# Perspectives on Emerging Water Quality Monitoring Technologies: Understanding Factors that Affect Technology Adoption in Coastal Management

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## Introduction

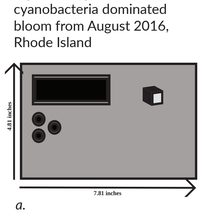
There are numerous technological acceptance and adoption theories and models that seek to explain how, why, and at what rate new ideas and technologies diffuse through human systems over time (e.g., Crann et al. 2015; Rice and Pearce 2015; Rogers 2003). While the models can be used to explain why users adopt technologies, they do so in a general way and few, if any, studies have addressed those factors that affect monitoring technology adoption in the field of coastal management. This study explores coastal stakeholders' perspectives on existing and emerging monitoring technologies to better understand the factors that affect water quality monitoring technology adoption in coastal management.

## Background

Twelve in-person interviews were conducted with RI coastal managers and other individuals responsible for monitoring coastal waters. Interview questions focused on: (1) technologies that coastal managers are currently utilizing and the factors that influenced adoption of these technologies; and (2) respondent's perceptions and attitudes related to the potential adoption of innovative technologies, such as the nanoscale biosensor. Interviews were transcribed from recordings and were coded and analyzed using NVivo software. Here we present preliminary findings from a sub-set of the interviews.

Harmful algal blooms (HABs) have increased in frequency, duration, geographic extent, number of toxic species, number of fisheries effects, and costs (Heisler et al. 2008). Historically, water quality monitoring techniques for HABs have utilized costly, time and labor intensive on-site sampling and have been limited on temporal and spatial scales (Glasgow et al. 2004). We are collaborating with researchers at Roger Williams University to develop a nanoscale biosensor that uses visible light spectroscopy to measure the presence of HABs (or other biological organisms) in a water sample. This innovation will allow for increased sensitivity and will ultimately aid in early detection of HABs and other biological contaminants in coastal waters.

Figure 1. Algae sample of a cyanobacteria dominated bloom from August 2016, Rhode Island




*a.*

*b.*

Figure 2*a* and 2*b*. *(a)* Nanoscale biosensor illustration. *(b)* First 3D printed prototype of the nanoscale biosensor (August 2016).

## Methods

Theories, such as Diffusion of Innovations Theory, Unified Theory of Acceptance and Use of Technology (UTAUT), and Technology Acceptance Model (TAM), explain social, individual, and contextual factors and processes that affect adoption and acceptance of information technologies. Individual predictors of technology adoption from these theories can be grouped into four broad categories: technological, contextual, individual, and organizational (Table 1). Factors affecting the adoption of technology vary depending on the user population (Renaud and van Biljon 2008). No studies have examined how different types of users adopt water quality monitoring technologies in a coastal management context.

| Predictor Category | Predictors of Technology Adoption | Technology Adoption or Acceptance Theory |
|---|---|---|
| Technological | Relative Advantage | DIT |
| | Complexity | DIT |
| | Trialability | DIT |
| | Observability | DIT |
| | Perceived Ease of Use | TAM |
| | Compatibility | DIT |
| Contextual | Compatibility | DIT |
| | Technological Conditions | UTATU |
| | Perceived Usefulness | TAM |
| Individual | Perceived Usefulness | UTATU |
| | Internal Conditions | UTATU |
| Organizational | External Conditions | UTATU |
| | Organizational Conditions | UTATU |

Table 1. Categorization of proposed predictors of successful technology adoption (Crann et al., 2015; Rice and Pearce, 2015; Rogers, 2003).

## PreliminaryResults

The five interview participants included in this analysis worked at state agencies, private companies, and non-profit organizations.

The most commonly used water quality sampling technologies for participants were the YSI Meter (85, 90, and 2030 models) and the Sea-Bird Coastal Sonde (models unknown). Both instruments are used to measure a suite of water quality parameters: dissolved oxygen, temperature, salinity, and pH. Other instruments used for monitoring include a Eureka, a Enterolert, Quantative PCR (QPCR), a refractometer, a secchi disk, a thermometer, an underwater camera and laser, a pH and alkalinity meter, a fluorometer, and a cyanoscope.

All interview participants were open to using new water quality monitoring technology. Several factors were cited as being the most important factor when deciding to adopt new technology: cost, relative advance (rapid response time), quality of customer service, organizational conditions (consistency across projects), and technological conditions (durability and portability of instrument). Three out of five participants cited cost as an important, and possibly, limiting factor when deciding to adopt new monitoring technologies (Figure 3).

Four out of five interview participants reacted positively towards the nanoscale biosensor for in situ algae monitoring. However, the reliability of the device was cited as a concern to coastal stakeholders. Additionally, at least three participants expressed concern that the small water sample volume may not be representative of the water body of interest and therefore, not accurately reflect the concentration of algae in the water body.

YSI Pro 2030

pH meter

IDEXX Enterolert Quanti-Tray 2000, showing a positive (flourescence) for enterococcus

Secchi disk

Refractometer

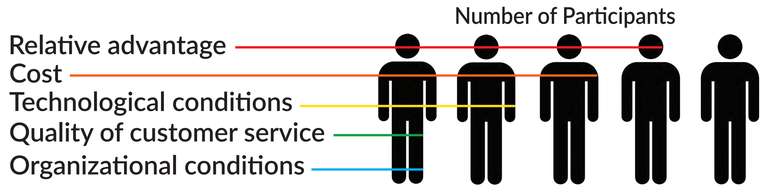



Figure 3. The length of each line represents the number of participants who cited relative advatages, cost, technological conditions, quality of customer service, and organizational condition as the most important factors when deciding to adopt new monitoring technology.

## Discussion and Next Steps

Findings from this study show that factors regarding technological conditions, external conditions (Table 1) greatly influence respondents' decisions to adopt new water quality monitoring technologies. These findings align with recent research regarding factors that likely influence technology adoption, with an emphasis on reliability and cost of the new monitoring technology (Crann et al. 2015; Renaud and van Biljon 2008). In addition, respondents felt that emerging technologies, like the nanoscale biosensor, had multiple applications in coastal management and would potentially be a useful device, as long as it is low cost and known to be reliable.

These preliminary findings build on the framework of factors affecting water quality technology adoption in coastal management. Further analysis of all of our interviews is required to fully understand attitudes of RI coastal managers towards factors that affect water quality monitoring technology adoption. These findings will also be used to inform the development of an on-line structured survey of coastal managers in the National Estuarine Research Reserve System (NERRS). The survey will test the framework of factors that affect technology adoption in coastal management within the NERRS system. Findings from this study provide a more detailed understanding of perceptions and attitudes toward existing and emerging monitoring technology and identify potential technological innovations that can be used to address changing environmental conditions.

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