**Nutrient Sensor Action Challenge** 

**Registration**

Upload the completed form to challenge.gov by clicking on the

“**Submit Solution**” tab on the [Nutrient Sensor Action Challenge](http://www.challenge.gov/nutrient-sensor-action-challenge-stage-II) page.

**General Information**

**Project Lead:**

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| First name: | | | Curtis | | Last name: | | Bohlen |
| Organization: | | | | Casco Bay Estuary Partnership | | | |
| Title: | Director | | | | | | |
| Phone: | | (207)780-4820 | | | Email: | [Curtis.bohlen@maine.edu](mailto:Curtis.bohlen@maine.edu) | |

**Contact for matters of communication and media:**

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| --- | --- | --- | --- | --- | --- | --- | --- |
| First name: | | | Curtis | | Last name: | | Bohlen |
| Organization: | | | | Casco Bay Estuary Partnership | | | |
| Title: | Director | | | | | | |
| Phone: | | (207) 780-4820 | | | Email: | curtis.bohlen@maine.edu | |

Do you agree to allow EPA to share project information with journalists for potential coverage of the project?

☒ Yes

☐ No

Are there others who should be notified via email about webinars and other updates? (provide as many as needed)

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| --- | --- | --- | --- | --- | --- | --- | --- |
| First name: | | | Nicholas | | Last name: | | Keeney |
| Organization: | | | | University of Maine | | | |
| Title: |  | | | | | | |
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Is there is any information about the project that should be treated as confidential?

☐ Yes

☒ No

If yes, please explain:

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**Project Description and Potential for Impact [limit 250 words]**

Describe the specific nutrient issue that the project will address.

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| Casco Bay borders Portland and South Portland, Maine's principal economic hub. The region houses one quarter of Maine’s population and one third of the state’s jobs and economic output. Portland Harbor and nearby waters have among the highest total nitrogen (TN) concentrations observed on the Maine coast, with median conditions exceeding 90% of coastal nitrogen measurements in the state. The Maine legislature has formally recognized Casco Bay as a priority for addressing nutrient pollution and developing coastal nutrient criteria. 2017 saw an increase in both number and severity of toxic and nuisance algae blooms in Casco Bay. Reports of green algae mats smothering tidal flats are also increasing.  The Portland area has the fastest growing population of any part of Maine. Population growth increases both point source and nonpoint source nitrogen loads, raising concerns regarding the long-term combined impact of a growing population, changing land use, increasing precipitation and warming waters on the health of Casco Bay. But our understanding of both nutrient sources and dynamics of nutrients in the waters near Portland is limited by lack of time-resolved data.  Nutrients enter the waters near Portland from numerous sources, including stormwater runoff, combined sewer overflows (CSOs) and wastewater treatment facilities. A coalition of organizations has come together to improve understanding of nutrient dynamics in Casco Bay and identify cost-effective solutions for reducing nutrients entering the Bay. The data to be collected using high frequency nitrogen sensors will help us understand the contribution of different sources to local water quality problems. |

How will the addition of data and information from nutrient sensors inform and improve specific decisions and actions pertaining to nutrient management?

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| Existing nutrient monitoring in Casco Bay waters (relying on grab samples) lacks the temporal resolution to allow us to assess how water chemistry changes on small time scales. Time resolved data will allow us to correlate nitrogen concentrations with time-varying phenomena, such as tidal flux, precipitation, combined sewer overflow (CSO) events, and river discharge, thus helping clarify the relative contributions of different nutrient sources. In particular, these data will facilitate estimating the magnitude of non-point source nutrient loads to complement knowledge of point source loads. This improved understanding of nutrient sources will help prioritize nutrient reduction strategies.  Specifically, time-resolved nutrient data from our coastal waters will have near-term value in setting the context for several regulatory and management decisions, including:   1. The City of Portland, Maine faces three interlocking Clean Water Act permits, for wastewater, stormwater, and combined sewer overflow discharges. The City has recently embarked on integrated water planning, to identify cost-effective approaches to improve water quality in the waters around Portland across all three permits. Our nutrient monitoring data will provide essential information to the City and their technical consultants on levels and temporal dynamics of nutrients in nearshore waters. 2. Both the Portland and South Portland wastewater treatment plant permits were recently renewed, and for the first time, nitrogen discharges were an important part of the permitting process. The Portland Water District’s East End Wastewater Treatment Facility (the largest discharger in the state) has subsequently begun to modify plant operations to reduce nitrogen loads to the Bay by an anticipated 20-40%. The South Portland facility will soon begin to explore ways to optimize nitrogen removal as well. Our monitoring data will be used in future to understand the impact of these operational changes on conditions in the Bay 3. Twelve municipalities in the greater Portland region hold municipal stormwater permits. Preliminary data suggests that stormwater is a major contributor to nitrogen, yet municipal stormwater programs have not been tapped to reduce nitrogen entering the Bay. Time resolved nitrogen data will help us understand the importance of urban runoff as a source of nearshore nutrients, and influence future efforts at the municipal level to address stormwater-related pollutants. 4. Both the Maine state legislature and participants in the Casco Bay Nutrient Council (See below) have expressed interest in developing numerical nutrient criteria for Maine’s coastal waters. While the technical challenges of developing statewide criteria are formidable, more data on coastal nutrients are available in Casco Bay than elsewhere in the state. Our time resolved data will complement existing data and directly inform efforts to develop numerical criteria. |

What are the potential impacts and benefits of the project?

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| The primary purpose of better nutrient monitoring is to improve understanding of near-shore nutrient processes in Casco Bay. These data are especially valuable because they are directly linked to other ongoing efforts to improve understanding of coastal nutrients through the collaborative work of the Casco Bay Nutrient Council.  In 2017, Casco Bay Estuary Partnership convened the “Casco Bay Nutrient Council” to develop regional understanding of nutrient pollution and identify strategies for reducing nutrient loads to Casco Bay. The Council comprises twelve members drawn from dischargers, regulators, engineers, scientists and environmental advocates. In addition, members of an “advisory network” with nearly 50 members are invited to attend Council meetings to provide additional perspective and insight. The central goal of the Nutrient Council has been to identify effective and cost-effective strategies for reducing nitrogen loads to Casco Bay across multiple sources, including wastewater, stormwater, and combined sewer overflows. A preliminary report from the Nutrient Council is being drafted, and will be finalized by the end of the year.  The nitrogen monitoring program outlined here emerged in part from conversations at the Nutrient Council, and has been specifically designed to complement studies being led by Maine DEP and the University of Maine, including: collection of nutrient grab samples, mapping of surface nutrient concentrations, documentation of riverine nutrient inputs, and hydrodynamic modelling. Our goal is to share our growing understanding of nutrient processes with the members of the Council in the context of shared learning, to form the basis for future regulatory and water quality management decisions. The goal is collaborative problem solving based on the best available science, to identify cost-effective solutions to our region’s water quality challenges. |

**Sensors**

Provide the following information for each type of sensor that will be used in the project.

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| Manufacturer/Model | NOC “Lab on a Chip” Nitrate Sensor |
| Parameter being measured | Nitrate + Nitrate |
| Sensor Price | On loan from manufacturer. Estimated Cost: $8,000 to $10,000 |
| Maintenance Requirements | Seasonal deployment, with all reagents, standards and waste internal to device. Periodic checks to remove biofouling, download data, and check battery condition |
| Accuracy | Anticipated performance based on tests conducted as part of the Nutrient Sensor Challenge: +/- 10 % (~ 0.8 uM) at anticipated nitrate concentrations |
| Precision | Estimated ~ 0.3 uM, based on testing done as part of the Nutrient Sensor Challenge |
| Range | 0.025 to 1000 uM |

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| Manufacturer/Model | Greeneyes NuLAB, 2 Channel |
| Parameter being measured | Nitrate+ nitrite and ammonium |
| Sensor Price | $14,950 (Cost of core two channel sensor, without upgrades and peripherals)  $19,795 (combined cost for sensor system and all upgrades and peripherals)  ($10,000 Nutrient Action Challenge, Phase 1 prize applied to purchase) |
| Maintenance Requirements | Maintain waterproof housing. Periodic replacement of reagents and removal of wastes. Periodic checks to remove biofouling. Data telemetered via cell phone modem |
| Accuracy | Depends on accuracy of on-board standards and method interferences.  Anticipated performance: NOx: < 1 uM; NH4: < .5 uM |
| Precision | NOx: 3%; NH4: 3% (Typical, one SD at mid-range of scale, from manufacturer’s literature) |
| Range | NOx: 0.7 to 200 uM; NH4: 0.3 to 21.5 uM |

**Monitoring [limit 250 words]**

What is the general schedule for the project? Include: sensor deployment, maintenance and calibration, data analysis, and approximate date that data will be available to the Challenge Administrator.

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| We plan to deploy two nitrogen sensor systems in the waters of Casco Bay, Maine, to provide insight into nitrogen entering Casco Bay from the Portland region from wastewater treatment facilities, stormwater, combined sewer overflows, and river discharge.  Sensors will be deployed beginning in July of 2018 and remain in operation through October. Data will be downloaded, and equipment checked and serviced as needed approximately every three weeks throughout the deployment period. QA/QC samples will be collected every time the sensors are serviced, and equipment will be recalibrated at least every six weeks during deployment, or more often if comparison with QA/QC samples suggests corrective action is needed.  We plan for initial data to be available for on-line access in waterML format by October 1. Preliminary data visualizations will be available on-line by October 1 as well. The full season’s QA/QC’d data will be available on-line by mid-November. Data visualizations and integrated data delivery products incorporating all sensor data, complementary grab samples, and ancillary data will be available online by December 1.  This effort is part of a larger, ongoing effort to establish a long-term nutrient monitoring strategy for Casco Bay, and especially the waters in and around Portland. We anticipate deploying nutrient sensors again in 2019. Any funds available from the Challenge prize will go directly towards purchasing and deploying equipment for nitrogen analysis in 2019. Our goal in 2019 will be to deploy equipment by early May, to directly observe the effects on water quality of (seasonal) nutrient optimization by the East End Wastewater Treatment Facility. |

Describe location (provide map or link to a map) and monitoring frequency for each sensor.

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| Sensors will be deployed at two locations, shown as green hexagons on the accompanying map.   1. NOC Lab on chip: Off a mooring in the mooring field at Portland’s East End (approximate location: 43.67134 N, 70.23514 W ; WGS84). This site is within 100 meters of the main discharge point from Portland Water District’s East End Wastewater Treatment Plant. 2. Greeneyes NuLAB: In a water-resistant enclosure from the Portland Street Pier, in South Portland, Maine (Approximate location: 43.651285 N, 70.24367 W; WGS 1984). This site samples waters strongly influenced by stormwater runoff and combined sewer overflows.   Other locations shown on the map are for coordinated grab sample and sonde deployments being managed by Maine’s Department of Environmental Protection. Nitrogen sensor data will be used to provide temporal context for the DEP grab samples, while DEP sonde data will provide additional spatial context for data from the nitroegen monitoring devices.  C:\Users\cbohlen\Desktop\Nutrient Monitoring 2018\Monitoring Locations FINAL.jpg |

If applicable, describe any existing monitoring data being collected in the area and whether these data will be integrated:

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| * A complementary monitoring program, managed by the Maine Department of Environmental Protection and Friends of Casco Bay will deploy four water quality sondes in nearby waters, collecting data on temperature, salinity, dissolved oxygen, pH and Chlorophyll A. Grab samples will be collected from nine nearby locations, on eight dates, to be analyzed for major nutrients, among other parameters. * Maine DEP is monitoring the health and extent of eelgrass beds at various distances from major nutrient sources, to evaluate whether nutrient pollution is having detrimental effects on eelgrass. * University of Maine scientists have developed a system of boat-mounted nitrogen (ammonium and nitrate+nitrite) sensors coupled to GPS equipment to allow rapid mapping of surface nutrients. Three cruises in Portland waters are planned for the summer of 2018. * University of Maine researchers are wrapping up a two years study of nutrients in the Bay’s major tributaries and in selected urban streams, documenting watershed loadings of nitrogen. * Friends of Casco Bay has been measuring nitrogen concentrations in grab samples collected from nearby waters for nearly two decades, providing important historical data for comparison. In July of 2016, they managed simultaneous collection of dozens of surface grab samples by volunteers, providing excellent spatial coverage for the waters of Portland Harbor.   Our data analysis strategy also taps ancillary data sources, including data on weather, tides, and river discharge downloaded from on-line sources, and data on sewage treatment plant discharges and CSO events, from dischargers collaborating with us on this project. |

**Data Architecture [limit 250 words]** [Web service endpoint and authentication information are due to Challenge Administrator by November 1, 2018.]

Describe the plan for sensor data collection and management. Please provide any information about plans to meet data and web interface standards. Also identify any software products you intend to use that support the use of the standards.

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| Data will be downloaded in the field during regular cleaning and maintenance. Raw data are processed by vendor-supplied software into an intermediate form, for visual and automatic QA of drift and outliers using WRDB 6.1 and R as defined in existing DEP-approved Quality Assurance Project Plans. Data are compared to laboratory analyses to validate/flag observations, and correct for linear drift if appropriate. Cleaned data will be converted to WaterML using R/Python scripts, and archived along with raw files in the Maine Dataverse Network (MDVN). They will also be combined with similarly processed complimentary and ancillary data sets (to include multi-parameter sondes, river discharge measurements, and tidal heights) and concatenated as single series. Project members will explore data for relationships and inconsistencies, and a final release version with full metadata will be prepared as WaterML files (additional options include CSV and JSON). Data will be publicly accessible and permanently archived (with version control) through MDVN, which is maintained by the UMaine Advanced Computing Group. Dataverse also provides clear terms of use and persistent citation path, and storage of accompanying analyses and reports. Upload is either manual or through a RESTful API. Access is either manual through a web interface, or through programmatic search and access methods. A public-facing visualization and data access application will be developed to take advantage of the MDVN APIs, and provide a OGC-compliant web service that incorporates other available API accessible streams. |