inputs for research and restoration activities.

3. Station Description

a) Overview of Study Area:

Florida State University Coastal and Marine Laboratory (FSUCML) is located ~ 80 km south of Tallahassee, Florida. This area is well-known for both diffuse seeps near the coast, originating from an unconfined aquifer, and submarine springs further offshore, coming from a confined karstic aquifer. The area sits on a layered dolomite and limestone platform that is home to the Floridan Aquifer, considered one of the most prolific aquifers in the world. This aquifer is covered by an unconfined aquifer with clay, silt, and sand, which is recharged locally by precipitation. Annual mean rainfall for the region is ~150 cm, but in 2006 and 2007 it was considerably lower with values of 87 and 62 cm, respectively (Santos et al., 2009), resulting in extensive drought in the area. Peak rainfall is typically from June to October, while the lowest precipitation rates occur in November/December and March/May. The tides in the area are mixed and semi-diurnal with an average range of 0.85 m. The seafloor is characterized by a gently sloping topography away from the coast, resulting in a water depth of ~2 m as far as 1000 m offshore (Cable et al., 1997; Lambert and Burnett, 2003). FSUCML includes 82 acres, with 70 acres on the north side of US Highway 98 and 12 acres on the south. The totality of FSUCML's infrastructure is located on the seaward side of US 98, with a dredged channel and boat basin acting as a divider. Of the acreage north of US 98, nearly 36 acres are forested, and 17 acres contain long-leaf pine habitat that is being restored.

b) Detailed Station Descriptions:

The FSUCML Real-time Seawater Monitoring System consists of three strategically located coastal stations in the northeastern Gulf of Mexico: Seawater Intake (SI), Alligator Harbor (AH), and Oyster Bay (OB) (Figure 1). These stations span a gradient of tidal exchange, salinity variability, and aquaculture activity. Station coordinates, deployment dates, and QAQC codes are summarized in Table 1.

The SI station is positioned approximately 300 meters offshore of the FSUCML at 29° 54.799' N, 84° 30.697' W. Constructed in 2023 on a single, 3-meter-tall piling, this station operates at a sampling depth of 2.4 meters, with the depth sensor mounted 0.3 meters above the benthic substrate. Water depth at this location ranges from 0.5 to 2.7 meters, depending on tidal conditions. The site experiences mixed semi-diurnal tides with amplitudes between 1.2 and 2.5 meters. Salinity fluctuates between 29 and 33 psu, primarily influenced by nearby freshwater creek discharge and precipitation events. The seafloor is composed of fine silty mud, a typical substrate in this low-energy, nearshore environment.

Located at 29° 55.145' N, 84° 24.576' W, the AH station was installed in 2023 on a single piling within a designated oyster aquaculture lease area managed by FSUCML. This lease is also utilized by the Apalachicola Bay System Initiative (ABSI) for hatchery research and spat deployment, initiated in 2022. The station records data at a depth of approximately 1.7 meters, with sensors positioned 0.3 meters above the sediment-water interface. Salinity at this site ranges from 27 to 35 psu, reflecting both oceanic inflow and estuarine influences. The substrate is characterized by shell hash, consistent with active oyster farming zones.

The OB station, installed in April 2023, is located at 30° 3.187' N, 84° 20.279' W within a region dedicated to oyster aquaculture. Like AH, this station was constructed on a single piling to support collaborative field studies with commercial oyster growers. The sampling depth is approximately 1.5 meters, with the sonde mounted 0.3 meters above the sediment. Salinity levels at OB typically range from 28 to 32 psu, with values moderated by local runoff and estuarine exchange. The benthic substrate is primarily composed of shell hash, a byproduct of shellfish activity and aquaculture operations.

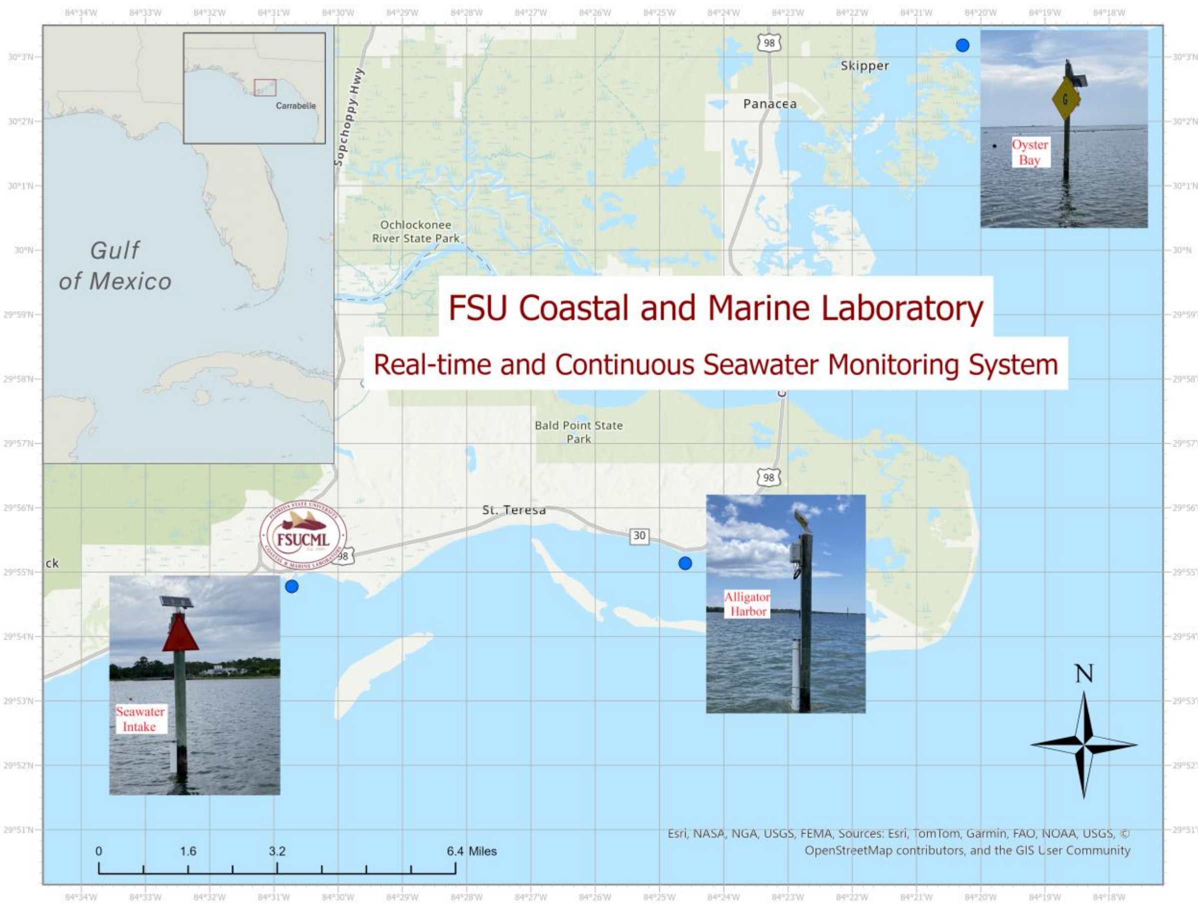

Figure 1. Geographic locations of FSUCML's three real-time seawater monitoring stations in the northeastern Gulf of Mexico: Seawater Intake (SI), Alligator Harbor (AH), and Oyster Bay (OB). These stations are strategically positioned to capture coastal water quality dynamics across gradients of salinity, tidal exchange, and human activity.

Table 1. Geographic coordinates, active dates, and QAQC station codes for FSUCML's real-time seawater monitoring stations.

Station Code	Station Name	Location	Active Dates	QAQC Station Code
SI	Seawater Intake	29° 54.799'N 084° 30.697'W	2023-Present	cmlsiwq
AH	Alligator Harbor	29° 55.145'N 084° 24.576'W	2023-Present	cmlahwq
OB	Oyster Bay	30° 3.187'N 084° 20.279'W	2023-Present	cmlobwq

4. Sensor Setup and Calibration

a) YSI EXO3 Sonde: Sensor Specifications and Calibration Parameters:

- Parameter: Temperature

Units: Celsius (C)
Sensor Type: Thermistor
Model#: 599827
Range: -5 to 50°C
Accuracy: ± 0.2°C
Resolution: 0.001°C

- Parameter: Conductivity

Units: milli-Siemens per cm (mS/cm)
Sensor Type: 4-electrode cell with auto-ranging
Model#: 599827
Range: 0 to 100 mS/cm
Accuracy: ± 1% of reading or 0.002 mS/cm, whichever is greater
Resolution: 0.0001 mS/cm to 0.01 mS/cm (range dependent)

- Parameter: Salinity

Units: practical salinity units (psu)/parts per thousand (ppt)
Sensor Type: Calculated from conductivity and temperature
Range: 0 to 70 psu/ppt
Accuracy: ± 2% of the reading or 0.2 ppt, whichever is greater
Resolution: 0.01 psu/ppt

- Parameter: Dissolved Oxygen % saturation

Sensor Type: Optical probe w/ mechanical cleaning
Model#: 599100-01
Range: 0 to 500% air saturation
Accuracy: 0-200% air saturation: ± 1% of the reading or 1% air saturation, whichever is greater, 200-500% air saturation: ± 5% or reading
Resolution: 0.1% air saturation

- Parameter: Dissolved Oxygen mg/L (Calculated from % air saturation, temperature, and salinity)

Units: % Saturation, milligrams/Liter (mg/L)
Sensor Type: Optical, luminescence lifetime
Model#: 599100-01
Range: 0 to 500% air sat, 0 to 50 mg/L
Accuracy: 0-200% = ±1% reading or 1%, air sat., whichever is greater; 200-500% = ±5% reading; 0-20 mg/L = ± 0.1 mg/L or 1% of the reading, whichever is greater; 20 to 50 mg/L = ± 5% of the reading
Resolution: 0.1% air sat, 0.01 mg/L

- Parameter: Non-vented Level - Shallow (Depth)

Units: feet or meters (ft or m)
Sensor Type: Stainless steel strain gauge
Range: 0 to 33 ft (10 m)
Accuracy: ± 0.013 ft or ± 0.004 m)
Resolution: 0.001 ft (0.001 m)

- Parameter: pH

Units: pH units
Sensor Type: Glass combination electrode
Model#: 577602 (unguarded)
Range: 0 to 14 units
Accuracy: ± 0.1 units within ± 10° of calibration temperature, ± 0.2 units for entire temperature range
Resolution: 0.01 units

- Parameter: Turbidity

Units: formazin nephelometric units (FNU)/ Nephelometric Turbidity Units (NTU)
Sensor Type: Optical, 90-degree scatter
Model#: 599101-01
Range: 0 to 4000 FNU/NTU
Accuracy: 0 to 999 FNU = 0.3 FNU or ± 2% of reading (whichever is greater); 1000 to 4000 FNU = ± 5% of reading
Resolution: 0 to 999 FNU = 0.01 FNU, 1000 to 4000 FNU = 0.1 FNU/NTU

- Parameter: Total Algae-PE (Chlorophyll and Phycoerythrin)

Units: Micrograms per Liter (μg/L), Relative Fluorescence Units (RFU)
Sensor Type: Optical, fluorescence
Model#: 599103-01
Range: Chlorophyll = 0-100 RFU, 0-400 μg/l chlorophyll; BGA-PE: 0-100 RFU, 0-280 μg/l
Accuracy:
Resolution: Chlorophyll = 0,01 RFU, 0,01 μg/l chlorophyll; BGA-PE: 0,01 RFU, 0,01 μg/l

Salinity Units Qualifier:
The EXO sondes report on practical salinity units (psu). These units are essentially the same as ppt and, for FSUCML purposes, are understood to be equivalent; however, psu is considered the more appropriate designation. The FSUCML System will assign psu as a unit for salinity.

Turbidity Qualifier:
EXO sondes report turbidity in formazin nephelometric units (FNU). These units are essentially the same as nephelometric turbidity units (NTU) but indicate a difference in sensor methodology; for FSUCML purposes, they will be considered equivalent. The FSUCML System will use NTU as the designated unit for all turbidity data.

b) Calibration Adjustments and Special Notes:

Data gaps labeled as NAN (Not a Number) indicate missing observations caused by one or more of the following: non-deployed or failed sensors, periods of active equipment maintenance or calibration, or the repair/replacement of a station platform. For inquiries related to specific missing records, users should contact the FSUCML information manager.

Turbidity spikes are observed year-round across all monitoring stations. These events are likely driven by episodic factors such as rainfall, riverine discharge, and wind-driven sediment resuspension.

In line with QAQC protocols, dependent parameters are flagged or rejected when one or more foundational variables are compromised. Specifically:

- If Temperature fails QAQC, all parameters except Turbidity are flagged.

- If Specific Conductivity or Salinity fails QAQC, then both DO (mg/L) and Depth are also rejected.

During several deployments in 2023–2024, incorrect C/T probe calibrations were performed using conductivity rather than specific conductivity, which accounts for temperature variation. This affected recorded values at all three stations and required post-processing correction. The affected periods were:

SI = 4/26/23 16:00 – 6/28/23 14:30, 8/24/23 9:30 – 2/13/24 13:15
AH = 8/23/23 12:30 – 2/13/24 13:45
OB = 8/23/23 11:00 – 9/29/23 1:15, 10/10/23 13:15 – 1/23/24 14:00

The correction formula applied is:

$$\textbf{Conductivity} = (\textbf{Conductivity at } 25^\circ\textbf{C}) \times (A + B\cdot t + C\cdot t^2)$$

Where t is the temperature in °C at the time of calibration.

Conductivity at 25.00°C	**A**	**B**	**C**
10,000 μSiemens/cm	0.5538	0.0168	0.000042
50,000 μSiemens/cm	0.5666	0.0163	0.000041

5. QAQC Flag Definitions and Metadata Codes

This section provides the full reference for QAQC flags and associated metadata codes used in the FSUCML seawater dataset. QAQC flags provide documentation of the data and are applied to individual data points by insertion into the parameter's associated flag column (header preceded by an F_). During primary automated QAQC (performed by the CDMO macro; NOAA, n.d.), -5, -4, and -2 flags are applied automatically to indicate data that is missing and above or below the sensor range. All remaining data are then flagged 0, passing initial QAQC checks. During secondary and tertiary QAQC 1, -3, and 5 flags may be used to note data as suspect, rejected due to QAQC, or corrected.

-5 Outside High Sensor Range
-4 Outside Low Sensor Range
-3 Data Rejected due to QAQC
-2 Missing Data
-1 Optional Supported Parameter
0 Data Passed Initial QAQC Checks
1 Suspect Data
2 Open - reserved for later flag
3 Calculated data: non-vented depth/level sensor correction for changes in barometric pressure
4 Historical Data: Pre-Auto QAQC
5 Corrected Data

QAQC codes are used in conjunction with QAQC flags to provide further documentation of the data and are also applied by insertion into the associated flag column. There are three (3) different code categories: general, sensor, and comment. General errors document general problems with the deployment or YSI data sonde, sensor errors are sensor-specific, and comment codes are used to further document conditions or a problem with the data. Only one general or sensor error and one comment code can be applied to a particular data point, but some comment codes (marked with an * below) can be applied to the entire record in the F_Record column.

General Errors
GIC No instrument deployed due to ice

GIM	Instrument malfunction
GIT	Instrument recording error; recovered telemetry data
GMC	No instrument deployed due to maintenance/calibration
GNF	Deployment tube clogged / no flow
GOW	Out of water event
GPF	Power failure / low battery
GQR	Data rejected due to QA/QC checks
GSM	See metadata

Sensor Errors

SBO	Blocked optic
SCF	Conductivity sensor failure
SCS	Chlorophyll spike
SDF	Depth port frozen
SDG	Suspect due to sensor diagnostics
SDO	DO suspect
SDP	DO membrane puncture
SIC	Incorrect calibration / contaminated standard
SNV	Negative value
SOW	Sensor out of water
SPC	Post calibration out of range
SQR	Data rejected due to QAQC checks
SSD	Sensor drift
SSM	Sensor malfunction
SSR	Sensor removed / not deployed
STF	Catastrophic temperature sensor failure
STS	Turbidity spike
SWM	Wiper malfunction/loss

Comments

CAB*	Algal bloom
CAF	Acceptable calibration/accuracy error of the sensor
CAP	Depth sensor in water, affected by atmospheric pressure
CBF	Biofouling
CCU	Cause unknown
CDA*	DO hypoxia (<3 mg/L)
CDB*	Disturbed bottom
CDF	Data appear to fit the conditions
CFK*	Fishkill
CIP*	Surface ice present at the sample station
CLT*	Low tide
CMC*	In-field maintenance/cleaning
CMD*	Mud in probe guard
CND	New deployment begins
CRE*	Significant rain event
CSM*	See metadata
CTS	Turbidity spike
CVT*	Possible vandalism/tampering
CWD*	Data collected at the wrong depth
CWE*	Significant weather event

6. Data Acquisition and Telemetry

Data from the FSUCML monitoring stations is collected using YSI EXO3 sondes connected to Campbell dataloggers. These systems are configured to log high-frequency environmental measurements and transmit the data in near real-time to a secure cloud-based platform. The primary mode of transmission is via cellular telemetry, although other methods such as satellite or radio link may be employed under specific conditions.

Once transmitted, data are made available through the Xylem cloud interface, which can be accessed at https://cloud.xylem.com. This platform provides visualizations of real-time water quality metrics, station status, and historical trends for all three monitoring sites. Users can explore customizable time-series plots and export data for further analysis.

In addition to cloud-based access, all raw data are redundantly stored onboard the dataloggers using SD cards. These internal logs serve as a backup in case of telemetry failure and are retrieved during routine redeployments. Data backups are performed biweekly and reviewed for completeness and continuity.

Communication interruptions due to power loss, environmental disturbances (e.g., hurricanes), or sensor malfunction are expected and documented. These interruptions are noted in deployment logs and discussed in detail in Sections 5 (Sensor Setup and Calibration) and 13 (Environmental Events and Anomalies).

7. Deployment Performance Summary (May 2023 – June 2024)

Between May 2023 and June 2024, the FSUCML coastal monitoring program conducted routine sonde deployments at three fixed stations—Seawater Intake (SI), Alligator Harbor (AH), and Oyster Bay (OB)—on a rotating schedule, typically ranging from 4 to 6 weeks per deployment. Based on deployment and recovery records, a total of 11 deployments were completed at SI, 10 at AH, and 11 at OB. For detailed deployment dates, times, and field notes, see Appendix A – Deployment Schedule (Tables A-1 to A-3). A visual summary of deployment counts and average station uptime is provided in Figure 2.

At SI, data collection began in June 2023 following a preliminary test in April. Despite a regular deployment rhythm, the site experienced a few shortened deployments due to operational challenges such as battery limitations and early retrievals. Nonetheless, 11 full deployment cycles were completed through July 2024, reflecting sustained monitoring efforts throughout the year.

AH demonstrated consistent field performance with 10 uninterrupted deployments over the 12 months (June 2023-July 2024). The site exhibited strong telemetry and data continuity, with no deployment gaps or early terminations noted in the schedule. This reliability positioned AH as the most stable station operationally.

In contrast, OB faced several site-specific difficulties. Although 11 deployments were completed, one early deployment (May–July 2023) lacked telemetry connectivity, and two deployments (in October 2023 and March 2024) were cut short due to environmental or technical issues. Challenges related to shallow depth and tidal exposure contributed to these interruptions. However, the site still maintained a steady deployment pace, with adjustments improving data quality over time.

Overall, the monitoring program maintained high deployment frequency and spatial coverage despite occasional equipment or environmental setbacks. The coordinated rotation and regular field servicing helped ensure robust environmental data collection across all three coastal sites.

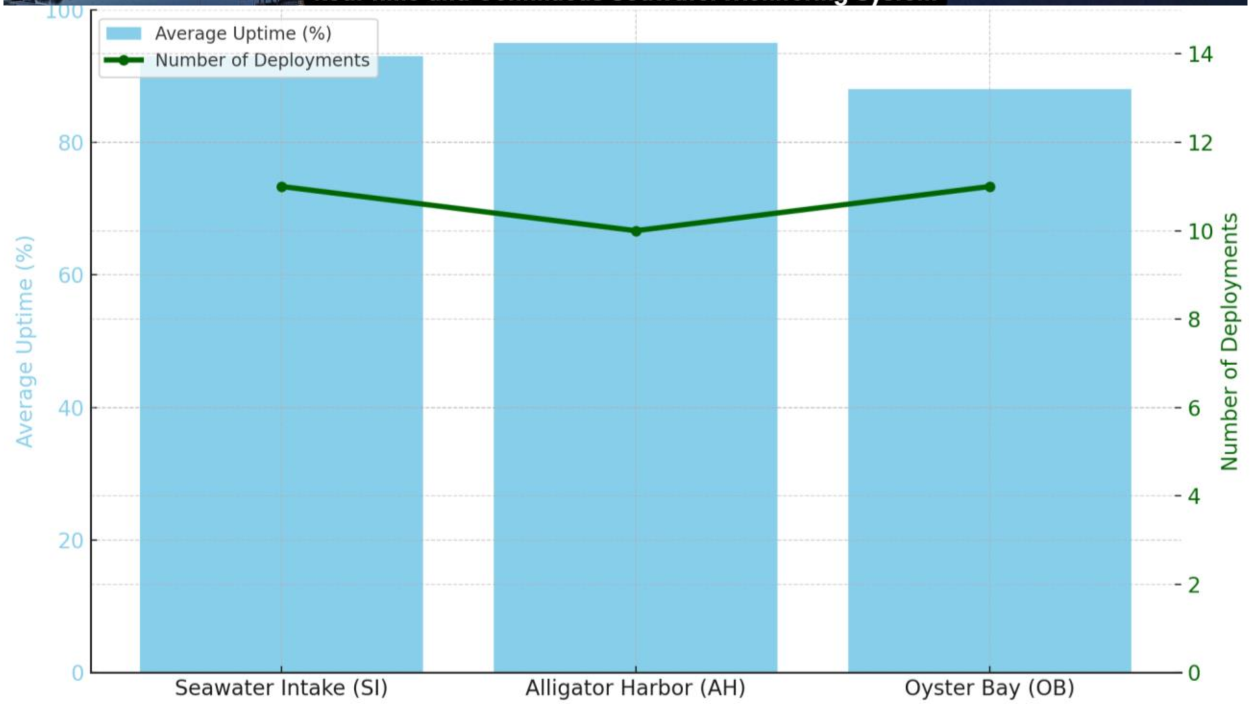

Figure 2. Deployment performance summary from May 2023 to July 2024. Blue bars indicate average uptime per station; green line shows total number of deployments.

8. Station-Level Field Observations and Operational Insights

A detailed review of deployments at the Seawater Intake (SI), Alligator Harbor (AH), and Oyster Bay (OB) stations from May 2023 to June 2024 reveals distinct site-level challenges and operational patterns. These insights, documented in Appendix B, are essential for understanding data continuity, maintenance needs, and exposure to environmental stressors.

SI was the most operationally dynamic site, with 11 deployments over the year. While generally regular in its deployment schedule, the station experienced multiple short interruptions due to weather and instrument issues. Notably, Hurricane Idalia in August 2023 led to a full loss of signal and abnormal depth readings. Additional downtime occurred when the sonde cable was dislodged during deployment in late August. Despite these challenges, the site was consistently repaired and redeployed promptly, showcasing a strong, responsive field.

AH proved to be the most stable station operationally, with 10 deployments and minimal disruptions. Most issues were limited to brief telemetry gaps during redeployments or short-term storm impacts. The site maintained excellent data quality throughout, with no major sensor failures or prolonged outages, even during Hurricane Idalia.

OB posed the most complex operational challenges due to its shallow and highly variable conditions. Across 11 deployments, the station experienced repeated low-tide exposure that led to numerous periods of invalid sensor readings. Additionally, negative depth values, flooded battery compartments, and instrument malfunctions, especially in late 2023, contributed to higher data rejection rates. However, operational adjustments in early 2024 improved sonde positioning and reduced downtime.

These field-based insights emphasize the value of station-specific calibration, resilient hardware design, and responsive redeployment protocols. Additional details on these deployments and events are provided in Appendix B. A summary of site-level performance and operational patterns is presented in Table 2 below.

Table 2. Summary of deployment activity, average uptime, and operational challenges across FSUCML monitoring stations (May 2023 – June 2024).

Station	# of Deployments	Avg. Uptime (%)	Common Issues	Notable Events
Seawater Intake (SI)	11	~93%	Lightning damage, cable dislodgement, intermittent telemetry	Frequent rainstorms, sonde out of water (Aug), Hurricane Idalia (Aug 30)
Alligator Harbor (AH)	10	~95%	Minor sensor fouling, occasionally missing data from redeployment	High-depth readings during Hurricane Idalia (Aug), minimal operational interruptions
Oyster Bay (OB)	11	~88%	Shallow depth exposure, sensor out-of-water events, battery flooding	Extended low tide sensor exposure, instrument flooding (Sep–Oct), multiple out-of-water periods

9. Post-deployment Calibration Values

To ensure data accuracy and instrument reliability, post-deployment calibrations were conducted after each sonde recovery at the three FSUCML monitoring stations: Seawater Intake (SI), Alligator Harbor (AH), and Oyster Bay (OB). These calibrations assessed four key parameters: dissolved oxygen (DO), specific conductivity, pH, and turbidity.

Across all stations, calibration checks demonstrated strong agreement with standard reference values, with most deviations falling to within 2% of expected targets. These results confirm the robustness of pre-deployment calibration procedures and the effectiveness of maintenance protocols during the deployment period.

At SI, DO values generally remained within ±2% of the 100% standard, with only one reading falling below 90%. Specific conductivity values were consistently close to the 50 mS/cm reference, and pH measurements stayed tightly clustered around the target of 7. Turbidity values showed good agreement, with only one outlier near the end of the deployment series.

AH showed similar consistency, although a single low DO reading (72.7%) in September 2023 suggests potential sensor degradation during that deployment. Otherwise, DO and pH remained within expected bounds, and conductivity readings were stable. Turbidity returned to within the standard range following this anomaly.

OB calibrations were also largely within expected tolerances, despite the site's challenging conditions. DO values occasionally exceed 105%, which may reflect sensor drift or calibration artifacts following prolonged exposure. Most pH, conductivity, and turbidity readings were stable and close to reference values, confirming good post-deployment performance despite environmental stressors.

Overall, the post-deployment calibration data support the conclusion that sensors remained well-calibrated and effective throughout the monitoring year. Any deviations were infrequent and likely tied to short-term field conditions rather than systemic instrumentation faults.

For detailed calibration records, including raw values and reference standards, see Appendix C: Post-deployment Calibration Tables (Tables C-1 to C-3).

10. Descriptive Water Quality Statistics (QC-Filtered)

Quality-controlled water quality data collected between May 2023 and July 2024 at the three FSUCML coastal monitoring stations—Seawater Intake (SI), Alligator Harbor (AH), and Oyster Bay (OB)—reveal distinct spatial variability and consistent seasonal trends across parameters.

Temperature was remarkably consistent across all sites, with mean values near 23°C and seasonal fluctuations ranging from winter lows around 5–7°C to summer highs exceeding 34°C. This trend reflects the subtropical climate influence across the region.

Salinity exhibited the clearest site-level contrast. SI and AH maintained high and stable salinity averages (~31 psu), consistent with their open Gulf locations. In contrast, OB displayed significantly fresher conditions, with an average salinity of 24.4 psu and minimum values as low as 10.9 psu, highlighting the site's stronger freshwater influence and estuarine dynamics.

Dissolved oxygen (DO) values were generally healthy across all stations, with saturation levels averaging between 79.5% and 92.1%. OB recorded the highest DO levels (mean: 92.1%, max: 132%), likely due to higher primary production in this shallow estuarine system. Hypoxic conditions (<3 mg/L) were rare, though low DO events were captured, particularly at SI and AH during late summer and storm-driven stratification events.

Turbidity remained low on average across the network (~3–5 NTU), but each station recorded short-lived but extreme turbidity spikes during storm events, especially at SI (max: 478 NTU) and OB (max: 387 NTU). These brief peaks emphasize the importance of high-frequency monitoring in capturing episodic disturbances.

pH was relatively stable at all sites, with averages near 7.9 and standard deviations under 0.1, indicating generally well-buffered systems. However, brief drops below 7.5 were observed during extreme weather, particularly cold fronts and post-hurricane events.

Depth variability across sites reflects differences in sensor mounting and tidal exposure. SI recorded the deepest water column (~2 m average), while OB experienced the shallowest and most variable conditions (average ~0.8 m), including occasional sensor exposure at low tide.

These descriptive statistics highlight the system's ability to detect both baseline conditions and episodic environmental changes. The high-resolution, quality-controlled dataset is a valuable tool for aquaculture site selection, ecosystem assessments, and long-term coastal change monitoring.

For full statistical breakdowns and quality control thresholds, refer to Appendix D: Descriptive Statistics Tables (D-1 to D-3). For time-series plots visualizing these trends by station, see Appendix E: Station Time Series.

11. Data Distribution Policy

a) Use and Liability Disclaimer:

According to the FSUCML Policy, the FSUCML Seawater Monitoring System retains the right to analyze, synthesize, and publish data summaries. The PI maintains the right to be fully credited for collecting and processing the data. Following academic courtesy standards, the PI and FSUCML site, where the data were collected, will be contacted and fully acknowledged in any subsequent publications in which any part of the data is used. The dataset included within this package is only as good as the quality assurance and quality control procedures described by the enclosed metadata reporting statement. The user assumes all responsibility for any subsequent use or misuse of the data in further analyses or comparisons. FSUCML does not assume liability to the recipient or any third parties and will not indemnify the recipient for any losses resulting from the use of this dataset.

b) Requested data citation format:

Florida State University Coastal and Marine Laboratory (FSUCML). Real-time and Continuous Seawater Monitoring System. Data accessed from the FSUCML website: https://marinelab.fsu.edu/research/seawater-monitoring-system/; accessed July 07, 2025.

c) Data Access Links:

FSUCML water quality data and metadata can be obtained online at the FSUCML – Seawater Monitoring System website (https://marinelab.fsu.edu/research/seawater-monitoring-system/).

12. References

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Lambert, M. J., & Burnett, W. C. (2003). Submarine groundwater discharge estimates at a Florida coastal site based on continuous radon measurements. Biogeochemistry, 66, 55-73.

Mejia-Mercado, B.E. (2023). EXO3 Multi-Parameter Water Quality Monitoring Procedure SOP (Version 1). Internal standard operating protocol.

NOAA Centralized Data Management Office (CDMO). (n.d.). QAQC Macros and Flag System Documentation. National Estuarine Research Reserve System. http://cdmo.baruch.sc.edu/data/qaqc.cfm

NOAA National Estuarine Research Reserve System (NERRS). System-wide Monitoring Program. Data is processed using tools provided by the NOAA NERRS Centralized Data Management Office. Website: http://www.nerrsdata.org.

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Ventusky Weather Visualization. InMeteo, Czech Republic. Accessed June 2025. https://www.ventusky.com

Appendix A. Deployment Schedule

Deployment history and operational notes for each FSUCML monitoring station (Seawater Intake, Alligator Harbor, and Oyster Bay), including deployment and recovery dates, special conditions, and interruptions.

A1. Seawater Intake (SI)

Deployment Start	Time	Deployment End	Time	Notes
06/28/2023	14:30	08/23/2023	08:45	
08/23/2023	09:00	09/20/2023	10:45	
09/20/2023	10:55	10/26/2023	08:50	
10/26/2023	09:00	11/30/2023	14:20	
11/30/2023	14:27	01/10/2024	12:39	
01/10/2024	12:55	02/13/2024	13:15	
02/13/2024	13:22	03/14/2024	11:08	
03/14/2024	11:15	04/17/2024	13:05	
04/17/2024	13:10	05/21/2024	12:42	
05/21/2024	12:53	06/10/2024	11:51	
06/10/2024	12:06	07/01/2024	11:59	

A2. Alligator Harbor (AH)

Deployment Start	Time	Deployment End	Time	Notes
06/29/2023	12:51	08/23/2023	12:14	
08/23/2023	12:22	09/25/2023	12:05	
09/25/2023	12:14	10/26/2023	09:30	
10/26/2023	09:45	11/30/2023	13:29	
11/30/2023	13:38	01/10/2024	13:22	
01/10/2024	13:32	02/13/2024	13:51	
02/13/2024	13:59	03/20/2024	13:55	
03/20/2024	14:07	04/25/2024	11:24	
04/25/2024	11:29	05/30/2024	09:32	
05/30/2024	09:43	07/01/2024	11:20	

A3. Oyster Bay (OB)

Deployment Start	Time	Deployment End	Time	Notes
05/18/2023	09:00	07/11/2023	09:24	No telemetry data
07/11/2023	10:00	08/23/2023	10:44	
08/23/2023	10:50	09/27/2023	09:50	
09/27/2023	10:02	10/10/2023	13:00	Deployment stopped early
10/10/2023	13:15	11/13/2023	14:48	
11/13/2023	14:54	12/14/2023	14:45	

12/14/2023	14:50	01/23/2024	14:02	
01/23/2024	14:12	02/27/2024	14:17	
02/27/2024	14:25	03/20/2024	10:22	Deployment stopped early
03/20/2024	10:35	04/25/2024	09:48	
04/25/2024	09:53	05/22/2024	10:07	

Appendix B. Environmental Events and Anomalies

B1. Seawater Intake (SI)

- 7/16/2023 19:00 – 22:00 Significant rain event in the area 0.8” – >2.0” with strong winds of 17-21 mph.
- 7/22/2023 19:00 – 22:00 Significant rain event in the area 0.8” – >2.0”.
- 8/05/2023 13:00 – 19:00 Significant rain event in the area 0.8” – >2.0”.
- 8/23/2023 09:00 – 8/24/2023 09:15 Sonde out of the water because the sonde cable got caught during deployment.
- 8/26/2023 01:00 – 04:00 Significant rain event in the area 0.8” – >2.0” with strong winds of 19-22 mph.
- 8/29/2023 22:00 – 8/30/2023 05:15 Hurricane Idalia, which impacted the area as a tropical storm, brought increased winds (20 mph) and heavy precipitation (~ 1.2 inches). This resulted in high-level reading.
- 8/30/2023 05:30 – 8/30/2023 13:15 Significant weather event. Hurricane Idalia caused increased winds, which led to high-level readings.
- 9/01/2023 10:00 – 13:00 Significant rain event in the area 0.8” – >2.0”.
- 9/02/2023 10:00 – 13:00 Significant rain event in the area 0.8” – >2.0”.
- 9/12/2023 16:00 – 19:00 Significant rain event in the area 0.8” – >2.0”.
- 9/13/2023 3:30 Missing data from sonde and telemetry. The cause is unknown.
- 9/15/2023 16:00 – 19:00 Significant rain event in the area 0.8” – >2.0”.
- 10/11/2023 22:00 – 10/12/2023 4:00 Significant weather event, intense winds (20-27 mph) and heavy precipitation (0.8 – 1.5 inches). Sonde went deeper than usual.
- 10/18/2023 3:15, 3:45, and 8:00 Missing data from sonde and telemetry
- 11/26/2023 13:00 – 16:00 Significant weather event, intense winds (20-27 mph) and heavy precipitation (1.0 – 1.3 inches).
- 12/02/2023 13:00 – 16:00 Significant rain event in the area 1.7” – >2.0”.
- 12/03/2023 07:00 – 10:00 Significant rain event in the area 0.6” – 0.8”.
- 12/10/2023 14:00 – 17:00 Significant rain event in the area 1.2” – 1.4” with intense winds of 11-15 mph.
- 12/17/2023 02:00 – 08:00 Significant rain event in the area 0.6” – 1.0” with intense winds of 19-24 mph.
- 01/06/2024 03:00 – 07:00 Significant rain event in the area 1.2” – 2.0” with intense winds of 24-26 mph.
- 01/09/2024 14:00 – 17:00 Significant rain event in the area 0.7” – 0.9”.
- 01/24/2024 23:00 – 01/25/2024 01:00 Significant rain event in the area 0.9” – 1.0”.
- 03/05/2024 14:00 – 23:00 Significant rain event in the area 0.7” – 1.0”.
- 03/09/2024 17:00 – 20:00 Significant rain event in the area >1.0”.
- 03/27/2024 05:00 – 08:00 Significant rain event in the area 1.6” – >2.0”.
- 04/08/2024 08:00 – 11:00 Significant rain event in the area 0.6” – 0.8” with intense winds of 16-21 mph.
- 04/11/2024 08:00 – 11:00 Significant rain event in the area 1.1” – 1.7”.

- 05/10/2024 07:00 – 10:00. 14:00 – 17:00. 20:00 – 23:00 Significant weather event. A strong storm generated tornadoes, causing winds (20-28 mph) and precipitation (0.4-0.7 inches).
- 05/13/2024 15:00 – 20:00. Significant rain event in the area 0.5" – 1.9" with intense winds of 15-32 mph.
- 05/14/2024 5:00 – 06:00. Significant rain event in the area 0.4" – 0.7" with intense winds of 17-21 mph.
- 06/02/2024 22:00 – 06/203/2024 05:30 Extremely low pH values may be linked to low dissolved oxygen levels.
- 06/10/2024 12:00 Missing data caused by the recovery and deployment of the sonde.
- 06/16/2024 21:00 – 22:00. Significant rain event in the area 0.4" – 0.8".

B2. Alligator Harbor (AH)

- 7/16/2023 19:00 – 22:00 Significant rain event in the area 0.8" – >2.0" with intense winds of 14-15 mph.
- 8/05/2023 13:00 – 19:00 Significant rain event in the area 0.8" – >2.0".
- 8/16/2023 19:00 – 22:00 Significant rain event in the area 0.8" – >2.0".
- 8/26/2023 01:00 – 04:00 Significant rain event in the area 0.8" – >2.0".
- 8/29/2023 22:00 – 8/30/2023 16:00 Significant weather event. Hurricane Idalia, which impacted the area as a tropical storm, brought increased winds (20-30 mph) and heavy precipitation (~ 1.7 inches). This resulted in decreased temperature, salinity, and conductivity values. The depth read during this time was the highest (2.38 m).
- 9/01/2023 07:00 – 13:00 Significant rain event in the area 0.8" – >2.0".
- 10/11/2023 22:00 – 10/12/2023 4:00 Significant weather event, intense winds (17-24 mph) and heavy precipitation (1.3 – 1.7 inches). Sonde went deeper than usual.
- 11/26/2023 13:00 – 16:00 Significant weather event, intense winds (20-27 mph) and heavy precipitation (1.0 – 1.3 inches).
- 11/30/2023 13:30 Missing data caused by the recovery and deployment of the sonde.
- 12/02/2023 13:00 – 16:00 Significant rain event in the area 1.7" – >2.0".
- 12/03/2023 07:00 – 10:00 Significant rain event in the area 0.6" – 0.8".
- 12/04/2023 13:30 Missing data. Unknown cause.
- 12/10/2023 14:00 – 17:00 Significant rain event in the area 1.2" – 1.4" with intense winds of 11-15 mph.
- 12/17/2023 02:00 – 08:00 Significant rain event in the area 0.6" – 1.0" with intense winds of 19-24 mph.
- 01/06/2024 03:00 – 07:00 Significant rain event in the area 1.2" – 2.0" with intense winds of 24-26 mph.
- 01/09/2024 14:00 – 17:00 Significant rain event in the area 0.7" – 0.9".
- 01/10/2024 13:30 Missing data caused by the recovery and deployment of the sonde.
- 01/24/2024 23:00 – 01/25/2024 01:00 Significant rain event in the area 0.9" – 1.0".
- 03/05/2024 14:00 – 23:00 Significant rain event in the area 0.7" – 1.0".
- 03/09/2024 17:00 – 20:00 Significant rain event in the area >1.0".
- 03/20/2024 14:00 Missing data caused by the recovery and deployment of the sonde.
- 03/27/2024 05:00 – 08:00 Significant rain event in the area 1.6" – >2.0".
- 04/08/2024 08:00 – 11:00 Significant rain event in the area 0.6" – 0.8" with intense winds of 16-21 mph.
- 04/11/2024 08:00 – 11:00 Significant rain event in the area 1.1" – 1.7".
- 05/10/2024 07:00 – 10:00. 14:00– 17:00. 20:00 – 23:00 Significant weather event. A strong storm generated tornadoes, causing winds (20-28 mph) and precipitation (0.4-0.7 inches).
- 05/13/2024 15:00 – 20:00. Significant rain event in the area 0.5" – 1.9" with intense winds of 15-32 mph.

- 05/14/2024 5:00 – 06:00. Significant rain event in the area 0.4" – 0.7" with intense winds of 17-21 mph.
- 06/16/2024 21:00 – 22:00. Significant rain event in the area 0.8" – 1.4".
- 06/30/2024 14:00 – 17:00. Significant rain event in the area 0.4" – 0.6".

B3. Oyster Bay (OB)

- 5/18/2023 – 7/11/2023 This deployment lasted over 45 days (56 days), and these extra days can impact the data.
- 5/19/2023 15:15-17:00 Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 5/20/2023 15:45-18:00 Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 5/21/2023 16:45-18:00 Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 6/02/2023 14:30-15:45 Negative depth values with no possibility of the sonde being out of the water. Conductivity and salinity readings are within range.
- 6/03/2023 14:15-17:15 Negative depth values with no possibility of the sonde being out of the water. Conductivity and salinity readings are within range.
- 6/04/2023 15:15-15:45 Negative depth values with no possibility of the sonde being out of the water. Conductivity and salinity readings are within range.
- 6/04/2023 16:00-17:15 Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 6/04/2023 17:30-18:00 Negative depth values with no possibility of the sonde being out of the water. Conductivity and salinity readings are within range.
- 6/05/2023 16:45-18:30 Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 6/06/2023 18:15 Very low conductivity and salinity. Negative depth values and high turbidity values. Cause unknown.
- 6/06/2023 18:30-19:15 Negative depth values with no possibility of the sonde being out of the water. Conductivity and salinity readings are within range.
- 6/07/2023 18:45-19:15 Negative depth values with no possibility of the sonde being out of the water. Conductivity and salinity readings are within range.
- 6/16/2023 14:30-15:15 Negative depth values with no possibility of the sonde being out of the water. Conductivity and salinity readings are within range.
- 6/17/2023 14:45-16:45 Negative depth values with no possibility of the sonde being out of the water. Conductivity and salinity readings are within range.
- 6/18/2023 15:00-15:45 Negative depth values with no possibility of the sonde being out of the water. Conductivity and salinity readings are within range.
- 6/18/2023 16:15-16:45 Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 6/18/2023 17:00-17:15 Negative depth values with no possibility of the sonde being out of the water. Conductivity and salinity readings are within the range.
- 6/20/2023 11:00 – 12:45 Missing data for this period, cause unknown. No data in telemetry either.
- 6/21/2023 19:00 – 22:00 Significant rain event in the area 0.8" – >2.0".
- 6/22/2023 19:00 – 22:00 Significant rain event in the area 0.8" – >2.0" with intense winds of 15-17 mph.
- 6/23/2023 16:00 – 19:00 Significant rain event in the area 0.8" – >2.0" with intense winds of 15-17 mph.
- 7/02/2023 16:30-17:00 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and the sonde was likely out of water.

- 7/03/2023 17:00-18:15 Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 7/04/2023 17:30-19:15 Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water. The readings of conductivity, salinity, and turbidity at 22:30 are different from the other time frame, in which it is assumed that the sonde was out of water. However, these readings may be due to the sonde going to the surface.
- 7/05/2023 19:15-19:30 Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 7/09/2023 16:00 – 19:00 Significant rain event in the area 0.8” – >2.0”.
- 7/11/2023 06:00 – 10:00 Missing data for this period, cause unknown. No data in telemetry either.
- 7/13/2023 19:00 – 22:00 Significant rain event in the area 0.8” – >2.0”.
- 7/15/2023 16:00 – 19:00 Significant rain event in the area 0.8” – >2.0”.
- 7/22/2023 16:00 – 19:00 Significant rain event in the area 0.8” – >2.0”.
- 7/29/2023 16:00 – 19:00 Significant rain event in the area 0.8” – >2.0”.
- 7/30/2023 19:00-20:30 Very low conductivity and salinity with shallow readings depth due to very low tide (-0.59 ft). Values close to 0. All data was rejected, and the sonde was likely out of water.
- 7/31/2023 20:00-21:30 Very low conductivity and salinity along with shallow readings depth due to very low tide (-0.78 ft). Values close to 0. All data was rejected, and the sonde was likely out of water.
- 8/1/2023 21:00-22:15 Very low conductivity and salinity along with shallow readings depth due to very low tide (-0.81 ft). Values close to 0. All data was rejected, and the sonde was likely out of water.
- 8/16/2023 19:00 – 22:00 Significant rain event in the area 0.8” – >2.0”.
- 8/26/2023 01:00 – 04:00 Significant rain event in the area 0.8” – >2.0”.
- 8/30/2023 04:00 – 8/30/2023 18:45 Significant weather event. Hurricane Idalia, which was a tropical storm when it impacted this area, caused increased winds (20-30 mph) and heavy precipitation (~ 1.3 inches) from 4:00 to 10:00 am, which led to a decrease in temperature, salinity, and pH values, and an increase in turbidity and dissolved oxygen values.
- 8/30/2023 7:45 – 9:15 Negative depth values with no possibility of the sonde being out of the water. Conductivity and salinity readings are within range.
- 9/01/2023 07:00 – 13:00 Significant rain event in the area 0.8” – >2.0”.
- 9/26/2023 10:00 – 13:00 Significant rain event in the area 0.8” – >2.0”.
- 9/27/2023 10:00 – 9/29/2023 1:15 Missing data for this period due to instrument malfunction. Water got into the battery and circuit compartments. Data were able to be recovered from telemetry.
- 9/29/2023 1:30 – 10/10/2023 13:00 Missing data for this period due to instrument malfunction. Water got into the battery and circuit compartments. Deployment stopped early on 10/10/2023 at 10:00.
- 10/16/2023 09:15-10:15 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 11/01/2023 09:30-12:45 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 11/26/2023 13:00 – 16:00 Significant weather event, strong winds (20-27 mph) and heavy precipitation (1.0 – 1.3 inches).
- 11/27/2023 08:00-10:15 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 11/28/2023 08:15-11:15 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 11/29/2023 09:00-11:15 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 12/02/2023 10:00 – 16:00 Significant rain event in the area 1.7” – >2.0”.
- 12/10/2023 14:00 – 17:00 Significant rain event in the area 1.2” – 1.4”.
- 12/11/2023 06:30-10:00 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and the sonde was likely out of water.

- 12/12/2023 07:15-09:30 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 12/13/2023 07:45-10:45 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and it is likely the sonde was out of water.
- 12/14/2023 08:30-12:15 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and it is likely the sonde was out of water.
- 12/15/2023 10:15-12:30 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and it is likely the sonde was out of water.
- 12/17/2023 02:00 – 08:00 Significant rain event in the area 0.6" – 1.0" with strong winds of 14-16 mph.
- 12/29/2023 09:30-11:45 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and it is likely the sonde was out of water.
- 12/30/2023 10:45-11:45 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and it is likely the sonde was out of water.
- 01/06/2024 03:00 – 07:00 Significant rain event in the area 1.2" – 2.0" with strong winds of 17-24 mph.
- 01/08/2024 05:45-06:30 Very low conductivity and salinity with shallow readings depth due to very low tide. All data was rejected, but the reason for these readings is uncertain.
- 01/09/2024 14:00 – 17:00 Significant rain event in the area 0.7" – 0.9".
- 01/10/2024 07:15-10:30 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and it is likely the sonde was out of water.
- 01/11/2024 08:45-10:00 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and it is likely the sonde was out of water.
- 01/13/2024 09:30-13:00 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and it is likely the sonde was out of water.
- 01/14/2024 11:15-12:00 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 01/20/2024 02:45-07:15 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 01/21/2024 03:15-09:00 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 01/28/2024 10:30-12:00 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 01/29/2024 09:15-12:45 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 02/04/2024 02:00 –14:00 Significant weather events caused increased winds (15-38 mph).
- 02/06/2024 05:45–07:00 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 02/07/2024 05:45–09:00 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 02/09/2024 08:45–09:15 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 02/21/2024 07:00–08:45 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 02/27/2024 14:30 – 03/20/24 10:15 Very low readings of specific conductivity and salinity without finding the cause. Calibration and post-calibration information were revised, and nothing unusual was found. Readings of specific conductivity and salinity were rejected along with depth and DO mg/L.
- 03/05/2024 14:00 – 03/06/2024 02:00 Significant rain event in the area 0.7" – 2.0".
- 03/07/2024 07:00–07:15 Very low conductivity and salinity, but the cause was unknown. All data was rejected.
- 03/10/2024 08:30–11:00 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and it is likely the sonde was out of water

- 03/10/2024 21:30 Very low conductivity and salinity, but the cause was unknown. All data was rejected.
- 03/11/2024 08:45–11:00 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and it is likely the sonde was out of water
- 03/11/2024 21:30–22:45 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and it is likely the sonde was out of water
- 03/19/2024 02:45–08:15 Very low conductivity and salinity with shallow readings depth due to very low tide. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 03/20/2024 10:30 Missing data caused by the recovery and deployment of the sonde.
- 03/27/2024 05:00 – 08:00 Significant rain event in the area 1.6" – >2.0".
- 04/08/2024 08:00 – 11:00 Significant rain event in the area 0.9" with intense winds of 16-21 mph.
- 04/11/2024 08:00 – 11:00 Significant rain event in the area 1.3" – 1.4".
- 05/10/2024 07:00 – 10:00. 14:00– 17:00 Significant weather event. A strong storm generated tornadoes, causing winds (20-28 mph) and precipitation (0.4-0.7").
- 05/13/2024 15:00 – 17:00. Significant rain event in the area 0.5" – 1.9" with intense winds of 15-32 mph.
- 05/14/2024 5:00 – 06:00. Significant rain event in the area 0.4" – 0.7" with intense winds of 17-21 mph.
- 05/18/2024 14:00 – 17:00. Significant rain event in the area 0.4" – 0.7" with intense winds of 14-21 mph.
- 05/22/2024 10:15 Missing data caused by the recovery and deployment of the sonde.

Appendix C. Post-deployment Calibration Values

Post-deployment calibration values to verify the accuracy of DO, specific conductivity, pH, and turbidity measurements.

C1. Seawater Intake (SI)

Deployment Date	DO_pct	SpCond_mS/cm	pH		Turb_NTU	
	(Std: 100%)	(Std: 50@25°)	(Std: 7)	(Std: 10)	(Std: 0)	(Std: 124)
06/28/2023	88.4	50.28	7.01	10.15	0.14	124.30
08/23/2023	101.0	52.21	7.05	10.05	0.83	113.15
09/20/2023	100.4	55.92	6.98	9.87	0.06	133.5
10/26/2023	99.7	51.92	7.17	10.20	0.52	123.23
11/30/2023	99.7	59.85	7.04	9.87	0.95	123.99
01/10/2024	100.6	53.54	7.04	10.11	2.80	123.80
02/13/2024	101.3	49.71	6.95	10.04	0.04	122.83
03/14/2024	100.6	50.40	7.08	9.94	0.03	121.43
04/17/2024	99.6	49.65	7.11	10.14	1.11	124.76
05/21/2024	100.3	49.99	7.02	10.05	0.48	121.79
06/10/2024	100.2	49.65	7.04	10.07	-0.63	124.35
07/01/2024	98.7	50.20	6.96	9.96	0.57	115.74

C2. Alligator Harbor (AH)

Deployment Date	DO_pct	SpCond_mS/cm	pH		Turb_NTU	
	(Std: 100%)	(Std: 50@25°)	(Std: 7)	(Std: 10)	(Std: 0)	(Std: 124)

06/28/2023	103.9	50.36	7.00	10.04	0.58	124.28
08/23/2023	100.2	51.89	7.12	10.09	-0.39	119.16
09/25/2023	72.65	55.73	7.02	9.89	0.01	126.29
10/26/2023	99.35	51.80	7.03	10.00	0.70	122.40
11/30/2023	99.40	59.64	7.01	9.87	3.40	125.63
01/10/2024	100.00	54.11	7.05	10.04	0.34	124.45
02/13/2024	99.2	49.95	7.00	9.93	0.14	122.56
03/20/2024	100.4	49.83	7.14	10.14	-1.13	124.82
04/25/2024	100.5	49.82	7.08	10.09	-0.02	123.27
05/30/2024	99.7	49.77	7.04	9.82	1.16	122.82
07/01/2024	98.55	50.18	6.59	6.60	0.15	124.00

C3. Oyster Bay (OB)

Deployment Date	DO_pct	SpCond_mS/cm	pH		Turb_NTU	
	(Std: 100%)	(Std: 50@25°)	(Std: 7)	(Std: 10)	(Std: 0)	(Std: 124)
05/18/2023	101.5	49.51	7.15	10.03	0.54	124.78
07/11/2023	101.2	49.19	7.06	10.13	0.67	130.80
08/23/2023	105.1	53.04	7.08	10.05	0.22	123.06
09/27/2023	99.5	54.82	7.07	10.05	1.30	125.11
10/10/2023	102.3	55.51	7.25	10.24	-0.30	125.10
11/13/2023	100.7	56.23	7.01	10.07	2.40	125.4
12/14/2023	100.3	55.95	6.92	9.88	0.83	124.90
01/23/2024	99.7	49.94	7.11	10.17	0.27	143.10
02/27/2024	100.3	50.09	7.00	9.96	0.87	121.97
03/20/2024	100.4	49.86	7.06	10.03	1.40	123.28
04/25/2024	101.0	49.78	7.13	10.22	1.50	128.30
05/22/2024	100.0	50.02	7.01	9.94	-2.64	121.90

Appendix D: Descriptive Statistics

Summary statistics for depth, temperature, salinity, dissolved oxygen, pH, and turbidity at each monitoring station after quality control filtering.

D1. Seawater Intake (SI) ---> 06/28/2023 – 07/01/2024

Stats with QC flag >= 0 n = 35,255								
	Depth_m	Temp_C	SpCond_mS/cm	Sal_psu	DO_pct	DO_mgl	pH	Turb_NTU
Min	0.95	6.2	26.30	16.3	6.3	0.4	7.1	-1
Max	3.13	34.2	53.12	35.1	159.3	10.0	8.3	478
Average	1.97	23.3	47.38	31.0	79.6	5.7	7.9	4
Std Dev	0.29	6.65	2.83	2.1	16.2	1.5	0.1	16

Stats with QC flag >= 0 excluding 1 flags n = 35,080								
	Depth_m	Temp_C	SpCond_mS/cm	Sal_psu	DO_pct	DO_mgl	pH	Turb_NTU
Min	0.95	6.2	26.30	16.3	6.3	0.4	7.3	0
Max	3.13	34.2	53.12	35.1	159.3	10.0	8.3	478
Average	1.97	23.3	47.38	31.0	79.5	5.7	7.9	4
Std Dev	0.29	6.5	2.83	2.1	16.2	1.5	0.1	12

D2. Alligator Harbor (AH) ---> 06/29/2023 – 07/01/2024

Stats with QC flag >= 0 n = 35,171								
	Depth_m	Temp_C	SpCond_mS/cm	Sal_psu	DO_pct	DO_mgl	pH	Turb_NTU
Min	0.25	5.2	28.56	17.6	14.3	0.9	7.5	-1
Max	2.41	34.4	52.98	34.7	137.1	9.7	8.1	356
Average	1.16	23.3	47.65	31.1	85.0	6.1	7.9	5
Std Dev	0.30	6.6	2.02	1.5	16.6	1.6	0.1	8
Stats with QC flag >= 0 excluding 1 flags n = 35,125								
	Depth_m	Temp_C	SpCond_mS/cm	Sal_psu	DO_pct	DO_mgl	pH	Turb_NTU
Min	0.25	5.2	28.56	17.6	14.3	0.9	7.5	0
Max	2.41	34.4	52.98	34.7	137.1	9.7	8.1	294
Average	1.16	23.3	47.66	31.1	85.0	6.1	7.9	5
Std Dev	0.30	6.6	2.02	1.5	16.6	1.6	0.1	6

D3. Oyster Bay (OB) ---> 05/18/2023 – 05/22/2024

Stats with QC flag >= 0 n = 31,893								
	Depth_m	Temp_C	SpCond_mS/cm	Sal_psu	DO_pct	DO_mgl	pH	Turb_NTU
Min	-0.16	7.0	18.40	10.9	21.4	1.5	7.3	-1
Max	2.22	34.2	49.04	31.9	132.0	11.3	8.3	387
Average	0.81	22.8	37.80	24.1	92.1	7.0	7.9	3
Std Dev	0.35	6.4	6.24	4.4	9.7	1.2	0.1	5
Stats with QC flag >= 0 excluding 1 flags n = 31,456								
	Depth_m	Temp_C	SpCond_mS/cm	Sal_psu	DO_pct	DO_mgl	pH	Turb_NTU
Min	0.00	7.0	18.40	10.9	21.4	1.5	7.3	0
Max	2.22	34.2	49.04	31.9	132.0	11.3	8.3	106
Average	0.81	22.8	37.80	24.4	92.1	7.0	7.9	3
Std Dev	0.35	6.4	6.24	4.4	9.7	1.2	0.1	3

Appendix E. Station Time Series

Time-series plots illustrating water quality dynamics at Seawater Intake (SI), Alligator Harbor (AH), and Oyster Bay (OB) from May 2023 to July 2024. These figures highlight seasonal variability, storm events, and sensor responses over the monitoring period.

- **Seawater Intake (SI) ---> 06/28/2023 – 07/01/2024**

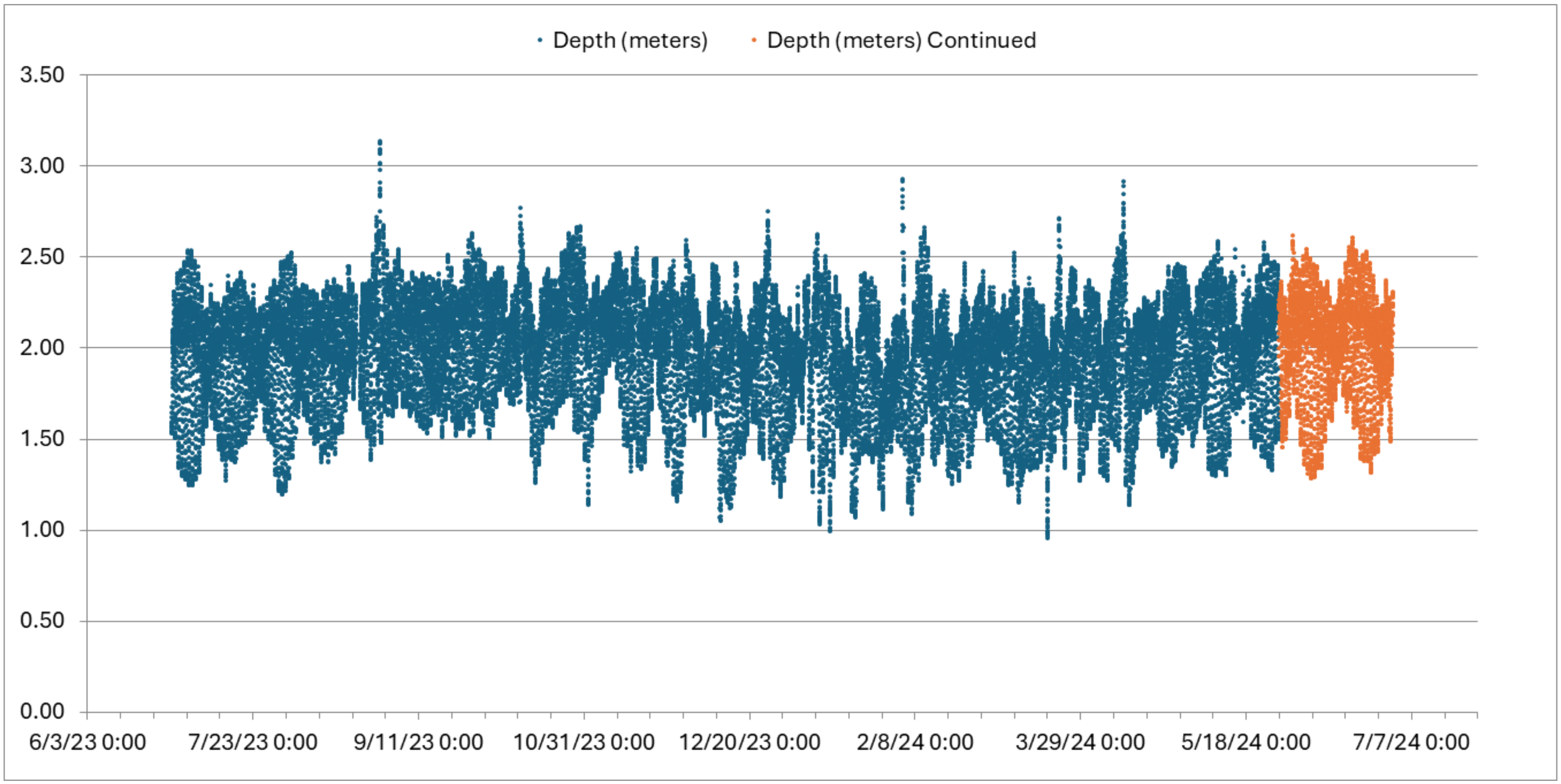

Figure E1. Seawater Intake – Depth Time Series

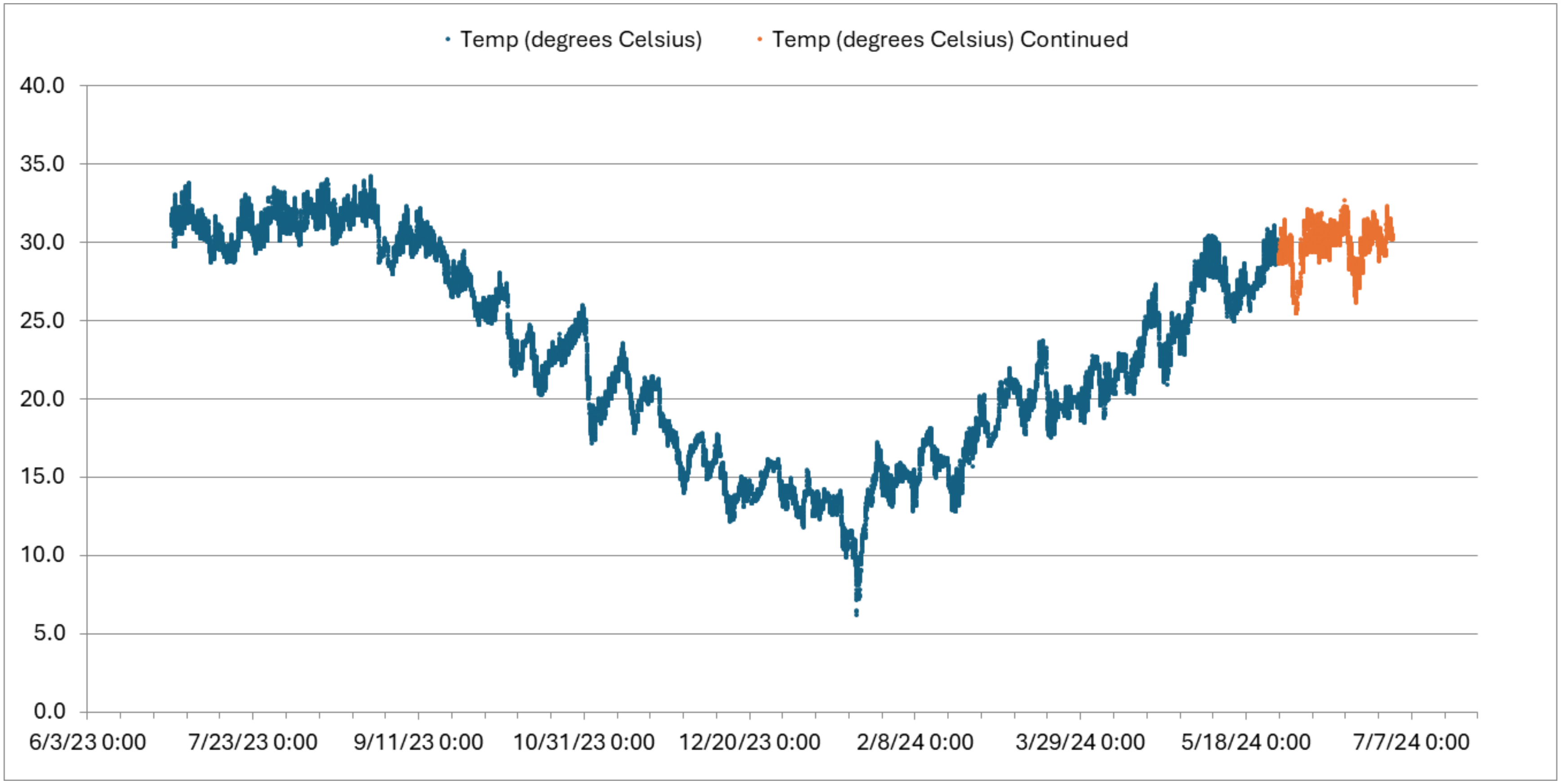

Figure E2. Seawater Intake – Temperature Time Series

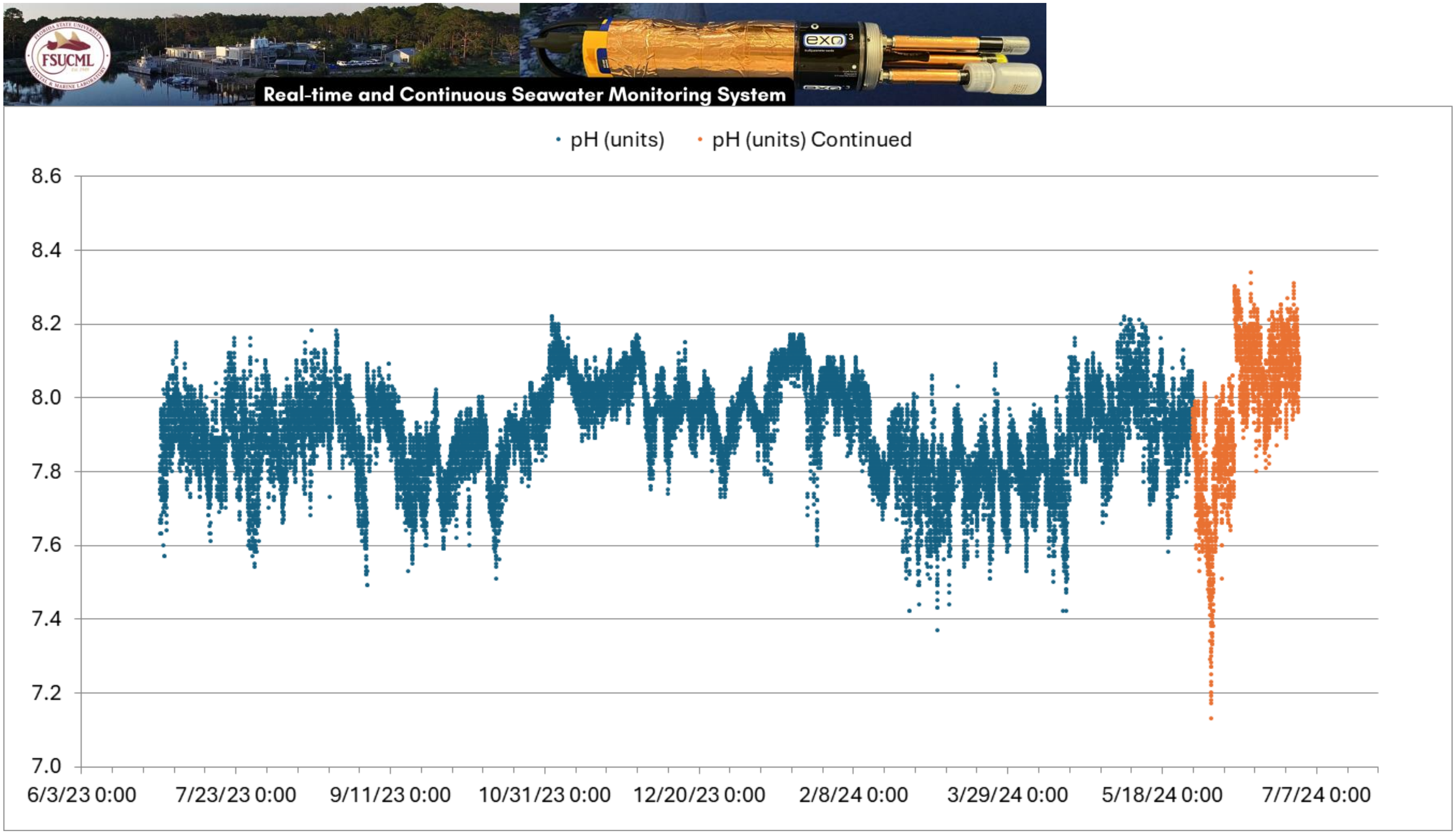

Figure E3. Seawater Intake – pH Time Series

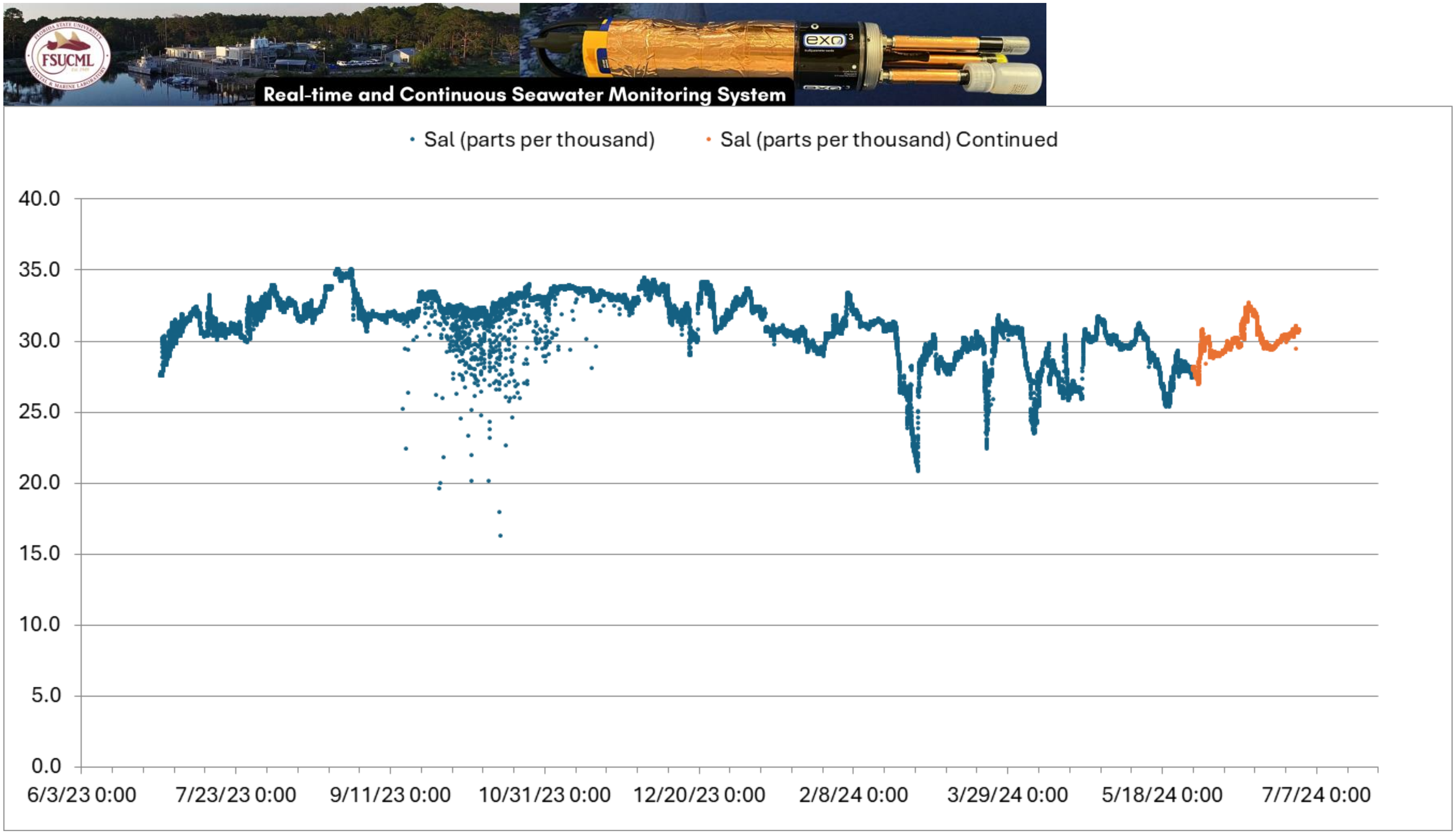

Figure E4. Seawater Intake – Salinity Time Series

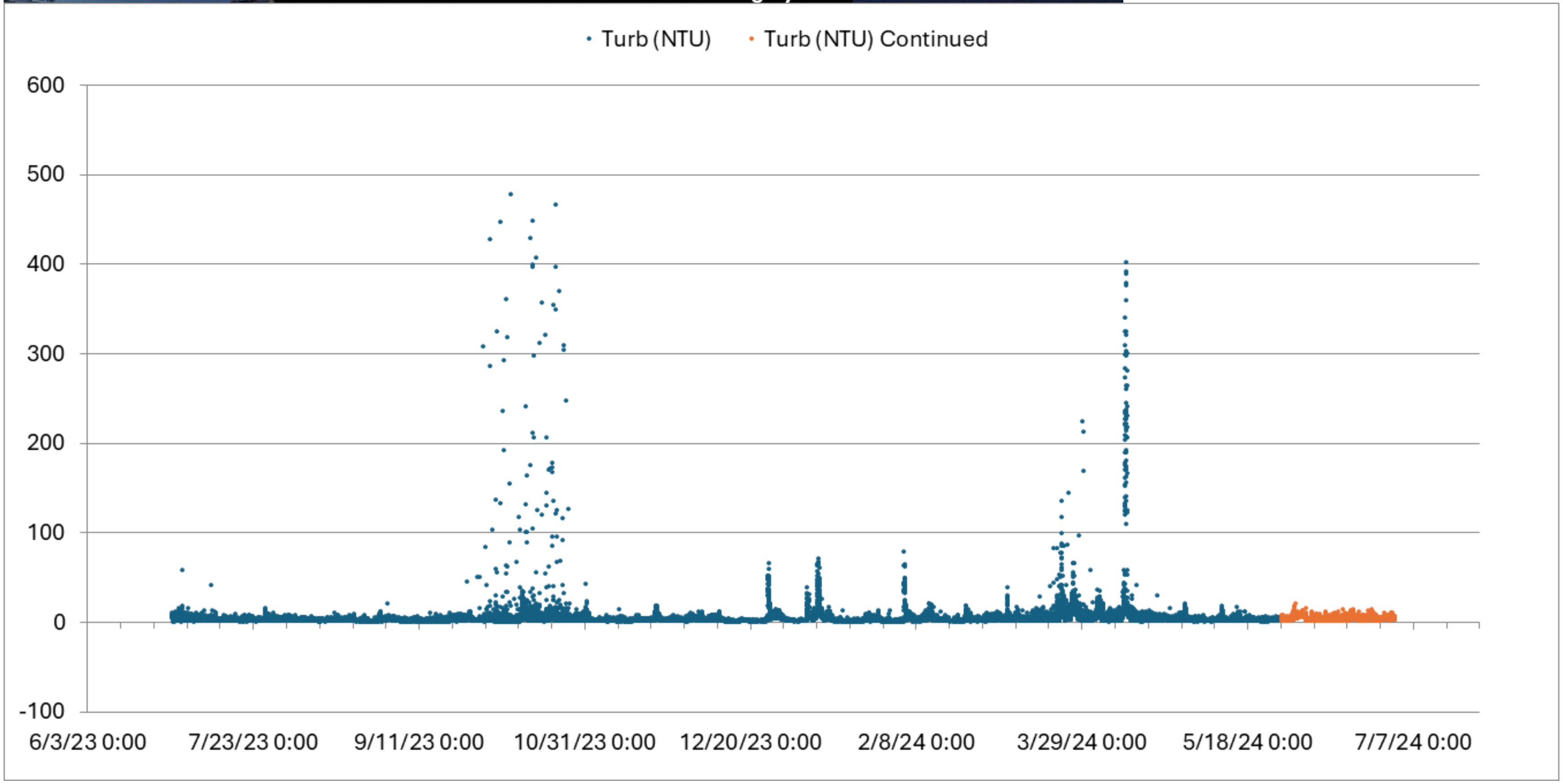

Figure E5. Seawater Intake – Turbidity Time Series

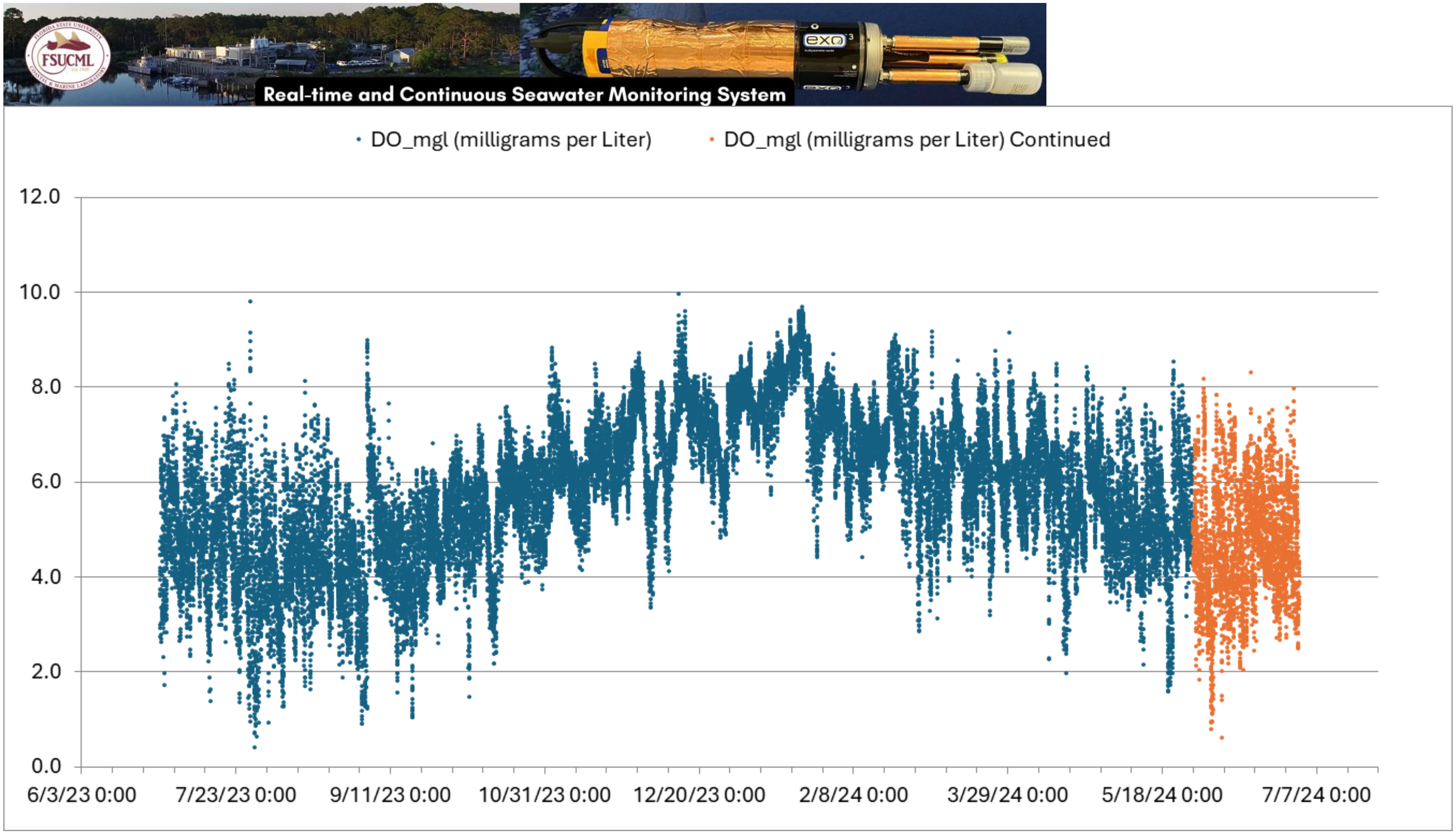

Figure E6. Seawater Intake – Dissolved Oxygen Time Series

- **Alligator Harbor (AH) ---> 06/29/2023 – 07/01/2024**

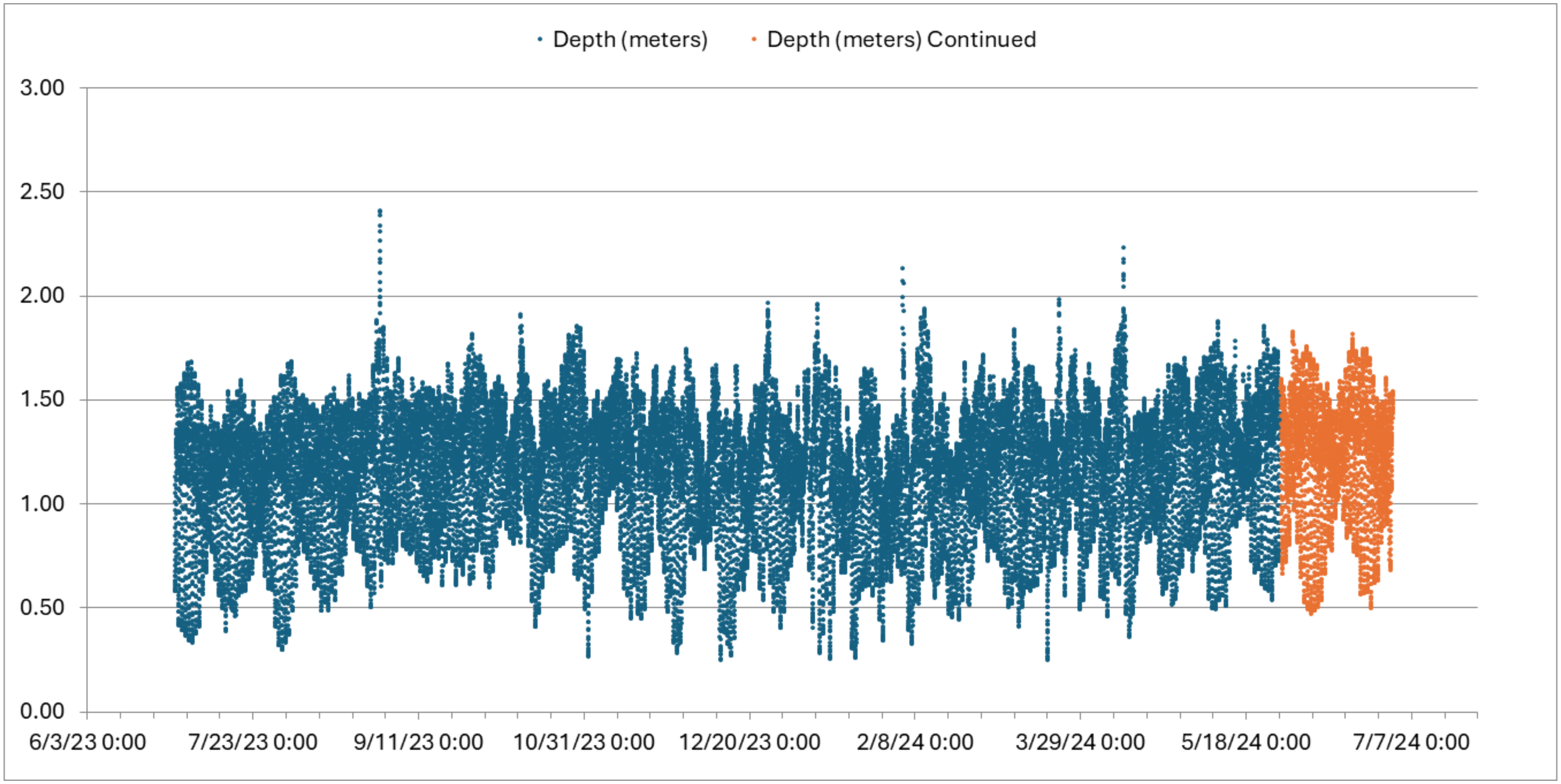

Figure E7. Alligator Harbor – Depth Time Series

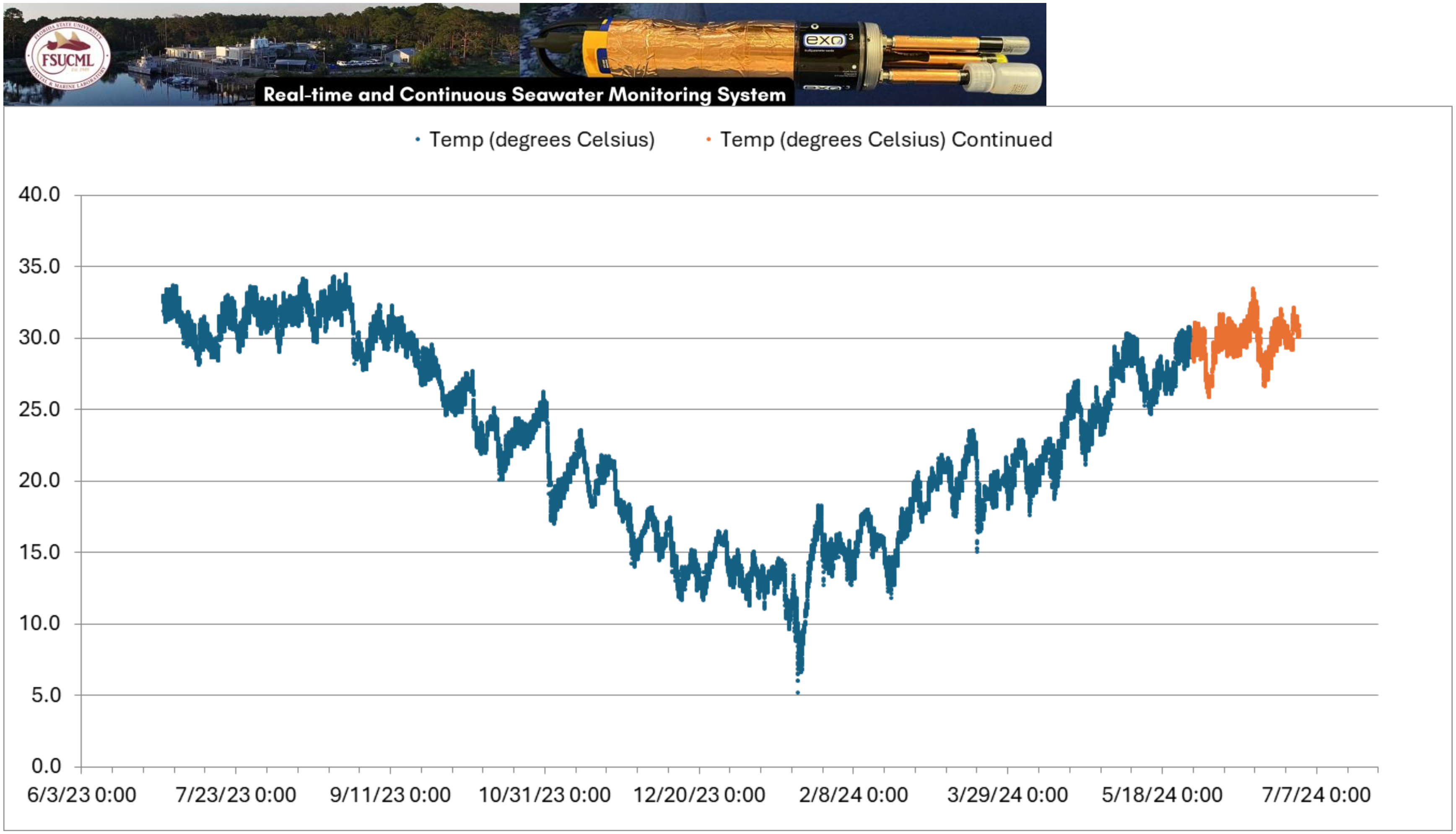

Figure E8. Alligator Harbor – Temperature Time Series

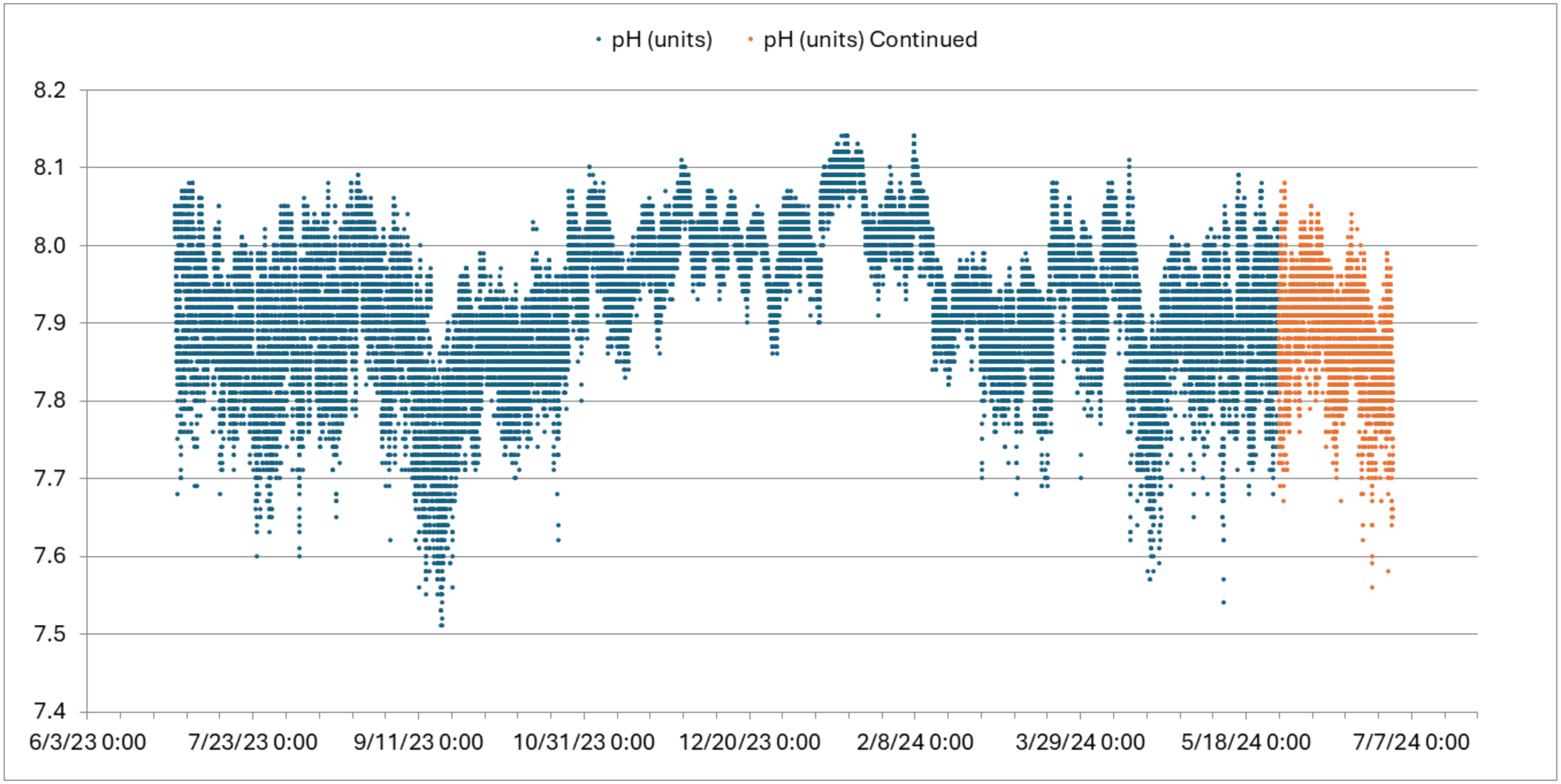

Figure E9. Alligator Harbor – pH Time Series

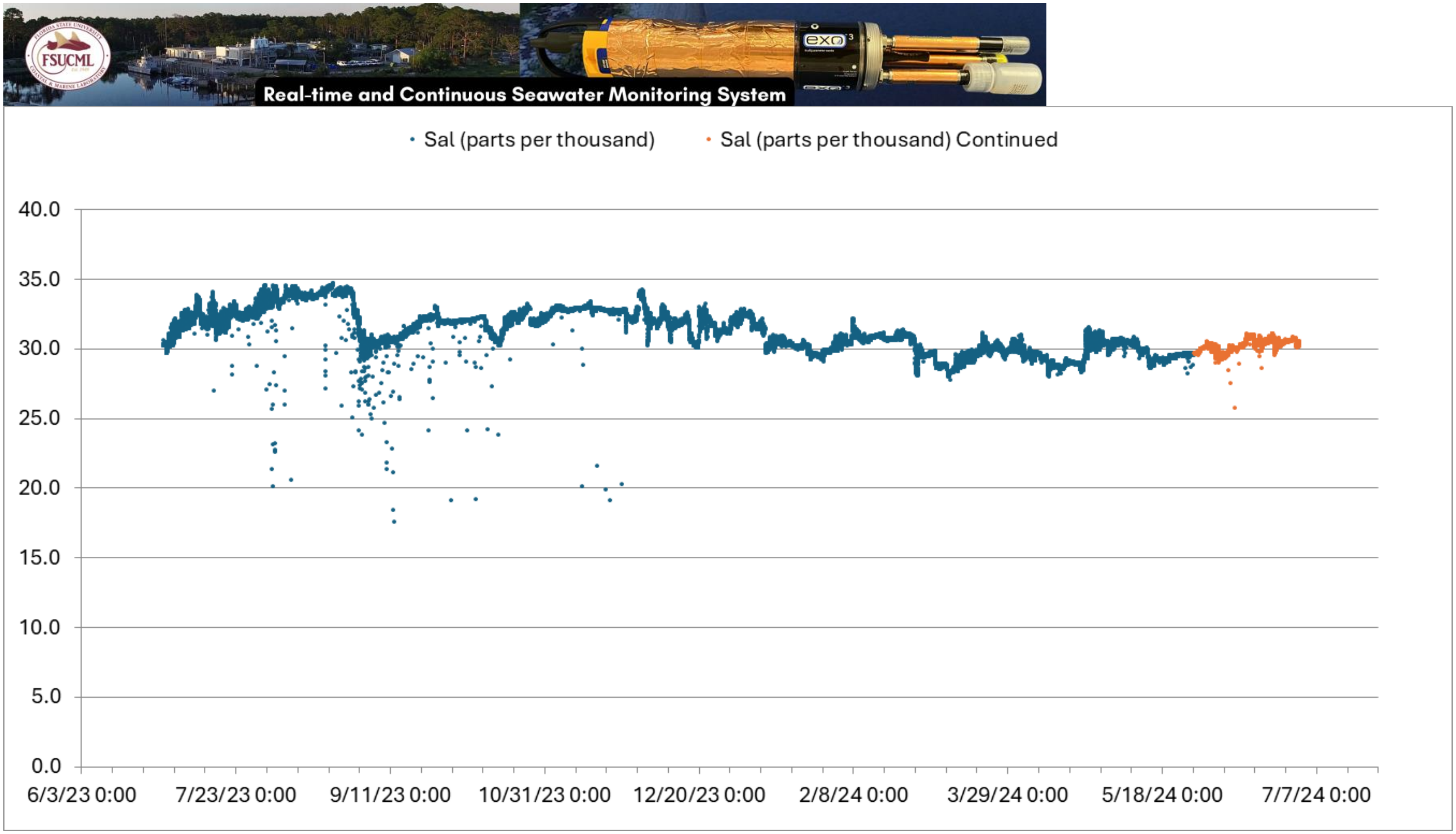

Figure E10. Alligator Harbor – Salinity Time Series

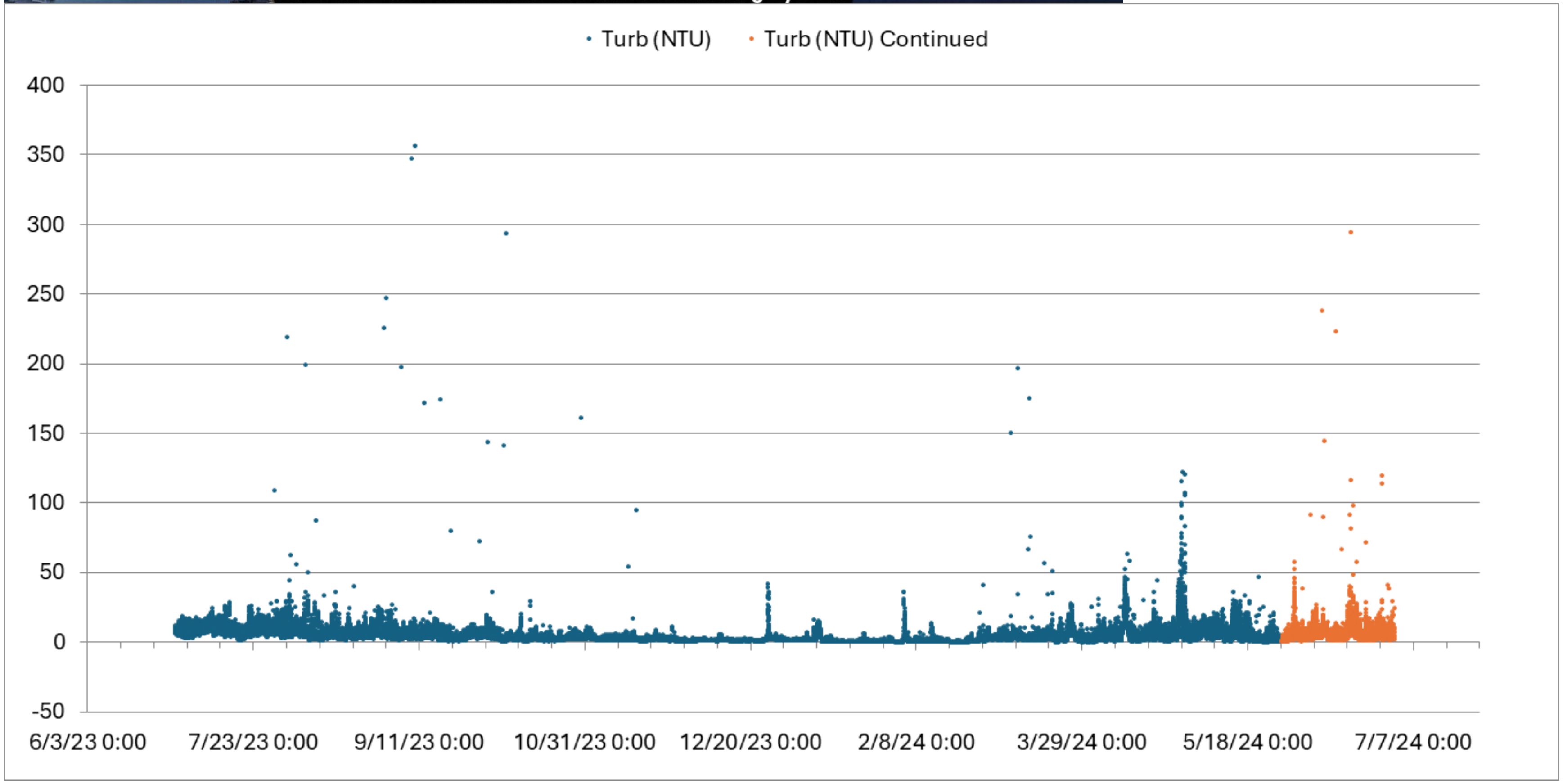

Figure E11. Alligator Harbor – Turbidity Time Series

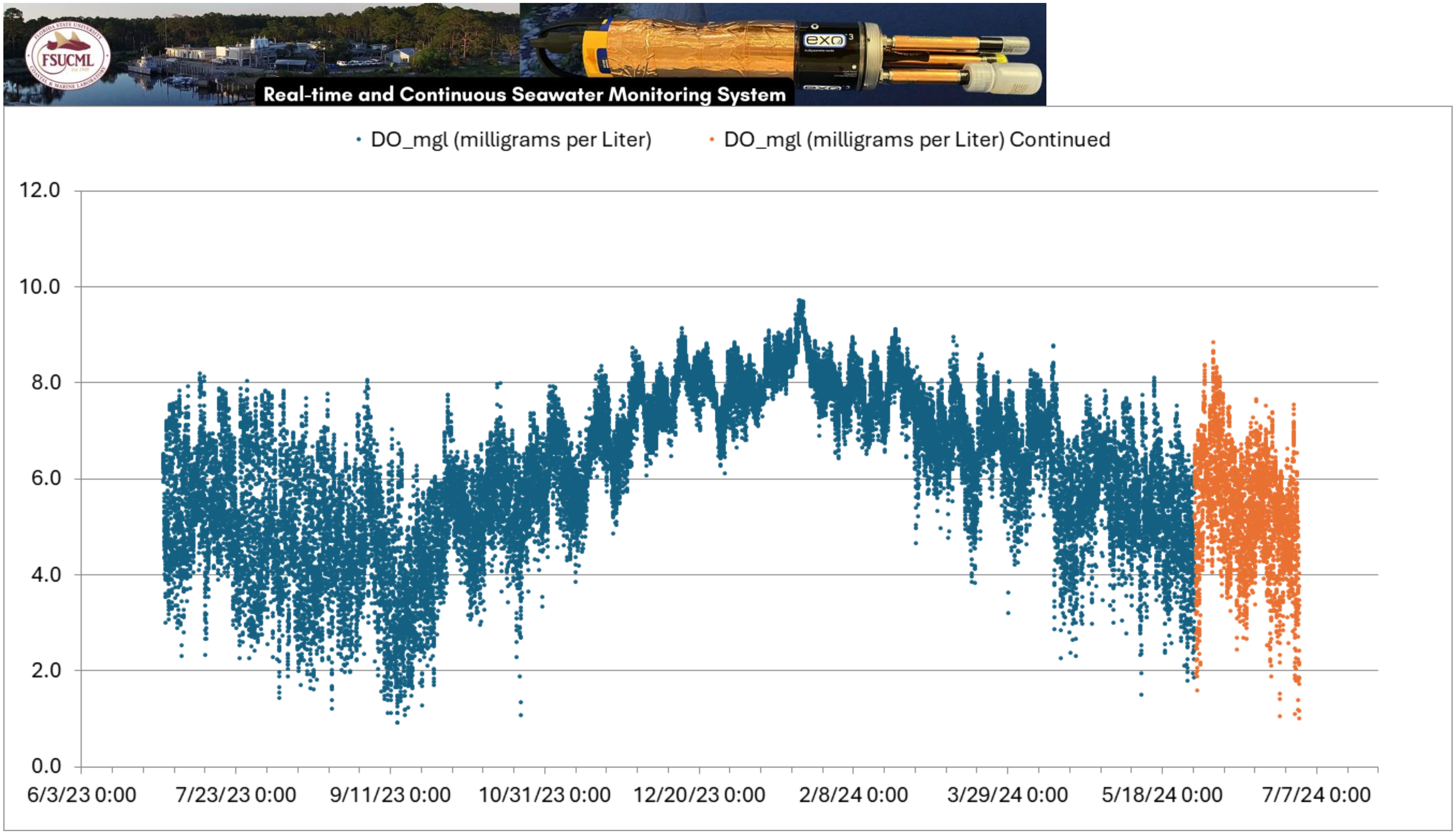

Figure E12. Alligator Harbor – Dissolved Oxygen Time Series

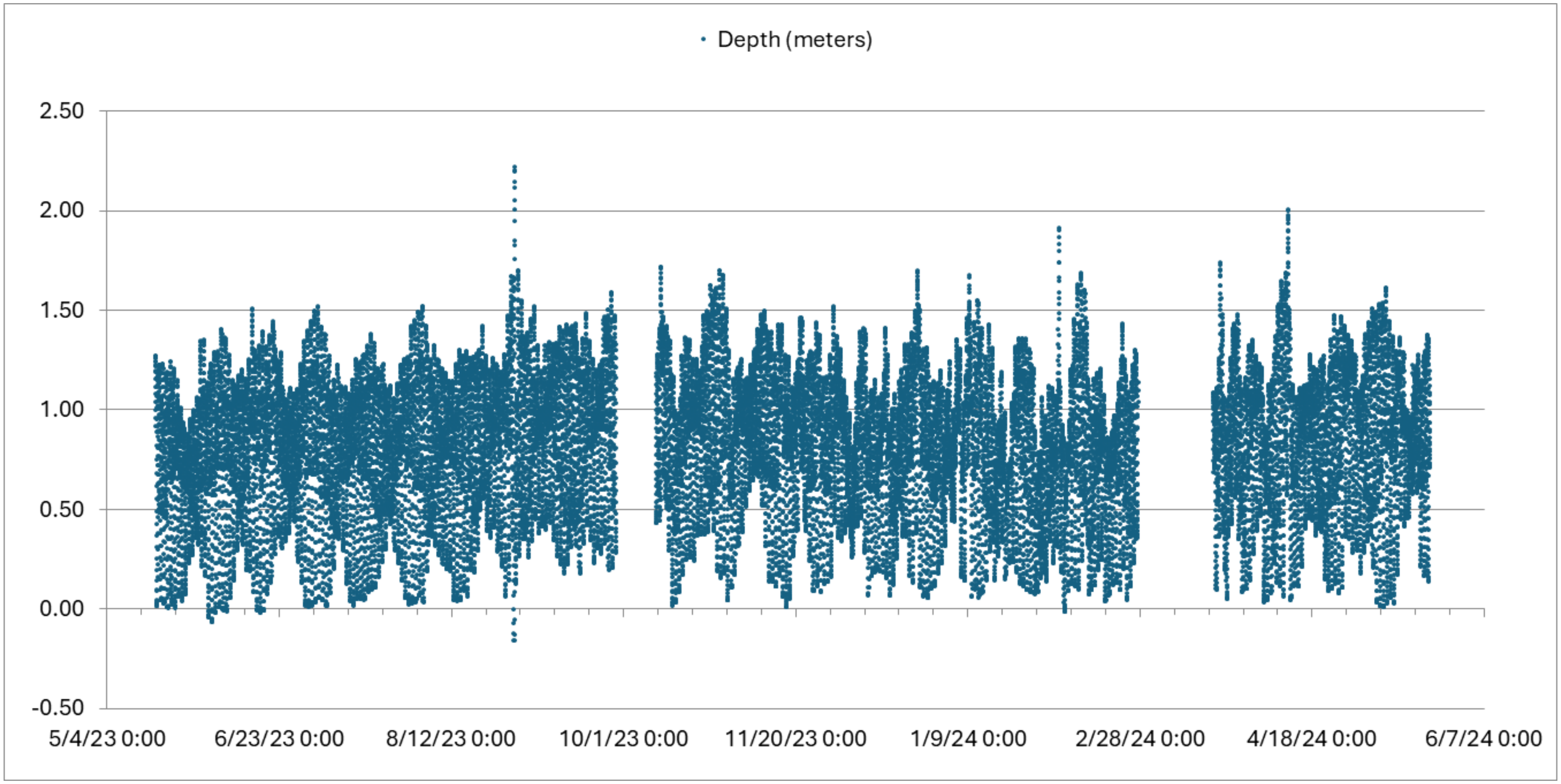

Figure E13. Oyster Bay – Depth Time Series

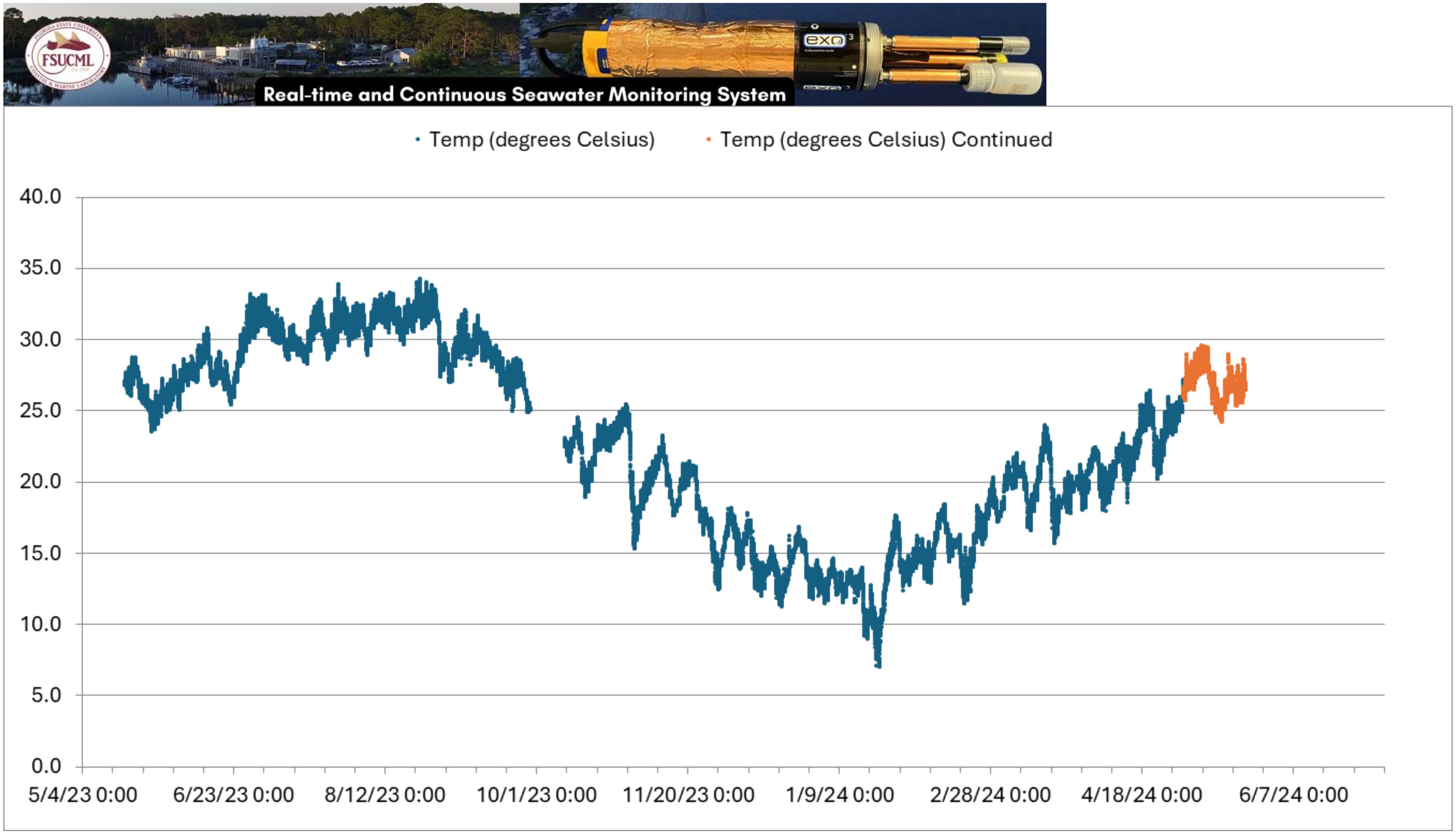

Figure E14. Oyster Bay – Temperature Time Series

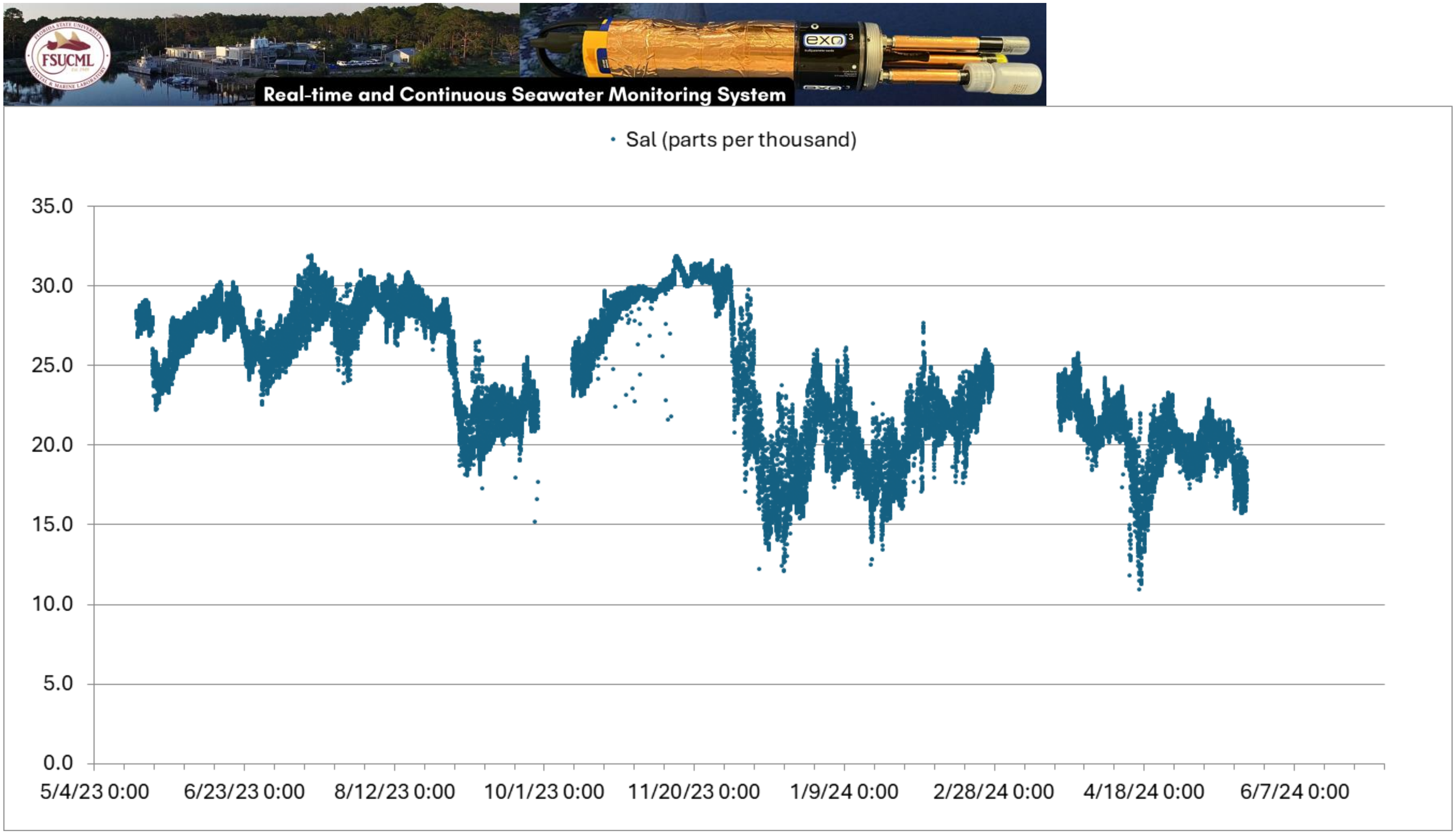

Figure E15. Oyster Bay – pH Time Series

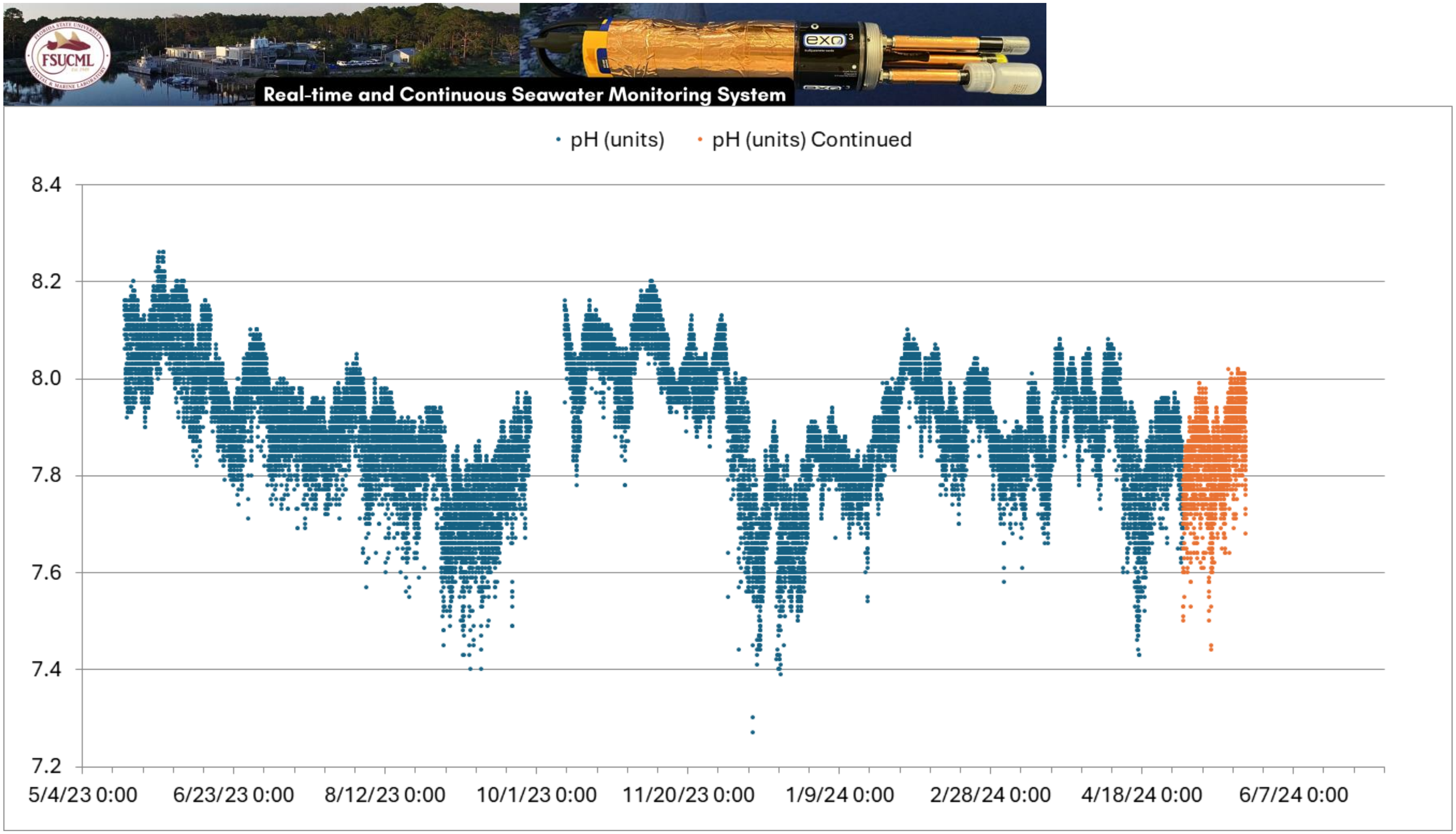

Figure E16. Oyster Bay – Salinity Time Series

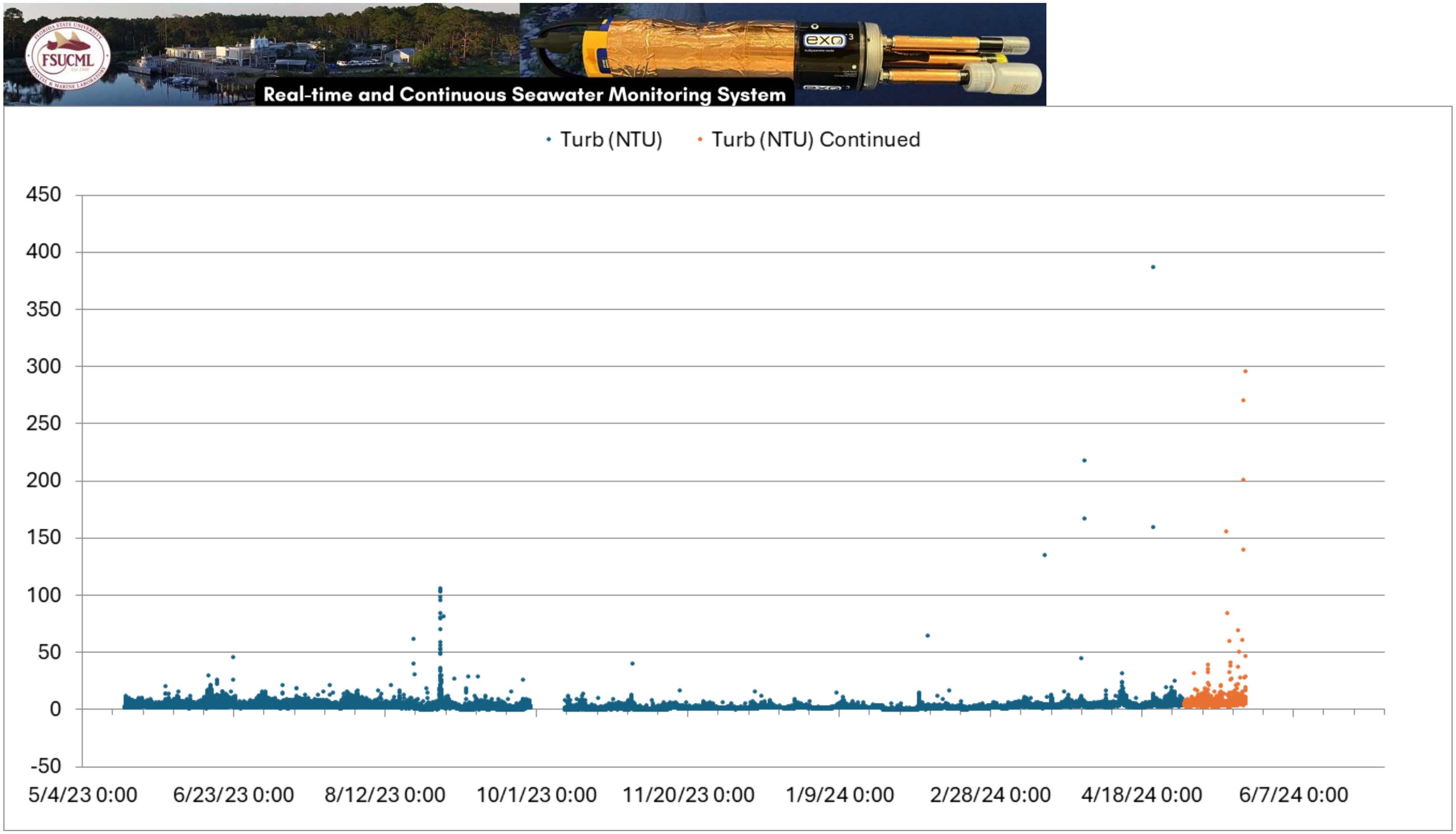

Figure E17. Oyster Bay – Turbidity Time Series

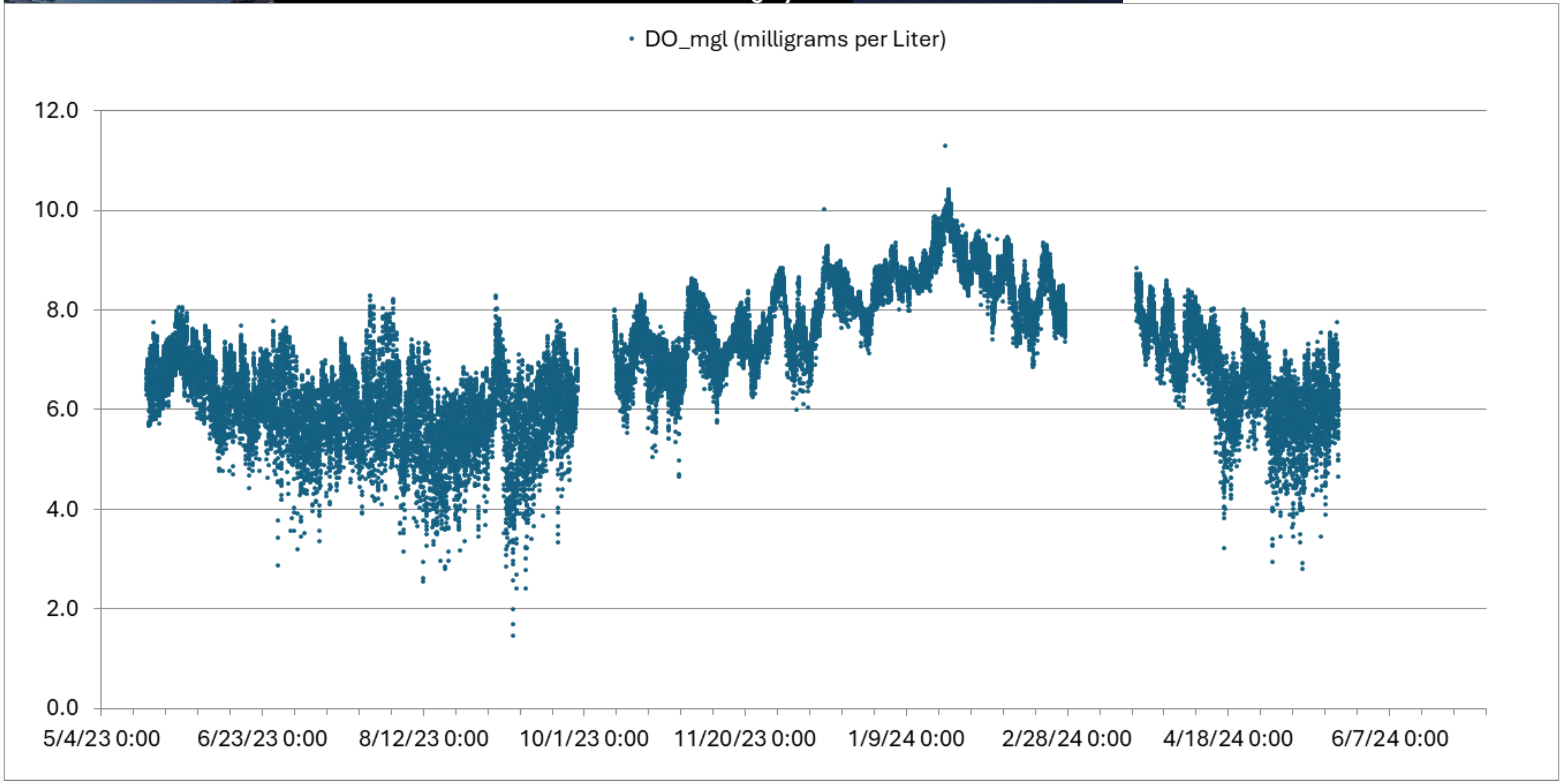

Figure E18. Oyster Bay – Dissolved Oxygen Time Series