FSUCML Real-time and Continuous Seawater Monitoring System: Annual Report 2024 - 2025

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., Hurricanes Helene and Milton in Fall 2024),
- 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 2024-2025 monitoring year include:

- Storms, including Tropical Storm Debby and Hurricanes Helene and Milton, caused sharp water quality shifts. Turbidity reached 477 NTU at SI, and salinity dropped to 13.1 psu at OB.
- Low pH (< 7.5) occurred frequently, especially during cold fronts. The lowest value (~7.3) was at OB, stressing shellfish habitats.
- Hypoxia (DO < 2 mg/L) was detected at all stations, with a minimum of 0.7 mg/L at SI, linked to summer stratification and storms.
- Network uptime was generally high, with AH showing the highest reliability (~95%). SI with ~93%, while OB had the lowest (~88%) due to tidal exposure, though performance improved with adjustments.

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2. Project Overview

a) Principal investigators and contact information:

Beatriz Mejia-Mercado; Principal Investigator, Data Management *Main contact
E-mail: bmejiamercado@fsu.edu, (850) 645-3493

Joel Trexler, Research Coordinator
E-mail: jtrexler@fsu.edu; (850) 645-3480

Cullen Morris, Research Assistant
E-mail: ccmorris@fsu.edu; (850) 645-3475

FSU Coastal and Marine Laboratory
3618 Highway 98
St. Teresa, FL 32358

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 utilize YSI EXO3 multiparameter sondes, mounted near the water surface and connected to a Campbell CR310 or DL310 datalogger, which transmits data via a 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.

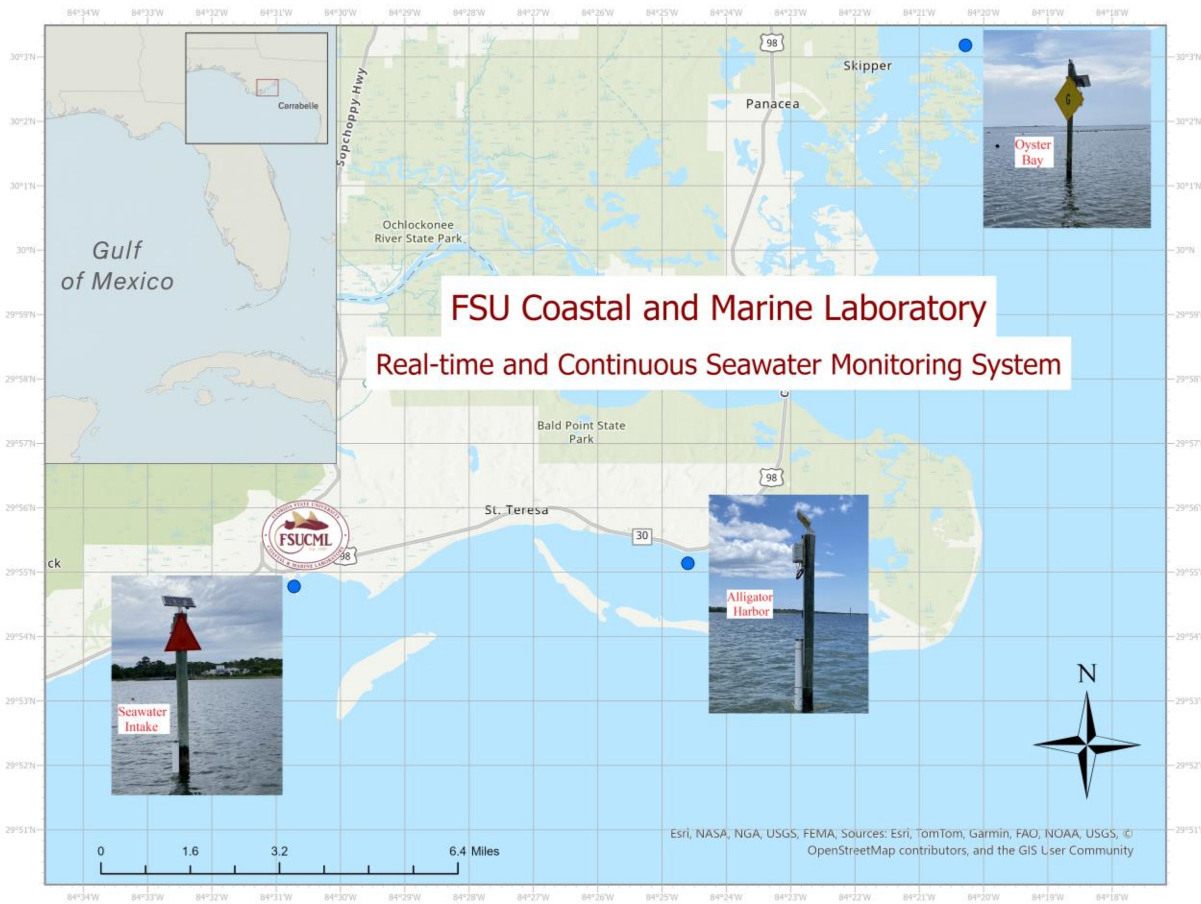

Figure 1. Geographic locations of FSUCML's three real-time seawater monitoring stations in the northeastern Gulf of Mexico: Seawater Intake (SI), Alligator Harbor (AH), and Oyster Bay (OB). These stations are strategically positioned to capture coastal water quality dynamics across gradients of salinity,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

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.

Once collected, data is made available through the Xylem cloud interface called HydroSphere, which can be accessed at https://cloud.xylem.com/hydrosphere/. 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 is 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 2024 – July 2025)

Between May 2024 and July 2025, the FSUCML coastal monitoring program continued routine sonde deployments at three fixed stations—Seawater Intake (SI), Alligator Harbor (AH), and Oyster Bay (OB)—on a rotating schedule, typically lasting 4 to 6 weeks per deployment. Based on deployment and recovery records, a total of 14 deployments were conducted at SI, 11 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, 14 deployments were attempted, including two short cycles and one failed deployment. Despite challenges, such as a lightning strike in September 2024 and some equipment downtime, the site maintained a high deployment rate and demonstrated responsive field servicing.

AH completed 11 uninterrupted deployments with no early retrievals or missed cycles. This station maintained strong telemetry and consistent data continuity, affirming its position as the most operationally stable site in the network.

OB also completed 11 deployments, with durations closely matching the intended schedule. Although this station is prone to low-tide exposure and sensor issues, operational adjustments throughout the year improved data reliability and minimized data loss.

Overall, the program maintained consistent coverage and frequency across all stations, with rapid recovery following disruptions. The regular servicing cycle and robust infrastructure contributed to the success of the 2024–2025 monitoring year.

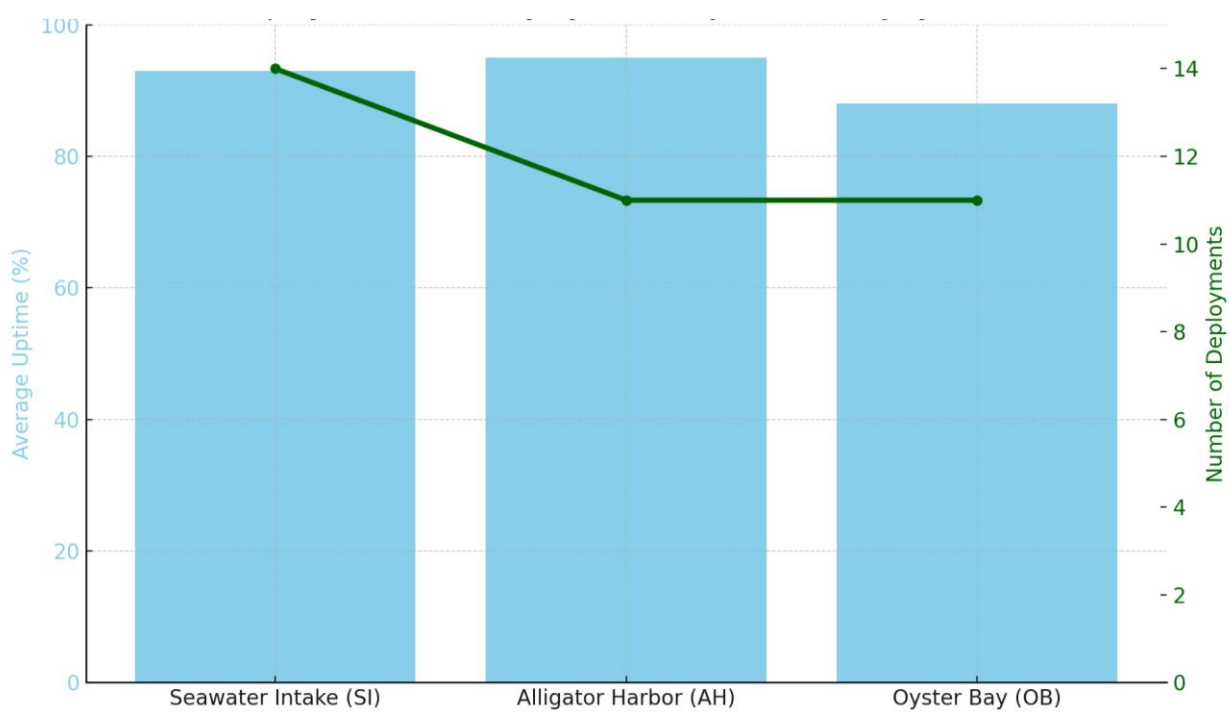

Figure 2. Deployment performance summary from June 2024 to July 2025. Blue bars indicate average uptime per station; green line shows total number of deployments.

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 over the May 2024 to July 2025 period 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 14 deployments over the year. While generally regular in its deployment schedule, the station experienced several interruptions due to equipment malfunctions and weather. Notably, a lightning strike in September 2024 destroyed the station, requiring a full rebuild. Tropical Storm Debby, snowfall in January, and frequent heavy rain events also contributed to downtime. Despite these challenges, the site was consistently repaired and redeployed, showcasing strong responsiveness.

AH proved to be the most stable station operationally, with 11 uninterrupted deployments. Most issues were limited to brief telemetry gaps during redeployments or minor sensor problems, such as a broken pH sensor in July and a wiper loss in August. The site maintained excellent data quality throughout, even during Tropical Storm Debby and Hurricanes Helene and Milton.

OB presented the most complex operational environment, with 11 deployments completed. The station was prone to repeated low-tide exposure, leading to invalid conductivity and salinity readings, especially during the winter. Battery flooding and sensor errors further contributed to increased data rejection. However, operational adjustments in early 2025 improved sonde positioning and reduced downtime.

These field-based insights emphasize the importance of site-specific calibration, robust hardware, and rapid redeployment protocols. Additional details on these deployments and anomalies are provided in Appendix B. A summary of site-level performance is presented in Table 2 below.

Table 2. Summary of deployment activity, average uptime, and operational challenges across FSUCML monitoring stations (May 2024 – July 2025).

Station	# of Deployments	Avg. Uptime (%)	Common Issues	Notable Events
Seawater Intake (SI)	14	~93%	Lightning damage, equipment malfunctions, and telemetry interruptions	Tropical Storm Debby (Aug), lightning strike (Sep), heavy rain, snow (Jan)
Alligator Harbor (AH)	11	~95%	Broken pH sensor, wiper loss, brief redeployment gaps	Tropical Storm Debby, Hurricanes Helene & Milton, minimal data loss
Oyster Bay (OB)	11	~88%	Low-tide exposure, sensor out-of-water events, and battery flooding	Hurricanes Helene & Milton, repeated salinity anomalies (Dec–Mar), data loss

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 underscore the effectiveness of pre-deployment calibration protocols and field maintenance throughout the year.

At SI, 14 calibrations were performed. DO values were generally stable, with all but one reading falling to within 2% of the 100% standard. Conductivity measurements remained tightly clustered around the 50 mS/cm reference, while pH values consistently hovered near 7. Turbidity checks were also within expected bounds, with minor variability in late deployments but no persistent drift.

AH displayed high calibration consistency across 10 deployments. Most DO readings were within tolerance, except for one outlier (75.4%) in late March 2025, suggesting either field-related sensor degradation or fouling. Specific conductivity, pH, and turbidity values remained well-aligned with reference standards, and no repeated anomalies were observed.

OB calibrations reflected the site's more variable field conditions. While DO values occasionally exceeded 102%, indicating mild over-response likely due to sensor exposure or calibration drift, they remained within an acceptable range. pH and conductivity readings were generally consistent, and turbidity calibrations showed acceptable performance across all cycles. Notably, the sonde recovered on August 8 showed a high turbidity zero offset (6.12), which was corrected in subsequent cycles.

Overall, the calibration records confirm reliable post-deployment sensor performance across all three sites. Isolated deviations were rare and likely tied to environmental conditions rather than persistent instrument issues. For full calibration records and comparison to standard values, 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 2024 and July 2025 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 remained consistent across sites, with mean values around 23.0 °C and seasonal variation ranging from winter lows near 5–7 °C to summer peaks above 34 °C. These fluctuations reflect typical subtropical climate cycles observed across the northern Gulf coast.

Salinity showed strong site-level contrast. SI and AH maintained high and stable values (~31.4 psu), characteristic of their open Gulf settings. OB, in contrast, exhibited much fresher conditions, with an average salinity of 25.0 psu and minimum values down to 13.1 psu, consistent with estuarine influence and tidal exposure.

Dissolved oxygen (DO) levels were generally healthy across all stations. DO saturation ranged from 82.7% at SI to 91.3% at OB, with OB again showing the highest mean due to its shallow depth and potential for elevated primary production. Hypoxia (<2 mg/L) was recorded but infrequently, most notably at SI during summer and post-storm conditions.

Turbidity was typically low at all sites, averaging 3–5 NTU, but all stations captured extreme short-lived spikes linked to storm activity. SI reached the highest maximum (477 NTU), followed by AH (371 NTU) and OB (157 NTU). These transient events underscore the importance of continuous, high-resolution monitoring to capture episodic changes.

pH values remained stable and well-buffered across the network, with averages near 7.9–8.0 and low standard deviations (~0.1). However, values dipped below 7.5 on occasion, particularly at OB, reflecting storm-driven acidification and freshwater pulses.

Depth patterns followed expected site configurations. SI maintained the deepest average (~1.9 m), while OB exhibited the shallowest and most variable conditions (~0.9 m average), often nearing sensor exposure during low tide. AH showed mid-range depths (~1.2 m) with low variability.

These statistics affirm the system's capacity to monitor both baseline conditions and acute environmental changes. The continuous, quality-controlled dataset offers valuable insights into ecological research, aquaculture planning, and coastal management.

For full statistical summaries and QC thresholds, refer to Appendix D: Descriptive Statistics Tables (D-1 to D-3). For visualization of seasonal patterns and anomalies, 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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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
07/01/2024	12:07	08/07/2024	11:43	
08/07/2024	12:08	08/13/2024	13:44	Short deployment
08/13/2024	13:50	08/14/2024	08:15	Deployment was not started
08/14/2024	08:30	09/03/2024	22:10	The station was struck by lightning and destroyed
10/11/2024	13:28	11/08/2024	10:39	
11/08/2024	10:49	12/02/2024	14:15	
12/02/2024	14:23	01/07/2025	15:50	
01/15/2025	15:27	01/27/2025	14:35	Short deployment
01/27/2025	14:45	02/12/2025	13:25	
02/12/2025	13:31	03/10/2025	13:40	
03/10/2025	13:48	04/22/2025	12:40	
04/22/2025	12:47	05/15/2025	13:56	
05/15/2025	14:05	06/12/2025	10:53	
06/12/2025	10:59	07/08/2025	15:36	

A2. Alligator Harbor (AH)

Deployment Start	Time	Deployment End	Time	Notes
07/01/2024	11:28	08/07/2024	12:35	
08/07/2024	12:47	08/28/2024	11:02	
08/28/2024	11:11	09/19/2024	12:29	
09/19/2024	12:38	10/17/2024	12:26	
10/17/2024	12:43	11/26/2024	12:02	
11/26/2024	12:12	01/07/2025	14:08	
01/07/2025	14:19	02/12/2025	14:40	
02/12/2025	14:46	03/26/2025	12:31	
03/26/2025	12:43	05/01/2025	11:20	
05/01/2025	11:26	05/29/2025	13:50	
05/29/2025	13:57	07/02/2025	09:01	

A3. Oyster Bay (OB)

Deployment Start	Time	Deployment End	Time	Notes
05/22/2024	10:16	06/11/2024	09:29	
06/11/2024	09:38	07/02/2024	11:40	

07/02/2024	11:48	08/08/2024	09:41
08/08/2024	09:51	09/19/2024	10:52
09/19/2024	11:02	10/17/2024	10:39
10/17/2024	10:52	11/26/2024	10:27
11/26/2024	10:37	01/07/2025	10:55
01/07/2025	11:03	02/18/2025	10:20
02/18/2025	10:27	04/02/2025	10:11
04/02/2025	10:20	05/07/2025	10:43
05/07/2025	10:49	06/05/2025	11:20

Appendix B. Environmental Events and Anomalies

B1. Seawater Intake (SI)

- 07/29/2024 17:00 – 20:00. Significant rain event in the area 0.4" – 0.7".
- 08/04/2024 17:00 – 08/05/2024 11:00 Significant weather event. Tropical Storm Debby impacted the area, causing increased winds (16-31 mph) and heavy precipitation (~ 0.53 inches).
- 08/07/2024 12:15 – 08/13/2024 13:45 The depth sensor stopped working, but the sonde was deployed at the proper depth during that time.
- 08/07/2024 12:00 Missing data caused by the recovery and deployment of the sonde.
- 08/08/2024 14:00. Significant rain event in the area 0.4".
- 08/13/2024 14:00 – 08/14/2024 08:15 Deployment was not started.
- 08/14/2024 00:00 – 09/03/2024 19:00 Data recovered from telemetry due to the station being damaged.
- 08/25/2024 13:30 – 08/26/2024 10:45 No readings recovered from telemetry.
- 09/03/2024 20:00 – 23:00. Significant rain event in the area 1.0-1.56".
- 09/03/2024 22:10 The station was struck by lightning and destroyed.
- 09/03/2024 19:15 – 10/11/2024 13:00 Missing data due to the station being rebuilt.
- 10/11/2024 13:15 The station resumed operation.
- 11/08/2024 10:45 Missing data caused by the recovery and deployment of the sonde.
- 11/13/2024 10:15, 11/22/2024 19:30, 11/25/2024 14:15, 11/25/2024 18:15 – 11/26/2024 13:45, 11/29/2024 00:00, 12/01/2024 06:15-16:45, 12/02/2024 04:45, 12/02/2024 13:15-13:30 Missing data. Unknown cause.
- 11/19/2024 22:00 – 1:00 Significant rain event in the area 1.4"
- 12/02/2024 15:00 – 01/07/2025 15:00 Negative turbidity values were suspected, but they were not lower than -4 NTU
- 12/11/2024 07:00 – 10:00. Significant rain event in the area 0.5" – 0.6"
- 12/29/2024 10:00 – 13:00. Significant rain event in the area 0.6" – 0.7"
- 01/07/2025 15:45 – 01/15/2025 15:15 No data was recorded because the DCP failed.
- 01/18/2025 16:00 – 19:00. Significant rain event in the area 0.8"
- 01/21/2025 19:00 – 01/22/2025 10:00. Significant weather event in the area – snow.
- 01/26/2025 09:15 – 01/27/2025 14:30. Missing data caused by battery failure.
- 02/10/2025 16:30 – 02/12/2025 13:15. Missing data caused by equipment malfunction.
- 02/13/2025 14:00 – 17:00. Significant rain event in the area 0.6" – 0.7".
- 02/19/2025 05:00 – 17:00. Significant rain event in the area 0.4" – 0.5".

- 03/04/2025 09:30 – 03/07/2025 10:45. Missing data caused by equipment malfunction.
- 03/08/2025 11:00 – 14:00. Significant rain event in the area 0.4” – 0.5”.
- 03/10/2025 13:45. Missing data caused by the recovery and deployment of the sonde.
- 03/16/2025 08:00 – 11:00. Significant rain event in the area 1.0”.
- 03/29/2025 18:45 – 04/02/2025 11:45. Missing data caused by equipment malfunction.
- 04/07/2025 14:00 – 17:00. Significant rain event in the area 1.0” – 1.1”.
- 04/11/2025 13:15 – 04/16/2025 11:15. Missing data caused by equipment malfunction.
- 05/04/2025 02:00 – 05:00. Significant rain event in the area 0.9” – 1.0”.
- 05/10/2025 05:00 – 08:00. Significant rain event in the area 0.7” – 0.8”.
- 05/11/2025 11:00 – 14:00. Significant rain event in the area 0.4” – 0.5”.
- 05/15/2025 14:00. Missing data caused by the recovery and deployment of the sonde.
- 05/21/2025 17:00 – 20:00. Significant rain event in the area 0.4”.
- 06/04/2025 11:00 – 14:00. Significant rain event in the area 0.6” – 0.8”.
- 06/07/2025 17:00 – 20:00. Significant rain event in the area 1.1” – 1.2”.
- 07/02/2025 20:00 – 23:00. Significant rain event in the area 1.3”.

B2. Alligator Harbor (AH)

- 07/24/2024 2:45 – 08/07/2024 12:30 pH sensor readings were inaccurate. Upon retrieval, the pH sensor was found to be broken. Post-calibration results confirmed the discrepancy in the readings.
- 07/29/2024 17:00 – 20:00. Significant rain event in the area 0.4” – 0.7”.
- 08/04/2024 14:00 – 08/05/2024 11:00 Significant weather event. Tropical Storm Debby impacted the area, causing increased winds (16-33 mph) and heavy precipitation (~ 0.61 inches).
- 08/07/2024 12:45 Missing data caused by the recovery and deployment of the sonde.
- 08/08/2024 14:00. Significant rain event in the area 0.4”.
- 08/11/2024 07:15 – 08//28/2024 11:00 The wiper was lost, so turbidity, specific conductivity, and salinity were affected. These parameters were rejected along with depth and dissolved oxygen (mg/L).
- 09/03/2024 20:00 – 23:00. Significant rain event in the area 1.0-1.56”.
- 09/08/2024 08:00 – 14:00. Significant rain event in the area 1.3-2.0”.
- 09/12/2024 11:00 – 17:00. Significant rain event in the area 0.4-1.7”.
- 09/13/2024 08:00 – 11:00. Significant rain event in the area 0.7-1.5”
- 09/26/2024 17:00 – 09/27/2024 11:00 Significant weather event. Hurricane Helene impacted the area, causing increased winds (17-43 mph) and heavy precipitation (0.4-1.48 inches).
- 10/09/2024 14:00 – 10/10/2024 11:00 Significant weather event. Hurricane Milton impacted the area of Tampa, causing increased winds (17-25 mph) and heavy precipitation on the 9th (~ 0.30 inches).
- 10/17/2024 12:30 Missing data caused by the recovery and deployment of the sonde.
- 11/19/2024 22:00 – 11/20/2024 1:00 Significant rain event in the area 1.3”
- 12/11/2024 07:00 – 10:00. Significant rain event in the area 0.5” – 0.6”
- 12/29/2024 10:00 – 13:00. Significant rain event in the area 0.6” – 0.7”
- 01/18/2025 16:00 – 19:00. Significant rain event in the area 0.7”
- 01/21/2025 19:00 – 01/22/2025 10:00. Significant weather event in the area – snow.
- 02/13/2025 14:00 – 17:00. Significant rain event in the area 0.7” – 0.8”.
- 02/19/2025 05:00 – 17:00. Significant rain event in the area 0.4” – 0.6”.
- 03/05/2025 08:00 – 11:00. Significant rain event in the area 0.6” – 0.7”.
- 03/08/2025 11:00 – 14:00. Significant rain event in the area 0.4”.
- 03/09/2025 08:00 – 11:00. Significant rain event in the area 0.4”.
- 03/16/2025 08:00 – 11:00. Significant rain event in the area 0.8” – 1.0”.
- 04/07/2025 14:00 – 17:00. Significant rain event in the area 1.1” – 1.2”.
- 05/04/2025 02:00 – 05:00. Significant rain event in the area 0.8” – 0.9”.
- 05/10/2025 05:00 – 08:00. Significant rain event in the area 0.8”.

- 05/11/2025 11:00 – 14:00. Significant rain event in the area 0.4” – 0.5”.
- 05/21/2025 17:00 – 20:00. Significant rain event in the area 0.5”.
- 06/04/2025 11:00 – 14:00. Significant rain event in the area 0.6” – 0.8”.
- 06/07/2025 17:00 – 20:00. Significant rain event in the area 1.2” – 1.3”.

B3. Oyster Bay (OB)

- 06/30/2024 17:00 – 20:00. Significant rain event in the area 0.4” – 0.9”.
- 07/02/2024 10:15 Missing data caused by the recovery and deployment of the sonde.
- 07/17/2024 14:00 – 17:00. Significant rain event in the area 0.4” – 0.6”.
- 07/20/2024 17:00 – 20:00. Significant rain event in the area 1.0” – 1.5” with intense winds of 15-16 mph.
- 07/21/2024 14:00 – 17:00. Significant rain event in the area 0.3” – 0.5”.
- 08/04/2024 05:00 – 08:00. Significant rain event in the area 0.5” – 0.7”.
- 08/04/2024 14:00 – 08/05/2024 11:00 Significant weather event. Tropical Storm Debby impacted the area, causing increased winds (14-30 mph) and heavy precipitation (~ 0.46 inches).
- 08/08/2024 09:45 Missing data caused by the recovery and deployment of the sonde.
- 08/26/2024 23:00. Significant rain event in the area ~0.6”.
- 09/03/2024 20:00. Significant rain event in the area 1.0-1.26”.
- 09/06/2024 02:00. Significant rain event in the area ~ 0.8”.
- 09/12/2024 11:00 – 17:00. Significant rain event in the area 0.5-1.8”.
- 09/19/2024 11:00 Missing data caused by the recovery and deployment of the sonde.
- 09/26/2024 08:00 – 09/27/2024 02:00 Significant weather event. Hurricane Helene impacted the area, causing increased winds (14-30 mph) and heavy precipitation (~ 0.46 inches).
- 10/09/2024 14:00 – 10/10/2024 11:00 Significant weather event. Hurricane Milton impacted the area of Tampa, causing increased winds (17-25 mph) and heavy precipitation on the 9th (~ 0.30 inches).
- 10/17/2024 10:45 Missing data caused by the recovery and deployment of the sonde.
- 11/07/2024 4:00 – 7:00 Significant rain event in the area 1.1” – 1.2”.
- 11/19/2024 22:00 – 11/20/2024 22:00 1:00 Significant rain event in the area 2.0” – 2.1”.
- 11/30/2024 06:45-10:30 Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 12/02/2024 08:30-11:30 Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 12/03/2024 09:00-12:00 Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 12/11/2024 07:00 – 10:00. Significant rain event in the area 0.5” – 0.6”
- 12/12/2024 04:30-09:30 Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 12/13/2024 06:15-09:00 Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 12/14/2024 06:45-09:30 Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 12/15/2024 08:15-10:00 Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 12/16/2024 09:30-10:30 Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 12/29/2024 10:00 – 13:00. Significant rain event in the area 0.6”
- 01/01/2025 09:15-11:45. Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water.

- 01/02/2025 10:00-12:00. Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 01/07/2025 11:00. Missing data caused by the recovery and deployment of the sonde.
- 01/18/2025 16:00 – 19:00. Significant rain event in the area 0.6”-0.7”
- 01/21/2025 19:00 – 01/22/2025 10:00. Significant weather event in the area – snow.
- 02/13/2025 14:00 – 17:00. Significant rain event in the area 0.4” – 0.5”.
- 02/19/2025 05:00 – 17:00. Significant rain event in the area 0.4” – 1.05”.
- 02/21/2025 01:45-05:15 Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 02/28/2025 09:15-09:45 Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 03/02/2025 23:15-23:45 Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 03/05/2025 08:00 – 11:00. Significant rain event in the area 0.9”.
- 03/06/2025 02:30-04:15 Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 03/08/2025 11:00 – 14:00. Significant rain event in the area 0.7” – 0.8”.
- 03/16/2025 08:00 – 11:00. Significant rain event in the area 0.9” – 1.0”.
- 03/17/2025 22:00- 03/18/2025 01:00 Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 03/21/2025 00:15- 02:15 Very low conductivity and salinity. Values close to 0. All data was rejected, and the sonde was likely out of water.
- 02/23/2025 07:00, 03/04/2025 16:15, 03/14/2025 01:30, 03/23/2025 10:45, 04/01/2025 20:00. Missing data, cause unknown.
- 04/07/2025 14:00 – 17:00. Significant rain event in the area 0.5”.
- 05/04/2025 02:00 – 05:00. Significant rain event in the area 1.2” – 1.5”.
- 05/07/2025 10:45. Missing data caused by the recovery and deployment of the sonde.
- 05/10/2025 05:00 – 08:00. Significant rain event in the area 0.6”.
- 05/29/2025 14:00 – 17:00. Significant rain event in the area 0.6” – 1.0”.
- 05/12/2025 07:00, 05/21/2025 16:15, 05/31/2025 01:30 Missing data, cause unknown.
- 06/05/2025 11:00 – 14:00. Significant rain event in the area 0.5” – 0.8”.
- 06/06/2025 14:00 – 17:00. Significant rain event in the area 0.4” – 0.7”.

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)
07/01/2024	98.7	50.20	6.96	9.96	0.57	115.74
08/07/2024	99.7	50.00	7.02	10.01	-0.45	129.28
08/14/2024	NA	NA	7.02	9.96	NA	NA
10/11/2024	101.3	49.90	7.17	10.11	2.46	136.90
11/08/2024	104.2	50.52	7.01	10.09	0.07	123.03

11/30/2024	99.7	59.85	7.04	9.87	0.95	124.07
12/02/2024	101.9	50.35	7.06	10.12	-1.25	123.22
01/15/2025	100.5	49.84	7.04	10.06	-0.44	124.00
01/27/2025	101.1	50.15	7.01	10.04	2.66	114.70
02/12/2025	99.6	50.08	7.09	10.08	-0.90	123.91
03/10/2025	100.4	50.04	7.02	10.03	0.84	124.61
04/22/2025	99.9	49.89	7.06	10.03	0.18	122.83
05/15/2025	100.7	50.12	7.06	10.07	3.34	125.81
06/12/2025	100.3	49.63	7.01	10.00	0.40	121.55

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)
08/07/2024	101.6	50.15	6.94	9.90	0.98	123.64
08/28/2024	99.6	49.88	7.0	10.00	1.46	124.50
09/19/2024	100.8	50.41	6.96	9.84	0.98	122.85
10/17/2024	101.0	50.12	6.94	9.96	3.40	120.54
11/26/2024	100.7	50.26	7.02	10.14	0.43	121.56
01/07/2025	100.5	49.81	7.02	10.02	1.19	124.60
02/12/2025	100.3	49.72	7.05	9.99	1.08	124.38
03/26/2025	75.4	50.01	7.06	10.06	2.20	123.73
05/01/2025	99.9	50.24	7.03	10.09	0.18	124.77
05/27/2025	100.6	49.79	7.11	10.06	4.43	146.42

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)
06/11/2024	100.3	49.44	7.05	10.06	0.31	129.20
07/02/2024	99.3	49.95	6.95	9.97	0.44	124.04
08/08/2024	100.2	49.88	7.14	10.10	6.12	124.75
09/19/2024	102.3	50.60	7.03	10.09	-0.53	126.60
10/17/2024	101.0	50.16	6.97	9.81	0.16	121.40
11/26/2024	101.4	50.58	7.08	10.12	0.85	122.81
01/07/2025	101.0	50.07	7.07	10.11	4.22	127.64
02/18/2025	100.3	49.74	7.02	10.09	-0.17	124.96
04/02/2025	100.2	49.96	7.06	10.06	1.30	125.12
05/07/2025	100.6	50.16	6.90	9.92	0.8	125.80
06/03/2025	99.9	49.50	7.12	10.10	4.26	123.30

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) ---> 07/01/2024 – 07/08/2025

Stats with QC flag >= 0 n = 28,213								
	Depth_m	Temp_C	SpCond_mS/cm	Sal_psu	DO_pct	DO_mg/L	pH	Turb_NTU
Min	0.88	7.1	27.42	16.8	11.4	0.7	7.5	-3
Max	3.04	34.2	51.42	33.6	148.8	10.4	8.4	477
Average	1.92	23.4	48.18	31.4	82.7	6.0	8.0	4
Std Dev	0.30	6.5	2.41	1.7	17.2	1.6	0.1	8
Stats with QC flag >= 0 excluding 1 flags n = 22,692								
	Depth_m	Temp_C	SpCond_mS/cm	Sal_psu	DO_pct	DO_mg/L	pH	Turb_NTU
Min	0.88	7.1	27.42	16.8	11.4	0.7	7.5	0
Max	3.04	34.2	51.42	33.6	148.8	10.4	8.4	82
Average	1.92	23.4	48.18	31.4	82.7	6.0	8.0	5
Std Dev	0.30	6.5	2.41	1.7	17.2	1.6	0.1	5

D2. Alligator Harbor (AH) ---> 07/01/2024 – 07/02/2025

Stats with QC flag >= 0 n = 32,039								
	Depth_m	Temp_C	SpCond_mS/cm	Sal_psu	DO_pct	DO_mg/L	pH	Turb_NTU
Min	0.19	5.8	28.24	17.3	14.1	0.9	7.5	0
Max	3.31	34.1	51.55	33.7	140.3	10.7	8.2	371
Average	1.23	23.6	48.27	31.4	84.4	6.2	7.9	5
Std Dev	0.32	6.5	1.94	1.4	17.2	1.7	0.1	9
Stats with QC flag >= 0 excluding 1 flags n = 32,031								
	Depth_m	Temp_C	SpCond_mS/cm	Sal_psu	DO_pct	DO_mg/L	pH	Turb_NTU
Min	0.19	5.8	28.24	17.3	14.1	0.9	7.5	0
Max	3.31	34.1	51.55	33.7	140.3	10.7	8.2	347
Average	1.23	23.6	48.27	31.4	84.4	6.2	7.9	5
Std Dev	0.32	6.5	1.93	1.4	17.2	1.7	0.1	8

D3. Oyster Bay (OB) ---> 05/22/2024 – 06/05/2025

Stats with QC flag >= 0 n = 36,017								
	Depth_m	Temp_C	SpCond_mS/cm	Sal_psu	DO_pct	DO_mg/L	pH	Turb_NTU
Min	-0.02	4.9	21.73	13.1	30.1	2.0	7.3	-3
Max	2.99	33.5	48.87	31.8	124.2	10.9	8.2	157
Average	0.89	23.4	39.27	25.0	91.3	6.9	7.9	3
Std Dev	0.37	6.5	5.01	3.5	11.2	1.4	0.1	4
Stats with QC flag >= 0 excluding 1 flags n = 35,136								

	Depth_m	Temp_C	SpCond_mS/cm	Sal_psu	DO_pct	DO_mg/L	pH	Turb_NTU
Min	-0.02	4.9	21.73	13.1	30.1	2.0	7.3	0
Max	2.99	33.5	48.87	31.8	124.2	10.9	8.2	157
Average	0.89	23.4	39.27	25.0	91.3	6.9	7.9	3
Std Dev	0.37	6.5	5.01	3.5	11.2	1.4	0.1	4

Appendix E. Station Time Series

Time-series plots illustrate water quality dynamics at Seawater Intake (SI), Alligator Harbor (AH), and Oyster Bay (OB) from May 2024 to July 2025. These figures highlight seasonal variability, storm events, and sensor responses over the monitoring period.

- **Seawater Intake (SI) ---> 07/01/2024 – 07/08/2025**

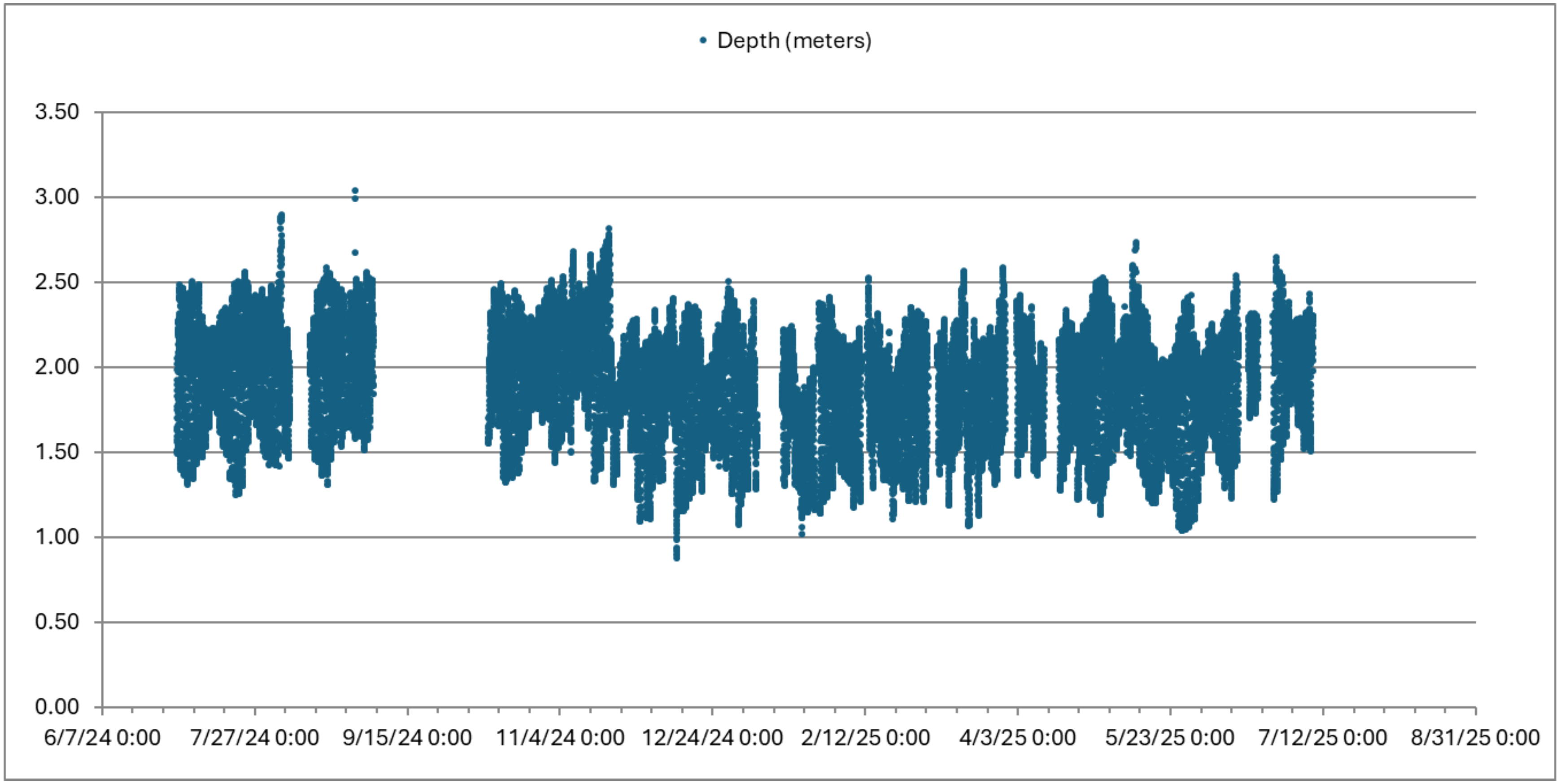

Figure E1. Seawater Intake – Depth Time Series

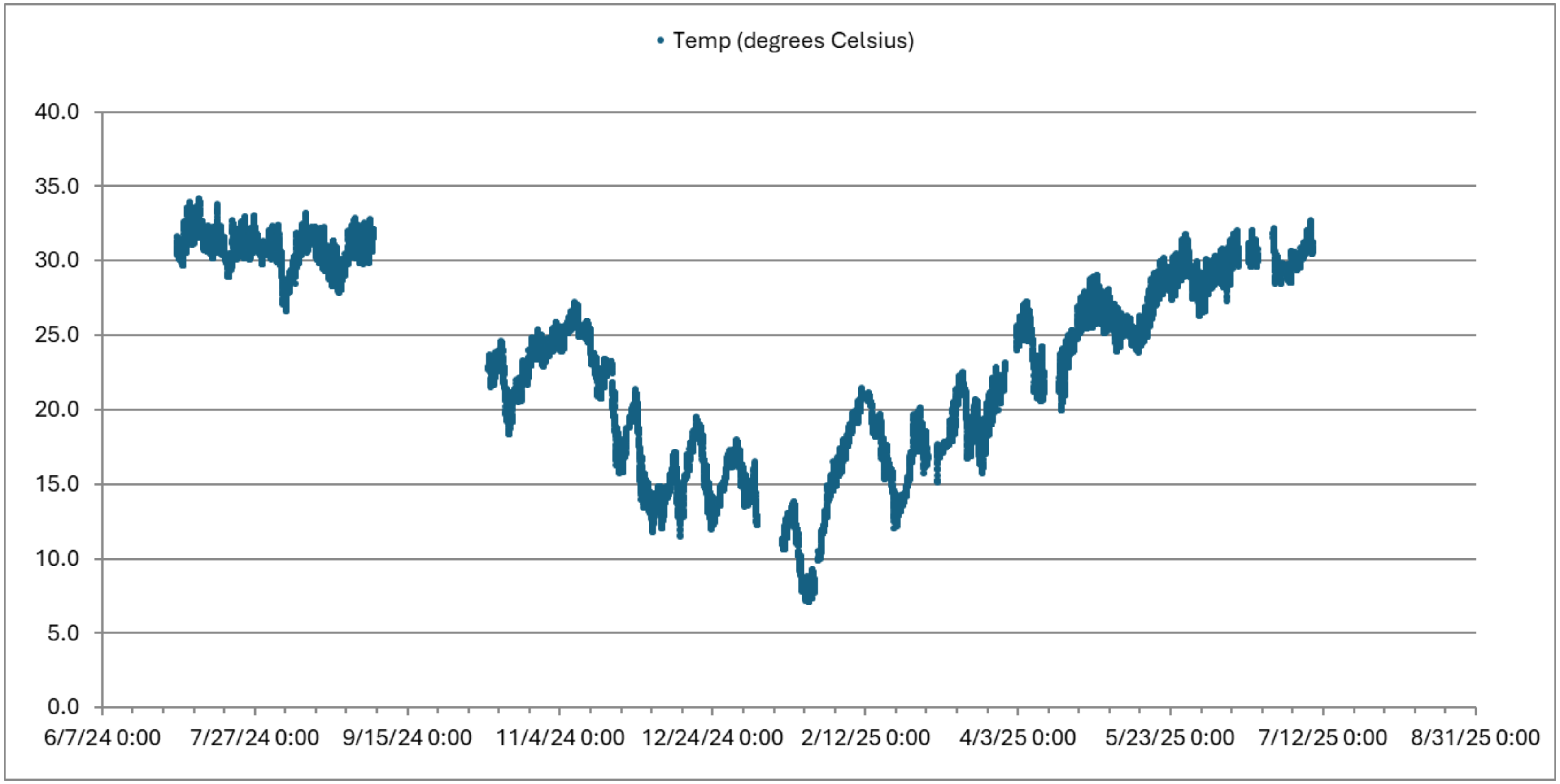

Figure E2. Seawater Intake – Temperature Time Series

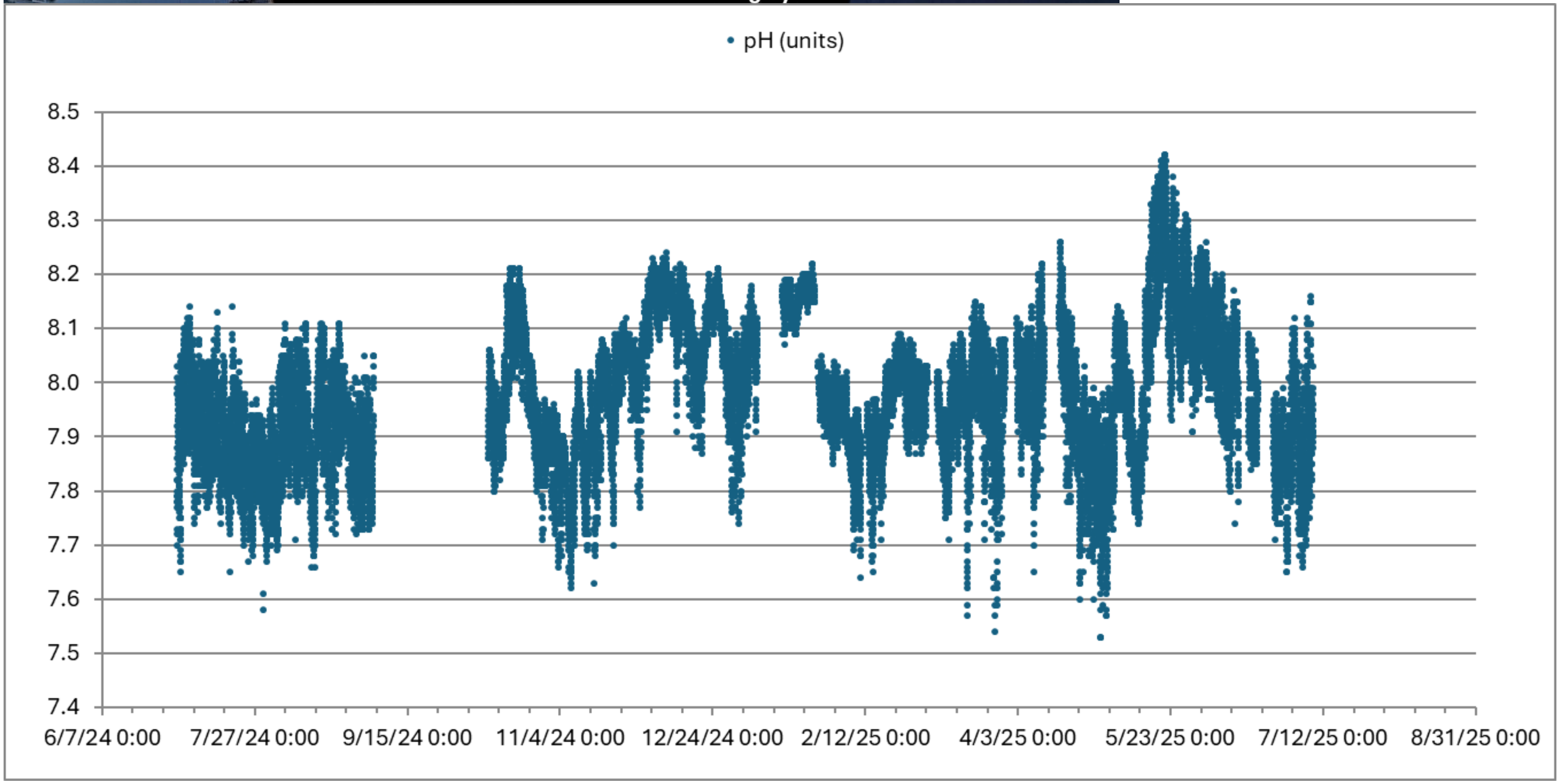

Figure E3. Seawater Intake – pH Time Series

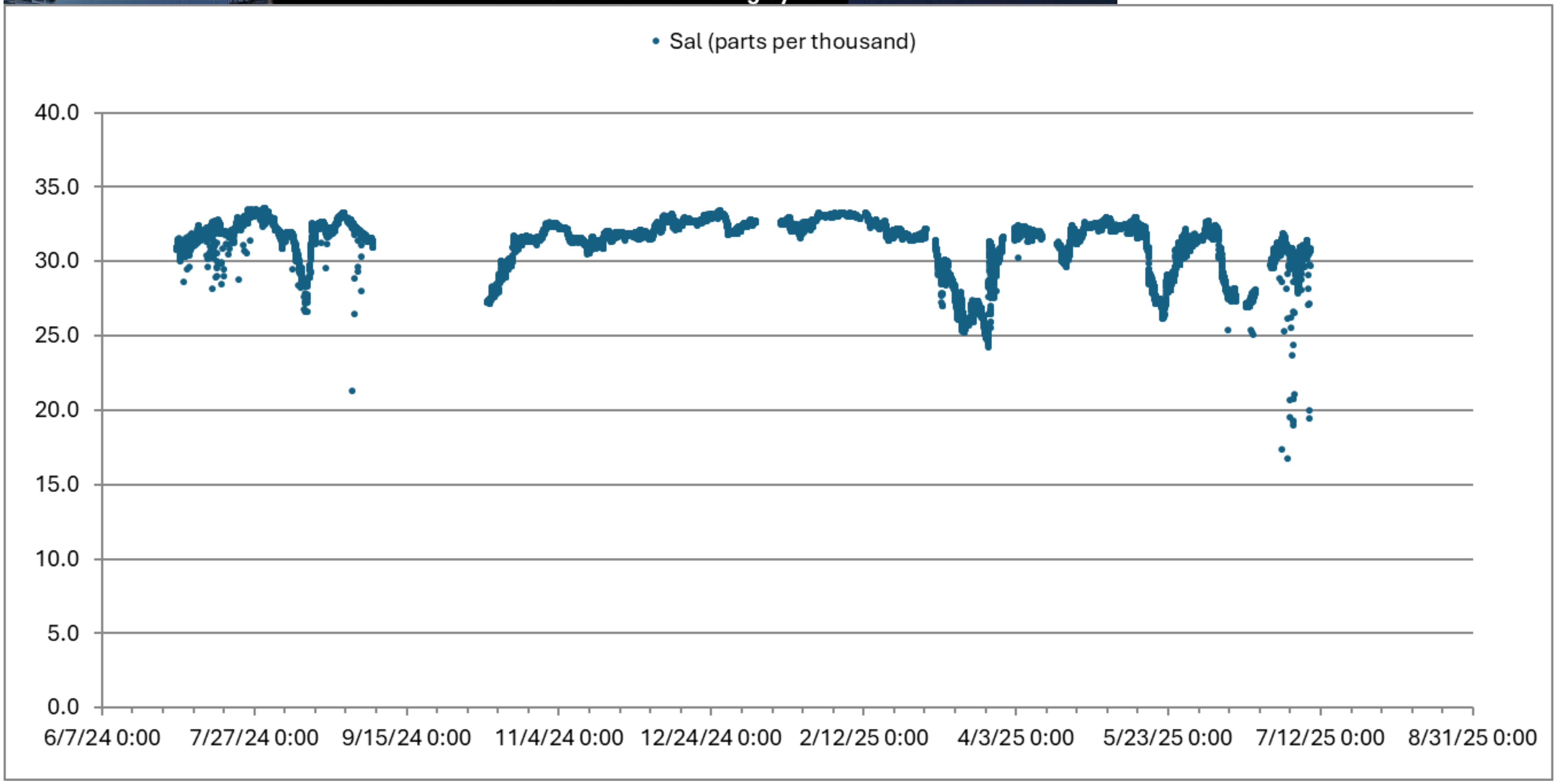

Figure E4. Seawater Intake – Salinity Time Series

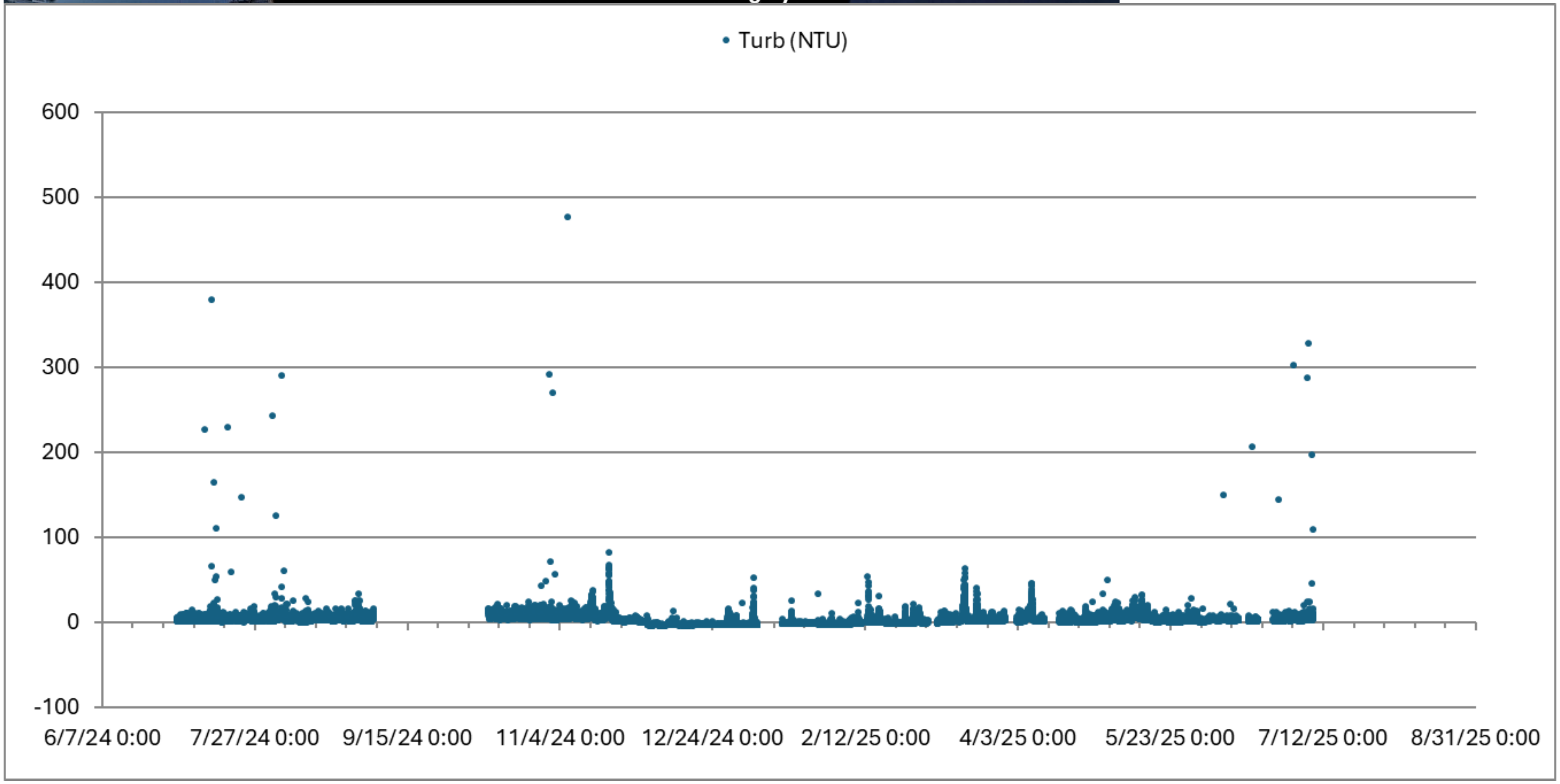

Figure E5. Seawater Intake – Turbidity Time Series

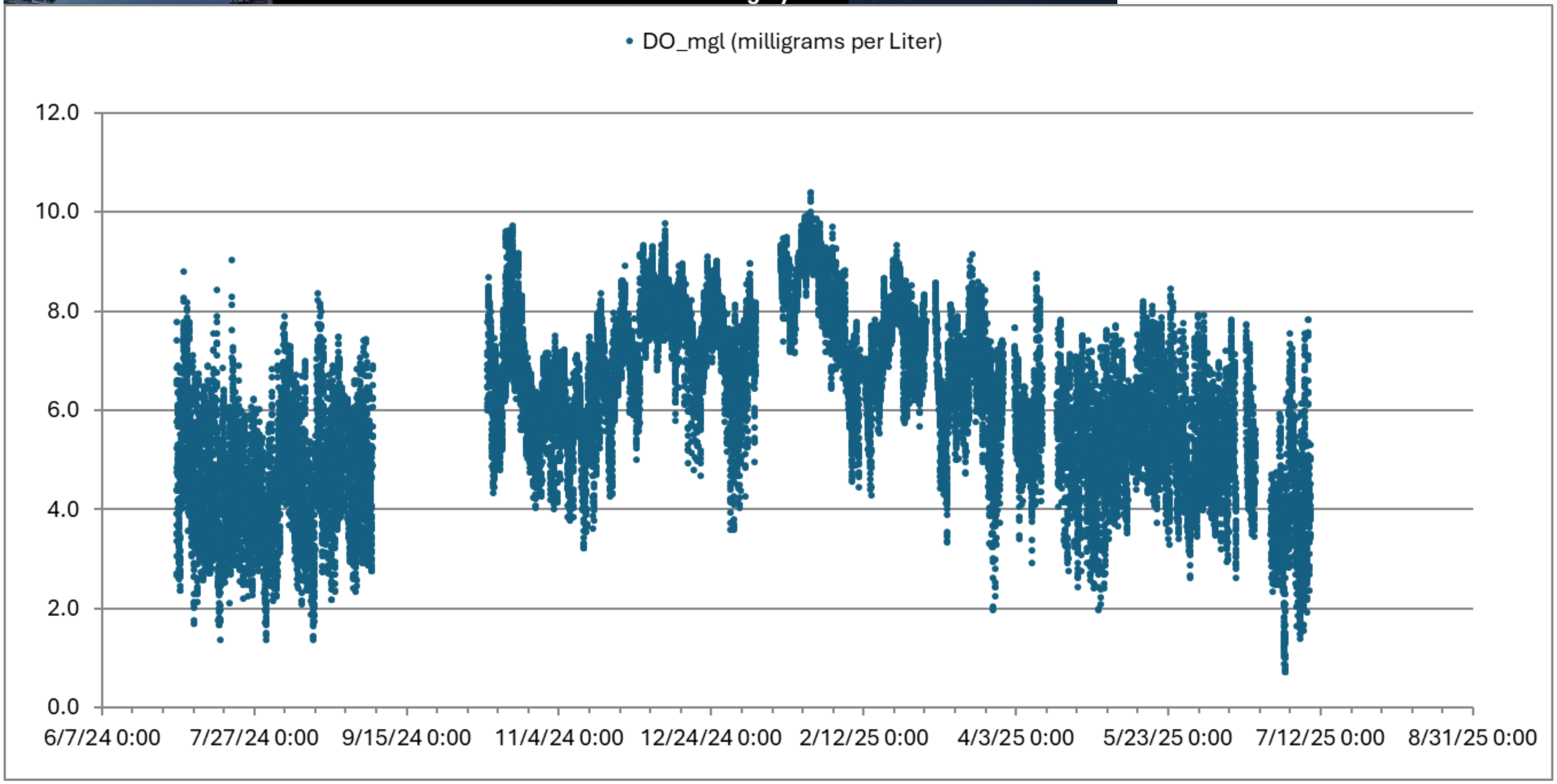

Figure E6. Seawater Intake – Dissolved Oxygen Time Series

- **Alligator Harbor (AH) ---> 07/01/2024 – 07/02/2025**

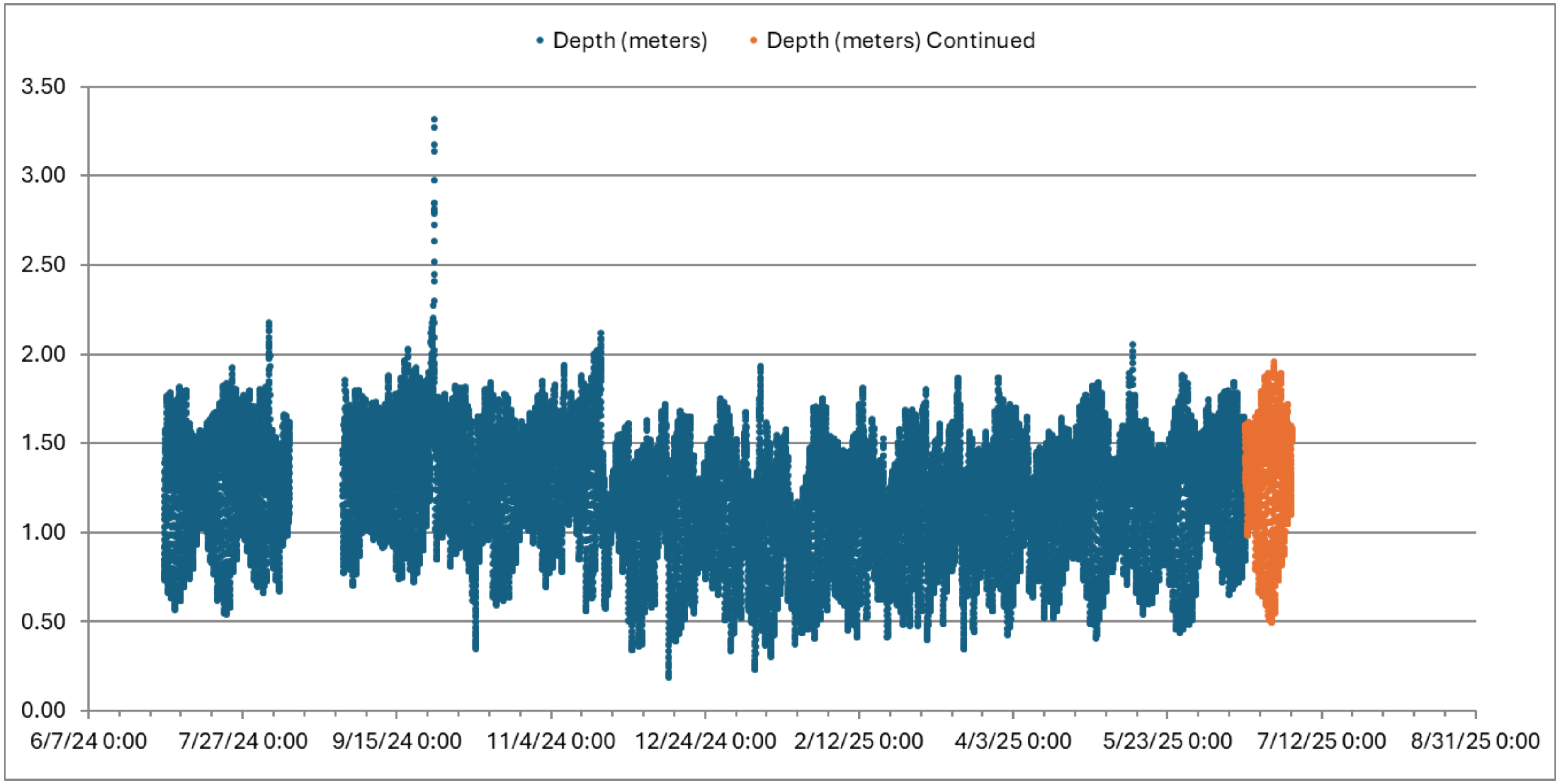

Figure E7. Alligator Harbor – Depth Time Series

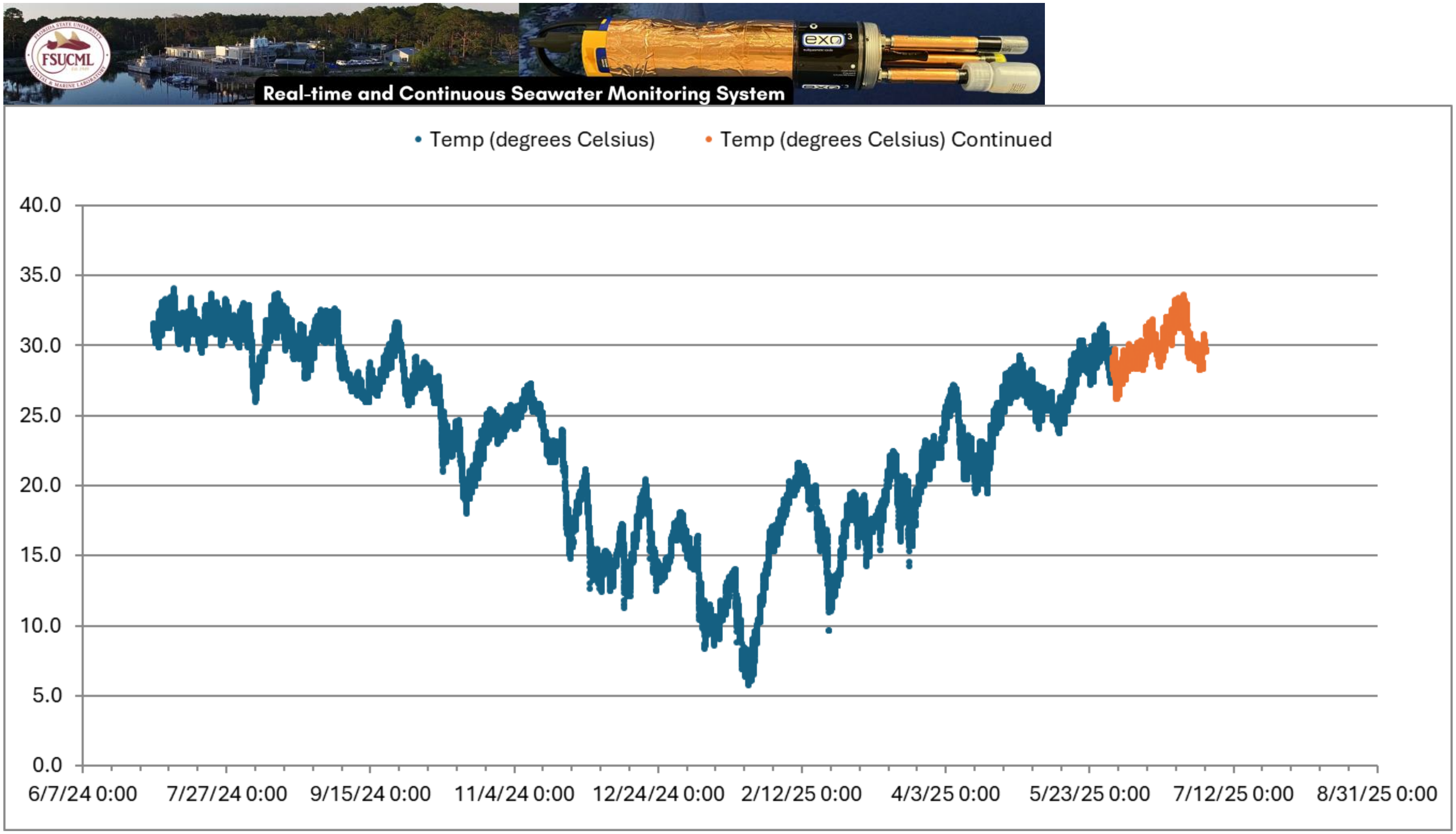

Figure E8. Alligator Harbor – Temperature Time Series

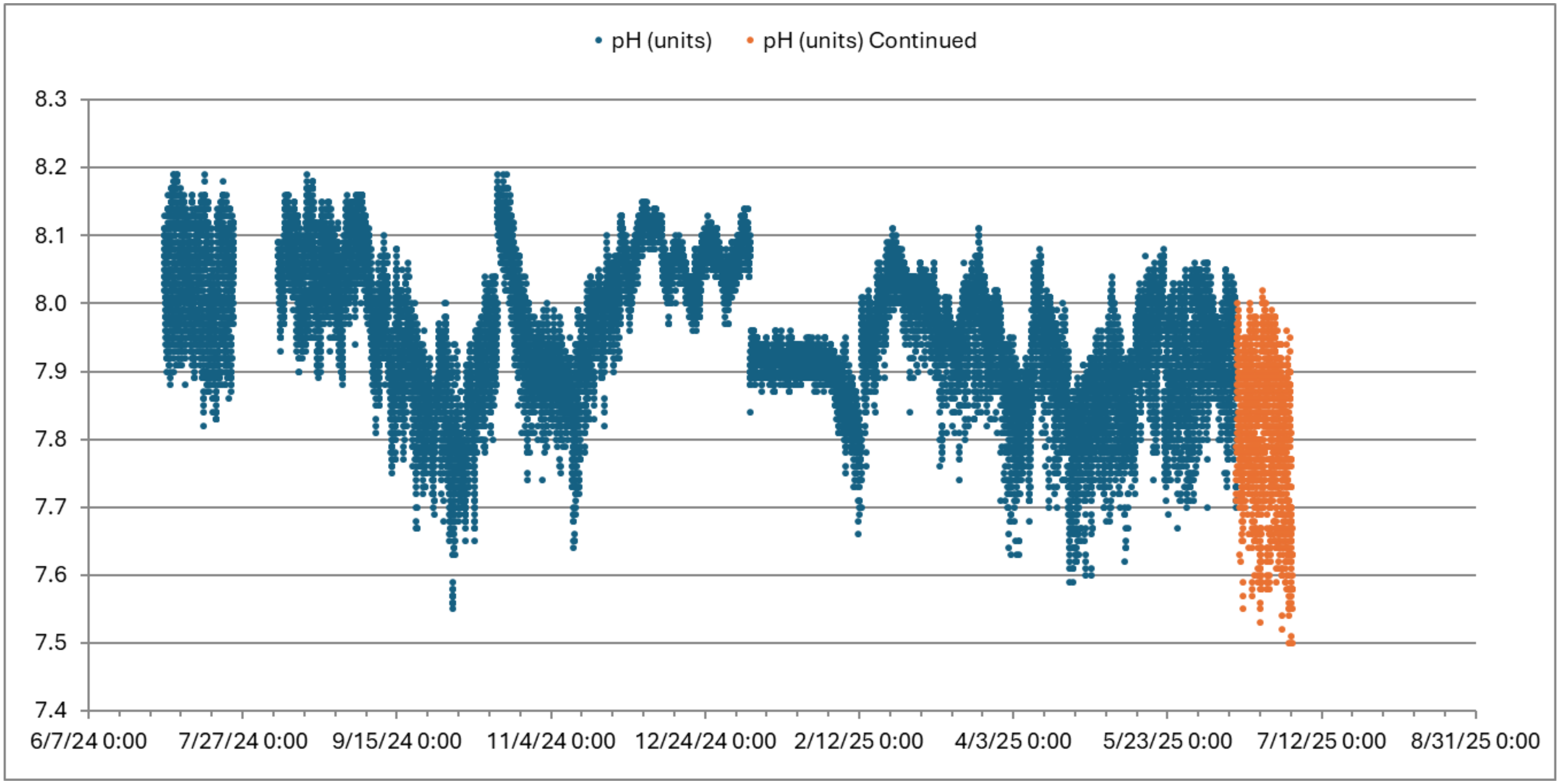

Figure E9. Alligator Harbor – pH Time Series

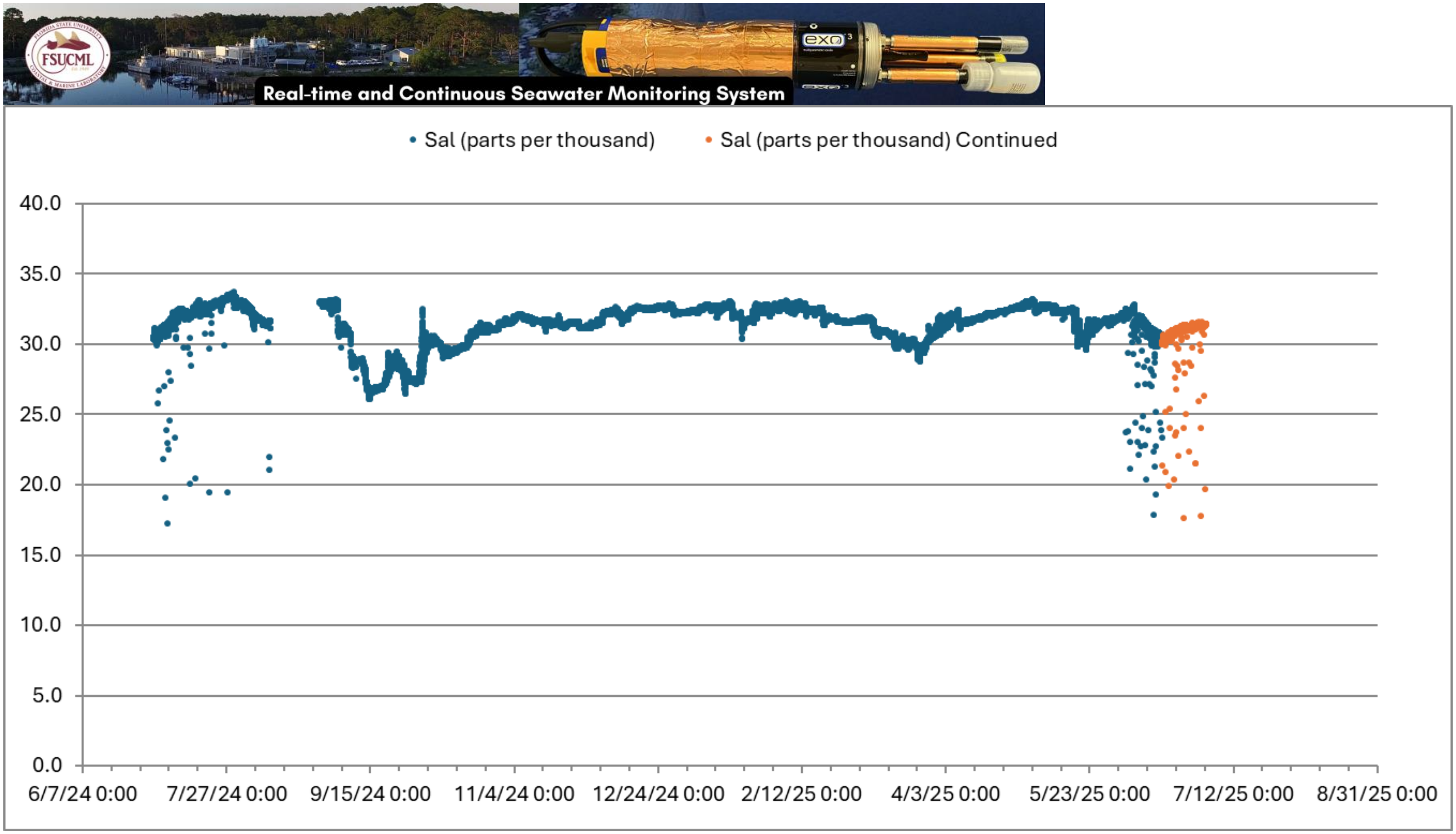

Figure E10. Alligator Harbor – Salinity Time Series

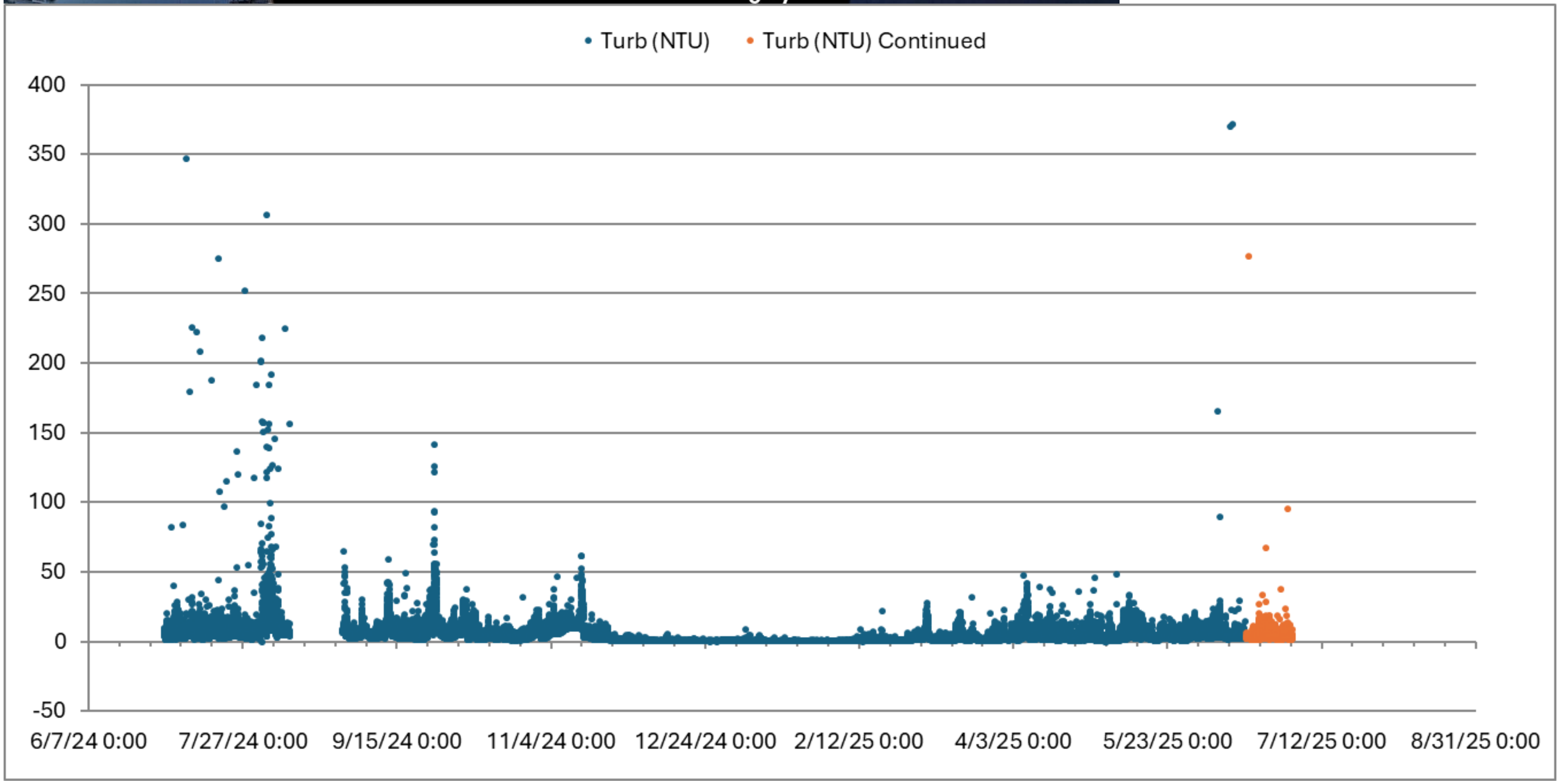

Figure E11. Alligator Harbor – Turbidity Time Series

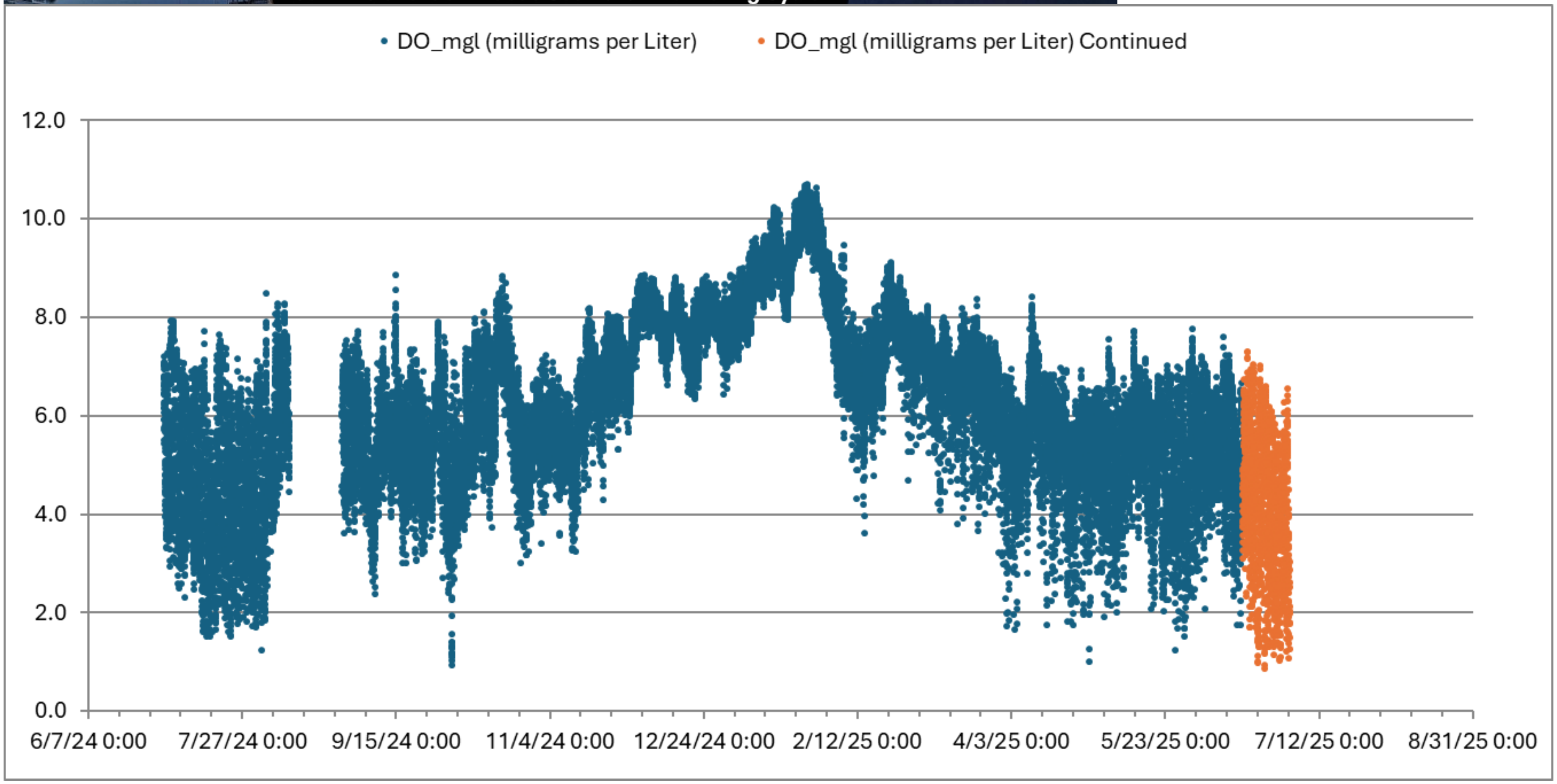

Figure E12. Alligator Harbor – Dissolved Oxygen Time Series

Oyster Bay (OB) ---> 05/22/2024 – 06/05/2025

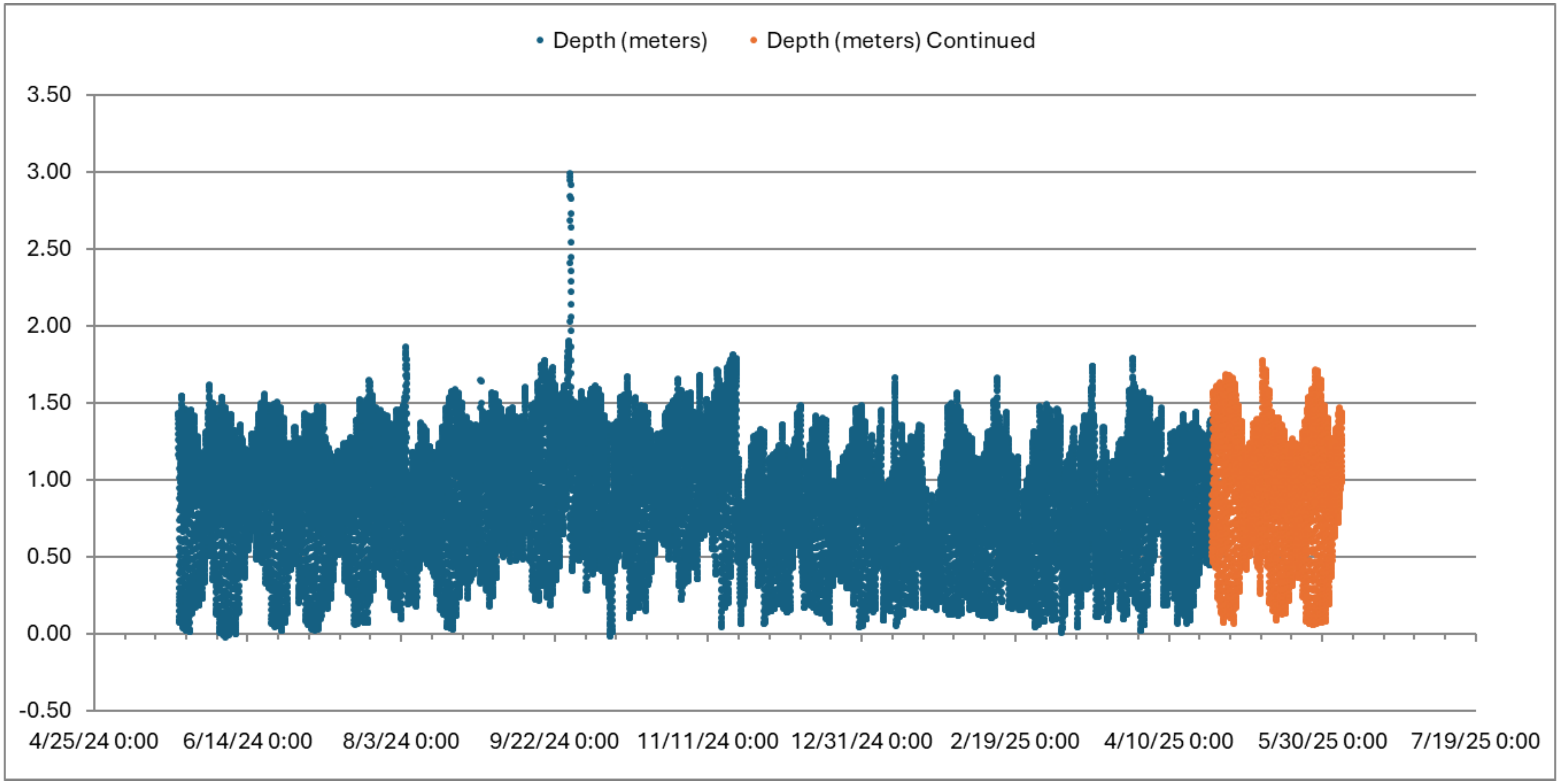

Figure E13. Oyster Bay – Depth Time Series

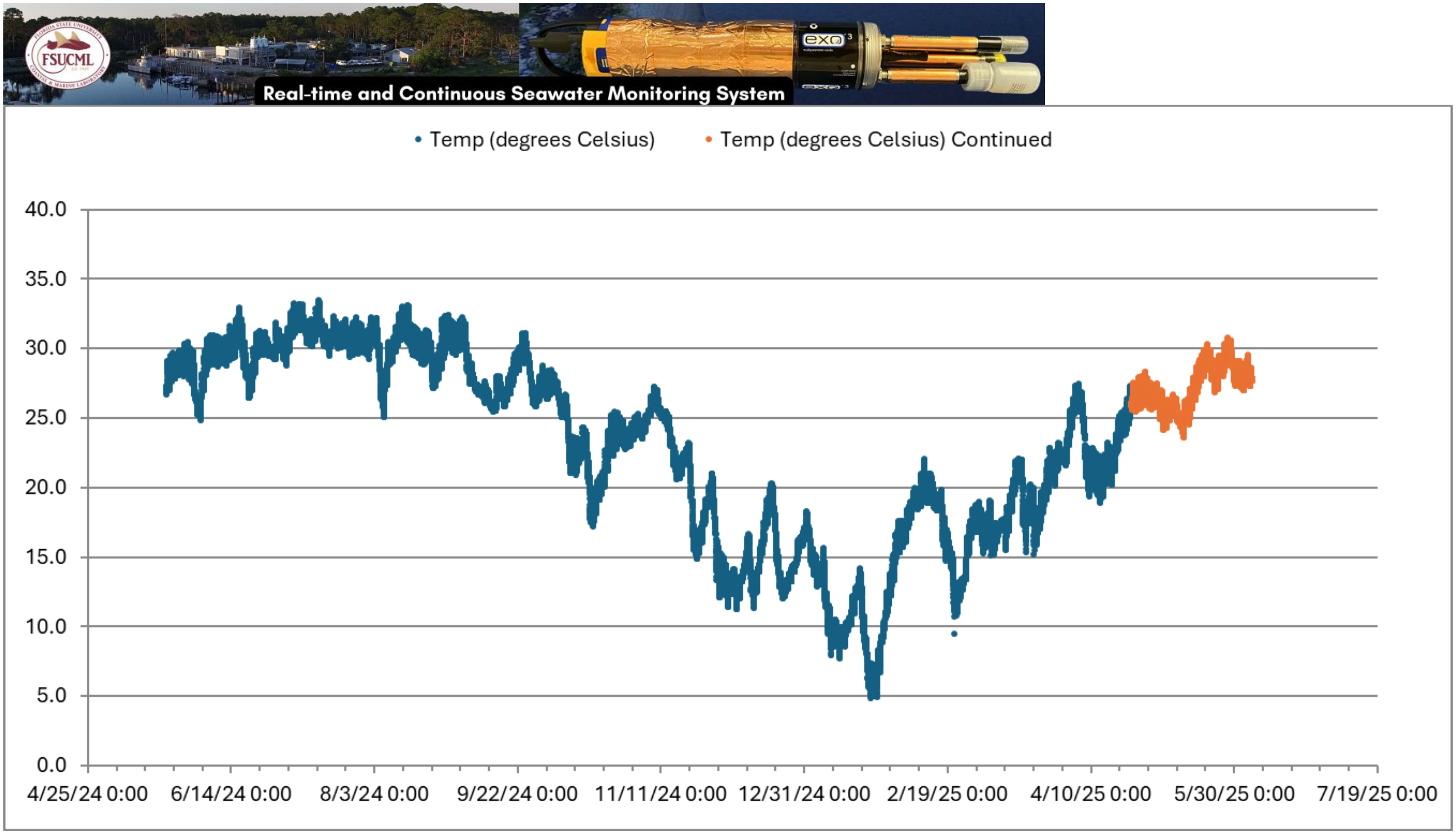

Figure E14. Oyster Bay – Temperature Time Series

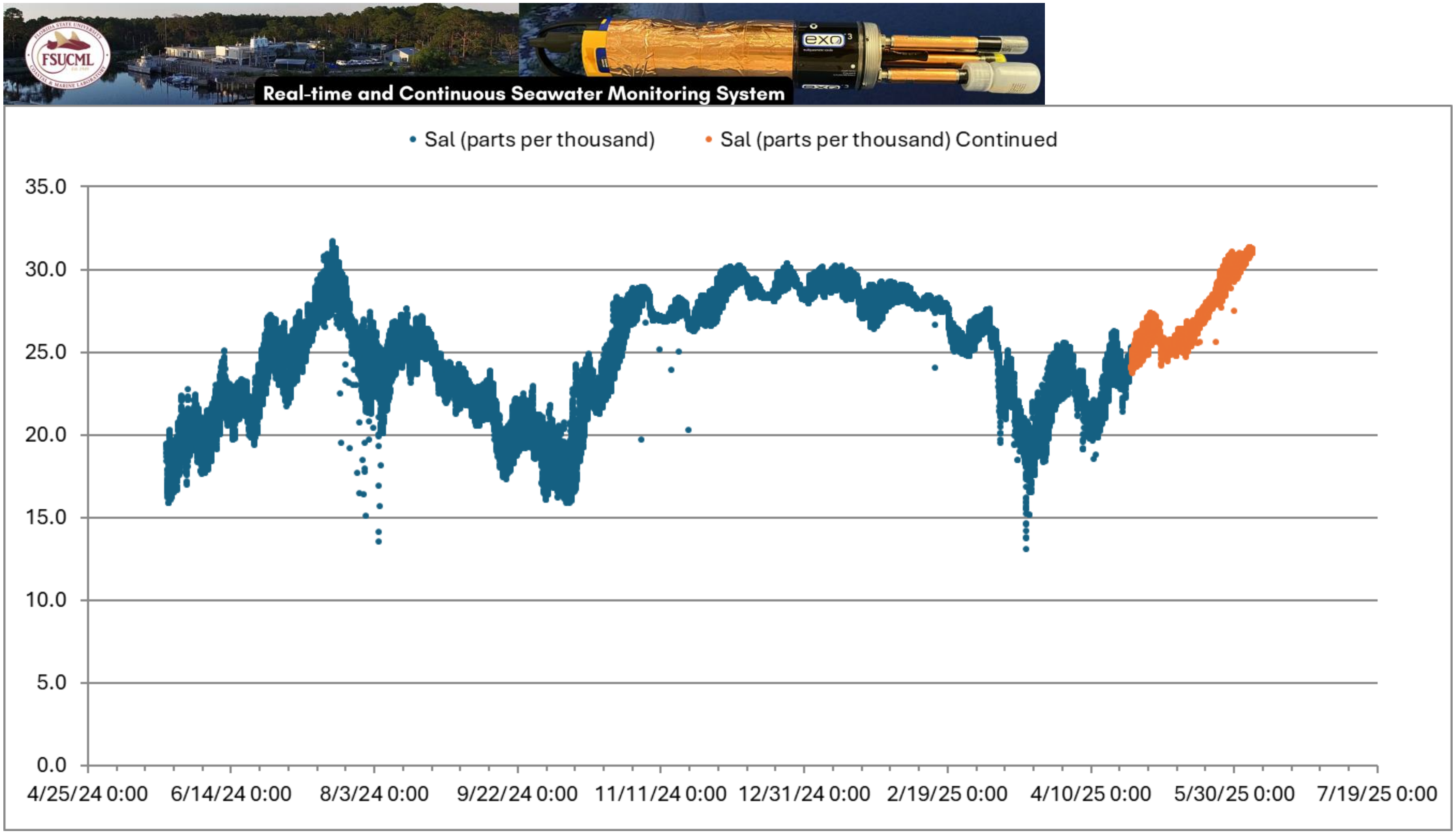

Figure E15. Oyster Bay – pH Time Series

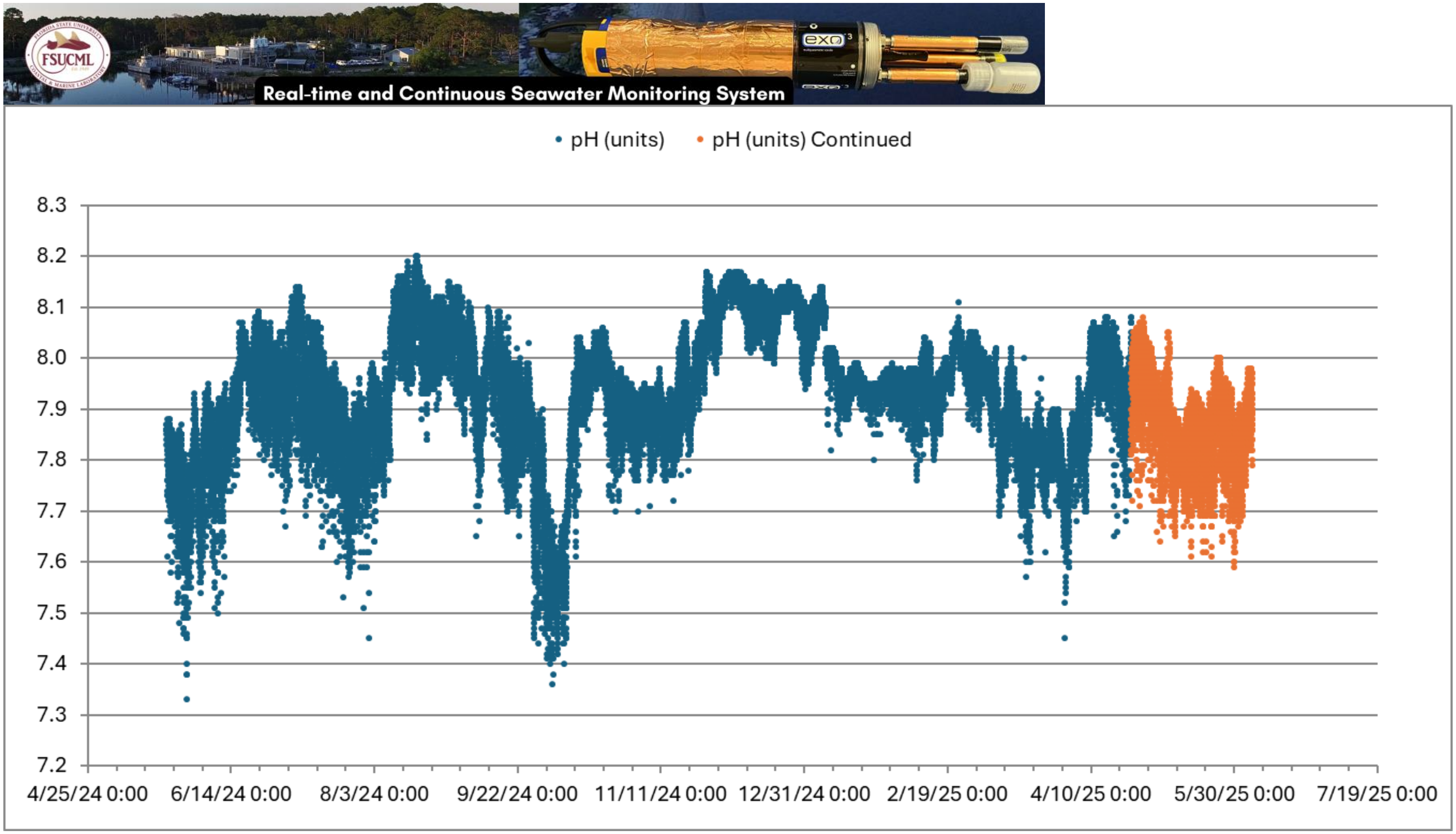

Figure E16. Oyster Bay – Salinity Time Series

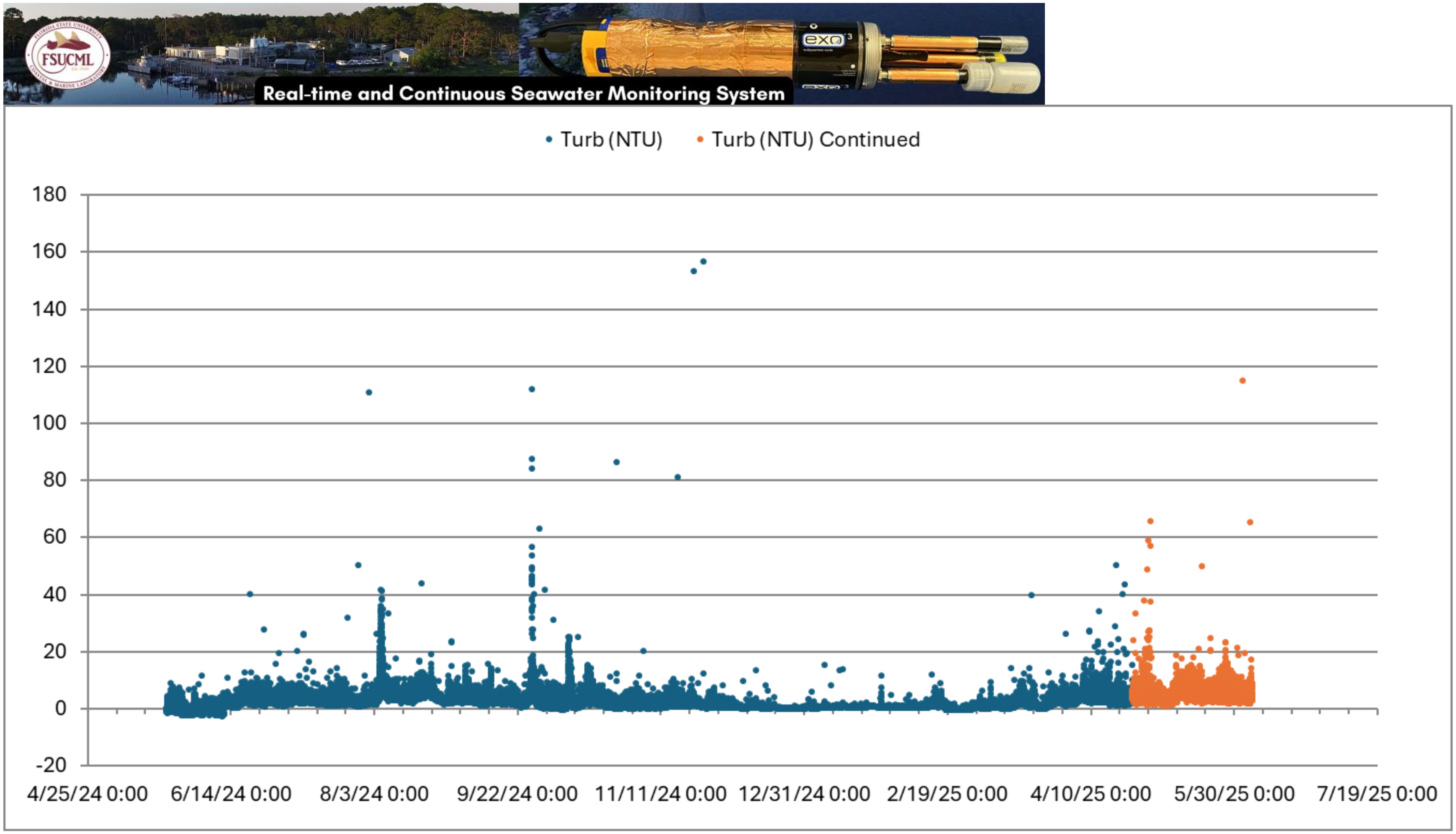

Figure E17. Oyster Bay – Turbidity Time Series

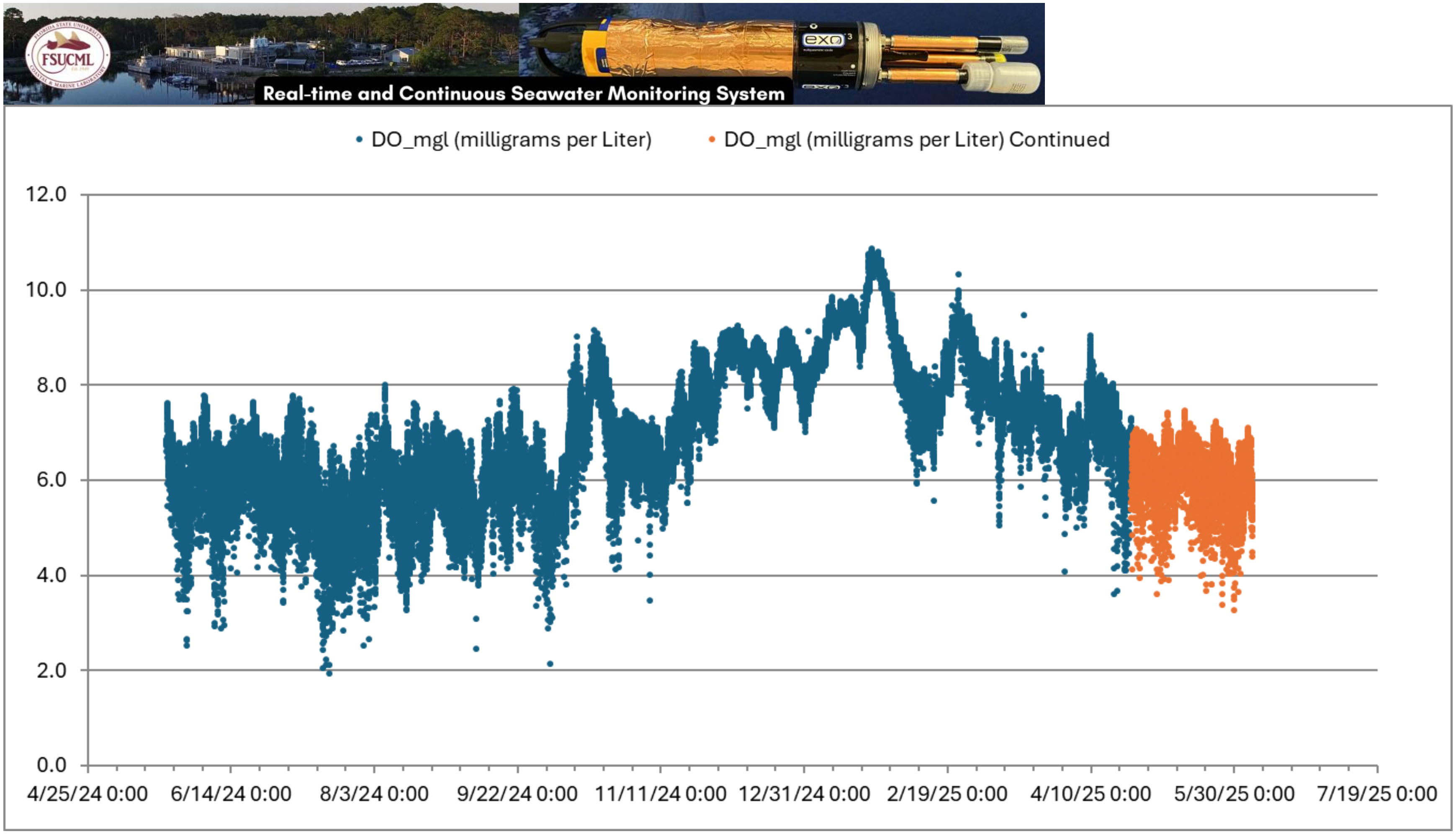

Figure E18. Oyster Bay – Dissolved Oxygen Time Series