Enabling a CO_2 release experiment in the North Sea

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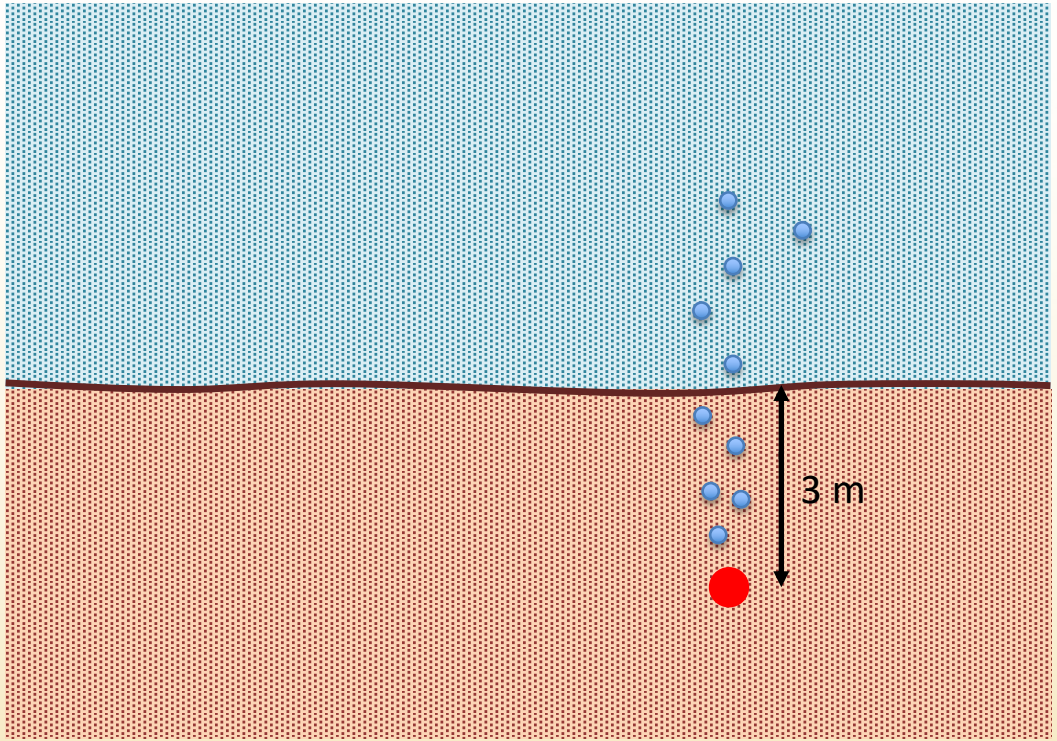
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 654462

The challenge…



1. Release gas from a point 3 m below the seafloor at 120 m

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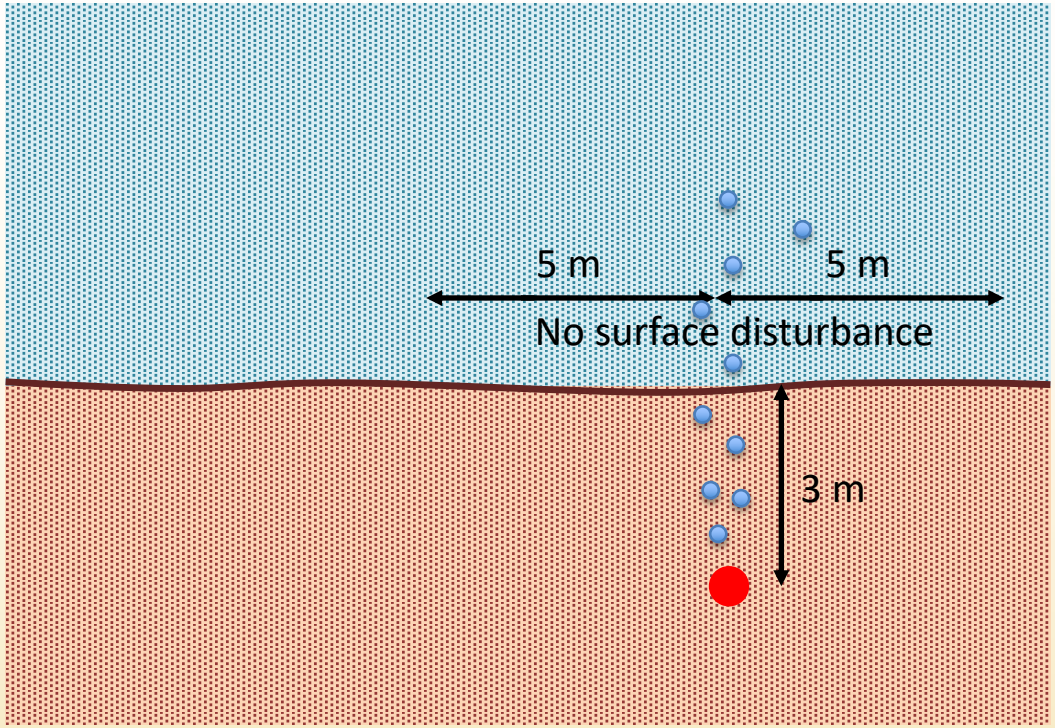

1. Release gas from a point 3 m below the seafloor at 120 m
2. No surface disturbance within 5 m radius

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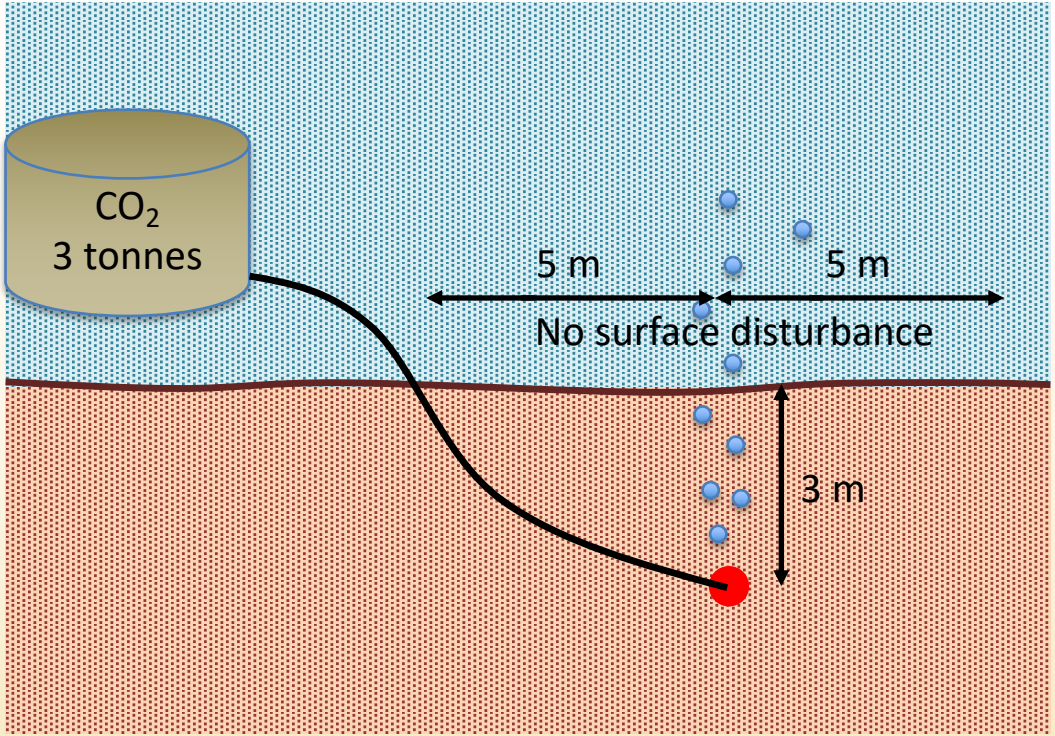

1. Release gas from a point 3 m below the seafloor at 120 m
2. No surface disturbance within 5 m radius
3. Provide 3 tonnes of CO_2

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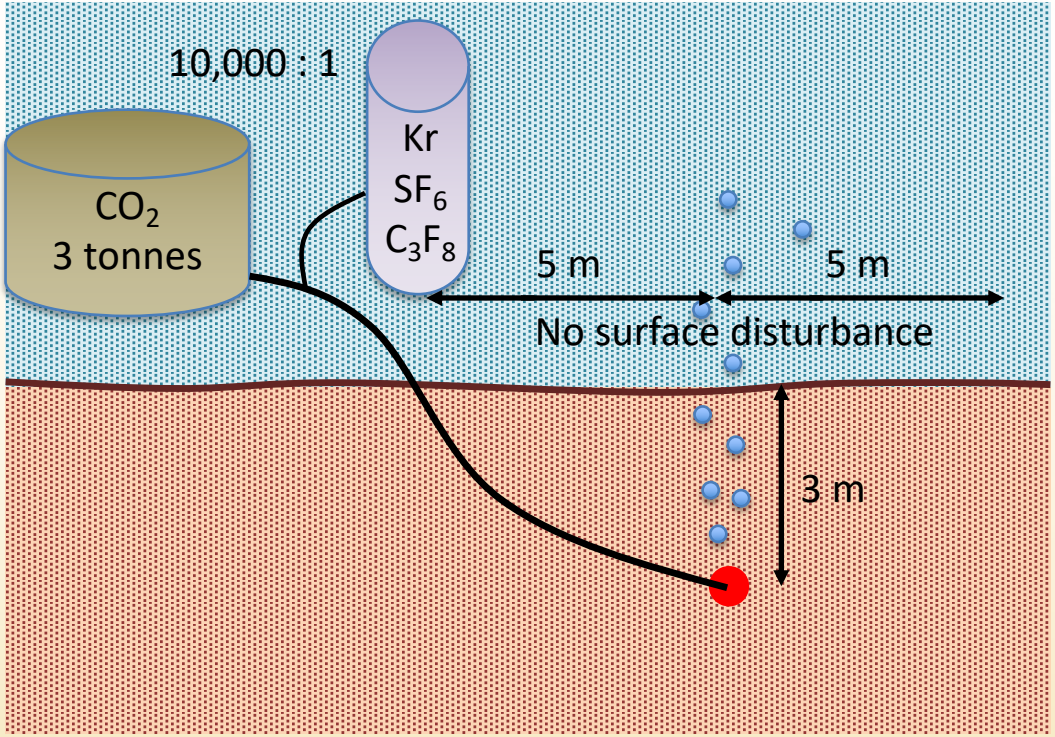

1. Release gas from a point 3 m below the seafloor at 120 m
2. No surface disturbance within 5 m radius
3. Provide 3 tonnes of CO_2
4. Add trace gas mix at precise mass ratio of 10,000:1

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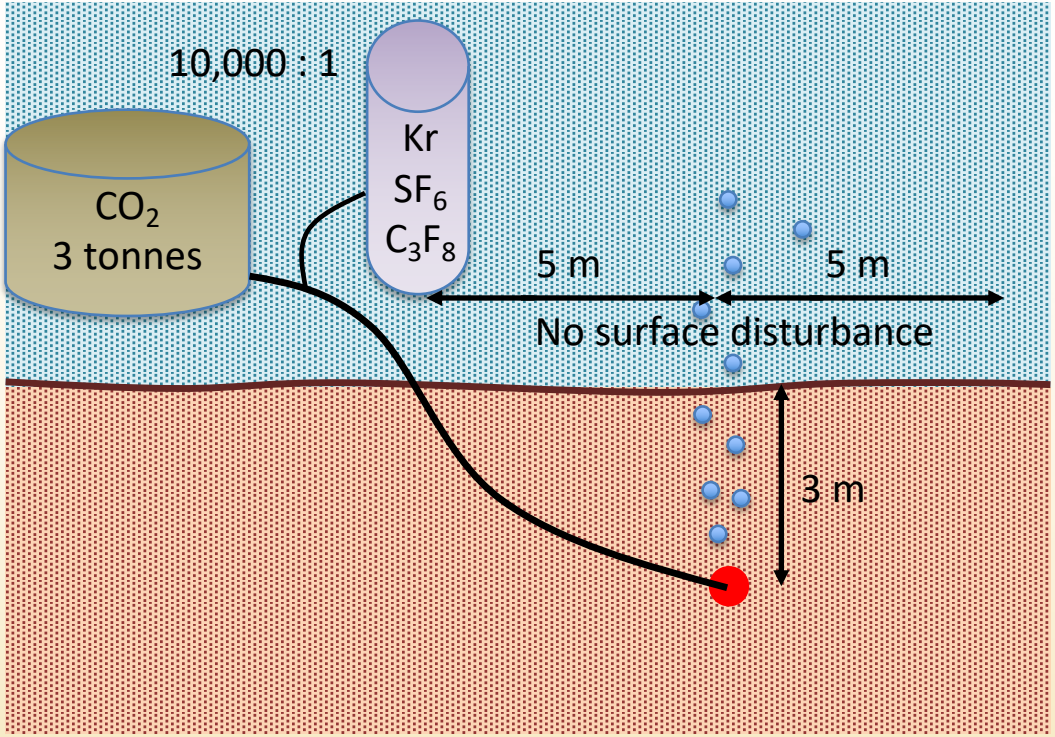

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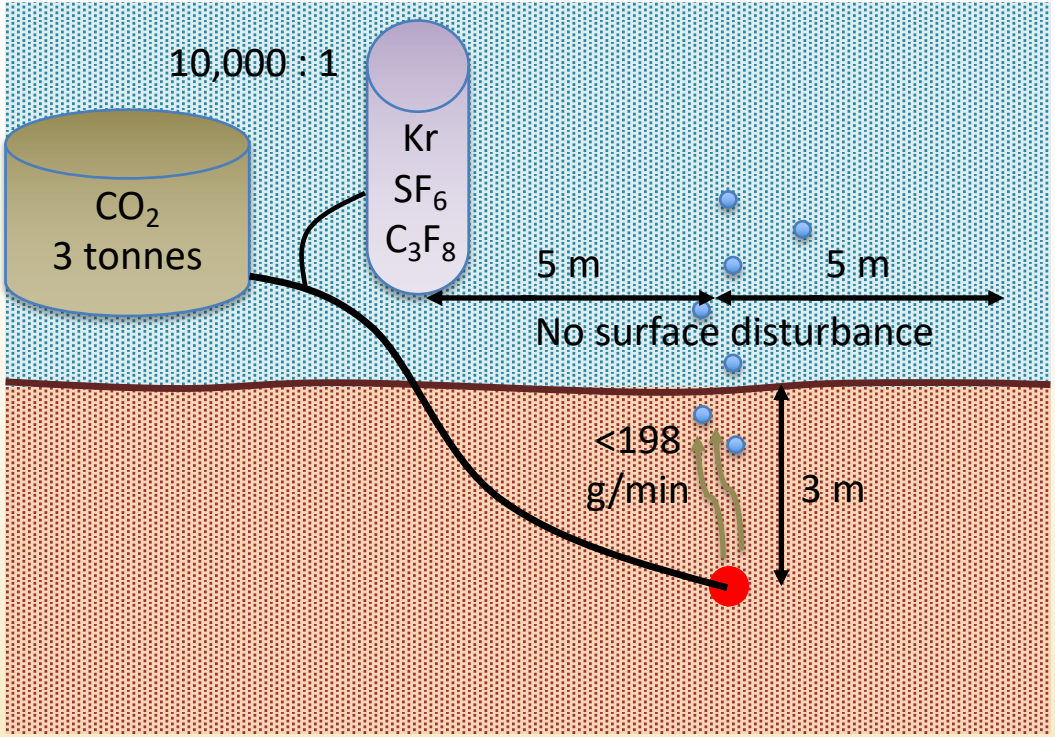

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2. No surface disturbance within 5 m radius
3. Provide 3 tonnes of CO_2
4. Add trace gas mix at precise mass ratio of 10,000:1
5. Do not disturb water flow in vicinity of release point
6. Flow rate < 198 grams per min

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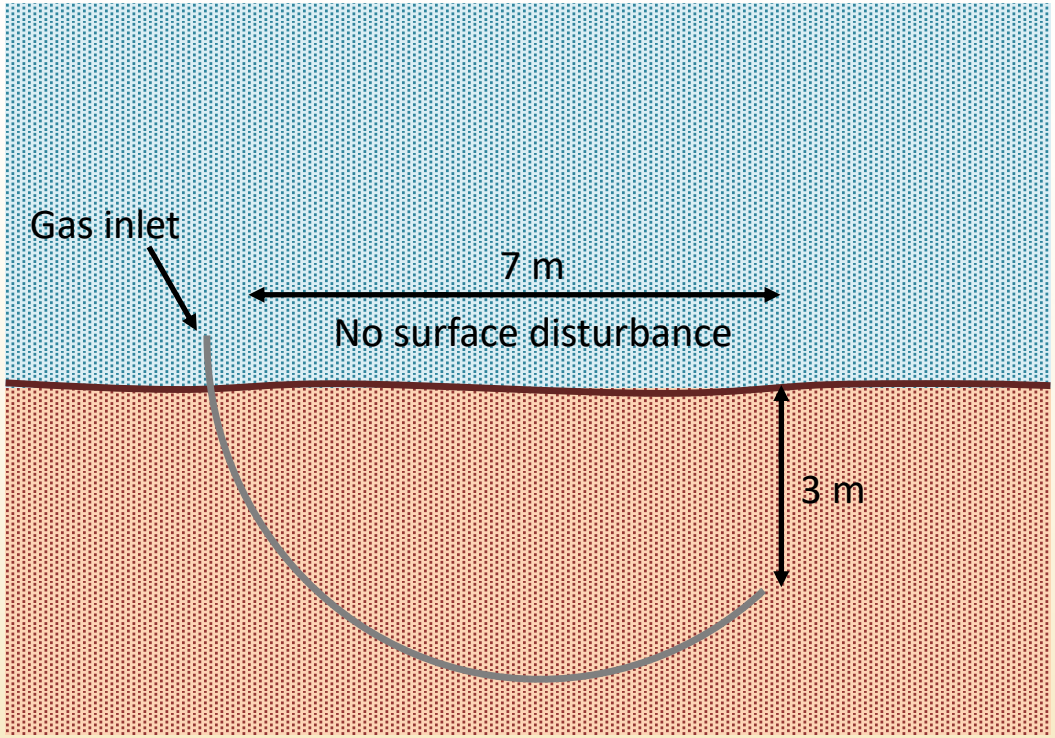
The solution…



Gas release pipe

- Pre-curved, rigid pipe inserted from a point ~7 m from release point
- 38.1 mm OD x 12.7 mm ID
- 9 µm diffuser, multiple outlet holes
- Upwardly pointing outlet to minimise chance of gas tracking back up outside of pipe
- Inlet provided with quick-connect fitting for connection by ROV

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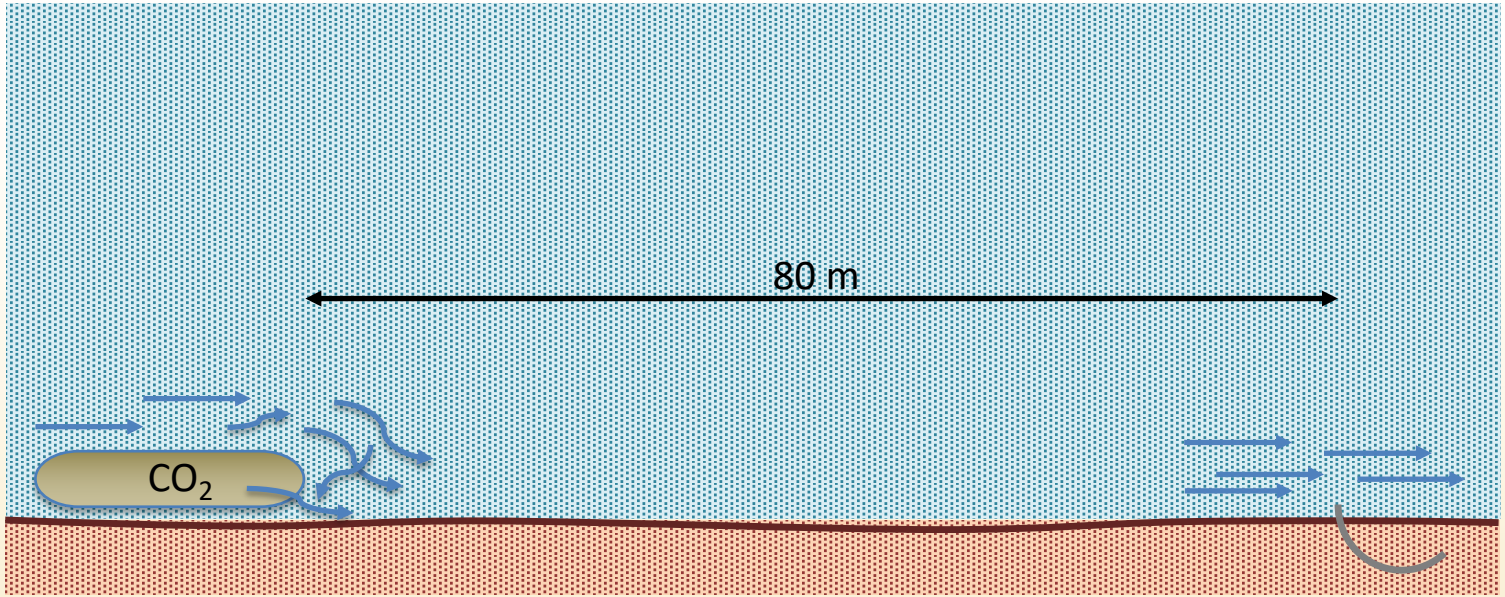
The solution…



Gas tanks

- 80 m separation to minimise water flow disturbance at release point

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Gas release pipe…

Photo: Ben Roche

- Pipe insertion rig designed and built by Cellula Robotics in Canada
- Here being deployed from RRS James Cook
- More to follow from Allan Spencer…

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Gas delivery…

Palletised standard gas cylinders

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Gas delivery…

~~Palletised standard gas cylinders~~

- Unwilling to supply for subsea use

- Bespoke gas tank package

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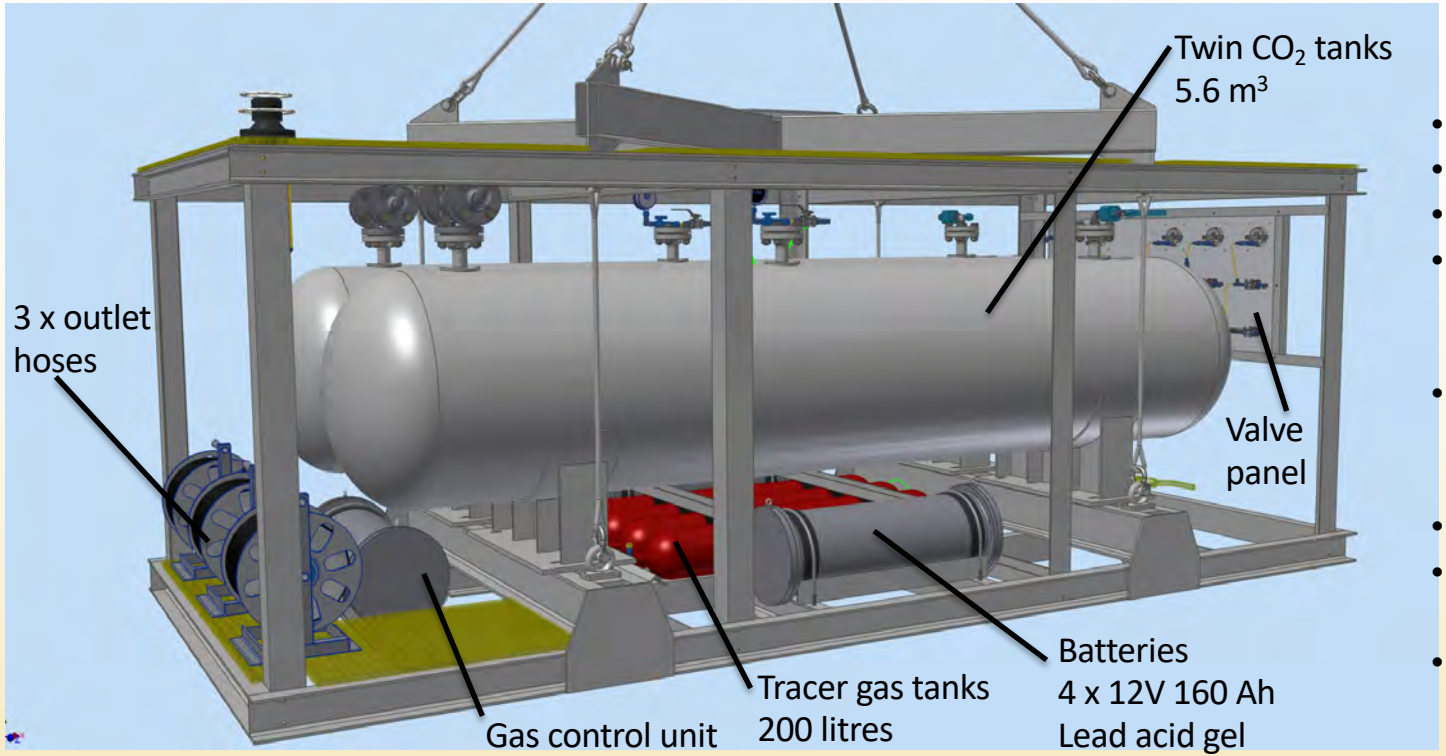
Gas delivery…



- 5.5 x 2.5 x 2.0 m
- Weight in air: 13 tonnes
- Weight in water: 6 tonnes
- CO_2 tank capacity: 5.6 m^3
  ~ 3 tonnes liquid
  ~ $1.5x10^6$ litres gas
- CO_2 tanks uninsulated so pressure dependent on ambient temperature
- Max pressure 80 bar
- 42 bar at seawater temp ~8°C
- Tracer mix: 200 litres (gas) at 30 bar

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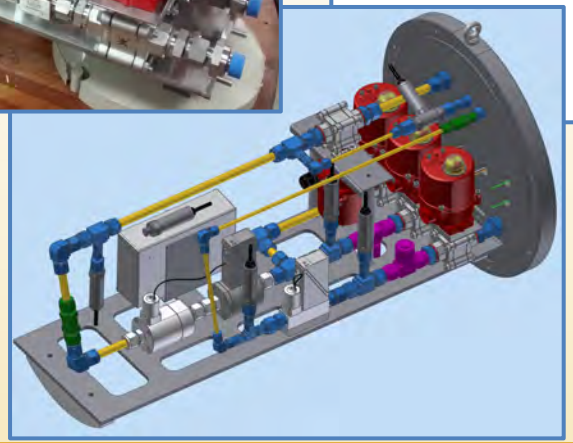
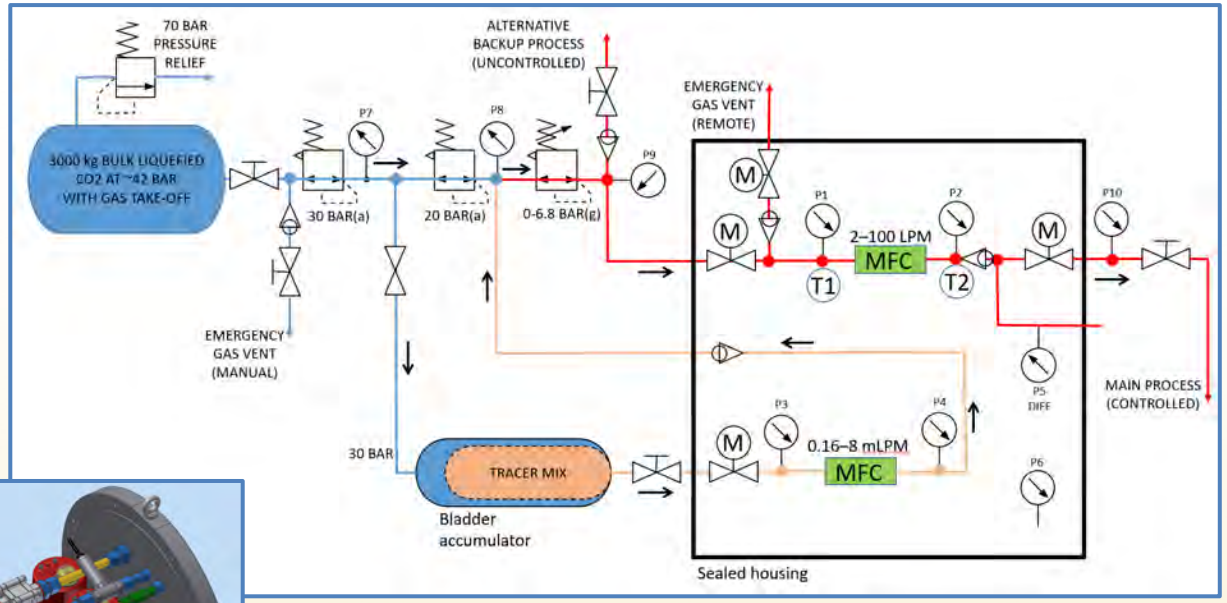
Gas control…





- Tracer MFC, 0.16 to 8 mL/min
- Main MFC, 2 to 100 L/min (CO2 + tracer mix)
- Mass flow ratio 10,000:1
- All user interaction, set points, flow, pressure and temperature values logged
- Remote control via PC based GUI using acoustic or optical modems

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Gas control…

- Manual ROV panel
- Isolating valves, diverting valves, dump valves
- Final stage pressure regulator
- Pressure gauges
- Heat transfer coils to mitigate Joule Thomson cooling through pressure regulators

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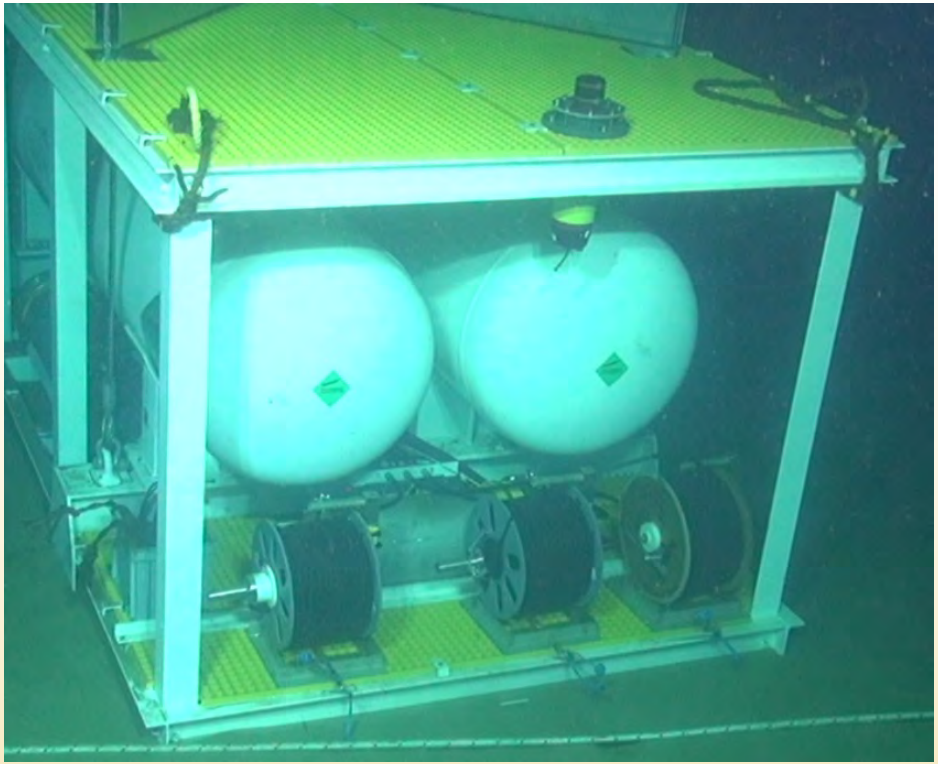
Gas connection…



- PVC “self-sinking” hose, 100 m reels
- 3 reels; 2 for connection to buried gas pipe; 1 for simply extending and laying on seabed should buried pipe fail to produce gas
- Reel picked up by ROV and unwound as ROV moves away
- Ends fitted with quick-release couplings for connection to buried gas pipes

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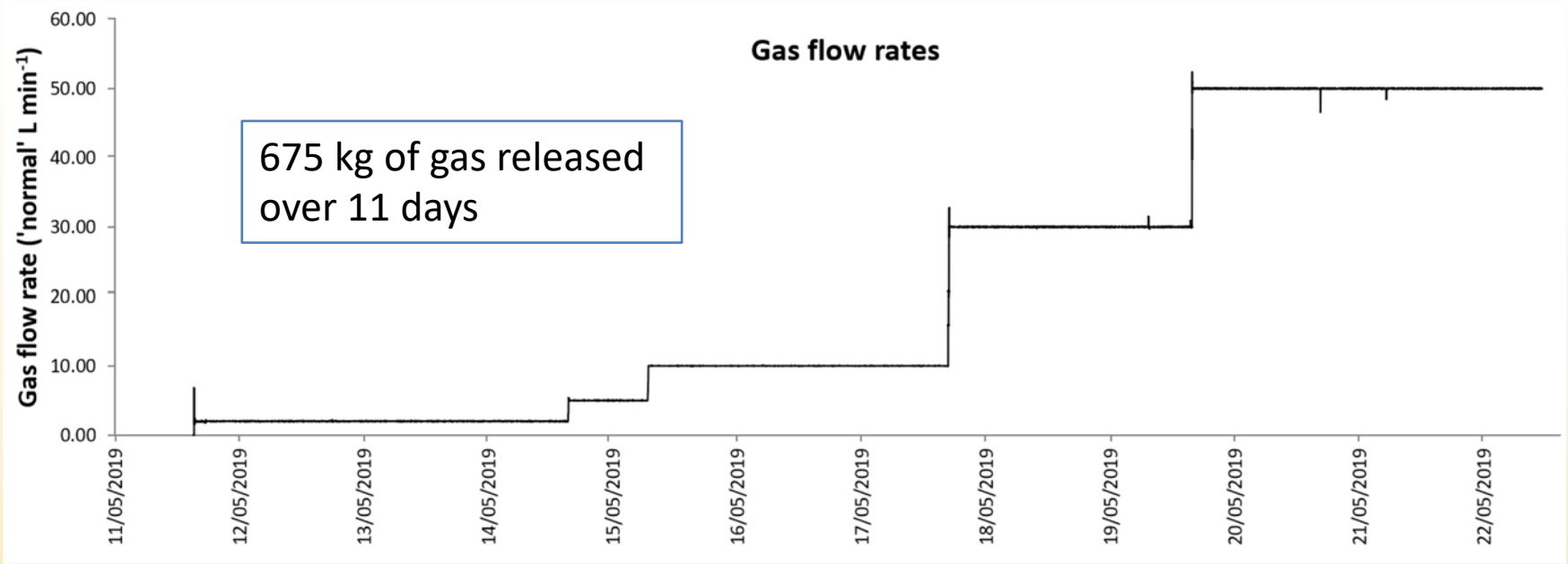
Gas flow…



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