ACTOM

ACT on Offshore Monitoring

Webinar: Initial findings of legal & technical requirements of CO_2 monitoring for Carbon Capture and Storage (CCS)

Plymouth Marine Laboratory

Bureau of Economic Geology

Los Alamos National Laboratory

TNO innovation for life

Centre for Energy, Petroleum and Mineral Law and Policy
University of Dundee

Accelerating CCS Technologies

Moderator

Dorothy Jane Dankel is a researcher at the Department of Biological Sciences at the University of Bergen. She works inter- and transdisciplinary, making connections in Marine Science, Biotechnology & Responsible Research & Innovation (RRI) to address the challenges of the Sustainable Development Goals.

Accelerating CCS Technologies

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Acknowledgements

This project, ACTOM, is funded through the ACT programme (Accelerating CCS Technologies, Horizon2020 Project No 294766). Financial contributions made from; The Research Council of Norway, (RCN), Norway, Netherlands Enterprise Agency (RVO), Netherlands, Department for Business, Energy & Industrial Strategy (BEIS) together with extra funding from NERC and EPSRC research councils, United Kingdom, US-Department of Energy (US-DOE), USA.

www.act-ccs.eu

The Research Council of Norway

Netherlands Enterprise Agency

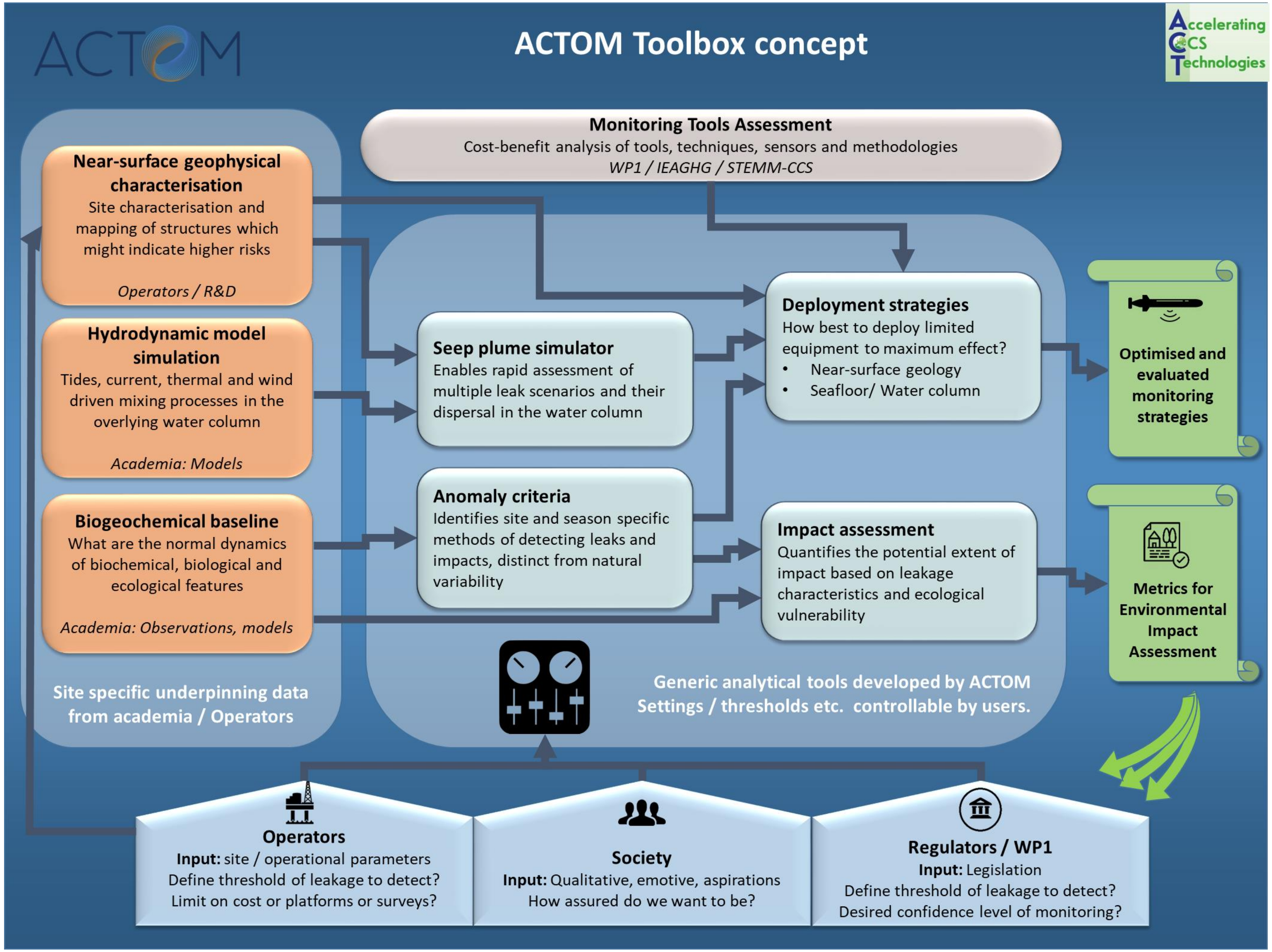
Department for Business, Energy & Industrial Strategy

Department of Energy United States of America

What does international and national law require of marine monitoring?

What tools for marine monitoring, including shallow sub-surface tools, can be used today?

What are the capabilities of these tools?



ACTOM Toolbox concept
Accelerating CCS Technologies
Monitoring Tools Assessment
Cost-benefit analysis of tools, techniques, sensors and methodologies
WP1 / IEAGHG / STEMM-CCS
Near-surface geophysical characterisation
Site characterisation and mapping of structures which might indicate higher risks
Operators / R&D
Hydrodynamic model simulation
Tides, current, thermal and wind driven mixing processes in the overlying water column
Academia: Models
Biogeochemical baseline
What are the normal dynamics of biochemical, biological and ecological features
Academia: Observations, models
Site specific underpinning data from academia / Operators
Seep plume simulator
Enables rapid assessment of multiple leak scenarios and their dispersal in the water column
Anomaly criteria
Identifies site and season specific methods of detecting leaks and impacts, distinct from natural variability
Deployment strategies
How best to deploy limited equipment to maximum effect?
• Near-surface geology
• Seafloor/ Water column
Impact assessment
Quantifies the potential extent of impact based on leakage characteristics and ecological vulnerability
Generic analytical tools developed by ACTOM
Settings / thresholds etc. controllable by users.
Optimised and evaluated monitoring strategies
Metrics for Environmental Impact Assessment
Operators
Input: site / operational parameters
Define threshold of leakage to detect?
Limit on cost or platforms or surveys?
Society
Input: Qualitative, emotive, aspirations
How assured do we want to be?
Regulators / WP1
Input: Legislation
Define threshold of leakage to detect?
Desired confidence level of monitoring?

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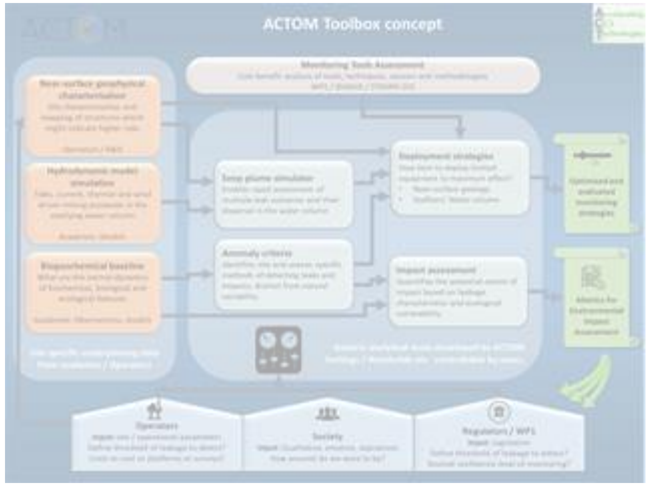
ACTOM, WP1 https://actom.w.uib.no/

- ACTOM is developing a web-based toolbox which will enable the derivation of optimal environmental monitoring strategies for CCS in the marine subseabed, reducing costs.



The toolbox should:

- enable operators to combine different monitoring technologies to design adequate and efficient monitoring programs
- enable regulators and operators to communicate to the effectiveness of proposed monitoring strategies, in line with Marine Spatial Planning.

- **WP1 "ACTOM project Baseline"**: Document that the toolbox meets regulatory monitoring requirements. Does technology exist for all project phases, surfaces, and monitoring aspects? What are the capabilities of these tools?

Webinar Program

14:00–14:10	**Welcome & webinar framing** Dorothy Dankel (UiB)
14:10–14:30	**Part 1: CCS regulatory frameworks** Sigrid Eskeland Schütz (UiB)
14:30–14:50	**Part 2: Assessment of geophysical and marine monitoring technologies** Abdirahman Omar (NORCE)
14:50–14:55	**Discussant: International CCS legal perspectives** Raphael Heffron (Univ. of Dundee)
14:55–15:00	**Discussant: International perspectives** Katherine Romanak (Univ. of Texas, Austin)
15:00–15:20	**Questions & comments from the audience** Moderated by Dorothy Dankel

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Part 1: CCS Regulatory Frameworks

Sigrid Eskeland Schütz is a professor of Law at the University of Bergen. Schütz is an expert on EU/EEA environmental law, resource management and terrestrial and marine land use and impact assessments. She works in the science policy interface, and is partner in several research projects on the alignment of Sustainable Development Goals, environmental concerns and regulations.

What does international and national law require of marine monitoring?

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Accelerating CCS Technologies

What does international and national law require of marine monitoring?

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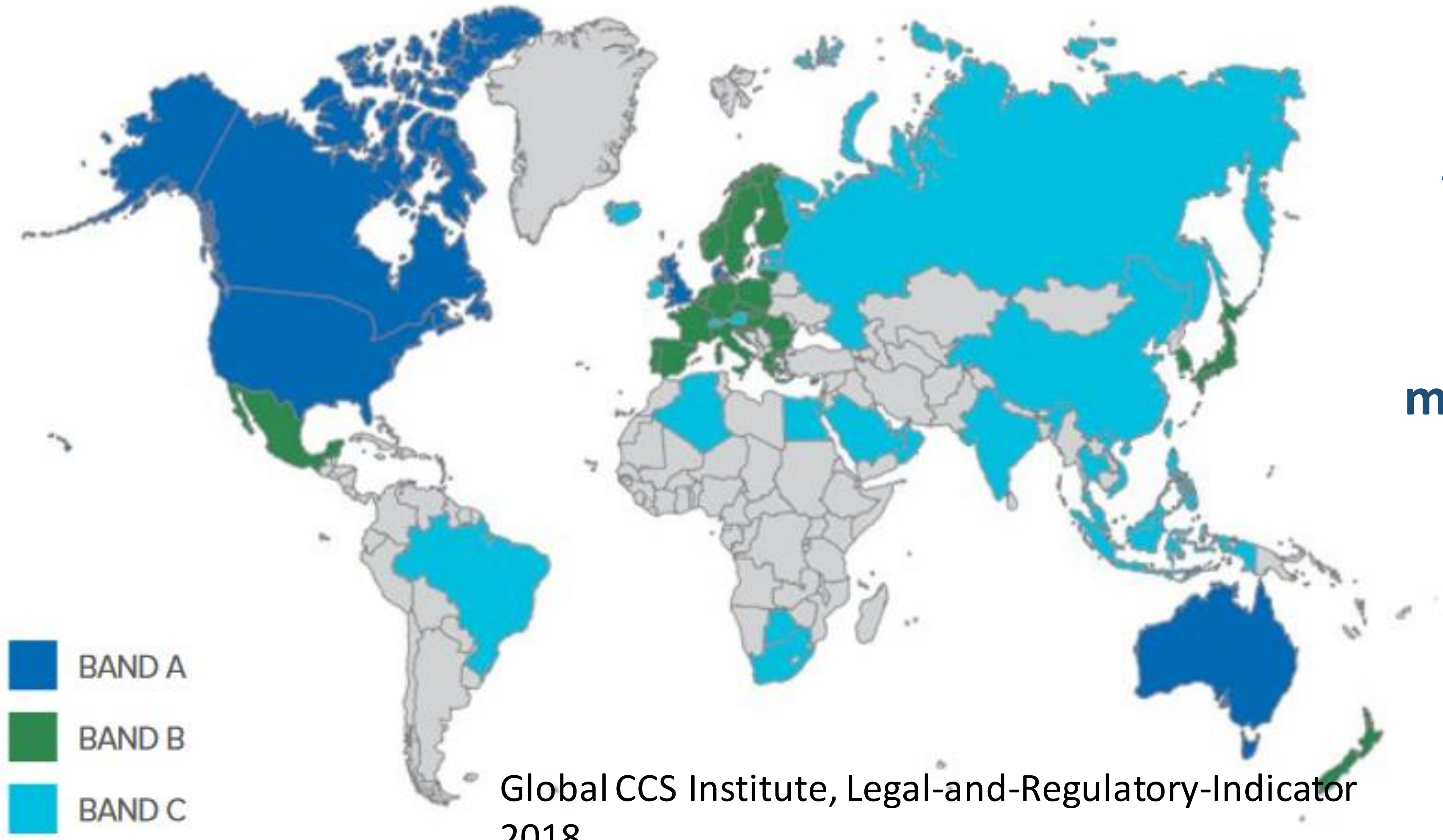
Figure 2: CCS Rank Map – Legal and Regulatory Indicator – World



Global CCS Institute, Legal-and-Regulatory-Indicator 2018

Are there any minimum legal requirements or precise descriptive requirements for monitoring and monitoring technologies?

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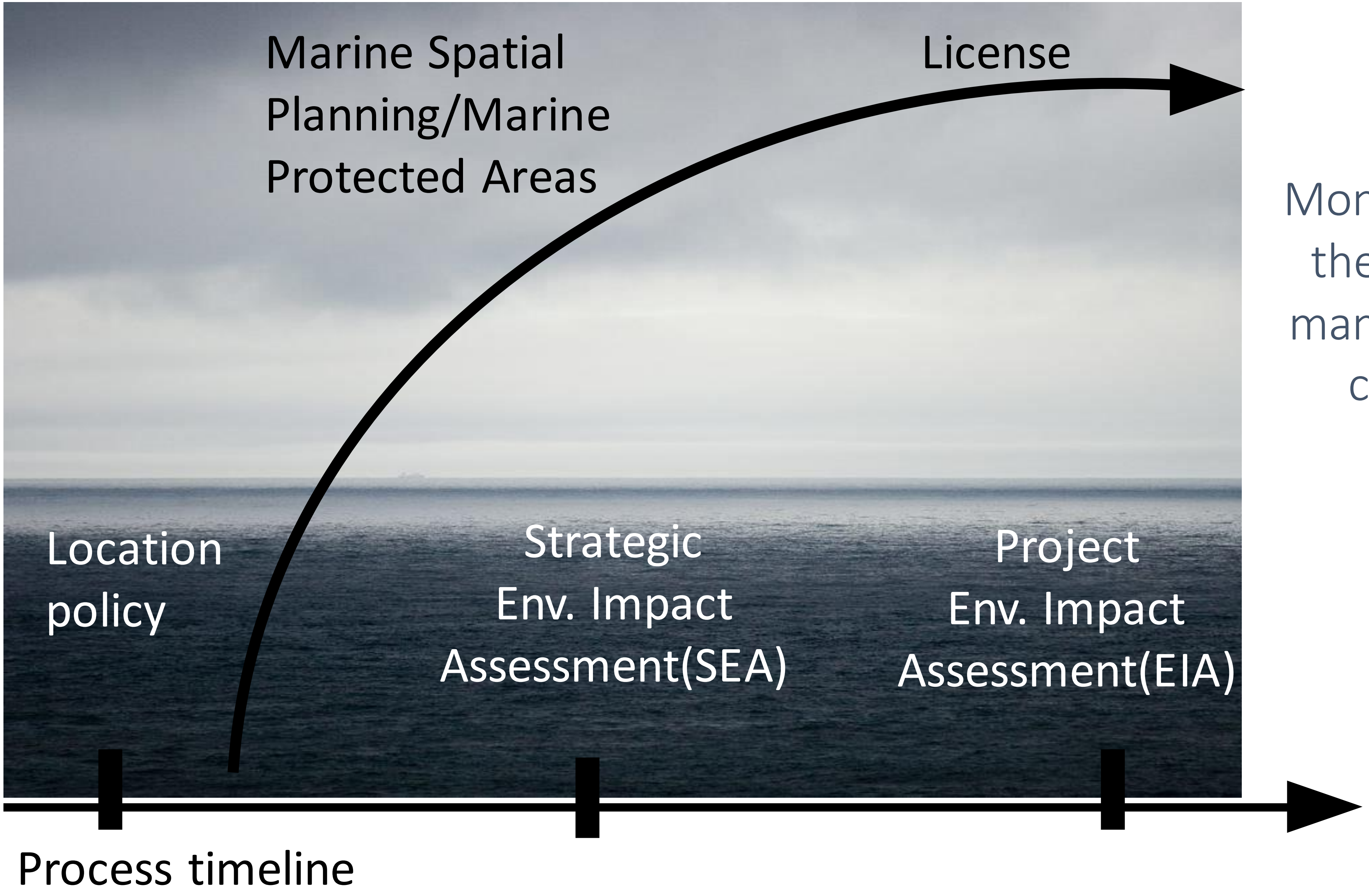
Monitoring in the marine management context



Regulatory approach

- Command and control (top-down); involve a centralised authority, usually wielding legal powers of inspection and sanction, to oversee the sector. CCS-regulation bear these traits.
- Reflexive regulation; facilitate a close linkage between the latest scientific knowledge on the condition and functioning of the marine environment on the one hand, and the management of human activities at sea on the other.
- Co-production; the particular monitoring elements of the regulation could better be characterized as co-production (bottom-up); flexible principle-based regimes and with reflexive and adaptive management-instruments.

Global and Regional Regulations

- The IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006).
- The United Nations Framework Convention on Climate Change (UNFCCC) Clean Development Mechanism (CDM) Modalities and Procedures (for developing countries).
- The London Convention and Protocol, regional instruments like the European Union (EU) CCS Directive and Emission Trading Scheme (ETS) Directive and the United States Environmental Protection Agency (US EPA) Final Rules.

The Guidelines;

- "The suitability and efficacy of these [monitoring] technologies can be strongly influenced by the geology … so the choice of monitoring technologies will need to be made on a *site-by-site basis*.
- Monitoring technologies are advancing rapidly and it would be *good practice* to keep up to date on new technologies."

Regional & EU Directive, example

L 140/114 EN Official Journal of the European Union 5.6.2009

DIRECTIVE 2009/31/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 23 April 2009

on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006

(Text with EEA relevance)

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community, and in particular Article 175(1) thereof,

Having regard to the proposal from the Commission,

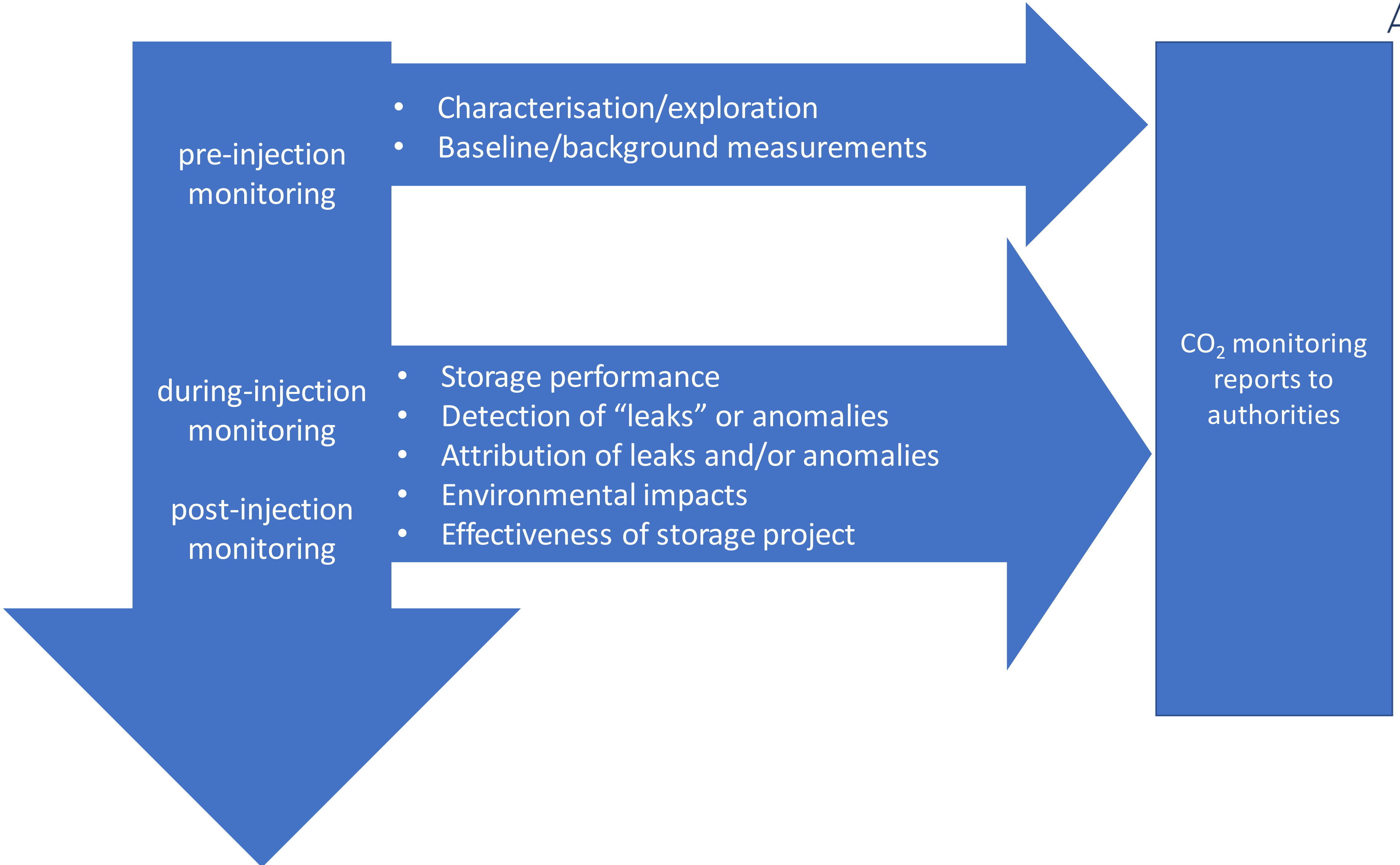
in the context of the envisaged global reduction of greenhouse gas emissions of 50 % by 2050, a reduction in greenhouse gas emissions of 30 % in the developed world by 2020 is required, rising to 60 %-80 % by 2050, that this reduction is technically feasible and the benefits far outweigh the costs, but that, to achieve it, all mitigation options must be harnessed.

Best available technology

- No examples on specific technologies.
- On the opposite; site-specific solutions and best available technologies stressed.
- Could one state that any potential (national) prescriptive rules on technology could stand in contradiction to the principle of best available technology?

Summary 1

- Globally the guidelines and regulations are based on the principles of
- best available practice
- best available technology
- recognition of the fact that monitoring needs to be site-specific
- in EU, *a level playing field/disturbance of competiton* are arguments that further supports this approach of technology-neutrality in prescriptive rules.
- designing the monitoring program could be regarded as co-production


pre-injection
monitoring
Characterisation/exploration
Baseline/background measurements
during-injection
monitoring
post-injection
monitoring
Storage performance
Detection of “leaks” or anomalies
Attribution of leaks and/or anomalies
Environmental impacts
Effectiveness of storage project
CO_2 monitoring
reports to
authorities

Summary 2

- Global, regional and national regulation and guidelines identifies different monitoring *phases*; *pre* injection monitoring, *during* and after. Monitoring relates to different parameters and *monitoring aims* in these respective phases (Dixon and Romanak 2015). In some circumstances terminology differs.
- Thus, monitoring phases with respective aims are recommended (soft law, guidelines) or mandatory (hard law, prescribed).
- Our presumption is that existing and future national regulation *could potentially relate to all these phases and prescribe all these monitoring aims.* An online monitoring tool *needs to be able to address these phases and aims*, to be relevant in all jurisdictions globally.

Part 2: Assessment of geophysical and marine monitoring technologies

What tools for marine monitoring can be used today?

What are the capabilities of these tools?

Abdirahman Omar is a researcher in chemical oceanography in Norwegian Research Center, NORCE, and at the Bjerknes Centre for Climate Research, BCCR, working on the marine carbon cycle and environmental monitoring of offshore CO2 storage sites. He has been involved in the EU funded projects ECO2 and STEMM-CCS.

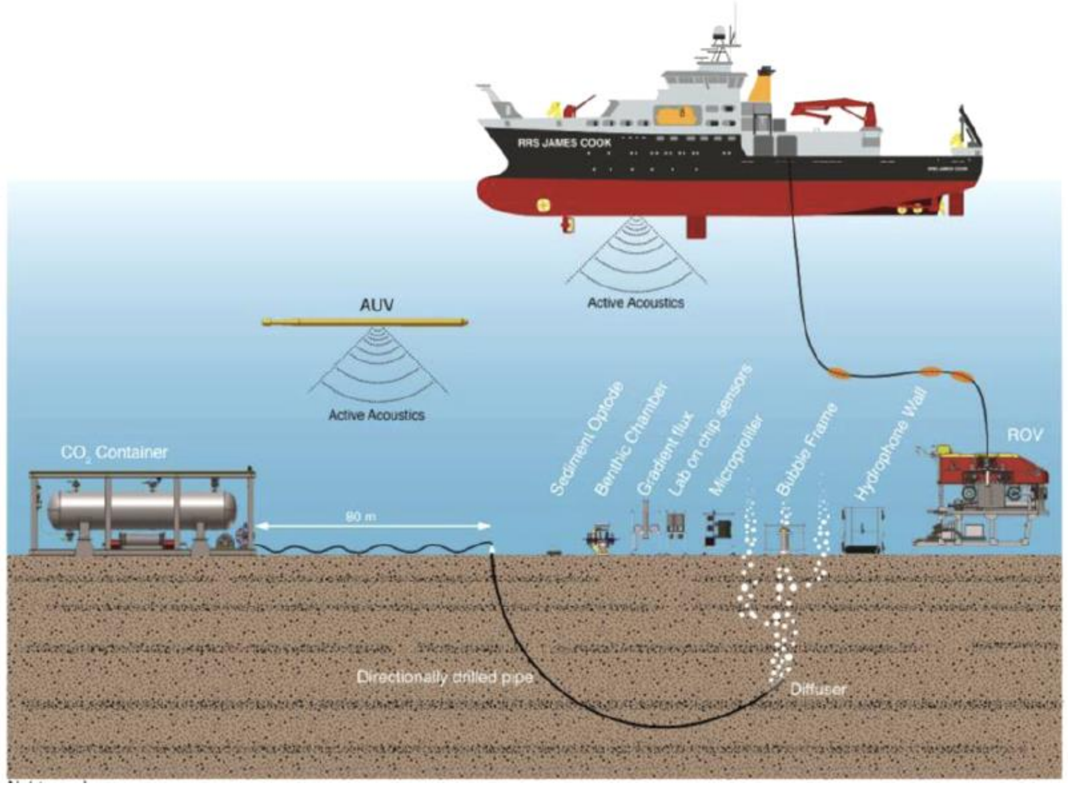
Developed with Stefan Carpentier from TNO

ACTOM framework for assessing measurement techs and data analysis methods w.r.t regulation

Ingredients:

- Monitoring protocols
- Inventory of tech./methods
- Capabilities (Criteria)
- Scoring system

ACTOM PI: Stefan Carpentier from TNO



Modified from Dean et al. 2020, *IJGGC*, 100.

Monitoring Protocols

Monitor for:

- Background i.e. baseline measurements (B)
- Performance of the CO_2 storage in the reservoir (P)
- Detection of leakage/anomalies (D)
- If leakage is detected, suspected or alleged
  - Attribution of source (A) – suggested own step
  - Quantify leakage (Q)
  - Assess Impacts (IA)

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journal homepage: www.elsevier.com/locate/ijggc

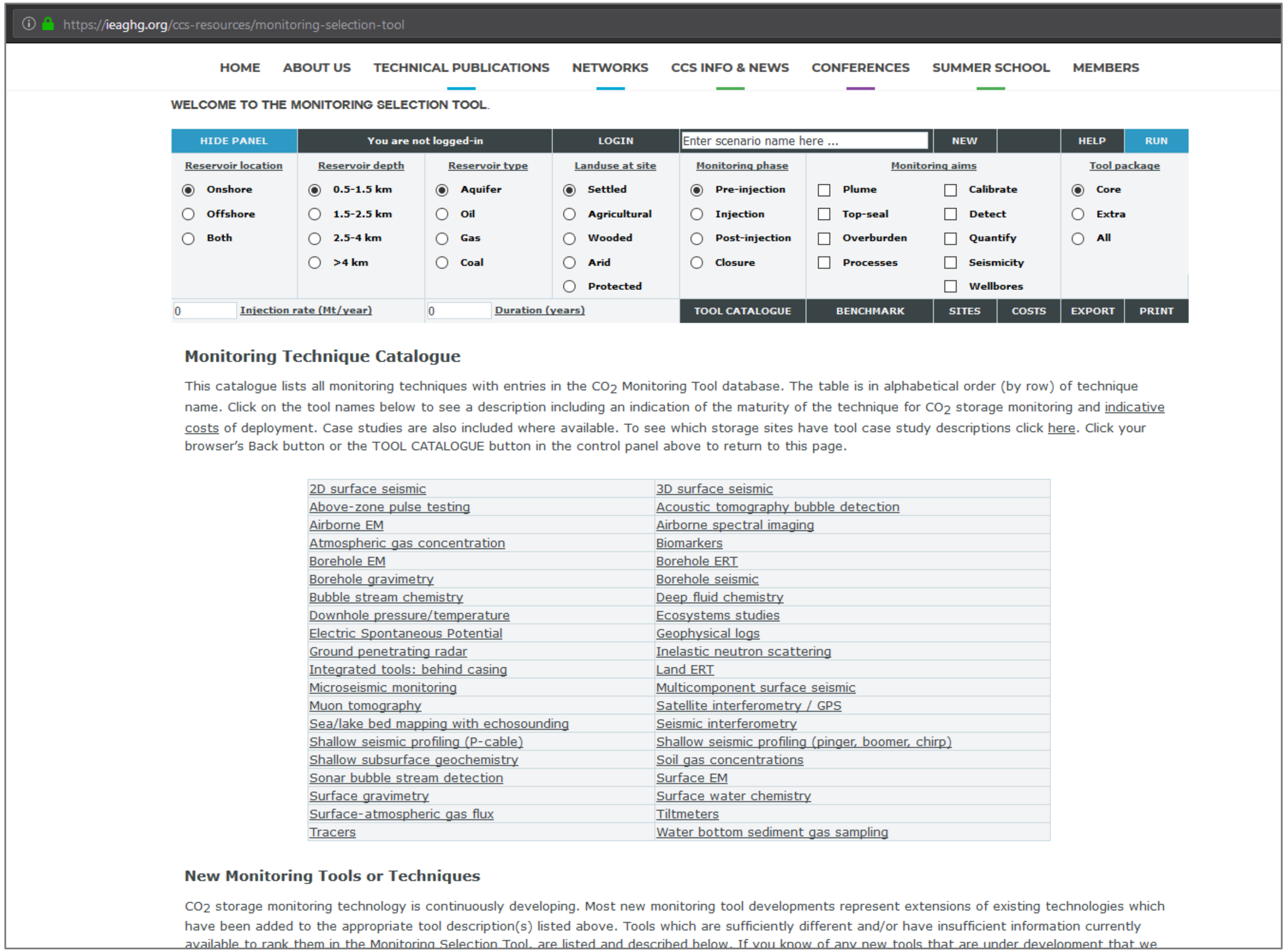
Improving monitoring protocols for CO_2 geological storage with technical advances in CO_2 attribution monitoring

Tim Dixon[a], Katherine D. Romanak[b,*]

[a] IEA Greenhouse Gas R&D Programme, Cheltenham, GL51 6SH, UK
[b] Gulf Coast Carbon Center, Bureau of Economic Geology, The University of Texas at Austin, Austin, TX 78713, USA

Inventory of measurement tech./methods (I)

IEAGHG monitoring selection tool



https://ieaghg.org/ccs-resources/monitoring-selection-tool

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WELCOME TO THE MONITORING SELECTION TOOL.

HIDE PANEL	You are not logged-in		LOGIN	Enter scenario name here ...	NEW		HELP	RUN
Reservoir location	Reservoir depth	Reservoir type	Landuse at site	Monitoring phase	Monitoring aims		Tool package	
Onshore	0.5-1.5 km	Aquifer	Settled	Pre-injection	Plume	Calibrate	Core	
Offshore	1.5-2.5 km	Oil	Agricultural	Injection	Top-seal	Detect	Extra	
Both	2.5-4 km	Gas	Wooded	Post-injection	Overburden	Quantify	All	
	>4 km	Coal	Arid	Closure	Processes	Seismicity		
			Protected			Wellbores		
0 Injection rate (Mt/year)		0 Duration (years)		TOOL CATALOGUE	BENCHMARK	SITES	COSTS	EXPORT PRINT

Monitoring Technique Catalogue

This catalogue lists all monitoring techniques with entries in the CO_2 Monitoring Tool database. The table is in alphabetical order (by row) of technique name. Click on the tool names below to see a description including an indication of the maturity of the technique for CO_2 storage monitoring and indicative costs of deployment. Case studies are also included where available. To see which storage sites have tool case study descriptions click here. Click your browser's Back button or the TOOL CATALOGUE button in the control panel above to return to this page.

2D surface seismic	3D surface seismic
Above-zone pulse testing	Acoustic tomography bubble detection
Airborne EM	Airborne spectral imaging
Atmospheric gas concentration	Biomarkers
Borehole EM	Borehole ERT
Borehole gravimetry	Borehole seismic
Bubble stream chemistry	Deep fluid chemistry
Downhole pressure/temperature	Ecosystems studies
Electric Spontaneous Potential	Geophysical logs
Ground penetrating radar	Inelastic neutron scattering
Integrated tools: behind casing	Land ERT
Microseismic monitoring	Multicomponent surface seismic
Muon tomography	Satellite interferometry / GPS
Sea/lake bed mapping with echosounding	Seismic interferometry
Shallow seismic profiling (P-cable)	Shallow seismic profiling (pinger, boomer, chirp)
Shallow subsurface geochemistry	Soil gas concentrations
Sonar bubble stream detection	Surface EM
Surface gravimetry	Surface water chemistry
Surface-atmospheric gas flux	Tiltmeters
Tracers	Water bottom sediment gas sampling

New Monitoring Tools or Techniques

CO_2 storage monitoring technology is continuously developing. Most new monitoring tool developments represent extensions of existing technologies which have been added to the appropriate tool description(s) listed above. Tools which are sufficiently different and/or have insufficient information currently available to rank them in the Monitoring Selection Tool, are listed and described below. If you know of any new tools that are under development that we

Inventory of measurement tech./methods (II)

STEMM CCS inventory of monitoring tools

Monitoring Selection Tool

stemm-ccs.eu/monitoring-tool/

STEMM-CCS

Strategies for Environmental Monitoring
of Marine Carbon Capture and Storage

STEMM-CCS Online Monitoring and Decision Tool

- **Purpose of the Tool**
- **Description**

Monitoring Tasks

- **Characterisation of Injection Site**
- **Leakage Detection**
- **Source Attribution**
- **Leakage Quantification**
- **Environmental Impact Assessment**

Glossary of Terms

- **Warranty Disclaimer**

Scoring system

1: performs poorly in the given criterium or setting

2: gives overall reasonable performance

3: has high performance, impact & value of information

Developed with Stefan Carpentier from TNO

Assessment criteria

Criteria	Legend
1. Cumulative score	Sum of all scores
2. Sea water column	Performance in sea water column
3. Seabottom	Performance around sea bottom
4. Seabottom subsurface	Performance in sea bottom subsurface
5. Regulation	CCS site regulation phase (Dixon and Romanak, 2015), either: baseline (B), performance (P), detection (D), attribution (A), quantification (Q), or impact assessment (IA)
6. Sensitivity	Sensitivity / signal-to-noise of method
7. Effort	Overall required effort regarding power, logistics
8. Accessbility	Method capability to access target measurement area
9. Time required	Time required to perform acquisition / processing of method
10. Practical	Practicality of executing the method at site
11. Coverage	Spatial coverage of a method
	Temporal coverage of a method
12. Resolution	Spatial resolution of a method
	Temporal resolution of a method
13. Penetration	Penetration depth / distance of method
14. Repeatability	Repeatability of comparable results of method
15. Baseline/versus/repeat	Suitability of method to be used for baseline or repeat surveys
16. Cost/km	Cost of method per kilometer
17. Cost/hour	Cost of method per hour
18. Synergy	Synergy of method with other methods

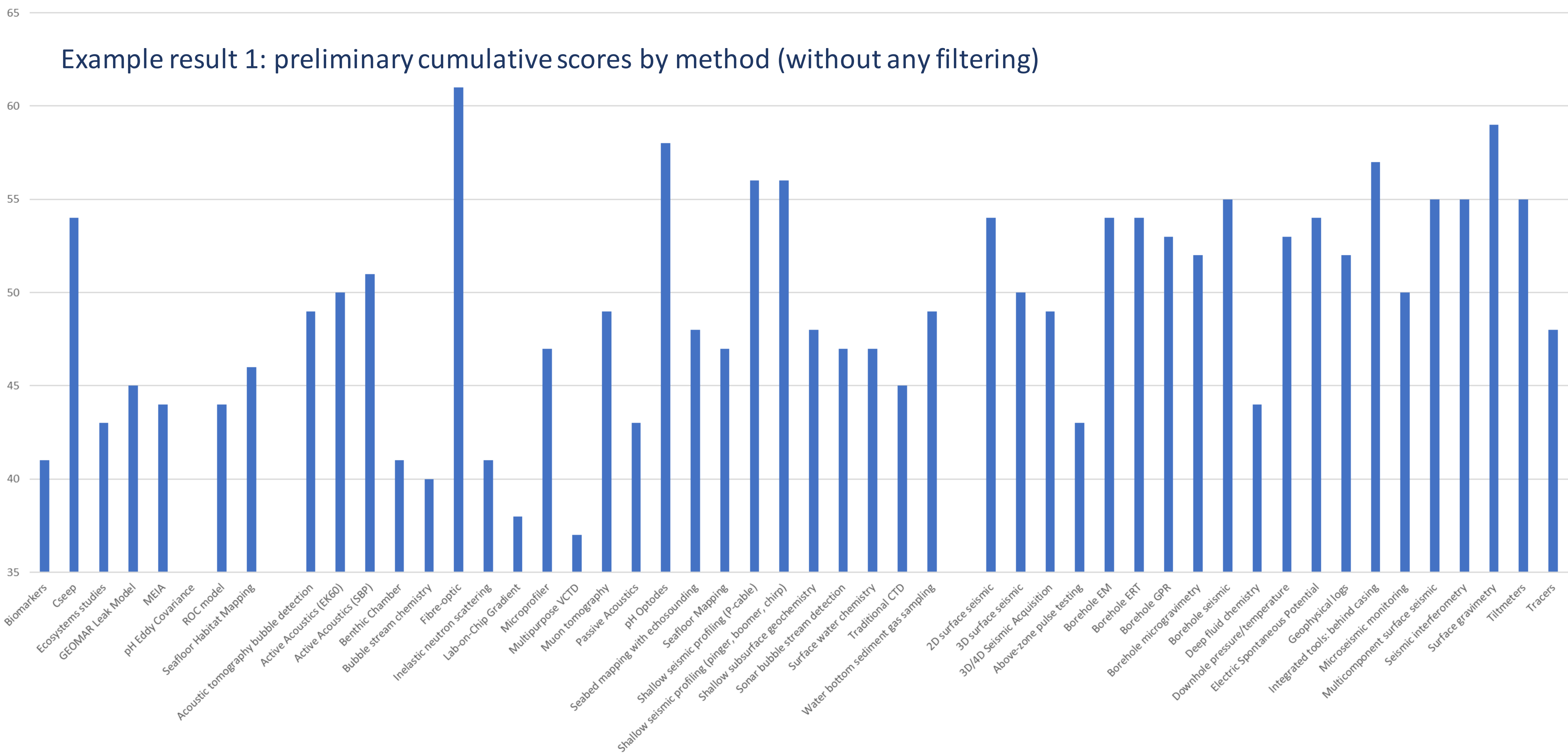
ACTOM inventory table

Domain	Category	Method	Result	Cumulative score
Near-surface	Meta-analysis	Biomarkers	A useful low cost seabed monitoring method of physiological responses to CO_2 exposure by increases in dissolved CO_2 in the sediment	41
Near-surface	Meta-analysis	Cseep	Quantified natural variability in the concentration of Dissolved Inorganic Carbon (DIC) and filter it out for easy identification of the impact of CO_2 seepage	54
Near-surface	Meta-analysis	Ecosystems studies	Identified particular species or patterns that can act as bioindicators enabling early detection of potential CO_2 leaks using a variety of microbiological, macrofaunal, botanical and biogeochemical techniques	43
Near-surface	Meta-analysis	GEOMAR Leak Model	Simulated behavior of gaseous or liquid carbon dioxide released in the sea to assess the footprint of impact for different leak scenarios, such as they are typically executed for an environmental impact assessment	45
Near-surface	Meta-analysis	MEIA	A model system, which allow us to predict gaseous and dissolved CO_2 flow through the water column as a result of bouyant bubble plumes and hydrodynamic flow in the water column and "what if" scenarios	44
Near-surface	Meta-analysis	pH Eddy Covariance	Quantified natural variations in seafloor biological O_2 uptake and dissolved inorganic carbon (DIC) production, exceedingly sensitive to a seafloor source of DIC	35
Near-surface	Meta-analysis	ROC model	Recognized unnatural rates of change (ROCs) in CO_2 concentrations utilizing the tidally induced mobility of CO_2 plumes, creating fluctuations over space and timescales that differ from those of natural processes	44
Near-surface	Meta-analysis	Seafloor Habitat Mapping	Habitat maps based on a combination of full-coverage environmental information and point-based direct observations, typically recorded with a survey vessel or on an Autonomous Underwater Vehicle	46

All scores are preliminary!

Near-surface	Sensoric data	Acoustic tomography bubble detection	Acoustic tomography detecting dispersion of the acoustic signal by CO_2 bubbles leaking from the sea floor and causing upward currents, thus pin-pointing the source of the CO_2 leakage	49
Near-surface	Sensoric data	Active Acoustics (EK60)	Detected gas within the water column by on hull mounted EK60 data, detectable most prominently at 18 kHz. Combined backscatter measurements at different frequencies can determine gas flux	50
Near-surface	Sensoric data	Active Acoustics (SBP)	Gaseous material within the seabed and in the water column easily seen on high resolution seismic reflection data. Presence of gas is detected, and repeat surveys allow the migration of the gas to be seen in the sub-surface	51
Near-surface	Sensoric data	Benthic Chamber	Monitored evolution of solute CO_2 concentrations within incubated volume over 1-2 days, their fluxes across the sediment-water interface can be quantified	41
Near-surface	Sensoric data	Bubble stream chemistry	Collected bubbles of gas using inverted funnels by divers in the offshore environment. The bubbles are collected in sealed containers allowing detailed analyses of the gas composition to be made, to help identify the source of the gas	40
Near-surface	Sensoric data	Fibre-optic	Distributed Strain Sensoring (DSS), Distributed Acoustic Sensoring (DAS), Distributed Chemical Sensoring (DCS), Distributed Temperature Sensoring (DTS, highly repeatable and having large coverage of tens of kilometers	61
Near-surface	Sensoric data	Inelastic neutron scattering	Mapping of elemental concentrations (including carbon, silicon, oxygen) in the soil. A reduction in carbon relative to the other elements in the soil could indicate CO_2 leakage (successfully tested at a site described below	41
Near-surface	Sensoric data	Lab-on-Chip Gradient	A lab-on-chip sensor for dissolved inorganic carbon (DIC), or a combination of pH and total alkalinity sensor, quantifies the excess DIC in the water which is a results of dissolved CO_2 bubbles	38
Near-surface	Sensoric data	Microprofiler	Strongly miniaturized electrochemical sensors with a tip diameter of less than 50 µm and a sensing surface of less than 0.5 µm recording CO_2, O_2, pH, H_2S, redox and temperature	47
Near-surface	Sensoric data	Multipurpose VCTD	Multipurpose Video Conductivity Temperature Depth (VCTD) system for detecting and monitoring gas-rich fluid seepage from the seafloor investigating natural CO_2-and CH_4-seepages	37
Near-surface	Sensoric data	Muon tomography	Monitoring density changes based on the changing muon flux could allowing accurate long term passive monitoring of a CO_2 storage site	49
Near-surface	Sensoric data	Passive Acoustics	The acoustic signal recorded by multiple hydrophones can be used to determine the gaseous flux. Quiet sounds of the bubbles can be measured above the background noise	43
Near-surface	Sensoric data	pH Optodes	Indicator dyes that change their fluorescent properties depending on pH in the analysed media enabling several months long continuous pH monitoring	58
Near-surface	Sensoric data	Seabed mapping with echosounding	One of the most accurate tools for imaging large areas of the seabed. Allowing detailed mapping of seafloor bathymetry and providing information about the nature of the sediment / seawater interface.	48
Near-surface	Sensoric data	Seafloor Mapping	Seafloor mappingcarried out with acoustic techniques, either using multibeam echosounders or sidescan sonars. Acoustic reflectivity of the seabed ('backscatter'): a proxy for seafloor hardness, and hence sediment type	47
Near-surface	Sensoric data	Shallow seismic profiling (P-cable)	Very high resolution 3D seismic in the top ~1000m of the subsurface. Time lapse surveying would be required to identify changes that may indicate migration and leakage of CO_2	56
Near-surface	Sensoric data	Shallow seismic profiling (pinger, boomer, chirp)	Resolved bed thickness of a metre or less likely having considerable potential for resolving small amounts of gas (typically represented by acoustic blanking, bright spots, etc.)	56
Near-surface	Sensoric data	Shallow subsurface geochemistry	Geochemical computer codes using measurements of the relative proportions of these individual components to estimate the total CO_2 flux into the groundwater	48
Near-surface	Sensoric data	Sonar bubble stream detection	Detected bubbles allow for bubble stream chemistry techniques to be used for confirming the gas and source of the bubbles and quantification of gas flux	47
Near-surface	Sensoric data	Surface water chemistry	Four typically measured parameters that, together with ancillary information such as conductivity, temperature, pressure, pH and salinity, can be used to describe the CO_2 system for a given water sample	47
Near-surface	Sensoric data	Traditional CTD	A variety of parameters are recorded (hydrography and carbonate chemistry) and several water samples are collected including dissolved gasses (such as O_2, DIC, CH_4...) inorganic nutrients (such as nitrates, phosphate and silicate)	45
Near-surface	Sensoric data	Water bottom sediment gas sampling	Seabottom gas sampling and analysis allowing monitoring of the composition and origins of very shallow gas in the near-surface seabed indicating CO_2 leakage or precursor fluid detection	49

Example result 1: preliminary cumulative scores by method (without any filtering)



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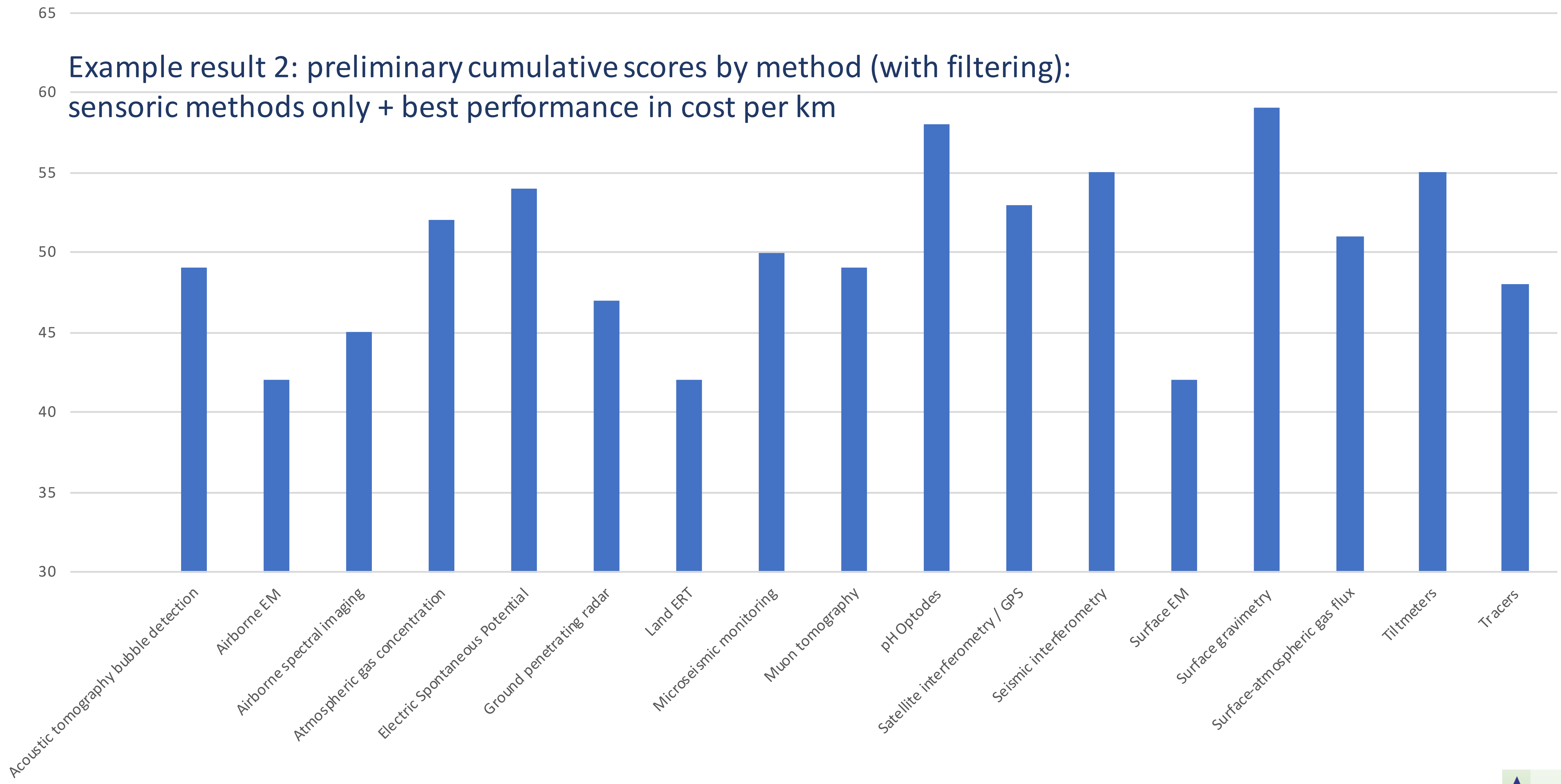
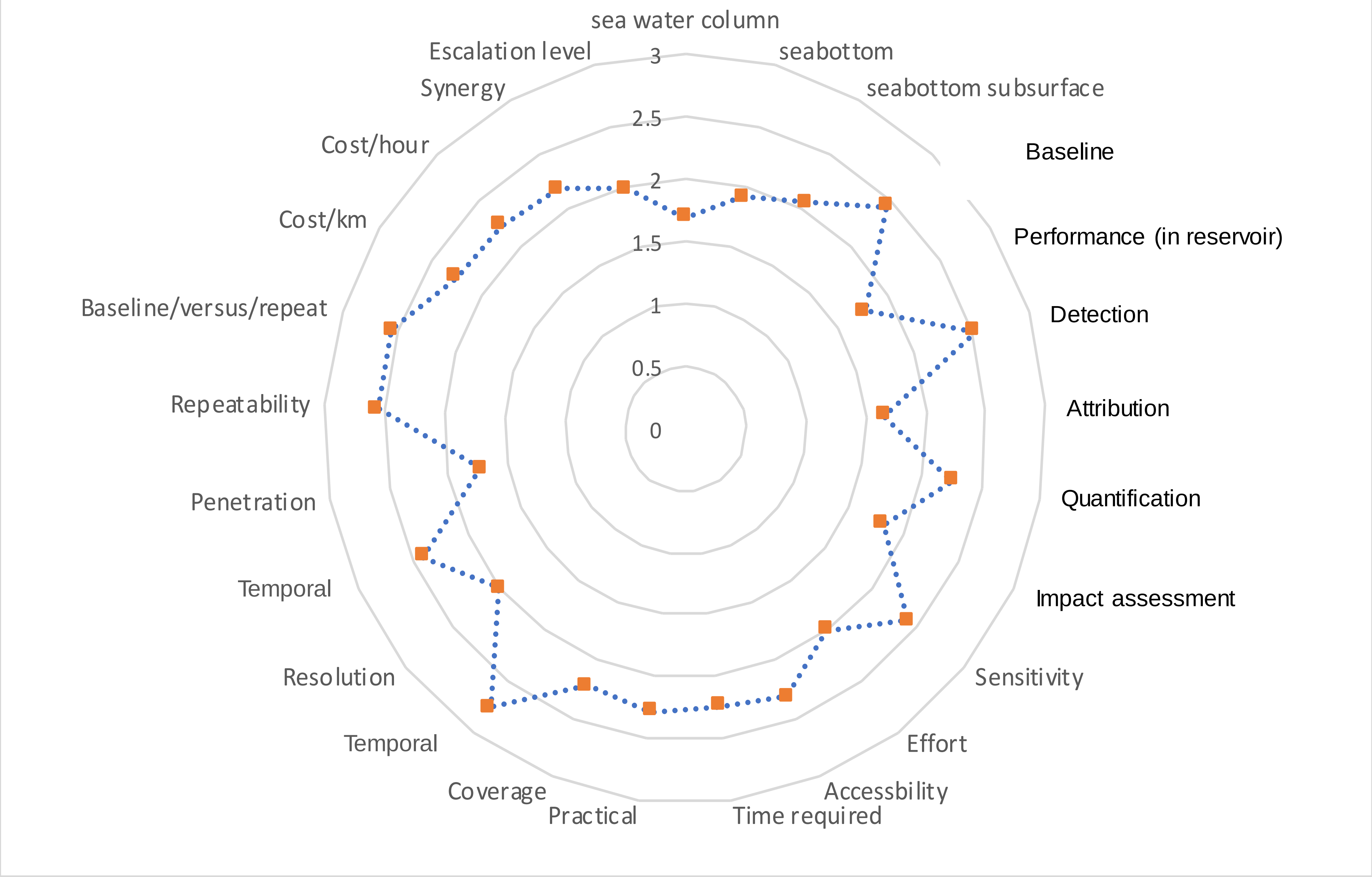
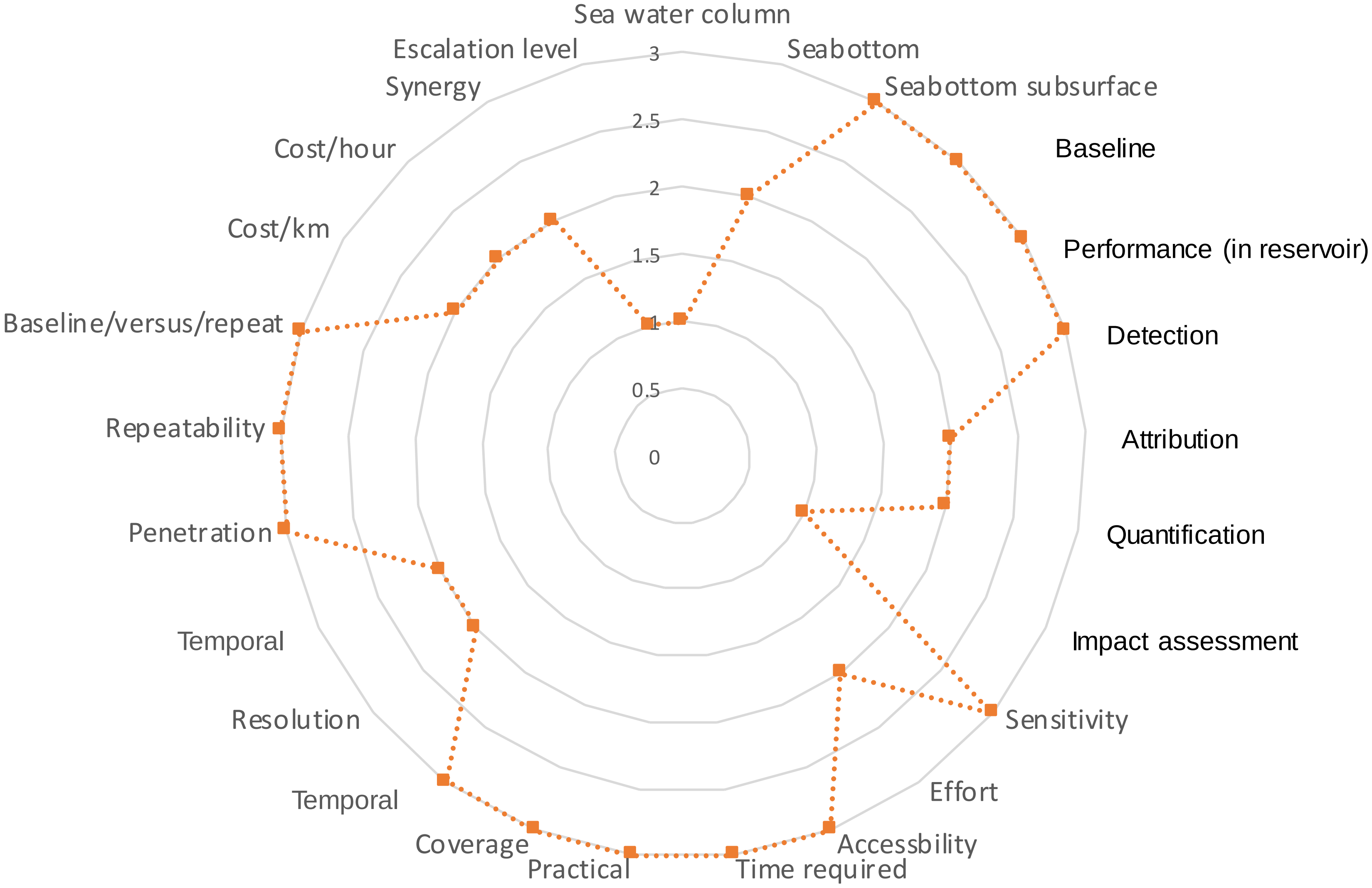
Example result 2: preliminary cumulative scores by method (with filtering): sensoric methods only + best performance in cost per km



Example result 3: average preliminary scores by criteria for all technologies & methods



Example result 4: preliminary scores by criteria for a sensor



ACTOM ranking of monitoring tools

Ideas to further improve the ranking table:

- Include depth-relation: can certain shallow monitoring be ruled out/excluded by deep monitoring or vice versa?
- Include CO_2 flux detection threshold per method as a function of distance, time, site characteristics etc: which method is sensitive enough to pick up CCS site anomalies at which distance and moment in time?
- Include more options to make the scores site-dependent: which methods work for a rig, work for aquifer/depeleted gasfield, work for active shipping lanes, work for fishery grounds, etc.

Methods in focus in ACTOM project

Distinguish anomalous signals (e.g. seeps) from the high spatio-temporal natural variability of the marine environment.

- Rate of Change method (Blackford et al. 2017)
- Stiochiometric methods: Cseep method (Omar et al 2020, *in Rev*)
- AI methods: time series classification through machine learning (Gundersen et al. 2020)

Where and when to deploy monitoring to maximise its value

- Fixed installations (Hvidevold 2016, Oleynik et al. 2020)
- Moving platforms (Alendal 2017)

Summary and conclusion

- Gathered a comprehensive inventory of geophysical and marine monitoring technologies (a subset to be included in the toolkit, WP2).
- Developed a framework for assessing different technologies w.r.t. capabilities, costs & regulations.
- Assessment results are based on expert opinion and are preliminary. ACTOM is to develop tools that give clearer and more nuanced information.
- So far, monitoring technology exists for all project phases, surfaces, and monitoring aspects.
- We find no conflict between regulation requirements and technical capabilities for marine monitoring in CCS projects.

Webinar Program

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14:30–14:50	**Part 2: Assessment of geophysical and marine monitoring technologies** Abdirahman Omar (NORCE)
14:50–14:55	**Discussant: International CCS legal perspectives** Raphael Heffron (Univ. of Dundee)
14:55–15:00	**Discussant: International perspectives** Katherine Romanak (Univ. of Texas, Austin)
15:00–15:20	**Questions & comments from the audience** Moderated by Dorothy Dankel

Discussant: International CCS legal perspectives

Raphael Heffron is Professor for Global Energy Law & Sustainability at the Centre for Energy, Petroleum and Mineral Law and Policy at the University of Dundee. He as of July 2019 is a Jean Monnet Professor in the Just Transition to a Low-Carbon Economy awarded by the European Commission. Professor Heffron is a qualified Barrister-at-Law, and a graduate of both Oxford (MSc) and Cambridge (MPhil & PhD). His work all has a principal focus on achieving a just transition to a low-carbon economy and combines a mix of energy law, policy and economics.

Professor Raphael Heffron
University of Dundee

Discussant: International perspectives

Dr. Romanak is an expert in environmental monitoring at geologic CO2 storage sites and has developed and implemented several environmental monitoring programs with an innovative "process-based" method for assessing potential leakage at CCS sites. Dr. Romanak has worked internationally at CO_2 storage sites and is a member of the International Steering Committees for the IEAGHG Monitoring and the Environmental Science Networks. She regularly informs global policy within the United Nations Framework Convention on Climate Change (UNFCCC) and has informed the U.S. Congress on environmental monitoring at geologic CO2 storage sites. She is passionate about working with developing countries to build their national CCS programs.

Dr. Katherine Romanak
University of Texas, Austin

ACT on Offshore Monitoring

Monitoring Offshore CCS

PROBLEM

What are regulatory monitoring requirements, and does technology exist for all project phases, surfaces, and monitoring aims? What are the capabilities of these tools?

BENEFITS

A web-based toolbox of global relevance, regardless of jurisdiction and CCS site.

ISSUE

Ensure that the marine monitoring toolbox meets regulatory requirements and examine the capabilities of tools.

SO WHAT?

Enable the derivation of optimal environmental monitoring strategies, reducing costs.

SOLUTIONS

International and regional CCS guidelines and regulations require no specific technology, but identify storage *phases and monitoring aims.* Technology exists for all project phases, surfaces, and monitoring aims, optimal methods have emerged.

Questions and Comments from Audience