



Nutrient Sensor Challenge

Preliminary Overview of Markets for Challenge-based Nutrient Sensors

By

Dennis King, Patrick Hagan, and Elizabeth Price

University of Maryland Center for Environmental Science and

Alliance for Coastal Technologies

Introduction

The Nutrient Sensor Challenge is designed to accelerate the development and deployment of sensors that can measure in water (in situ) dissolved nitrogen and phosphorus reliably, with reasonable precision and accuracy, in real time for three months without maintenance, and be easy to use and cost less than \$5,000. Sensor systems with these characteristics would represent a dramatic improvement over conventional methods of measuring in water nutrients which involve either manually collecting water samples and sending them to a laboratory for analysis, or inserting probes at accessible sites to take sample measurements.

Members of the Challenge team have conducted informal preliminary surveys of some prospective users of sensors meeting Challenge requirements. These surveys indicated that their low cost and ease of use would allow them to out-compete conventional nutrient measurement methods in most existing markets, and also result in existing markets expanding and new markets developing. Responses from the hundred or so individuals surveyed indicated they represented a market for thousands of units. Economists from the University of Maryland, working with the Alliance for Coastal Technologies (ACT) and the rest of the Challenge team, are building on the results of that initial research, examining data, and conducting interviews to assess the full extent of potential markets, identify critical market drivers in specific market segments, and determine likely levels and rates of adoption of Challenge-based nutrient sensors in selected market segments.

Twenty-nine teams registered to participate in the Nutrient Sensor Challenge and are engaged in research to develop sensor-based technologies that will be ready for market in 2017. They have made these commitments primarily because they anticipate that there will be significant markets within the U.S. for these sensors, and potentially many more markets overseas. The Challenge participants recognize that the sensors they develop may not exactly meet challenge targets, but they also know that potential users of these types of sensors have different needs in terms of the frequency, precision, and accuracy of nutrient measurements, water conditions where they can be used, and ease of use. Additionally, potential users have different cost constraints that will affect their willingness to pay for sensors. Sensors under development that do not exactly meet challenge targets, and slightly modified versions of sensors that do, may have significant specialized markets beyond those targeted by the challenge. To the extent possible, ongoing market research is aimed at identifying potential in these specialized markets as well as broader markets for sensors that meet Challenge cost/performance targets.



Nutrient Sensor Challenge

Overall Demand

High concentrations of nitrogen and phosphorus in rivers, streams, lakes, estuaries, and coastal waters have been determined to be the direct and indirect cause of many localized and regional environmental, public health, and economic problems. The search for solutions to these problems has already resulted in significant demand for measurements of in water nutrients—to support scientific research, monitor water quality, estimate safe maximum nutrient loads, determine acceptable discharge standards, set discharge limits, predict hypoxic conditions or “dead zones”, and comply with regulation-driven reporting requirements. This research and regulation driven demand will be the source of the most significant markets for Challenge-based sensors.

However, there are other potential markets among users such as waste water and drinking water treatment facilities and agriculture, aquaculture, and energy production sectors that need nutrient measures to manage operations, reduce operating costs and waste, and control risks.

Preliminary surveys of government, university, and non-profit organizations by the Challenge team determined that while the use of nutrient measurement tools has increased in recent years, the high cost of acquiring and using them has limited their ability to supply affordable nutrient measurement data. This, in turn has limited the amount of location-specific research, monitoring and reporting of nutrient measurements that are required to assess, compare, and validate the effectiveness of nutrient management options.

The organizations that took part in Challenge-based focus groups and surveys indicated that they believe the demand for sensors that met challenge targets among researchers, regulators, the regulated community, and among the science and engineering companies who supply these groups with nutrient measurements would be substantial. Emerging regional strategies for reducing the cost of achieving nutrient discharge reduction goals and managing urban and rural sources of in water nutrients, such as water quality trading and tax/subsidy programs, require measurements of nutrient flows to establish treatment “efficiencies”, “score” water quality trades, and target compliance assistance programs. This is creating other potentially large markets.

Market Characteristics

While all indicators show that the market for nutrient measurements in the U.S. and overseas will be large, the different needs of users indicate that markets for Challenge-based nutrient sensors will be fragmented with several distinct market segments. General market segments include: federal, state, and local governments, universities and research institutions, non-profit organizations, and specific industrial sectors, such as waste water treatment and drinking water treatment facilities, aquaculture and agricultural operations, and energy producers.

The needs of users in these market segments will differ, but the market potential for Challenge-based technologies in each of these market segments will depend primarily on their size (number of entities) and expected levels and rates of adoption of sensor-based technologies in those market segments (% of entities). We are currently estimating the potential size of these market segments. Industry data, for example, indicate there are more than 16,000 waste water treatment



Nutrient Sensor Challenge

facilities, or publicly owned treatment works (POTWs), treating sewage water in the United States. More than 500 of these POTWs treat more than ten million gallons of waste water per day and currently measure in water nutrients to both manage internal operations and comply with reporting requirements. Initial interviews indicate that if sensors that met Challenge targets were available, each of these larger facilities may demand 20 or more of them to deploy at different locations within treatment tanks in order to improve internal water flow and treatment decisions. Industrial outfalls that do not treat sewage, but need to control nutrient inflows and outflows represent an additional potential market.

Another market segment is the academic research community. A significant source of long-term aquatic nutrient research takes place at the more than 500 marine laboratories or biological field stations worldwide. While some of these institutions are large, initial interviews at some smaller ones suggest that demand of up to 10 sensors per laboratory might be expected if Challenge targets are met.

Aquaculture and agriculture are additional market segments that may be significant.. For example, there are several hundred hydroponic greenhouse operations in the U.S. that may utilize Challenge-based nutrient sensors to control their fertilizer application rates. Employing these sensors in this type of application has the potential to yield benefits for growers in terms of reduced fertilizer and water use as well as increased crop yield and product quality. The more than 3,000 aquaculture farms in the U.S. represent another significant potential market for Challenge-based sensors .More research and interviewing is necessary to determine which types of agriculture (e.g., greenhouses, nurseries, field crops) and aquaculture (e.g., freshwater/saltwater, intensive/extensive) show the greatest sensor market potential and what types of sensors have the greatest potential in those markets.

Adoption rates in each market segment will be driven by many factors that may be beyond the control of some users, such as government and university research priorities, federal and state regulatory requirements, the acceptance of sensor-based nutrient measurements by regulators, and the cost of supplying nutrient measurements using competing technologies. Other factors related to the overall economy, government grant-making and regulatory monitoring budgets, the perceived urgency of nutrient-related and other environmental problems, and the pace at which nutrient-related regulations and related reporting requirements are promulgated and enforced will also affect adoption rates. As a result, there will always be significant uncertainty associated with predictions of the size of potential nutrient sensor markets and expected levels and rates of adoption of sensor-based technologies.



Nutrient Sensor Challenge

Market Drivers

We are attempting to predict major markets for sensor technologies that meet Challenge specifications by examining their potential size and market drivers that are likely to affect levels and rates of adoption. . Some of the concepts and factors that are guiding our research are as follows:

- Actual and potential markets for nutrient sensors can be characterized generally in terms of market segments (e.g., who might buy them) and market drivers (e.g., why they will buy them).
- Increases in market demand for nutrient sensors in each market segment can be characterized in two ways: (1) the slope of a downward sloping demand curve that shows how quantity demand increases as price decreases (2) factors that will shift the demand curve up, resulting in more nutrient sensors being sold at any given price.
- Market and regulatory forces that determine the demand for nutrient information and the resulting demand for nutrient sensors are all trending upward, but demand can be expected to be extremely price sensitive, especially, related to applications in less developed parts of the world.
- Users of nutrient-related information differ significantly in terms of why they want nutrient measurements, the frequency, precision, and accuracy of the nutrient measurements they need, where they need nutrient measurements, and the amount they can spend.
- Market demand (willingness to pay) for nutrient sensors depends on the “value of information” they provide compared to technology and methods currently being used. This will differ among users.
- The “value of information” about nutrients to various users (market segments) will depend on how it can be used to reduce risks or costs, or to increase some measure of benefits. This will depend to a large extent on the value of the results of research and monitoring programs that rely on nutrient measurements.
- Market demand for nutrient sensors will depend partly on their capacity to supply valuable information at a lower cost, and/or a more useful way, and/or a more reliable basis than competing methods.
- Market demand for nutrient sensors will reflect levels and rates of adoption by various market segments, which will depend partly on their availability and acceptability as sources of nutrient measurements for purposes of: a) conducting nutrient-related research; b) monitoring nutrients and sources of nutrients; c) validating the effectiveness of nutrient management practices, d) verifying compliance with nutrient-related regulations, e) justifying the basis of “scoring” nutrient-related water quality trades.
- Many users of in water nutrient measurements to make decisions and meet regulatory requirements rely on data supplied by outside contractors, such as engineering and environmental consulting firms, which may represent the most significant direct market for nutrient sensors.



Nutrient Sensor Challenge

Next Steps

We have nearly completed the first two phases of our project: background research, which includes a review of available information about supply and demand for nutrient measurements and related technologies and methods, and preliminary interviews to identify general market segments and subcategories within each market segment. We are using available data and interviews to address many different questions, including the following:

- What are the rates and levels of adoption of new technologies in research, government, industry contexts?
- What is driving the current need for nutrient observations (e.g., research, compliance, internal decision making, advocacy)?
- What are the types, frequencies, and accuracy and precision of nutrient observations current adopters use or could use?
- Is demand for nutrient measurements determined by unit costs, regulatory requirements, internal process management, or other factors?
- Will demand for nutrient observations be affected by sharp decline in price with and without any associated change in regulatory requirements?
- What are likely adoption rates of challenge-based technologies, and are there related opportunities and challenges?

The next phases of our research will involve the development of interview protocols, including discussion of potential contacts, methods, and questions with Challenge management team; preparing draft interview materials for review by Challenge management team; pretesting draft interview materials; conducting interviews; analyzing interview results; and preparing a draft report for review by project team members. A final report will be prepared this fall (2015).