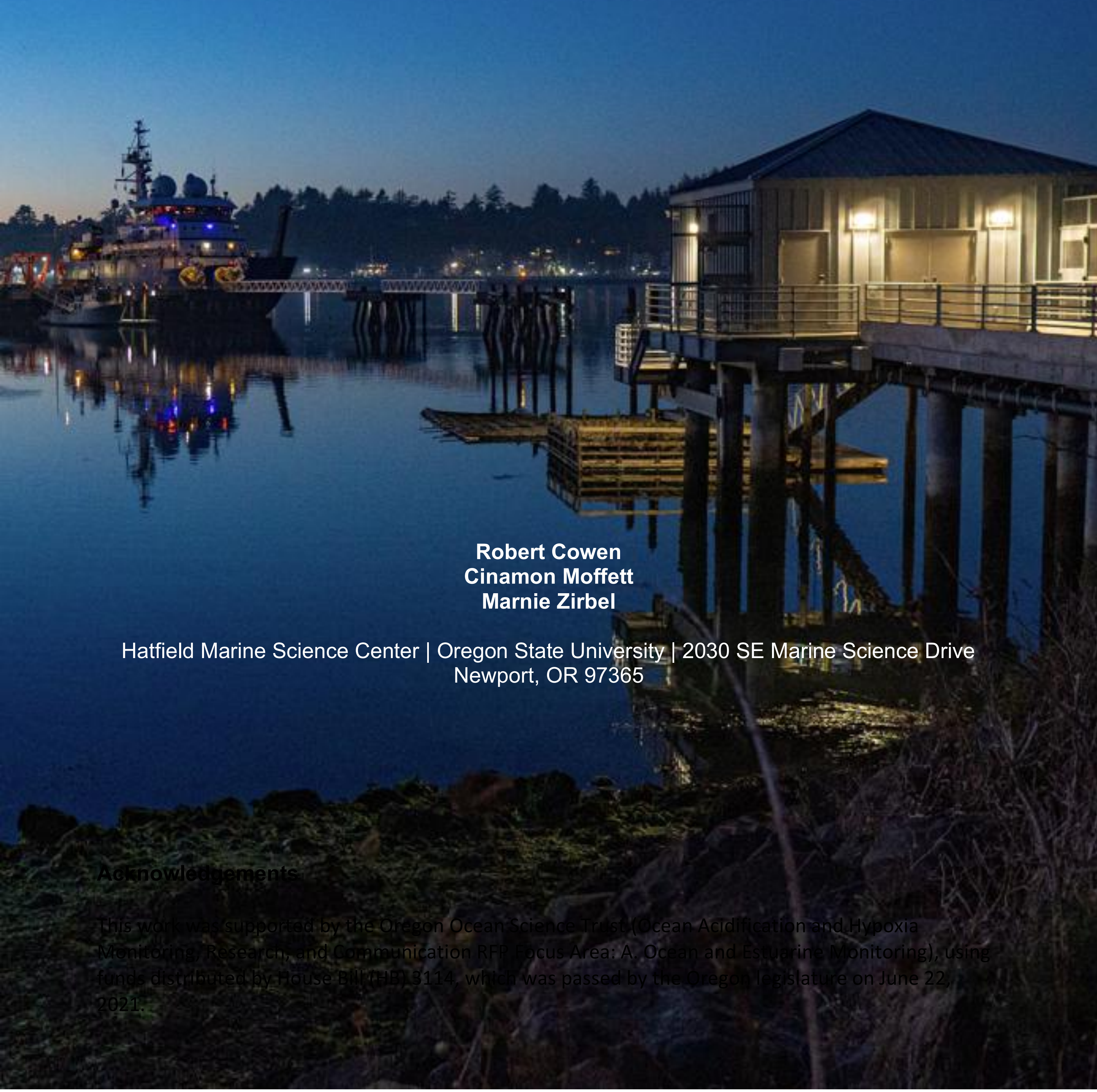
Oregon Ocean Science Trust Final Report

Ocean Acidification and Hypoxia Monitoring, Research, and Communication

Hatfield Marine Science Center Coastal Monitoring Station



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Executive Summary

The Coastal Monitoring Station (CMS) at Oregon State University's Hatfield Marine Science Center (HMSC) began collecting and transmitting real-time, climate-grade water quality data to a public website in April 2025. Measurements at the estuary dock site have been ongoing since 1988, but funding for support has been sporadic. In 2021, the Oregon legislature allocated funds to enhance ocean acidification and hypoxia (OAH) monitoring. The CMS is a direct result of that funding, administered by the Oregon Ocean Science Trust.

The CMS located in Yaquina Bay, Oregon, includes core *in situ* and benchtop sampling instruments, as well as an innovation test berth. The station is designed to be modular; it began with physical, chemical, and biological water sampling instruments, and a weather package is being installed in winter 2025-26. The system's data logging and visualization infrastructure is based on a system used by the University-National Oceanographic Laboratory System (UNOLS). framework. The CMS is part of HMSC's broader effort to increase public engagement with water quality issues through the real-time data website, a time series database, and a new public exhibit at the Hatfield Sea Grant Visitor Center. Researchers, resource managers, and the general public benefit from access to the data, which are also published to public repositories like ERDDAP. The CMS addresses critical OAH data gaps in the Yaquina estuary by providing a highly accurate and stable long-term data collection system. HMSC is committed to supporting this cost-effective and sustainable monitoring system for Yaquina Bay.

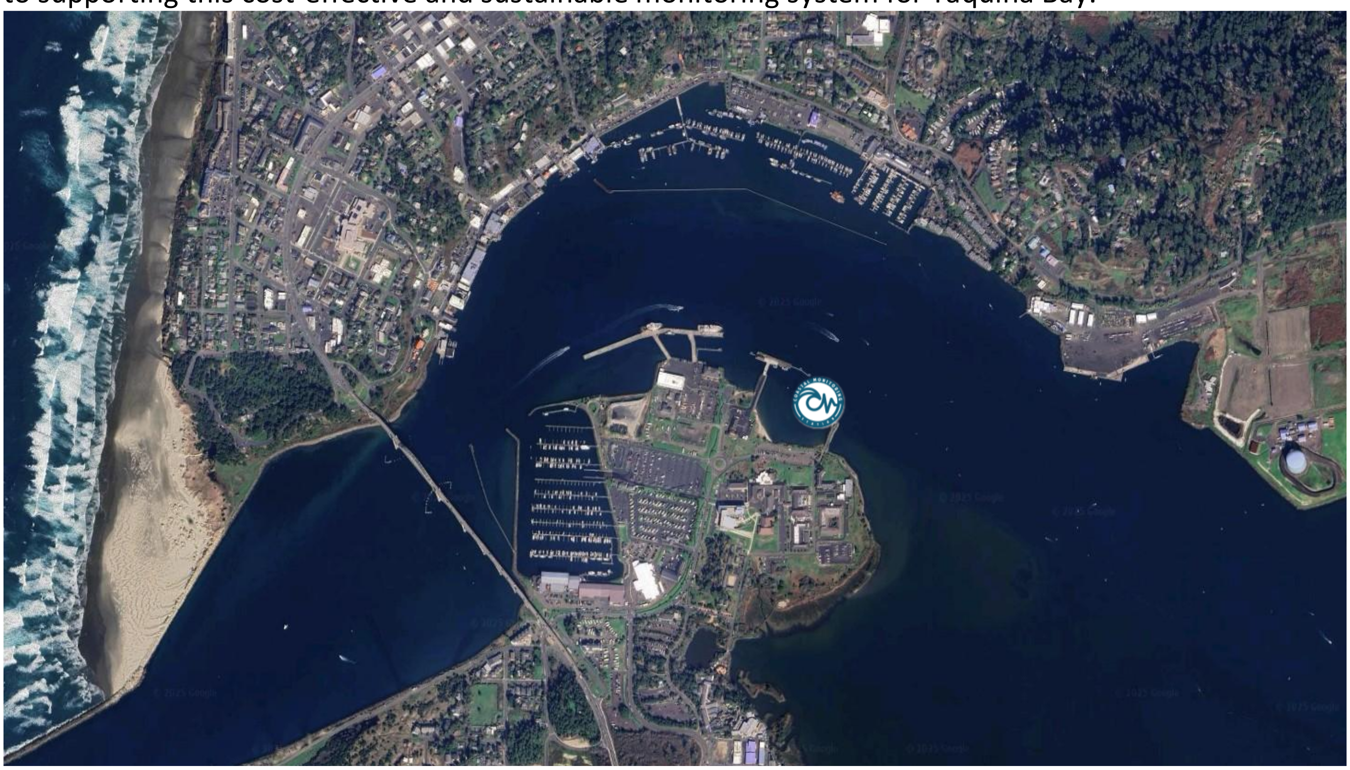

Figure 1. The Coastal Monitoring Station is located on the Hatfield Marine Science Center dock on Yaquina Bay.

Introduction

In the fall of 2021, Oregon State University's Hatfield Marine Science Center (OSU) (HMSC) received funds to replace its pump house, pier, and groin that support the seawater distribution system . During the pump house remodel planning effort, HMSC designed a dedicated equipment space in the new pump house for a significantly upgraded, ultramodern HMSC Coastal Monitoring Station (CMS). Funding originated when the Oregon Legislature passed funding bill HB 3114 in 2021, to provide $1,000,000 to priority actions from the Oregon Ocean Acidification and Hypoxia Action Plan 2019-2025. In consultation with the Oregon Coordinating Council on Ocean Acidification and Hypoxia (OAH Council) the Oregon Ocean Science Trust (OOST) began a competitive grant process to fund strategic research and address the risks and vulnerabilities caused by OAH that threaten Oregon's economy and ecosystems. With funds provided by an OOST OAH grant, the HMSC has realized the goal of providing accessible long-term, reliable, and robust ocean acidification and hypoxia (OAH) data for Yaquina Bay.

The HMSC dock (Fig. 1) is a significant estuarine research reference site with a historic monitoring effort. For over 60 years the Newport Hydrographic (NH) Line, originating near the mouth of the Yaquina estuary, has provided valuable California Current ecosystem indicator data across multiple temporal scales (Harvey, 2020). Yaquina Bay has also been the testbed for several independent short-term OAH monitoring projects. However, many of these vital monitoring programs have lapsed, struggled with data gaps, or have functionally inaccessible data due to a lack of resources. In addition, these standalone projects did not provide a comprehensive suite of sampled parameters. The EPA acknowledged "the potential difficulties in sustaining the data collection needed" to separate oceanic from anthropogenic inputs in the lower estuary (Brown et al 2007). The CMS fills these vital OAH data gaps by intentionally collecting a comprehensive suite of parameters with consistently maintained regulatory instruments, creating a stable long-term data collection and dissemination system incorporated into HMSC's core mission.

The CMS room in the pump house includes space and infrastructure for *in situ* and benchtop sampling instruments. In addition to the core *in situ* instrumentation suite, the CMS also has an instrumentation innovation test berth. The intended CMS design is modular. The first instrumentation package deployed consisted of physical, chemical, and biological water sampling instruments, and a weather package will be installed winter 2025-26. HMSC established memoranda of understanding with the EPA for instrumentation and lab space to perform routine maintenance. HMSC also collaborated with Sea Bird Scientific, who donated several instruments and created agreements to keep those instruments repaired or replaced if needed when feasible. The CMS leverages a robust and expandable back-end infrastructure for data acquisition, processing, storage, and dissemination called CORIOLIX, which is used by the University-National Oceanographic Laboratory System (UNOLS). In addition to creating a long-term time-series OAH database, the CMS streams data in real-time on a HMSC website (https://hmsc-cms.dri.oregonstate.edu/plots/flowthrough/) and will publish to NANOOS's data visualization platform. Real-time CMS data is also streaming to a display in a new Ocean Health exhibit in the HMSC Visitor Center managed by Sea Grant.

Project Objectives

The project deliverables from the original proposal with dates of completion included the following:

- **Objective 1:** Complete equipment room to accommodate all OAH instruments - Oct 2023

- **Objective 2:** Order the instruments, cables and data loggers – Oct 2023
- **Objective 3:** Finalize MOUs with partners - Mar 2023
- **Objective 4:** Hire the team to put the IT infrastructure and backup plan in place - Apr 2024
- **Objective 5:** Programming contractors to integrate the full instrumentation suite - Jun 2024
- **Objective 6:** Design and install the HMSC Visitor Center Ocean Health Exhibit - Dec 2025

Activities and Methods

Objective 1: Complete the equipment room to accommodate all OAH instruments – Oct 2023

CMS Physical Infrastructure

During the 2021 pump house remodel, HMSC built a designated equipment space in the new pumphouse building for significantly upgraded water quality monitoring instrumentation and deployment infrastructure. The new pump house, pier, and groin were completed in Spring 2022. The CMS room and in-water infrastructure was completed in 2023. The CMS room and aluminum instrument frames were designed and welded by the HMSC iLab (Fig. 2).

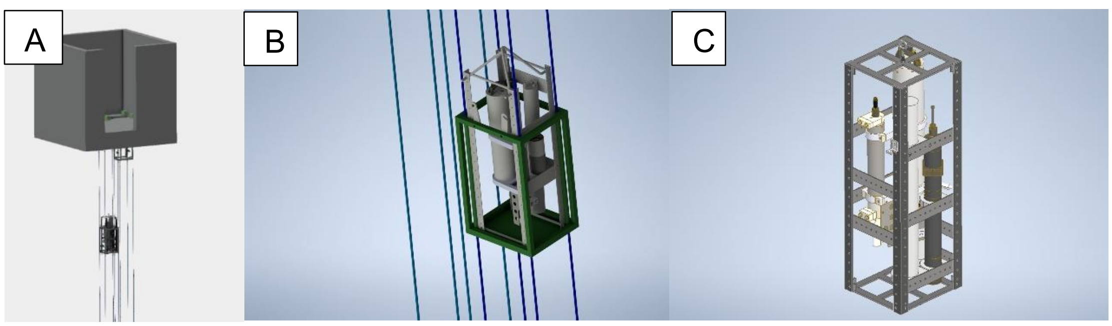

Figure 2. Initial CAD drawing of CMS room (A), static lines (B) and instrument frame (C).

Within the CMS room, a 31 cm x 84 cm opening in the deck allows space to deploy two frames for the CMS core instruments and the experimental test berth (Fig. 3A). There are two electric winches and ceiling mounted pulleys installed above the deployment bay for ease of instrument deployment and testing. The two winches are fitted with 1.3 cm (½”) silver Amsteel line and 316 stainless hardware. There are several 120-volt outlets and an ethernet switch with 8 ports, providing constant power and data to CMS instruments. The instrument sea cables terminate inside a waterproof enclosure which houses the logger computer, power supply, surge protection, serial to USB adapters and ethernet connection to the OSU fiber network (Fig. 3B). The CMS dock building is equipped with an emergency generator that starts automatically when the utility power is lost.

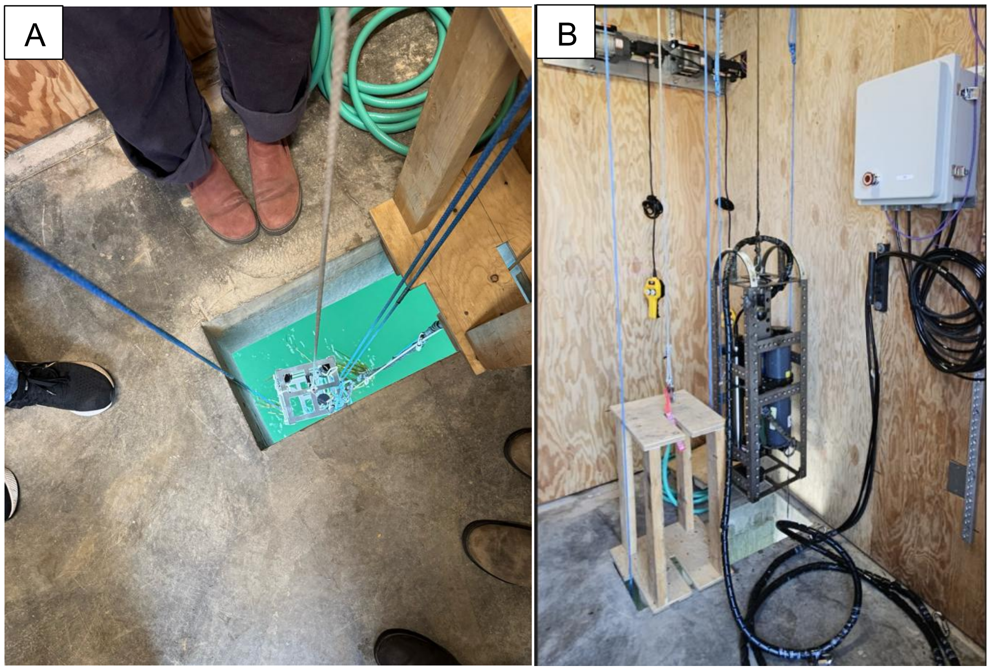

Figure 3. The deployment bay (A) provides through-deck access for two instrument frames. The CMS room (B) includes the winches, sea cables with power and data, and logger enclosure.

Directly below the deployment bay, a 1 m^2 anchor plate (Fig. 4) is secured to the estuary floor with anchor screws and sandbags, and four ½” Amsteel static lines are secured from the CMS ceiling joists to the anchor plate. The instrument frames are clipped into the static lines with stainless carabiners to prevent the instrument frames from moving with the tides and currents. The instrument frame is deployed approximately 1 m above the estuary floor (Fig 4).

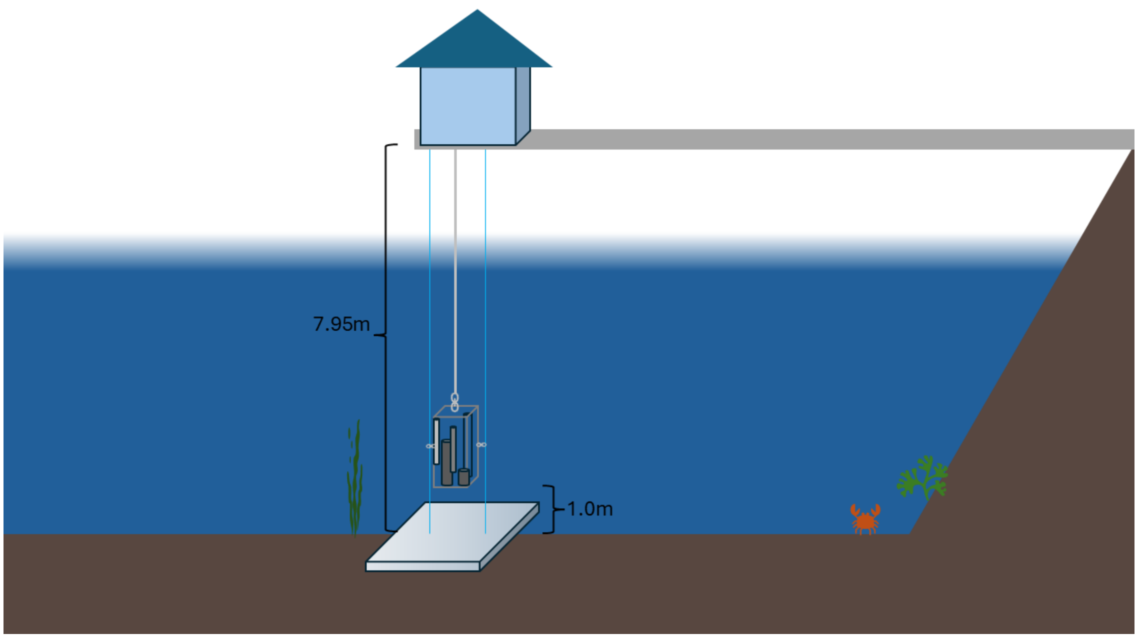

Figure 4. The instrument frame is deployed ~1m above the estuary floor.

Objective 2: Order the instruments, cables and data loggers – Oct 2023

Core *In situ* Measurements

The in-water instruments, cables and loggers were onsite at HMSC by Oct 2023. The complete suite of in-water instruments (Fig. 5) includes the EXO Sonde (YSI), ECO Triplet, SUNA and SeapHOx (Sea-Bird).

Figure 5. In-water instruments deployed at the CMS.

The Sonde measures temperature, depth, salinity, dissolved oxygen, pH, turbidity and algal fluorescence. The ECO Triplet measures phytoplankton chlorophyll fluorescence at 695nm, fluorescent dissolved organic matter (FDOM) at 460nm, and particulate scattering at 700nm. The SeapHOx is a combination of a SBE 37 CTD (conductivity, temperature, depth), an SBE 63 to measure optical dissolved oxygen, and an ion-sensitive field-effect transistor (ISFET) to measure pH. We are working with Sea-Bird to troubleshoot the SeapHOx for our application in the estuary, and expect to deploy it in 2026. The Sea-Bird SUNA V2 measures nitrate dissolved in seawater, calculated from nitrate's absorption in the UV spectrum and corrected for absorption due to bromide. The instruments are secured in the frame with clamps that were 3D printed in the HMSC iLab (Fig 6).

Figure 6. The instrument frame as deployed in Dec 2025.

For this suite of instruments to create a robust climate-grade long-term data set, consideration was made about instrument sample interval times, in other words, how often the different sensors would make measurements of the various water quality parameters. The CMS team decided to continue the EPA's sampling effort started in 2009, sampling every 15 minutes with the EXO Sonde deployed from the Hatfield pumphouse dock. However, because the ECO Triplet fluorometer and SeapHOx take redundant or similar measurements to the Sonde, they are programmed to sample slightly more often to establish a thorough data set, which will overlap with and complement the historical Sonde measurements (Table 1).

Instrument	Measurands	Sample Rate fs (Hz)	Burst Size (samples)	Burst Interval (sec)	Burst Length (sec)	Bursts / day	Raw Samples /day
EcoTriplet-W	Chl470, BB700, FDOM	1.0	5	60	5	1440	7200
SeapHOx	T, C, S, P, O2, pH	1.00	1	300	39	288	288
SUNA	Nitrate, UV spectrum	1.0	10	900	10	96	960
YSI EXO2	*T, S, Chl, Turbidity, pH, O2*	*1.0*	1	900	1	96	96
Burkeolator + TSG	CO2, TCO2, Ωar, T, S	tbs	tbs	tbs	tbs	tbs	tbs

Table 1. CMS instrumentation and sample rates.

Benchtop Flow-through Measurements

The Burke-o-lator (BOL) makes high resolution measurements of the carbonate system, including pCO_2 and TCO_2, incorporating a Sea-Bird 45 MicroTSG thermosalinograph for temperature and salinity measurements. Estuary water is pumped from next to the instrument frame into the CMS room (Fig. 7), where dissolved gases in the sample water flow from a headspace equilibrator through a sample loop for analysis with a LICOR for CO_2 absorption in the infrared. Aragonite saturation state and pH are then calculated from these measurements in LabView, to describe biocalcification stress. The BOL is operated by the EPA under the MOU with HMSC described below.

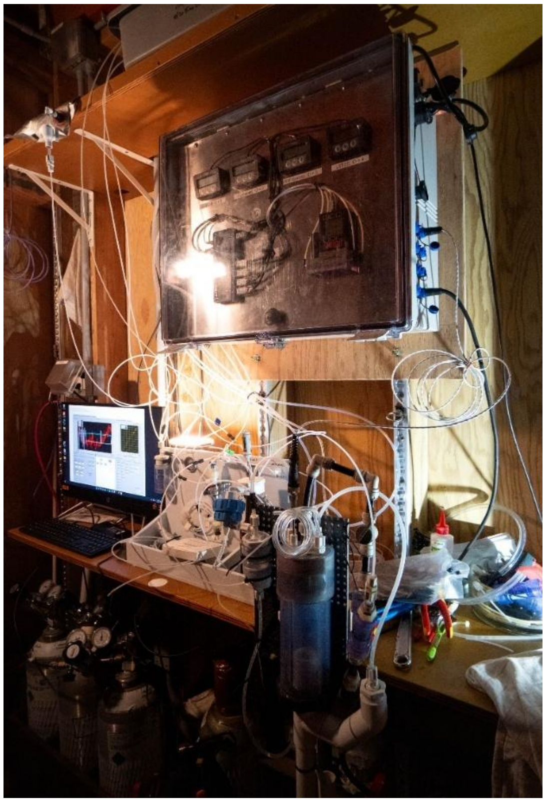
Figure 7. The Burke-o-lator (BOL) installed in the CMS.

Objective 3: Finalize MOUs with partners - Mar 2023

Since 2012, OSU and EPA have been conducting cooperative research activities under an MOU concerning the operation of the YSI EXO Sonde at the HMSC dock, and its resulting water quality data. In Dec 2023, OSU and EPA finalized a new MOU adding the Burke-o-lator (BOL) benchtop instrument, as well as agreements for data sharing and quality assurance and control (QA/QC). These ongoing agreements leverage the human skills and physical infrastructure of both institutions and foster future collaborations at other coastal systems up and down the Oregon coast.

OSU and Sea-Bird Scientific have a draft MOU in review as of Dec 2025, which provides for the generous donation of the 6 Sea-Bird instruments in the CMS to HMSC, as well as collaborative use of CMS infrastructure to test Sea-Bird instrument prototypes.

Objective 4: Hire the team to put the IT infrastructure and backup plan in place - Apr 2024

The instrument frame and Campbell logger were first tested in spring 2024. It became apparent that, reliable as the proprietary Campbell logger systems have been over the past 25 years, recent developments in open source logging software have led to more powerful, compact and flexible solutions. In 2025 Hatfield shifted the CMS data logging and visualization system to an existing open source, Python-based Regional Class Research Vessel (RCRV) model. This more modern and modular system, called CORIOLIX, will continue to be supported at OSU by the College of Earth, Ocean, and Atmospheric Sciences (CEOAS), leverages the imminent arrival of R/V Taani in 2026 for future UNOLS research vessels, and is already in use on R/V Sikuliaq and R/V Pt Sur. R/V Taani's home port will be about 100m from the CMS dock. This close physical proximity of the two CORIOLIX systems will be useful for instrument calibration and testing, as R/V Taani will have several of the same water quality and weather instruments installed on its flowthrough seawater lab bulkhead and met mast, respectively. Scientists preparing to deploy on R/V Taani can check instrumentation using the CMS test berth, with the full suite of co-located CMS water quality data accessible on a smartphone in real-time. Thus, the problem of imminent logger obsolescence was solved with a better, more robust system that is already being utilized and is readily accessible to more scientists and community members.

Objective 5: Programming contractors to integrate the full instrumentation suite - Jun 2024

CMS Data Architecture

HMSC used funds from this grant to support staff in CEOAS to customize CORIOLIX for its first-ever use with a stationary dock platform, rather than on a research vessel. As described in the section above, this data acquisition and visualization system is integral to the CMS mission to make real-time Yaquina water quality data available to scientists, resource managers and the general public.

In the CMS room on the HMSC dock, raw data are telemetered directly from the in-water instruments via serial signal to a Raspberry Pi 5 running OpenRVDAS open source logging software (https://github.com/OceanDataTools/openrvdas). This logging software reads in the raw data, parses it, applies calibration coefficients and writes out the transformed data. Raw and transformed data are transmitted over OSU's fiber network at 100 GB/second to the Oregon State Data Center in Salem, OR. The Data Center houses OSU's virtual machines, which host the CORIOLIX database and web services including the CMS real-time data visualization tools, website, ERDDAP and REST API data services (Fig. 8).

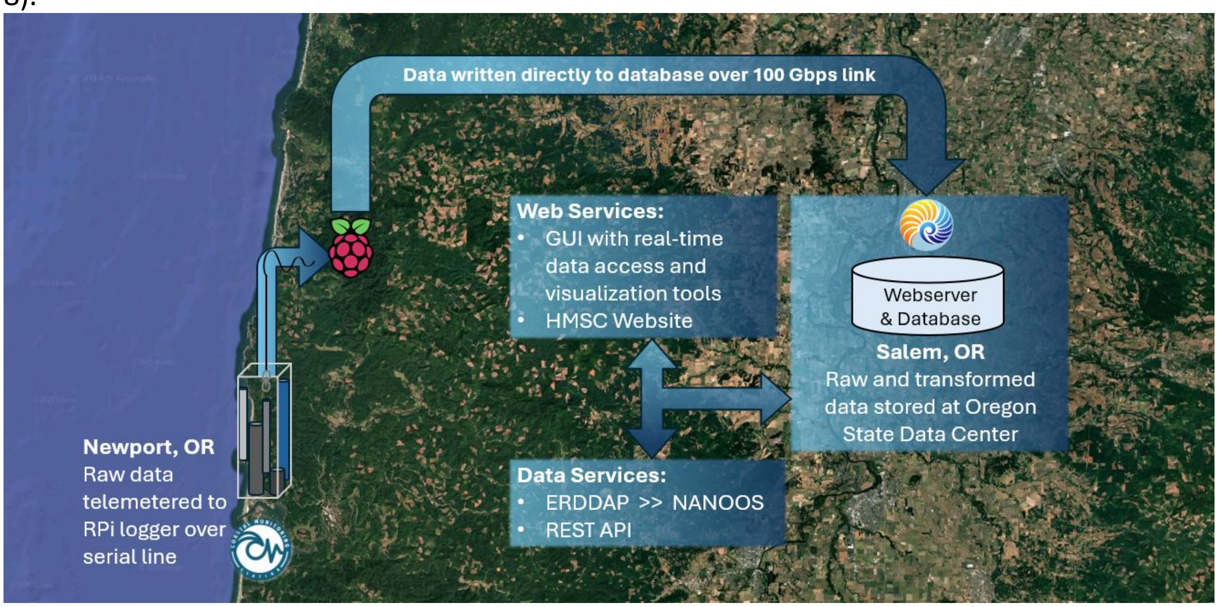

Fig. 8. CMS data architecture.

Real-time QA/QC

As real-time data acquisition from automated oceanographic sensors has become more common, the scientific community has created best practices manuals for real-time data quality assurance and control (QA/QC). These manuals are collectively known as QA/QC of Real-Time Oceanographic Data (QARTOD). QARTOD publishes a separate manual for each oceanographic parameter, with recommendations for flags to attach to data. The CMS QA/QC protocols are designed to meet QARTOD recommendations. For example, all CMS parameters are required by QARTOD to include flags for Gap (correct time stamp), Syntax (good sensor communication), Gross Range (within expected values for the sensor), Climatology (within expected values for the local environment), and Location (expected values for latitude and longitude). Because the CMS is stationary, the Location flag is not used.

The CORIOLIX system includes the same QARTOD flags (Fig. 9), with the addition of Global Range (within expected values globally) and Sensor Status (whether the sensor is in operation or undergoing maintenance). More information about the CORIOLIX QA/QC can be found at https://hmsc-cms.dri.oregonstate.edu/data/flags/. Flags resulting from real-time QARTOD analysis will be used during final QA/QC before publication to data archives and long-term repositories like Zenodo or Scholars Archive. All CMS data including raw, transformed and QA/QC'd are backed up in the Oregon State Data Center.

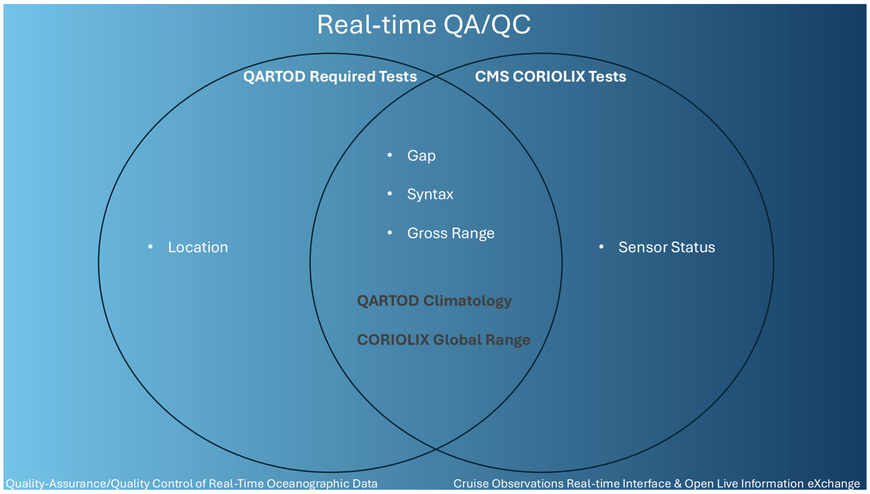

Figure 9. Real-time data QA/QC tests applied by QARTOD and CORIOLIX.

Objective 6: Design and install the HMSC Visitor Center Ocean Health Exhibit - Dec 2025

The "Changing Ocean" exhibit at the Hatfield Visitor Center was installed in May 2024 with a new visual panel describing how climate change worsens OAH and upwelling issues specific to the Oregon coast. The panel was the first part of the Ocean Health exhibit.

During summer 2025, an intern funded by Marine and Coastal Opportunities (MACO) conducted feedback surveys with visitors about poster designs. They also tested a prototype of a touch screen video game (Fig. 10) that will be added to the exhibit in winter 2026(?). This interactive game is designed to engaging visitors with the OA challenges faced by local oyster growers.

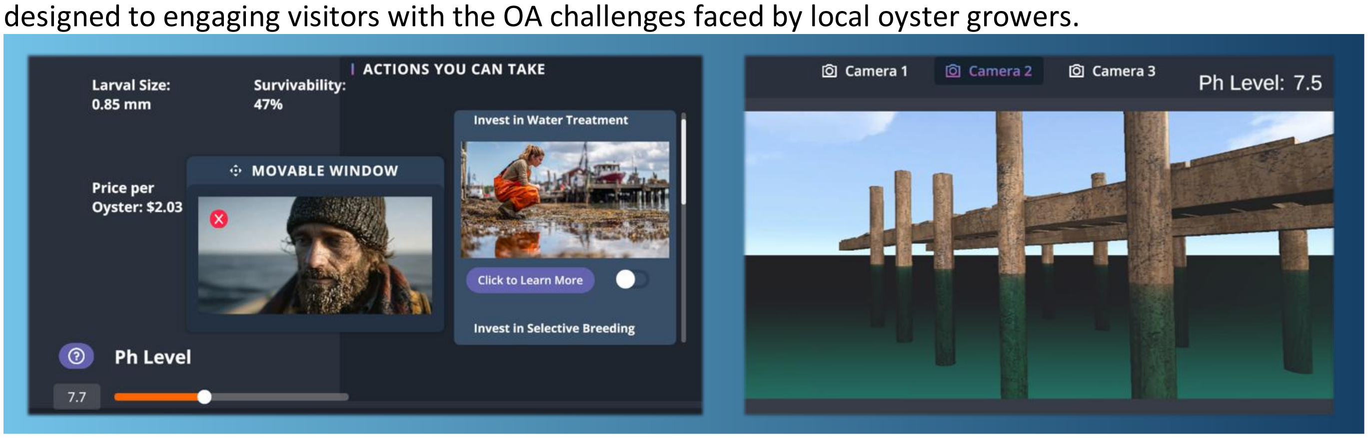

Figure 10. Screenshots of OAH video game developed for the Visitor Center exhibit.

In fall 2025, a replica of the instrument frame was mounted in the exhibit, and the CMS real-time data website began streaming on the exhibit monitor (Fig. 11 A).

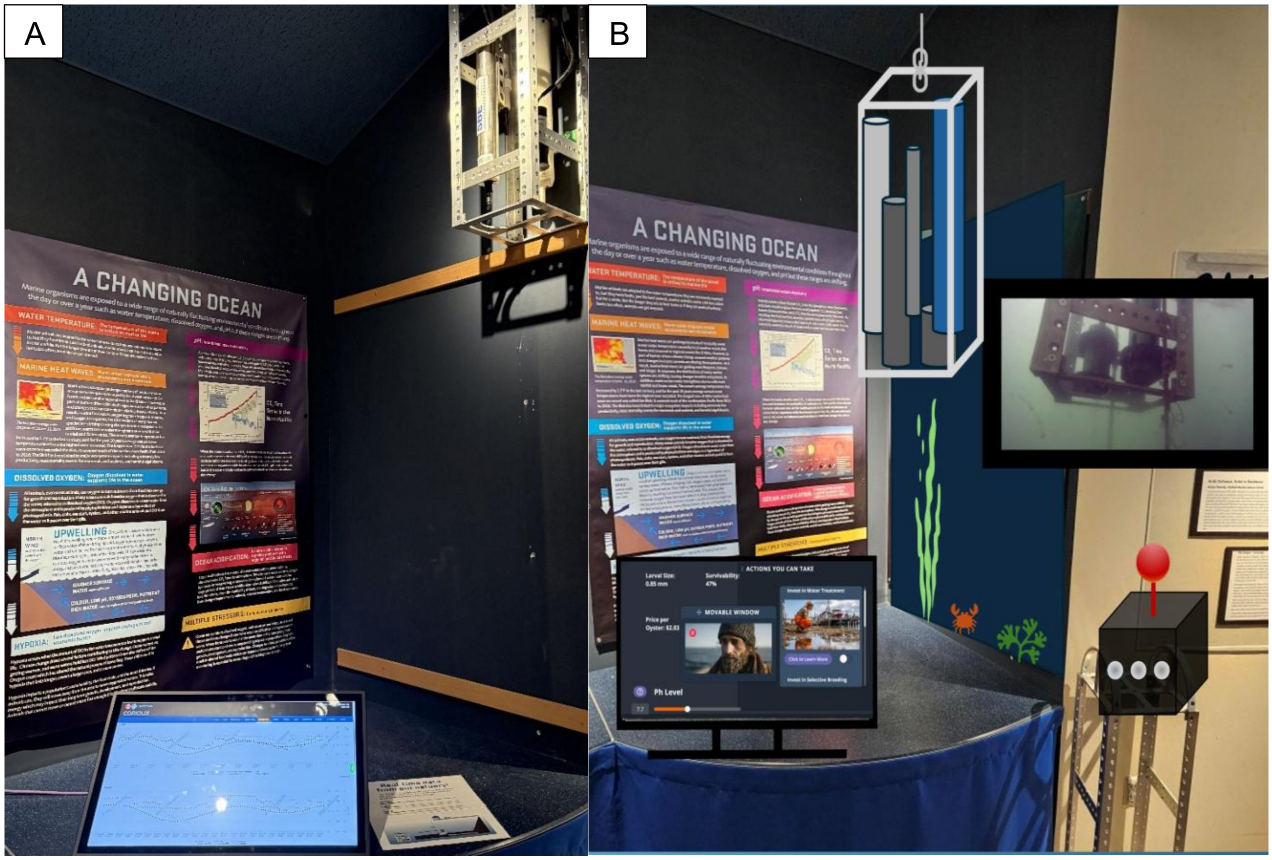

Figure 11. The CMS exhibit (A) in Nov 2025, with live data streaming and instrument frame replica, and (B) final design to be completed winter 2025-26.

Also, in the summer of 2025 a Roundhouse intern in the HMSC iLab developed an underwater webcam to be deployed below the CMS instrument frame. In winter 2025-26 the live webcam footage will be streamed to a screen in the exhibit, and a console will be installed for visitors to operate pan, zoom and light controls. The final step of the exhibit is being completed by the MACO student intern who is completing a background mural depicting the underwater scene below the CMS dock (Fig. 11 B).

Results and Impact

Public Data Access

The publicly accessible real-time CMS data website went live in April 2025, at [https://hmsc-cms.dri.oregonstate.edu/plots/flowthrough/.](https://hmsc-cms.dri.oregonstate.edu/plots/flowthrough/) The main page (Fig. 12) displays up to the previous 24 hours of data from each sensor, plotted over time on the x-axis with depth (tide) on each plot.

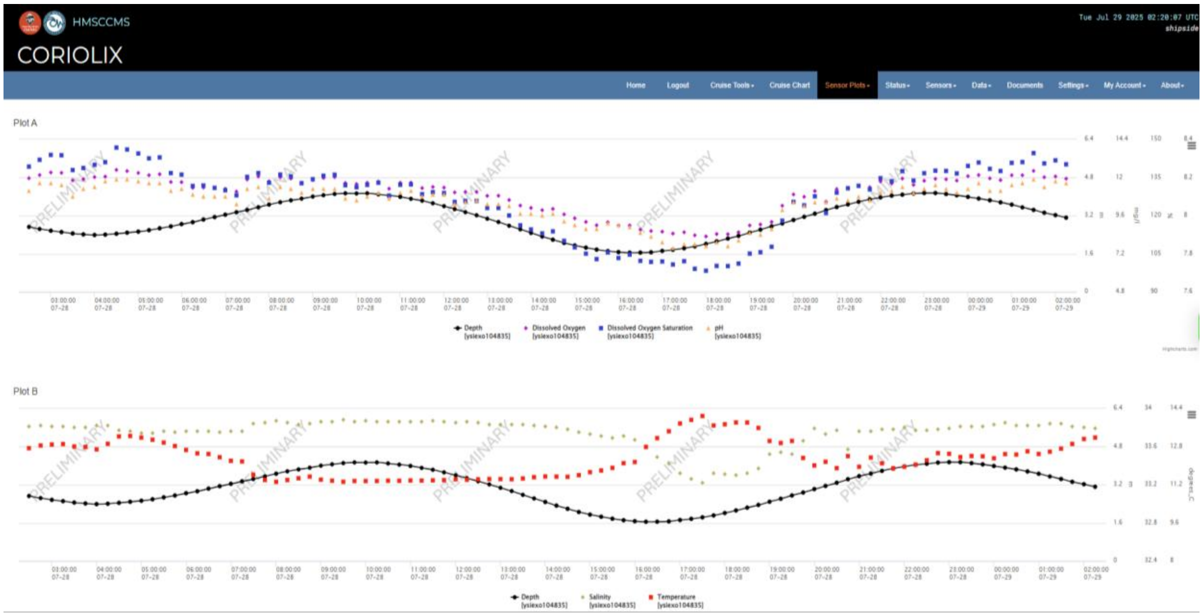

Figure 12. A screenshot of the CMS real-time data.

The Customizable Plot page at https://hmsc-cms.dri.oregonstate.edu/plots/custom/ displays up to 4 user-defined parameters over time, for up to 3 weeks of data from any time since the CMS began logging to CORIOLIX in April 2025 (Fig. 13).

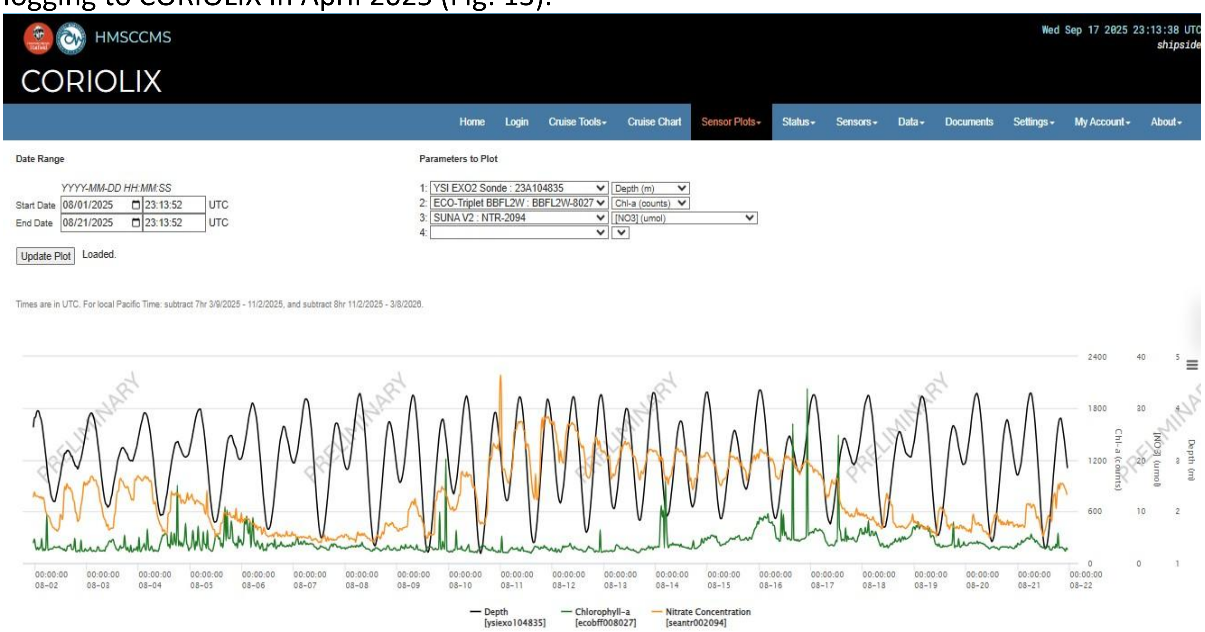

Figure 13. A screenshot of the CMS Customizable plot.

In addition to the CORIOLIX real-time data visualization website, CMS data is published to a NOAA Environmental Research Division Data Access Program (ERDDAP) site (https://hmsc-cms.dri.oregonstate.edu/erddap/info). Through the ERDDAP (Fig. 14), CMS data are available in comma separated value (CSV), network common data form (NetCDF), JavaScript object notation (JSON), HyperText markup language (HTML), and many other common file types.

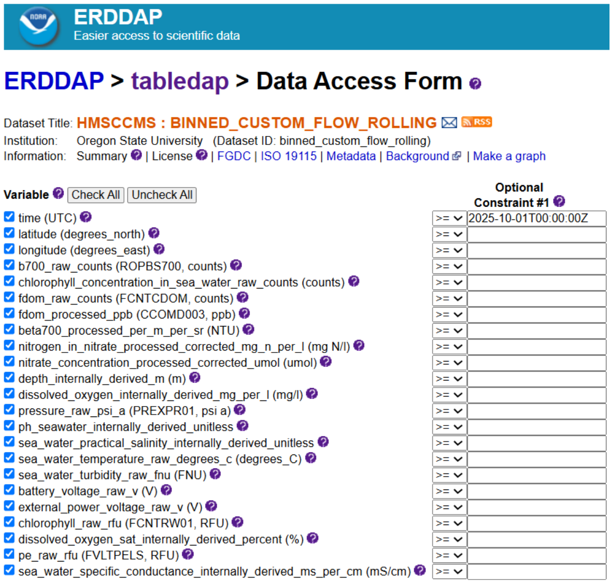

Figure 14. CMS ERDDAP access form.

Current Users of CMS Data

Several user groups have identified the CMS as a useful source of data for their programs. Federal researchers at HMSC, including the USDA Pacific Shellfish Research Unit and NOAA Northwest Fisheries Science Center, use CMS data to inform decisions about their oyster and juvenile groundfish and salmon programs, respectively. OSU scientists and visiting researchers use CMS data for their experiments, as well as for coursework like Oceanographic Data Analysis (OC 301).

Daily operations at HMSC rely on reliable, high quality water quality data. For example, the HMSC Facilities team can only pump water for the seawater system at high tide due to the large fluctuations in salinity at the pumphouse location in the estuary (Fig. 15).

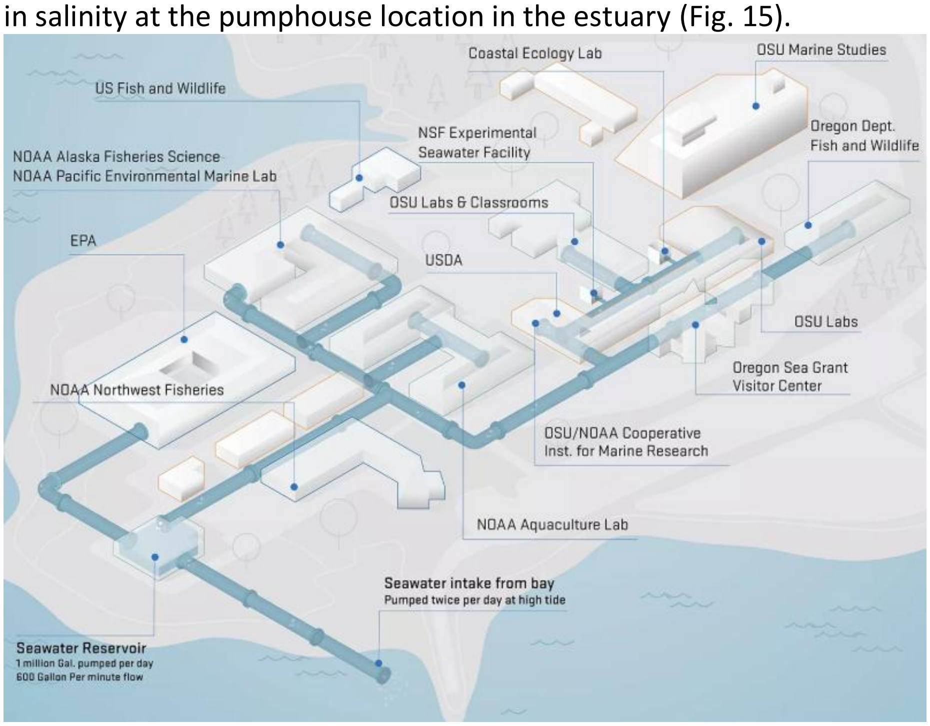

Figure 15. Map of the HMSC seawater system.

This seawater is pumped to reservoirs that supply the various federal and state labs at HMSC, as well as tanks used by the Hatfield Animal Care Team and Visitor Center animal exhibits. Only seawater with salinity above 28 ppt can be used, to avoid injury or death for animals in captivity on campus, and similar salinity risks to high value experiments. Therefore, HMSC facilities staff regularly compare CMS real-time data with their instruments to ensure estuary water pumped to the reservoirs is at the required salinity. Other users of the CMS data include the OR Coast Aquarium and K-12 educators with Sea Grant and the MBARI EARTH program.

Case Studies

April 2025 Spring Transition

On April 18, 2025, a shift occurred in the CMS dissolved oxygen (DO) data with respect to the depth (tide) data. For the first time that year, the DO dropped precipitously as the tide came in. Subsequent high tides brought with them very low DO values (Fig 16).

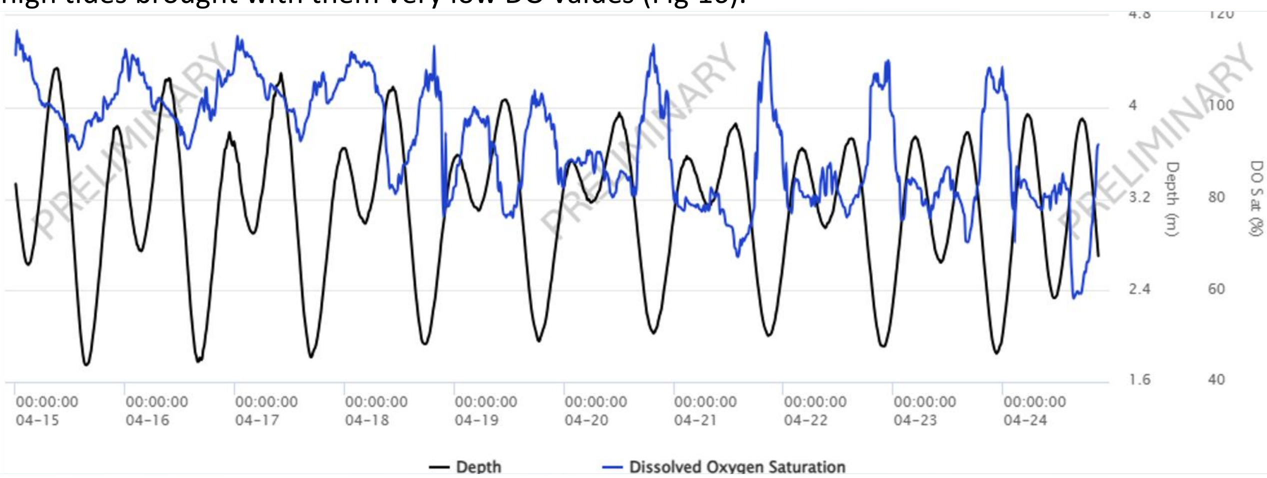

Figure 16. Dissolved oxygen (DO) and depth (tide) data at the CMS, 15-24 April 2025.

It was hypothesized that the Spring Transition had occurred, a yearly phenomenon when winds and currents along the NW coast transition from varying to strongly southward. This begins the upwelling season, when surface waters move away and are replaced by deep, cold, nutrient rich water that is low in DO, high in CO_2 and thus more acidic in pH. Sure enough, ocean current data from high frequency radar during the days prior (Fig. 17) supports this hypothesis, as the current direction changed from mixed on 10 April to strongly moving southward by 12 April.

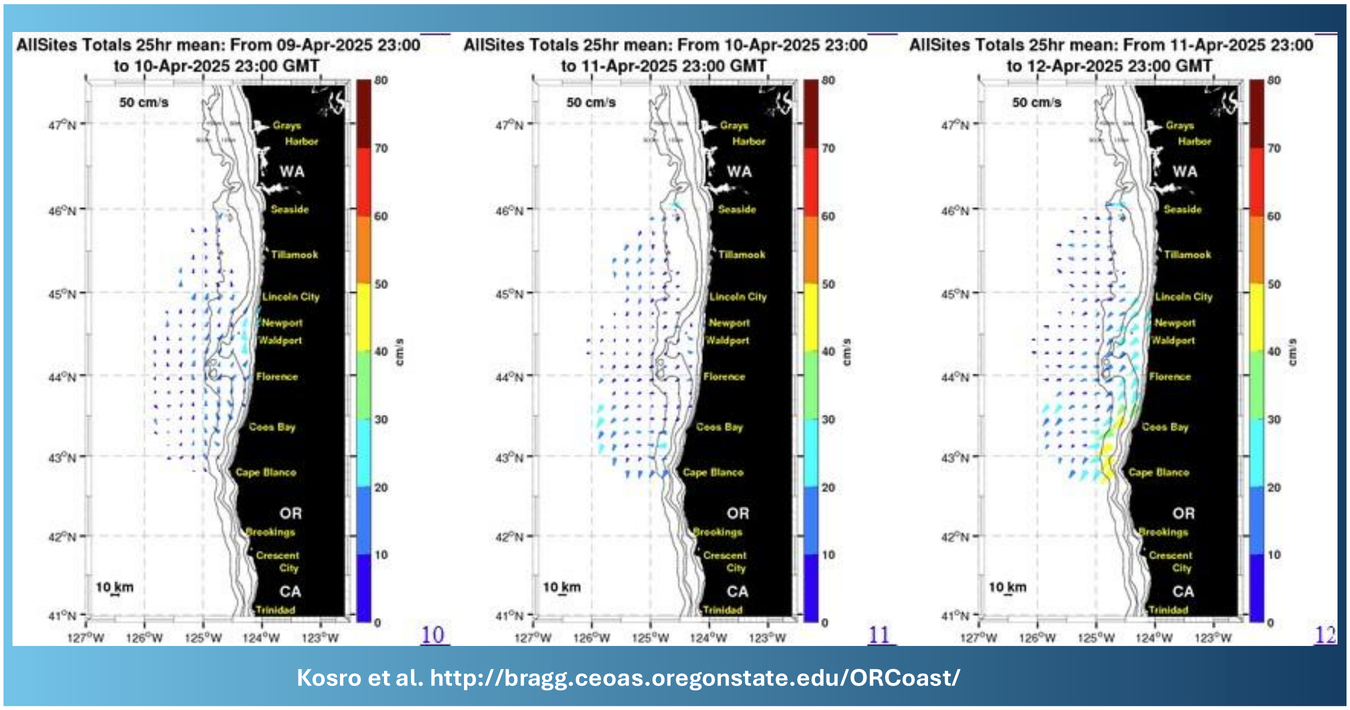

Figure 17. High frequency radar data from the Pacific Northwest coast, 10-12 April 2025.

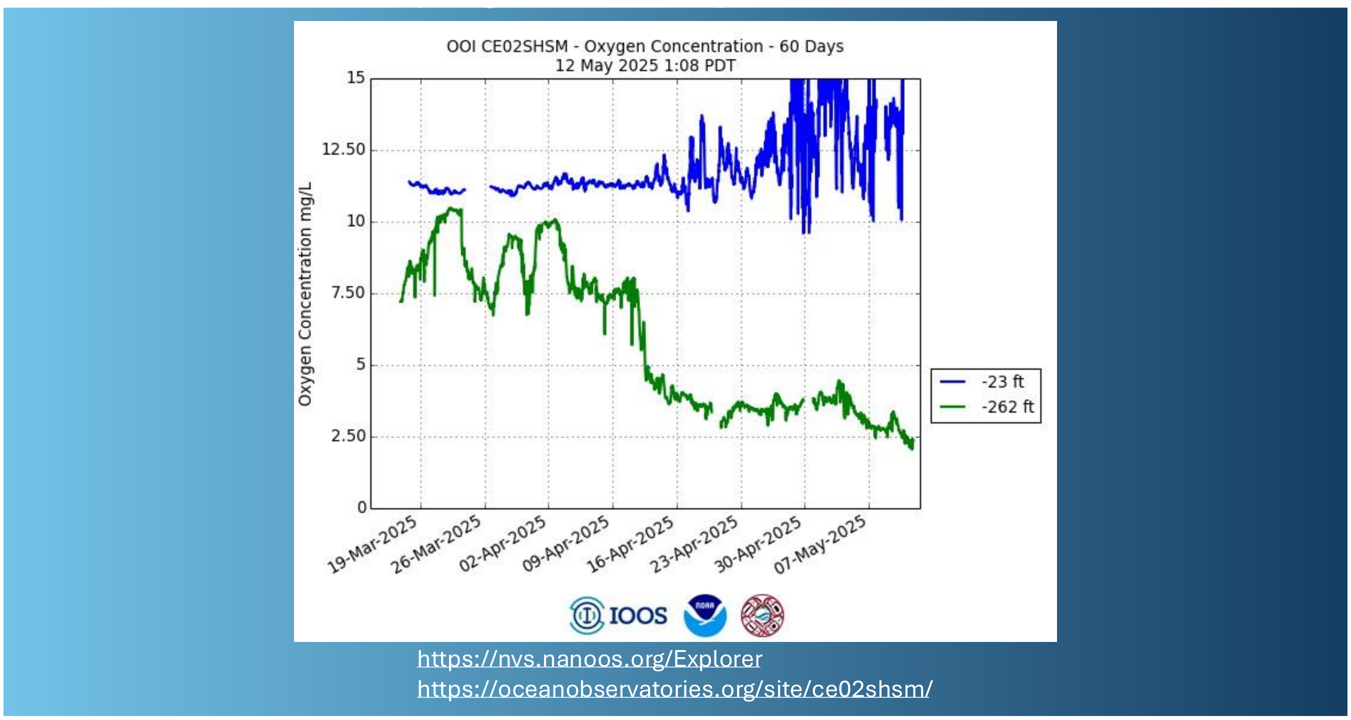

Figure 18. Dissolved oxygen concentrations on the OR Shelf mooring, 19 March-07 May 2025.

Ocean floor DO data from the Ocean Observatories Initiative (OOI) shelf mooring also supports placing the 2025 spring transition during this date. While the near-surface DO levels remained similar albeit noisier, DO on the shelf bottom at a depth of 262 feet dropped to almost hypoxic levels on around 12 April 2025 (Fig. 18). This low DO water was transported into the Yaquina estuary by 18 April 2025.

July 2025 Kamchatka earthquake and seiche

On 29 July 2025, a magnitude 8.8 earthquake occurred offshore of the Kamchatka peninsula in Russia, the largest on earth since the 2011 Mw 9.1 earthquake in Tohoku, Japan (USGS, 2025). The Newport, OR area went under a distant tsunami advisory, and the resulting water level fluctuation inside the

Yaquina estuary was 6 inches. The CMS live data feed displayed the first wave to reach the HMSC dock at about 07:30 UTC (00:30 PST), as well as the resulting increases in turbidity, scattering and fluorescent dissolved organic matter (FDOM) (Fig. 19).

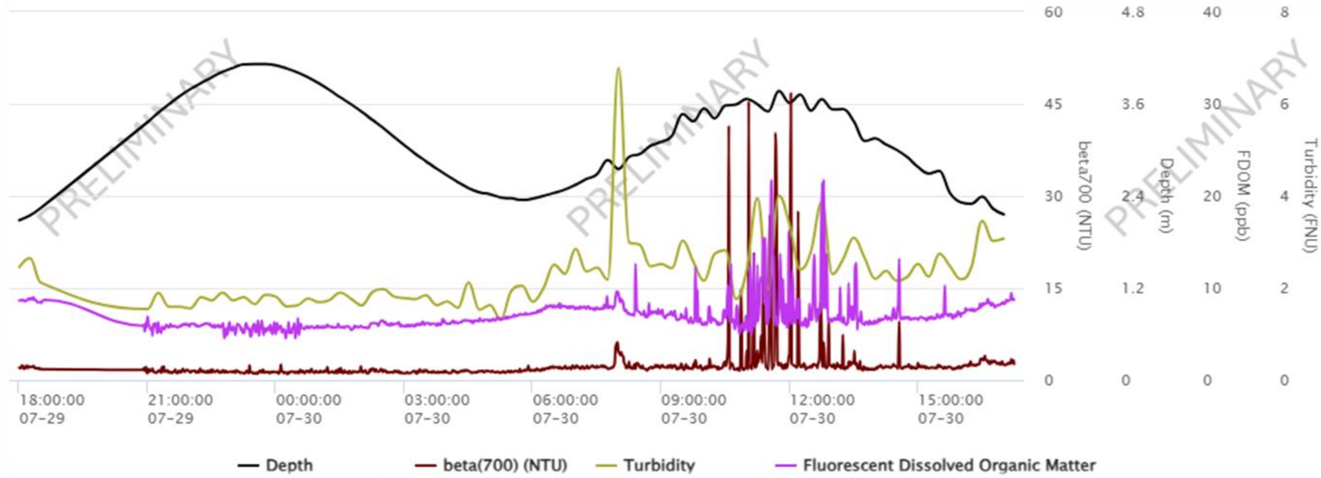

Figure 19. CMS depth (tide), scattering, turbidity and FDOM, 29-30 Jul 2025.

The seiche, or disturbance-induced sloshing oscillation, that resulted in the estuary after the earthquake continued for almost 7 days (Fig. 20).

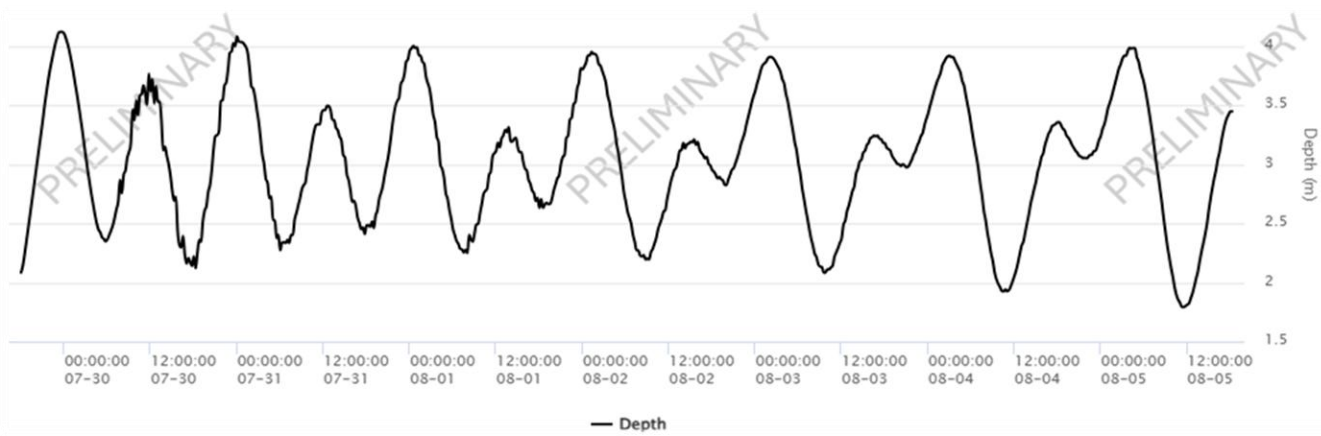

Figure 20. CMS depth (tide), 30 Jul – 5 Aug 2025.

August 2025 Burke-o-Lator (BOL) Deployment

During the summer 2025 deployment of the BOL, significant increases in pCO_2 were measured, and pH values as low as 7.35 were calculated. These low pH values were also measured by the YSI EXO Sonde (Fig. 21). High pCO_2, low pH values were measured at both low and high tides, indicating this part of the estuary is likely subject to upwelling and respiration effects on water biogeochemistry.

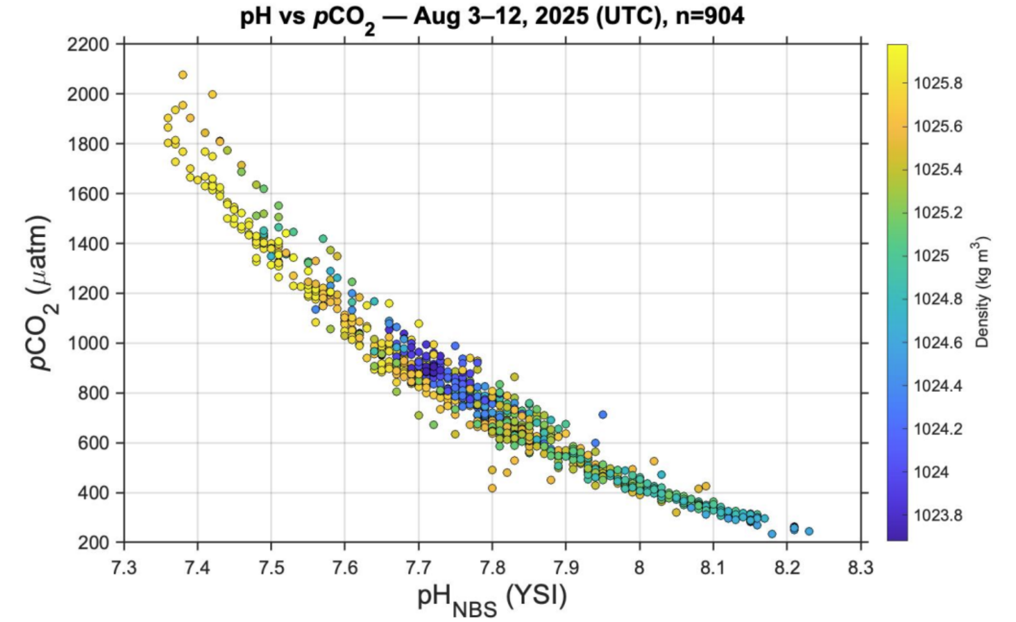

Figure 21. CMS BOL deployment pCO2 and density data from August 2025, with YSI pH data.

Summer 2025 Turbidity Issue

Animal care staff and HMSC researchers noticed abnormally high turbidity values during 2025, and HMSC Facilities staff were concerned the sand filtration system was failing. Using data collected by the CMS in 2025 and comparing it to high tide summer data from the previous 15 years (Fig. 22), it was determined that the turbidity issue was originating in the estuary, not within the HMSC seawater system. The most recent high turbidity events corresponded to the reconstruction of the HMSC dock in 2021, and the May 2025 construction of USDA's oyster research raft.

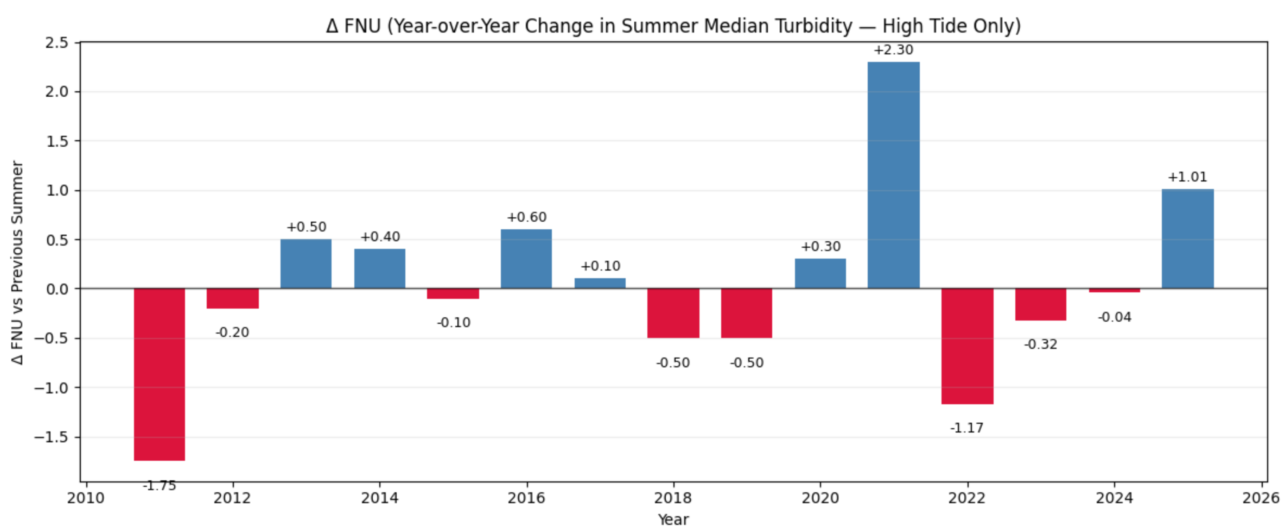

Figure 22. Year-over-year change in turbidity median values at the CMS location at the HMSC dock. Data are from the 2 hours around high tide for all days June-Aug.

December 2025 Atmospheric rivers

In early December 2025, a series of at least 3 atmospheric rivers began impacting Western Washington and Oregon, leading to historic flooding, landslides and record river levels. For several days, the HMSC facilities team wasn't able to pump water to the seawater system as its salinity wasn't high enough even during high tide. An initial analysis revealed that turbidity levels were twice baseline levels, even during high tide when the sediment-rich riverine signal is usually much weaker (Fig. 23).

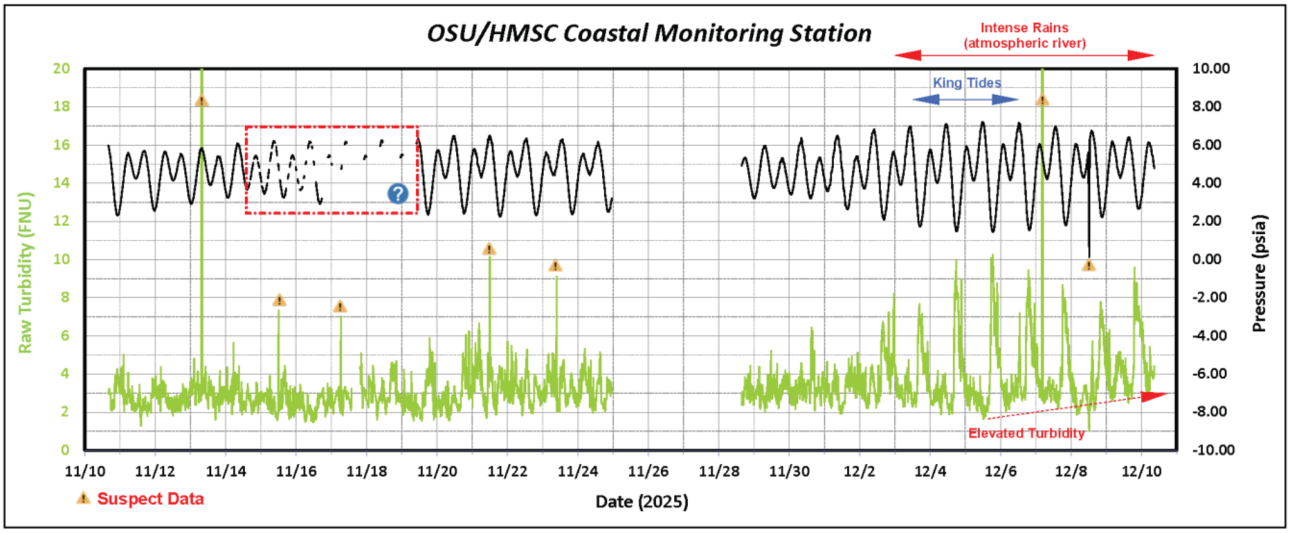

Figure 23. Initial analysis of CMS turbidity and tide data, Nov – Dec 2025.

Community Outreach and Engagement

Oral Presentations

MBARI EARTH K-12 Curriculum workshop 29 Jul 2025
Eastern Pacific Ocean Conference (EPOC) 22 Sept 2025 (Zirbel et al. 2025)
Scripps Technical Forum 9 Oct 2025
Hatfield Research Seminar Series 16 Oct 2025

Public Tours

Hatfield Marine Science Day 2024, 2025
Hatfield Research Summit 2024
South Korea International Exchange Students 2/20/2025
NSF Louis Stokes Alliances for Minority Participation (LSAMP) 9/15/2025

Interns & Volunteers

Justus Eaglesmith, Oregon Health Authority data scientist, summer 2025 -present. Volunteer statistical analysis of 2009-2025 CMS data.

Maja White, OSU CEOAS undergraduate MACO intern, summer 2025. Exhibit surveys, poster edits, instrument service, exhibit mural.

Michael Tomlinson, retired coastal oceanographer, fall 2025 – present. Data analysis and QA/QC.

Challenges and Lessons Learned

Supply Chain

A major challenge for the CMS team has been the turnaround time for factory instrument parts and calibrations. The ion-selective field effect transistor (ISFET) to measure pH, originally used by Sea-Bird Scientific, was only available in China, and supply chain issues during the COVID pandemic caused delays of over a year in delivery times. At the time of publication of this report, the SeapHOx, Triplet fluorometer and SUNA nitrate sensor have been in the manufacturer's queue for calibration for 11 months. Fortunately, the YSI EXO Sonde can be calibrated by the user and includes a pH sensor. When the BOL is in operation it includes another check on pH, calculated from its carbonate system measurements. Future CMS projects may include domestically produced, custom-fabricated Durafet® based (Honeywell Instruments) pH sensors such as those deployed successfully along the OR coast (Chan, 2022-2024) and described in Martz et al. (2010).

Government Downsizing and Shutdown

The other main challenge in 2025 came with cuts to the federal workforce, and subsequent shutdown from 1 Oct – 12 Nov. The instrument technician who had managed the YSI EXO Sonde was forced to retire in May. This retirement and other personnel cuts added to the workload of the state funded HMSC staff. The ECO Triplet fluorometer and SUNA nitrate sensor were cleaned and calibrated less frequently in order to continue the existing historical monthly maintenance schedule for the Sonde. Since the BOL is operated by EPA staff, it was taken offline on 1 Oct. The EPA team is regrouping from the shutdown, and plans are underway to restart the BOL in 2026 after standards and reagents have been replaced.

Next Steps

CMS Website

The Hatfield CMS website went live in May 2025 with links to the real-time data, descriptions of the instruments, and a narrative of the project (Fig. 24). Hatfield staff continue work with Sea Grant K-12 educators to create short videos and other content to engage website users and increase data literacy. The website will feature a web-based version of the exhibit video game and a link to the estuary floor webcam.

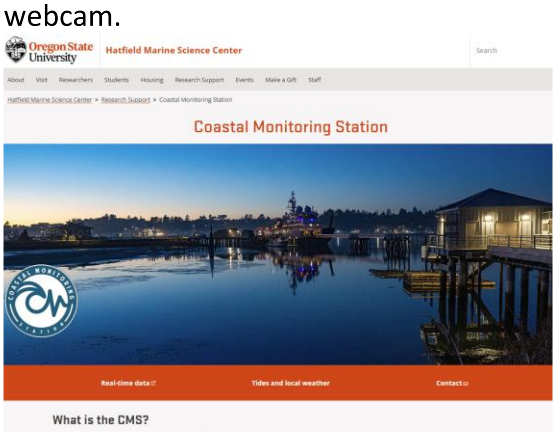

Figure 24. The Coastal Monitoring Station website and QR code.

New Instrumentation

Using funds from a no-cost extension within the present OOST grant, Hatfield purchased a Vaisala WXT536 weather unit in fall 2025 (Fig. 25A). This compact instrument will measure temperature, humidity, wind speed and direction, barometric pressure, and precipitation. CMS staff are working with the OR State Climatologist and the HMSC iLab for placement and installation.

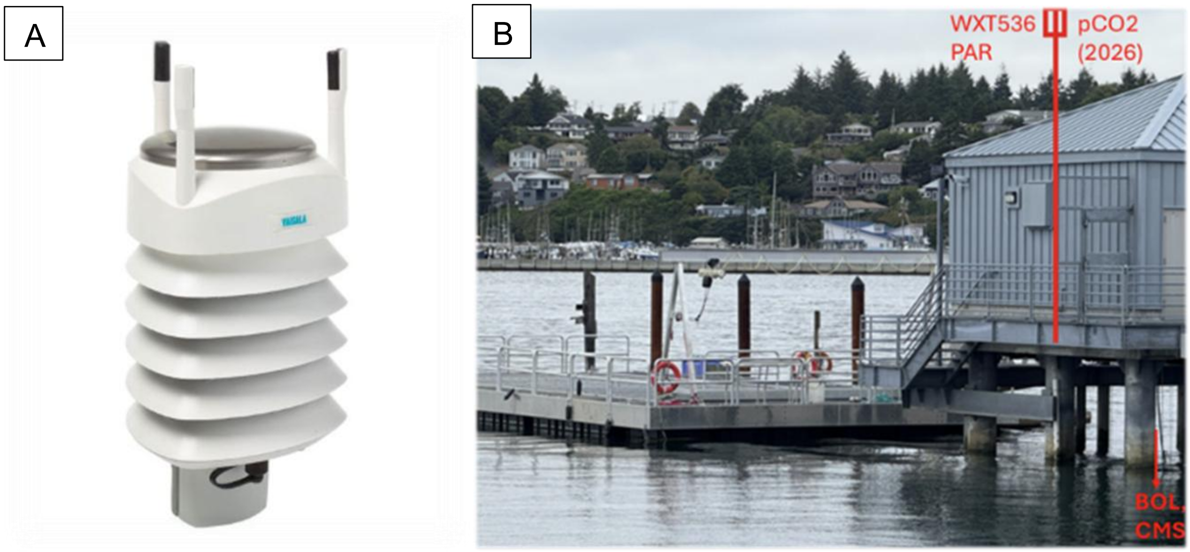

Figure 25. Vaisala WXT536 weather unit (A) and air pCO2 proposed locations (B) on the HMSC dock.

The air pCO_2 inlet tube from the BOL will be installed on the new weather mast (Fig. 25B). In combination with wind speed and in-water pCO_2, the calculated air-estuary CO_2 flux will be added to the CMS data stream in 2026.

Ongoing Collaborations

Cooperative partnerships are at the core of the CMS and are critical moving forward. Below are four examples of new and developing collaborations:

1. **Reinstatement on NANOOS.** The HMSC monitoring site has been inactive on NANOOS since 2017, when the EPA's data acquisition and logger system became obsolete. OSU's CORIOLIX team is overhauling the plotting software, metadata and transformed data formats of the CMS database during winter 2025-26. The new CMS ERDDAP (Fig. 14) adheres to the Climate-Forecast (CF) metadata conventions, which are scientific community standards for sharing data. Publishing CMS data in the CF convention will allow public data portals like NANOOS to easily harvest data from the CMS ERDDAP. The CF convention also maintains the CMS within the findable, accessible, interoperable and reusable (FAIR) principles for scientific data management and stewardship (https://www.go-fair.org/fair-principles/).

2. **Standardized Dataset, 1988-present.** There are now four sets of water quality data from the HMSC dock dating back to the 1980s, in different formats with varying metadata. HMSC staff are working with librarians at OSU's Guin and Valley libraries to merge and format all four datasets into the CF convention. The final product will be a data article in Scholars Archive or similar, with almost 40 years of CF-compliant water quality data assigned a single, citable Digital Object Identifier (DOI), which also aligns with FAIR principles.

3. **West Coast Monitoring Network**. The highly accurate OAH instruments selected for this project are industry and research standards used at other research stations along the West Coast, and on most modern oceanographic research vessels. This instrument set (Fig. 5) works in concert and links the HMSC Coastal Monitoring Station into a larger coastal monitoring effort with comparable measurements. For example, National Estuarine Research Reserves (NERRs) nation-wide, including the South Slough NERR in Charleston OR, also use the YSI EXO Sonde for real-time estuary monitoring. The OR Department of Environmental Quality and Tillamook Estuaries Partnership operate a monitoring station with an EXO Sonde and SeapHOx. The Burke-o-lator

(BOL) is deployed at oyster hatcheries in estuaries in WA and OR, and at a Coastal Margin Observation and Prediction (CMOP) site within the Columbia River Inter-Tribal Fish Commission (CRITFC). SeaBird Scientific's EcoTriplet, SeapHOx and SUNA are installed on the NH10 Oregon shelf mooring, and on many UNOLS research vessels in the NE Pacific. As Oregonian estuaries have unique characteristics regarding upwelling and biofouling, HMSC staff have begun collaborating with several of these groups to establish best practices for Oregonian marine stations as observatories. These collaborations will strengthen connections within the existing network of marine stations north to south, as well as ocean observatories to the west.

4. **IFCB HAB Identification Project.** In an ongoing collaboration with CEOAS at OSU, the IFCB (Fig. 26A) will be deployed in the CMS during 2026, to continue work on AI models for HAB species identification. There are currently no permanent IFCB deployments in coastal WA or OR. California has a network of 12 IFCBs that are already detecting HABs in coastal waters (Kenitz et al. 2023). Oregon resource management agencies depend on accurate, timely environmental data for effective decision-making regarding shellfish and water quality monitoring. The Oregon Department of Fish and Wildlife (ODFW) utilizes data on harmful algal blooms (HABs) to monitor and manage shellfish safety, ensuring public health protection and sustainable fisheries. CMS IFCB data (Fig. 26B) may add HAB species identification to the data available for this kind of critical resource management.

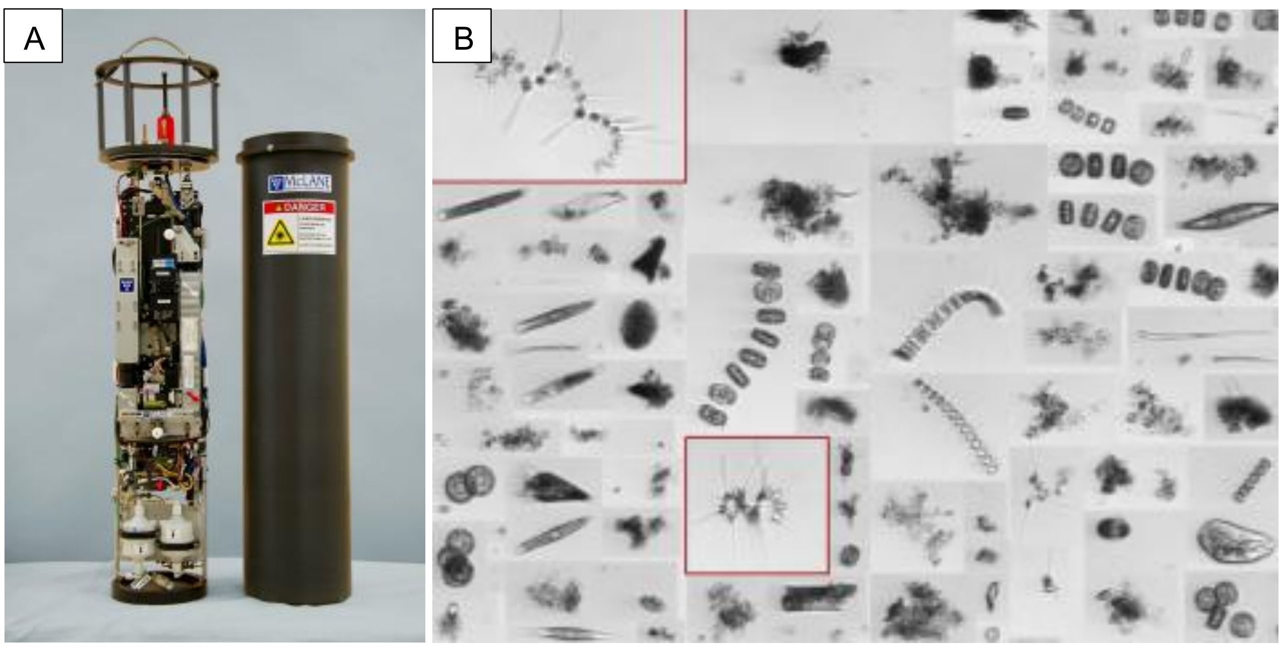

Figure 26. The Imaging Flow Cytobot (A) and (B) a mosaic of phytoplankton and microzooplankton images from the July 2025 IFCB deployment in the CMS.

Conclusion

Theme 1 of the 2019 Oregon OAH Action Plan (OAH Plan, 2019) was to "Strengthen OAH science, monitoring, and research". The CMS has accomplished items within this theme, including documenting oceanographic and biological conditions relating to OAH with open access data on the public CMS website, and supporting data collection and synthesis with regularly calibrated instruments and real-time QA/QC.

HMSC activities throughout 2025 and into 2026 are covering *Theme 4* of the OAH Plan to "Raise awareness of OAH science, impacts, and solutions". The Visitor Center exhibit, K-12 teacher workshops, and public CMS tours all build outreach for OAH science to the general public. Visitor surveys at the exhibit will continue to evaluate the effectiveness of OAH communication tools.

The CMS has remedied sampling deficiencies and data gaps identified in the 2020 Oregon OAH Legislative Report (OR Council on Ocean Acidification and Hypoxia, 2020):

- Funding to purchase and maintain additional high-resolution monitoring station(s) equipment in key location(s)
- Staff resources for maintaining equipment in the water
- Staff resources to process data to allow for real-time access to datasets and to disseminate processed data to stakeholders in actionable formats
- Additional analytical equipment to process discrete carbonate samples

The monitoring station equipment, new staff and data processing infrastructure are in place, and the additional equipment for carbonate samples (BOL) is rebuilding after the 2025 government shutdown. Discrete sample analysis will begin in 2026.

A broad range of users—from commercial industries to government agencies and the public—depend on environmental monitoring for informed decision-making and sustainable coastal resource use. The CMS enhances resilience and supports Oregon's economic and ecological goals. Yaquina Bay will continue to be "an economic, research, and management hub for Oregon (OR OAH Council, 2020) and the CMS will form the cornerstone of an expanding network of monitoring stations up and down the Oregon coast.

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