Deepwater Hydrocarbon Seep Detection: Tools and Techniques using Multibeam Echosounders

Future of the Ocean Floor Forum

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SEEP HUNTING

FUGRO

Abstract

Despite steep declines in Oil and Gas market expenditures, demand for hydrocarbon seep surveys continues to grow. Hydrocarbon seep features are ephemeral, small, discrete, and often difficult to sample on the seafloor. Locating geologic and biologic features created by the upward ascent of petroleum fluids such as authigenic carbonate deposits, chemo-synthetic fauna, pockmarks, mud volcanoes, and other fluid expulsion features are greatly aided by the use of multibeam echosounders (MBES). Datasets created by multibeam echosounders (bathymetry, seafloor, backscatter, and midwater backscatter) can quickly and efficiently detect and locate hydrocarbon seeps. As frontier exploration surveys migrate into deeper waters in search of oil and gas reserves, it is desired to examine the acoustic frequency responses of multibeam sonars to seep features in deep water.

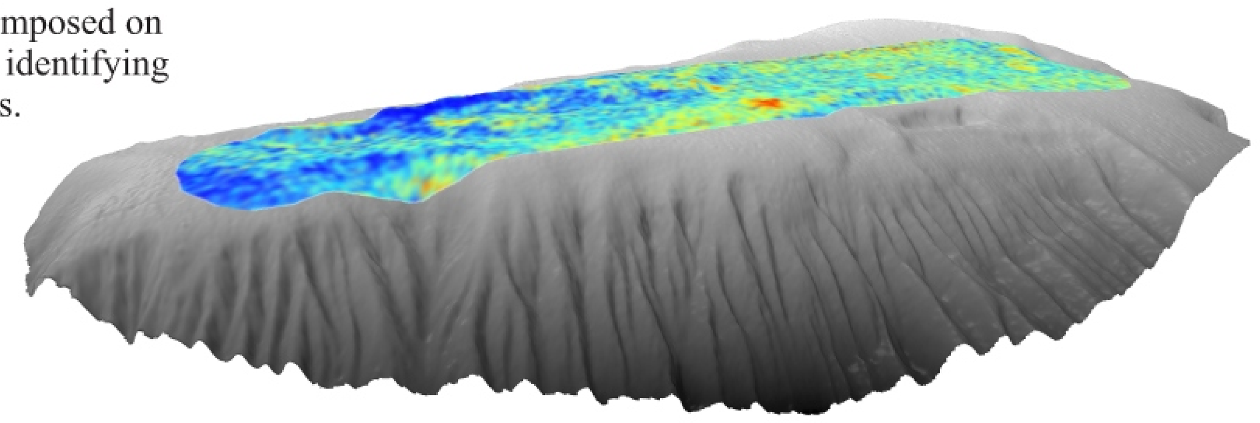
Fugro has conducted over 50 seep hunting campaigns globally since 2001 and include single exploration blocks to multi-client "mega surveys" in Indonesia, Brazil, and currently Mexico. In total, over 2 million square km of seafloor has been mapped with modern multibeam systems specifically in search for Hydrocarbon Seeps. While much of the data is commercially sensitive and owned by Oil and Gas companies, lower resolution versions of these datasets could be made to the public (GEBCO) to further leverage their societal and commercial

The currently ongoing "Mega Survey" in Mexico encompasses over 600,000 km^2 of an unexplored frontier basin in the Southern Gulf Of Mexico. Prior to the start of the Gigante Mega Survey, we utilized Green Canyon Block (Gc600), an area of known prolific seepage, as a seep calibration site to analyze the new Kongsberg EM302 multibeam (30 kHz) to optimize hardware and software parameters to increase the detection of seeps. Some of the studies completed are presented here.

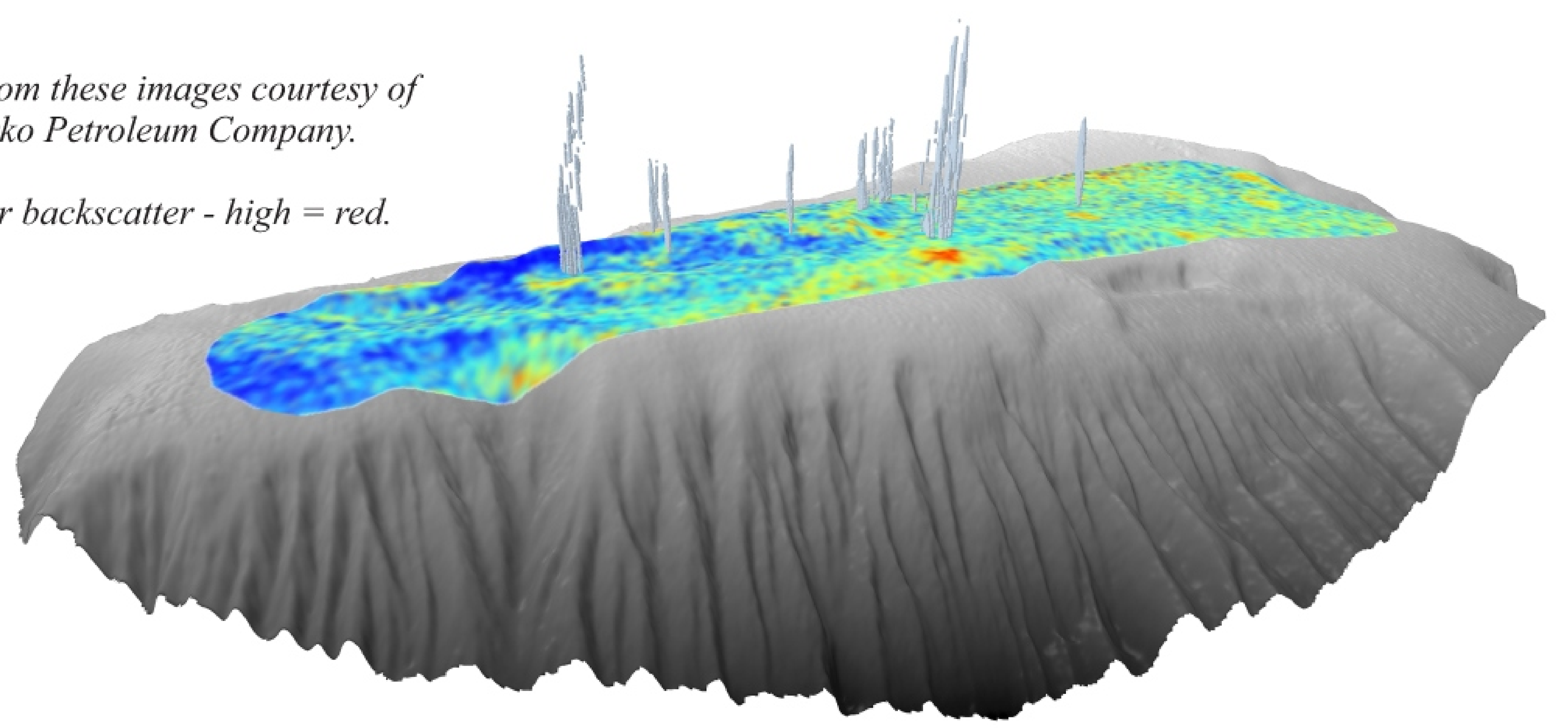
General Seep Hunting Methodology

Bathymetry from multibeam data is used to identify geologic features.

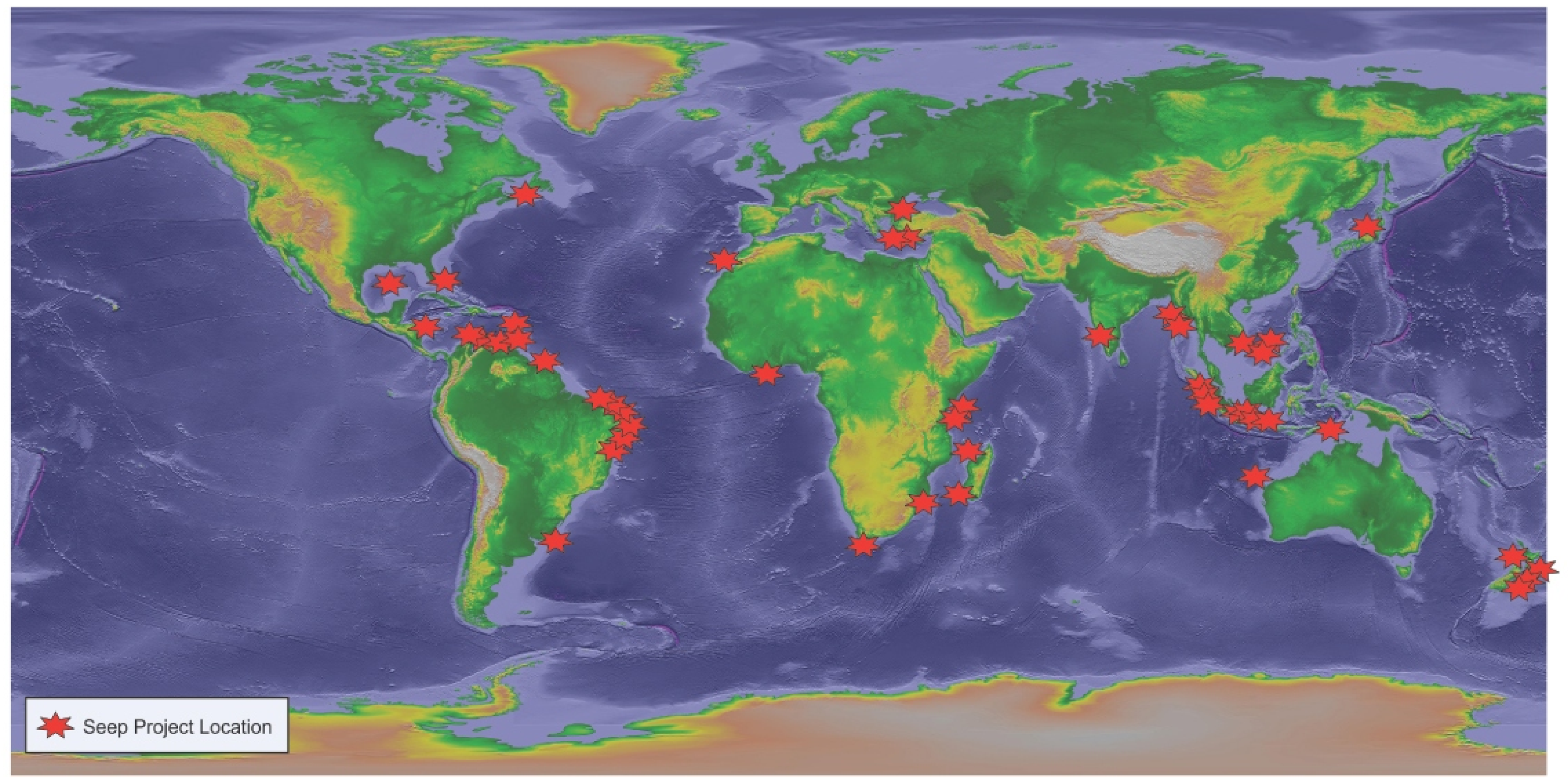
Backscatter data is superimposed on bathymetry and assists in identifying high-potential seep targets.



Data from these images courtesy of Anadarko Petroleum Company.
V.E.6x.
Seafloor backscatter - high = red.



Water column information helps fine-tune and rank high-potential seeps targets by revealing midwater acoustic backscatter anomalies characteristic of gas plumes.



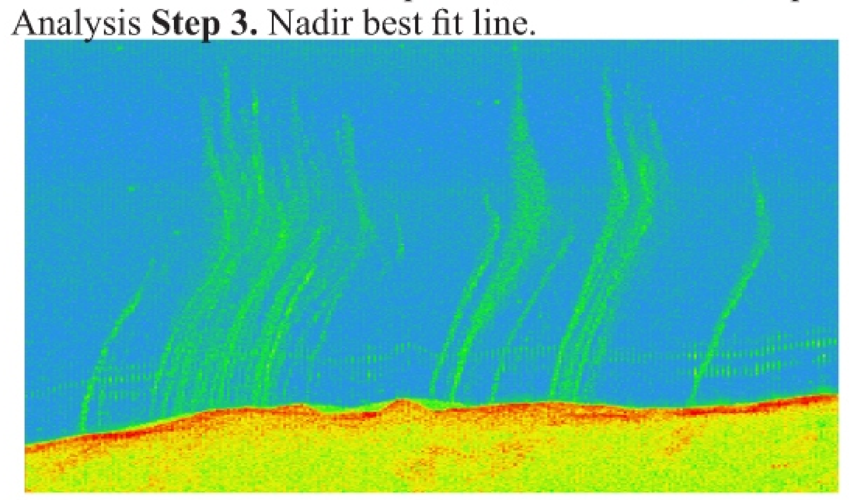
Map showing locations of Fugro Seep Studies since 2001.

Mapping Seep Bubbles with Midwater Backscatter Fledermaus Feature Detector

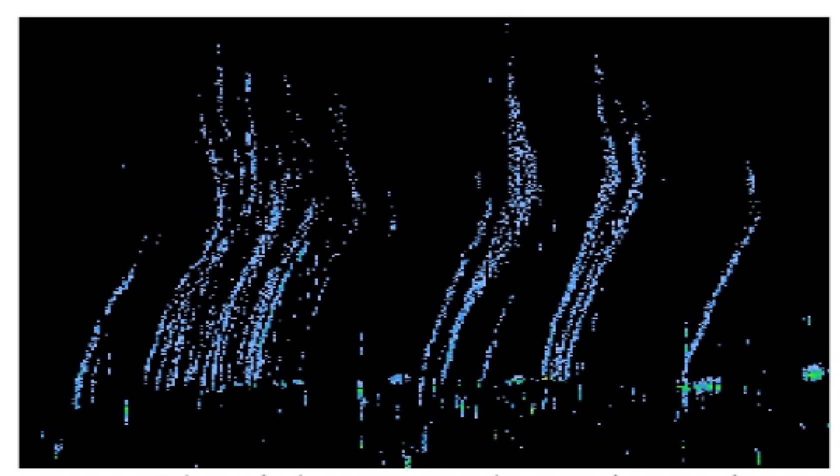
New tools in Fledermaus MidWater (FMMW) allow us to extract the plume bubble signal from the acoustic backscatter data in the water column using a variety of new filters.

We use these tools to filter the data during the first survey to pinpoint precise locations of the seafloor emission sites. Knowing these locations assisted with the line planning for the second survey in which we were testing off-nadir detection limits of the EM302 MBES. We use FMMW in 3 steps to map plumes:

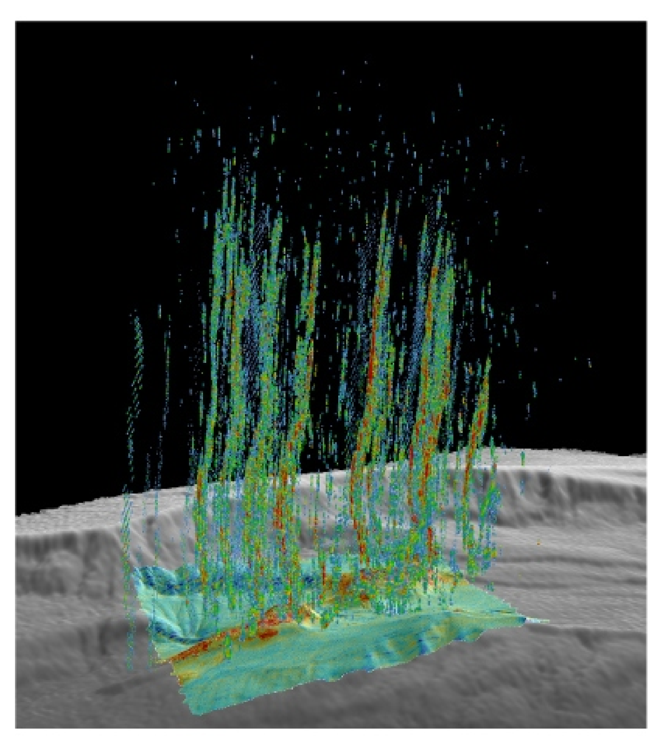
Step 1. Feature Detection Batch Processing, Normalization Filter Options, Sidelobe Supression Filter Options, Bottom Detection Filter Options, Threshold Filter Options, and Despeckle Filter Options. **Step 2.** Cluster Analysis **Step 3.** Nadir best fit line.



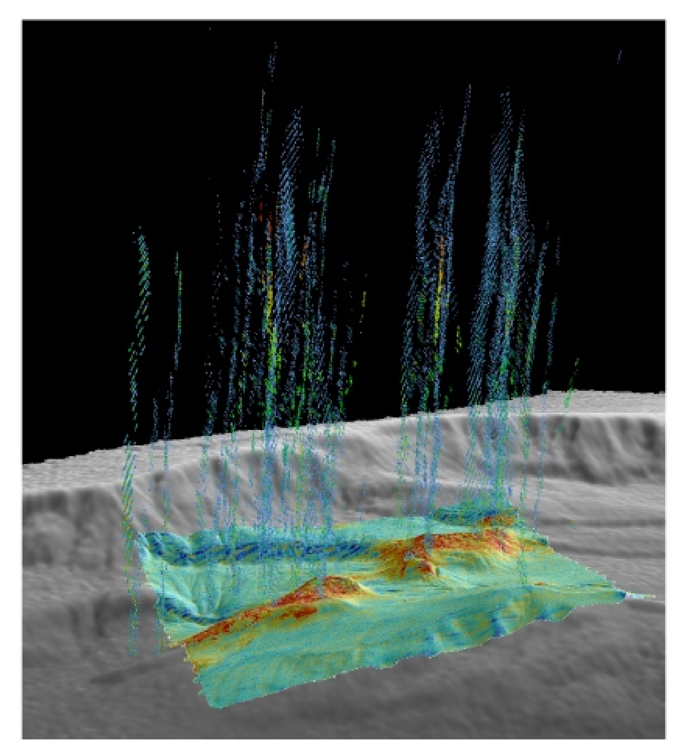
Stacked view of successive multibeam pings showing midwater plumes.



Step 1. Filtered plumes using the new feature detector toolset in FMMW.



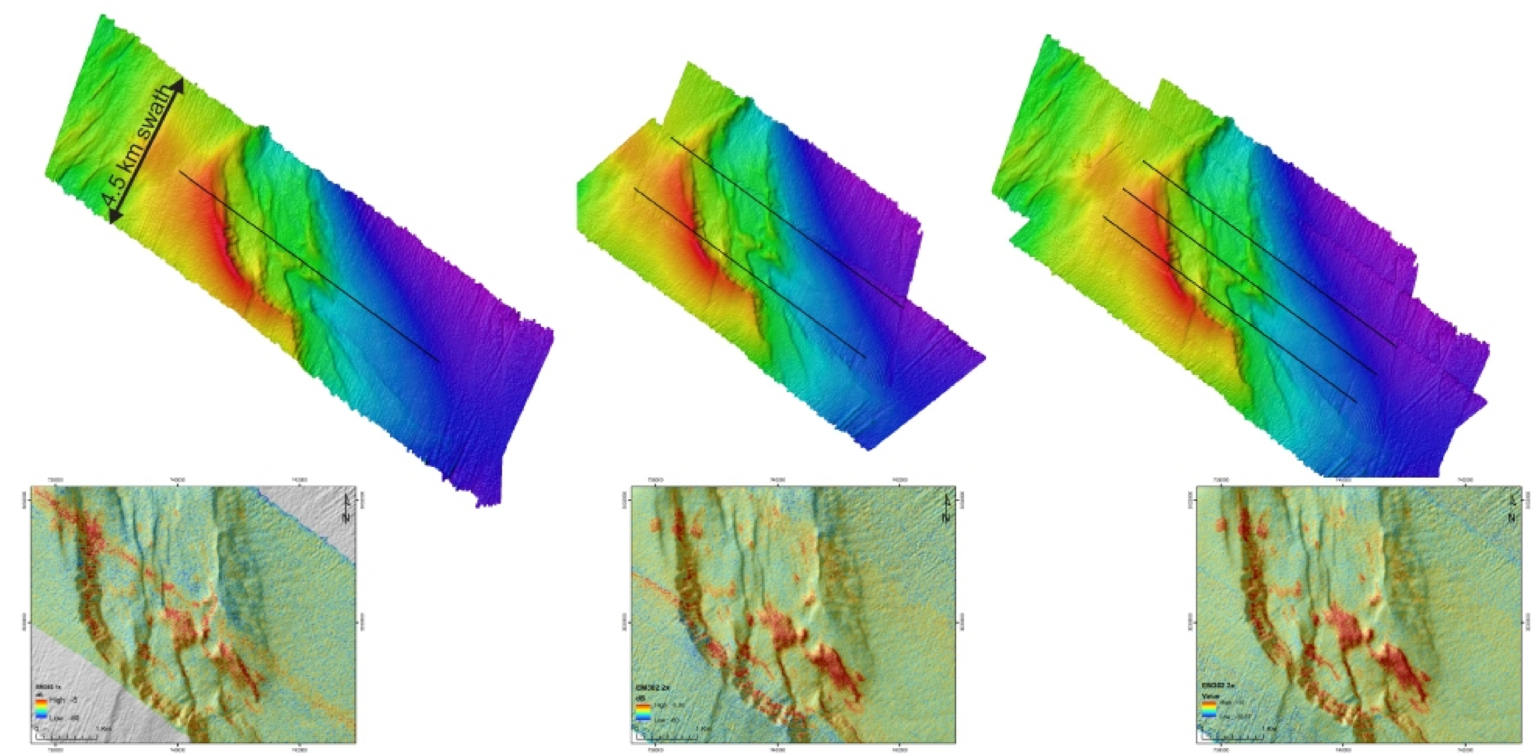
Filtered plumes using the new feature detector toolset in a Fledermaus Scene.



Step 2.Filtered plumes after a cluster analysis to improve midwater resolvability of plume shape and seafloor emission site.

2x Seafloor Backscatter Technique

2x seafloor backscatter technique is used to enhance the backscatter intensity signal while suppressing the undesired noise that can result from angular response, seafloor grazing angles, and beam pattern residuals (Kluesner et al., 2013). Decreasing the survey line spacing allows for oversampling, creating high-sounding densities and enhanced geological resolvability of seep features on the seafloor. These datasets were processed using Kongsberg Poseidon software using a weighted averaging on backscatter intensity.

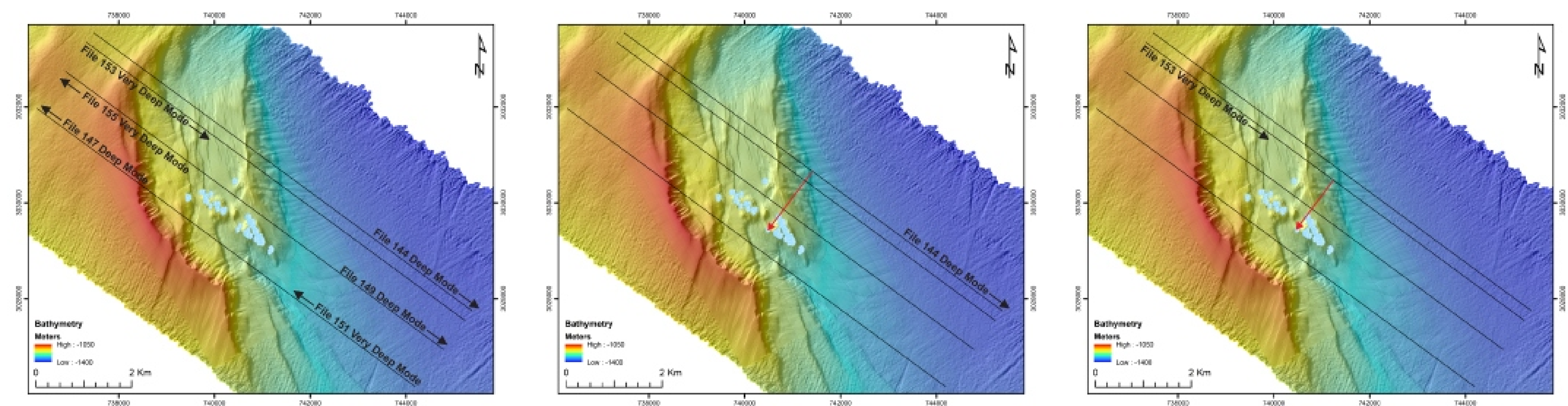


EM302 3m Deep Mode 1x Kongsberg Poseidon

EM302 3m Deep Mode 2x Kongsberg Poseidon Weighted Average

EM302 3m Deep Mode 3x Kongsberg Poseidon Weighted Average

Detection of Plumes using Midwater Backscatter Analysis of Kongsberg EM302 Detection Limits

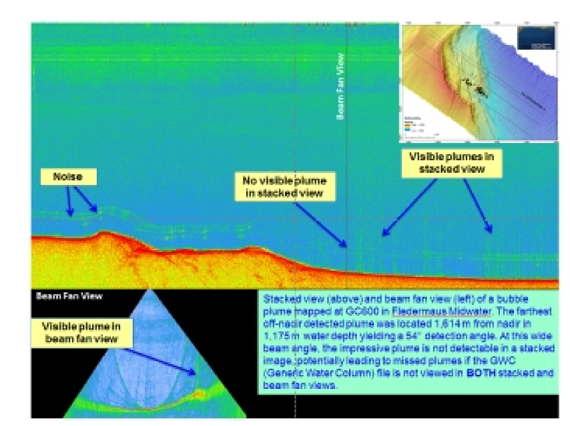


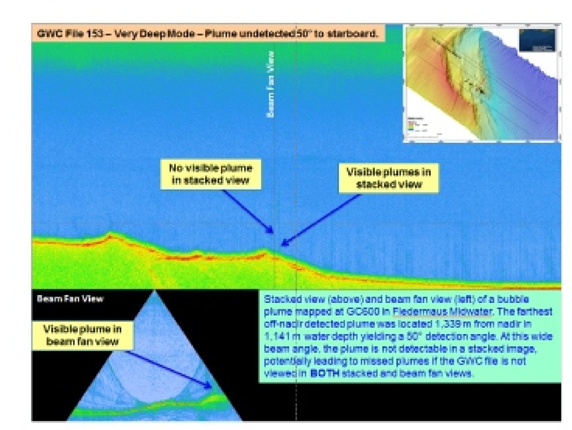
Goals of the Study

Determine detection limits of an EM302 (1º x 0.5º beamwidth) 30 kHz MBES over seeps at GC600.

Lines were designed to test water column mapping at slant range angles from 10º to > 50º.

Table 1 shows the farthest off-nadir detected plumes and the depths to calculate beam angles. The initial survey at GC600 (Files 0-3) were used to map the locations of the bubble plumes on the seafloor. The second survey was designed to test plume detection using a variety of near-nadir and far off-nadir beam angles.





Raw File	SIS Mode	Heading	Off-Nadir Detection (Slant Range, Port)	Depth (Port)	Max Detection Angle (Port)	Off-Nadir Detection (Slant Range, Stbd)	Depth (Stbd)	Max Detection Angle (Stbd)
0	**Deep**	**300**	**1440**	**1173**	**51**			
1	Deep	120	990	1187	40			
3	Deep	300	414	1175	19	448	1205	20
144	**Deep**	**120**				**1614**	**1175**	**54**
147	Deep	300				780	1209	33
149	Deep	120	219	1221	10	637	1083	30
151	Very Deep	300				800	1219	33
153	**Very Deep**	**120**				**1339**	**1141**	**50**
155	Very Deep	300	561	1191	25	510	1229	23
156	Very Deep	120	360	1196	17	541	1184	25

References

Brooks, J.M., C. Fisher, H. Roberts, B. Bernard, I. McDonald, R. Carney, S. Joye, E. Cordes, G. Wolff, E. Goehring. (2014), Investigations of chemosynthetic communities on the lower continental slope of the Gulf of Mexico: Volume I: Final report. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEM 2014-650. 560 pp.

Kluesner, J.W., E.A. Silver, N.L. Bangs, K.D. McIntosh, J. Gibson, D. Orange, C.R. Ranero, and R. von Huene. (2013), High density of structurally controlled, shallow to deep water fluid indicators imaged offshore Costa Rica, *Geochem. Geophys, Geosys., 14,* doi:10.1002/ggge.20058.