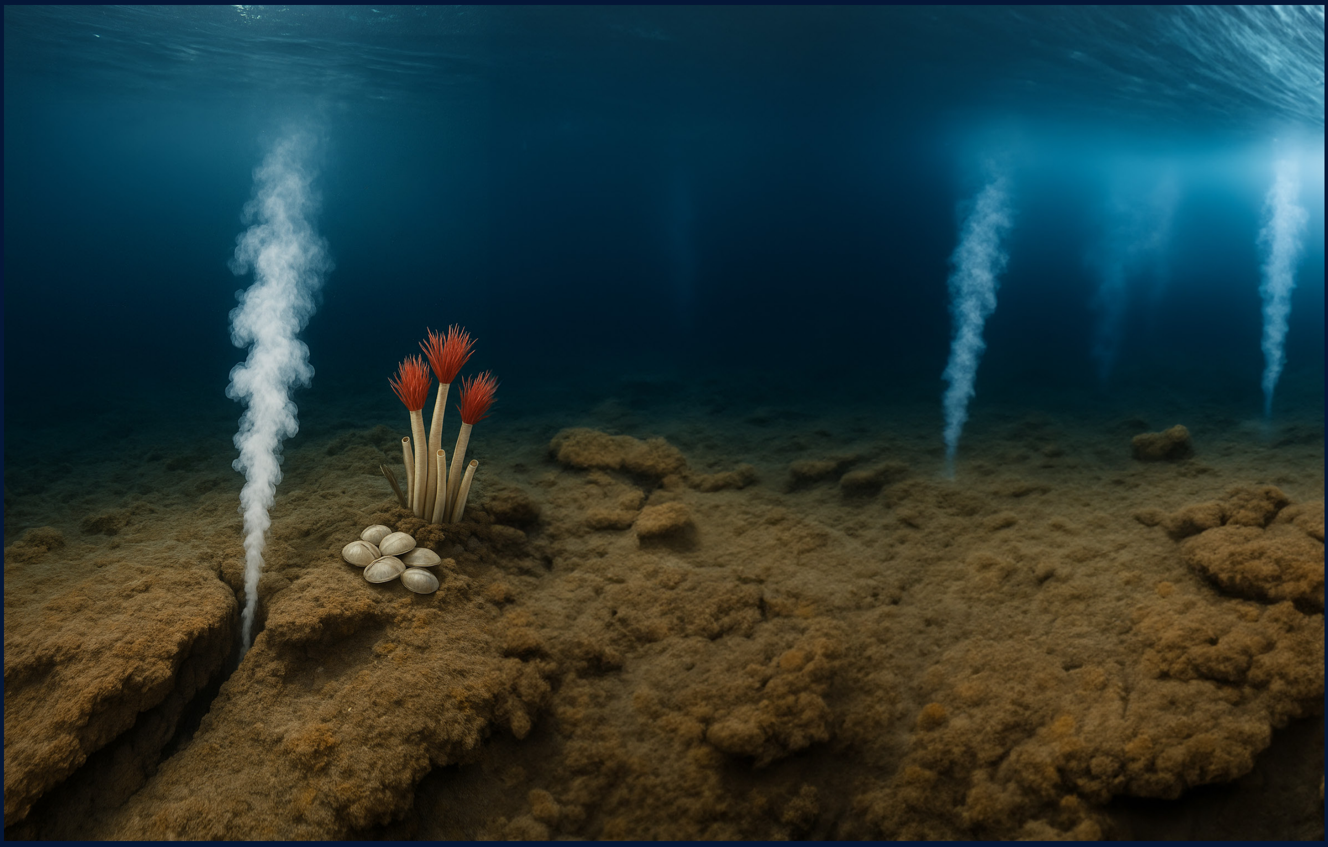
KONGSBERG

Case Study

# M3 Sonar® SeepHunter

Multi-instrument integration for efficient survey of natural seafloor seeps in the Gulf of Mexico.




## Summary

This case study examines an innovative multi-instrument system developed by Kongsberg Discovery for detecting, localizing, and identifying natural seafloor oil and gas seeps. M3 Sonar® SeepHunter, which can be mounted on remotely operated vehicles (ROVs) or autonomous underwater vehicles (AUVs), represents a significant advancement in seep survey technology. In March 2022, the system was deployed on two work-class ROVs in the Gulf of Mexico, successfully identifying 83 active seeps at depths ranging from 500m to 2600m. This deployment demonstrated the system's ability to detect oil droplets at ranges exceeding 200m and to efficiently transition from initial detection to visual monitoring within minutes—a dramatic improvement over previous methods.

## The challenge

Natural seafloor seeps that release oil and gas into the water column are common phenomena in the world's oceans. These seeps constitute the largest source of petroleum hydrocarbon contamination in marine environments and are valuable indicators of underlying hydrocarbon reservoirs. For decades, detection and monitoring of these seeps have relied on satellite imagery, surface vessels equipped with side-scan sonars, split-beam sonars, and/or multibeam echosounders for large-scale reconnaissance.

However, as the oil and gas industry moves operations into deeper waters (exceeding 1000m), the presence of seeps with little or no gas phase (low-flux oil seeps) becomes increasingly common. These seeps are particularly challenging to detect using traditional geohazard survey methods that rely on shipboard sonar systems.

Traditional detection methods have several limitations:

- Satellite radar can locate seeping oil over large areas but cannot precisely identify the source.
- Conventional sonar systems make precise localization expensive and time-consuming.
- Ship-based multibeam echosounder (MBES) systems have limited detection areas due to side lobe artifacts.

Existing sonar technologies therefore make it prohibitively expensive to precisely locate the source point of seeps, obtain samples for analysis, and plan seafloor infrastructure. These limitations highlighted the need for a more efficient survey methodology with specially-designed sonar systems capable of detecting, localizing, and characterizing effluents from natural seafloor seeps.

## The solution

M3 Sonar® SeepHunter is a comprehensive instrument package deployable on underwater vehicles that can efficiently detect, localize, and identify seeps in a single mission. The system comprises several integrated components:

**Primary Forward Looking Sonar (M3 Sonar® FLS)**

- Operating frequency: 200 kHz
- Coverage: 200° in azimuth, adjustable 10°/20°/40° in elevation
- Detection range: >200m for oil/gas bubbles

**Secondary Forward Looking Sonar (M3 Sonar® HF)**

- Operating frequency: Selectable between 0.7-1.4 MHz
- Coverage: 30° × 140° (azimuth × elevation) at 0.7 MHz; 21° × 75° at 1.2 MHz
- Mounted below M3 Sonar FLS and oriented to produce a vertical fan of beams
- Effective range: <50m for close-range localization and identification

**Twin Lasers**

- Aligned with the forward axis of the M3 Sonar HF
- Allows operator to pinpoint the source of bubbles on the seafloor
- Provides a visual reference during transition from sonar to HD camera

**Attitude and Heading Reference System (AHRS)**

Provides attitude data for sonar beamforming and georeferencing.

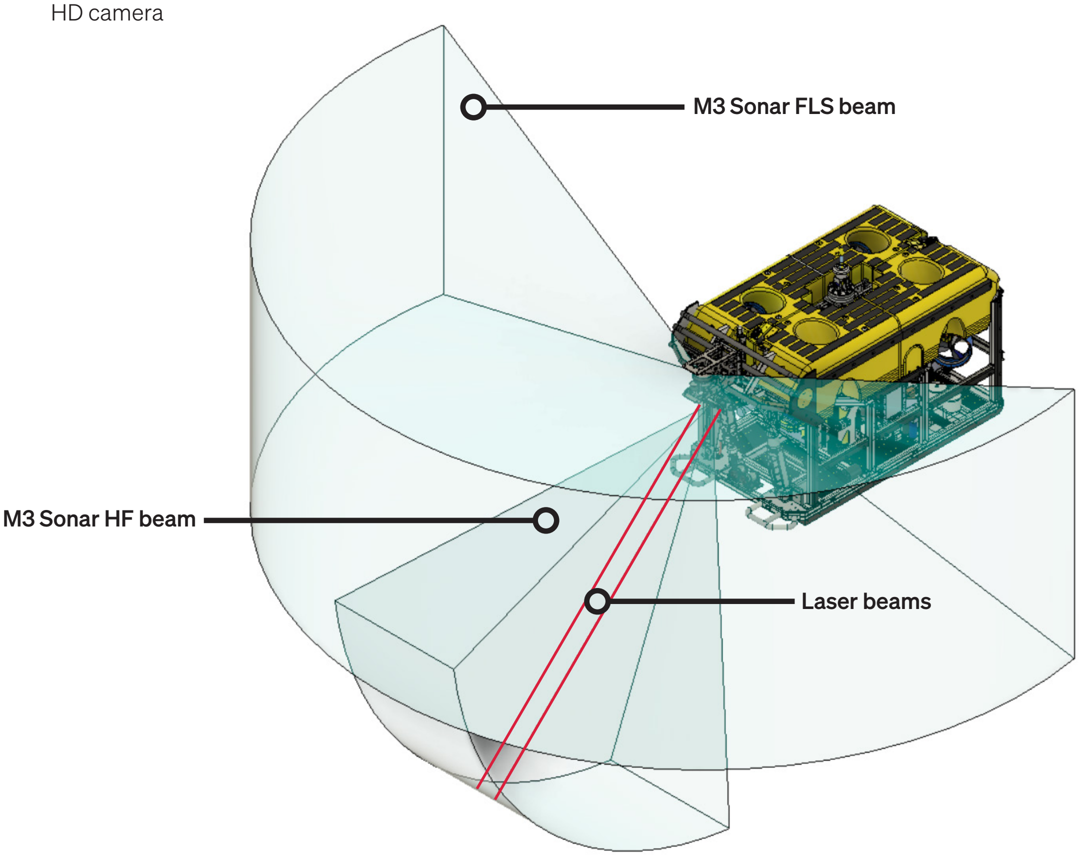
**Conductivity, Temperature, Depth plus Sound Speed (CTD_SS) System**

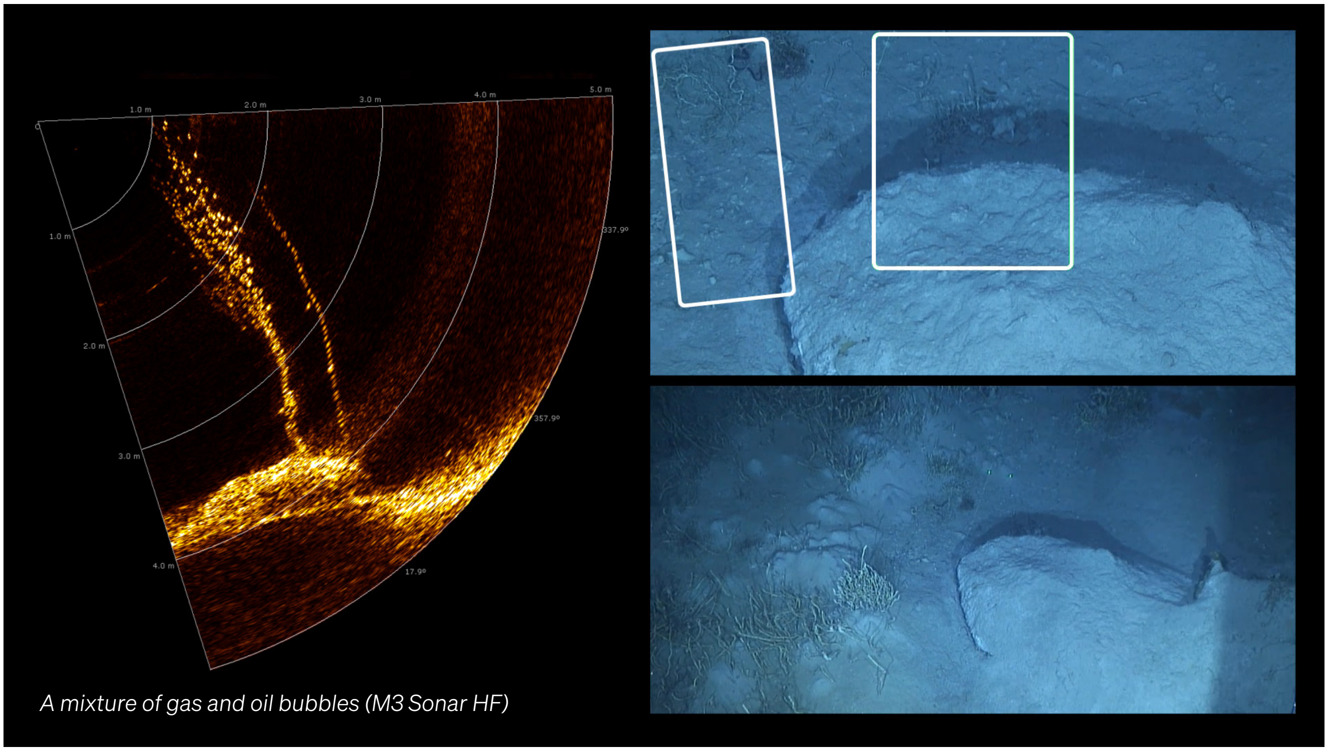
Provides environmental data for accurate sonar beamforming and range calculations.

## Key benefits

The integration of these instruments offers several key advantages:

- **Wide Coverage**—The 200° azimuthal coverage and 200m+ detection range allow complete reconnaissance of an area with a nominal swath width of 400m.
- **Blind Zone Elimination**—The combination of M3 Sonar FLS and M3 Sonar HF eliminates the blind zone that would normally exist below the primary sonar beam.
- **Rapid Transition**—The system enables efficient transition from sonar detection to HD video monitoring within minutes rather than the 30+ minutes required with previous methods.
- **Compact Design**—The package is compact enough to fit on AUVs, potentially improving geohazard surveys for subsea installation planning.






*A mixture of gas and oil bubbles (M3 Sonar HF)*

## Implementation: Gulf of Mexico Survey

Two sets of the instrument package were deployed on work-class ROVs operating in tandem from the vessel M/V Ross Candies. The survey was conducted on behalf of Shell International Exploration and Production Inc.

Survey Details:

- Duration: March 2022
- Location: Gulf of Mexico
- Water Depths: 500m to 2600m
- Results: 83 seeps were detected and investigated
- Verification Method: Gas-tight sampling confirmed the detection of oil droplets at ranges up to 200m

Survey Methodology:

The survey followed a systematic four-step approach.

**1. Reconnaissance Mode**

- ROV positioned at approximately 70m altitude.
- Pre-programmed path with complete coverage of a 400m swath.
- M3 Sonar FLS set to maximum range (220m) with 10° elevation beamwidth.

**2. Detection and Approach**

- Upon detection of bubble streams, ROV operators used real-time M3 Sonar FLS imagery to navigate toward the seep.
- For intermittent seeps, the vertical beamwidth could be widened from 10° to 40° to capture more bubbles.

**3. Close-Range Localization**

- As the ROV approached within 50m of the target, the M3 Sonar HF took over as primary acoustic imaging tool.
- The M3 Sonar HF, tilted 45° downward, provided coverage of the blind zone below the M3 Sonar FLS beam.
- Laser beams aligned with the M3 Sonar HF's forward axis provided visual reference points.

**4. Visual Confirmation and Sampling**

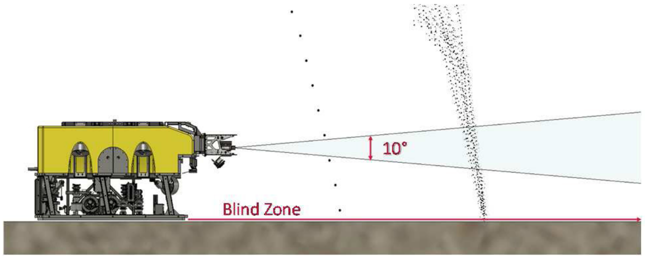
- Within 2m range, HD video cameras provided visual confirmation of the seep source.
- Gas-tight sampling of droplet/bubble streams enabled subsequent chemical analysis.

## Results

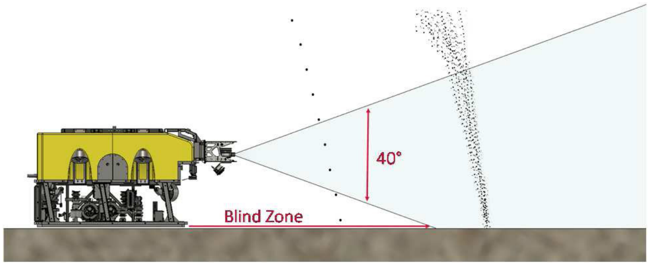
The system demonstrated impressive performance during the Gulf of Mexico deployment:

- **Enhanced Detection Capability**—The system successfully detected low-flux oil seeps (as infrequent as 1 oil droplet every 15 seconds), which would be impossible to efficiently detect with previous methods.
- **Rapid Localization**—Vent source points were located within as little as 15 minutes from initial detection at 200m range.
- **Differentiation of Target Types**—The high-resolution acoustic imagery detected gas bubbles and oil droplets.

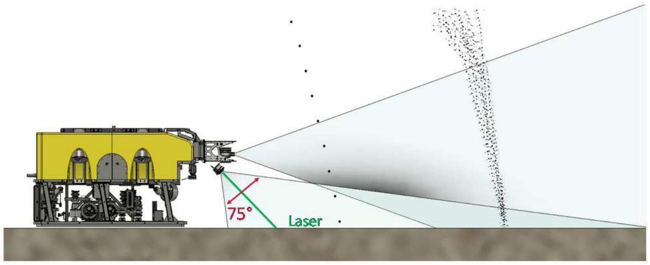
- **Seep Characterization**—Observations at close range provided access to previously unavailable oil seep properties, including flux, rise speed, and fate.
- **Blind Zone Management**—The traditional FLS configuration created a substantial blind zone between the sonar and the point where the transmit beam intersects the bottom. The addition of the vertically-oriented M3 Sonar HF sonar covered the blind zone.
- **Intermittent Seeps Detection**—Seeps that release bubbles only every few seconds appeared as isolated, random targets rather than defined streams. Widening the vertical beamwidth from 10° to 40° captured more bubbles in a single ping.
- **False Positives**—Marine life such as fish schools and giant siphonophores can appear as seep-like targets. However, unlike seeps, marine life tends to disappear from FLS imagery as they move out of the sonar beam. Combined use of multiple sensors helped differentiate actual seeps from biological targets.




*The M3 Sonar FLS with a vertical beamwidth of 10° experiences few detections on bubble streams with slow emission rate.*




*The M3 Sonar FLS with a vertical beamwidth of 40° gains more returns on the bubble streams with a slow emission rate but still suffers from a blind zone at short ranges.*



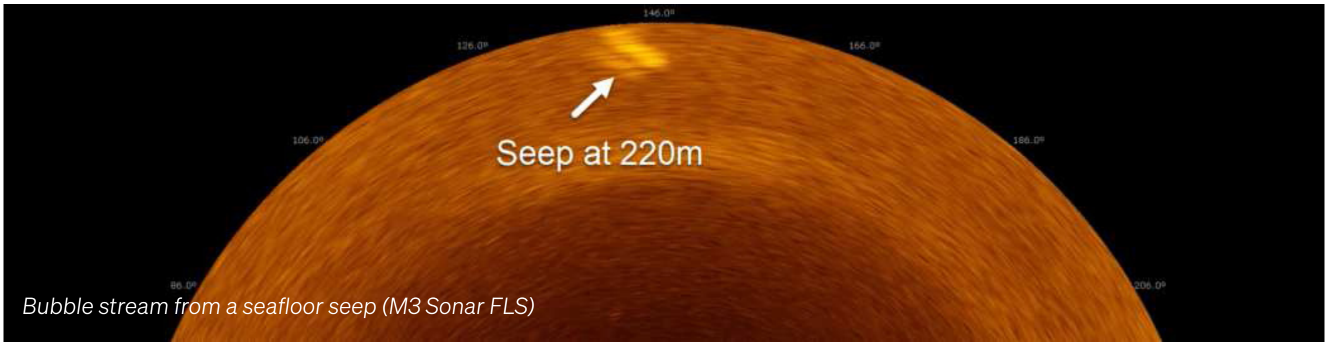

*The M3 Sonar FLS with a vertical beamwidth of 40° plus the 75° M3 Sonar HF and lasers makes the localization of the seeps very efficient.*

## Conclusion

The multi-instrument integration system developed by Kongsberg Discovery represents a significant advancement in the field of seafloor seep detection and characterization. Through its successful deployment in the Gulf of Mexico, M3 Sonar® SeepHunter has demonstrated its ability to efficiently detect, localize, and identify natural oil and gas seeps at ranges exceeding 200m.

The combination of a wide-coverage primary sonar, high-frequency secondary sonar, precision laser guidance, and comprehensive environmental sensors has dramatically reduced the time and resources required for seep surveys. This efficiency improvement, coupled with enhanced detection capabilities for low-flux oil seeps, provides valuable tools for both the oil and gas industry and environmental monitoring efforts.

As underwater exploration continues to push into deeper waters, this integrated approach to seep detection will likely play an increasingly important role in understanding the distribution and characteristics of natural seafloor hydrocarbon releases.

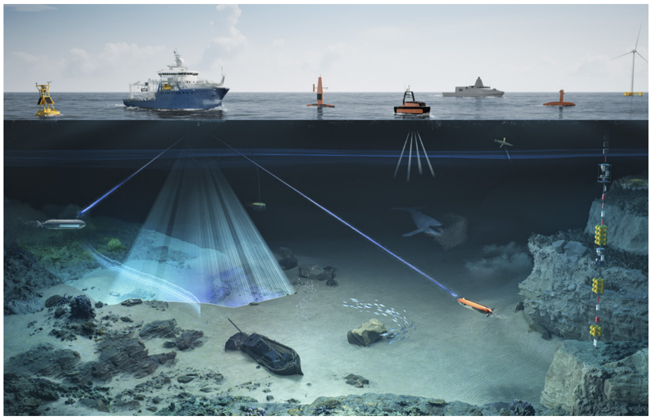



*Bubble stream from a seafloor seep (M3 Sonar FLS)*

Kongsberg Discovery

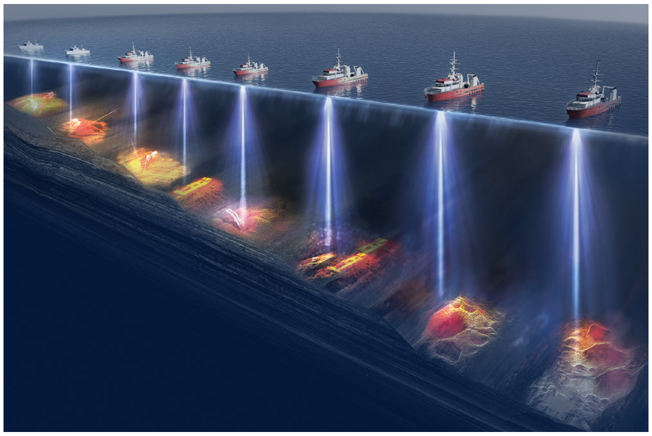
# Protecting people and planet

## From the deepest sea to outer space



Kongsberg Discovery serves the ocean space from the deepest sea to outer space. We develop technology to ensure sustainable management of marine resources, monitor climate change and critical infrastructure, and safeguard national security.

Our technology aims to sustainably manage marine resources, monitor climate change, secure infrastructure, protect national security, and address crucial global challenges. It is vital for offshore operations, fisheries, marine research, maritime activities, ocean energy production, infrastructure monitoring, and naval operations.



## Committed to protecting our planet

We recognize the global sustainability challenges and are committed to developing solutions and products that resolve operational issues while addressing environmental impacts on the ocean ecosystem.

The business has over 1,100 employees located in Horten, Trondheim, and Oslo in Norway, as well as operations in Alicante in Spain, Aberdeen in the UK, Lynnwood (Seattle), Houston, and New Orleans in the USA, Vancouver and Halifax in Canada, Kuala Lumpur in Malaysia, and Singapore. Kongsberg Discovery is part of KONGSBERG, a leading technology group based in Norway.

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