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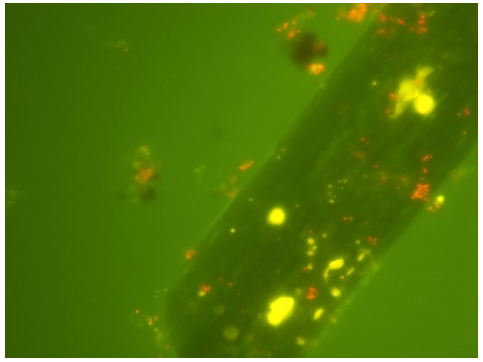
Hamburg University of Technology

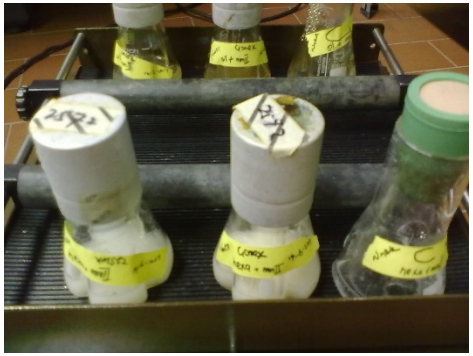
TECHNICAL BIOCATALYSIS TUHH

GULF OF MEXICO RESEARCH INITIATIVE

Deep Sea in a Can:
Microbial Degradation Under High Pressure

Andreas Liese, Rudi Müller, Paul Bubenheim
Steffen Hackbusch, Nuttapol Noirungsee, Juan Viamonte





C-IMAGE-II

C-IMAGE-III
Center for the Integrated Modeling and Analysis of Gulf Ecosystems

05.02.2018, Advancing Oil Spill Technology: Beyond the Horizon, New Orleans, USA

C-IMAGE-III

Center for the Integrated Modeling and Analysis of Gulf Ecosystems

(3) Massive-scale Barcoding of Ichthyoplankton

(1) High-Pressure Low Temperature Studies of sub-surface oil releases

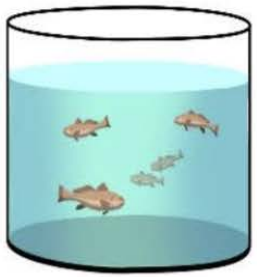
Michael Schlüter
TUHH Hamburg University of Technology
TUHH Institute of Multiphase Flows ims
Experiments

Thomas Oldenburg
University of Calgary
prg
Partitioning

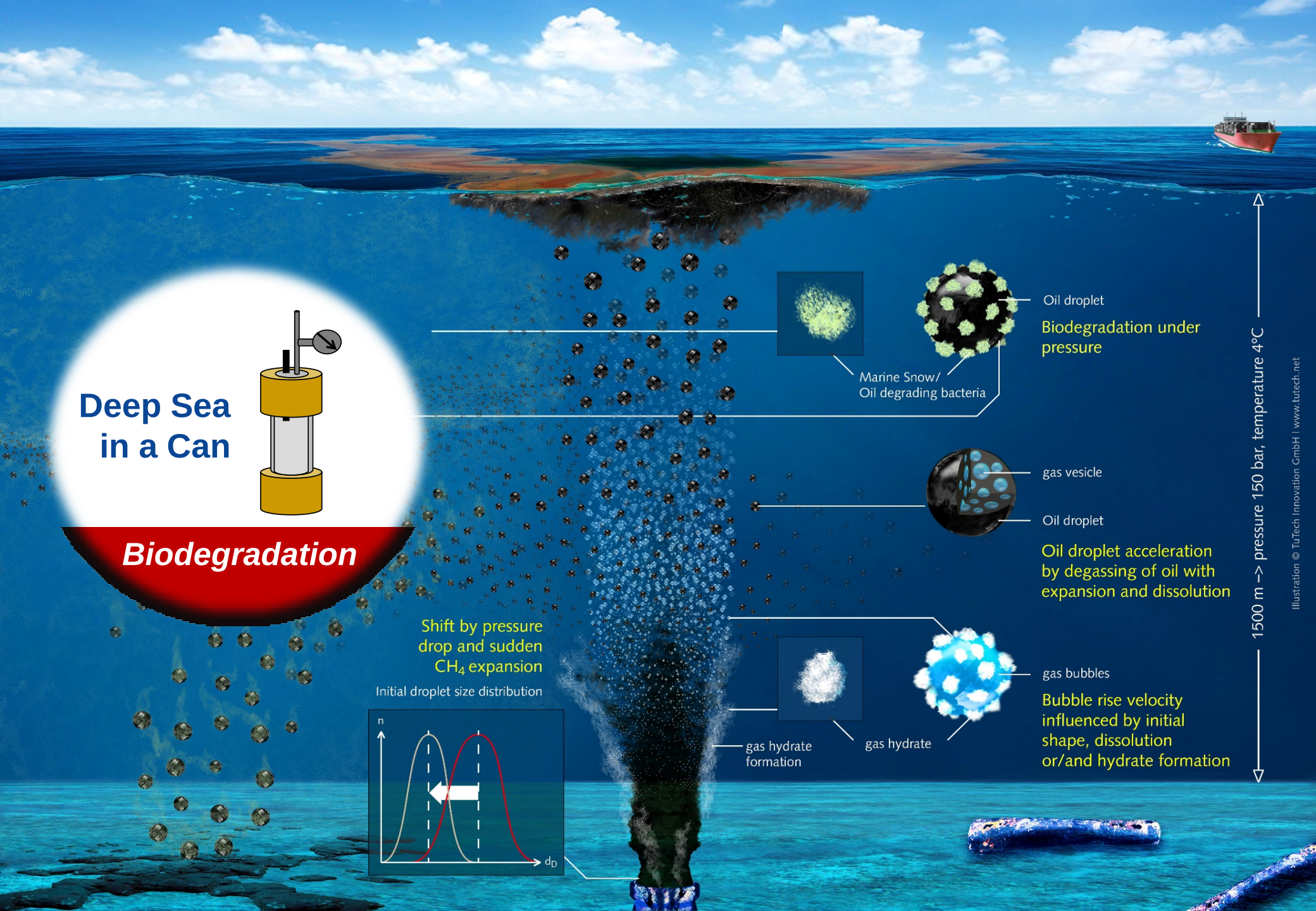
Andreas Liese
TUHH Hamburg University of Technology
Technical Biocatalysis TUHH
Biodegradation

Dieter Krause
TUHH Hamburg University of Technology
PKT Institute of Product Development and Mechanical Engineering Design
Pressure Lab

Zach Aman
The University of Western Australia
Hydrate Formation & Scale Down

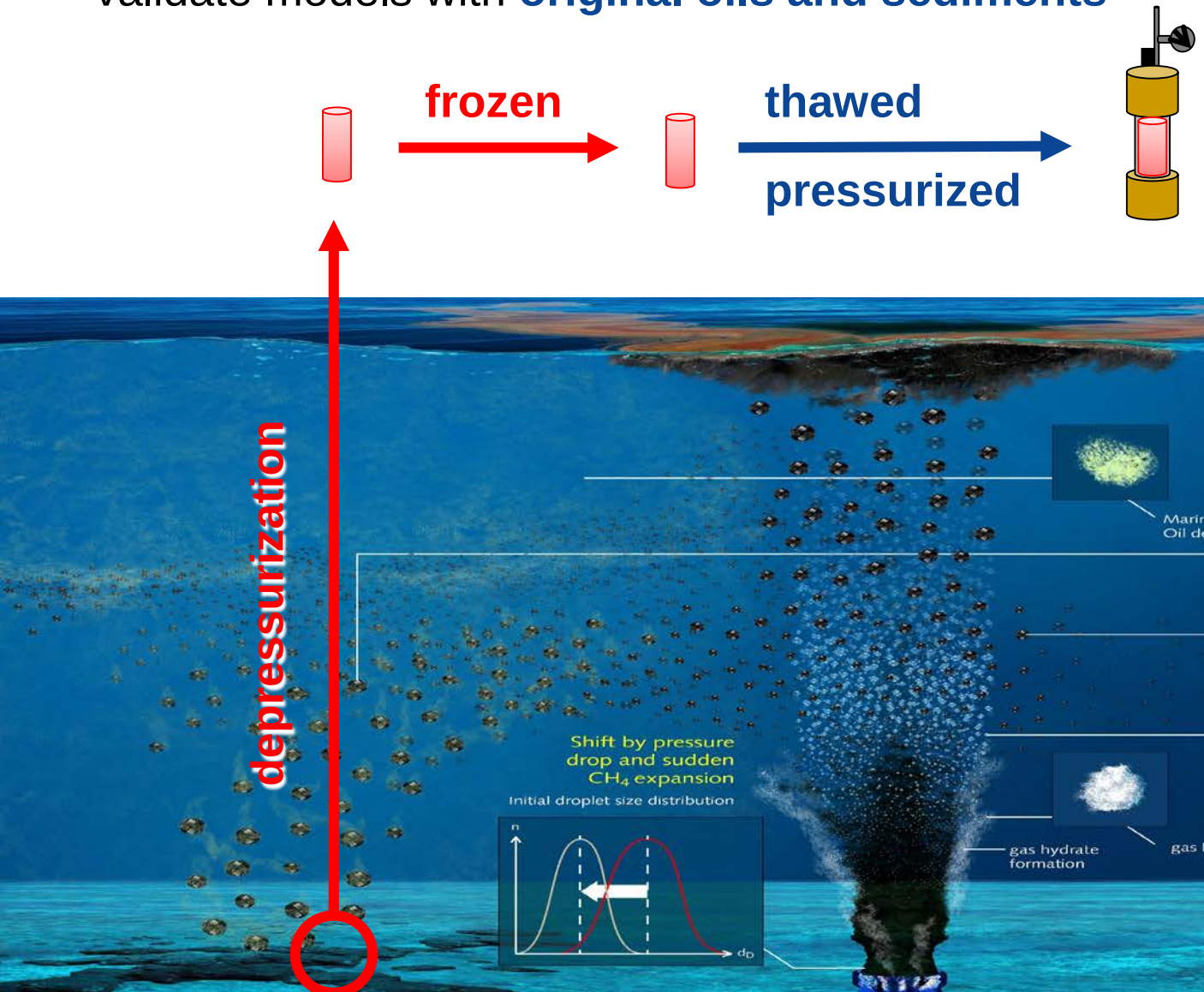


(2) Advanced "'omics" approaches to oil spill impacts on biota


Deep Sea
in a Can
Biodegradation
Oil droplet
Biodegradation under
pressure
Marine Snow/
Oil degrading bacteria
gas vesicle
Oil droplet
Oil droplet acceleration
by degassing of oil with
expansion and dissolution
Shift by pressure
drop and sudden
CH4 expansion
Initial droplet size distribution
n
dD
gas bubbles
Bubble rise velocity
influenced by initial
shape, dissolution
or/and hydrate formation
gas hydrate
formation
gas hydrate
1500 m –> pressure 150 bar, temperature 4°C
Illustration © TuTech Innovation GmbH | www.tutech.net

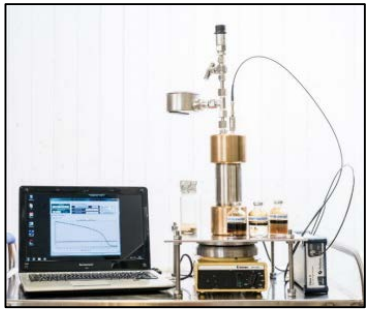
Deep Sea in a Can

experimental biodegradation simulation under controlled lab conditions to validate models with **original oils and sediments**



High Pressure Reactor Setup

- **pressure reactors** for bacterial growth and O_2-analysis up to 40 MPa



- **methane reactor** for bacterial growth and analysis up to 15 MPa

- **spindle press system** for mechanical pressurization up to 100 MPa

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High Pressure Reactor Setup

innoculated with

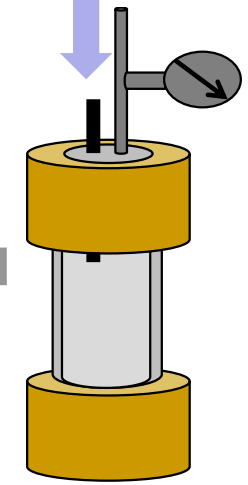
- **GoM sediment samples** (7 sites; top 1cm)
- **GoM hydrocarbon degrading model strains**
- added **crude oil / CH_4 / dispersant**

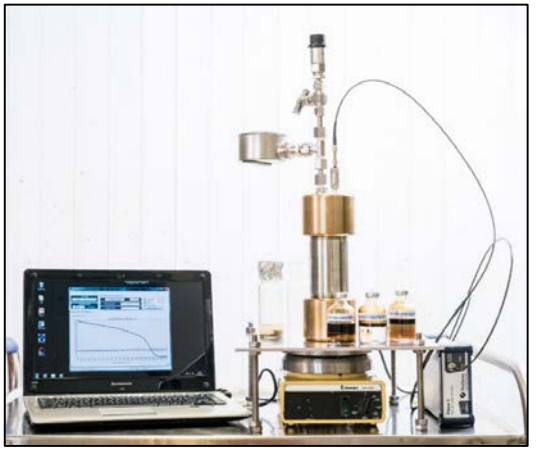
pressure

CH_4	**max 20 MPa**
N_2	**max 20 MPa**
air	**max 20 MPa**

determination of

- **growth (CFU)**
- **bacterial communities**
- **O_2 / CH_4 consumption**
- **crude oil analysis (FTIR / GC-MS)**





reactor volume	160 ml
pressure max	40 MPa
T	4°C - 20°C

research focus

- effect of **pressure & dispersant**
- changes in **bacterial community**
- **crude oil / CH_4 biodegradation rates**

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High Pressure Single Strain Experiments

after 120 h

S. Hackbusch

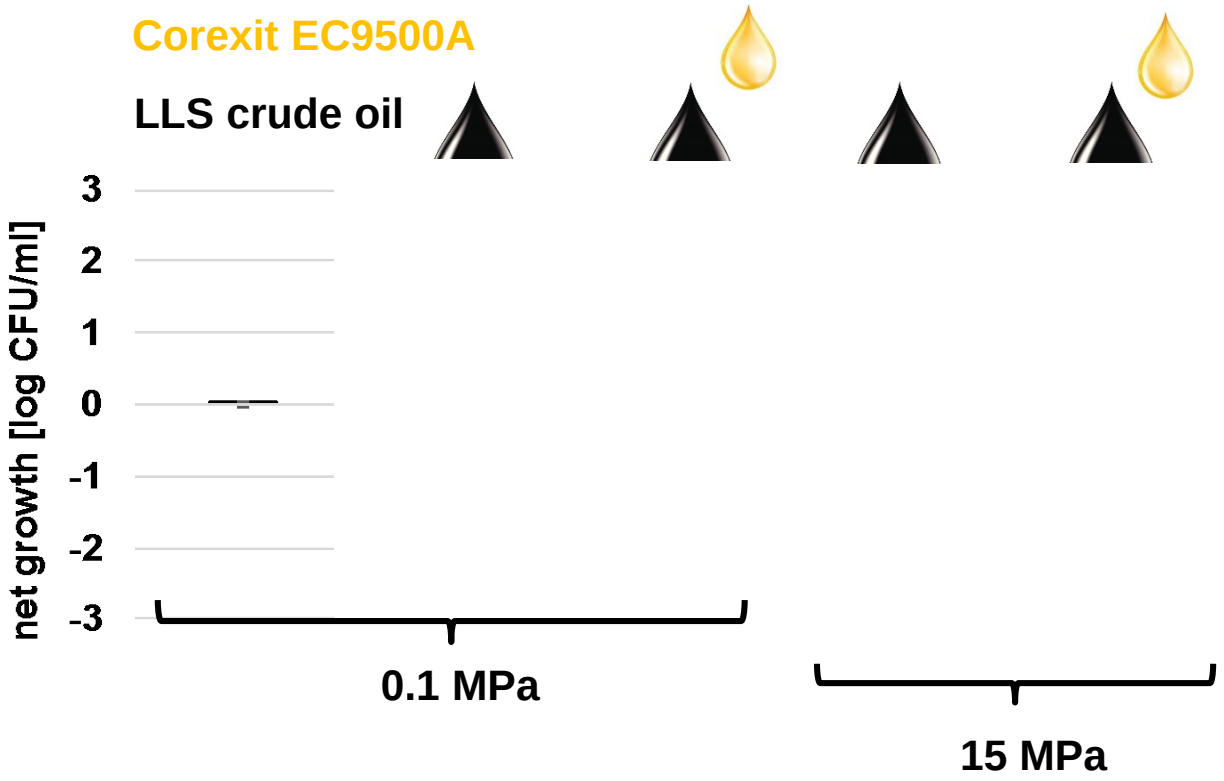
In cooperation with
Joel Kostka and Xiaoxu Sun

Georgia Tech

Rhodococcus PC20

isolated from nGoM sediment

with crude oil



dispersant effects
the growth and metabolic activity

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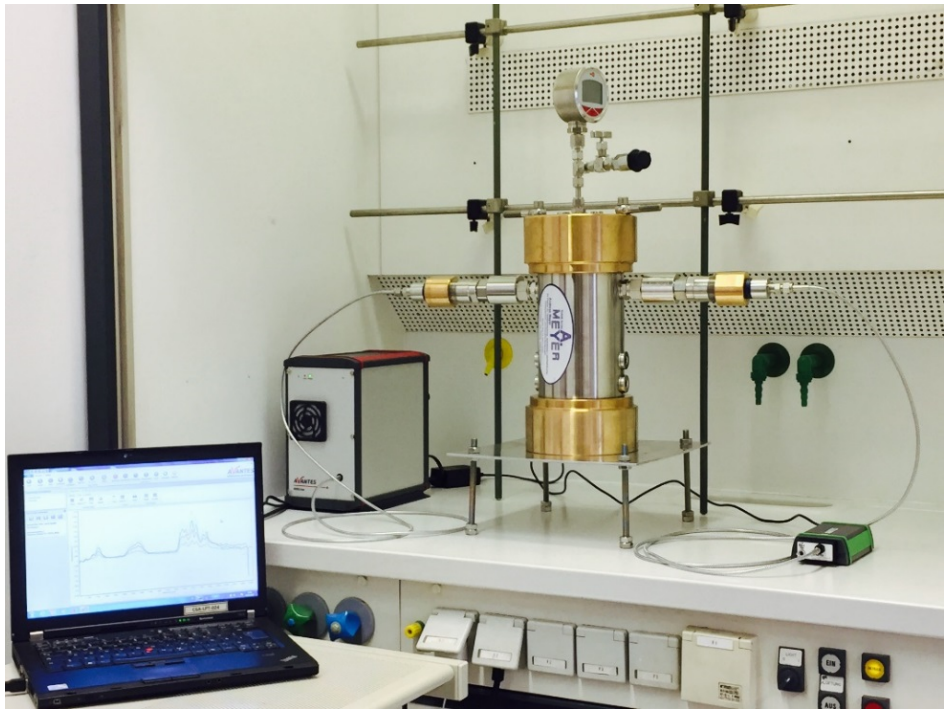
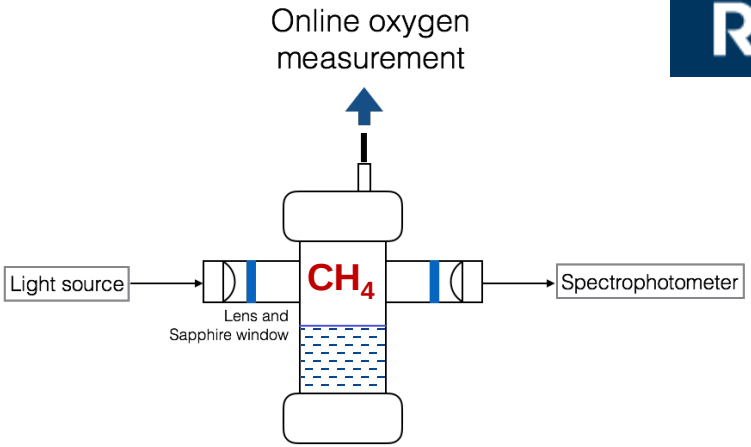
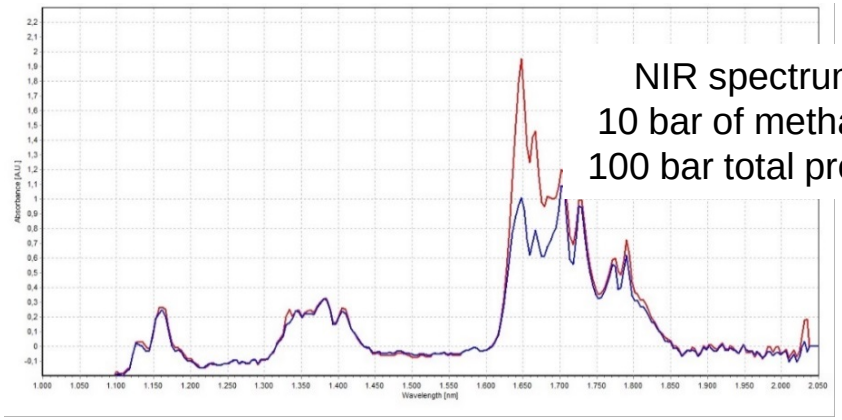
20 ml MM2 medium, 1% crude oil (LLS, 200 µl), 200 rpm, 20°C.
Dispersant (Corexit EC9500A) addition: 2 µl. N = 3.

Online NIR Spectroscopic Analysis at High Pressure

in cooperation with:
Ruhr-Universität Bochum







NIR spectrum of
10 bar of methane at
100 bar total pressure

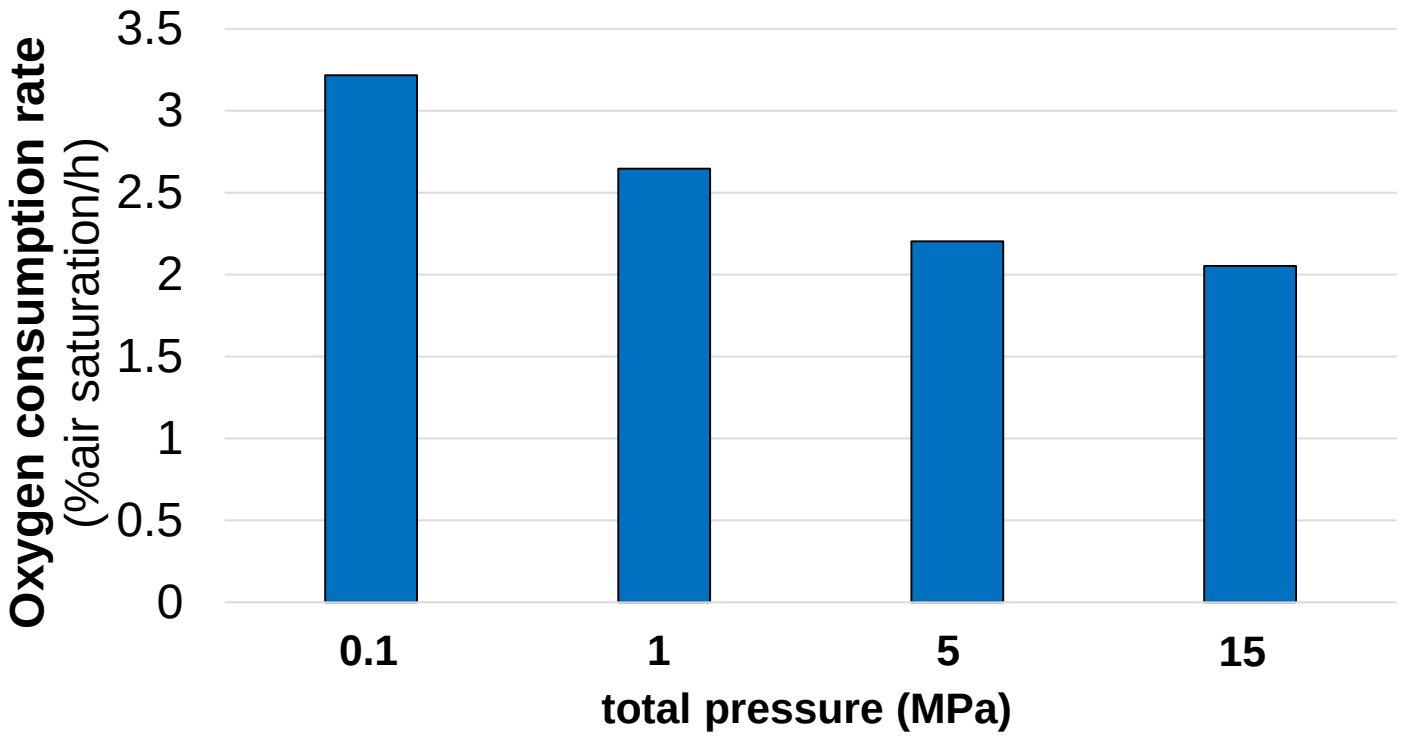
CH_4 and O_2
can be simultaneously measured
@ high pressure up to 15 MPa

NIR = near infrared

Methane Biodegradation (0.1 MPa methane)

N. Noirungsee

Oxygen consumption rates of *Methylocaldum* P9 under **pressure**

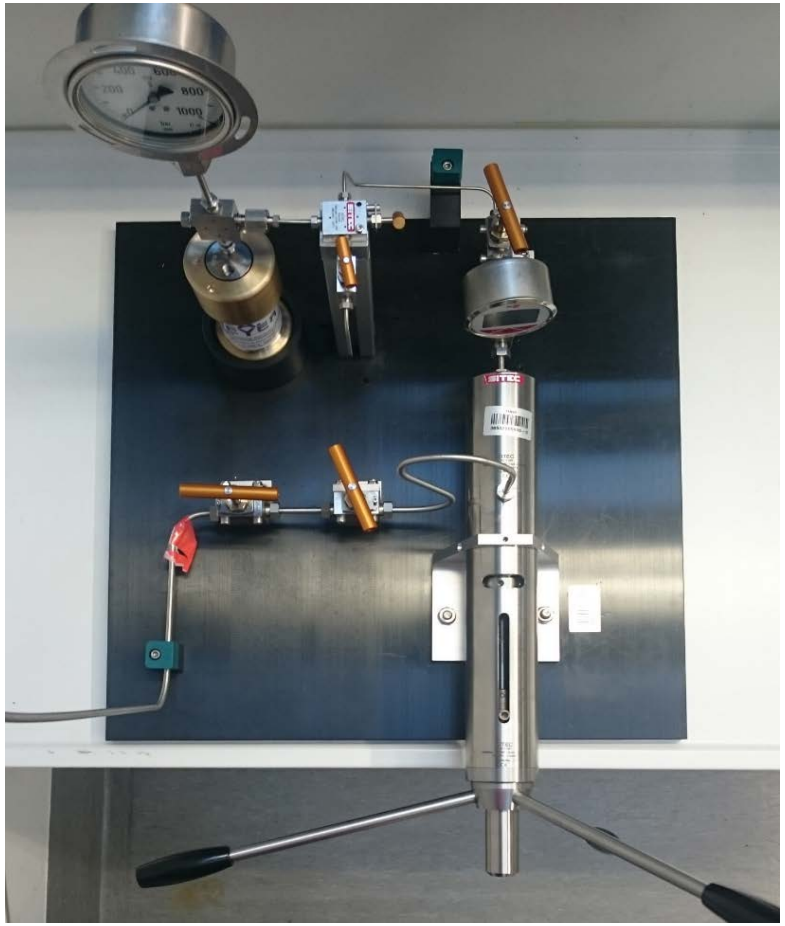


decreased oxygen consumption with increased total pressure

0.1 MPa methane @ each experiment

High Pressure Reactor Setup (40 MPa)

Mechanical pressurization with N_2 up to 40 MPa (1 MPa max CH_4 pressure)

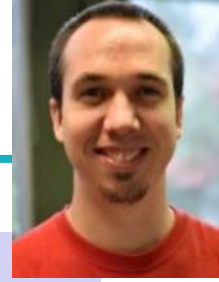


Spindle Press System

High Pressure reactor

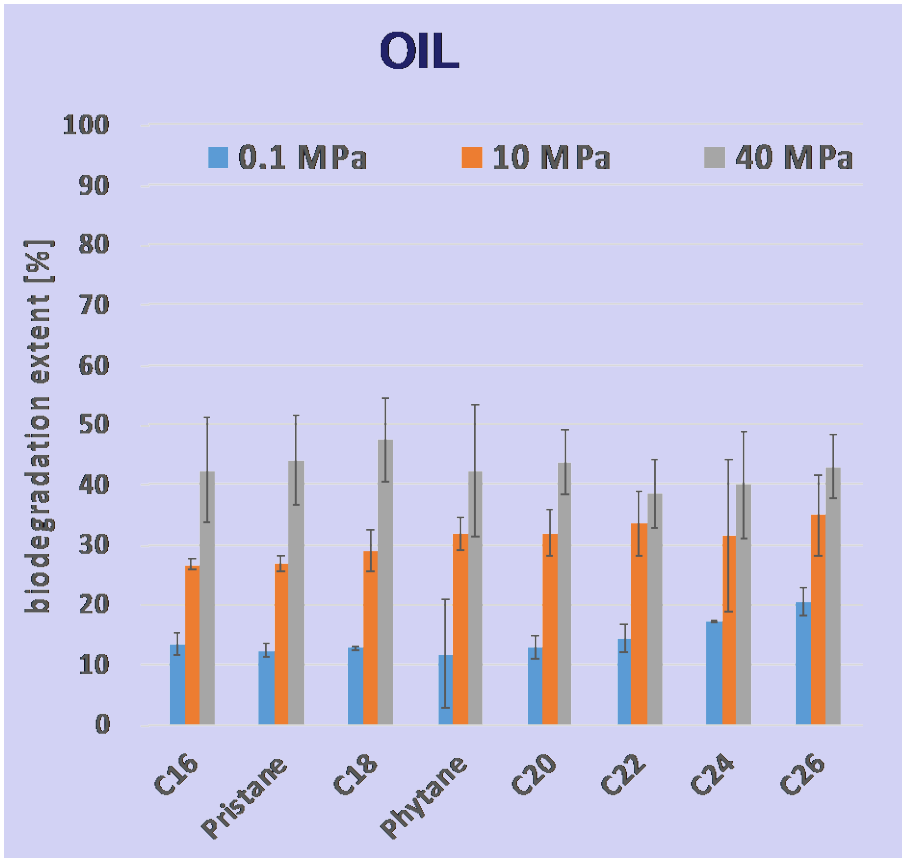
High Pressure reactor volume 160 ml; pressure max 40 MPa N_2 (max 10 bar CH_4).

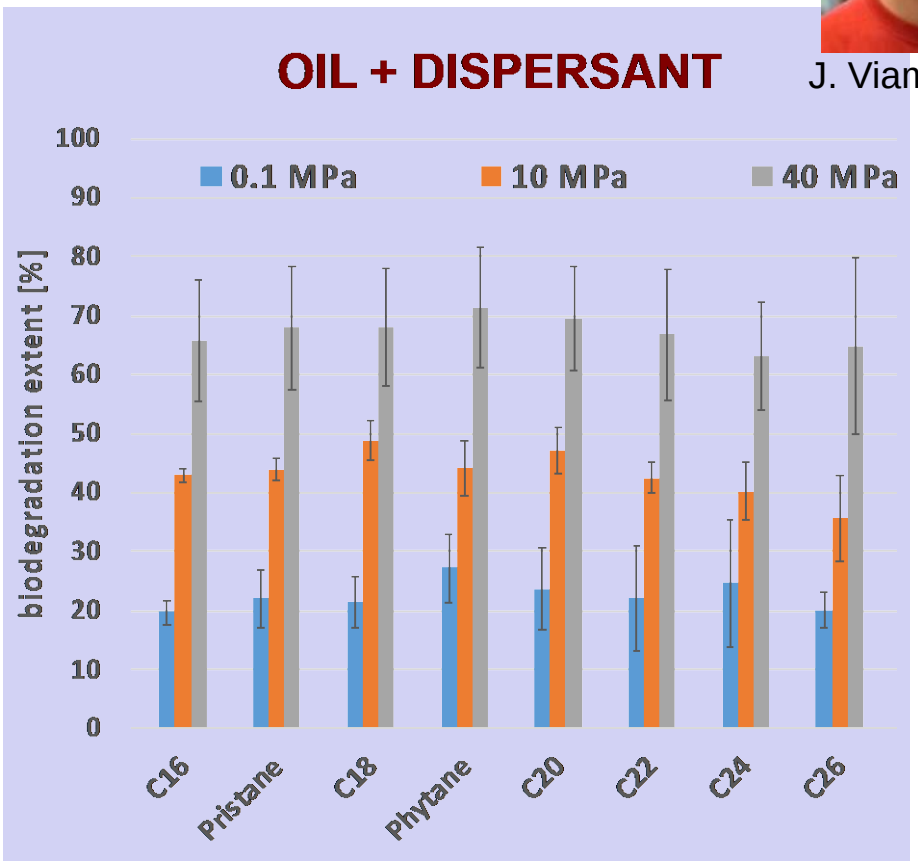
Crude Oil Biodegradation (sediment)



J. Viamonte

Saturates





Biodegradation extent effected by pressure & Corexit EC9500A

Influence of Corexit EC9500A (1:25 DOR), LLS crude oil (1% v/v), 1 g of top layer sediment mix (DWH01, DSH08, DSH10, SW01, PCB06), 0.1, 10 and 40 MPa; 4°C; 14 and 28 days. GC-MS

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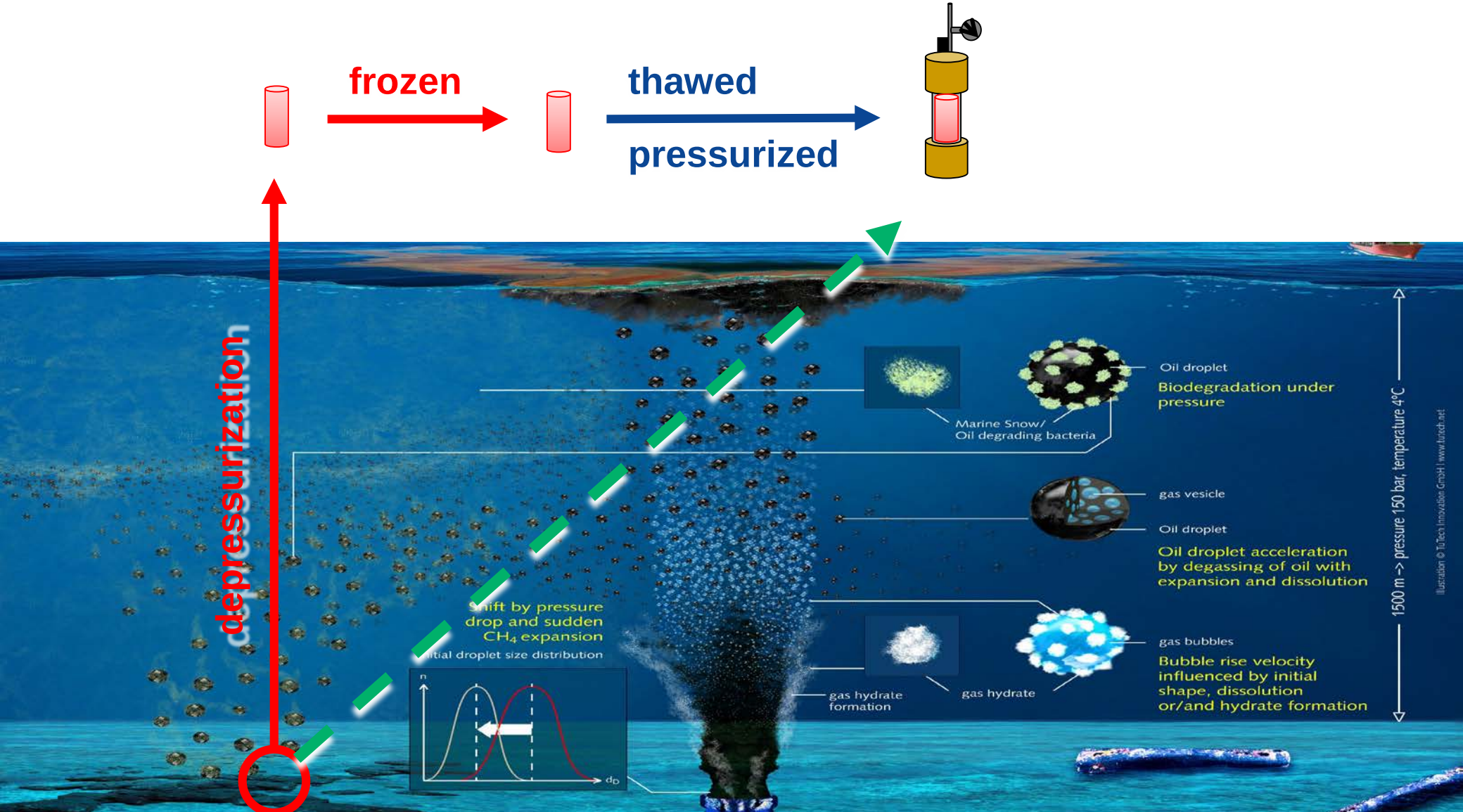
Research Uncertainties / Technical Challenges

Are the **research results relevant ?**



Areas Ripe for Technological Advancements

$\sum$

- Efficiency of biodegradation
  ... depends on microbial activity / community
- Industry is pushing to deeper dwells
  ... pressure effect becomes more important

- **Sampling**

  @ **deep sea** @ high pressure
  ... without decompression

  @ **small volumes** from high **pressure reactors**

  of **sediment** and **water column prior to drilling** to generate better models

- **Biodegradation** studies @ **deep sea**

  improved *in situ* sensors for tracking chemicals & concentrations