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Customer Needs and Use Assessment Survey

USE OF, SATISFACTION WITH, AND REQUIREMENTS FOR IN SITU HYDROCARBON SENSORS

Conducted by the Alliance for Coastal Technologies

2011

I. OBJECTIVE

The fundamental goal of this survey was to assess user needs and applications and to provide the focus for an Alliance for Coastal Technologies (ACT, www.act-us.info) Technology Verification of hydrocarbon sensors. The Customer Needs and Use Assessment strives to better understand how hydrocarbon sensors are used, and not to promote a specific approach to recording/reporting hydrocarbon values. We hope this information can also assist manufacturers in refining hydrocarbon sensor technologies to better address user priorities.

II. SURVEY COMPOSITION

From January 6th to January 31st, 2011, ACT conducted a web-based survey to aid in a Customer Needs and Use Assessment of hydrocarbon sensors. ACT Headquarters, Partners and Hydrocarbon Technical Advisory Committee members developed the questionnaire. SurveyMonkey.com provided the web-based survey tool. The survey contained a total of fifteen questions (listed below along with their responses), divided into three sections: Application, Specification, and Recommendations.

III. DISTRIBUTION OF SURVEY

Survey participants were divided into two groups: "Users" and "Vendors." Users were asked to consider the primary in situ hydrocarbon sensor(s) they used when responding to each question. Unaware if any specific vendor (sensor manufacturer) had its own proprietary statistics collected already, Vendors were simply asked to summarize what they felt were the perspectives of their "typical" customers. All participants received emailed requests to participate in this online survey.

IV. PARTICIPANT SELECTION PROCESS

To assure broad geographic coverage, regional outreach personnel at the six ACT Partner Institutions and members of the Technical Advisory committee nominated participants based on their professional interests, background, and expertise. Approximately 100 coastal resource mangers, regulatory and environmental health agency representatives, manufacturers, and scientific researchers were targeted to take part in the survey; one-third responded.

Who Participated in this Survey?

Among ACT Workshop Participants in ACT's Hydrocarbon Workshop held in Seward, Alaska 2008, the following participated:

- California Department of Fish and Game
- Alaska Department of Environmental Conservation
- Minerals Management Service Engineering and Research Branch
- United States Coast Guard Research and Development
- Environment Canada Emergencies Science and Technology
- Exxon Mobil Upstream Research Company
- Oil Spill Recovery Institute

Among recommended technology users:

- Centre for Offshore Oil and Gas, Energy Research, Bedford Institute of Oceanography
- Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia
- Department of Civil Engineering, University of South Alabama
- Department of Crop and Soil Environmental Science, Virginia Tech University
- Lamont-Doherty Earth Observatory, Columbia University
- Louisiana Universities Marine Consortium
- Marine Sciences, University of North Carolina, Chapel Hill
- NOAA Office of Response and Restoration
- Prince William Sound Science Center
- Southeast Coastal Ocean Observing Regional Association of IOOS
- Texas A&M University
- U. S. Geological Survey
- University of Southern Mississippi
- University of Washington
- USM Institute of Marine Sciences, Stennis Space Center

The following manufacturers responded to the survey:

- Chelsea Technologies Group, Ltd.
- Hach
- Nereides
- Turner Designs
- Turner Designs Hydrocarbon Instruments
- WET Labs
- S-Can
- SAIC

V. SURVEY RESPONSES

This section presents a synthesis of the answers to the survey questions. Survey questions could be answered either quantitatively or as narratives. The results are presented as comprehensibly as possible. Answers with quantitative data are typically shown as bar charts. Each chart shows the percentage of respondents who selected each option. Actual numbers of respondents are shown in parentheses next to the percentages. Simple, quantitative data are at times summarized as narratives and, sometimes, complex narratives (as in Question 7) are distilled down and shown graphically. Some answers have both bar charts and narrative summaries below each section.

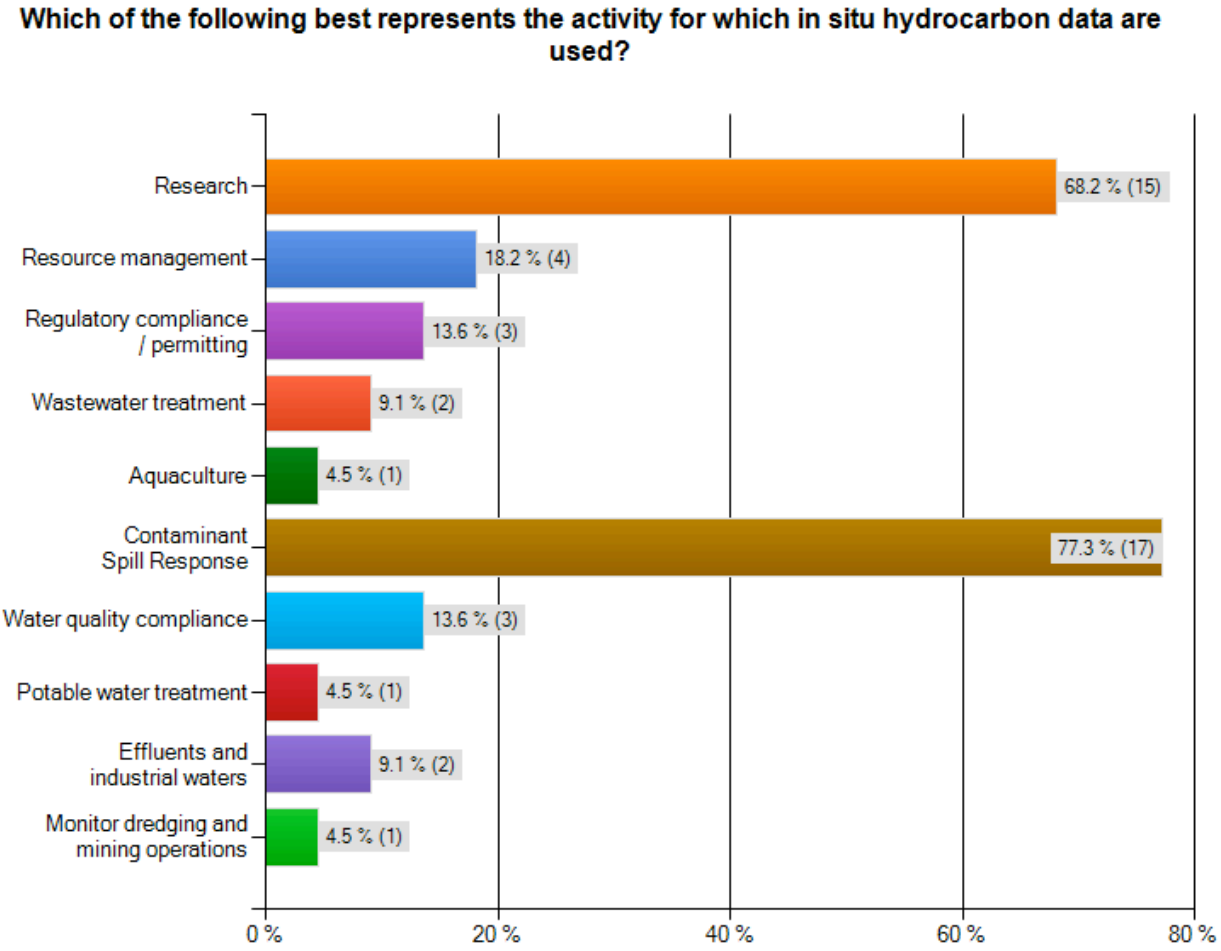
Note that Users and Vendors are capitalized when referred to as the survey groups in this study. Thus, Users constitute a set users and Vendors a set of vendors. User responses are presented first, followed by Vendor responses. In cases where responses were basically indistinguishable or if the bias was not noticeable or a discrepancy deemed irrelevant, responses were combined. Finally, when applicable, additional narratives were divided between Users and Vendors and shown with very little editing as they appeared in the survey responses.

Understandably, there is bias in such a small, focused survey. By dividing the results between Users and Vendors, we feel it may be informative to compare and contrast responses. For the purpose of designing the protocols for the Performance Evaluation, ACT presented a synthesis of Colleague and Vendor responses before an audience of Technical Advisors, ACT personnel, and vendors in order to capture a broad view of applications and needs that extend beyond just instrument users. For instance, Users are heavily weighted by researchers more than by representatives from industry. Range (detection limits), reliability, accuracy and precision ranked mutually as priority concerns among both groups, as well the need to test in estuarine and nearshore environments under moored and profiling modes. ACT hopes to attract as wide an audience as possible while fulfilling our primary mission.

A. Application

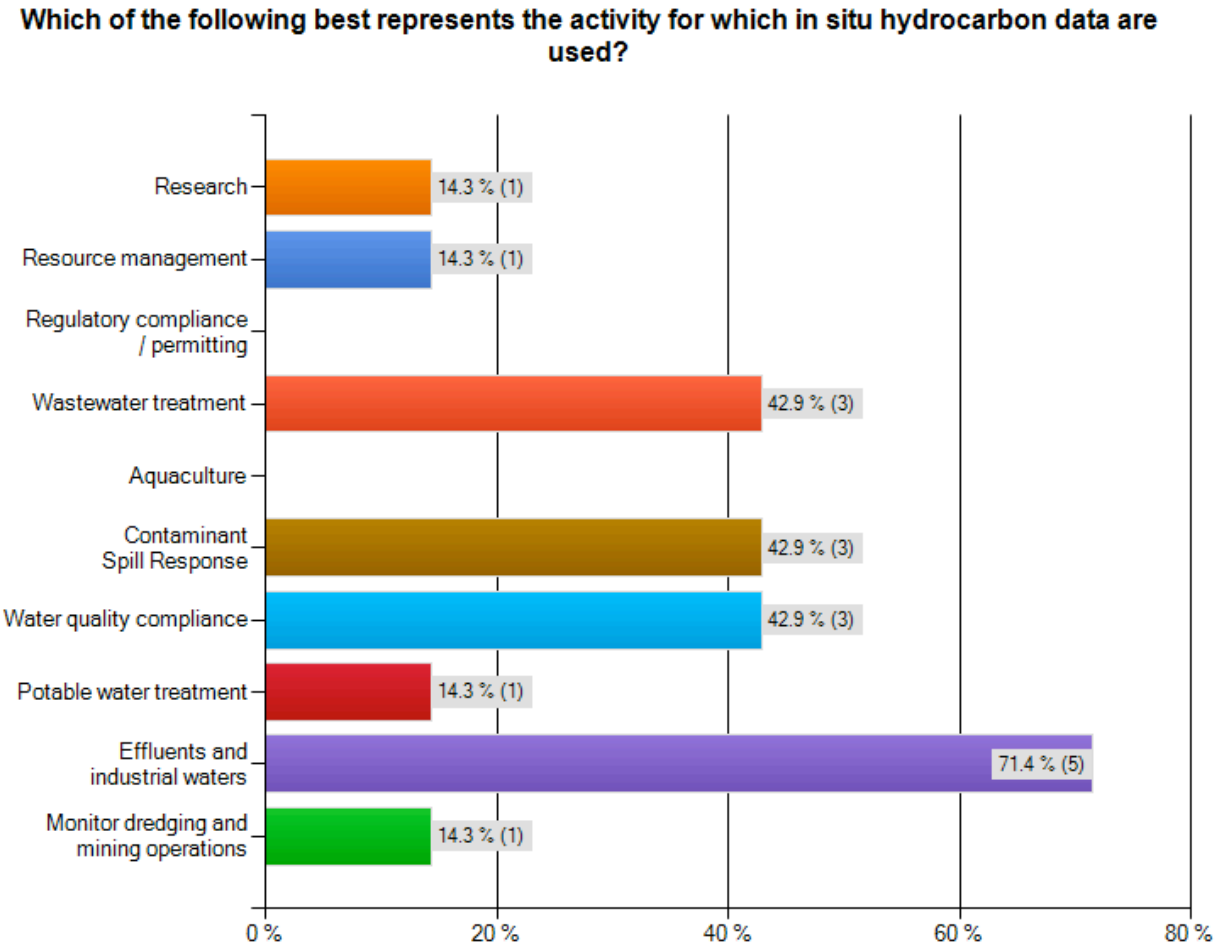
1. Which of the following best represents the activity for which in situ hydrocarbon data are used?

Users:



Users not answering this question commented that they do not currently measure hydrocarbons but plan to in the future. Two respondents were specifically intent on incorporating hydrocarbon sensors into ocean observing networks.

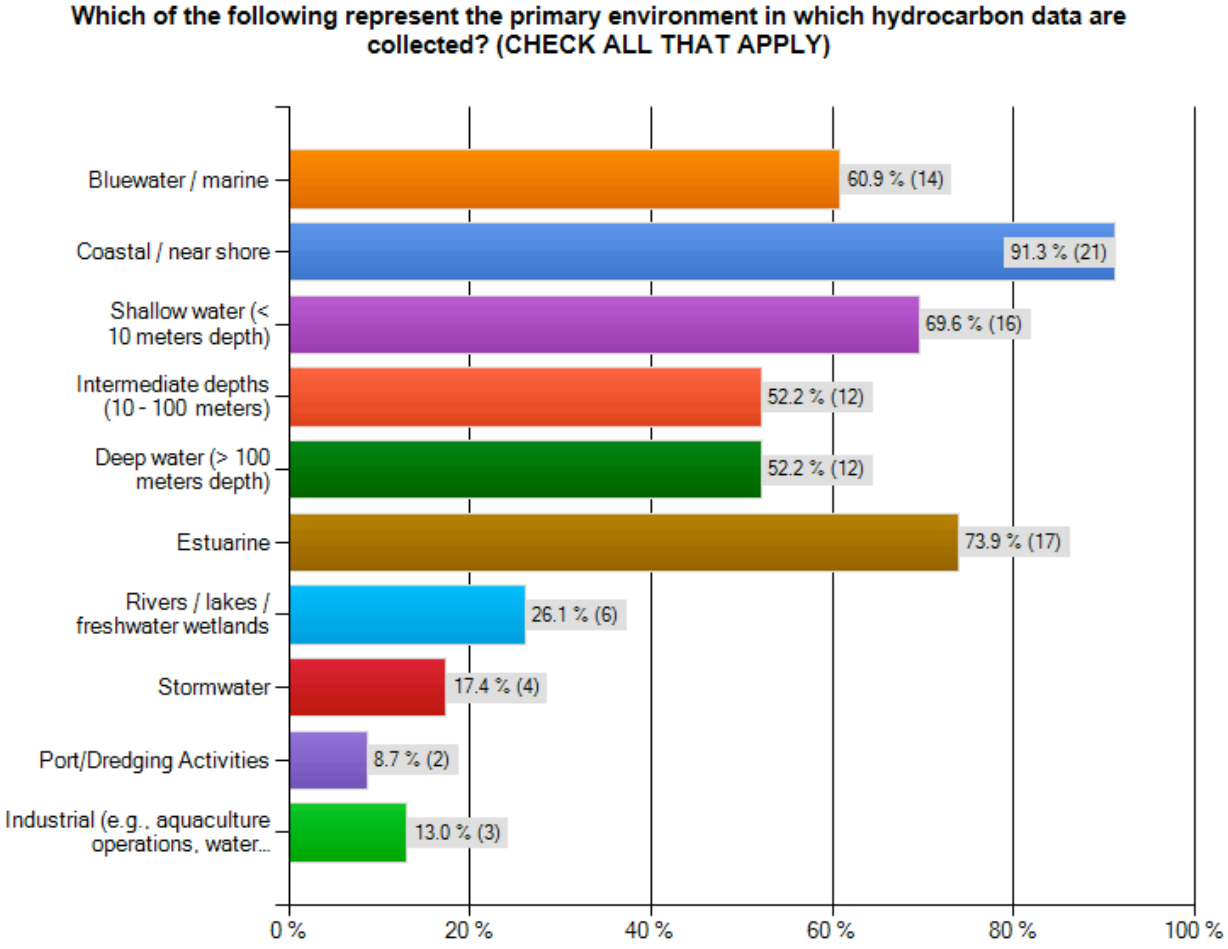
Vendors:



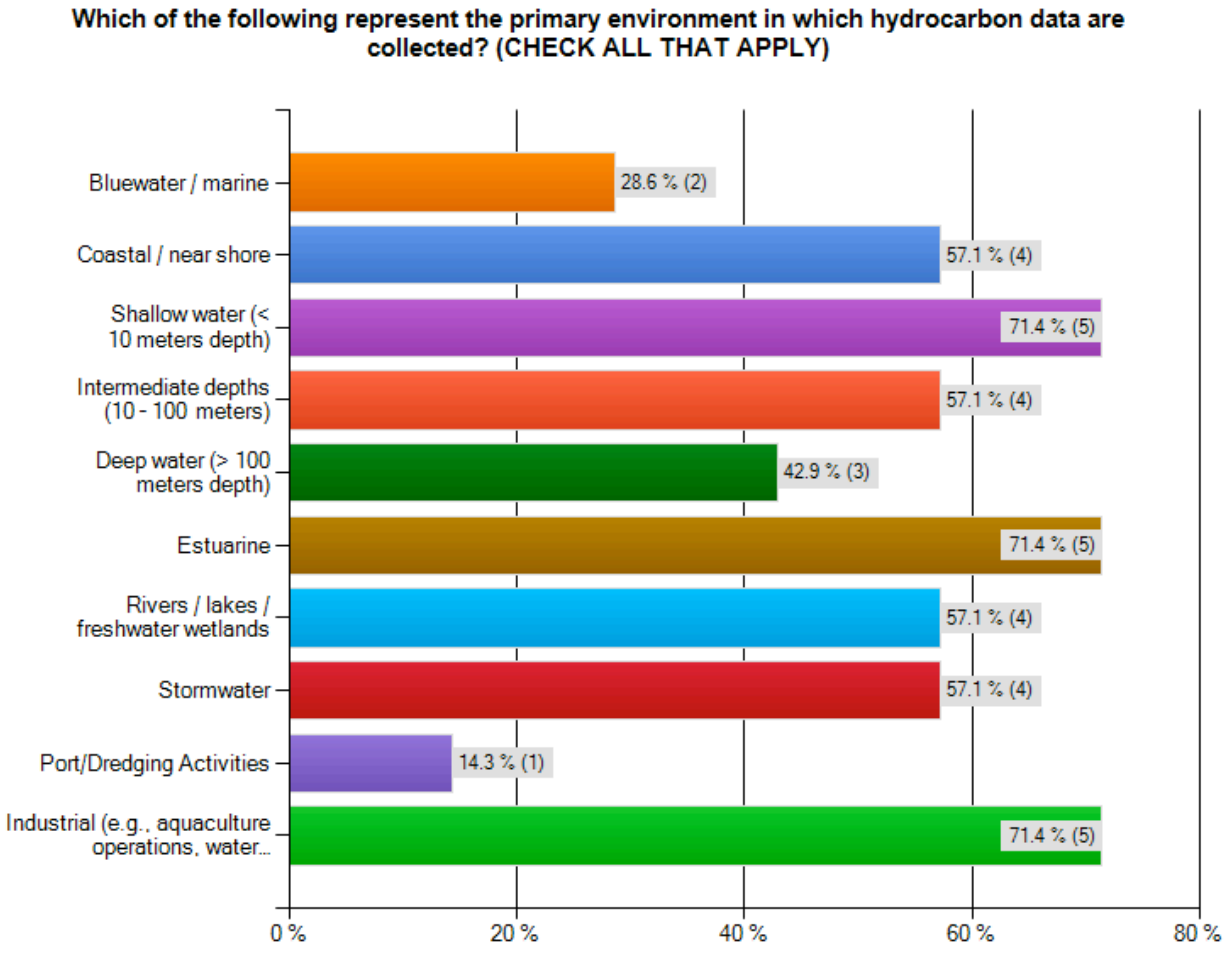
Vendors highlighted the Deep Horizon incident and the detection of hydrocarbons on storage sites as major activities. Note that industrial applications dominate the Vendors' perspective whereas research and contaminant spill response dominate the Users' activities.

2. Which of the following represent your primary environment in which hydrocarbon data are collected?

Users:



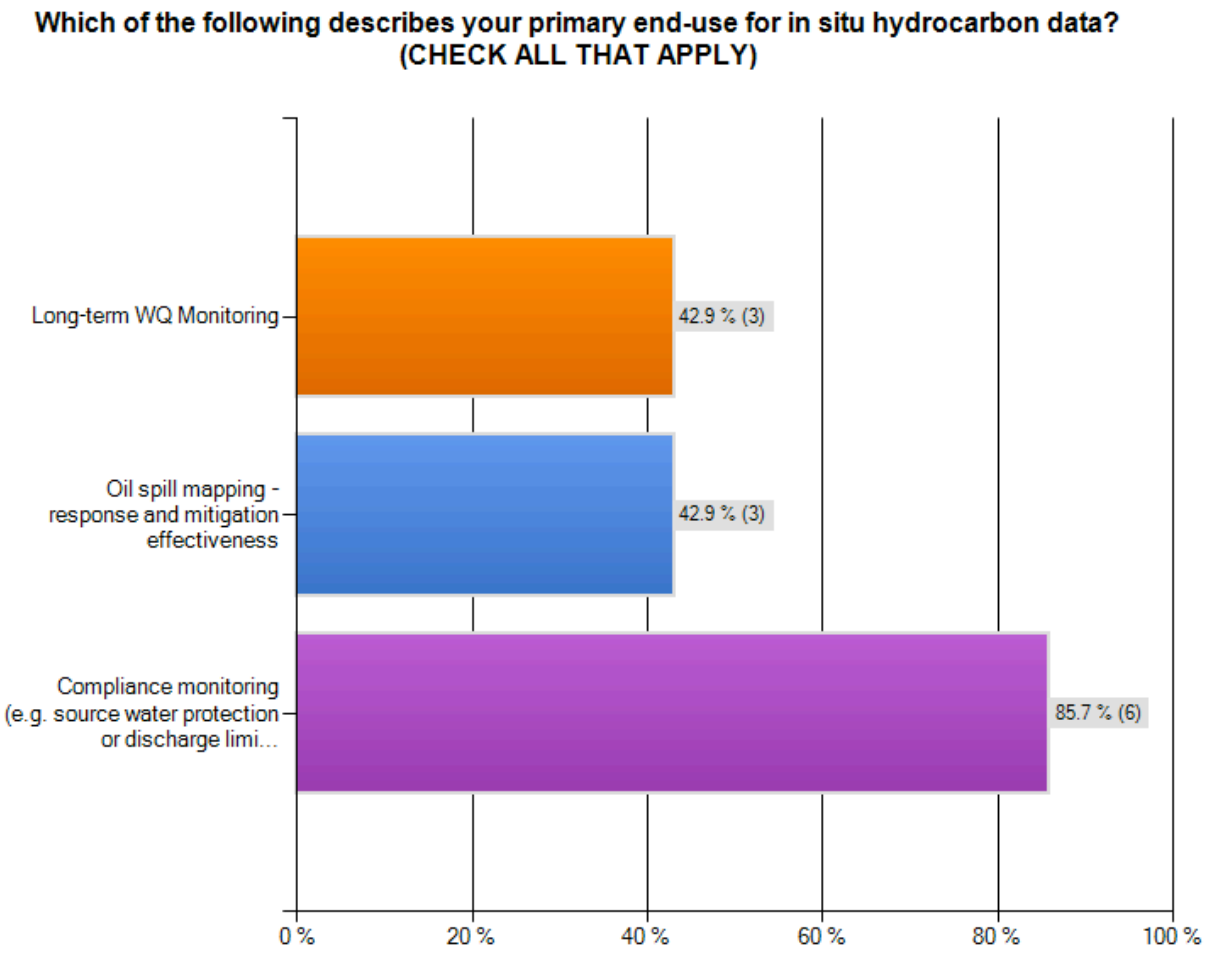
Vendors:



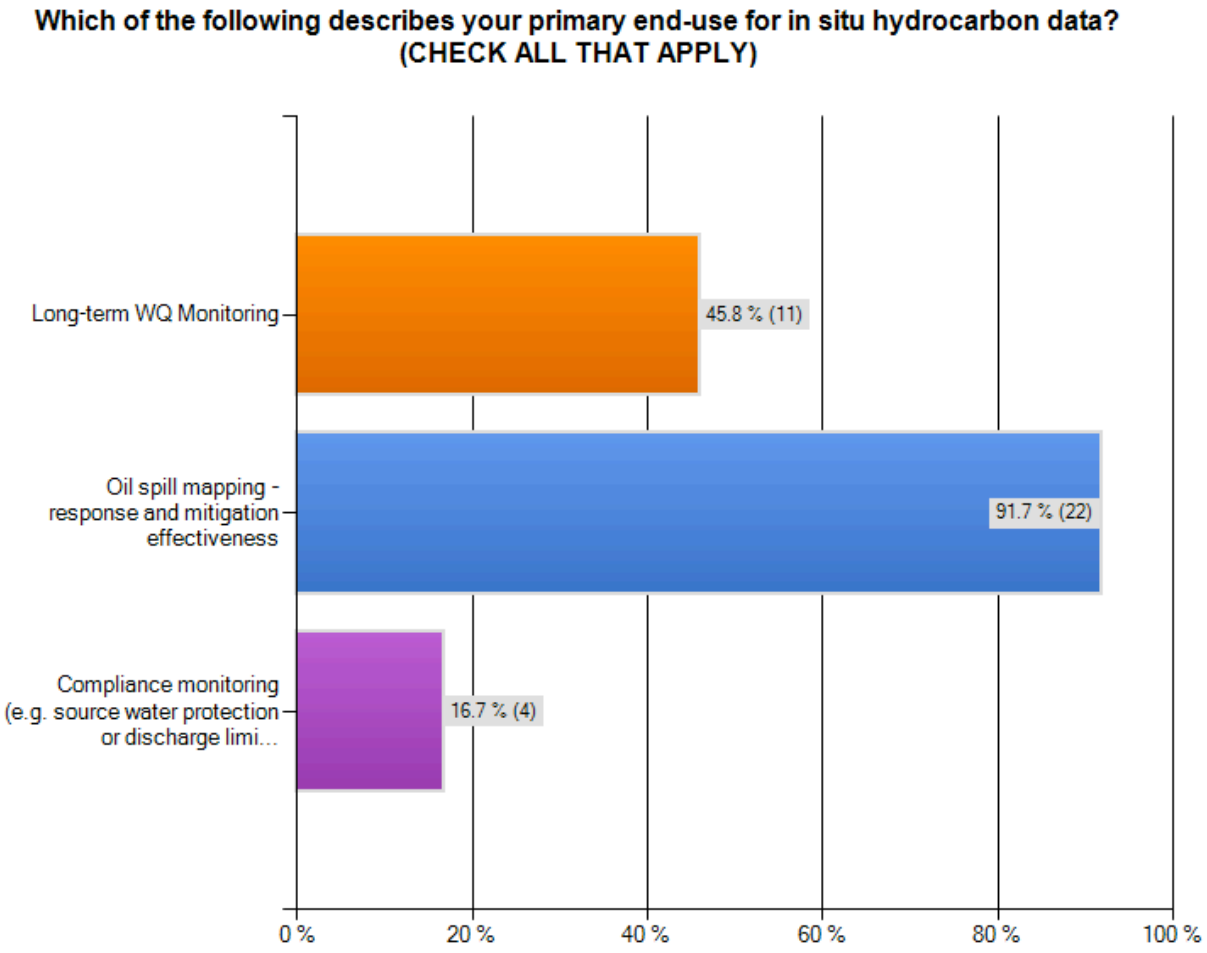
Both groups indicated a broad representation of environments. Comments by Users reflected the bar chart above. The Vendors' comments highlighted sites of offshore oil and gas production (e.g., Deep Horizon) and refineries as primary "environments," underscoring that it is the industrial setting that sets the environmental setting and not necessarily the environment that sets the industrial setting.

3. Which of the following describes your primary end-use for in situ hydrocarbon data?

Users:



Vendors :


Which of the following describes your primary end-use for in situ hydrocarbon data? (CHECK ALL THAT APPLY)
Long-term WQ Monitoring
45.8 % (11)
Oil spill mapping - response and mitigation effectiveness
91.7 % (22)
Compliance monitoring (e.g. source water protection or discharge limi...
16.7 % (4)
0 %
20 %
40 %
60 %
80 %
100 %

4. In what form are hydrocarbon data presented?

a) What do you measure? Specific hydrocarbon classes, species, or organic loads in general?

Four Users reported that they currently do not measure hydrocarbons, but they plan to in the future. Their needs are yet to be defined but trend toward requiring quantitative systems that measure total [HC] in addition to specific compounds. Of the Users that do routinely measure hydrocarbons, 41% (7) measure hydrocarbon organic loads in general, while the majority of Users, 59% (10), measure hydrocarbons at least down to class and often down to specific compounds. Changing research missions often drives what is measured as hydrocarbon organic loads are often measured to detect and map surface slicks (their extent and thickness), and then ranges of hydrocarbon classes and individual compounds identified in forensic work and to enforce specific regulations. Identification from TPH down to range of organics (GRO, DRO, RRO, BTEX, PAH) is common.

Six out 6 vendors cite measurement of hydrocarbon loads in general with specificity and tuning to specific classes of hydrocarbons as set up by the sensor manufacturer to fit the users' needs.

b) Is your detection system 'concentration' based (quantitative), or based on detecting the presence or absence of specific compounds?

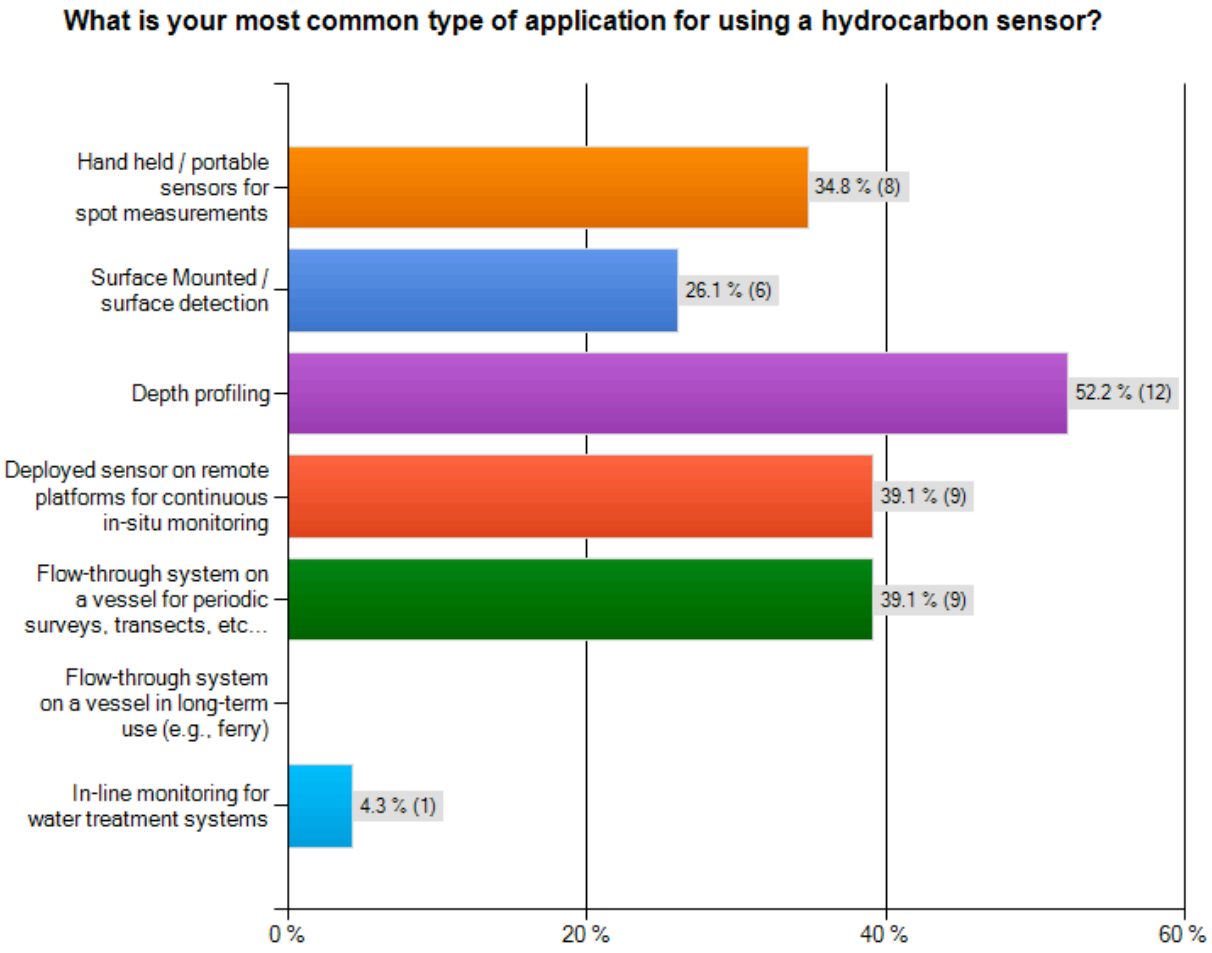
Seventy-eight percent of Users (14) use concentration-based systems while 22% (4) depend only on presence or absence of specific compounds. Two thirds of Vendors' detection systems are concentration-based; the remaining third detect presence or absence.

5. What is your most common sensor application?

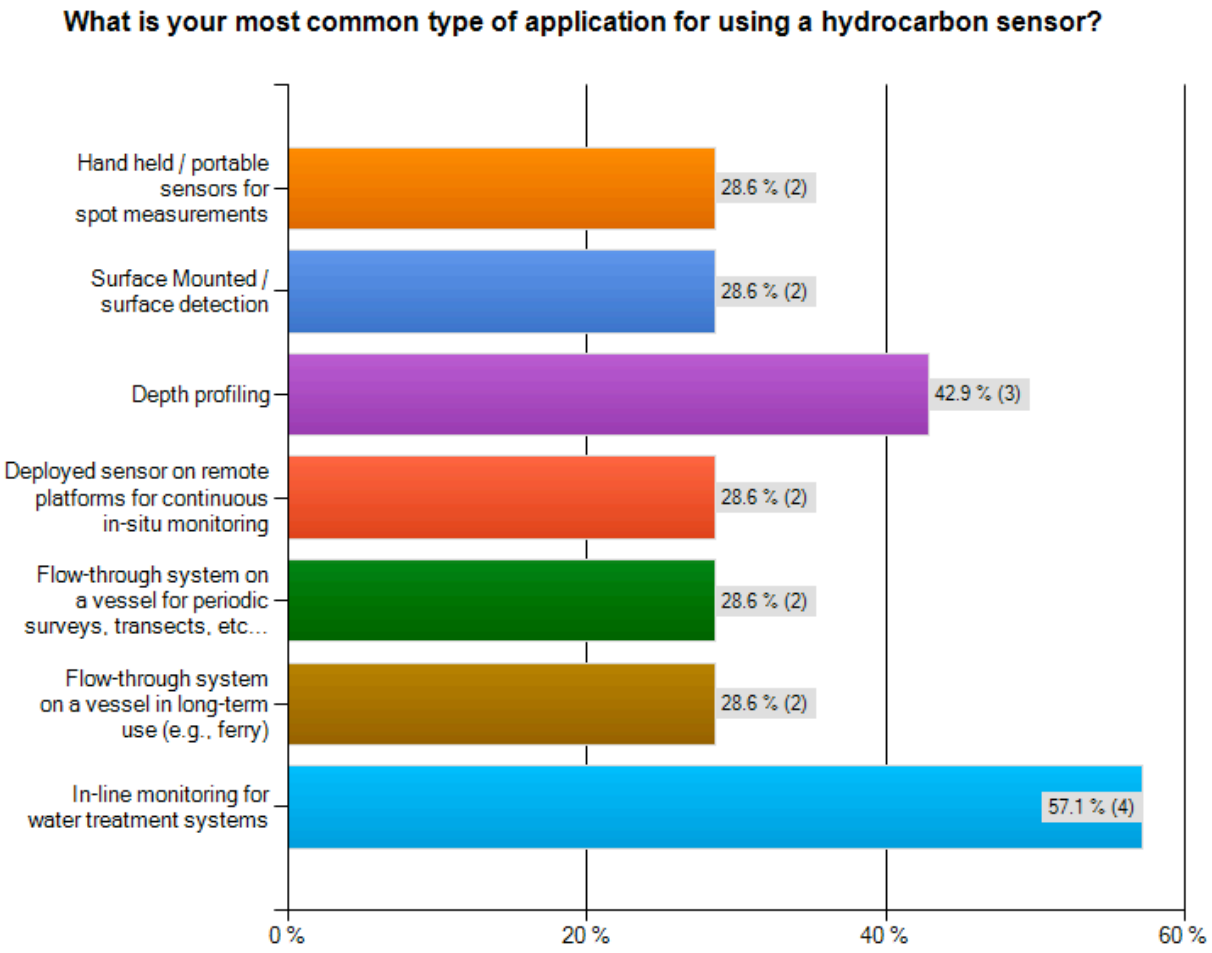
As their most common sensor application, 67% (16) of Users use their hydrocarbon sensor as part of a suite of water quality instruments; 46% (11) use their hydrocarbon sensor as a stand-alone instrument. Vendors showed similar trends with the majority 86% (6) of their users using their hydrocarbon sensors as part of a suite and 57% (4) as stand-alones. Note that multiple answers were allowed for this question, so percentages do not add to 100%.

6. What is your most common type of application for using a hydrocarbon sensor?

Users:



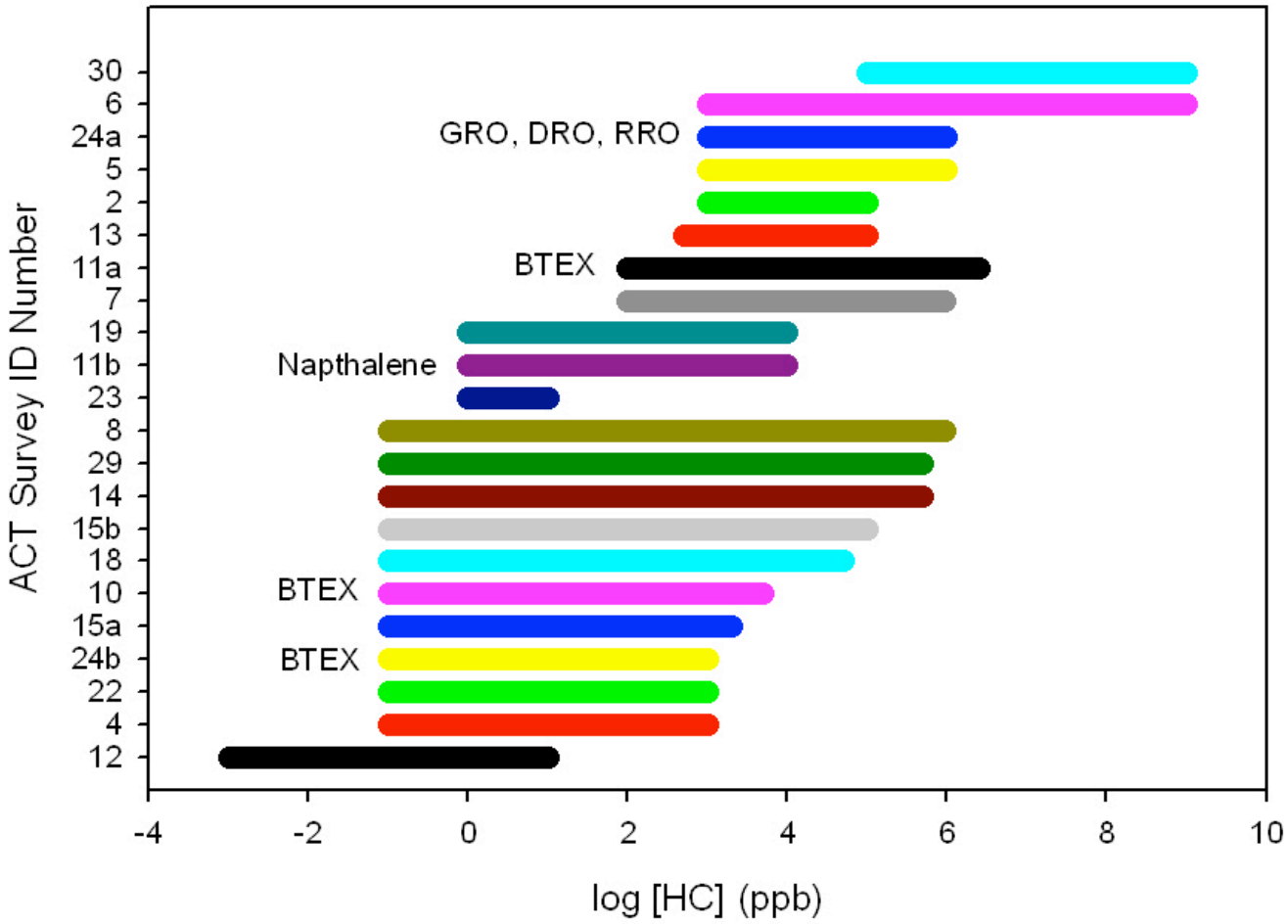
Vendors:



Note the bias against flow-through systems on vessels and in-line monitoring for water treatment systems among Colleague applications.

B. Specifications

7. What is the typical range of hydrocarbon concentration for your application?



The survey respondents answered this question in general terms over a very broad range of hydrocarbon concentrations ([HC]). Respondents also expressed these concentrations in a variety of units. The question is perhaps best answered graphically as a synthesis all of the narrative responses given by Users and Vendors normalized to a common unit of measurement. Concentration ranges were converted to parts per billion (ppb) and expressed as the log of hydrocarbon concentration (log [HC]). Note that one vendor commented that they detect hydrocarbons from a 0.1 mm surface layer. Most respondents indicated 0 ppb as their lower range, here interpreted as 0.1 (10^{-1}) ppb (or close to zero). Individual ranges are plotted in the figure above step-wise from lowest to highest concentration. Responses span twelve orders of magnitude. As noted in the

figure, some of these ranges were expressed in context to a particular reference standard or hydrocarbon class.

8. What level of accuracy do you require for this priority application?

Users (7) had a greater tendency to answer this question non-quantitatively using terms such as "low" or "best possible" as responses. Of those responses that could be quantified, ACT normalized and grouped accuracies either as ppb or as percentages depending on how this question was answered. Accuracy with respect to false negatives or false positives is the key issue, one colleague noted. This could be expressed or thought of as reliability of detection.

As ppb:

- 1 states ± 1 ppb
- 5 state ± 10 – 100 ppb

As percentages:

- ± 1 %
- 1% of Full Scale
- If napthalene is used as a standard for a refined fuel sensor, ± 5% of reading or ± 20 ppb, whichever is greater (Vendor).
- 4 state ± 10 %
- 1 states ± 20 % (Vendor)
- Depends on the accuracy of your pipet (Vendor).
- As accurate as the calibration technique (i.e. UV absorption, GC-FID, GC-MS) you use.

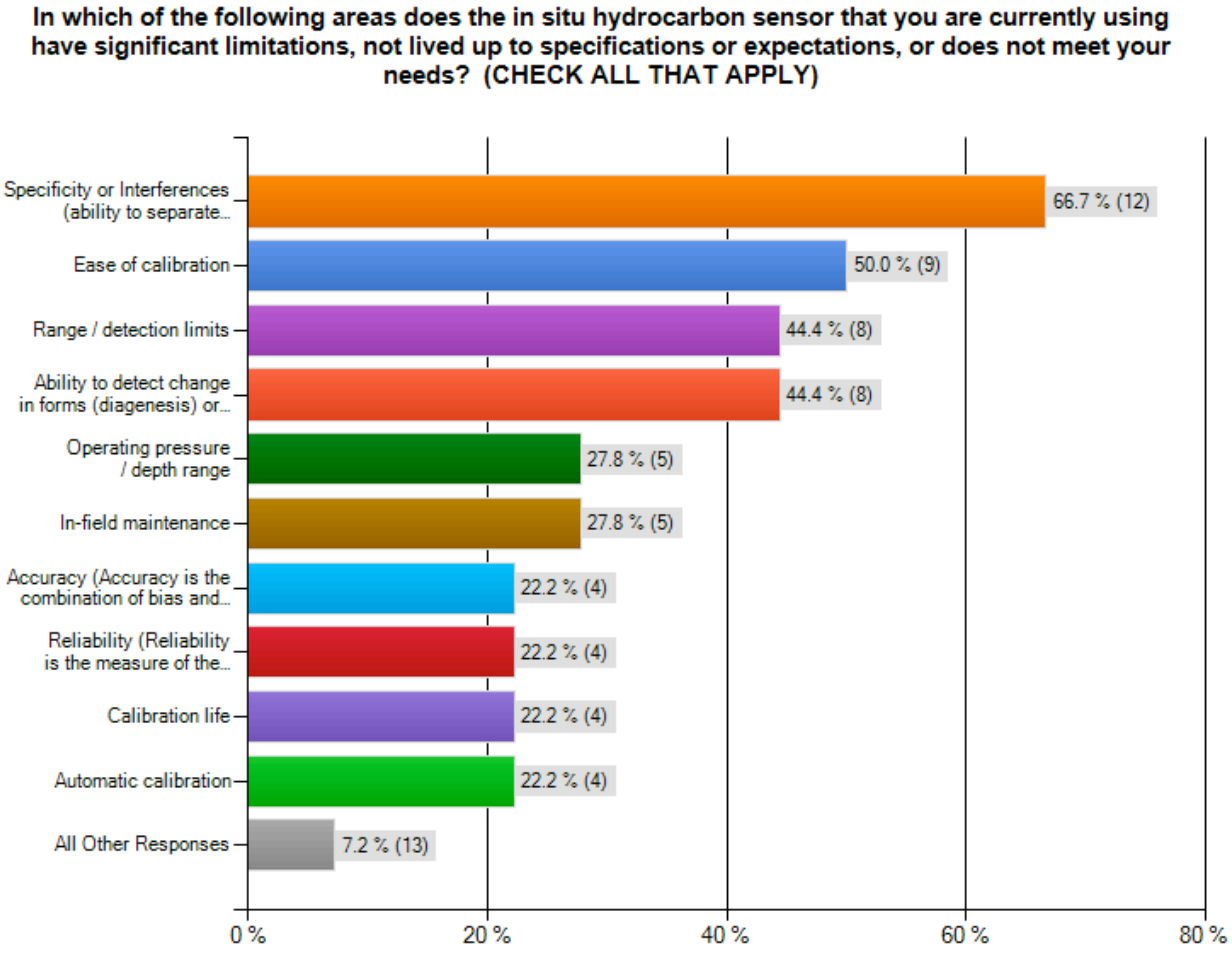
9. Are your current sensors:
[ ] Primarily commercial products
[ ] Primarily designs you developed yourself
[ ] A combination of both

Users:
Ninety-five percent (19) of Users primarily used commercial products. No one designed their own sensors; however, 10% agree that their sensors are a combination of off-the-shelf sensors and their own design.

Vendors:
Among the Vendors' only 29% used commercial products primarily while 14% used technologies designed by themselves and 57% as hybrids of off-the-shelf sensors and their own designs.

10. In which of the following areas does the in situ hydrocarbon sensor that you are currently using have significant limitations, not lived up to specifications or expectations, or does not meet your needs? (CHECK ALL THAT APPLY) Please provide details regarding issues of primary concern.

Users:



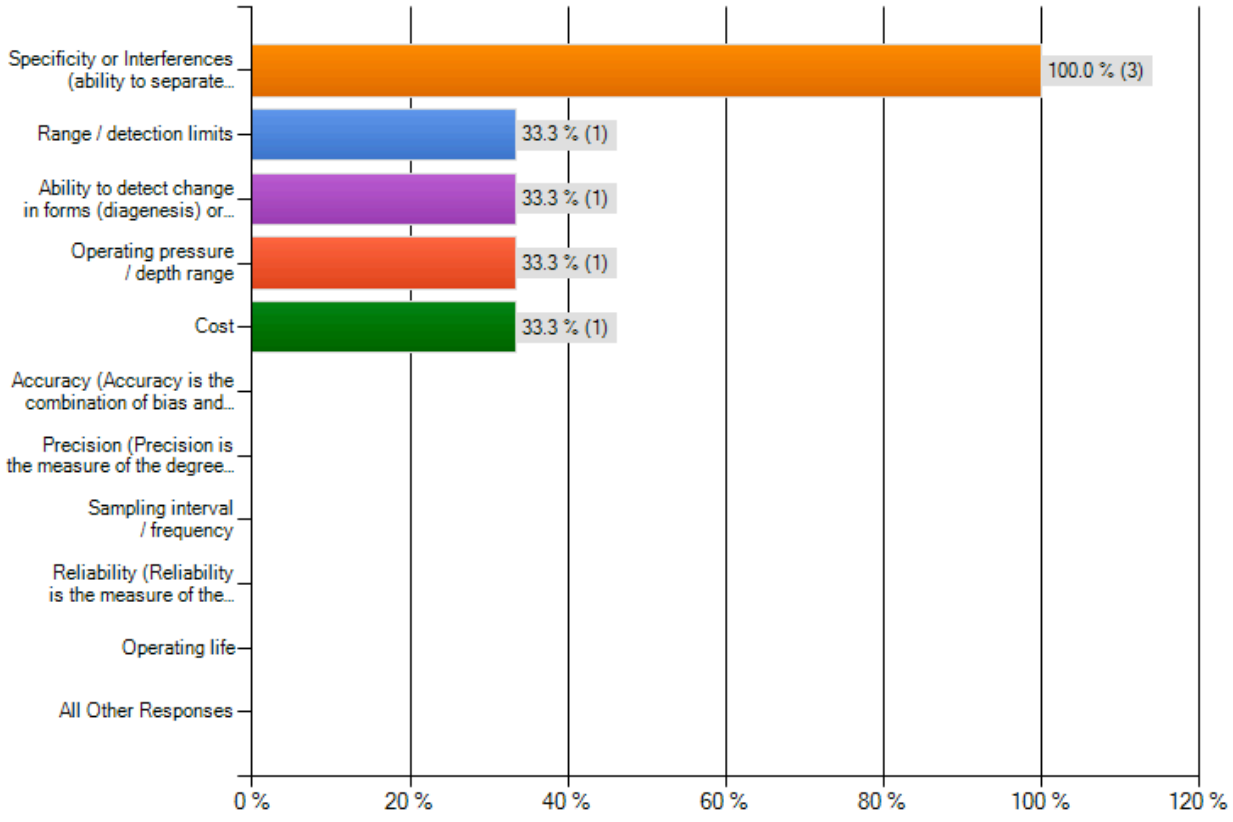
- An ocean observing system will need instrumentation that is easily deployed and cost effective, in addition to having the capability to detect with accuracy.
- For fluorometry, in situ units excitation wavelengths fit better for chlorophyll than for oil hydrocarbons; therefore, not very sensitive, high LDL. Can't deploy flow thru systems at great depths to analyze underwater plumes, like what was happening during Deepwater Horizon.
- Manufacturers are not interested in the calibration of their instruments to actual hydrocarbons encountered in the field, which leads to a lack of consistent calibration methods throughout the industry. Also, there is opportunistic re-

branding of products, which many not be suitable for the application areas (somewhat cynical and also will damage the reputation of the deployment of sensors for marine applications).

- Have not had a chance to calibrate as yet.
- Not clear if wavelength of current sensors really match oil fluorescence well.
- Detecting different oil components (VIC, TPH) and phases (dispersed, dissolved).
- Some of the multi wavelength, combination sensors have inadequate dataloggers and the software interface is very limited. The bio-wiper on these sensors are very limited in functionality and the overall design is not robust.

Vendors:

In which of the following areas does the in situ hydrocarbon sensor that you are currently using have significant limitations, not lived up to specifications or expectations, or does not meet your needs? (CHECK ALL THAT APPLY)



- Interference from other fluorescent UV absorbing materials; Rated for 600 meters.
- There is no in field maintenance other than cleaning optical windows;
  Instrument does not have any onboard telemetry;
  No automatic calibration.

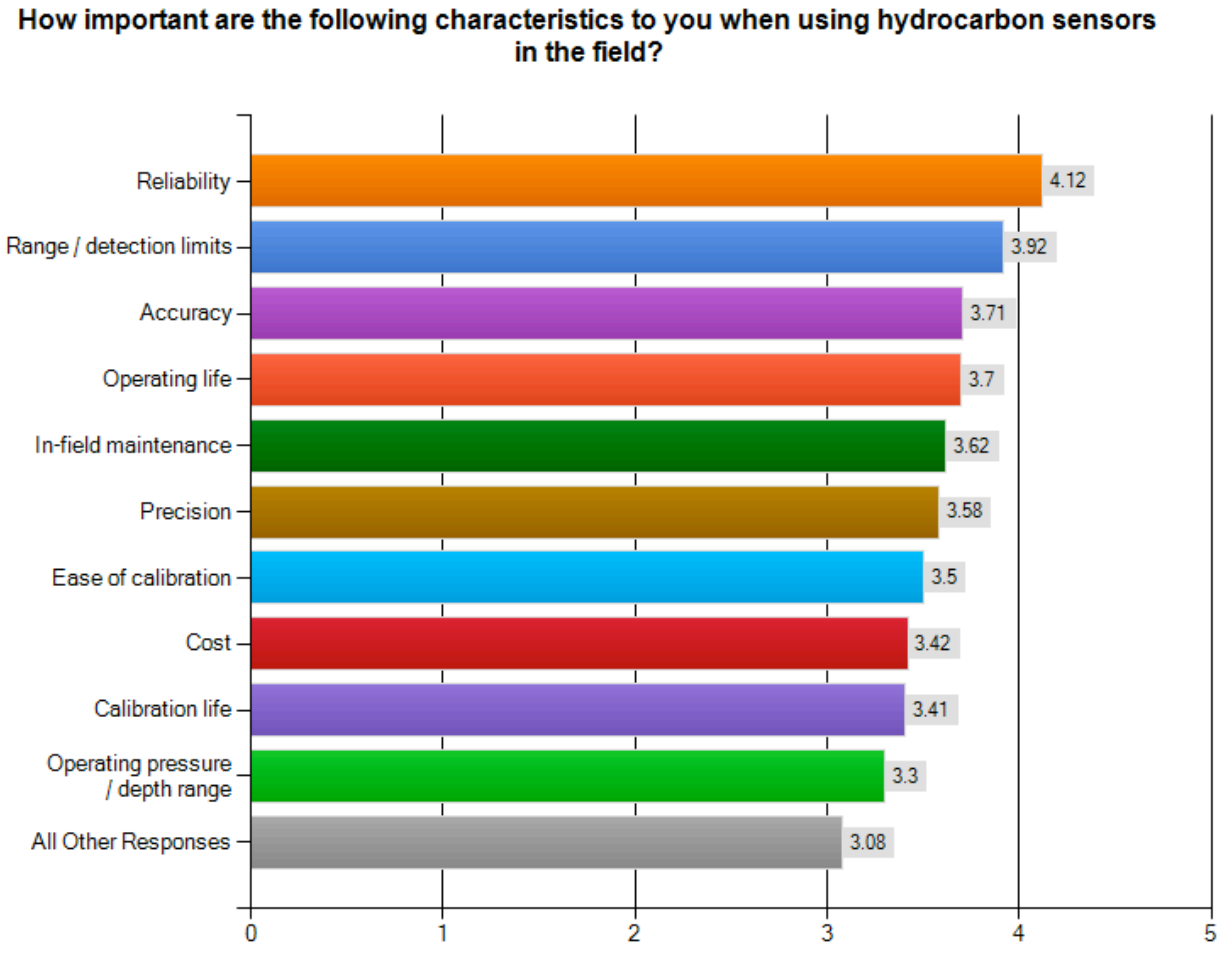
- Our monitors are used in a wide range of installations and applications. When attention is paid to the installation and maintenance, the systems perform well.
- It is not a selective system, meaning we detect all kinds of hydrocarbons; Change of the membrane each time you have a detection or every 6 months; Special installation is required when the water flow is too important.

C. Recommendations

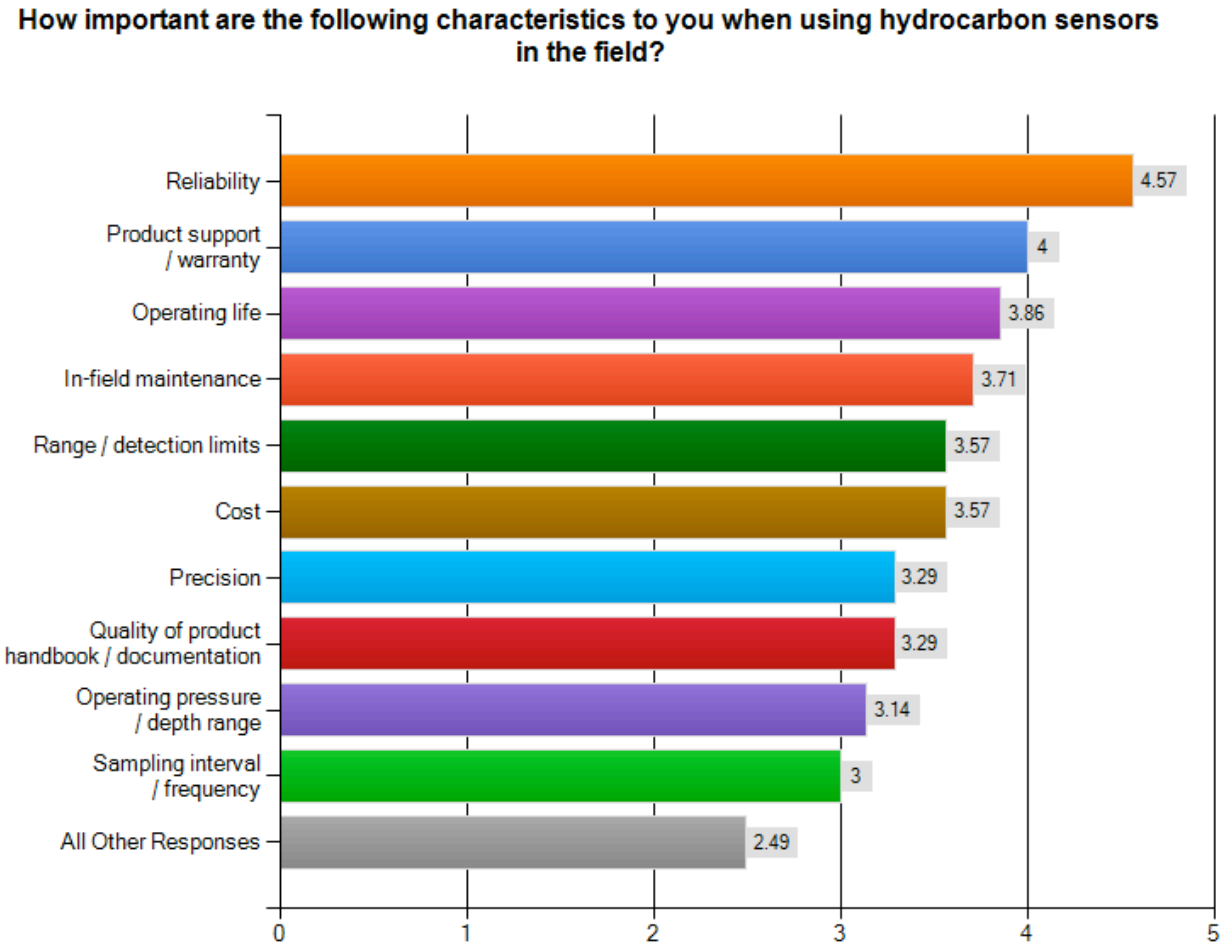
11. How important are the following characteristics to you when using hydrocarbon sensors in the field? Please enter a value between 1-5 for each box, where:

1 = not at all important
5 = very important

Users:



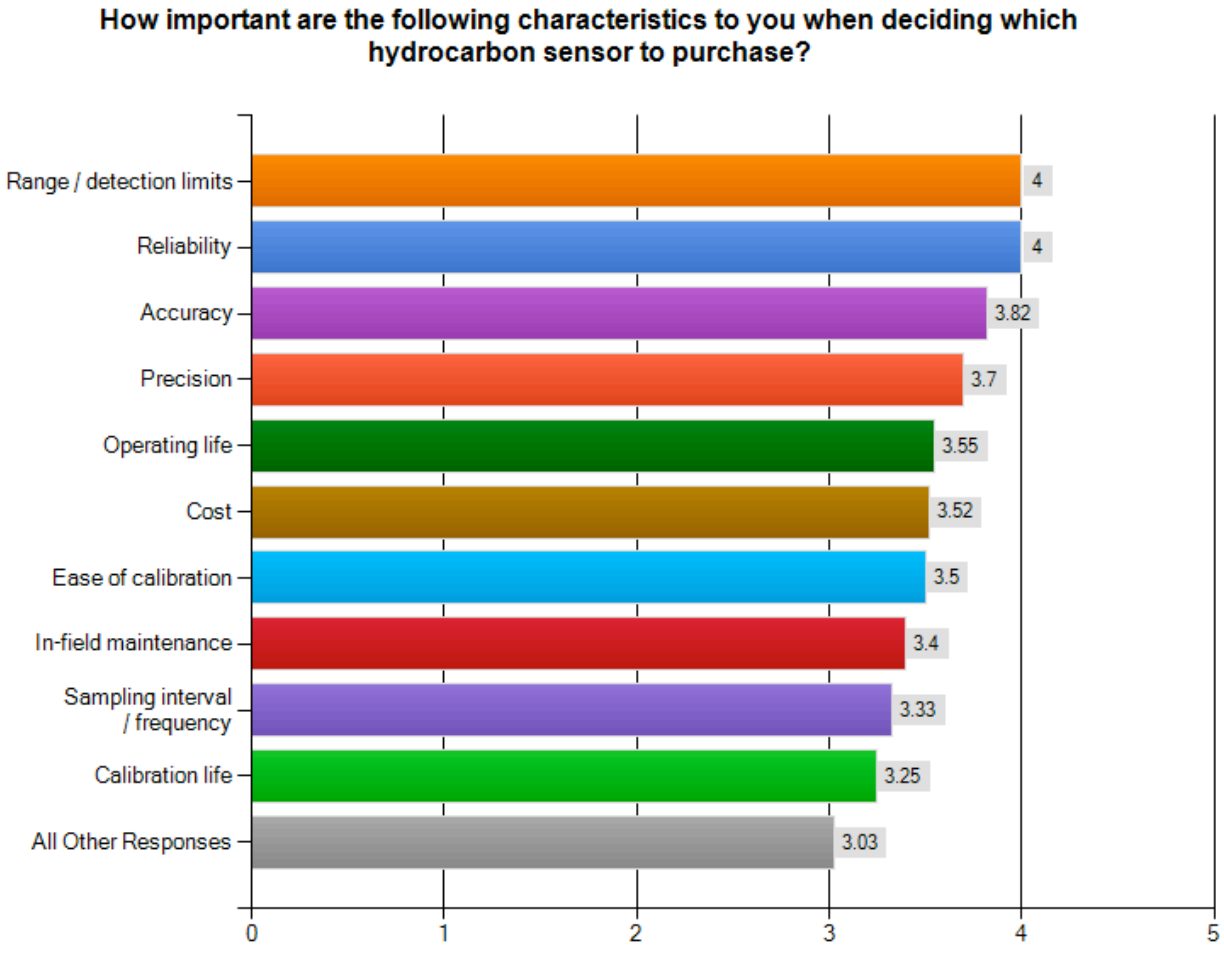
Vendors:



12. How important are the following characteristics to you when deciding which hydrocarbon sensor to purchase? Please enter a value between 1-5 for each box, where:

1 = not at all important
5 = very important

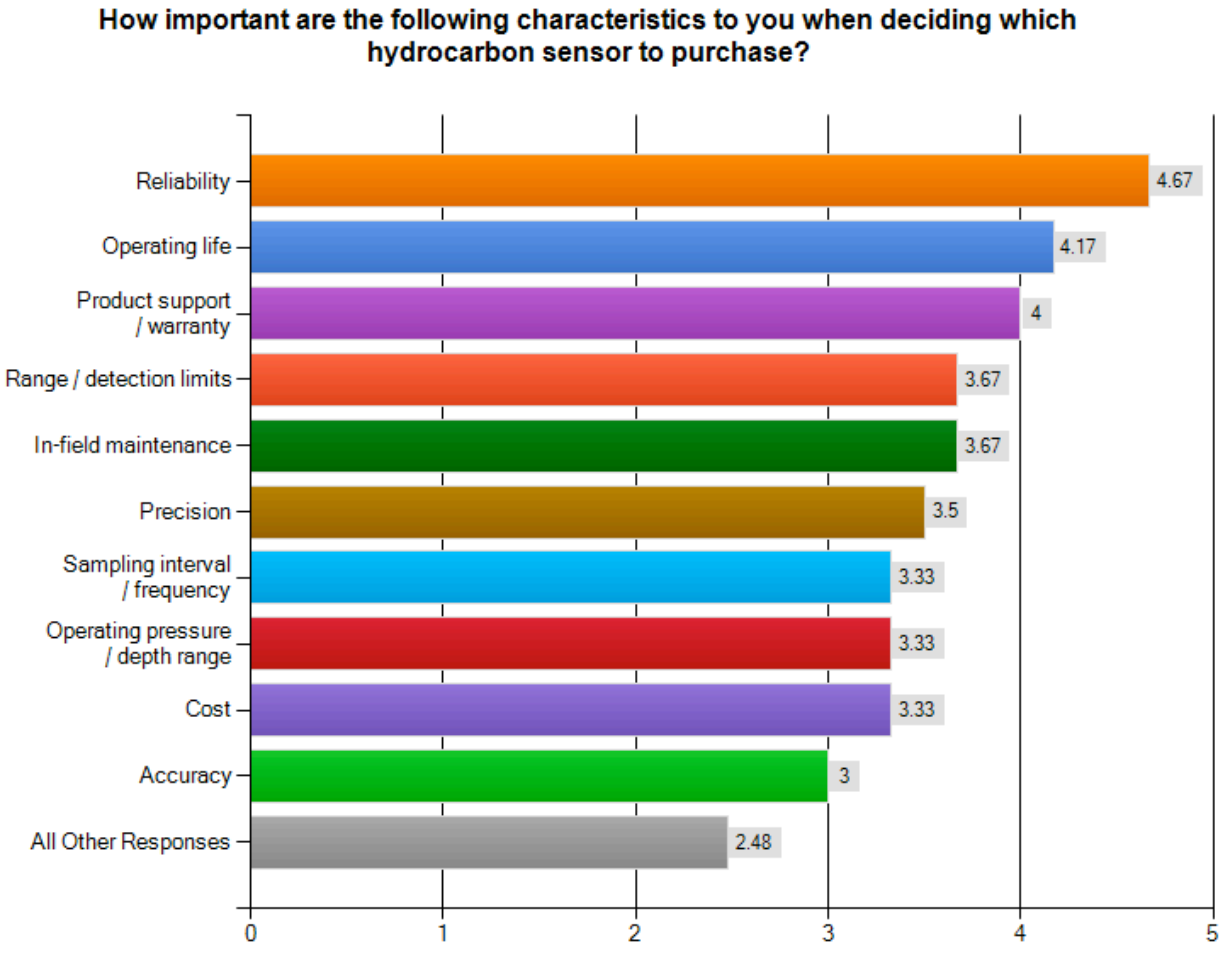
Users:



Colleague Comment:

- As we and other efforts across the country are looking into developing sensor networks, cost and reliability (especially knowing mean time between failure) will become a concern. For each sensor station we develop, we will need to purchase, at a minimum, one spare sensor/wiper system for sensor swap outs to keep data gaps at a minimum.

Vendors:


How important are the following characteristics to you when deciding which hydrocarbon sensor to purchase?
Reliability
4.67
Operating life
4.17
Product support / warranty
4
Range / detection limits
3.67
In-field maintenance
3.67
Precision
3.5
Sampling interval / frequency
3.33
Operating pressure / depth range
3.33
Cost
3.33
Accuracy
3
All Other Responses
2.48
0
1
2
3
4
5

13. Relative to the above (Questions #11 and #12) sensor system characteristics, are any of your sensor needs or requirements "non-standard" or custom made?

Users: 91% (21) No; 9% (2) Yes.
Colleague Comments:

- Need to employ excitation and emission wavelengths that are more representative of real (crude) oil fluorescence.

- We would like to speak with someone about developing user selectable ex and em fluorometers, and user selectable amplifier gains. We are also interested in changing the output of some of these sensors from linear outputs to logarithmic to avoid changing gain settings in the field (i.e. automatic gain control ; "AGC"). AGC causes some grief in applying real time data corrections.

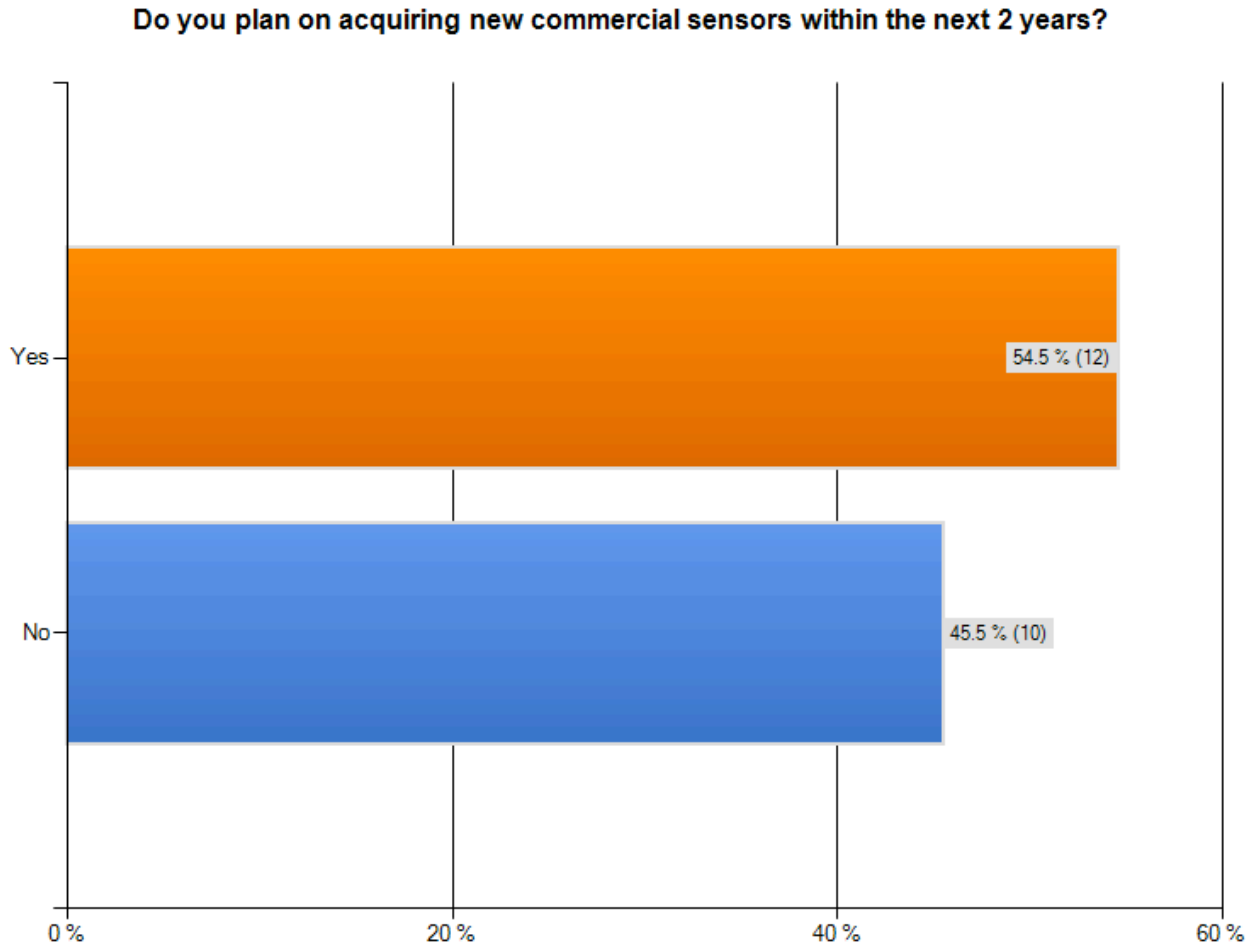
Vendors: 71% (5) Yes ; 29% (2) No.
Vendor Comments:

- Calibration standards.
- We can supply specific sensor configurations to meet individual customer requirements.
- Some of our products are engineered to meet the customer's needs. The monitors suggested for this project are standard.

14. Do you plan on acquiring new commercial sensors within the next 2 years?

If yes, will you consider a different sensor type than the one you are currently using to measure hydrocarbons?

Users:



- Need to improve sensitivity
- Yes, some of the sensors used in our field trials have had poor performance. Also we would like to augment our current systems with other sensors to validate the current sensor responses.
- Yes, technology and requirements of the mission have changed
- Different sensor cannot be too far different that current in-situ ones due to operational requirements.
- Depends on the grant received
- Our present systems do not excite deep enough in the UV.

Vendor Responses. Three vendors responded and all were decidedly 50% "Yes" and 50% "No" when speculating if their typical client planned to acquire a commercial sensor within the next 2 years.

- We are developing new hydrocarbon sensors for commercial use.
- The basic technology and function of the sensors will remain the same. There are plans to make the flow cell more flexible for installations.

15. Based on your experience with in situ hydrocarbon sensors, are there any shortfalls modifications for the specific application noted above in current designs or additions you would like to see in future designs?

Users:

- For fluorometry, use better excitation wavelengths.
- Need instruments we can use in situ that are at great depths.
- Lower power options.
- Self calibrations.
- Much more comprehensive data provided on calibration methods and responses. Also would like some honesty over what the interferences are in some of the systems so that appropriate deployment decisions can be made or certainly responses can be interpreted in much more detail. If users are unfamiliar with the pitfalls of the sensor operations, this can easily lead to flawed interpretations of results.
- Many modifications required for a true hydrocarbon sensor rather than one derived for something else (e.g., CDOM).
- The instruments need to have multiple excitation and emission capability to deal with changing characteristics of hydrocarbons due to natural degradation.
- We prefer to have a digital output, integral bio wiping system and an instrument case design that lends to easy maintenance in the field. The user software interface must be easy to use and read in the field and have an advance mode for advanced users with more control over sampling rates, and statistics on the fly (e.g. averaging, standard deviation, coefficient of variation, etc).

Vendors:

- Increased sensitivity for hydrocarbon sensors.
- Commonality of calibration and performance in order to accurately compare sensors from different manufacturers.
- Automatic sensor validation is important.