AGU PUBLICATIONS

Earth and Space Science

Supporting Information for

Shallow seafloor gas emissions near Heard and McDonald Island on the Kerguelen Plateau, southern Indian Ocean

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Contents of this file

Text S1
Figures S1 to S2

Additional Supporting Information (Files uploaded separately)

Table S1
Captions for Tables S2 to S4

Introduction

Supporting information includes more information about analyses undertaken on data collected during the IN2016_V01 voyage from Jan-Feb 2016, in particular more detailed acoustic methods.

Text S1.

A minimum threshold of -70 dB and a maximum threshold of -40 dB were applied to all raw 38 kHz and 120 kHz echograms (Jerram et al., 2013; Jerram et al., 2015; Veloso et al., 2015). A 3 x 3 convolution matrix was applied to remove stochastic variance. Background noise was filtered out using a synthetic noise filter with a signal-to-noise ratio <10 dB (De Robertis & Higginbottom, 2007). An exclusion line removed all data shallower than 10 m water depth. A Best-Bottom Candidate line pick algorithm was applied to determine the seafloor and a 0.3 m offset was applied above the line pick to remove all data below, removing acoustic interference from seafloor backscatter or benthic environments. Echograms were then averaged into bins 4 pings wide by 1 m deep to remove sample-to-sample variability, producing the final cleaned echograms (Supp. Fig. S1a-e).

Acoustic anomalies of high backscatter were located in the cleaned and thresholded echograms using Echoview's School Detection algorithm, which uses image analysis techniques based on Barange (1994) to identify and group adjacent sample values that exceed a data threshold, and then apply size- and linking-based criterions to the resulting groups. The criterions applied were:

- Minimum total school length: 3 m
- Minimum total school height: 5 m
- Minimum candidate length: 3 m
- Minimum candidate height: 10 m
- Maximum vertical linking distance: 10 m
- Maximum horizontal linking distance: 10 m

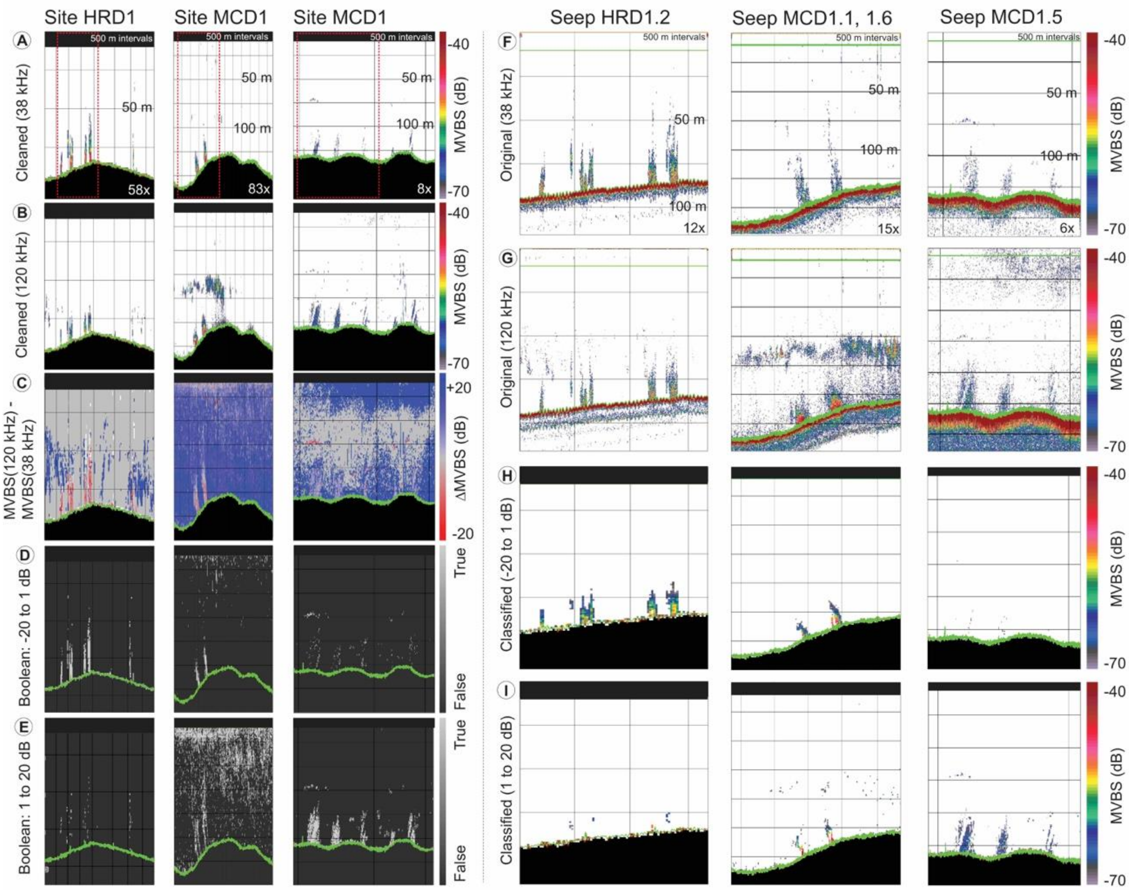

Figure S1. Multi-frequency decibel differencing was used to determine if the unverified MCD flares were caused by gas emission. Bubbles produce different backscatter at different wavelengths based on their size; **(a)** cleaned (background noise and 3x3 convolution matrix filters) 38 kHz echograms (red dashed boxes show subset echogram location; vertical exaggeration in bottom right corner); **(b)** cleaned 120 kHz echograms; **(c)** decibel difference (38 kHz backscatter subtracted from 120 kHz); **(d)** Boolean filter to extract areas with -20 to 1 dB difference (based on HRD1 ground-truthed flare response); **(e)** Boolean filter to extract areas with 1 to 20 dB difference (based on MCD1 unverified flare response); **(f)** original uncleaned, unfiltered 38 kHz echogram from HRD1 and MCD1 (vertical exaggeration bottom right corner); **(g)** original uncleaned, unfiltered 120 kHz echogram; **(h)** cleaned 120 kHz echogram filtered with decibel difference window of -20 to 1 dB; **(i)** cleaned 120 kHz echogram filtered with decibel difference window of 1 to 20 dB. Flares colored by MVBS (acoustic intensity; dB). For synthetic ∆MVBS echograms, colours represent the difference (dB) between 120 kHz and 38 kHz echogram. For Boolean echogram, colours represent true/false adherence to the two decibel difference classifications. For all echograms: green lines show seafloor exclusion line; black areas show uppermost 10m of water and all data below the seafloor; horizontal bars 25 m depth intervals; vertical bars 500 m intervals).

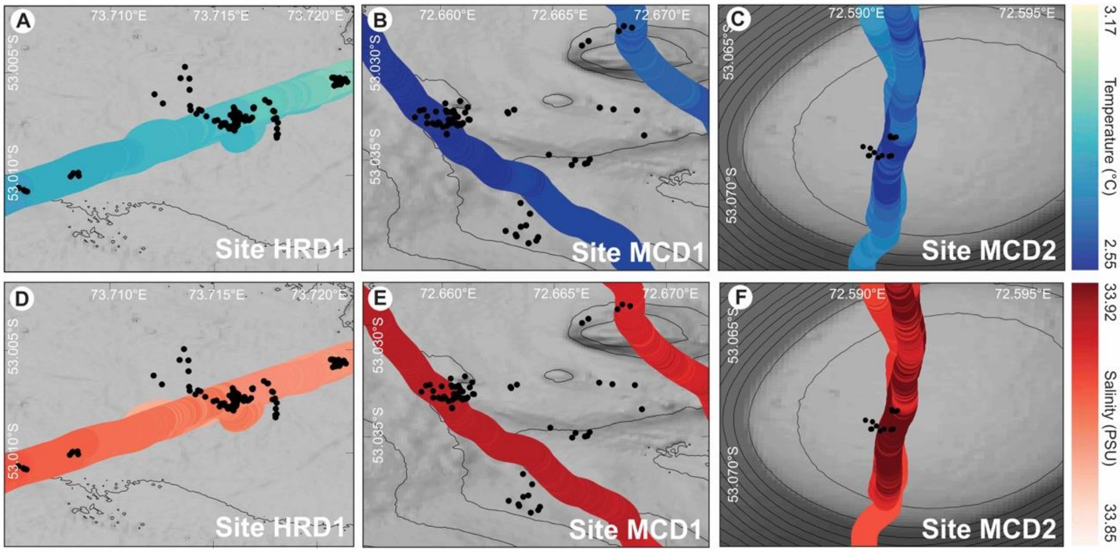

Figure S2. (a-b) MicroCAT CTD recording of temperature during deep-tow camera deployments; **(d-e)** MicroCAT CTD recording of salinity during deep-tow camera deployments. Black dots: acoustic flare locations. All contours: 10 m.

SITE	SEEP	DATE (UTC)	DISTANCE (km)	ALTITUDE MEAN (m)	ALTITUDE MEDIAN (m)	VISIBILITY (m)
MCD1	MCD1.1, 1.7	27/01/2016	1.9	3.3	3.0	< 2
MCD1	MCD1.4	27/01/2016	1.8	4.1	3.5	< 2
MCD2	MCD1.1, 1.2	29/01/2016	0.6	2.8	2.3	< 2
MCD2	MCD1.1, 1.2	29/01/2016	0.5	2.9	2.3	< 2
MCD2	MCD1.1, 1.2	29/01/2016	0.7	2.5	2.1	< 2
HRD1	HRD1.1, 1.2, 1.3, 1.4	02/02/2016	2.5	2.4	2.2	> 4
HRD1	HRD1.1, 1.2, 1.3, 1.4	02/02/2016	2.5	2.5	2.2	> 4
HRD1	HRD1.1, 1.2, 1.3, 1.4	02/02/2016	2.5	2.4	2.2	> 4
HRD1	HRD1.2	12/02/2016	0.5	2.8	2.5	> 5

Table S1. Deep-tow camera transect details; mean and median altitude determined from the camera USBL logs.

CAPTIONS for Tables S2 to S4

Table S2. δ^3He analysis of shipboard CTD casts.

Table S3. Record of all EK60 acoustic flares analyzed in this study from voyage IN2016_V01, including location, seep, depth, height, and intensity (dB).

Table S4. Carbon and sulfur isotope analysis of Smith McIntyre Grab sediments.