NRC IOT Workshop on Underwater Technology

sophisticated underwater gas detection

CONTROS Systems & Solutions GmbH

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Facts:

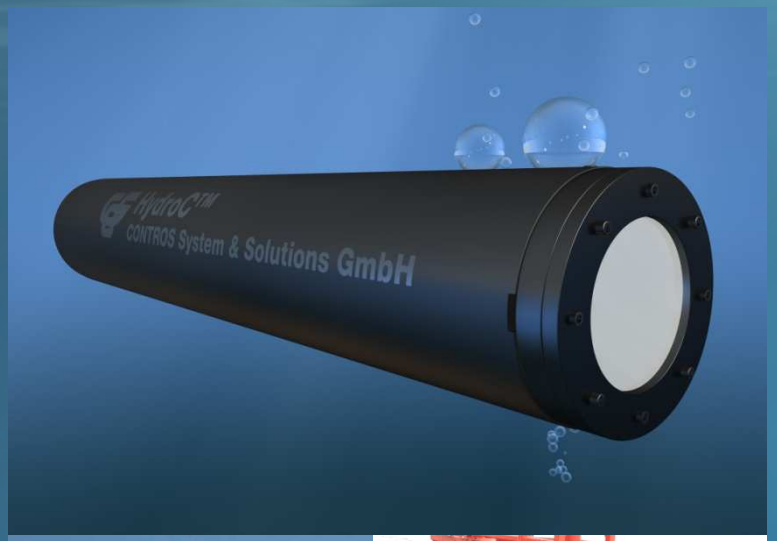
- Established in 2003
- Based in Kiel / Germany

Team:

- 21 employees + freelancer

Fields of Business:

- Subsea Monitoring and Leak detection
- Methane Hydrate Exploration & Research
- Environmental / Greenhouse Gas Monitoring
- Ocean Observation Systems / ROV / AUV
- Industrial Development Projects
- Lake Gas Extraction Systems
- CO_2 Applications / CCS



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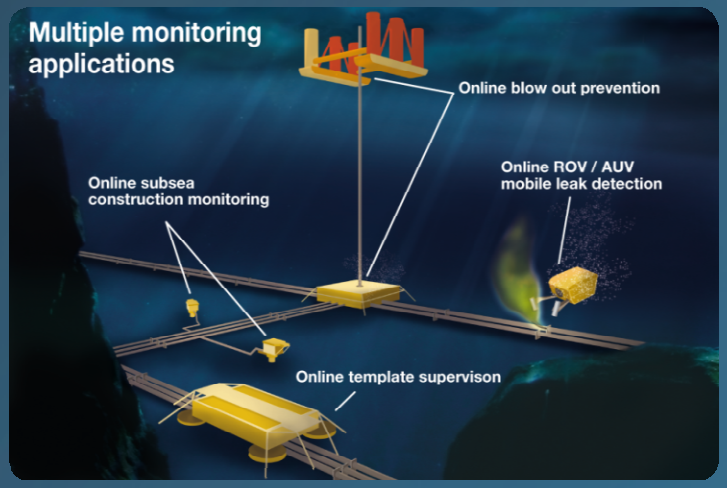
Systems

HydroC™ Methane sniffer for dissolved gas/ low-hydrocarbon leakages

HydroC™ Oil in water detector for pollution monitoring



Leak Detection Systems and Environmental protection

Flow-Through CO_2 Systems

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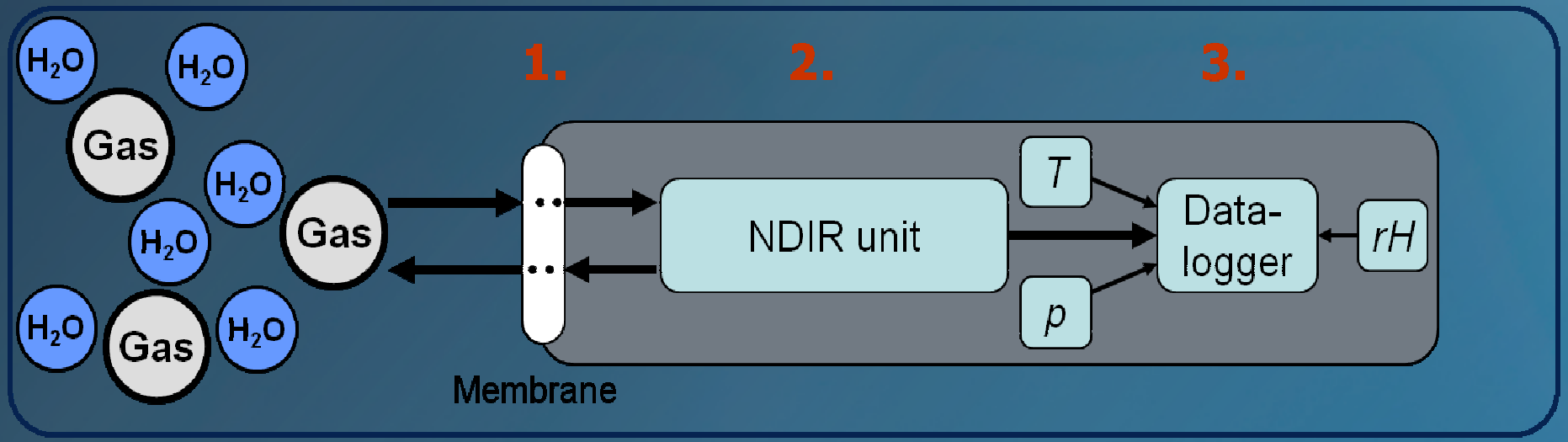
Measuring Principle HydroC



1. **Dissolved gasses and water vapor pass the hydrophobic membrane**
   - **Equilibration**
2. **Gas concentration measured by non-dispersive infrared spectrometry (NDIR) within a gas circuit**
3. **Internal Data logger saves CO_2 concentration along with *T*, *p* and *RH;* optionally the data is transmitted by cable**

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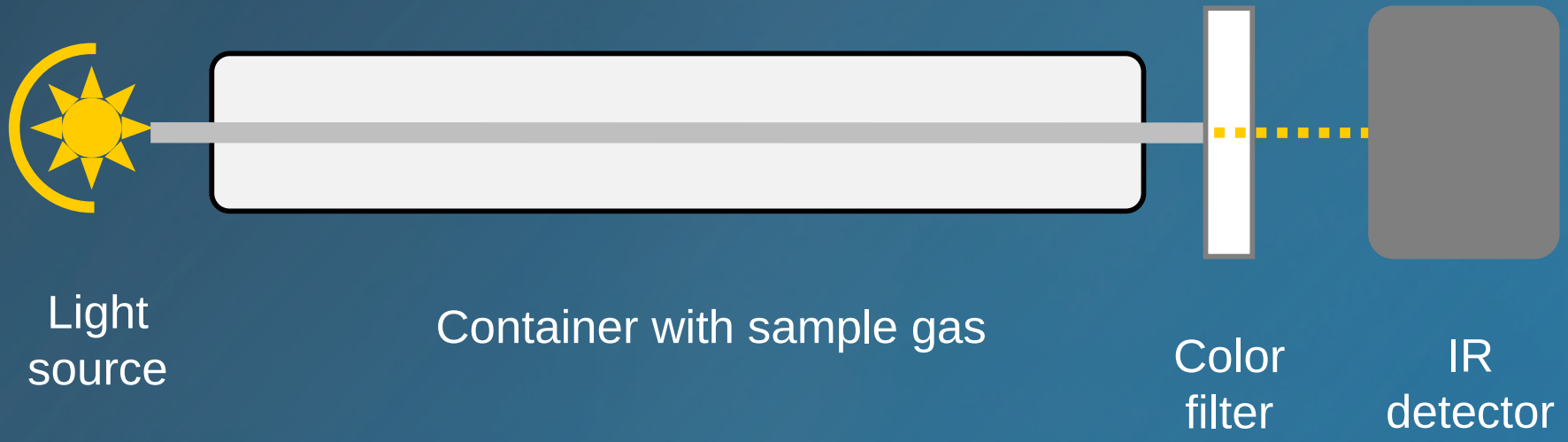
IR-Spectometry

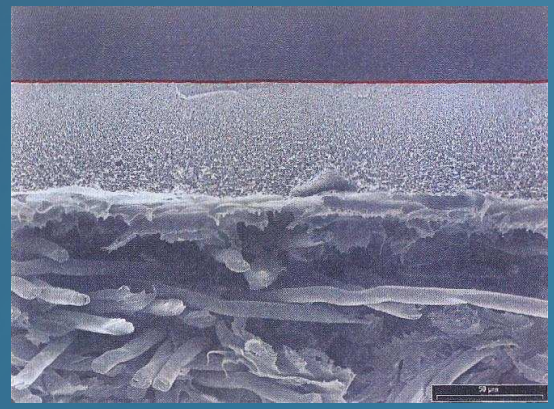
- Molecule selective technique
- IR light excites higher energy levels of the molecules
- H_2O, CO_2, CO, CH_4, HCs, N_2O, NH_3, CFCs, HFCs, PFCs, etc.

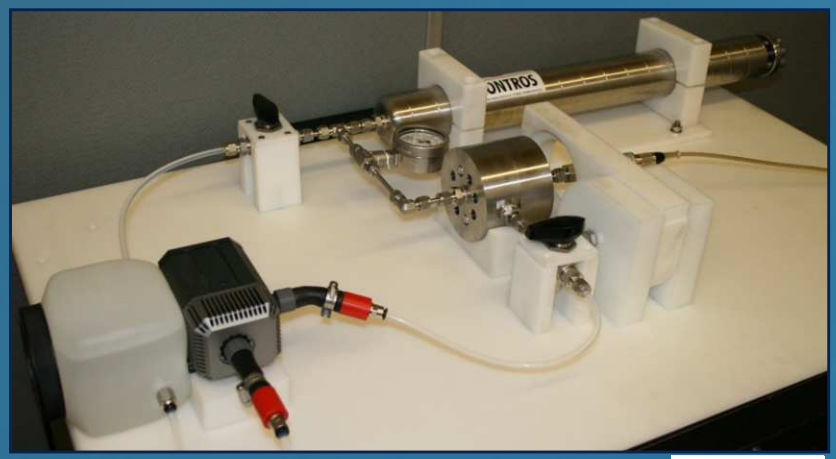


* Source: thermophysica minima, Jürgen Schilz, PerkinElmer

Membranes

- Material: silicone (high permeability)
- Different designs: Single layered vs. composite membranes
- Layer thicknesses <10μm
  → Fast response time
- In house setups:
  - Pressure tests (<700bar)
  - Permeability measurements (with O2, N2, CO2 and CH4)



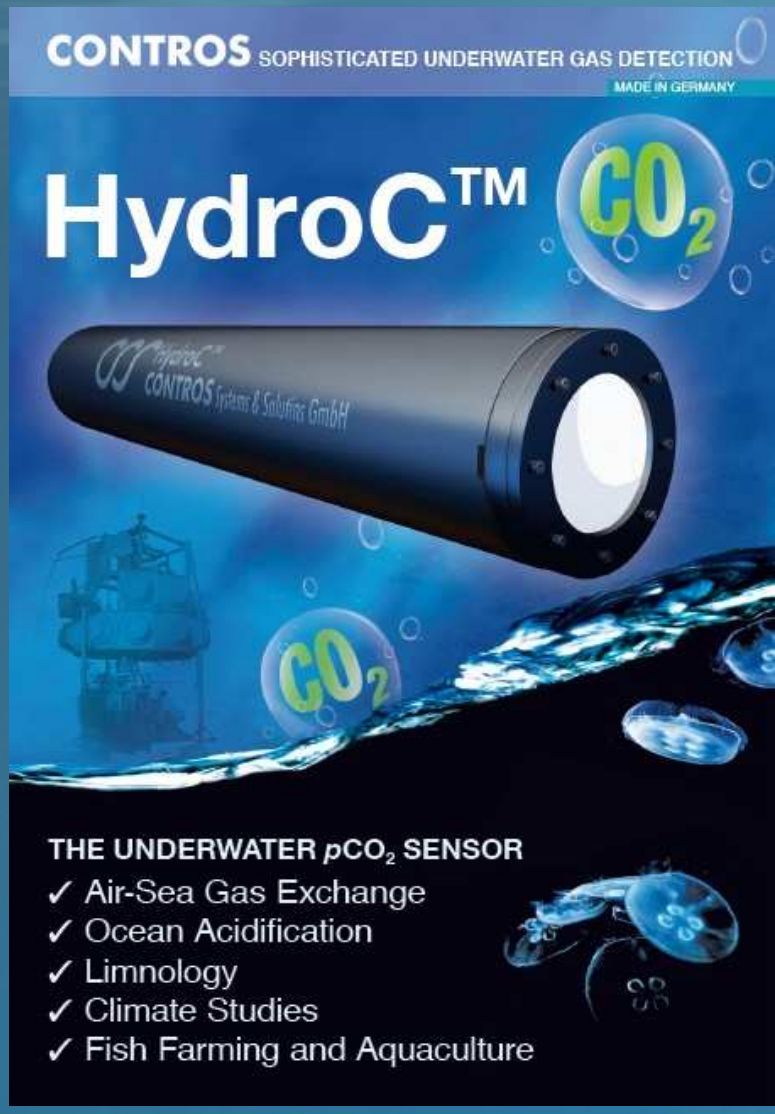


HydroC™ / CO_2 System

- Titanium housing
- Dimensions: 90 x 526 mm (550 mm)
- Weight (Ti): 5,9 kg (2,6 kg in water)
- Power: 11-24 VDC, 3-4 W (+700mA pump)
- Warm-up: 2-25 min, <10 W
- Specs:

measuring range*:	0 – 1000 ppm
accuracy:	± 1% reading
resolution:	± 1 ppm
response time:	T_{63}< 70 sec (T_{90}< 210 sec)

*standard



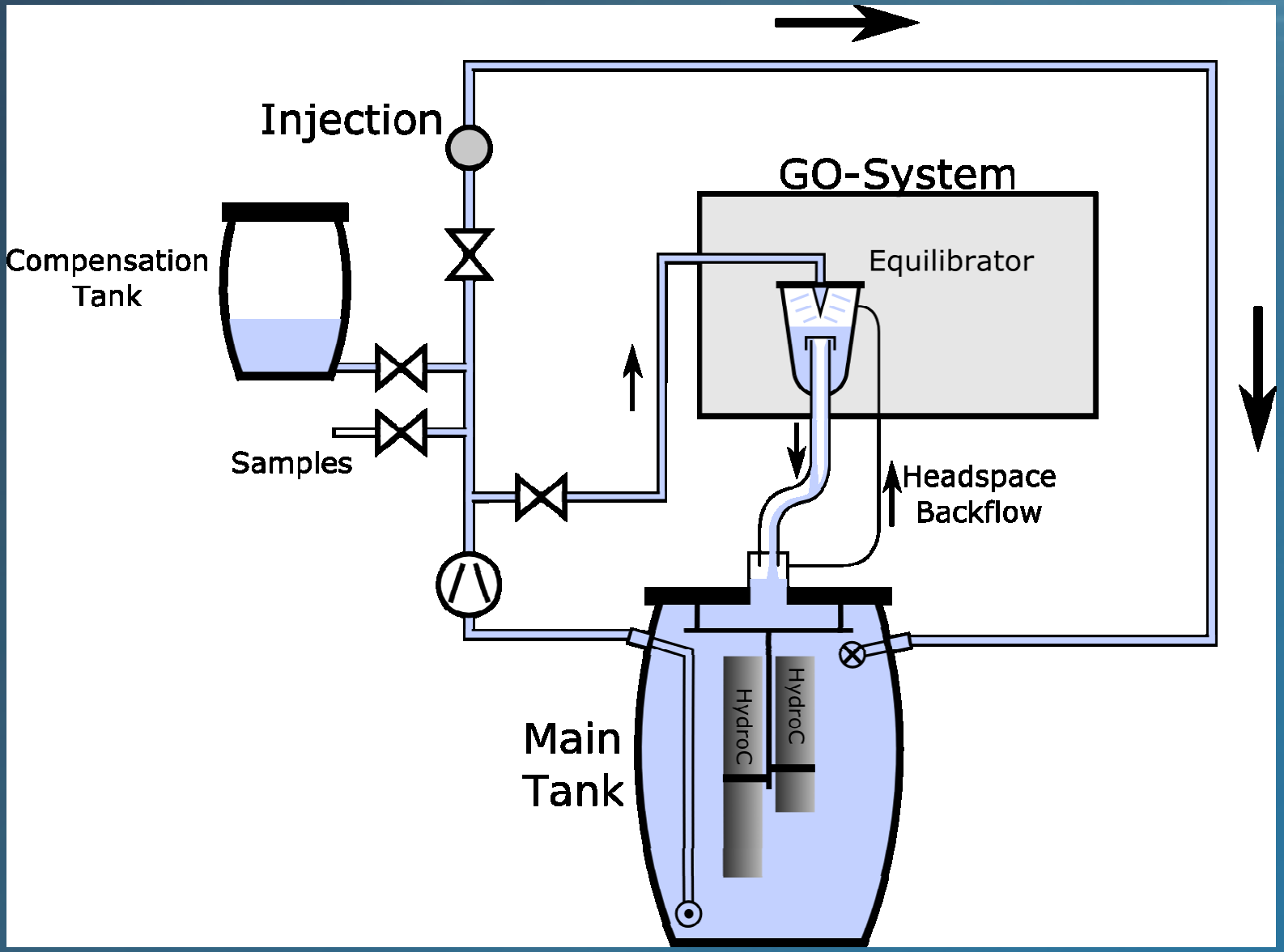
HydroC™ / CH_4 System

- Titanium housing
- Dimensions: 90d x 430 mm
- Weight (Ti): 5,9 kg (2,6 kg in water)
- Power: 11-24 VDC, 400mA (+700mA/ 5T)
- Warm-up: 2- 20 min
- Specs:

measuring range*:	0.15 µmol –50µmol/l
accuracy:	± 3% reading
resolution:	10 nmol
response time:	T_{63}< 2 min (T_{90}< 5 min)

*standard

Calibration Setup



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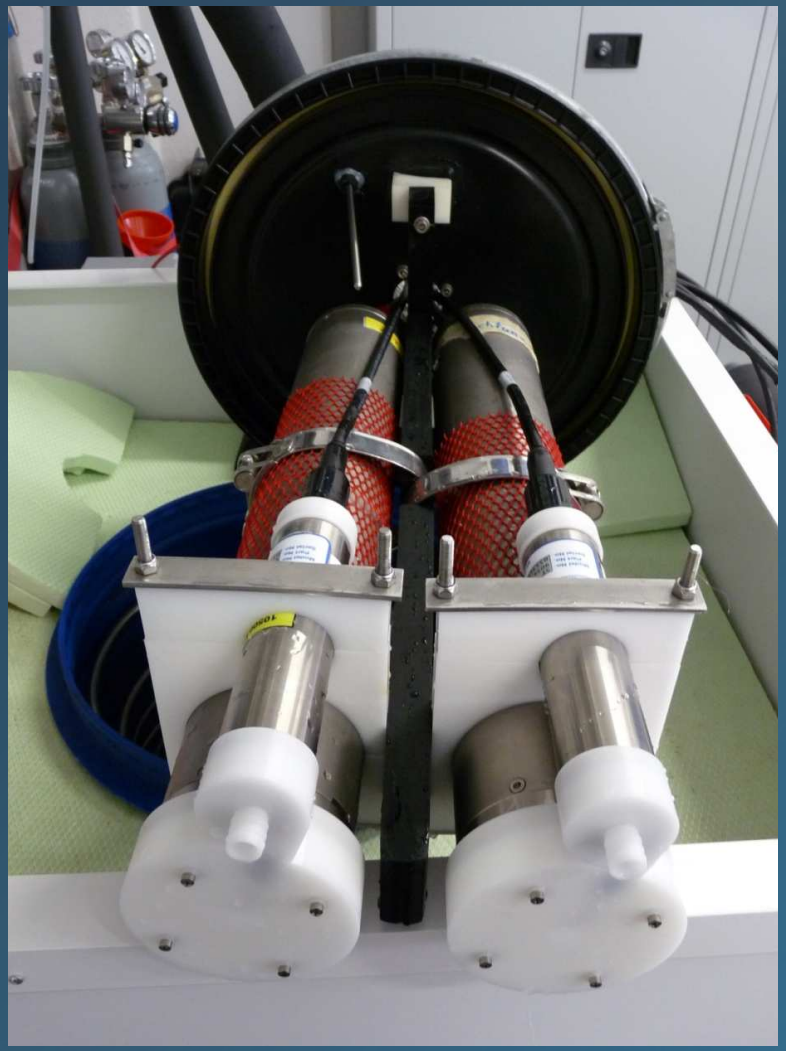
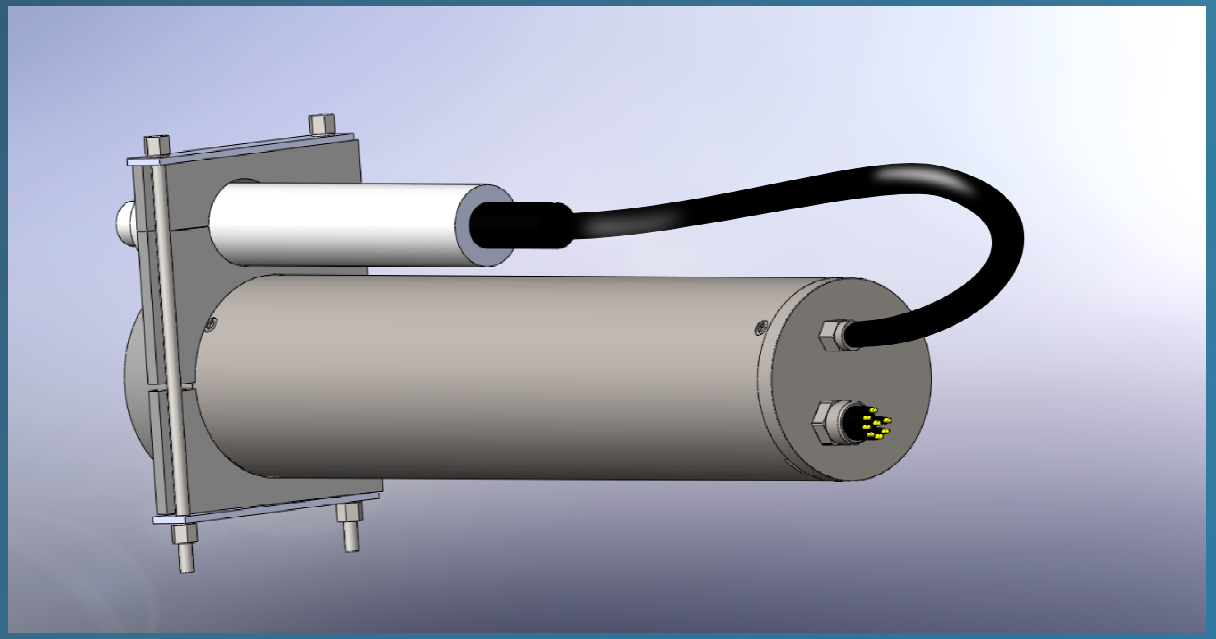
Response time reduced using pump





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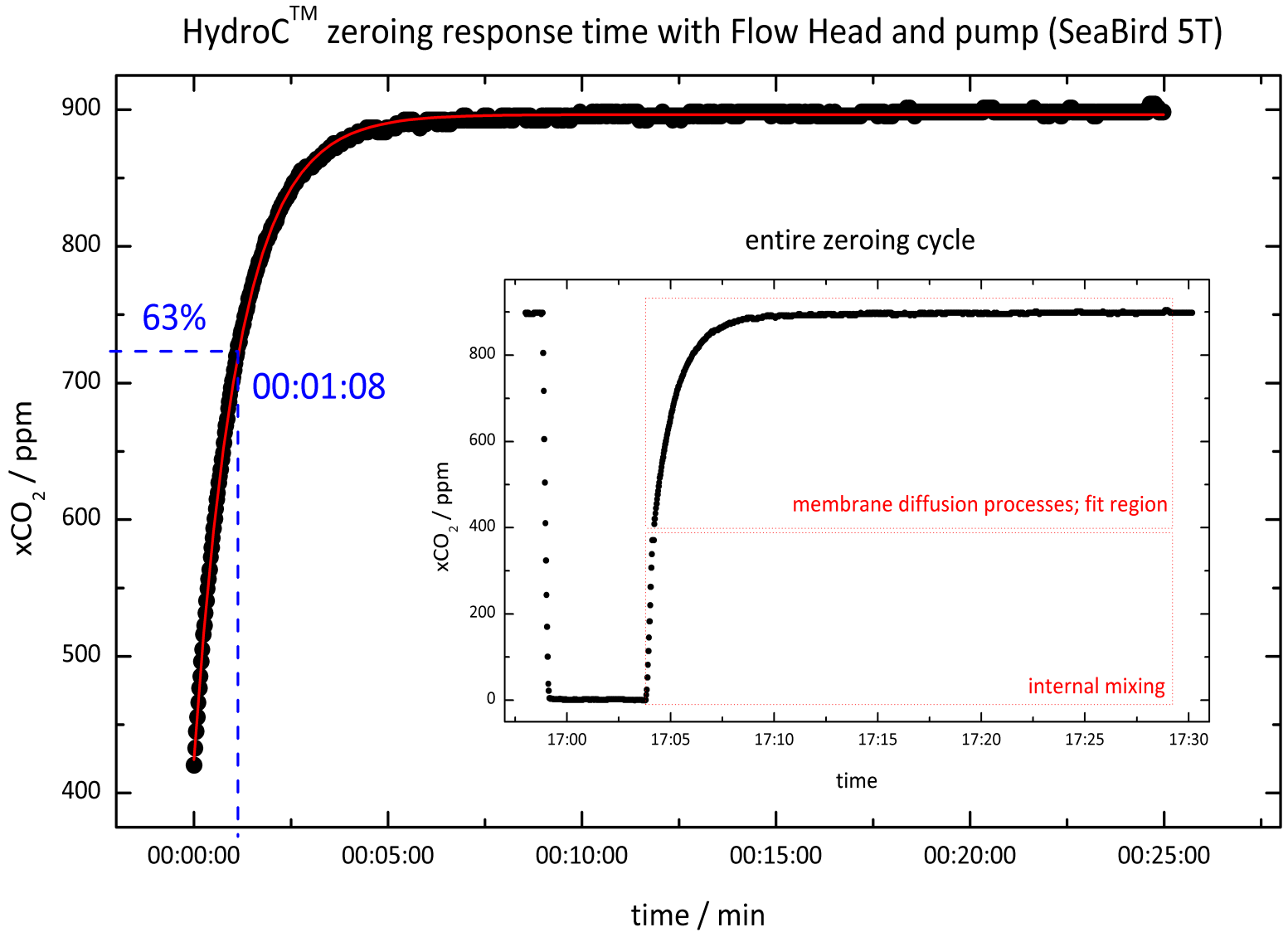

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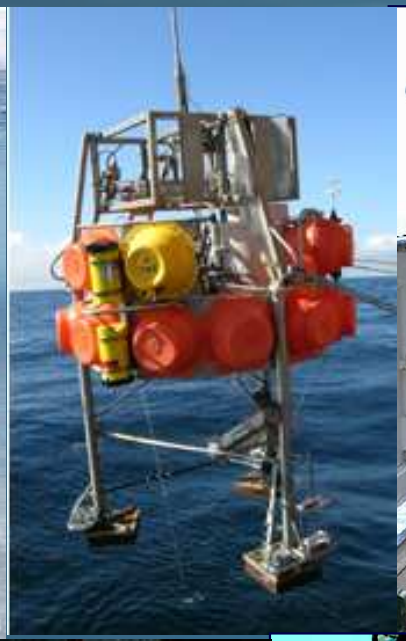
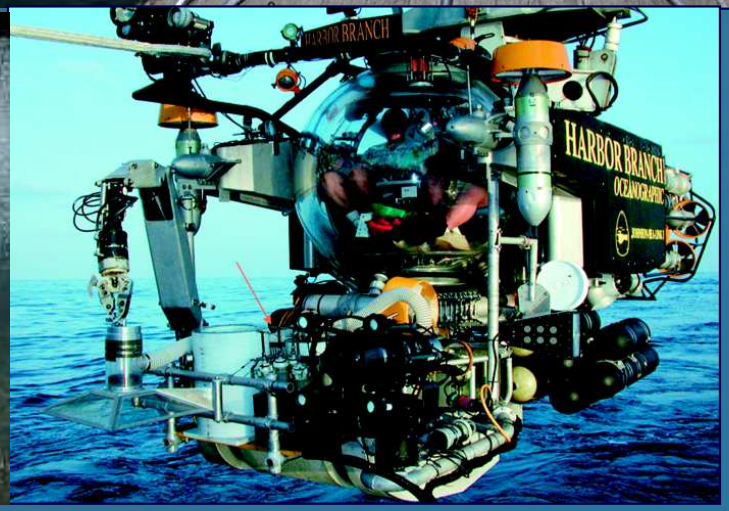
System with mounting

Applications





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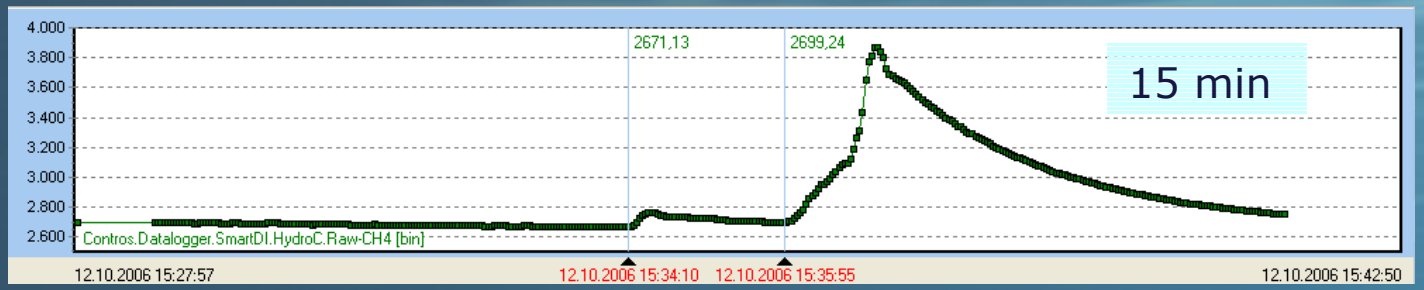
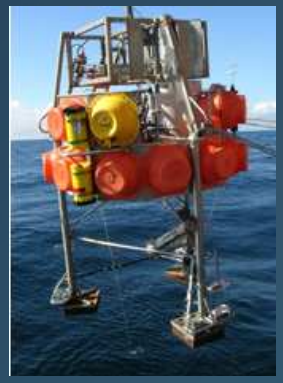
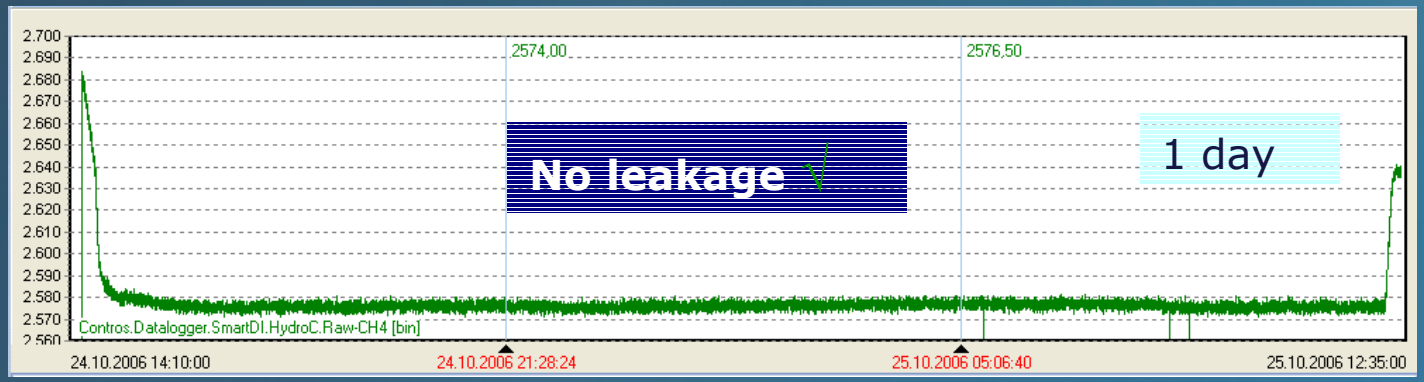
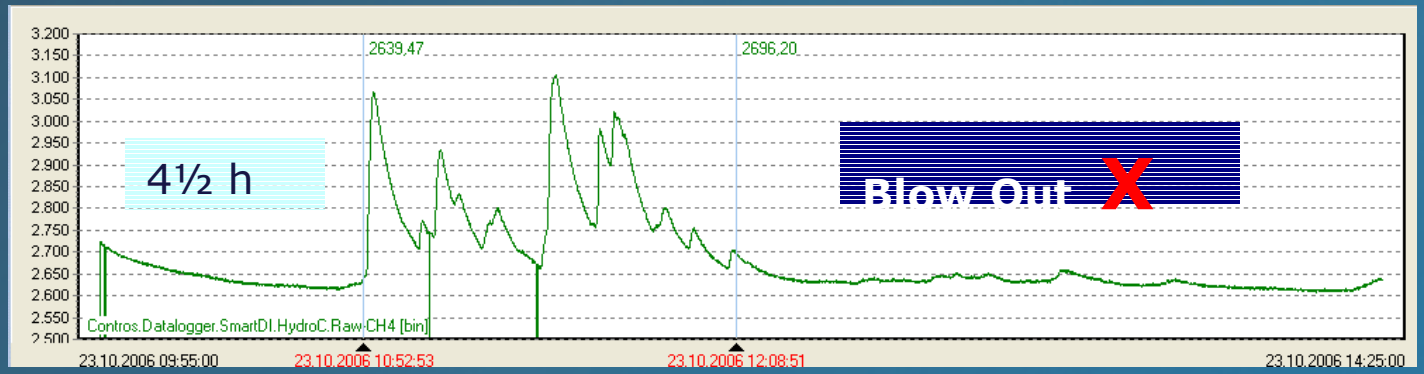


Profile with Multisensor CTD





Monitoring station with Lander



Blow-Out survey with submarine JAGO

Photos
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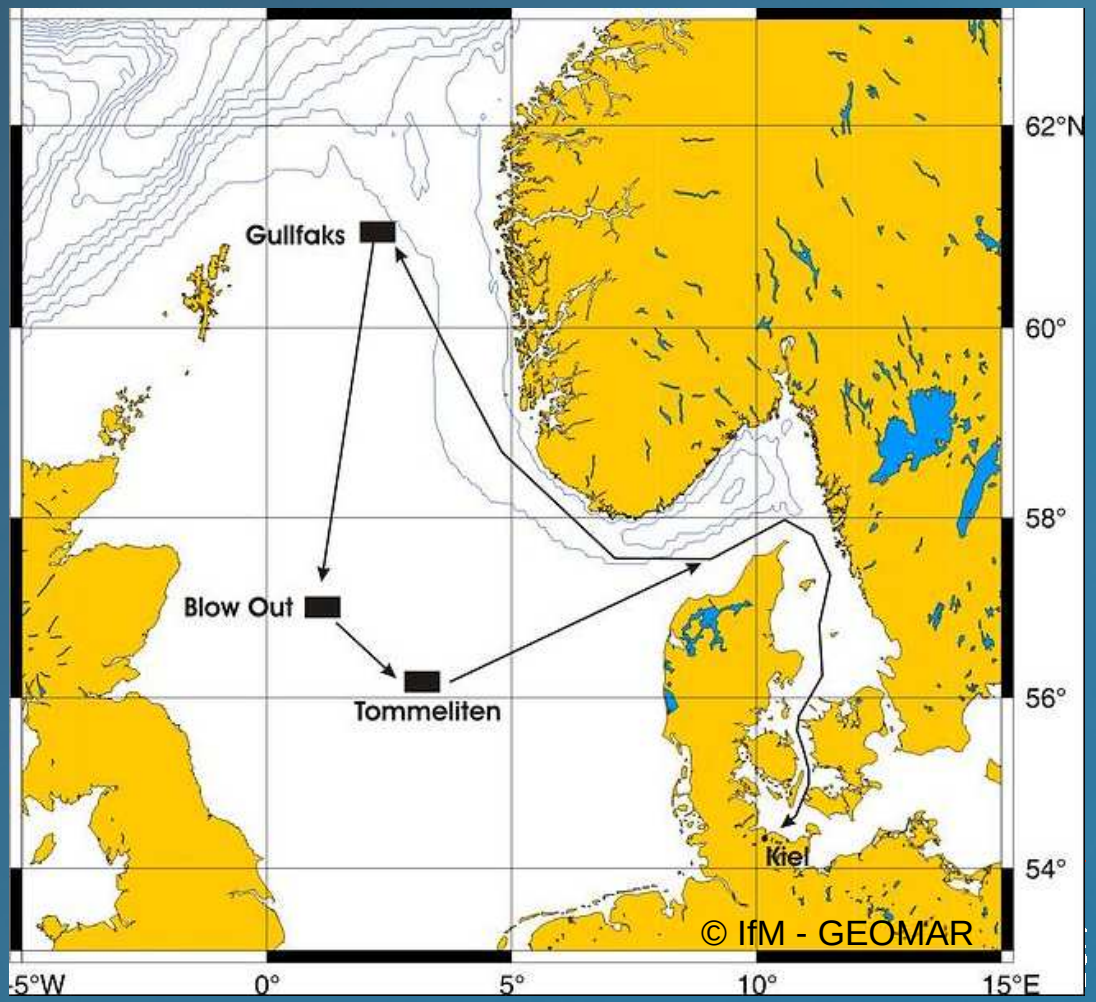
CONTROS sensor on an ROV

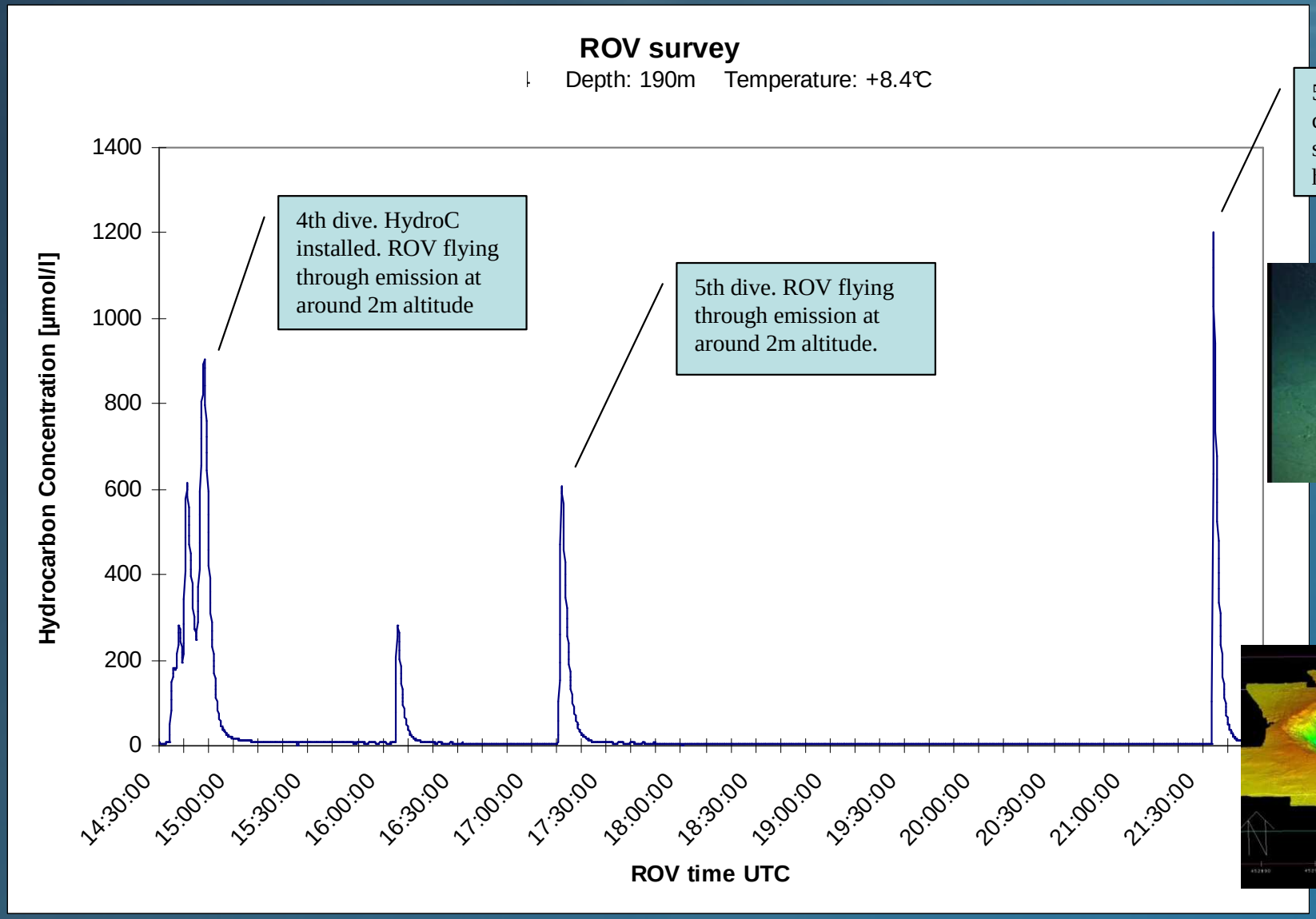
- **RV Alkor Tour 2006**
- Gullfaks Oilfield
- Tommeliten Oilfield
- Blow-Out 57°33'N, 1°37'E

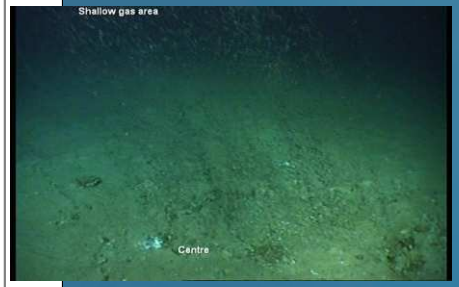
Massive Blow-Out

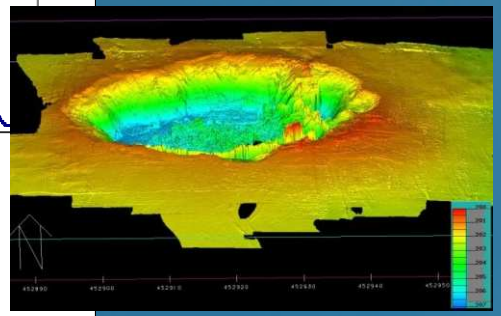
R/V ALKOR



Mobile Leak Detection







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CONTROS sensor on inspection class ROV

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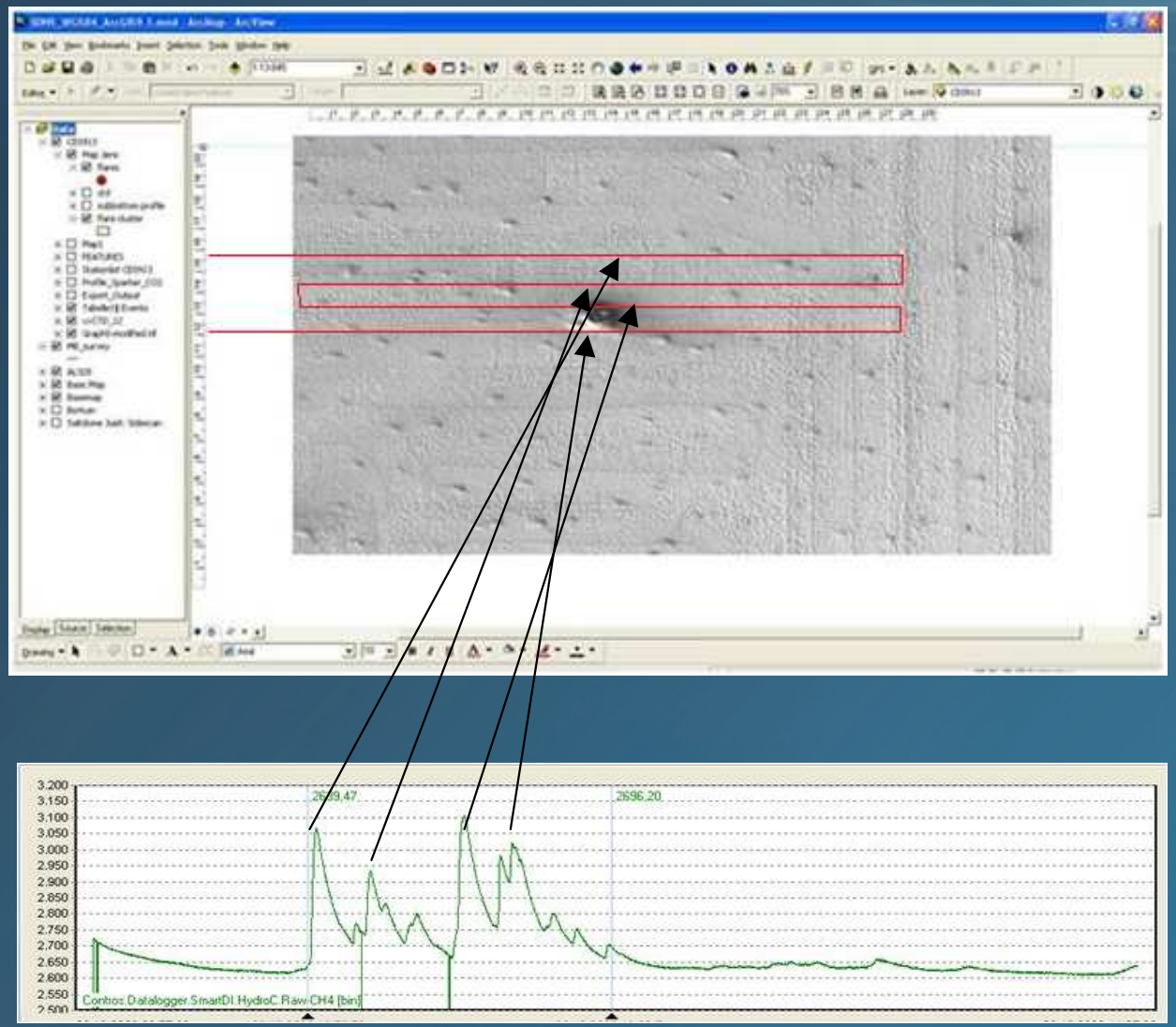
Methane sensor on a HUGIN AUV (North Sea)



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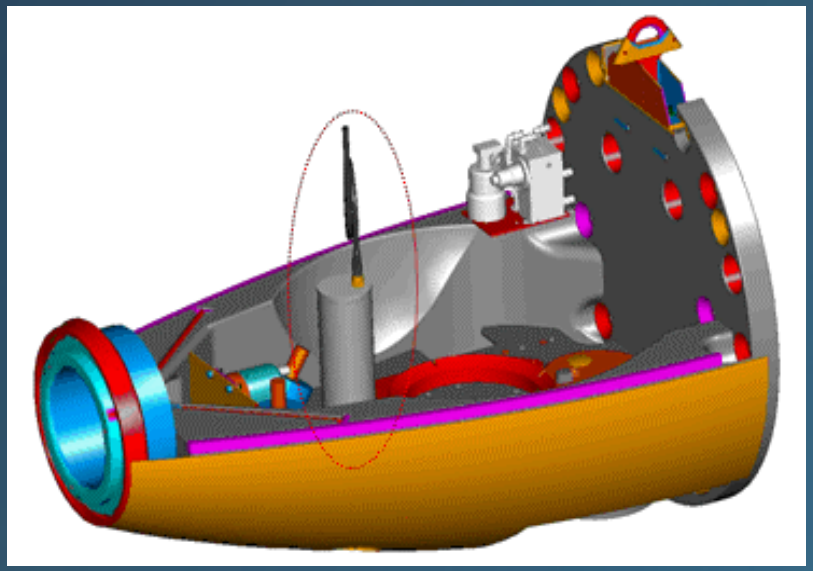
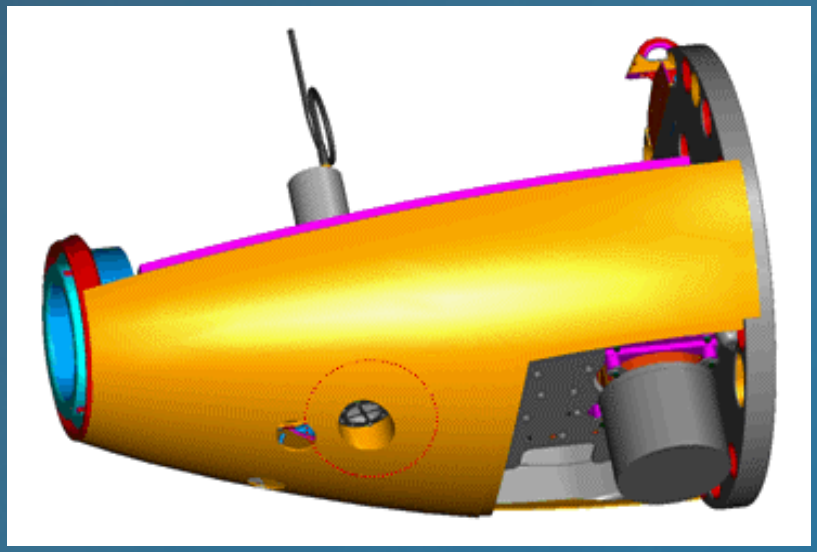
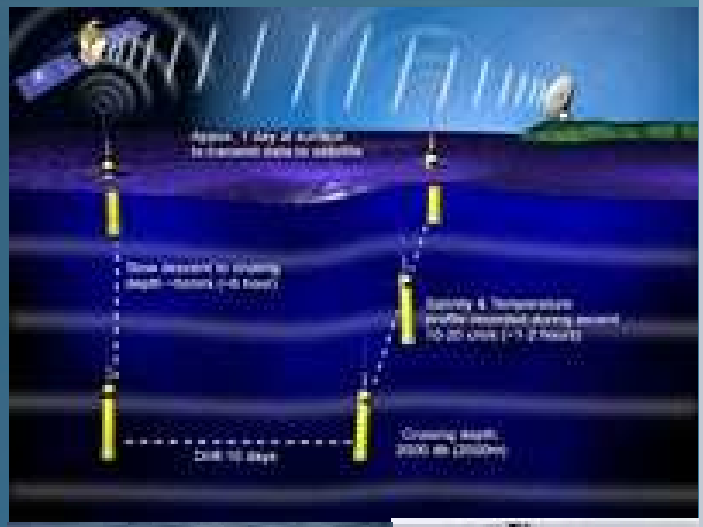
CH_4 sensor mounted in nose of an AUV

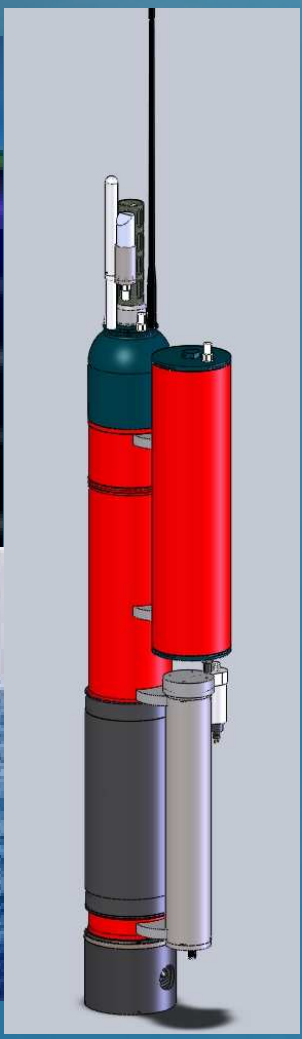




Reference: Optimare NEMO Float Integration

- First Deployment near Capverdes Island in 2010
- 6 weeks ~ 40 profiles in up to 200m water depths
- Redundant data storage system on float and sensor
- Datafields to be sent via satelite after each profile





CONTROS Role in SUGAR Project

- CONTROS developed the necessary measuring system for the laboratory experiments under in-situ conditions.
- Various approaches are tested to accelerate gas swapping in hydrates and to improve the rate of natural gas production from hydrates.
- The CONTROS HydroC™ CO2 and CH4 sensors provide a reliable measuring system for the project.

SolOceans Project

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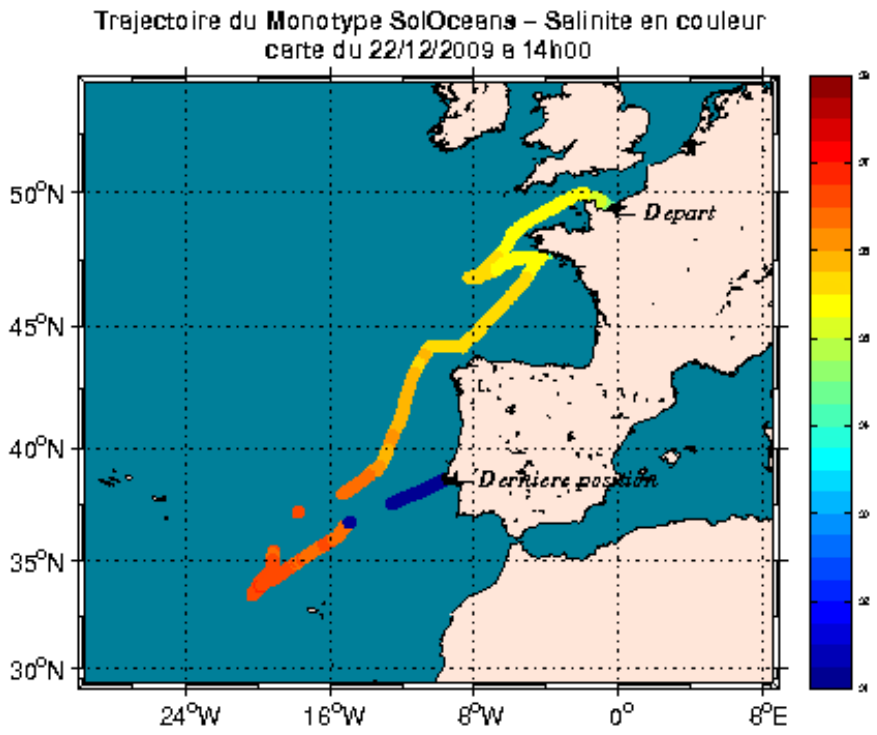
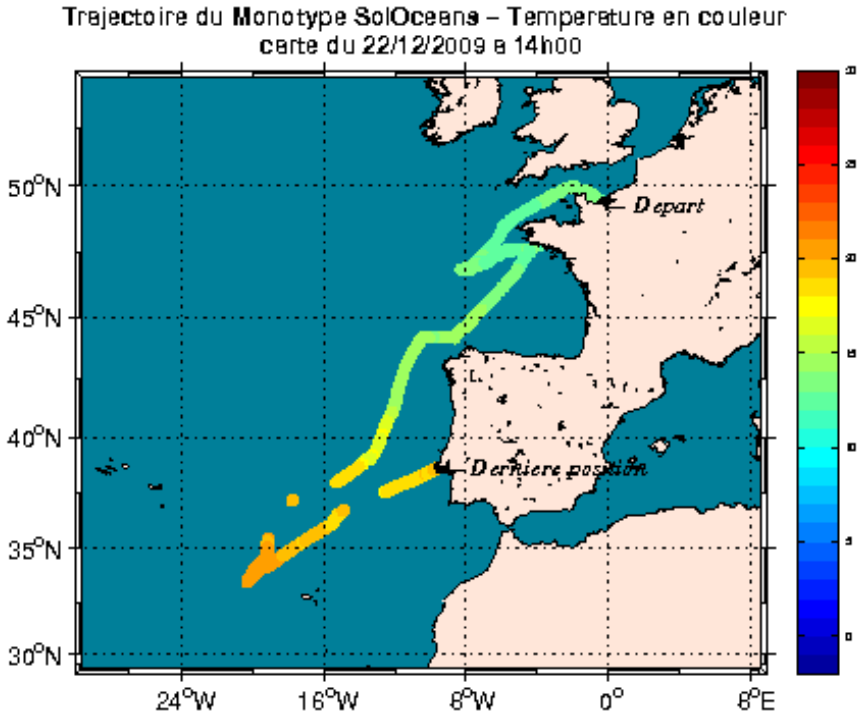
Example data





Source: Ifremer

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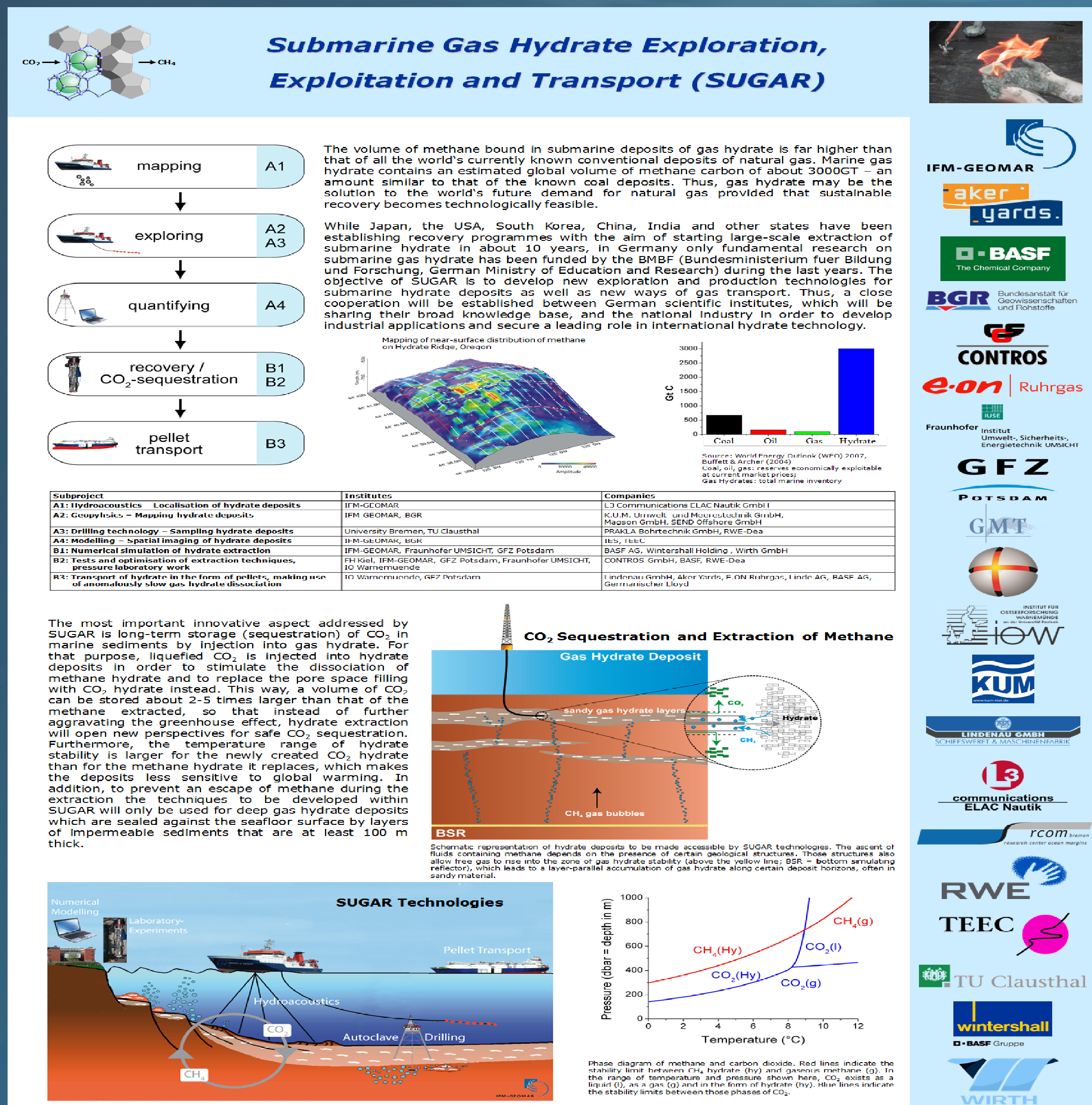

Submarine Gas Hydrate Exploration, Exploitation and Transport (SUGAR)

The volume of methane bound in submarine deposits of gas hydrate is far higher than that of all the world's currently known conventional deposits of natural gas. Marine gas hydrate contains an estimated global volume of methane carbon of about 3000GT – an amount similar to that of the known coal deposits. Thus, gas hydrate may be the solution to the world's future demand for natural gas provided that sustainable recovery becomes technologically feasible.

While Japan, the USA, South Korea, China, India and other states have been establishing recovery programmes with the aim of starting large-scale extraction of submarine hydrate in about 10 years, in Germany only fundamental research on submarine gas hydrate has been funded by the BMBF (Bundesministerium fuer Bildung und Forschung, German Ministry of Education and Research) during the last years. The objective of SUGAR is to develop new exploration and production technologies for submarine hydrate deposits as well as new ways of gas transport. Thus, a close cooperation will be established between German scientific institutes, which will be sharing their broad knowledge base, and the national industry in order to develop industrial applications and secure a leading role in international hydrate technology.

Source: World Energy Outlook (WEO) 2007, Buffett & Archer (2004)
Coal, oil, gas: reserves economically exploitable at current market prices;
Gas Hydrates: total marine inventory

Subproject	Institutes	Companies
A1: Hydroacoustics – Localisation of hydrate deposits	IFM-GEOMAR	L3 Communications ELAC Nautik GmbH
A2: Geophysics – Mapping hydrate deposits	IFM GEOMAR, BGR	K.U.M. Umwelt- und Meerestechnik GmbH, Magson GmbH, SEND Offshore GmbH
A3: Drilling technology – Sampling hydrate deposits	University Bremen, TU Clausthal	PRAKLA Bohrtechnik GmbH, RWE-Dea
A4: Modelling – Spatial imaging of hydrate deposits	IFM-GEOMAR, BGR	IES, TEEC
B1: Numerical simulation of hydrate extraction	IFM-GEOMAR, Fraunhofer UMSICHT, GFZ Potsdam	BASF AG, Wintershall Holding, Wirth GmbH
B2: Tests and optimisation of extraction techniques, pressure laboratory work	FH Kiel, IFM-GEOMAR, GFZ Potsdam, Fraunhofer UMSICHT, IO Warnemuende	CONTROS GmbH, BASF, RWE-Dea
B3: Transport of hydrate in the form of pellets, making use of anomalously slow gas hydrate dissociation	IO Warnemuende, GFZ Potsdam	Lindenau GmbH, Aker Yards, E.ON Ruhrgas, Linde AG, BASF AG, Germanischer Lloyd

The most important innovative aspect addressed by SUGAR is long-term storage (sequestration) of CO_2 in marine sediments by injection into gas hydrate. For that purpose, liquefied CO_2 is injected into hydrate deposits in order to stimulate the dissociation of methane hydrate and to replace the pore space filling with CO_2 hydrate instead. This way, a volume of CO_2 can be stored about 2-5 times larger than that of the methane extracted, so that instead of further aggravating the greenhouse effect, hydrate extraction will open new perspectives for safe CO_2 sequestration. Furthermore, the temperature range of hydrate stability is larger for the newly created CO_2 hydrate than for the methane hydrate it replaces, which makes the deposits less sensitive to global warming. In addition, to prevent an escape of methane during the extraction the techniques to be developed within SUGAR will only be used for deep gas hydrate deposits which are sealed against the seafloor surface by layers of impermeable sediments that are at least 100 m thick.

Schematic representation of hydrate deposits to be made accessible by SUGAR technologies. The ascent of fluids containing methane depends on the presence of certain geological structures. Those structures also allow free gas to rise into the zone of gas hydrate stability (above the yellow line; BSR = bottom simulating reflector), which leads to a layer-parallel accumulation of gas hydrate along certain deposit horizons, often in sandy material.

Phase diagram of methane and carbon dioxide. Red lines indicate the stability limit between CH_4 hydrate (hy) and gaseous methane (g). In the range of temperature and pressure shown here, CO_2 exists as a liquid (l), as a gas (g) and in the form of hydrate (hy). Blue lines indicate the stability limits between those phases of CO_2.

detection

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SUGAR Project Overview

- The SUGAR Project aims to mitigate the industrial CO2 emissions, by injecting CO2 in to the sea bed and at the same time extracting gas hydrate that can be used as a reliable energy source.
- CONTROS developed the necessary measuring system for this purpose.

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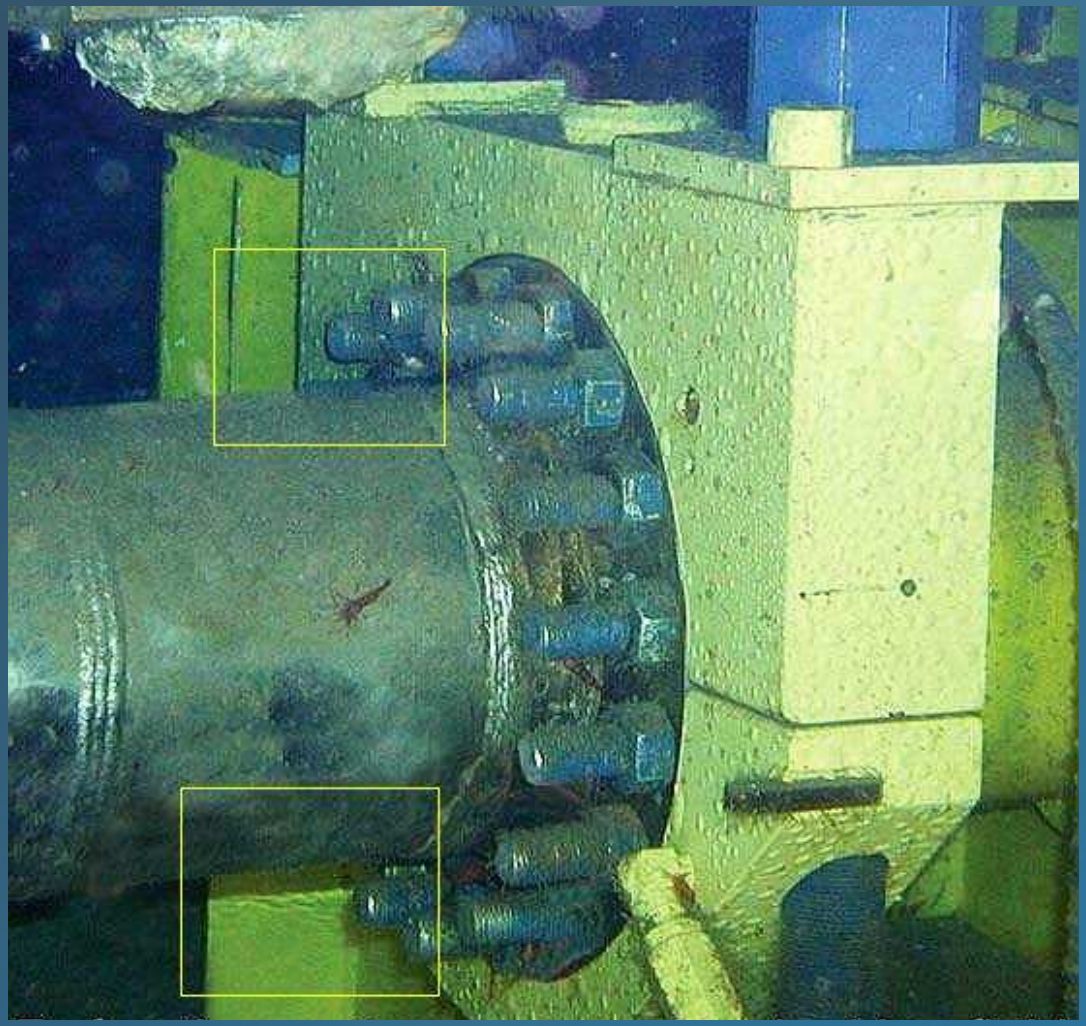
AUV/ Glider Integration

Kongsberg

iRobot

Liquid Robotics

A little oil in sea water



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A little gas in sea water

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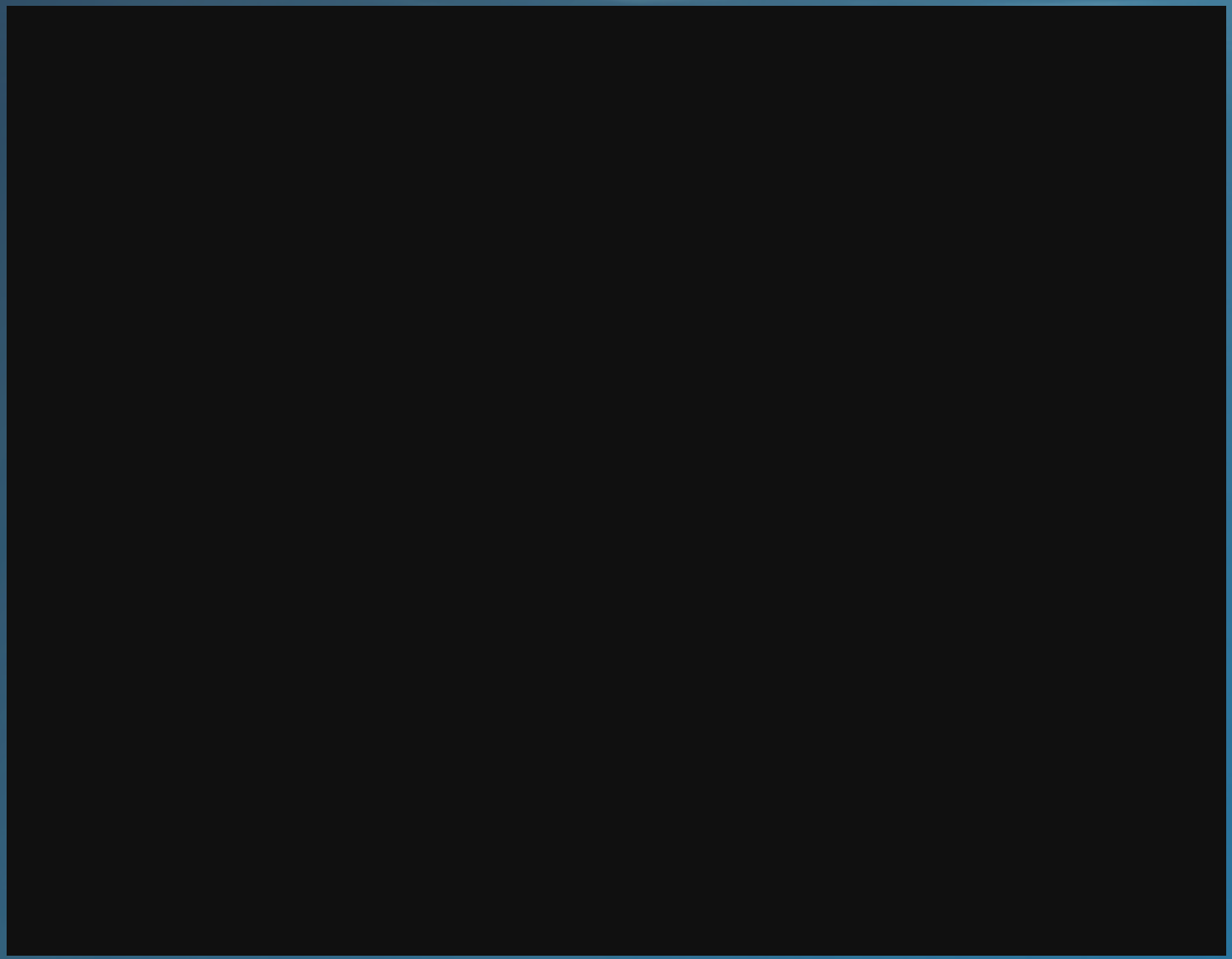
A lot of gas in the sea water



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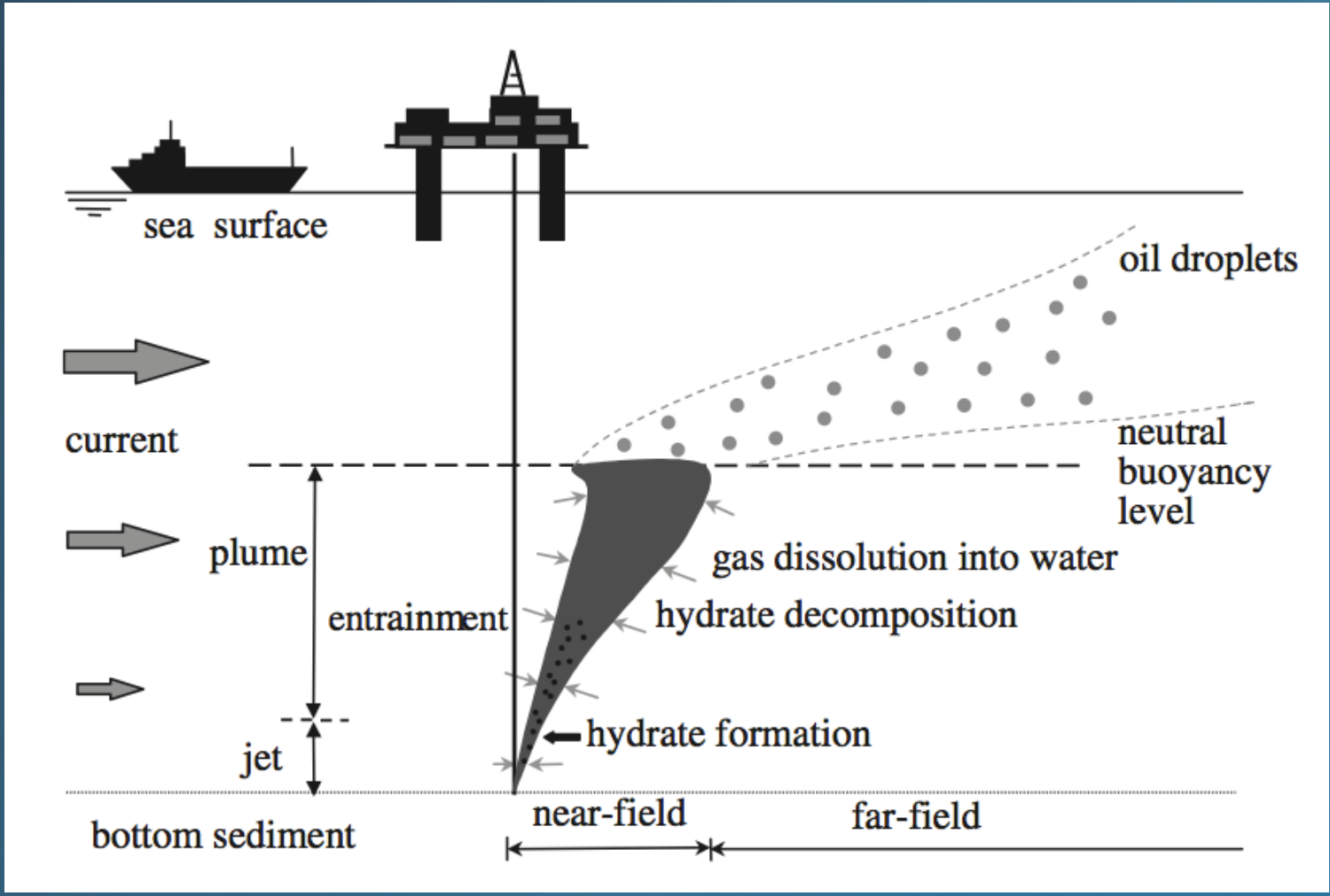
Hydrocarbons in seawater



(Zheng et al., 2002)

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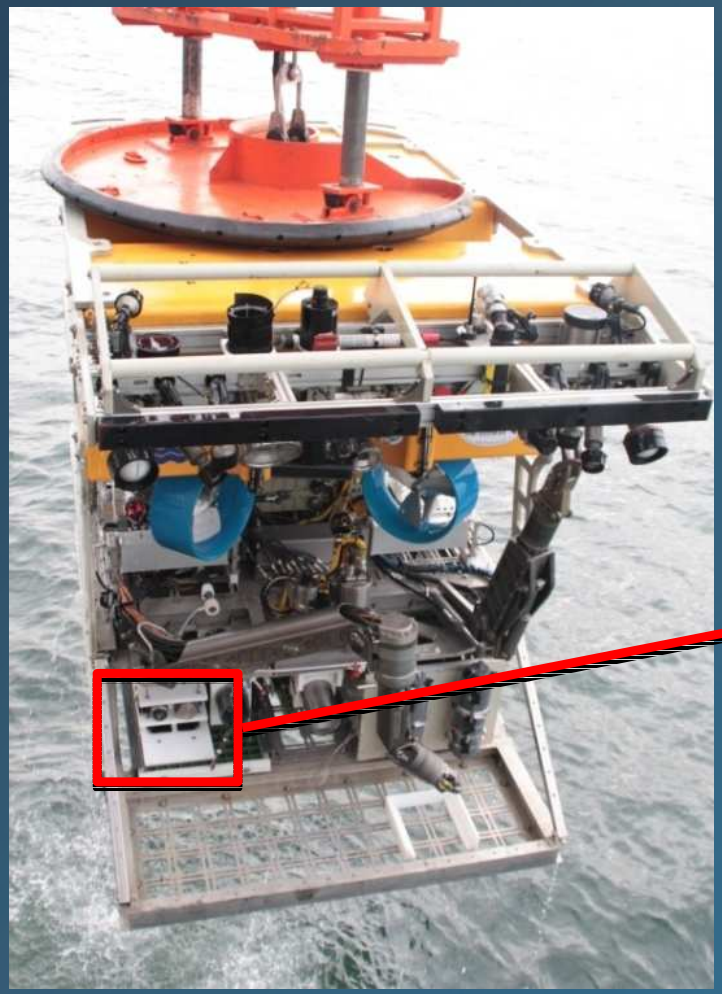
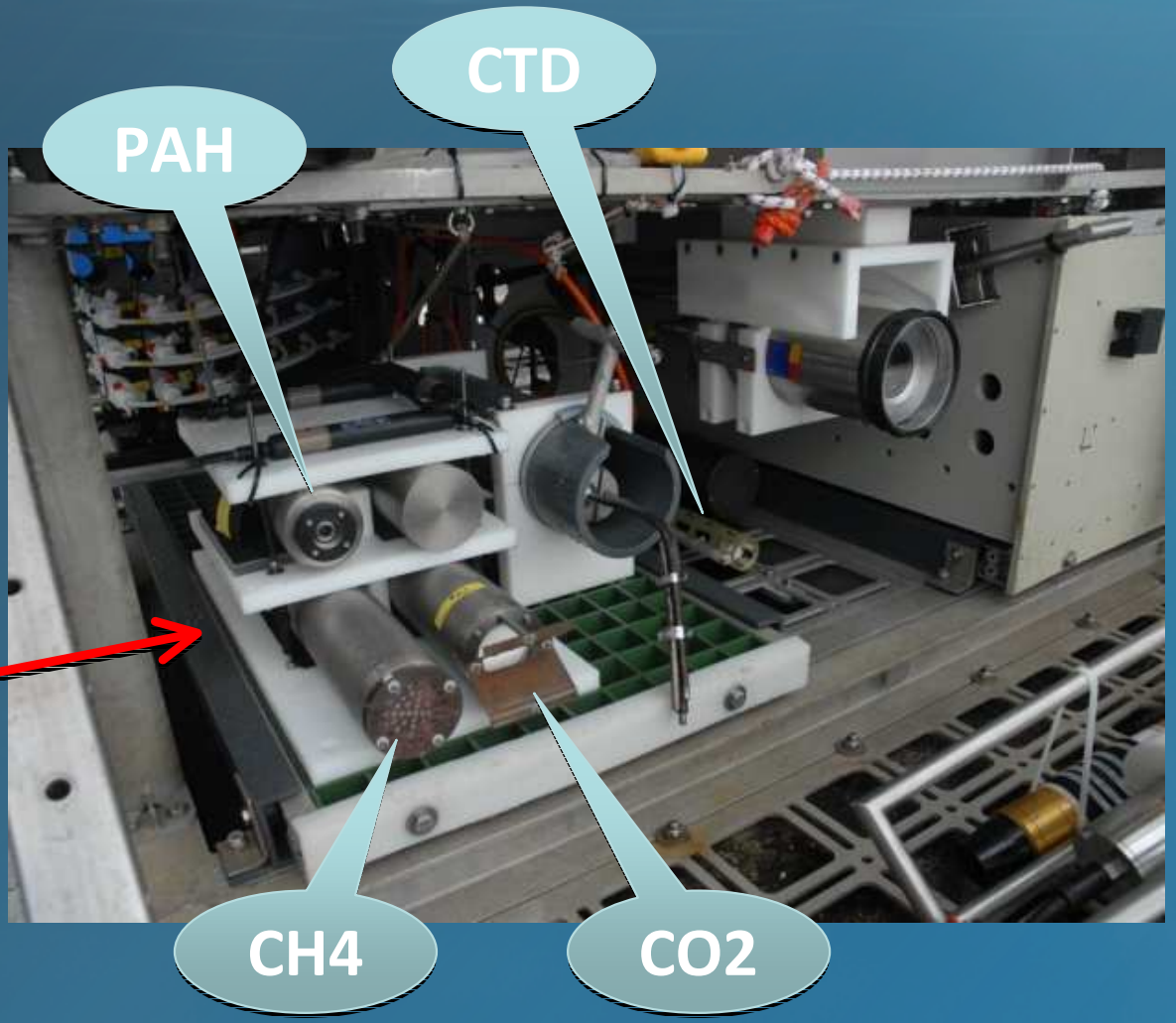
Leak detection on ROV

- Direct detection by optical Sniffer (optical NDIR) for gaseous and dissolved Methane
- Direct detection of oil in water by PAH sensor (fluorescent)
- Indirectly by Seabird CTD for temperature and salinity changes

Sensor Selection





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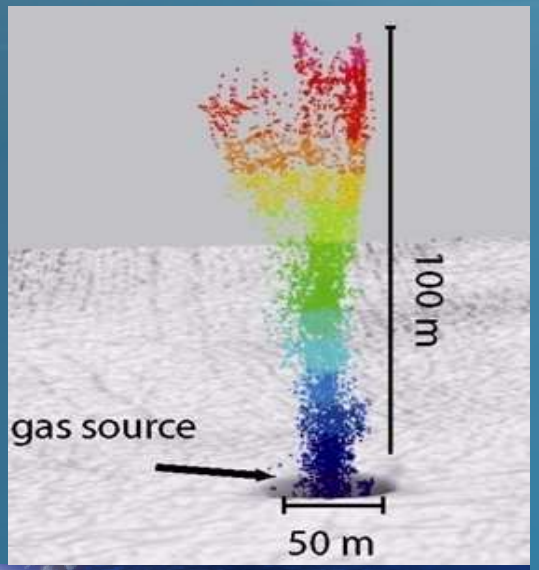
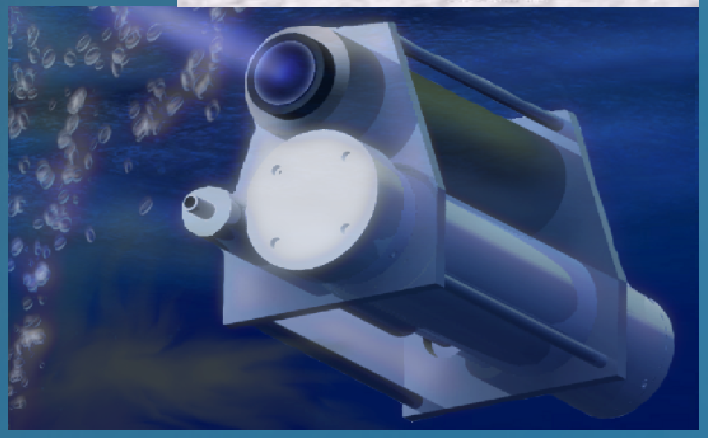
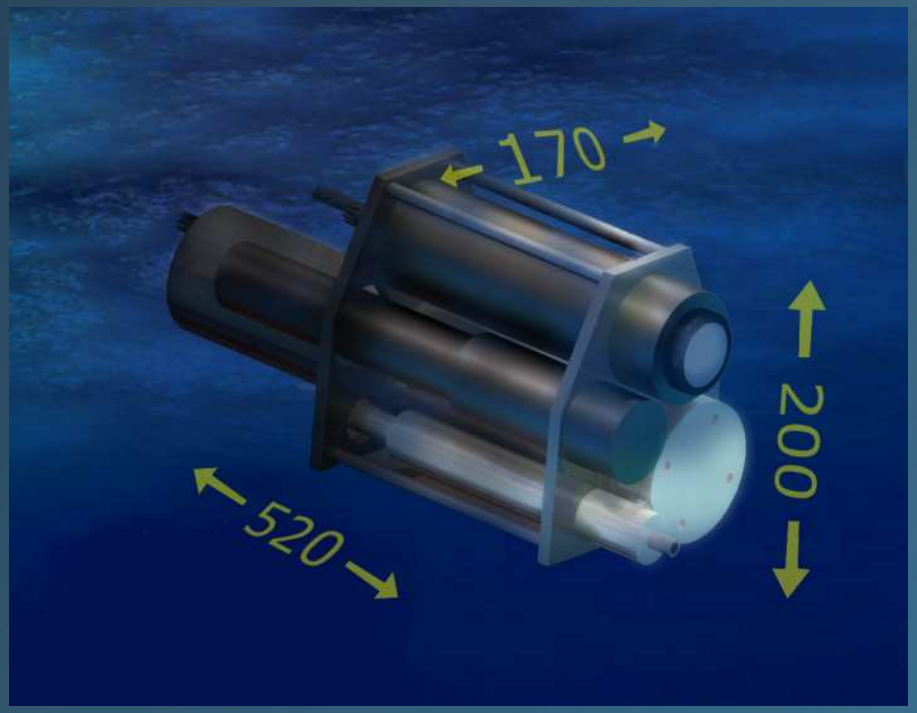
Lessons from the survey

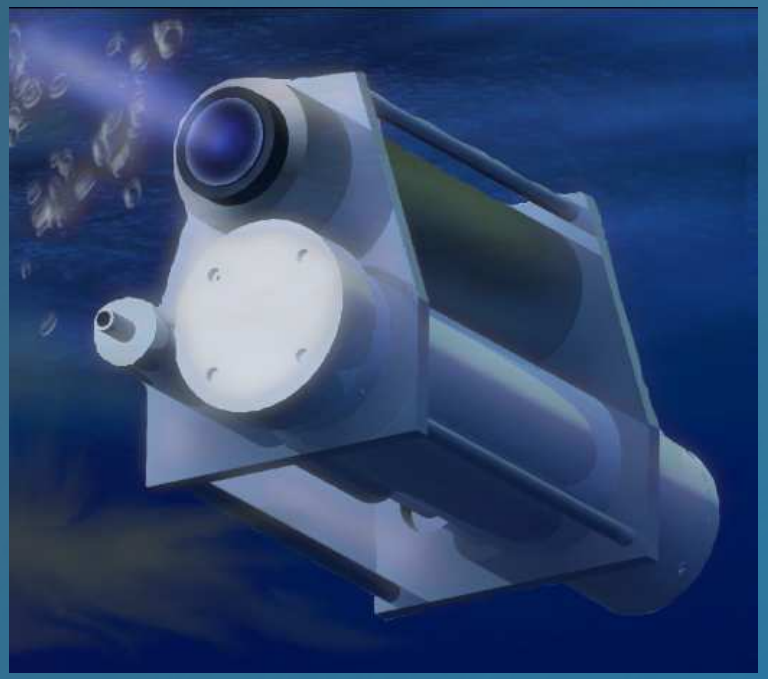
1. Detection and localisation of leaks
   - quick sensors with low detection limit
   - direct and indirect methods
2. Qualification of leaks (false alarm!)
   - direct methods only
   - selective methods
3. Quantification of leaks
   - direct methods only
   - very precise sensors





CONTROS Leak Detection System





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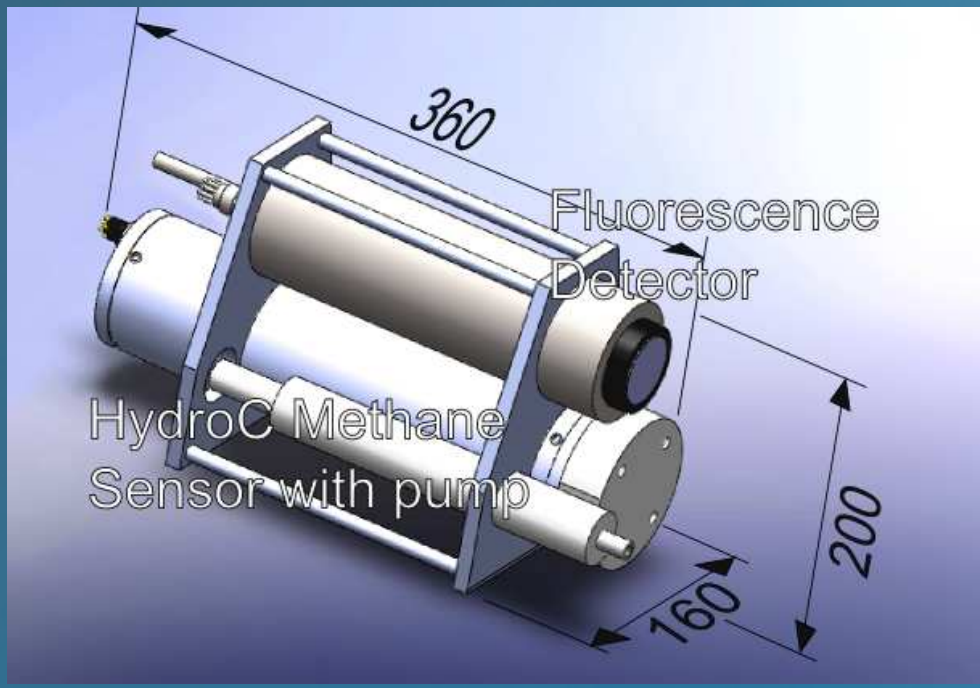
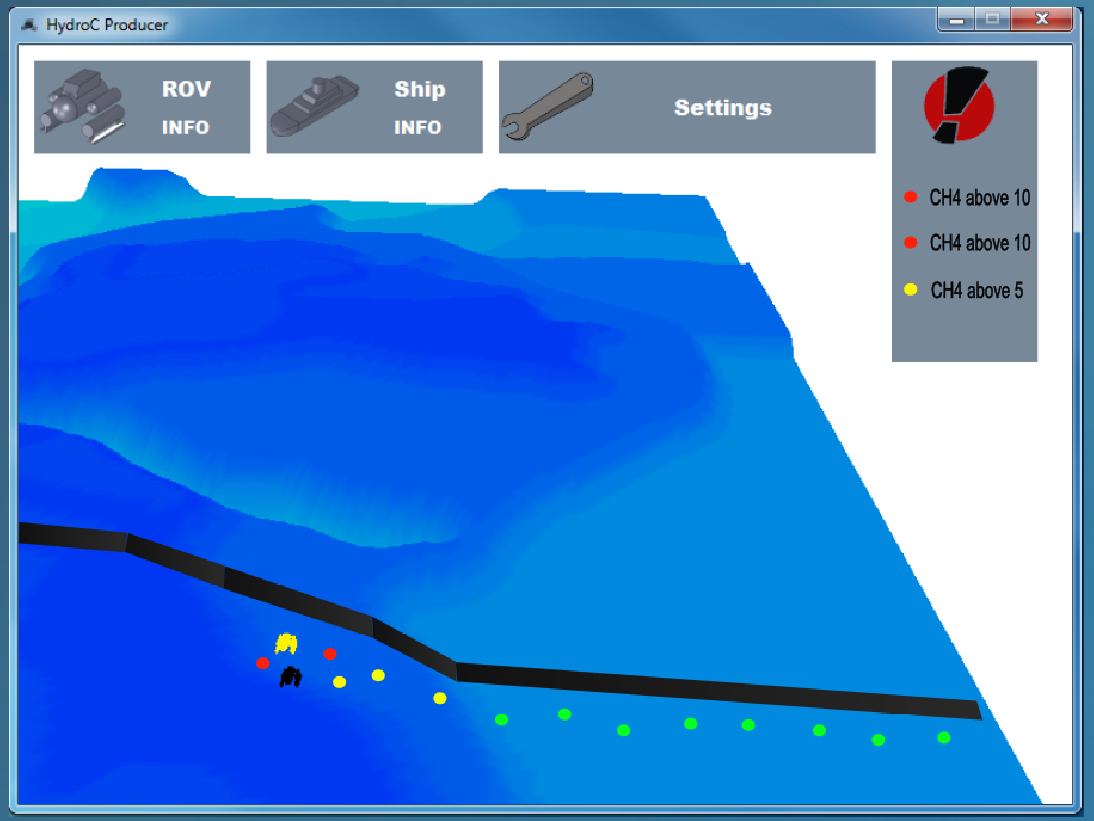
Mobile Leak Detection Sensor Suite

- PAH Sensor for detection of any oil in water.
- CH4 Sensor for detection of gaseous and dissolved Hydrocarbons in water and for validation of anomaly (selective method, no cross-contamination)
- CTD as optional backup for further input on hydrographic baseline.



Detect™ Leak Detection Software Suite

- Automated detection of any anomalies (e.g. plumes of emissions)
- Broad variety of fully integrated sensors
- Interface to GIS and ROV Operator Displays



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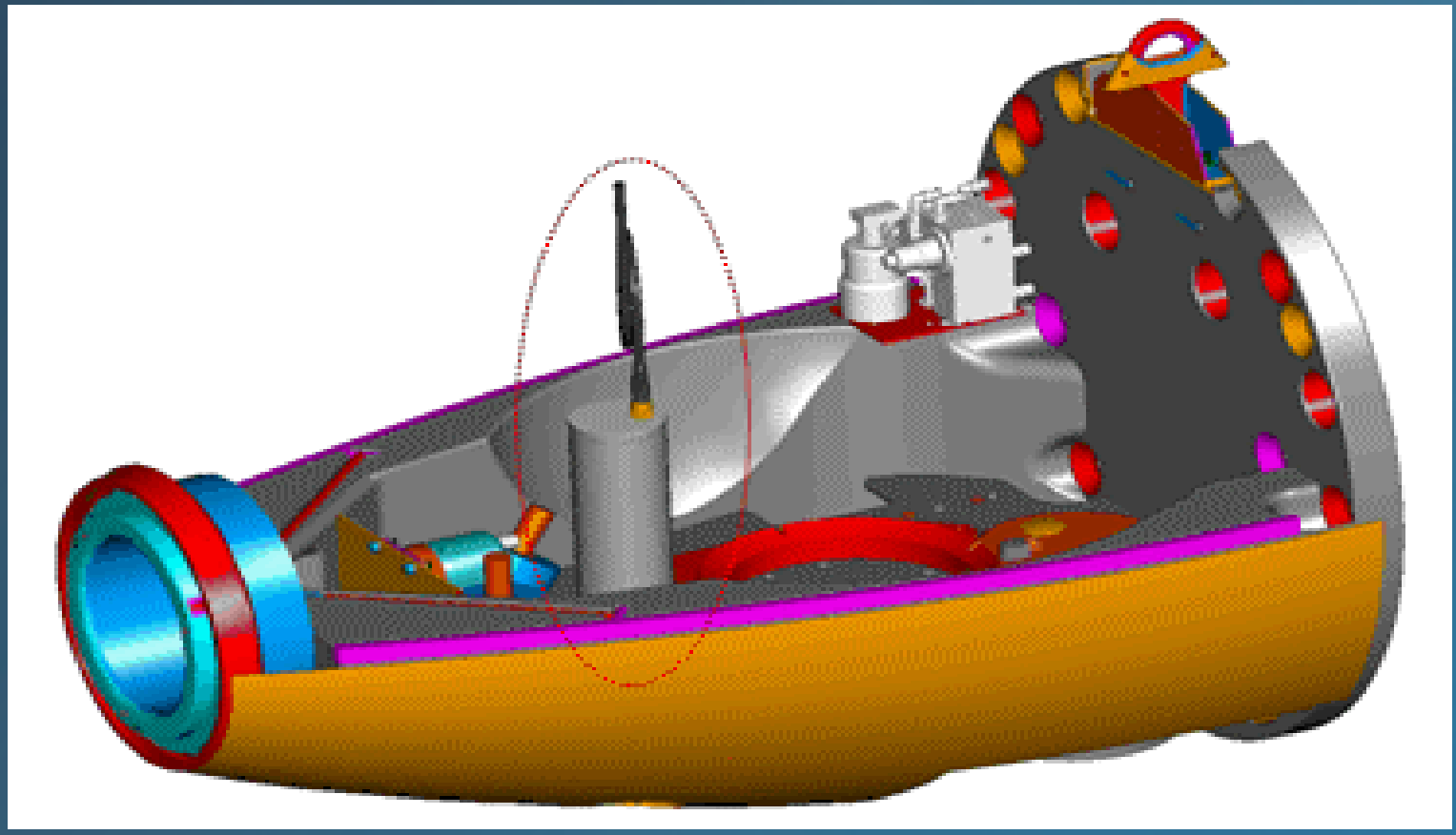
Thank You

- Questions ?

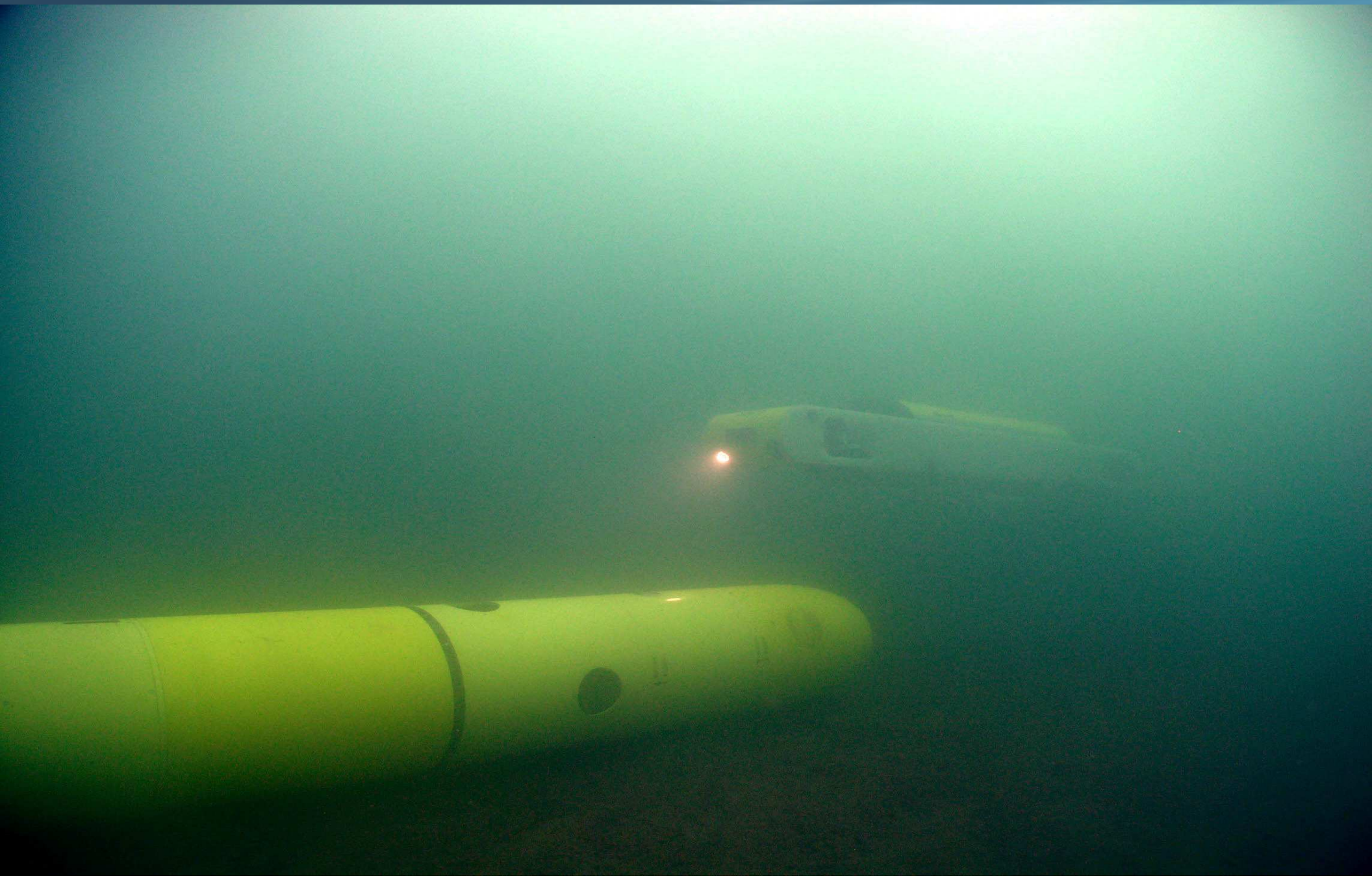


- Chris@RoperResources.com
- Tel. 250 361 9115

sophisticated underwater gas detection

CONTROS Systems & Solutions GmbH

SAAB SubROV Approaching AUV 62



SAAB SubROV Positioning to pick up AUV 62

SAAB SubROV Transporting AUV 62