American University Nutrient Sensor Questionnaire
Summary Findings
May 15, 2014

Respondents:

- n=84 (filters for: corporate conflict of interest, foreign, no substantive answers)
- from 29 states and Washington, DC

Organization type (n=84)

sector	Academic	Corporate	Government	Non-profit
n	26	5	29	24
%	31	6	35	29

Primary use of in situ nutrient data (n=84)

Data use	Monitoring	Research	Regulation	Other
n	65	53	15	10
%	77	63	18	12

- Other included education, policy and communication initiatives

Primary aquatic environment(s) in which sensors would need to operate (n=84)

environment	Freshwater	Brackish	Marine	All of the above	Other
n	77	33	26	18	9
%	92	39	31	21	11

- Other included groundwater, hypersaline waters, activated sludge, agricultural wastes

Maximum flow rate a sensor would need to withstand

- Exclude due to wording

Likely presence of significant levels of CDOM and turbidity in the target environment(s)(n=80)

CDOM/turbidity	High	Medium	Low	Other
n	53	31	8	2
%	66	39	10	3

- Other: varies
- Some respondents had more than one answer

Mean nutrient preference for sensor (1 most interested- 5 least interested)(n=83)

nutrient	NO3	NH4	Total N	SRP	Total P
mean rank	1.9	3.4	2.8	3.3	3.2

- 55% or respondents listed NO3 as #1

Nitrate + nitrite sensors:

Interest in: 93% of respondents (n=82)
Proposed detection limits: 0.05-60 mg/l

LDL (n=71)

mg/l	0.05	0.1	0.5	1	Other
n	30	20	5	5	11
%	42	28	7	7	15

UDL (n=71)

mg/l	20	40	60	80	Other
n	27	20	9	5	10
%	38	28	13	7	14

- LDL of 0.05 mg/l satisfies 85% of respondents
- UDL of 60 mg/l satisfies 85% of respondents (including some of other)

Ammonium/ammonia sensors:

Interest in: 81% of respondents (n=78)
Proposed detection limits: 0.05-20 mg/l

LDL (n=56)

mg/l	0.05	0.1	0.5	1	Other
n	29	13	3	1	10
%	52	23	5	2	18

UDL (n=57)

mg/l	1	5	10	20	Other
n	5	16	16	15	5
%	9	28	28	26	9

- LDL of 0.05 mg/l satisfies 82% of respondents
- UDL of 20 mg/l satisfies 98% of respondents (including some of other)

Total N sensors:

Interest in: 77% of respondents (n=77)
Proposed detection limits: 0.1-60 mg/l

LDL (n=52)

mg/l	0.1	0.5	1	5	Other
n	34	10	3	0	5
%	65	19	6	0	10

UDL (n=52)

mg/l	20	40	60	80	Other
n	19	14	7	7	5
%	37	27	13	13	10

- LDL of 0.1 mg/l satisfies 90% of respondents
- UDL of 60 mg/l satisfies 85% of respondents (including some of other)

Soluble reactive P sensors:

Interest in: 79% respondents (n=76)
Proposed detection limits: 0.005-5 mg/l

LDL (n=53)

mg/l	0.005	0.01	0.05	0.1	Other
n	21	15	5	4	8
%	40	28	9	8	15

UDL (n=53)

mg/l	0.5	1	2	3	4	5	Other
n	5	11	9	6	3	16	3
%	9	21	17	11	6	30	6

- LDL of 0.005 mg/l satisfies 85% of respondents
- UDL of 5 mg/l satisfies 96% of respondents (including some of other)

Total P sensors:

Interest in: 83% respondents (n=76)
Proposed detection limits: 0.1-5 mg/l

LDL (n=55)

mg/l	0.01	0.05	0.1	Other
n	26	15	5	9
%	47	27	9	16

UDL (n=56)

mg/l	1	2	3	4	5	Other
n	4	10	9	8	22	3
%	7	18	16	14	39	5

- LDL of 0.01 mg/l satisfies 84% of respondents
- UDL of 5 mg/l satisfies 97% of respondents

Minimum level of accuracy needed in a sensor (n=54)

Accuracy	1%	5%	10%	Other
n	15	28	8	3
%	28	52	15	6

- 5% accuracy would satisfy 67% of respondents; 1% accuracy would satisfy 94% of respondents
- 72% of respondents say that the minimum accuracy needed would not vary by nutrient (n=54).

Minimum level of precision needed in a sensor

Precision	1%	5%	10%	Other
n	19	25	7	1
%	37	48	13	2

- 5% accuracy would satisfy 62% of respondents; 1% accuracy would satisfy 98% of respondents (n=52)
- 77% of respondents say that the minimum accuracy needed will not vary by nutrient (n=53).

Other technical specifications (n=24):

Respondents were interested in low-maintenance sensors that could be deployed in a wide variety of aquatic environments, with variability in salinity, temperature, turbidity and CDOM. There was widespread interest in sensors that resisted biofouling and were easy to clean. Wipers and cleaners were recommends by several respondents. Individual respondents offered a number of other suggestions including:

- A triggering feature that allowed sensors to record under particular conditions (e.g. high flow rates)
- Ability to deploy in various orientations/ measure flows from different directions
- Simple mechanism to allow for mounting in housings
- External indicator to show running
- Bromide sensors (if it could detect concentrations as low as 0.002-0.005 mg/l)
- Paired pH sensors

Preferred method of data transmission sensors deployed in situ (n=64)

Data transmission mechanism	WiFi	Cellular	Satelite	HF Radio	Other
n	23	51	17	11	7
%	36	80	27	17	11

- Other included manual download and bluetooth

Preference for nutrient sensor integration into existing instruments/systems/ data bases (n=59)

Integration mechanism	integrated into existing datalogger	integrated into new commercial datalogger	stand-alone units with internal datalogging	Other
n	37	13	35	2
%	63	22	59	3

- Other: streaming capability to web database

Measurement frequency (n=67)

Measurement frequency	Hourly	Daily	Weekly	Monthly	Other
n	45	22	9	3	18
%	67	33	13	4	27

- Other: < hourly, during storm events

Effort on QA/QC of sensor data (n=64)

QA/QC	Dedicated technical support	No-dedicated (e.g. < half-time) technical support	Little or no technical support
n	24	28	14
%	38	44	22

- Some respondents had different levels depending on site

Expectation for instrument lifetime, e.g. the amount of time before component replacement needs to occur (at your cost) (n=66)

Instrument lifetime	1-2 years	2-4 years	4-6 years	> 6 years	Other
n	8	26	19	11	4
%	12	39	29	17	6

- Other: depends on the cost
- 79% of respondents would be happy with 4-6 years or less
- Some respondents had more than one answer (including in 1-6 year pool)

Ability to provide in-house maintenance/calibration of the instrument (n=65)

In-house maintenance	monthly	seasonally	annually	less than 1 time per year	Other
n	36	20	8	1	8
%	55	31	12	2	12

- Other: weekly, biweekly, varies
- Some respondents had more than one answer

Frequency of off-site manufacturer maintenance/calibration of the instrument (n=62)

Manufacturer maintenance	once per year	once every 2 years	once every 4 years	once every > 4 years	Other
n	24	24	8	4	5
%	39	39	13	6	8

- Other: field only, frequently (snarky tone based on past experience)
- 77% of respondents satisfied with once every 2 years, 90% of respondents satisfied with once every 4 years
- Some respondents had more than one answer

Difficulty in accessing measurement site for sensor deployment or retrieval purposes (n=63)

Site Access	Easily accessible (could access within a day if needed)	Moderately accessible (could access within a week)	Difficult to access (access challenging in less than a week)	Other
n	40	25	6	2
%	63	40	10	3

- Other: varies depending on site
- Some respondents had more than one answer

Sensor deployment setting (n=64)

Deployment	Submerged, on an unattended buoy	Submerged, shore-side	Submerged, deployed from a vessel	Not submerged, shore-side	Not submerged, on a vessel	Other
n	27	37	11	13	4	13
%	42	58	17	20	6	20

- Other: profiling floats; autonomous vehicles; gliders; from bridge; in water remediation facility; deployed and anchored near bottom; submerged attached to piling; in headwater or intermittent stream; in well
- Some respondents had more than one answer

Willingness to consider using sensors with slightly lower precision and/or accuracy if they were significantly less expensive (n=66)

Response	No	Yes	Other
n	13	43	10
%	20	65	15

- Other: in certain cases; depends on how much cost and accuracy/precision change

Affordable price range (n=66):

Affordable price	<$1,000, purchase fewer than 10	<$1,000, purchase 10 or more	$1,000 - $5,000, purchase fewer than 10	$1,000 - $5,000, purchase 10 or more	$5,000 - $10,000, purchase fewer than 10	$5,000 - $10,000, purchase 10 or more	Other
n	9	14	32	14	6	4	2
%	14	21	48	21	9	6	3

- Other: depends on quality and longevity; depends on bids on comparable equipment
- Quote: “If a field verified TP or TN sensor costs less than $5,000 and met spec for more than 2-3 years, you would have a very large interests from a variety of organizations”
- Some respondents had more than one answer

Other general requirements for use (e.g. size, weight, power, how you would like to interact with the device) (n=34)

Size/Weight

Sensors should be small, lightweight, and potentially concealable. They should be easy to transport to field sites and be easily handled by a single person. 4” diameter and 18-24”length were recommended.

Size and weight are less of an issue if sites are readily accessible. Respondents noted that they would care less about size and weight if the sensor measured multiple nutrient parameters or if the power demands were not large.

Power

Respondents indicated an interest in sensors that had low power requirements so that they could be used reliably in areas that did not have access to power lines. Ideally, they could be powered by a battery with a long life time (eg. 4-8 weeks) or rechargeable through solar panels. DC power (eg. 12VDC battery) was cited more often than AC power. A sleep mode feature was recommended to minimize power loss between sampling.

Interaction

Interaction with the unit should be as simple as possible, allowing users to use a computer to easily download data and check the status of the sensor. The output signal could be analog or digital. There was interest in compatibility with existing data loggers and sonades (Campbell and YSI, in particular), and an interest in improved methods for retrieving data from self-logging sensors. The option for downloading data into Excel or compatible software was noted by one respondent. Another respondent requested PnP functionality/integrated metadata and optional board processing/data storage.

Other features of interest included:

- Data acquisition interface (LEDs that denote sample acquisition)
- Reference beam variable path length for dealing with varying optical densities of water
- Sensor handle or loop at the top for securing
- Stability with time, temperature, salinity
- Durability
- Ability to service in field
- Resistance to biofouling and sedimentation
- Multi parameter measurements (particularly for educational purposes)
- Security feature to avoid vandalism