Sensors, Infrastructures, Innovation: Oil and Gas

Eric Monteiro

www.idi.ntnu.no/~ericm
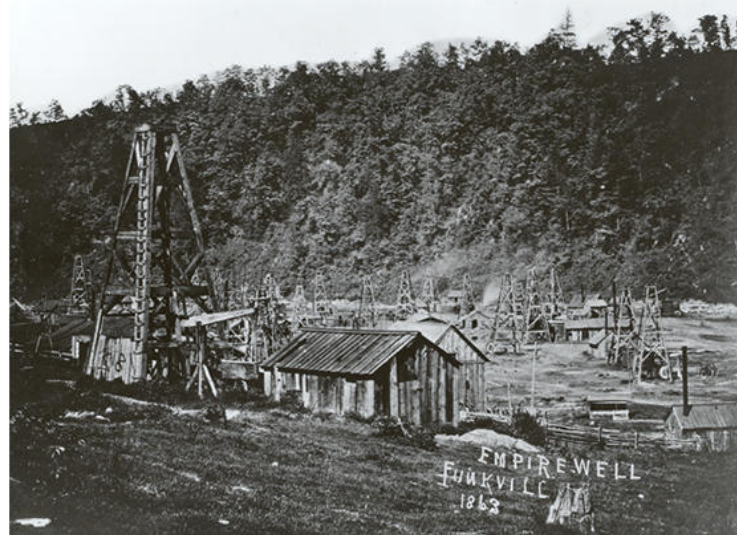
Digital Oil project, www.doil.no

INF 5210

Context

History

- "Just drill!"

- In Norway: the Americans

- Expertise, capacity

  - Old maritime clusters
  - Institutions
  - Regulation

Information in Oil

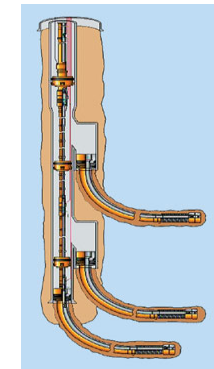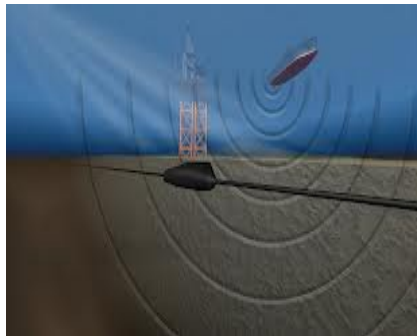| Exploration	Drilling	Production

Acoustic reflection:

- vessels or grid

Pressure, volume, **torque**:

- well head, rig

Resistivity, radiation, density:
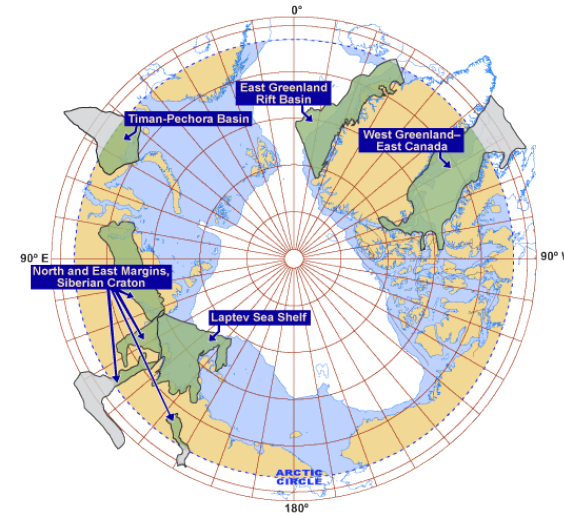
- well logging assembly

Pressure, temp., **volume, sand, vibration**:

- well section, separators

"We have **massive** amounts of data, but underutilsed" (Manager, Exploration)

Increasingly difficult

- Hostile **enviornment**
  - Arctic

- **Politically** contested
  - Environmental concern
  - Fish

- **Mature** fields
  - Brown- not green-fields
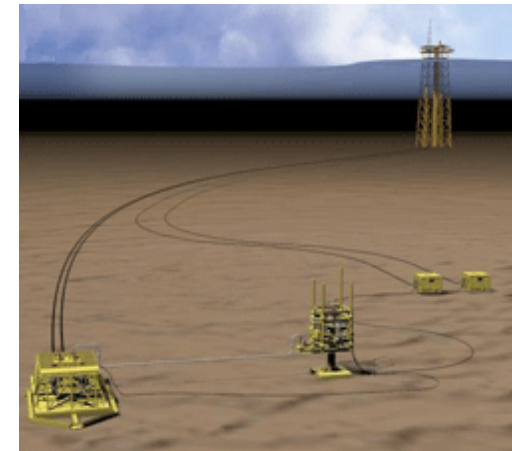
- Deep wells
  - **High** pressure
  - High temperature

Technologies

- Sensors
- Subsea

Mode of working

- Interdisciplinary
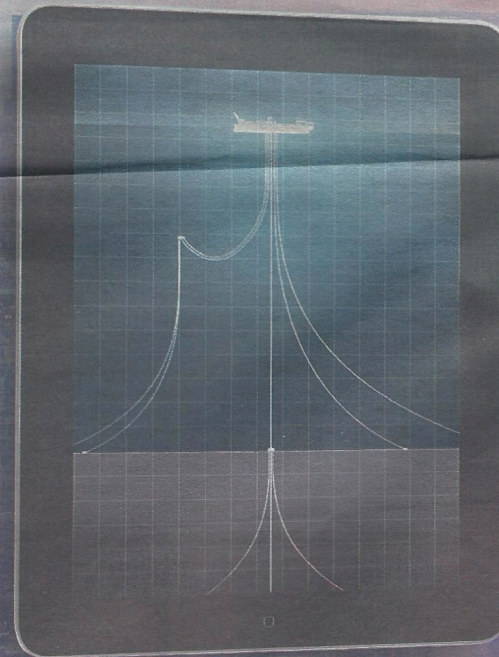- Real – time
- Onshore, not offshore (dis-embed)

"You need to know the personality of the well"

Amerikanske ingeniører skapte
historie 381 meter over bakken.
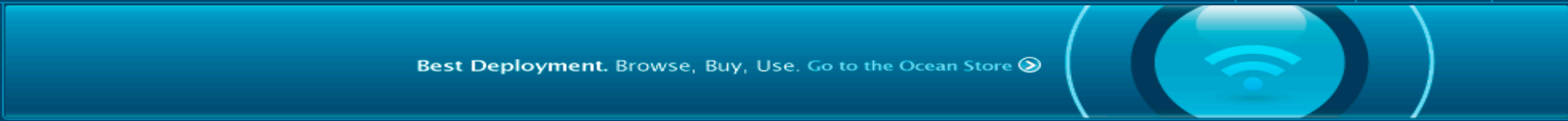
Våre ingeniører skaper historie
2.800 meter under vann.

Specialisation: outsourcing

- Operators
- Rig owners
- Drilling
- Maintenance/ constructions
- Equipment
- Services
- Ex.: Schlumberger

Best Deployment. Browse, Buy, Use. Go to the Ocean Store ⊙

ocean

| Store | Petrel | Academia | Energy Co. | Software Co. | Developers | Search |

Store

Plug-in Summary   News

| All | New | Geophysics | Geology | Petrophysics | Reservoir Modeling | Reservoir Engineering | Drilling | Production | Information Management |

Help   Cart 🛒 0 Item ▸

Adjacent Cell
★★★★★
Access adjacent cells for use in Petrel's Property calculator

$0 10 days   Add to Cart

ARK CLS OpendTect Connector
★★★☆☆
Facility to transfer 3D seismic and horizon data between Petrel and OpendTect

$0 14 days   Add to Cart

ARK CLS Seismic Colored Inversion
★★★★★
A superior fast-track method for the inversion of seismic data

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ARK CLS Seismic Net Pay
NEW
★★★★★
Seismic Net Pay (SNP) provides an improved workflow from seismic attributes

$0 14 days   Add to Cart

ARK CLS Seismic Spectral Blueing
★★★★★
Shapes spectra of seismic data to be consistent with the Earth's reflectivity

$0 14 days   Add to Cart

ARK CLS Seismic Toolbox
NEW
★★★★★
A package of powerful software tools to enhance data

$0 14 days   Add to Cart

Blueback Geodata Investigator
NEW
★★★★★
Investigate and analyse your data through histograms, crossplots, etc.

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Blueback Geology Toolbox
★★★★★
A series of plug-ins enhancing functionality in the geomodeling workflow

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Blueback Geophysics Toolbox
★★★★★
More than 50 plug-ins enhancing the functionality in Petrel geophysics

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Blueback Project Management Toolbox
★★★★★
Control your Petrel projects and content with the Project Management Toolbox

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Blueback Project Time Machine
NEW
★★★★★
Back-up and restore your Petrel projects on NetApp storage servers

$4,000 12 months   Add to Cart

Blueback Project Tracker
★★★★★
Track and monitor your Petrel projects for data management

$15,000 12 mo-20   Add to Cart

Blueback Project Tracker Geodata Exchange
NEW
★★★★★
Monitor data imported using OpenSpirit

$0 10 days   Add to Cart

Blueback Project Tracker Spatial
★★★★★
Visualize the BBR Project Tracker database via integration with ESRI ArcGis®"

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Blueback Reservoir Engineering Toolbox
★★★★★
A set of plug-ins to complement and enhance reservoir engineering workflows

$0 14 days   Add to Cart

Blueback Seismic Reservoir Characterization
★★★★★
Seismic Net Pay workflow including colored inversion, and AVO seismic classifi

$0 14 days   Add to Cart

Information: increased complexity

- More (**volume** + type)
  - "intelligent" wells, 4D seismic
- Speed (**real-time**)
  - monitoring
- Sensors: faulty, inaccurate
- **Biography** of well
- **Integration**/ interconnected
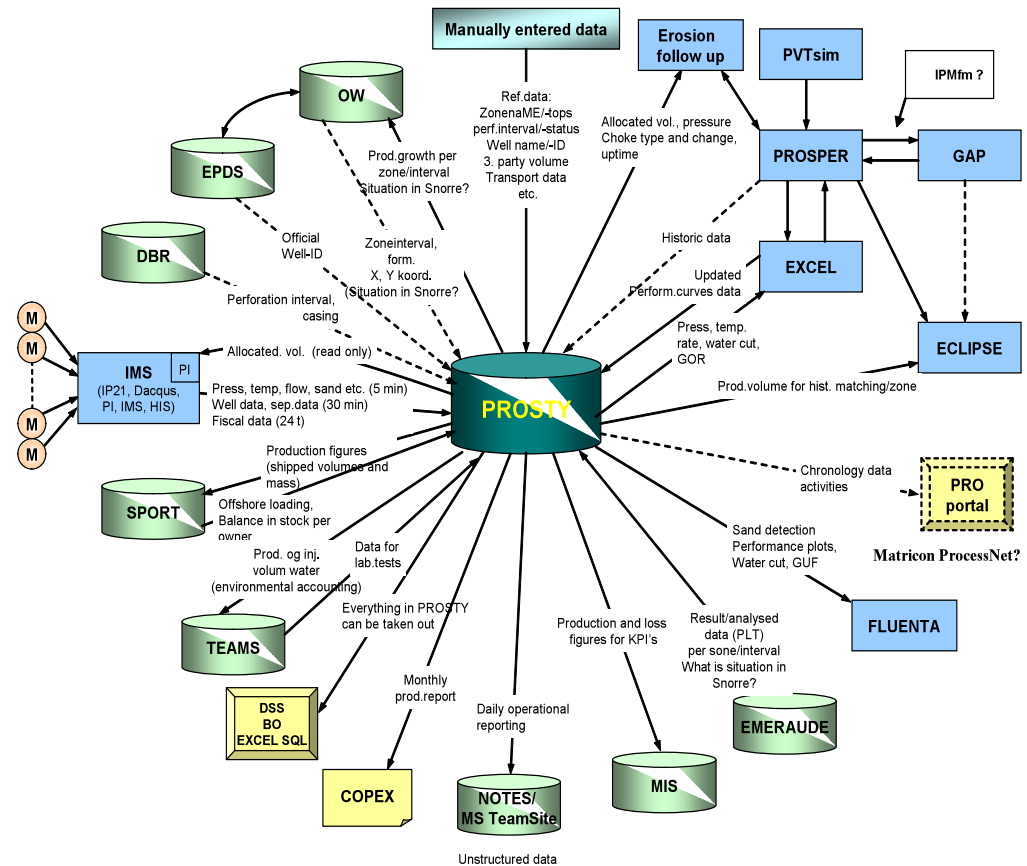 - overlapping, supplementing
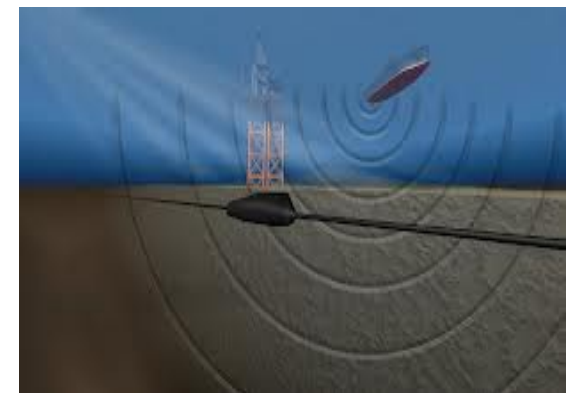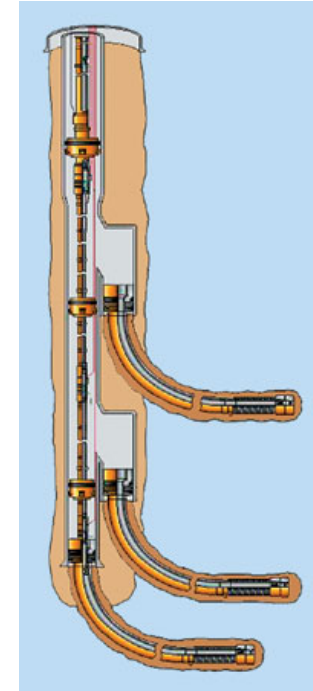
Big data

- **Volume** (TB: national, corporate, local)

- **Variety** (structured, free-text, graph, images, drawings, slides, pictures,...)

- **Velocity** (real-time streams)

- **Veracity** (uncertainty, noise/ faults)

Historical stratification

Drowning in information

- Numerous systems
- Structured data
- Summaries
- Historical knowledge
- Excel!

MS Sharepoint (2002 -)

- Lotus Notes (1992 -): effective locally
  - But 'out of control' with estimated 5000 databases so "locating relevant information stored outside your immediate project scope was non-trivial"
- NYSE: Sarbanes-Oxley act (SOX) / Basel II,post-Enron
- MS Sharepoint
  - Tagging, meta-data but "one size fits nobody"
  - 'Plain vanilla', unlike SAP project (USD 300m)

Well history

Shared disk

Lotus Notes

Sharepoint

"We develop a increased understanding of how wells interact through the production history. The key is to see the wells together since the optimization of one well might lead to loss of overall production given the right circumstances. When doing this evaluation and analysis work we juggle between parameters; temperature, pressure, water production, production rates, gas and availability of equipment in the offshore process plant."

Navigation

- **Index** to locate: age/ IT platform
- Partial but never complete transition between platforms
- **Legacy**

"If you didn't follow the well from its inception, there is no way you can know where to find the information or what kind of information that is available. Thus, it is also impossible to just use the **search engine**"

Dialectics: fragment – tidy up - hybrid

"that's how [referring to file servers] we were working onshore before we got
Lotus Notes. It was so much information in use that we were not able to quit with
 it and fully migrate to LN. So this [file servers] lived further with LN. Later we got
[LN Team sites]… and then file servers and LN lived further because it was impossible to
migrate with all the historical data we needed. When you need it
[the historical system(s)] you can always add some new information
to it… [smiling]. So now you have file servers, Lotus Notes and MSP… when
something new comes [after MSP], we will probably still keep those three old
ones" [smiling] (manager responsible for operational support).

History & overview

"Over the time it becomes difficult to have overview… especially with oldest documents [which are by default in the end of the list]. There are 160 documents now [in a MS SP team site library] and this well is only halfway finished. In addition, you have documents in workspaces [user shows number of workspaces on the screen]. Sometimes documents are duplicated [in team site library and workspaces], but sometimes you find them only in one place. It would be possible to have everything in one place, but people do not want to miss overview over documents e.g. related to Recommendation to Drill) process so they create a workspace. So if you have used particular TS a lot you can find information, because you know what to look for… but very often you have to go and ask people where things are stored…" (Drilling engineer)

Local & global

contingent local qualitative context actors ethnographic praxis interpretative situated users practices

Lucy A. Suchman

PLANS AND SITUATED ACTIONS

The problem of human machine communication

TALKING ABOUT MACHINES

An Ethnography of a Modern Job

JULIAN E. ORR
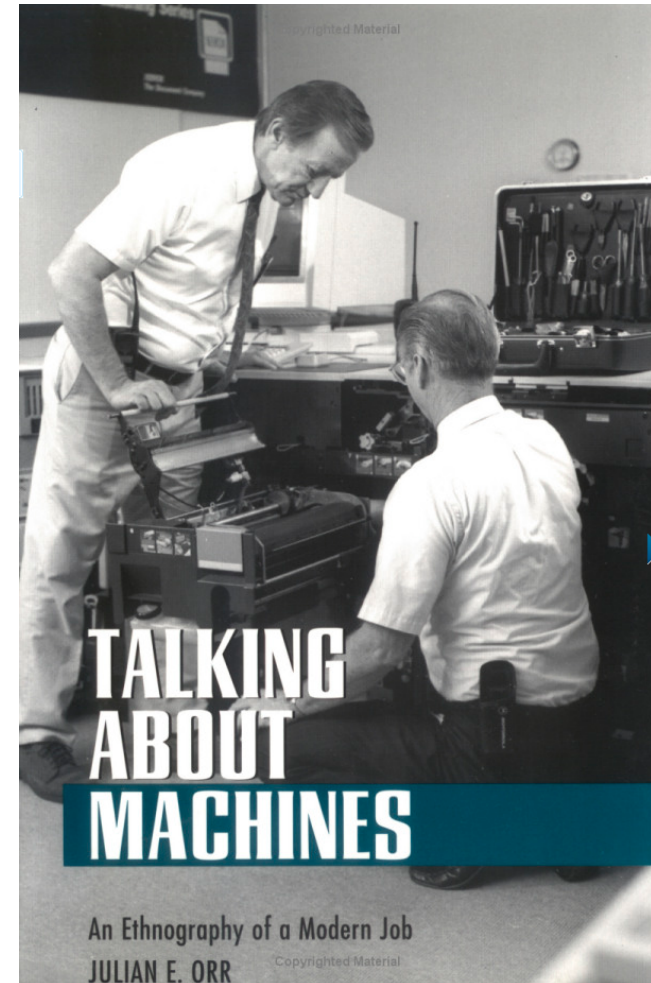
Sociomateriality

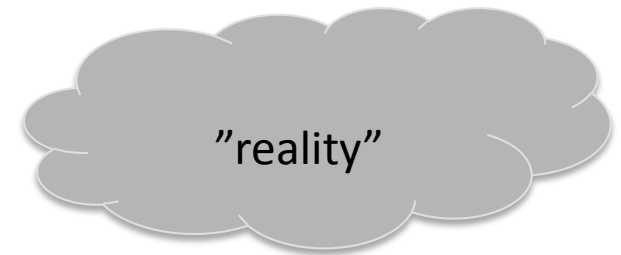materiality$_1$ materiality$_2$ materiality$_3$
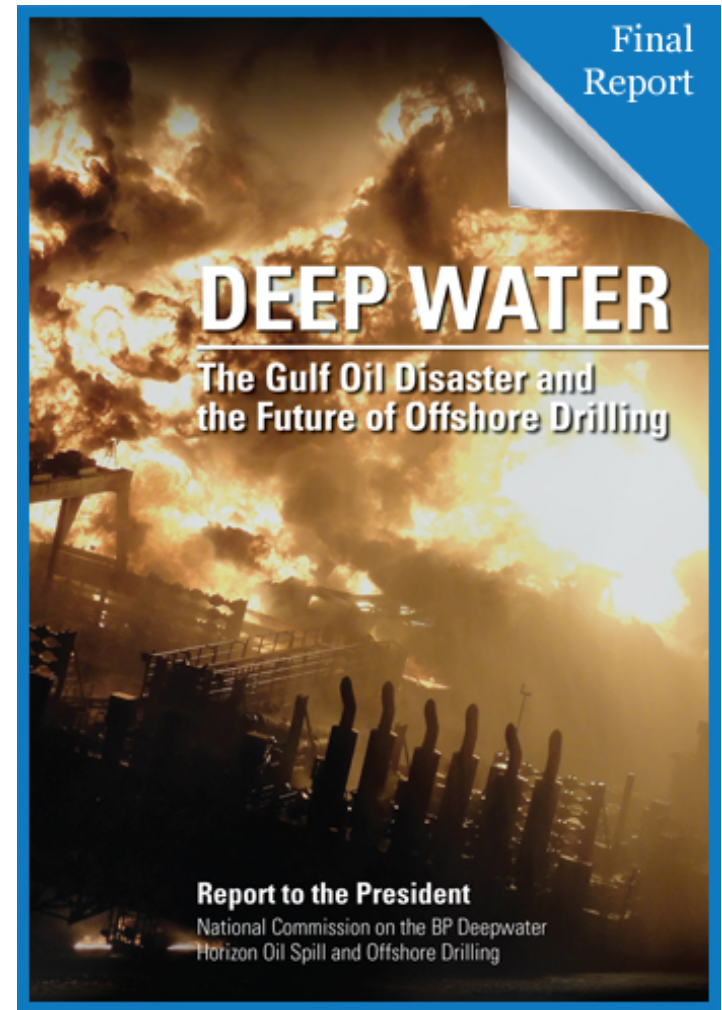
Sensor

"reality"

A

B

C
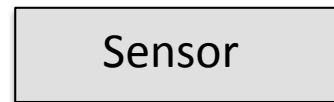
Deepwater Horizon

- Deep water/ high pressure
  - Water depth 1500m, well 10.000m, 6000 psi/400 bar

- "Every well is unique"

- Context of information: Transocean's email to BP

- "Gransking av gassutblåsning på Snorre A, brønn 34/7-P31 A" 28.11.2004, PTIL

Final Report

DEEP WATER
The Gulf Oil Disaster and the Future of Offshore Drilling

Report to the President
National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling

Integrated operations, IO

- **Onshore** vs. offshore
- Expert centres
- Across **disciplines**
- Across assets/ **geography**

"There are 34 assets on the NCS [for NorthOil] and they all have their own **naming** conventions which make it difficult to search for information"
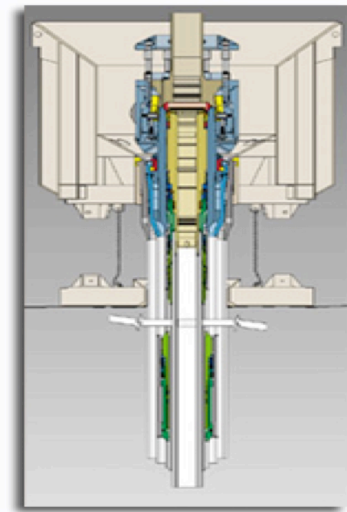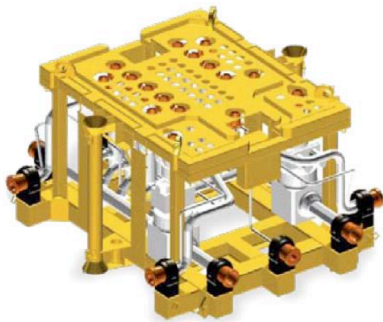
"We had to shut down the intranet for 3 months [because **search engine** located sensitive information]"

Well maintenance (LWI)

"You need to know the **personality** of the well"

"There is no plug & play possibilities [across vendors of subsea equipment]"

"I call the vendor for technical details [of equipment]"

Heterogenity, local variation

"The problem is that we have a complex tree-structure [of folders] and you have to have been working here for years in order to find something"

"Earlier experience could indicate specific failures that would prohibit us from doing an Intervention...For instance, recently we discovered that the control system on the x-mas tree [equipment installed on the sea floor] was not compatible with our equipment."

Revised protocols

- Start with template/ protocol, but:

- Not only in-situ improvisations/ workarounds

- Gradually fed back into revised template/ protocols/ checklist. Cross-assets forums.
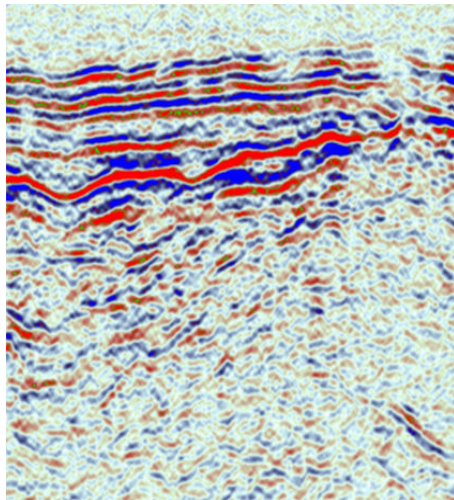
- Institutionalisation
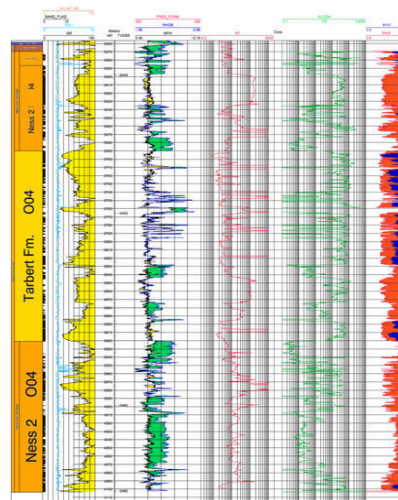
Performative models

Working with reservoir models

- Abstractions…

- … but necessary

- Static: geology model

- **Dynamic**: reservoir model

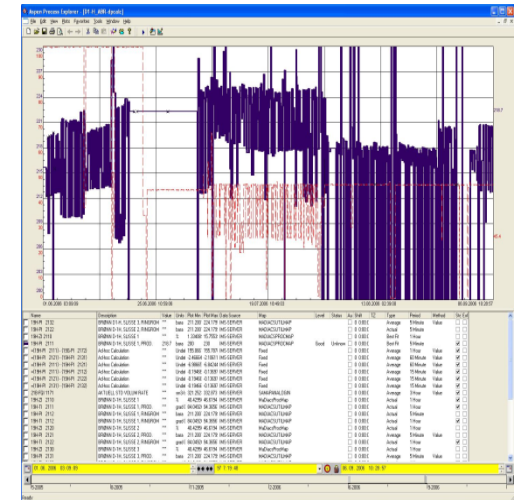- Computationally challenging

- Feedback: history matching
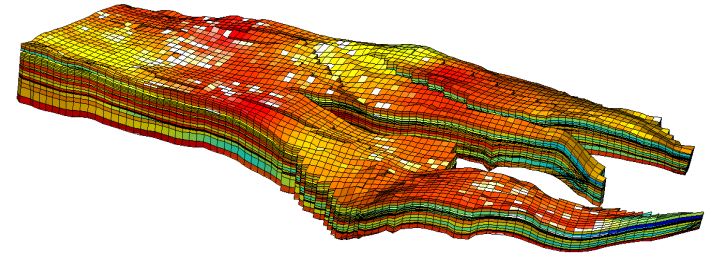
3 sources of sensor-based information

Seismic
(accustic)

Well logs
(resistivity, gamma-radiation)
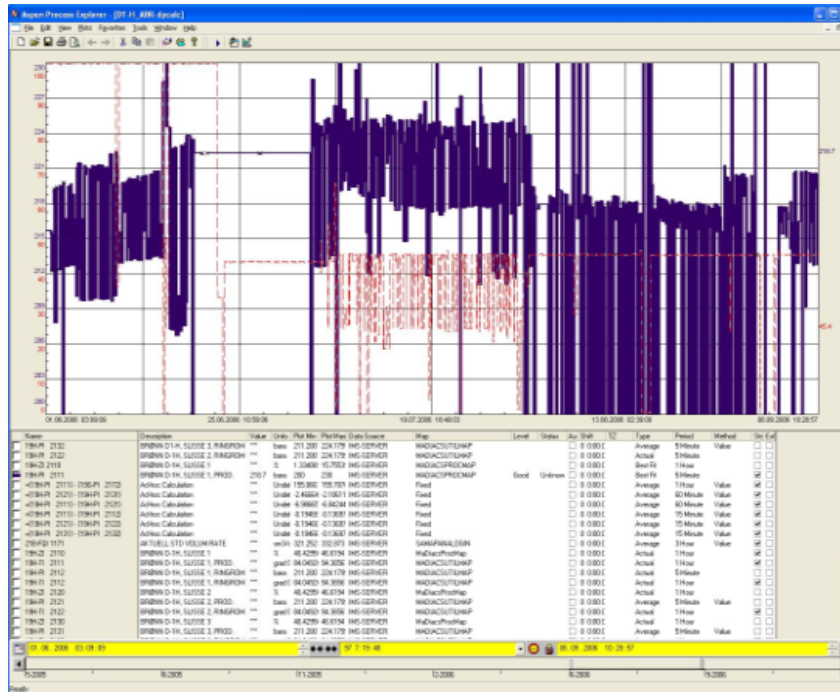
Production data
(temperature, pressure, volume)

Inter/extrapolate. Interconnected

"Obviously, if you have three wells they're going to tell you a lot about the vertical [well paths]. So you have at least the understanding of the vertical sense of the layers and you can build your sedimentological understanding…You have three wells and … you try to interpolate between those wells with your information and then you try to extrapolate away from those wells into areas that are further away. And then with the help of the seismic, you try to calibrate and use the seismic to help you, and then come up with some sort of feeling about whether, you know, how much reservoir you've actually captured with the data you have?"

"[Then] we have to figure out, how the heck are we going to update this monster? Because, if you start fiddling with two wells, then you do something with the rest as well."

Trust

- **Faulty**
- Inaccurate
- Drown in information
- Triangulate
- Collective **deliberations**

"We've given up fixing that choke. It's too costly to replace. I tell [the production engineer] that he simply has to **shut his eyes** and disregard the readings from it."

Double-check

"All of us should be aware that information in [name of the system] is not always correct. Preferably, it should be double-checked and compared with other sources for instance [name of the system]. For example information about equipment can be slightly wrong… for instance wrong diameter… it is critical for us to have correct information as we will have to put equipment in the well." (well engineer)

Ex: Well planning (Ekofisk)

"To use reservoir **models** for well planning is **very dangerous!**...You look at the model, but also all the **other data** you have: other wells in the area, you look at the seismic, you look at recent data not included in the model. You have a whole portfolio of data you use"

EKOFISK FIELD
TOP EKOFISK FORMATION
WAG PILOT
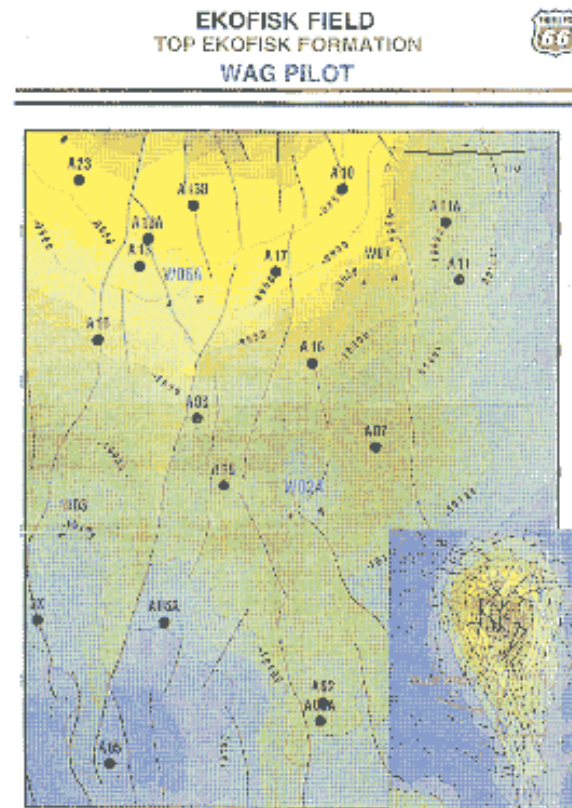
History matching (Ekofisk)

"Permeability changes over time, due to compacting [of the chalk]. I have never seen it before. We are at the limit of the [reservoir simulation] software's ability which is designed for constant permeability"

"[There is] accumulated critique from the compacting of the reservoir! We have adjusted a lot, by inserting parameters. But we have not done it properly in the [static] physical model"


Cliffs of Middle Chalk at the back of Beer Harbour (eastern side) in 2005. Notice the well-defined bedding and the small step-faults downthrowing to the east (right). Ian West & Tonya West (c) 2006.

Pragmatism

"[I]f we can do history matching that is the best. Because then you learn something about the flooding processes in the reservoir, in the process. But that doesn't mean that you should use the model afterwards [laughs]. It is the understanding, the understanding of the reservoir, which is important to gain from it. And if you have that, then a good engineer will be able to work intuitively with the model he has in his head and be able to do much of his work"

Innovation, at the fringes

Ocean observatory
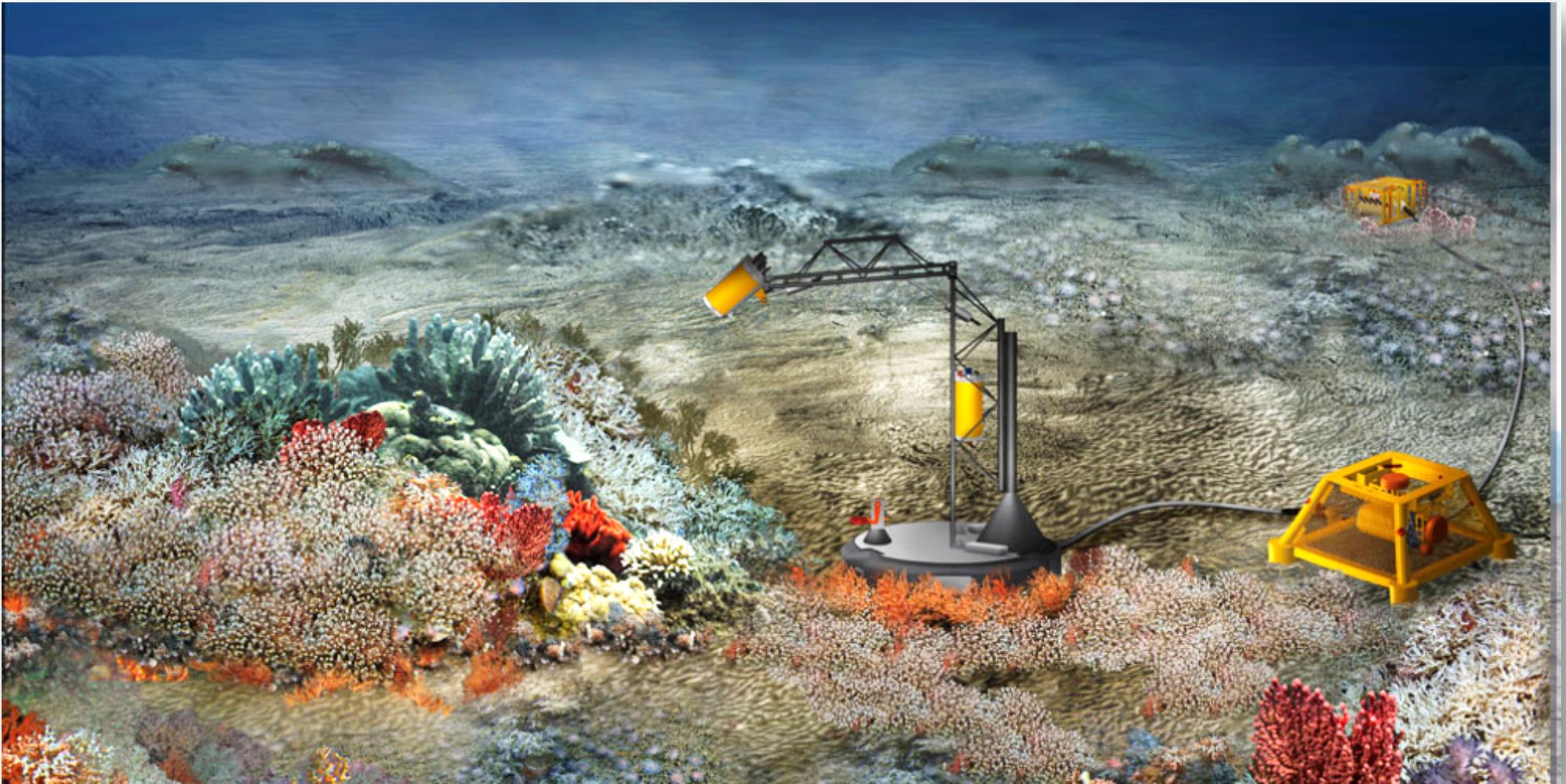
LoVe

Getting an environmental baseline

Subsea lander installed mid-2013

Approx. 250 m deep

15–20 km off the coast

Fibre-optic cable

Home | HOVDEN | Current Conditions | Timelapse | timelapse.mp4

Pictures source: http://lovedev.azurewebsites.net

Export

The LoVe portal

http://lovedev.azurewebsites.net/

New needs

New measurements

New phenomena

New problems
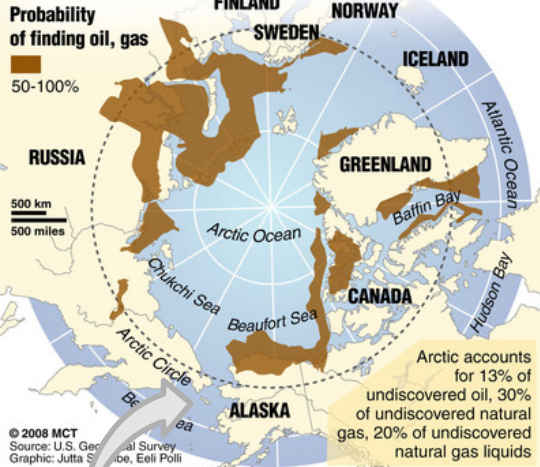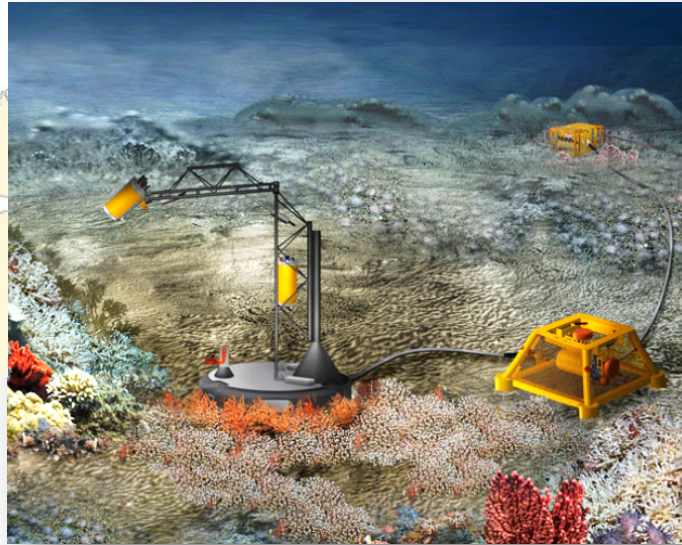
Oil and gas in the Arctic

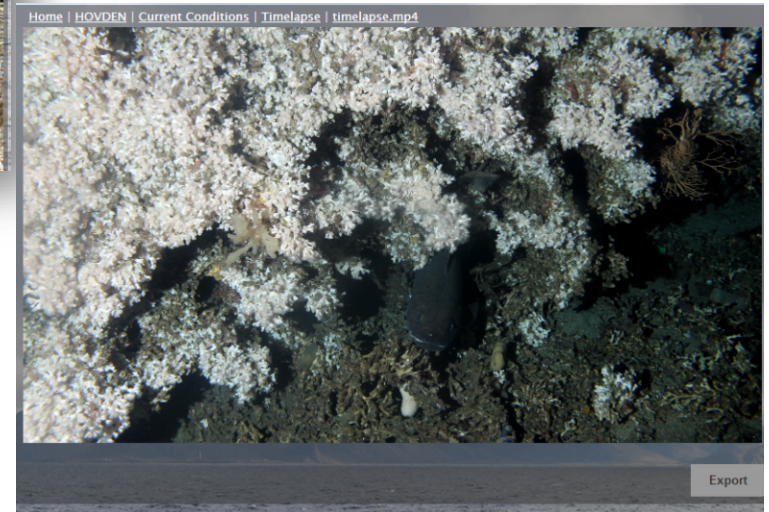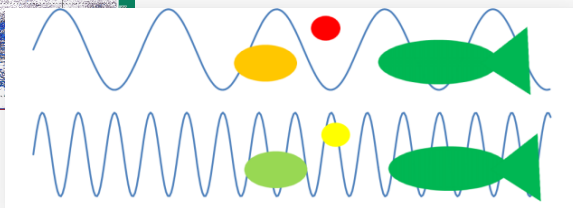Area north of the Arctic Circle has an estimated 90 billion barrels of undiscovered oil.

Probability of finding oil, gas
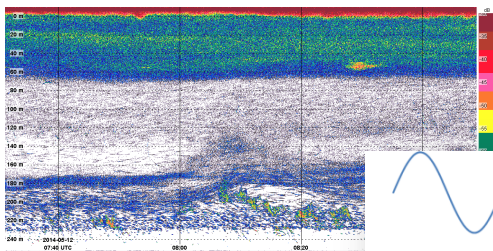
50-100%

Arctic accounts for 13% of undiscovered oil, 30% of undiscovered natural gas, 20% of undiscovered natural gas liquids

© 2008 MCT
Source: U.S. Geological Survey
Graphic: Jutta Scheibe, Eeli Polli

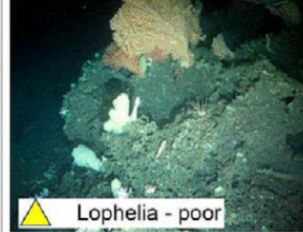Home | HOVDEN | Current Conditions | Timelapse | timelapse.mp4

Export

Environmental monitoring
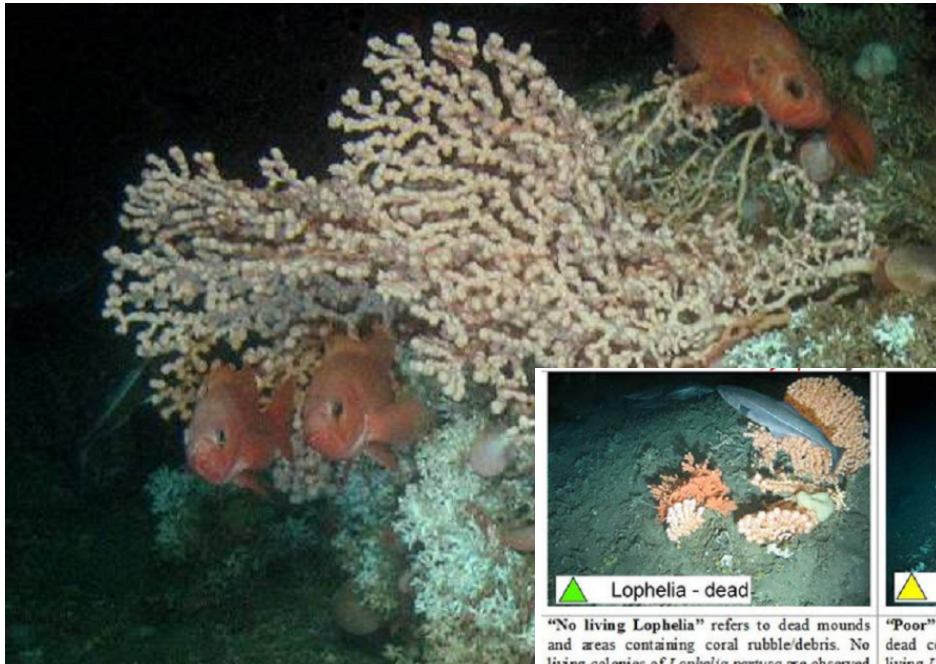
Lophelia - dead
"No living Lophelia" refers to dead mounds and areas containing coral rubble/debris. No living colonies of *Lophelia pertusa* are observed in these areas.
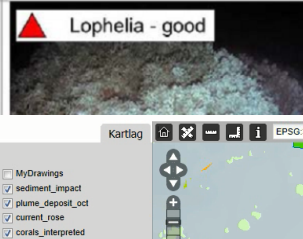
Lophelia - poor
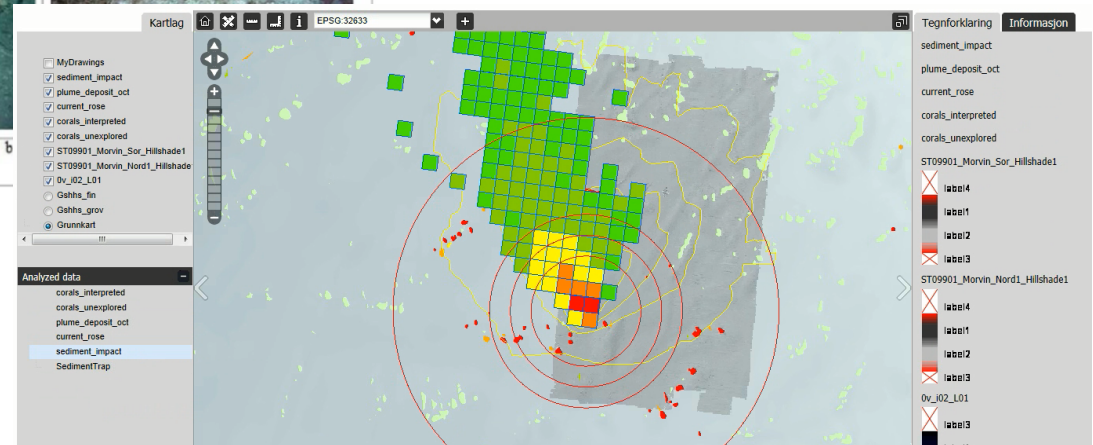"Poor" indicates an area dominated mostly by dead corals with relative small patches of living *Lophelia*.

Lophelia - moderate

Lophelia - good

"Moderate" refers to reefs containing b dead and living colonies of *Lophelia*.

Probability \ Consequence	Minor	Moderate	Serious	Severe
Unlikely				
Rare				
Likely				
Expected				

Concluding remarks

Sensor data, revisited

- Sensors = dis/re-embedding, but …

- **Pragmatic**
  - Relative to purpose
  - Partial knowledge: "what to do next?"

- **Performative**
  - What you know = how you know it (apparatus)
  - Materiality of tools

- **Political**
  - Vocabulary of 'learning' purged of conflicts
  - Integration is contested
  - Efficiency, costs, automated, economy-of-scale

Digital oil (Doil)

www.doil.no