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M87/2 COSY
Short Cruise Report

Reykjavik/Iceland – Stavanger/Norway
5 May 2012 – 27 May 2012

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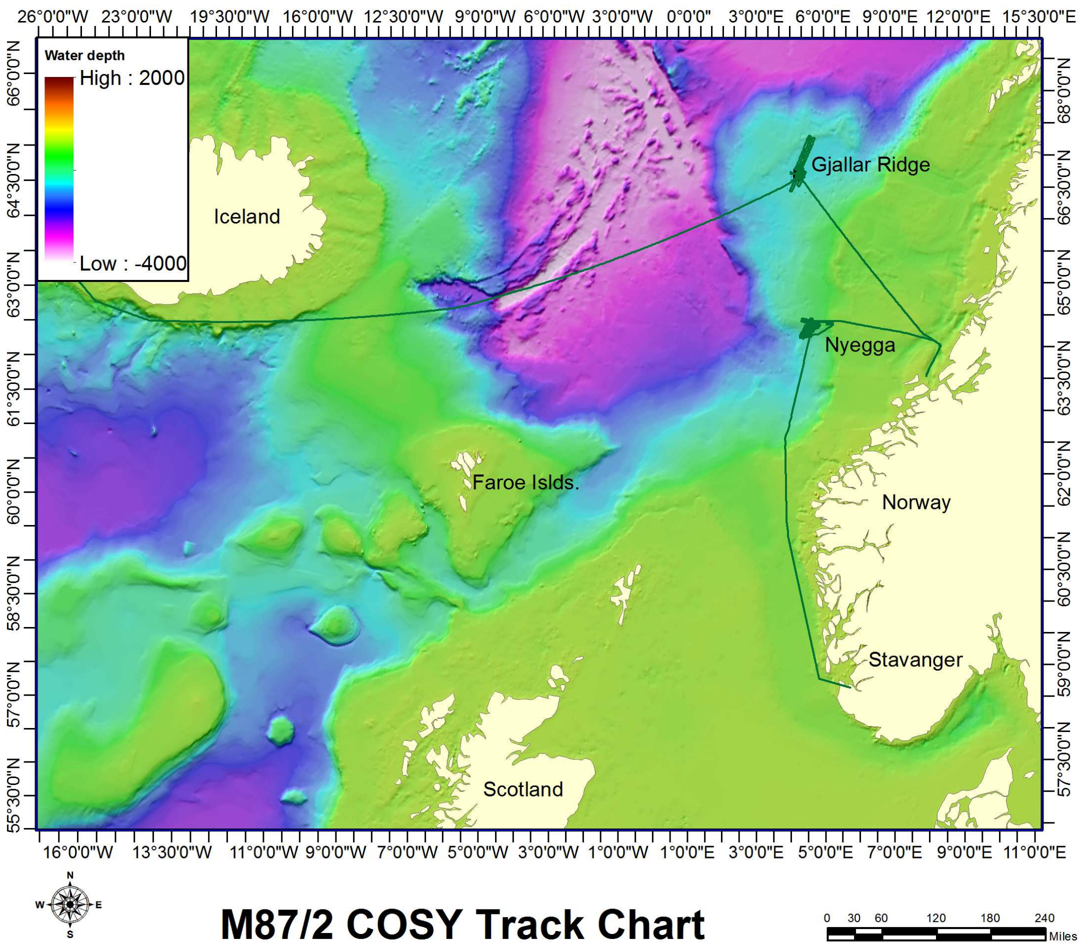

M87/2 COSY Track Chart

Objectives

M87/2 COSY set out to investigate the geological processes that may cause significant migration of carbon from the subsurface into the ocean and ultimately into the atmosphere. Understanding these processes is fundamental for understanding episodic climate forcing by geological processes, for assessing the role that subsurface fluid migration plays for slope stability, and for assessing the economic potential of hydrate bearing sediments as a future energy source. As such the cruise contributed mainly to two scientific projects: the Excellence Cluster Future Ocean and here in particular the sub-project Ocean Controls, and the BMBF-funded project Sugar2.

The two main objectives of the cruise were (1) to provide a controlled-source electromagnetic (CSEM) data set in an area where co-existing 3D ocean bottom seismometer data exist, and (2) to find out if the Giant Gjallar Vent on the north-western Voering Margin can serve as a window to the deeper structures of the Voering Basin which were strongly influenced by break-up volcanism-related hydrothermal activity.

We managed to achieve the first objective. Throughout the cruise we have collected a benchmark data set of different types of controlled source electromagnetic data. We surveyed a pipe structure called CN03 which is located in the Nyegga area on the northern flank of the Storegga Slide, and which is characterized by high hydrate concentration at approximately 300 mbsl. In this area we collected high-resolution EM data with Sputnik and deep-penetration EM data with DASI as well as towed, continuously recording surface data with Vulkan. These data will keep a generation of marine electromagnetic geophysicists busy until all ways have been found to invert them jointly with the existing 3D P- and S-wave data for determining the hydrate and free gas distribution in the top 300 m of sediments.

We also achieved the second objective of finding out whether the Giant Gjallar Vent is still active and can serve as a window to the underlying geological processes. Although we did not manage to collect a high-resolution 3D seismic data set because of technical problems in the beginning of the cruise and inclement weather conditions later on, we can now show that the Giant Gjallar Vent is still active to some extent, but much less than hoped before the cruise. The main phase of activity which generated the present seafloor morphology must have occurred during deposition of the late Kai Formation. The rugged seafloor was draped by hemipelagic sediments ever since. However, there are strong indications for ongoing neotectonic activity, significant accumulation of free gas below the Top Kai horizon, and minor evidence for formation of seepage-related authigenic carbonates.

Additionally, we managed to carry out a detailed survey of sea floor crevasses on the northern sidewall of the Storegga Slide. The excellent sub-bottom sediment profiler records obtained with the Parasound system strongly indicate very recent, i.e. post-Storegga Slide, deformation of the northern sidewall of the Storegga Slide. Although it was not possible to prove unequivocally this late age of activity by a HyBis video survey that we carried out for this purpose, the Parasound data are strongly indicative of this late phase of activity. The high-resolution seismic, multi-beam bathymetry, Parasound, and video data set that we managed to acquire provides deep insight into the ways that continental margins fail due to gravitational forces, e.g. that slopes may be mobilized down to failure surfaces that are deeper than the failure surface of immediately juxtaposed major landslides.

Cruise narrative

On Saturday 5 May we left Reykjavik under a clear blue sky with fresh northerly winds. With the large amount of equipment to set up, everybody was busy preparing the scientific instruments. In particular, the fibre optic connection between the friction winch and the DASI power supply required significant attention. Due to favourable weather forecasts we decided to sail first to the northern working area on the Gjallar Ridge in the western part of the Voering Plateau.

During Sunday 6 May and Monday 7 May the transit continued without interruptions with 2 m swell and moderate northerly winds. The time was used to assemble the scientific equipment and set up the laboratories.

Upon arrival in the study area 1 (Gjallar Ridge) on Tuesday 8 May at 16:00 UTC we conducted releaser tests. First we tested the GEOMAR releasers in a steel basket and then the NOC releasers in a custom-made frame. This was followed by a sound velocity profile taken by the ship's crew to calibrate the multibeam echosounder. After setup of the multibeam and the parasound system we deployed two ocean bottom seismometers in the southern and northern end of the planned 3D seismic cube. At 11 pm we started deployment of the P-Cable system in excellent weather conditions.

Deployment of the P-Cable system was completed after 3.5 hours and shooting of seismic lines began at 3 am on Wednesday 9 May. At 7:15 something got caught in the streamer and shooting had to be discontinued. Recovery of the data cable and inspection of the seaward router and the first T-junction of the cross-cable revealed bending of the data cable at the connection point with the cross-cable and the first part of the cross-cable was replaced. After initial problems with the airguns the system was started again at 13:00 but broke down another time at 13:45. The entire system was recovered for a full inspection. Surveying with multibeam echosounder and Parasound continued and the course was changed to collect a dense grid of Parasound lines across the Gjallar Vent and then to a wider spread to obtain maximum coverage with the multibeam system.

After finishing the multibeam transect at 13:00 on Thursday 10 May we redeployed the repaired 3D seismic system. Deployment took approximately 3 hours and at 16:00 the system was working fine. However, after approximately 15 minutes seismic recording stopped again with a technical failure of the streamer power supply unit. Until 18:00 we tried to repair the seismic recording system, but when that failed we recovered the entire system. We finished recovery at approximately 20:00 and steamed back to the center of the Gjallar Giant Vent. From 21 to 23 we tested four Posidonia receivers and collected a sound velocity profile, before beginning multibeam and Parasound profiles to map the near-surface expression of the vent which is characterized by shallow faulting.

During the morning of Friday 11 May we continued profiling and mapping while fixing the seismic acquisition system. Wind NW 4-5. From 14:00 to 17:00 we deployed the seismic system in 2D mode and at 18:00 we began shooting seismic profiles across the OBS locations. Except for a one hour delay due to a broken part in the compressor we continued shooting during the night.

In good weather conditions we collected several 2D seismic lines across the two ocean bottom seismometer locations. On Saturday 12 May at 14:00 we retrieved the seismic equipment and steamed to the first ocean bottom seismometer location. 20 minutes after releasing the ocean bottom seismometer it surfaced and was brought on board. The data was retrieved after a GPS clock check (skew = +2 ms). We then tried to release the second ocean bottom seismometer, but it did not respond. However, when steaming towards its expected position it surfaced and we acquired it at 16:30. This ocean bottom seismometer also acquired data and the clock worked properly (skew = +17 ms). Because of the unfavourable weather forecast for both the northern (Force 8 on Monday, Force 7 on Tuesday with expected significant wave heights in excess of 7 meters on both days) and the southern (Force 9 on Sunday-Wednesday and expected significant wave height of 7-9 meters) working areas we decided to seek shelter in the Trondheim Fjord until the weather became suitable for further work.

With the low pressure Vera approaching and winds of up to force 9 we steamed to the Trondheim Fjord which we reached at 16:00 on Sunday 13 May. The rest of the day was used to process the seismic data from the Giant Gjallar Vent and wind down the P-Cable cross cable from the winch to prepare it for the DASI streamer.

During the morning of Monday 14 May we prepared the DASI streamer and put it on the P-Cable winch. This was followed by shifting the HyBis to the back deck and terminating its cables. Unfortunately, the chief discovered that the air compressor for the seismic acquisition had a jammed piston and a spare part had to be ordered from Kiel.

In the morning of Tuesday 15 May we held a seminar on the Gjallar Vent Site, while the high voltage power test was conducted on deck. After arrival of the spare part for the compressor we left the Trondheim Fjord at 23:00. In hindsight it was good luck that we decided to steam to Trondheim instead of weathering off in working area 1. Only as a result of this decision it was possible to obtain the necessary spare part for the compressor and keep the option of further seismic work.

In the morning of Wednesday 16 May we held a seminar on the Nyegga gas hydrate province while approaching the study area. Upon arrival at noon we carried out a sound velocity profile to calibrate the multibeam echosounder. Then we started to deploy the GEOMAR OBEM receivers. In fair weather (NW 5-6) it took about eight hours to deploy the first four instruments.

While the first four OBEM were deployed with the HyBis vehicle over the stern of the vessel the last two were deployed with a Posidonia releaser over the starboard side of the ship. This change was necessary because the power supply of HyBis was faulty since the early morning hours of Thursday 17 May. After a successful trial of the Sputnik EM source from 07:00 to 10:00 we began to deploy the Southampton OBEM receivers again over the side of the vessel. Because of their large water resistance and low weight their deployment was slower than that of the GEOMAR receivers. In parallel we started to work on the HyBis power supply. A dirty connector in the junction box was found to cause the leakage and the system could be repaired at 18:00.

Deployment of the Southampton OBEM finished at 04:30 on Friday 18 May. Until noon we collected a multibeam echosounder and Parasound grid across the Storegga area, before starting electromagnetic soundings along a S-N profile across the centre of the CN03 structure using the Sputnik system. We collected data at four stations before we had to stop because of a technical failure in the power supply. Throughout the night we carried on surveying the area with multibeam and Parasound profiles to map out the extent of slope instabilities above the gas hydrate zone in the northern side wall of the Storegga Slide.

The multibeam survey continued throughout the night and after a successful Posidonia transponder test at 13:00 on Saturday 19 May we arrived at 14:00 at the first DASI deployment location. After powering up DASI the communication link to the system broke down. After hours of fault finding, we decided to continue the Sputnik transect and moved back to transect 1. There we deployed Sputnik at 18:00.

Throughout Sunday 20 May the Sputnik profiles continued without interruptions across the vent site CN03. The weather was fine with light northerly winds. At the same time the Southampton team carried out repairs and further tests of the DASI vehicle, discovering two broken connections in the main antenna power supply which could be fixed until the evening.

We finished the third Sputnik profile at 08:00 in the morning of Monday 21 May. After recovery of the vehicle we steamed 8 miles south to the deployment position of DASI which was deployed at noon. With fine weather we acquired data with DASI throughout the rest of the day.

With fresh north-easterlies we continued DASI profiling until 15:00 in the afternoon of Tuesday 22 May. After retrieval of DASI we picked up the GEOMAR OBEMs, which was finished at 20:00. Then we used the time for a multibeam and Parasound survey along the crest of the contourite that hosts the hydrate system, while DASI was disconnected from the fibre optic cable and HyBis was connected.

At 04:00 on Wednesday 23 May we started to pick up the Southampton OBEMs. In ideal weather conditions this work lasted until noon. After steaming to the beginning of a video transect close to the Storegga Slide sidewall we deployed HyBIS at 14:00. However, after powering it up and lowering it down to approximately 60 m the front lights went out and the vehicle had to be recovered. It turned out that there was a short circuit in one of the light power supplies that damaged the cable of the bulb and required replacement of a fuse inside the vehicle. The repair works lasted until 17:40 when we redeployed the vehicle for a very interesting video transect through a sea floor crevasse and down the Storegga Slide side wall. This transect was completed at 8:40. At 9:40 we deployed the instrument a second time to survey another crevasse that we believed to be active. However, the results of this transect were somewhat disappointing as in spite of strong seafloor diffractions in the Parasound data only little seafloor morphology could be observed.

HyBIS was recovered from the second transect at 00:15 on Thursday 24 May. Afterwards we disconnected it from the fibre optic cable and cleared the deck for acquiring more high-resolution 2D seismic data while steaming to the beginning of the first profile. Deployment of the seismic system commenced at 00:30. From 03:00 onwards we collected seven N-S seismic profiles across the area with crevasses and fluid escape structures in the Nyegga Region. In the afternoon the weather became foggy but the sea stayed calm, resulting in some exceptionally good data.

Seismic data acquisition continued without interruptions in calm, sunny weather until Friday 25 May. At 14:00 we retrieved the seismic equipment and end the scientific work programme with another sound velocity profile for calibrating the multibeam echosounders. This was finished at 15:45 and we started the transit to Stavanger.

Acknowledgements

We like to thank captain Michael Schneider, his officers and crew of RV Meteor for their professional support of our science programme and for very pleasant company on board. We also thank our technical team Martin Wollatz-Vogt, Gero Wetzel and Torge Matthiessen for the many hours of relentless effort trying to fix the scientific equipment.

The ship time of RV Meteor was provided by the Deutsche Forschungsgemeinschaft within the core program METEOR/MERIAN. Financial support for the different projects carried out during the cruise was provided though the BMBF Sugar 2 project and funding through the institutions involved. We gratefully appreciate all this support.

Cruise participants

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Sebastian Hölz	CSEM	GEOMAR
Malte Sommer	CSEM	GEOMAR
Prof. Martin Sinha	CSEM	NOCS
Dr. Karen Weitemeyer	CSEM	NOCS
Hector Marin Moreno	CSEM	NOCS
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Jens Karstens	P-Cable	GEOMAR
Holger Berndt	P-Cable	VBPR
Ines Dumke	P-Cable	GEOMAR
Dr. Adriano Mazzini	Sedimentology	UiO
Arno Lettmann	Bathymetry	GEOMAR
Veit Hühnerbach	HyBis	NOCS
Melanie Couillard	Sedimentology	UMont
Moritz Lüdemann	Watch keeper	GEOMAR
Thomas Eckardt	Watch keeper	GEOMAR
Tarik Kiyan	Watch keeper	GEOMAR
Johannes Käufl	Watch keeper	KIT
Wu-Cheng Chi	Seismologist	SINICA
Martin Wollatz-Vogt	CSEM engineer	GEOMAR
Torge Matthiessen	Seismic technician	GEOMAR
Gero Wetzel .	Electronic engineer	GEOMAR
Ian Tan	CSEM engineer	NOCS
Anett Mickoleit	Meteorology	DWD
Andreas Raeke	Meteorology	DWD

GEOMAR	Helmholtz Centre for Ocean Research Kiel (GEOMAR)
NOCS	National Oceanography Centre Southampton
VBPR	Volcanic Basin Petroleum Research, Oslo
UiO	University of Oslo
UMont	University of Montpellier 2
KIT	Karlsruhe Institute of Technology
SINICA	Academia Sinica, Taipei
DWD	Deutscher Wetterdienst, Hamburg

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)$#	'.%!&%'!"'#	"("'#	+.-#)!/)$G#1 #	.-#&!/"+G#2#	'.%!&%'!"'#	.('*#	+.-#../.,G#1 #	.-#&"/&.G#2#
)*#	'.%!&%'!"'#	.(.,#	+.-#../.+G#1 #	.-#&)/,+G#2#	'.%!&%'!"'#	,(&!#	+.-#)!/$&G#1 #	.-#&'/,.G#2#
.!#	'.%!&%'!"'#	$("'#	+.-#)!/$!G#1 #	.-#&&/.&G#2#	'.%!&%'!"'#	""(""#	+.-#../).G#1 #	.-#&+/!+G#2#
."#	'.%!&%'!"'#	""()'#	+.-#../)$G#1 #	.-#&$/).G#2#	'.%!&%'!"'#	".())#	+.-#)!/,!G#1 #	.-#&$/"&G#2#
.'#	'.%!&%'!"'#	".(&)#	+.-#)!/,&G#1 #	&-#!!/$'G#2#	'.%!&%'!"'#	",(&.#	+.-#../).G#1 #	&-#!!/+.G#2#
.)#	'.%!&%'!"'#	"$(".#	+.-#../'$G#1 #	&-#!'/*!G#2#	'.%!&%'!"'#	'!("'#	+.-#)&/.,G#1 #	&-#!'/*+G#2#
..#	'.%!&%'!"'#	'!()+#	+.-#)&/&"G#1 #	&-#!&/**G#2#	'.%!&%'!"'#	''()"#	+.-#.)/$$G#1 #	&-#!+/.+G#2#
.&#	'.%!&%'!"'#	''(.!#	+.-#../.)G#1 #	&-#!+/"'G#2#	'.%!&%'!"'#	''(&*#	+.-#.&/"&G#1 #	&-#!)/'&G#2#
.+#	'.%!&%'!"'#	')()&#	+.-#../$$G#1 #	&-#!)/')G#2#	'&%!&%'!"'#	)(&)#	+.-#.)/&'G#1 #	&-#.$/,'G#2#
.,#	'&%!&%'!"'#	.(!$#	+.-#.'/,*G#1 #	&-#.*/"'G#2#	'&%!&%'!"'#	&("*#	+.-#.'/."G#1 #	&-#)+/!+G#2#
.$#	'&%!&%'!"'#	&(),#	+.-#."/)*G#1 #	&-#)+/")G#2#	'&%!&%'!"'#	+(.+#	+.-#.'/""G#1 #	&-#.$/$,G#2#
.*#	'&%!&%'!"'#	,(!.#	+.-#."/"'G#1 #	&-#.*/&'G#2#	'&%!&%'!"'#	"!(.)#	+.-#)'/&)G#1 #	&-#"./,+G#2#
&!#	'&%!&%'!"'#	"!(.+#	+.-#)'/.,G#1 #	&-#"./')G#2#	'&%!&%'!"'#	"'(!!#	+.-#)'/..G#1 #	&-#!!/+&G#2#

Seismic Profiles

)$*+,-&%	!"#$"%				&'(%			
	(#"&%	",. &%	-#",'/(&%	-*' 0,"/(&%	(#"&%	",. &%	-#",'/(&%	-*' 0,"/(&%
67%&,!. ,8%1 2#-#$%,(0&:%								
!"#	*%!&%'!"'#	'(")#	+,-#"!/)'G#1#	.-#.+/*$G#2#	*%!&%'!"'#	.(!+#	+,-#!./."G#1#	.-#.!/)"G#2#
!'#	*%!&%'!"'#	.(')#	+,-#!./,"G#1#	.-#)$/$&G#2#	*%!&%'!"'#	&(&+#	+,-#"!/'$G#1#	.-#.&/")G#2#
!)#	*%!&%'!"'#	+("'#	+,-#!*/*$G#1#	.-#.+/&"G#2#	*%!&%'!"'#	+()'#	+,-#!$/$+G#1#	.-#.&/'+G#2#
;7%&,!. ,8%1 2#-#$%,(0&:%								
!"#	""%!&%'!"'#	"$(.!#	+,-#!,/+$G#1#	.-#',/',G#2#	""%!&%'!"'#	'!(&'#	+,-#!)/.)G#1#	.-#.*/&!G#2#
!'#	""%!&%'!"'#	''(&&#	+,-#!)/),G#1#	.-#.*/.+G#2#	"'%!&%'!"'#	!("*#	+,-#!"/"$G#1#	.-#)./&.G#2#
!)#	"'%!&%'!"'#	!()!#	+,-#!"/&*G#1#	.-#))/&"G#2#	"'%!&%'!"'#	)(&"#	+,-#"./,.G#1#	.-#.*/)+G#2#
!.#	"'%!&%'!"'#	.(!!#	+,-#"&/".G#1#	.-#.$/..G#2#	"'%!&%'!"'#	&()*#	+,-#""/,.G#1#	.-#))/&)G#2#
!&#	"'%!&%'!"'#	&(.*#	+,-#""/"*G#1#	.-#))/++G#2#	"'%!&%'!"'#	,(.)#	+,-#!,/+,G#1#	.-#&)/&!G#2#
!+#	"'%!&%'!"'#	,(&)#	+,-#!,/*)G#1#	.-#&./,*G#2#	"'%!&%'!"'#	*('+#	+,-#"./+,G#1#	.-#&)/!)G#2#
!,#	"'%!&%'!"'#	*()+#	+,-#"./,$G#1#	.-#&"/&+G#2#	"'%!&%'!"'#	")(!&#	+,-#!"/!!G#1#	.-#)+/!'G#2#
;7%&,!. ,8%1 45&00#:%								
!$#	'.%!&%'!"'#	"("'#	+.-#)!/)$G#1#	.-#&!/"+G#2#	'.%!&%'!"'#	.('*#	+.-#../.,G#1#	.-#&"/&.G#2#
!*#	'.%!&%'!"'#	.(.,#	+.-#../.+G#1#	.-#&)/,+G#2#	'.%!&%'!"'#	,(&!#	+.-#)!/$&G#1#	.-#&'/,.G#2#
"!#	'.%!&%'!"'#	$("'#	+.-#)!/$!G#1#	.-#&&/.&G#2#	'.%!&%'!"'#	""(""#	+.-#../).G#1#	.-#&+/!+G#2#
""#	'.%!&%'!"'#	""()'#	+.-#../)$G#1#	.-#&$/).G#2#	'.%!&%'!"'#	".())#	+.-#)!/,!G#1#	.-#&$/"&G#2#
"'#	'.%!&%'!"'#	".(&)#	+.-#)!/,&G#1#	&-#!!/$'G#2#	'.%!&%'!"'#	",(&.#	+.-#../).G#1#	&-#!!/+.G#2#
")#	'.%!&%'!"'#	"$(".#	+.-#../'$G#1#	&-#!'/*!G#2#	'.%!&%'!"'#	'!("'#	+.-#)&/.,G#1#	&-#!'/*+G#2#
".#	'.%!&%'!"'#	'!()+#	+.-#)&/&"G#1#	&-#!&/**G#2#	'.%!&%'!"'#	''()"#	+.-#.)/$$G#1#	&-#!+/.+G#2#
"&#	'.%!&%'!"'#	''(.!#	+.-#../.)G#1#	&-#!+/"'G#2#	'.%!&%'!"'#	''(&*#	+.-#.&/"&G#1#	&-#!)/'&G#2#
"+#	'.%!&%'!"'#	')()&#	+.-#../$$G#1#	&-#!)/')G#2#	'&%!&%'!"'#	)(&)#	+.-#.)/&'G#1#	&-#.$/,'G#2#
",#	'&%!&%'!"'#	.(!$#	+.-#.'/,*G#1#	&-#.*/"'G#2#	'&%!&%'!"'#	&("*#	+.-#.'/."G#1#	&-#)+/!+G#2#
"$#	'&%!&%'!"'#	&(),#	+.-#."/)*G#1#	&-#)+/")G#2#	'&%!&%'!"'#	+(.+#	+.-#.'/""G#1#	&-#.$/$,G#2#

"*#	'&%!&%'!"'#	,(!.#	+.-#."/"'G#1 #	&-#.*/&'G#2#	'&%!&%'!"'#	"!(.)#	+.-#)'/&)G#1 #	&-#"./,+G#2#
'!#	'&%!&%'!"'#	"!(.+#	+.-#)'/.,G#1 #	&-#"./")G#2#	'&%!&%'!"'#	"'(!!#	+.-#)'/..G#1 #	&-#!!/+&G#2#

Dasi Profiles

-,' &%	!"#$"%				&' (%			
	(#"&%	",. &%	-#","/ (&%	-*' 0,"/ (&%	(#"&%	",. &%	-#","/ (&%	-*' 0,"/ (&%
3#	'"%!&%'!"'#	"'(&*#	+.-#.)/&+G#1 #	&-#!./""G#2#	'"%!&%'!"'#	"&(.!#	+.-#.,/.'G#1 #	&-#!./.!G#2#
4#	'"%!&%'!"'#	"$()$#	+.-#.&/*&G#1 #	&-#!!/$"G#2#	'"%!&%'!"'#	'"(!*#	+.-#../"*G#1 #	&-#!$/+.G#2#
5#	'"%!&%'!"'#	')(")#	+.-#.&/$,G#1 #	&-#!&/)!G#2#	''%!&%'!"'#	!(",#	+.-#.+/+&G#1 #	&-#!"/&)G#2#
6##	''%!&%'!"'#	'()+#	+.-#../$'G#1 #	&-#!'/".G#2#	''%!&%'!"'#	+(.$#	+.-#.'/$'G#1 #	&-#"&/+&G#2#
2#	''%!&%'!"'#	"!(!!#	+.-#)*/*+G#1 #	&-#"&/$"G#2#	''%!&%'!"'#	""())#	+.-#.'/"+G#1 #	&-#"+/!+G#2#

HyBIS transects

"$#' !&8"%	!"#$"%				&' (%			
	(#"&%	",. &%	-#","/ (&%	-*' 0,"/ (&%	(#"&%	",. &%	-#","/ (&%	-*' 0,"/ (&%
"#	')%!&%'!"'#	"+(."#	+.-#)*/!+G#1 #	&-#!&/",G#2#	')%!&%'!"'#	"$("+#	+.-#)$/&!G#1 #	&-#!&/)&G#2#
'#	')%!&%'!"'#	'"(&)#	+.-#)./*+G#1 #	.-#&"/")G#2#	')%!&%'!"'#	''('"#	+.-#)./$'G#1 #	.-#&"/!&G#2#