National
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NATURAL ENVIRONMENT RESEARCH COUNCIL

National Oceanography Centre

Cruise Report No. 13

RRS *James Clark Ross* Cruise 253

26 JUL -25 AUG 2011

Arctic methane hydrates

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2012

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ABSTRACT

The cruise built on the successful geophysical and geochemical mapping, undertaken during the 2008 IPY voyage JCR211 (Westbrook et al., 2009) that made the first comprehensive survey of methane bubble plume venting along the western Svalbard margin. The main achievements of JCR253 included the recovery of the ESONET demonstration mission AOEM - MASOX seafloor lander (with recovery of 10 months of physical and biogeochemical parameters from a vigorous bubble plume site) and its deployment for a further 12 months at the same site (for recovery in August 2012), completion of 23 HyBIS ROV dives, totaling 35 hr. Seafloor video and photographs, were completed along transects in both 420 – 380 m and 80-90 m water-depths, but additionally HyBIS was used to sample bubble plume fluids at seafloor "vents" for geochemical analysis, and bubble imaging to measure bubble sizes and ascent rates. A suite of 14 piston / gravity cores were acquired along three transects perpendicular to both the interpreted position of the hydrate stability zone outcropping at the seafloor and general linear band of bubble plumes emitting from the seafloor around ~ 390 m. A comprehensive suite of 28 CTD stations were completed for physical / chemical sensing and water-sampling along the three transects (co-located with sediment and box cores) and the shallow-water sites. Additionally, the active acoustic bubble BOB imaging system was deployed to record active methane bubble release at a representative bubble stream at 390 m for an 18-day deployment. A major "discovery" of the cruise is the observation of active methane bubble release in shallow-water (80-90 m water-depth) landward of the previously described edge of the hydrate stability zone outcropping near the seafloor at water-depths of 420 – 380 m.

KEYWORDS

Biogeochemistry, bubble acoustics, cruise 253 2011, CTD, Hybsis, *James Clark Ross,* methane hydrate, methane gas flares, microbial biology, geochemistry, piston cores, sediment cores, seafloor geology, western Svalbard continental shelf

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Graham Raworth	Steward
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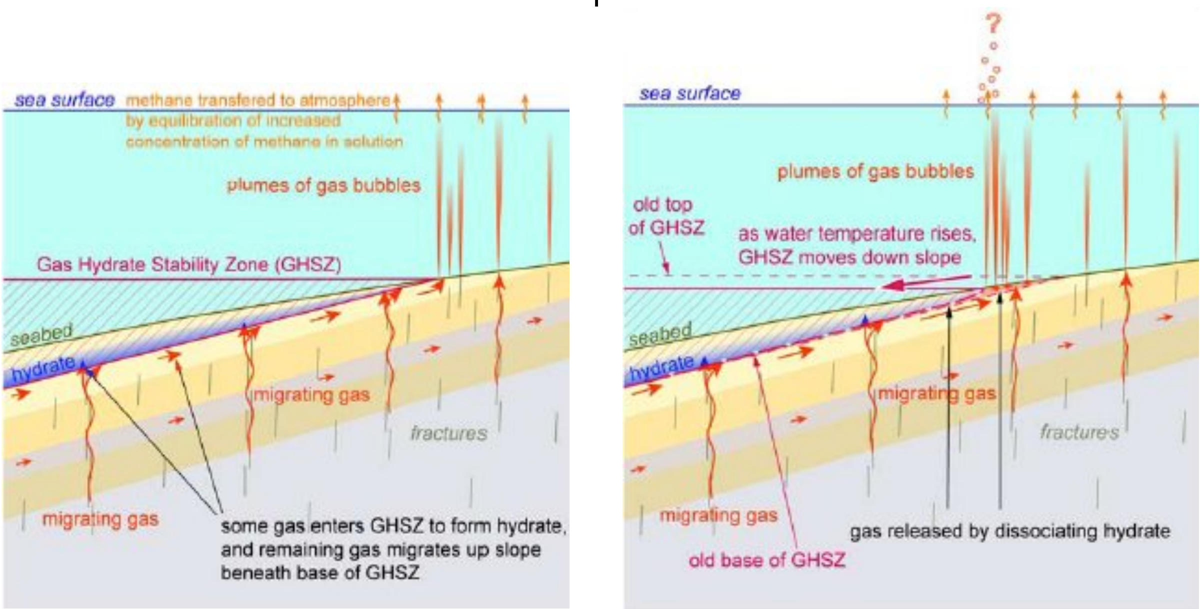
ITINERARY
Departed Glasgow, UK 26th July 2011
Arrived Longyearbyen, Svalbard (Norway), 25th August 2011

CRUISE OBJECTIVES
Background

All global climate change scenarios (with CO_2 concentration increasing to at least 500 ppm), forecast large and irreversible change in the Arctic Ocean. Coupled ocean – atmosphere modelling (e.g., the CHIME model) predicts warming of shallow Arctic seas by +5°C and +14°C for surface-waters by the year 2100. Indeed, direct observations of upper-waters (at 250 m water-depth) in the western Fram Strait, record a ~+1°C increase between 1998 and 2006 (Schauer et al., 2008). Recent marine geophysical research has identified methane hydrate in the Arctic Ocean (including west of Svalbard) and determined some bounds of their thermodynamic stability. Recent discoveries show the Svalbard site to be venting methane as free gas (into at least the lower water-column) where the hydrate outcrops at the seafloor at a water-depth of 350-400 m (Westbrook et al., 2009). A crucial unknown science question is to determine whether there is a causative effect of warming shallow Arctic seas that will perturb the stability of sub-seabed gas hydrates leading (Figure 1) to different / faster dissociation fluxes and / or processes?



The critical unknowns in methane dissociation processes in shallow Arctic seas are:

1. What is the volume / inventory of sub-seabed methane hydrate of Arctic continental shelf and slopes?
2. What is the volume / inventory of free methane gas beneath the hydrate?
3. What are the mechanisms, and physical – chemical processes that releases free gas from hydrate?
4. What is the flux, physical state, and chemical fate of methane vented from the seafloor?
5. What is the flux of free methane venting to the atmosphere?

Within the Arctic, the western Svalbard shelf and slope is sited a critical location. The site is bathed by a northward flowing filament of the North Atlantic Current that is a crucial "barometer" of global ocean warming, which shows evidence of warming (and localised cooling) over time scales of years (Figure 2), and is an area of known methane venting with over 250 individual gas bubble plumes ascending through the water-column (with the pre-dominant majority located at the immediate landward edge of the gas hydrate stability zone at ~396 m water depth) (Figure 3).

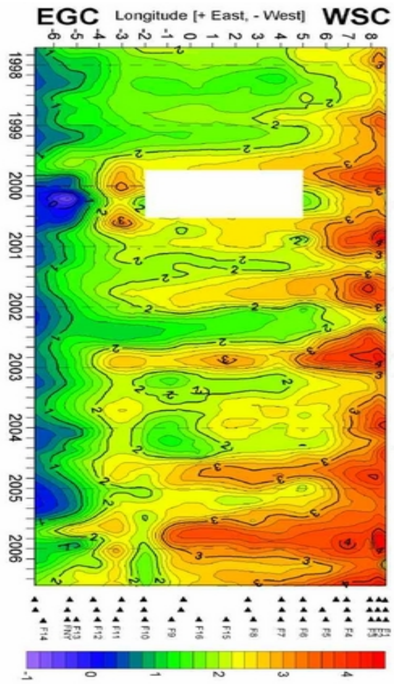
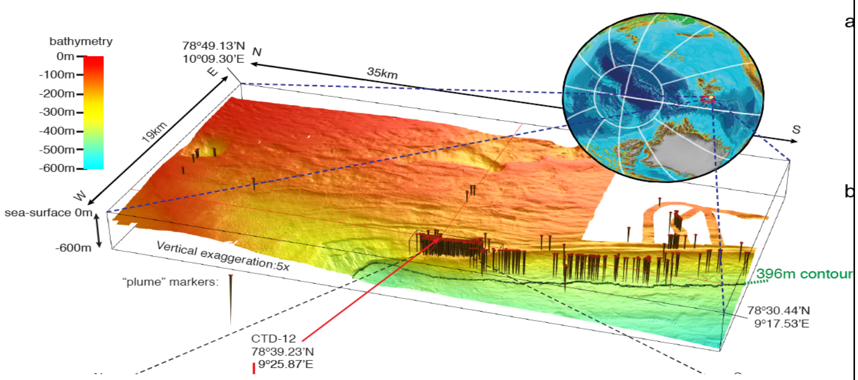


Figure 2. Time-series record of bottom water temperature across Fram Strait between 1998 and 2006 showing the progressive warming of the Western Svalbard Current and shelf at 250 m.

Figure 3. Distribution of some 250 plumes along the western Svalbard shelf and slope (Westbrook et al. 2009).



Following the success of the 2008 IPY cruise (Westbrook et al. 2009) a joint ESONET Demonstration Mission proposal was successfully funded with the deployment of the MASOX / AOEM Arctic ESONET lander as a joint project between NOC, GEOMAR, and University of Tromso. The lander was deployed in October 2010 at 78° 33.272' N, 09° 28.699'E (water-depth of 389m) by the *RV Jan Mayen*. The deployment is designed for two years with servicing in July / August 2011 by *James Clark Ross*, and retrieval in summer 2013 by the RV *Merian*. The lander comprises a suite of geophysical and geochemical sensor including K/MT Seismometer (4.5-200 Hz), HTI-04 Hydrophone, SENS Geolon-MLS data logger (14 Gb), OceanLine Water Current Sensor HS-2X, lithium battery packs, Aanderaa Seaguard Recording Current Meters (RCM's), and CTD sensors including oxygen, using the fast response optodes, and turbidity, TriTech underwater video camera, gas flow-meter.

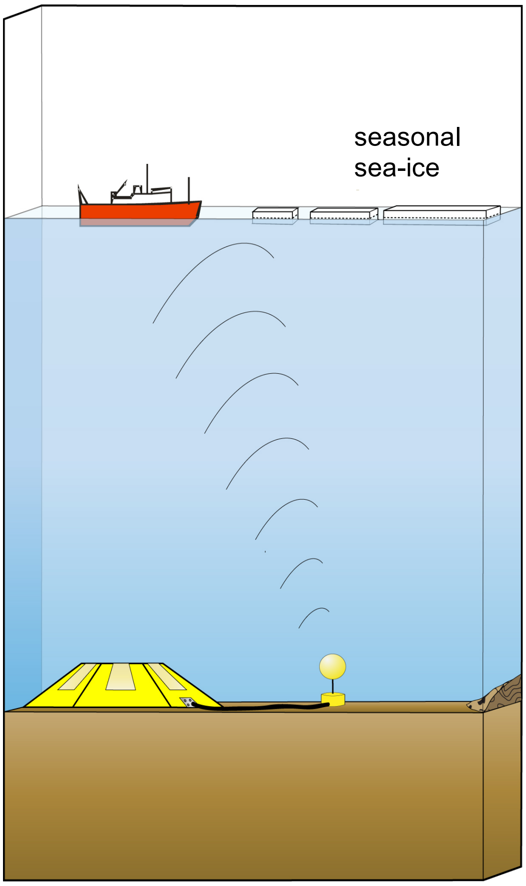


Figure 5. Schematic cartoon of the MASOX / AOEM lander at the Western Svalbard shelf / slope site.

Figure 6. MASOX / AOEM lander being deployed by the Jan Mayen in October 2010.

JCR253 programme

The main JCR253 cruise objectives are to:

1. Service the AOEM seafloor lander with data downloading and installation of replacement batteries and subsequent redeployment at the site;
2. Undertake acoustic mapping of ascending gas plumes along the western Svalbard slope;
3. Undertake seafloor ROV and side-scan mapping of seafloor "vent" sites along the western Svalbard slope;
4. Undertake CTD survey and biogeochemical analysis of water-column around AOEM site and along the western Svalbard slope;
5. Undertake sediment coring and biogeochemical analysis of sediments and pore-water around AOEM site and along the western Svalbard slope;
6. Undertake ship-board air-sampling during the cruise.

The principal focus of the sampling will be along 4-5 down-slope transects (including a transect through the AOEM site) to test the hypothesis whether the landward edge of the hydrate-stability zone has migrated seaward down-slope using seafloor observations and sampling, geophysical and biogeochemical data (Figure 7). A smaller sampling effort will be to target along slope to establish processes of subsea saturation and seafloor diffusion (Figure 8).

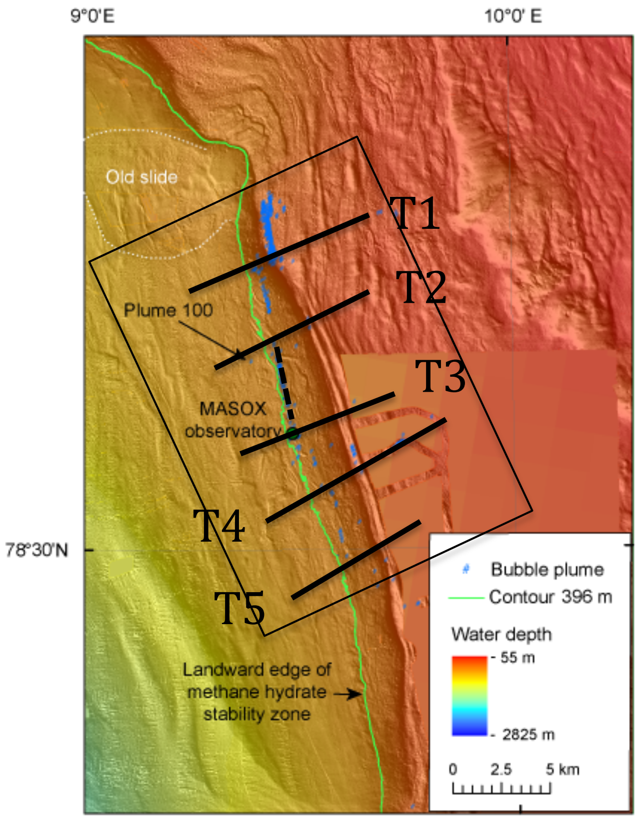
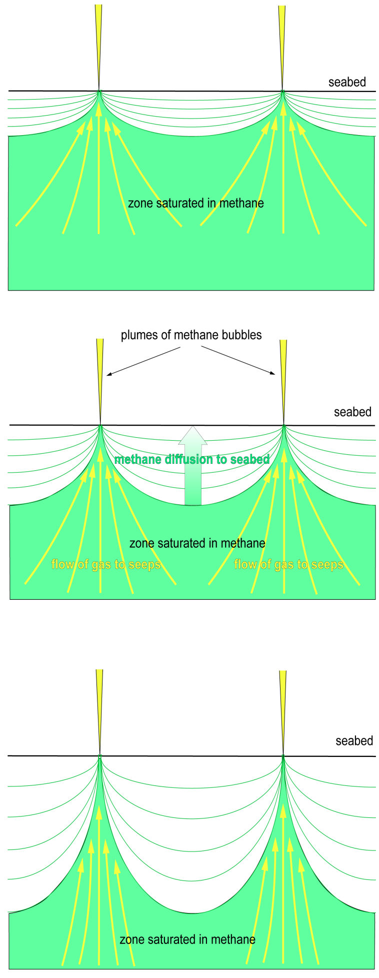


Figure 7. Synoptic location map of down-slope sampling transects (solid lines) and along-slope transect (dashed line) at the Western Svalbard shelf / slope site.

Figure 8. Hypothesised fluid transport and release mechanisms between methane plumes (Westbrook pers comm.).



NARRATIVE (times in GMT except where otherwise noted)

26th July 2011 (JD207).
0900 (1000 local time). Ship departed from Glasgow.
0900-2400. On passage to Stornoway with TOPAS trials in transit south of Isle of Mull.

27th July 2011 (JD208).
0000-1205. In transit to Stornoway.
1205-1410. Disembark Kongsberg TOPAS engineer to Stornoway via small boat.
1410-2400. In transit to Svalbard
2055. Air sample taken whilst in transit to Svalbard (Sample JCR253-01-Air Sample-01).

28th July 2011 (JD209).
0000-2400. In transit to Svalbard.
0853. Air sample taken whilst in transit to Svalbard (Sample JCR253-02-Air Sample-02).
2058. Air sample taken whilst in transit to Svalbard (Sample JCR253-03-Air Sample-03).

29th July 2011 (JD210).
0000-2400. In transit to Svalbard.
0853. Air sample taken whilst in transit to Svalbard (Sample JCR253-04-Air Sample-04).
2100. Air sample taken whilst in transit to Svalbard (Sample JCR253-05-Air Sample-05).

30th July 2011 (JD211).
0000-2400. In transit to Svalbard.
0859. Air sample taken whilst in transit to Svalbard (Sample JCR253-06-Air Sample-06).
2100. Air sample taken whilst in transit to Svalbard (Sample JCR253-07-Air Sample-07).
Local time moved forward one hour at midnight.

31th July 2011 (JD212).
0000-1123. In transit to Svalbard.
0856. Air sample taken whilst in transit to Svalbard (Sample JCR253-08-Air Sample-08).
1123-1250. Test CTD cast to 1000 m with water sampling (Sampling JCR253-09-CTD-01)
1250-2400. In transit to Svalbard.
2045. Air sample taken whilst in transit (Sample JCR253-10-Air Sample-09).

1st August 2011 (JD213).
0000-0051. In transit to AOEM lander site.
0052-0148. On station for CTD cast at AOEM lander site (Sample site JCR253-11-CTD-02).
0152-0207. Positioning for under-way track 1.
0208-0405. Run underway track north from AOEM lander with ADCP, EM122, and EK60 systems. Seafloor plumes observed in 38 and 120 kHZ data.
0405-0700. Transit to Ny Alusend.
0700-1200. Off-load cargo to NERC station at Ny Alusend.
1200-1608. Depart Ny Alesend and transit to outer slope for underway track 2.
1609-0000. Run underway tracks south along 400 m isobath with ADCP, EM122, and EK60 systems. Tracks 2 and part of 3 acquired up to midnight.
1954. Air sample taken whilst in transit (Sample JCR253-12-Air Sample-10).

2nd August 2011 (JD214).

0000-0356. Continue underway tracks 3 and 4 along 400 m isobath with ADCP, EM122, and EK60 systems.
0357. Commence transit to Longyearbyen.
0837. Air sample taken whilst in transit (Sample JCR253-13-Air Sample-11).
1100. Arrive Longyearbyen harbor and alongside wharf between 1200-1400 and onboard remainder of the science party and lander deployment equipment stored by Norwegian Polar Institute.
1500. Depart Longyearbyen with coring equipment mobilized on deck while in harbor.
1600. Depart Longyearbyen harbor for transit to offshore recommence acoustic survey mapping.
2325-0000. Recommence hydroacoustic mapping with lines 5 through 11.

3rd August 2011 (JD215).
0000-0554. Continued mapping of hydroacoustic mapping with lines 5 through 11.
0600. Repositioning for side-scan deployment.
0610. Side-scan deployed for survey, but problems with winch paying out and side-scan recovered.
0800. Side-scan recovered on deck and ship repositioning for box core / piston core site in deeper water.
0913-1051. Box core site sampled in 470 m water-depth (JCR253-15-Box core-01). Good push cores taken for geochemistry.
1032. Repositioning for piston core at same site in 470 m water-depth.
1137-1359. Piston core taken at 470 m site (JCR253-16-Piston core-01) after core rigging delays but successful core acquired 3.7 m in length comprising grey gravelly mud.
1542-1625. HyBIS deployed to 250 m water-depth for test and pressuring dive.
1626. Repositioning for hydro-acoustic mapping.
1708-000. Ship running underway tracks 20-25

4th August 2011 (JD216).
0000-0554. Continued mapping of hydroacoustic mapping with lines 20 through 25.
0608. Preparing HyBIS for dive on MASOX lander site.
0709-1324. HyBIS dive (JCR253-17-HyBIS-01; HyBIS Dive 34) on the MASOX land site. Lander sighted at 1218 GMT at position of 78°33.282273' N, 9°28.642803' E in 396 m water-depth.
0813. Air sample taken (JCR253-18-Air sample-13).
1330-1433. Box core 20 m north of the MASOX lander. First box core had muds washed out so station repeated at same site. No sample in second box core.
1435. Re-rigging for a piston core.
1515-1611. Piston core with 20 m north of the MASOX lander site. Sample JCR253-19-Piston core-02.
1628. Start acoustic mapping with line 26.
1727-0000. Acoustic mapping along lines 26-28.

5th August 2011 (JD217).
0000-0524. Continued mapping of hydroacoustic mapping with lines 26 through 28.
0738-0904. HyBIS dive for first attempt at MASOX lander recovery (JCR253-20-HyBIS-02; HyBIS Dive 35) not successful. Dive terminated.
0822. Air sample taken (JCR253-21-Air sample-14).
0915. Reposition for box core station in 320 m water-depth.
0920-1058. Two attempts of box coring with little recovery – mud and few individual

macrofauns specimens – station Sample JCR253-22-Box core-03.
1059-1244. Re-rigging for piston core at same site with station JCR253-23-Piston core-03;
1245-1333. Repositioning ship for HyBIS dive.
1334-1750. Three HyBIS dives to move lifting ring and strops on lander hooking and recovery using Dyneema rope (JCR253-24-HyBIS-03 – Dive 36; JCR253-25-HyBIS-04 - Dive 37; and JCR253-25A-HyBIS-05 – Dive 38). MASOX hooked and HyBIS recovered to deck on JCR253-25A-HyBIS-05 – Dive 38.
1750-1900. MASOX lander hauled to surface and lowered to deck.
1901. Repositioning for multibeam and TOPAS survey on Transect 3.
1929-000. Running underway lines for 40-44 mapping with TOPAS on lines 40-42, and multibeam on lines 43 and 44 on Transect 3.

6th August 2011 (JD218).
0000-0630. Continued mapping of underway lines for 40-44 mapping with TOPAS on lines 40-42, and multibeam on lines 43 and 44.
0650-0718. Box core in 350 m – station JCR253-26-BC04. Poor recovery with 10.5 cm deep box core.
0720-0826. Re-rigging for gravity core. Gravity core (JCR-27-Gravity core-01) taken at 350 m water-depth. Core 2.1 m long comprising grey gravelly mud.
0911. Air sample taken (JCR253-28-Air sample-15).
0827-0913. Reposition for BOB site survey.
0914-1104. Hydroacoustic survey (underway lines 46-49) of proposed BOB site for optimal deployment site.
1132-1232. Stationary hydroacoustic imaging of flare within wider MASOX lander site using EK60.
1233-1349. Reposition ship.
1350-1449. Stationary hydroacoustic imaging of flare within wider MASOX lander site using EK60.
1450-1537. Reposition ship to MASOX / BOB flare.
1538-1723. BOB acoustic imager deployed at 78°33.2878' N, 9°28.5980 aligned and scanning due north at methane flare sited at 78°33.3000' N, 9°28.6020 E ~30 m north of BOB.
1724-1757. Repositioning ship to northwest on deeper water flares.
1758-1915. Hydroacoustic survey (along lines underway lines 50-54) of 2008 mapped flares in 420 m water depth to constrain position of Transect 2.
1916-1940. Reposition ship to shallower water.
1941-2133. Hydroacoustic survey (along lines underway lines 55-60) in shallower water to constrain position of Transect 2.
2133-000. Running underway lines for 61-65 mapping with TOPAS on lines 40-42, and multibeam on lines 43 and 44 on Transect 3.

7th August 2011 (JD219).
0000-0623 Running underway lines for 61-65 mapping with TOPAS on lines 40-42, and multibeam on lines 43 and 44 on Transect 3.
0624-0645 Reposition ship to deep-water core site on Transect 2.
0646-0728. Box core in 472 m – station JCR253-29-Box core-05; 12 cm long push cores
0730. Re-rigging for gravity core.
0802-0924. Gravity core in 472 m water-depth – station JCR253-31-Gravity core-02;
0813. Air sample taken (JCR253-30-Air sample-16).
0925-1026. Reposition ship back to MASOX / BOB deployment site.

1026-2300. Stationary hydroacoustic imaging of BOB flare using EK60, EM122, and ADCP for 12 hour period.
1316. Air sample taken (JCR253-32-Air sample-17) taken above the BOB flare while stationary.
2312-0000. CTD station and water sampling on Transect 3 at BOB flare site – station JCR253-33-CTD-03. On the bottom at 2327.

8th August 2011 (JD220).
0000-0015. continued CTD station and water sampling on Transect 3 at BOB flare site – station JCR253-33-CTD-03.
0130-0217. Reposition ship for next CTD station.
0218-0300. CTD station and water sampling in 457 m water-depth on Transect 3 – station JCR253-34-CTD-04. On the bottom at 0232.
0233-0425. Reposition ship along Transect 3 to 340 m
0426-0429. Commence CTD station but CTD wire stringing with station aborted.
0430-0614. Reposition ship back to BOB deployment site for HyBIS.
0615- 0718. Prepare for HyBIS dive JCR253-35-HyBIS-06; Dive 39.
0719-0954. HyBIS dive JCR253-35-HyBIS-06; Dive 39 to check BOB deployment and do video survey of the MASOX / BOB flare at 78°33.3000' N, 9°28.6020 E and map site for MASOX lander deployment. Weak gas bubble plumes observed during the dive at 78°33.29943' N, 9°28.6002 E and is interpreted as true position of MASOX / BOB flare.
0824. Air sample taken (JCR253-36-Air sample-18).
0954-1558. Deck preparation, instrument installation, and reconstruction of MASOX lander for re-deployment.
1559-1643. MASOX lander deployed 1632 GMT on seafloor navigated by USBL at 78°33.30442' N, 9°28.6110 E approximately 8 m NNE of MASOX / BOC flare.
1644-1735. Reposition ship for next CTD station and water / chemistry sample processing.
1736-1818. CTD station and water sampling in 337 m water-depth on Transect 3 – station JCR253-37-CTD-05. On the bottom at 1748.
1819-2148. Reposition ship for next CTD station and water / chemistry sample processing.
2149-2224. CTD station and water sampling in 313 m water-depth on Transect 3 – station JCR253-38-CTD-06. On the bottom at 2202.
2225-0000. Reposition ship for next CTD station and water / chemistry sample processing.

9th August 2011 (JD221).
000-0145. Reposition ship for next CTD station and water / chemistry sample processing.
0146-0218. CTD station and water sampling in 210 m water-depth on Transect 2 – station JCR253-39-CTD-07. On the bottom at 0159.
0219-0514. Reposition ship for next CTD station and water / chemistry sample processing.
0515-0547. CTD station and water sampling in 316 m water-depth on Transect 2 – station JCR253-40-CTD-08. On the bottom at 0527.
0548-0914. Reposition ship for next CTD station and water / chemistry sample processing.
0830. Air sample taken (JCR253-41-Air sample-19).
0915-1002. CTD station and water sampling in 316 m water-depth on Transect 2 – station JCR253-42-CTD-09. On the bottom at 0929.
1003-1253. CTD station and water / chemistry sample processing.
1254-1316. Box core in 417 m, – station JCR253-43-Box core-06 on Transect 2. One rock and few biological specimens. Station to be repeated.
1329-1353. Repeat station box core station – station JCR253-44-Box core-07.
1354-1412. Re-rigging for piston core.

1413-1608. Piston core station 417 m – station JCR253-45-Piston core-04. Problems encountered in removing core cutter.
1619-0000. Running multibeam underway lines 66-75 (multibeam, TOPAS, and EK60 systems) along Transects 2 and 3.

10th August 2011 (JD222).
0000-0700. Completing underway lines 66-75 (multibeam, TOPAS, and EK60 systems) along Transects 2 and 3, but EK60 crashing during survey.
0701-1207. HyBIS dive (JCR253-46-HyBIS-07; Dive 40) to deploy seafloor thermistor chain from the MASOX lander to the west and downslope. Initial part of the dive was to ensure smooth deployment of the chain from the lander, with the thermistor chain finally laid on the seafloor from the MASOX extending ~ 88 m west with the end of the chain located at 78°33.309891' N, 9°28.37381 E.
0830. Air sample taken (JCR253-47-Air sample-20).
1257-1549. HyBIS dive (JCR253-48-HyBIS-08; Dive 41) on deeper acoustic flares at 420 m; little evidence of active bubble venting but white bacterial mats and ?seafloor carbonate deposition observed.
1500-1526.. Reposition ship for box / piston core station.
1527-1551. Box core in 392 m, – station JCR253-49-Box core-08 on Transect 2. Single push core recovered.
1552-1621. Re-rigging for piston core.
1622-1814. Piston core in 392 m, - station JCR253-50-Box core-05 on Transect 2.
1815-2027. Repositioning ship for transit line (Line 76) for multibeam mapping.
2028-000. EM122 and EK60 mapping along north-south lines 77-80 in shallower water.

11th August 2011 (JD223).
0000-0614. Continued EM122 and EK60 mapping along north-south lines 77-80 in shallower water.
0614-0829. Repositioning ship for HyBIS dive.
0822. Air sample taken (JCR253-50-Air sample-21).
0830-0952. HyBIS dive (JCR253-52-HyBIS-09; Dive 42) on strong acoustic flares at 382 m; no observable bubble venting and patchy white bacterial mats but dive terminated due to ship's heave.
0953-1114. Reposition ship for box and piston core station.
1115-1148. Attempted box core at strong flare site in 382 m water-depth (Transect 2) recovered no sediment with jaws jammed with rock boulders. Station aborted.
1149-1215. Re-rigging for piston core at same site.
1216-1318. Piston core recovered – station JCR253-53-Piston core-06 at strong flare site in 382 m water-depth. EM122 recording hydroacoustic water-column flares while stationary during box and piston core stations.
1319-1355. Reposition ship for for multibeam / hydracoustic mapping.
1356-2313. EM122 and EK60 mapping along east-west lines 81-87 in shallower water.
2315-2340. Moving to CTD station.
2341-0015. CTD station on shallow-water site (89 m water-depth) with acoustic plume reaching the sea surface; station JCR253-54-CTD-10.

12th August 2011 (JD224).
0016-0033. Moving to mapping lines.
0034-0223. EM122 and EK60 mapping along east-west lines 88-90 in shallower water.
0224-0250. Moving to CTD station.

0250-0315. CTD station on shallow-water site (88 m water-depth) with acoustic plume reaching the sea surface; station JCR253-55-CTD-11.
0809. Air sample taken (JCR253-56-Air sample-22).
0316-0333. Moving back to mapping lines.
0333-0734. EM122 and EK60 mapping along east-west lines 91-94 in shallower water.
0735-0842. Reposition ship for CTD station.
0842-0933. CTD station on Transect 2 – station JCR253-57-CTD-12.
0933-1019. Reposition ship for HyBIS dive.
1020-1246. HyBIS dive on active plume north of immediately north of Transect (JCR253-58-HyBIS-10 (Dive 43). Tens of metres wide area of patchy white bacterial mats, ?carbonate cruts, carbonate filled seafloor cracks, and zones of dispersed gas bubble venting from seafloor observed. Most vigorous bubble venting site at 78°36.696967' N, 9°25.534992' E. Rock sample recovered – sample JCR253-58-Rock-01.
1246-1301. Reposition ship for CTD station.
1302-1406. CTD station on Transect 2 – station JCR253-59-CTD-13.
1407-1712. On station filtering CTD water for chemistry / microbal samples and download HyBIS HD video data from vehicle.
1713-1739. Moving to mapping lines.
1740-0005. EM122 and EK60 mapping along east-west lines 95-103 in shallower water.

13th August 2011 (JD225).
0005-0538. EM122 and EK60 mapping along east-west lines 104-109 in shallower water.
0538-0621. Reposition ship for box core / piston core site on Transect 2.
0622-0657. Box core station in shallow water (323 m) on Transect 2 – station JCR253-60-Box core-09. Rock with encrusting biology recovered.
0658-0727. Re-rigging for piston core.
0728-0815. Piston core station in shallow water (323 m) on Transect 2 – station JCR253-61-Piston core-07.
0809. Air sample taken (JCR253-62-Air sample-23).
0815-1206. Hydroacoustic survey of shallow venting sites on Transect 1 (Lines 110-113)
1207-1232. Reposition ship for HyBIS dive.
1233-1424. HyBIS dive to count size and ascent rate of bubbles at known vent site – station JCR253-63-HyBIS-11: Dive 44.
1425-1516. Reposition ship for box-core station.
1517-1541. Box core station on Transect 1 (373 m) – station JCR253-64-Box-core-10.
1542-1551. Re-rigging for piston core.
1552-1828. Two attempts at coring site with both piston and gravity core with no success.
1829-1913. CTD station on Transect 1 (373 m water-depth); station JCR253-65-CTD-14.
1914-000. Processing and filtering water samples.

14th August 2011 (JD226).
0011-0055. CTD station on Transect 1 (450 m water-depth); station JCR253-66-CTD-15.
0056-0225. Processing and filtering water samples.
0226-0254. CTD station on Transect 1 (320 m water-depth); station JCR253-67-CTD-16.
0255-0432. Processing and filtering water samples.
0433-0454. CTD station on Transect 1 (218 m water-depth); station JCR253-68-CTD-17.
0455-0659. Processing and filtering water samples.
0700-0720. Box core station on Transect 1 (218 m) – station JCR253-69-Box-core-11.
0721-0745. Re-rigging for piston core.
0746-0844. Piston core station on Transect 1 (218 m) – station JCR253-70-Piston core-08.

0813. Air sample taken (JCR253-71-Air sample-24).
0845-0907. Re-rigging piston core.
0908-1051. Piston core station on Transect 1 (218 m) – station JCR253-72-Piston core-09.
1052-1114. Reposition ship to 450 m water-depth on Transect 1.
1115-1200. Box core station on Transect 1 (450 m) – station JCR253-73-Box-core-12.
1200-1321. Piston core station on Transect 1 (450 m) – station JCR253-74-Piston core-10.
1322-1422. Position ship for HyBIS dive.
1423-1715. HyBIS dive (JCR253-75-HyBIS-12; Dive 45) to sample emitting seafloor methane enriched seep fluids. 10 L Niskin bottle sampled at seep vent.
1716-1800. Reposition ship for EM122 and EK60 mapping along east-west lines 95-103 in shallower water.
1801-0000. EM122 and EK60 mapping along east-west lines 114-122 in shallower water.

15th August 2011 (JD227).
000-0516. EM122 and EK60 mapping along east-west lines 122-129 in shallower water.
0517-0636. Reposition ship to MASOX site for CTD station.
0637- 0744. CTD station at MASOX site on (383 m water-depth); station JR253-76-CTD-18.
0744-0802. Sampling and water filtering of CTD station JR253-76-CTD-18.
0803. Air sample taken (JCR253-77-Air sample-25)
0851-0943. Piston core station at MASOX site (383 m); station JCR253-78-Piston core-03.
1032-1230. HyBIS dive at MASOX site; visibility conditions poor with bubble streams not observed; JCR253-79-HyBIS-13 (Dive 46).
1231-1405. Reposition ship to shallow flare sites,
1406-1523. HyBIS dive on shallow flare to the east in 85-90 m water-depth – identified as strong flare from EM122 hydroacoustics; visibility poor with significant heave and strong current and station aborted – station JCR253-80-HyBIS-14 (Dive 47).
1539-1817. Fine resolution hydroacoustic survey over another shallow flare to precisely locate for CTD cast- strong flare located at 78°34.5138’ N, 10°10.4610’ E.
1818-2023. CTD station through strong shallow flare reaching the sea surface (JCR253-81-CTD-19), but problems with bottles closing properly during cast,
1925. Air sample taken (JCR253-82-Air sample-26) taken above strong shallow flare site.
1940. Air sample taken (JCR253-83-Air sample-27) taken above strong shallow flare site.
2024-2123. Clean CTD bottles and preparation for next CTD casts.
2124-2318. Four CTD stations on 100 m grid spacing around the 78°34.5138’ N, 10°10.4610’ E site- stations JCR253-84-CTD-20; JCR253-85-CTD-21; JCR253-86-CTD-22; JCR253-87-CTD-23).
2319-0000. Water sampling and filtering of four CTD casts.

16th August 2011 (JD228).
0000-0148. Water sampling and filtering CTD casts.
0149-0328. Four CTD stations on 100 m grid spacing around the 78°34.5138’ N, 10°10.4610’ E site- stations JCR253-88-CTD-24; JCR253-89-CTD-25; JCR253-90-CTD-26; JCR253-91-CTD-27).
0329-0602. Water sampling and filtering of four CTD casts.
0603-0925. HyBIS dive on very strong flare to sample flare fluids at the sea floor – station JCR253-92-HyBIS-15 (Dive 48). Bubbles sampled at site 78°34.5048’ N, 10°10.4625’ E. TOPAS mapping.
0818. Air sample taken (JCR253-93-Air sample-28) taken above strong shallow flare site.
0926-0950. Position ship for TOPAS lines.

0951-1305. Acquisition of four TOPAS lines over shallow site to identify potential shallow flare core sites.
1305-1330. Position ship for core station.
1331-1504. Three attempted 3 m gravity cores within centre of bubble plume with small se0925-ctions of consolidated clay sediments recovered at two – stations JCR253-94-Gravity core-04 and JCR253-95-Gravity core-05.
1505-1604. Repair and load test of HyBIS tow cable significant cable kink following JCR253-92-HyBIS-15.
1605-1639. CTD station within acoustic >100 m wide bubble plume - station JCR253-96-CTD-28.
2038-2348. Three CTD stations on 200 m grid spacing around the 78°34.5138' N, 10°10.4610' E site – stations JCR253-97-CTD-29; JCR253-98-CTD-30; JCR253-99-CTD-31.

17th August 2011 (JD229).
0000-0412. Five CTD stations on 200 m grid spacing around the 78°34.5138' N, 10°10.4610' E site – stations - stations JCR253-100-CTD-32, JCR253-101-CTD-33; JCR253-102-CTD-34; JCR253-103-CTD-35; JCR253-104-CTD-36.
0413-0633. Processing and filtering CTD water samples.
0634-0839. HyBIS dive on strong flare to sample flare fluids at the sea floor – station JCR253-105-HyBIS-16A (Dive 49). Bubbles sampled at site 78°34.509' N, 10°10.460' E. Towed cable kinked upon recovery and requiring repair.
0712. Air sample taken (JCR253-106(A)-Air sample-29) taken above strong shallow flare site from ship's rib 30 m from ship.
0840-0929. Reposition ship for EM122 and EK60 hydroacoustic mapping
0930-1148. EM122 and EK60 mapping along east-west lines 134-136.
0905. Air sample taken JCR253-106(B)-Air sample-30.
1149-1311. Reposition ship and preparation for HyBIS dive.
1312-1830. Three HyBIS dives (JCR253-107-HyBIS-16B [Dive 50]; JCR253-108-HyBIS-17 [Dive 51]; JCR253-109-HyBIS-18 [Dive 52]) to sample seep vent fluids. First two dives aborted due to bubble funnel and Niskin bottle failure, but 10 L sample recovered in third dive.
1831-1857. Reposition ship for CTD casts.
1858-2133. Four CTD stations on 400 m grid spacing around the 78°34.5138' N, 10°10.4610' E site – stations JCR253-110-CTD-37, JCR253-111-CTD-38; JCR253-112-CTD-39; JCR253-113-CTD-40.
2134-000. Processing and filtering CTD water samples.

18th August 2011 (JD230).
0010-0327. Four CTD stations on 400 m grid spacing around the 78°34.5138' N, 10°10.4610' E site – stations JCR253-114-CTD-41, JCR253-115-CTD-42; JCR253-116-CTD-43; JCR253-117-CTD-44.
0327-0555. Processing and filtering CTD water samples.
0556-0644. Preparation for HyBIS dive – station JCR253-118-HyBIS-19; Dive 53.
0645-0827. HyBIS dive (station JCR253-118-HyBIS-19; Dive 53) to make visual recording of bubble size stream and ascent rate from shallow vent site.
0810. Air sample taken (JCR253-119-Air sample-31).
0828-1118. Transit to and discharge of ship's tanks beyond the 12 M limit.
1119-1346. Three attempts of short barrel gravity and piston coring at shallow flare site (within centre of CTD grid) with gravity core taken at 1132 (station JCR253-120-Gravity core-06) and piston core at 1323 (station JCR253-121-Piston core-11).

1345-1451. Reposition ship and preparation for HyBIS .
1452- 1820. HyBIS dive – 600 m long transect through shallow flare grid (station JCR253-122-HyBIS-20; [Dive 54]). With TV grab sample taken near end of the dive.
1821-1929. Position ship and prepare for CTD cast.
1930-2249. Four CTD stations on 1000 m grid spacing around the 78°34.5138' N, 10°10.4610' E site – stations JCR253-123-CTD-45, JCR253-124-CTD-46; JCR253-125-CTD-47; JCR253-126-CTD-48.
2250-0000. Processing and filtering CTD water samples.

19th August 2011 (JD231).
0000-0124. Processing and filtering CTD water samples.
00125-0435. Four CTD stations on 1000 m grid spacing around the 78°34.5138' N, 10°10.4610' E site – stations JCR253-127-CTD-49, JCR253-128-CTD-50; JCR253-129-CTD-51; JCR253-130-CTD-52.
0436-0555. Processing and filtering CTD water samples.
0556-0621. Preparation for HyBIS dive.
0622-0735. HyBIS dive on shallow flare site (station JCR253-131-HyBIS-21; Dive 55) to recover seafloor samples using TV grab. Sediment sample with reduced sediment, dead bivalve shells and minor live biota recovered.
0832. Air sample taken (JCR253-132-Air sample-32).
0805-0947. HyBIS dive on shallow flare site (station JCR253-133-HyBIS-22; Dive 56) to recover seafloor samples using TV grab. Sediment sample with reduced sediment, dead bivalve shells and minor live biota recovered.
0948-1020. Reposition ship for hydroacoustic survey.
1020-1547. Detailed EM122 and EK60 mapping within the 1 km centred on the shallow flare site at 150 m line spacing – Lines 137-150.
1548-0000. EM122 and EK60 hydroacoustic mapping along southern sector of shallow flare site.

20th August 2011 (JD232).
0000-0700. Transit to Longyearbyen.
0700-0730. Disembark three of science party to shore via small boat and embark one science party onboard.
0730-1730. Transit from Longyearbyen to "pock-mark" site.
1730-0000. EM122 and EK60 hydroacoustic mapping along eastern area of the "pock mark site" along lines 158-169.

21st August 2011 (JD233).
0000-0604. EM122 and EK60 hydroacoustic mapping along eastern area of the "pock mark site" along lines 158-169.
0605-0646. Reposition ship for box and piston coring.
0647-0745. Box core at "pock mark site" (station JCR253-134-Box core-13) recovered black heavily anoxic sediments.
0746-0815. Re-rigging for piston core.
0816-0937. Piston core at "pock mark site" – station JCR253-135-Piston core-12 – with 7 m core recovered of anoxic sediments.
0811. Air sample taken (JCR253-136-Air sample-33).
0938-1213. Splitting and processing of JCR253-135-Piston core-12 looking for hydrate.
1214-1427. Acquisition of four TOPAS lines across pock mark site –three east – west lines and one north – south line; lines 170-173.

1428-1602. Piston core at "pock mark site" – station JCR253-137-Piston core-13 – with 2m core recovered of anoxic sediments.
1603-1712. Processing and splitting of core to find hydrate.
1713-0000. EM122 and EK60 hydroacoustic mapping along eastern area of the "pock mark site" along lines 174-184.

22nd August 2011 (JD234).
0000-0604. EM122 and EK60 hydroacoustic mapping along western area of the "pock mark site" along lines 174-184.
0605-0644. Reposition ship for HyBIS dive.
0645-1112. HyBIS dive (west – east video transect) from the central pock mark depression up eastern flank across zone seismically imaged "fluid escape zone" (station JCR253-138-HyBIS-23 (Dive 57). Carbonate concentrations / deposits and bacterial mats sampled using HyBIS TV grab.
0811. Air sample taken (JCR253-139-Air sample-34).
1112-1218. Push core and bacterial mats sampled from HyBIS grab.
1219-1455. Piston core on eastern rim of "pock mark site" – station JCR253-140-Piston core-14 – with 3m core recovered of anoxic sediments.
1456-1607. Splitting and processing of JCR253-140-Piston core-14 core for assessment to repeat the station.
1608-1720. Acquisition of line 185 north- south line across pock-mark at medium EM122 resolution.
1720-2010. Transit from pock mark site to BOB deployment site – line 186.
2010-2311. Stationary above BOB lander to ensure communications with lander and ascertain BOB active sonar ceases as programmed.
2311-0000. EM122 and EK60 hydroacoustic mapping along northern sector of the shallow flare region along lines 187-196.

23rd August 2011 (JD235).
0000-0530. EM122 and EK60 hydroacoustic mapping along northern sector of the shallow flare region along lines 187-196.
0530-0630. Transit to BOB site for recovery.
0631-0832. Acoustic release and recovery of BOB lander to ship.
0811. Air sample taken (JCR253-141-Air sample-35).
0833-1016. Transit to shallow flare 1 km grid site
1017-1422. Re-occupation of six CTD stations around the 1 km grid – stations JCR253-142-CTD-53, JCR253-143-CTD-54; JCR253-144-CTD-55; JCR253-145-CTD-56; JCR253-146-CTD-57; JCR253-147-CTD-58.
1423-1450. Reposition ship for EM122 and EK60 hydroacoustic mapping along northern sector of the shallow flare region.
1451-0000. EM122 and EK60 hydroacoustic mapping along northern sector along lines 197-219.

24th August 2011 (JD236).
0000-0620. EM122 and EK60 hydroacoustic mapping along northern sector of the shallow flare region along lines 197-219.
0621-0810. Fast speed transit to deeper water and then to the southern sector of the shallow flare region.
0811. Air sample taken (JCR253-148-Air sample-36).
0810-1700. EM122 and EK60 hydroacoustic mapping along southern sector of the shallow

flare region along lines.

25th August 2011 (JD237).
0000-0600. Transit to Longyearbyen (Svalbard).
0700. (0800 Local time). Cruise ends with ship anchored off Longyearbyen with progressive disembarkation of cruise party personnel to shore via small boat during day.

SCIENTIFIC REPORTS

HyBIS Operations and Narrative Report

Prior to the first deployment, there was some trouble getting HyBIS operational when running on the HV system – it worked perfectly when running on its 110 volt deck-lead. Eventually the problem was traced to the input voltage to the step-up transformer. The actual issue seemed to be that the step-down transformer on the HyBIS vehicle was being saturated by too high a voltage, due (we believe) to length of the cable on the MacArtney winch being only ~4,500 metres rather than 9-10,000 metres,of tow-cable that the system was designed. This was because there was not enough "voltage loss" in the shorter cable so that in when "stepped up" there were too many volts arriving at the vehicle and thus saturating the step-down transformer. The answer was to provide an input voltage less than the 244.7 volts that was available from the ships 32 Amp sockets, and this was achieved by using the NMF-supplied clean laboratory container transformer, that produced an output of only 235 volts (230 volts after the step-down on HyBIS). A 32 Amp breaker was purchased in Longyearbyen and fitted to the container domestic supply board.

3 August
Dive#33 JCR253 Test Dive (No Station No.)
This dive was used to (a) ensure that the vehicle was in fact running properly and (b) to purge the air that was in the hydraulic system. The vehicle was configured with the Dyneema rope module attached along with the manipulator arm.

Following pre-dive checks, the vehicle was deployed at 1525 (GMT), and the protocol of stopping at 50m for power-up was followed without incident. The vehicle was lowered to 250m where all systems – lights, thrusters and the manipulator were successfully tested. The vehicle was recovered to 50m, powered-down and then recovered on deck by 1612.

4 August
Dive #34 (JCR253-17-HyBIS01)
To search for the MASOX lander, with Dyneema attached (but the heavy hook removed), two lights and one camera were fully downward looking.

The system was HV deck-tested at 0654 and deployed by 0706. The vehicle was at the seabed (388m) by 0734 and a search pattern begun using the recorded position of the MASOX deployment vessel. We begun by looking to the east and south of the recorded position using the Fusion USBL system for tracking the vehicle location, and having the vessel move in 10-metre steps. The lander was found at 1218, its position recorded, and a video survey of how the recovery strop arrangement was lying on the lander. At 1250 HyBIS recovery was begun, and HyBIS recovered to the deck at 1315. During this deployment the vehicle behaved perfectly and drew ~18 Amps maximum.

5 August
Dive #35 (JCR253-20-HyBIS02)
To recover the MASOX lander, with Dyneema and hook attached, two lights and one camera were (partially) downward looking so we could monitor how the Dyneema unspooled from the storage drum. The hook had a length of ~5mm diameter threaded bar attached at act as a "lead" to put through the master link and then hopefully rotate the master link onto the hook itself.

The vehicle was launched at 0740, and reached the seabed at 0801, with the vessel positioned adjacent to the lander. This first attempt was unsuccessful at hooking the recovery ring which was located almost in the centre of the 82cm-high benthic instrument package. Although contact was made with one of the strops and an attempt made to drag the recovery ring to the side of the lander, the manipulator claw was not strong enough to maintain its hold on the hook T-bar, which was dropped. We had worries about fouling the hook and so it was recovered into the manipulator claw and we decided that we should recover HyBIS and try and rig something that would allow us to "sweep" the recovery rig to one side of the lander to ease the recovery attempt. By 0902 HyBIS was back on deck.

Dive #36 (JCR253-24-HyBIS03)

To recover the MASOX lander, with Dyneema and hook attached, two lights and one camera were (partially) downward looking so we could monitor how the Dyneema unspooled from the storage drum.

The hook was removed from the Dyneema rope to ease the load on the manipulator arm, and a length of wood (~75cm) attached to the manipulator arm to act as a "broom" and hopefully sweep the landing strops and master link to the edge of the lander. HyBIS was launched at 1334 and was at the lander by 1357. After much vehicle manoeuvring and careful driving, the recovery rig was moved so that the master link joining all the lifting strops was in place near to the edge of the lander top. HyBIS was recovered to the deck by 1522 for removal of the wooden "broom" and replacement of the recovery hook.

Dive #37 (JCR253-25-HyBIS04)

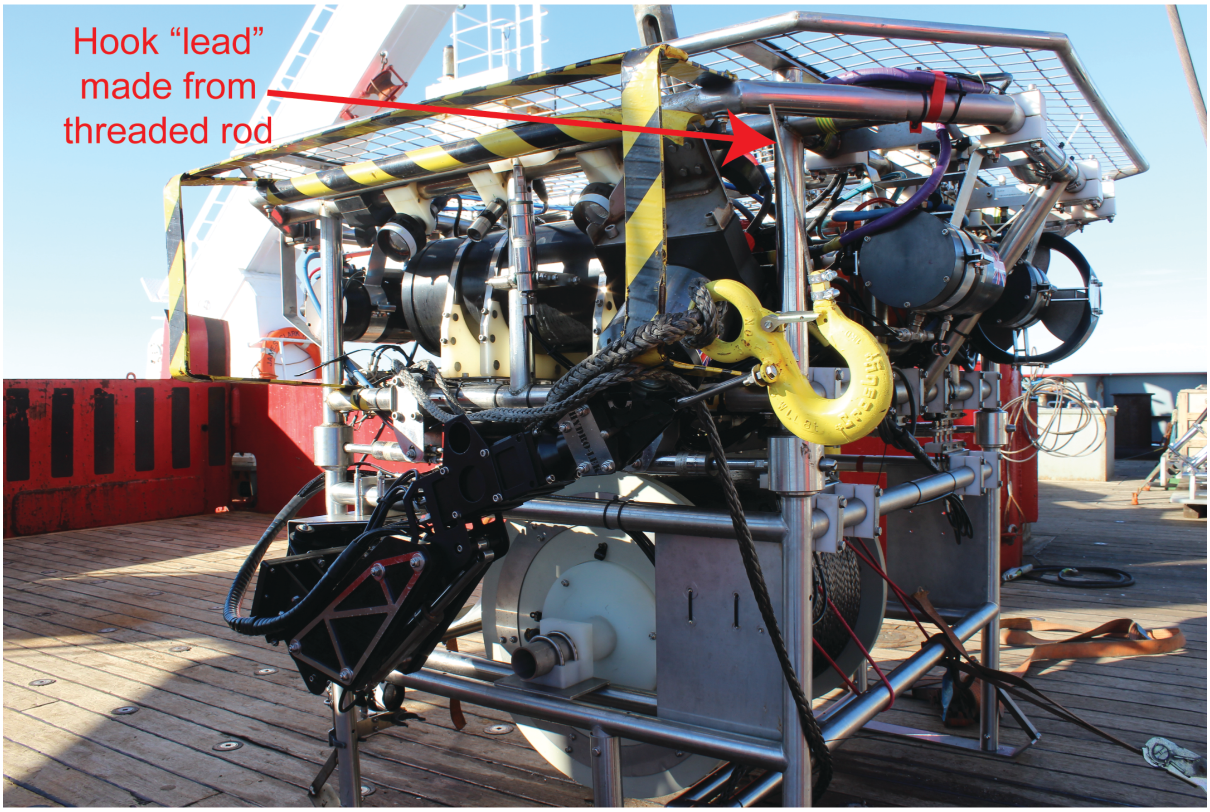
To recover the MASOX lander, with Dyneema and hook attached, two lights and one camera were (partially) downward looking so we could monitor how the Dyneema unspooled from the storage drum.

The lifting hook was re-fitted and the wooden baton removed from the manipulator arm and HyBIS was re-launched at 1539. This attempt to hook –up with the master-link also failed, the threaded bar "lead" became entangled with the master link and the three shackles connecting the strops to the master link. Due to the weight of these shackles and the master link acting as lateral forces against it, the hook's T-bar again became detached from the manipulator claw, so the vehicle was recovered on deck by 1632 for a hook re-set.

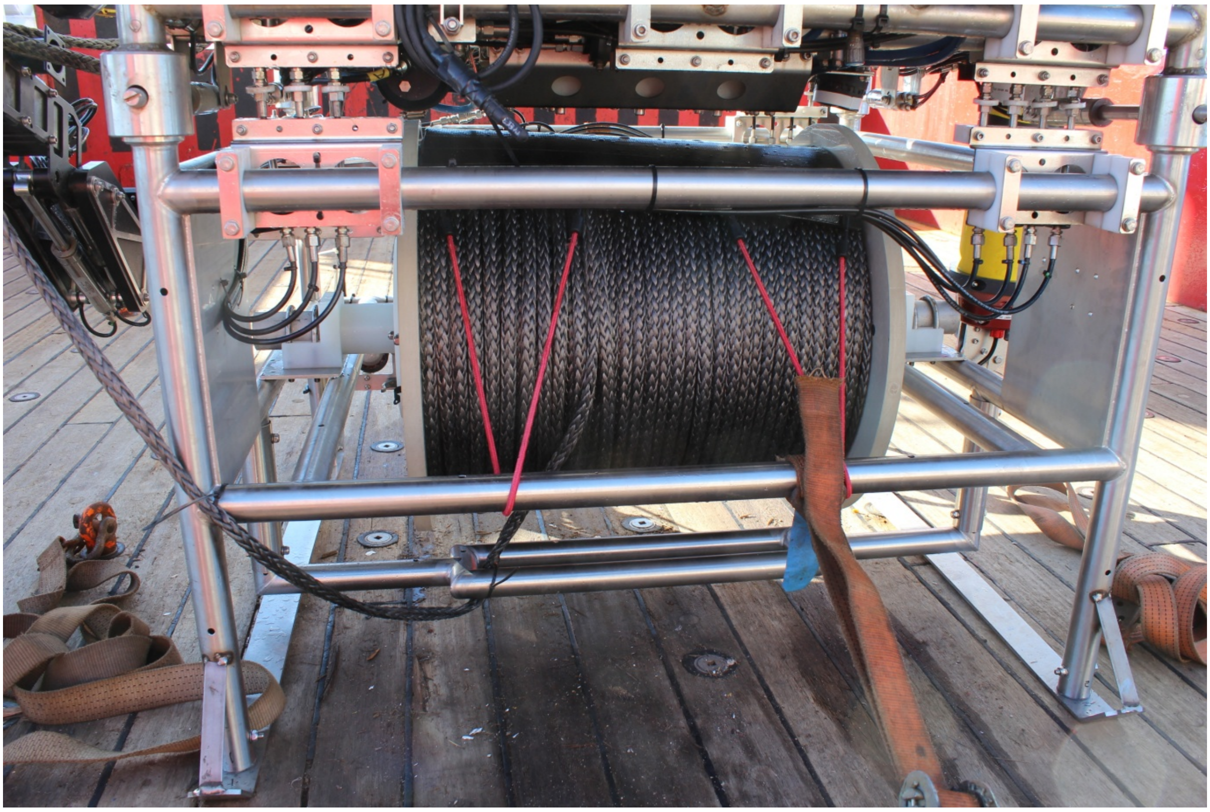
Dive #38 (JCR253-26-HyBIS05)

To recover the MASOX lander, with Dyneema and hook attached, two lights and one camera were (partially) downward looking so we could monitor how the Dyneema unspooled from the storage drum.

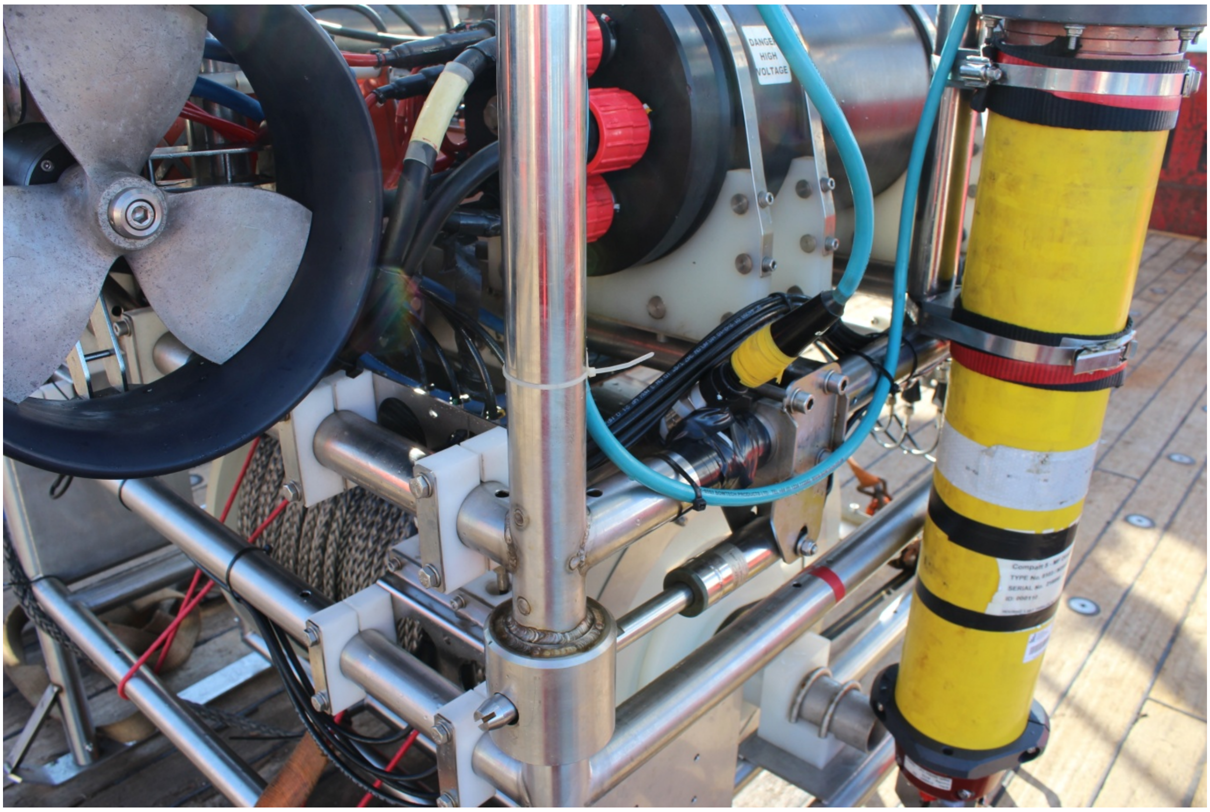
HyBIS was deployed at 1640, and the "lead" was successfully passed through the master link that was then rotated onto the hook and captured. After visual inspection to ensure the master link was captured fully and securely, HyBIS was recovered on deck by 1745, the remaining Dyneema was removed from the vehicle drum and the MASOX lander recovery begun. The vehicle was powered-down as usual at 50m water depth, which meant that the Dyneema rope unfurling final stages of recovery



HyBIS showing the hook with its threaded rod “lead”. Note the Dyneema rope was cable-tied to the manipulator arm to stop it being swept loose during the descent.



The HyBIS Dyneema rope drum module. A plastic flap was secured over the top of the rope to ensure that any potential loose turns would not snag on the vehicle frame (this was blackened with tape to minimise glare).



The rear-mounted camera gave a good view of both the seabed (for landing adjacent to the lander) and the unspooling Dyneema rope.

8 August
Dive #39 (JCR253-35-HyBIS06)
To examine the BOB lander (IFREMER) site and then look for nearby bubble plumes mapped by the on-board acoustic instruments. Vehicle configured with 3 forward lights and one downward on the Dyneema drum module, with the drum detached. The secondary camera was configured as for the Dyneema pay-out on previous dive allowing a forward and downward view (about 45° inboard and downward) . There remained no indication of control of the HD camera through the iMac monitor.

As the vehicle had been detached from the MacArtney winch for the MASOX lander recovery, a HV test was run on-deck prior to deployment to ensure all systems functioning correctly. Deployment was begun at 0711 and HyBIS was at the seabed by 0736. BOB was filmed (for the first time) in-situ, and then a survey carried out to find any bubble streams that had been indicated by acoustics. At 0912 the first bubble streams were imaged. Some time was spent observing these streams, they seemed to originate in areas of seabed that were very dark (possibly due to chemical reduction). At 0940 it was decided to terminate the dive and HyBIS was recovered on board without incident by 0955.

9 August
The HD camera was removed to try to understand why the menus on the LCD screen of the camera do not repeat onto the iMac when the HD camera "remembers" all other settings as programmed after powering off and then re-starting (as it did on Discovery 360 in January). On examining the HD camera it seems that there was some limited HD footage recovered, probably as a result of pushing the "record" button on the HD camera remote

control several times after not seeing any indication on the iMac screen that it was being controlled. Despite reprogramming so that the correct settings indicated by various HD camera icons did appear on the iMac, after power-off, these settings always lost their "mirror" to an external monitor. It was decided that on future dives we would assume that we had control – and would test by using the zoom function – if this worked we would then press the "record" button once, switching off after leaving the seabed, and checking by downloading after every dive.

10 August

Dive #40 (JCR253-46-HyBIS07)

To lay the thermistor string, running (hopefully) westward away from the MASOX lander, and to examine and record the end position of the thermistor string and the surroundings of the MASOX lander.

As the vehicle had been detached from the MacArtney winch for the MASOX lander recovery, a HV test was run on-deck prior to deployment to ensure all systems functioning correctly. The vehicle was configured as per Dive 39, with the addition of a towing hook attached to the lower part of the Dyneema module.

The vehicle was launched at 0658, and was at the seabed and all cameras recording by 0708. Upon arrival at the MASOX lander, it was noted that during its descent to the seabed, the thermistor cable had been floated or otherwise moved due to drag through the seawater and after landing it had fallen back so that 4-5 loops now covered one of the *Seaguard*™ current meters attached to the lander. Also the handling loop that we had carefully positioned to ensure an "easy" pick-up, prior to launch of the MASOX lander had been mostly covered by the thermistor cable. The handling loop was eventually retrieved from the thermistor bundle and dropped to the seafloor adjacent to the lander for pick-up immediately prior to deployment of the cable array. HyBIS was then manoeuvred to the affected *Seaguard*, and after much careful repositioning and manipulation the *Seaguard* was cleared of cable lays. HyBIS was then guided back to the handling loop which was recovered and placed onto the towing hook. HyBIS was hauled in by 30 metres and once there, the vessel was moved 20 metres to the west whilst the MacArtney winch was slowly veered. Once back at the seabed the handling loop was again removed from the HyBIS towing hook and HyBIS used to examine how the remaining thermistor cable lays were hanging on the side of the lander. Once back at the MASOX lander it became clear that as the face(s) holding the thermistor were actually facing ~northeast, so the only realistic method of deployment would be to haul the thermistor vertically and then, as before, move the vessel whilst slowly paying out the MacArtney winch. HyBIS returned to pick up the towing hoop and then continued to haul until it was ~95 metres above the seabed. The vessel was then moved west-northwest and then west for 80m as the MacArtney winch was veered. By careful watching the tensioning and sudden releases on the towing hook on the front of HyBIS we could tell that the cable-tied thermistor string was coming off the side of the MASOX lander as planned. However, by the time the vessel had moved the 80 metres to the west of the lander site, there was sufficient tension on the strain cable of the thermistor string to hold it up in plain view of the HyBIS cameras. Bearing in mind that the thermistor string was attached to the "wrong side" of the lander for a western deployment, and that the supplying organisation has told us that it was only 50 metres in length (during rigging we had realised that that was a grossly inaccurate figure, we estimated somewhere closer to 100 metres would have been more accurate) we decided that this was probably far enough. As the vessel moved at 0.1 knots HyBIS was lowered to the seabed whilst paying out at ~3 metres per minute. Once at the seabed we released the strain rope from the towing hoop and made a film transect along the thermistor cable back to the MASOX lander. Once at the lander we found that there were still 7-8 turns rigged to the side of the lander (~20 metres) that included two of the thermistors. It was decided to leave the deployment as it was. HyBIS was recovered aboard by 1207 and the towing hook removed.

Dive #41 (JCR253-48-HyBIS08)
This was to be a "discovery" dive on a venting plume (as mapped by the vessel acoustic suite).

HyBIS launched at 1303 and was at the seabed by 1319. There were no active plumes seen, though patches of possible bacterial mats were evident. HyBIS recovered at 1440.

11 August
Dive #42 (JCR253-52-HyBIS09)
This was to be a "discovery" dive on a venting plume (as mapped by the vessel acoustic suite).

HyBIS was launched at 0829 and upon descent to the seabed it became clear that conditions were marginal and it would not be possible to get good images of any bubbles should we find the plume. The dive was aborted and HyBIS recovered on deck at 0952.

12 August
Dive #43 (JCR253-58-HyBIS10)
Discovery dive on strongly venting plume site.

HyBIS was deployed at 1036 and recording stared at 1048. Many bubble plumes were imaged and a large lump of what appears to be carbonate crust was collected using the manipulator arm, despite being attacked by a wolf-fish! Upon recovery it was noted that neither of the downward lights were working, and the fault was traced to the connector if the single downward light that illuminates the bucket/basket area being undone. The female plug connector had "fizzed" and some of the rubber surround had melted. We tested the bulbs on the "forward" light circuit and they were OK, but the downward circuit is U/S. Rather than break open the pressure tube though, as we can operate with one circuit and lighting is (just about) adequate, we have decided to continue and use the third light connector of that lighting bundle, and to move the light to where it is most needed, either extra forward or downward. We also decide to replace the now-empty Dyneema lower module, as the front legs were very bent and there is potential for collapse on the seabed and we could damage the manipulator arm. The sample try module was connected up.

13 August
Dive #44 (JCR253-63-HyBIS11)
To image the strongly venting plume site with a graduated backdrop and try and get a quantitative gas flux measurement.

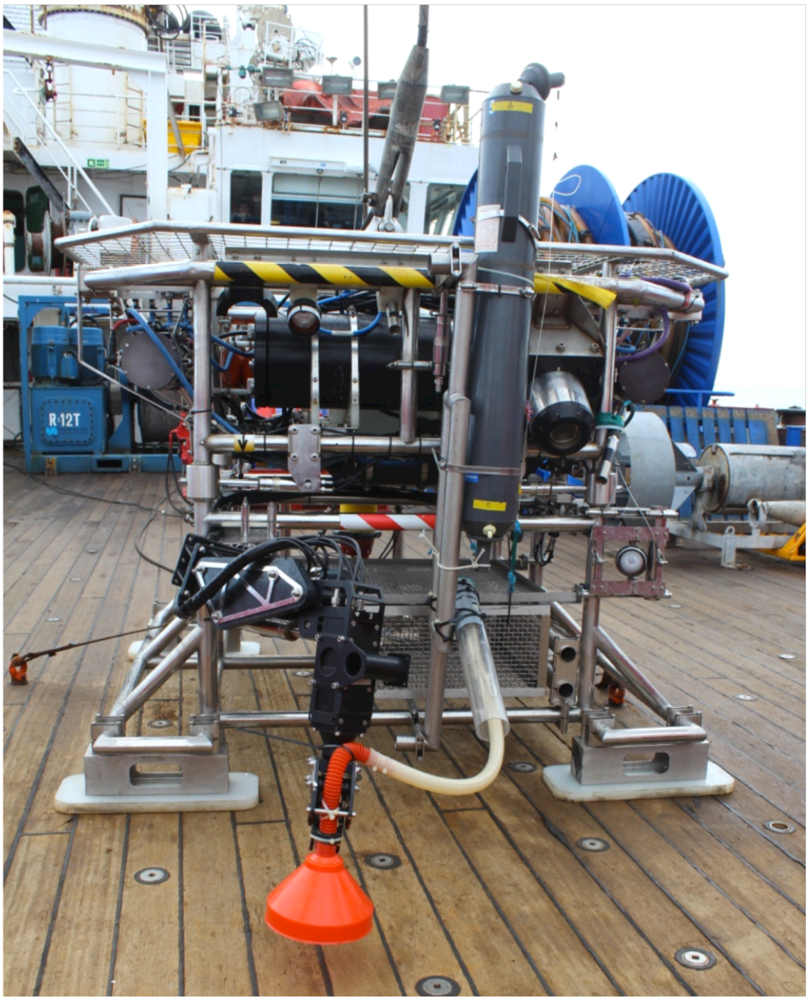
During the night there was an electrical power failure in the laboratory and the smaller iMac died. For this dive, the Principal Scientists' iBook was used as a vehicle to get the image data onto the external drive through iMovie. There were no spares or bootable discs in the HyBIS boxes! After testing the new hydraulic and lighting set-up on the sampling module, and directly bolting the "measuring board" to the manipulator arm, HyBIS was deployed at

1238 and recording stared at 1248. It proved difficult to position HyBIS precisely, but we did manage to image bubble streams against the graduated backdrop, albeit not with the HD camera. We did however mange to get some HD video of bubble streams. HyBIS was back on deck at 1423.

14 August
Dive #45 (JCR253-75-HyBIS12)
To try and sample, using a Niskin bottle attached to HyBIS water with gas bubbles from a plume site.

Prior to this dive the BAS computing technician had successfully installed a new 200GB hard drive into the IMac that had failed during the power-failure. He had also produced a start-up/boot disk and managed to clone the existing iMac, so we could log imagery using our own computers again. Doug Willis should be highly commended for this.

A Niskin bottle was attached to HyBIS (see picture below) with an inverted funnel and tube to try and catch methane bubbles venting from the seabed. The Niskin bottle was fired by using the sample tray action, with first the top cap being closed and then with a permanent halyard between the bottom Niskin cap and the sample tray, the bottle could be opened and closed over various closely-spaced bubble vents. With the second light circuit U/S, we decided to place all three lights facing forward, with the "moveable" lamp placed low on the vehicle's port side.



Hybis was deployed at 1438 and at the seabed by 1510. The funnel was opened to hopefully capture methane in the Niskin bottle for an hour (1539-1639), although precise location of the funnel arrangement was difficult with the camera placement. When ascending (at 10 m min^{-1}) following bottle closure at the end of the dive bubbles were observed escaping from the top of the funnel where it was attached to the pipe. HyBIS was recovered to the deck by 1715 where water samples were collected for analysis.

15 August

Dive #46 (JCR253-79-HyBIS13)

To try and sample, using a Niskin bottle attached to HyBIS water with gas bubbles from a plume site.

The lower camera from Dive 45 was moved to give a downward view onto the funnel capture equipment ~1 metre in front of the vehicle in the hope of better positioning above the seafloor vents. HyBIS was deployed at 1036, but there were no gas bubbles seen in the area of the predicted gas flare, nor within a radius of approximately 25 metres of the predicted site. There was a re-visit to the BOB and MASOX lander sites, which now appeared to be 7-8 metres SSE of their previously logged positions. HyBIS was recovered to the deck by 1230.

Dive #47 (JCR253-80-HyBIS14)

To try and sample, using a Niskin bottle attached to HyBIS water with gas bubbles from a shallow water (80m) plume site.

HyBIS was launched at 1407, and similar to the above site no evidence of bubble plumes was observed. Visibility was restricted by a large amount of biogenic material in the water, and as above the dive was terminated early without capture of any Methane. HyBIS was recovered by 1523.

16 August

Dive #48 (JCR253-92-HyBIS15)

To try and sample, using a Niskin bottle attached to HyBIS water with gas bubbles from a shallow water (90m) plume site.

HyBIS was deployed at 0612 and at the seabed by 0621. Gas was observed at several locations (within a small (50m) area, and the funnel was placed over flumes and gas apparently captured – there was not a good camera angle to see bubbles actually entering the Niskin bottle. The bottle was closed (by use of the sample tray) at 0912, and HyBIS was recovered by 0925.

Upon recovery there was a large kink in the armoured cable, possibly due to torque. As there was still a good signal from the fibre, this was rectified by removing the bent armoured layers and moving the Evagrip termination along the cable to an undamaged section. There "extra" un-armoured section of cable (~2 m) was then coiled on the top of the vehicle cage.

17 August

Dive #49 (JCR253-105-HyBIS16A)

To try and sample, using a Niskin bottle attached to HyBIS water with gas bubbles from a shallow water (90m) plume site.

This was a repeat of the above dive technique, with HyBIS deployed at 0622, the top of the bottle closed at 0734 and the bottom closed (after gas collection) at 0834. The vehicle was back on deck at 0849.

Once again there was a twist in the cable armour strands and this was rectified by moving the Evagrip and laying the newly bared conductor on the top of the vehicle.

Dive #50 (JCR253-107-HyBIS16B)

To try and sample, using a Niskin bottle attached to HyBIS water with gas bubbles from a shallow water (85m) plume site.

HyBIS was deployed at 1310 and gas bubbles were noted on the descent, but the hose was accidentally pulled from the inverted funnel, so the vehicle was recovered to teh deck for repair by 1403.

Dive #51 (JCR253-108-HyBIS17)

This was a repeat of the above dive, to try and sample, using a Niskin bottle attached to HyBIS water with gas bubbles from a shallow water (85m) plume site.

HyBIS was launched at 1410 and at the seabed by 1423, with the bottle top fired and gas collection started at 1437. The bottle was closed at 1508 and the vehicle was recovered, however with the new camera mount (looking vertically down over the collection point in front of the vehicle), it was noted that bubbles were escaping from the Niskin bottle during the ascent, and rising at ~ 15 m min^{-1}. Once HyBIS was recovered at 1519, it was evident that the top of the Niskin bottle had not closed properly.

Dive #52 (JCR253-109-HyBIS89)

This was a repeat of the above dive, to try and sample, using a Niskin bottle attached to HyBIS water with gas bubbles from a shallow water (85m) plume site.

HyBIS was launched at 1530, and a suitable bubble plume found and gas collection started by 1659 (it seems that the accuracy of the GPS-USBL was ~8-10m). The bottle was closed at 1759 HyBIS was back on deck by 1820.

18 August

Dive #53 (JCR253-118-HyBIS19)

This dive was to image the bubble streams against a graduated board for quantitative studies. The board was this time attached to the sample tray and the “downward” camera held by the HyBIS manipulator arm.

HyBIS was launched at 0645 and recorded bubble streams for ~ 80 minutes. The vehicle was recovered by 0827.

Dive #54 (JCR253-122-HyBIS20)
This dive was to undertake a video transect, and the hydraulic bucket module was fitted to also take a sample if a suitable area was imaged.

HyBIS was launched at 1451 and at the seabed by 1504. The seabed was mostly boulders with very small patches of possibly rippled sediment. Benthic animal life seemed sparse and visibility was poor due to material in the water column. A grab was taken at 1812, and the vehicle was recovered by 1820.

19 August
Dive #55 (JCR253-131-HyBIS21)
This dive was to undertake a video transect, and the hydraulic bucket module was fitted to also take a sample if a suitable area was imaged.

HyBIS was launched at 0622 and at the seabed by 0635. The seabed was mostly cobbles and boulders with almost no areas of bare sediment. A grab was made at 0720 and the vehicle recovered by 0735. Sediment showed signs of authigenic carbonate deposition.

Dive #56 (JCR253-133-HyBIS22)
This dive was to undertake another video transect, and the hydraulic bucket module was fitted to also take a sample if a suitable area was imaged.

HyBIS was launched at 0805 and at the seabed by 0811. The seabed was mostly cobbles and boulders with almost no areas of bare sediment. A grab was made at 0853 and the vehicle recovered by 0904. Once again the sandy sediment showed signs of authigenic carbonate deposition.

22 August
Dive #57 (JCR253-138-HyBIS23)
This dive was to undertake a video transect inside a pockmark, and the hydraulic bucket module was fitted to also take a sample if a suitable area was imaged.

The seabed was largely burrowed light brown mud and/or fine sand, with dropstones, and in places white areas that could well be carbonate crusts and/or biogenic mats. The HyBIS grab sample was taken on one of the areas that showed white crusts at the surface. The sediments were a mixture of biogenic mats and hard carbonate nodules within a largely sandy matrix.

Other Notes
The data (imagery) recording systems of HyBIS produced in excess of 1.3TB of digital data that were stored on external had disc drives. However we also decided that we should have a back-up of this data stored on the ships computer system (especially after the failure of one of the iMac hard drives). The sheer volume of data made backing-up over the network a very long and tedious process, with some data files taking longer to copy than they did to actually collect.

Sediment Coring and Geochemistry (Rachael James NOC)

Systematic sampling of marine sediments was undertaken in order to help to parameterise the seafloor processes that affect levels of methane released in to the Arctic environment. Methane released from hydrates undergoes biogeochemical transformations in the sediments: the methane that dissolves in sediment pore waters undergoes a complex series of reactions, which are to a large part governed by the microbial process of anaerobic oxidation of methane (AOM):

$$CH_4 + SO_4^{2-} \rightarrow HCO_3^- + HS^- + H_2O \text{ (Eq. 1)}$$

AOM is interpreted to be mediated by a syntrophic consortium of methanotrophic archaea and sulphate-reducing bacteria. Although this process is widely considered to be energetically unfavourable, AOM may facilitate the build-up of an enormous microbial biomass in environments with high methane fluxes, such that the emission of methane across the sediment-seawater interface is suppressed, and methane is ultimately buried in the sediments as authigenic carbonate ($CaCO_3$):

$$Ca^{2+} + 2HCO_3^- \rightarrow CaCO_3 \text{ (s)} + CO_2 + H_2O \text{ (Eq. 2)}$$

However, the methane that remains in gas bubbles (and does not dissolve) is inaccessible to methanotrophic organisms, and may be released into the water column. Thus, another important objective of our coring programme was to quantify the proportion of methane present in the dissolved phase, and as free gas. By sampling of sediments up-slope of the present-day gas hydrate stability zone, we also sought to obtain evidence for migration of the gas hydrate stability zone in recent times, as recorded by the presence of authigenic carbonate phases (Eq. 2).

Sampling

A total of 13 box cores, 6 gravity cores and 14 piston cores succeeded in recovering marine sediments. A number of other cores were attempted; however, it proved very difficult to recover sediments both to the north of the survey area, and at shallower sites, because of the presence of glacigenic dropstones, gravels and sands.

Core material was successfully obtained for two full transects (Transects 2 and 3), from 'shallow' to 'deep' water depths across the continental slope (including the MASOX lander and BOB sites), as well as the deeper pockmark site. Some core material was also recovered from the shallow flare sites, at ~90m water depth. Seafloor sediments were also recovered using the HyBIS grab system; sub-samples of this material were collected via a push core. A summary of the material recovered is given in Table 1.

Box cores and push cores were sampled by extrusion at intervals of 2-3 cm. Gravity and piston cores were cut into sections of ~50cm in length and then split lengthways. Samples were taken at intervals from one half of the core; the other half was archived. Sediment sampling was done under a nitrogen atmosphere in a glove bag; porefluids were extracted by centrifugation, also under a nitrogen atmosphere.

Analyses

Analyses of porefluid pH, alkalinity and ammonia concentration, and headspace concentrations of methane and higher (C2-C6) hydrocarbons) were made onboard ship. Porefluids were sub-sampled for analyses of anions, cations, nutrients and hydrogen sulphide, and, if enough porefluid was obtained, for analyses of stable isotopes and dissolved inorganic carbon, back onshore. A number of samples were also taken for stable isotope analysis of headspace hydrocarbons, back at the NOC. Finally, sub-samples of the sediment were taken for the analysis of various sediment properties (porosity, grain size, etc).

Where found, samples of authigenic carbonate phases were retained. These will be analysed back onshore to confirm their relationship to methane seepage. We also intend to undertake ^{14}C (or U-series) dating of this material (onshore) to provide crucial information on the rate of retreat of the gas hydrate stability zone.

Core	Type	Date	Time	Lat	Long	Site	Water depth	Core length
			GMT	N	E		m	cm
JR253-15-BC01	box	03/08/2011	09:27	78.5462	9.35748	Transect 3 deep	457	16
JR253-16-PC01	piston	03/08/2011	13:19	78.5461	9.35663	Transect 3 deep	458	379
JR253-19-BC02	box	04/08/2011	14:20	78.5549	9.47606	Transect 3 Lander Site	381	0
JR253-19-PC02	piston	04/08/2011	15:33	78.5549	9.47621	Transect 3 Lander Site	384	92
JR253-22-BC03	box	05/08/2011	10:38	78.5602	9.55178	Transect 3 shallow	311	0
JR253-23-PC03	piston	05/08/2011	12:07	78.5602	9.55167	Transect 3 shallow	313	32
JR253-26-BC04	box	06/08/2011	07:06	78.559	9.53487	Transect 3 shallow	340	10.5
JR253-27-GC01	gravity	06/08/2011	08:16	78.559	9.53487	Transect 3 shallow	340	209
JR253-29-BC05	box	07/08/2011	07:14	78.5763	9.29066	Transect 2 deep	457	12
JR253-31-GC02	gravity	07/08/2011	08:20	78.5763	9.29078	Transect 2 deep	454	360
JR253-43-BC06	box	09/08/2011	13:05	78.5917	9.38312	Transect 2 deep flare site	407	0
JR253-44-BC07	box	09/08/2011	13:40	78.5917	9.38307	Transect 2 deep flare site	407	0
JR253-45-PC04	piston	09/08/2011	14:44	78.5917	9.38328	Transect 2 deep flare site	407	343
JR253-49-BC08	box	10/08/2011	15:41	78.5987	9.44384	Transect 2 375m site	375	9.5
JR253-50-PC05	piston	10/08/2011	16:39	78.5988	9.44391	Transect 2 375m site	374	351
JR253-53-PC06	piston	11/08/2011	12:43	78.6111	9.42555	Transect 2 flare site	374	224
JR253-60-BC09	box	13/08/2011	06:44	78.5985	9.48501	Transect 2 shallow	323	0
JR253-61-PC07	piston	13/08/2011	07:43	78.5985	9.48507	Transect 2 shallow	323	137
JR253-64-BC10	box	13/08/2011	15:29	78.6177	9.42273	Transect 1 370m flare site	371	0
JR253-69-BC11	box	14/08/2011	07:30	78.6373	9.44131	Transect 1 shallow flare site	217	0
JR-253-70-PC08	piston	14/08/2011	08:09	78.6374	9.44143	Transect 1 shallow flare site	217	20
JR-253-72-PC09	piston	14/08/2011	09:45	78.6373	9.44127	Transect 1 shallow flare site	218	20
JR253-73-BC-12	box	14/08/2011	11:43	78.6177	9.3027	Transect 1 deep	440	15
JR253-74-PC10	piston	14/08/2011	12:50	78.6177	9.30238	Transect 1 deep	441	core catcher
JR253-78-GC03	gravity	15/08/2011	09:20	78.5549	9.47742	Transect 3 BOB flare site	386	162
JR253-94-GC04	gravity	16/08/2011	14:08	78.575	10.175	Shallow flare site	87	18; core cutter
JR253-95-GC05	gravity	16/08/2011	14:48	78.575	10.1741	Shallow flare site	88	core cutter
JR253-120-GC06	gravity	18/08/2011	11:32	78.5759	10.1751	Shallow flare site	86	25.5; core cutter
JR253-121-PC11	piston	18/08/2011	13:24	78.575	10.175	Shallow flare site	87	core cutter
JR253-134-BC13	box	21/08/2011	07:23	78.6845	8.27296	Pockmark site	886	16.5
JR253-135-PC12	piston	21/08/2011	08:55	78.6845	8.27298	Pockmark site	885	613.5
JR253-137-PC13	piston	21/08/2011	15:10	78.685	8.27882	Pockmark site	881	234
JR253-138-HyBIS23	push	22/08/2011	09:50	78.6859	8.27855	Pockmark site	880	14
JR253-140-PC14	piston	22/08/2011	14:55	78.6856	8.27934	Pockmark site	880	350

Table 1: Summary of core material obtained on JR253.

Preliminary observations

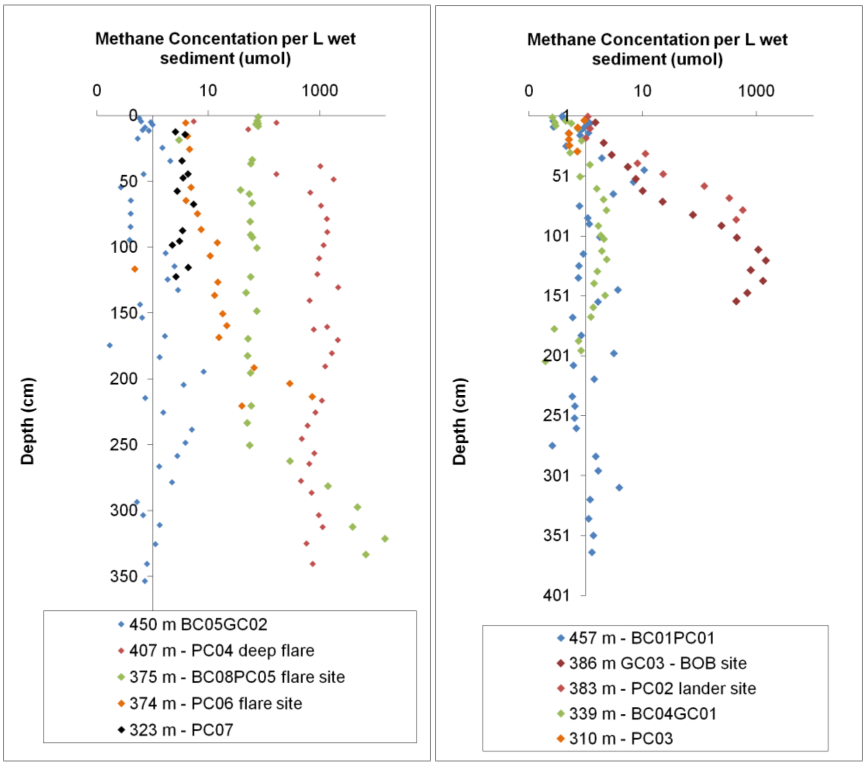


Fig. 1: Profiles of headspace methane concentration in sediments recovered from offshore western Svalbard. Left hand side shows Transect 2; right hand side shows Transect 3.

Measurements of headspace methane concentrations in sediments recovered from both Transect 2 and Transect 3 show little evidence for migration of methane through sediments at water depths either shallower or deeper than the modern-day gas hydrate stability zone. However, at the depth of the modern-day gas hydrate stability zone (~380m), and at the deeper flare site (~410m, Transect 2), concentrations of methane reach up to 2200 mmol/L. The proportion of ethane and other higher hydrocarbons relative to methane is always <0.1%.

Air Sampling (Royal Holloway, University of London)

Air samples were collected from the Bridge of RRS *James Clark Ross* at 12-hourly intervals during the passage from Glasgow to Longyearbyen and daily during cruises JR253 and JR269. Air samples were also collected daily at the Zeppelin monitoring station on Svalbard, during cruises JR253 and JR269, by Norwegian colleagues. Additional samples were collected from the shallow flare areas, either from the Bridge or close to the sea surface from a small boat. A further suite of samples will be collected at 12-hourly intervals during the passage back from Longyearbyen to Immingham (UK).

All of these air samples will be analysed for methane concentration ('mixing ratio') and $\delta^{13}C\text{-}CH_4$ by Dave Lowry/ Rebecca Fisher at Royal Holloway, University of London. Crucially, RHUL has developed continuous flow GC-IRMS instrumentation to allow automated, high precision (±0.05 ‰ external reproducibility) measurements at low concentration in ambient air. Comparison of samples collected from the ship, with samples collected at Zeppelin, will establish whether areas affected by bubble plumes emit methane to the atmosphere.

MASOX Observatory Data – Benedicte Ferre (University of Tromso)

Instrument Configuration

The MASOX lander was initially deployed in October 2010 by the RV Jan Mayen with its first recovery and servicing undertaken during JCR 253. Two Seaguard RCMs were moored in opposite sides inside MASOX lander. One recorded for 4 months and the other recorded during the initial 10-month deployment. However, the one recording for 4 month had inaccurate data, probably due to compass problems. This report focuses on the second one, (a RCM IW - serial number 194). This RCM includes several sensors, including current speed and direction, temperature, conductivity, pressure, turbidity and oxygen sensors.

Data

Temperature is measured by a thermistor fitted into a stud on the top end-plate which extends into the water. Conductivity is measured by an electrodeless induction type conductivity sensor and turbidity is measured by use of back-scattered infra-red light. The instrument depth is calculated from pressure measurements taken by a piezoresistive bridge. The current speed and direction are measured by the RCM Doppler Current Sensor, in an area from 0.4 to 2.2 meters from the instrument. The measurements are compensated for tilt, and referred to magnetic North by means of an internal Hall-effect compass. A microprocessor computes vector averaged speed and direction over the last sampling interval, 15min here. Current sensor took measurement 1.4m above the seabed, and all other parameters were measured 1.15 meters above the seabed. Salinity was calculated from conductivity, temperature and pressure and using 1978 Practical Salinity Scale (IEEE Journal of Ocean Engineering, Vol. OE-5, No. 1, January 1980, page 14.).

Results

Time series

The current is mainly north-westward during the entire period with some south-westward events until mid-march and stronger south-eastward events becoming more consistent from the end of May (Fig. 1a). Current amplitude has a median of ~10cm/s with a median direction of ~33°N, is higher in the beginning of February and April, and lower from the end of May (Fig.1b), and the pressure indicates that the largest constituent is the semidiurnal principal lunar tide (M2), which has a period of 12.42 and maximum amplitude of ~1.7m (Fig. 1c). The other large semidiurnal constituent is the principal solar S2 tide, which has a period of 12.00 hours. Annual median temperature is 3 ± 0.63°C and varies from 0.6 to 4.2°C (Fig. 1d). Temperature increases by ~1°C from the beginning of the experiment (~3°C in October 2010) until the beginning of December 2010 (up to 4°C) and decreases regularly by 1°C until the end of January 2011.

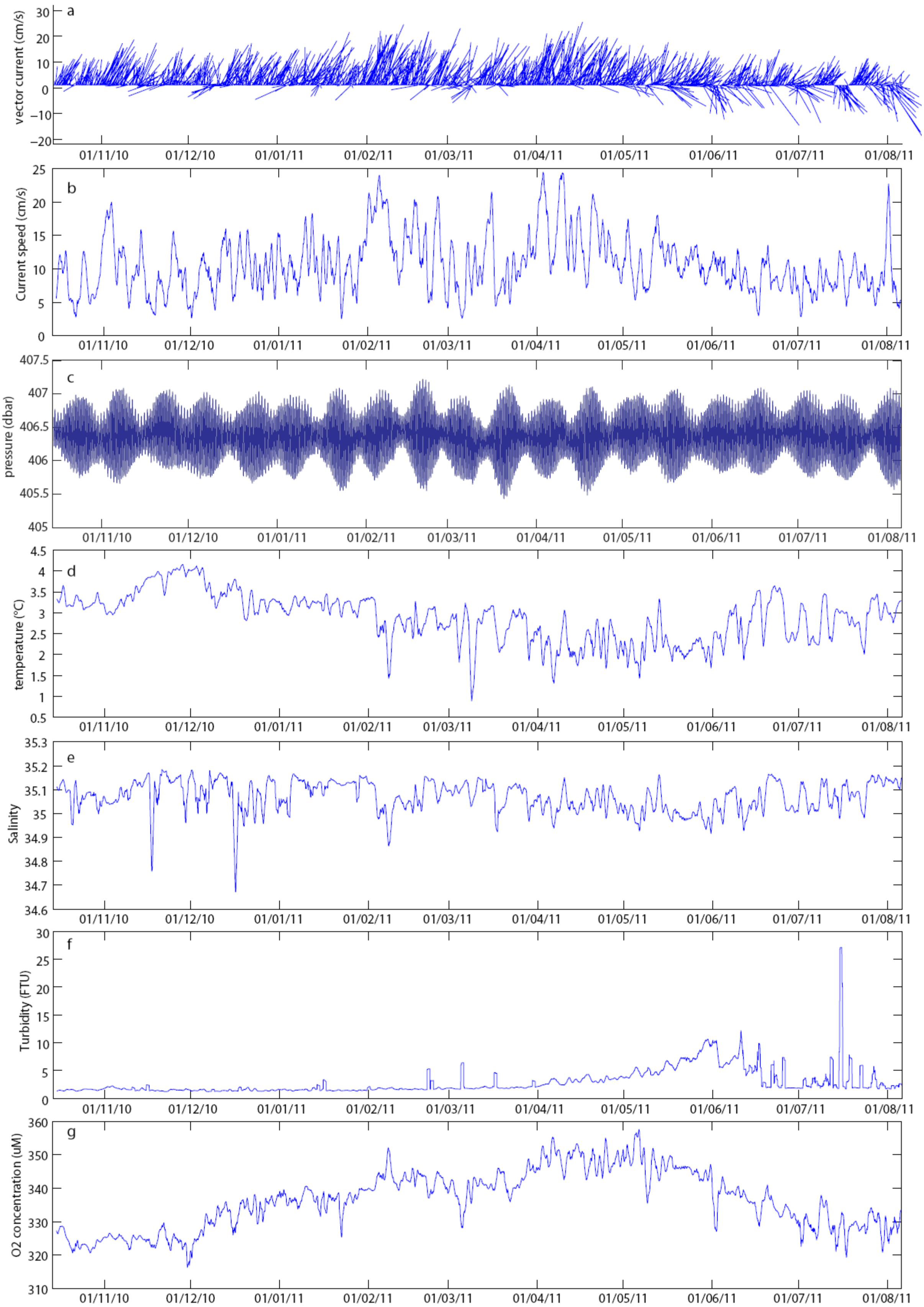


Fig. 1 a) Current vectors; graphs b to g are running mean over 12h for b) current amplitude c) pressure d) temperature e) salinity f) turbidity and g) O2 concentration.

Temperature signal is highly variable after January 2011 but continues decreasing until the end of March 2011, reaching temperatures of ~1°C. The trend shows a monotonous signal (~2°C in average) until the end of May 2011 and a regular increase until MASOX was recovered in the beginning of August 2011 (~3°C). Median salinity during the experiment is 35.09 ± 0.09 PSU and varies from 33.34 to 35.20 PSU (Fig. 1e). The signal is highly variable in this range. Turbidity has a median of 1.8 ± 8.11 Formazin Turbidity Unit (FTU). It is low until the beginning of April (~1.2FTU) when it increases regularly up to 15 FTU until the end of May (Fig. 1f shows the running mean signal), and then decreases by steps with a spike in mid-July. A few other spikes are observed in mid-January, end of March, beginning and mid of March, and a maximum in mid-July that seem to correspond to intrusions of south current (Fig. 1a). However, the regular increase from April to June might be explained by the sinking of biological material to the bottom after the bloom in spring.

Oxygen concentration has a median of 337.5 ± 9.9 µM (Fig. 1g). It shows an increase from the beginning of the experiment in October 2010 ($O2$~320uM) until the end of April ($O2$~355uM), followed by a regular decrease until MASOX was recovered in August 2011 ($O2$~330uM). This trend could confirm the increase of biological material, as they consume oxygen.

Water masses variation

T-S diagram allows a more general view of the different water masses present in the water column during the 10-month experiment (Fig. 2). The main component of the water mass around MASOX and present all year round is the North Atlantic Water (NAW), carried by West Spitsbergen Current and with temperature > 2°C and salinity > 35 (e.g. Schlichthotz and Goszczko, 2006). The other water masses result from a mixing between NAW and Arctic Intermediate Water (AIW, temperature < 2°C and salinity < 34.9, Skogseth et al. 2005), East Spitsbergen Water (ESW, temperature between -1 and 0.5°C and salinity between 34.8 and 34.9, Skogseth et al. 2005), Upper Norwegian Deep Water (uNwDW, temperature ~ -0.5°C and salinity ~ 34.92, Hopkins, 1991) and Norwegian Shelf Water (NShW, temperature between 2 and 13°C, salinity between 32 and 35, Hopkins, 1991). These water masses are not permanent during the experiment. Arctic Intermediate Water is only observed in the beginning of February, when currents are strongly northward. This water is likely to be transported from the Icelandic Current. East Spitsbergen Water, transported with the East Spitsbergen Current, starts to appear in the end of March and persist until mid-May. A short intrusion of uNwDW is observed in the beginning of March that can be explained by late deep reaching convection due to ice formation and brine water induced. This delayed intrusion of brine water could be due to fresh surface water caused by river run-off or ice-melt during summer (Backhaus et al., 1997). Cold and fresh NShW is mainly observed from October 2010 to January 2011 and in June and July 2011 and is likely due to river run-off or ice melting.

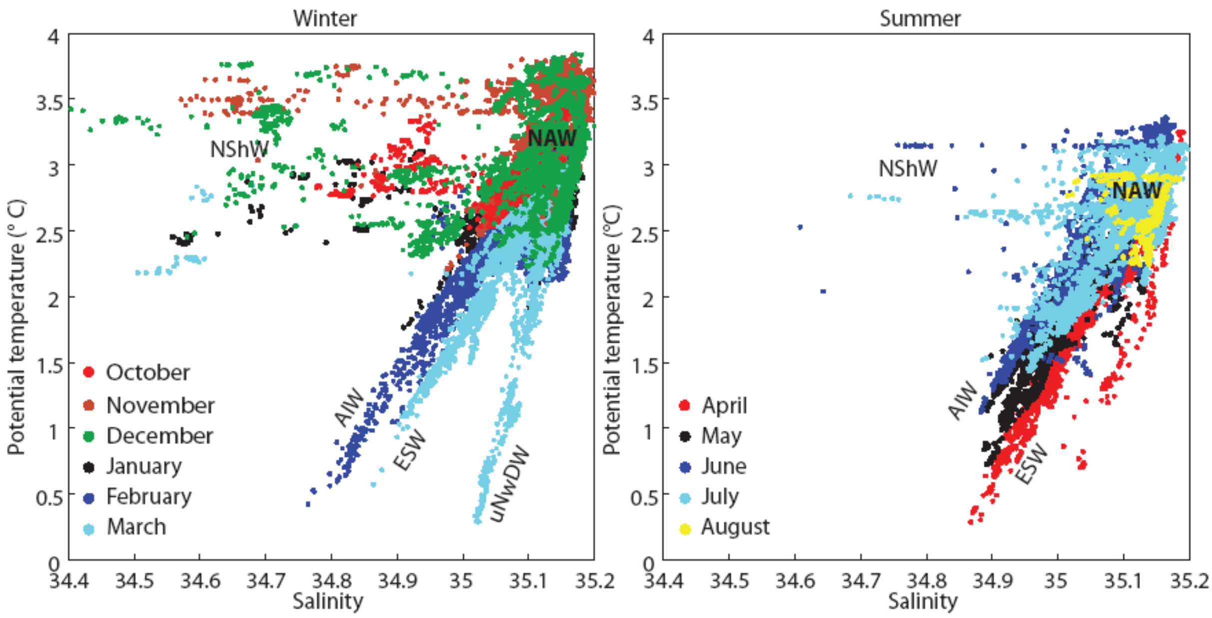


Fig. 3 T-S diagram for winter months (October 2010-March 2011) and summer months (April 2010-August 2010). No measurements were made in September. Acronyms are NAW (North Atlantic Water), NShW (Norwegian Shelf water), ESW (East Spitsbergen Water), AIW (Arctic Intermediate Water) and uNwDW (Upper Norwegian Deep Water)

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Water-column CTD Operations

The CTD system comprised of the following equipment:
Seabird 911+ CTD with dual pumped temperature and conductivity sensor pairs; a Seabird SBE43 dissolved oxygen sensor; Seabird SBE32 carousel with twenty-three OTE, internally sprung, ten litre water bottles; Chelsea Instruments Alphatracka (transmissometer) and Aquatracka (fluorometer); a Benthos 916T altimeter; an IOS 10 KHz pinger Sonardyne location beacon; Seatech LSS back-scatter sensor and a Wet-Labs BBRTD.

CTD operations were generally vertical deployments on all casts. The first set of CTD's were deployed over the gas flares along the 3 transects of the study; Transect 1, 2 and 3. On the discovery of the shallow flare sites a more in depth study involving a grid of vertical CTD's around the largest of the new flares was undertaken. Fixed depths of surface, 10m, 50m and close to bottom, within 3 m weather and ship heave permitting. The samples from these CTD's were analysed for dissolved methane on board (see below), it was noted that some were anomalously low. Investigation of the water mass properties recorded by the CTD revealed that some samples were taken in different water masses along the 50m depth. To correct for this 6 sites were re-occupied and successfully sampled. The full CTD station list and sampling metric can be seen in Appendix 1.

Initial Processing Using SeaBird

The files output by Seasave (Version 7) have the appendices: .hex, .HDR, .bl, .CON. The .CON files for each cast contain the calibration coefficients for the instrument. The .HDR files contain the information in the header of each cast file. The .hex files are the data files for each cast and are in hex format. The .bl files contain information on bottle firings of the rosette.

Initial data processing was performed on a PC using the Seabird processing software SBE Data Processing, Version 7. We used the following options in the given order:

Data Conversion - turns the raw data into physical units. It takes the .CON files and .hex files. The input files were named jc044_NNN.hex where NNN refers to the three-digit station number.

Align CTD - takes the .cnv file and applies a temporal shift to align the sensor readings. The offsets applied were zero for the primary and secondary temperature and conductivity sensors as the CTD deck unit automatically applies the conductivity lag to the conductivity sensors. An offset of 5 was applied to the oxygen sensor.

Cell Thermal Mass - takes the .cnv files output from Align CTD and makes corrections for the thermal mass of the cell, in an attempt to minimize salinity spiking in steep vertical gradients due to a temperature/conductivity mismatch. The constants applied were; thermal anomaly amplitude α= 0.03; thermal anomaly time constant $1/\beta$= 7.

Methane analysis

The first samples to be drawn from the Niskin bottles were for methane. These samples were collected in 500 ml triple layer parenteral bags. These bags have been designed for the medical industry and are low permeability with regard to low molecular weight gases. The samples were taken to the laboratory where 20ml of UHP nitrogen was added and the bags were left to equilibrate as they warmed to room temperature, and they were vigorously shaken. If the samples were to be left for any length of time they were poisoned by the addition of 100µl of a saturated solution of mercuric chloride. A sample of the headspace gas was taken from each bag and analysed using a 7850 Agilent Gas Chromatograph. The7850 system on board had an FID (Flame ionisation detector) for C1-C6 detection. Standards were run using either a 20 ppm methane standard or a 100 ppm standard of mixed C1-C6 compounds.

Raman Scattering - Anna Kolomijeca (TU-Berlin)

Raman Theory

Raman scattering is a powerful light scattering technique used to diagnose the internal structure of molecules and crystals. In a light scattering experiment, light of a known frequency and polarization is scattered from a sample. The scattered light is then analyzed for frequency and polarization. Raman scattered light is frequency-shifted with respect to the excitation frequency, but the magnitude of the shift is independent of the excitation frequency. This "Raman shift" is therefore an intrinsic property of the sample. It is of a great interest to apply Raman technique for in-situ measurements. For this purpose an in-situ measurement system was developed in our laboratory. It contains a mini spectrometer, pressure tested optode and microsystem diode laser (shown below).

One of the most interesting areas would be Arctic Ocean because of the climate change problems. The area of research was focused on detecting PAHs (polychlorinated aromatic hydrocarbons). These are toxic substances that come from incomplete combustion of oil and gas. Once they come to environment it leads to uncontrollable negative effects to marine life. Even very small concentrations can make major changes. Also it is very difficult to detect such small concentrations. That's why it makes sense to implement SERS technique to increase measurements sensitivity.

Surface Enhanced Raman Scattering (SERS) Raman

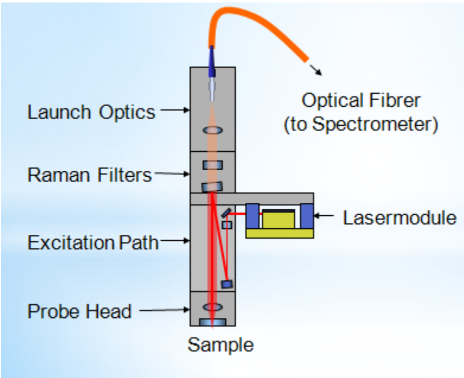
The Raman scattering from a compound (or ion) adsorbed on or even within a few Angstroms of a structured metal surface can be 10^3 to 10^6 x greater than in solution. This surface-enhanced Raman scattering is strongest on silver, but is observable on gold and copper as well. At practical excitation wavelengths, enhancement on other metals is unimportant. SERS arises from two mechanisms:

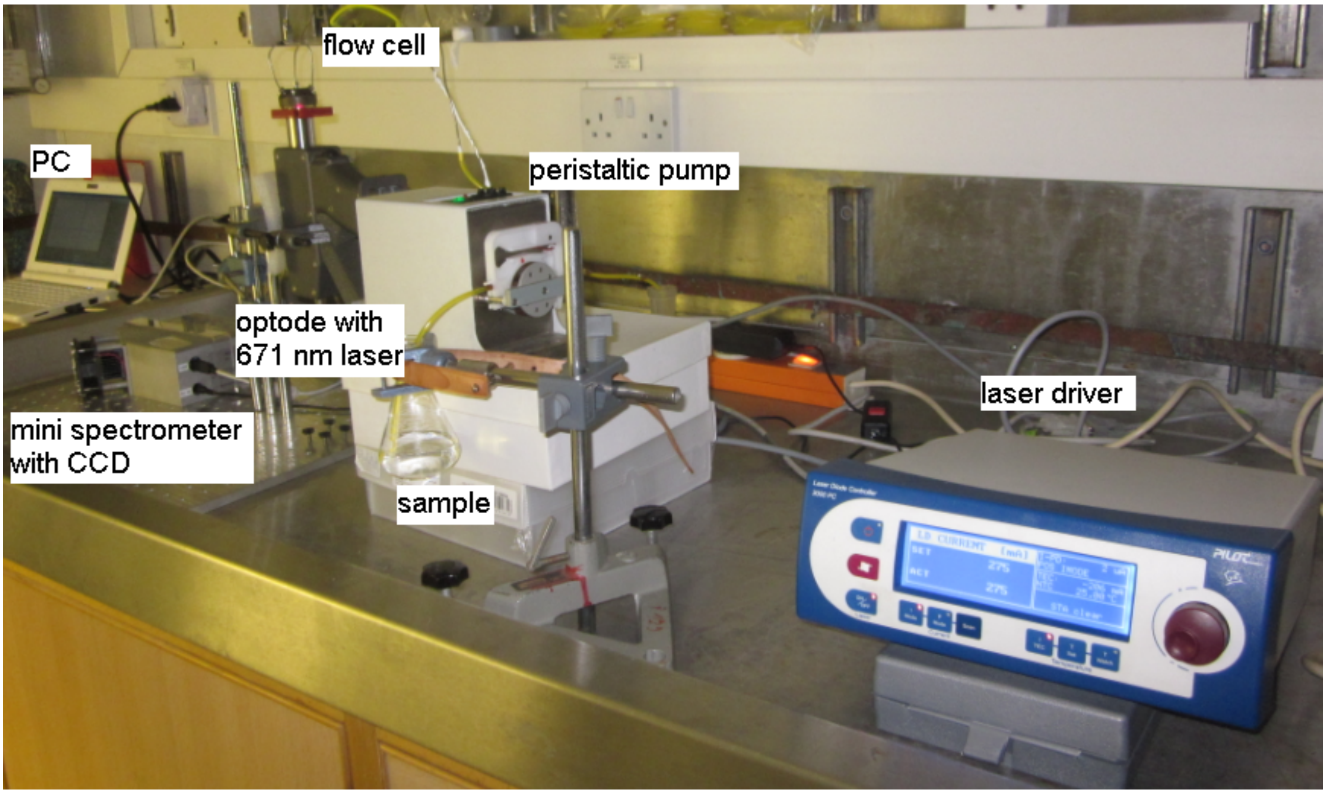
- The first is an enhanced electromagnetic field produced at the surface of the metal. When the wavelength of the incident light is close to the plasma wavelength of the metal, conduction electrons in the metal surface are excited into an extended surface electronic excited state called a surface plasmon resonance. Molecules adsorbed or in close proximity to the surface experience an exceptionally large electromagnetic field. Vibrational modes normal to the surface are most strongly enhanced.
- The second mode of enhancement is by the formation of a charge-transfer complex between the surface and analyte molecule. The electronic transitions of many charge transfer complexes are in the visible, so that resonance enhancement occurs. Molecules with lone pair electrons or pi clouds show the strongest SERS.

Instrumentation:

The 671 nm micro system diode laser together with the optode (developed in our group) consist housing for safety reasons and to make construction simple to use.

The intensity of the collimated beam of the diode laser module is set to 18mW at the sample to protect the SERS substrate in a flow-through cell used for water samples. The laser beam is directed through a band pass filter reflected by two dielectric mirrors and a Raman edge filter, focused on to the SERS substrate by a lens. The injection current, and temperature of the laser module were controlled by a laser driver. The backscattered radiation from the SERS substrate adsorbing the PAH molecules is collected by the same lens and only the Raman Stokes signal passes through the edge filters and is focused by a lens to the spectrograph. Raman spectra were recorded by a CCD detector. Scheme of self-developed optode with 671 nm micro system diode laser.





Microsystem-Raman-SERS- Setup in the laboratory on board of the James Clark Ross

Experimental:

The aim of the experiment was to investigate water samples taken in different locations as well as sediment samples. It was of a great interest to discover the difference in sensitivity between SERS technique and conventional RAMAN and efficiency of both techniques (applied for the first time in the Arctic Ocean). Surface seawater samples from different locations were examined. It was constant surface water supply to the laboratory (through the pipe). Additional water samples were taken at each location in order to check in laboratory if results achieved are correct. Since PAHs more likely adsorb in sediments I also examined different sediment samples. The mad sample was ether mixed with surface water (and filtered before test) or placed on the top of substrate. I also tested substrate stability and selectivity for 1, 2 or 3 PAHs dissolved in the seawater in different concentrations.

Experimental conditions:
Micro system diode Laser Wavelength: 671 nm; Power at the sample: 18mW (275mA, t=25^{0}C); Flow through cell flow rate 0.05ml/s

Integration Time: average from 10 spectra x 0.3s, 0.5s, 1s, 5s, 10s, 25s, 35s, 50s.

Techniques applied:
- Conventional Raman and SERS
- Substrates examined were 25 of Ag,DMCX:MTEOS substrates, 6 of MTEOS substrates, and 5 of Gold Coated Substrates

Additional experiments:
- Substrate stability test
  - 5 substrates were stored in a fridge in real sea water/fresh water for time period around 2 weeks. Measurements done before and after storage.
  - Substrate was exposed to the real seawater for 24 hours (without taking it out of flow cell). The measurements done in 1st hour, in 10 h and after 24 h.
  - Laser power dependence for RAMAN measurements were 12 mW (265 mA), 18 mW (275 mA), 24 mW (285 mA), 30 mW (295 mA), 36 mW (305 mA), 42 mW (315 mA)
- Water turbulence dependence (flow rate change)
  - flow rate 0.05ml/s and 2.5 ml/s

Samples exanimated:
- **Surface water samples:**

1: Location: from 78^{0}38.74443 N; 009^{0}17.2733 E to 78^{0}33.3059N; 009^{0}28.6100 E
Temperature: 5^{0}C, Salinity: 55 %
2: Location: 78^{0}33.9485 N; 009^{0}34.0791 E; (T=3.8 ^{0}C, Sal. = 55 %)
3: Location: 78^{0}32.6458 N; 009^{0}11.8842 E; (T=5.37 ^{0}C, Sal. = 55 %)
4: Location: 78^{0} 33.6100 N; 009^{0} 33.1100 E; (T=5.57 ^{0}C, Sal. = 55%)
5: Location: 78^{0}29.1230 N, 010^{0}14.562 E; (T=3^{0}C,Sal. = 55%)
6: Location: 78^{0}34.3301 N, 010^{0}13.4279 E; (T=3^{0}C, Sal. = 55%)
7: Location: 78^{0}33.7700 N, 010^{0}10.4700 E; (T=3^{0}C, Sal. = 55%)
8: Location: 78^{0}33.6399 N, 009^{0}59.1944 E; (T=3^{0}C, Sal. = 55%)
9: Location: 78°33.4527 N; 010^{0}03.9969 E; (T=4.5^{0}C, Sal.=55%)
10: Location: 78°33.4527 N; 010^{0}03.9969 E; (Sal.=55%)
11: Location: 78^{0}34.5101N; 010^{0}10.8581 E; (t=4.5^{0}C, Sal=55%)
12: Location: 78^{0}34.4800 N; 101^{0}10.5500E (Sal.=55%)
13: Location: 78^{0}35.0605 N; 010^{0}10.3946 E (Sal.55%)

- **Mud Samples:**

50 (surface water) : 50 (mud), by volume (heat + mix)

1. Sample JCR 253-26-BC04, Location 78^{0}55.899 N, 009^{0}53.483 E; 339.6 m water-depth. Location of surface water: 78^{0}36.2730 N; 009^{0}31.7442 E

2. Sample JCR 253-43-BC06; Location 78^{0}59167 N; 9^{0}38312 E; depth: 407.3 m Surface water Location: 78^{0}37.1333 N, 009^{0}19.1777 E

3. Sample: JCR 253-49-BL08; Location 78^{0}59874 N; 9^{0}44384 E; depth: 375.45 m

4. Sample : JCR 253-64-BC10; Location 78^{0}61773 N; 9^{0}42273 E; depth: 307.7 m. Surface water location: 78^{0}37.0617 N, 009^{0}18.1350 E

5. Sample JCR 253-69- BC11; Location 78^{0}59167 N; 9^{0}38312 E; depth: 407.3

6. Sample JCR 253-73-BC12; Location 78^{0}61767 N; 009^{0}3027 E, depth: 439.74 m. Surface water location: 78^{0}34.2900 N; 010^{0}11.5000 E.

Real sea water spiked with PAHs samples:

Spiking PYRENE

Water Location: 78^0 33.6100 N; 009^0 33.1100 E

Pyrene concentrations: 0.25nM/l, 0.5nM/l, 1nM/l, 2nM/l, 4nM/l, 8nM/l, 12nM/l, 20nM/l, 100nM/l, 200nM/l, 400 nM/l

Spiking ANTHRACENE

Water Location: 78^{0}34.2556N, 009^{0}38.3196 E

Concentrations: 0.3nM/l, 0.75nM/l, 1.5nM/l, 3nM/l, 7.5nM/l, 15nM/l, 30nM/l, 75nM/l, 150 nM/l

Spiking FLUORENTHENE

Water Location: 78^{0}34.2319 N, 009^{0}25.5464 E

Concentrations: 1nM/l, 2nM/l, 4nM/l, 8nM/l, 12nM/l, 20nM/l, 100nM/l, 200nM/l, 600 nM/l

PAH solution mixes:

Water location: 78^{0}38.2371 N; 009^{0}18.1350 E

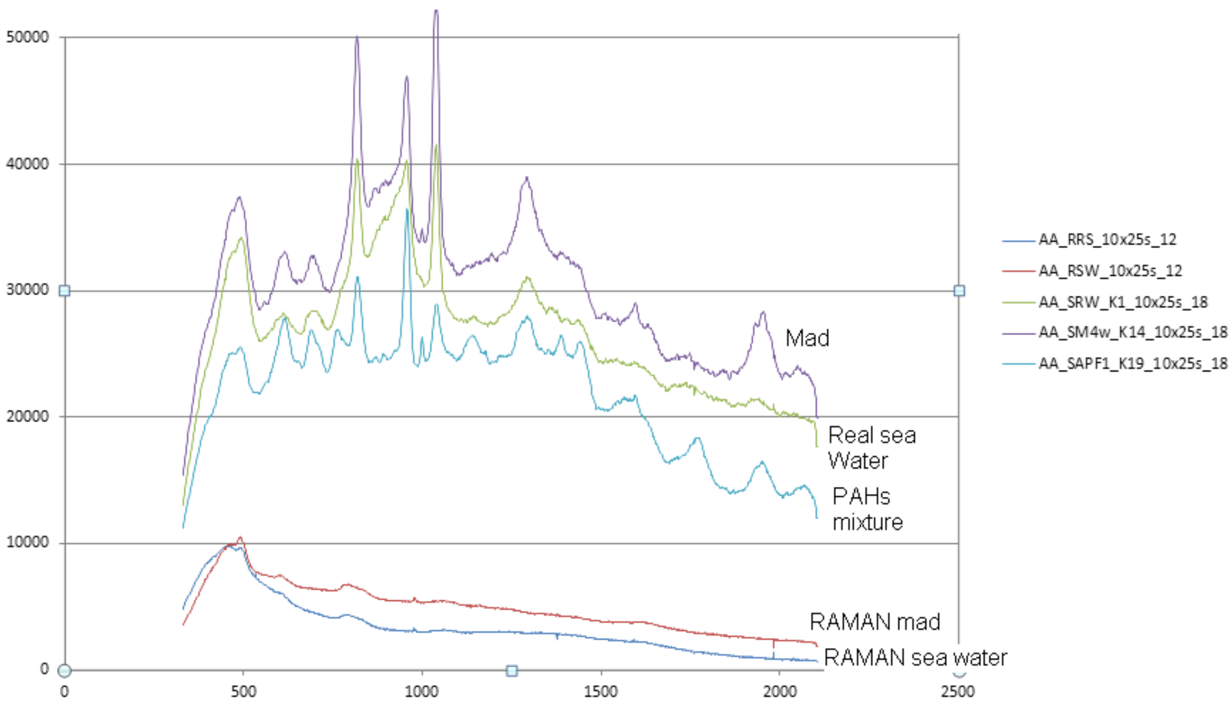
- PYR 400 nM/l (50) : ANT 150 (50) nM/l
- PYR 0,25 nM/l (50) : ANT 0,3 nM/l (50)
- PYR 8 nM/l (50) : ANT 7,5 nM/l (50)
- PYR 400 nM/l (50) : FLO 600 nM/l (50)
- PYR 0,25nM/l (50) : FLO 1 nM/l (50)
- PYR 8 nM/l (50) : FLO 8 nM/l (50)
- FLO 600 nM/l (50) : ANT150 nM/l (50)
- FLO 1 nM/l (50) : ANT 0,3 nM/l (50)
- FLO 8 nM/l (50) : ANT 7,5 nM/l (50)
- PYR 400 nM/l (33) : FLO 600 nM/l (33) : ANT 150 nM/l (33)
- PYR 0,25 nM/l (33) : FLO 1 nM/l (33) : ANT 0,3 nM/l (33)

- PYR 8 nM/l (33) : FLO 8 nM/l (33) : ANT 7,5 nM/l (33)

Pre-Results:

Since I have done many measurements results evaluation will take some time. Picture below shows five spectra with integration time 25s (averaged from 10) and laser power 12 and 18 mW on the sample. Substrates used: Ag,DMCX:MTEOS.

1. "RRS" – Raman Real Sea water
2. "RSW"- Raman Sediment Water
3. "SRW" – SERS Real sea Water
4. "SM4w" – SERS Mad 4 in Water
5. "SAPF1"- SERS AnthracenePyreneFlourenthene mix in small concentrations



First very obvious conclusion from the spectra is the difference in sensitivity between conventional RAMAN and application of SERS technique. Real sea water spectrum gives less spikes then spectrum from mud which means then muddy water contains more Raman active compounds. This is not unexpected. The solution mix of anthracene, pyrene and fluorenthene gives very good signals (even at small concentrations (PYR 0,25nM/l: FLO 1 nM/l: ANT 0,3 nM/l) which means that the substrate used is sensitive enough to detect these pollutants even in small concentrations.

This is a small subset of the measurements done. The evaluation of all measurements is being in progress and expected to be completed in 1-2 month.

Data and Sampling Appendices

Appendix 1. Summary of JCR253 HyBIS Dive Logs

Station No.	HyBIS Dive No.	Date & Time Deployed	Date & Time Recovered	Notes
-	33	3 Aug - 1525	3 Aug - 1612	System check and purge of air from hydraulic system
JCR253-17-HyBIS01	34	4 Aug - 0706	4 Aug - 1315	Search for MASOX lander
JCR253-20-HyBIS02	35	5 Aug – 0740	5 Aug – 0902	MASOX lander recovery
JCR253-24-HyBIS03	36	5 Aug - 1334	5 Aug – 1522	MASOX lander recovery
JCR253-25-HyBIS04	37	5 Aug – 1539	5 Aug – 1632	MASOX lander recovery
JCR253-26-HyBIS05	38	5 Aug – 1640	5 Aug – 1745	MASOX lander recovery
JCR253-35-HyBIS06	39	8 Aug – 0711	8 Aug – 0955	Examine BOB lander site
JCR253-46-HyBIS07	40	10 Aug – 0658	10 Aug – 1207	Lay thermistor string from MASOX lander
JCR253-48-HyBIS08	41	10 Aug – 1303	10 Aug - 1440	Discovery dive on plume site
JCR253-52-HyBIS09	42	11 Aug - 0829	11 Aug – 0952	Discovery dive on plume site (aborted, swell too high)
JCR253-58-HyBIS10	43	12 Aug – 1036	12 Aug – 1243	Discovery dive on strongly venting plume site
JCR253-63-HyBIS11	44	13 Aug - 1238	13 Aug – 1423	Dive on strongly venting plume site with graduated board to get quantitative flux measurements
JCR253-75-HyBIS12	45	14 Aug - 1438	14 Aug – 1715	Dive on plume site with Niskin bottle to collect concentrated Methane sample
JCR253-79-HyBIS13	46	15 Aug -1036	15 Aug – 1230	Dive on plume site with Niskin bottle to collect concentrated Methane sample
JCR253-80-HyBIS14	47	15 Aug – 1407	15 Aug – 1407	Dive on shallow plume site with Niskin bottle to collect concentrated Methane sample
JCR253-92-HyBIS15	48	16 Aug – 0612	16 Aug –0925	Dive on shallow plume site with Niskin bottle to collect concentrated Methane sample
JCR253-105-HyBIS16A	49	17 Aug - 0622	17 Aug – 0849	Dive on shallow plume site with Niskin bottle to collect concentrated Methane sample
JCR253-107-HyBIS16B	50	17 Aug - 1310	17 Aug – 1403	Dive on shallow plume site with Niskin bottle to collect concentrated Methane sample
JCR253-108-HyBIS17	51	17 Aug - 1410	17 Aug – 1519	Dive on shallow plume site with Niskin bottle to collect concentrated Methane sample
JCR253-109-HyBIS18	52	17 Aug - 1530	17 Aug – 1820	Dive on shallow plume site with Niskin bottle to collect concentrated Methane sample
JCR253-118-HyBIS19	53	18 Aug - 0645	18 Aug - 0827	Dive on plume site with graduated board to get quantitative flux measurements
JCR253-122-HyBIS20	54	18 Aug - 1451	18 Aug – 1820	Video transect and grab sample
JCR253-131-HyBIS21	55	19 Aug - 0622	19 Aug – 0735	Video transect and grab sample
JCR253-133-HyBIS22	56	19 Aug - 0805	19 Aug - 0904	Video transect and grab sample
JCR253-138-HyBIS23	57	22 Aug - 0645	22 Aug - 1112	Video transect and grab sample in pockmark

Summary Table of HyBIS HD Video Files

Station #	Dive #	Video File Name	Start Time YrMoDy:HrMnSc	Duration Hr:Mn:Sc
JCR253-17-HyBIS01	34	HyBIS34_HD.m2ts*	20110804:??????	29:56
JCR253-20-HyBIS02	35	-	-	-
JCR253-24-HyBIS03	36	-	-	-
JCR253-25-HyBIS04	37	-	-	-
JCR253-26-HyBIS05	38	-	-	-
JCR253-35-HyBIS06	39	-	-	-
JCR253-46-HyBIS07	40	HyBIS40_HD.m2ts	20110809:071611	4:36:22
JCR253-48-HyBIS08	41	HyBIS41_HD.m2ts	20110810:131706	1:32:22
JCR253-52-HyBIS09	42	HyBIS42_HD.m2ts	20110811:084925	34:16
JCR253-58-HyBIS10	43	HyBIS43_HD.m2ts	20110812:104809	1:46:23
JCR253-63-HyBIS11	44	HyBIS44_HD.m2ts	20110813:125427	1:10:22
JCR253-75-HyBIS12	45	HyBIS45_HD.m2ts	20110814:150353	2:02:02
JCR253-79-HyBIS13	46	HyBIS46_HD.m2ts	20110815:105325	1:27:40
JCR253-80-HyBIS14	47	HyBIS47_HD.m2ts	20110815:141612	56:31
JCR253-92-HyBIS15	48	HyBIS48_HD.m2ts	20110816:061940	2:54:54
JCR253-105-HyBIS16A	49	HyBIS49_HD.m2ts	20110817:063548	2:01:24
JCR253-107-HyBIS16B	50	HyBIS50_HD.m2ts	20110817:132137	31:44
JCR253-108-HyBIS17	51	HyBIS51_HD.m2ts	20110817:142006	49:15
JCR253-109-HyBIS18	52	HyBIS52_HD.m2ts	20110817:153738	2:25:24
JCR253-118-HyBIS19	53	HyBIS53_HD.m2ts	20110818:065445	1:21:38
JCR253-122-HyBIS20	54	HyBIS54_HD.m2ts	20110818:150008	3:12:45
JCR253-131-HyBIS21	55	HyBIS55_HD.m2ts	20110819:062939	51:37
JCR253-133-HyBIS22	56	HyBIS56_HD.m2ts	20110819:081051	43:37
JCR253-138-HyBIS23	57	HyBIS57_HD.m2ts	20110822:071851	3:33:36

* video start and end time not known, contains some limited footage of the MASOX lander prior to recovery

Summary Table of HyBIS Sony Camera Video Folders/Files

Station #	Dive #	Video Folder Name	Start Time YrMoDy:HrMnSc	Duration Hr:Mn:Sc:Fr
JCR253-17-HyBIS01	34	HyBIS34_Sony	20110804:073637	5:12:24:14
JCR253-20-HyBIS02	35	HyBIS35_Sony	20110805:082053	22:19:06
JCR253-24-HyBIS03	36	HyBIS36_Sony	20110805:135256	1:08:11:21
JCR253-25-HyBIS04	37	HyBIS37_Sony	20110805:155426	24:43:01
JCR253-26-HyBIS05	38	HyBIS38_Sony	20110805:165919	18:06:00
JCR253-35-HyBIS06	39	HyBIS39_Sony	20110808:073200	2:08:44:04
JCR253-46-HyBIS07	40	HyBIS40_Sony	20110810:071508	4:37:52:12
JCR253-48-HyBIS08	41	HyBIS41_Sony	20110810:131601	1:24:59:19
JCR253-52-HyBIS09	42	HyBIS42_Sony	20110811:084906	35:13:09
JCR253-58-HyBIS10	43	HyBIS43_Sony	20110812:104802	1:45:15:18
JCR253-63-HyBIS11	44	HyBIS44_Sony	20110813:124847	1:17:44:09
JCR253-75-HyBIS12	45	HyBIS45_Sony	20110814:150443	2:00:58:17
JCR253-79-HyBIS13	46	HyBIS46_Sony	20110815:104450	1:36:11:14
JCR253-80-HyBIS14	47	HyBIS47_Sony	20110815:141707	56:16:03
JCR253-92-HyBIS15	48	HyBIS48_Sony	20110816:062022	2:56:42:20
JCR253-105-HyBIS16A	49	HyBIS49_Sony	20110817:063124	2:06:36:24
JCR253-107-HyBIS16B	50	HyBIS50_Sony	20110817:132228	31:41:18
JCR253-108-HyBIS17	51	HyBIS51_Sony	20110817:141830	51:00:00
JCR253-109-HyBIS18	52	HyBIS52_Sony	20110817:153827	2:35:43:20
JCR253-118-HyBIS19	53	HyBIS53_Sony	20110818:065326	1:23:56:18
JCR253-122-HyBIS20	54	HyBIS54_Sony	20110818:150119	3:12:06:12
JCR253-131-HyBIS21	55	HyBIS55_Sony	20110819:063048	51:30:13
JCR253-133-HyBIS22	56	HyBIS56_Sony	20110819:081141	43:46:21
JCR253-138-HyBIS23	57	HyBIS57_Sony	20110822:072008	3:05:30:23

Summary Table of HyBIS Downward Camera Video Folders/Files

Station #	Dive #	Video Folder Name	Start Time YrMoDyHrMnSc	Duration Hr:Mn:Sc:Fr
JCR253-17-HyBIS01	34	HyBIS34_downward	20110804:073654	5:15:11:00
JCR253-20-HyBIS02	35	HyBIS35_downward	20110805:082120	21:59:17
JCR253-24-HyBIS03	36	HyBIS36_downward	20110805:135329	1:07:57:14
JCR253-25-HyBIS04	37	HyBIS37_downward	20110805:155424	24:44:15
JCR253-26-HyBIS05	38	HyBIS38_downward	20110805:165920	41:59:03
JCR253-35-HyBIS06	39	HyBIS39_downward	20110808:073216	2:08:50:01
JCR253-46-HyBIS07	40	HyBIS40_downward	20110810:071613	31:42:07
JCR253-46-HyBIS07	40	HyBIS40B_downward	20110810:092758	2:25:49:00
JCR253-48-HyBIS08	41	HyBIS41_downward	20110810:131741	1:23:38:23
JCR253-52-HyBIS09	42	HyBIS42_downward	20110811:085031	34:24:22
JCR253-58-HyBIS10	43	HyBIS43_downward	20110812:104917	1:44:28:06
JCR253-63-HyBIS11	44	HyBIS44_downward	20110813:125414	1:12:28:19
JCR253-75-HyBIS12	45	HyBIS45_downward	20110814:150525	2:01:04:07
JCR253-79-HyBIS13	46	HyBIS46_downward	20110815:104529	1:36:21:02
JCR253-80-HyBIS14	47	HyBIS47_downward	20110815:141744	56:13:08
JCR253-92-HyBIS15	48	HyBIS48_downward	20110816:062038	2:56:36:05
JCR253-105-HyBIS16A	49	HyBIS49_downward	20110817:063100	2:06:45:23
JCR253-107-HyBIS16B	50	HyBIS50_downward	20110817:132208	31:58:11
JCR253-108-HyBIS17	51	HyBIS51_downward	20110817:141901	50:39:05
JCR253-109-HyBIS18	52	HyBIS52_downward	20110817:153829	2:25:41:16
JCR253-118-HyBIS19	53	HyBIS53_downward	20110818:065333	1:23:31:16
JCR253-122-HyBIS20	54	HyBIS54_downward	20110818:150154	3:11:49:12
JCR253-131-HyBIS21	55	HyBIS55_downward	20110819:063040	52:28:20
JCR253-133-HyBIS22	56	HyBIS56_downward	20110819:081151	43:45:23
JCR253-138-HyBIS23	57	HyBIS57_downward	20110822:071907	3:09:32:24

Summary Table of HyBIS Forward Camera with Data Overlay Video Files

Station #	Video File Name	Dive #	Start Time YrMoDy:HrMnSc	End Time YrMoDy:HrMnSc	Duration Hr:Mn:Sc
JCR253-17-HyBIS01	HyBIS34_20110804_0740-0918.AVI	34	20110804:074020	20110804:091846	1:38:28
JCR253-17-HyBIS01	HyBIS34_20110804_0918-1057.AVI	34	20110804:091848	20110804:105716	1:38:28
JCR253-17-HyBIS01	HyBIS34_20110804_1057-1235.AVI	34	20110804:105716	20110804:123546	1:38:28
JCR253-17-HyBIS01	HyBIS34_20110804_1235-1252.AVI	34	20110804:123546	20110804:125226	16:39
JCR253-20-HyBIS02 JCR253-24-HyBIS03 JCR253-25-HyBIS04	HyBIS35_36_37_20110805_0820-1602.AVI	35 36 37	20110805:082048 20110805:135326 20110805:155422	20110805:084310 20110805:150124 20110805:160234	1:38:36
JCR253-25-HyBIS04 JCR253-26-HyBIS05	HyBIS37_38_20110805_1602-1717.AVI	37 38	20110805:160236 20110805:165912	20110805:161906 20110805:171720	34:37
JCR253-35-HyBIS06	HyBIS39_20110808_0732-0910.AVI	39	20110808:073208	20110808:091040	1:38:32
JCR253-35-HyBIS06	HyBIS39_20110808_0910-0940.AVI	39	20110808:091042	20110808:094048	30:06
JCR253-46-HyBIS07	HyBIS40_20110810_0729-0907.AVI	40	20110810:072918	20110810:090758	1:38:39
JCR253-46-HyBIS07	HyBIS40_20110810_0908-1046.AVI	40	20110810:090800	20110810:104634	1:38:34
JCR253-46-HyBIS07	HyBIS40_20110810_1046-1153.AVI	40	20110810:104634	20110810:115318	1:06:45
JCR253-48-HyBIS08	HyBIS41_20110810_1317-1444.AVI	41	20110810:131000	20110810:144400	1:26:58
JCR253-52-HyBIS09	HyBIS42_20110811_0850-0924.AVI	42	20110810:085022	20110810:092432	34:10
JCR253-58-HyBIS10	HyBIS43_20110812_1048-1227.AVI	43	20110812:104824	20110812:122700	1:38:37
JCR253-63-HyBIS11	HyBIS44_20110813_1257-1406.AVI	44	20110813:125712	20110813:140636	1:09:25
JCR253-75-HyBIS12	HyBIS45_20110814_1504-1643.AVI	45	20110814:150450	20110814164334	1:38:45
JCR253-75-HyBIS12	HyBIS45_20110814_1643-1706.AVI	45	20110814:164336	20110814:170622	22:46
JCR253-79-HyBIS13	HyBIS46_20110815_1045-1222.AVI	46	20110815:104550	20110815:122232	1:39:12
JCR253-80-HyBIS14	HyBIS47_20110815_1417-1513.AVI	47	20110815:141724	20110815:151356	1:02:24
JCR253-80-HyBIS14	HyBIS48_20110816_0620-0759.AVI	48	20110816:062044	20110816:075928	1:38:43
JCR253-92-HyBIS15	HyBIS48_20110816_0759-0917.AVI	48	20110816:075928	20110816:091722	1:17:53
JCR253-105-HyBIS16A	HyBIS49_20110817_0631-0810.AVI	49	20110817:063146	20110817:081034	1:38:46
JCR253-105-HyBIS16A	HyBIS49_20110817_0810-0838.AVI	49	20110817:081036	20110817:083832	27:57
JCR253-107-HyBIS16B	HyBIS50_20110817_1322-1355.AVI	50	20110817:132254	20110817:135542	32:49
JCR253-108-HyBIS17	HyBIS51_20110817_1418-1510.AVI	51	20110817:141832	20110817:151006	51:39
JCR253-109-HyBIS18	HyBIS52_20110817_1538-1717.AVI	52	20110817:153858	20110817:171742	1:38:45
JCR253-109-HyBIS18	HyBIS52_20110817_1717-1804.AVI	52	20110817:171742	20110817:180428	46:58
JCR253-118-HyBIS19	HyBIS53_20110818_0653-0817.AVI	53	20110818:065338	20110818:081746	1:24:09
JCR253-122-HyBIS20	HyBIS54_20110818_1501-1639.AVI	54	20110818:150114	20110818:163958	1:38:44
JCR253-122-HyBIS20	HyBIS54_20110818_1639-1813.AVI	54	20110818:163958	20110818:181346	1:33:48
JCR253-131-HyBIS21	HyBIS55_20110819_0631-0722.AVI	55	20110819:063102	20110819:072246	51:44
JCR253-133-HyBIS22	HyBIS56_20110819_0811-0855.AVI	56	20110819:081158	20110819:085520	43:22

JCR253-138-HyBIS23	HyBIS57_22110819_0720-0855.AVI	57	22110819:072026	22110819:085904	1:38:37
JCR253-138-HyBIS23	HyBIS57_22110819_0859-1028.AVI	57	22110819:085904	22110819:102822	1:29:19

Appendix 2. Summary of JCR253 CTD Stations

CTD No.	**Date**	**Time**	**Latitude (N)**	**Longitude (E)**	**Area**	**Depth (m)**	**Bottles fired**	**Samples collected**	**Analyses**						
		start							*CH4*	*DIC*	*pH*	*Ammonia*	*Oxygen*	*Microbiology*	*NOTES*
2	31/07/2011	11:22	78.25865	9.57535	Test Cast	348	24	10	X	X	X	X	X	X	
3	07/08/2011	23:14	78.52585	9.57535	Transect 3	384	24	12	X	X	X	X	X	X	
4	08/08/2011	02:18	78.54623	9.35594	Transect 3	460	24	12	X	X	X	X	X		
5	08/08/2011	17:36	78.55897	9.53419	Transect 3	340	24	12	X	X		X	X		
6	08/08/2011	21:51	78.56016	9.55159	Transect 3	312	24	12	X	X	X	X	X		
7	09/08/2011	01:50	78.6031	9.52699	Transect 2	212	24	12	X	X	X	X	X	X	
8	09/08/2011	05:16	78.59842	9.485	Transect 2	318	24	12	X	X	X	X	X		
9	09/08/2011	09:15	78.59167	9.38303	Transect 2	407	24	12	X	X		X	X	X	
10	11-12/8/11	23:45	78.5483	10.24592	Shallow Flare	83	24	12	X	X	X	X	X		
11	12/08/2011	02:55	78.5482	10.24581	Shallow Flare	87	24	12	X	X	X	X	X		
12	12/08/2011	08:51	78.57626	9.29061	Transect 2	463	24	11	X		X	X	X		
13	12/08/2011	13:19	78.59858	9.4445	Transect 2	374	24	11	X		X	X	X		
14	13/08/2011	18:31	78.61774	9.42269	Transect 1	379	24	12	X			X	X		
15	14/08/2011	00:20	78.61769	9.30257	Transect 1	438	24	12	X		X	X			
16	14/08/2011	02:23	78.6352	9.40566	Transect 1	311	24	12	X		X		X		
17	14/08/2011	04:33	78.63735	9.44128	Transect 1	221	24	12	X		X		X		
18	15/08/2011	06:44	78.55491	9.47767	Transect 1	381	24	12	X			X	X		
19	16/08/2011	19:13			Shallow Flare										
20-23	16/08/2011	21:29	78.5762	10.17306	Shallow Flare	90	20	4	X			X	X	X	Grid K-N
24-27	16/08/2011	01:57	78.574179	10.173707	Shallow Flare	90	20	4	X			X	X	X	I, J, O, P
28	16/08/2011	16:10	78.57501	10.17403	Shallow Flare	90	24	12	X			X	X		
29-32	17/08/2011	20:56	78.57688	10.164531	Shallow Flare	102	20	4	X			X	X	X	Grid A-D
33-36	17/08/2011	02:28	78.57332	10.182046	Shallow Flare	98	20	4	X			X	X	X	Grid E-H
37-40	17/08/2011	19:12	78.578688	10.154855	Shallow Flare	105	20	4	X			X	X	X	Grid W -Z
41-44	18/08/2011	00:16	78.57149	10.19157	Shallow Flare	105	20	4	X			X	X	X	Grid S-V
45-48	18/08/2011	19:29	78.584085	10.128698	Shallow Flare	138	20	4	X			X	X	X	Aa-Dd
49-52	19/08/2011	01:20	78.566002	10.219058	Shallow Flare	114	20	4	X			X	X	X	Ee-Hh
53-58	23/08/2011	10:22	78.57492	10.12795	Shallow Flare	100	12	6	X						A, DD, EE, FF, GG, HH

Appendix 3. Summary of JCR253 Box Corer Stations

Box corer Station	Latitude (N)	Longitude (E)	Water-depth (m)
JCR253-15-Box core-01	78.54623	9.35748	456
JCR253-15-Box core-02	78.55486	9.47627	378
JCR253-22-Box core-03	78.56016	9.55172	311
JCR253-26-Box core-04	78.55897	9.53487	340
JCR253-29-Box core-05	78.57629	9.29066	457
JCR253-43-Box core-06	78.59167	9.3831	407
JCR253-44-Box core-07	78.59168	9.38307	407
JCR253-49-Box core-08	78.59874	9.44384	375
JCR253-60-Box core-09	78.59846	9.48501	323
JCR253-64-Box core-10	78.61773	9.42273	371
JCR253-69-Box core-11	78.63733	9.44138	218
JCR253-73-Box core-12	78.61767	9.30227	440
JCR253-134-Box core-13	78.68448	8.27296	886

Appendix 4. Summary of JCR253 Sediment Core Stations

Piston core Station	Latitude (N)	Longitude (E)	Water-depth (m)
JR253-16-Piston core-01	78.54610	9.35663	458
JR253-19-Piston core-02	78.55485	9.47621	384
JCR253-23-Piston core-03	78.56015	9.55167	313
JCR253-27-Gravity core-01	78.55898	9.5349	339
JCR253-31-Gravity core-02	78.57632	9.29078	453
JCR253-45-Piston core-04	78.59165	9.38328	407
JCR253-50-Piston core-05	78.59875	9.44391	374
JCR253-53-Piston core-06	78.61109	9.42555	374
JCR253-61-Piston core-07	78.59846	9.48507	323
JCR253-70-Piston core-08	78.63735	9.44138	218
JCR253-72-Piston core-09	78.63733	9.44127	218
JCR253-74-Piston core-10	78.61769	9.30262	440
JR253-78-Gravity core-03	78.55492	9.47742	386
JCR253-94-Gravity core-04	78.57504	10.1741	87
JCR253-95-Gravity core-05	78.57502	10.17411	86
JCR253-120-Gravity core-06	78.57493	10.17507	86
JCR253-121-Gravity core-07	78.57495	10.175	87
JCR253-121-Piston core-11	78.57496	10.175	87
JCR253-135-Piston core-12	78.68447	8.27289	886
JCR253-137-Piston core-13	78.68519	8.27911	878
JCR253-140-Piston core-14	78.68559	8.27932	880