Seabed mapping - Experiences and technologies we like to see in the future

Harald Brunstad, Chief Geologist Lundin

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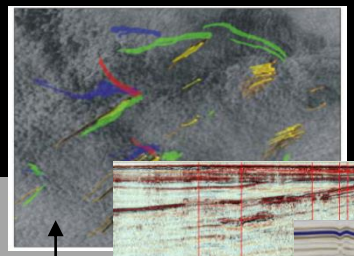
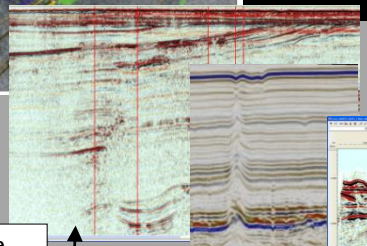
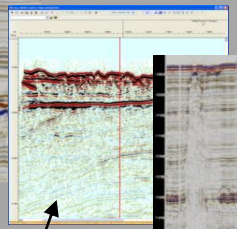
- Outline
  - Introduction
  - Site surveys and Environmental Baseline Studies
  - R&D and regional geological understanding
  - Long term monitoring by seabed Lander
  - Future development and improvement

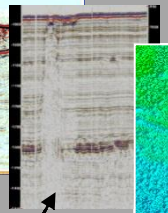
Holistic approach

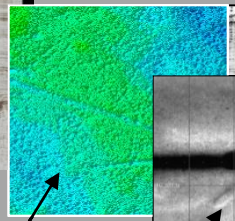
Investigating at most scales.
(Defocusing before focusing)

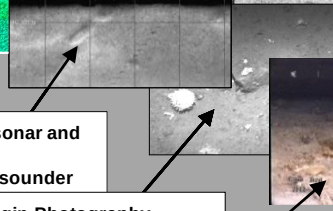


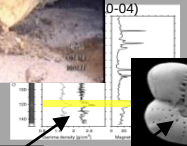


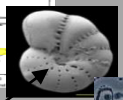


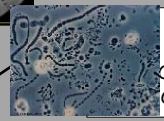


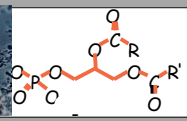












SAR satellite data

Regional 2D seismic

Conventional 3D Seismic

P Cable Seismic

Multibeam echosounder and Topaz

Hugin side scan sonar and depth penetrating echo sounder

Hugin Photography patchwork

ROV Video inspection

Physical scanning of cores

Microbial analysis

Chemical analysis

Mega scale

Meso scale

Scale

Resolution (detail order)

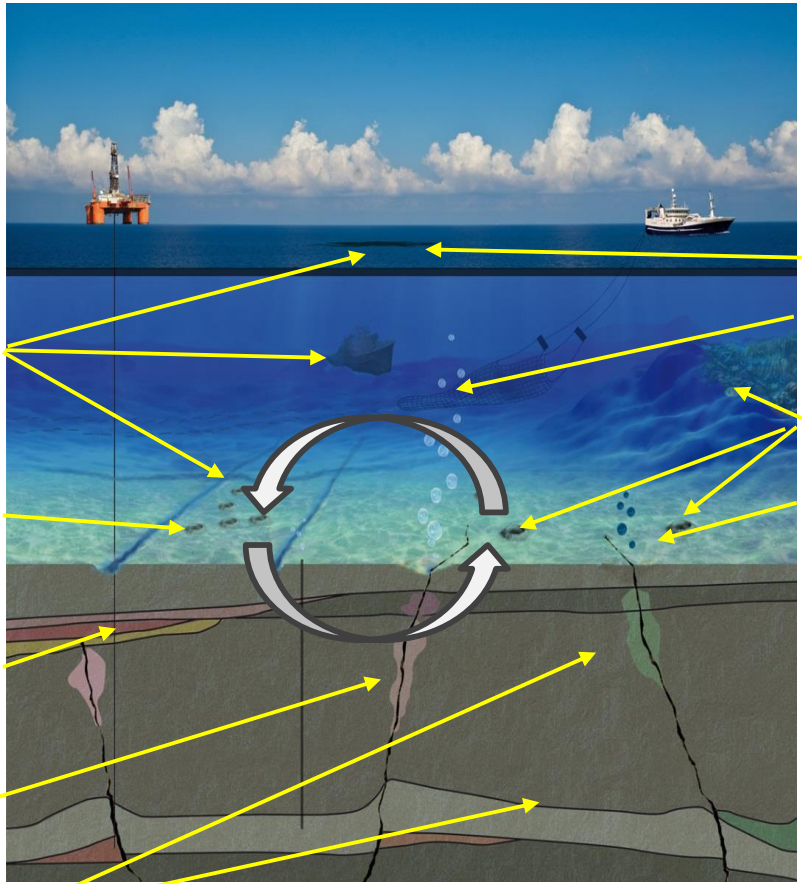
When perspectives from stake holders are shared, more can be seen

Credit: BillionPhotos.com/Shutterstock

…… this gives an increased understanding of the total environment.

Commercial actors

Governmental organisations:



Environmental conditions

Geotechnical conditions

Geohazards

Petroleum system

Geology from sea bed into the depth

Environmental conditions

Climate

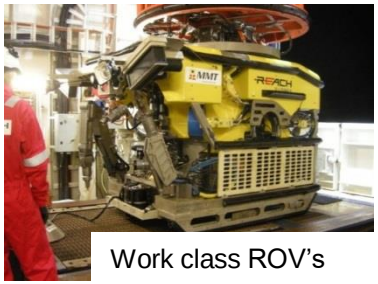
Seabed biology

Seabed geology

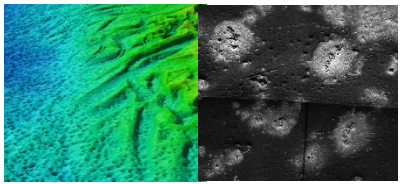
Several subjects studied from a common technology platform

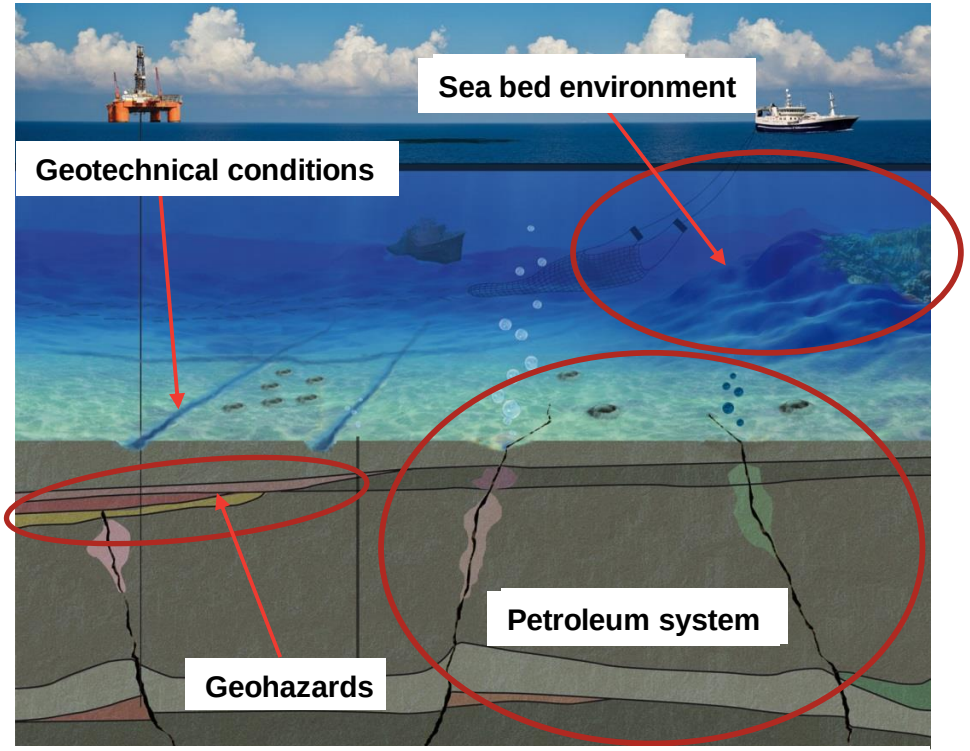
FFI Research vessel M/S HU Sverdrup

MS/Borboun Arctic



Work class ROV's





Cooperation with academia an commercial vendors

Continous expansion of sample database analysing for chemistry, microbal activity, radiometric dating and geology using numerous of sampling methods

Gravity coring

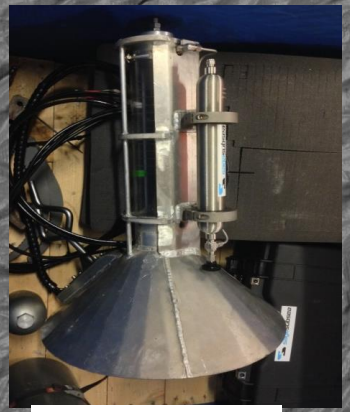
Box coring

Grinding

Sawing

Sample picking by ROV

Push coring



Gas collection

Near Surface Drilling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Site surveys and Environmental Baseline Studies

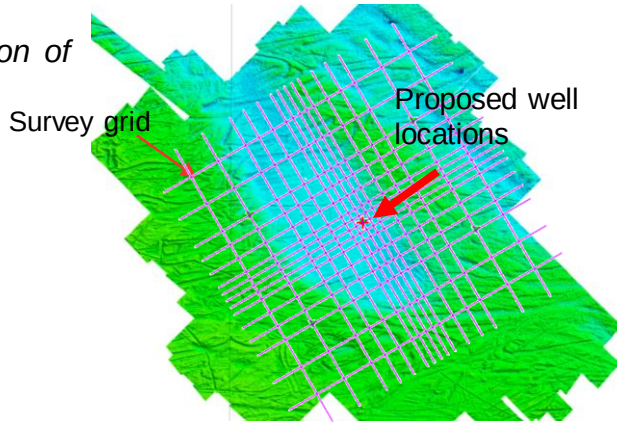
Site survey experiences and new technology

- ***Background:***

Performed to minimize the risk of harm to personnel and equipment and to protect the natural environment.

- *Site surveys are performed for various types of subsurface activities and installation of Subsurface facilities*

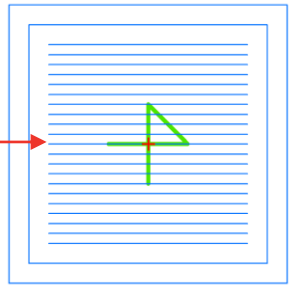
Rig site survey



- **<u>Traditional rig site survey:</u>**
  - 5x5km survey grid covering the area around a proposed well location and is
  - Typically performed by a survey vessel conducting;

    - **Geophysical survey**
      - Multibeam Echosounder + (Water Column & Backscatter data)
      - 2D High Resolution Seismic (2DHR – 1200m streamer+152 cu.in source)
      - Sub-bottom Profilers (Pinger/Chirp + Mini Air Gun & Mini streamer)
      - Sidescan sonar
      - Magnetometer
    - **Geotechnical Survey**
      - Cone Penetration Testing (CPT) – 20m depth
      - Gravity coring
    - **Environmental Survey/Baseline survey**
      - Remotely operated vehicle (ROV) for Video and Photos of seabed

Environmental ROV transects around a planned well location



2D high res seismic is the normal data used for detecting shallow gas as drilling hazard. This technology is old fashioned and has not been developed much for the last years

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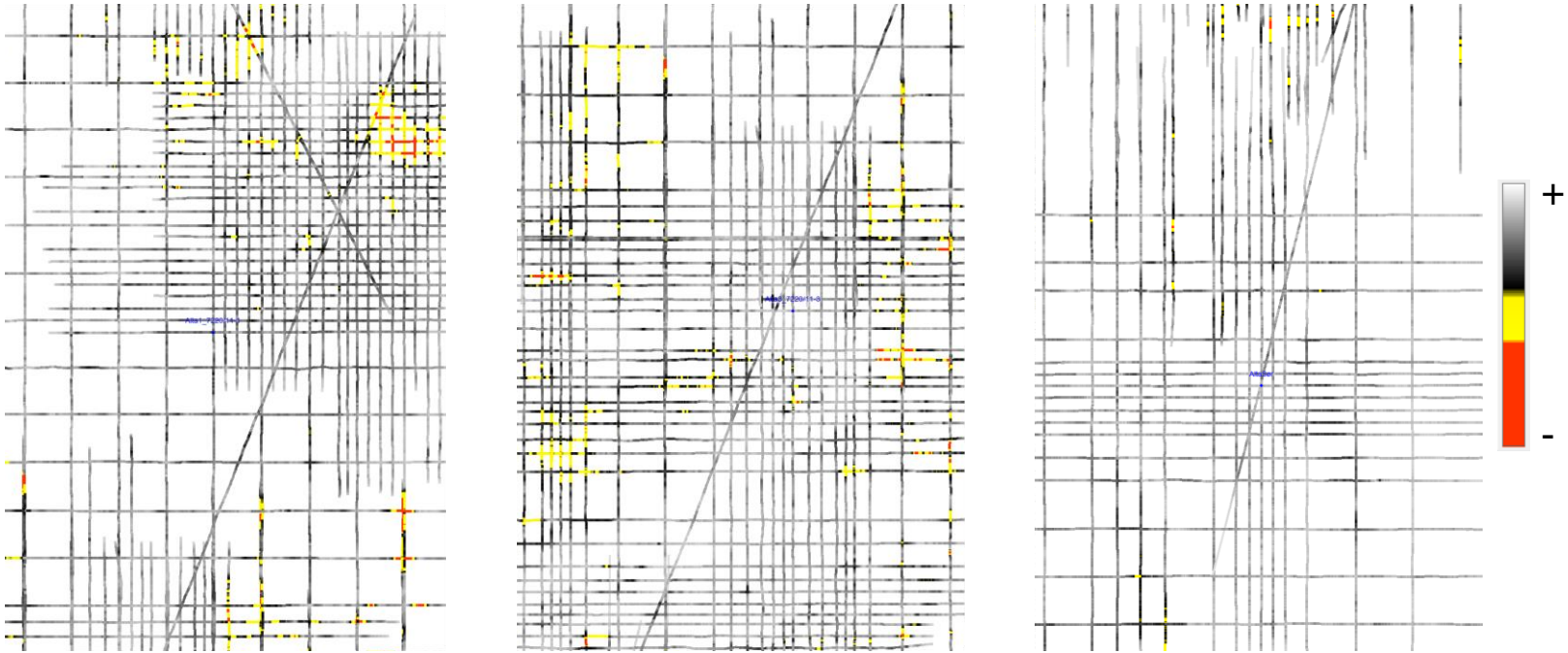
Traditional Shallow hazard)
2D high res site survey lines



Intra Unit 3 formation (-10ms to +15ms) (710ms), Most negative amplitude

3D seismic has developed a lot the resent years through methods like TopSeis, taking care of more of the higher frequency. In many cases this type of data gives a much better imaging of shallow gas.

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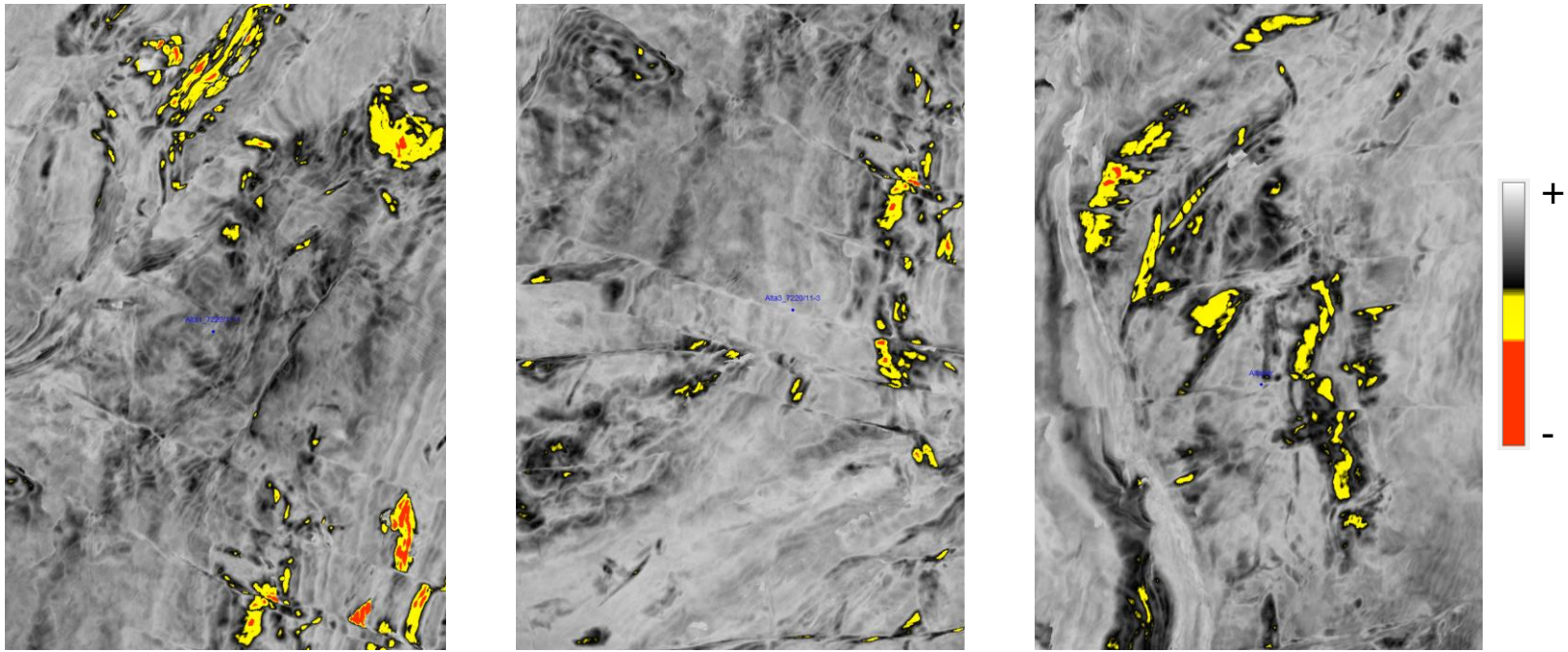
Improved shallow hazard drilling detection (gas)
Seen from 3D TopSeis split-spread data



Intra Unit 3 formation (-10ms to +15ms) (710ms), Most negative amplitude

Ongoing development of metods for Developing better photo mosaics from individual photos.

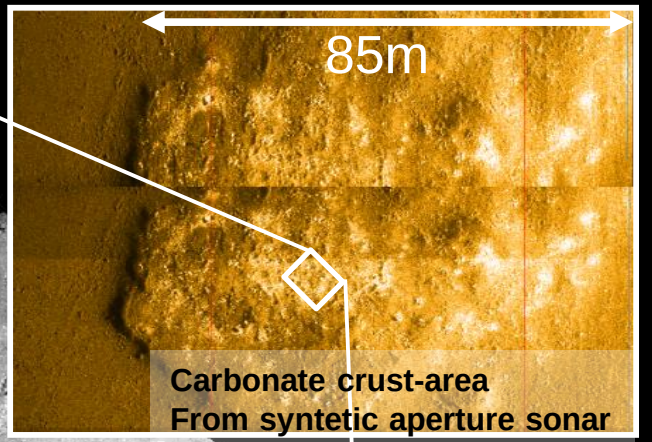
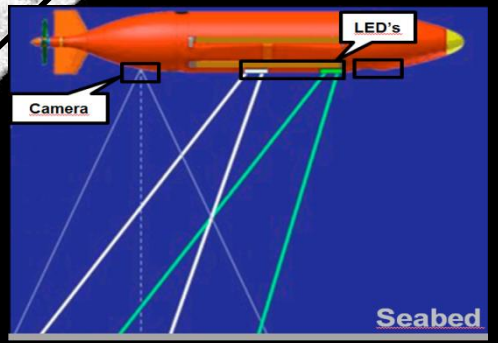


Photo mosasiv from 30 photos

- Seamless splicing of photo
- Balanced black/hvite scaling
- High resolution

Carbonate Crust-Area
Mosaic from optical photo



Ongoing development of metods for Developing better mosaics from ROV Videos.

These have been used to quantification of species Photo and Video mosaics of value for environmental baseline studies

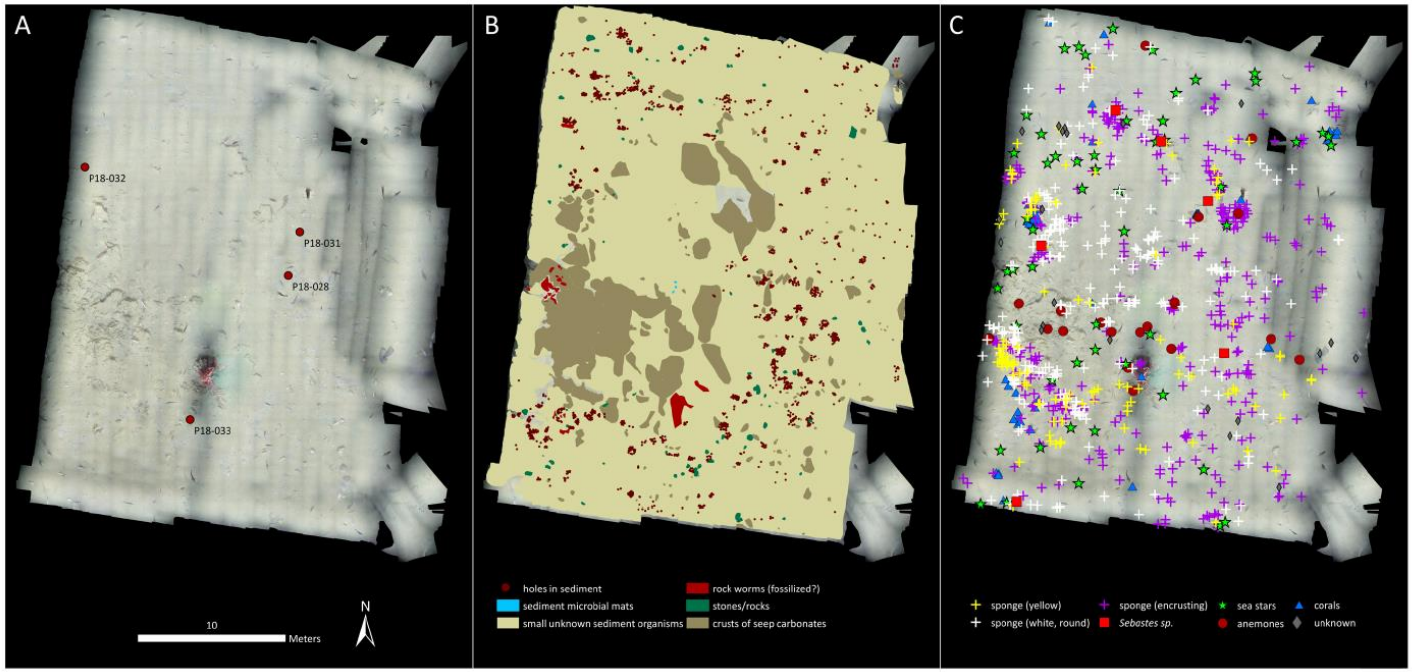


Figure 2 **Mosaic A.** (A) The georeferenced mosaic with the locations where push cores were taken marked. (B) The mosaic with polygon categories shown, plus the locations of the holes in the sediment. (C) The mosaic with all living fauna (point categories) shown. Note that cod were not marked.

From Arunima et al. 2019

Full-size DOI: 10.7717/peerj.7398/fig-2

The large amounts of images and videos calls for further use of AI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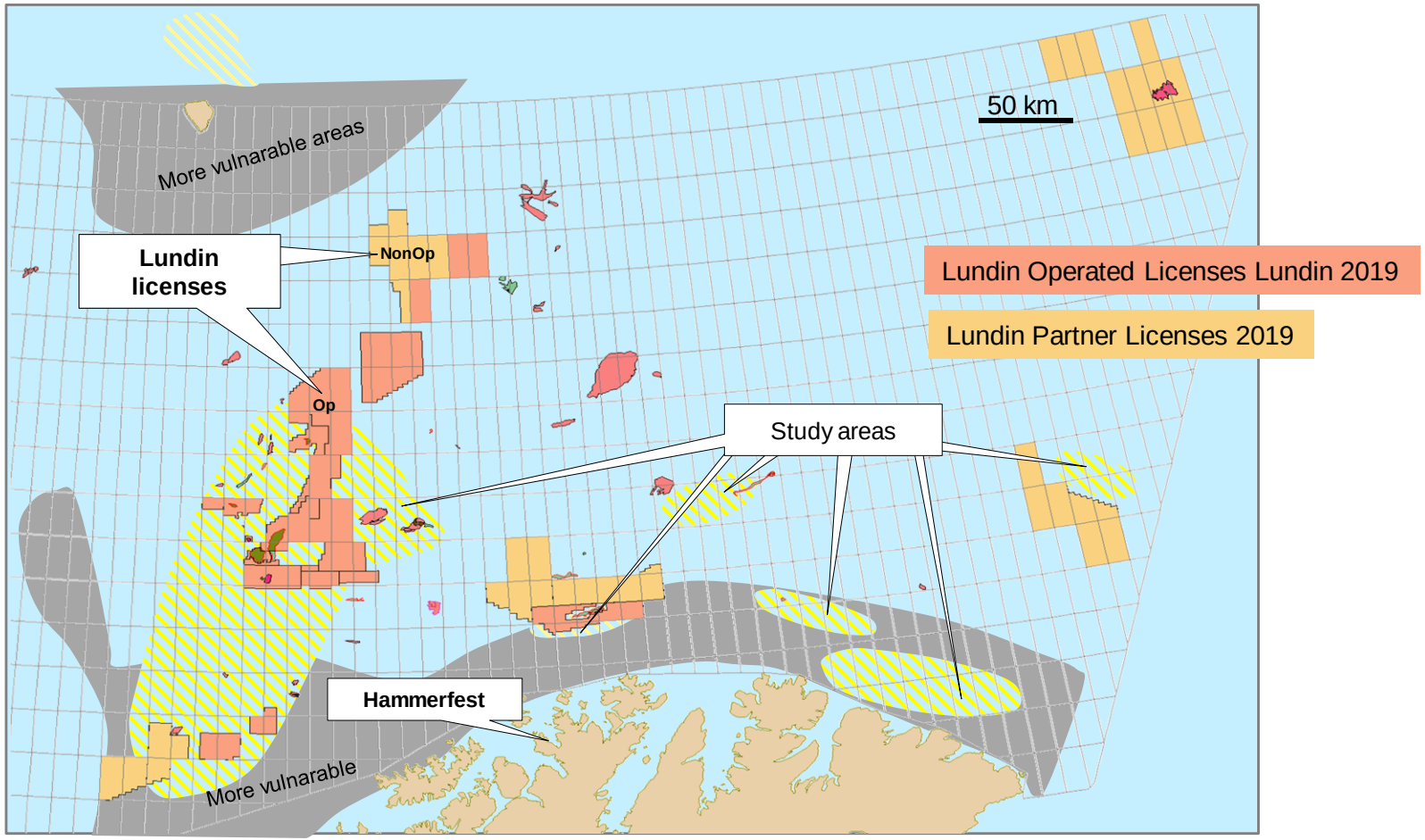
R&D and regional geological understanding

Study areas Lundins' R&D seabed mapping program

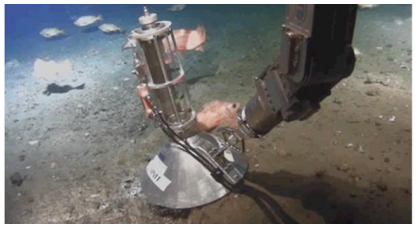
(**SGSE**: «**S**hallow **G**as, shallow **S**ediments and the **E**nvironment», program since 2007)



Lundins' R&D Sea bed mapping Program

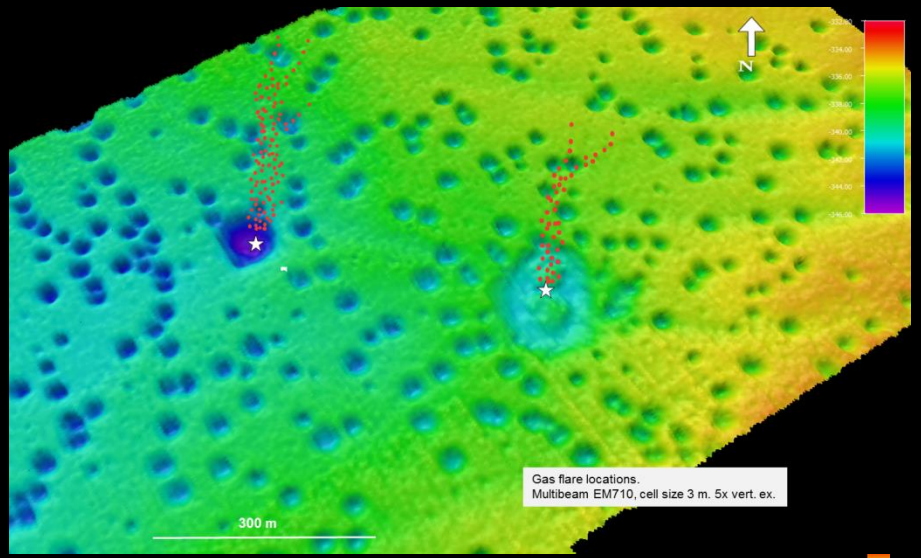
(**SGSE**: «**S**hallow **G**as, shallow **S**ediments and the **E**nvironment», program since 2007)

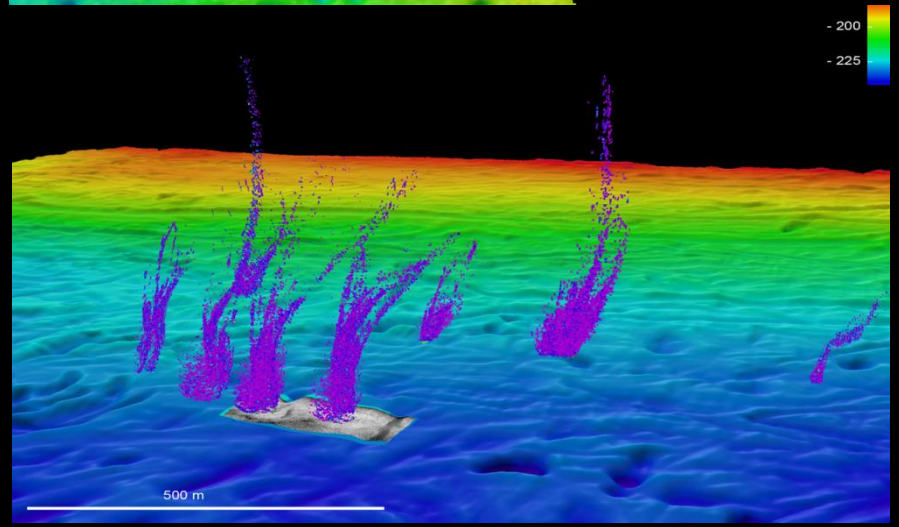
- The wish to close knowledge gaps has given Lundin a steeper learning curve
- Mapping large areas on a wide range of scales.
- A large amount of sea bed samples have been collected and analysed
- A large amount of data and samples are made available for academia and Mareano, such as photo, videos and Multibeam echo sounder data.
- This program has resulted i a number of academic publications about various themes, and has resulted in several MSc's og PhD's and finansing og Post Docs and other researchers



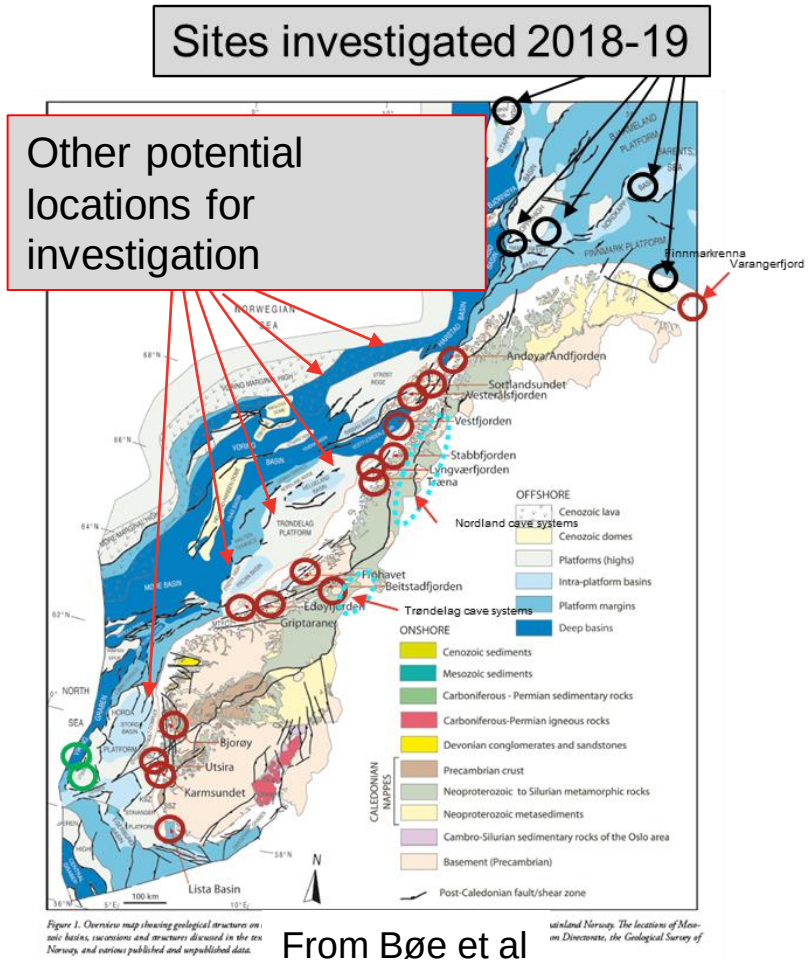
Reference:
www.kongsberg
.com

Ocean floor of the Barents Sea is heavily affected by glacial processes and subsequent fluid flow processes (pock marks and seeps)

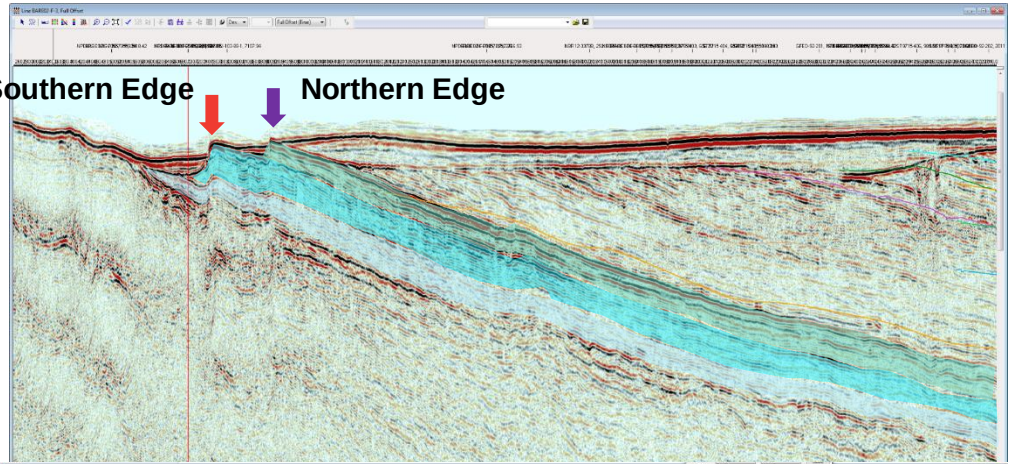


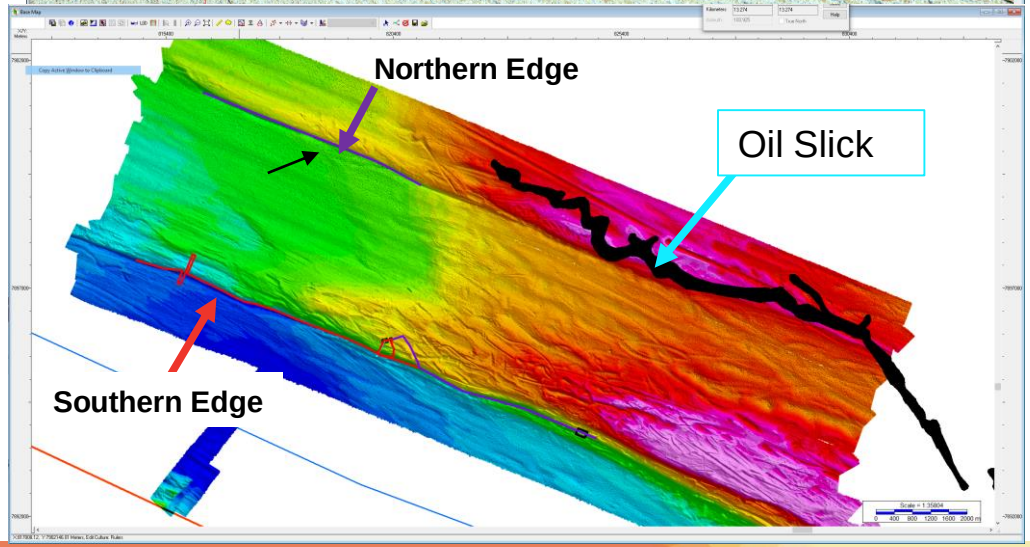


Investigation sedimentary rocks outcropping of on the sea floor



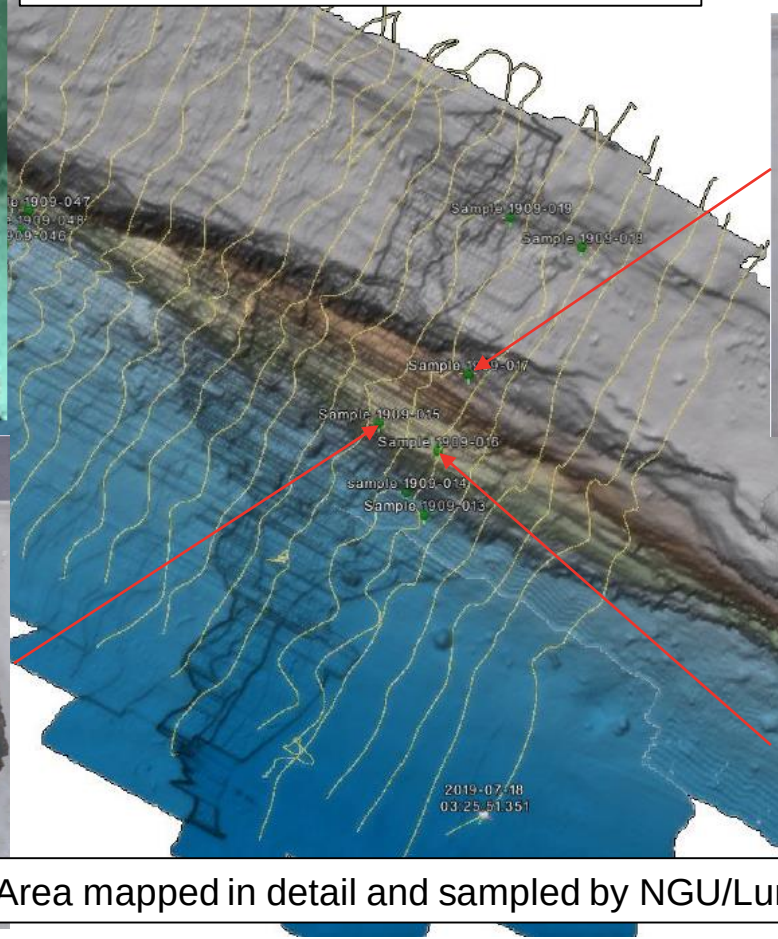
From Bøe et al

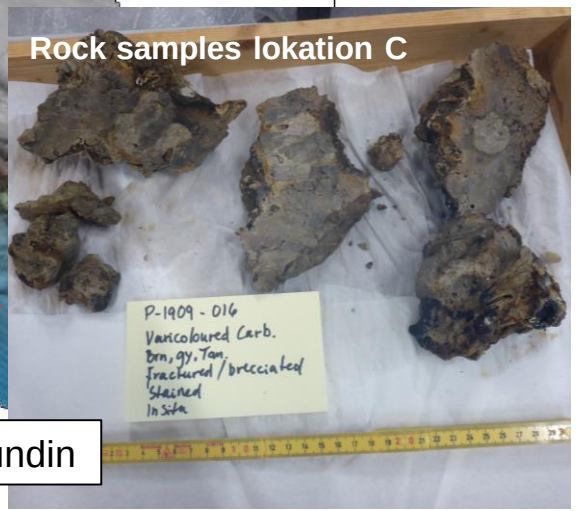




Aquired Rock Material and high resolution bathymetry from ROV

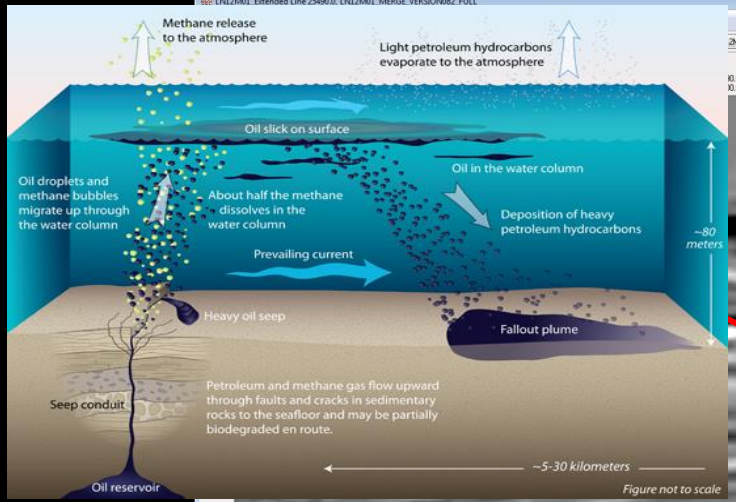
Cliff with outcropping Permo-Carboniferous sedimentary rocks

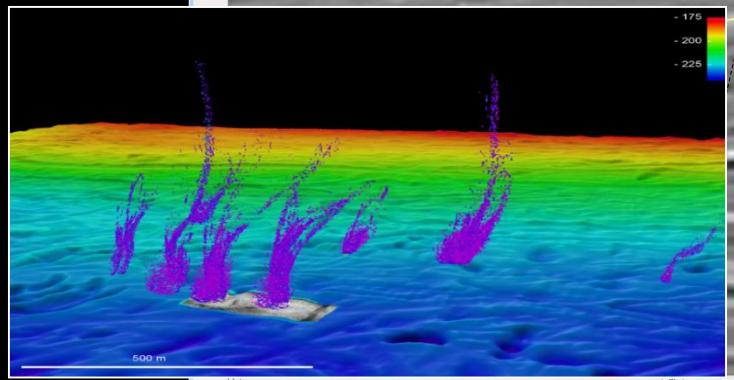




Area mapped in detail and sampled by NGU/Lundin

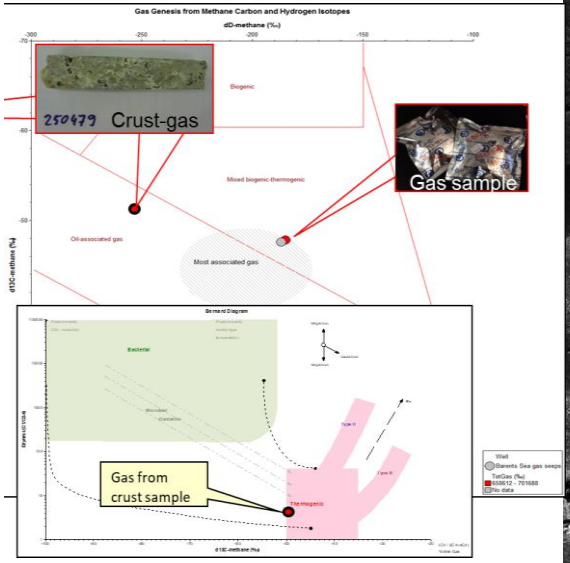
Evidence of hydrocarbons on the move. Example of ongoing migration/remigration from deeper levels to sea surface



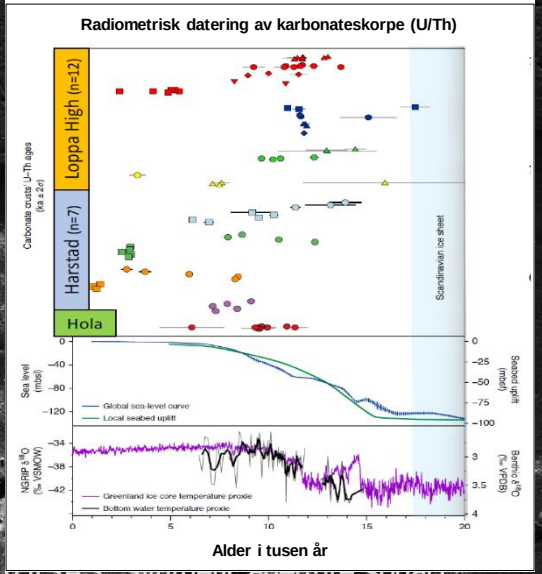


Gas flares often found inside crust forming Pock marks

Hovedvekten av gassen viser dannelse fra mikrobiell nedbrytning, men med innslag av metan fra oljekilder



Karbonsement i skorper er dannet fra nedbrytning av utstrømmende metan. Dateringer gir aldre fra siste istid fram til nå, men mesteparten av skorpene ble danne rett etter istiden.



(HiSAS–Synthetic aperture Sonar)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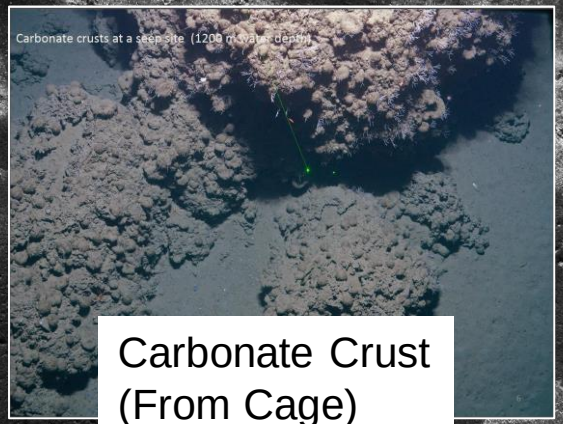
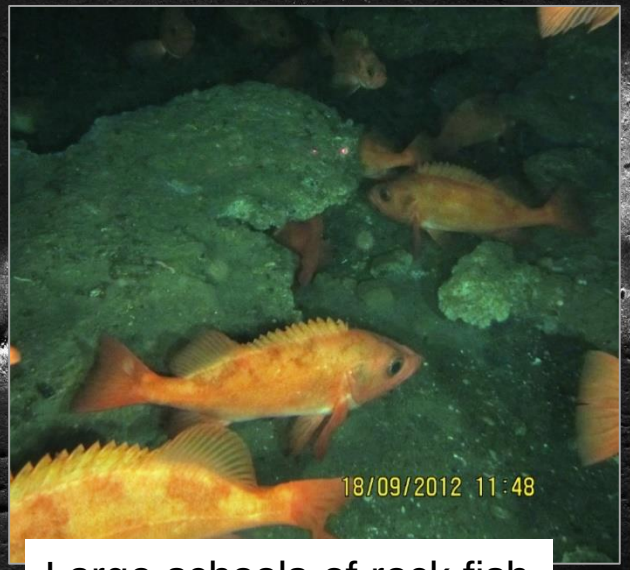
Long term monitoring by seabed Lander

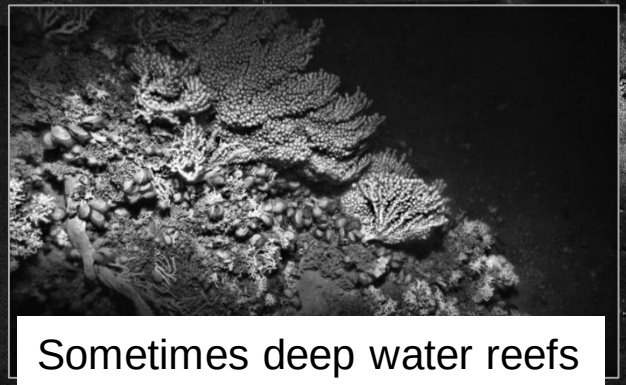
Carbonate Crust areas are hot spots for life



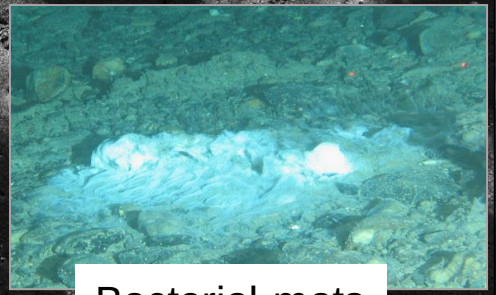
Carbonate Crust (From Cage)



Large schools of rock fish



Sometimes deep water reefs

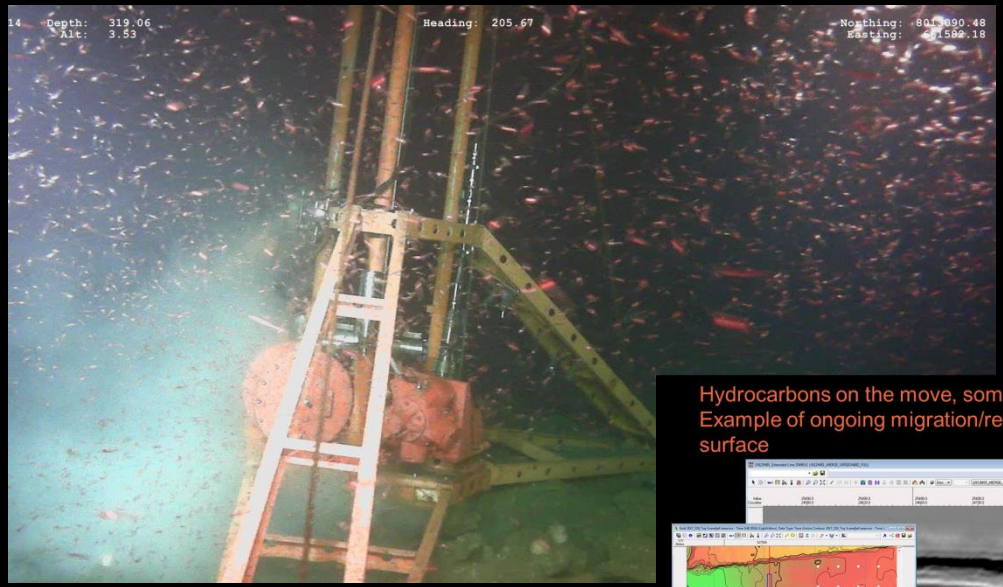


Bacterial mats

Swarms of shrimps

The Lundin Lander Project

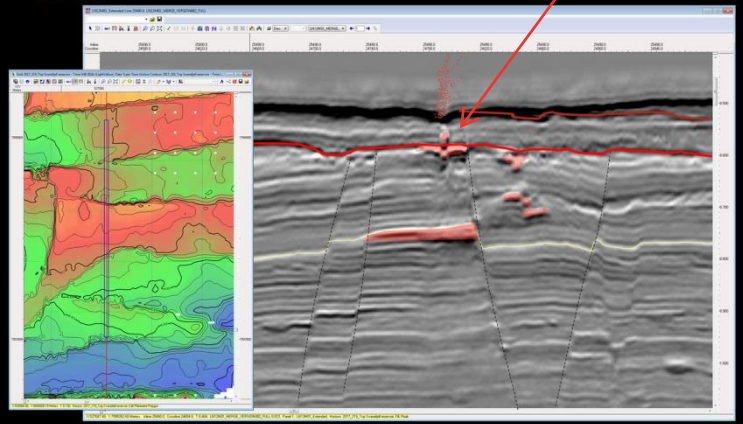
Crust and flare sites have a rich benthic and hyper benthic fauna - why?
Is this related to hydrocarbons as a food source or to the special sea bed topographical conditions?



Understand the external vs. subsurface controls on intensity and composition of seeping gas

The Lundin Lander

Hydrocarbons on the move, somewhere at the Loppa High: Example of ongoing migration/remigration from deeper levels to sea surface



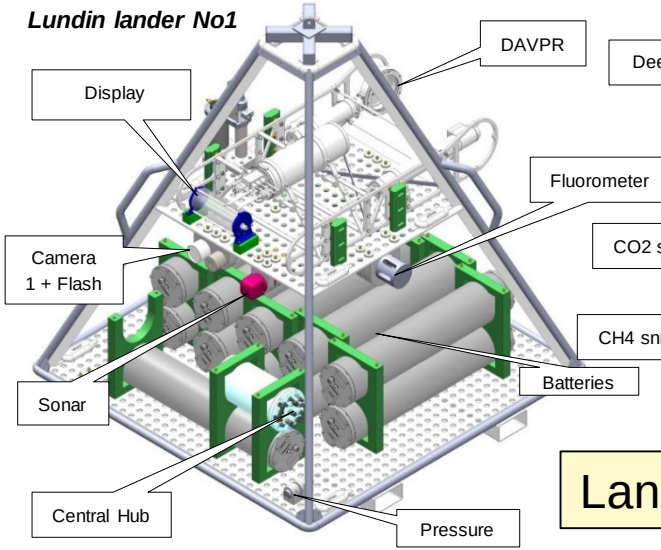
We plan to learn more about the dynamics of flares, their effects on environment and how they relate to slicks

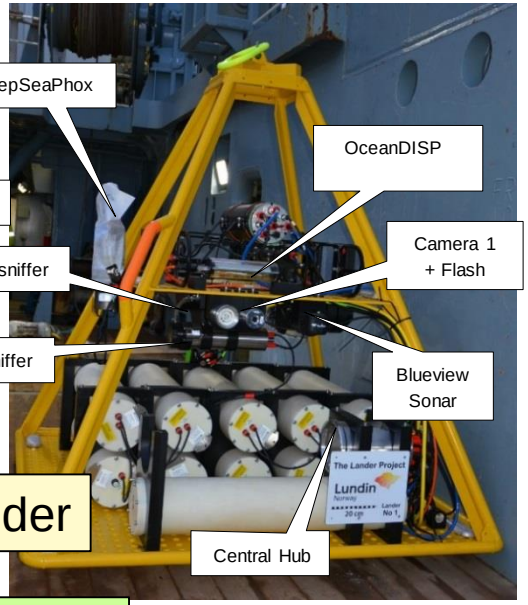
<u>Partners:</u>
NGU,
FRANATECH
University of Tromsø
Akvaplan NIVA
Arctos
CIVITAS
DNMI

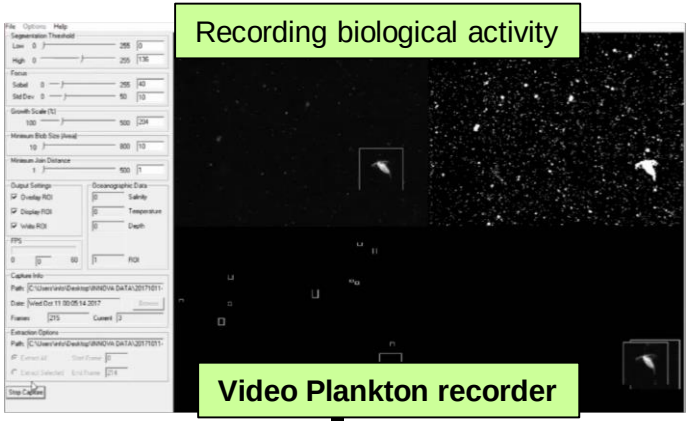
The Lundin Lander Project

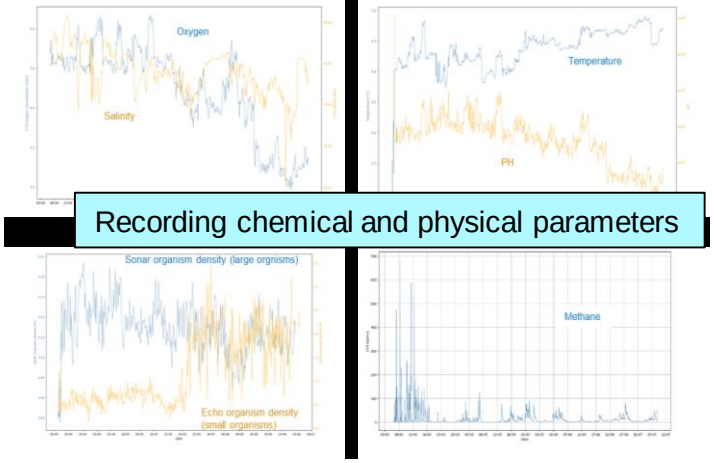
Longterm monitoring of the sea bed environment on seep sites:

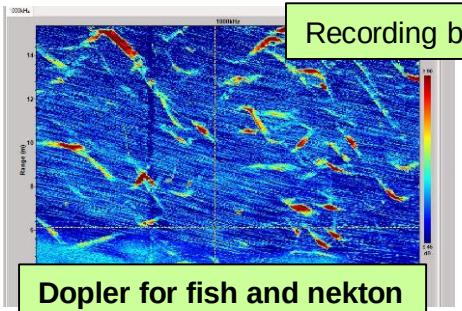
- Sea bed monitoring stations give information about variation through the year, ogalso when there is no human activity.
- Lundin lander No1. the activity on gas-seep lokalitions through time, and may contribute with new understanding.

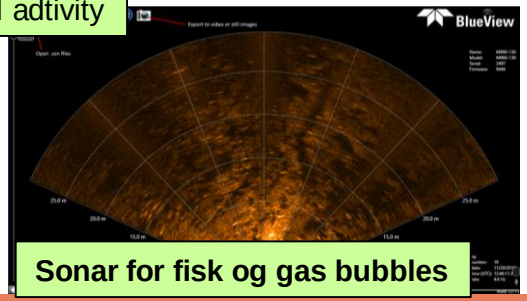










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Future development and improvement

Future dreams: Sea bed mapping operations

Reference: www.ixblue.com

- More and cheaper data for each site with less use of fuel on mother ship
- Large datasets for use of AI.
- Large number of water and sediment samples in a cost effective way
- Develop autonomous units with a long range
- Develop a AUV software that can recognize and report objects (koraller, seeps, crusts, pockmarks…)
- Develop a system for autonomous deployment and retrieval of nodes/instruments
- Tow a seismic source & streamer for ultra high resolution seismic?

ROV

- More robust deployment in poor weather
- Increase travelling speed
- Improve operating distance to mothership

AUV

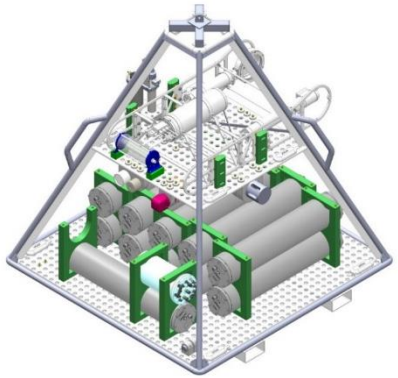
Reference: www.kongsberg.com

- Longer lasting batteries
- Improved online communication
- Better data quality and better handling
- Needs better underwater positioning
- Needs more robust and reliable equipment
- Optimalization of Visibility/light for cameras etc. an issue

Future dreams: Longterm monitoring by landers

- Cheaper deployment, less depending on weather

- Continuous/long term power supply in remote areas
  - Sub sea battery charging and data offloading for Landers or AUVs reduce reliance on expensive surface vessels and extend mission
  - Potential technologies for power supply:
    - Fuels cells, Ocean current energy or Sea-surface energy (solar, wind)



- High bandwidth subsea data offloading/transfer technologies (e.g. gliders, or to floating facility with satellite link)
  - Optical
  - Acoustic
  - Microwave
  - Cable bound to floating facility
  - Data transmission eggs released from lander at given time intervals

Future dreams: Sea bed sampling operations

- Develop a cheap and efficient multi-sampling system for soft sediment and water samples from AUV/ROV/ASV
  - Needs multiple chambers that can be filled during one mission.

- Develop a cheap light weight surface drilling method that can give tens of meters penetration and can be deployed by small boats


Lundin
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Thank you for your attention!