Permanent Monitoring systems for Seabed Leakage Detection

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Seabed leaks
Where do they come from?

- Natural vents: Faults, Pockmarks, and Chimneys
- Melting hydrates
- Shallow gas layers
- Long term leakage along well casings (cracked cement)
- Injection: fault re-activation/fracturing
- Lost well control and failing barriers
The mysterious pockmarks at the Troll field
Footprints from melted hydrate lumps (after the last glacial period)

Images by courtesy from Statoil
Santa Barbara Tar seeps

From Woods Hole Oceanographic Institution (www.whoi.edu)
Barents Sea - Loppa High

Arctic Methane Flares
Seabed leakage in conjunction with production “An Operators Nightmare”

Frade/Roncador 2011 and 2012

Water injection - fracturing

Reservoir “kick”/ Fault reactivation

Lost well control/failing barriers

3x3m Leakage hole

All illustrations from the internet
Leakage along casing
Charging shallow layers with gas

Data acquisition

Permeable sandlayer

Down-hole pore pressure sensors

Logger and sensor segment
NGI multilevel piezometer

Gas trap with Fluxrate meter

Relief well
Seabed leaks
Natural or introduced by production?

Chimneys West coast of Africa

Bubble seeps present before production?
Early long term monitoring may also be useful in order to establish the baseline before injection!

Seismic gas chimney cube from Statoil

Chimneys

Sea floor

Shallow reservoir sands

Deep reservoir sands

Salt
Characteristics of Seabed Gas Leaks

Monitoring solution for Permanent seabed leakage detection in the vicinity of production facilities:

Traces and Features:
- Gas bubble trains or plumes
- Concentration of dissolved gas
- Seabed currents

Instrumentation:
- Sonars
- Sniffers
- Current meters

From SOCOLOFSKY et al “Multi-phase plumes in uniform and stratified crossflow” JOURNAL OF HYDRAULIC RESEARCH, VOL. 40, 2002, NO. 6
Sonar gas leak detection

- Multibeam or Scanning sonar?
- Aspect and detection capability
- Point of View, backscatter and acoustic shadows
- Automatic detection – Filtering and identification

![Graph showing backscattered energy versus frequency, depth=70m](image1)

**Frequency range multibeam/scanning sonars**

- First side-lobe
- Main lobe
- Second side-lobe

![SLD monitoring head with MS1000 sonars](image2)

- Cerberus diver detection sonar
Sonar gas leak detection

Horizontal aspect and detection capability

Sonar head

VideoRay photos by Stinger Technology AS
Sonar gas leak detection
Vertical aspect and detection capability

1 ltr/min leak at 30m distance

Micro ROV
Pile
Sonar on tripod

10 ltr/min leak at 30m distance

50 ltr/min leak at 30m distance
Sonar gas leak detection
Acoustic shadows and blind zones

MS1000 Sonar image from Kongsberg Mesotech
Sonar gas leak detection
Point of view and “Blind” zones 30m sonar range

Node A
Node B
Node C
Node F

Simulated leak

Node A
Node B
Node C
Node F

Node B
Node C
Node F
Node A

Node F
Node A
Node B

Node C
Node B
Node F
Node A
Automatic detection algorithms

Horizontal scanning sonar images are processed on a continuous basis including coherence of multiple images for automatic detection.
Alarm confirmation by vertical sonar

Find target by rotating vertical sonar

30m range

Alarm

20m range

Simulated leak 50 ltr/min

Leakage detection node

Leakage detection node
“Sniffers” and Current meters
Dissolved gas distributed by the water current

CDOG simulation of gas plume
Yapa and Zheng, (1997)
“Sniffers” and Current meters
Example showing CH4 variations related to tidal cycles

Note that measured concentrations are well below predicted response for a leakage
Prototype system in operation

An array of subsea leakage detection nodes including chemical sensors, active sonar’s and current meters, has been installed at the seabed beneath an existing platform complex to monitor possible increased concentration of dissolved gas and detect possible leaks ranging from seeping bubbles (10 ltrs/min) to significant gas plumes. The objective is to provide early warning for conditions which may develop into critical leakage scenarios.
Prototype system installation

Seabed frames

Monitoring modules and riser umbilical

Docking Instrument module to seabed frame

Hooking up COM and power line

Subsea images: DeepOcean (responsible for subsea installation)

Subsea image: Stinger Technology AS

“Watch tower” on duty
Insitu testing
Stinger Technology AS

Recorded in-situ response injecting 10ml Methane in seawater close to a Sniffer

Seabed Gas leakage simulator

MicroROV with methane injector tubes
Remote operated “Watch dog”
Onshore remote operated MicroROV
Permanent Monitoring systems for Seabed Leakage Detection

Conclusions

What’s next?

Sonar hugging Starfish

Thank You for the Attention!

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