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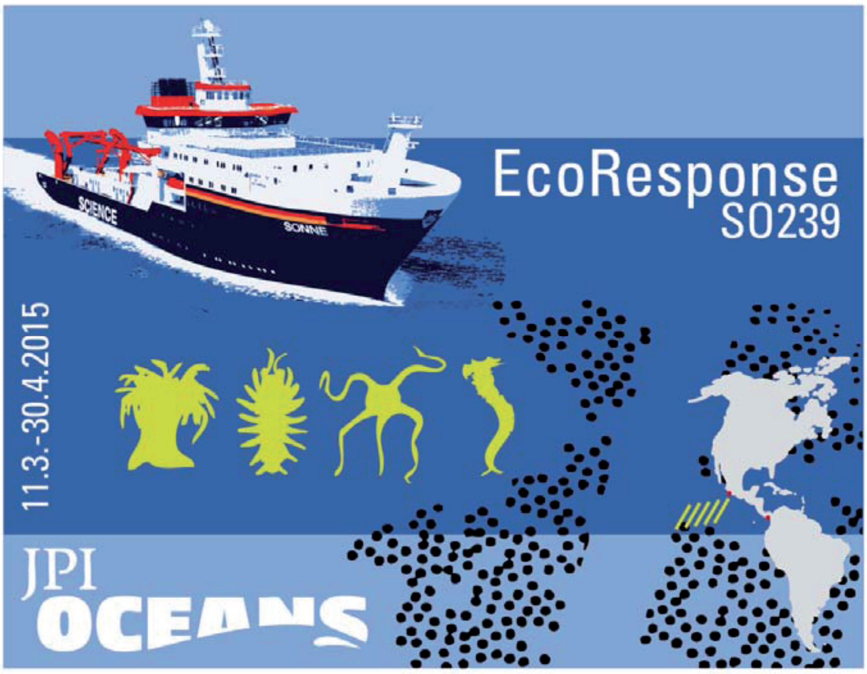
RV SONNE
Fahrtbericht / Cruise Report
SO239

EcoResponse Assessing the Ecology, Connectivity and Resilience of Polymetallic Nodule Field Systems

Balboa (Panama) – Manzanillo (Mexico)
11.03. -30.04.2015



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Helmholtz-Zentrum für Ozeanforschung Kiel

Nr. 25 (N. Ser.)

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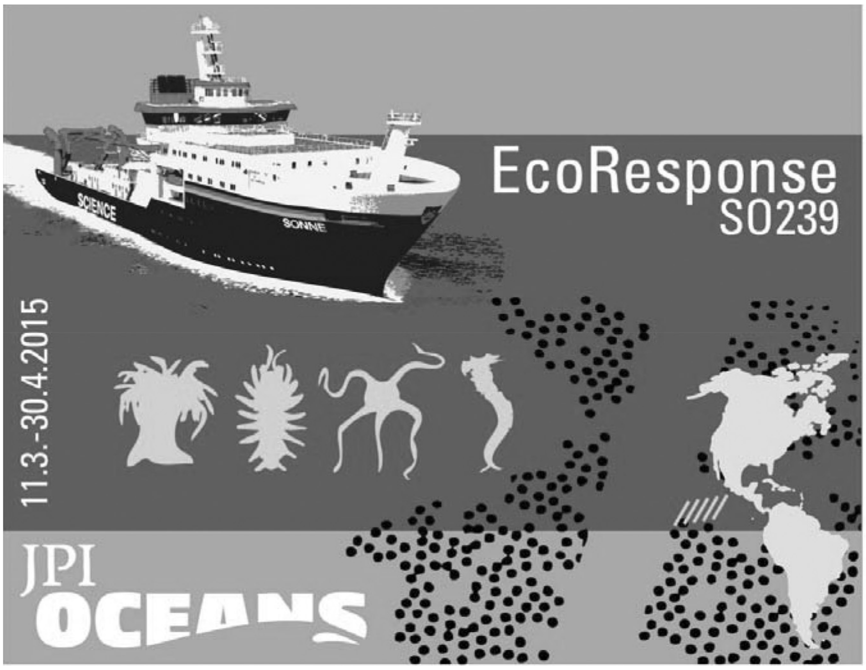

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RV SONNE SO239
Cruise Report / Fahrtbericht

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11th March 2015 – 30th April 2015

SO239 EcoResponse

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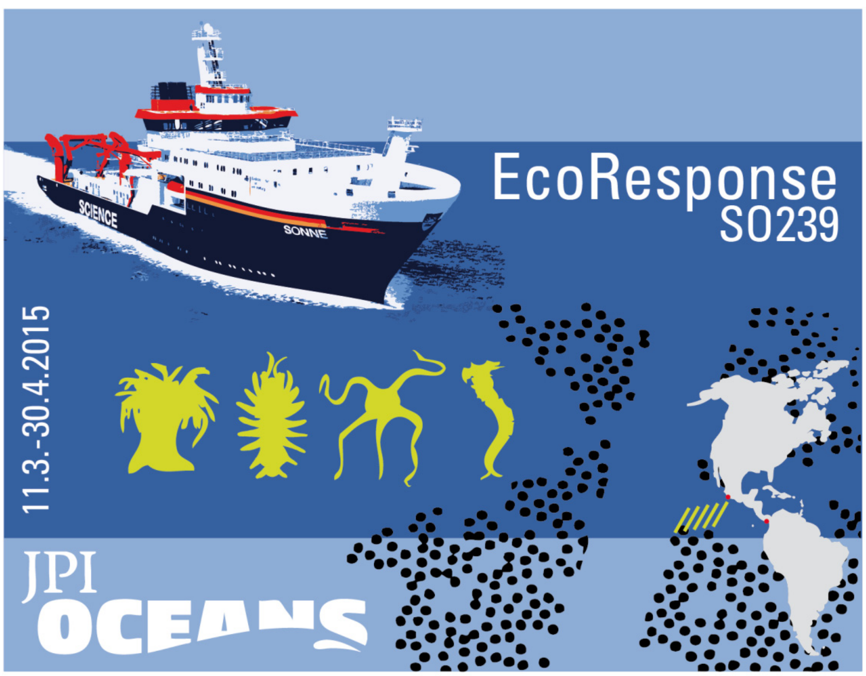


Chief scientist: Prof. Dr. Pedro Martínez Arbizu,
Senckenberg am Meer, Deutsches Zentrum für
Marine Biodiversitätsforschung, Wilhelmshaven

TOC / Inhaltsverzeichnis

Inhalt

1. Cruise summary / Zusammenfassung

1.1 German / Deutsch

Die Fahrt SO239 EcoResponse wurde vom 11. März bis zum 30. April durchgeführt. Schwerpunkt der Reise war die Untersuchung der Biodiversität und der geologischen und geochemischen Gegebenheiten entlang eines Produktivitätsgradienten in der CCZ. Dazu kommt die Untersuchung der genetischen Konektivität zwischen weit entfernten Populationen in der Tiefsee, der Vergleich zwischen der Fauna der Seeberge und der Fauna, die auf den Manganknollen lebt sowie die erste Untersuchung eines APEI Gebietes. Das AUV wurde auf seine Einsetzbarkeit für die zukünftige Erfassung und Evaluierung der Bergbauaktivitäten getestet. Es wurden 6 Arbeitsgebiete in 4 ISA-Kontraktoren-Gebieten (BGR, IOM, DEME, Ifremer) und eine APEI besucht. In allen Gebieten wurden Sedimente mit dem Multicorer, dem Kastengreifer und dem Schwerelot gesammelt. Epibenthische Organismen und Aasfresser wurden jeweils mit dem epibenthischen Schlitten und einer Amphipodenfalle gesammelt. In allen Gebieten wurde das CTD benutzt und die Wassersäule untersucht. Ein AUV wurde benutzt, um detaillierte Tiefenkarten herzustellen, aber auch Seitensichtsonar und fotografische Untersuchungen. Mit dem ROV wurden Megafauna-Organismen gesammelt, mit dem Pushcorer wurde in alten Dredgespuren gesammelt, und es wurden Videotransekte gefahren.

1.2 English / Englisch

The cruise SO239 EcoResponse took place between 11th of March and 30th of April 2015. Aim of the cruise was to study the biodiversity, geological and geochemical settings across a productivity gradient in the CCZ. Also to study the genetic connectivity between distant deep-sea populations, to compare the fauna from seamounts with the fauna living attached to the nodules and to sample an APEI for the first time. The AUV was used to test the usefulness of photographic and side-scan sonar survey for future monitoring of mining activities. We visited 6 working areas in 4 ISA contractor areas (from BGR, IOM, DEME, Ifremer) and the APEI number 3. On all sites sediment samples were taken with the Multicorer, Box-Corer and Gravity Corer. Additionally epibenthic fauna and scavengers were sampled with the Epibenthic Sledge and Amphipod Trap, respectively. CTD cast and water samples were taken on each of the areas. An AUV was used to perform detail bathymetric mapping in addition to side-scan sonar and photographic surveys. ROV was used to sample megafauna organisms, to sample sediments inside dredge tracks, and to perform video transect.

2. Participants / Teilnehmer

2.1 Principal investigators / Leitende Wissenschaftler

Prof. Dr. Pedro Martinez, DZMB , Senckenberg am Meer, Südstrand 44, 26382 Wilhelmshaven

Prof. Dr. Jens Greinert, Geomar Helmholtz Centre for Ocean Research Kiel, Wischhofstr. 1-3, 24148 Kiel, Germany

Prof. Dr. Ann Vanreusel, Marine Biology, Ghent University, 9000 Belgium

Prof. Dr. Magdalena Błażewicz-Paszkowycz, Department of Invertebrate Zoology and Hydrobiology, University of Łódź, Poland

Dr. Lenaick Menot, French Institute for the Exploitation of the Sea, IFREMER Centre de Brest (IFREMER/SISMER)

2.2 Scientific party / wissenschaftliche Fahrtteilnehmer

Name	Institute	Team/task
Pedro Martinez Arbizu	Senckenberg	Chief Scientist
Timm Schoening	U Bielefeld	DIAS Database, Imaging
Dan Vasiliu	GeoEcoMar	Water column
Pedro Miguel de Azevedo Ribeiro	IMAR	Seamounts
Henri Robert	RBINS	Scavengers
Andrea Fioretti	Conisma	Microbiology, metagenomics
Uwe Raschka	Senckenberg	Meiofauna
Ann Vanreusel	U Gent	Meiofauna
Lara Macheriotou	U Gent	Meiofauna
Brygida Wydrowska	Uszczecin	Meiofauna
Daniel Kersken	Senckenberg	Megafauna
Ana Hilario	U Aveiro	Megafauna / macrofauna
Jens Greinert	Geomar	mapping / lander /mooring
Tim Weiss	Geomar	mapping / lander /mooring
Lenaick Menot	Ifremer	Infauna
Paulo Bonifacio	Ifremer	Infauna

Lenka Nealova	U Gothenburg	Infauna
Jessica Volz	AWI	Geochemistry
Benjamin Löffler	AWI	Geochemistry
Vincent OZEGOWSKI	AWI	Geochemistry
Inken-Marie Preuss	JUB	Geochemistry
Annika Moje	JUB	Geochemistry
Magdalena Błażewicz-Paszkowycz	U Łódź	Epifauna/infauna
Stefanie Kaiser	Senckenberg	Epifauna,
Sarah Schnurr	Senckenberg	Epifauna
Marcel Rothenbeck	Geomar	AUV
Emanuel Wenzlaff	Geomar	AUV
Steinführer, Anja	Geomar	AUV
Lars Triebe	Geomar	AUV
Fritz Abegg	Geomar	ROV
Martin Pieper	Geomar	ROV
Hannes Huusmann	Geomar	ROV
Patrick Cuno	Geomar	ROV
Inken Suck	Geomar	ROV
Jan Hennke	Geomar	ROV
Miriam Ploeger	Geomar	ROV
Matthias Bodendorfer	Geomar	ROV
Sven Hoffmann	Senckenberg	TA, GKG, EBS, MUC
Sahar Khodami	Senckenberg	DNA Lab
Jennifer Ciomber	AWI	Geochemistry technician

Institutes:

Senckenberg: Senckenberg Gesellschaft für Naturforschung, Institute Senckenberg am Meer, Wilhelmshaven und Forschungsinstitut und Naturmuseum, Frankfurt am Main.

JUB: Jacobs University Bremen, Germany

AWI: Alfred Wegener Institut für Polar- und Meeresforschung, Bremerhaven, Germany

U Bielfed: Universität Bielefeld, Germany

GeoEcoMar: National Research and Development Institute for Marine Geology and Geoecology, Bucarest, Romania

IMAR: Institute of Marine Research, University of Azores, Portugal

RBINS: Royal Belgian Institute of Natural Sciences, Brussels, Belgium

Conisma: Consorzio Nazionale Interuniversitario per la Scienze del Mare, Ancona, Italy

U Gent: University of Gent, Gent, Belgium

Uszczecin: University of Szczecin, Poland

U Aveiro: University of Aveiro, Portugal

Geomar: Helmholtz-Zentrum für Ozeanforschung, Kiel, Germany

Ifremer: Institut français de recherche pour l'exploitation de la mer, Brest, France

U Gothenburg: University of Gothenburg, Sweden

U Lodz: University of Łódź, Poland

2.3 Crew / Mannschaft

Name	Given Name	Rank
MALLON	Lutz	Master
ADEN	Nils	Chief Officer
HENNING	Tim	2. Officer
GOEBEL	Jens Christian	2. Officer
WOLTERS	Gabriele	Ship´s Doctor
GROSSMANN	Mathias	Chief Electronic Engineer
PREGLER	Hermann Josef	System Manager
BORCHERT	Wolfgang	System Manager
SCHÜLER	Achim	Chief Engineer
GENSCHOW	Steffen	2. Engineer
HEIKENS	Kartsen	2. Engineer
SCHMIDT	Hendrik	Electrician
BLOHM	Volker	Fitter
HOFFMANN	Georg	MPC / Motorman
KUDERSKI	Jens	MPC / Motorman
ALTENDORF	Denis	MPC / Motorman
TIEMANN	Frank	Chief Cook
GARNITZ	André	2. Cook
POHL	Andreas	1. Steward
KROEGER	Sven	2. Steward
STEEP	Maik	Steward
ROYO	Luis	2. Steward
BIERSTEDT	Torsten	Boatswain
FISCHER	Sascha	MPC / A.B.
ERNST	Arnold	MPC / A.B.
DE MOLINER	Ralf	MPC / A.B.
EIDAM	Oliver	MPC / A. B.
SIEFKEN	Tobias	MPC / A.B.
KRUSZONA	Torsten	MPC / A.B.
SUHR	Robert	MPC / A.B.

3. Narrative of the cruise / Ablauf der Forschungsfahrt

Cruise SO-239 started in Balboa, Panama on March 9th with the embarkation of the crew and scientist and loading the containers and instruments. Scientists from 12 different countries came on board. We departed from Balboa on March 11th with one day of delay respective to schedule. The transit time to the first working area located in German License Area on the eastern site of the CCZ took 8 days, only interrupted by a test CTD station (and sound velocity measurement to calibrate the multibeam) in international waters on March 14th.

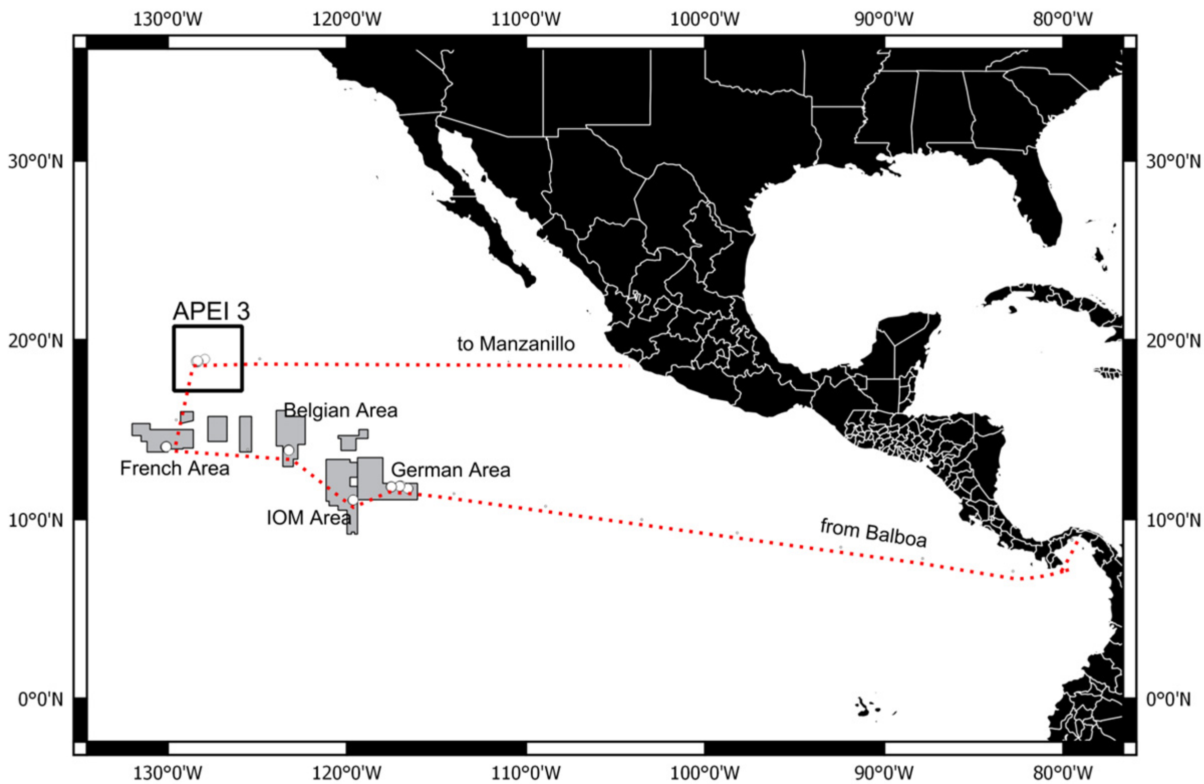


Fig 3.1: Ship track and location of the sites visited during SO239

The long transit time was used to set up the laboratories and the instruments get trained in safety issue and get familiar with the new vessel. Science meetings were held every day until the end of the cruise to discuss on logistic and scientific issues. In total 5 working areas were visited during SO-239. On each area, following set of gears was deployed routinely. The ship's own multibeam system was used to produce bathymetric charts of the study sites. The CTD was used for oceanographic study and water sampling. For the study of benthic diversity, the Boxcorer (infauna) and the Epibenthic Sledge 'EBS' (epifauna) were used. For the study of the meiofauna, the protists and the sediment geochemistry the Multicorer was used. A free fall Amphipod Trap was used to study the scavengers. The Gravity Corer (10m) was used to study the geological settings. ROV was used to collect megafauna organisms, as well as to perform video transects and to sample sediments within (old and new) dredge tracks. The AUV was used to do photographic surveys as well as high resolution multibeam mapping and side-scan sonar mapping.
The German License Area (BGR), was reached on March 19th. The one of the objectives in this area was to study the bottom currents and to logistically support the time-series oceanographic measurements started by the BGR 2 years before. For this, we deployed a Bottom Boundary Layer Lander (BOBO Lander) and a Deep-Sea Observation System (DOS Lander) equipped by oceanographic measuring instruments and a 400 m long thermistor chain. The DOS Lander was recovered and re-deployed after one week at the bottom. Finally

these moorings were left at the bottom, to be recovered 3 months later, during next cruise SO240.

On 21 march 2015 one prototype Amphipod Trap (Fig. 3.2) from Senckenberg was deployed at 11° 50,63' N 117° 3,57' W. The trap was built with Polyethylene plates to achieve positive buoyancy. To compensate the weight of the Posidonia acoustic releaser and increase positive buoyancy the trap was equipped with 2 blocks of synthetic foam SF8000. In addition a 15 m rope was attached at the upper end of the trap and was equipped with a 17” Vitrovex flotation sphere at the other end to facilitate recovery of the trap. As weight an 80 cm x 80 cm common concrete plate was used. The acoustic releaser responded satisfactorily during descent, but ceased communication when the trap was at about 1000 m depth. After several unsuccessful attempts to establish communication, the trap was declared as lost.

Fig. 3.2: The prototype Amphipod Trap lost in the German Area

The AUV side-scan sonar system proved to be excellent for detecting old dredge tracks in the abyss. We were able to map the exact position of chain dredge and EBS tracks produced by SO205 (2010) and subsequent BGR cruises in the area. Biodiversity and geochemistry was studied in two areas defined by BGR in previous cruises, the so called ‘Prospective Areas’ and the ‘Reference Area’. In both areas also AUV mapping and side-scan sonar maps were produced, as well as photographic surveys. ROV dives were used to collect megafauna at both sides, and for video transecting.

Two seamounts were sampled and video-documented with the ROV. One seamount located eastern of the Impact Reference Zone was baptized as 'Rüppell Seamount' in honor to the German naturalist Eduard Rüppell (1794–1884). It is a very steep conical volcano (Fig 3.3).

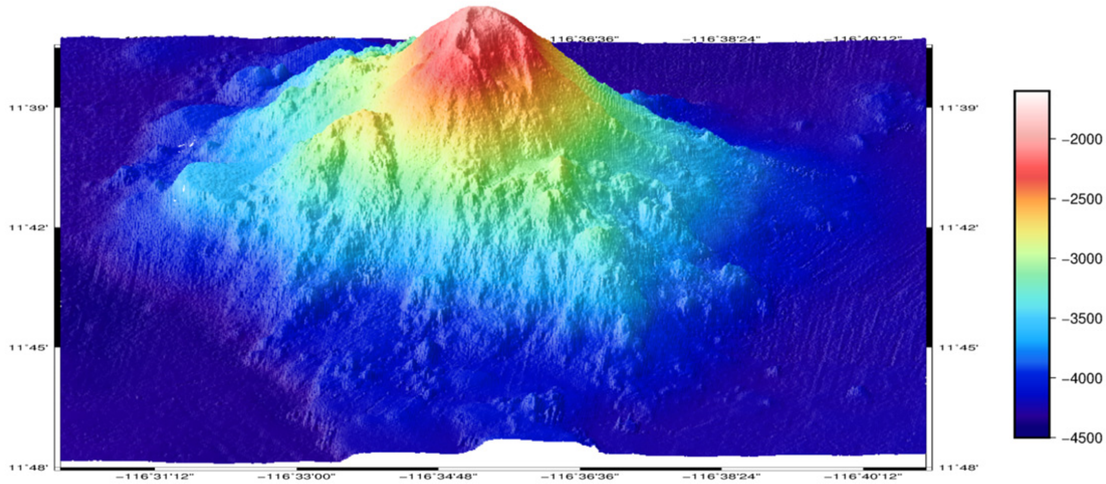


Fig. 3.3: Topography of the Rüppell Seamount from the North.

The other seamount (Fig. 3.4) located to the south of the Preservation Reference Zone is a chain of adjacent volcanoes called by us 'Senckenberg Mountains' in honor to the German philanthropist Johann Christian Senckenberg (1707–1772). In the Impact Reference Zone we sampled inside a 3 years old chain dredge track. In the Reference Zone we sampled with the ROV inside an EBS track produced by us only few days before. In both sides CTD and Gravity Corer were used. The Amphipod trap collected a great number of Amphipods and some fish at both sites. A search for the lost Amphipod trap in the Reference Zone with the ROV remain unsuccessful.

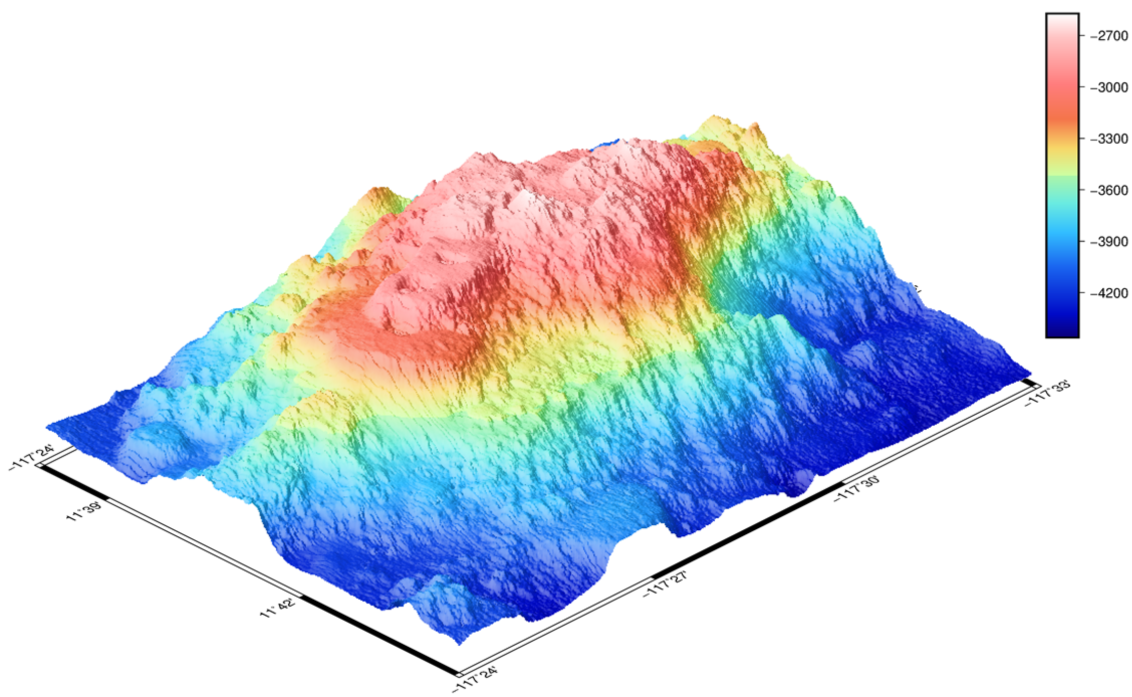


Fig. 3.4. Topography of the Senckenberg Mountains from North-East

The Interoceanmetal (IOM) area was reached on 31th of March and we performed CTD cast and water sampling followed by multibeam mapping. Main objective in this area was to find the site were IOM performed a Benthic Impact Experiment in 1995 (Fig 3.5), and to resample this area in order to study the recovery of benthic communities after 20 years. The disturbed area was found using the AUVs side-scan sonar and three treatments, viz ‘control’, ‘disturbed’ and ‘resedimentation’ areas were sampled with the Multicorer and the Boxcorer. Additional AUV photographic survey documented old tracks and old and new imprints of the sampling gears. One ROV dive was devoted to sample directly inside an old track in the impacted area. In addition basic biodiversity survey and geological and geochemical sampling of sediments was performed in a non-impacted nodule area east to the Benthic Impact Experiment (BIE) site.

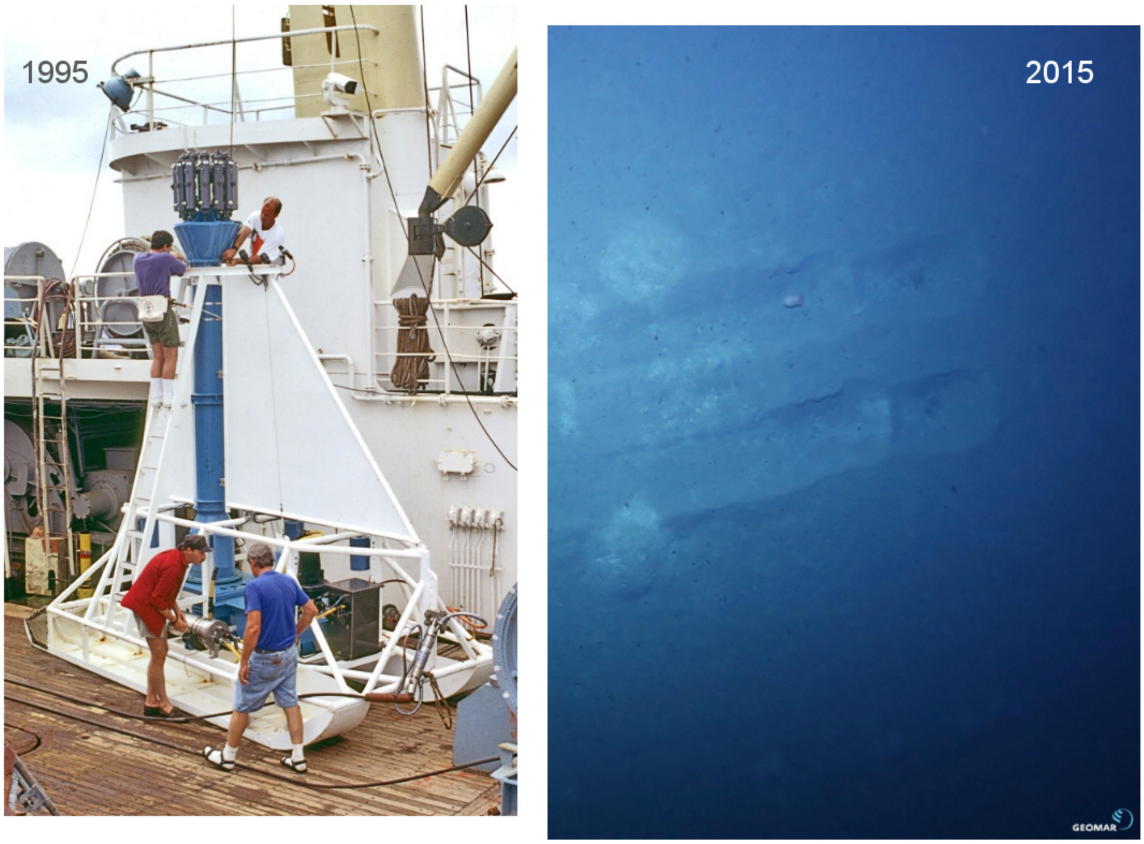


Fig. 3.5: Left, the gear used in 1995 by IOM to produce the experimental sediment plume. Right, marks of the landing of the gear at the seafloor photographed 20 years later with the AUV, during SO239.

A total lunar eclipse was observed in the night of the 4th of April, having a duration of about 5 minutes.

After 23 hours of transit, we reached the Belgian License area on April 6th was reached. In this area we performed the routine biodiversity survey and geochemical characterization with Multicorer, Boxcorer, EBS, Gravity Corer, Amphipod trap, CTD and AUV photographic survey. In addition we sampled a chain dredge track produced by the Belgian dredging company DEME 8 months before and a few days old EBS track produced by ourselves. One large seamount (Fig. 3.6) was mapped with the multibeam and sampled with the ROV. We called this large seamount the 'Heip mountains' in honour to the Belgian Professor Carlo Heip (1945–2012).

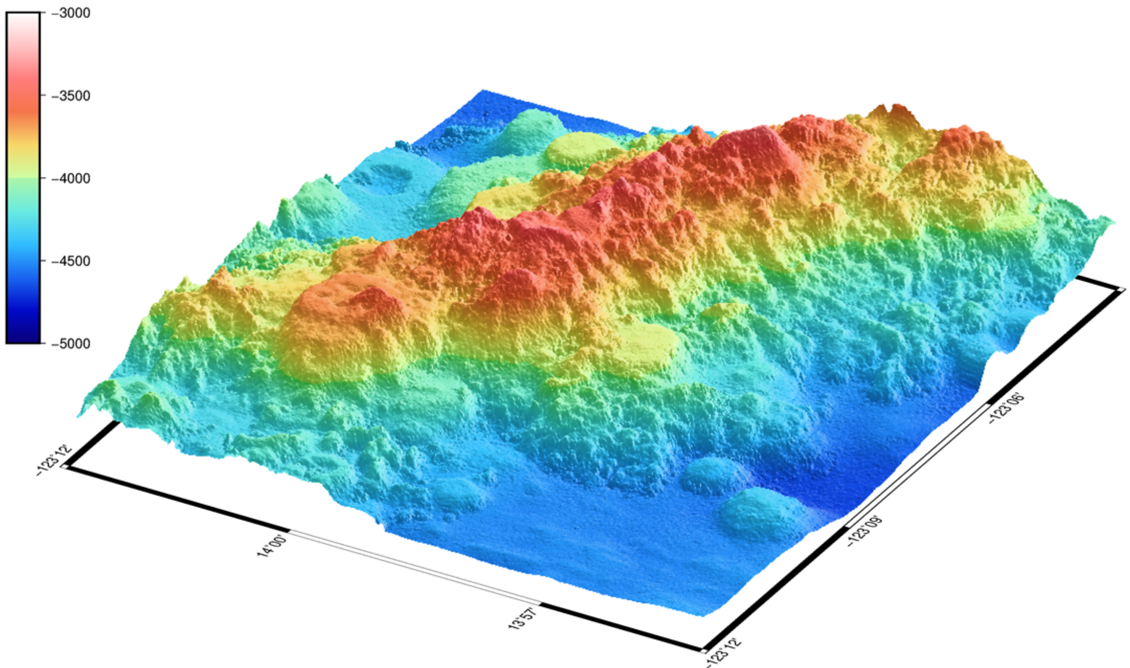


Fig. 3.6 Topography of the Heip Mountains from the South-West.

We left the Belgian area on April 12th and reached to the French License Area one day later. Main objective was to revisit an old chain dredge track produced by OMCO 36 years ago (Fig. 3.7). We had sampled and studied the recovery of this track in 2004 during the French cruise NODINAUT with submersible NAUTILE, and now we resampled it 10 years later.

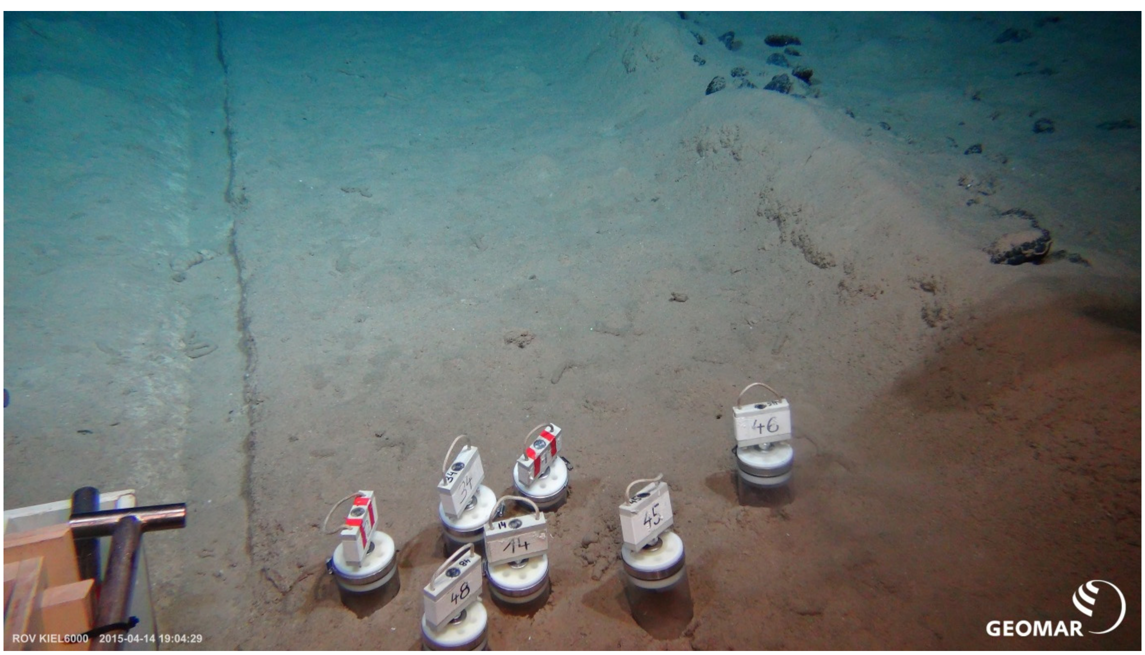


Fig. 3.7 Dredge track produced by OMCO 36 years ago, and sample during this cruise.

With the aid of the AUV side-scan sonar, we were able to georeference that track and the other old tracks, including some EBS tracks produced by us during cruise BIONOD 3 years ago. Both the 36 and the 3 year old tracks were sampled with the ROV. A third ROV dive to sample an additional track was aborted due to bad weather conditions. As in the other areas, baseline biodiversity study and geochemical characterization were also performed in undisturbed areas. The Amphipod trap collected enough material from all areas to study the long range (across 1000 km) gene flow between populations.

Last study site was the APEI number 3 located north off the French License Area, outside the CCZ (Fig. 3.1). These APEIs have never been studied before and therefore our objective was to obtain first baseline data about this area in order to compare the biodiversity and the fauna with the core CCZ nodule areas. We arrived at the APEI on April 19th and started our sampling design as the previous areas with CTD and multibeam mapping. During this survey a large seamount was discovered in the central part of the APEI. The standard set of gears was used to study the biodiversity, geological and geochemical settings. AUV dives mapped and photographed large areas and the ROV was used to collect megafauna and video document the benthic communities in the abyssal plain. The Seamount discovered with the multibeam was sampled with the ROV on April 24th. We agreed to name this conical volcano 'Mann Borgese Seamount' after the German maritime law expert Elisabeth Mann Borgese (1918–2002).

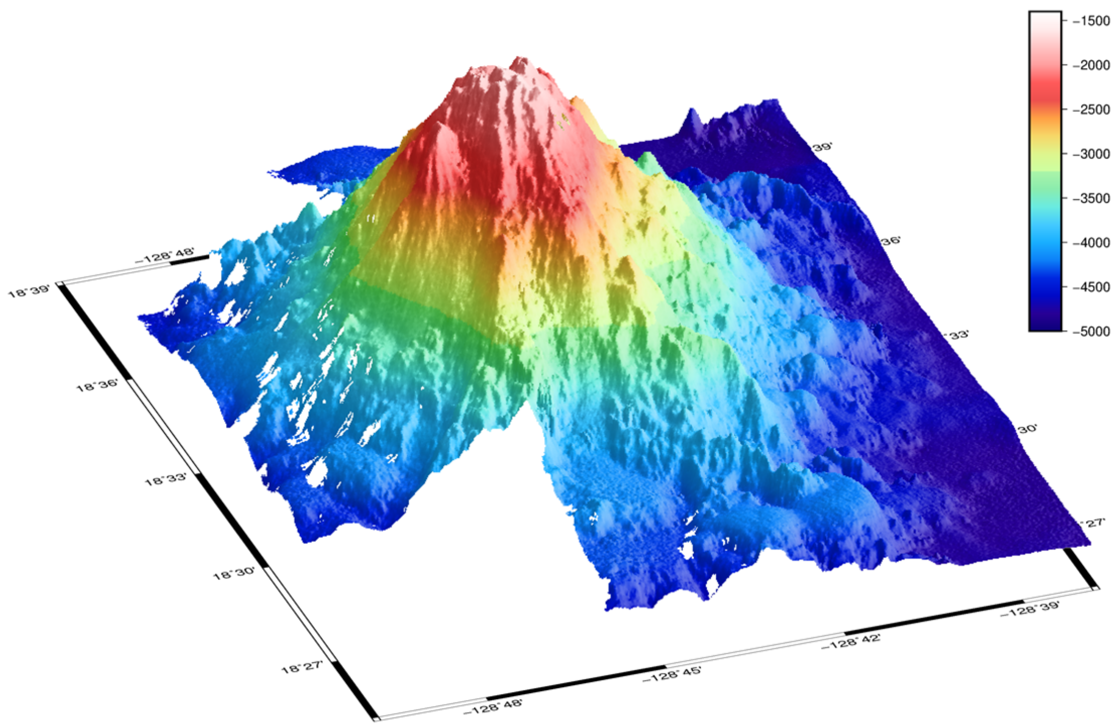


Fig. 3.7 Topography of the Mann Borgese Seamount from the South-West.

Due to bad weather conditions a final Gravity corer and one Multicorer could not be deployed and we departed to Manzanillo on April 25th. From the beginning of the cruise 214 gear operations were performed in total.

We arrived in Manzanillo in the morning of the 30th April 2015. Container logistics and, especially, shipping of frozen samples turned out to be very complicated due to severe harbor regulations. This could be only solved after few days and provoked a delay in the departure of the next cruise SO-240

4. Aims of the Cruise / Zielsetzung der Forschungsfahrt

There is an increasing interest for developing an exploitation framework for deep-sea mineral resources. Polymetallic nodules are one of the mineral deposits with potential economic importance, due to its high content of metals like nickel, copper or cobalt, as well as rare earth elements. The area between the Clarion and the Clipperton Fracture zone (short CCZ) harbors the highest know concentration of polymetallic nodules worldwide at depths between 4500 m and 5500 m. The CCZ is managed by the International Seabed Authority (ISA), who has granted contracts to a number of countries (or consortia) for the exploration of marine mineral resources in defined License Areas across the CCZ. The ISA has also defined 9 non-mining areas as Areas of Particular Environmental Interest (APEIs).

Mining activities will result in the removing of the polymetallic nodules and in mechanical alteration of the upper sediment layers, this most probably creating a large sediment plume at the seabed. It is not known what impact these activities will cause on the highly diverse benthic and bathypelagic communities in the CCZ. Furthermore, it is not known how large will be the spatial extension of the impacts and how long it will take for biodiversity to recover after mining.

The most important factors which influence resilience of benthic communities will be the biodiversity (how many species are there and what dominance patterns are present at CCZ), connectivity (how distant populations are connected and how large is the gene flow?) and live history (where and how often benthic organism reproduce, do they have any dispersal potential e.g. larval stages?). On the other hand, the extent of the mining impact will depend on how sediments behave after resuspension, how long the plume will expand and how they stay suspended and how strong and which predominant direction are bottom currents in this area.

Better understanding of the oceanographic conditions and benthic biodiversity at the seafloor will improve the mitigation of potential harm to the environment provoked by mining activities in future and it will help to design more environmentally friendly mining operations. The European Joint Project Initiative – Oceans (JPI-O) “Ecological Aspects of Deep-Sea Mining” is designed to address these questions. The present cruise SO-239 “EcoResponse” is a contribution to JPI-O.

Specific objectives of the cruise are:

- To investigate and model deep-sea bottom currents;
- To perform baseline studies on biodiversity, sediment geochemistry and water column chemistry at selected sites in the CCZ across a (East-West) productivity gradient;
- To investigate connectivity and gene flow of benthic populations across the CCZ;
- To investigate the recovery times of benthic populations after sediment alteration;
- To test usefulness of AUV imagery and echo-sounding for baseline habitat mapping and future monitoring of impacted sites;
- To study the sessile fauna on Seamounts in the CCZ and to compare to the fauna attached to polymetalic nodules;
- To perform the first baseline studies in an APEI and to compare to CCZ sites.

All activities, sampling and measurements performed during this cruise are basic Marine Research on international waters as defined by the United Nations Convention on the Law of the Sea UNCLOS.

5. Agenda of the cruise / Programm der Forschungsfahrt

Five areas were visited during SO239. The working strategy was the applied in the same way at all sites, with some slight adaptations each site (see reports below). First, an initial CTD cast was deployed from the surface to 50 m above the bottom. The sound velocity profile was obtained from this CTD. At each site a bathymetric chart was produced with the Multibeam EM122. This was the basis for detailed positioning of the sampling sites and for planning the AUV und ROV dives. Benthic samples for the study of meiofauna, protists and for geochemical analysis were obtained with 5 Multicorer deployments. Additional 5 Boxcorer deployments were used to study the macrofauna and to estimate nodule coverage. No resource assessment will be undertaken using samples from this cruise, but values of nodule density per site are necessary to understand the importance of the nodules as hard substrate habitat in structuring benthic deep-sea communities. A Brenke-type epibenthic sledge was used to collect epibenthic organism. The gear was deployed 2 times per site. One 10 m gravity corer per site was used to study the geological settings. One Amphipod trap was deployed per site to study the biodiversity and biogeography of the scavenging communities. ROV dives were planned at each site. The dives were used to collect megafauna organisms: mainly sponges, echinoderms and corals and to perform video transects for the study of megafauna communities. Whenever it was possible we also sampled with push-corers inside and outside dredge tracks, to study the recovery of benthic communities after disturbance. In addition 4 seamounts were visited.

6. Settings of the working area / Beschreibung des Arbeitsgebiets

The CCZ is located in the northeastern Equatorial Pacific between Hawaii and Mexico. It is the area enclosed between the Clarion and the Clipperton Fracture Zones, also known as polymetallic nodule belt. In this area, the International Seabed Authority has granted exploration licenses for nodule mining to 15 contractors and also defined a 9 Areas of Particular Environmental Interest were mining should not take place (Fig. 6.1)

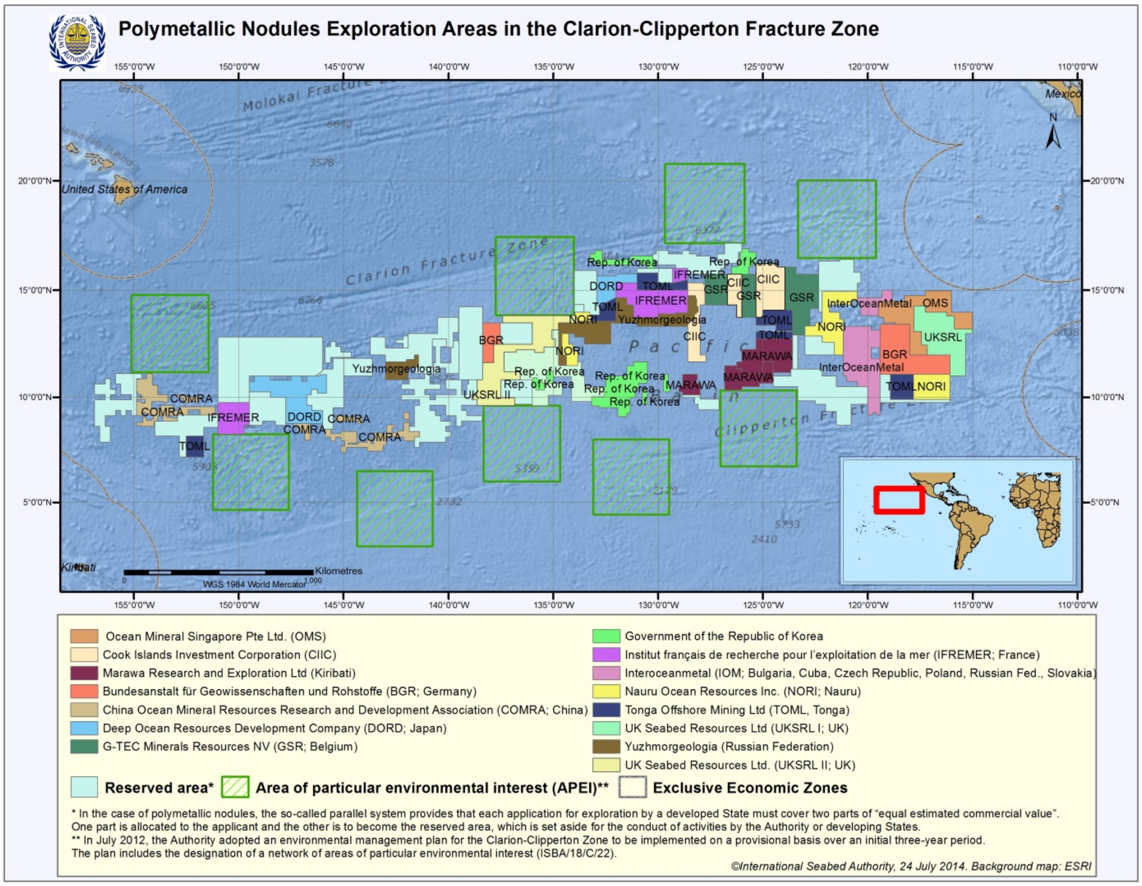


Fig. 6.1: Map of the CCZ showing the contractor areas the reserved areas and the APEIs. Copyright ISA.

There is a marked bathymetric gradient form East to West, depth ranging from average 4100 m to 5400 m. Also the Particulate Organic Matter (POM) flux to the seafloor varies from East to West and from South (more productive) to North (more oligotrophic).

The different Areas sampled during this cruise are described in more detailed in Chapter 7.2.1

We present here some maps to show the position of the gears in the target areas. Note that in those maps the epibenthic sledge is shown as starting point and ending point, rather than using a line.

The position of the gears in the first German area and the names of prospective area are shown in Fif. 6.2. the ROV transect performed at the Rüppell Seamount and the position of the gears and ROV dives at the German reference area are shown in Figs 6.3 and 6.4, respecitivelly.

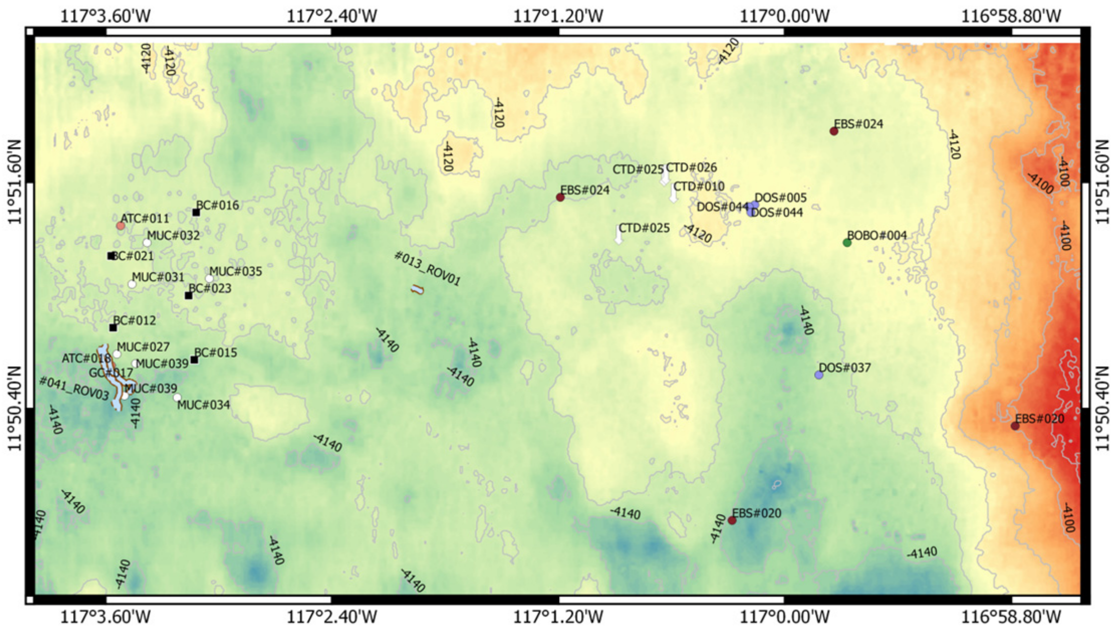
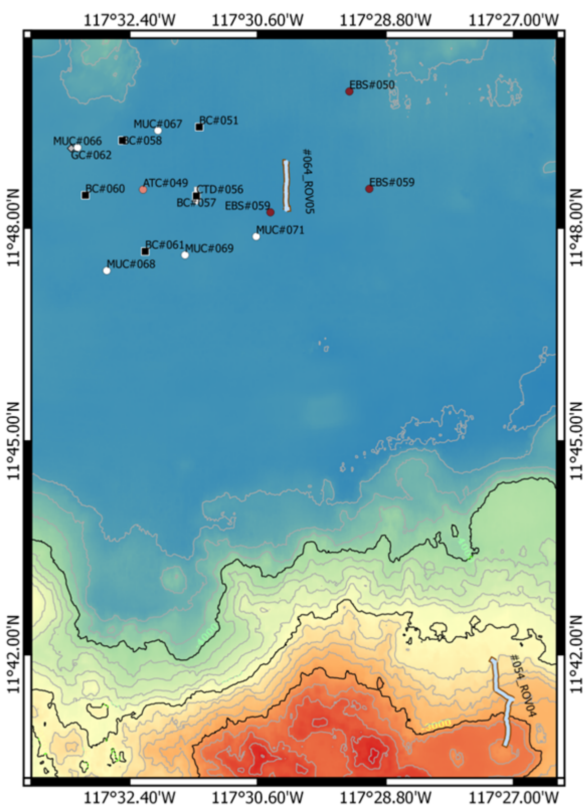


Fig. 6.2: Gear deployments in the German prospective area (BGR).



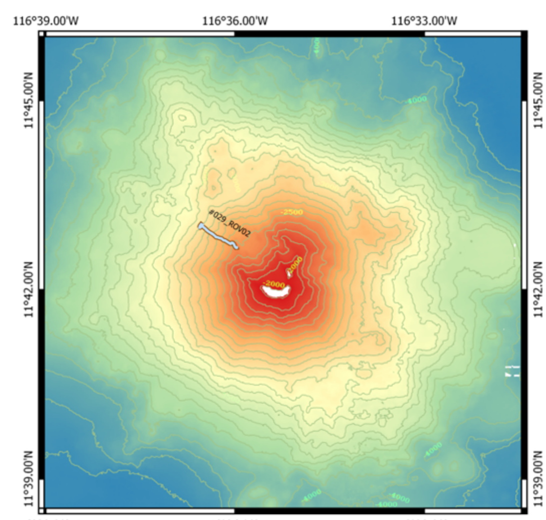


Fig.6.3: The position of ROV dive at the Rüppell Seamount

Fig. 6.4: Location of gear deployment in German reference Area and ROV dive in the Senckenberg Mountains

In the IOM area we performed 2 ROV dives and deployed the gears in the BIE area. The position of the EBS deployments where chosen outside the BIE area to prevent disturbing the long term experiment (Figs 6.5 and 6.6).

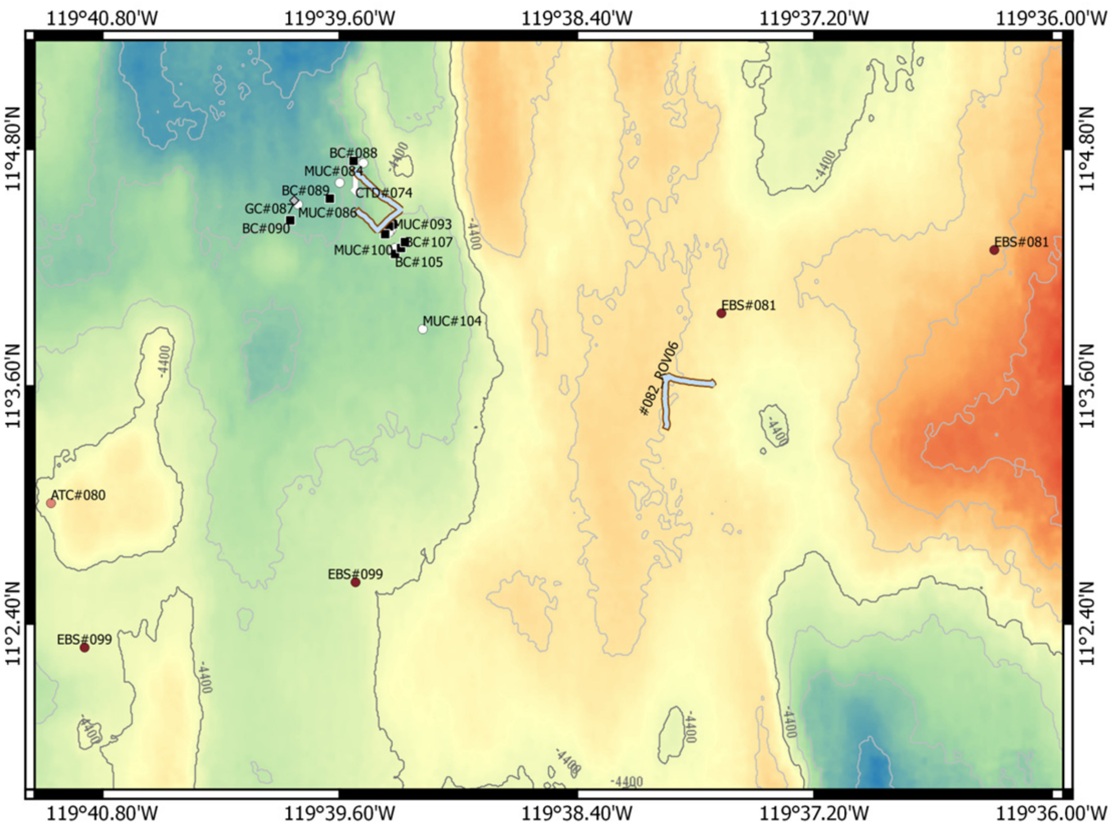


Fig. 6.5: General map of the IOM area with the positions of the gear deployments

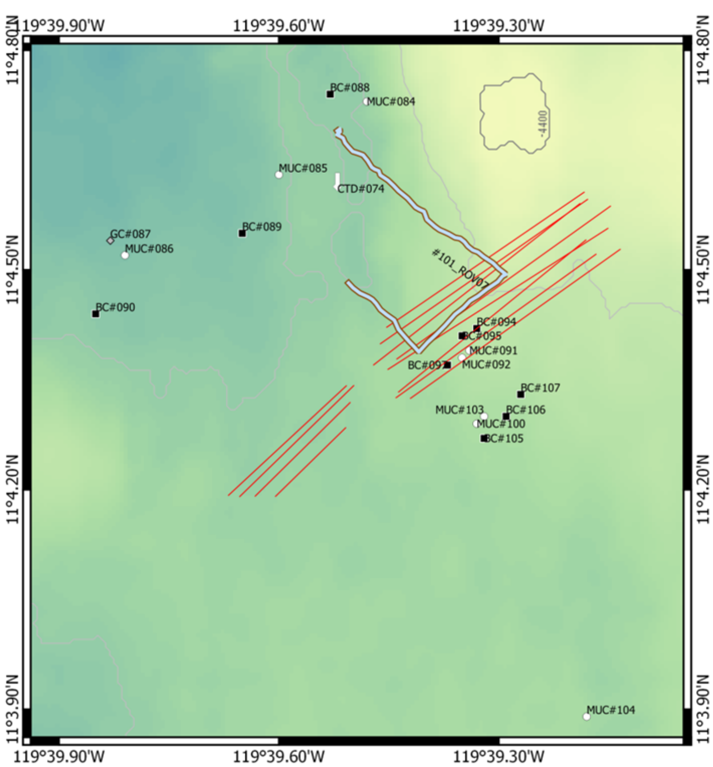


Fig 6.6: Details of the IOM area showing the tracks of the BIE performed in 1995 (red lines) as mapped by the AUV side-scan sonar, and the position of the gear

deployments

Fig. 6.7 shows the Belgian Area and the position of the deployments. The Heip Mountains are located to the northeast of the main working area.

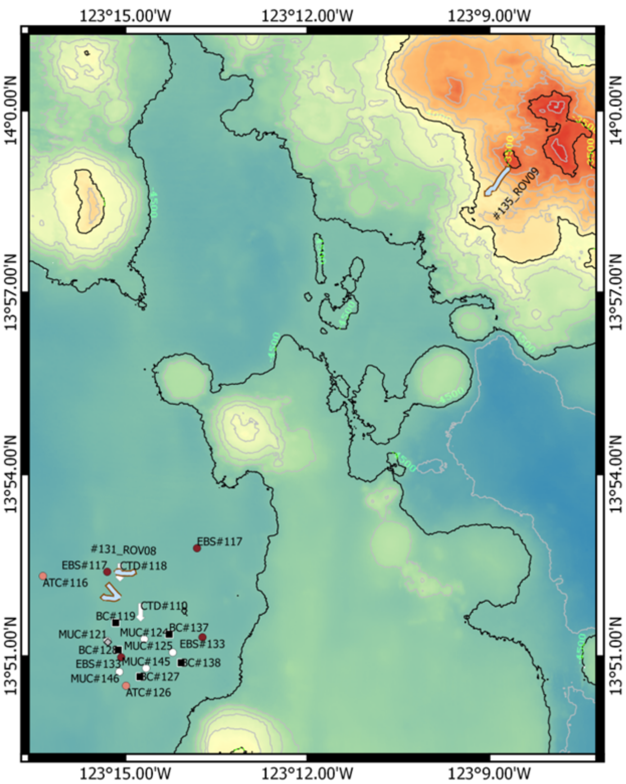


Fig.6.7: An overview of the working sites in the Belgian Area showing the main working area (lower left corner) and the Heip Mountains (upper right corner).

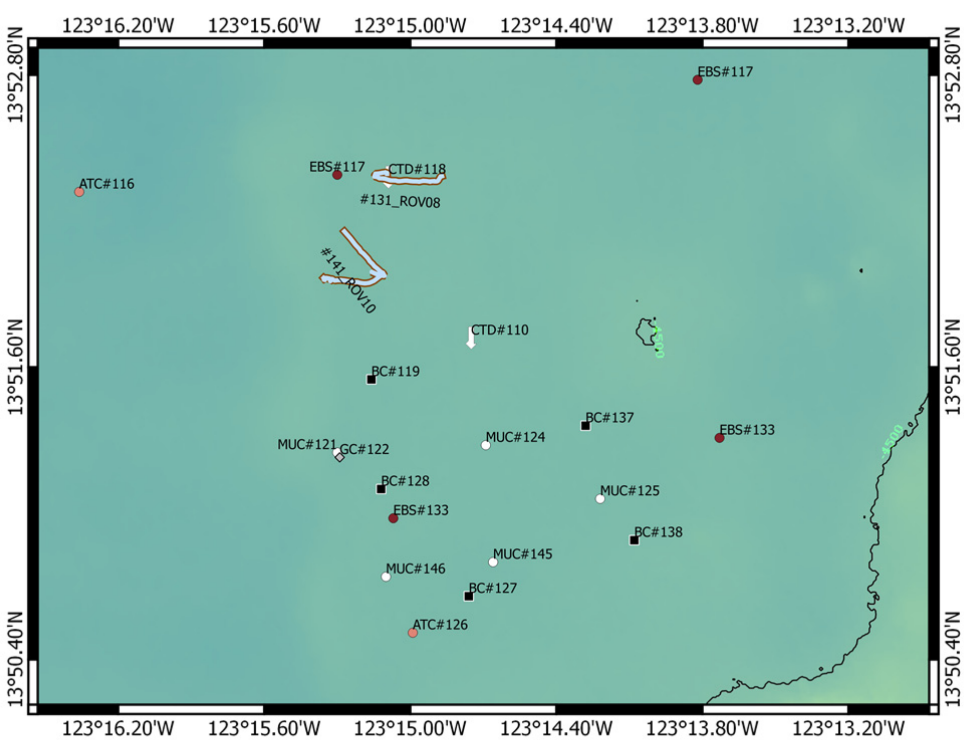


Fig. 6.8: Detail of gear operations in the main site (Belgian Area)

Gear operations in the Eastern French Area were shown in Fig. 6.9.

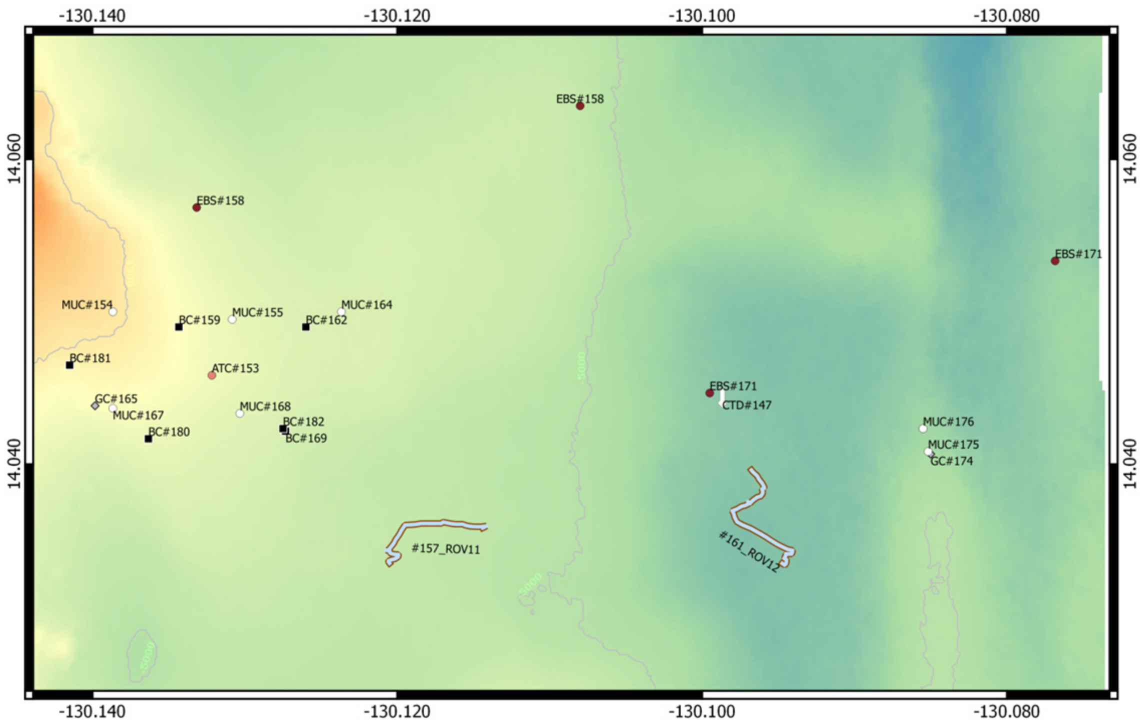


Fig. 6.9: Position of gear deployments in the French Area

The position of the gears deployments in main working area in the APEI number 3 in relation to the Mann Borgese Seamount is shown in Fig. 6.10.

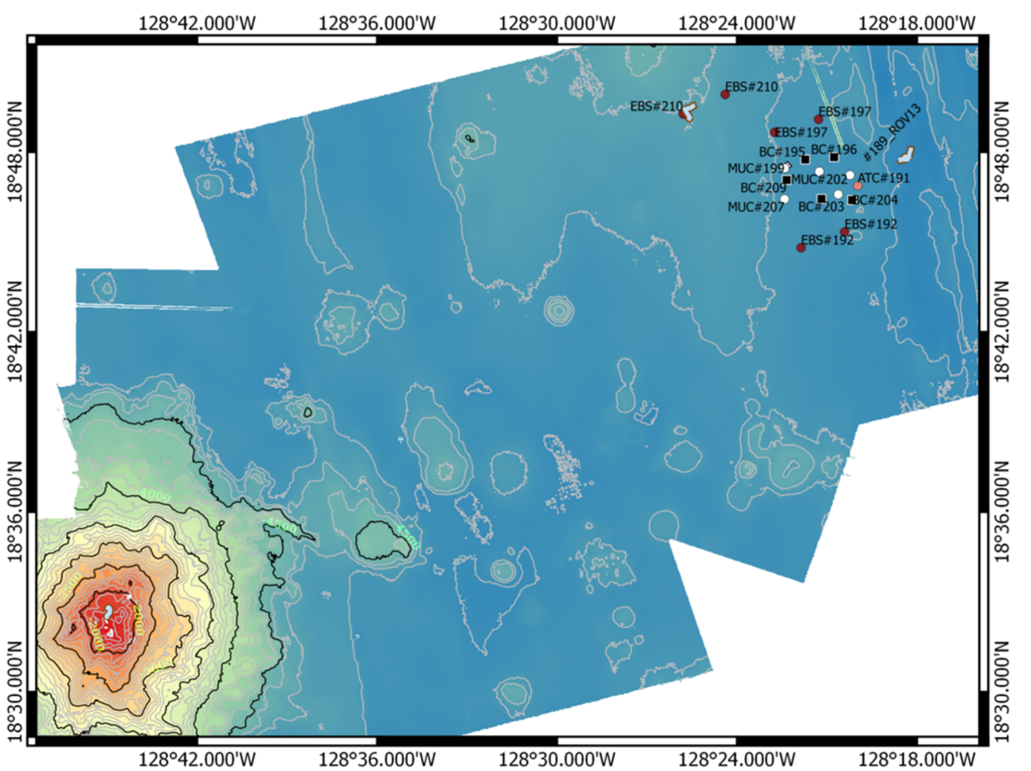


Fig. 6.10: APEI no. 3, position of main sampling site and ROV dive on Mann Borgese Seamount

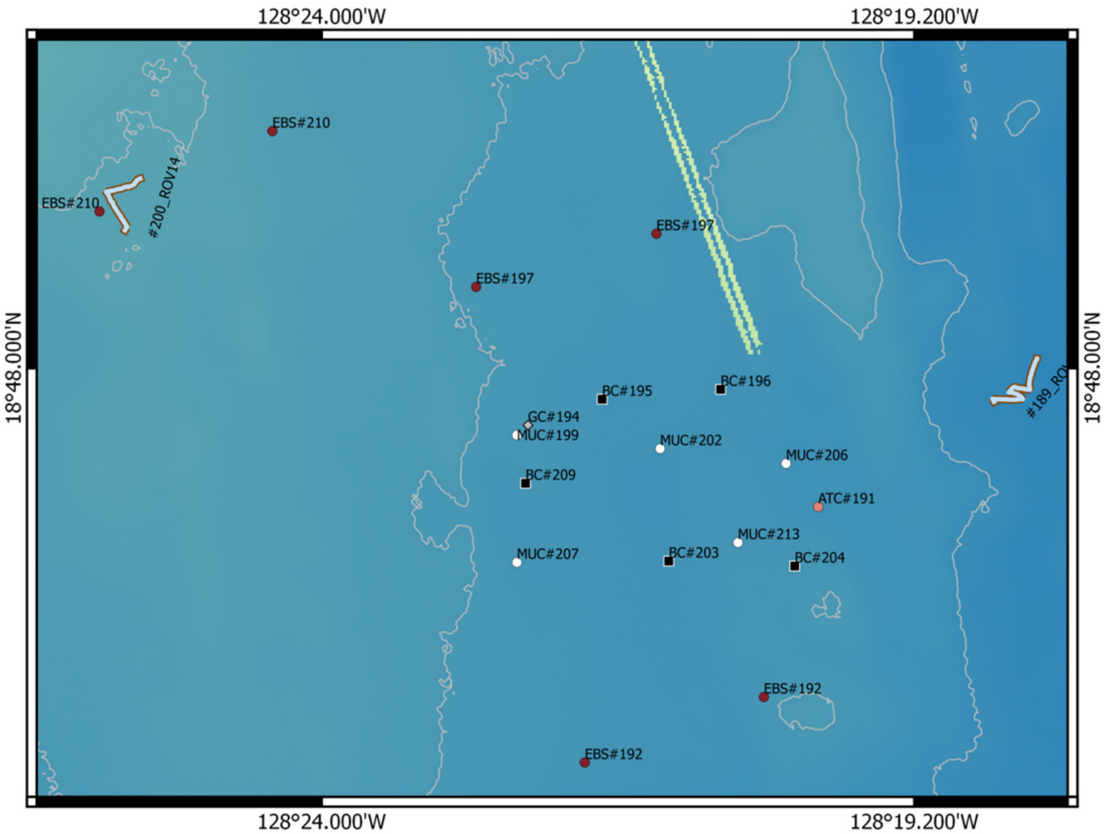


Fig.6.11: APEI no. 3 close up of the main working sites showing position of gear deployments.

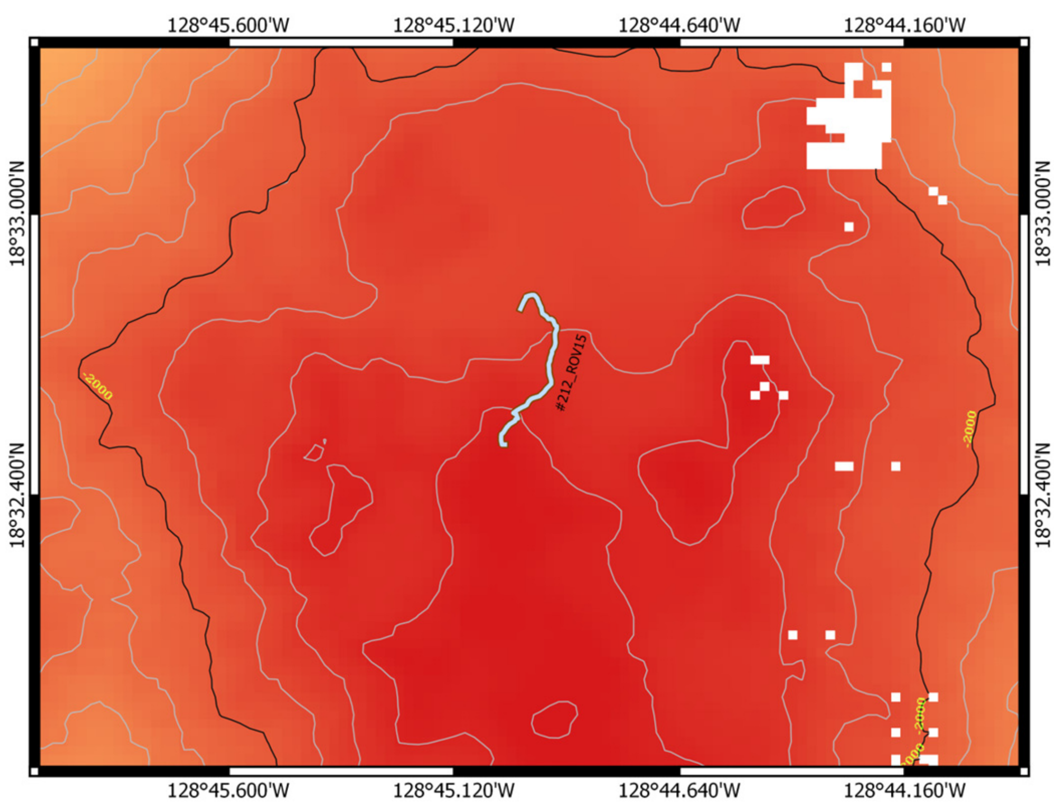


Fig.6.12: ROV dive on the Mann Borgese Seamount in the APEI no. 3.

7. Work details and first results / Beschreibung der Arbeiten im Detail einschließlich erster Ergebnisse

7.1 Description of the Gears

7.1.1 Ship-based hydroacoustic mapping (EM122) (Greinert)

The EM122 is a 12kHz multibeam system with 432 beams each having 1° along track and 0.5° across track beam angles. During SO239 the system was recording during transit time between the working areas and dedicated multibeam surveys for mapping the respective working areas in the German, Belgian and French license areas, APEI - 3 as well as the IOM disturbance area. Data are stored in the common Kongsberg .all file format. Motion data and static offset correction is done by a Seapath MRU-GPS system that directly feeds into the EM122 electronic. Sound velocity profiles from CTD casts have been uploaded into the system upon arrival at a new working area. Survey speed during transit was 12 to 15kn. For dedicated surveys in the working areas the speed was reduced to 10 or even 6kn for getting a higher data density along track. The swath width during transit was set to 130 deg (65° starboard and portside) and has been restricted to ca. 15km swath width after half of the cruise. With wider swath width, the outer sections become rather noisy. During work area surveys the swath was reduced to 120° - 100°. The system was run in equidistance mode for the spacing of the beams across track. In general the system worked very well and gave very good results.

Data processing was performed with Fledermaus for data cleaning and export of xyz data. The exported xyz data were gridded and plotted using GMT 5.1.1. The nearneighbor command was used as gridding algorithms, cell sizes varied from 50 to 10m depending on water depth and data quality. Results of the ship-based multibeam mapping are shown throughout the cruise report, as well as in section 7.2.1.

During our surveys we encountered a strange behavior of the system when working with a swath width of less than 100°. In the German reference area we mapped the entire area upon arrival with three parallel lines and a swath width of 120°. When turning in at the NW corner towards the SE, the swath was reduced to 60° (Fig. 7.1.1.1) to increase the ping frequency and the footprint overlap. However, this resulted in wrong detections of the actual seafloor depth over a large area, not in a reendow way but mimicking a wrong seafloor.
Something similar happened when mapping a sea mount in the same area. Here a swath of 80° gave wrong data but a 100° swath resulted in good data (Figure 7.1.1.2). The respective data sets are listed in Table 1. They have been stored on the EM122 logging computer in separate folder for further inspection. The reason for this behavior is not clear but might be worth further inspection. With 432 beam per ping, we did not check again if a swath angle of less than 100° always gives some kind of wrong data. This might be a task for coming cruises that strongly depend on high resolution maps in deep water.

Table7.1.1.1: Data files which show wrong depth readings and those for comparison.

File name	Swath width	Remark
0179_20150326_140322_Sonne_EM122.all	120°	Good data
0181_20150326_154442_Sonne_EM122.all	60°	Bad data
0188_20150328_041525_Sonne_EM122.all	100°	Good data
0186_20150328_035531_Sonne_EM122.all	80°	Bad data

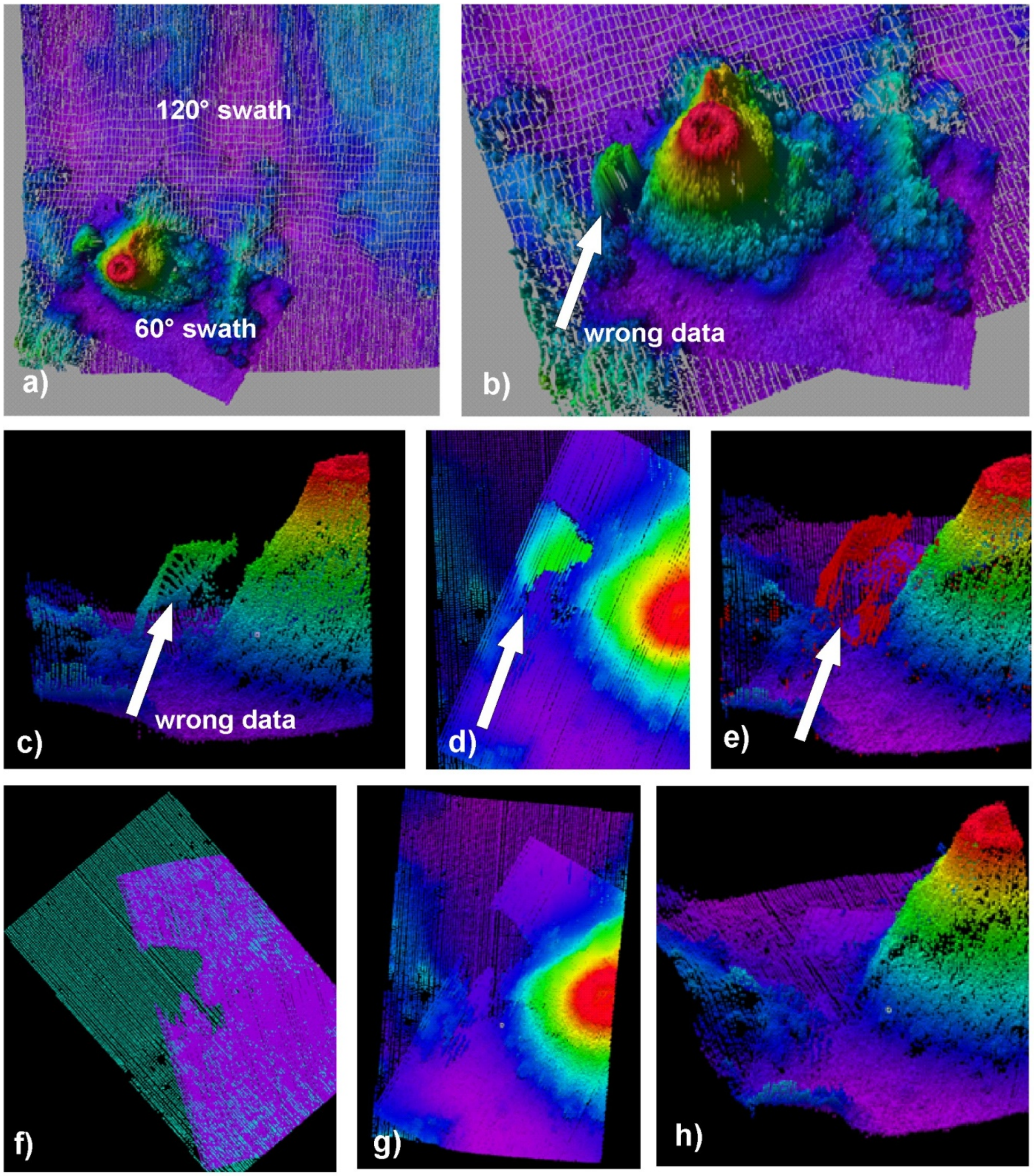


Fig. 7.1.1.1: Example 1 of wrong data when running with a reduced swath. Images a to e show the wrong data that are not random noise but clearly show some kind of morphology. Images f to h show edited data. A significant portion of the 60° swath angle data had to be deleted.

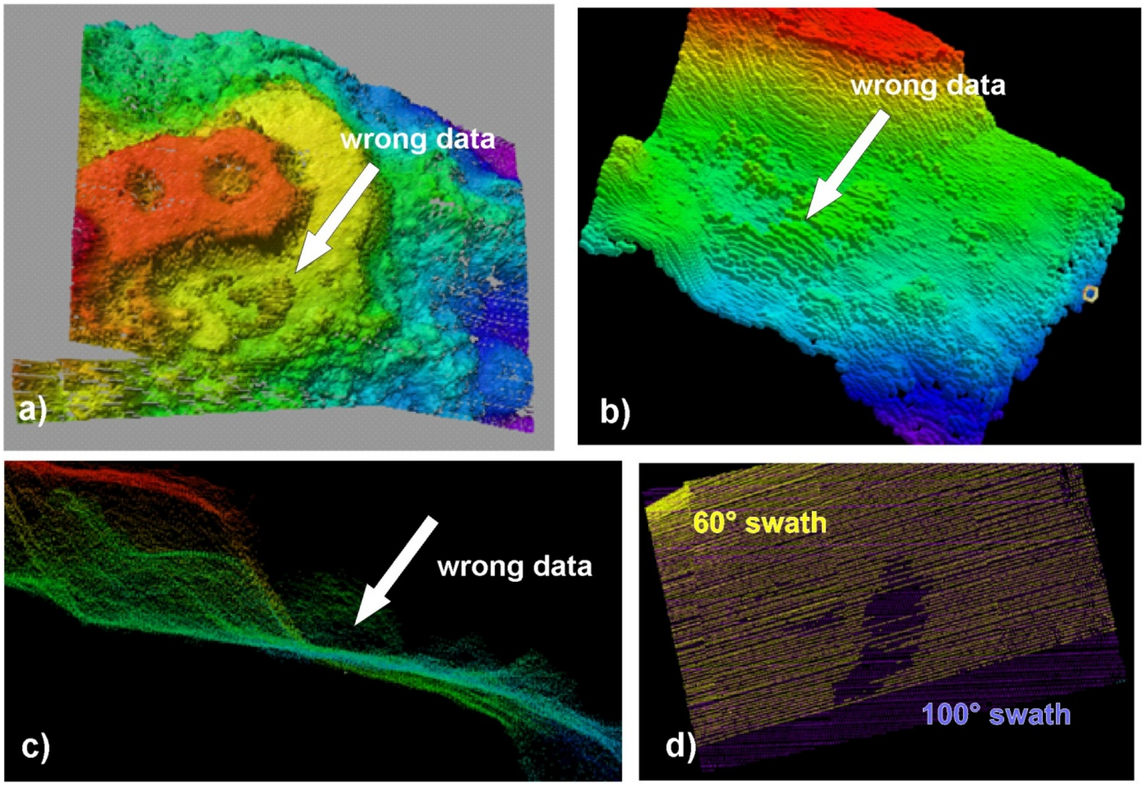


Fig. 7.1.1.2: Wrong data with a reduced swath of 80°. The system measured correctly with a swath of 100°.

7.1.2. AUV Mission Summary (Rothenbeck, Steinführer, Triebe, Wenzlaff)

The Autonomous Underwater Vehicle (AUV) Abyss (built by HYDROID Inc.) from GEOMAR can be operated in water depths up to 6000 m. The system comprises the AUV itself, a control and workshop container (container place 315-317), and a mobile Launch and Recovery System (LARS) with a deployment frame that was installed at the starboard side on the afterdeck of R/V Sonne (container place 321). The self-contained LARS was developed by Woods Hole Oceanographic Institution (WHOI) to support ship-based operations so that no Zodiac or crane is required for launch and recovery. The LARS is mounted on steel plates, which are screwed to the deck of the ship. The LARS is configured in a way that the AUV can be deployed over the stern or port/starboard side of the German medium and ocean-going research vessels. The AUV Abyss can be launched and recovered at weather conditions with a swell up to 2.5 m and wind speeds of up to 6 Beaufort. For the recovery the nose float pops off when triggered through an acoustic command. The float and the ca. 19 m recovery line drift away from the vehicle so that a grapnel hook can snag the line. The line is then connected to the LARS winch, and the vehicle is pulled up. Finally, the AUV is brought up on deck and secured in the LARS.

During cruise SO239 twenty missions were flown by Abyss (Table 7.1.2.1). The missions were flown using the multibeam or camera configuration. Primary sensors were the RESON Seabat 7125 (multibeam; 200 kHz; for 5 missions), the electronic still camera (for 10 missions) and the Edgetech sidescan sonar (for 5 missions).

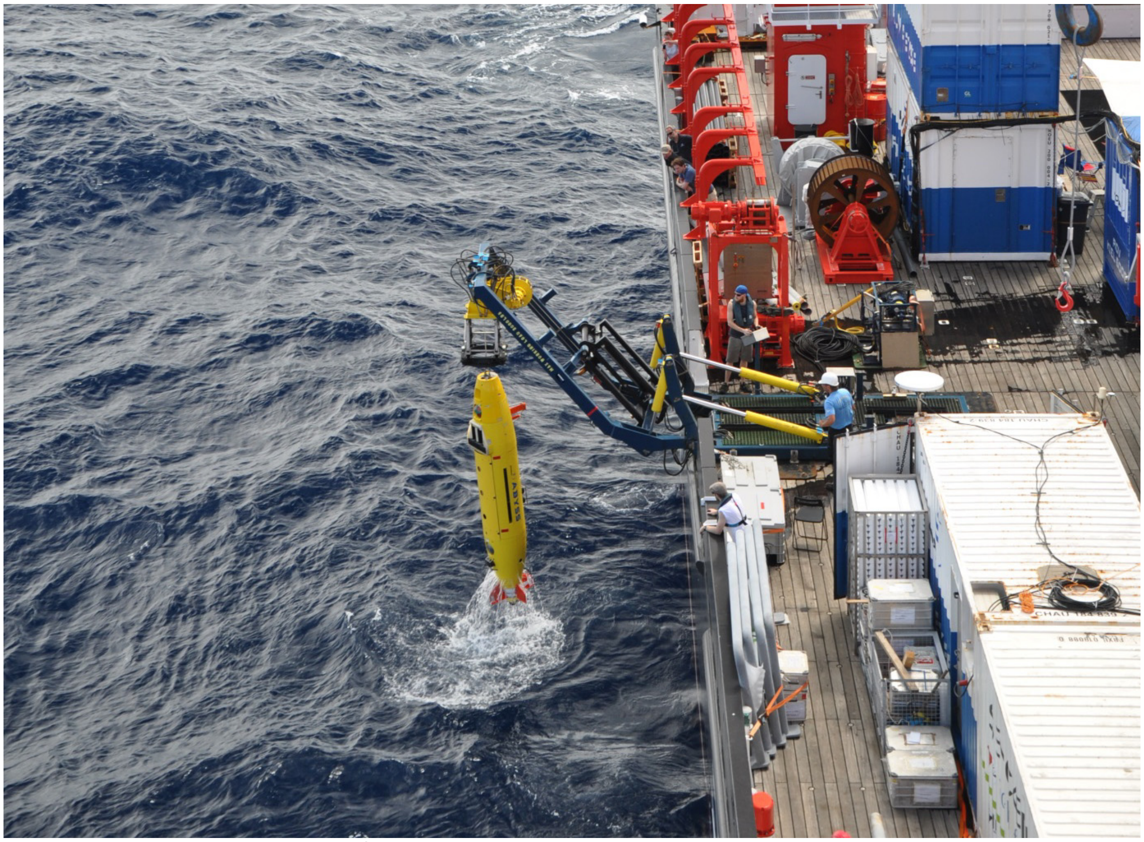


Fig. 7.1.2.1: Launch and Recovery System in use while recovering AUV (Photo: Inken Preuss)

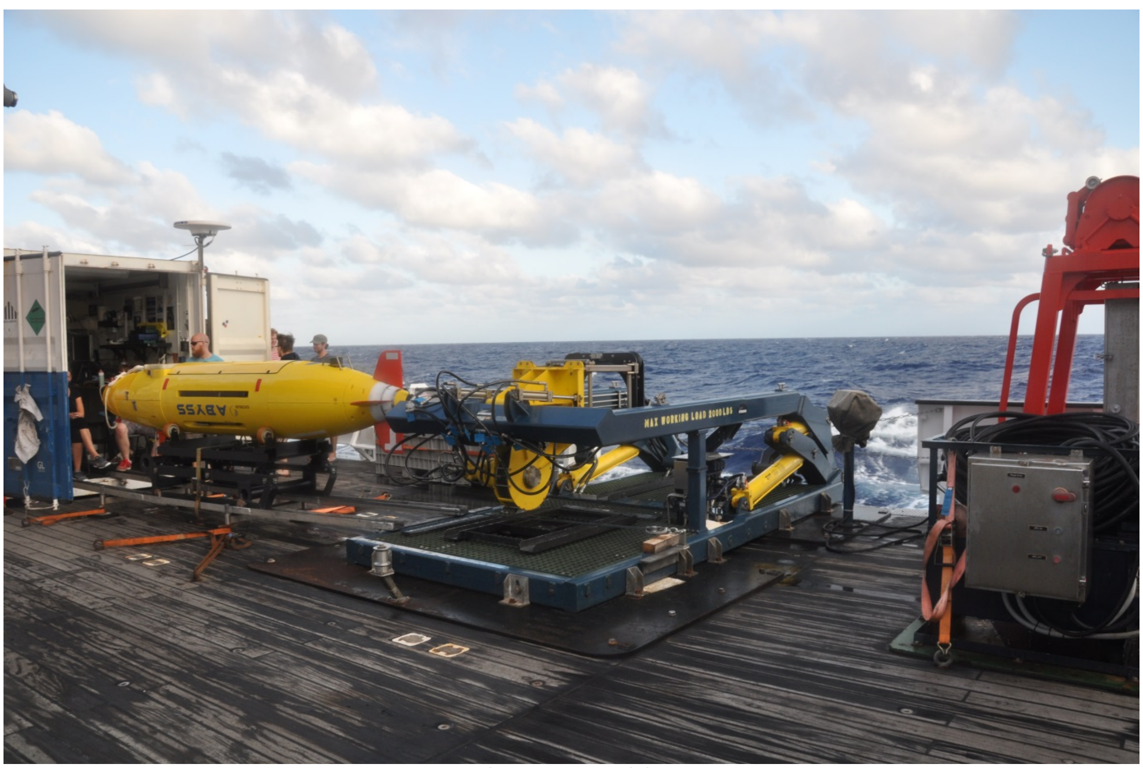


Fig. 7.1.2.2: AUV system composition on board Sonne during SO239 (Photo: Inken Preuss)

Table 7.1.2.1: AUV Mission Statistics for cruise SO239

Station deploymen t/recovery	Area	Dive	Date	Survey time	Mission time	Distance travelled	Sensors	Comment
9/14	German area	167	March 20	14.0 h	18.3 h	86.4 km	SSS (120 kHz) / Cam Test	95 jsf raw files
19/22	German area	168	March 21	10.9 h	15.0 h	66.7 km	Camera	30,730 good images
28/30	German area	169	March 23	11.9 h	18.5 h	89.5 km	Camera	23,730 good images
38/42	German area	170	March 25	10.9 h	13.2 h	73.5 km	MB (200 kHz)	50 s7k raw files
53/55	German ref area	171	March 27	13.2 h	17.9 h	92.4 km	MB (200 kHz)	59 s7k raw files
65/70	German ref area	172	March 30	13.9 h	19.3 h	88.2 km	Camera	25,180 good images
79/83	IOM	173	April 01	10.5 h	15.0 h	65.2 km	SSS (120 kHz) / Camera	10,052 good images
98/102	IOM	174	April 04	15.6 h	18.5 h	84.6 km	Camera	2,374 good images
115/120	Belgian area	175	April 07	12.8 h	18.2 h	84.0 km	Camera / SSS (120 kHz)	71 jsf raw files / 3280 good images
130/132	Belgian area	176	April 09	10.9 h	15.4 h	69.3 km	Camera	9898 good images
134/136	Belgian area	177	April 10	10.8 h	14.6 h	79.6 km	MB (200 kHz)	53 s7k raw files
140/144	Belgian area	178	April 11	10.0 h	14.2 h	69.1 km	MB (200 kHz)	40 s7k raw files
152/156	French area	179	April 14	-	4.9 h	15.9 km	ABORTED	-
160/163	French area	180	April 15	11.1 h	16.1 h	79.9 km	SSS (120 kHz)	79 jsf raw files
166/170	French area	181	April 16	5.1 h	10.9 h	53.8 km	Camera	9,582 good images
172/178	French area	182	April 17	9.5 h	14.1 h	70.8 km	Camera	17,975 good images
188/190	APEI	183	April 20	11.6 h	15.5 h	77.6 km	Camera	30,059 good images
193/198	APEI	184	April 21	9.6 h	14.6 h	74.3 km	Camera	21,825 good images
201/208	APEI	185	April 23	11.4 h	16.1 h	81.1 km	SSS (120 kHz) / Cam Test	77 jsf raw files / 1,560 good images
211/216	APEI	186	April 24	9.9 h	13.6 h	74.3 km	MB (200 kHz)	50 s7k raw files
			Total:	213.6 h	303.8 h	1,476.4 km		

(Station = Launch/Recovery; Survey time = time spent mapping on the seafloor; Mission time = time including descent, survey and ascent phase; Distance travelled = total distance during mission; MB = Multibeam Echo Sounder; SSS = Sidescan Sonar)

Fig. 7.1.2.3: AUV Abyss ready for launch in the LARS (Photo: Henry Robert)

The gathered data from the AUV were processed into a usable format during the cruise. The positional drift of the AUV demands navigational adjustment to grid either a bathymetric or a sidescan map. The RESON multibeam logs its raw data as *.s7k. The navigation adjustment is done by using MB-Systems (Caress and Chayes 1996, 2008), relative by overlapping swath areas and absolute related to ship-based bathymetry (command *mbnavadjust*). The re-navigated multibeam data were processed and gridded using QINSy (QPS, Quality Positioning Services BV). Sidescan data were processed using OIC's CleanSweep

7.1.3 CTD (Vasiliu, Preuss)

During the SO 239 cruise, 10 CTD stations were carried out in 5 working areas using a SBE 911 plus CTD profiler attached to a Sea Bird SBE 32 carrousel water sampler. CTD water column profiles were obtained to get information about general physico-chemical composition of the water column (i.e. the vertical variability of temperature, salinity and oxygen) and to select the appropriate water depths for water sampling. At two stations the CTD was deployed directly before and after the deployment of the epibenthic sledge to obtain water samples of the produced sediment plume.
The registration of the hydrographic parameters was performed from the sea surface down to the sea bottom and vice versa.
The system consists of:

- ***SBE 9 plus CTD*** which is supplied with: titanium main housing and T and C sensors, to 10,500 meters; digiquartz pressure sensor; secondary T and C sensors; auxiliary sensors (an SBE 43 oxygen self-regenerative Clark-sensor with Teflon membrane, WetLabs sensors (ECO-NTU turbidity meter and ECO-AFL/FL fluorimeter, and altimeter); TC duct (it ensures that temperature and conductivity measurements are made on the same parcel of water); submersible pump; 300 baud modem for water sampler control; eight 12-bit A/D differential input, low pass-filtered channels for auxiliary sensors
- ***SBE 11 plus V2*** Desk Unit - The Deck Unit supplies DC power to the SBE9plus, decodes the SBE 9*plus* data stream, and passes the data to a computer. Other features: NMEA interface (it permits the Deck Unit to integrate Latitude, Longitude, and Time data into the CTD data stream); 300 baud modem interface - provides power and real-time control for water sampler (bottles are fired sequential); remote output; RS-232 Serial Data Uplink interface.
- ***SBE 32 carrousel water sampler*** equipped with twenty-four 10 L Niskin bottles.

The system provides real-time data acquisition (both upcast and downcast) for the following parameters:

- pressure
- temperature
- conductivity
- oxygen
- fluorescence
- turbidity

From these data, the following parameters are derived (formulas for their computation are given in "Algorithms for computation of fundamental properties of seawater", by N.P. Fofonoff and R.C Millard Jr.; Unesco technical papers in marine science #44, 1983):

- depth
- potential temperature
- salinity
- density

- oxygen (requires pressure, temperature, and conductivity, as well as oxygen signal)
- sound velocity
- acceleration

Fig. 7.1.3.1: The Sea Bird SBE 32 carrousel water sampler with the SBE 911 plus CTD profiler

The SBE 9 *plus* is supplied with a powerful Windows software package which includes:
• Seaterm – terminal program for easy communication and setup
• Seasave V7 – program for acquiring, converting, and displaying real-time or archived raw data.
• SBE Data Processing Win32- to process the .hex data from the Deck Unit (created by Seasave). The program calculates and plots the conductivity, temperature, pressure, data from auxiliary sensors, and derived variables such as salinity, density, and sound velocity.
The Niskin bottles are fired sequentially on upcast at different sampling depths selected based on downcast profiles.

7.1.4 Deployment of ROV KIEL 6000 during expedition SO239 onboard RV SONNE in the Clarion Clipperton Fracture Zone (CCZ) in the northern tropical Pacific Ocean (ROV-Team GEOMAR, Kiel: Abegg, Bodendorfer, Cuno, Hennke, Huusmann, Pieper, Plöger and Suck)

ROV KIEL 6000 is a 6000 m rated deep diving platform manufactured by Schilling Robotics LLC, Davis, USA. It is based on commercially available ROVs, but customized to research demands, e.g. being truly mobile. As a truly versatile system it has been operated from a variety of different national and international research vessels (R/V Sonne, N/O l'Atalante, RV Maria S. Merian, RV Meteor, RV Celtic Explorer, RRS James Cook and RV Polarstern) until today. It is an electrically driven work class ROV of the type QUEST, build No. 7. ROV

KIEL 6000 is based at the Helmholtz Centre for Marine Sciences GEOMAR in Kiel, Germany.

Table 7.1.4.1: ROV station list SO239

Station Number SO239	Dive No.	Date (UTC)	Time Start (UTC)	At Bottom (UTC)	Off Bottom (UTC)	Time End (UTC)	Location	Depth (m)	ROV Bottom Time
Test 1	197	11.03.2015					Harbour Test Balboa Reede, Panama		
Test 2	197b	11.03.2015					Harbour Test Balboa Reede, Panama		
013ROV01	198	20./21.3.15	15:32	18:19	21:57	03:51	German Licence Area CCZ	4125	03:38
029ROV02	199	23./24.3.15	16:14	18:02	01:49	03:15	German Licence Area CCZ Seamount	2987	07:47
041ROV03	200	25./26.3.15	16:58	19:32	02:04	04:15	German Licence Area CCZ track pockmark	4107	06:32
054ROV04	201	27./28.3.15	15:31	17:16	02:01	03:45	Seamount Reference Area	3354	08:45
064ROV05	202	29./30.3.15	16:49	19:19	01:55	01:54	Reference Area EBS Track	4332	06:36
082ROV06	203	1./2.4.15	14:55	17:12	01:27	03:59	IOM	4347	08:15
101ROV07	204	4./5.4.15	15:21	18:03	01:38	04:01	IOM Tracks	4398	07:35
131ROV08	205	9./10.4.15	15:59	17:47	02:14	04:12	Belgian Licence Area EBS Track	4478	07:35
135ROV09	206	10./11.4.15	16:52	18:21	02:13	03:37	Belgian Licence Area Seamount	3893	07:35
141ROV10	207	11./12.4.15	16:40	18:16	02:14	04:07	Belgian Licence Area DEME Track	4481	07:35
157ROV11	208	14./15. 4.15	15:15	17:27	23:56	02:06	French Lic. Area OMCO Track 1	4953	06:29
161ROV12	209	15./16.4.15	16:20	19:01	01:57	04:08	French Lic. Area EBS Track	5000	06:56
189ROV13	210	20./21.4.15	15:40	17:29	02:30	04:25	APEI Nodules	4931	09:01
200ROV14	211	22./23.04.2015	15:07	16:54	02:13	04:08	APEI Nodules 2	4672	09:19
212ROV15	212	24./25.04.2015	14:54	15:43	22:08	22:52	APEI Seamount	1844	06:25
				Total: 15 scientific dives					**111:35**

Including this cruise, ROV KIEL 6000 has accomplished 212 dives during 18 missions. During SO239, 15 scientific dives (Tab. 1) could be accomplished. Maximum diving depth was about 5000 m and maximum bottom time was 9:19 hours. In total, bottom time accumulated to approximately 111 hours (total dive time approx. 172 hours).

ROV Tasks during SO239

The tasks of ROV KIEL 6000 during this cruise were the scientific exploration of the biodiversity in nodule areas (license areas of Germany, IOM, Belgium and France, the area of particular environmental interest (APEI) No. 3) and of selected seamounts. The techniques applied included video-transecting, fauna sampling and sediment sampling using pushcores. The latter was to investigate the recovery of the benthic communities after impact by trawling, comparing inside-track sediments with outside-track sediments of recent and older tracks (up to 36 years old).

One of the geological scientific questions was if manganese nodules show the same strength at in-situ depth than on board. For this, a device called nodule crasher was used once in the IOM area and also in the Belgium License area. The device was operated while using the hydraulics of the ROV. The experiments were video recorded.

In the French License area, three 5l Niskin Bottles replaced the front box on the port side drawer in order to sample the sediment plume after causing a disturbance with the ROV.

Besides the manganese nodule fields, 4 seamounts were investigated. Those are considered to be a source of recolonization after an extended dredging of manganese nodules.

For more details on samples please see the respective chapters.

Fig. 7.1.4.1: Front View of ROV KIEL 6000 with general setup for mainly fauna sampling during SO 239: 2 lidded bioboxes on portside, 3 pushcores, nets, shovel, nodule scoop on portside / Senckenberg biobox and larvae pots on starboard side. On starboard frame nozzle of slurp gun.

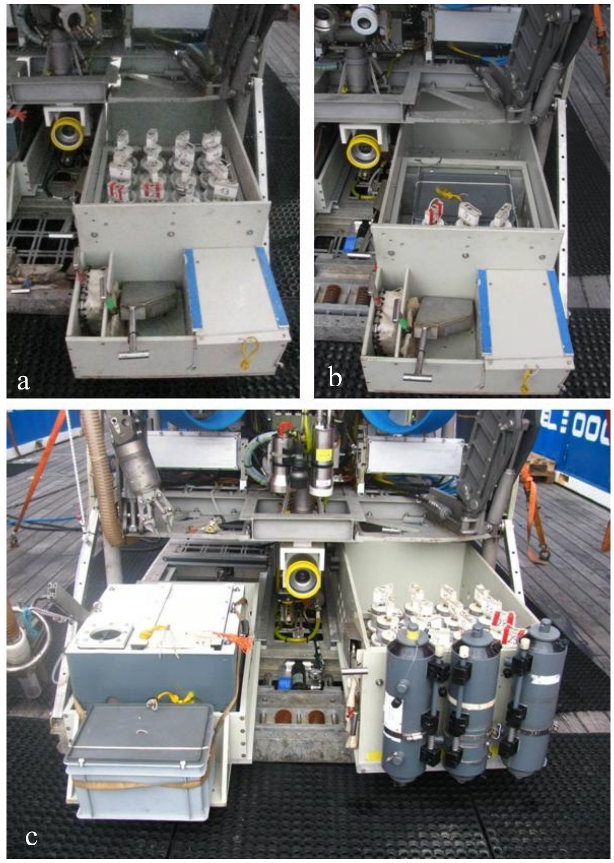


Fig. 7.1.4.2: Different configurations of the drawers: **a)** 16 push cores on portside, biobox, nets, shovel, scoop **b)** 3 pushcores, 2 bioboxes, nets, shovel, scoop on portside **c)** 16 pushcores and 3 Niskins on portside, lidded biobox and Senckenberg biobox on starboard side.

Tools used during SO 239 (Figs 1and 2):

- Slurp gun w/ 8 sampling containers (ROV-Team GEOMAR)
- Pushcores (ROV-Team GEOMAR)
- Handnets (mesh size 500 and 1000 µm) (ROV-Team GEOMAR)
- Shovel (ROV-Team GEOMAR)
- Larvae Catch Pots (ROV-Team GEOMAR)
- “Nodule Scoop” (ROV-Team GEOMAR)
- “Senckenberg” Biobox (large) (Senckenberg Inst.)
- Small lidded Bioboxes (ROV-Team GEOMAR)
- 5 Liter Niskin Bottles (metal-free) (ROV-Team GEOMAR)
- Lasers (integrated) (Alpha Cam, ROV)
- MAPR (autonomous)
- Nodule Crusher (SOSI)

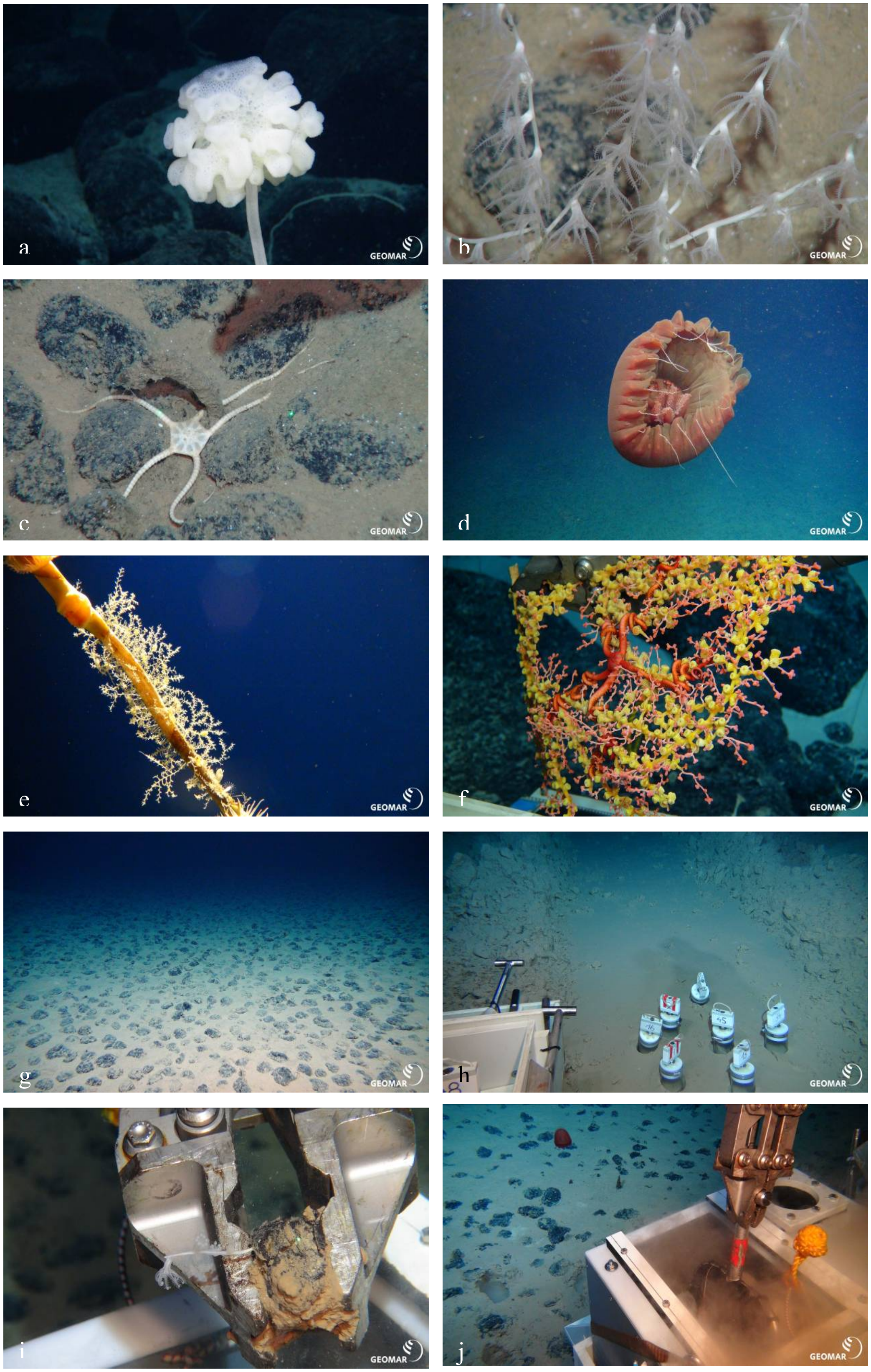


Fig. 7.1.4.3: **Choice of underwater images,** a) hexactinellid sponge; b) soft coral; c) ophiuroid d) large medusa; e) corals on an old sponge stalk; f) coral with ophiuroid; g) manganese nodule landscape; h) push-corer sampling in a dredge track; i) coral sampling; j) emptying a scoop in the Senckenberg biobox.

7.1.5 Multi-corer (MUC) (Vanreusel, Macheriotou, Khodami, Raschka, Fioretti, Martinez Arbizu)

Research Objectives

Sediment and overlaying bottom water samples were collected within five localities of the CCZ; namely the German, InterOcean Metal (IOM), Belgian and French concession areas as well as one Area of Particular Environmental Interest (APEI no. 3). The sampling was conducted in such a way as to achieve a comprehensive description of the yet unknown meiofaunal biodiversity of nematodes and copepods in the CCZ. Moreover, through subsequent molecular analyses we aim to uncover the degree of population connectivity across this area at both the local scale within stations (centimeters to meters) as well as the regional (up to kilometers) across stations.

Description of gear

The multicorer (MUC) is designed to recover undisturbed surface sediment sections along with the overlying bottom water. The multicorer of the Senckenberg Institute (Fig. 7.1.5.1) was equipped with twelve 60 cm long plastic tubes (inner diameter: 94 mm, area of 69.4 cm2) and was used at 37 stations. The multicorer was lowered with a speed of 1 m/s till about 50 m above the seafloor, where it was stopped for approximately 1 minute and then lowered with a speed of 0.5 m/s until contact with the seafloor was monitored through the cable tension or a video camera. The corer was left on the seafloor for about 1 minute, then pulled out with 0.1 m/s and finally heaved onboard with a speed of 1 m/s. Each station was sampled with five deployments and processed as follows:

Table 7.1.5.1 Distribution of the corers

1ST DEPLOYMENT	2ND/3RD DEPLOYMENT	4TH/5TH DEPLOYMENT
5 : GEOCHEMISTRY*	**4 : FORMOL**	**4 : FORMOL**
4 : FORMOL⁺	**4 : DESS▼**	**4 : DESS**
1 : LIPIDS•	**1 : ABIOTIC▲**	**1 : ABIOTIC**
1 : ECOTOXICOLOGY°	**1 : LIPIDS**	**1 : OSTRACODS†**
1 : PROKARYOTES⌂	**1 : PROKARYOTES**	**1 : FROZEN DNA**
	1 : FROZEN DNA◊	**1 : PROKARYOTES**

Refer to chapter 7.2.3

Sliced by 1 cm down to 5 cm when no nodules were present, otherwise bulk sample of 5 cm

• Sliced in two parts: 0–1 cm and 1–5 cm

° Sliced in two parts: 0–1 cm and 1–5 cm

⌂ Refer to chapter 7.2.4

▼Bulk sample 0–5 cm

▲ Sliced in two parts: 0–1 cm and 1–5 cm and 1 ml subsample obtained from each layer for Total Organic Carbon (TOM) and pigment analyses

†Bulk sample 0–5–cm preserved in 96% Ethanol

In most cases eleven to twelve tubes were filled with about 40 cm of sediment. Sediment cores were distributed among the research groups. Cores of every MUC were used for meiofaunal investigations, from the first deployment for porewater geochemical research, one core for microbiological analyses. An overview on the distribution of the multicorer samples between the working groups is given in table 7.1.5.1. Furthermore, push-cores from several Remotely Operated Vehicle (ROV) dives were processed in addition to the sediment cores obtained with the use of the multicorer (inner diameter 74 mm). Table 7.1.5.2 gives the date, depth and position of the stations sampled with the MUC.

Fig. 7.1.5.1: Multicorer used for undisturbed seafloor sampling, equipped with TV-Camera

Table 7.1.5.2 Stations sampled with the Multicorer

Station	Station_date	Longitude	Latitude	Depth
27	23/03/2015	117° 03.53' W	11° 50.68' N	4141
31	24/03/2015	117° 03.46' W	11° 51.06' N	4120
32	24/03/2015	117° 03.38' W	11° 51.28' N	4138
34	24/03/2015	117° 03.23' W	11° 50.46' N	4133
35	24/03/2015	117° 03.05' W	11° 51.09' N	4126
39	25/03/2015	117° 03.41' W	11° 50.60' N	4076
66	30/03/2015	117° 33.13' W	11° 49.12' N	4315
67	30/03/2015	117° 32.00' W	11° 49.37' N	4347
68	30/03/2015	117° 32.72' W	11° 47.40' N	4352
69	30/03/2015	117° 31.62' W	11° 47.61' N	4348
71	31/03/2015	117° 30.62' W	11° 47.88' N	4355
84	02/04/2015	119° 39.48' W	11° 04.73' N	4431
85	02/04/2015	119° 39.06' W	11° 04.63' N	4434
86	02/04/2015	119° 39.81' W	11° 45.02' N	4439
91	03/04/2015	119° 39.34' W	11° 04.39' N	4419
92	03/04/2015	119° 39.35' W	11° 04.38' N	4423
93	03/04/2015	119° 39.33' W	11° 04.42' N	4414
100	04/04/2015	119° 39.33' W	11° 04.29' N	4428
103	05/04/2015	119° 39.32' W	11° 04.30' N	4425
104	05/04/2015	119° 39.18' W	11° 03.89' N	4424
121	08/04/2015	123° 15.29' W	13° 51.24' N	4516
124	08/04/2015	123° 14.69' W	13° 51.28' N	4510
125	09/04/2015	123° 14.22' W	13° 51.06' N	4512
145	12/04/2015	123° 04.66' W	13° 50.80' N	4514
146	12/04/2015	123° 15.10' W	13° 50.74' N	4511
154	14/04/2015	130° 08.32' W	14° 03.00' N	4890
155	14/04/2015	130° 07.85' W	14° 02.97' N	4940
164	16/04/2015	130° 07.42' W	14° 03.00' N	4955
167	16/04/2015	130° 08.32' W	14° 02.62' N	4918
168	16/04/2015	130° 07.82' W	14° 02.60' N	4948
175	17/04/2015	130° 05.11' W	14° 02.45' N	5008
176	18/04/2015	130° 05.13' W	14° 02.54' N	5012
199	22/04/2015	128° 22.41' W	18° 47.45' N	48166
202	23/04/2015	128° 21.26' W	18° 47.35' N	4835
206	23/04/2015	128° 20.24' W	18° 47.23' N	4857
207	23/04/2015	128° 22.42' W	18° 46.43' N	4825

7.1.6 Box-corer (Menot, Hoffmann)

A box-corer was used to sample the macrofauna as well as nodules (Fig. 7.1.6.1). The box-corer is made of a 50 cm x 50 cm x 50 cm gravity core that sinks into the bottom. Its path is guided at its upper end by a column that sinks through a sleeve which is part of a frame that rests on the bottom. Buffers are screwed on two sides of the column to adjust its course and thus the penetration of the core in sediments. The course can be adjusted to 70 cm, 60 cm, 50 cm and 40 cm. The shortest course was used for most box-corer deployments. However, in areas without nodules, the sediments were so soft that even with the shortest course, the core was penetrating too deep into sediments. The box-corer was thus modified to lower down the buffers by 5 cm.
A friction release frees the spade arm when the weight of the corer is relieved from the wire. When wire is reeled in to return the device to the ship, the initial action is to lever the spade down into the substrate until it closes off the bottom of the core. Subsequent take-up on the wire pulls the apparatus out of the bottom. At the top of the core box a cylindrical valve allow free passage to water entering at the mouth. This reduces the bow-wave effect and allows the corer to sink into the bottom. The valve is opened during descend and closed by a friction release mechanism triggered by the spade closure.

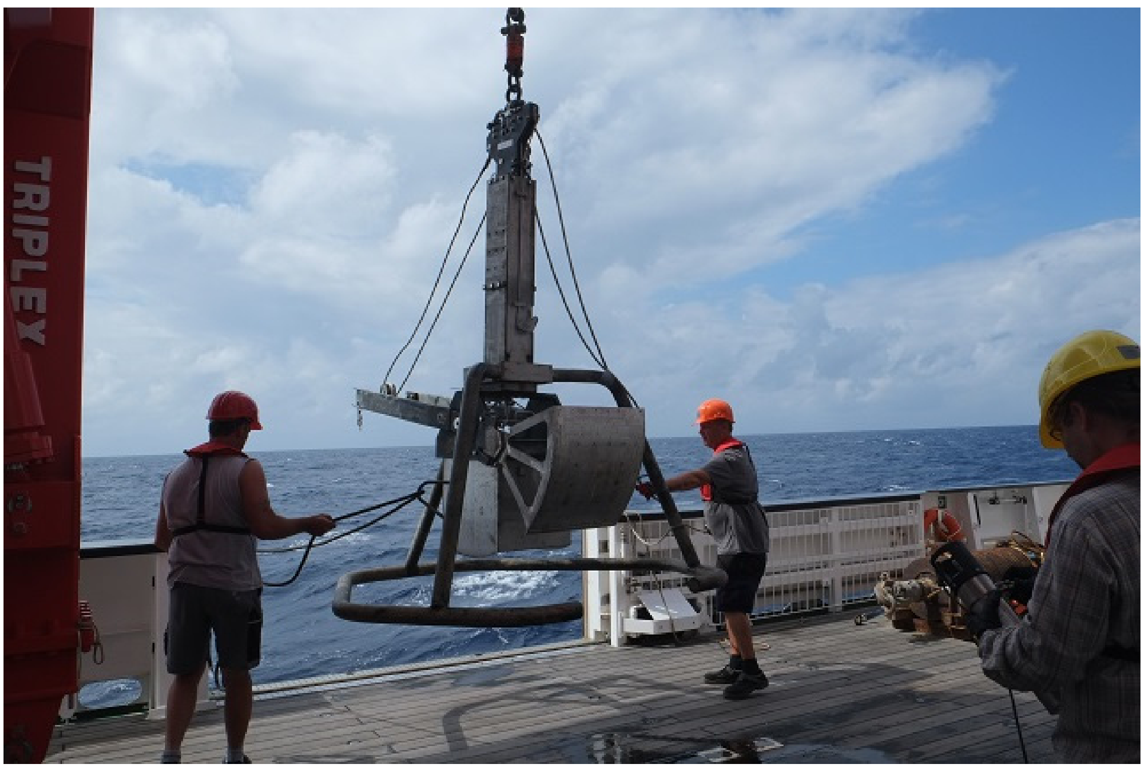


Fig. 7.1.6.1 Deployment of the box-corer during the EcoResponse cruise

Operation of the gear

The box-corer was deployed from starboard side and lowered at a speed of 1 m/s until it reaches an altitude of 100 m above the seafloor. After a stop of about one minute, the box-corer was lowered at a speed of 0.4 m/s down to 50 m above the seafloor and landed at a speed of 0.2 to 0.3 m/s, except for the two first box-corers, which were landed at 0.4 m/s. Landing and pull out were monitored on a plot of rope tension (Fig. 7.1.6.2). Landing was visually assessed by a significant drop in rope tension. The winch was stopped 20 seconds after landing and the box-corer was pulled out after another 20 seconds. Pull out tension for a successful box-core ranges from 65 to 70 kN according to substrate and depth.
In total, the box-corer was deployed 35 times, 34 deployments were successful.

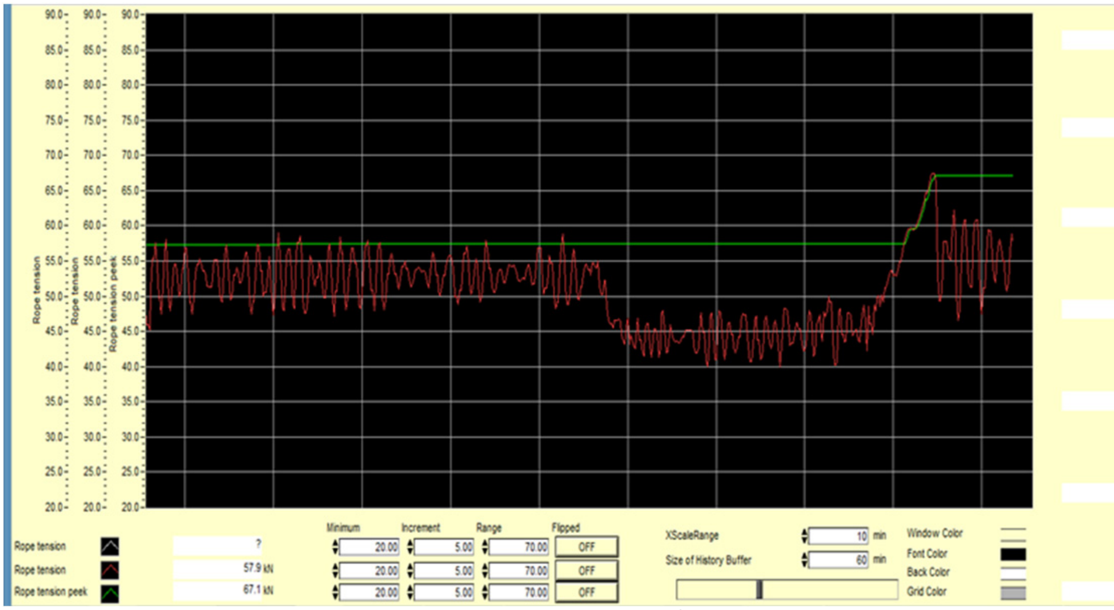


Fig. 7.1.6.2: Variations in rope tension during landing and pull out of a box-corer (station 88).

7.1.7 Epibenthic sledge (Kaiser)

Description of the Gear

The epibenthic sledge (EBS, Fig. 7.1.7.1-2) has been widely used for sampling of benthic macrofauna (Brenke 2005). The EBS is equipped with two nets, i.e. an upper supranet and a lower epinet (Fig. 7.1.7.1-2). The mesh size of the nets is 500 µm. The cod ends are equipped with net-buckets containing a 300 µm mesh window (Brenke 2005). Additionally, a box has been designed for sampling in warm, tropical waters that covers the cod ends and keeps the samples cool on their way through the water column. To avoid contamination by planktonic organisms a lever mechanism is attached to the front doors, which are closed while the gear has no contact to the bottom. Metallic grids (about 3 cm mesh size) were attached to the entrance of the nets to avoid collection of big nodules, which may clog or damage the nets (Fig. 7.1.7. 2, right).

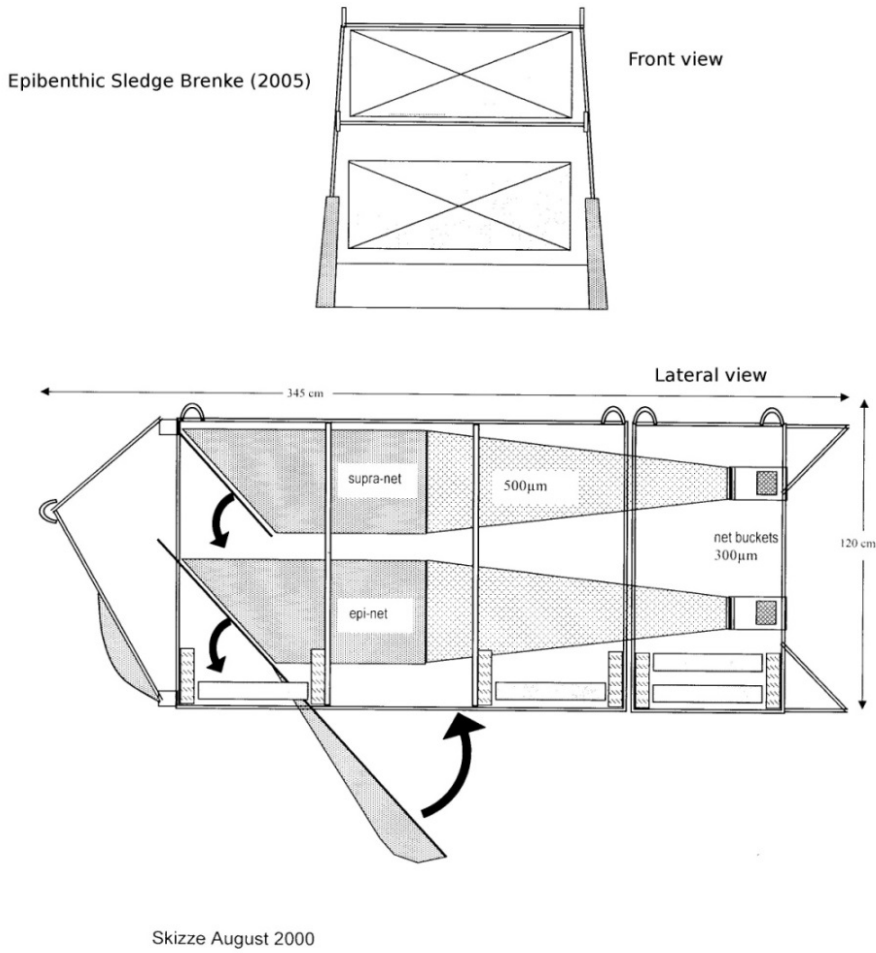
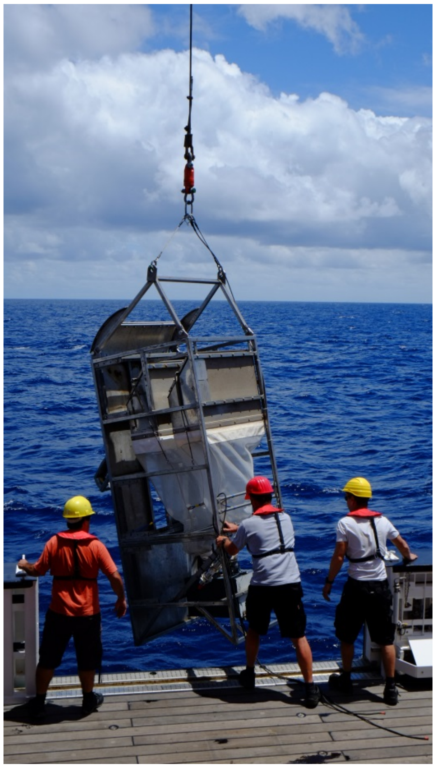


Fig. 7.1.7.1: Schematic sketch of the Brenke epibenthic sledge.

Operation of the gear and handling of samples on board

The EBS was lowered over the backboard side of RV Sonne at a rope speed of 0.7 m/s while the vessel was holding position. About 50 to 100 m above the ground, the winch stopped for 1 to 2 minutes. Then the vessel started to go at 1 kn, while cable was paid out at a speed of 0.3 m/s. As soon as the EBS reached the seafloor, the winch speed was increased to 0.5 m/s and more wire was paid out to an optimal wire-water-depth ratio (equaling 1.5 times water depth); then the winch stopped but the vessel maintained course at a speed of 1 kn over ground for 10 minutes in order to strengthen the wire. After 10 minutes, the vessel stopped and maintained position, while the winch started recovering the gear at a speed of 0.5 m/s. Once the EBS was off the bottom, the winch speed was increased to 0.7 m/s. In order to monitor the position of the sledge in the water columns and on the ground a Posidonia transponder system was used in addition to the rope tension indicating the time of landing of the gear on the seafloor and subsequent clearing the ground. In total 13 EBS were deployed across the six study areas. Each deployment took between 6 and 7.5 hours, while trawling distance varied between 2289 and 3789 m.



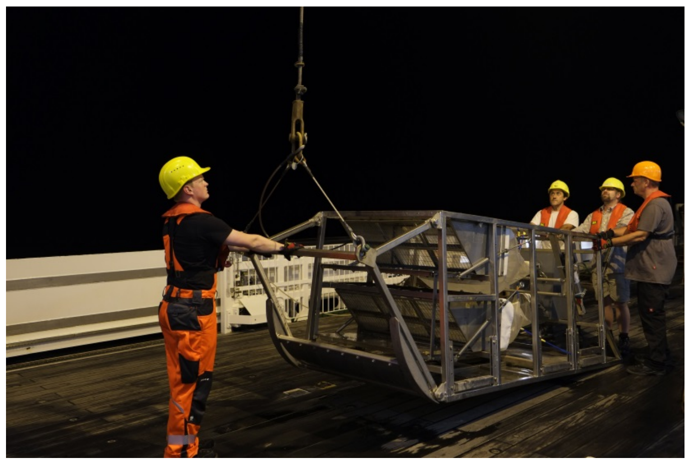


Fig. 7.1.7.2: Deploying the epibenthic sledge (pictures courtesy of A. Hilario)

7.1.8 Gravity corer (Volz, Preuss, Ozegowski)

During the cruise a gravity corer with a two piece steel pipe of a total length of 10 m, equipped with a plastic liner of 12 cm in diameter, and a weight of 2 tons on top was used at seven stations. The corer was lowered with an average speed of 1 m/s and equipped with a MAPR 80 m above the weight on the rope. Lowering to the bottom it was stopped at about 80 m above the seafloor for 2 min and then lowered with 0.4-0.5 m/s depending on sediment conditions investigated before with box corer or multi corer. After a tension drop at the point of penetration about 10 m slack was given to ensure the weight can fully press into the sediment. After penetration into the sediment the corer was heaved with 0.2 m/s until it was free from the bottom. Then the corer was heaved with 1 m/s on board. The plastic liner was cut into one meter long segments. Those were stored in the scientific cool storage for 12 h at 4°C. Oxygen saturation was measured through drilled holes every 5 cm and subsequently the liner was cut along-core into a work and an archive half. The work half was sampled at 20 cm spacing for pore water and sediment samples. Finally both halves were stored in d-tubes at 4° C.

Table 7.1.8.1: stations were the Gravity corer was deployed

Station	Date	Penetration speed
SO239/017-1 GC	21.03.2015	0.5 m/s
SO239/062-1 GC	29.03.2015	0.5 m/s
SO239/087-1 GC	02.04.2015	0.4 m/s
SO239/122-2 GC	08.04.2015	0.5 m/s
SO239/165-1 GC	16.04.2015	0.5 m/s
SO239/174-1 GC	17.04.2015	0.5 m/s
SO239/194-1 GC	21.04.2015	0.5 m/s

Fig. 7.1.8.1: Gravity Corer with 2000 kg weight (photo: V.Ozegowski)

7.1.9 Amphipod/Ostracod Traps (Robert)

During this cruise, amphipods were collected using baited traps, EBS and occasionnaly with the ROV. Two different types of traps were used, small ones (20x25x40 cm) and large ones (25x40x60 cm) made of plastic boxes equiped with fine mesh on each side to allow bait smell diffusion, attraction and trapping as well as 2 funnels per trap directed inwards with opening of 2 and 4 cm for the small traps and 4 and 8 cm for the large ones. The size of the entrance is measured to capture small scavengers (amphipods) in the small traps and larger ones (larger amphipod, fish or decapod) in the larger traps. The bait used consist of about 800gr of unprocessed defrosted mackerel per trap. Mackerel is wrapped into two layer of cotton net (1 cm mesh size) to empeach fast access to the bait and to keep specimens tangled in during recovery of the traps. All traps are attached at the bottom of a cubic metallic lander (120x120x120 cm) equiped with six 15" flotation spheres, a Novatech radio beacon, a Novatech flash unit, a flag and an Ixsea Oceano acoustic release transponder (RT861-CS) Posidonia compatible for positionning at the sea-floor and monitoring of the ascenssion through the water column while recovery. The weight used as ballast consist of 3 plates of metal (75x75 cm) attached together at the center with a 30cm screw and bolts connected to a small chain and a metal ring for easy disconnection of the ballast and the releaser while recovery operation.
Occasionnaly amphipod specimens were also raptured by the ROV , either as a bycatch (commensal species caught in sponge) or with the "slurp gun" (unfortunately these specimens got lost during the recovery of the ROV onboard).
The EBS captured several specimens of amphipod (aprox. 10 to 20 individual) at each dive.

Ostracod were captured with specially designed "Ostracod traps" (inspired from the traps described in Nakajima *et al*., 2013 and Nishida *et al.*, 1999). These traps consist of PVC cylindrical tubes of aproximatively 1 liter (base of 8 cm in diameter) obstrued at each extremities by 125 µm mesh in which 14 holes (diameter of 2 mm) were made. During each deployment, 4 ostracod trap were attached on the amphipod lander as close as possible to the bottom of the frame and to the sea-floor sediment. This to increase contact between the traps and the sediment and to allow ostracod to crawl up on the mesh and enter the trap. Ostracod from the water column were also collected at each lander deployment site using a small plankton net (entrance: 15x30 cm) attached to the upper surface of the lander.

7.1.10 DIAS Image Annotation (Schoening)

During SO239, visual image data was acquired by ROV, Landers and TV-MUC but mostly by the AUV “Abyss”. For the rapid assessment of image content, manual image annotation was implemented using a prototype of the JPIO Image Annotation software DIAS. DIAS is a web-based software for the manual annotation of benthic images and the special use case of ship-based annotation (“Discol Image Annotation Software”). It is a successor of the software BIIGLE that is being used for the same purpose on shore. Annotation thereby refers to marking pixels within images and not adding semantics to the images as a whole.
DIAS is designed for image annotation only (no videos, frame grabs will work) and does not allow for live annotation (i.e. the annotation of live video feeds from the deep). The images have to be stored on the DIAS server for annotation.
To be able to annotate during the cruise, DIAS was installed on a webserver onboard and made accessible over the ship’s intranet. The hardware structure of the setup is shown in Fig 7.1.10.

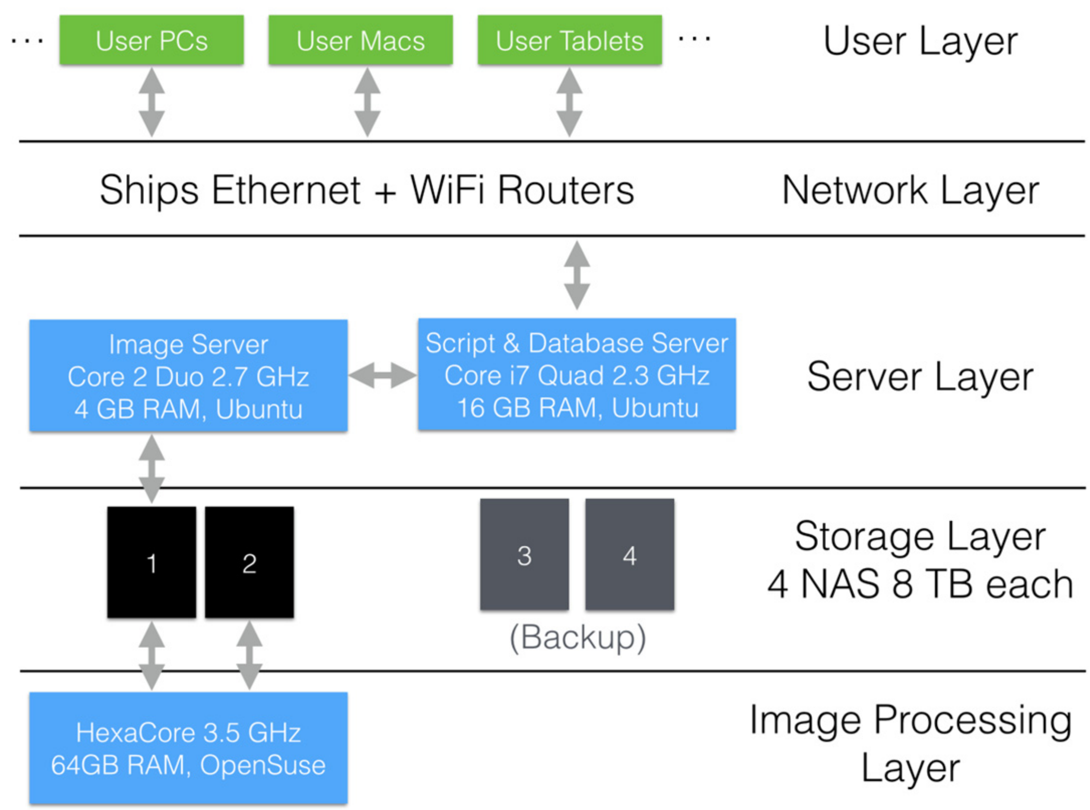


Fig. 7.1.10.1: Shematic representation of the Software and Hardware if the DIAS system

Users connect to the DIAS system using their own computers and the ships Ethernet. Additional WiFi routers were added in some spots for connection convenience. The central parts of the system are two servers that distribute the data. The first is the image server that is connected to the hard disk storages and distributes images through URLs. The second is the more powerful Script and Database server. Here, the DIAS software is installed in the form of a PostgreSQL database and an Apache/PHP webserver. Users login on this server through the DIAS URL and with their credentials. This server manages all the image browsing, data visualization and annotation methods.

The storage currently consists of one NAS server (16 TB, partitioned as RAID 1 with 8 TB). Another NAS is kept with copies of the same data for safety and later distribution among scientists. Two further NASs are available in case the data amounts become too large for one NAS alone, which did not occur during SO239. The final, somewhat external, part is the Image Processing machine that is used for removing the FishEye distortion from the images (see AUV Image Processing section).

The Image server was set up together with the two NASs in the Hydro-acoustic lab and all were connected to the ship's Ethernet. Image access in DIAS is handled by cryptic file hashes and the Image Server has the purpose to translate these hashes to paths in the file system. The Script and Database server was set up in the Data lab for ease of access by the administrator (Timm Schoening). DIAS was accessed during SO239 by the URL http://dias:8080. As less than 8 TB of data were recorded by AUV and Landers during SO239, NASs 3 and 4 were not used but kept as Backup devices. They will be used during SO242-1.

The S&D server ran through the whole cruise without problems whereas the Image Server crashed three times, forcing a restart of the computer. During the first days of the cruise, scientists gathered to learn how to operate DIAS by annotating images from SO205. In this period, 13 experts created 3557 annotations of 69 categories. For this dataset, strict rules were defined on what shape of annotation marker to use (Ellipse, Polygon, Polyline, etc.). Annotation categories focused on biological items with some abiotic categories for seafloor characteristics. At this time it was agreed that frame grabs and stills taken by the ROV should also be added to DIAS for annotation (which stopped after two ROV dives as no annotation was conducted) as well as photos taken of other sampling gear (BoxCorer, Microscope pictures of species, etc. – this was never actually done).

All twelve AUV dives were added to DIAS and two sets of images were selected randomly from these for the first manual annotation. During the last days of the cruise, another annotation session was planned to provide annotations for these selected sets of images by as many experts as possible.
Annotation on board was no central part of this cruise. Sampling specimens was more important and thus there was hardly time for annotation. The AUV images were on one hand not suitable for species identification as they show a low pixel to centimeter ratio. This gives, on the other hand, a very large overview of species distribution in the observed habitats.

7.1.11 MAPR measurements (Weiß, Schoening and Greinert)

Throughout SO239 we attached MAPRs (Miniature Autonomous Plume Recorders) directly to different gear or on the wire 40 to 50 m above the gear. The idea was to get as many temperature recordings as possible to see temporal and spatial variability during the cruise and acquire a comprehensive data set for water turbidity close to the seafloor.
The MAPR is a CTD type device equipped with a pressure and temperature sensor as well as an light backscatter sensor (LBSS) and oxygen reduction potential sensor (ORP). Four of such sensors were used during the cruise; they were rented from NOAA, who kindly supported those sensors on very short notice. Figure 1 shows the mapper attached to the cable and the EBS before deployment, they were attached to GC, MUC, BC, EBS, ROV deployment s as well as the LBL moorings used for AUV underwater navigation and to the

CTD for direct comparison between pressure and temperature readings. The fastest sampling interval of the MAPR is 5 seconds, this was chosen during most of the deployments, the sample interval was extended to 60 seconds for the LBL deployments. On the LBL moorings, the MAPR were placed ca 15m above the bottom.

Fig. 7.1.11.1: MAPRs being attached to the wire, fixed to the EBS (top right) or the mooring rope of the LBL transponders just before deployment.

Data were converted from raw sensor readings to depth (m), temperature (°C) and voltage levels for LBSS (V) and OPR (mV) and stored as simple ascii files; date and time information, Julian day as well as the position of the deployment were added and final data sets were loaded into ODV for visualization and interpretation (see chapter 2). A total of 106 MAPR deployments have been recorded and will be accessible via the JPIO data base.

7.1.12 BoBo, DOS Lander and thermistor mooring (Greinert, de Stigter, van Haren, Weiß and Schoening)

One thermistor mooring and two landers were deployed during SO239 in the German License area PA1. They will be recovered at the end of SO240 by BGR

Thermistor mooring:
The thermistor mooring from NIOZ is equipped with 201 NIOZ-4 thermistors & 3 AquaDopp acoustic current meters. The layout of the mooring is shown in Figure 7.1.13_1. A total of 201 'NIOZ-4' self-contained temperature (T) sensors were used sampling at 2 Hz, with precision better than 0.001°C and a noise level of about 6×10^{-5}°C. NIOZ4 is an upgrade of NIOZ3 (van Haren et al., 2009; van Haren and Gostiaux, 2010), with similar characteristics, except for its reduced size (2/3 smaller) and reduced power consumption (with the capacity of sampling at a rate of 2 Hz for the duration of 1 year). Sensors were taped at 2.0 m vertical intervals to a nylon-coated steel cable, with the lowest sensor 6 m above the bottom and the upper 406m above the bottom The sensors are synchronized via induction every 6 hours. Thus, timing mismatch is less than 0.04 s. A special steel drum was used in the ships own mobile winch

for deployment over the stern. The deployment without additional block went smooth and successfully.

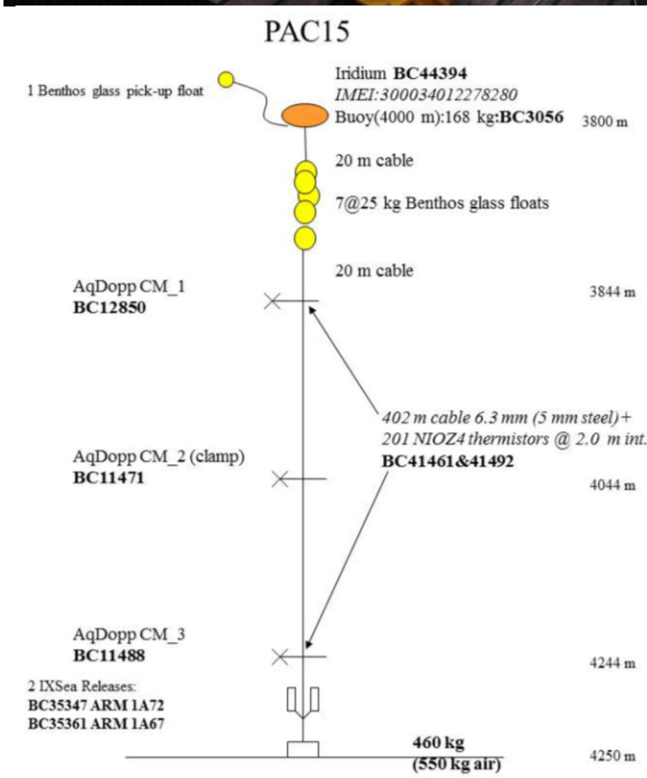


Fig. 7.1.12.1: Images of the mooring on deck before deployment and scheme of the deployment layout.

BoBo lander:

The Bottom Boundary Layer lander (BoBo) from NIOZ was specifically designed to study physical processes and sediment transport near the seabed (Van Weering et al.,2000). To avoid disturbances of the current regime, the BoBo lander is a long leged lander with a downward looking 1200kHz RDI ADCP, and upward looking 300kHz RDI ADCP, a Technicap Sediement trap and a Seabird 16 CT with Wetlabs ECO-FLNTURTD. Two Benthos releasers keep three weights in place until release, flash, radio beacon and an Iridium transmitter are added for better localization after surfacing. BoBo is always deployed as freefall lander.

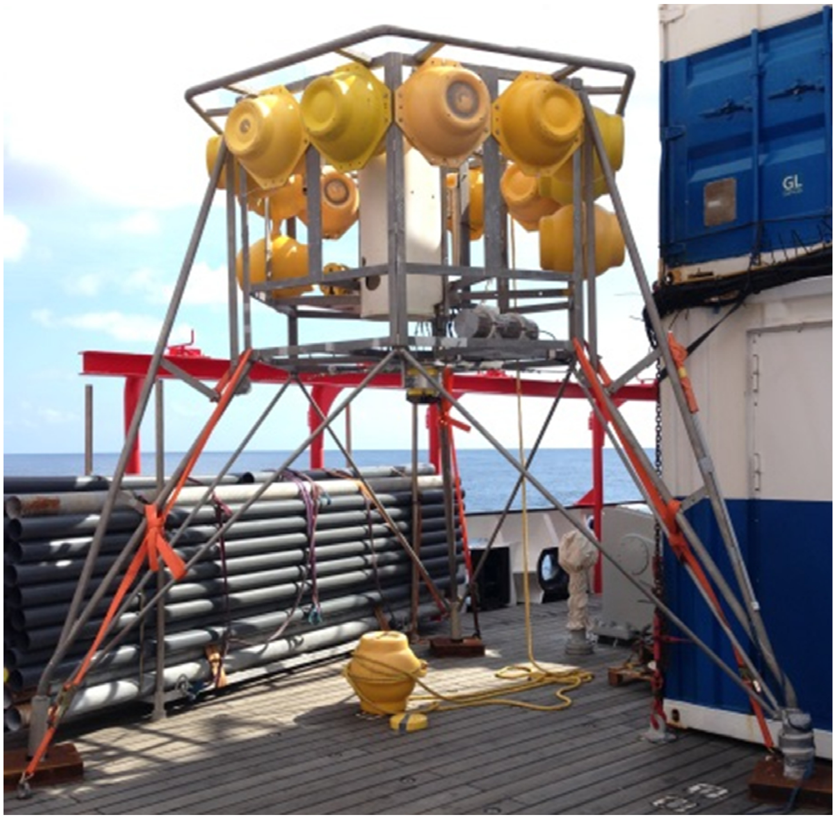


Fig. 7.1.12.2: BoBo lander.

DOS Lander:
The Deep-Sea Observation System (DOS) lander from GEOMAR is based on a multipurpose platform (Pfannkuche and Linke, 2003) and equipped with a 300kHz upward looking ADCP, a KUM sediment trap with max 21 bottles, a Seabird 16plus CTD with Wetlabs ECO-FLNTURTD, Ocean Imaging Systems stereographic camera system, as well as a self-logging temperature sensor supplied by University of Bremen (H. Villinger). The lander was deployed as freefall lander but can be also launched in a TV-guided mode. In addition a flash, radio beacon and ARGIS transmitter are attached.

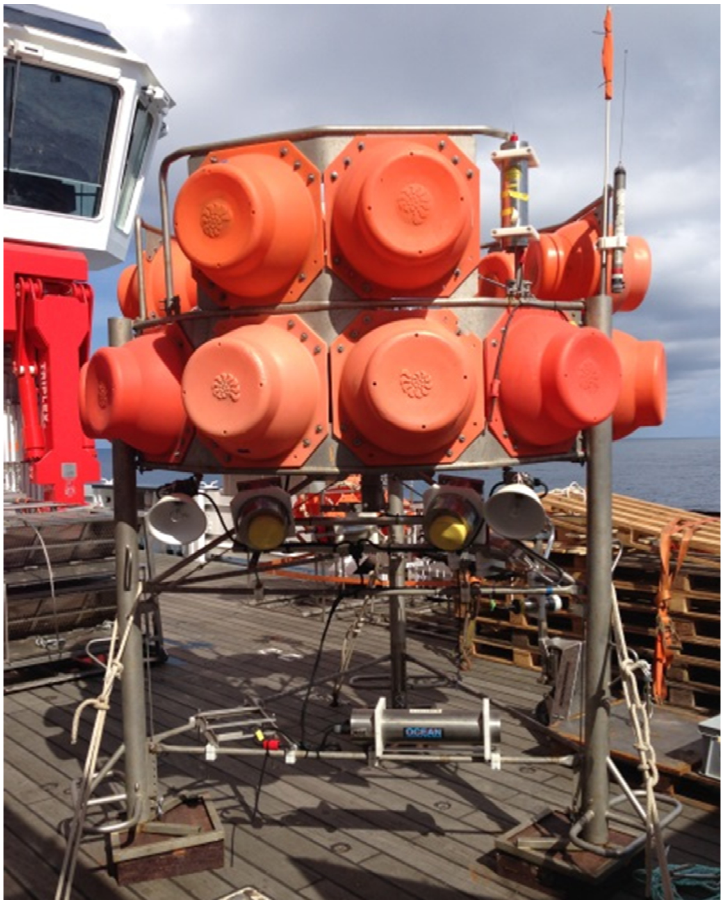


Fig. 7.1.12.3: The DOS lander and the stereographic camera system.

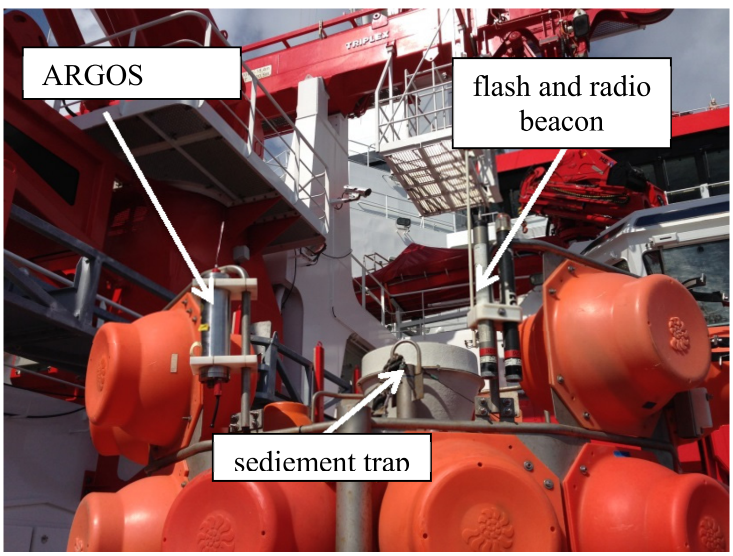


Fig. 7.1.12.4: Safety equipment and sediment trap of the DOS lander.

Fig. 7.1.12.5: CTD (blue arrow) with ECO-FLNTURTD (red arrow) and temperature logger (green arrow).

7.2 First results

7.2.1 Ship-based hydroacoustic mapping (EM122), some results (Greinert)

Each working area was mapped upon arrival during a short (1h) or longer (6 to 16h) survey. Data were immediately processed and plotted for further station planning or designing AUV missions. Each working area is presented in the following. Table 1 gives an overview about the .all data files of the different working areas that have been used for processing. Many data files of the transit where only scanned briefly, the show many different types of sea mounts, sea mount clusters as well as horst and graben structures.

Table 7.2.1.1: Data files of the different working areas.

Area	Data files
German PA1 work	0159, 0160, 0169 - 0173
German SMT (ROV-2)	0158, 0163, 0164, 0166, 0167
German RA	0176 - 0181
German RA SMT (ROV-4)	0186 - 0188
IOM	0195 - 0198
Belgian	0212 - 0221
French	0240 - 0242
APEI	0256 - 0270

Bathymetric data of the AUV are described in the AUV section of this cruise report.

German License area

Prior to the cruise, BGR kindly supported bathymetric data for station planning. The data included the PA1 area and only a small part of the final working area was mapped. The reference area (RA) was not part of the BGR data and thus was mapped completely.

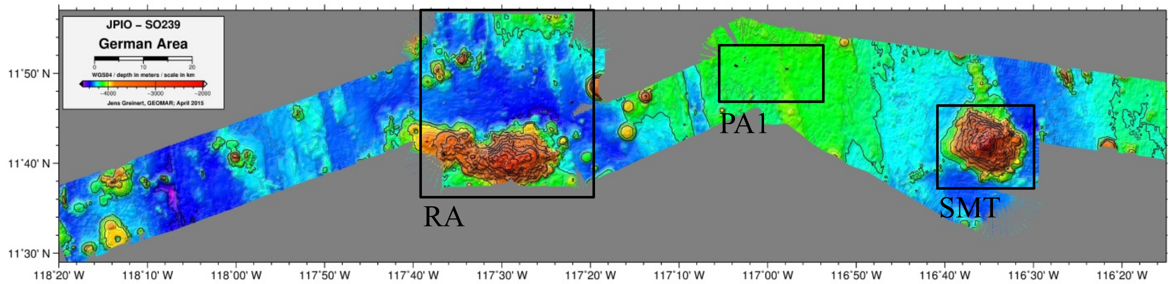


Fig. 7.2.1.1: Overview of the German License area with its three study sites.

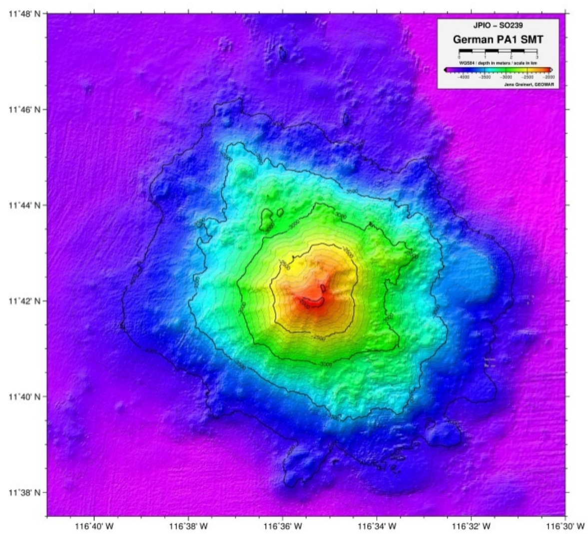


Fig. 7.2.1.2: Overview bathymetry of the 2000m high conical seamount east of the German prospective area (Rüppell Seamount) and a zoom onto its top with a clearly visible mass failure structure toward NNW.

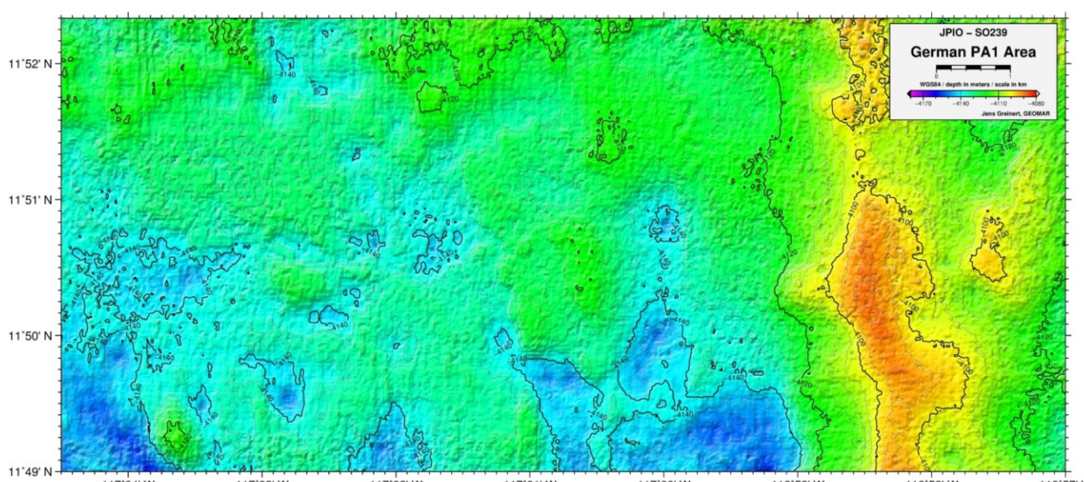


Fig. 7.2.1.3: The main working area in PA1.

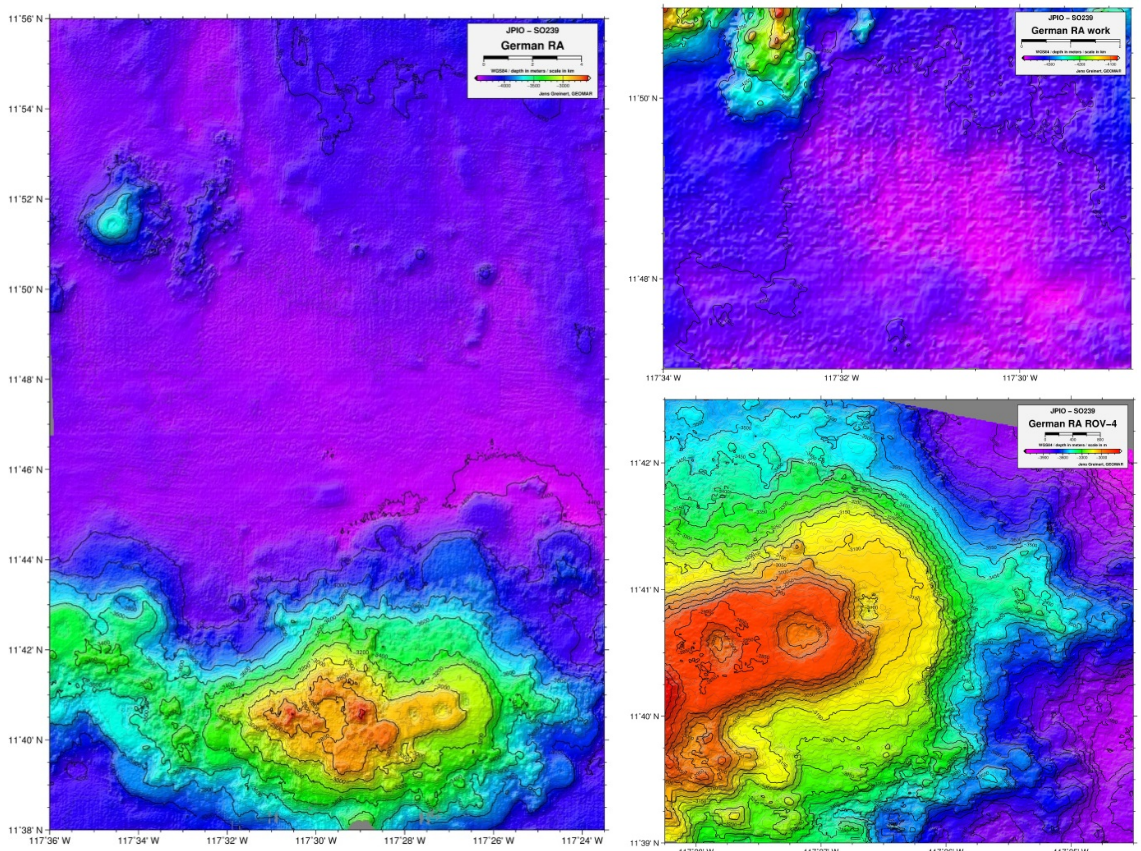


Fig. 7.2.1.4: Overview of the German Reference Area (RA) with a E-W striking Bank defining the southern border (Senckenberg Mountains) and a volcano structure with caldera and small ridge in the NW (left). Top-left; the main working area of the RA. The seafloor is largely flat; the shown pattern of N-S and E-W oriented lines is caused by noisy data and gridding artefacts.

IOM License area

Prior to the cruise, IOM supported bathymetric data from their disturbance experimental site. The data only covered the direct area of their disturbance area. As part of our mapping efforts we extended this area in all directions.

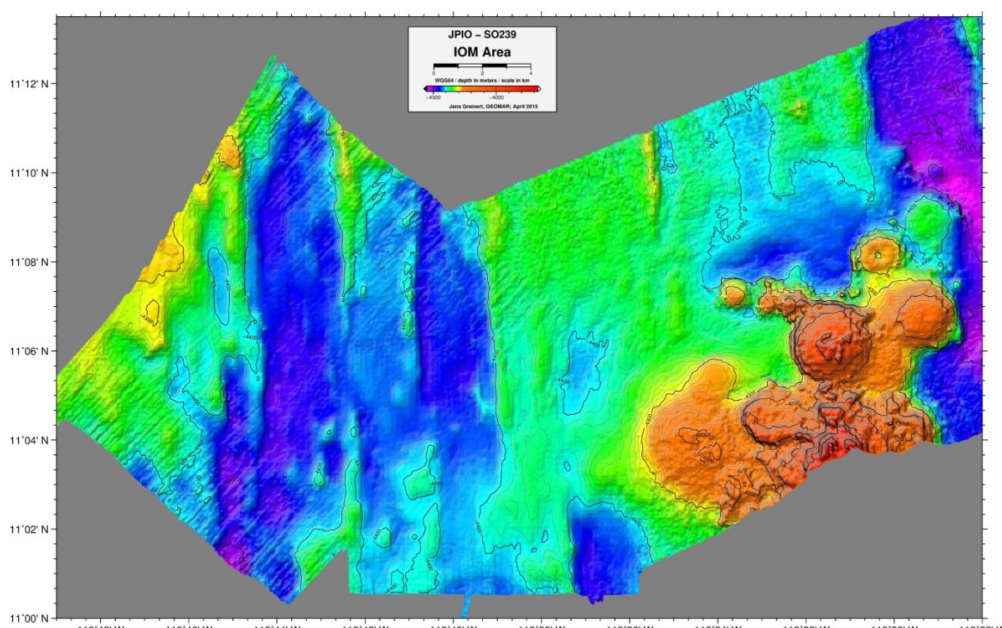


Fig. 7.2.1.5: Overview of the IOM area.

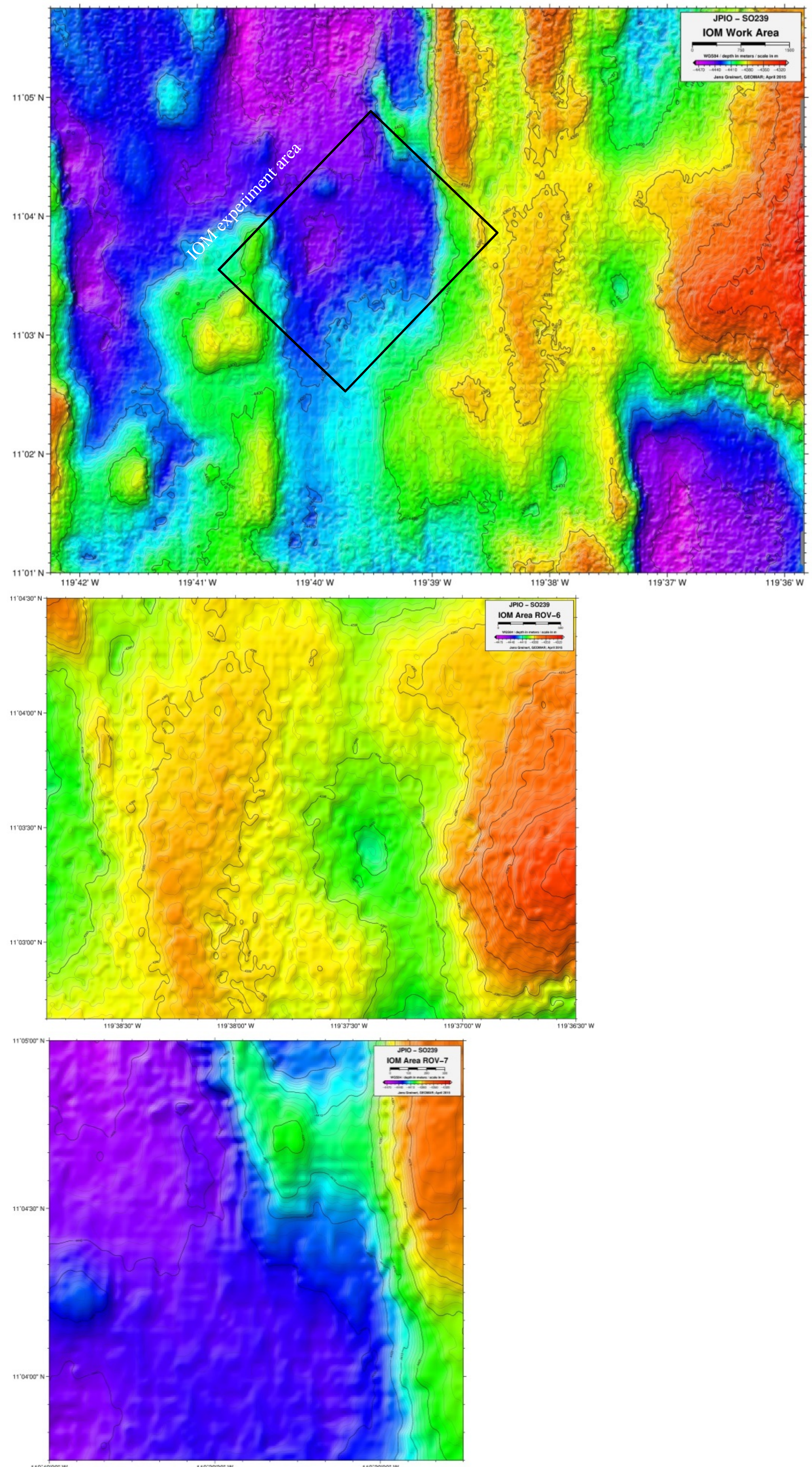


Fig.7.2.1.6: Top; IOM main working area with the area of the IOM disturbance experiment indicated. Bottom-left; Area of ROV dive #6. Bottom-right; Area of ROV dive #7

Belgian License area
As for the German area we had good information about the bathymetry from the license holder GSR. As these data cannot be used in any following publication we mapped the main working area, including a large sea mount bank during a 7h survey.

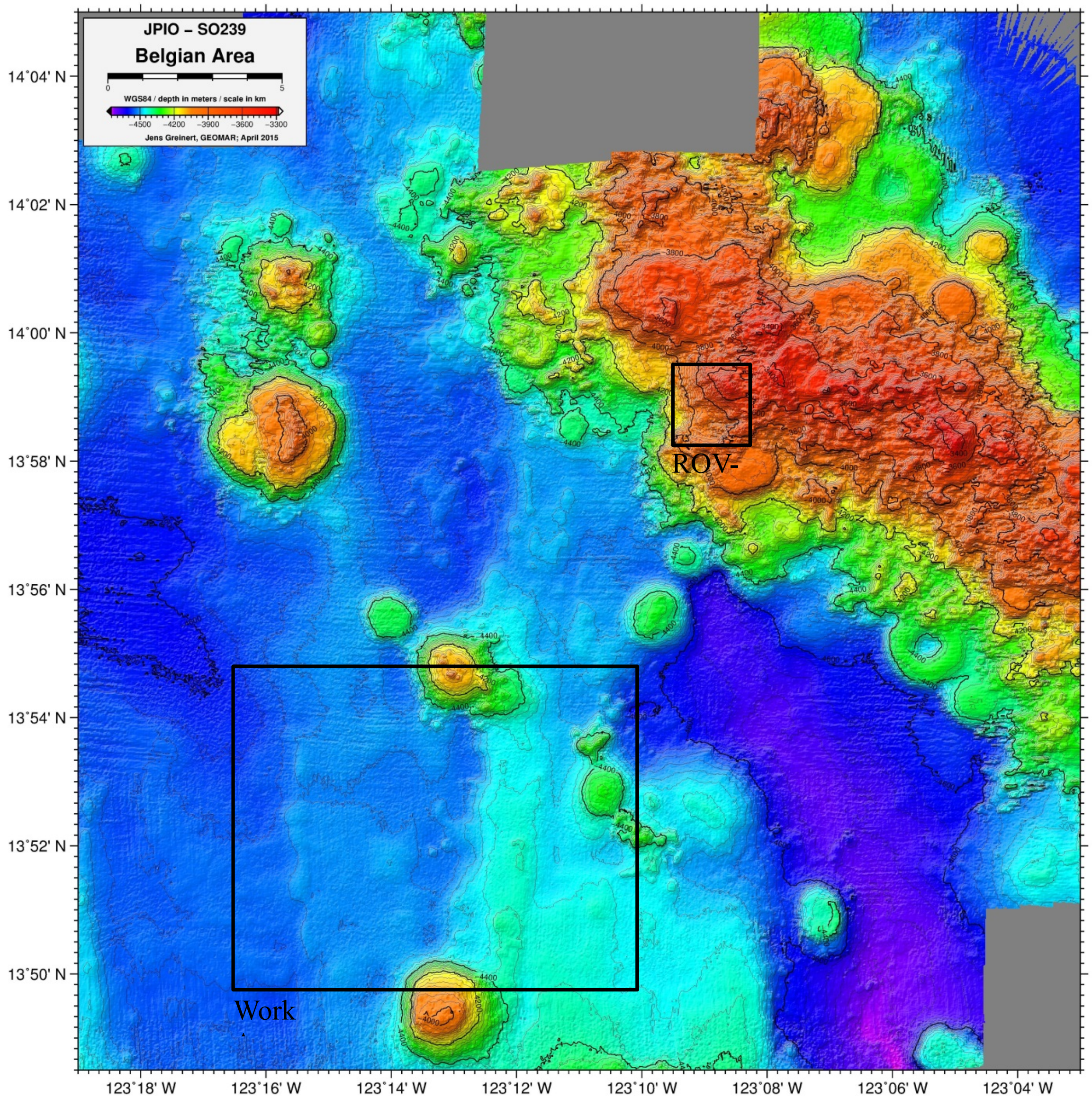


Fig.7.2.1.7: Bathymetric map of a part of the Belgian license are.

Two main working areas, on around a 6 month old dredge track and a ROV-dive area on the seamount complex were studied in detail.

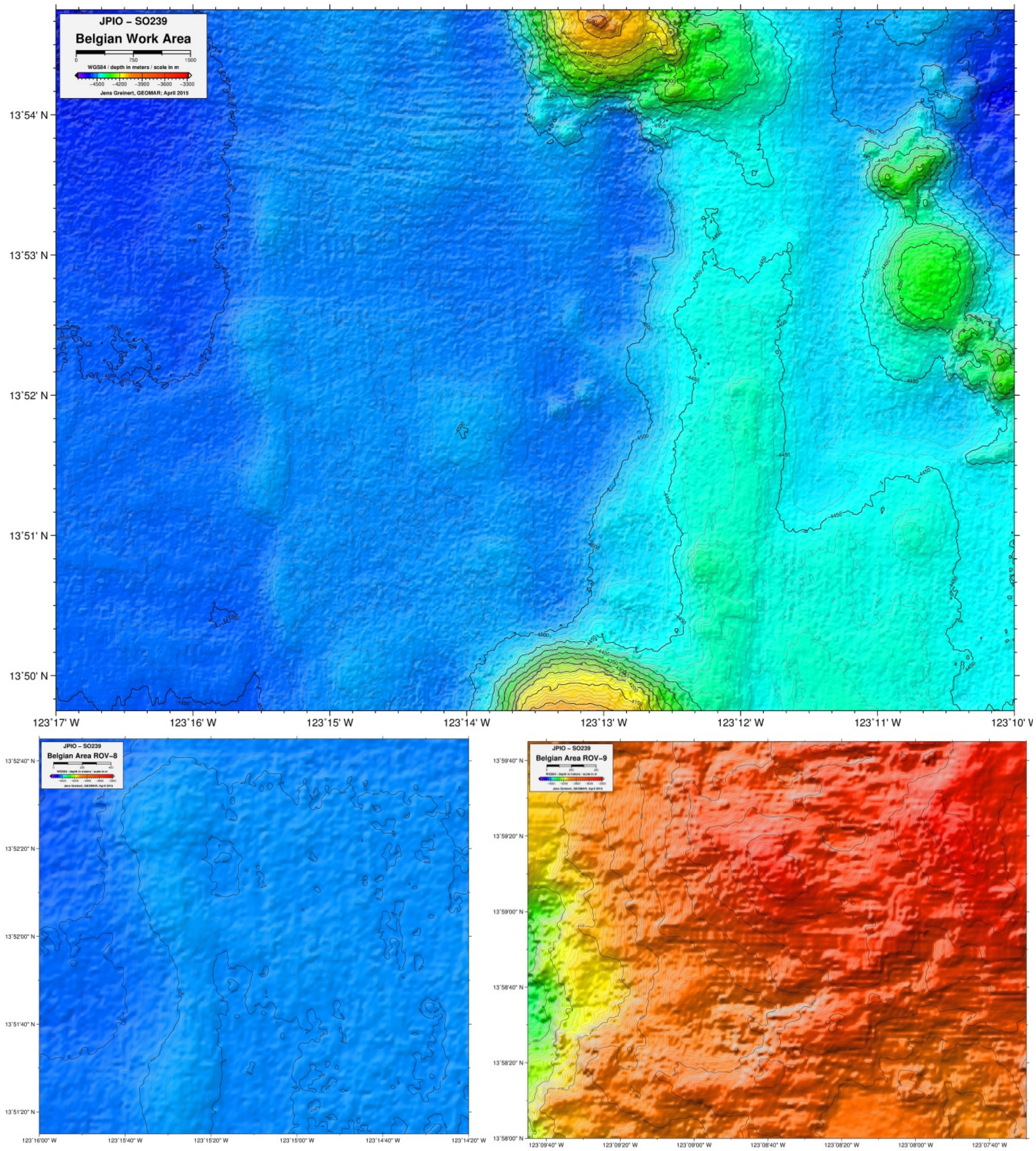


Fig.7.2.1.8: Top; main working area. Bottom-left, area of ROV dive #8 and #10. Bottom-right; area of ROV dive #9.

French License area

A few hours were spent for mapping the working area in the French License. An area around the old OMCO experiment tracks was chosen.

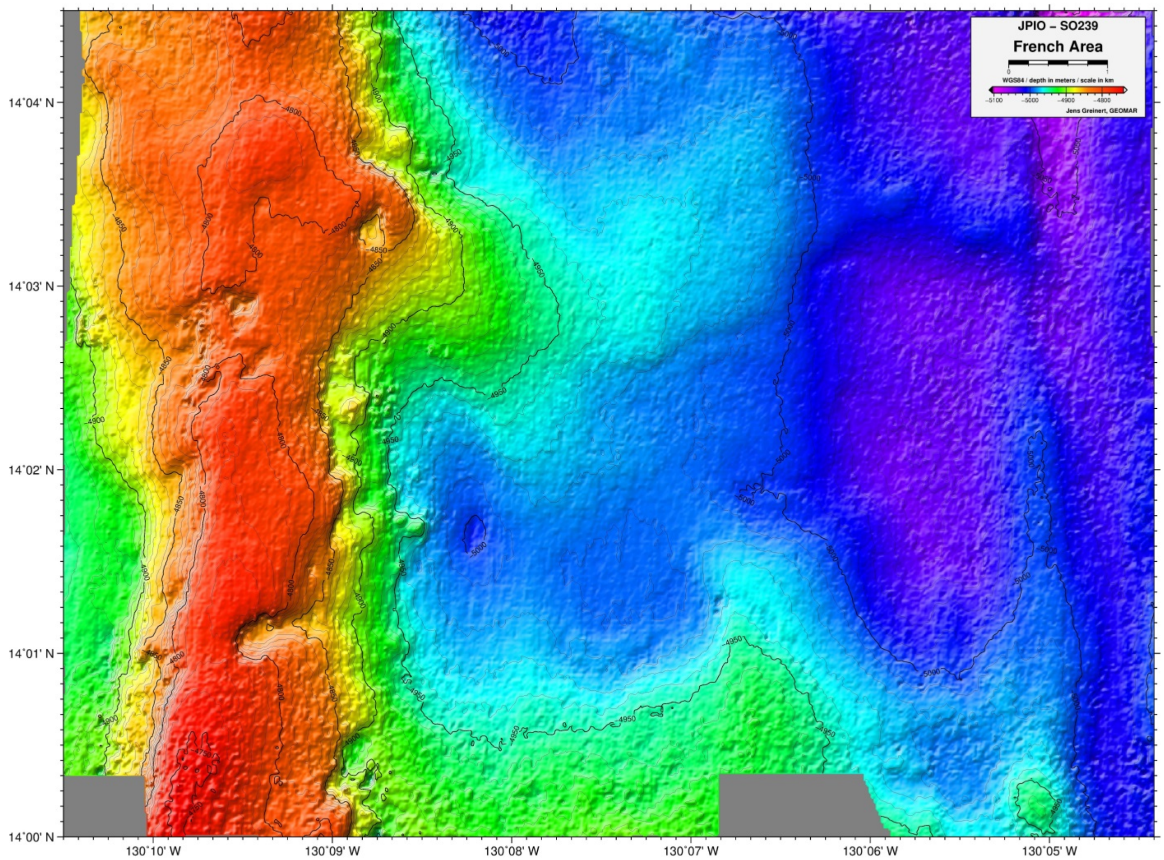
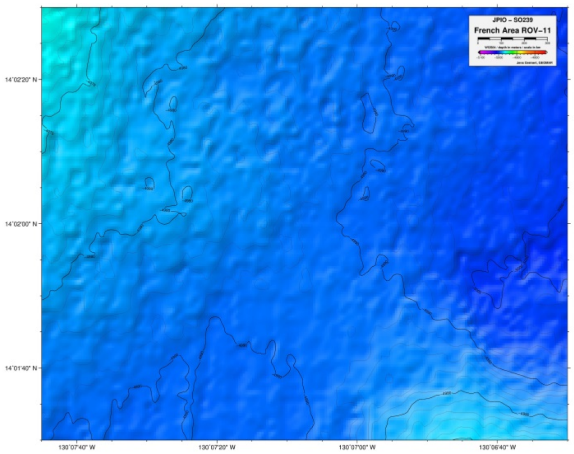
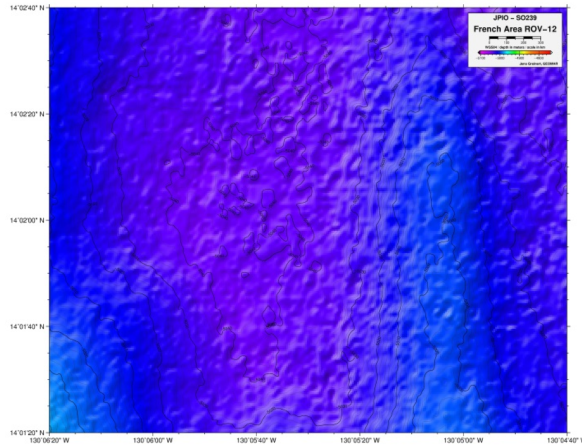


Fig.7.2.1.9: French working area.





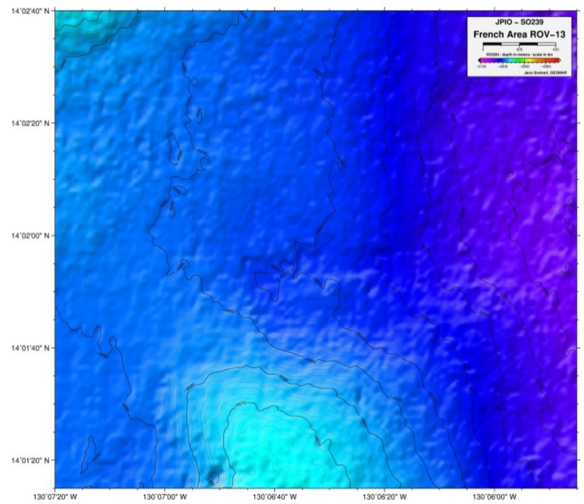


Fig. 7.2.1.10: Bathymetric maps of the two ROV dive #11 and #12. Dive #13 in the French area was canceled due to bad weather. The final dive #13 happened in APEI-3.

APEI-3

The only area without prior bathymetric information was the ‘Area of Particular Environmental Interest’ number 3, north of the Clarion Zone. As this are to our knowledge has never been studied before a 16h multibeam survey was planned. Based on the ETOPO 2 data set survey lines where planned to cover a substantial seamount in the SW corner of the inner 200 x 200km core area of the APEI and proceed towards the center of this core area. Different to the ETOPO data, the Mann Borgese seamount turned out to much higher, 1590m water depth instead of 3400m, and further to the east. Already during the survey a working area next to an area of N-S striking graben and horst structures was selected.

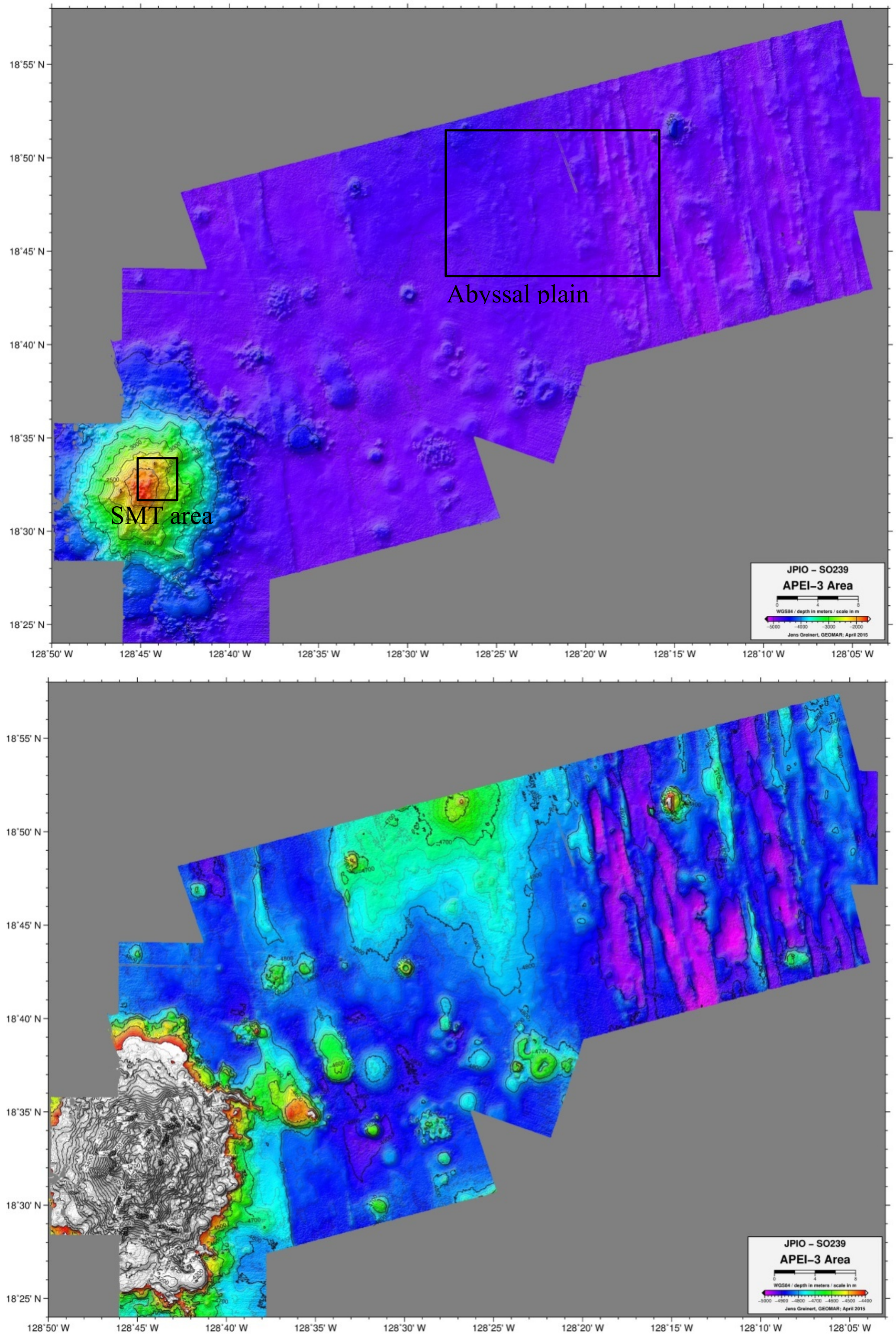


Fig.7.2.1.11: Overview of the APEI-3 extended area with the two main working areas at the seamount and the abyssal plain. The bottom image uses a different color palette for highlighting the bathymetric changes of the abyssal 'plain'.

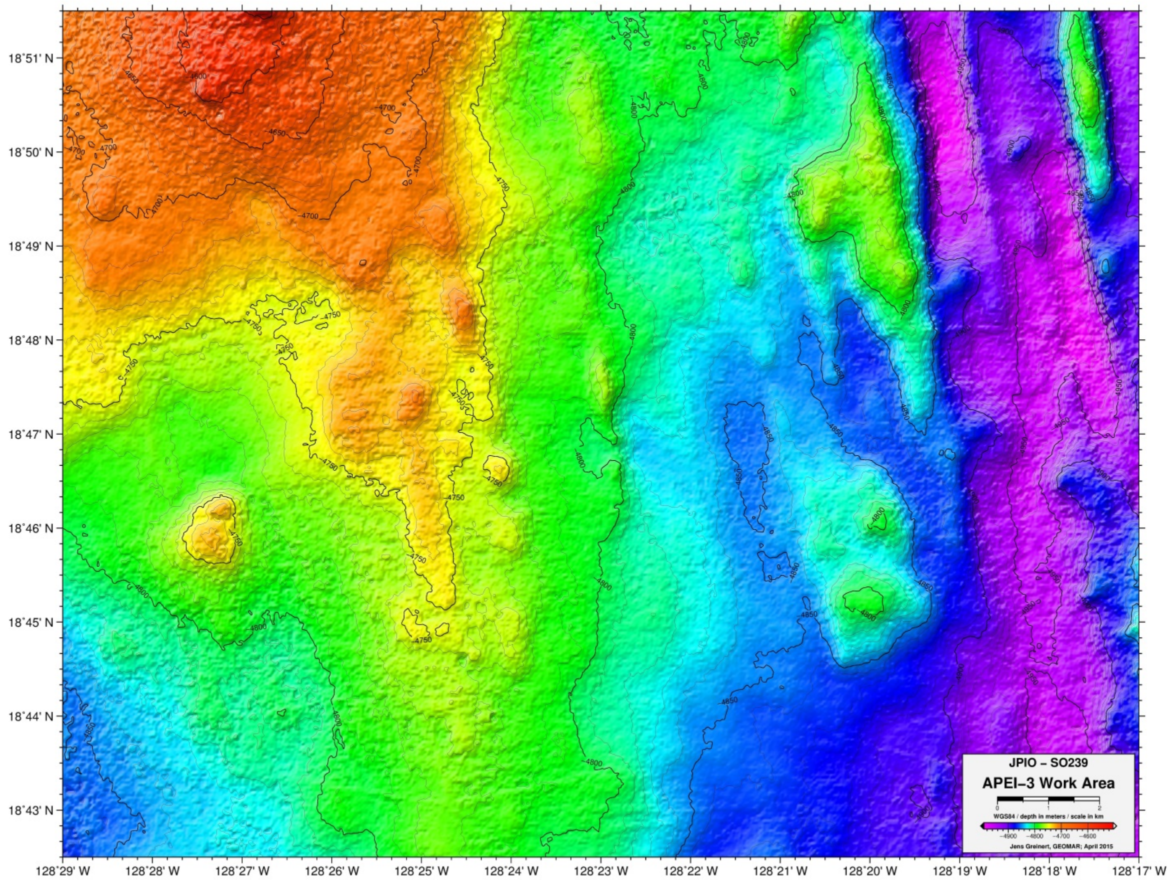


Fig.7.2.1.12: Overview of the APEI-3 abyssal plain working area.

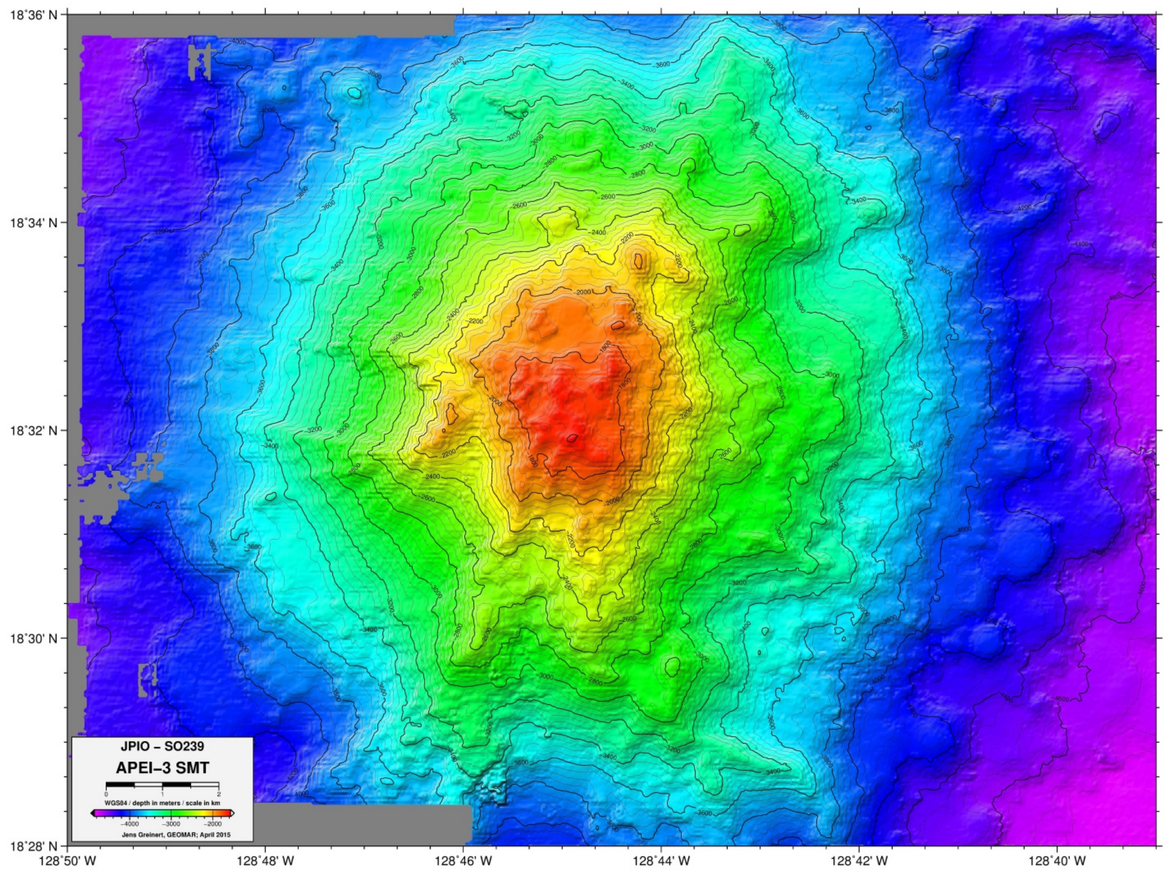
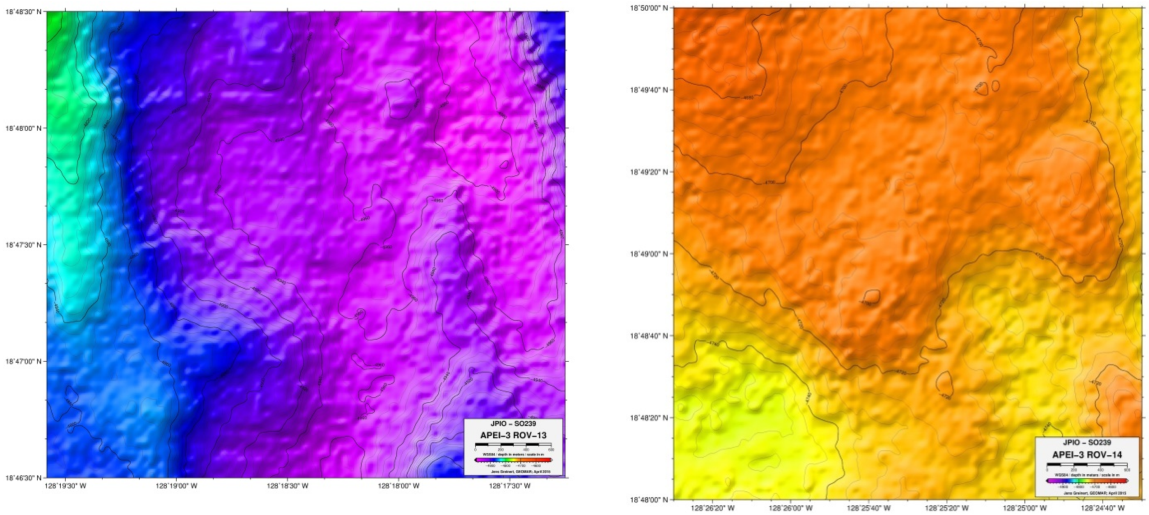


Fig.7.2.1.13: Overview of the 1590m deep Mann Borgese seamount in the APEI no. 3.



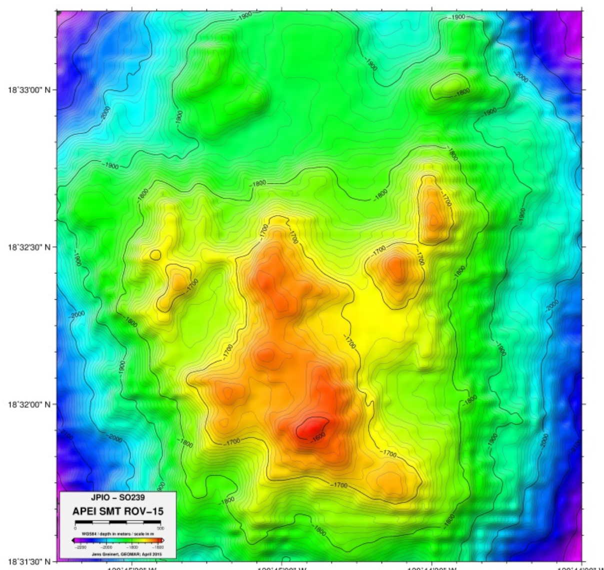


Fig.7.2.1.14: Bathymetric maps of the two ROV dives on the abyssal plain (#13 and #14) and the top of the seamount in APEI no. 3.

7.2.2 Water column characteristics (Vasiliu)

7.2.2.1 Hydrographic conditions

Hydrographic conditions in the studied areas were investigated based on CTD profiles. CTD stations (see Annex 11.3) were selected in order to obtain a more complete picture of the sampled areas in terms of physical, chemical and biological conditions within the water column.

The studied areas are situated within the North Equatorial Current, flowing westward under the influence of the NE trade winds. The German and IMO areas, lying within the westward extension of the eastern Pacific warm pool, showed the highest sea surface temperatures (within 27.5 – 28 °C), while the north-westernmost area (APEI) showed the lowest one (23.9°C) (Fig.7.2.2.1). Sea surface salinity showed the lowest values in the eastern part of the studied area (German area – PA1, 33.14 – 33.38 PSU) due to the influence of the Intertropical Convergence Zone (where precipitation exceeds evaporation). Significantly higher sea surface salinity was found in the western stations (in the APEI and French areas) (34.11 – 34.23 PSU) (Fig.7.2.2.1).

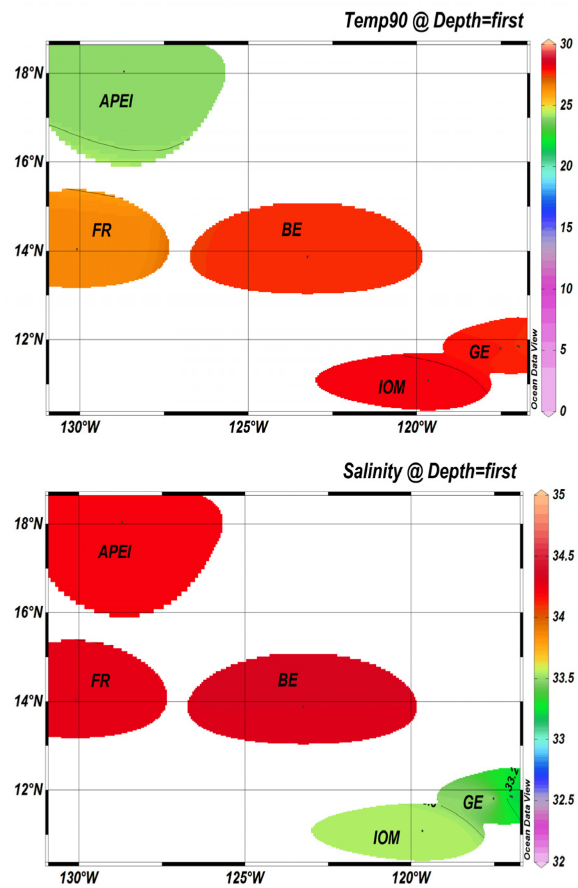
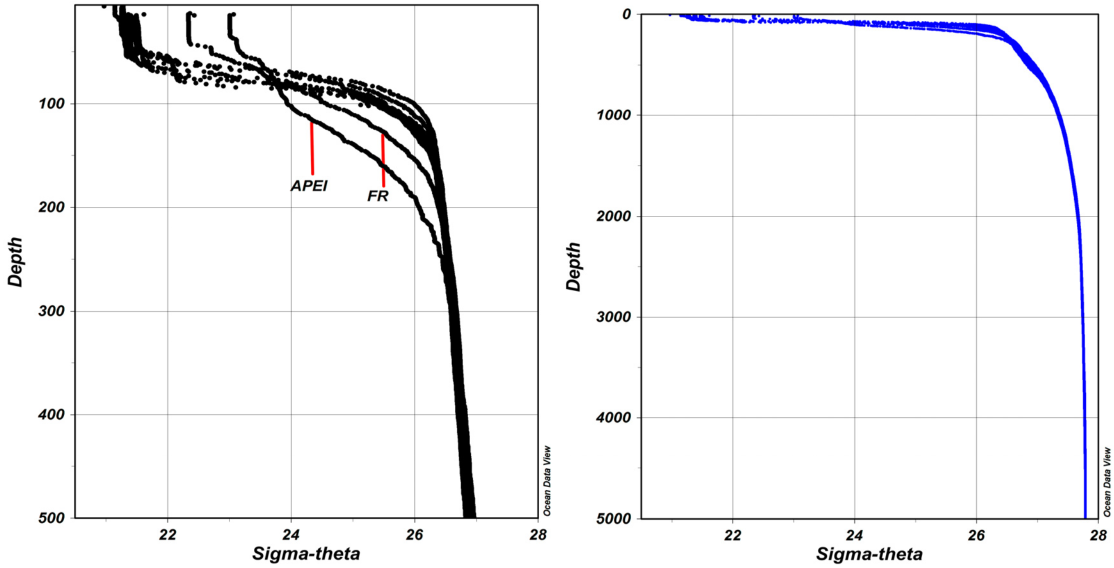


Fig. 7.2.2.1: Sea Surface Temperature and Salinity distributions in the studied area

Density (expressed as Sigma-theta) CTD profiles showed an upper mixed layer which varied between 35 and 55 m in thickness, followed by a sharp and shallow pycnocline (Fig 7.2.2.2). Generally, the density stratification is due to vertical temperature gradient, but is reinforced by halocline. Beneath the warm, low-salinity upper mixed layer a pronounced thermocline/halocline separates surface and subpycnocline waters (Fig.7.2.2.3). This cooler, more saline thermocline water is upwelled at the equator and contributes to the formation of Equatorial Surface Water. North Pacific Subtropical Surface Water is subducted southward into the thermocline north of 20°N and forms a subsurface salinity maximum (34.5 – 34.82 PSU) that is clearly visible at stations located north of 13°N (particularly in the Belgian, French, and APEI areas). At those stations, a subsurface salinity minimum (33.96 – 34.1 PSU) can be also observed, just below the subsurface maximum (Fig.7.2.2.3).



a) b)

Fig 7.2.2.2: Sigma-theta vertical distribution within the upper (a) and throughout (b) water column

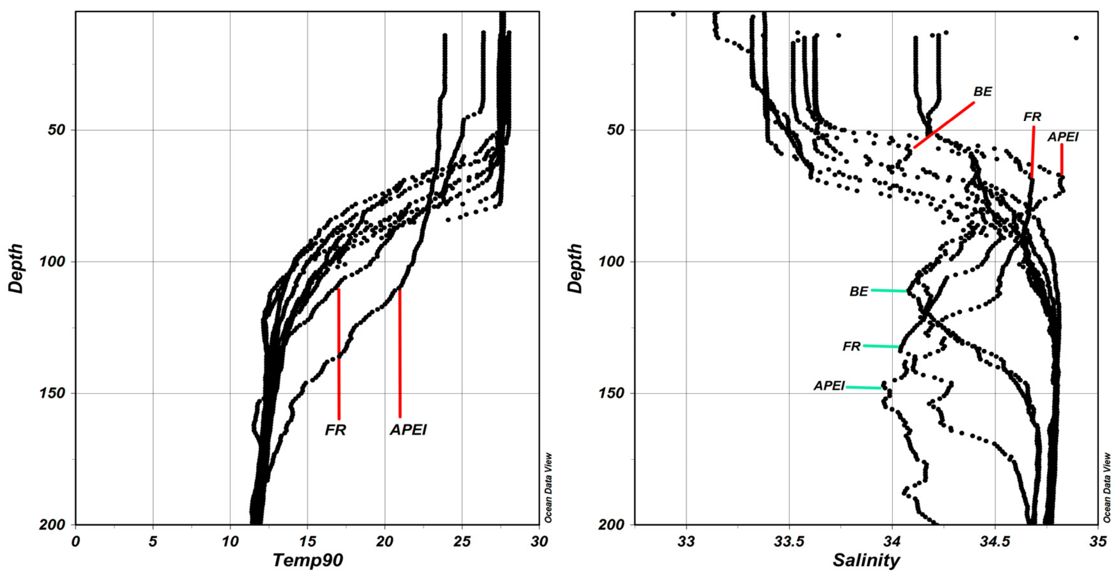


Fig. 7.2.2.3: Temperature and Salinity distribution in the upper 200 m layer

Between 500 and 1000 m depth a low salinity subpycnocline water mass is lying, originating from 2 sources: the Antarctic Intermediate Water (AIW) formed from the deep, winter mixed layer north of the Subantarctic Front in the southeast Pacific (Hanawa and Talley, 2001) and spread equatorward and westward in the Pacific and the North Pacific Intermediate Water (NPIW) originates from subsidence in the Sea of Okhotsk and at the Oyashio Front in the western North Pacific, with some contribution from the Gulf of Alaska (You, 2003).

The deep water (DW) between 1000 and 2500 m is characterized by a steady decrease in temperature (from 4.4 – 4.8 °C to 1.8 – 1.9°C) and an increase in salinity (from 34.51 – 34.55 PSU to 34.65 PSU) (Fig. 7.2.2.4). Deeper than 2500 m, the North Pacific Deep Water (NPDW) is characterized by temperatures within 1.4 – 1.9 °C overlying the near bottom water (bottom depths > 4000m) (Fig. 7.2.2.4). The latter is formed by the Lower Circumpolar Water (LCPW), a mixture of AABW and the North Atlantic Deep Water (NADW) formed in the northern North Atlantic (Fiedler and Talley, 2006).

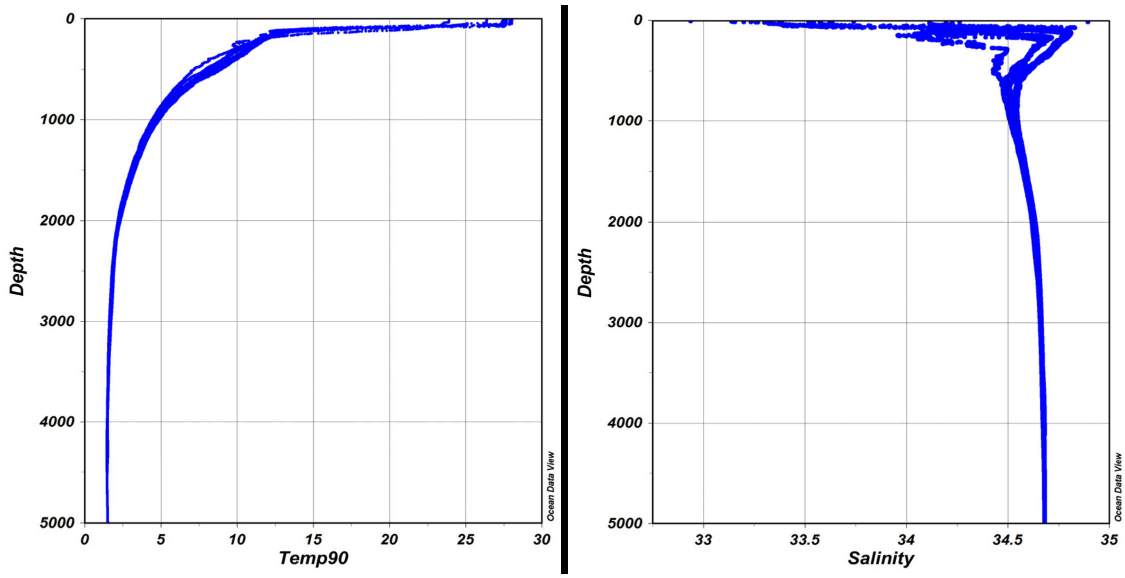


Fig. 7.2.2.4: Temperature and Salinity distribution throughout the water column

7.2.2.2 Turbidity and Suspended Particulate Matter

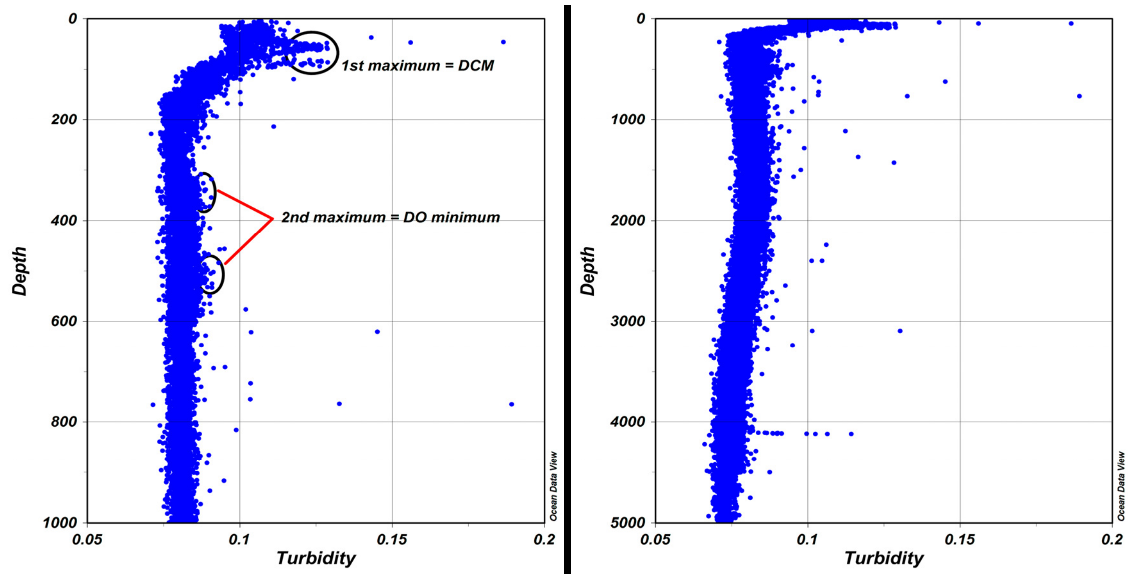
CTD turbidity profiles showed a maximum in the euphotic zone, coinciding with the deep chlorophyll maximum (DCM) layer, more pronounced at the stations where the fluorescence maxima were also observed (Fig. 7.2.2.5). A second weaker maximum can be observed in the layers where the DO concentrations dropped close to 0 (Fig. 7.2.2.5). This maximum, not observed at the stations where the DO minima were slight higher (147_1_CTD and 183_1_CTD), can be associated with the particulate organics sinking from the productive layer. A very slight decrease in turbidity can be observed between 2500 m and 3300-3500 m depth. Below 3500 m depth, the turbidity remained constant (0.07-0.08 NTU) up to the bottom (Fig. 2.2.2.5).

Special attention was paid to the small scale epibenthic sledge (EBS) disturbance experiments carried out in the German area – PA1 and Belgian area, especially in terms of turbidity distribution in the near bottom water.

Before the experiments, the background conditions were measured at the stations 010_1CTD and 110_1_CTD, respectively. After the experiments, turbidity CTD measurements were done by moving the CTD around the EBS tracks (stations 025_1_CTD and 026_1_CTD in the German area-PA1 and 118_1_CTD in the Belgian area). There were two stations in the German area, since the first CTD profile did not show any sediment plume (station 025_1_CTD). During the second downcast (station 026_1_CTD) the equipment was lowered slightly deeper (down to ~4 m above the seafloor) and an increase in turbidity was observed while the CTD equipment was moved along the EBS track (Fig. 7.2.2.6).No sediment plume was observed in the Belgian area (station 118_1_CTD), most likely due to CTD movement in a wrong direction (no data of current direction nor current velocity were available).

Large volumes of near bottom waters were collected from 2 depths (both before and after EBS disturbances) and filtered onboard for SPM (glass fiber filters, porosity of 0.8 μm) and trace metal composition in suspended particles (cellulose nitrate filters, porosity of 0.8 μm).

The sampling depths and the filtered water volumes are shown in the Annex 11.3.



a) b)

Fig. 7.2.2.5: Turbidity distribution in the upper 1500 m (a) and throughout water column (b)

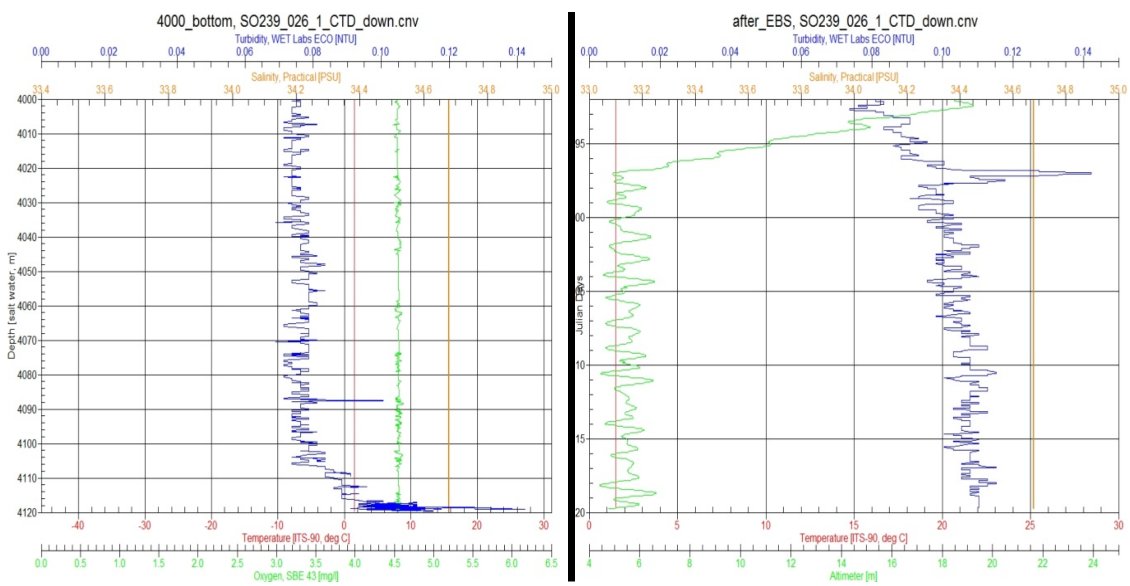


Fig. 7.2.2.6: Turbidity distribution in the near bottom waters after the EBS disturbance experiment (station 026_1_CTD)

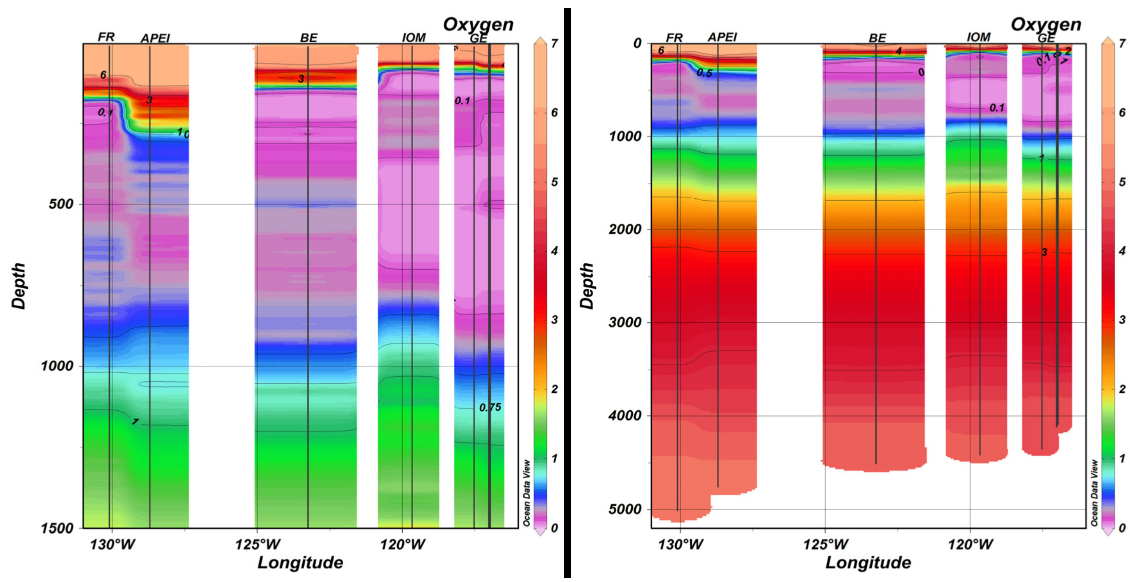
7.2.2.3 Chemistry

Dissolved Oxygen

Dissolved oxygen (DO) distribution in the water column was measured only by CTD SBE 43 oxygen sensor.

The upper mixed layer is well oxygenated, the DO concentrations varying between 5.93 and 6.48 mg L^{-1} (maximum at station 183_1_CTD – APEI) (Fig. 7.2.2.7). A sharp oxycline is observed at the southernmost stations (IOM and German areas), starting with the upper limit

of thermocline (55 – 60 m) down to 85–115 m where DO dropped close to 0 (Fig. 7.2.2.7). The upper limit of oxycline descended to 100 – 120 m in the northernmost stations, where also the thickness of oxycline increased significantly (Fig. 7.2.2.7). At the stations where subsurface salinity minima were observed, the oxycline was interrupted by a slight increase in DO in the less saline water masses.
Beneath the oxycline, the Oxygen Minimum Zone (OMZ) encompasses the depth range of 90 – 1100 m (Fig. 7.2.2.7). The thickness of OMZ varied from ~1000 m in the southeastern part of the studied area (at stations located in the German area) to ~600 m in the northwestern part (APEI). Within OMZ, DO concentrations dropped to well below 0.1 mg L^{-1}, except the APEI area, in relation to the less pronounced pycnocline which allows slight vertical ventilation. In general OMZ is assumed to be formed by the combination of poor ventilation of the deep water, through import into the region by horizontal transport and by the local oxidation of particulate organics sinking from the productive surface layer (subject to oxidation).
Beneath the OMZ, the oxygen showed a steady increase down to near bottom waters where its concentrations ranged between 4.5 and 4.7 mg L^{-1} (Fig. 7.2.2.7).



a) b)
Fig. 7.2.2.7: DO distribution in the upper 1500 m (a) and throughout water column (b)

Nutrients
Water samples for nutrient analyses were collected by Sea Bird SBE 32 carrousel water sampler (24 Niskin bottlesx10L) from different depth selected according to the CTD profiles at 9 stations Annex 11.3.

Approximately 250 ml seawater were transferred immediately from the Niskin bottles into 0.5 L plastic bottles (rinsed before with seawater) for nutrient analyses and stored in dark in a refrigerator (at < 8°C) until their subsequent analyses (no more than 2 - 3 hours).

Nutrients were analyzed onboard (GeoEcoMar) by spectrometry (UV-VIS Lambda 35 spectrophotometer) following the analytical procedures briefly described below:

- Phosphate was determined was by the ascorbic acid-potassium antimony tartrate method of Murphy and Riley (1962);
- Nitrite was determined by the method of Bendschneider and Robinson (1952);
- Nitrate was measured based on the heterogeneous reduction (using a reductor column filled with copper-coated cadmium granules) of nitrate to nitrite (Grasshoff, 1970), which is then determined according to method described above;

- Silicate was determined by reducing (with ascorbic acid) the silicomolybdic acid formed when the sample is treated with a molybdate solution (Koroleff, 1971).

Nutrients showed relatively low concentrations in the upper mixed layer, ranging within 0.1 – 0.37 µM – PO_4, 0.23 – 1.38 µM – SiO_4, 0.09 – 0.60 µM – NOx (NO_3+NO_2) (Fig. 7.2.2.8). However, an increase in nutrients stock can be observed towards the upper limit of thermocline (which coincides with the DCM), followed by a sharper nutricline in the OMZ. Phosphate and nitrate reached maxima (2.78 – 3.17 µM and 53.3 – 59.49 µM, respectively) generally at the lower limit of OMZ (~1000 – 1200 m); while silicate showed maximum (81.07 – 104.25 µM) deeper than OMZ, between 2500 – 3300 m (Fig. 7.2.2.8).

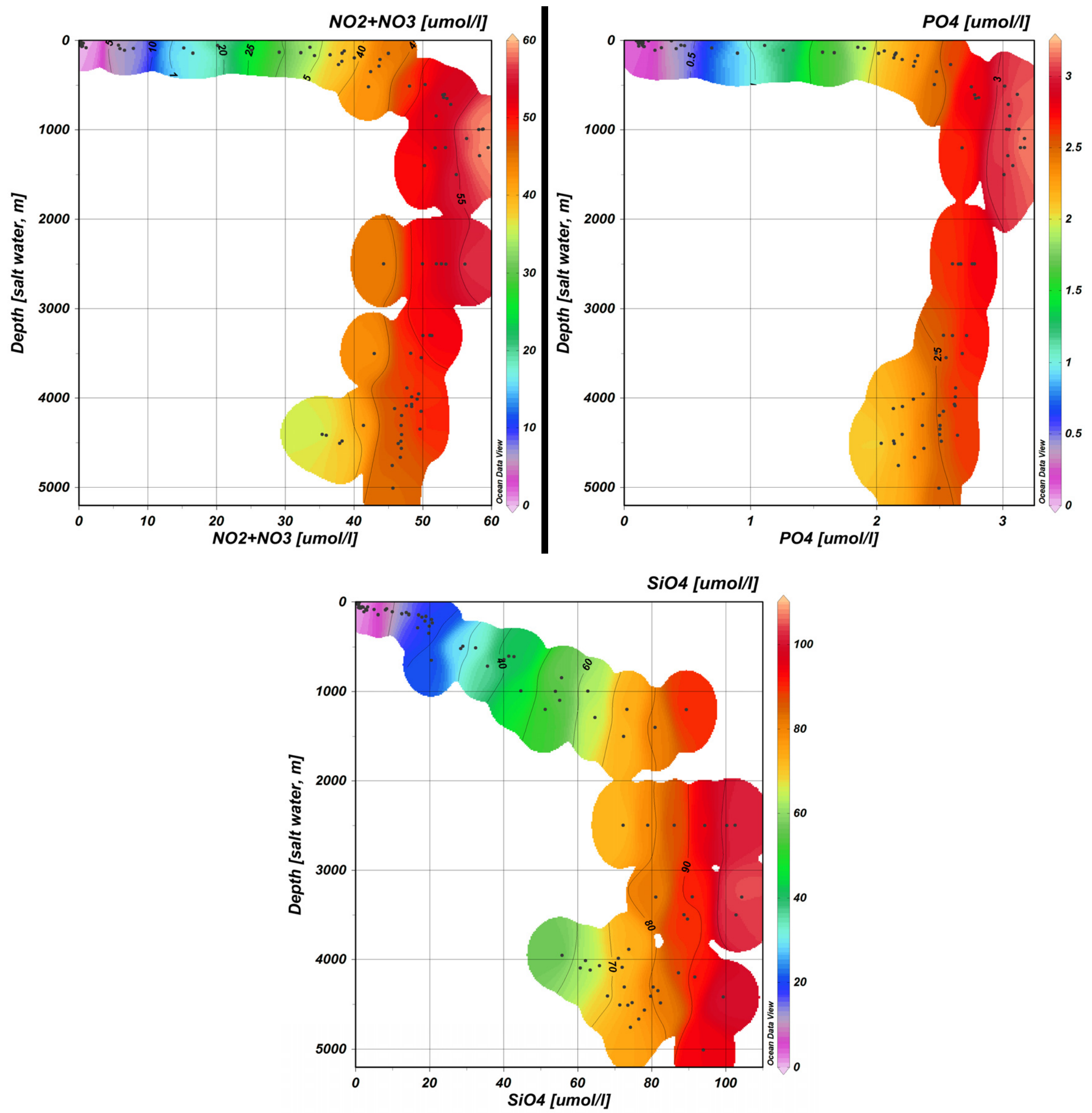


Fig. 7.2.2.8: Nutrient distribution throughout water column (NOx, PO_4, and SiO_4)

Beneath the nutricline, the nutrient concentrations showed a slight decrease down to near bottom waters, where they reached values between 2.04 – 2.64 µM – PO_4, 35.37 – 49.72 µM – NOx, and 60.66 – 99.29 µM – SiO_4 (Fig. 7.2.2.8).

Although most of the nitrite concentrations were below detection limit (0.03 µM), it showed a maximum (0.02 – 1.16 µM) in the DCM (at the upper limit of thermocline), most likely associated with excretion by phytoplankton (Vaccaro and Ryther 1960). For some of the stations a secondary nitrite maximum (much weaker – 0.03 – 0.21 μM) was observed within the upper half of OMZ.

TOC/DOC

Water samples for TOC/DOC analyses were collected by GeoEcoMar and Jacobs University Bremen in the German and Belgian areas, where the EBS disturbances experiments were performed. 35 water samples (see Annex 11.3) were collected by GeoEcoMar and kept frozen until the subsequent analyses in the GeoEcoMar laboratory (High-Temperature Combustion method). In addition, 67 samples were filtered through 0.2 μm cellulose acetate filters (Satorius), acidified and kept cooled until subsequent DOC analyses in the home laboratory of Jacobs University Bremen.Samples collected from the near bottom waters (before and after EBS experiments were filtered through pre-combusted glass fiber filters (0.8 μm pore size) in order to determine the Particulate Organic Carbon (POC).

Trace elements

In the German License Area and the APEI 41 samples were taken for background analyses of minor and trace elements and Mn II/III speciation in the water column which will be conducted in the home laboratory. Further subsamples were taken before and after EBS experiments.

7.2.2.4 Biology

Biological investigations within the water column have been carried out in terms of chlorophyll *a*, phytoplankton and zooplankton. The CTD fluorescence data were examined in order to obtain information on the distribution of chlorophyll (a proxy for the primary productivity).

The fluorescence profiles suggest low productive surface waters since the chlorophyll concentrations did not exceed 0.1 $\mu g \cdot L^{-1}$, excepting the station 056_1_CTD (0.34 $\mu g \cdot L^{-1}$). Surface chlorophyll showed a decrease to the west (minimum in APEI – see Fig. 7.2.2.9) in connection with deeper thermocline which results in decreasing euphotic zone nutrient supply.

A well pronounced deep chlorophyll maximum (DCM) layer, with cores at depths ranging between 60 and 110 m (Fig. 7.2.2.9), was generally observed around the upper limit of thermocline. Only in the northernmost stations (183_1_CTD and 147_1_CTD) the DCM was clearly located within thermocline. The shallowest DCM layer (54 – 63 m depth) was found in the German area - RA with the maximum chlorophyll concentration of 1.13 $\mu g \cdot L^{-1}$ at 57 m depth. The deepest one (at depth of 103 – 130 m), at the same time less pronounced DCM layer (maximum concentration of 0.63 $\mu g \cdot L^{-1}$ at 110 m depth) was observed in the APEI area.

The highest chlorophyll concentrations were found in the German area – PA1, particularly at the stations 025_1_CTD (1.46 $\mu g \cdot L^{-1}$ at 53 m depth) and 026_1_CTD (1.51 $\mu g \cdot L^{-1}$ at 64 m depth). Also, high chlorophyll concentrations were registered in the Belgian area, at the both stations, at depths of 82 – 88 m (1.31 – 1.35 $\mu g \cdot L^{-1}$).

It is worth noting the presence of a second subsurface chlorophyll maximum layer, deeper (90 – 130 m depth) and less pronounced (concentrations between 0.52 – 0.98 $\mu g \cdot L^{-1}$), in the IOM and German–RA areas (Fig. 7.2.2.9).

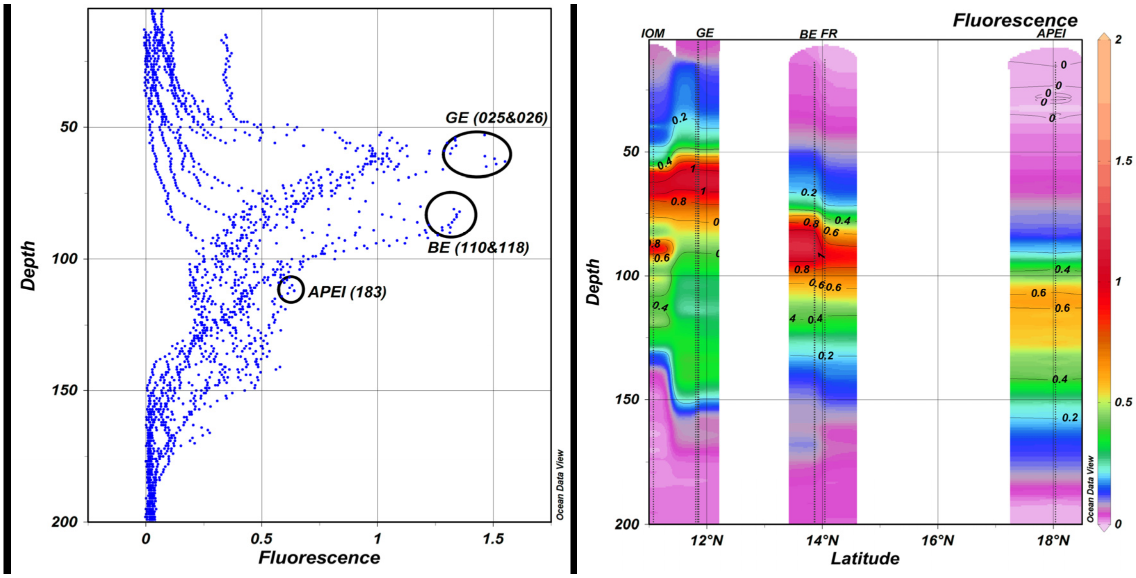


Fig. 7.2.2.9: Chlorophyll distribution in the upper column (200 m)

According to the CTD fluorescence profiles, water samples for chlorophyll and phytoplankton analysis were collected from depths between surface and ~ 200 m.

For chlorophyll analyses, 37 water samples were filtered onboard through Millipore nitrocellulose membrane (pore size of 0.8 µm). The filters were frozen at – 60 °C until the subsequent analyses in the GeoEcoMar laboratory (solvent – acetone; extraction - homogenization and sonication; spectrophotometry, Jeffrey-Humphrey (1975) equations).

Approximately 100 ml seawater samples were collected by GeoEcoMar for phytoplankton analyses (both quantitative and qualitative) from the stations 147_1_CTD and 183_1_CTD. The samples were preserved onboard with 4 ml formaline 10 % solution/bottle.

The sampling depths for chlorophyll and phytoplankton and the volume of seawater filtered are shown in the Annex 11.3

7.2.3 Water column, pore water and sediment geochemistry (Preuss, Volz, Löffler, Ozegowski, Moje)

Research objectives

The main objectives of the geochemical investigations carried out during this cruise were (1) to characterize the geochemical environment and redox zonation found in the undisturbed sediments of the different license areas in the abyssal plain of the CCZ and (2) to study the impact of small-scale disturbance experiments on the geochemical zonation as well as the trace metal budget in the bottom-water as well as in the pore water of the sediments. In order to provide a detailed geochemical characterization of the different license areas, sediment cores from adjacent sites with different nodule coverage were investigated. In addition, sites with small-scale disturbances performed up to 37 years ago were studied to assess their state of recovery by comparing disturbed with adjacent undisturbed sites. To investigate short-time effects of anthropogenic disturbances on the geochemical zonation of sediments, comparable with potential future mining activities, the disturbances of the deployed epibenthic sledge (EBS) on this cruise were sampled at two sites.

One key task of the shipboard analyses was to determine the thickness of the upper oxic zone of the sediments in the different study areas as it has been shown recently that slight differences in the oxygen penetration depth cause differences in nodule size and abundance (Mewes *et al.*, 2014).

Methods

Immediately after CTD and sediment core recovery with different coring devices (GC: gravity corer, MUC: multi-corer, ROV-PC: push-cores retrieved with the ROV Kiel 6000), all sediment cores taken for geochemical analyses were transferred into the cold room at *in situ* temperatures of approximately 4°C. In each working area at least 1 CTD, 5 MUC cores and 1 GC were taken at adjacent sites. Furthermore, during ROV dives 4 ROV-PC cores were taken for high-resolution oxygen measurements, pore-water extraction and solid-phase sampling.

Oxygen measurements

Oxygen saturation in the sediment was determined using amperometric Clark-type oxygen sensors with an internal reference and equipped with a guard cathode (Revsbech, 1989). The electrodes (Unisense, Denmark) were made of glass with a 6 cm long tip that was inserted into a hyperdermic needle (diameter 1.1 mm, length 50 mm) and had a response time shorter than 10 s. Signals were amplified and transformed to mV by a picoamperemeter, digitalized by an analogue/digital converter (ADC 216, Unisense, Denmark) and recorded by a computer using the software PROFIX (Unisense, Denmark). Measurements were recorded at each sampling point for 2-3 minutes and mean saturation values were taken when signals were stable to calculate the depth profiles of oxygen concentrations. Measurements were performed at least 12 hours after core recovery in order to allow temperature equilibration of the sediments at *in situ* temperatures of about 4°C in the cold room. For the calibration of the oxygen sensors, local bottom water was used.

High-resolution (1 mm depth resolution) vertical profiles of oxygen saturation across the sediment/water interface were accomplished for multiple corer (MUC) cores and ROV-push cores (ROV-PC) by use of a micromanipulator down to a maximum sediment depth of 5-6 cm. For the measurement of oxygen in deeper parts of the MUC and ROV-PC cores as well as for all gravity cores (GC), holes were drilled through the walls of the core liners in intervals of 1 cm for MUC and ROV-PC cores and of 5 cm for the GC for the insertion of the microelectrode.

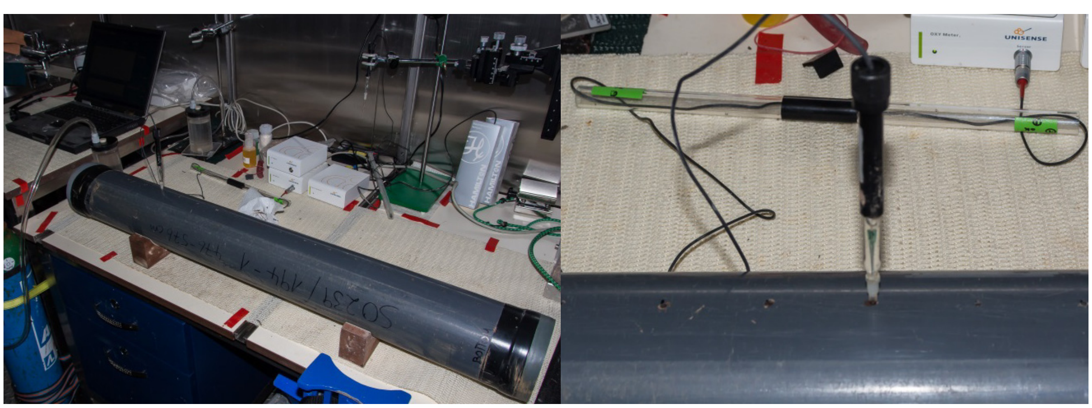


Fig. 7.2.3.1: Oxygen measurements performed with a gravity core at an *in situ* temperature of approximately 4°C (Photos: Vincent Ozegowski).

Water-column, bottom-water and pore-water sampling

Water-column, bottom-water and pore-water samples were collected from CTD-rosette, MUC, ROV-PC and GC cores and stored at 4°C until further analyses took place.

Water samples collected from the CTD-rosette (see chapter 7.1.3) and bottom-water samples from MUC cores, ROV-PC cores and the ROV-Niskin bottles were filtered with 0.2 µm cellulose acetate filters (Sartorius) and subsamples were taken for minor and trace elements analyses, Mn II/III speciation and dissolved organic carbon (DOC) in the home laboratories at the Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI) in Bremerhaven and the Jacobs University Bremen (JUB). Water samples from the small scale disturbance experiments were filtered onto 0.8 µm cellulose nitrate filters (Sartorius) for particle analyses at home. Further samples from the bottom-water samples from MUC cores and the ROV-PC cores were taken and filtered through rhizons for subsequent analyses onboard. In each case, the remaining bottom water was carefully removed from the MUC and the ROV-PC cores by means of a siphon to avoid destruction of the sediment surface.

Pore water from MUC, ROV-PC and GC cores was extracted by using (1) rhizon samplers with an average pore size of 0.1 µm (Seeberg-Elverfeldt *et al.*, 2005) and by (2) transferring sediment subsamples into 50 ml acid-cleaned centrifuge tubes and centrifuging at 2,800 rpm for > 40 min.

The supernatant was filtered through a 0.2 µm acid-cleaned cellulose acetate (Whatman, FP 30) filter. To preserve the anoxic conditions of the pore water, sediment samples of the anoxic part of the core were flushed with argon and subsamples processed in a glove bag under a steady stream of argon. Pore water from GC cores was retrieved at 20 cm depth resolution, from MUC and ROV-PC cores at 1 cm depth resolution by rhizon sampling and at 7 cm depth resolution by centrifuge sampling. From each sampling depth subsamples were taken for minor and trace elements analyses and DOC in the home laboratory. Further subsamples were taken from the GC cores and pooled from 1 m-segments for REE analyses. One GC and the related MUC core from the French License Area were further subsampled for amino acid and N-isotope analyses and stored at -20°C.

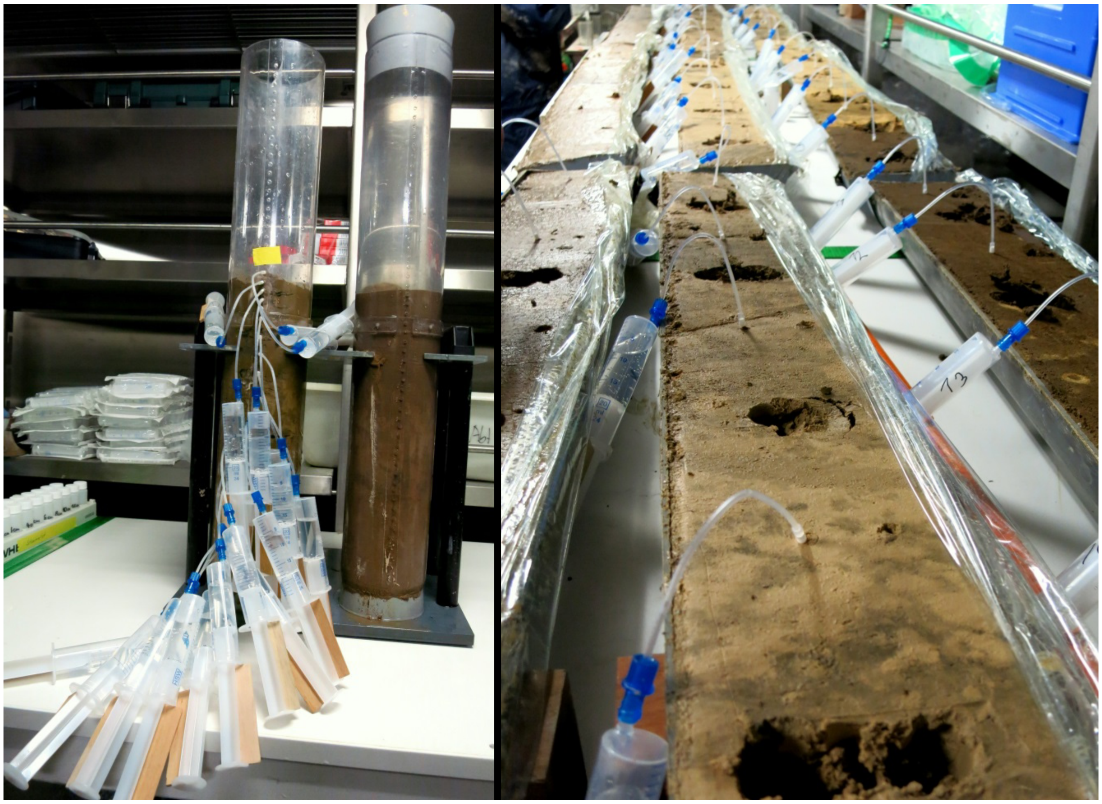


Fig. 7.2.3.2: Pore-water sampling using rhizon samplers with MUC cores and GC cores. The gravity core was sampled in an alternating interval of 10 cm with both sampling methods, rhizon samplers and syringes. Sampling was performed at an *in situ* temperature of approximately 4°C (Photos: Jessica Volz).

Shipboard pore-water analyses

After the supernatant bottom water was taken and filtered through a rhizon for subsequent analyses, the remaining bottom water was carefully removed by means of a siphon to avoid destruction of the sediment surface. In order to avoid any oxidation processes, the first 1 ml of extracted pore water was disposed during rhizon sampling. Subsequent to the extraction, analyses were performed onboard including the determination of Eh and pH, alkalinity, dissolved iron (Fe^{2+}), phosphate (PO_4^{3-}), silica and ammonia (NH_4^+).

Alkalinity

Alkalinity was determined on a 1 ml aliquot of sample by titration with 10 mM HCl. The pH measurements were performed using a Hamilton micro-electrode. The samples were titrated with a digital burette to a pH interval of 4.1 - 3.4 and both titration volume as well as the final pH were recorded. The alkalinity was calculated using a modified equation from Grasshoff et al. (1999).

Dissolved iron (Fe^{2+})

Fe^{2+} was determined photometrically at 565 nm (CECIL 2021 photometer, Lange DR 2800 photometer). 1 ml of sample was added to 50 µL of Ferrosprectral solution to complex the Fe^{2+} for colorimetric measurement.

Phosphate (PO_4^{3-})

PO_4^{3-} was determined using the molybdenum blue method (Grasshoff *et al.*, 1999). To 1 ml of sample 50 µL of an ammonium molybdate solution was added and spiked with 50 µL of an ascorbic acid solution. The phosphomolybdate complex was reduced to molybdenum blue and measured photometrically at 820 nm wavelength (CECIL 2021 photometer, Lange DR 2800 photometer).

Silica

Silica was determined photometrically as silica molybdate complex at 810 nm wavelength (CECIL 2021 photometer, Lange DR 2800 photometer).

Ammonia (NH_4^+)

NH_4^+ was determined by means of the flow-injection method as well as photometrically using phenol (CECIL 2021 photometer, Lange DR 2800 photometer).

Sample aliquots

Sample aliquots of ideally 2 ml for NH_4^+ and nitrate (NO_3^-) were stored in an amber vial sealed with a PTFE septum-bearing lid at -20°C until analyses by means of a continuous flow analyzer (QuAAtro auto-analyzer) at the Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI) in Bremerhaven. For the analyses of further dissolved pore-water constituents, aliquots of the remaining pore water samples were diluted 1:10 and acidified with concentrated suprapure HNO_3 in Zinsser vials for the determination of cations (Ca, Mg, Sr, K, Ba, S, Mn, Si, B, Li) by optical emission spectrometry. Subsamples for the determination of sulfate and chloride were stored at 4°C in Zinsser vials for ion chromatography (HPLC) analyses.

About 2 ml of pore water were transferred into an amber vial filled with 10 µl of $HgCl_2$, sealed with a PTFE septum-bearing lid and stored at 4°C for the later analysis of dissolved inorganic carbon (DIC).

Solid phase sampling

After the measurement of oxygen, sediment samples from each MUC and ROV-PC core were taken in 1 cm resolution. For every GC, the solid phase was sampled every 20 cm in parallel to the oxygen analysis depth. All solid phase samples were taken using either cut-off syringes with a volume of around 12 ml or with a plastic spatula and stored at -20°C in plastic vials until the determination of the bulk sediment composition, sequential extractions and mineralogical analyses. Sediment samples from anoxic intervals of the cores were stored in argon-flushed gas-tight glass bottles at -20°C until further analysis.

List of samples

During the cruise, 7 CTD stations, 1 bottom-water sample with ROV-Niskin bottles, 7 GC, 10 MUC and 10 ROV-PC stations were sampled for either water column or bottom-water and pore-water investigations (for CTD samples see chapter 7.1.3).

Table 1 shows the sites sampled geochemically during this cruise with the parameters analyzed onboard. All aliquots of pore-water and solid-phase samples taken and stored for further analyses at the Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI) in Bremerhaven and at the Jacobs University Bremen (JUB), Germany are listed in Table 2.

First samples are shipped by airfreight right after the cruise for home lab analyses of major, minor and trace metals. All remaining samples will be shipped after the last JPI-Oceans cruise (SO 242-2) at the beginning of October 2015.

Table 7.2.3.1: Sites investigated geochemically during this cruise showing parameters analyzed on board.

Station SO239/	O_2 (1 mm)	O_2 (1 cm)	O_2 (5 cm)	Rhizon sampling	Centri-fugation	Alk.	Fe^{2+}	PO_4^{3-}	Si	NH_4^+	Eh pH
German license area, prospective area											
013-1 PC				X	X	X	X	X	X	X	
017-1 GC			5-787 cm	X	X	X	X	X	X	X	X
027-1 MUC				X	X	X	X	X	X	X	
039-1 MUC	X	X		X	X	X	X	X	X	X	
041-1 PC	X	X		X	X	X	X	X	X	X	
German license area, preservation area											
062-1 GC			5-901 cm	X	X	X	X	X	X	X	X
064-1 MUC	X	X		X	X	X	X	X	X	X	
066-1 MUC	X	X		X	X	X	X	X	X	X	
IOM area (Interoceanmetal)											
084-1 MUC	X	X		X	X	X	X	X	X	X	
087-1 GC			5-937 cm	X	X	X	X	X	X	X	X
091-1 MUC	X	X		X	X	X	X	X	X	X	
101-1 PC	X	X		X	X	X	X	X	X		
103-1 MUC	X	X		X	X	X	X	X	X		
Belgian license area											
121-1 MUC	X	X		X	X	X	X	X	X		
122-2 GC			5-756 cm	X	X	X	X	X	X		X
131-1 PC	X	X		X	X	X	X	X	X		
141-1 PC	X	X		X	X	X	X	X	X		
French license area											
157-1 PC	X	X		X	X	X	X	X	X		
161-1 PC	X	X		X	X	X	X	X	X		
165-1 GC			6-922 cm	X	X	X	X	X	X		X
167-1 MUC	X	X		X	X	X	X	X	X		
174-1 GC			5-729 cm	X	X	X	X	X	X		X
175-1 MUC	X	X		X	X	X	X	X	X		
APEI 3 (Area of particular environmental interest)											
189-1 PC	X	X		X	X	X	X	X	X		
194-1 GC			7-571 cm	X	X	X	X	X	X		X
199-1 MUC	X	X		X	X	X	X	X	X		
200-1 PC	X	X		X	X	X	X	X	X		

Table 7.2.3.2: Sites investigated geochemically during this cruise showing aliquots of samples taken and stored for further analyses in the home lab.

Station SO239/	NH_4^+	NO_3^-	DIC	Cations	Anions	Wet Sed.	Trace el.	Mn	DOC	Pooled for REEs	Aminoacids/ N-isotops	filter (0.2 µm)	filter (0.8 µm)
German license area, prospective area													
013-1 PC	X		X	X	X	X							
017-1 GC	X		X	X	X	X	X	X	X	X			
027-1 MUC	X		X	X	X	X	X	X	X			X	
039-1 MUC	X		X	X	X	X							
041-1 PC	X		X	X	X	X	X	X	X			X	
German license area, preservation area													
062-1 GC	X		X	X	X	X	X	X	X	X			
064-1 MUC	X		X	X	X	X	X	X	X			X	
066-1 MUC	X		X	X	X	X	X	X	X			X	
IOM area (Interoceanmetal)													
084-1 MUC	X		X	X	X	X	X	X	X			X	
087-1 GC	X		X	X	X	X	X	X	X	X			
091-1 MUC	X		X	X	X	X	X	X	X			X	
101-1 PC	X		X	X	X	X	X	X	X			X	
103-1 MUC	X		X	X	X	X	X	X	X			X	
Belgian license area													
121-1 MUC	X	X	X	X	X	X	X	X	X			X	
122-2 GC	X	X	X	X	X	X	X	X	X	X			
131-1 PC	X	X	X	X	X	X	X	X	X			X	
141-1 PC	X	X	X	X	X	X	X	X	X			X	
French license area													
157-1 PC	X	X	X	X	X	X	X	X	X			X	
161-1 PC	X	X	X	X	X	X	X	X	X			X	
165-1 GC	X	X	X	X	X	X	X	X	X		X		
167-1 MUC	X	X	X	X	X	X	X	X	X		X	X	
174-1 GC	X	X	X	X	X	X	X	X	X	X			
175-1 MUC	X	X	X	X	X	X	X	X	X			X	
APEI 3 (Area of particular environmental interest)													
189-1 PC	X	X	X	X	X	X							
194-1 GC	X	X	X	X	X	X	X	X	X	X			
199-1 MUC	X	X	X	X	X	X	X	X	X			X	
200-1 PC	X	X	X	X	X	X							

Remarks: For stations SO239/013-1 PC and SO239/027-1 MUC only 1 core was sampled and therefore no oxygen measurements were conducted. Pore-water and sediment sampling was performed on one sediment core.

Shipboard results

During the Nodinaut cruise on RV L'Atlalante in 2004 a detailed map was created showing the nodule coverage at a large scale in the French license area. Based on this map, sediment cores were taken in an undisturbed area with small nodules (165-1 GC, 167-1 MUC, Fig. 7.2.3.3) and from nodule-free sediments (174-1 GC, 175-1 MUC, Fig. 7.2.3.4). The oxygen profiles determined for the nodule-free sediments indicate rapid oxygen consumption with depth as the gradient decreases steeply within the upper 0.3 mbsf. At around 3.6 mbsf oxygen concentrations close to the detection limit were found. In comparison, oxygen profiles determined for the sediments covered with small nodules show a more slight decrease of oxygen over depth until depletion is reached at around 4.1 mbsf. This is in good agreement with previous investigations by Mewes *et al.* (2014) who stated an oxygen penetration depth of around 2-3 mbsf in sediments covered with big nodules compared to oxygen penetration depths that are located 0.5-1 m deeper in sediments with small nodules.

While phosphate shows similar gradients and the same range of concentrations at both sediment sampling locations, the concentrations of dissolved silica are almost 0.1 mM higher in the small-nodule area (cf. Fig. 7.2.3.3 and Fig. 7.2.3.4). This may result from the increased occurrence of siliceous biota (e.g., sponges) that grows preferentially on hard substrates such as manganese nodules.

Interestingly, the profiles of phosphate and oxygen show local maxima at around 2.55 mbsf and 5.8 mbsf (Fig. 7.2.3.4). This may be driven by changes in lithology, however lithological transitions could not be observed at these depths in the sediment cores.

The elevated phosphate concentrations in sediment core 167-1 MUC compared to 165-1 GC can be explained with lateral variations of the phosphate concentrations caused by different contents or organic carbon (TOC). The same can be addressed for the higher alkalinities in sediment core 174-1 GC compared to 175-1 MUC.

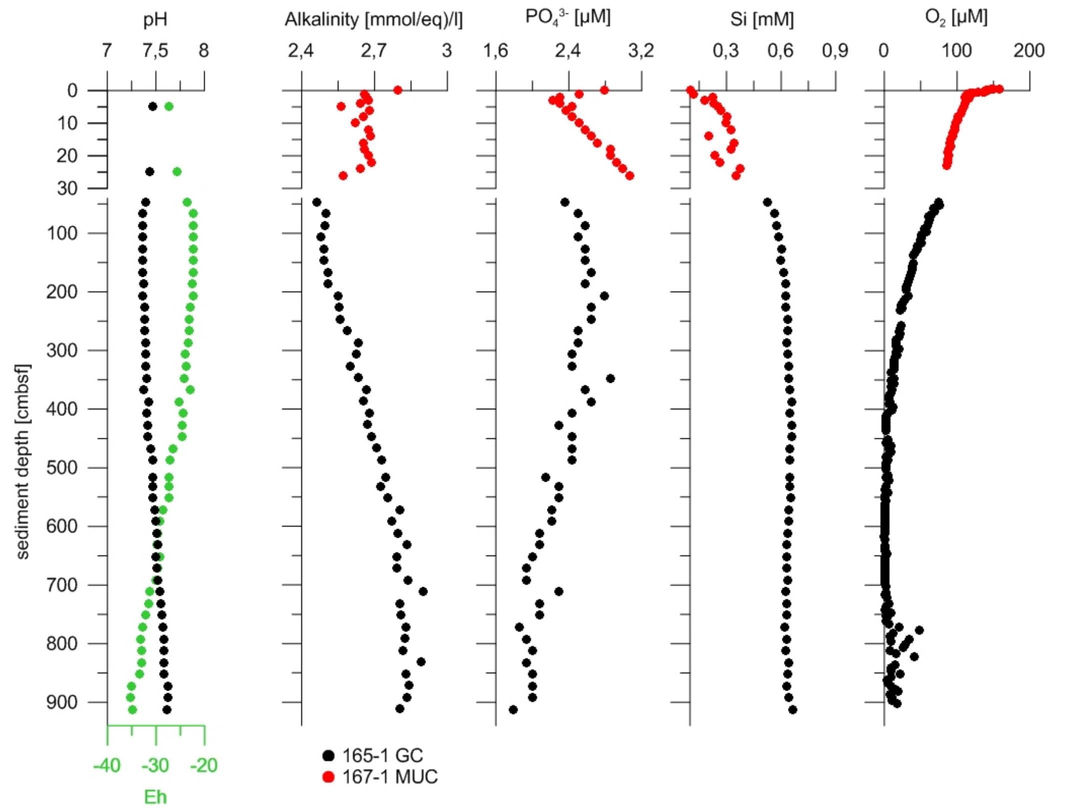


Fig.7.2.3.3: Pore-water concentration profiles for undisturbed sediments with small Mn nodules in the French License area.

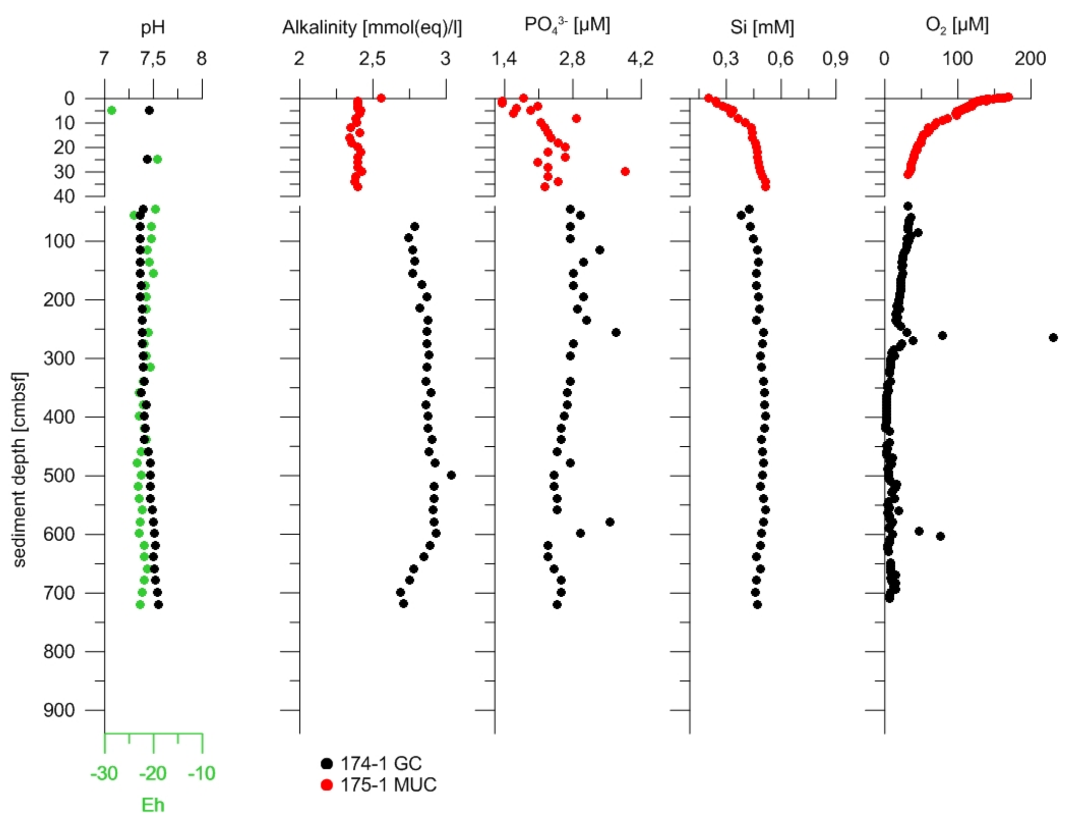


Fig. 7.2.3.4: Pore-water concentration profiles for undisturbed sediments without Mn nodules in the French

License area.

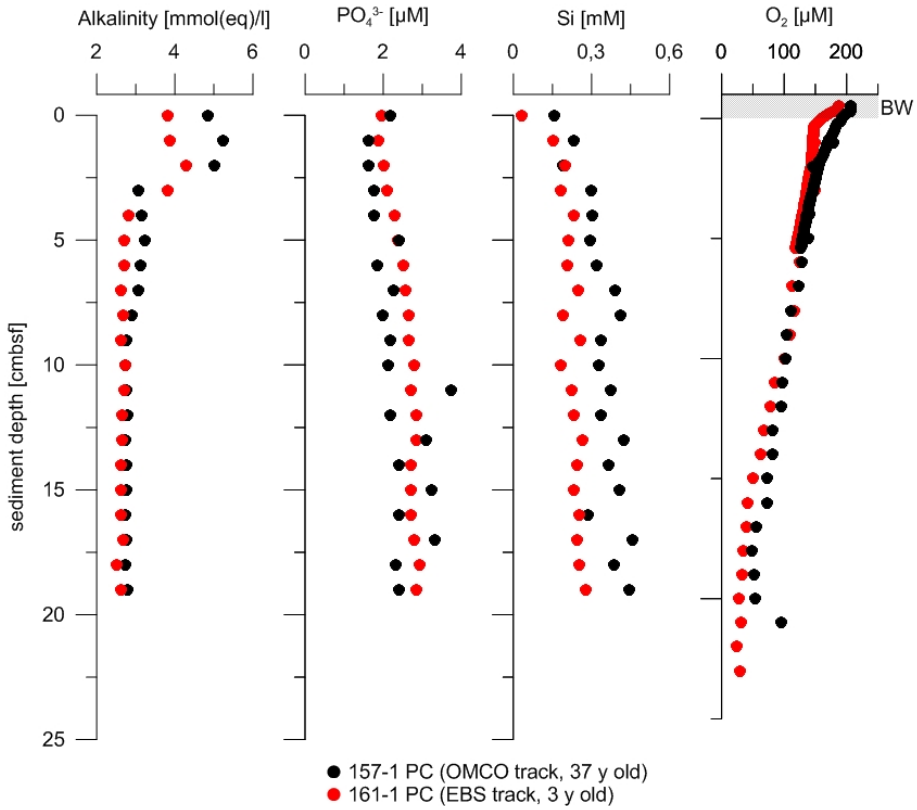


Fig. 7.2.3.5: Pore-water concentration profiles for disturbed sediments in the French license area. The OMCO track was made by an American consortium in 1978 whereas the EBS track is comparably fresh and only 3 years old.

As the assessment of the impact of anthropogenic disturbances on the geochemistry of sediments is one of the main goals of the cruise, Fig. 7.2.3.5 shows the comparison of the pore-water profiles of two sediment cores that experienced disturbances at different times. The pore-water profiles of 157-1 PC (37 y old disturbance zone) and 161-1 PC (3 y old disturbance zone) do not show pronounced differences. This might indicate that the fluxes of dissolved constituents have mainly compensated the disturbances of 37 and 3 years ago and that fresh disturbances – less than 3 years ago – are key to reveal the impact of anthropogenic disturbances on the geochemical condition of the sediments.

7.2.4 Metazoan meiofauna (Vanreusel, Macheriotou, Khodami, Raschka, Martinez Arbizu)

Samples for meiofauna analysis were collected in all four license areas (BGR, IOM, GSR and IFREMER) and the APEI no. 3.
The BGR area was sampled for (in? Or at?) two sites (prospective and reference site) each time with five MUC deployments. The IOM area was sampled in three stations related to the IOM BIE experiment: a disturbed station, a resedimentation station and a controle or reference station. Each station was sampled with three deployments. The GSR and IFREMER area were sampled each in one station where 5 MUC deployments took place; in the APEI only four MUC deployments took place; the last MUC deployment was cancelled due to bad weather conditions. Distribution of the different cores of each MUC deployment are provided in chapter 7.1.5.

Samples from the track were collected by means of ROV pushcores. Details on sampling design and processing of samples for each of the tracks are provided in chapter 7.2.8. Table 7.2.4.1 indicates the responsable research groups for analysis of the samples from the different areas.

Table 7.2.4.1 distribution of push-corer samples

	BGR prosp.		**BGR ref.**		**IOM**		**GSR**		**IFREMER**		**APEI**
	Track 0 yr 3 yr	ref	Track	ref	Track 20 yr	Experiment (3 sites)	Track 0,5 yr 0 yr	ref	Track 36 yr 3 yr	ref	ref
Abiotic	UGent (TOM, C/N, granulometry and pigments)										
Geochem.	AWI and JUB (Oxygen, trace metals, …..										
Meiofauna						+ USzcecin					
Nematodes	UG	UG	UG	UG	UG	USzcecin	UG	UG	UG	UG	UG
Copepods						DZMB					

Gent (UG)	**All samples to Gent for meiofauna analysis, copepods to DZMB**
DZMB	All samples to DZMB for meiofauna analysis, nematodes to Gent
Gent-DZMB shared	Part of samples to Gent (1 formol and 1 Dess per deployment), other to DZMB

From each MUC deployment also 1 sample for abiotic characterization was collected. These samples will be processed at UGent for pigment concentrations, granulometry, C/N and TOM.

Samples will be processed for meiofauna densities and higher taxa composition. Nematodes identification up to species level will be done by UGent and USzcecin (only for IOM); copepods will be identified by DZMB.

The following research objectives were identified:

- To identify meiofauna densities and biomass from all reference areas in relation to nodule distribution and along a longitudinal/latitudinal (surface productivity and bathymetry)

Lead DZMB, input from USzczecin (IOM meiofauna) and UGent (abiot, and meiofauna counts), AWI, JUB (geochem.)

- To identify meiofauna composition and diversity in tracks compared to references

Lead DZMB, input from UGent (abiot, and meiofauna counts Belgian exp), AWI, UB (geochem.)
UGent specifically will process sample for nematode biodiversity analysis based on a combination of molecular and morphological analysis and the same approaches will be proposed by DZMB for copepods. The following research objectives were identified:

- To identify the nematode and copepoda composition from all study areas in relation to nodule distribution and along a longitudinal/latitudinal (surface productivity and bathymetry;
- To identify the nematode and copepoda composition and diversity in tracks compared to references;
- To identify nematode and copepoda population connectivity at different spatial scales in CCZ;
- To use nematodes and copepods as a tool in biomonitoring.

DNA extractions from 373 copepod specimens were carried out using 25–35 µl Chelex (InstaGene Matrix, Bio−Rad) according to the protocol.

7.2.6 *Macrofauna (Kaiser, Menot, Błażewicz-Paszkowycz, Bonifacio, Neal, Schnurr, Wawrzyniak-Wydrowska)*

Abyssal macrobenthic communities are characterized by low densities and high local diversity, made up by a large number of singletons (species occurring only once in a sample). Most of these species however are undescribed and their distribution is unknown. Nodule mining may thus cause a major threat for deep-sea biodiversity which, however, cannot be quantified nor mitigated without further knowledge on the distribution and diversity patterns across the CCZ. In order to address these uncertainties, macrobenthic communities were studied in four exploration licenses (BGR, IOM, GSR, Ifremer) and an Area of Particular Environmental Interest (APEI), along a gradient of surface primary productivity. We undertook a qualitative biodiversity assessment by means of epibenthic sledge (EBS) sampling as well as a quantitative assessment of the community structure by means of box-coring. Samples were processed in order to allow for both morphological and genetic description of species. In addition, the large number of individuals sampled with the EBS may allow for population genetic analyses and connectivity pattern assessment for abundant species. Our primary focus was on two major taxa dominating the abyssal macrobenthos: Polychaeta (Annelida) and Peracarida (Crustacea)

Our objective is to test three hypotheses:

1. Elevated turnover rates in species composition with increasing spatial scales lead to high regional diversity.
2. Reduced gene flow over long distances limits connectivity over large spatial scales.
3. Different taxonomical groups representing different ecological groups show different distribution patterns.

Box-corer samples

BGR license areas

In the BGR license, two areas were targeted, the Prospective Area (PA) and the Reference Area (RA). In the PA, five box-cores were located on the western and eastern sides of a chain dredge track orientated North-South. In the RA, five box-cores were located on stations previously sampled by the BGR. In the RA however, one box-core failed while a second one penetrated too deeply into the sediment, the box being filled with sediment with no overlying water. This sample was processed as usual but is considered as a qualitative sample.

Table 7.2.6.1 Description of box-core deployments and samples in the Prospective Area, BGR license

Station	Box-core sample	Nodule sample

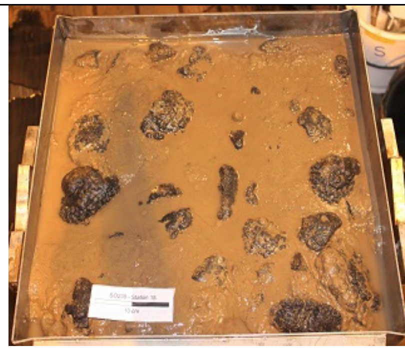
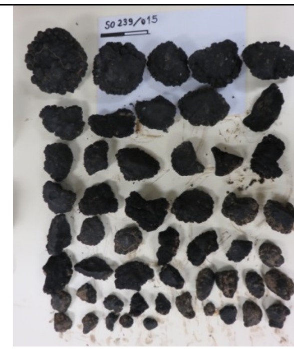
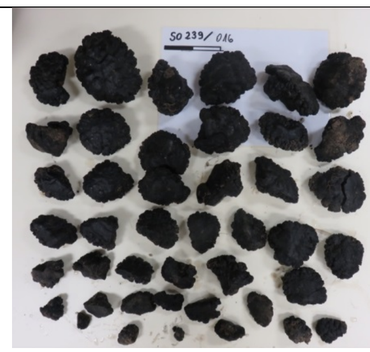
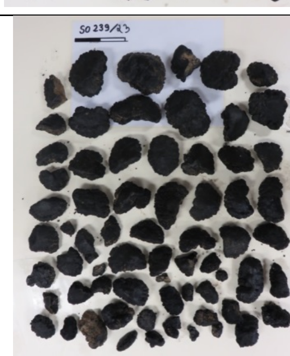
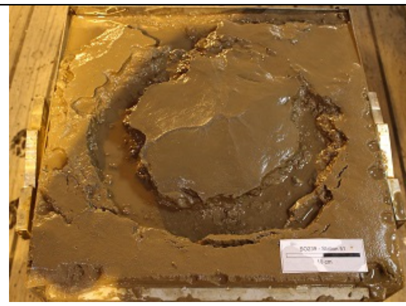
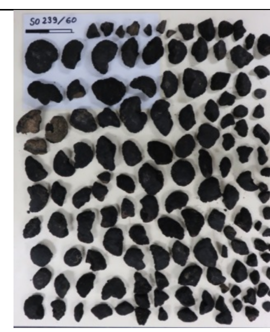
SO239-12-BC01 Lat N: 11° 50.83' Long W: 117° 3.56' Depth: 4117 m Lowering speed: 0.4 m/s Description: Overlying water 5cm. Red clay, covered with large nodules, some partly buried. Nodule density: 26.4 kg/m²		
SO239-15-BC02 Lat N: 11° 50.66' Long W: 117° 3.13' Depth: 4132 m Lowering speed: 0.3 m/s Description: Overlying water 5cm. Red clay, covered with large nodules, some partly buried. Nodule density: 26.8 kg/m²		
SO239-16-BC03 Lat N: 11° 51.44' Long W: 117° 3.12' Depth: 4122 m Lowering speed: 0.2 m/s Description: Overlying water 15cm. Red clay, covered with large nodules, some partly buried. Nodule density: 24 kg/m²		
SO239-21-BC04 Lat N: 11° 51.21' Long W: 117° 3.57' Depth: Lowering speed: 0.2 m/s Description: Overlying water 15cm. Red clay, covered with large nodules, some partly buried. Nodule density: 22.8 kg/m2		
SO239-23-BC05 Lat N: 11° 51.00' Long W: 117° 3.16' Depth: 4122 m Lowering speed: 0.2 m/s Description: Overlying water 15cm. Red clay, covered with large nodules, some partly buried. Nodule density: 20.8 kg/m²		

Table 7.2.6.2 Description of box-core deployments and samples in the Reference Area, BGR license

Station	Box-core sample	Nodule sample
SO239-51-BC06 Lat N: 11° 49.42' Long W: 117° 31.42' Depth: 4347 m Lowering speed: 0.2 m/s Description: Sample disturbed, no overlying water, very soft sediments, no nodule. Nodule density: 0 kg/m²		
SO239-57-BC07 Lat N: 11° 48.45' Long W: 117° 31.46' Depth: 4369 m Lowering speed: 0.2 m/s Description: Overlying water 5 cm. Surface slightly disturbed, soft sediment, tiny nodules on surface, large nodules at 10 to 25 cm depth Nodule density: 8 kg/m²		
SO239-58-BC08 Lat N: 11° 49.23' Long W: 117° 32.50' Depth: Lowering speed: 0.2 m/s Description: Overlying water 10 cm. Good sample, soft sediment, tiny nodules on surface, large nodules at 10 to 25 cm depth Nodule density: 1.6 kg/m²		
SO239-60-BC09 Lat N: 11° 48.46' Long W: 117° 33.02' Depth: 4324 m Lowering speed: 0.2 m/s Description: Overlying water 15 cm. Covered with nodules, one large nodule at 5 cm Nodule density: 18 kg/m²		
SO239-61-BC10 Lat N: 11° 47.67' Long W: 117° 32.18' Depth: 4335 m Lowering speed: 0.2 m/s Description: Failed, box-core empty, cable entangled in the head of the box-corer prevented the closure of the core		

IOM License area

In the IOM license, box-core sampling was stratified according to a Benthic Impact Experiment (BIE) carried out in 1994. Three box-cores were sampled in each of three strata: *Control* (stations 88, 89, 90), *Impact* (stations 94, 95, 97) and *Resedimented* sediment (stations 105, 106, 107). Impact is the area where the experiment was carried out. Indeed, a picture from the AUV Abyss showed that one box core (station 94) was sampled in the track of the device used to simulate sediment resuspension (Fig. 7.2.6.1). *Resedimented*, located south of the *Impact* area, is the area where most of the sediment plume was documented to settle down during the experiment. *Control* is an undisturbed area located north of the *Impact*.

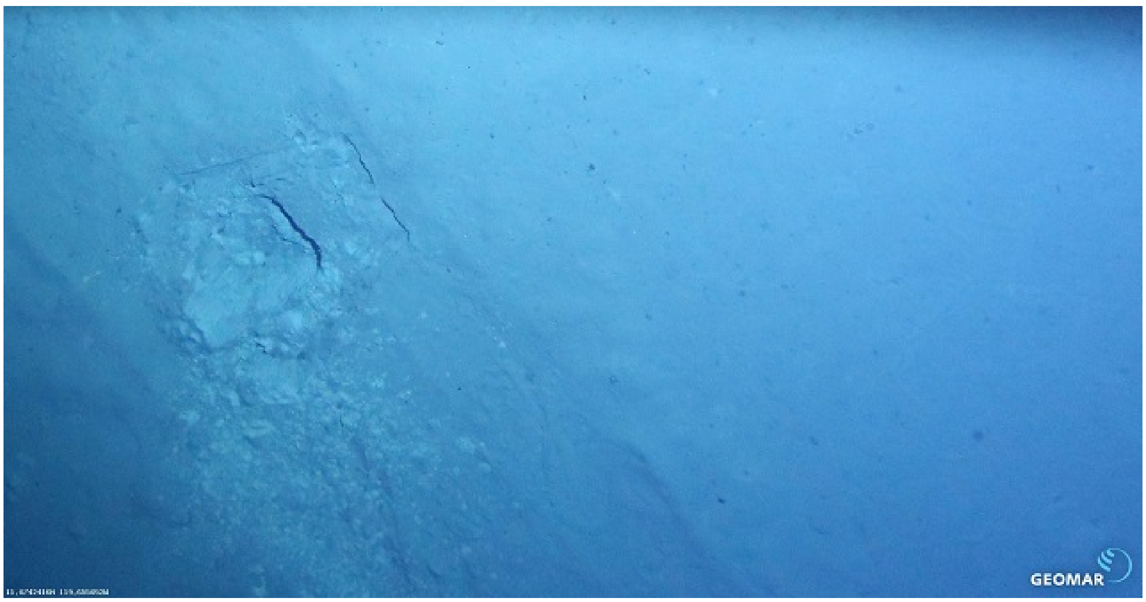
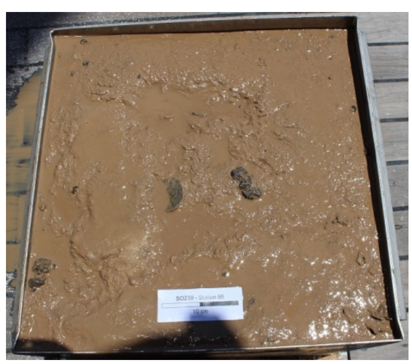
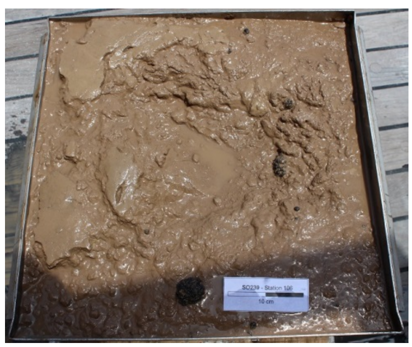
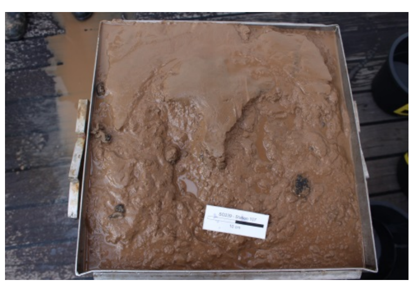
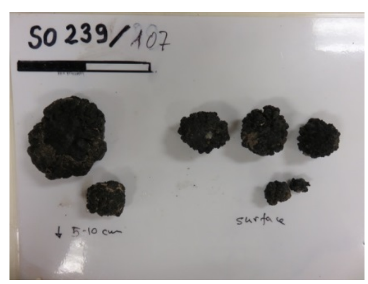


Fig. 7.2.6.1 Picture from the AUV Abyss of box-core sample 94-BC14 inside a track of the benthic disturber in the IOM license.

Table 7.2.6.3 Description of box-core deployments and samples in the IOM license

Station	Box-core sample	Nodule sample
SO239-88-BC11 *Control* Latitude: 11°04.74' N Longitude: 119°39.53' W Depth: 4433 Lowering speed: 0.2 m/s Description: Red clay, few small nodules at surface, semi-liquid layer down to 4-5cm, overlying water less than 1 cm Nodule density: 1.2 kg/m²		

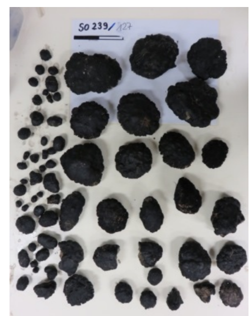
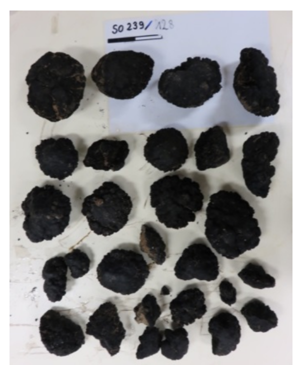
SO239-89-BC12 *Control* Latitude: 11°04.55' N Longitude: 119°39.65' W Depth: 4436 Lowering speed: 0.2 m/s Description: Red clay, few small nodules at surface, semi-liquid layer down to 4-5cm, overlying water less than 1 cm Nodule density: 0.5 kg/m²		
SO239-90-BC13 *Control* Latitude: 11°04.44' N Longitude: 119°39.85' W Depth: 4434 Lowering speed: 0.2 m/s Description: Red clay, few small nodules at surface, semi-liquid layer down to 4-5cm, overlying water less than 1 cm Nodule density: 0.4 kg/m²		
SO239-94-BC14 *Impact* Latitude: 11°04.42' N Longitude: 119°39.33' W Depth: 4414 Lowering speed: 0.2 m/s Description: Red clay, few small nodules at surface, semi-liquid layer down to 3 cm, overlying water about 5 cm Nodule density: kg/m²		
SO239-95-BC15 *Impact* Latitude: 11°04.41' N Longitude: 119°39.35' W Depth: 4418 Lowering speed: 0.2 m/s Description: Red clay, few small nodules at surface, semi-liquid layer down to 4-5cm, overlying water less than 1 cm Nodule density: 0.8 kg/m²		

SO239-97-BC16 *Impact* Latitude: 11°04.37' N Longitude: 119°39.37' W Depth: 4421 Lowering speed: 0.2 m/s Description: Red clay, few small nodules at surface, semi-liquid layer down to 4-5cm, overlying water less than 1 cm Nodule density: 0.2 kg/m²		
SO239-105-BC17 *Resedimented* Latitude: 11°04.27' N Longitude: 119°39.32' W Depth: 4423 Lowering speed: 0.2 m/s Description: Surface heavily disturbed, not quantitative Nodule density: 0 kg/m²		
SO239-106-BC18 *Resedimented* Latitude: 11°04.30' N Longitude: 119°39.29' W Depth: 4425 Lowering speed: 0.2 m/s Description: Red clay, no overlying water, surface slightly disturbed, few small nodules Nodule density: 0.2 kg/m²		
SO239-107-BC19 *Resedimented* Latitude: 11°04.33' N Longitude: 119°39.27' W Depth: 4425 Lowering speed: 0.2 m/s Description: Red clay, no overlying water, surface slightly disturbed, few small nodules Nodule density: 0.3 kg/m²		

GSR license (Belgian Area)

In the GSR license, five box-corers were randomly sampled in an area with high nodule coverage.

Table 7.2.6.4 Description of box-core deployments and samples in the GSR license

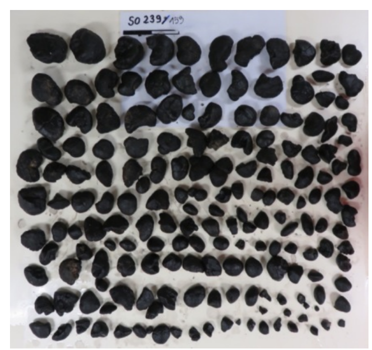
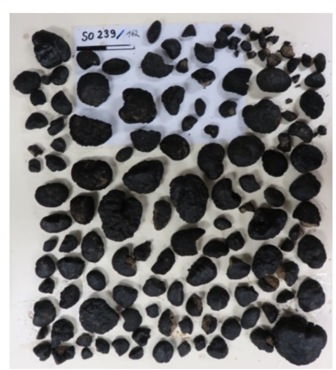
Station	Box-core sample	Nodule sample
SO239-119-BC20 Latitude: 13° 51.55' N Longitude: 123° 15.16' W Depth: 4516 Lowering speed: Description: Good core, 30 cm of overlying water, covered with large nodules. Nodule density:		
SO239-127-BC21 Latitude: 13° 50.66' N Longitude: 123° 14.76' W Depth: 4514 Lowering speed: Description: Good core, 25 cm of overlying water, covered with large nodules. Nodule density: 27.1 kg/m²		
SO239-128-BC22 Latitude: 13° 51.10' N Longitude: 123° 15.12' W Depth: 4511 Lowering speed: Description: Good core, 25 cm of overlying water, surface slightly disturbed, covered with large nodules. Nodule density: 27.1 kg/m²		
SO239-137-BC23 Latitude: 13° 51.36' N Longitude: 123° 14.28' W Depth: 4510 Lowering speed: Description: Good core, 25 cm of overlying water, covered with large nodules. Nodule density: 25.2 kg/m²		

SO239-138-BC24 Latitude: 13° 50.89' N Longitude: 123° 14.08' W Depth: 4503 Lowering speed: Description: Good core, 25 cm of overlying water, covered with large nodules. Nodule density:		

Ifremer license

In the Ifremer license area, the aim was to collect five box-cores. As one box-core sample was disturbed (station 169), an additional box-corer deployment was carried out. All box-cores were randomly sampled in an area with high nodule coverage.

Table 7.2.6.5 Description of box-core deployments and samples in the Ifremer license

Station	Box-core sample	Nodule sample
SO239-159-BC25 Latitude: 14° 02 94' N Longitude: 130° 08 06' W Depth: 4921 Lowering speed: 0.3 m/s Description: Overlying water: 25 cm. Surface undisturbed, covered with small nodules. No semi-liquid surface sediments, sediments brown to dark brown down to 10 cm. 5-10 cm layer compact and sticky. Nodules: 19.8 kg/m²		
SO239-162-BC26 Latitude: 14° 02 94' N Longitude: 130° 07 56' W Depth: 4951 Lowering speed: 0.3 m/s Description: Overlying water: 25 cm. Surface undisturbed, covered with small nodules. No semi-liquid surface sediments, sediments brown to dark brown down to 10 cm. 5-10 cm layer compact and sticky. Nodule density: 20.2 kg/m²		

SO239-169-BC27 Latitude: 14° 02 53' N Longitude: 130° 07 64' W Depth: 4964 Lowering speed: 0.3 m/s Description: Overlying water 30 cm. Surface disturbed, covered with large nodules. No semi-liquid surface sediments, sediments brown to dark brown down to 10 cm. 5-10 cm layer compact and sticky.n: Nodule density: 24.1 kg/m²		
SO239-180-BC28 Latitude: 14° 02 50' N Longitude: 130° 08 18' W Depth: 4936 Lowering speed: 0.3 m/s Description: Overlying water: 25 cm. Surface undisturbed, covered with medium-size to large nodules. No semi-liquid surface sediments, sediments brown to dark brown down to 10 cm. 5-10 cm layer compact and sticky. Nodule density: 16.0 kg/m²		
SO239-181-BC29 Latitude: 14° 02 79' N Longitude: 130° 08 49' W Depth: 4896 Lowering speed: Description: Overlying water: 25 cm. Surface undisturbed, covered with small nodules. No semi-liquid surface sediments, sediments brown to dark brown down to 10 cm. 5-10 cm layer compact and sticky. Nodule density: 16.8 kg/m²		
SO239-182-BC30 Latitude: 14° 02 54' N Longitude: 130° 07 65' W Depth: 4957 Lowering speed: Description: Overlying water: 25 cm. Surface undisturbed, covered with large nodules. No semi-liquid surface sediments, sediments brown to dark brown down to 10 cm. 5-10 cm layer compact and sticky. Nodule density: 22.4 kg/m²		

APEI no. 3

In the APEI, five box-corers were randomly sampled. Due to bad weather, two box-core samples (stations 203 and 209) were disturbed (the box-corer touched down the seafloor twice before sampling).

Table 7.2.6.6 Description of box-core deployments and samples in the APEI.

Station	Box-core sample	Nodule sample
SO239-195-BC31 Latitude: 18° 47.75' N Longitude: 128° 21.73' W Depth: 4833 Lowering speed: Description: Overlying water 25 cm. Surface covered with small nodules. Sediment dark brown and compact from the surface. Nodule density: 6.28 kg/m²		
SO239-196-BC32 Latitude: 18° 47.83' N Longitude: 128° 20.77' W Depth: 4847 Lowering speed: Description: Overlying water 25 cm. Surface covered with small nodules. Sediment dark brown and compact from the surface. Nodule density: 1.8 kg/m²		
SO239-203-BC33 Latitude: 18° 46.44' N Longitude: 128° 21.19' W Depth: 4843 Lowering speed: Description: Qualitative. Qualitative, surface disturbed. Overlying water 25 cm. Small nodules, sediment dark brown and compact from the surface. Nodule density:		

SO239-204-BC34 Latitude: 18° 46.40' N Longitude: 128° 20.17' W Depth: 4816 Lowering speed: Description: Overlying water 25 cm. A few small nodules. Sediment dark brown and compact from the surface. Nodule density:		
SO239-209-BC35 Latitude: 18° 47.07' N Longitude: 128° 22.35' W Depth: 4819 Lowering speed: Description: Qualitative. Qualitative, surface disturbed. Overlying water 25 cm. Small nodules, sediment dark brown and compact from the surface. Nodule density: 2.88 kg/m²		

EBS samples

Table 7.2.6.7 Epibenthic sledge stations conducted during the SO239 cruise. Information includes area, latitude and longitude (in degree), depth (m), time and trawling distance. LA: licence area, PA: prospective mining area; PA: preservation reference zone

Station	Date	Area	Start lat (°N)	Start long (°W)	End lat (°N)	End long (°W)	Depth (m)	Trawling distance (m)
020	21/03/2015	German PA	11°50.15	117°58.49	11°50.18	116°58. 46	4144-4093	2769
024	22/03/2015	German PA	11°51.32	117°1.5	11°51.51	116°59.44	4137-4118	2619
050	26/03/2015	German RA	11°49.592	117°30.786	11°49.756	117°29.574	4360-4328	2469
059	28/03/2015	German RA	11°48.201	117°30.500	11°48.442	117°29.395	4384-4307	2469
081	01/04/2015	IOM	11°3.900	119°37.812	11°4.171	119°36.661	4365-4346	2739
099	04/04/2015	IOM	11°2.296	119°40.825	11°2.612	119°39.512	4398-4402	2529
117	07/04/2015	Belgium LA	13°52.317	123°15.442	13°52.622	123°14.263	4498-4521	3129
133	10/04/2015	Belgium LA	13°50.751	123°15.649	13°51.126	123°14.131	4516-4427	2289
158	15/04/2015	French LA	14°3.411	130°7.989	14°3.813	130°6.481	4946-4978	3789
171	17/04/2015	French LA	14°2.687	130°5.951	14°3.205	130°4.606	5024-5017	2979
192	21/04/2015	APEI 3	18°44.807	128°21.874	18°45.338	128°20.418	4821-4820	2799
197	22/04/2015	APEI 3	18°48.659	128°22.753	18°49.088	128°21.289	4805-4823	2529
210	24/04/2015	APEI 3	18°49.271	128°25.804	18°49.926	128°24.401	4700-4740	3399

Box corer processing

Once the box-corer was back on board, the water overlying the sediment sample was siphoned off through a 300-µm mesh sieve. A picture of the surface of the core was then taken. The larger epifauna attached to the nodules was immediately picked up before nodules were removed and gently washed in cold sea water to remove most of the sediment sticking to the nodules. The core was then sliced into three layers, from 0-3 cm, 3-5 cm and 5-10 cm. Sediments from each layer were transferred into cold sea water. The 0-3 cm layer was immediately sieved in the cold room and with cold sea water (4°C) on a 300-µm mesh sieve. Sieve residues from the overlying water and nodule washing were added to the 0-3 cm layer. Sediments from the two deeper layers were stored in the cool room until sieving. Sieving of these two layers was done at ambient temperature on a 300-µm mesh sieve.
The 0-3 cm layer was sorted immediately after sieving. Polychaetes were identified down to family/genus level, photographed and then preserved in 80% ethanol. All other taxa were preserved in 96% undenaturated ethanol. Sieve residues of the two deeper layers were fixed in 4% formalin for 2 to 4 days and later transferred in 80% ethanol.

Distribution of samples

By the end of the cruise samples from 34 box-core deployments were processed. All top layers were lived sorted, specimens counted and databased. The two deeper sediment layers will be further processed at Ifremer. Following sorting, collections of each major taxa will be examined further by specialists. All box-core samples will be stored at Ifremer and can be made available upon request (contact: Lenaick Menot). Lenaick Menot, Paulo Bonifacio (IREMER), Lenka Neal, Thomas Dahlgren, (University of Gothenburg) and Karin Meißner (DZMB Hamburg) will examine polychaetes; Stefanie Kaiser and Sarah Schnurr (DZMB) will identify the isopod crustaceans, while Magdalena Błażewicz-Paszkowycz from the University of Łódź (Poland) will do the same for the tanaidacean specimens. Foraminiferans will be processed by Radziejewska, de Stigter, nematodes by Ann Vanreusel and her working group, amphipods and decapods by Henri Robert (RBINS), ostracods by RBINS and copepods by Senckenberg. Trends and discoveries in these data will be analyzed and reported within and across taxa.

Epibenthic sledge processing

Macrofaunal samples were collected by means of an epibenthic sledge (Brenke, 2005) from six different areas across the CCZ (see chapter 7.1.7). In total sampling consisted of 13 deployments ranging in depth between 4093 and 5028 m.
Upon arrival on deck, the supra- and epi-net cod ends were removed. In the cold room, the samples were carefully elutriated with cold (+4°C) sea water, then sieved through a 300-µm mesh and immediately transferred to pre-cooled (-20°C) undenaturated 96% EtOH. These

samples were stored at -20°C for at least 48 h for later DNA extractions. During this time (for the first 12 hours) the samples were gently rotated every three hours to ensure thorough fixation and avoid freezing of the samples. After 12-24 hours these samples were refixed with 96% EtOH and kept at -20° until further sample processing. Additional sediment and manganese nodules present in the nets were collected into a bucket and gently washed with cold seawater; if present, sessile fauna was carefully removed from the nodules and separately fixed in undenaturated 96% EtOH. After removal of the nodules the water was sieved through a 300-µm sieve, and the remaining fixed in undenaturated 96% EtOH. Nodules located in the net openings in front of the metal grids were also collected and washed with warm sea water; encrusting fauna was then removed, while the sediment was discarded, as it did not contain any specimens. From each supra-net (for first two stations from the epi-net) a subsample was taken, which was kept in cold seawater for one hour for sorting of live specimens. Polychaetes were identified down to family/genus level, photographed and then preserved in 80% ethanol. All other taxa were preserved in 96% undenaturated ethanol. After sorting, the sample was kept in 96% undenaturated ethanol for later re-assessment.

The samples collected by epi- and supra nets were sorted into separate taxa and photographed on board using a Leica and Nikon binocular microscope, respectively. Polychaetes, isopod and tanaid crustaceans were partly identified with higher resolution to differing taxonomic levels (mostly family and genus level). The remaining sediment samples will be kept for later more detailed sorting at the laboratories of Senckenberg, DZMB. For further analyses supra- and epi-net samples were counted as one sample per station.

Preparation for genetic work onboard was carried out for polychaetes, tanaidacean and isopod crustaceans, respectively. Depending on the size of the isopod, one to three appendages were dissected from each specimen, whereas one to three parapodia or small tissue samples were taken from the middle part of each polychaete to keep an intact voucher for further morphological work. In case of tanaids, DNA extraction was done using whole animals using Chelex standard protocol (see below). After the extraction, the exoskeleton of the specimen was recovered, and preserved in 96% ethanol for taxonomical analysis. After the cruise, these filled “barcoding racks” will be send to Macrogen for subsequent extraction and sequencing.

Distribution of samples

By the end of the cruise samples from 12 EBS deployments were completely sorted except station 210, which will be further processed at Senckenberg. Following this initial sorting, collections of each major taxa will be examined further by specialists. All EBS samples will be stored at DZMB Wilhelmshaven and can be made available upon request (contact: Pedro Martinez Arbizu). Lenaick Menot, Paulo Bonifacio (IREMER), Lenka Neal, Thomas Dahlgren, (University of Gothenburg) and Karin Meißner (DZMB Hamburg) will examine polychaetes;

Stefanie Kaiser and Sarah Schnurr (DZMB) will identify the isopod crustaceans, while Magdalena Błażewicz-Paszkowycz from the University of Łódź (Poland) will do the same for the tanaidacean specimens. Foraminiferans will be processed by Radziejewska, de Stigter, nematodes by Ann Vanreusel and her working group, amphipods and decapods by Henri Robert (RBINS), ostracods by RBINS and copepods by Senckenberg. Trends and discoveries in these data will be analyzed and reported within and across taxa.

ROV samples

Water and sediments from the bio-boxes were sieved on a 300 µm mesh sieve and sorted immediately after sieving. Polychaetes were identified down to family/genus level, photographed and then preserved in 80% ethanol. All other taxa were preserved in 96% ethanol.

7.2.6.1 Preliminary Results

a) General patterns

<u>Box corer</u>

A total of 825 specimens belonging to the macrofauna *sensu stricto* have been sorted from the top layer of the box cores. The Polychaeta is the dominant group (56%), followed by Tanaidacea (23%) and Isopoda (10%) (Fig. 7.2.6.2).

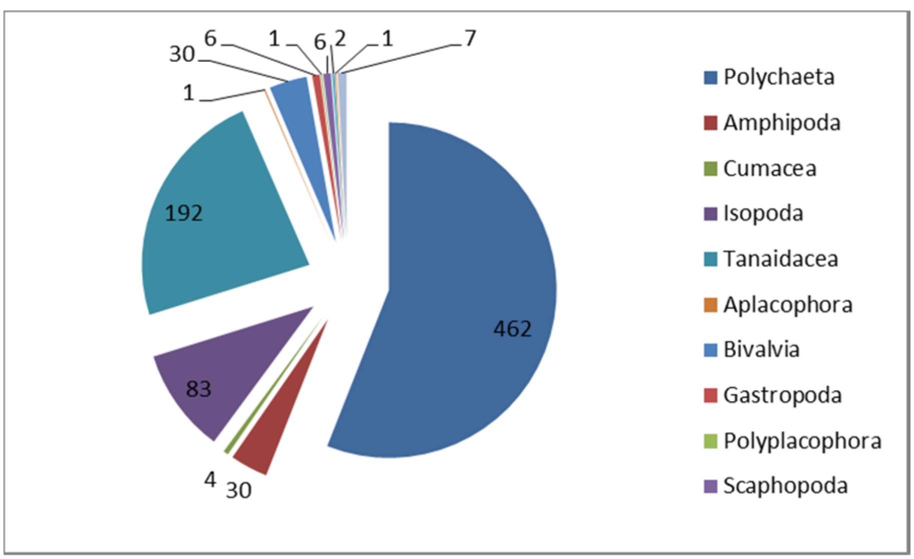


Fig. 7.2.6.2: Total abundance and taxonomic composition of the macrofauna sampled from the first three centimeters of 33 box cores.

Macrofaunal densities are low, ranging on average from 10 to 40 individuals per box core (Fig. 7.2.6.3). The highest densities were observed in the GSR license area, which does not agree with a westward trend of decreasing primary productivity in the CCZ. It should be noted however that areas with low or no nodule coverage were sampled in the two eastern licenses (BGR and IOM), while nodule coverage was always high from box cores of the western licenses (GSR and Ifremer). Macrofaunal densities were on average two times higher in sediments with high nodule density (Fig. 7.2.6.4). Whether this reflects a true biological pattern or a sampling artifact remains unclear. Areas with low nodule coverage were located in the deepest valleys between abyssal hills. The sediment surface was semi-liquid, which contrasted with areas with high nodule coverage where sediments were more compact. As a consequence, the box-corer penetrated deeper in sediments with low nodule coverage. The overlying water in the core never exceeded 5 cm and we cannot exclude that part of the sediment surface was flushed during sampling.

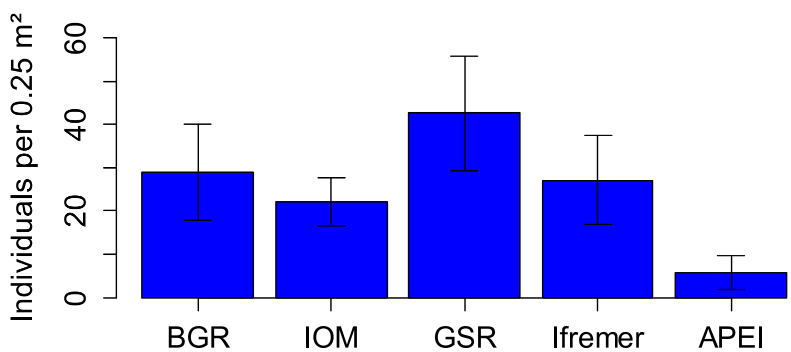


Fig. 7.2.6.3: Mean densities of the macrofauna in the four license areas and the APEI (bars denotes standard deviation).

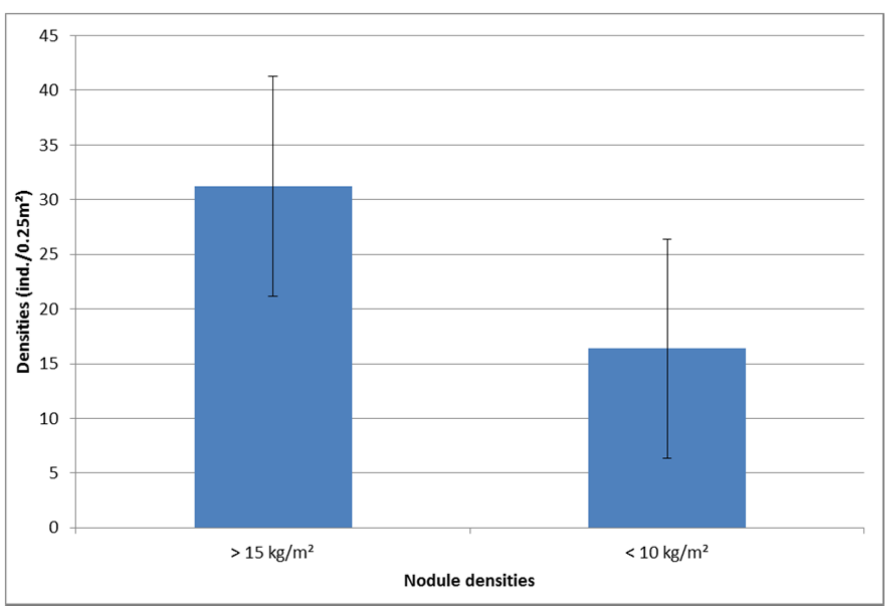


Fig.7.2.6.4: Mean macrofaunal densities according to nodule density (bars denotes standard deviation).

EBS

In total 11540 specimens were picked from the EBS collections, which could be assigned to 16 phyla and a minimum of 28 classes (for examples of different macrofaunal groups see Figs. 7.2.6.5-13). Overall malacostracan crustaceans were the most dominant groups examined comprising between 24.9 and 57.95% of total macrofauna. Polychaetes and copepod crustaceans were also important encompassing between 7.3% and 24.9% and 14.9% and 42.0% of total macrofauna, respectively.

Among malacostracans, Isopoda were by far the most abundant order in the suprabenthic samples followed by tanaidaceans, amphipods, and cumaceans. Decapoda, Mysidacea and Leptostraca were also present, yet yielded only a few specimens specimen (see Table 7.2.6.8).

Table 7.2.6.8 Proportion (%) of crustaceans collected in 12 EBS supra-net samples during SO239 of total macrofauna.

	Station	**20**	**24**	**50**	**59**	**81**	**99**	**118**	**133**	**158**	**171**	**192**	**197**
Class	**Order**												
Copepoda		30.51	39.44	26.96	0.00	14.91	18.57	34.03	42.00	23.83	31.62	31.75	25.50
Ostracoda		2.56	2.41	2.29	2.78	4.26	1.69	5.97	6.62	3.00	2.89	2.68	2.65
Malacostraca	Amphipoda	6.89	6.41	5.23	2.32	8.72	8.23	3.05	2.41	1.83	8.53	5.62	7.73
	Cumacea	2.62	1.06	2.61	16.94	4.06	3.80	2.24	1.68	4.17	5.77	2.16	3.75
	Isopoda	18.67	21.72	30.56	6.03	20.69	23.42	20.20	14.92	30.17	27.60	34.08	38.30
	Mysidacea	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.48	0.50	0.50	0.09	0.88
	Tanaidacea	5.58	3.92	4.41	0.00	8.62	11.39	4.68	3.25	7.00	4.89	4.93	7.28
	Decapoda	1.14	0.98	0.82	1.62	0.91	0.00	0.07	2.17	0.00	0.00	0.09	0.00
	Euphausiacea	0.00	0.00	0.00	0.00	0.00	0.00	1.08	0.00	0.00	0.00	0.00	0.00
	Leptostraca	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00

Fig. 7.2.6.5: Selected amphipod crustaceans collected during SO239 to the CCZ. Photos: B. Wawrzyniak-Wydrowska

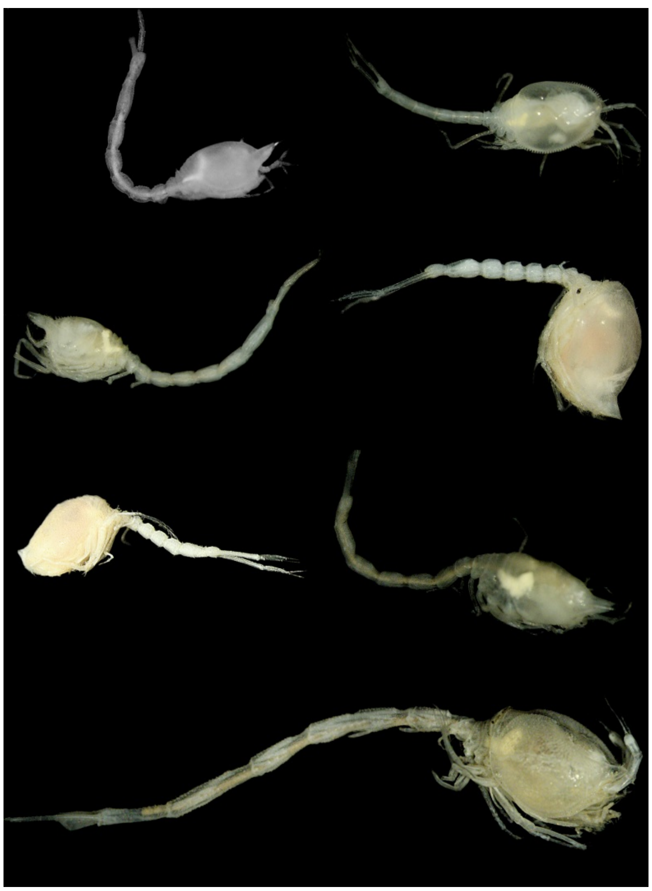


Fig. 7.2.6.6: Selected cumacean crustaceans collected during SO239 to the CCZ. Photos: B. Wawrzyniak-Wydrowska

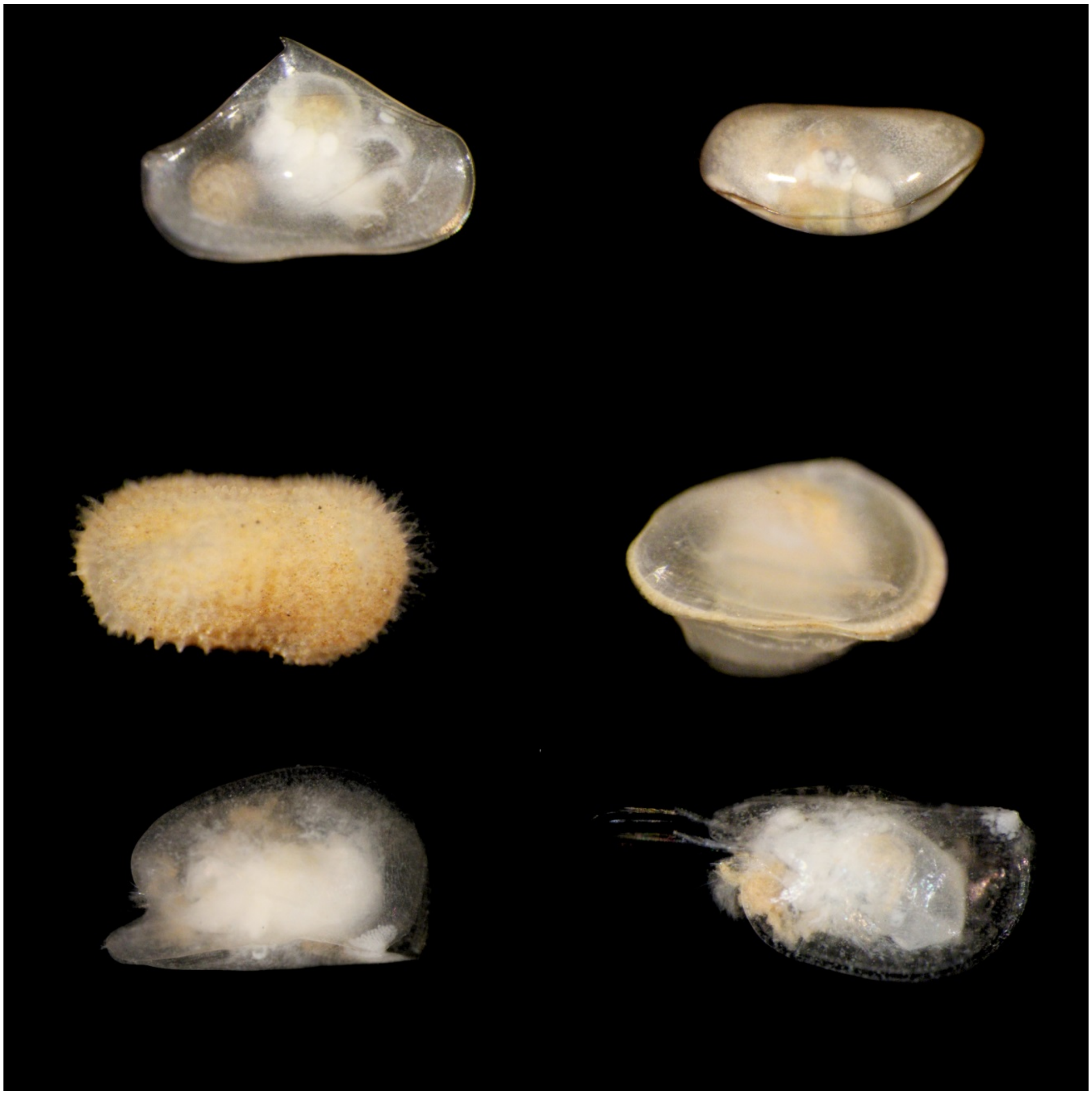


Fig. 7.2.6.7:

Selected ostracod crustaceans collected during SO239 to the CCZ. Photos: B. Wawrzyniak-Wydrowska

Fig. 7.2.6.8: Selected copepod crustaceans collected during SO239 to the CCZ. Photos: B. Wawrzyniak-Wydrowska

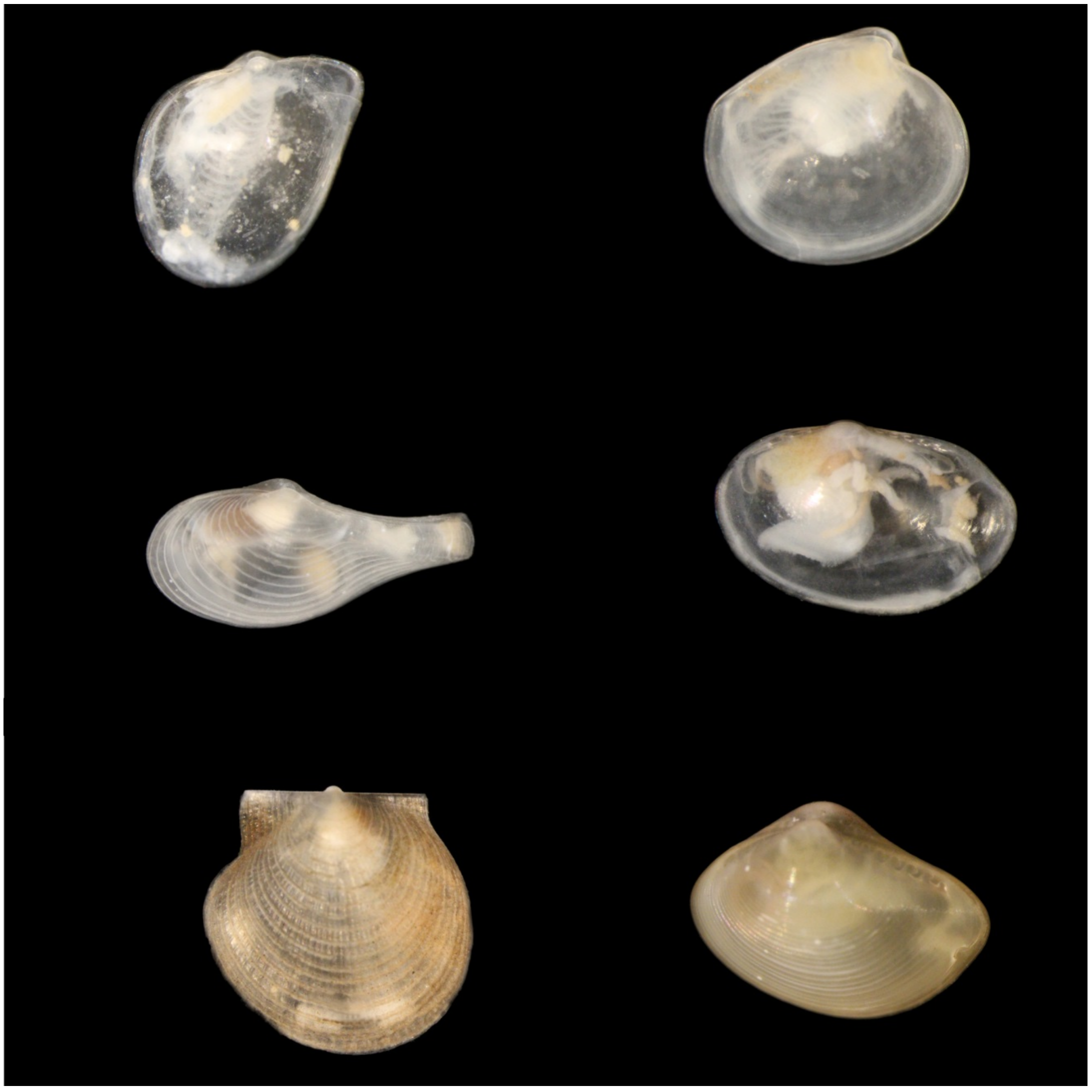


Fig. 7.2.6.9: Selected bivalve molluscs collected during SO239 to the CCZ. Photos: B. Wawrzyniak-Wydrowska

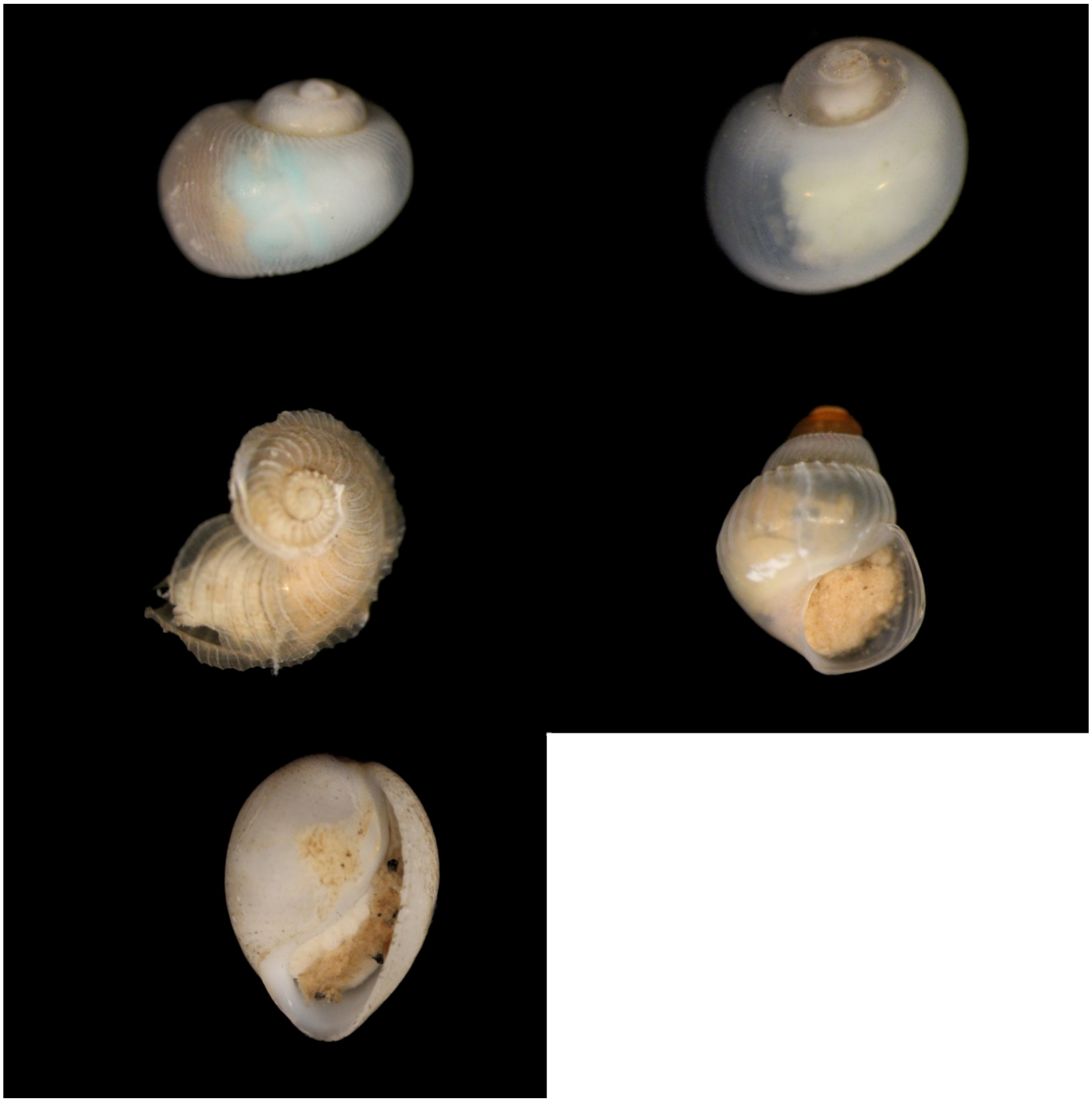


Fig: 7.2.6.10: Selected gastropod molluscs collected during SO239 to the CCZ. Photos: B. Wawrzyniak-Wydrowska

b) Polychaetes

Studies on polychaetes are jointly carried out by the University of Gothenburg (Sweden), the National History Museum (UK) and Ifremer (France). At the University of Gothenburg and NHM, taxonomic and population connectivity studies will be carried out on six targeted families (Glyceridae, Goniadidae, Lumbrineridae, Nereididae, Opheliidae and Paralacydoniidae). At Ifremer will be carried out:

- Taxonomic work for all other families,
- Phylogenetic analyses of the sub-family Macellicephalinae
- Community structure analyse of polychaete assemblages quantitatively sampled with a box-corer.

In total, 458 individuals were sorted from box-cores, 1902 from EBS and 50 from ROV samples. All specimens from box-cores and ROV samples were identified down to family/genus level while only a subset of 570 specimens were identified from EBS, yielding altogether 55 taxa belonging to 34 families (Fig. 7.2.6.11).

Fig. 7.2.6.11: Diversity of Polychaeta in the CCZ area: Polynoidae (a), Scalibregmatidae (b), Poecilochaetidae (c), Acrocirridae (d), Cirratulidae (e), Alciopidae (f), Lumbrineridae (g), Lopadorhynchidae (h), Opheliidae (i), Euphrosynidae (j), Syllidae (k), Sabellidae (l) and Ampharetidae (m).

A community analysis of box-core data shows a large dispersion among samples within each license with not clear pattern emerging (Fig. 7.2.6.12).

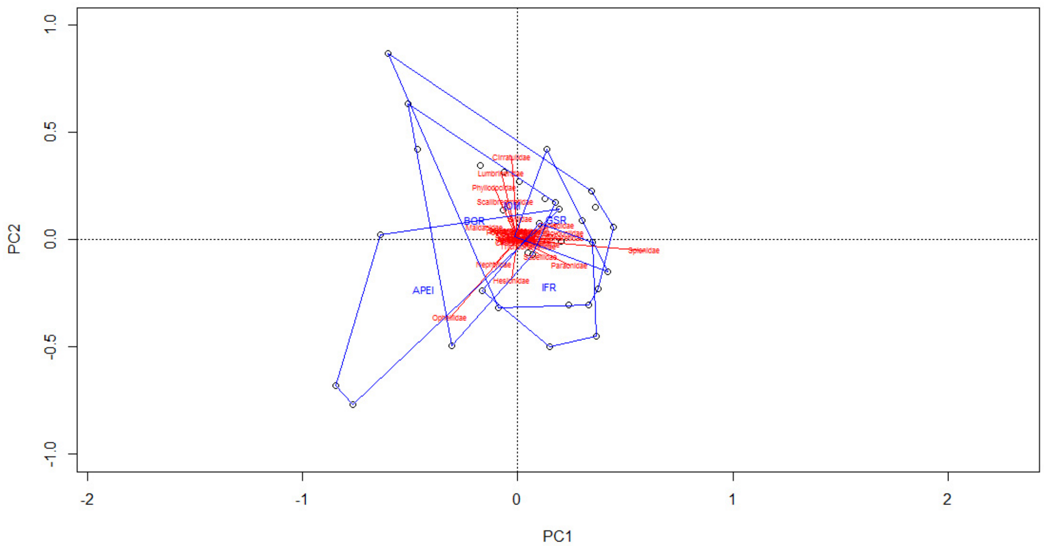


Fig. 7.2.6.12: Principal Component Analysis of polychaete family assemblages from box-cores. Densities were Hellinger-transformed prior to analysis.

c) Isopod crustaceans

Isopoda (Fig. 7.2.6.13) were obtained from the box corer, EBS, and ROV yielding a total of 2848, 70 and 50 individuals respectively. Specimens from EBS and box corer were further identified to family and, if possible, genus level. Isopods collected with the EBS could be assigned to 15 different families (Fig. 7.2.6.14). The most important isopod family were the Desmosomatidae with 35.9% of the total isopod fraction, followed by the Munnopsidae (27.8%). Macrostylidae, Haploniscidae, Nannoniscidae, Ischnomesidae and Dendrotionidae were present in almost all samples, but only comprised between 3.8 and 5.8% of total Isopoda (Fig 7.2.6.14). All other families, such as for example the Mesosignidae, Urstylidae *Sugoniscus* family incertae sedis, and Thambematidae occurred only with few individuals (Fig. 7.2.6.14).

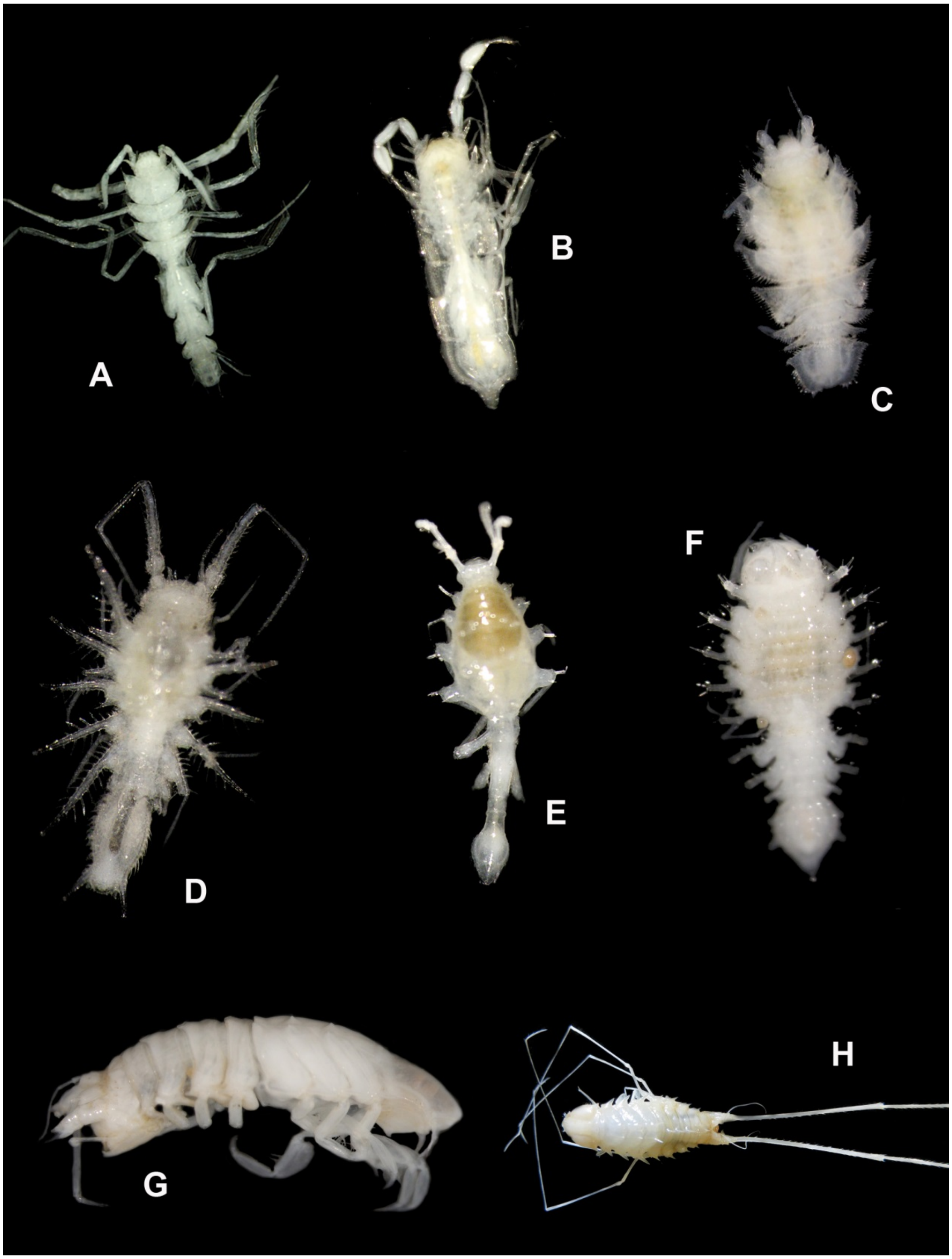


Fig. 7.2.6.12: Isopod specimens collected during the SO239 cruise to the CCZ. A) Desmosomatidae (*Prochelator* sp.), B) Nannoniscidae (*Nannoniscus* sp.), C) *Sugoniscus* fam. incertae sedis; D) Mesosignidae (*Mesosignum* sp.); E) Dendrotionidae; F) Janirellidae (*Janirella* sp.); G, H Munnopsidae (*Eurycope* spp.). Photos: B. Wawrzyniak-Wydrowska & S Kaiser.

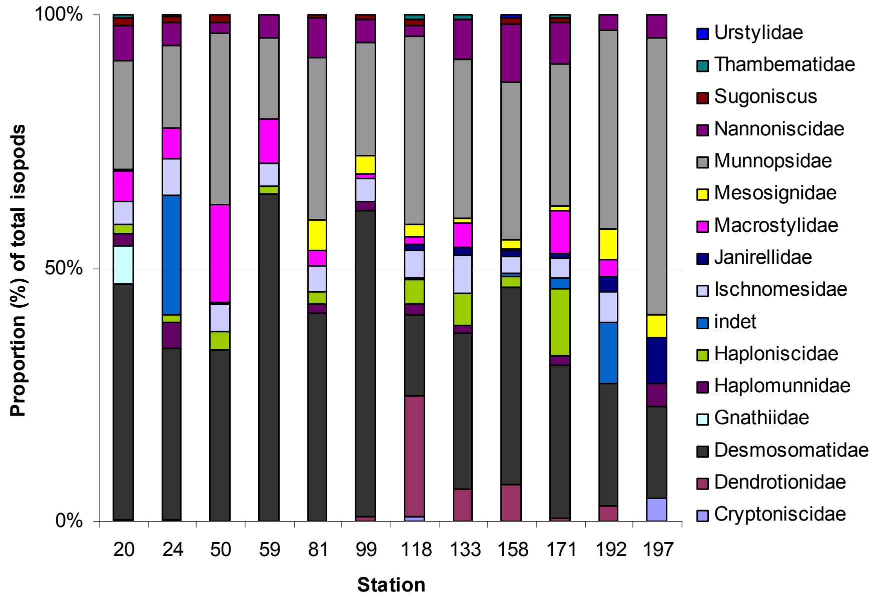


Fig. 7.2.6.13: Proportion (%) of isopod families sampled during SO239 across 12 epibenthic sledge stations.

Isopods were collected at 20 box-core stations in low abundances with each yielding between 1 and 9 specimens. These were assigned to 10 families: Desmosomatidae, Dendrotionidae, Haploniscidae, Ischnomesidae, Macrostylidae, Munnopsidae, Nannoniscidae, *Sugoniscus* family incertae sedis, Thambematidae, Urstylidae. Most dominant were the Desmosomatidae comprising 30.8% of all specimens, followed by the Nannoniscidae (20%). Macrostylidae (10.8%), Thambematidae (10.8%), Ischnomesidae (9.2%) were also common in the box core samples, whereas the remaining families contained only few specimens.

Some specimens from both the box corer and EBS were further identified to generic level and among these more than 20 genera could be identified so far, one of which is potentially new to science (within Desmosomatidae). Identification to species level will require further thorough morphological as well as genetic analyses (see below).

d) Tanaidacean crustaceans

Tanaidacea (Peracarida, Fig. 7.2.6.14) is a sister group of peracarid Isopoda and some tanaidaceans even resemble morphologically certain families of isopods (e.g. anthurids) although they usually have six free pereonites in the thorax (seven in isopods) and usually five free pleonites (often more than one pleonite is fused with a telson in Isopoda). Besides, tanaidaceans gills are fully reduced, thus gases are exchanged through inner walls of the branchial chamber located under the carapace.

Tanaidacea are characterized by usually elongated bodies and are rarely longer than 1–2 mm in length, although species longer than 10 mm are commonly recorded from the deep sea.

Currently formally over 1300 nominal species of tanaidaceans are known to science, which is apparently only a fraction of the real diversity. Tanaidacea are often divided into three recent suborders: free living Apseudomorpha (A) and Neotanaidomorpha (N) and living inside the self-building tubes – Tanaidomorpha (T). The first and the third suborder are represented in both shallow waters as well as in the deep sea, whereas Neotanaidomorpha are exclusively occurring in the deep sea.

Some tanaidaceans are relatively good swimmers. The majority however is slow moving and being virtually immobile organisms. The mature representatives of the suborder Tanaidomorpha stay in their tubes for most of their life and they only leave them when they are forced to by adverse environmental conditions. The males leave their tube during their reproductive period for mating, which takes place inside of the female's tube. Fertilized females lay the eggs into the brood pouch that is formed by the oostegites (the plates growing up from the bases of the pereopods). The eggs, as well as the first juvenile stages (manca 1) develop inside the brood pouches. The juveniles leave the maternal tube through actively drilled pores in the tube walls and then a new generation builds their own tubes next to the tube of the female.

Swimming abilities have been observed only for a few shallow-water Tanaidomorpha and it is also presumed that a specific type of deep-sea males are good swimmers and it is assumed that the swimming males maintain/increase the genetic diversity of the population, which might be crucial to survival in an environment as extreme as the deep sea. It is assumed that the above-mentioned low dispersal potential of Tanaidacea restricts gene flow among populations, thus increase genetic differentiation compared to taxa possessing strong swimming abilities. The preliminary molecular analysis based on the common North Atlantic species *Cryptocopoides arcticus* (Hansen, 1913) revealed several genetically distinct haplotypes, inhabiting waters around Iceland, indicating the potential and presence of cryptic taxa (Błażewicz-Paszkowycz, unpublished).

Fig. 7.2.6.14: Selection of tanaidacean crustaceans present in the EBS samples collected during SO239. Photos: M. Błażewicz and B. Wawrzyniak-Wydrowska

Taxonomical identification. During the JPIO cruise a total of 836 individuals of Taniadacea have been identified from samples taken by the EBS and the box corer. Almost 60% (496 specimens) have been identified to the lowest possible taxonomic level. Tanaidacea collected during the cruise were represented by the three currently defined suborders (Apseudomorpha, Neotanaidomorpha

and Tanaidomorpha), although the two first were further less abundant than the last, and contributed to the whole collection less than 15%. Each of those suborders was represented by one family, Apseudidae (A) and Neotanaidae (N), respectively and at least four genera: *Leviapseudes* (A), *Carpoapseudes* (A), *Zoidbergus* (A) and *Neotanais* (N).
Among Tanaidomorpha the most abundant family was Typhlotanaidae with a total of 173 individuals, compromising almost 35% of all sampled peracarid crustaceans, followed by Pseudotanaidae (18%), Akanthophoreidae (12%) and Agathotanaidae (9%). Other families as for instance Cryptocopoididae, Colletteidae and Tanaellidae contributed to the collection with less than 5%.
One-third of tanaidaceans could not be identified to family level onboard. Those were mainly juvenile and occasionally damaged specimens, although their identification is still possible thorough a taxonomical study and with the support of molecular techniques (e.g. DNA barcoding).

e) Genetics
Four-hundred-ninety-six tanaidacean specimens, 196 isopod specimens and 373 copepod specimens were used for DNA studies. Whole specimens of tanaidacean and copepods were used for DNA extractions, whereas only two to three pereopods according to the size of each isopod were dissected and prepared for extraction. The extraction was carried out using 40-50 µl of Chelex (InstaGene Matrix, Bio−Rad) according to the standard protocol. All DNA extracts are stored at −20C, while tanaidacean and isopod specimen vouchers are kept in the cryovials in 96% ethanol at temperature of 4°C. The recovered copepod specimens were mounted after the extraction in slides and used for taxonomical species determination.

The DNA from the rest of tanaidacean specimens and the isopod will be extracted applying the QIAamp DNA Micro Kit (Qiagen, USA) in University of Łódź in Poland and Senckenberg (Wilhelmshaven) in June-August 2015.

It is intended to gain results on three or four markers e.g. cytochrome c oxidase subunit I (COI), the mitochondrial RNA (12S) the mitochondrial ribosomal RNA large subunit (16S), and the nuclear small rRNA subunit (18S). Results on these markers will be used to detect cryptic species, population boundaries and testing for isolation by distance.

7.2.7 Scavengers (Robert)

Peracarid crustaceans represent a very speciose group. However, deep-sea amphipod and ostracod fauna composition of the CCZ area (North-East Pacific Ocean) remains very poorly known.
Phylogeny and phylogeography will be assessed with a molecular and morphological approach in an attempt to highlight population connectivity and understand the colonization history of the deep sea taxa.

Amphipod were collected at 21 stations located at 6 different areas of the CCFZ. Four amphipod trap were deployed on a regular basis set on the amphipod trap lander (ATC) at 7 stations for about 48 hours and one trap has been set on the DOS lander for about five days. Amphipod were also collected with the EBS at 13 stations.

A quantitative assessment of the amphipod biodiversity was performed on board with the samples collected with the ATC (see Table 7.2.7.1). Qualitative assessment will be performed at the Royal Belgian Institute of Natural Sciences (RBINS) in the next few months.

Ostracod crustceans were collected in small ostracod trap at each stations of ATC deployment (see Table 7.2.7.1). Specimens were fixed on board but sorting and biodiversity assessment will be performed at the RBINS.

Table 7.2.7.1 List of stations where the amphipod/ostracod trap lander was deployed.

Station	Gear	Date	UTC	Area/claim	Position Lat.	Position Lon.	Depth [m]	Number specimen collected	Morpho-types identified
SO 239/037-1	Trap on DOS lander	25-03-15	02:34	German	11° 48,63' N	117° 0,96' W	4138,2	300	Undetermined
SO 239/033-1	Amphipod trap	24-03-15	15:27	German	11° 51,29' N	117° 3,38' W	4126,9	3564	≥ 16
SO 239/063-1	Amphipod trap	29-03-15	16:00	Ref.	11° 48,64' N	117° 32,05' W	4343,3	2122	≥ 9
SO 239/096-1	Amphipod trap	03-04-15	22:42	IOM	11° 2,98' N	119° 41,16' W	4383,1	2229	≥ 10
SO 239/123-1	Amphipod trap	08-04-15	19:40	Belgian	13° 51,22' N	123° 15,30' W	4518,6	423	≥ 6
SO 239/139-1	Amphipod trap	11-04-15	13:33	French	13° 52,41' N	123° 16,46' W	4541	431	≥ 6
SO 239/173-1	Amphipod trap	17-04-15	14:03	French	14° 3,20' N	130° 4,61' W	5016,1	558	≥ 7
SO 239/205-1	Amphipod trap	23-04-15	14:11	APEI	18° 46,40' N	128° 20,17' W	4817,6	1251	≥ 8

7.2.8 Kiel6000 ROV dives (Ribeiro, Hilário, Vanreusel, Menot and Martinez Arbizu)

The remotely operated vehicle *Kiel6000*, operated by GEOMAR, performed a total of 15 dives over the abyssal plain and four seamounts on four license areas and APEI no. 3. The overall objectives of these dives were to:

1. Conduct HDTV video transects at nodule, non-nodule, track and seamount sites.
2. Collect voucher specimens of benthic fauna.
3. Obtain samples of sediment and its fauna using push cores.
4. Collect pelagic larvae near the seafloor using the suction sampler.

7.2.8.1 Dive summary

In this section we provide a brief account of the tasks performed during each dive. All times are in UTC.

SO239/13-1_ROV01; 11°51,06'N; 117°01,97'W (20/21.03.2015) BGR license area, nodules (4125m)	
1819h	At bottom.
1858h	Start of push-coring.
1912h	End of push-coring.
1915h	Start of faunal sampling.
2030h	End of faunal sampling.
2031h	Larval pump on (port side chamber).
2036h	Larval pump off.
2040h	Resuming faunal sampling.
2124h	End of faunal sampling.
2129h	Larval pump on (starboard side chamber).

2139h	Larval pump off.
2157h	Off bottom.

SO239/29-1_ROV02; 11°42,73'N 116°35,94'W (23/24.03.2015) BGR license area, seamount (2987m)	
1802h	At bottom.
1843h	Larval pump on (starboard side chamber).
1849h	Start of video transect.
1904h	Larval pump off.
1908h	End of video transect.
1913h	Start of push-coring.
1940h	End of push-coring.
1942h	Flying towards the summit while collecting fauna, taking photos and recording video.
0149h	Off bottom.

SO239/41-1_ROV3; 11°50,55'N 117°03,46'W (25/26.03.2015) BGR license area, track (4107m)	
1932h	At bottom.
1935h	Track found.
1952h	Push cores inside the track (plot 1).
2015h	Push cores outside the track (plot 1).
2028h	Push cores inside the track (plot 2).
2103h	Push cores outside the track (plot 2).
2120h	Push cores inside the track (plot 3).
2139h	Push cores outside the track (plot 3).
2200h	Flying towards amphipod trap position; recording video.
2325h	Amphitrap not found; heading to pock mark; taking stills and recording video.
0104h	Pock mark reached; flying across for video documentation.
0140h	Faunal sampling.
0155h	Video of isopod.
0204h	Off bottom.

SO239/54-1_ROV04; 11°41,93'N 117°27,23'W (27/28.03.2015) BGR reference area, seamount (3354m)	
1716h	At bottom.
1740h	Larval pump on (port side chamber).
1740h	Heading 184 while recording video.
1800h	Larval pump off.
1805h	Video transect up the slope.
1920h	Reached the first plateau.
1940h	End of video transect.
1944h	Start of faunal sampling.
2000h	Push core on a sediment area.
2025h	Push core on a sediment area.
2125h	End of faunal sampling; flying and recording video towards the summit.
2210h	Faunal sampling.

2230h	Heading for the summit.
2252h	Larval pump on (starboard side chamber) while flying towards the summit; video recording.
2313h	Larval pump off.
2320h	Start of faunal sampling.
0133h	End of faunal sampling / summit reached.
0135h	Flying down the crater.
0201h	Off bottom.

SO239/64-1_ROV05; 11°41,93'N 117°27,23'W (29/30.03.2015) BGR reference area, EBS track (4332m)	
1919h	At bottom.
1940h	Start of faunal sampling.
2135h	End of faunal sampling.
2140h	Start of video transect.
2318h	End of video transect.
2326h	Push cores inside the track (plot 1).
0008h	Push core outside the track (plot 1).
0046h	Push cores inside the track (plot 2).
0113h	Push cores inside the track (plot 3).
0136h	Push core outside the track (plot 2).
0151h	Push core outside the track (plot 3).
0155h	Off bottom.

SO239/82-1_ROV06; 11°03,45'N 119°37,89'W (01/02.04.2015) IOM license area (4347m)	
1712h	At bottom.
1733h	Start of faunal sampling.
2000h	End of faunal sampling.
2004h	Larval pump on (port side chamber).
2008h	Start of video transect 1.
2024h	Larval pump off.
2140h	End of video transect 1.
2147h	Start of faunal sampling.
2320h	End of faunal sampling.
2330h	Start of video transect 2.
0030h	End of video transect 2.
0036h	Resumed faunal sampling.
0126h	Larval pump on (starboard side chamber).
0127h	Off bottom.

SO239/101-1_ROV07; 11°04,49'N 119°39,39'W (04/05.04.2015) IOM license area, track (4398m)	
1803h	At bottom.
1810h	Transiting towards the track (video on).
1830h	Track reached.
1855h	Push cores inside the track (plot 1).
2003h	Push cores inside the track (plot 2).

2018h	Push core outside the track (plot 1).
2029h	Push core outside the track (plot 2).
2039h	Push core outside the track (plot 3).
2108h	Push cores inside the track (plot 3).
2115h	Start of video transect 1 (inside track).
2145h	End of video transect 1.
2147h	Start of faunal sampling.
0033h	End of faunal sampling.
0048h	Start of video transect 2 (outside track).
0136h	End of video transect 2.
0138h	Off bottom.

SO239/131-1_ROV08; 13°52,39'N 123°15,03'W (09/10.04.2015) GSR license area, EBS track (4478m)	
1747h	At bottom.
1820h	Push cores inside the track (plot 1).
1831h	Push core outside the track (plot 1).
1852h	Push cores inside the track (plot 2).
1928h	Push core outside the track (plot 2).
1946h	Push cores inside the track (plot 3).
2009h	Push core outside the track (plot 3).
2030h	Start of faunal sampling.
2310h	End of faunal sampling.
2334h	Start of video transects (2) on nodules.
0020h	Larval pump on (port side chamber).
0040h	Larval pump off.
0059h	End of video transects.
0138h	Faunal sampling.
0214h	Off bottom.

SO239/135-1_ROV09; 13°58,69'N 123°08,94'W (10/11.04.2015) GSR license area, seamount (3893)	
1821h	At bottom.
1900h	Flying up the slope; collecting fauna and recording video.
2140h	Continuous video transect for 15 min.
2200h	Flying up the slope; collecting fauna and recording video.
2219h	Continuous video transect for 20 min.
2240h	Flying up the slope; collecting fauna and recording video.
0213h	Off bottom.

SO239/141-1_ROV10; 13°52,03'N 123°15,33'W (11/12.04.2015) GSR license area, DEME track (4481m)	
1821h	At bottom.
1835h	Push cores inside the track (plot 1).
1915h	Push core outside the track (plot 1).
1920h	Push core outside the track (plot 2).
1930h	Push cores inside the track (plot 2).
2014h	Push cores inside the track (plot 3).

2030h	Push core outside the track (plot 3).
2123h	Start of video transect 1 (inside track).
2157h	End of video transect 1.
2250h	Start of faunal sampling.
0100h	End of faunal sampling.
0105h	Start of video transect 2 (outside track).
0200h	End of video transect 2.
0205h	Faunal sampling.
0213h	Off bottom.

SO239/157-1_ROV11; 13°52,03'N 123°15,33'W (14/15.04.2015)
IFREMER license area, OMCO track (4953m)

1727h	At bottom.
1800h	Push cores inside the track (plot 1).
1828h	Push core outside the track (plot 1).
1842h	Push core outside the track (plot 2).
1905h	Push cores inside the track (plot 2).
1945h	Push cores inside the track (plot 3).
2002h	Start of video transect 1 (inside track).
2032h	End of video transect 1.
2034h	Start of video transect 2 (outside track).
2138h	End of video transect 2.
2140h	Start of faunal sampling.
2352h	End of faunal sampling.
2356h	Off bottom.

SO239/161-1_ROV12; 14°02,07'N 130°05,60'W (15/16.04.2015)
French license area, EBS track (5000m)

1901h	At bottom.
1927h	Transit towards the track, recording video.
2000h	Found a wood fall.
2005h	Sampling wood fall fauna.
2102h	End of sampling on wood fall.
2105h	Start of video transect 1 (outside the track).
2205h	End of video transect 1.
2210h	Found EBS track.
2240h	Resuspension experiment - 3 Niskin water samples taken.
2245h	Start of push-coring.
2340h	Push cores taken.
2342h	Start of video transect 2 (inside the track).
0005h	End of video transect 2.
0015h	Start of faunal sampling.
0157h	Off bottom.

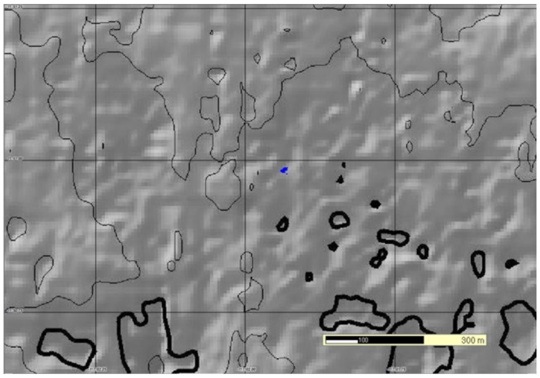
SO239/189-1_ROV13; 18°47,80'N 128°18,53'W (20/21.04.2015)
APEI no. 3, nodules (4931m)

1729h	At bottom.
1744h	Larval pump on (port side chamber).

1752h	Start of video transect 1.
1801h	Larval pump off.
1850h	End of video transect 1.
1850h	Start of specimen collection.
0125h	End of specimen collection.
0130h	Larval pump on (starboard side chamber).
0137h	Start of video transect 2.
0150h	Larval pump off.
0226h	End of video transect 2.
0230h	Off bottom.

SO239/200-1_ROV14; 18°49,22'N 128°25,55'W (22/23.04.2015) APEI no. 3, nodules (4673m)	
1654h	At bottom.
1708h	Start of video transect 1.
1716h	Larval pump on (starboard side chamber).
1740h	Larval pump off.
1815h	End of video transect 1.
1816h	Start of specimen collection.
2312h	End of specimen collection.
2315h	Start of video transect 2.
0015h	End of video transect 2.
0020h	Resuming specimen collection.
0213h	Off bottom.

SO239/212-1_ROV15; 18°32,83'N 128°44,88'W (24.04.2015) APEI no. 3,seamount (1844m)	
1543h	At bottom.
1556h	Larval pump on (port side chamber).
1616h	Larval pump off.
1620h	Start of specimen collection and video recording up the seamount slope.
2208h	Off bottom.



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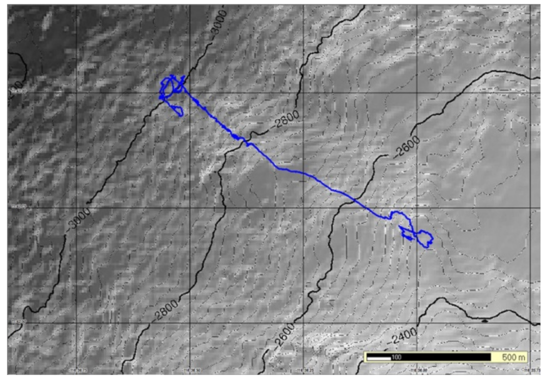

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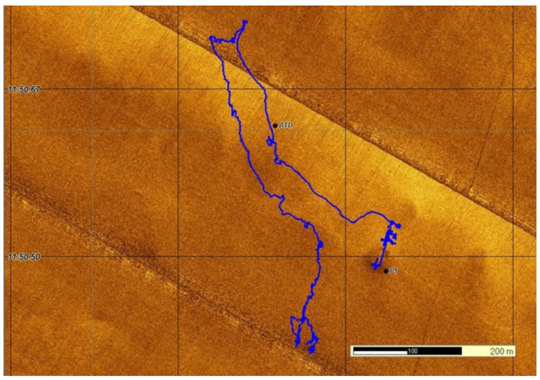

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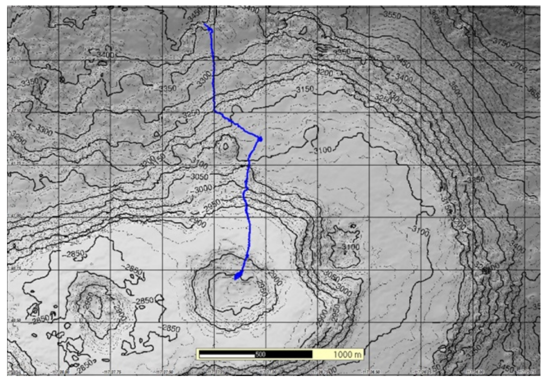

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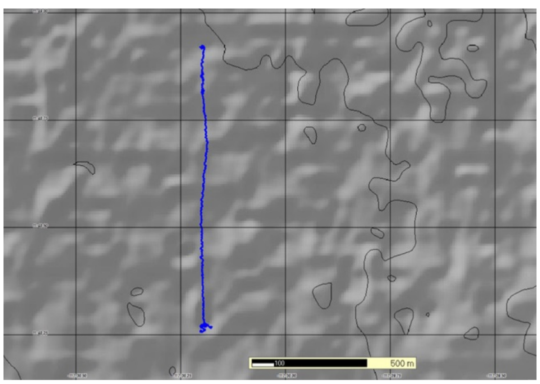

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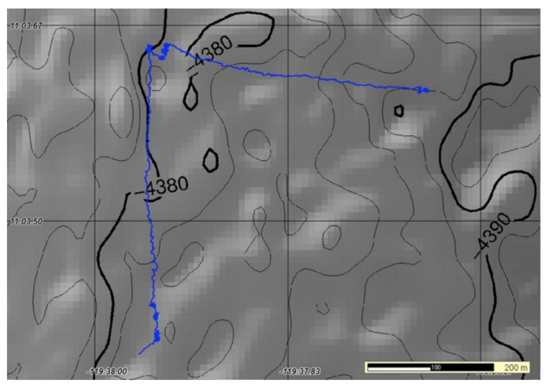

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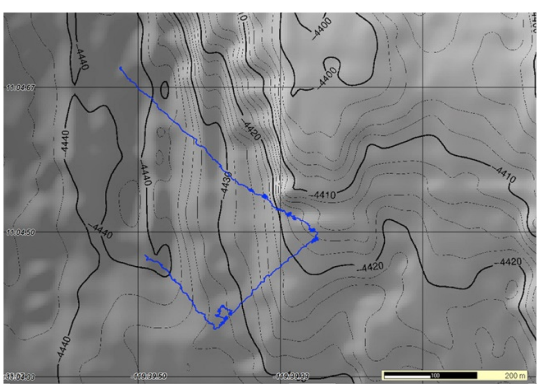

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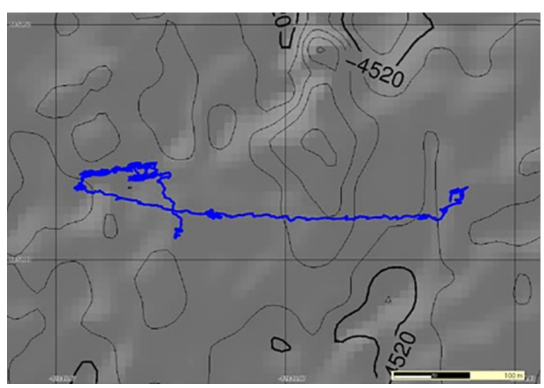
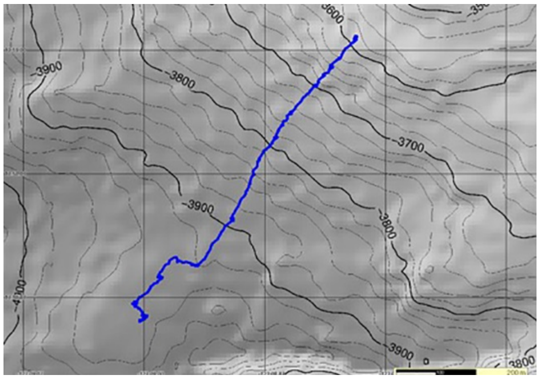


SO239/131-1_ROV08

Fig. 7.2.8.1: ROV tracks at the bottom for all 15 dives performed during the SO239 EcoResponse cruise.



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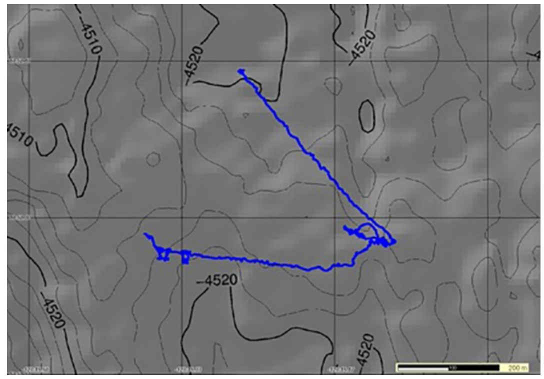

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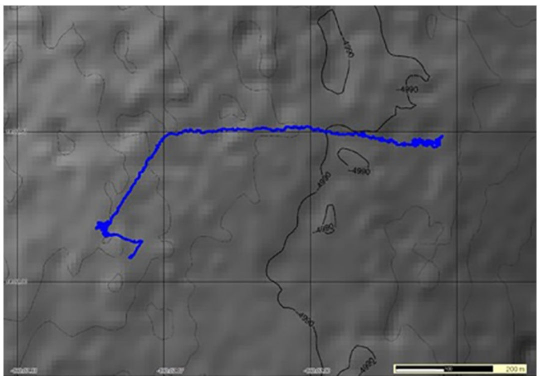

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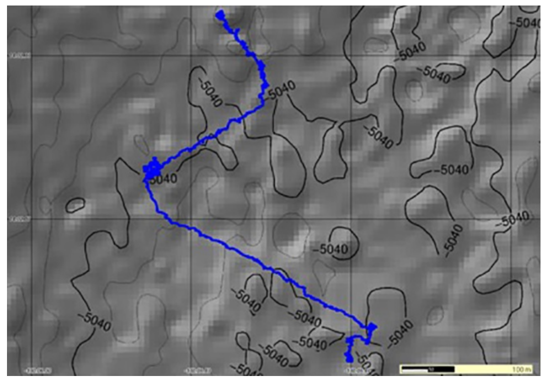

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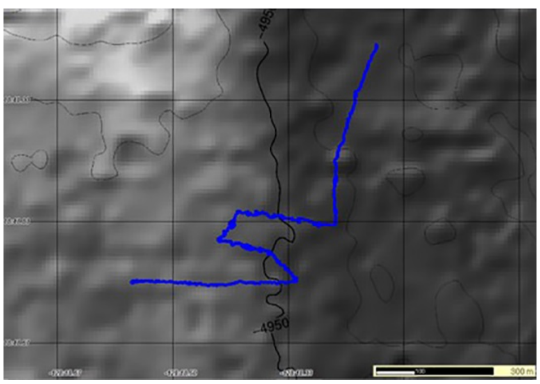
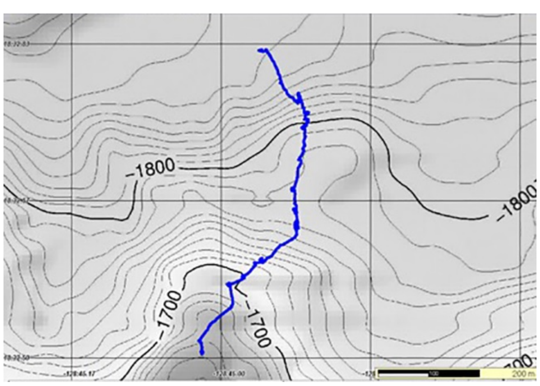


SO239/189-1_ROV13

SO239/200-1_ROV14



SO239/212-1_ROV15

Fig. 7.2.8.2: ROV tracks at the bottom (continued).

7.2.8.2 Video transects

A total of 17 standardized video transects (6420 m) were performed in all five areas visited: BGR (2 transects), IOM (4 transects), GSR (3 transects), IFREMER (4 transects) and APEI no.3 (4 transects). The primary goals were to:

a) assess the importance of nodule habitats to epifaunal biodiversity on the CCZ;
b) investigate the impact of nodule removal on epifaunal assemblages, as well as their recovery over decadal time-scales;
c) collect preliminary APEI data as these areas are virtually unstudied.

Transects were conducted on sites with high and low nodule densities, as well as four tracks where nodules have been experimentally removed (Table 7.2.8.1).

Table 7.2.8.1: Video transect details. Latitude and longitude are in degrees. Track transects are marked with an asterisk.

Station	Area	Lat. Start	Lon. Start	Lat. End	Lon. End	Length (m)
S0239_041	BGR	11.8452387	-117.0605550	11.8418512	-117.0587831	320
S0239_064	BGR	11.8124593	-117.5031872	11.8046433	-117.5032276	870
S0239_082	IOM	11.0572464	-119.6324857	11.0607799	-119.6325307	320
S0239_082	IOM	11.0606330	-119.6318236	11.0602037	-119.6286666	410
S0239_101	IOM	11.0734977	-119.6564279	11.0748438	-119.6548696	380
S0239_101	IOM*	11.0758375	-119.6561957	11.0781059	-119.6586458	250
S0239_131	GSR	13.8730207	-123.2522195	13.8728015	-123.2509114	420
S0239_141	GSR	13.8727686	-123.2508395	13.8727085	-123.2483495	450
S0239_141	GSR*	13.8662487	-123.2516787	13.8690796	-123.2543425	200
S0239_157	IFREMER	14.0345477	-130.1204139	14.0359979	-130.1194475	400
S0239_157	IFREMER*	14.0360368	-130.1194000	14.0360484	-130.1157292	200
S0239_161	IFREMER	14.0342730	-130.0940795	14.0361942	-130.0976579	450
S0239_161	IFREMER*	14.0370188	-130.0977215	14.0377971	-130.0964856	200
S0239_189	APEI #3	18.7958680	-128.3089939	18.7958674	-128.3053745	400
S0239_189	APEI #3	18.7981603	-128.3044230	18.8011983	-128.3034312	350
S0239_200	APEI #3	18.8191274	-128.4263160	18.8220937	-128.4281335	400
S0239_200	APEI #3	18.8238307	-128.4290327	18.8247282	-128.4254147	400

The ROV was flown approximately 1 m above the seafloor at a speed of approximately 0.2 m s^{-1} while recording video with the high-definition colour video camera (Kongsberg OE14-500). The camera was positioned at the minimum angle possible without the ROV frame blocking the field of view, or, in the case of transects in area where nodules have been removed, in the minimum zoom setting to view the whole width of the disturbed area. Transect width was calculated using two laser pointers on the seabed 6.5 cm apart from each other. The optical resolution of the cameras enabled the reliable identification of all organisms larger than 3 cm. All transects were annotated in real time for the presence of major sessile and mobile epifaunal groups using the software Ocean Floor Observation Protocol (OFOP, http://ofop.texel.com).

Significant spatial variation was found in epifaunal abundance among all areas visited. Epifaunal densities within each area were consistently higher on nodule-rich sites than on those without nodules, where typical hard-substrate taxa such as alcyonacean and antipatharian corals were nearly absent. Surveys conducted along experimental tracks revealed an extremely impoverished epifauna, compared to undisturbed areas in the vicinity.

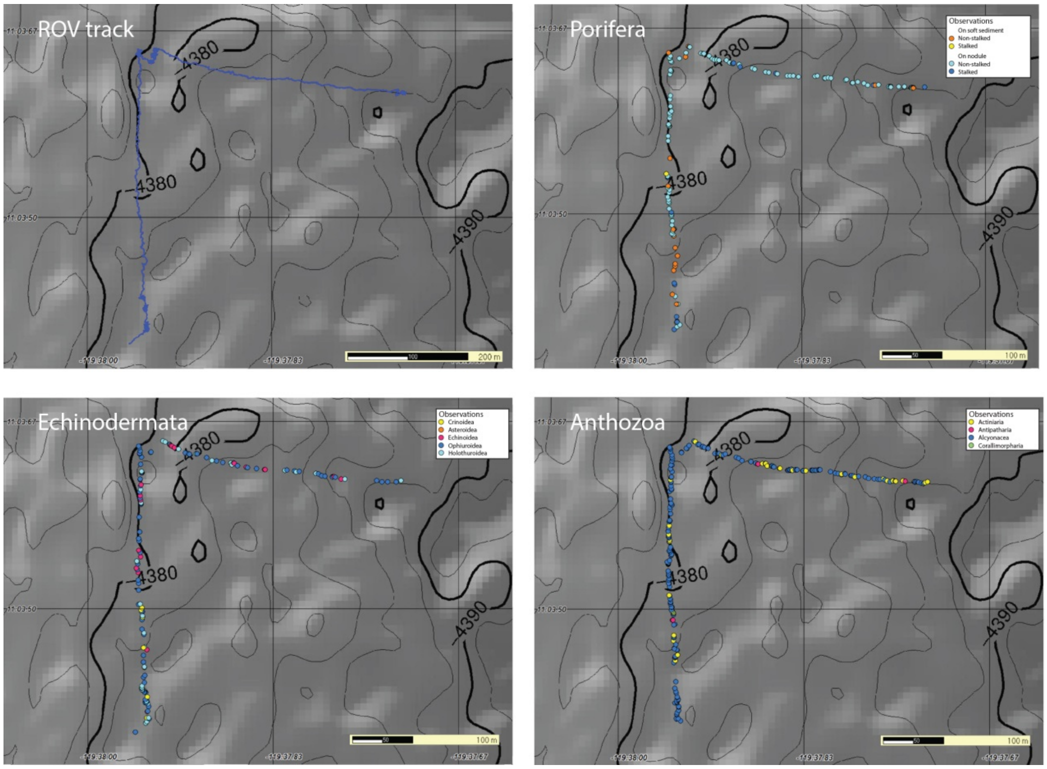


Fig.7.2.8.3: Example of epifaunal annotation during dive SO239/82-1_ROV06. Maps were produced in OFOP from post-processing of navigation and observation files generated during the dive.

7.2.8.3 Specimen collection

Depending on the targeted taxon, collection of benthic megafauna and macrofauna from the seafloor was performed using one of the following tools:

a) the ROV's manipulator arm (Orion), either by direct picking or by manipulating scoops, shovels and nets;

b) the suction sampler

In addition to eight containers fitted onto the suction sampler's carousel, the ROV also carried in all dives a large biobox on the drawer's starboard side (the Senckenberg biobox). Two additional lidded boxes (termed ´grey´ and ´small´ for practical purposes) were fitted on the port side of the ROV's drawer and used to store smaller and more fragile specimens collected with Orion, such as antipatharians and some octocorallians. Drawer configuration for 16 push cores did not allow space for the grey lidded biobox. Table 7.2.8.2 provides a detailed account of mega and macrofauna collection performed during the ROV dives.

Table 7.2.8.2: Specimen collection details for all *Kiel6000* dives.

Date	Station	Sample no.	Time (UTC)	Specimen	Collection method
20-03-2015	SO239/13-1	1	19:21	Ophiuroid	Scoop (Senckenberg box)
20-03-2015	SO239/13-1	2	19:26	Alcyonacean on nodule	Orion (Senckenberg box)
20-03-2015	SO239/13-1	3	19:50	Ophiuroid	Orion (Senckenberg box)
20-03-2015	SO239/13-1	4	19:59	Alcyonacean on nodule	Orion (grey lidded box)
20-03-2015	SO239/13-1	5	20:08	Alcyonacean	Orion (grey lidded box)
20-03-2015	SO239/13-1	6	20:23	Alcyonacean on nodule	Orion (grey lidded box)
20-03-2015	SO239/13-1	7	20:54	Stalked hexactinellid	Orion (Senckenberg box)
20-03-2015	SO239/13-1	8	20:55	Ophiuroid	Orion (Senckenberg box)
20-03-2015	SO239/13-1	9	20:57	Stalked hexactinellid	Orion (grey lidded box)
20-03-2015	SO239/13-1	10	21:03	Ophiuroid	Orion (grey lidded box)
23-03-2015	SO239/29-1	1	20:27	Ceriantharian	Slurp gun (chamber 1)
23-03-2015	SO239/29-1	2	21:27	Large hexactinellid	Orion (Senckenberg box)
23-03-2015	SO239/29-1	3	22:26	Stalked hexactinellid	Orion (Senckenberg box)

23-03-2015	SO239/29-1	4	23:04	Alcyonacean	Orion (Senckenberg box)
23-03-2015	SO239/29-1	5	23:14	Large polychaete	Slurp gun (chamber 4)
23-03-2015	SO239/29-1	6	23:48	Hexactinellid	Net (tray, port side)
26-03-2015	SO239/41-1	1	01:52	Antipatharian on nodule	Orion (small port side box)
26-03-2015	SO239/41-1	2	01:52	Hexactinellid on nodule	Orion (Senckenberg box)
27-03-2015	SO239/54-1	1	19:55	Pennatulacean	Orion (Senckenberg box)
27-03-2015	SO239/54-1	2	20:15	Pennatulacean	Orion (Senckenberg box)
27-03-2015	SO239/54-1	3	21:10	Echinoid	Scoop (grey lidded box)
27-03-2015	SO239/54-1	4	22:17	Alcyonacean	Orion (small port side box)
27-03-2015	SO239/54-1	5	22:27	Antipatharian	Orion (Senckenberg box)
27-03-2015	SO239/54-1	6	23:22	Hexactinellid	Orion (Senckenberg box)
27-03-2015	SO239/54-1	7	23:42	Hexactinellid	Orion (Senckenberg box)
27-03-2015	SO239/54-1	8; 9	23:49	Ophiuroids	Slurp gun (chamber 2)
28-03-2015	SO239/54-1	10	00:11	Ophiuroid	Slurp gun (chamber 3)
28-03-2015	SO239/54-1	11	00:33	Hexactinellid fragment	Orion (Senckenberg box)
28-03-2015	SO239/54-1	12	01:33	Dead bamboo coral	Orion (small port side box)
29-03-2015	SO239/64-1	1	19:43	Hexactinellid	Orion (Senckenberg box)
29-03-2015	SO239/64-1	2	20:20	Hexactinellid	Orion (Senckenberg box)
29-03-2015	SO239/64-1	3	20:32	Hexactinellid	Orion (Senckenberg box)
29-03-2015	SO239/64-1	4	20:32	Ophiuroid	Orion (Senckenberg box)
29-03-2015	SO239/64-1	5	20:54	Echinoid	Net (tray, port side)
29-03-2015	SO239/64-1	6	21:03	Hexactinellid	Orion (Senckenberg box)
29-03-2015	SO239/64-1	7	21:03	Ophiuroid	Orion (Senckenberg box)
29-03-2015	SO239/64-1	8	21:23	Hexactinellid	Orion (Senckenberg box)
29-03-2015	SO239/64-1	9; 10; 11	21:23	Ophiuroids	Orion (Senckenberg box)
29-03-2015	SO239/64-1	12; 13; 14	21:25	Ophiuroids	Orion (Senckenberg box)
29-03-2015	SO239/64-1	15	21:26	Hexactinellid stalk	Orion (Senckenberg box)
01-04-2015	SO239/82-1	1	17:33	Alcyonacean	Orion (Senckenberg box)
01-04-2015	SO239/82-1	2	17:59	Hexactinellid	Orion (Senckenberg box)
01-04-2015	SO239/82-1	3	18:03	Hexactinellid	Orion (Senckenberg box)
01-04-2015	SO239/82-1	4	18:18	Hexactinellid	Orion (Senckenberg box)
01-04-2015	SO239/82-1	5	18:29	Foraminifera	Orion (Senckenberg box)
01-04-2015	SO239/82-1	6	18:30	Ophiuroid	Orion (Senckenberg box)
01-04-2015	SO239/82-1	7	18:31	Alcyonacean	Orion (Senckenberg box)
01-04-2015	SO239/82-1	8	18:34	Alcyonacean	Orion (Senckenberg box)
01-04-2015	SO239/82-1	9	18:40	Alcyonacean	Orion (Senckenberg box)
01-04-2015	SO239/82-1	10	18:55	Ophiuroid	Orion (Senckenberg box)
01-04-2015	SO239/82-1	11	19:13	Ophiuroid	Orion (Senckenberg box)
01-04-2015	SO239/82-1	12	19:20	Alcyonacean	Orion (Senckenberg box)
01-04-2015	SO239/82-1	13	19:40	Hexactinellid	Orion (Senckenberg box)
01-04-2015	SO239/82-1	14	19:45	Ophiuroid	Orion (Senckenberg box)
01-04-2015	SO239/82-1	15	19:50	Hexactinellid	Orion (Senckenberg box)
01-04-2015	SO239/82-1	16	19:56	Ophiuroid	Orion (Senckenberg box)
01-04-2015	SO239/82-1	17	19:58	Alcyonacean	Orion (Senckenberg box)
01-04-2015	SO239/82-1	18	21:47	Hexactinellid	Orion (grey lidded box)
01-04-2015	SO239/82-1	19	21:55	Ophiuroid	Orion (small port side box)
01-04-2015	SO239/82-1	20	22:08	Hexactinellid	Orion (Senckenberg box)
01-04-2015	SO239/82-1	21	22:25	Hexactinellid	Orion (Senckenberg box)
01-04-2015	SO239/82-1	22	22:34	Alcyonacean on nodule	Orion (Senckenberg box)
01-04-2015	SO239/82-1	23	22:55	Alcyonacean	Orion (small port side box)
01-04-2015	SO239/82-1	24	23:07	Isopod	Slurp gun (chamber 2)
01-04-2015	SO239/82-1	25	23:19	Hexactinellid	Orion (Senckenberg box)
02-04-2015	SO239/82-1	26	00:36	Hexactinellid	Orion (Senckenberg box)
02-04-2015	SO239/82-1	27	00:52	Ophiuroid	Orion (Senckenberg box)
02-04-2015	SO239/82-1	28	01:08	Ophiuroid	Orion (Senckenberg box)
02-04-2015	SO239/82-1	29	01:12	Hexactinellid	Orion (Senckenberg box)
04-04-2015	SO239/101-1	1	22:02	Hexactinellid	Orion (Senckenberg box)
04-04-2015	SO239/101-1	2	22:35	Hexactinellid on nodule	Orion (Senckenberg box)
04-04-2015	SO239/101-1	3	22:55	Echinoid	Net (tray, port side)
04-04-2015	SO239/101-1	4	23:42	Ophiuroid	Orion (Senckenberg box)
04-04-2015	SO239/101-1	5	23:43	cf. Holothurian	Orion (Senckenberg box)
05-04-2015	SO239/101-1	6	00:07	Ophiuroid	Slurp gun (chamber 1)
05-04-2015	SO239/101-1	7	00:30	Ceriantharian tube	Slurp gun (lost)
09-04-2015	SO239/131-1	1	20:30	Hexactinellid	Orion (Senckenberg box)
09-04-2015	SO239/131-1	2	20:51	Hexactinellid	Orion (Senckenberg box)
09-04-2015	SO239/131-1	3	21:16	Alcyonacean on nodule	Orion (small port side box)
09-04-2015	SO239/131-1	4	21:28	Hexactinellid on nodule	Orion (Senckenberg box)
09-04-2015	SO239/131-1	5	21:34	Ophiuroid	Orion (Senckenberg box)
09-04-2015	SO239/131-1	6	21:38	Ophiuroid arm	Orion (Senckenberg box)
09-04-2015	SO239/131-1	7	21:47	Antipatharian	Orion (Senckenberg box)
09-04-2015	SO239/131-1	8	21:58	Ophiuroid	Orion (Senckenberg box)
09-04-2015	SO239/131-1	9	22:11	Ophiuroid	Orion (Senckenberg box)
09-04-2015	SO239/131-1	10	22:18	Ophiuroid	Orion (Senckenberg box)
09-04-2015	SO239/131-1	11	22:28	Hexactinellid	Orion (Senckenberg box)
09-04-2015	SO239/131-1	12; 13; 14	22:28	Ophiuroids on sponge	Orion (Senckenberg box)
09-04-2015	SO239/131-1	15	22:40	Alcyonacean	Orion (small port side box)
09-04-2015	SO239/131-1	16	23:03	Ophiuroid	Orion (Senckenberg box)
10-04-2015	SO239/131-1	17	00:05	Hexactinellid	Orion (Senckenberg box)
10-04-2015	SO239/131-1	18	01:45	Alcyonacean on nodule	Orion (small port side box)
10-04-2015	SO239/131-1	19	01:50	Hexactinellid	Orion (Senckenberg box)
10-04-2015	SO239/131-1	20	02:00	Ophiuroid	Orion (Senckenberg box)
10-04-2015	SO239/135-1	1	19:35	Bryozoan	Orion (Senckenberg box)
10-04-2015	SO239/135-1	2	19:43	Amphipod on stalk	Slurp gun (chamb. 1, lost)
10-04-2015	SO239/135-1	3	19:44	Ceriantharian tube	Slurp gun (chamb. 2, lost)
10-04-2015	SO239/135-1	4	19:56	Alcyonacean	Orion (Senckenberg box)
10-04-2015	SO239/135-1	5	20:26	Hexactinellid on rock	Orion (Senckenberg box)
10-04-2015	SO239/135-1	6	20:36	Hexactinellid	Orion (Senckenberg box)
10-04-2015	SO239/135-1	7	20:45	Hexactinellid	Orion (grey lidded box)

10-04-2015	SO239/135-1	8	21:01	Hexactinellid	Orion (Senckenberg box)
10-04-2015	SO239/135-1	9	21:13	Hexactinellid	Orion (Senckenberg box)
10-04-2015	SO239/135-1	10	21:13	Alcyonacean on 9	Orion (Senckenberg box)
10-04-2015	SO239/135-1	11	21:13	Cirripeds on 9	Orion (Senckenberg box)
10-04-2015	SO239/135-1	12	21:17	Freyella arms	Orion (small port side box)
10-04-2015	SO239/135-1	13; 14	22:00	Two Freyela	Slurp gun (chamber 2)
10-04-2015	SO239/135-1	15	22:00	Hexactinellid	Slurp gun (chamber 2)
10-04-2015	SO239/135-1	16	22:40	Hexactinellid	Orion (small port side box)
10-04-2015	SO239/135-1	17	23:22	Alcyonacean	Orion (small port side box)
10-04-2015	SO239/135-1	18	23:30	Ophiuroid	Slurp gun (chamber 3)
11-04-2015	SO239/135-1	19	00:00	Isopod	Slurp gun (chamber 4)
11-04-2015	SO239/135-1	20	00:12	Alcyonacean	Orion (small port side box)
11-04-2015	SO239/135-1	21	00:16	Alcyonacean	Orion (small port side box)
11-04-2015	SO239/135-1	22	01:00	Stalk with barnacles	Orion (Senckenberg box)
11-04-2015	SO239/135-1	23	01:21	Stalk with barnacles	Orion (Senckenberg box)
11-04-2015	SO239/135-1	24	01:36	Hexactinellid	Orion (Senckenberg box)
11-04-2015	SO239/135-1	25	02:03	Antipatharian on basalt	Orion (Senckenberg box)
11-04-2015	SO239/141-1	1	23:06	Ophiuroid	Orion (Senckenberg box)
11-04-2015	SO239/141-1	2	23:20	Ophiuroid	Orion (Senckenberg box)
11-04-2015	SO239/141-1	3	23:42	Ophiuroid	Orion (small port side box)
11-04-2015	SO239/141-1	4	23:57	Ophiuroid	Orion (Senckenberg box)
12-04-2015	SO239/141-1	5	00:03	Hexactinellid	Orion (Senckenberg box)
12-04-2015	SO239/141-1	6	00:07	Ophiuroid	Orion (Senckenberg box)
12-04-2015	SO239/141-1	7	00:20	Alcyonacean	Orion (small port side box)
12-04-2015	SO239/141-1	8	00:33	Alcyonacean	Orion (small port side box)
12-04-2015	SO239/141-1	9	00:48	Alcyonacean	Orion (small port side box)
12-04-2015	SO239/141-1	10	00:59	Alcyonacean	Orion (small port side box)
12-04-2015	SO239/141-1	11	01:00	Ophiuroid	Orion (small port side box)
12-04-2015	SO239/141-1	12	02:10	Hexactinellid	Orion (Senckenberg box)
12-04-2015	SO239/141-1	13	02:12	Ophiuroid	Orion (Senckenberg box)
14-04-2015	SO239/157-1	1	21:46	Hexactinellid	Orion (Senckenberg box)
14-04-2015	SO239/157-1	2	22:21	Hexactinellid	Orion (Senckenberg box)
14-04-2015	SO239/157-1	3	22:45	Hexactinellid	Orion (Senckenberg box)
14-04-2015	SO239/157-1	4	23:00	Antipatharian	Orion (small port side box)
14-04-2015	SO239/157-1	5	23:15	Hexactinellid	Orion (Senckenberg box)
14-04-2015	SO239/157-1	6	23:35	*Branchiocerianthus*	Orion (Senckenberg box)
14-04-2015	SO239/157-1	7	23:52	Hexactinellid	Orion (Senckenberg box)
15-04-2015	SO239/161-1	1	20:45	Hexactinellid	Slurp gun (chamber 1)
15-04-2015	SO239/161-1	2	20:50	Galatheid	Slurp gun (chamber 2)
15-04-2015	SO239/161-1	3	20:57	Vestimentiferan tubes	Orion (Senckenberg box)
15-04-2015	SO239/161-1	4	21:00	Wood fragment	Orion (Senckenberg box)
15-04-2015	SO239/161-1	5	21:02	Wood fragment	Orion (Senckenberg box)
16-04-2015	SO239/161-1	6	00:50	Hexactinellid	Orion (Senckenberg box)
16-04-2015	SO239/161-1	7	01:05	Antipatharian	Orion (Senckenberg box)
16-04-2015	SO239/161-1	8	01:41	Antipatharian	Orion (Senckenberg box)
16-04-2015	SO239/161-1	9	01:52	Isopod	Slurp gun (chamber 4)
16-04-2015	SO239/161-1	10	01:53	Tanaid	Slurp gun (chamber 5)
20-04-2015	SO239/189-1	1	19:30	Hexactinellid	Orion (Senckenberg box)
20-04-2015	SO239/189-1	2	19:55	Ophiuroid	Orion (Senckenberg box)
20-04-2015	SO239/189-1	3	20:12	Ophiuroid	Orion (Senckenberg box)
20-04-2015	SO239/189-1	4	20:25	Hexactinellid	Orion (Senckenberg box)
20-04-2015	SO239/189-1	5	20:35	Alcyonacean	Orion (small port side box)
20-04-2015	SO239/189-1	6	21:03	Hexactinellid	Orion (Senckenberg box)
20-04-2015	SO239/189-1	7	21:03	Polychaete on 6	Orion (Senckenberg box)
20-04-2015	SO239/189-1	8	21:25	Ophiuroid	Orion (Senckenberg box)
20-04-2015	SO239/189-1	9	21:33	Hexactinellid	Orion (Senckenberg box)
20-04-2015	SO239/189-1	10	21:48	Hexactinellid	Orion (Senckenberg box)
20-04-2015	SO239/189-1	11	21:58	Hexactinellid	Orion (Senckenberg box)
20-04-2015	SO239/189-1	12	22:23	Hexactinellid	Orion (Senckenberg box)
20-04-2015	SO239/189-1	13	22:42	Hexactinellid	Orion (Senckenberg box)
20-04-2015	SO239/189-1	14	23:00	Hexactinellid	Orion (Senckenberg box)
20-04-2015	SO239/189-1	15	23:12	Hexactinellid	Orion (Senckenberg box)
20-04-2015	SO239/189-1	16	23:35	Hexactinellid	Orion (Senckenberg box)
20-04-2015	SO239/189-1	17	23:50	Hexactinellid	Orion (Senckenberg box)
20-04-2015	SO239/189-1	18	23:57	Polychaete	Slurp gun (chamber 1)
21-04-2015	SO239/189-1	19	00:05	Hexactinellid	Orion (Senckenberg box)
21-04-2015	SO239/189-1	20	00:11	Hexactinellid	Orion (Senckenberg box)
21-04-2015	SO239/189-1	21	00:17	Hexactinellid	Orion (Senckenberg box)
21-04-2015	SO239/189-1	22	00:25	Stalk with cirripeds	Orion (Senckenberg box)
21-04-2015	SO239/189-1	23	01:05	Wood fragment	Orion (small port side box)
22-04-2015	SO239/200-1	1	18:25	Hexactinellid	Orion (Senckenberg box)
22-04-2015	SO239/200-1	2	18:30	Hexactinellid	Orion (grey lidded box)
22-04-2015	SO239/200-1	3	18:41	Ophiuroid	Orion (Senckenberg box)
22-04-2015	SO239/200-1	4	18:50	Alcyonacean	Orion (Senckenberg box)
22-04-2015	SO239/200-1	5	18:55	Alcyonacean on nodule	Orion (small port side box)
22-04-2015	SO239/200-1	6	19:05	Hexactinellid	Orion (Senckenberg box)
22-04-2015	SO239/200-1	7	19:13	Crinoid	Orion (Senckenberg box)
22-04-2015	SO239/200-1	8	19:23	Hexactinellid	Orion (Senckenberg box)
22-04-2015	SO239/200-1	9	19:49	Ophiuroid	Orion (Senckenberg box)
22-04-2015	SO239/200-1	10	20:13	Hexactinellid	Orion (Senckenberg box)
22-04-2015	SO239/200-1	11	20:23	Ophiuroid	Orion (Senckenberg box)
22-04-2015	SO239/200-1	12	20:32	Antipatharian	Orion (small port side box)
22-04-2015	SO239/200-1	13	20:55	Pennatulacean	Orion (Senckenberg box)
22-04-2015	SO239/200-1	14	21:12	Ophiuroid	Orion (Senckenberg box)
22-04-2015	SO239/200-1	15	21:12	Tunicate (?)	Orion (Senckenberg box)
22-04-2015	SO239/200-1	16	21:20	Ophiuroid	Orion (Senckenberg box)
22-04-2015	SO239/200-1	17	21:35	Ophiuroid	Orion (Senckenberg box)
22-04-2015	SO239/200-1	18	21:50	Alcyonacean	Orion (small port side box)

22-04-2015	SO239/200-1	19	22:04	Ophiuroid	Orion (Senckenberg box)
22-04-2015	SO239/200-1	20	22:20	Ophiuroid	Orion (Senckenberg box)
22-04-2015	SO239/200-1	21	22:57	Pennatulacean	Orion (small port side box)
22-04-2015	SO239/200-1	22	23:04	Galatheid	Slurp gun (chamber 1)
22-04-2015	SO239/200-1	23	23:12	Ophiuroid	Orion (Senckenberg box)
23-04-2015	SO239/200-1	24	00:50	*Branchiocerianthus*	Orion (Senckenberg box)
23-04-2015	SO239/200-1	25	01:09	Hexactinellid	Orion (Senckenberg box)
23-04-2015	SO239/200-1	26	01:34	Ophiuroid	Orion (Senckenberg box)
23-04-2015	SO239/200-1	27	01:45	Ophiuroid	Orion (Senckenberg box)
23-04-2015	SO239/200-1	28	01:48	Ophiuroid	Orion (Senckenberg box)
23-04-2015	SO239/200-1	29	01:54	Ophiuroid	Orion (Senckenberg box)
24-04-2015	SO239/212-1	1	16:21	Hexactinellid	Orion (Senckenberg box)
24-04-2015	SO239/212-1	2	16:30	Hexactinellid	Orion (Senckenberg box)
24-04-2015	SO239/212-1	3	16:51	Actinians on stalk	Orion (Senckenberg box)
24-04-2015	SO239/212-1	4	16:51	Alcyonacean on stalk	Orion (Senckenberg box)
24-04-2015	SO239/212-1	5	16:51	Cirripeds on stalk	Orion (Senckenberg box)
24-04-2015	SO239/212-1	6	17:25	Hexactinellid	Orion (Senckenberg box)
24-04-2015	SO239/212-1	7	17:28	Alcyonacean	Orion (Senckenberg box)
24-04-2015	SO239/212-1	8	18:00	Alcyonacean	Orion (grey lidded box)
24-04-2015	SO239/212-1	9	18:14	Pennatulacean	Orion (small port side box)
24-04-2015	SO239/212-1	10	18:24	Cirripeds on stalk	Orion (Senckenberg box)
24-04-2015	SO239/212-1	11	18:30	Alcyonacean	Orion (Senckenberg box)
24-04-2015	SO239/212-1	12	18:52	Hexactinellid	Orion (Senckenberg box)
24-04-2015	SO239/212-1	13	18:56	Goose barnacle	Orion (Senckenberg box)
24-04-2015	SO239/212-1	14	19:38	Hexactinellid	Orion (Senckenberg box)
24-04-2015	SO239/212-1	15	19:51	Alcyonacean	Orion (small port side box)
24-04-2015	SO239/212-1	16	20:15	Antipatharian	Orion (small port side box)
24-04-2015	SO239/212-1	17; 18	20:25	Scleractinians	Slurp gun (chamber 2)
24-04-2015	SO239/212-1	19	20:40	Hexactinellid fragment	Orion (Senckenberg box)
24-04-2015	SO239/212-1	20	21:08	Large alcyonacean	Orion (Senckenberg box)
24-04-2015	SO239/212-1	21	21:08	Large ophiuroid on 20	Orion (Senckenberg box)
24-04-2015	SO239/212-1	22	21:19	Ophiuroid	Slurp gun (chamber 3)
24-04-2015	SO239/212-1	23; 24	21:25	Scleractinians	Slurp gun (chamber 4)

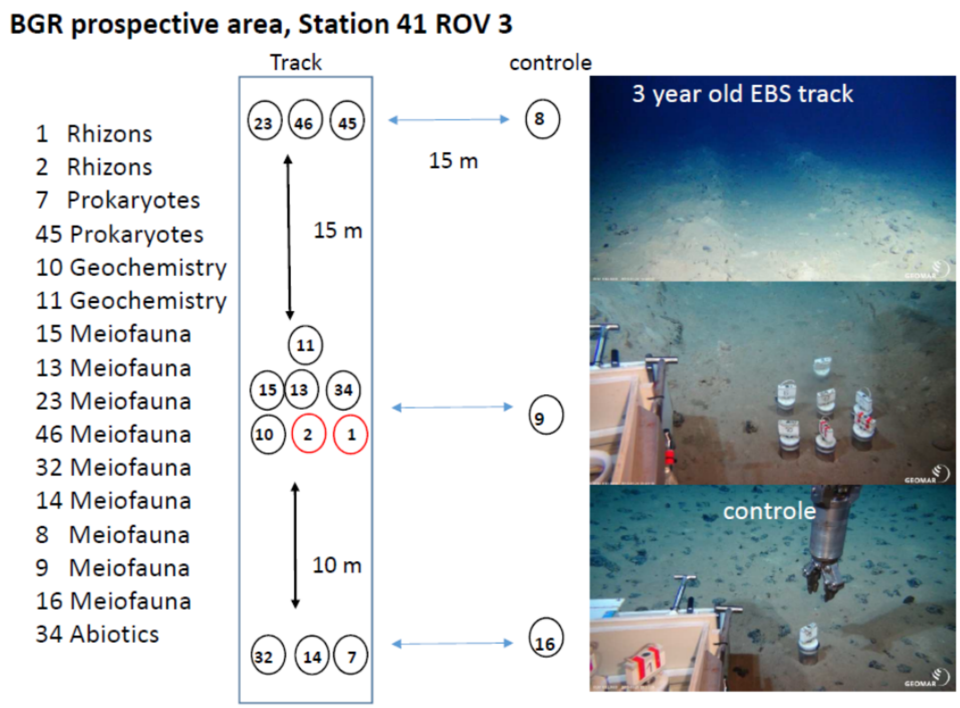
7.2.8.4 Push cores

Sediment samples were taken during several ROV dives by means of push cores (16 in total per dive with an inner diameter of 74 mm) for two areas (IOM and IFREMER) where more than two decades ago (20 and 37 years) mining simulations were performed experimentally, as well as in two areas with recent trawl tracks (8 months in GSR and 3 years old in IFREMER). Furthermore also two fresh EBS tracks (BGR and GSR) of 1 day old made during this cruise were sampled. Each time more or less the same approach was done, as visualized in the figures presented in ROV dive descriptions. Two cores were sampled for prokaryotes (processed by Andrea Fioretti, Conisma), 4 cores were sampled for geochemistry of which two cores had holes (indicated in red in the schematic representations and on the pictures) (processed by AWI and JUB), 1 core was sliced for abiotic factors (UGent) and the remaining were sliced in the cold room for meiofauna analysis. Upper 5 cm were sliced per cm and fixed in formaldehyde (occasionally DESS) for further community analysis. These samples will be processed by DZMB (focus on copepods) and UGent (focus on nematodes). The aim of these experiments is to investigate resilience and recovery of the micro and meiofauna after mining disturbance, in relation to the environmental changes following the mining.

In the following pages we present a description of push core samples per dive, as well as the respective sampling schemes.

ROV dive 3

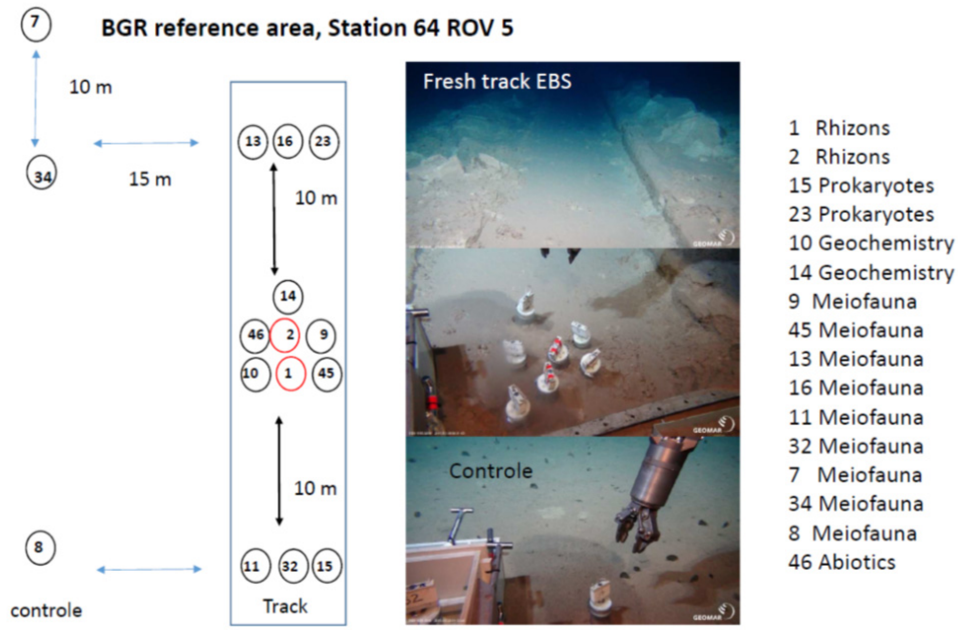
During ROV dive 3 on 25/05/2015 push cores samples were taken in a 3 year old track from the same EBS as used during So 239 cruise. Cores were taken according to the following scheme. Coordinates and water depth are given in the table below.



Latitude	Longitude	depth (m)	Labels of push cores
-117.0576553	**11.8419218**	**4099.6**	**7, 14, 32**
-117.0575104	**11.841918**	**4099.6**	**16**
-117.0576706	**11.8420944**	**4099.2**	**1, 2, 10, 13, 15, 34, 11**
-117.0575027	**11.8419743**	**4099.4**	**9**
-117.0575104	**11.8422184**	**4098.8**	**46, 23, 45**
-117.0574341	**11.8421745**	**4099.1**	**8**

ROV dive 5

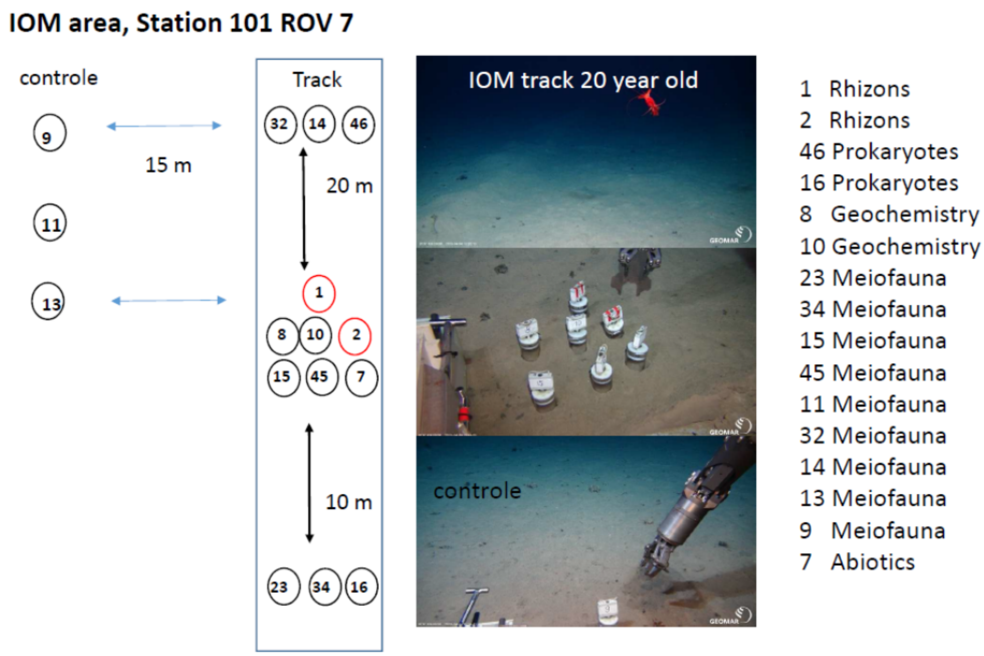
During ROV dive 5 on 30/03/2015 push cores samples were taken in a 1 day old track from the EBS used in this cruise. Cores were taken according to the following scheme. Coordinates and water depth are given in the table below.



Latitude	Longitude	depth (m)	Labels of push cores
-117.5032654	**11.8045263**	**4332**	**11, 32, 15**
-117.5031433	**11.8045435**	**4332**	**8**
--117.5032425	**11.8044662**	**4332**	**1,2,10,9,14,45,46**
-117.5033722	**11.804616**	**4332.1**	**13,16,23**
-117.5031815	**11.8043489**	**4332.2**	**34**
-117.5033951	**11.8043346**	**4332.2**	**7**

ROV dive 7

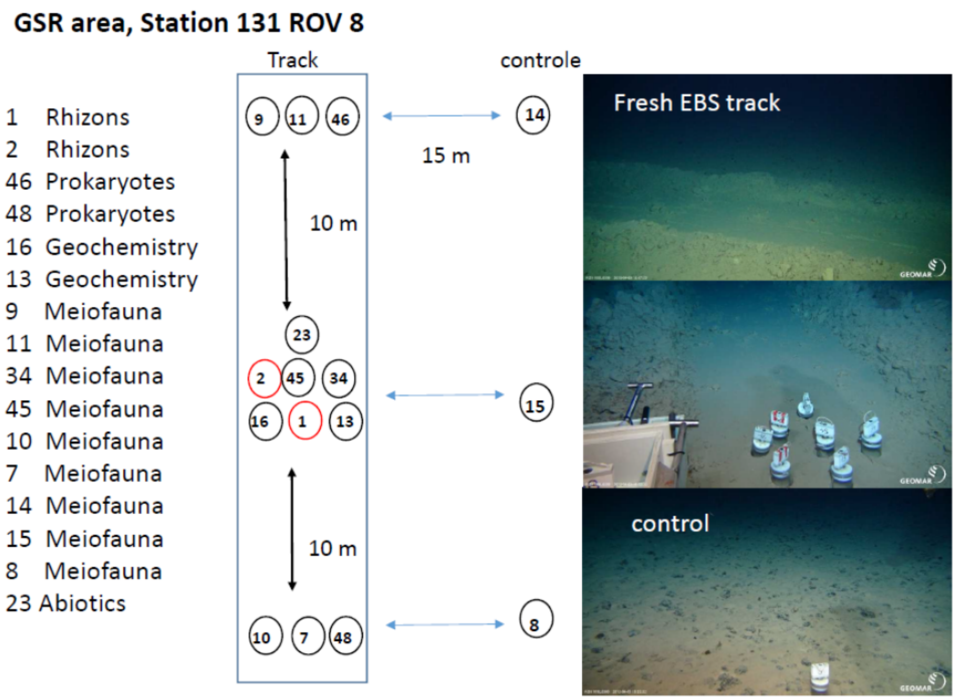
During ROV dive 7 on 04/04/2015 push cores samples were taken in a 20 year old track from IOM BIE. Cores were taken according to the following scheme. Coordinates and water depth are given in the table below.



Latitude	Longitude	depth (m)	Labels of push cores
-119.6567307	**11.0732336**	**4388.3**	**23,34,16**
-119.6565781	**11.0733414**	**4387.4**	**1,2,7,8,10,15,45**
-119.6567764	**11.0734158**	**4388**	**13**
-119.6567612	**11.0734701**	**4387.4**	**11**
-119.6567001	**11.0736055**	**4386.4**	**9**
-119.6565247	**11.0734367**	**4386**	**32,14,46**

ROV dive 8

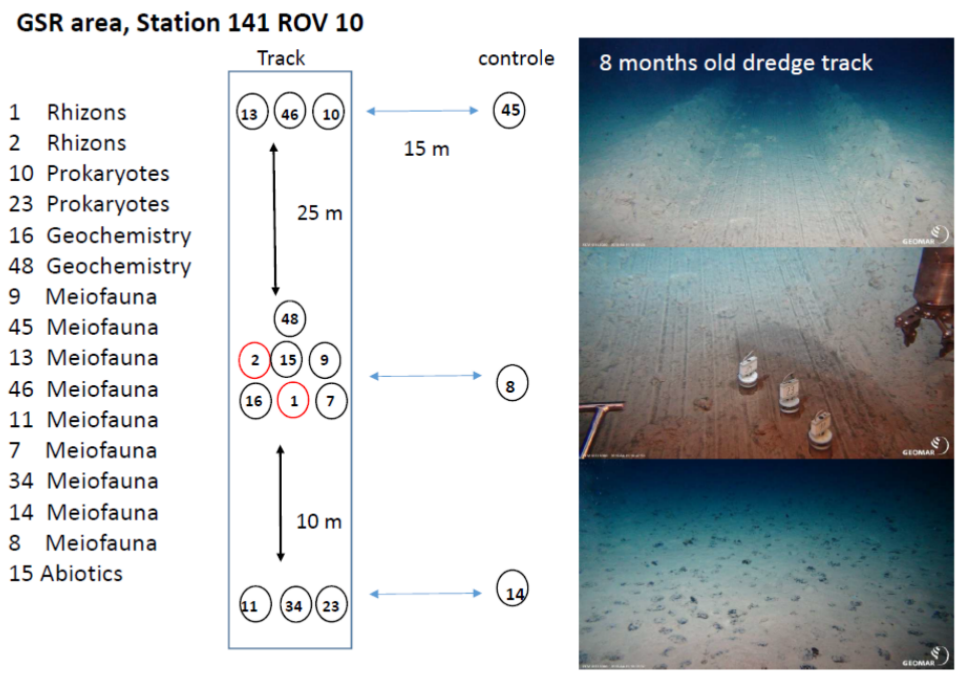
During ROV dive 8 on 09/04/2015 push cores samples were taken in a 1 day old track from the EBS used in this cruise. Cores were taken according to the following scheme. Coordinates and water depth are given in the table below.



Latitude	Longitude	depth (m)	Labels of push cores
-123.2516251	**13.8732166**	**4477.8**	**7,10,48**
-123.2516861	**13.8733263**	**4477.6**	**8**
-123.251709	**13.873189**	**4477.6**	**1,2,13,16,23,45,34**
-123.2520599	**13.8732338**	**4477.4**	**15**
-123.2516785	**13.8731699**	**4477.7**	**9,11,46**
-123.2518692	**13.873311**	**4477.3**	**14**

ROV dive 10

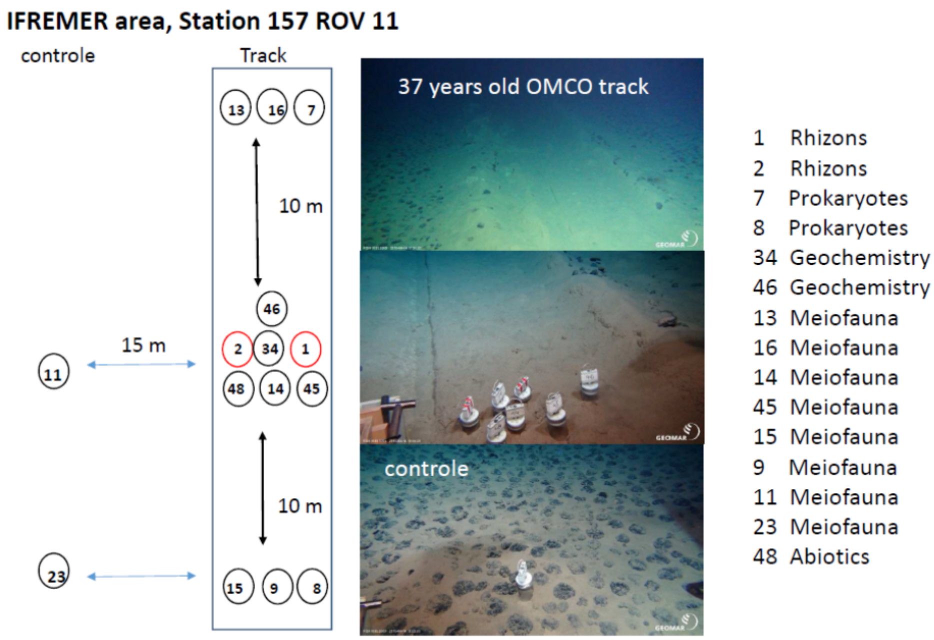
During ROV dive 10 on 11/04/2015 push cores samples were taken in a 8 month old dredge track from a dredge used during July/August 2014 GSR cruise. Cores were taken according to the following scheme. Coordinates and water depth are given in the table below.



Latitude	Longitude	depth (m)	Labels of push cores
-123.2557678	13.8661785	4476.7	11, 34, 23
-123.2560425	13.8659658	4477	14
-123.255806	13.8659239	4477.2	8
-123.2558517	13.866128	4477	1,2,7,9,15,16,48
-123.2555237	13.8660545	4477.9	10,13,46
-123.2555161	13.8659029	4478.3	45

ROV dive 11

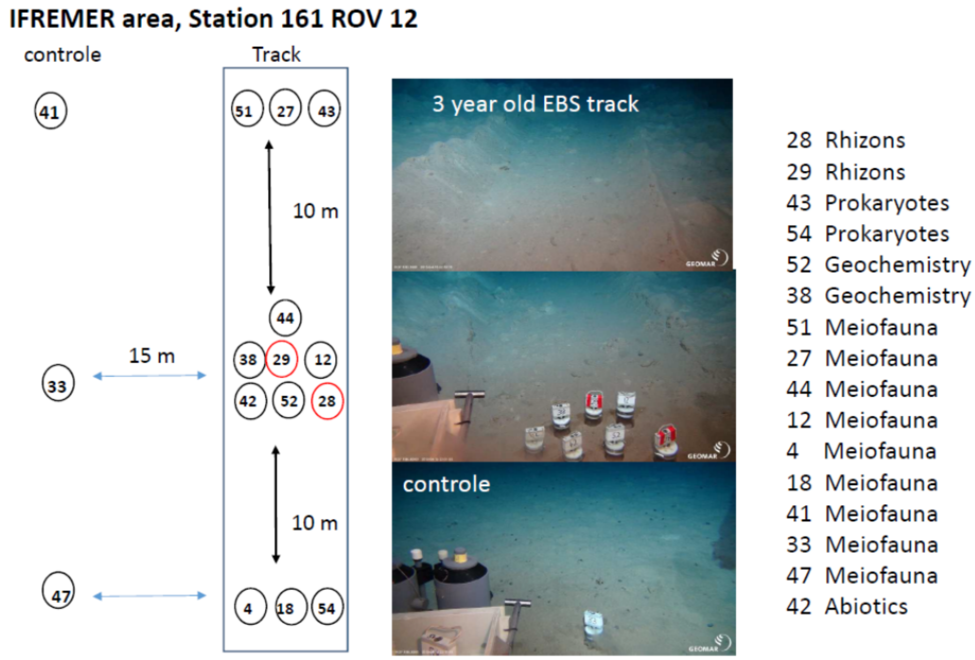
During ROV dive 11 on 14/04/2015 push cores samples were taken in a 37 years old track from the OMCO experiment. Cores were taken according to the following scheme. Coordinates and water depth are given in the table below.



Latitude	Longitude	depth (m)	Labels of push cores
-130.1205292	**14.0343323**	**4944.1**	**9,15,8**
-130.1206665	**14.0343533**	**4944.2**	**23**
-130.1206818	**14.0344257**	**4944.1**	**11**
-130.1205444	**14.0343752**	**4944.5**	**14,45,46,48,34,2,1**
-130.1205292	**14.0344324**	**4944.4**	**13,7,16**
Final control core failed			

ROV dive 12

During ROV dive 12 on 15/04/2015 push cores samples were taken in a 3 years old track from the EBS taken during the BIONOD cruise. Cores were taken according to the scheme as presented here. Coordinates and water depth are given in the following table.



Latitude	Longitude	depth (m)	Labels of push cores
-130.0979614	14.0369101	4998.6	18,4,54
-130.0979919	14.0370636	4998.3	47
-130.0982056	14.0369654	4999.1	12,28,29,38,42,44,52
-130.0979462	14.0371399	4998.6	33
-130.0977325	14.0371532	4998.7	41
-130.0978088	14.0369768	4999	27,43,51

7.2.9 Megafauna collection (Hilário, Kersken, Ribeiro)

7.2.9.1 Objectives

Previous cruises in the CCFZ revealed and documented by photography and video a considerable diversity of megafauna. Most of this diversity, however, remains undescribed due to the difficulty of sampling at abyssal depths. The use of the ROV Kiel 6000 allowed the collection of specimens that will be used for species identification and description, as well as population connectivity and reproductive and trophic ecology studies. Although the collection was focused in three main groups, Porifera, Anthozoa and Ophiurodea, representatives of other taxa were also collected.

7.2.9.2 Sample processing

A total of 186 individuals were collected during the 15 ROV dives, all of which were photographed in situ prior to collection (Table 7.2.9.1). Most specimens were collected individually using the manipulator arm "Orion" and placed in a thermally stable biobox for transport to the surface. When possible the hard substrate to which the animals were attached was collect to avoid damaging the specimens (Fig. 7.2.9.1). Occasionally specimens were also collected using the suction sampler.

Once on deck, all individuals were immediately transferred to clean, cold seawater and placed in a cold room (0 – 4°C) for processing. The specimens were photographed and then subsampled. Two tissue subsamples were taken from each individual: one was fixed in 96% ethanol and placed at -20ºC and the other was preserved at -80ºC. After subsampling the specimens were fixed in 96% ethanol or 10% formalin, the latter were transferred to 80% ethanol after 48 hours. Samples were distributed among different research groups as summarized in table 7.2.9.2.

Fig: 7.2.9.1 Ophiuroid and alcyonacean coral being collected with the Orion arm of the ROV Kiel 6000.

Table 7.2.9.1 Sampled corals, ophiuroids and sponges from 15 dives with ROV Kiel 6000 (Mn = Manganese nodule area, Sm = Seamount, Ref = Reference area; BGR = Bundesanstalt für Geowissenschaften und Rohstoffe, IOM = Interoceanmetal, GSR = G-TEC Minerals Resources NV, IFREMER = Institut Français de Rechérche pour l'Exploitation de la Mer, APEI = Area of particular environmental interest)

ROV Dive#	Station	Area	No. of specimens	Taxa
1	SO239/13-1	BGR Mn 1	3	Alcyonacea
			2	Hexactinellida
			5	Ophiuroidea
2	SO239/29-1	BGR Sm 1	1	Alcyonacea
			1	Aphroditidae
			3	Hexactinellida
3	SO239/41-1	BGR Mn 2	1	Antipatharia
			1	Hexactinellida
4	SO239/54-1	BGR Sm 2	1	Antipatharia
			1	Echinoidea
			3	Hexactinellida
			1	Isididae
			2	Pennatulacea
			1	Primnoidae
			3	Ophiuroidea
5	SO239/64-1	BGR Ref	6	Hexactinellida
			14	Ophiuroidea
6	SO239/82-1	IOM Mn	7	Alcyonacea
			11	Hexactinellida
			8	Ophiuroidea
7	SO239/101-1	IOM Ref	1	Alcyonacea
			1	Echinoidea
			2	Hexactinellida
			1	Holothuroidea
			2	Ophiuroidea
8	SO239/131-1	GSR Mn	3	Alcyonacea
			6	Hexactinellida
			9	Ophiuroidea
9	SO239/135-1	GSR Sm	1	Alcyonacea
			8	Hexactinellida
10	SO239/141-1	GSR Ref	4	Alcyonacea
			2	Hexactinellida
			7	Ophiuroidea
11	SO239/157-1	IFREMER 1	1	Alcyonacea
			4	Hexactinellida
12	SO239/161-1	IFREMER 2	2	Alcyonacea
			2	Hexactinellida
13	SO239/189-1	APEI 3	1	Alcyonacea
			11	Hexactinellida
			3	Ophiuroidea
14	SO239/200-1	APEI 3	1	Antipatharia
			1	Crinoidea
			6	Hexactinellida
			1	Hydrozoa
			12	Ophiuroidea
			1	Tunicata
15	SO239/212-1	APEI 3 Sm	4	Alcyonacea
			1	Antipatharia
			7	Hexactinellida
			5	Ophiuroidea
			1	Pennatulacea

Table 7.2.9.2 Distribution of samples.

Taxa	Subsample	Used for	Responsible
Porifera	96% ethanol	Taxonomy	D. Kersken
	96% ethanol (-20ºC)	Taxonomy, connectivity	D. Kersken
	-80ºC	Taxonomy, connectivity, trophic ecology	D. Kersken
Anthozoa	96% ethanol	Taxonomy	P. Ribeiro
	96% ethanol (-20ºC)	Taxonomy, connectivity	P. Ribeiro
	-80ºC	Taxonomy, connectivity, trophic ecology	P. Ribeiro
Ophiuroidea	10% Formalin	Taxonomy, reproductive ecology	A. Hilário
	96% ethanol (-20ºC)	Taxonomy, connectivity	P. Martinez
	-80ºC	Taxonomy, connectivity, trophic ecology	P. Martinez
Cirripedia	96% ethanol	Taxonomy, connectivity	H. Robert
Other	96% ethanol	Taxonomy	P. Martinez

7.2.9.3 Preliminary Results

a) Porifera

All sampled sponges (phylum Porifera) belong to the class Hexactinellida. Seventy-three specimens were collected from manganese nodules, sediment or pillow basalt (Fig. 7.2.9.2). A total of 19 morphotypes were identified, eight of which are known from previous research on pacific deep-sea sponges: *Caulophacus*, *Chonelasma*, *Docosaccus*, *Eurete*/*Aphrocallistes*, *Hyalonema*, *Euplectella*, *Staurocalyptus* and *Farrea*. Sponges of the *Caulophacus*, *Farrea*, and *Hyalonema* morphotype show great morphological variability and may indicate the occurrence of different or cryptic species. The remaining eleven morphotypes are new to science and their taxonomy can only be resolved with further morphological and molecular analyses.

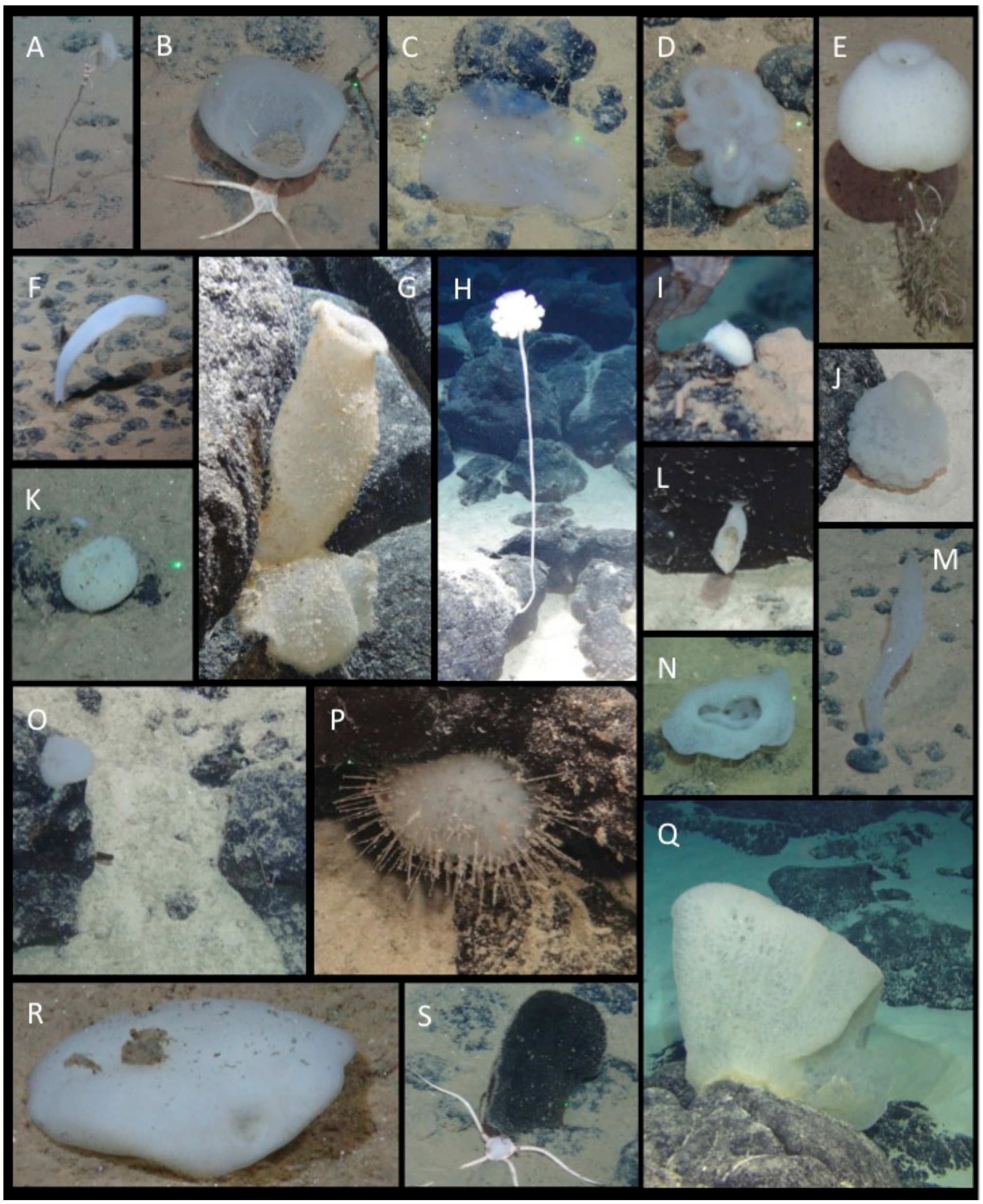


Fig. 7.2.9.2 Example of the different sponge morphotypes collected

b) Anthozoa

A total of 57 anthozoan samples were collected with ROV *Kiel6000* from manganese nodules, sediment or pillow basalt on seamounts (Figure 7.2.6.3). Specimens included 3 actiniarian samples with multiple individuals, 5 Pennatulaceans, 34 alcyonaceans, 9 antipatharians, 2 scleractinians, 1 bryozoan, and 3 hydrozoans, which in total comprised at least 18 morphotypes. Morphological and molecular analyses will be carried out to resolve their taxonomy. Based on availability of samples, selected alcyonaceans will also be the subject of phylogeographic analyses to investigate genetic structure across the CCZ.

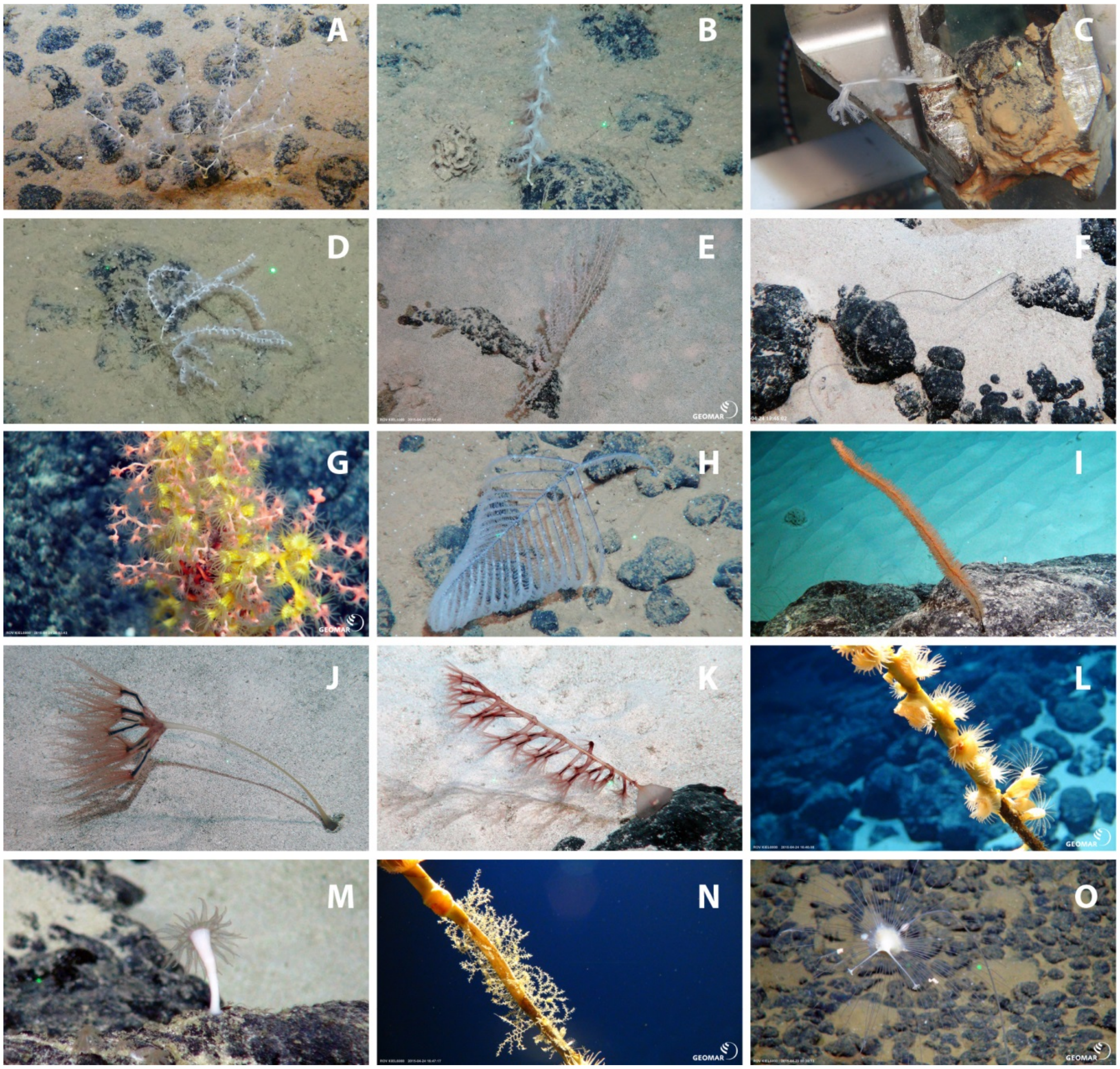


Fig. 7.2.6.3: Example of the different anthozoan morphotypes collected. A-G: Alcyonacea; H-I: Antipatharia; J-K: Pennatulacea; L: Actiniaria; M: Scleractinia; N-O: Hydrozoa.

c) Ophiuroidea (Hilario, Martinez Arbizu, Khodami)

We were able to collect specimens with the ROV. First look at large specimens reveal them to belong to the genus *Ophiomusium* while the species remain uncertain (cf. *armatum* or cf. *glabrum* or even a new species).

The material could be clustered in at least 7 different morphotypes, pending taxonomic identification.
.

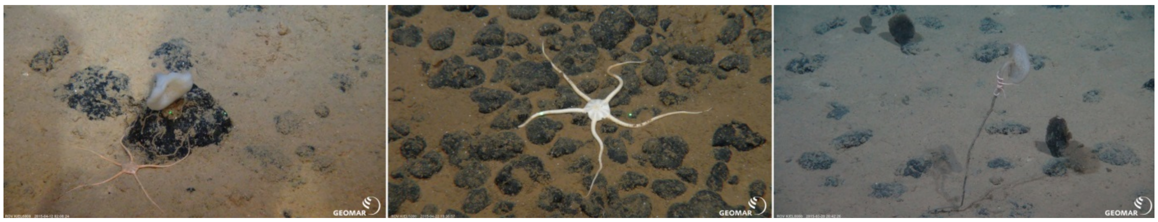


Fig. 7.2.9.4: Some Ophiuroids on nodule fields

Outlook

Based on results of morphological and biomolecular analyses it will be possible to give new insights into species distribution and connectivity as well as taxonomy and ecological resilience of megafauna from polymetallic nodule field systems in the Clarion Clipperton Fracture Zone. Results will be of crucial importance for establishment, assessment and evaluation of future protection strategies and help to understand the ecological aspects deep-sea mining.

7.2.10 AUV Image Management, Image Processing, Pattern Recognition & Mosaicking (Schoening)

Images were acquired by a customized Canon EOS 6D onboard the AUV „Abyss“. The camera was mounted behind a dome port and a fish-eye lens was used that produces wide field images with distortions that have to be calibrated for later analysis. „Abyss“ flew 7 to 12 meters above the seafloor so due to the light absorption under water, the images show a mostly blue color spectrum and an illumination drop-off towards the corners.

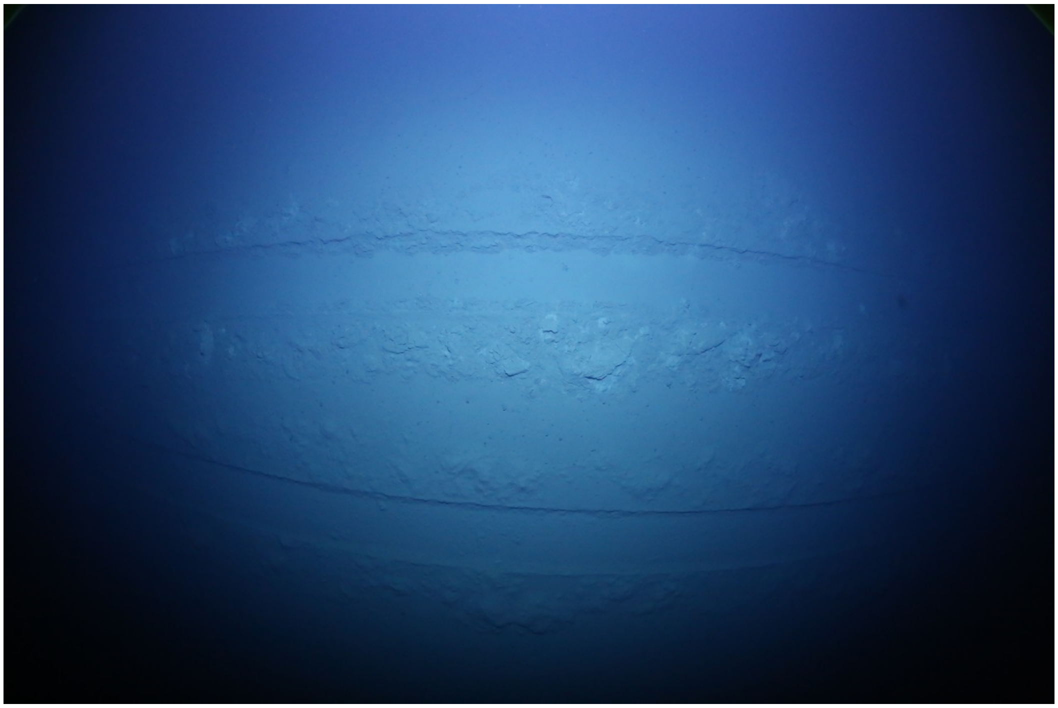


Fig. 7.2.10.1: One example of an AUV image, showing two EBS tracks.

Table 7.2.10.1: Overview of the dives. The image numbers in brackets show the amount of good images where the seafloor is clearly visible. SSS = Side Scan Sonar mission

Dive	Images	Area	Date	Notes
SO239_019_AUV2	44000 (30730)	German PA	21.03.15	
SO239_028_AUV3	24900 (23730)	German PA	23.03.15	
SO239_065_AUV6	30900 (25180)	German RA	30.03.15	
SO239_079_AUV7	19000 (10052)	IOM	01.04.15	SSS, Shutter broke
SO239_098_AUV8	22025 (2374)	IOM	04.04.15	Shutter broke
SO239_115_AUV9	6000 (3280)	Belgian	07.04.15	SSS
SO239_130_AUV10	10668 (9898)	Belgian	09.04.15	Camera broke
SO230_166_AUV15	14808 (9582)	French	16.04.15	
SO239_172_AUV16	18008 (17975)	French	17.04.15	
SO239_188_AUV17	30709 (30059)	APEI	20.04.15	
SO239_193_AUV18	22775 (21825)	APEI	21.04.15	SSS, RAW test
SO239_201_AUV19	5400 (1560)	APEI	23.04.15	
	249193 (186245)			

The following maps show the position of the AUV in red and positions with successful image acquisition (i.e. images that show the seafloor clearly) are marked in black.

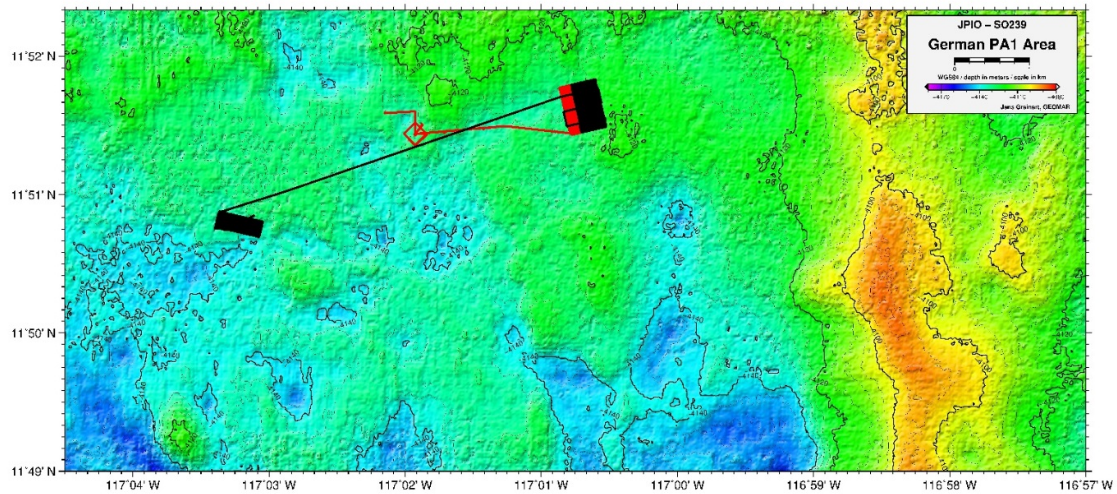


Fig. 7.2.10.2: SO239_019_AUV2 (Abyss_168, German PA, 21.03.15, 1Hz) – 44,000 images (30,730 good)
Notes: 0-7,600 (Water Col.) / 7,600-11,140 (Condensation) / 41,870-44,000 (Water Col.)

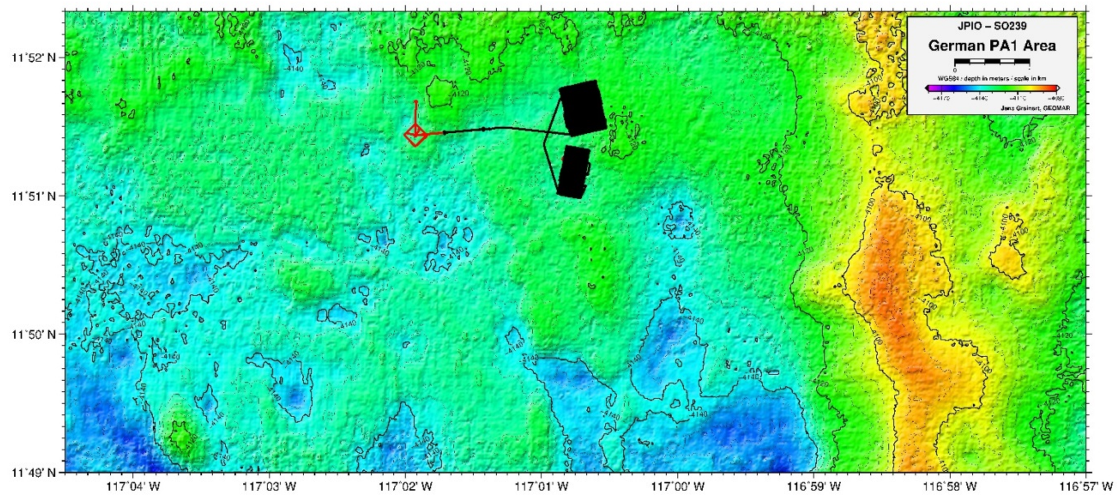


Fig. 7.2.10.3: SO239_028_AUV3 (Abyss_169, German PA, 23.03.15, 0.5 Hz) – 24,900 images (23730 good)
Notes: 0-4400 (Condensation), 24130-24900 (Water Column)

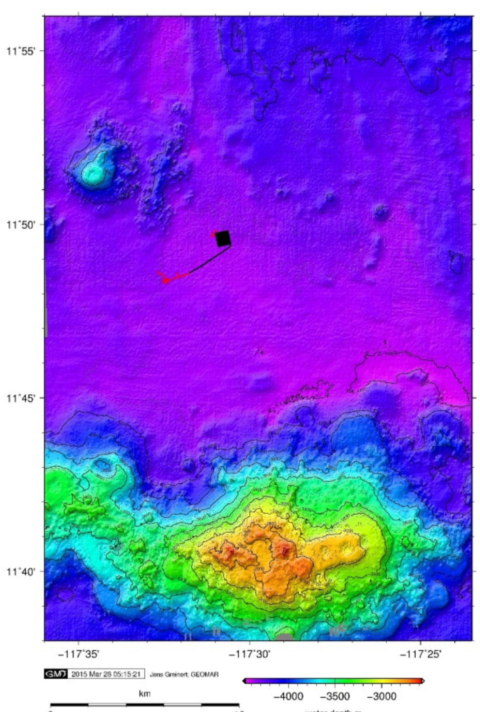


Fig. 7.2.10.4: SO239_065_AUV6 (Abyss_172, German RA, 30.03.15, 0.5 Hz) – 30,900 images (25180 good)
Notes: 0-650 (Water Colum), 25830-30900 (Water Column)

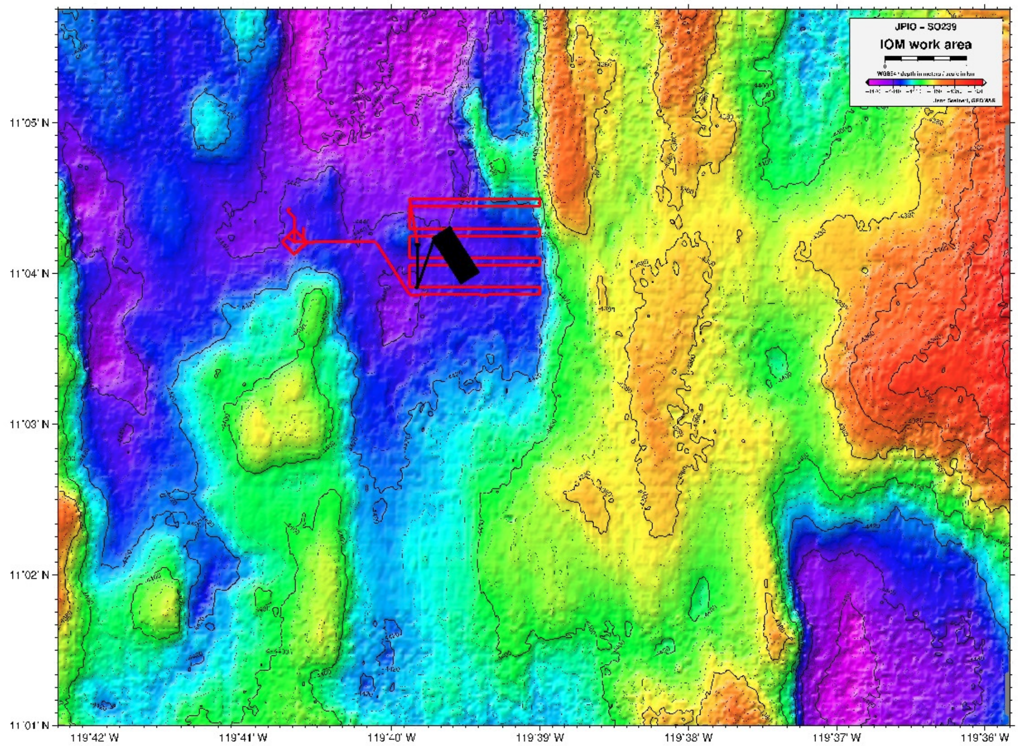


Fig. 7.2.10.5: SO239_079_AUV7 (Abyss_173, IOM, 01.04.15, 0.5 Hz) – 19,000 Images (10052 good)
Notes: SSS mission, 0-900 (Water Column), 10952-18561 (Broken Shutter)

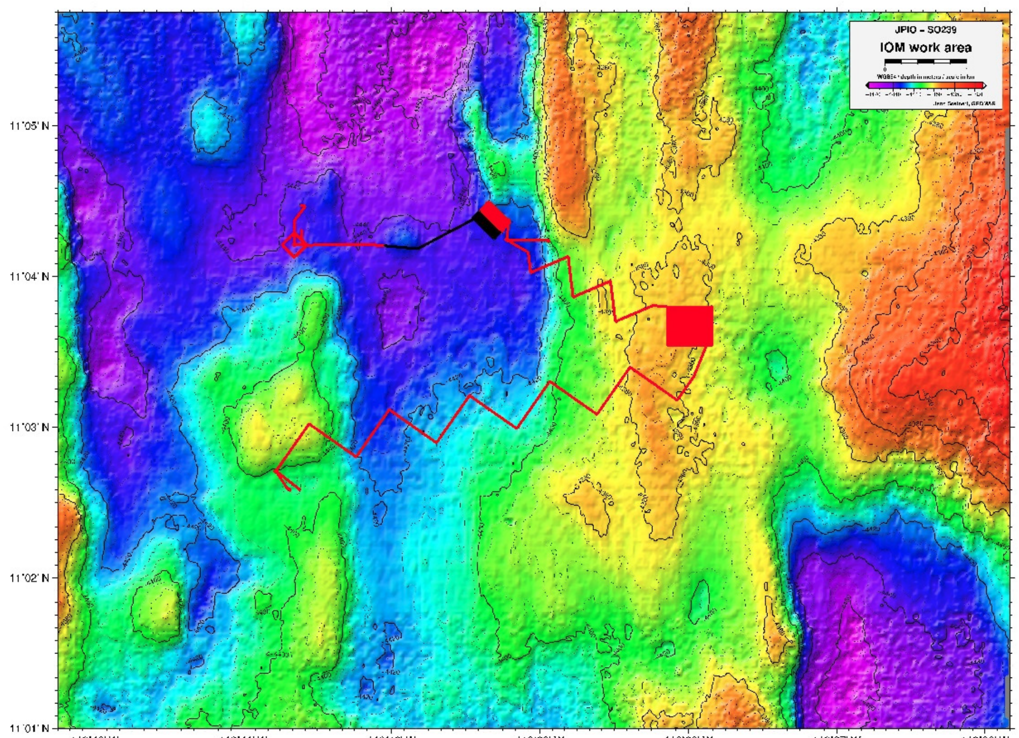


Fig. 7.2.10.6: SO239_098_AUV8 (Abyss_174, IOM, 04.04.15, 0.5 Hz) – 22025 Images (2374 good)
Notes: 0-690 (Water Column), 3065-22025 (Broken Shutter)

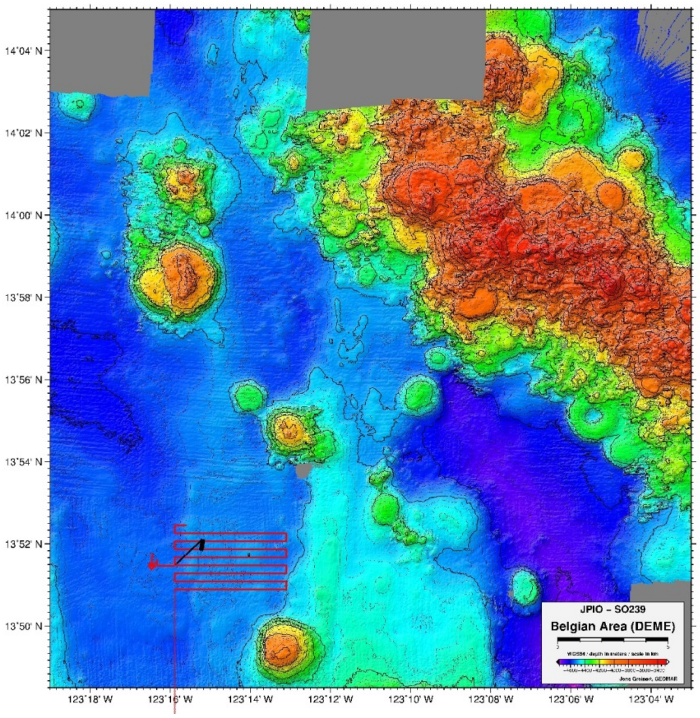


Fig. 7.2.10.7: SO239_115_AUV9 (Abyss_175, Belgian, 07.04.15, 0.5 Hz) – 6000 Images (3280 good)
Notes: SSS mission, 0-2720 (Water Column)

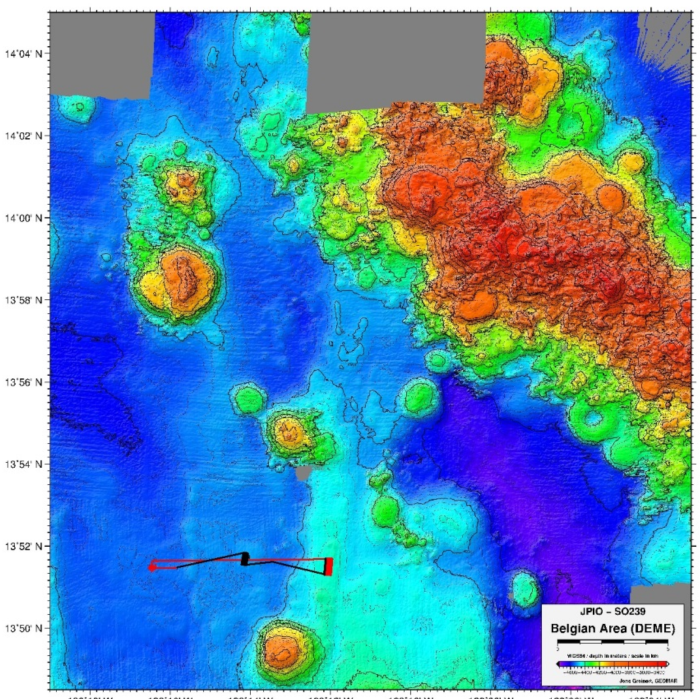


Fig. 7.2.10.8: SO239_130_AUV10 (Abyss_176, Belgian, 09.04.15, 0.5 Hz) – 10668 Images (9898 good)
Notes: 0-770 (Water Column)
Camera broke!

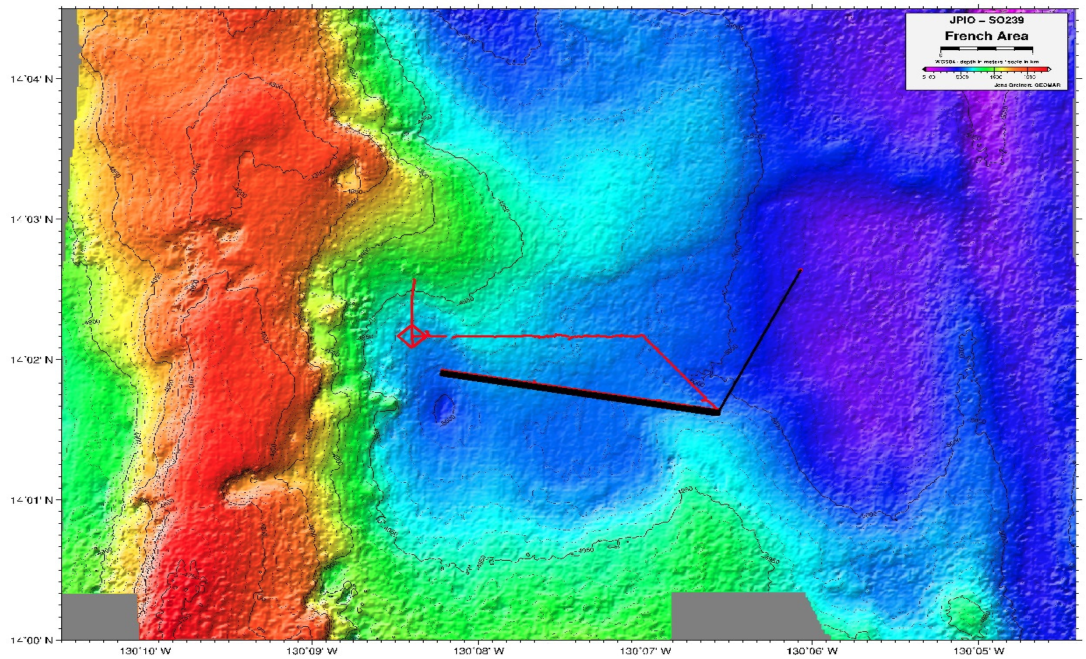


Fig. 7.2.10.9: SO239_166_AUV15 (Abyss_181, French, 16.04.15, 0.5 Hz) – 14808 Images (9582 good)
Notes: 0-2334 (Testpattern), 11916-14808 (Water Column)

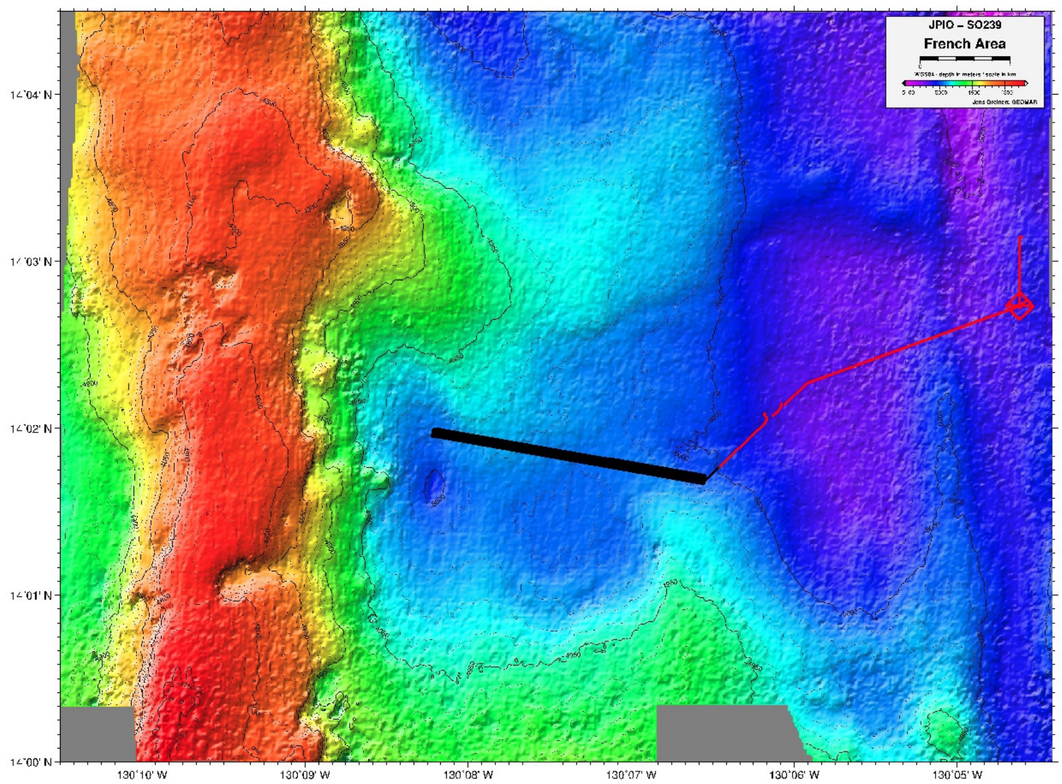


Fig. 7.2.10.10: SO239_172_AUV16 (Abyss_182, French, 17.04.15, 0.5 Hz) – 18008 Images (17975 good)
Notes: 0-33 (Testpattern), 17399-18008 (Water Column)

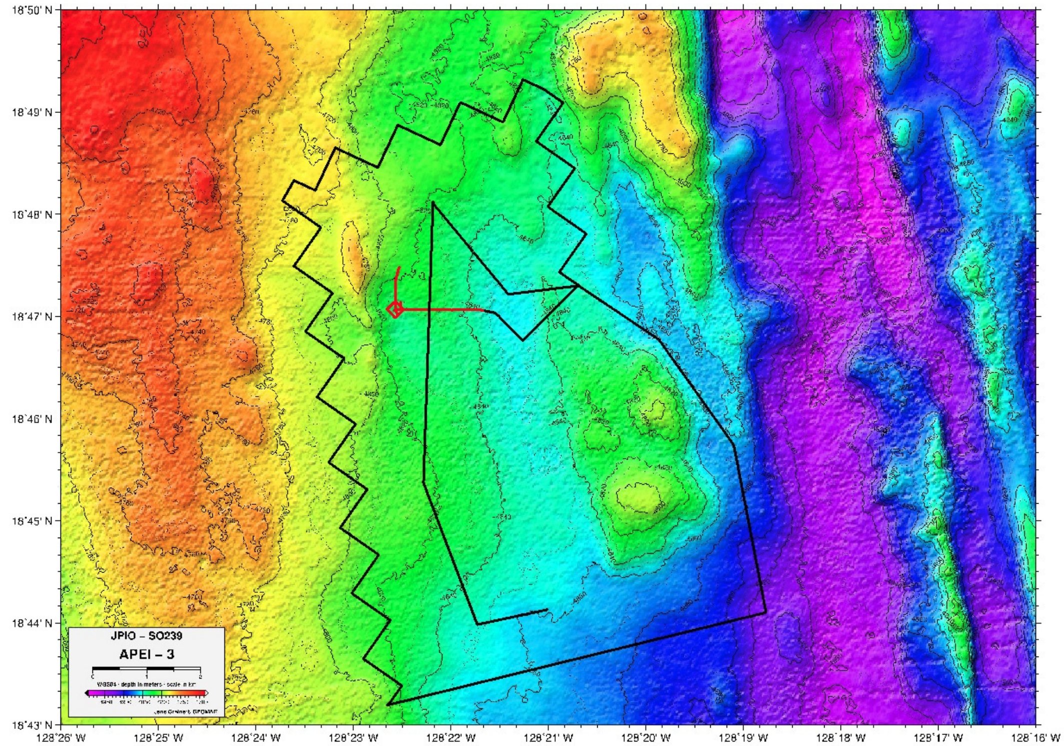


Fig. 7.2.10.11: SO239_188_AUV17 (Abyss_183, APEI, 20.04.15, 0.5 Hz) – 30709 Images (30059 good)
Notes: 0-650 (Water Column)

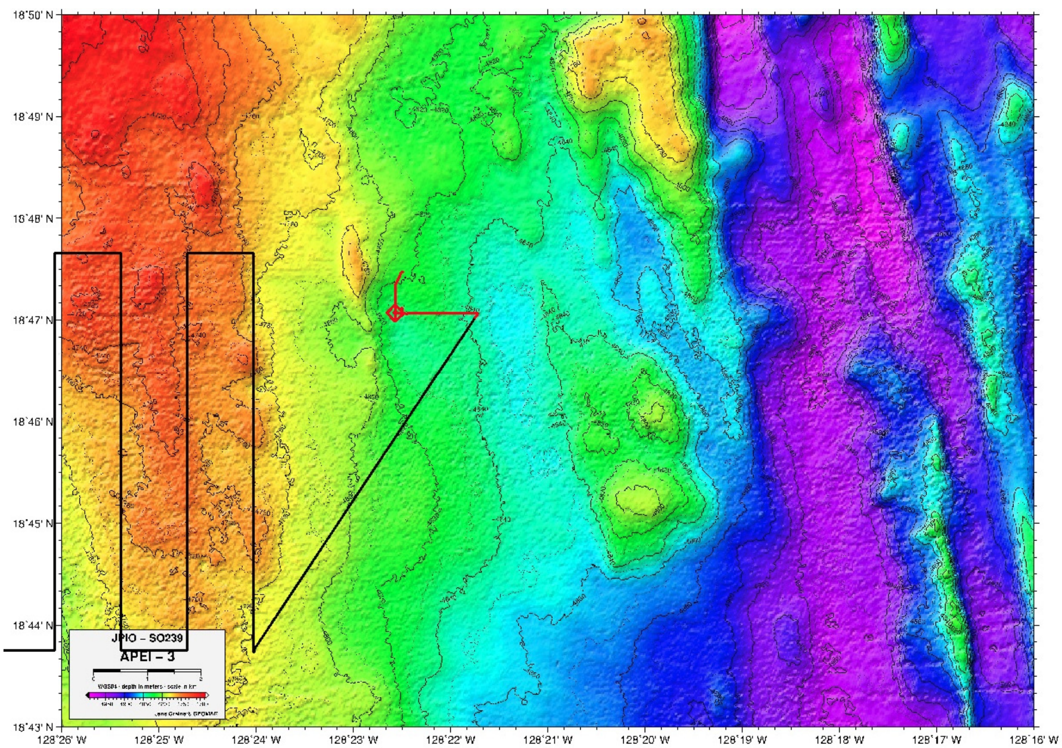


Fig. 7.2.10.12: SO239_193_AUV18 (Abyss_184, APEI, 21.04.15, 0.5 Hz) – 22775 Images (21825 good)
Notes: 0-950 (Water Column)

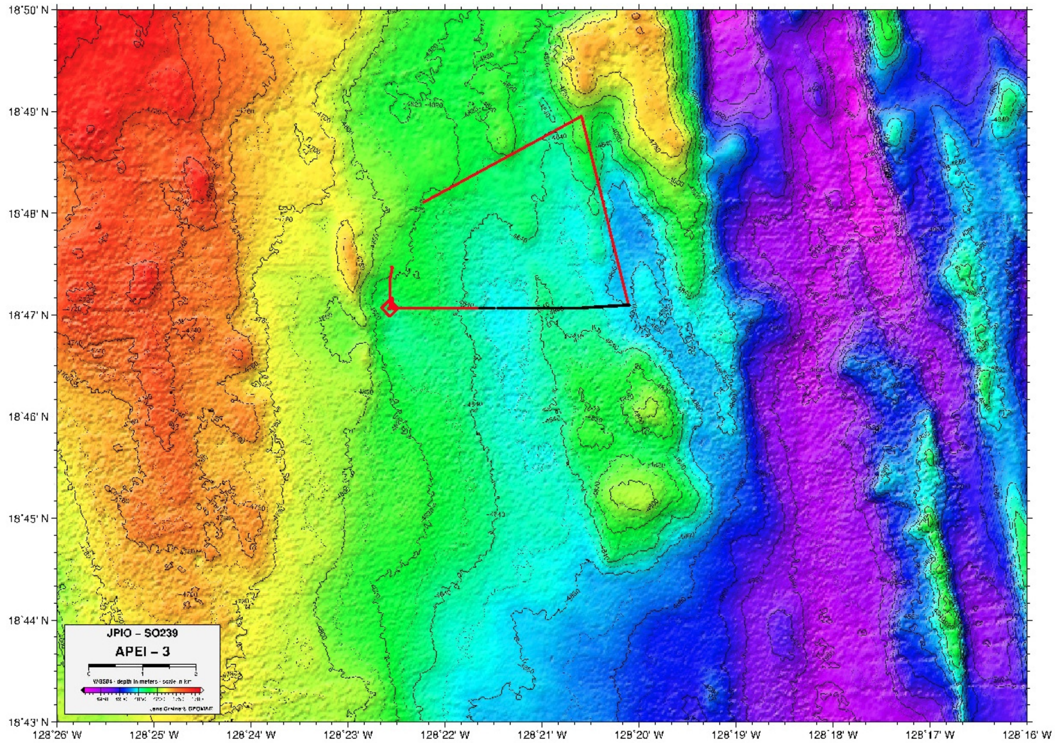


Fig. 7.2.10.13: SO239_201_AUV19 (Abyss_185, APEI, 23.04.15, 0.5 Hz) – 5400 Images (1560 good)
Notes: SSS mission + RAW image test, 0-1780 (Water Column), 3340-5400 (Water Column)

Image Management

In total, 12 dives with camera were conducted. 249,193 images were acquired of which 186,245 are of good quality. Further 26,569 are only partly usable.

After each dive with active camera setup, the data was transferred from the onboard hard disk to ship-based network-attached storage devices. Depending on the dive schedule, the transfer was conducted either via Ethernet (ca. 70 GB/h) by connecting the camera computer to the ships network or by disassembling the camera pressure bottle and retrieving the hard disk itself. Retrieving the hard disk is a time-consuming task (ca. 0.5h) but being able to copy the data from the hard disk via USB anyhow makes the whole process of data copying more efficient in most cases. The data was usually transferred to a portable USB hard disk first (ca. 700 GB/h) to be able to distribute the data to various target locations efficiently. Before distributing the data, the images where split up by time to subfolders, containing half an hour of images each (1800 images for the first dives with 1Hz, 900 for the later with 0.5 Hz). This step was necessary because even modern operating systems have difficulties to browse and display folders containing several ten thousands of files. After splitting, the first copy-target for the images is the image-processing computer that removes the image distortion caused by the employed fish-eye lens.

This calibration process takes around six seconds per image with the employed software. Thumbnails are generated alongside which takes another two seconds per image. On the employed processing computer (6 Cores, 3.5 GHz, 64 GB RAM) this step can be conducted in parallel in twelve processes and then takes around 1.9h per 10,000 (ca. 60 GB) images.

After calibration, the data was distributed to two of the NASs to provide access to the data for other scientists and to have a backup copy (ca. 2 x 350 GB/h).

During duplication of the data, the log files of the AUV were manually merged with available image meta-data (Filename, Filesize, ISO value, etc.). Therefore, first the data of the AUV state (roll, pitch, heading, temperature, turbidity, etc.) was merged with the ADCP data (altitude, latitude, longitude etc.) using the “Processing & Observations” tool in OFOP [CITE]. The available numerical data was splined to create one data-point per second. Afterwards the image data was added to this data array per time-stamp. The raw logs, as well as the merged and splined array, was saved alongside the images for long-time archival. This manual process takes ca. half an

hour. Afterwards, the images were added to the ship-based annotation software DIAS. Therefore, each dive was added as a project and each half-hour folder as a transect to the PostgreSQL database. Here, the thumbnails are required to provide a reasonably quick overview for the annotators. Adding the data to DIAS by parsing the files and accompanying splined log files takes ca. 5 minutes.
The complete pipeline from the AUV through all processing and copying steps to the final availability through the NASs and DIAS takes 0.55h per dive plus 22.5 min / GB i.e. ca. 22.3 h / 10,000 images. As some of the steps (Fish-Eye correction, Thumbnail generation) were conducted in parallel, this results in 7.3 days of continuous image processing for the annotation and archival preparation alone (on a single core computer it would have taken 23.2 days). Following steps like illumination correction, pattern recognition or mosaicking are not included!
To prevent data loss through baggage loss or disaster, the NASs were split up after the cruise between different flights and containers. Three of the participating institutions (Senckenberg, GEOMAR, Uni Bielefeld) received one copy of the data each. The data was made available online, again using the web-based annotation software DIAS [CITE] for continued manual annotation of objects of interest. The annotation database created onboard FS Sonne was made available through the server in Bielefeld and will be duplicated on the servers at the other two institutions.

Image processing was applied in three ways:

1. **Distortion calibration** using the BIAS Framework and the MIP software TFApplicationWx. This removes the fish-eye effect and so the straight lines as in the EBS tracks in the image appear straight rather than curved as in the original image.

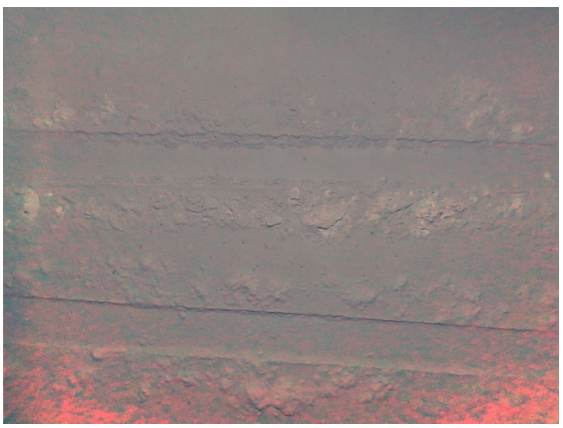
Fig. 7.2.10.14: Distortion calibration

2. **Colour and illumination correction** algorithms, were applied to selected images to find suitable methods for later image correction for the whole set of AUV images.

a) fSpice [1]

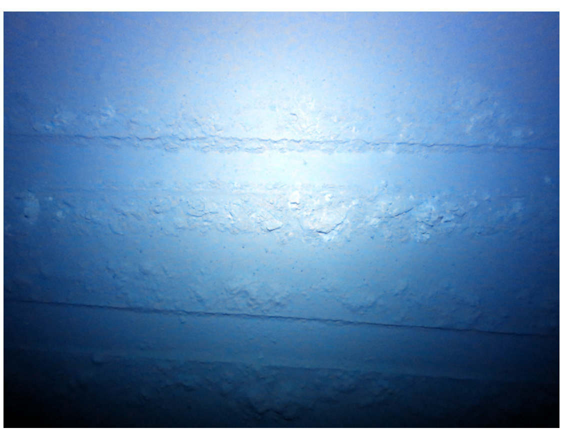
b) ACE [2]

c) MIP robustnormalization



d) RGB contrast correction

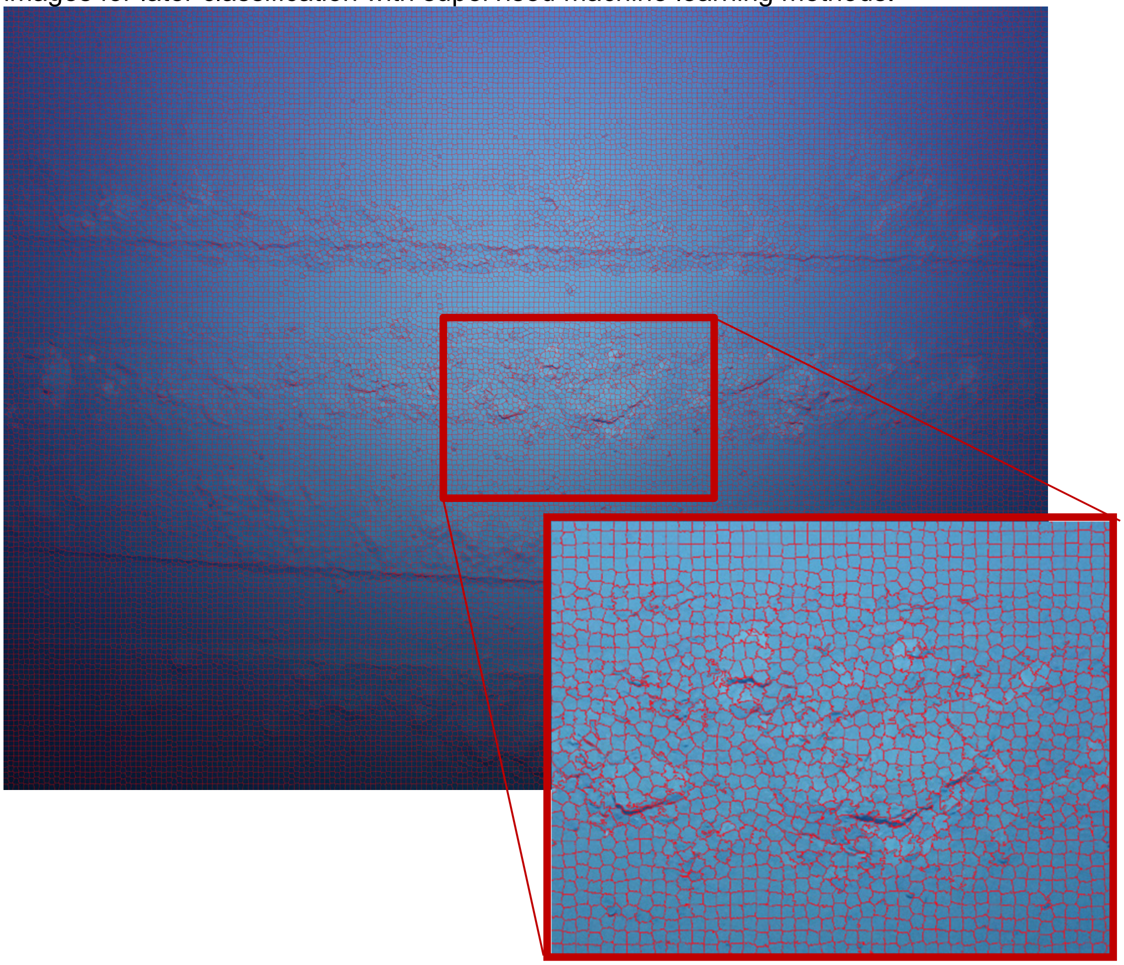
d) HSI contrast correction



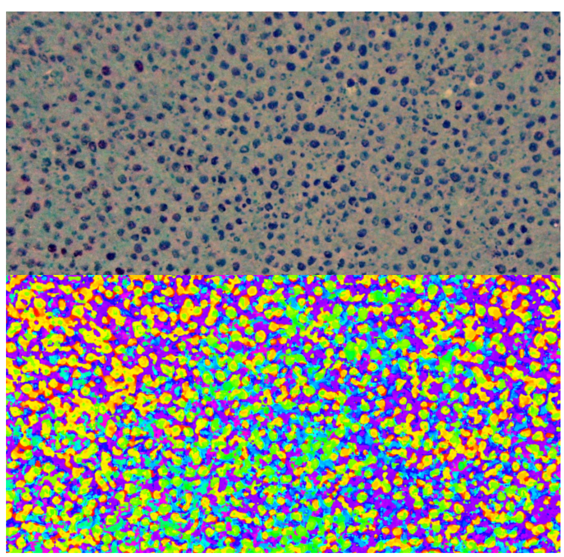
f) localSpaceAverageColorScaling

[1] Schoening, Timm, et al. "Semi-automated image analysis for the assessment of megafaunal densities at the Arctic deep-sea observatory HAUSGARTEN." PloS one 2012
[2] Chambah, Majed, et al. "Underwater color constancy: enhancement of automatic live fish recognition." Electronic Imaging 2004.

3. Superpixel segmentation to provide a low-level clustering of similar pixel patches in the images for later classification with supervised machine learning methods.



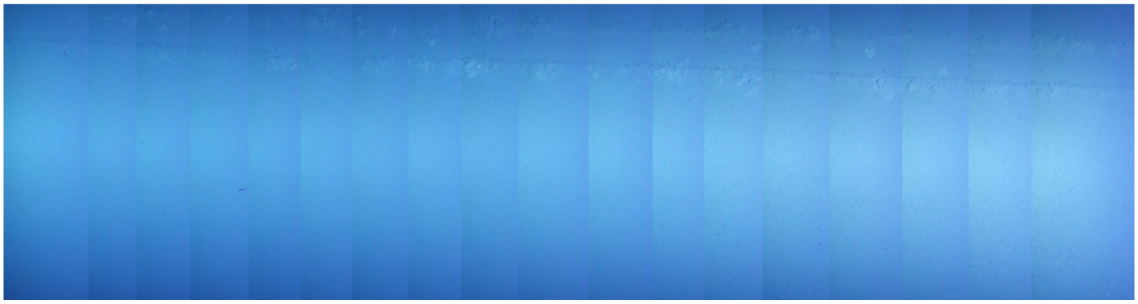
Pattern Recognition



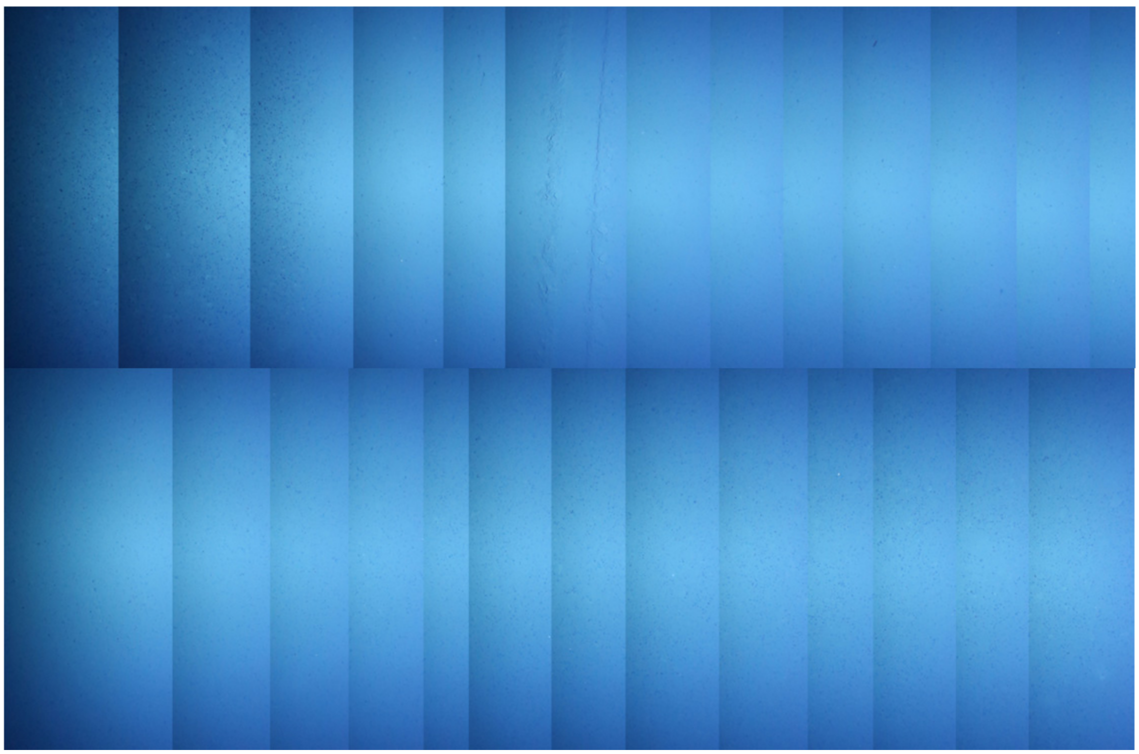
Due to the limit computation capabilities on board, only few image processing routines and only prerequisites for the nodule detection were executed. The fSpice corrected images were used as the input for a histogram feature computation. For each pixel in a set of input images, 48-dimensional feature vectors were computed (16 for each color channel) in a 15x15 pixel neighborhood. Those feature sets were then clusters with the unsupervised Hierarchical hyperbolical self-organizing map. Results of this clustering are colorful images where similar color represents similar features represented through cluster prototypes. Plotting the abundance of prototypes per image will gives an overview of the feature set along a transect of images.

Mosaicking

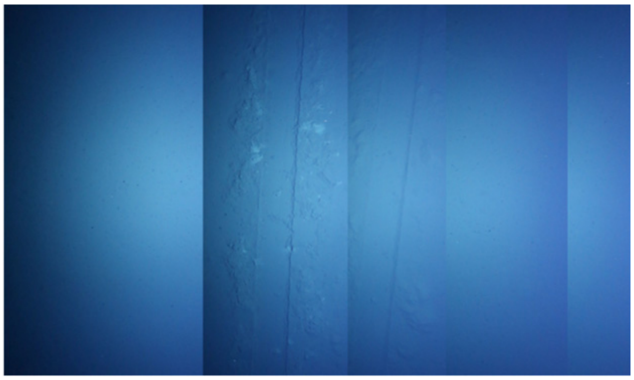
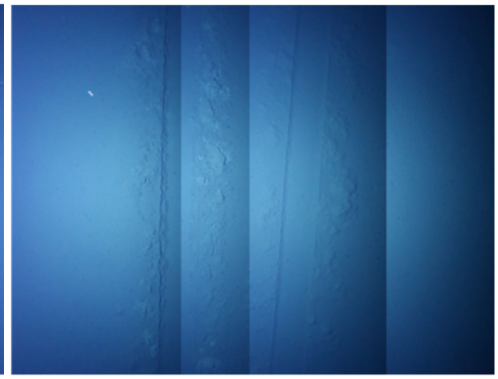
The images were acquired with an overlap of ca. 30% in each direction to create large-scale mosaics of the seafloor. Due to the low contrast in the images, mosaicking algorithms have problems to find corresponding points in subsequent images. Those “features” are required to correct for the visual distortion between images and estimate the pose of the camera in 3D. Attempts with multiple tools mostly failed so far. The MIP toolbox showed the most promising results and after the cruise the mosaicking with this tool will be continued. Some manually created mosaics are shown here.



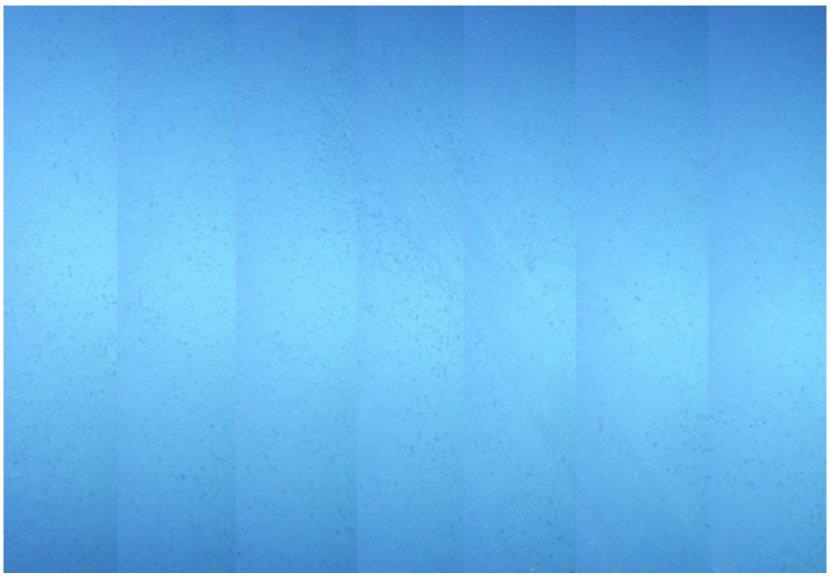
Track mosaic from SO239_028_AUV3.



The second row extends to the right of the first row. Here the distribution of the sediment plume around a track can be seen (SO239_019_AUV2).

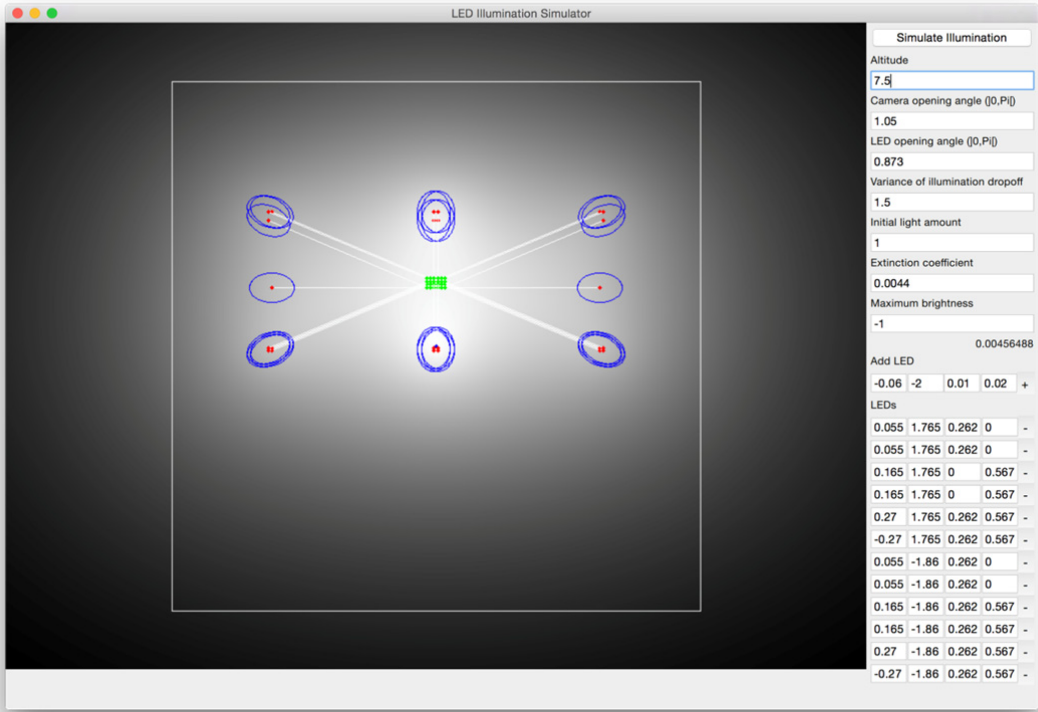



Two mosaics of different sections from SO239_065_AUV6 where two tracks are visible close together.



Beginning of a chain dredge track as seen in SO239_115_AUV9.

LED Simulator
An illumination simulator was implemented to be able to plan the LED settings onboard the AUV. An illumination model was created that takes the physical parameters of water into account. By testing different LED positions and view angles, the illumination of the seafloor can be estimated and thus the LED setup can be adjusted to different mission goals (flying close to/far away from the seafloor, bright spot in the middle/evenly distributed light).



The figure shows a screenshot of the simulator where at the right the parameters like camera view angle, light absorption, etc. can be defined alongside the LED positions and view directions. In the image to the left, the simulated illumination is encoded by gray value and the position of the LEDs is shown (in green) as well as their viewpoint on the seafloor (red). A blue ellipse of 1 square meter size surrounds the viewpoint.

7.2.11 Birds, turtles and mammals (Robert)

The main objectives of this top predator survey and assessment of the at sea distribution of seabirds and marine mammals are, on the one hand, to contribute to a better understanding of the mechanisms influencing their distribution (water masses, currents, temperature, food availability etc.) and, on the other hand, to try and detect spatial and temporal evolutions in these distributions with special attention to possible consequences of global climatic changes. Excellent bio-indicators (because relatively easily observed) sea birds and marine mammals constitute the upper trophic levels of the food chain. Their distribution reflects prey abundance (e.g. phytoplankton, zooplankton, nekton and fish) and is thereby a reflection of the ecology and the biological production of the whole water column. Improved knowledge of their distribution constitute therefore one of the best way to identify and localize areas of high biological productivity, hotspots of biodiversity, and to detect temporal changes.
Birds and mammals were recorded on a non-standardized but daily basis from the bridge or the fore castle of the ship, without width limitation. Top predators counts lasted 45 minutes on average (once or twice per day depending on time availability). Animals were detected with naked eye,

observations being confirmed and detailed with binocular Leica Ultravid (10x32).
A total of 25 bird species were observed during the cruise along with 6 species of cetaceans (see table 7.2.11.1). Marine turtles were also observed at several locations (about 15 individuals of different unidentified species).

Table 7.2.11.1: Species list of birds and marine mammals observed during SO239. For each species and every area an abundance index is given (I= one observation or rare species; II= fairly abundant species; III= dominant species).

	Species name (english)	Latin name	Transect Panama-BGR	German claim	IOM	Belgian claim	French claim	APEI	Transit to Manzanillo
Birds	Red-billed Tropicbird	*Phaethon aethereus*	II						I
	Red-tailed Tropicbird	*Phaethon rubicauda*		I	I	I			
	Brown Pelican	*Pelicanus (occidentalis) thagus*	III						
	Brown Booby	*Sula leucogaster*	III				I		II
	Red-footed Booby	*Sula sula*	I						II
	Masked Booby	*Sula dactylatra*	I	II	II	II			
	Olivaceous Cormorant	*Phalacrocorax olivaceus*	III						
	Magnificent Frigatbird	*Fregata magnificens*	II						I
	Great Frigatbird	*Fregata minor*					I		
	Red Phalarope	*Phalaropus fulicarius*	I	I	I	I			I
	Arctic Skua	*Stercorarius parasiticus*		I					
	Long-tailed Skua	*Stercorarius longicaudus*		I					I
	Laughing Gull	*Larus atricilla*	III						
	Sandwich Tern	*Sterna sandvicensis*	III						
	Sooty Tern	*Sterna fuscata*	I					II	
	Common Tern	*Sterna hirundo*			I	I			
	Kermadec Petrel	*Pterodroma negleta*						?	
	Juan Fernandez Petrel	*Pterodroma externa*			I	I			
	Cook's Patrel	*Pterodroma cookii*			I	II	I		
	Wedge-tailed Shearwater	*Puffinus pacificus*			I	I			
	Sooty Shearwater	*Puffinus griseus*				I	II	II	
	Buller's Shearwater	*Puffinus bulleri*	I						I
	Pink-footed Shearwater	*Puffinus creatopus*	II						I
	Leach's Storm Petrel	*Oceanodroma leucorhoa*	I	II	II	II	I	I	I
	Black Storm Petrel	*Oceanodroma melania*							?
Mammals	Sei Whale	*Balaenoptera borealis*	I						
	Bryde's Whale	*Balaenoptera brydei*	I						
	Minke Whale	*Balaenoptera acutorostrata*				I			
	Short-finned Pilot Whale	*Globicephala macrorhynchus*	I						
	Long-snouted Spinner Dolphin	*Stenella longirostris*	II						
	Bottlenose Dolphin	*Tursiops truncatus*	I						

7.2.12 Preliminary MAPR results (Greinert, Weiß, and Schoening)

The total of 106 deployments have been added to an ODV data base file for data examination. Figure 7.2.12.1 shows all temperature profiles over time of the top 500 m of the water column. The APEI-3 area shows cooler surface temperatures and a thicker surface mixed layer than the other areas.

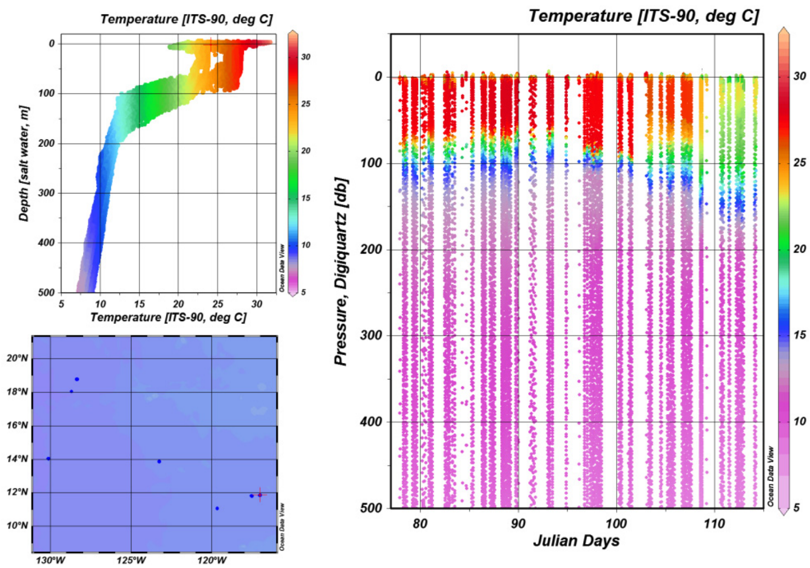


Fig. 7.2.12.1: Sea surface temperatures of the different working areas.

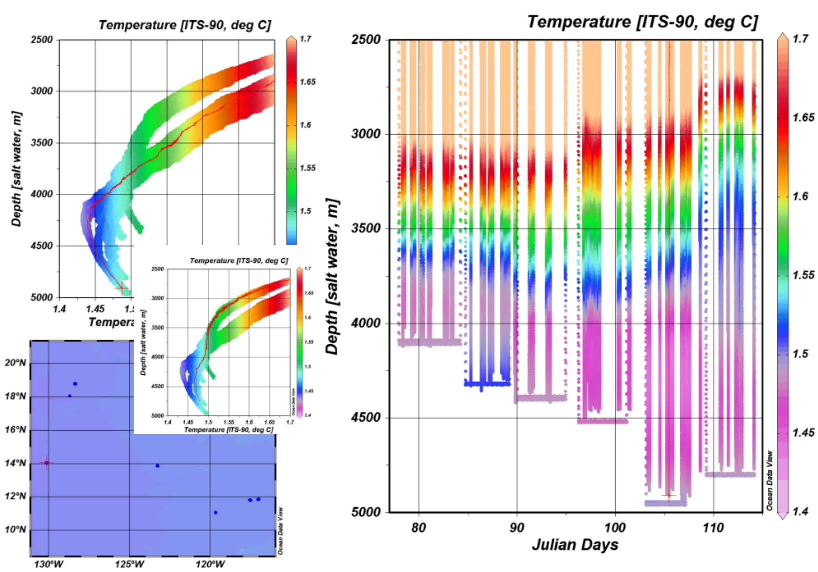


Fig. 7.2.12.2: Bottom temperatures of the different working areas. Highlighted in plot a) is a profile from the French area, in plot b) a profile from the APEI.

The bottom temperatures show a similar structure for all areas south of 16°N, the APEI area north of it is different with a less pronounced increase of temperature of the last few 100m above the bottom (Figure 7.2.12.2), pointing towards different water masses.

During the 'disturbance experiment' with the EBS deployment SO239_#024 in the German License area PA1 the DOS lander ADCP and turbidity sensor did not record clear signs of increased turbidity. However, the optical backscatter sensor of the MAPR on the southern LBL (SO239_#007) shows strong variations in the LBSS values that might be caused by the EBS sled deployment (SO239_#020) that happened ca. 800m south of the LBL position. The EBS started about 2.5h before the increase in LBSS began. For the sediment plume being able to reach the LBL location, a northward current of about 9cm/s would have been needed. This needs to be verified with lander ADCP data.

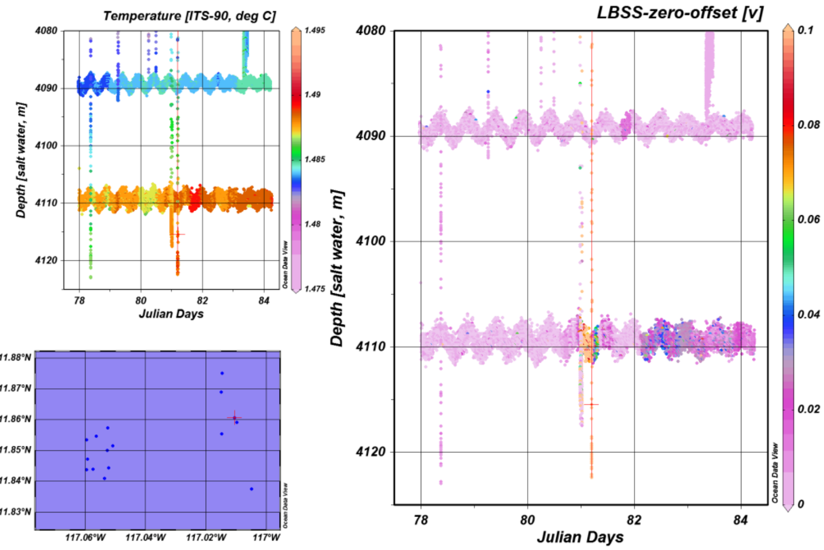


Fig. 7.2.12.3: Overview of the turbidity changes in the German License area PA1.

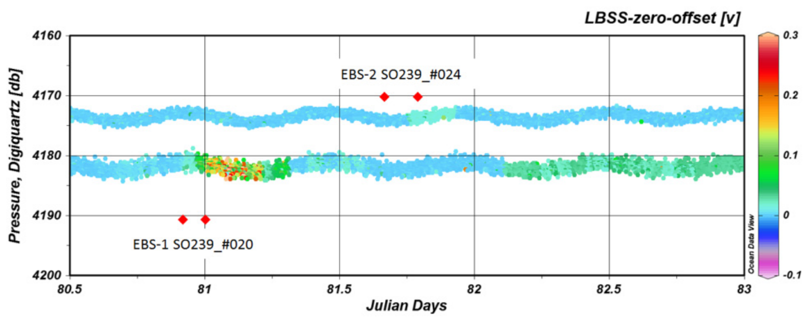


Fig. 7.2.12.4: Temporal relation between the two EBS deployments and increased turbidity values.

7.2.13 Lander and thermistor mooring deployments in the German PA1 area (Greinert, de Stigter, van Haren, Weiß and Schoening)

7.2.13.1 Deployments and sampling settings

During SO239, three oceanographic monitoring systems were deployed to record temperature, salinity, turbidity, ocean currents, collect ‘particles’ with sediment traps and take photos of the seafloor. Two landers, the BoBo lander from NIOZ (Bottom Boundary) and the DOS lander from GEOMAR (Deep-Sea Observation System) and one Thermistor String mooring also from NIOZ were deployed in the German Prospective Area for a duration of about 3 months. They will be recovered in early June (4-6) during SO240 led by BGR. The DOS lander was recovered after 5 days to be redeployed for the rest of the three months. More detailed deployment information is given in Table 1, 2 and 3.
The deployment locations where chosen to serve two purposes, they should be in close vicinity to four ADCP moorings deployed by BGR (adding to their oceanographic data set) and they were supposed to work as monitoring stations for detecting the re-suspension plume produced by an epibenthic sled (EBS) deployment in the PA1 area of the German license area (Figure 1). For this ‘small disturbance experiment’ the distance of the DOS lander was set to be 500m away from the EBS track downstream from the supposed plume drift direction between 100° and 120°. This current direction was based on a one year long ADCP deployment of the BGR in this area, the most common current speed during this time was 3 – 4 cm/s. The BoBo lander was deployed 1 km to the SE of the DOS lander (Figure 7.2.13.1). Table 1 gives an overview about the deployment details and used sensors for the three deployments.

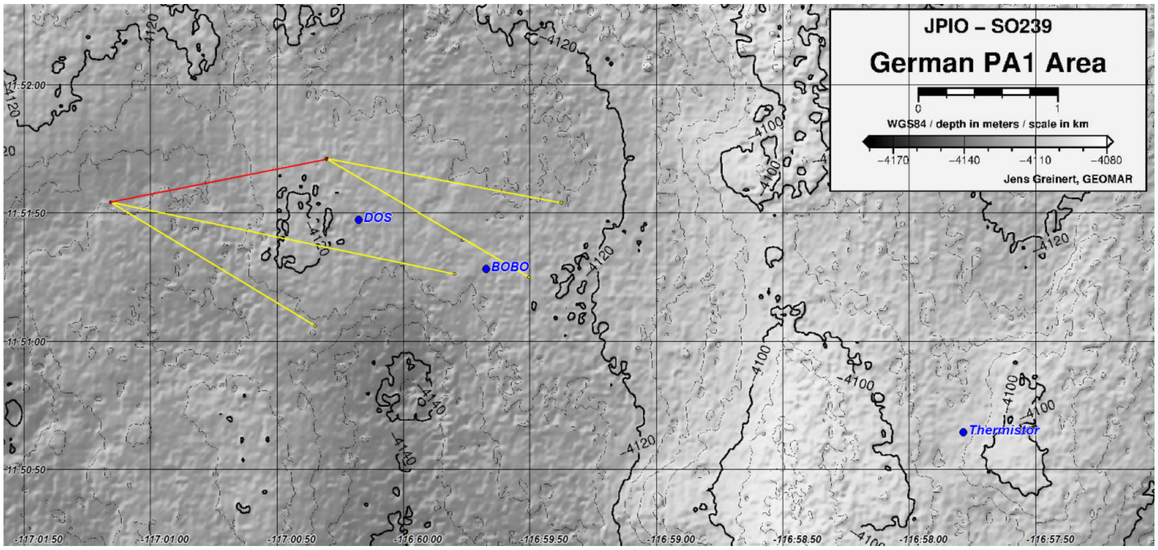


Fig. 7.2.13.1: Location of the Thermistor mooring and the DOS & BoBo lander during the disturbance experiment. The DOS lander was redeployed at the same position. Yellow lines are directions in 100° and 120° indicating the supposed drift of the sediment plume generated by the EBS.

Table 7.2.13.1: Deployment details for the mooring and landers

Station &Type	Date & Time	Position	Depth	Instruments
SO239 #2 Thermistor string mooring	Slipped at 15:30 on 19 March 2015	11°50.65'N 116°57.77'W Triangulated: 11°50.649'N 116°57.819'W	4101m	201 NIOZ-4 thermistors & 3 AquaDopp acoustic current meter
SO239 #4 BoBo-1	Slipped at: 20:48 on 19 March 2015	11°51.28'N 116°59.67'W Triangulated: 11°51.216'N 116°59.696'W	4117m	300kHz upward looking ADCP, 1200kHz downward looking ADCP, Seabird 16 CT with Wetlabs ECO-FLNTURTD, Technicap sediment trap with 12 sample bottles (bottom water from CTD-2; **poisoned with HgCl2**);
SO239 #5 DOS-1	Deployment: 21:33 on 19 Mach 2015	11°51.48'N 117°0.16'W Triangulated: 11°51.471'N 117°00.223'W	4115m	300kHz upward looking ADCP, KUM sediment trap with 10 bottles (bottom water not poisoned), Seabird 16plus CTD with Wetlabs ECO-FLNTURTD, Ocean Imaging Systems stereographic camera system (photo interval 5 minutes), improvised bait trap for amphipod sampling; temperature logger H. Villinger (U. Bremen).
SO239 #37 DOS-1	Released: 01:14 on 25 March 2015			On Deck at 03:12
SO239 #44 DOS-2	Slipped: 05:13 on 26 March 2015	11°51.47'N 117°00.19'W	4115m	Same equipment as for DOS-1; photo interval set to 15 minutes. The flash angle of the camera system was changed to illuminate further to the back of the visible area.

A detailed description about the sensor setting and sediment trap sampling intervals (bottle changing times) is given in Table 7.2.13.2 and 7.2.13.3.

Table 7.2.13.2: ADCP and CTD settings

Lander	1200kHz downward	300kHz upward	CT / CTD sampling interval
SO239 #4 BoBo-1	0.1m bin size, 25 samples, 50 pings per ensemble; 5 minutes sample interval	1m bin size, 127 samples, 11 pings per ensemble; 30 sec. sample interval (this high temporal resolution is for comparisons with thermistor string data	300sec
SO239 #5 DOS-1	-	5m bin size, 20 samples, 80 pings per ensemble; 15 minutes sample interval	150sec
SO239 #44 DOS-2	-	2m bin size, 25 samples, 80 pings per ensemble; 15 minutes sample interval	300sec

Table 7.2.13.2: Sediment trap sampling intervals

Lander	Bottle change on	Sample distribution
SO239 #4 **BoBo-1** **Sample 13 is open**	1) 21-03-2015/12:00:00 2) 27-03-2015/14:00:00 3) 02-04-2015/16:00:00 4) 08-04-2015/18:00:00 5) 14-04-2015/20:00:00 6) 20-04-2015/22:00:00 7) 27-04-2015/00:00:00 8) 03-05-2015/02:00:00 9) 09-05-2015/04:00:00 10) 15-05-2015/06:00:00 11) 21-05-2015/08:00:00 12) 27-05-2015/10:00:00 13) 02-06-2015/12:00:00	To be discussed
SO239 #5 **DOS-1** **Sample 21 is open**	1) 21-03-2015/12:00:00 2) 21-03-2015/16:00:00 3) 21-03-2015/20:00:00 4) 22-03-2015/00:00:00 5) 22-03-2015/04:00:00 6) 22-03-2015/08:00:00 7) 22-03-2015/12:00:00 8) 22-03-2015/16:00:00 9) 22-03-2015/20:00:00 10) 23-03-2015/00:00:00 11) 23-03-2015/04:00:00 12) 23-03-2015/08:00:00 13) 23-03-2015/12:00:00 14) 23-03-2015/16:00:00 15) 23-03-2015/20:00:00 16) 24-03-2015/00:00:00 17) 24-03-2015/04:00:00 18) 24-03-2015/08:00:00 19) 24-03-2015/12:00:00 20) 24-03-2015/16:00:00 21) 24-03-2015/18:00:00	Samples have been sieved at 40µm, the large fraction was preserved in DESS and is with Ana Hilario from University of Aveiro, Portugal.
SO239 #44 **DOS-2** **Sample 11 is open**	1) 28-03-2015/12:00:00 2) 05-04-2015/00:00:00 3) 12-04-2015/12:00:00 4) 20-04-2015/00:00:00 5) 27-04-2015/12:00:00 6) 05-05-2015/00:00:00 7) 12-05-2015/12:00:00 8) 20-05-2015/00:00:00 9) 27-05-2015/12:00:00 10) 04-06-2015/00:00:00 11) 11-06-2015/12:00:00	To be discussed

7.2.13.2 Preliminary DOS lander results

The DOS lander SO239 #5 DOS-1 was slipped on 19 March at 21:33 and arrived 1h later at the seafloor at 22:32 (sinking velocity of 1.16m/sec). It was released at 1:14 on 25 March 2015 and surfaced at 2:32 (rising speed of 0.76m/sec). Following some preliminary results of the photo system, the CTD and ADCP are shown.

DOS Camera

Due to the little extra ‘bait-trap’ attached to it, the lander was constantly visited by fish, shrimps and amphipods. A total of 1517 images were made; after free-fall landing of the lander, the sediment cloud was completely gone after 10 minutes. The first fish arrived 20 minutes after the lander reached the bottom. During the time the lander was at the bottom, no indications could be seen (so far) that a sediment plume generated by the EBS passed the lander. Assuming a current speed of 4cm/sec towards 100° to 120°, the plume should have reached the DOS lander 6 to 11h after the EBS was trawled over the seafloor. Stereographic reconstructions will be done at GEOMAR.

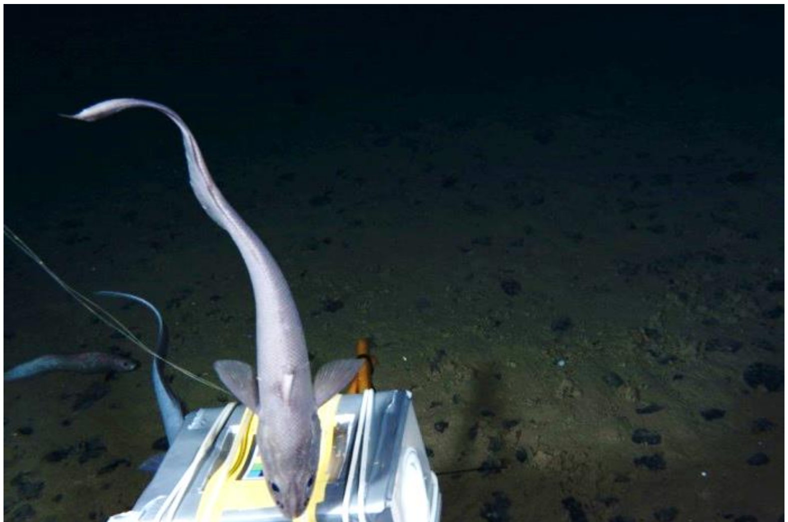


Fig. 7.2.13.2: Image of the right camera with rat tails and another fish.

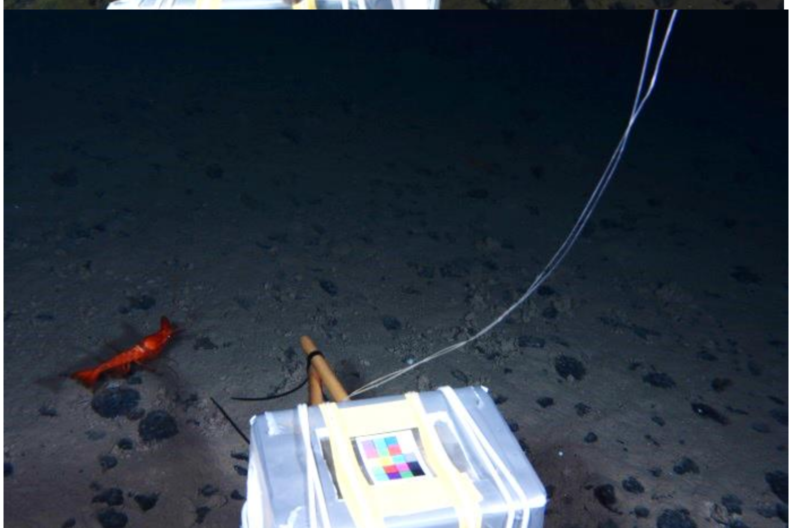


Fig. 7.2.13.3: Image of the left camera with big shrimp.

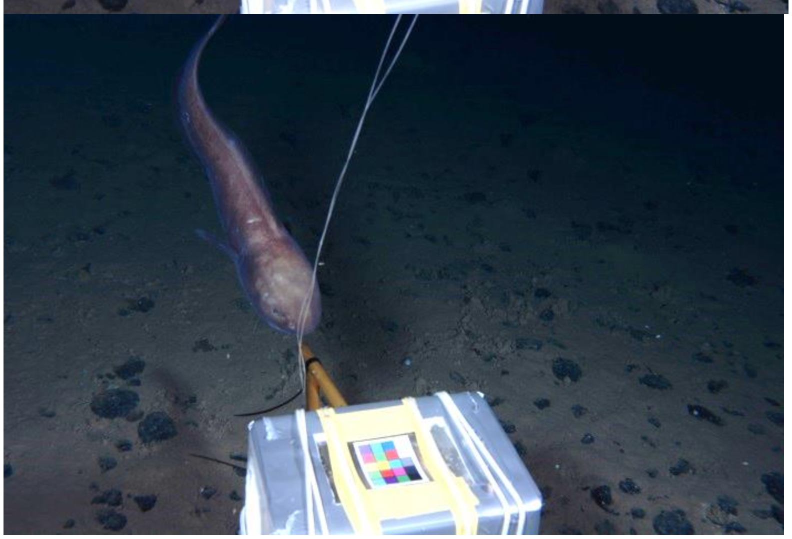


Fig. 7.2.13.4: Image of the left camera with a fish (species unknown).

DOS ADCP
The 300kHz upward looking ADCP of the lander gave good results for the lower 5 bin intervals, equivalent to about 30m above the bottom. After that distance, the backscattered intensity seems to be too low for good Doppler measurements. Figure 5 shows the current direction and magnitude. The two lower panels in Figure 5 indicate an average current velocity of 30 mm/sec towards the south. This speed correlates well with data measured by the BGR in 2014, the direction is more to the south with a substantial time even in westerly directions. Thus, it might be possible that the plume produced by the EBS was not directed towards the landers, but passed north of them.

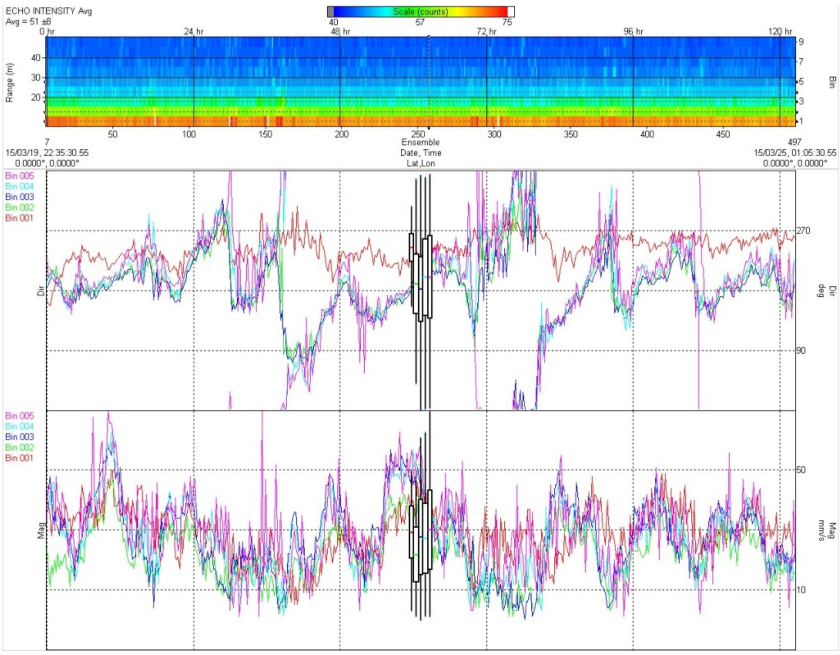


Fig. 7.2.13.5: Preliminarily processed ADCP data of the 5 day deployment. The top panel shows the echo intensity which drops strongly in 30m away from the transducer. The middle panel shows the current direction of the five depth layers closest to the transducer (bin 1 to 5). The lower panel shows the current speed that averages to about 30mm/sec.

DOS CTD
Data of the 5 day deployment were preliminary processed using the Seabird post processing software. Figure 6 shows temperature, pressure, salinity and the voltage level of the turbidity/fluorescence sensor. Short term temperature changes often coincide with salinity fluctuations, both seem not correlated with the clear tidal signal shown by the pressure sensor. The turbidity voltage level only slowly drops after 4 days from its saturation value; this is not consistent with the photo observations that show ‘clear water’ after 20m the lander reached the bottom. Both, CTD and camera data do not show the supposed plume from the EBS track 500m to the north.

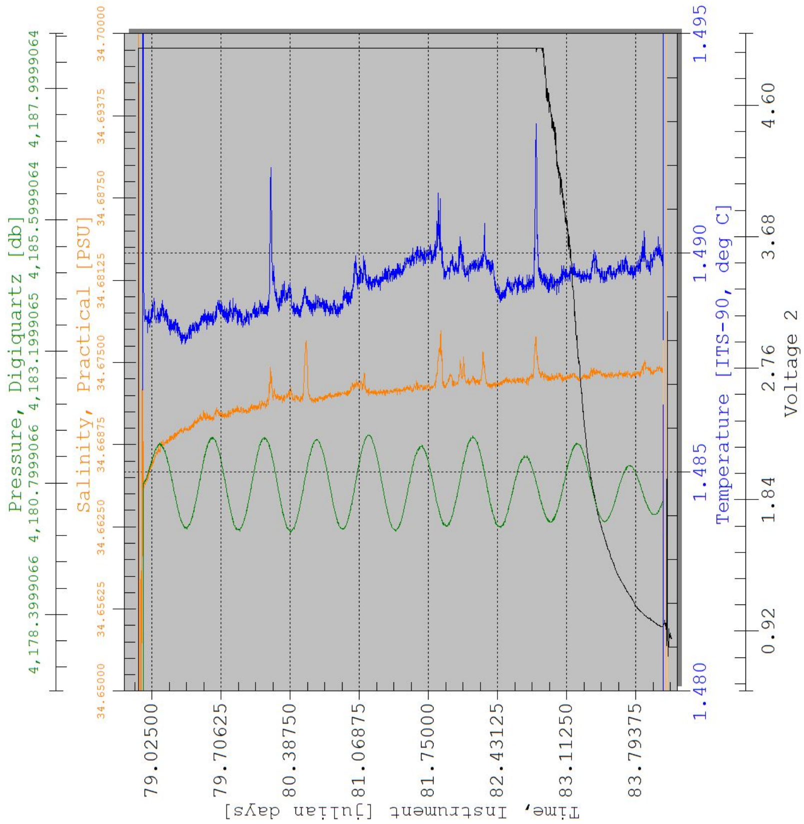


Fig. 7.2.13.6: CTD data of the 5 days deployment

7.2.14. AUV Mission Summaries (Rothenbeck, Steinführer, Triebe, Wenzlaff)

Station 9/14 / Dive Abyss0167 / Area German CCFZ

Date:	20th March 2015	Launch: 04:45 UTC	Recovery: 02:05 UTC
Survey time:	13.98 hours	Distance travelled: 86.4 km	

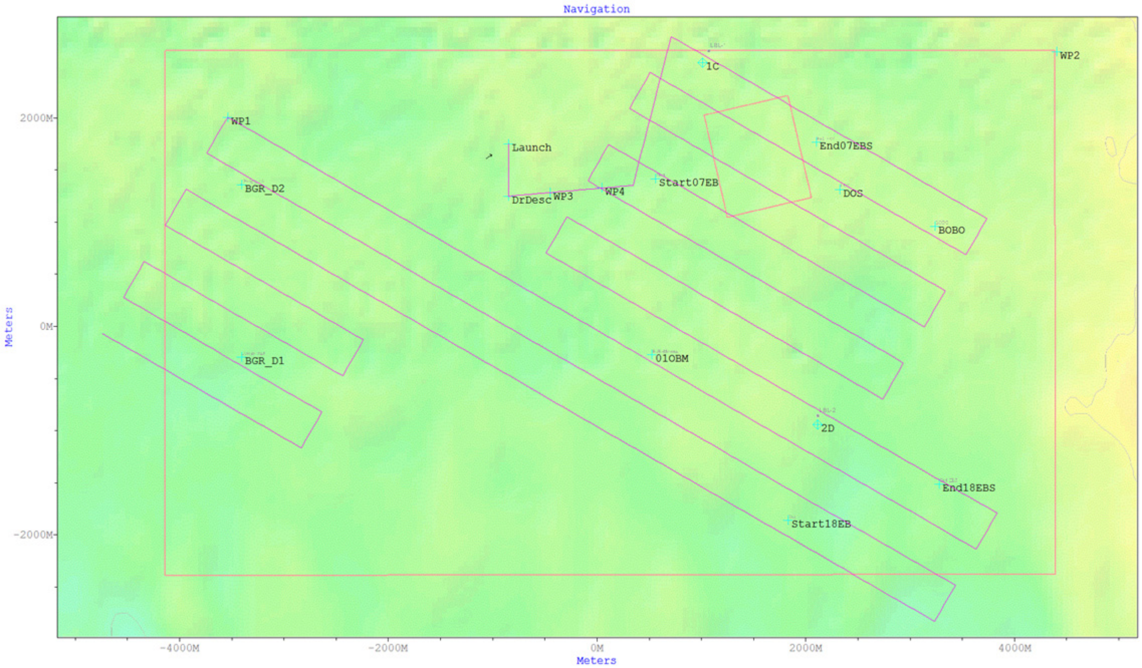


Fig. 7.2.14.1: Dive plan of mission 167

Sensors: Sidescan Sonar 120 kHz, Electronic Still Camera (Test, Canon 6D)

Mission 167 was supposed to map the working area and to find the tracks of dredges and EBS which have been done during former cruises. Figure 7.2.14.2 shows three of these tracks in the sidescan mosaik.

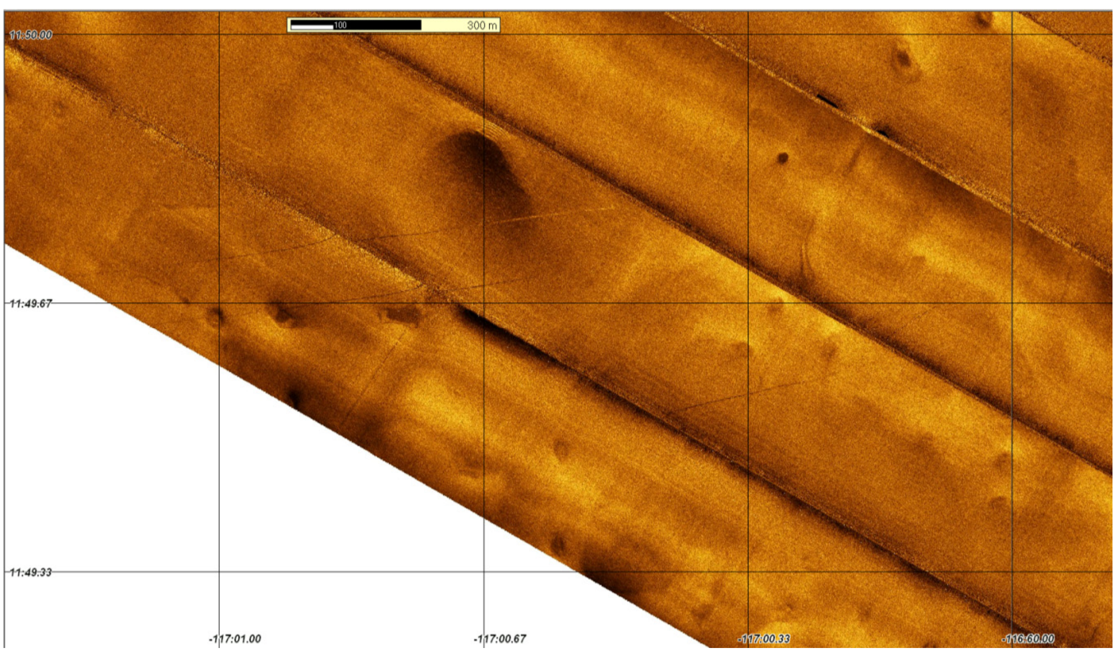


Fig. 7.2.14.2 Tracks shown in the sidescan mosaic

During the survey the positions of the DOS and BoBo lander were mapped as well and both landers could be seen as bright spots (Figure 7.2.14.3)

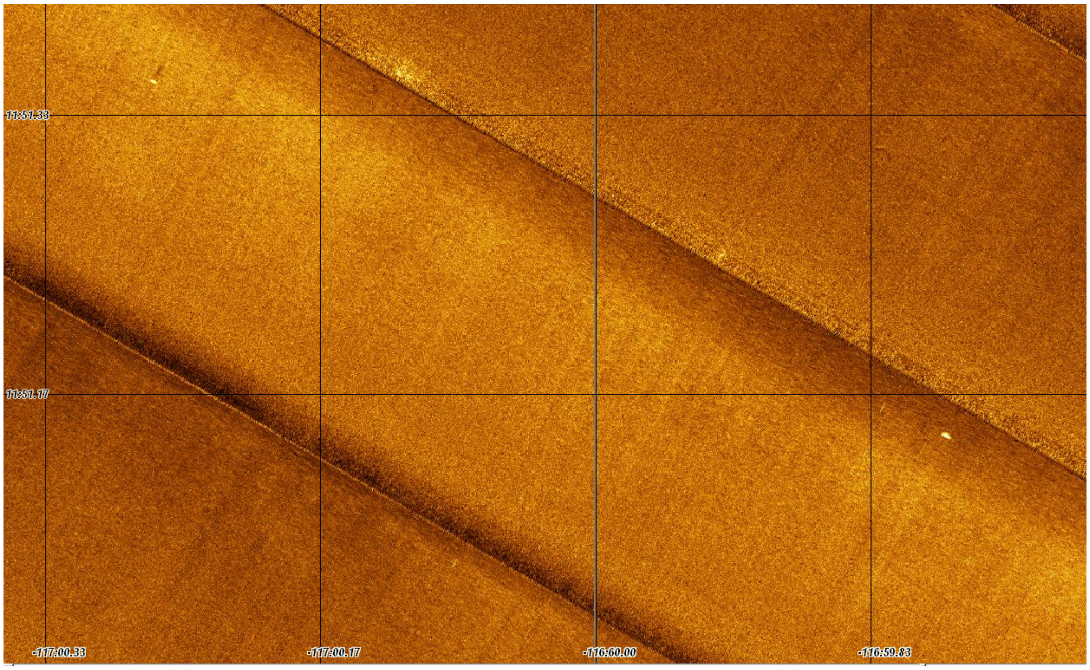


Fig. 7.2.14.3: DOS (west) and BoBo (east) seen in the sidescan data. The DOS lander also gives a nice shadow towards the north.

Dive 167 was done in camera configuration. The vehicle dived during the survey in depth between 4040 and 4120 meters. Since a camera system including new LED segment and new camera pressure housing was deployed the first time the mission started with some test legs just before the sidescan survey began. The camera test legs were done in different altitude steps (20/15/12/10/8 meters).
The following sidescan survey was done with the following settings:

Sidescan frequency:	120 kHz	Range:	400 m		
Vehicle speed:	3.0 knots	Altitude:	40 m	Line spacing:	400 m

Figure 7.2.14.4 shows the whole sidescan map that has been done with 100% overlap. The new LED segment has a kind of apron in front of the LED bars to guard them. This apron caused an expected increased drag particular below the vehicle. The descent phase run with the expected pitch but the vertical control struggled much more to keep the altitude and the vehicle couldn't the maximum nose up pitch while the ascent phase. That was why the vehicle reached in every camera mission the minimum battery capacity of 5%, aborted and drifted slowly to the surface.

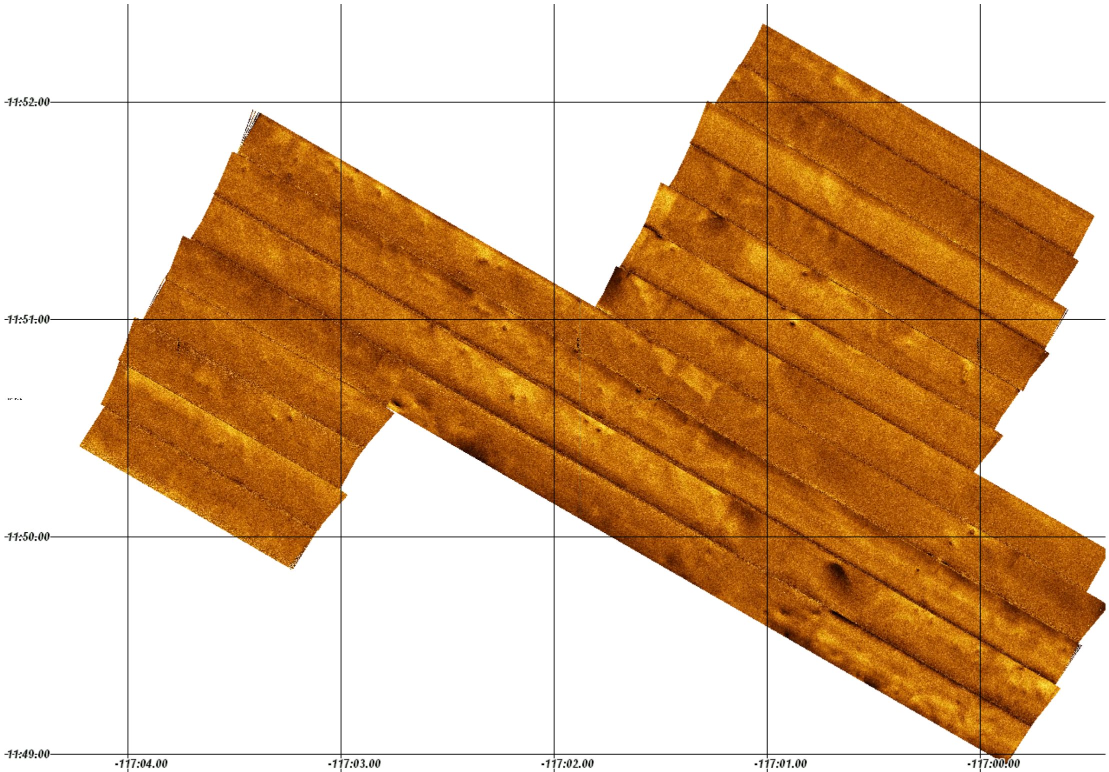


Fig. 7.2.14.4 Sidescan map of the working area in the German CCFZ claim

Based on later ROV dives in the western part of the working area (old BGR chain dredge tracks) the sidescan mosaic was shifted, to fit the USBL positions of ROV push core sampling inside the tracks. This caused that other positions in the east did not fit anymore due to the general drift of the AUV. The error in positioning can accumulate to about 100m mainly in east-west direction.

Station 19/2 / Dive Abyss0168 / Area German CCFZ

Date:	21st March 2015	Launch: 18:01 UTC	Recovery: 09:41 UTC
Survey time:	10.98 hours	Distance travelled: 66.7 km	

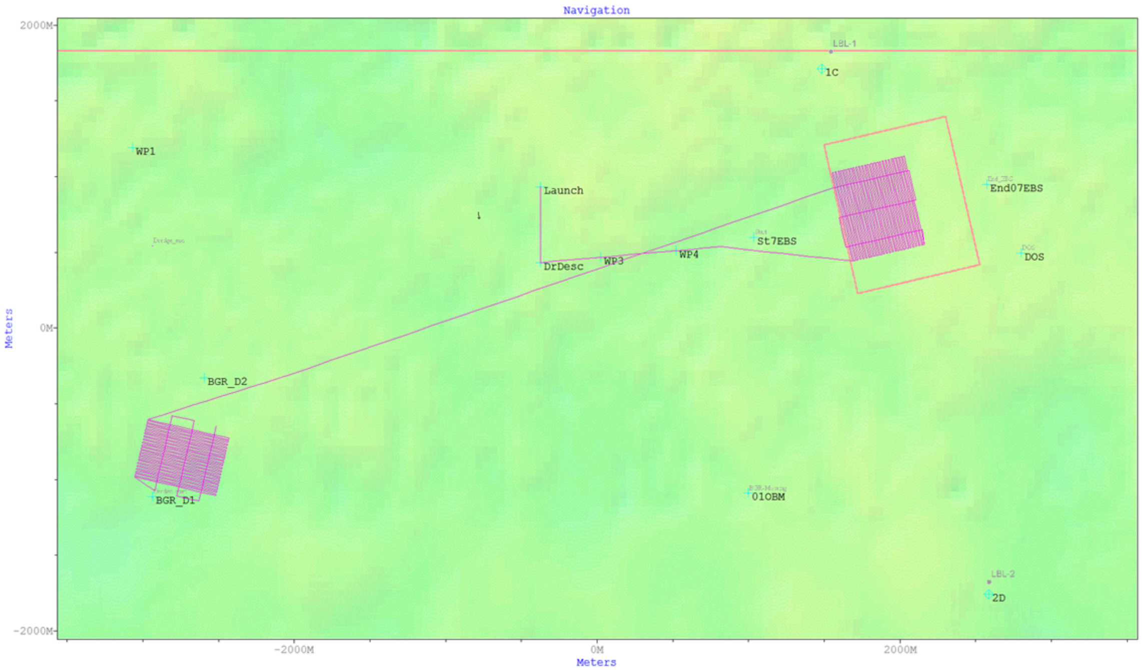


Fig. 7.2.14.5: Dive plan of mission 168

Sensors: Electronic Still Camera (Canon 6D)

Mission 168 was supposed to do photo surveys above the BGR dredge in the western part and above the planned EBS track before its deployment in the northeastern part of the working area. The dive was done in camera configuration and the photo surveys had the following settings:

Aperture:	11	Exposure time:	1/160	Sample rate:	1 Hz
Vehicle speed:	3.0 knots	Altitude:	9 m	Line spacing:	10 m

The vehicle dived during the survey in depths between 3850 and 4140 meters (it came up to 3850 meters due to programming mistake). After each photo survey several perpendicular lines above the pattern were done to support the post-processing mosaiking steps of the images.

Total amount images:	44,000
Designation of good images:	SO239_019_AUV2 Identifier 11140-41870

The vehicle showed the same attitudes how described in dive 167. Figure 7.2.14.6 shows the coverage of the AUV photos taken in relation to the done survey lines.

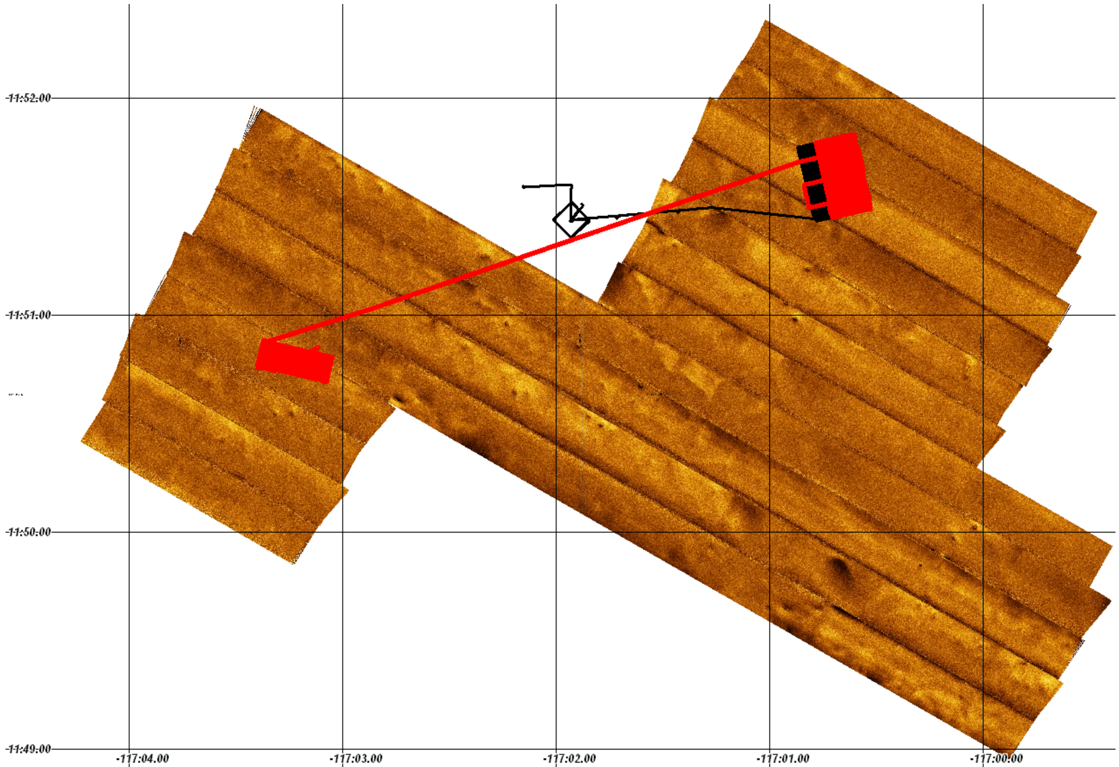


Fig. 7.2.14.6: Map showing the area of good (red) photos taken during the dive 0168.

Station 28/30 / Dive Abyss0169 / Area German CCFZ

Date:	23rd March 2015	Launch: 10:48 UTC	Recovery: 07:42 UTC
Survey time:	11.9 hours	Distance travelled: 89.5 km	

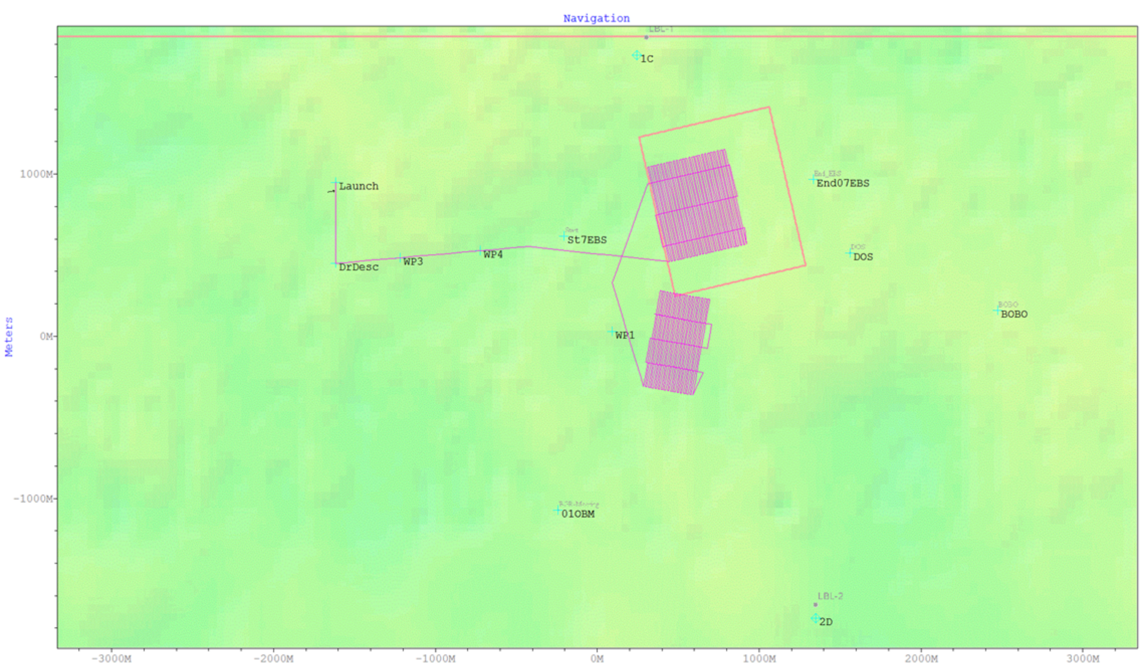


Fig. 7.2.14.7: Dive plan of mission 169

Sensors: Electronic Still Camera (Test Canon 6D)

Mission 169 was supposed to do photo surveys above the new sledge track after its deployment in the northeastern part of the working area and above a group of holes, which could be seen in the sidescan map. The dive was done in camera configuration and the photo surveys had the following settings:

Aperture:	8	Exposure time:	1/160	Sample rate:	0.5 Hz
Vehicle speed:	3.0 knots	Altitude:	8 m	Line spacing:	10 m

The vehicle dived during the survey in depth between 3820 and 4125 meters (it came up for up to 60 meters due to a programming error). After each photo survey several perpendicular lines above the pattern were done to support the post-processing of the images. The sample rate was decreased since particular features can be seen at least three times in the images what is enough for a photo mosaic. Before the actual survey pattern a aperture test was done on an altitude of 8 meters.

Total amount images:	24,900
Designation of good images:	SO239_028_AUV3 Identifier 400-24130

The vehicle showed the same attitudes how described in dive 167.

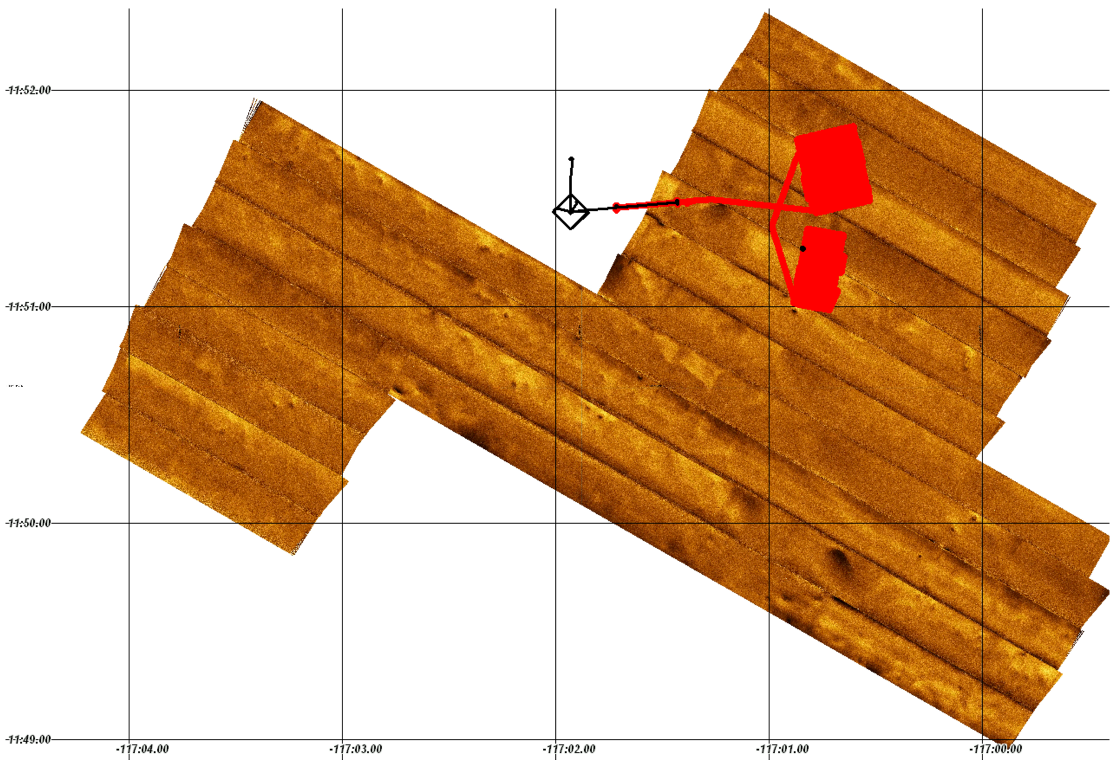


Fig. 7.2.14.8: Image showing the good image positions (red) during dive 0169 on the side scan map. The line where 'good' and 'bad'(black) images overlap was used for camera calibration purposes.

Station 38/42 / Dive Abyss0170 / Area German CCFZ

Date:	25th March 2015	Launch: 03:57 UTC	Recovery: 22:04 UTC
Survey time:	10.9 hours	Distance travelled: 73.5 km	

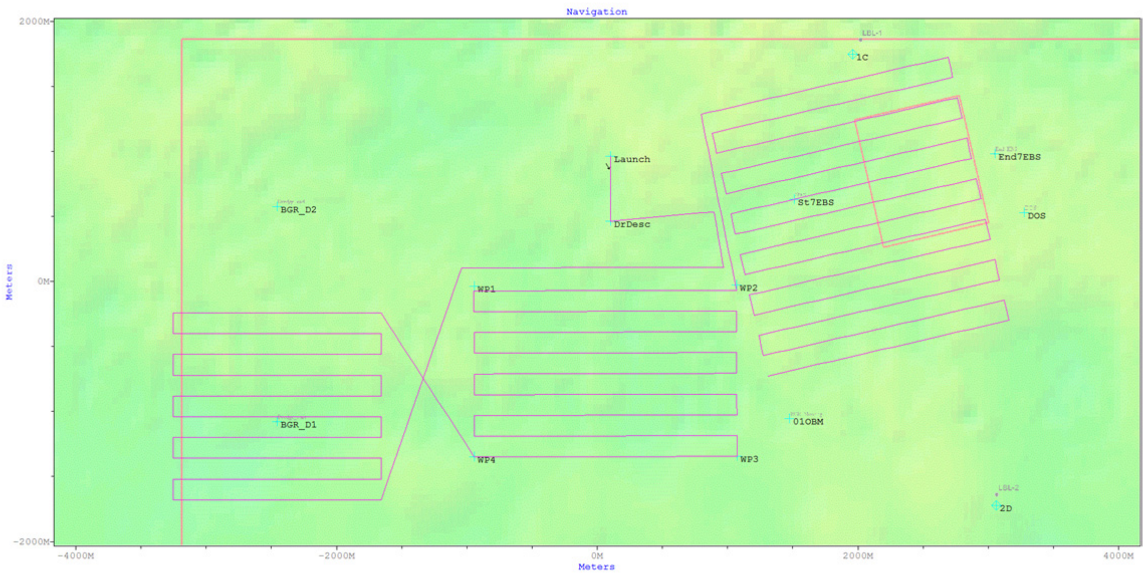


Fig. 7.2.14.9: Dive plan of mission 170

Sensors: RESON SeaBat 7125 Multibeam Sonar 200 kHz

Mission 170 was supposed to map the northern EBS (see figure 7.2.14.8) and the western BGR dredge (see figure 7.2.14.7) track and the "pock mark" area (see figure 7.2.14.8) in between. The dive was done in multibeam configuration and the following settings were used:

MB frequency:	200 Hz	Reson Range:	200 m	Vehicle speed:	3.0 knots
Altitude:	80 m	Line spacing:	160 m		

The vehicle showed normal and expected behavior. It dived during the survey in depth between 4030 and 4060 meters.

Total amount of MB raw files:	50
Designation of used MB raw files:	20150325_055531 - 20150325_170333

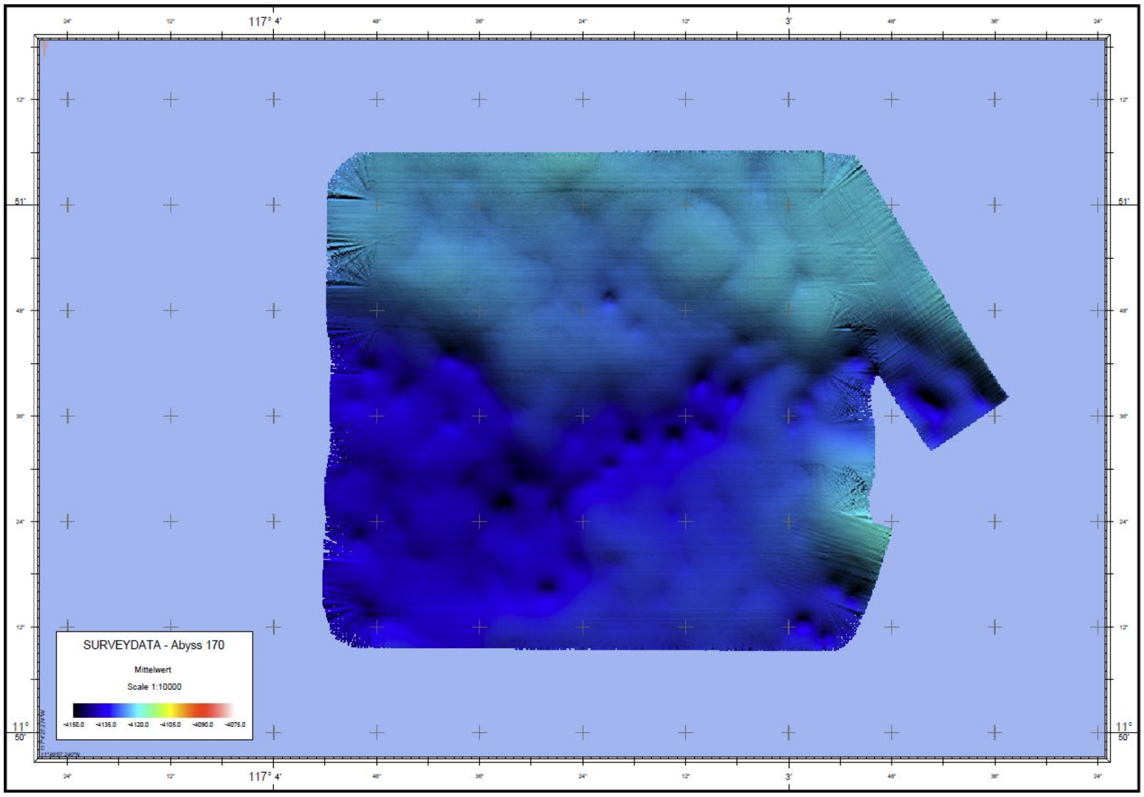


Fig. 7.2.14.10: Map of the western area above the BGR track

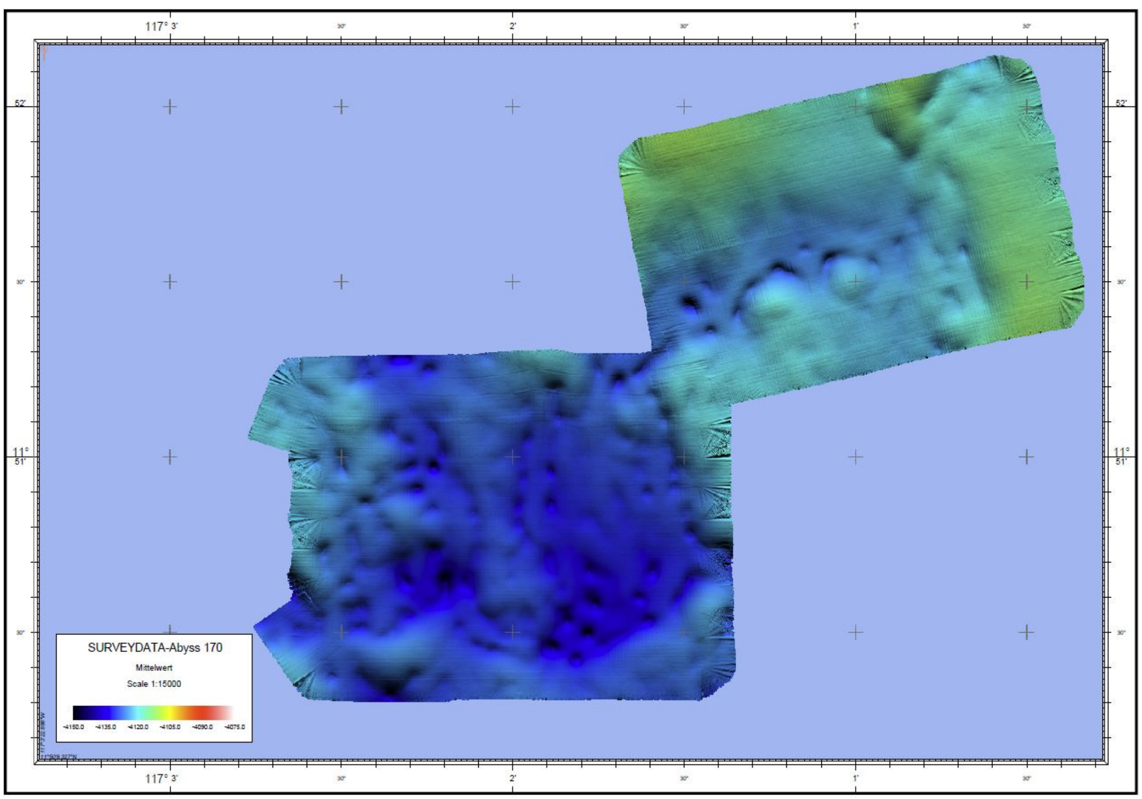


Fig: 7.2.14.11: Map of the northeastern area above the EBS track (right) and the pock mark area (left)

Station 53/55 / Dive Abyss0171 / Area German Reference CCFZ

Date:	27th March 2015	Launch: 12:16 UTC	Recovery: 06:34 UTC
Survey time:	13.23 hours	Distance travelled: 92.4 km	

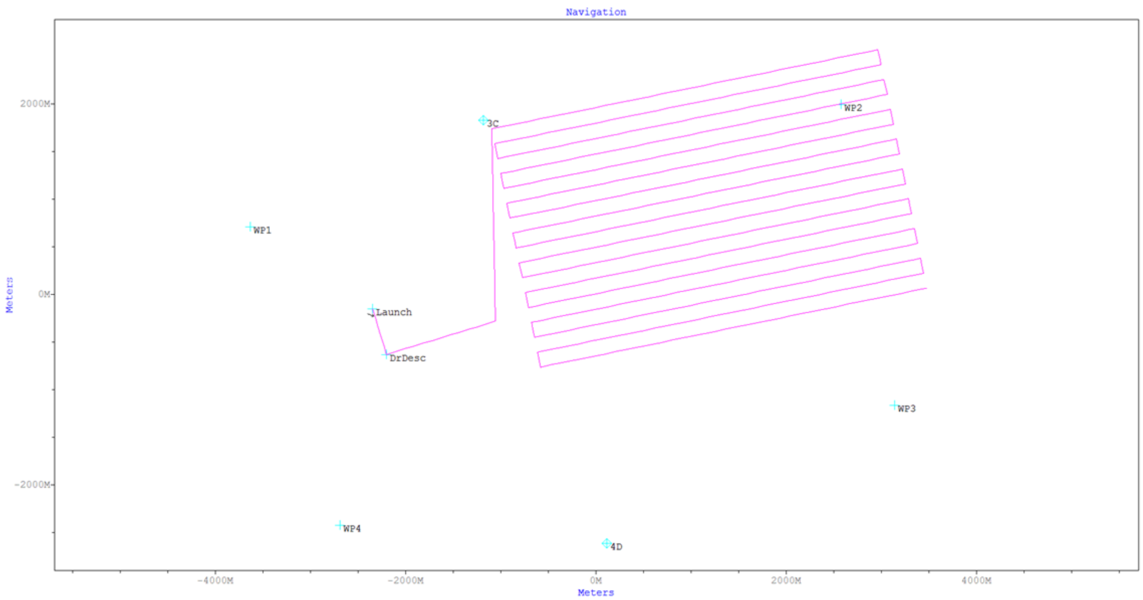


Figure7.2.14.12: Dive plan of mission 171

Sensors: Multibeam Sonar 200 kHz

Mission 171 was supposed to map the northeastern part of the German reference area (see figure X.12). The dive was done in multibeam configuration and the following settings were used:

MB frequency:	200 Hz	Reson Range:	200 m	Vehicle speed:	3.0 knots
Altitude:	80 m	Line spacing:	160 m		

The vehicle showed normal and expected behavior and it dived during the survey in depth between 4250 and 4285 meters.

Total amount of MB raw files:	59
Designation of used MB raw files:	20150327_141251 - 20150328_045719

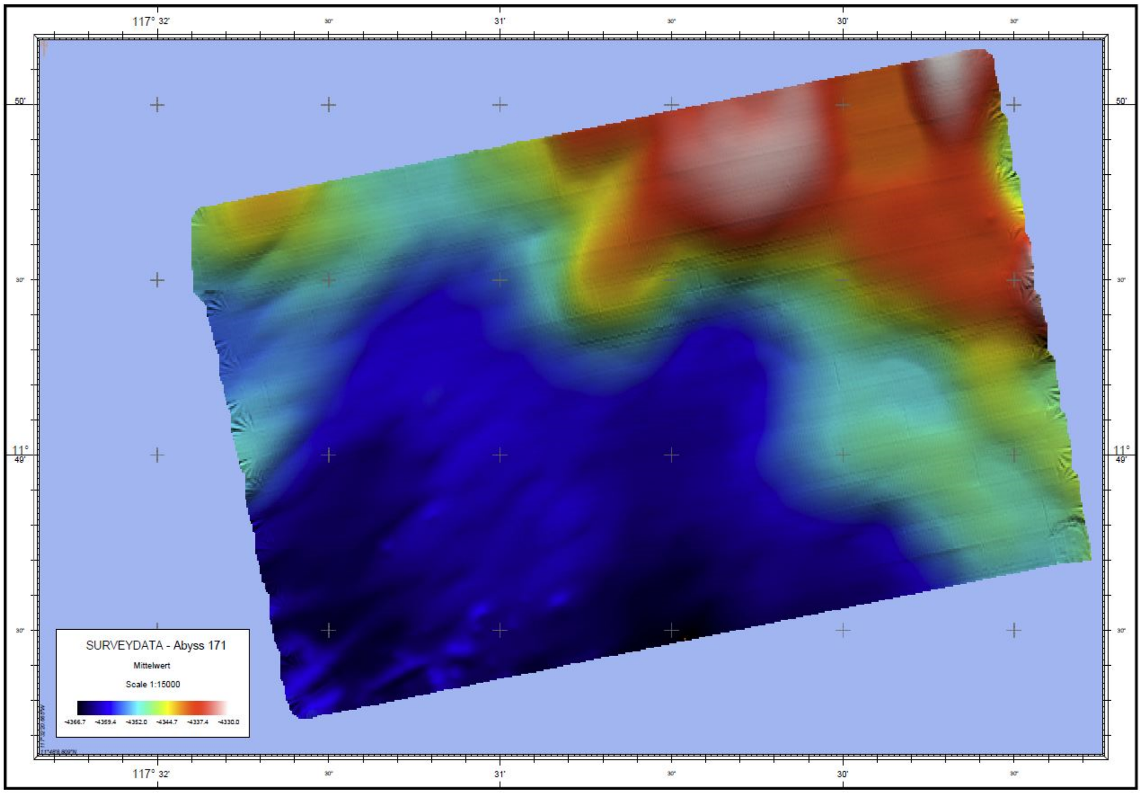


Fig. 7.2.14.13 Map of the most eastern part of the working area

Station 65/70 / Dive Abyss0172 / Area German Reference CCFZ

Date: 30th March 2015 Launch: 04:48 UTC Recovery: 00:59 UTC
Survey time: 13.87 hours Distance travelled: 88.2 km

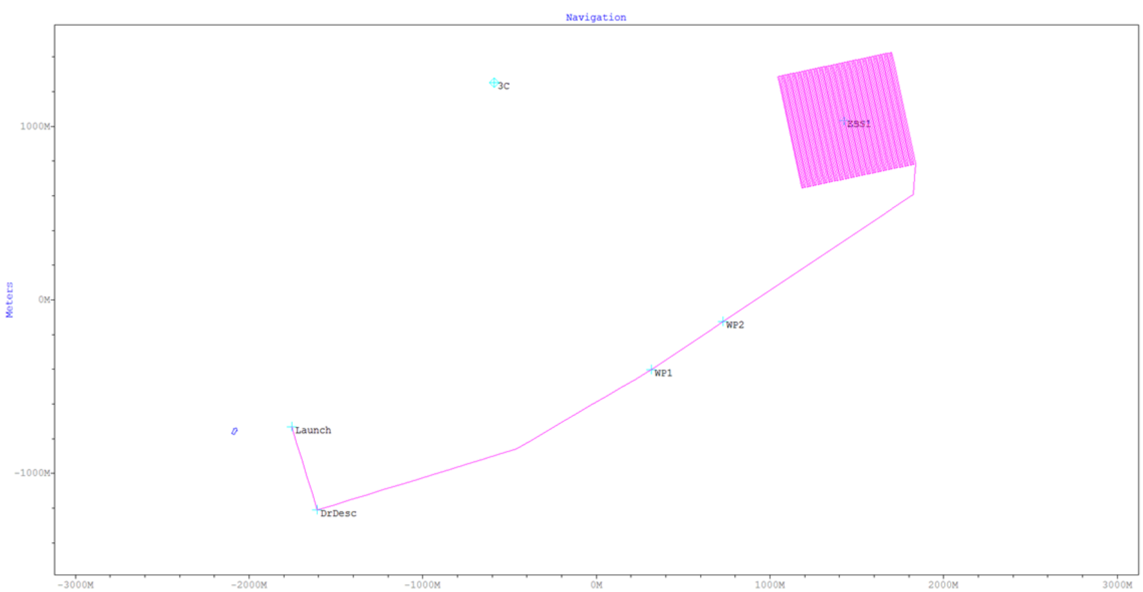


Fig. 7.2.14.14: Dive plan of mission 172

Sensors: Electronic Still Camera (Canon 6D)

Mission 172 was supposed to do photo surveys above the northern EBS track. The dive was done in camera configuration and the photo surveys had the following settings:

Aperture:	8	Exposure time:	1/160	Sample rate:	0.5 Hz
Vehicle speed:	3.0 knots	Altitude:	7.5 m	Line spacing:	8 m

The vehicle dived during the survey in depth between 4330 and 4355 meters. Before the actual survey pattern a aperture test was done on an altitude of 7.5 meters.

Total amount images:	30,900
Designation of good images:	SO239_065_AUV6 Identifier 650-25830

The vehicle showed the same attitudes how described in dive 167.

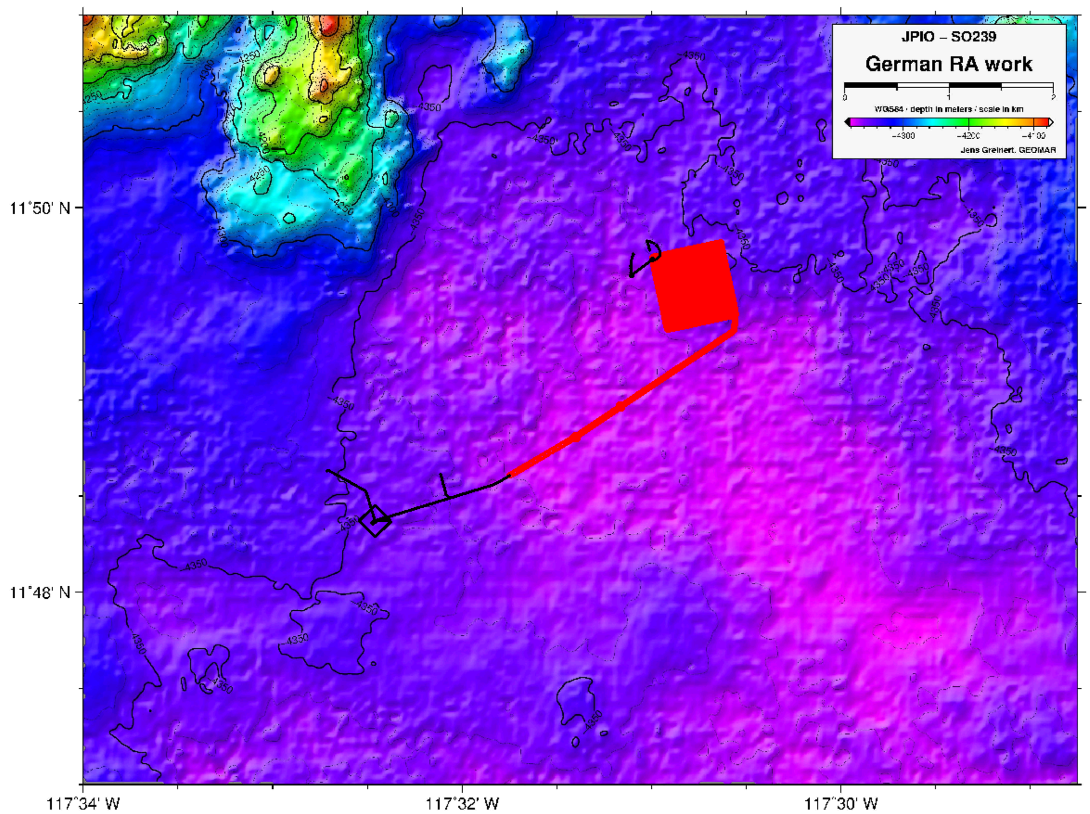


Fig. 7.2.14.15: Map showing the coverage of bad (black) and good (red) images of this camera dive.

Station 79/83 / Dive Abyss0173 / Area IOM CCFZ

Date:	1st April 2015	Launch: 04:49 UTC	Recovery: 2:59 UTC
Survey time:	10.52 hours	Distance travelled: 65.2 km	

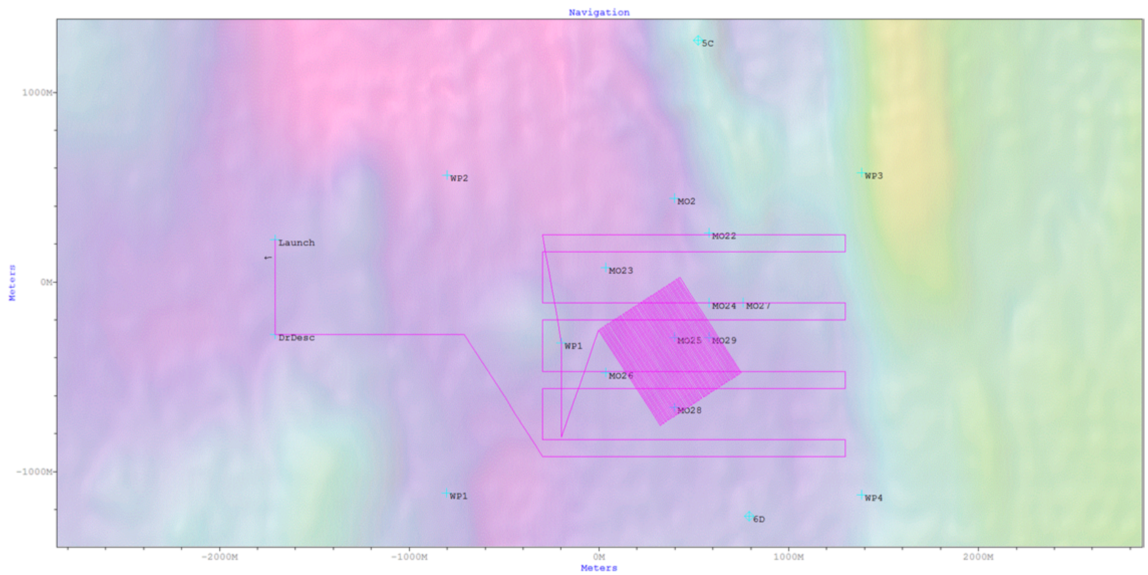


Figure 7.2.14.16: Dive plan of mission 173

Sensors: Sidescan Sonar 120 kHz, Electronic Still Camera (Canon 6D)

Mission 173 was a combined photo and sidescan mission and was supposed to map the central IOM working area and the former sample and dredge area. The dive was done in camera configuration and the sidescan survey had the following settings:

Sidescan frequency:	120 kHz	Range:	400 m		
Vehicle speed:	3.0 knots	Altitude:	40 m	Line spacing:	90/270 m

The vehicle dived during the survey in depth between 4340 and 4425 meters. The alternating line spacing was chosen to cover also the nadir and to achieve actually two maps with each one distinct illumination direction. The photo survey had the following settings:

Aperture:	4.5	Exposure time:	1/160	Sample rate:	0.5 Hz
Vehicle speed:	3.0 knots	Altitude:	7.5 m	Line spacing:	8 m

While the dive a part of the shutter curtain broke off, fell down into the objective and was seen on each photo which was made after this happened. This part was removed after the dive and the camera was used during the following camera dive without further actions.
Before the actual survey pattern a aperture test was done on an altitude of 7.5 meters.

Total amount images:	19,000
Designation of good images:	SO239_079_AUV7 Identifier 900-10952

The vehicle showed the same attitudes how described in dive 167.

Fig. 7.2.14.17 Sidescan map of the IOM working area

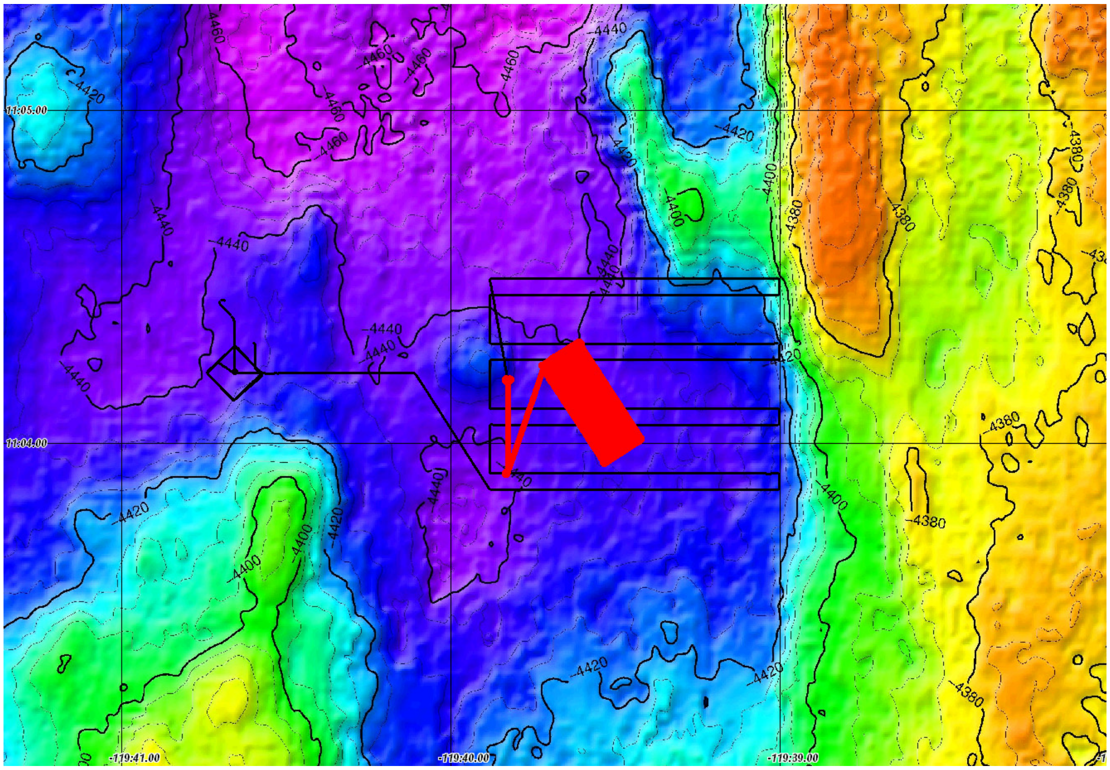


Fig. 7.2.14.18: Ships bathymetric map with dive track and the area with good images (red). Not the entire planned photo area could be mapped.

Station 98/102 / Dive Abyss0174 / Area IOM CCFZ

Date: 4th April 2015 Launch: 03:15 UTC Recovery: 05:26 UTC
Survey time: 15.58 hours Distance travelled: 84.6 km

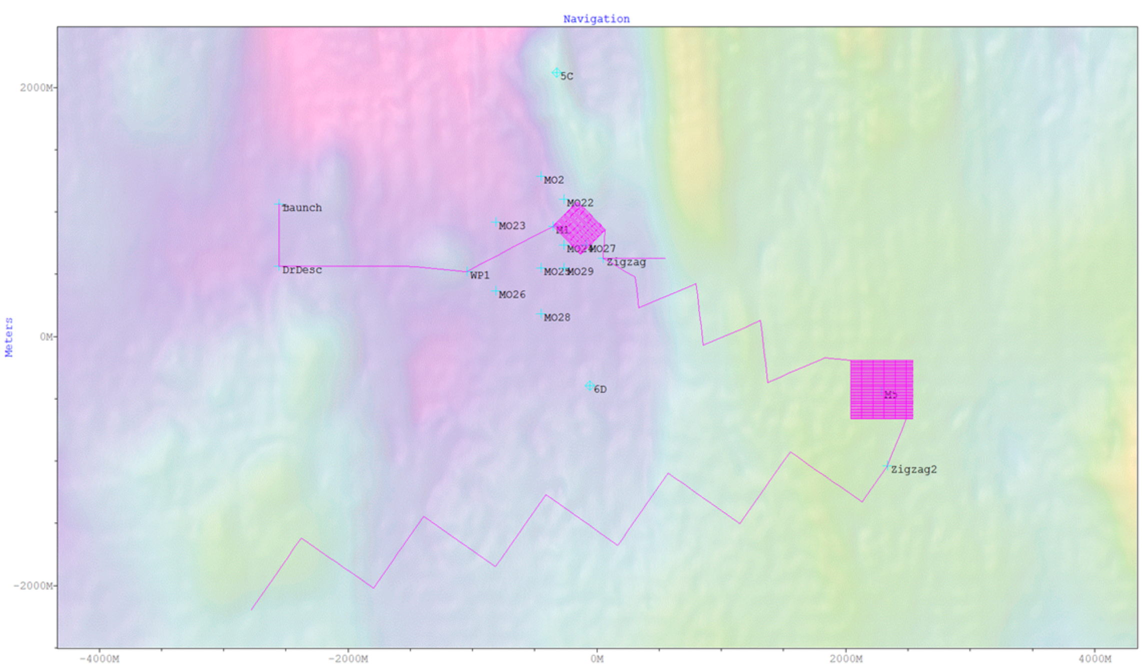


Fig. 7.2.14.19: Dive plan of mission 174

Sensors: Electronic Still Camera (Canon 6D)

Mission 174 was supposed to do photo surveys above the EBS track and above a former ROV dive area east of the working area. The zigzag photo pattern was to get a larger overview of the IOM area. The dive was done in camera configuration and the photo surveys had the following settings:

Aperture:	5.6	Exposure time:	1/160	Sample rate:	0.5 Hz
Vehicle speed:	3.0 knots	Altitude:	7.5 m	Line spacing:	8 m

The vehicle dived during the survey in depths between 4355 and 4420 meters. During the first part of the dive again a part of the shutter curtain broke off and was seen later on each photo. The transit phase to the Belgian area was used to disassemble the camera in total and to remove all parts of the shutter.

Total amount images:	22,025
Designation of good images:	SO239_098_AUV8 Identifier 690-3064

The vehicle showed the same attitudes how described in dive 167.

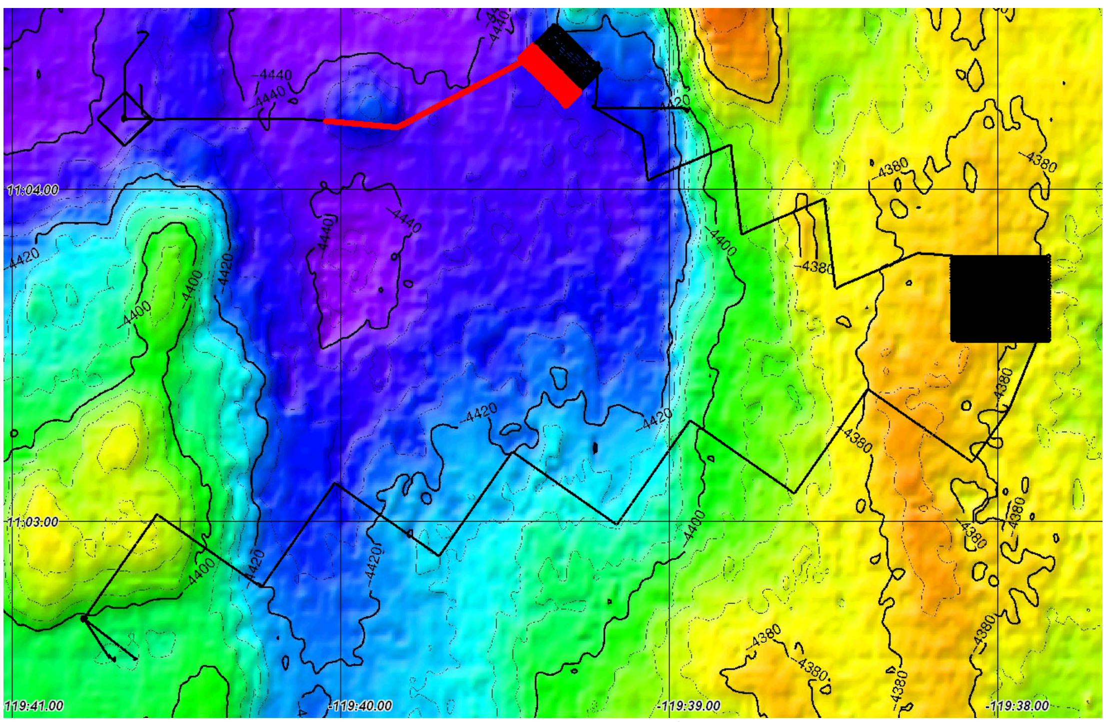


Fig. 7.2.14:20: Bathymetric map with dive track and the locations of good images (red).

Station 115/120 / Dive Abyss0175 / Area Belgian CCFZ

Date:	7th April 2015	Launch: 16:25 UTC	Recovery: 11:05 UTC
Survey time:	12.8 hours	Distance travelled: 84.0 km	

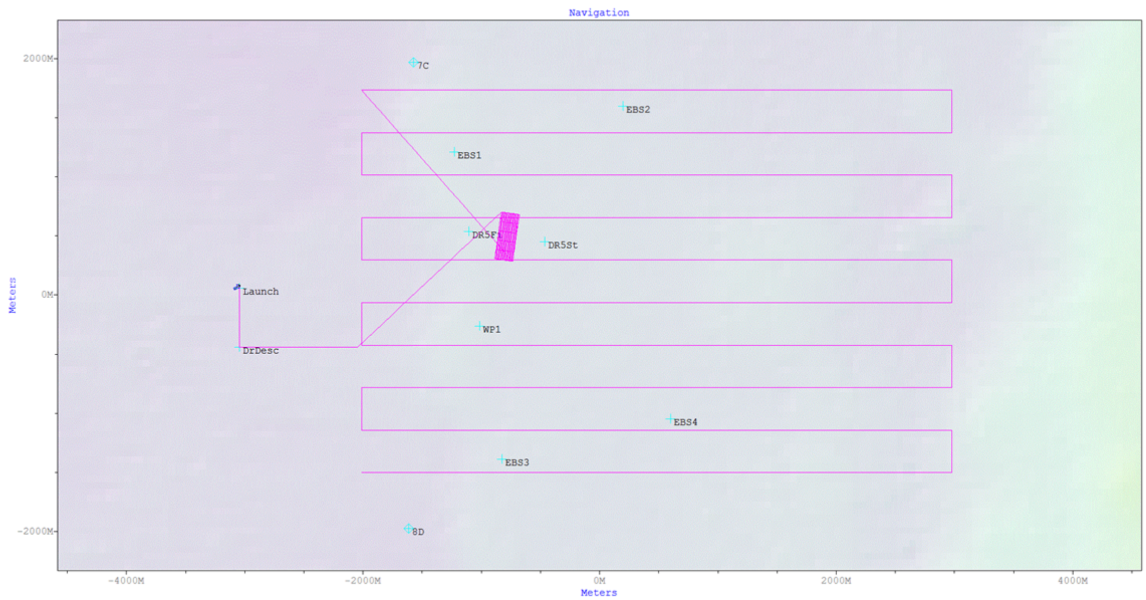


Figure 7.2.14.21: Dive plan of mission 175

Sensors: Sidescan Sonar 120 kHz, Electronic Still Camera (Canon 6D)

Mission 175 was the second combined photo and sidescan mission and was supposed to map the Belgian working area and to survey the former done dredge track for a photo mosaic. The dive was done in camera configuration and the sidescan survey had the following settings:

Sidescan frequency:	120 kHz	Range:	400 m		
Vehicle speed:	3.0 knots	Altitude:	40 m	Line spacing:	360 m

The line spacing was chosen to cover the nadir with a slight overlap of 40 meters and to achieve actually two maps with each one distinct illumination direction. The photo survey had the following settings:

Aperture:	5.6	Exposure time:	1/160	Sample rate:	0.5 Hz
Vehicle speed:	3.0 knots	Altitude:	7.5 m	Line spacing:	8 m

The camera worked with disassembled shutter without any problems.

Total amount images:	6,000
Designation of good images:	SO239_115_AUV9 Identifier 2720-6000

The vehicle showed the same attitudes how described in dive 167.

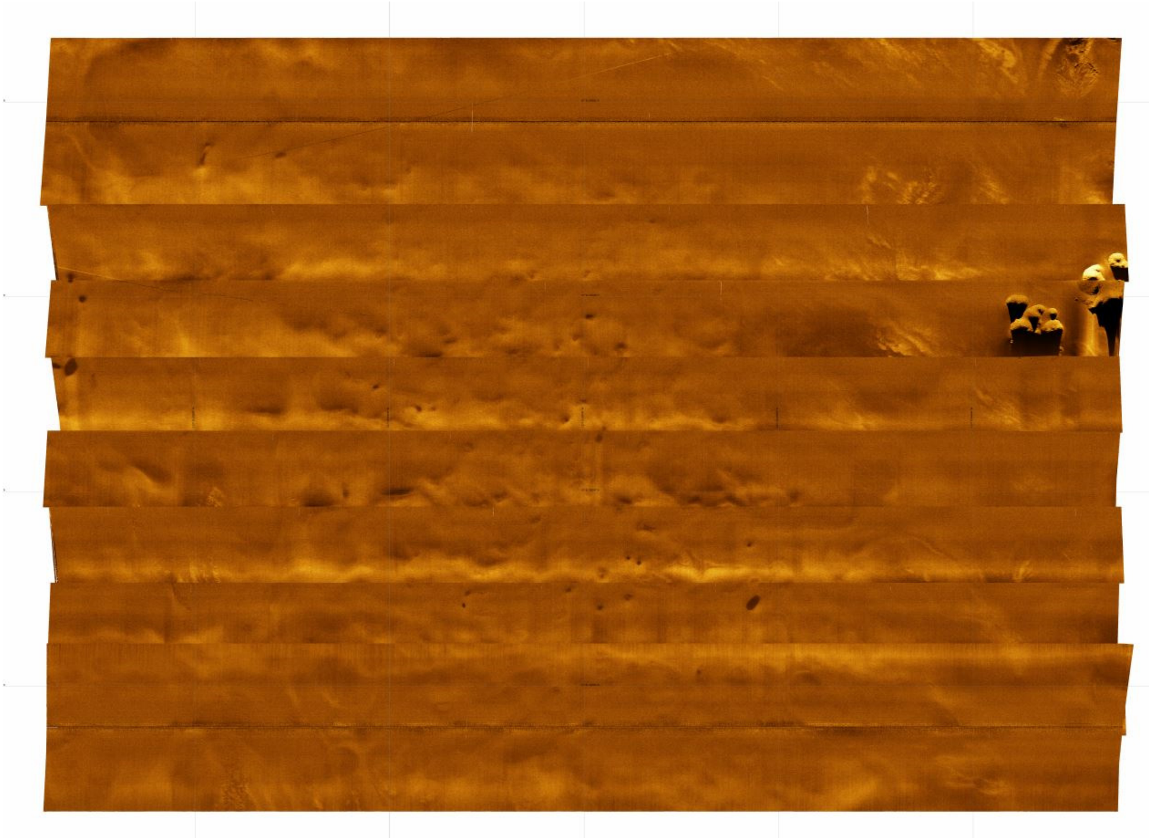


Fig. 7.2.14.22 Sidescan map of the Belgian working area

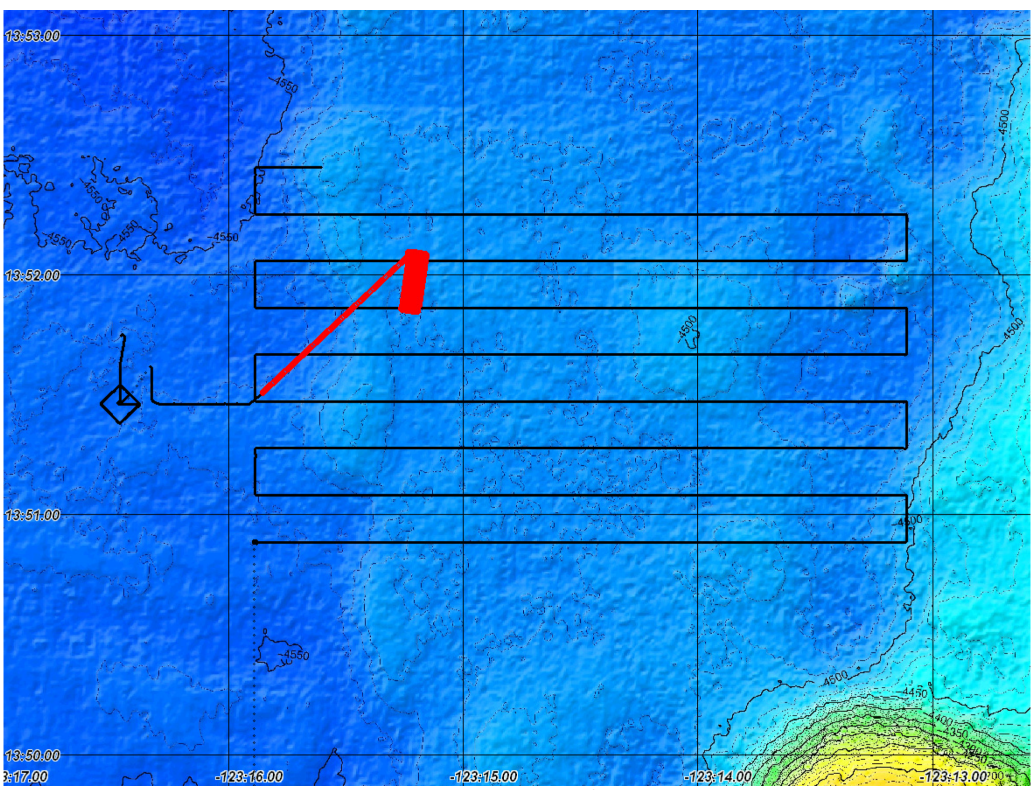


Fig. 7.2.14:23: Batyhmetric map with track and locations of good images (red)

Station 130/132 / Dive Abyss0176 / Area Belgian CCFZ

Date:	9th April 2015	Launch: 15:18 UTC	Recovery: 07:04 UTC
Survey time:	10.88 hours	Distance travelled: 69.3 km	

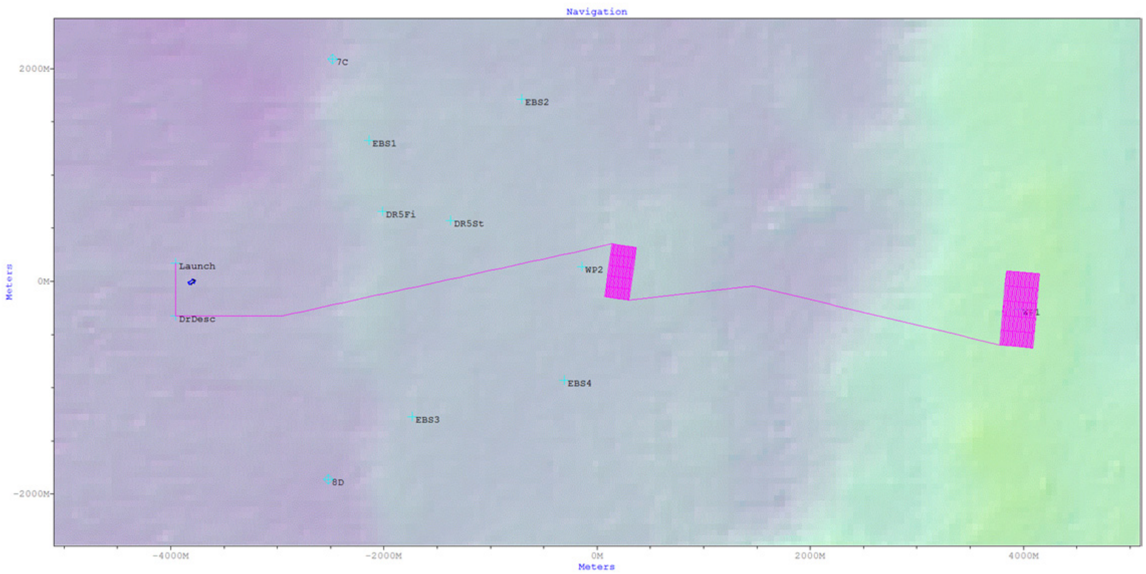


Fig. 7.2.14.24: Dive plan of mission 176

Sensors: Electronic Still Camera (Canon 6D)

Mission 176 was supposed to do photo surveys above the northern EBS track in the central Belgian working area and a small ridge east of the main area. The dive was done in camera configuration and the photo surveys had the following settings:

Aperture:	5.6	Exposure time:	1/160	Sample rate:	0.5 Hz
Vehicle speed:	3.0 knots	Altitude:	7.5 m	Line spacing:	8 m

The vehicle dived during the survey in depths between 4400 and 4525 meters. The camera with disassembled shutter worked as it should until image 10668 and broke totally during the dive. The fault showed as irreparable and was probably related to the guidance support of the shutter curtain.

Total amount images:	10,668
Designation of good images:	SO239_130_AUV10 Identifier 770-10668

The vehicle showed the same attitudes how described in dive 167.

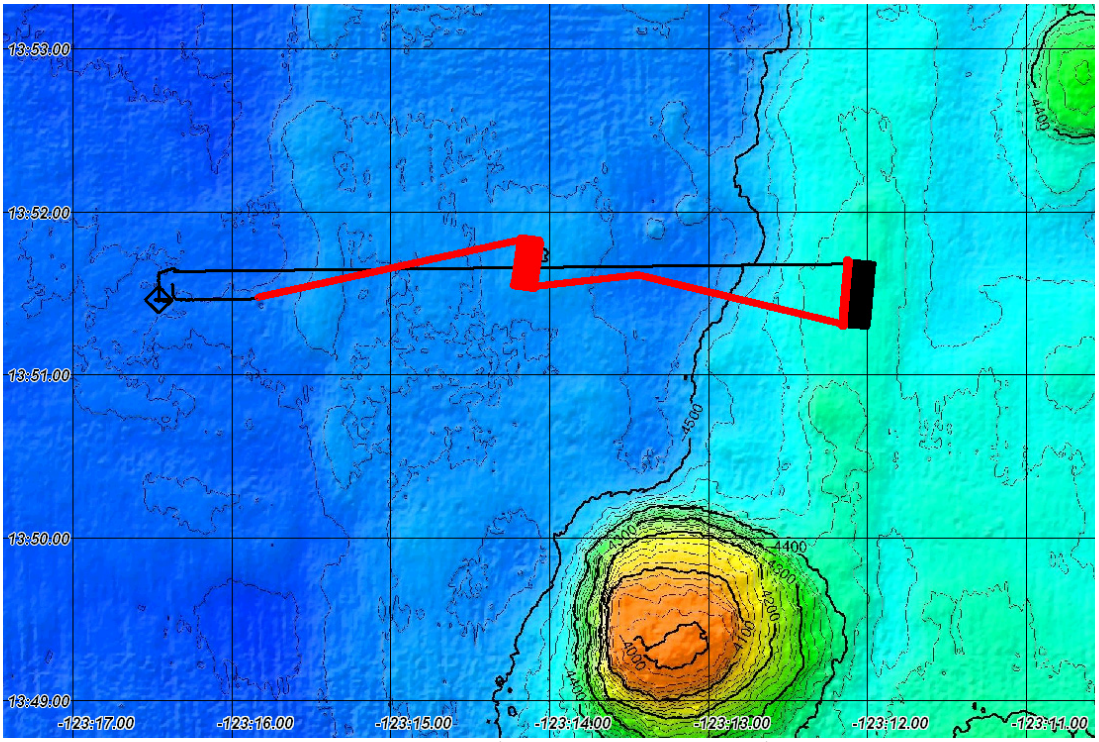


Fig. 7.2.14.25: Bathymetric map with dive track of AUV0176 and locations of good images (red).

Station 134/136 / Dive Abyss0177 / Area Belgian CCFZ

Date:	10th April 2015	Launch: 14:59 UTC	Recovery: 05:53 UTC
Survey time:	10.83 hours	Distance travelled: 79.6 km	

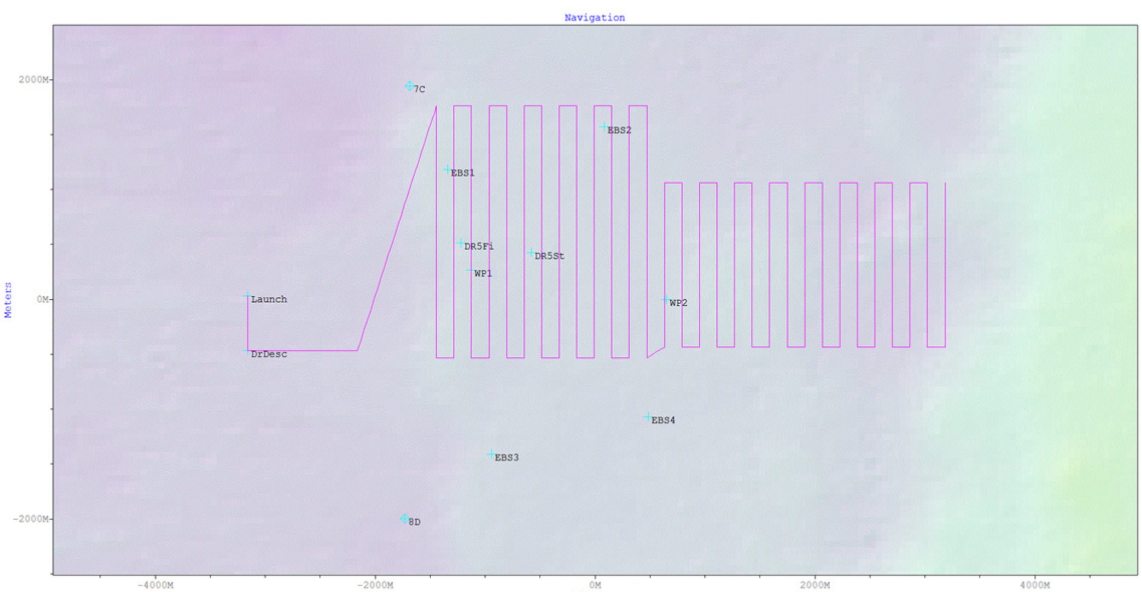


Fig. 7.2.14.26: Dive plan of mission 177

Sensors: Multibeam Sonar 200 kHz

Mission 177 was supposed to map the northeastern area of the Belgian working area including the northern EBS track (see figure X.19). The dive was done in multibeam configuration and the following settings were used:

MB frequecy:	200 Hz	Reson Range:	200 m	Vehicle speed:	3.0 knots
Altitude:	80 m	Line spacing:	160 m		

The vehicle dived during the survey in depths between 4110 and 4160 meters and showed normal and expected behavior.

Total amount of MB raw files:	53
Designation of used MB raw files:	20150410_165949 - 20150411_053217

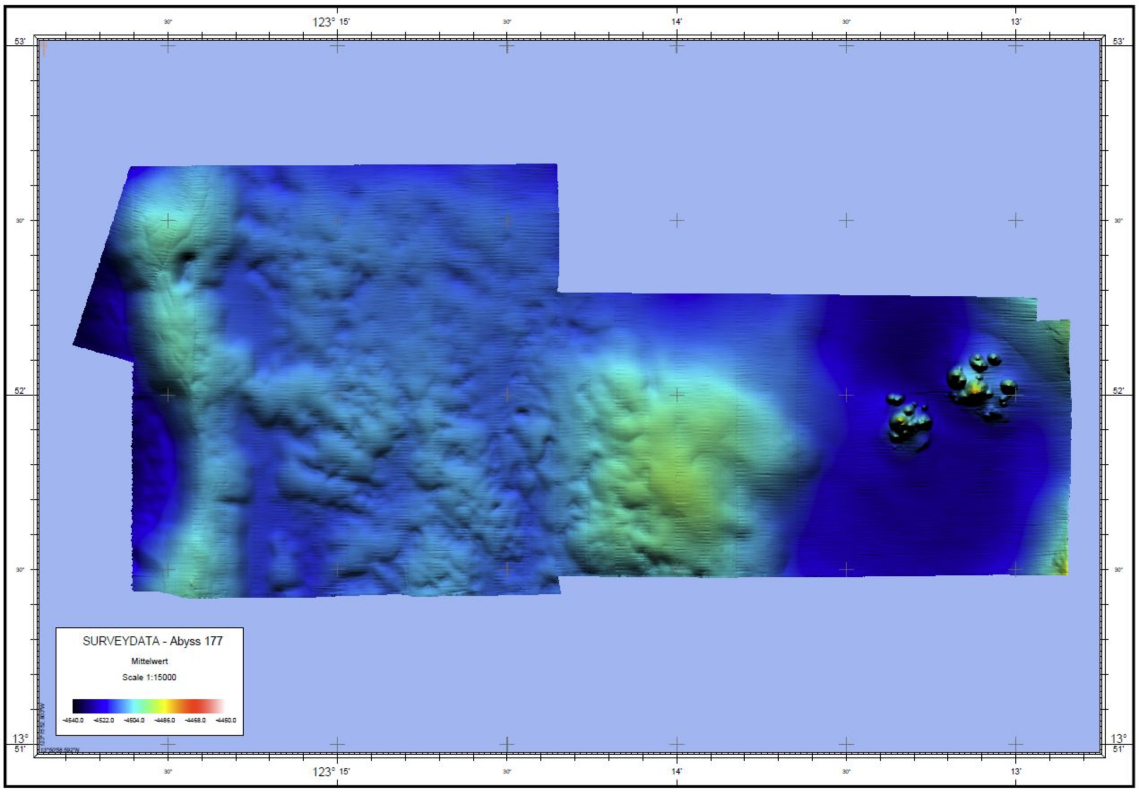


Fig. 7.2.14.27 Bathymetric map of the northeastern Belgian area

Station 140/144 / Dive Abyss0178 / Area Belgian CCFZ

Date:	11th April 2015	Launch: 15:57 UTC	Recovery: 06:35 UTC
Survey time:	9.98 hours	Distance travelled: 69.1 km	

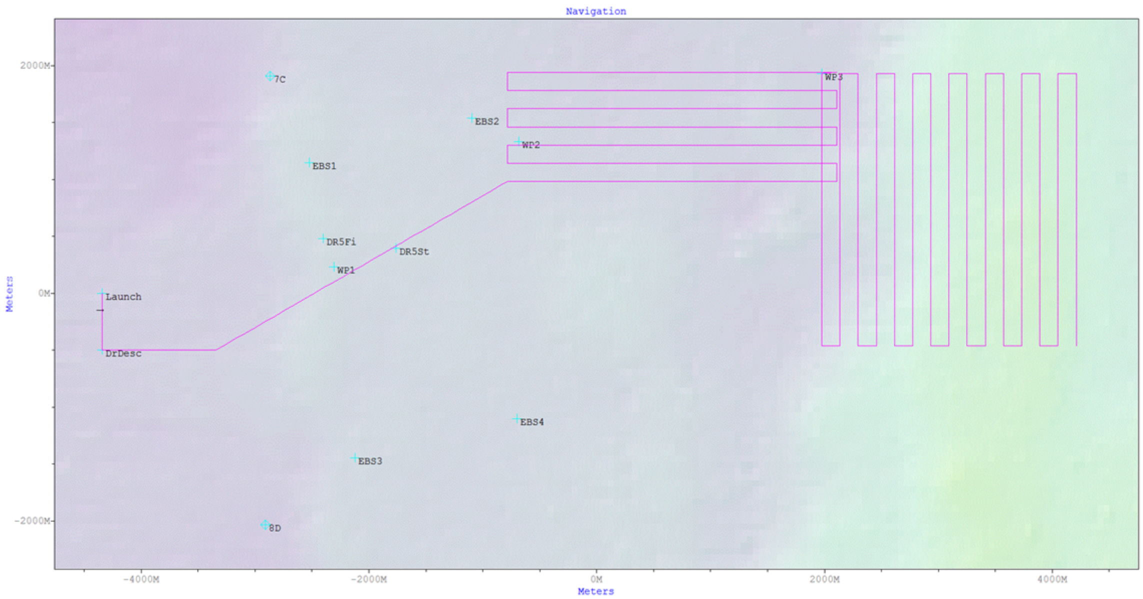


Fig. 7.2.14.28: Dive plan of mission 178

Sensors: Multibeam Sonar 200 kHz

Mission 178 was supposed to continue the mapping of dive 177 towards west (see figure X.21). The dive was done in multibeam configuration and the following settings were used:

MB frequecy:	200 Hz	Reson Range:	200 m	Vehicle speed:	3.0 knots
Altitude:	80 m	Line spacing:	160 m		

The vehicle dived during the survey in depth between 4325 and 4450 meters and showed normal and expected behavior.

Total amount of MB raw files:	40
Designation of used MB raw files:	20150411_180505 - 20150412_044319

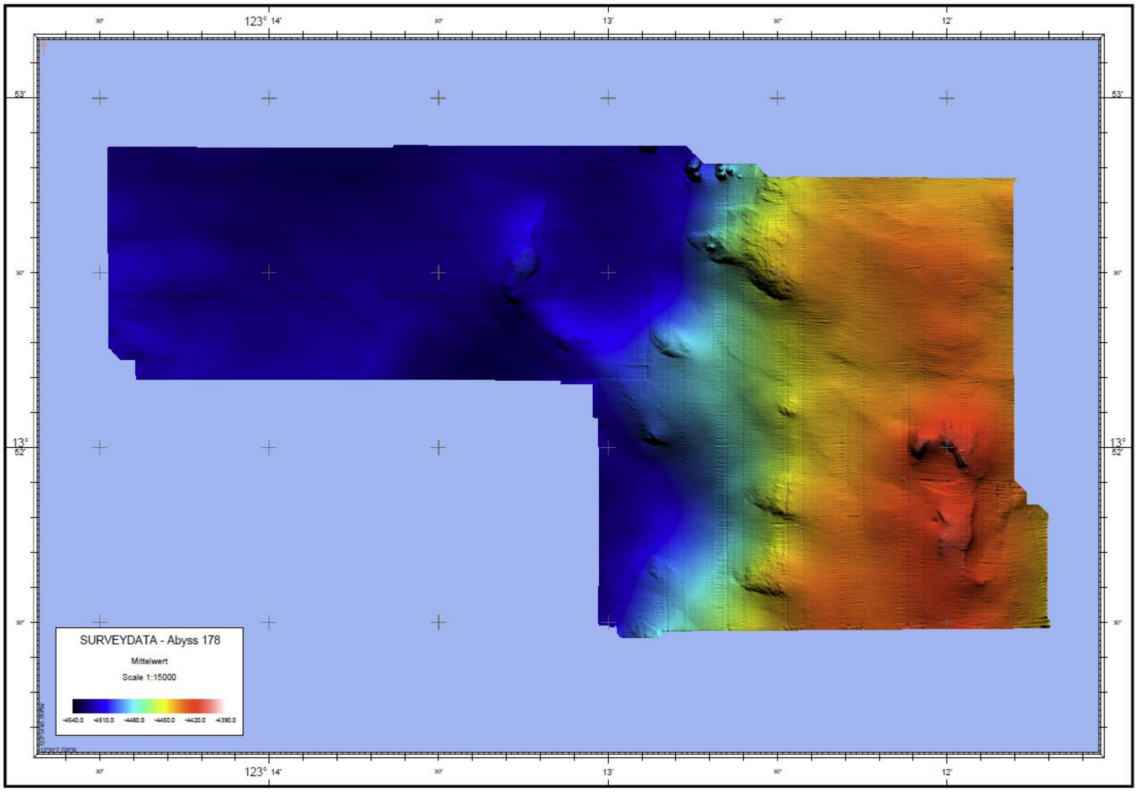


Fig. 7.2.14.29 Bathymetric map of the northeastern Belgian area

Station 152-1/156-1 / Dive Abyss0179 / Area French CCFZ

Date:	14th April 2015	Launch: 05:39 UTC	Recovery: 13:56 UTC
Survey time:	- hours	Distance travelled: 15.9 km	

The vehicle aborted the mission due to a time out event during the descent phase. It saw several times a higher power (caused by the sidescan sonar and the camera) than expected. An internal process handled this as an error and stopped the descent for some minutes. This happened so often that the vehicle was not able to reach the commanded depth in time.
The planned mission was done during dive 180.

Station 160/163 / Dive Abyss0180 / Area French CCFZ

Date:	15th April 2015	Launch: 15:07 UTC	Recovery: 09:54 UTC
Survey time:	11.8 hours	Distance travelled: 79.9 km	

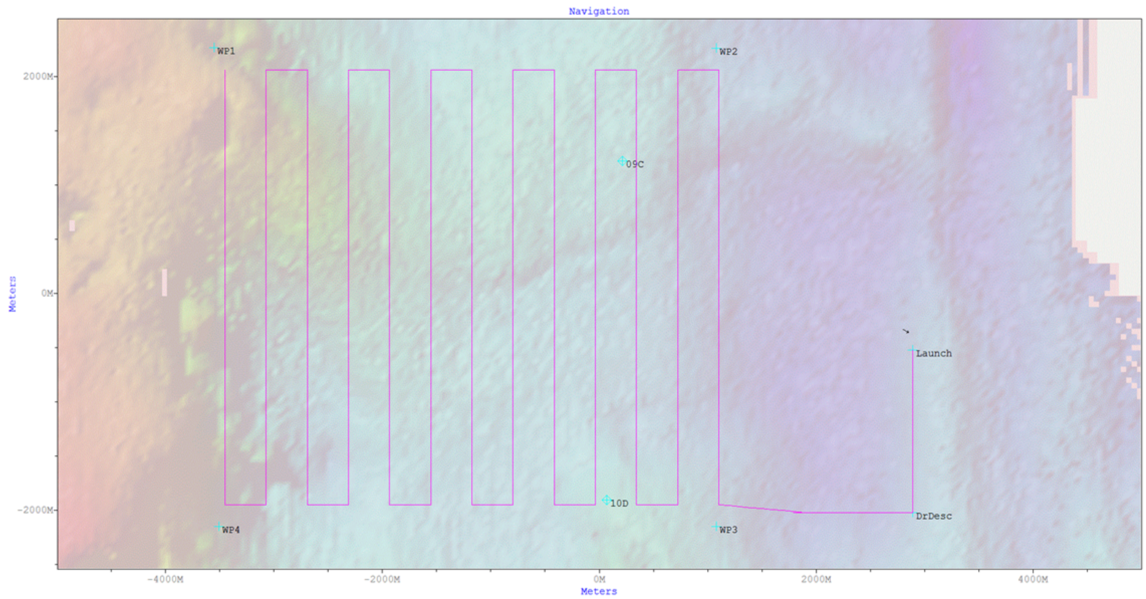


Fig. 7.2.14.23: Dive plan of mission 180

Sensors: Sidescan sonar 120 kHz

Mission 180 was supposed to map the French working area and the tracks which were done in former cruises. Dive 167 was done in camera configuration with the following settings:

Sidescan frequency:	120 kHz	Range:	400 m		
Vehicle speed:	3.0 knots	Altitude:	40 m	Line spacing:	380 m

The vehicle dived during the survey in depths between 4600 and 5025 meters. Figure X.X shows that part of the sidescan map where the seafloor was illuminated from east to west. It has been done with slightly more than 100% overlap to avoid the nadir zone.

Fig. 7.2.14.31 Sidescan map done in dive 180

Station 166/170 / Dive Abyss0181 / Area French CCFZ

Date: 16th April 2015 Launch: 18:20 UTC Recovery: 05:30 UTC
Survey time: 5.1 hours Distance travelled: 53.9 km

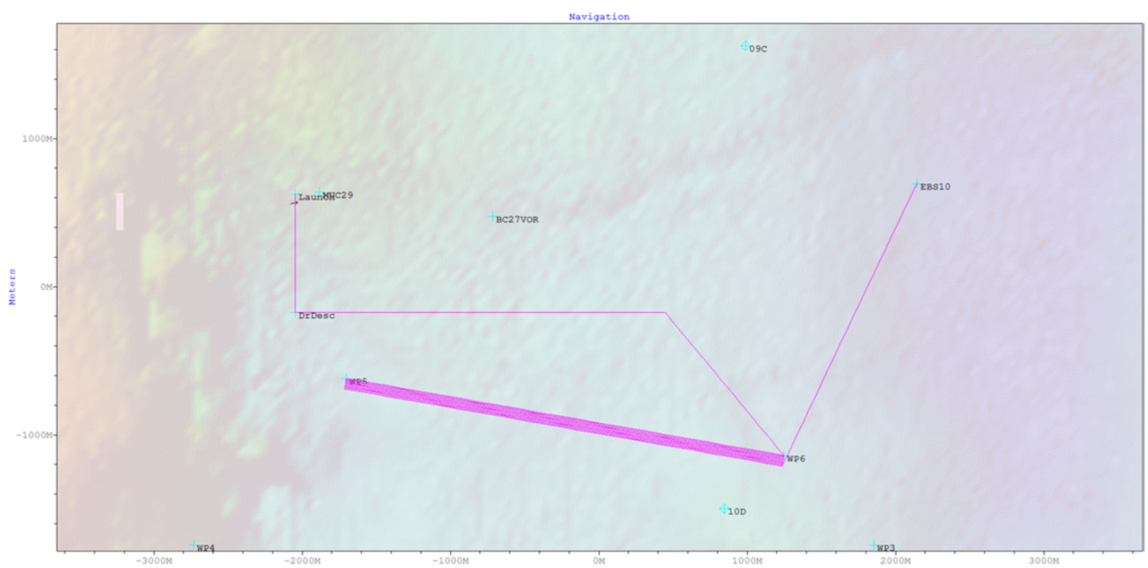


Fig. 7.2.14.32: Dive plan of mission 181

Sensors: Electronic Still Camera (Canon EOS 1100D)

Mission 181 was supposed to do a long transect for an overview of the French working area. The dive was done in camera configuration and the photo surveys had the following settings:

Aperture:	4.5	Exposure time:	1/160	Sample rate:	0.5 Hz
Vehicle speed:	3.0 knots	Altitude:	7.5 m	Line spacing:	8 m

Since the Canon 6D camera broke during dive 176 the spare Canon EOS 1100D camera was used.

Total amount images:	14,808
Designation of good images:	SO239_166_AUV15 Identifier 2334-11916

The vehicle dived during the survey in depths between 4960 and 5010 meters and showed the same attitudes how described in dive 167.

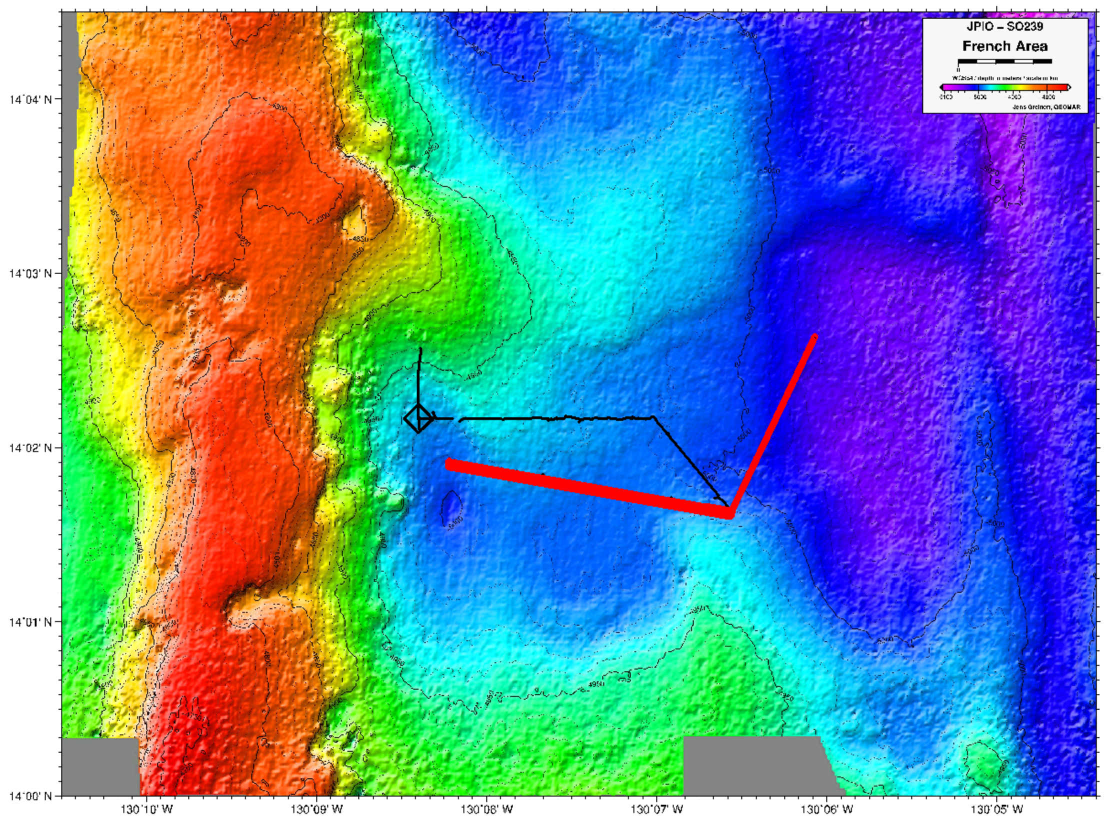


Fig. 7.2.14.33: Bathymetric map of the French area with locations of good images (red).

Station 172/178 / Dive Abyss0182 / Area French CCFZ

Date:	17th April 2015	Launch: 13:30 UTC	Recovery: 03:54 UTC
Survey time:	9.53 hours	Distance travelled: 70.8 km	

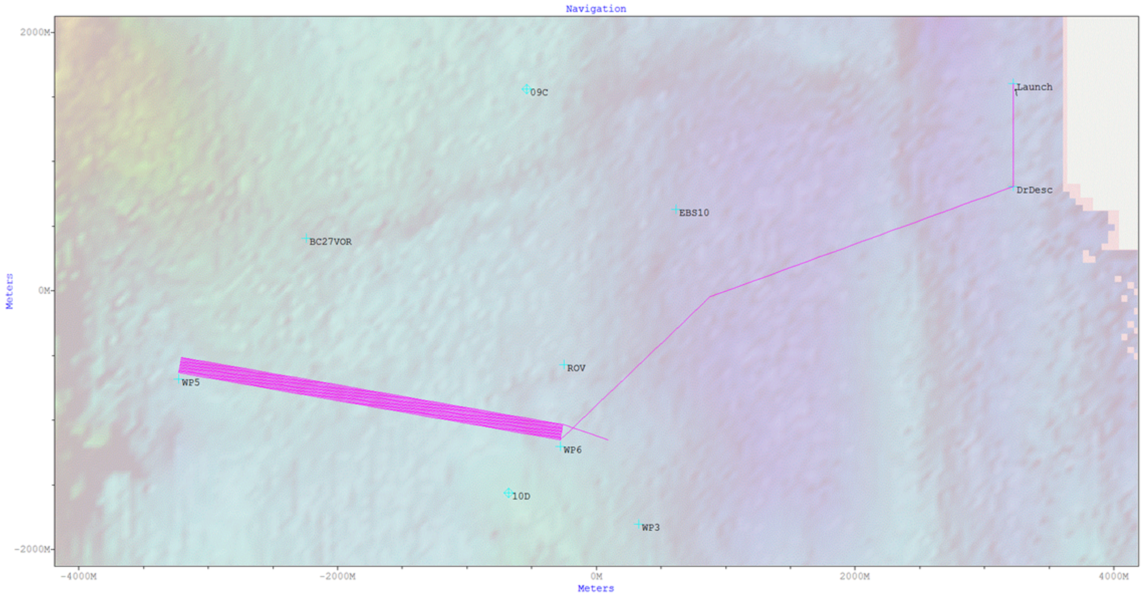


Fig. 7.2.14.34: Dive plan of mission 182

Sensors: Electronic Still Camera (Canon EOS 1100D)

Mission 182 was supposed to continue the photo survey of dive 181 towards north. The dive was done in camera configuration and the photo surveys had the following settings:

Aperture:	4.5	Exposure time:	1/160	Sample rate:	0.5 Hz
Vehicle speed:	3.0 knots	Altitude:	7.5 m	Line spacing:	8 m

Total amount images:	18,008
Designation of good images:	SO239_172_AUV16 Identifier 33-18008

The vehicle dived during the survey in depth between 4960 and 5015 meters and showed the same attitudes how described in dive 167.

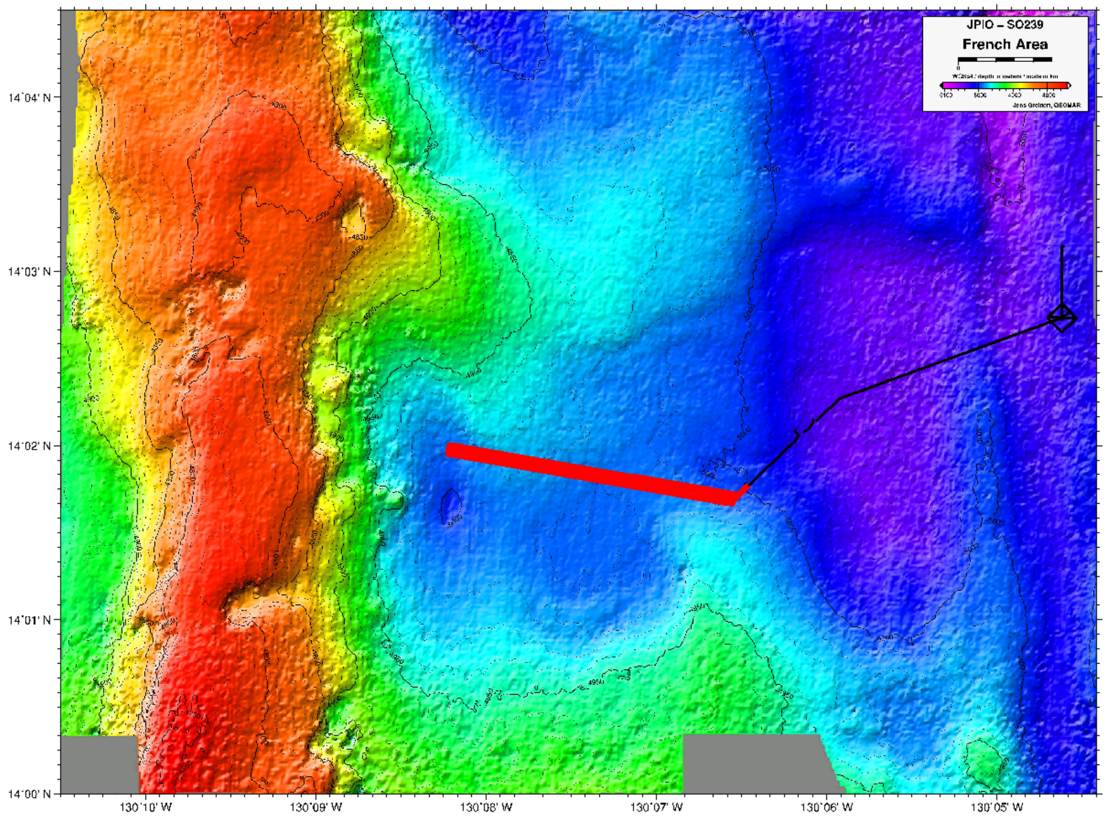


Fig. 7.2.14.35: Bathymetric map of the French area with locations of good images (red).

Station 188/190 / Dive Abyss0183 / Area APEI CCFZ

Date:	20th April 2015	Launch: 13:59 UTC	Recovery: 05:47 UTC
Survey time:	11.63 hours	Distance travelled: 77.6 km	

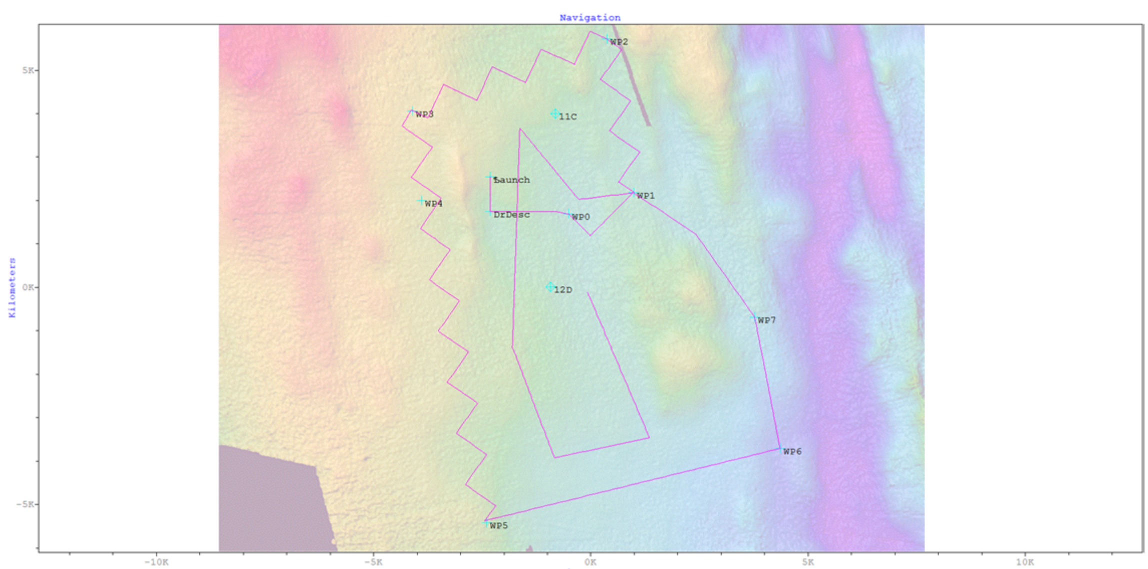


Fig. 7.2.14.36: Dive plan of mission 183

Sensors: Electronic Still Camera (Canon EOS 1100D)

Mission 183 was supposed to get a larger view how the seafloor looks like in the APEI area. The zigzagging seemed to be the best way to do this but the amount of waypoints was too high. That was why the second half of the dive was done with straight lines. The dive was done in camera configuration and the photo surveys had the following settings:

Aperture:	4.5	Exposure time:	1/160	Sample rate:	0.5 Hz
Vehicle speed:	3.0 knots	Altitude:	7.5 m		

Total amount images:	30,709
Designation of good images:	SO239_188_AUV17 Identifier 650-30709

The vehicle dived during the survey in depths between 4750 and 4900 meters and showed the same attitudes how described in dive 167.

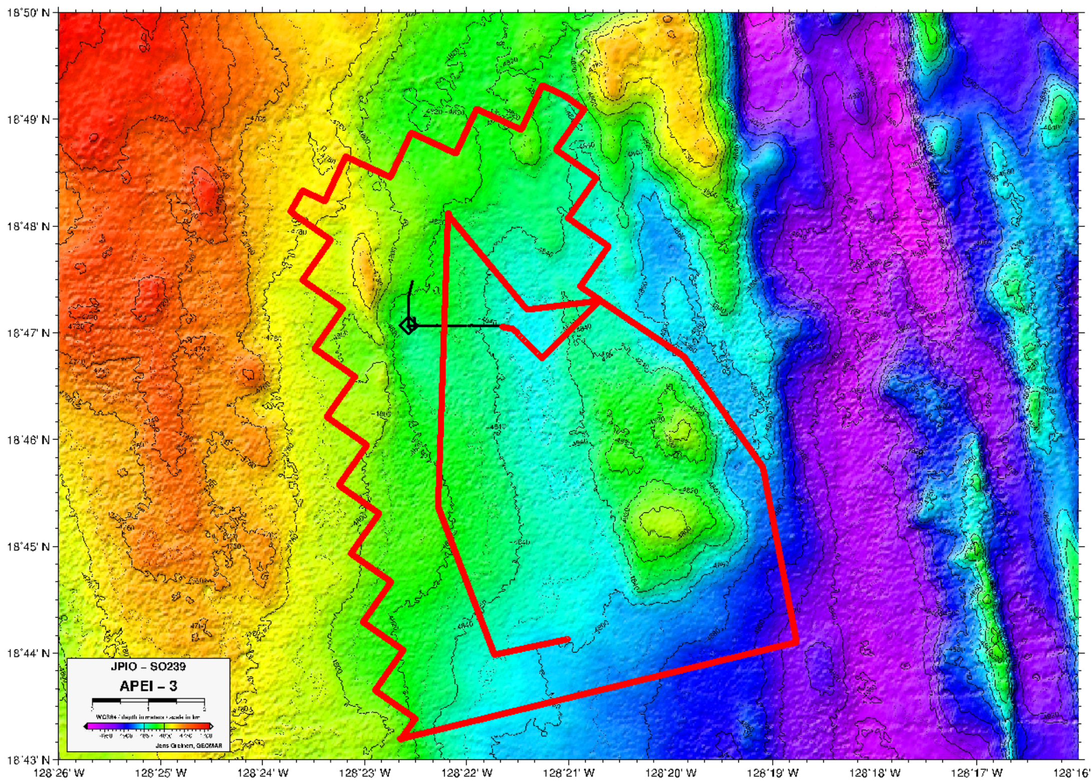


Fig. 7.2.14.37: Bathymetric map of APEI-3 area with locations of good images (red).

Station 193/198 / Dive Abyss0184 / Area APEI CCFZ

Date:	21th April 2015	Launch: 14:47 UTC	Recovery: 09:41 UTC
Survey time:	9.6 hours	Distance travelled: 74.3 km	

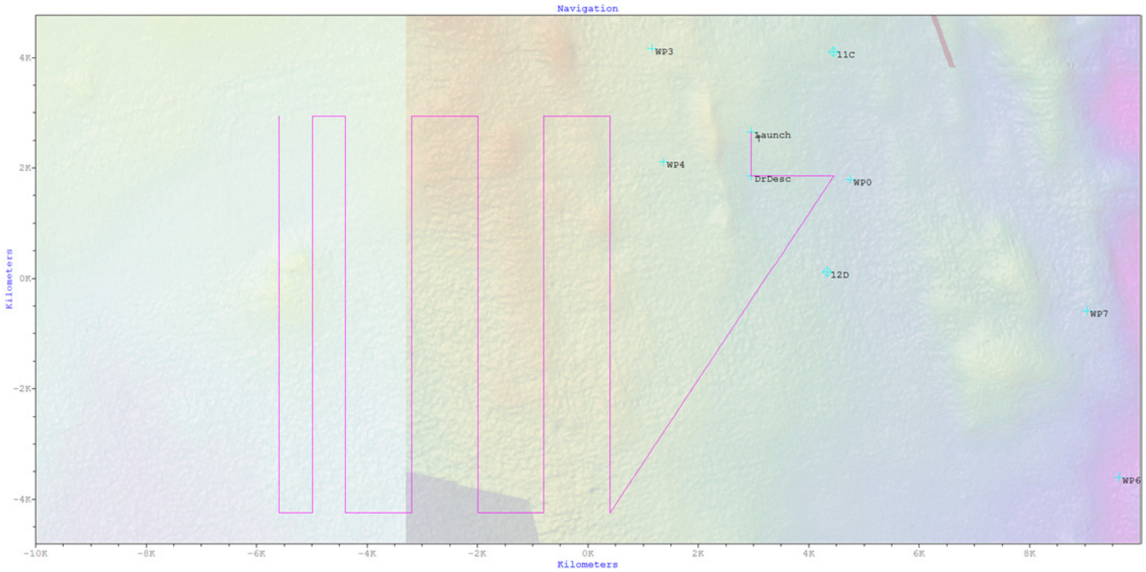


Fig. 7.2.14.38: Dive plan of mission 184

Sensors: Electronic Still Camera (Canon EOS 1100D)

Mission 184 was supposed to continue the photo survey of dive 183 towards west. The dive was done in camera configuration and the photo surveys had the following settings:

Aperture:	4.5	Exposure time:	1/160	Sample rate:	0.5 Hz
Vehicle speed:	3.0 knots	Altitude:	7.5 m	Line spacing:	1200/600 m

Total amount images:	22,775
Designation of good images:	SO239_193_AUV18 Identifier 950-22775

The vehicle dived during the survey between 4450 and 4850 meters and showed the same attitudes how described in dive 167.

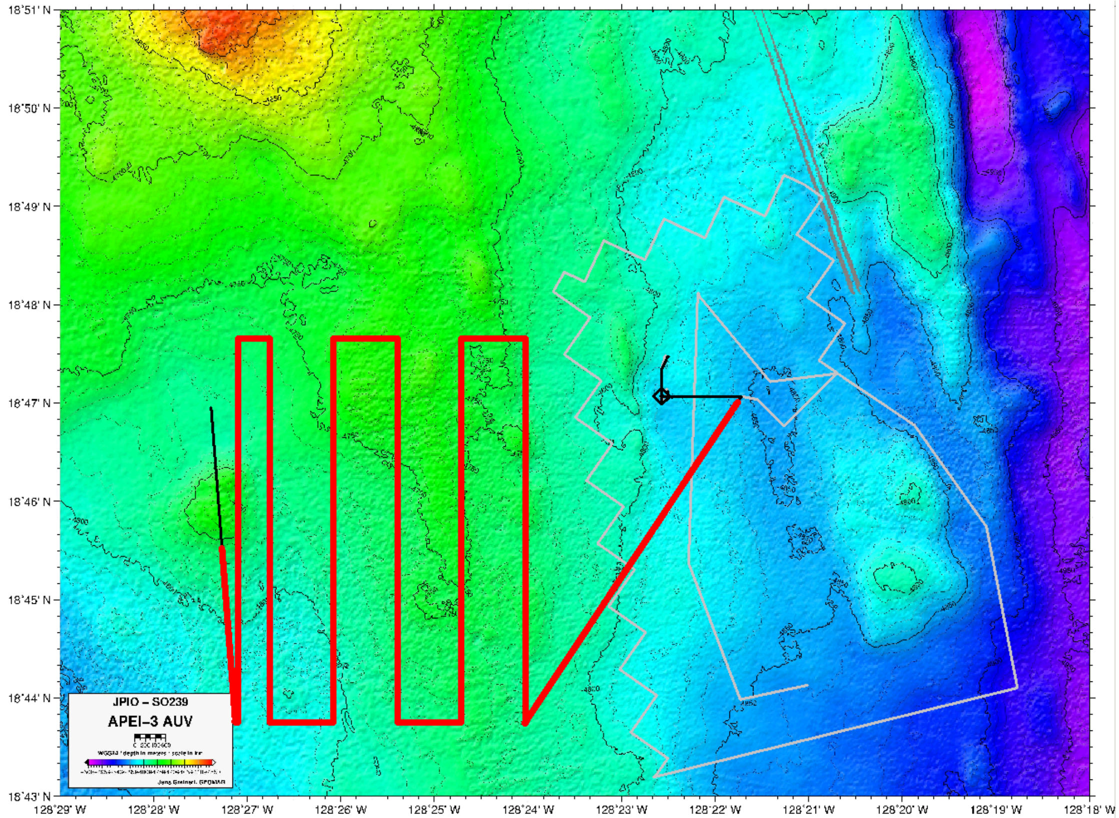


Fig. 7.2.14.39: Bathymetric map of APEI-3 area with locations of good images (red) during dive 0184. The track of dive 0183 is shown in light grey.

Station 201/208 / Dive Abyss0185 / Area APEI CCFZ

Date: 23th April 2015 Launch: 04:54 UTC Recovery: 23:51 UTC
Survey time: 11.42 hours Distance travelled: 81.1 km

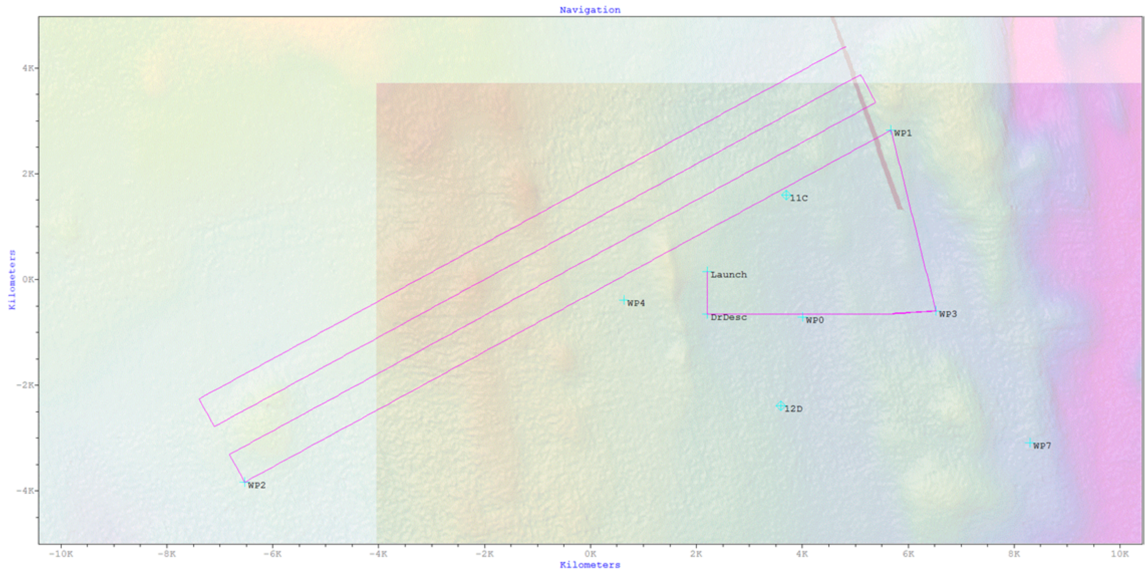


Fig. 7.2.14.40: Dive plan of mission 185

Sensors: Sidescan Sonar 120 kHz, Electronic Still Camera (Raw Data Test, Canon EOS 1100D)

Mission 185 was to map the northern area of dive 183 were a photo survey was done. The dive was done in camera configuration and the sidescan survey had the following settings:

Sidescan frequency:	120 kHz	Range:	400 m		
Vehicle speed:	3.0 knots	Altitude:	40 m	Line spacing:	600 m

The increased line spacing was chosen to cover a larger area. The small photo test survey at the beginning of the dive was to gather images in raw data format. The photo survey had the following settings:

Aperture:	4.5	Exposure time:	1/160	Sample rate:	0.5 Hz
Vehicle speed:	3.0 knots	Altitude:	7.5 m	Line spacing:	5 m

Total amount images:	5,400
Designation of good images:	SO239_201_AUV19 Identifier 1780-3340

The vehicle dived during the survey in depths between 4650 and 4850 meters and showed the same attitudes how described in dive 167.

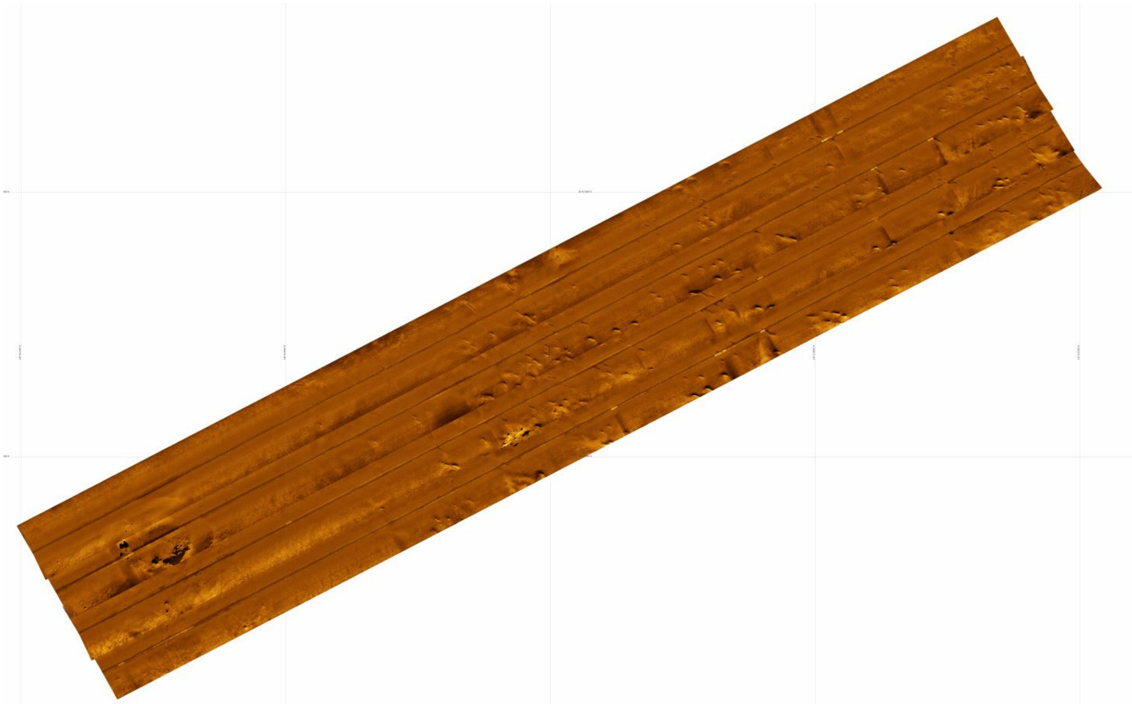


Fig. 7.2.14.41 Sidescan map done in dive 185

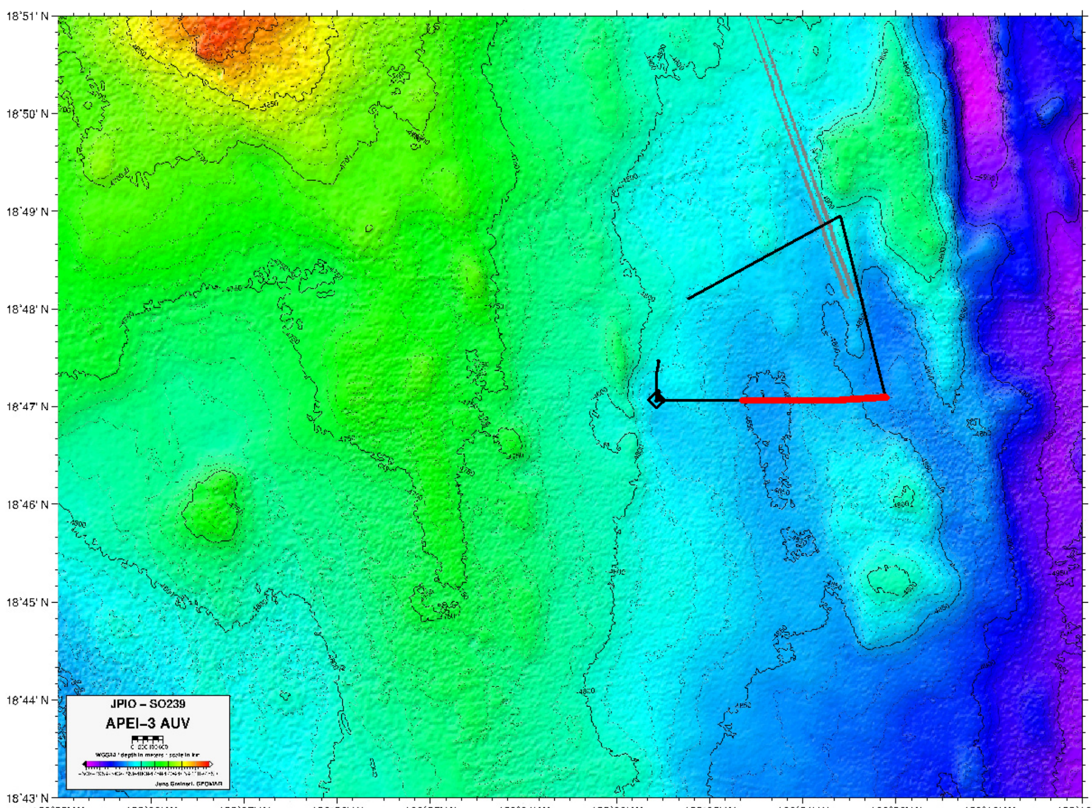


Fig. 7.2.14.42: Bathymetric map of APEI-3 area with locations of good images (red) during dive 0185 that was used for camera testing.

Station 211/216 / Dive Abyss0186 / Area APEI CCFZ

Date: 24th April 2015	Launch: 12:20 UTC	Recovery: 06:12 UTC
Survey time: 9.9 hours	Distance travelled: 74.3 km	

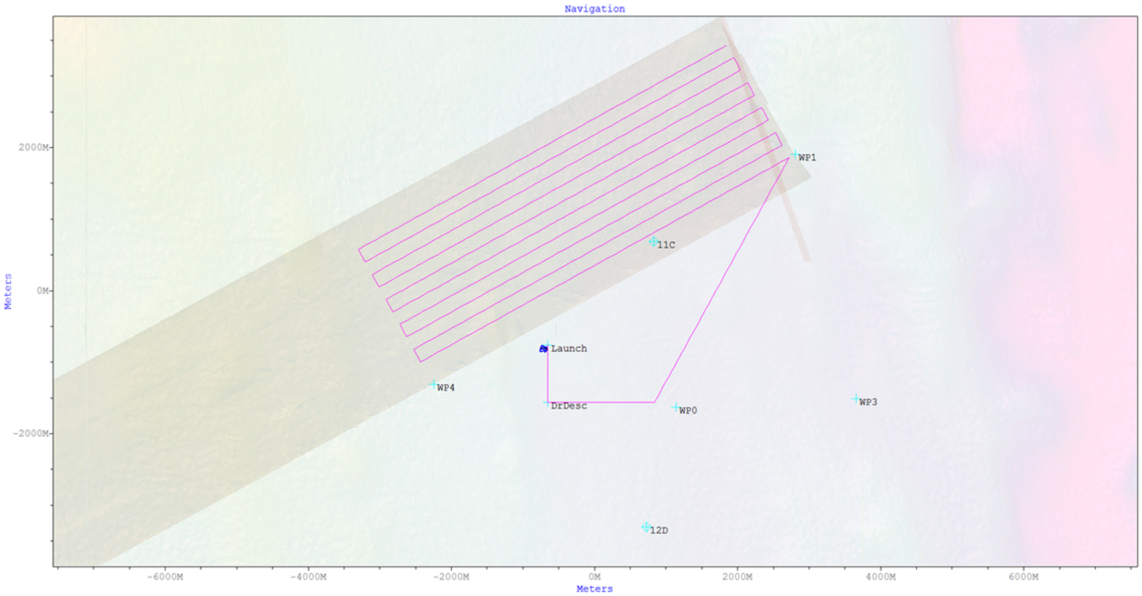


Fig. 7.2.14.30: Dive plan of mission 186

Sensors: Multibeam Sonar 200 kHz

Mission 186 was supposed to gather bathymetric data of the area that was already surveyed by photo and sidescan in the two dives before. The dive was done in multibeam configuration and the following settings were used:

MB frequecy:	200 Hz	Reson Range:	200 m	Vehicle speed:	3.0 knots
Altitude:	80 m	Line spacing:	200 m		

The vehicle dived during the survey in depths between 4675 and 4800 meters and showed normal and expected behavior.

Total amount of MB raw files:	50
Designation of used MB raw files:	20150424_143222 - 20150425_014932

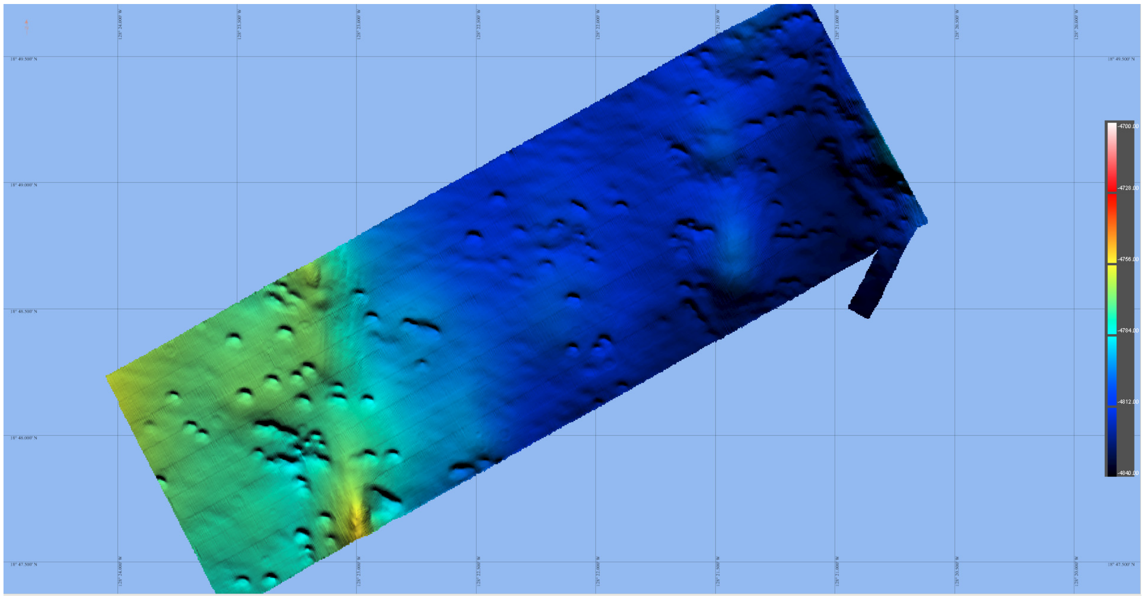


Fig. 7.2.14.31 Bathymetric map done in dive 186

7.2.15 Impact of deep-sea mining on microbial food webs (Fioretti, Gambi, Dell'Anno and Danovaro)

The main objective of the activities carried out during the field work was to collect sediment samples to investigate the potential effects of deep-sea mining on:

1) Prokaryotic diversity and prokaryote-virus interactions;
2) Quantity and biochemical composition of organic matter;
3) Organic matter degradation rates

Sampling activities

Sediment samples were collected during the cruise carried out in the CCFR (Clipperton-Clarion Fracture Zone) in four exclusive economy zones (Bundesansalt fur Geowissenschaften und Rohstoffe BGR, German; Interoceanmetal IOM; G-TEC Minerals Resources NV, GSR Belgium and Istitut fracais de recherche pour l'exploitation de la me, IFREMER France) and in one area of particular environmental interest (EPAI-3). Sampling strategy included the collection of sediment samples in impacted and in un-impacted areas (utilized as controls).

Sediment samples were collected by multiple-core (MUC) deployments in control stations and by push-corers mounted on ROV in impacted stations.

After recovery, sediment corers were sliced into 3 layers (0-1 cm; 3-5 cm; 10-15 cm). Sediment sub-aliquots were collected for the analyses of the biochemical composition of the organic matter and for microbiological variables. For the analyses of the biochemical composition of the organic matter in the sediments (in terms of protein, carbohydrate, lipid and total phytopigment concentrations) and microbial diversity (using metagenetic/metagenomic approaches), the samples were stored at -20°C.

To provide accurate estimates of viral abundance and production, the surface (0–1 cm) layer from different sediment core collected at selected sites was immediately processed onboard, without the addition of any preservative (Danovaro et al., 2001; Dell'Anno et al., 2009). This was because it is widely recognised that the use of formaldehyde or glutaraldehyde for sample storage can result in a rapid loss of viruses in sediment samples (Helton et al., 2006; Dell'Anno et al., 2009). Viral production in the sediments was determined by time-course incubation experiments of replicate sediment samples previously diluted with virus-free seawater (i.e. pre-filtered onto 0.02 µm pore size filters). Additional sediment sub-samples collected at selected sites were also processed on board for the determination of the extracellular enzymatic activities (in terms of aminopeptidases, β-glucosidases and alkaline phosphatases) used as proxies of organic matter degradation rates.

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10. Abbreviations /Abkürzungen

APEI: Areas of Particular Environmental Interest

AWI: Alfred-Wegener-Institute Helmholtz-Zentrum für Polar und Meeresforschung

BGR: Bundesanstalt für Geowissenschaften und Rohstoffe

DEME: Dredging, Environmental and Marine Engineering

EBS: Epibenthic Sledge

GEOMAR: Helmholtz-Zentrum für Ozeanforschung Kiel

IFREMER: Institut Français de Recherche pour l'Exploitation de la Mer

IOM: Interoceanmetal Joint Organization

ISA: Interantional Seabed Authority

MUC: Multicorer

NIOZ: Royal Netherlands Institute for Sea Research

SENCKENBERG: Senckenberg Gesellschaft für Naturforschung

UNCLOS: United Nations Convention on the Law of the Sea

11. Appendices /Anhänge

11.1 Station list

Station	Date	UTC	PositionLat	PositionLon	Depth [m]	Code	Action	Remarks
SO239/001-1	14.03.2015	15:04	8° 14,06' N	90° 57,08' W	3488.5	CTD	zu Wasser	Winch EL 2
SO239/002-1	19.03.2015	14:57	11° 50,66' N	116° 57,79' W	4100.2	MOR	Aktion	Auftriebskörper z/W
SO239/002-1	19.03.2015	15:09	11° 50,65' N	116° 57,77' W	4101	MOR	Aktion	Strömungsmesser
SO239/003-1	19.03.2015	15:47	11° 50,66' N	116° 57,76' W	4102.1	CTD	zu Wasser	
SO239/003-1	19.03.2015	17:17	11° 50,69' N	116° 57,68' W	4098.2	CTD	zu Wasser	Hydrophon
SO239/004-1	19.03.2015	20:48	11° 51,28' N	116° 59,67' W	4117.4	BOBO	zu Wasser	BOBO
SO239/005-1	19.03.2015	21:23	11° 51,48' N	117° 0,16' W	4115.6	DOS	zu Wasser	DOS
SO239/006-1	19.03.2015	21:55	11° 52,20' N	117° 0,87' W	4112.1	MOR	zu Wasser	LBL 1
SO239/007-1	19.03.2015	22:36	11° 50,29' N	117° 0,28' W	4125.2	MOR	zu Wasser	LBL 2
SO239/009-1	20.03.2015	04:50	11° 51,70' N	117° 1,90' W	0	AUV	zu Wasser	
SO239/010-1	20.03.2015	07:00	11° 51,54' N	117° 0,59' W	0	CTD	zu Wasser	
SO239/011-1	20.03.2015	11:07	11° 51,37' N	117° 3,52' W	4122.1	ATC	zu Wasser	Amphipod trap BE
SO239/012-1	20.03.2015	13:18	11° 50,83' N	117° 3,56' W	4117.6	BC	auf dem Grund	SL: 4160m, SZ: 64,4kN
SO239/013-1	20.03.2015	18:18	11° 51,06' N	117° 1,97' W	0	ROV	auf Tiefe	Bosi: 4115 m
SO239/013-1	20.03.2015	22:00	11° 51,06' N	117° 1,90' W	0	ROV	tauchen auf	Beginn Auftauchen
SO239/015-1	21.03.2015	06:16	11° 50,66' N	117° 3,13' W	4132.6	BC	auf dem Grund	SLmax: 4161m
SO239/016-1	21.03.2015	09:57	11° 51,44' N	117° 3,12' W	4122.1	BC	auf dem Grund	SLmax: 4156m, SZmax: 62kN
SO239/017-1	21.03.2015	13:47	11° 50,63' N	117° 3,57' W	4134.3	GC	am Grund	SL: 4189m, SZ: 74,1kN
SO239/018-1	21.03.2015	16:08	11° 50,63' N	117° 3,57' W	0	ATC	zu Wasser	Amphipod trap DE. Trap lost
SO239/019-1	21.03.2015	18:11	11° 51,70' N	117° 2,04' W	0	AUV	zu Wasser	
SO239/020-1	21.03.2015	22:06	11° 49,81' N	117° 0,28' W	0	EBS	am Grund	SL: 4050m
SO239/020-1	22.03.2015	01:19	11° 50,31' N	116° 58,78' W	4093	EBS	vom Grund	SL: 4145m
SO239/021-1	22.03.2015	06:00	11° 51,21' N	117° 3,57' W	0	BC	auf dem Grund	SLmax: 4146m
SO239/023-1	22.03.2015	11:42	11° 51,00' N	117° 3,16' W	4122	BC	auf dem Grund	SL: 4155m, SZ: 63,1kN
SO239/024-1	22.03.2015	16:01	11° 51,52' N	117° 1,19' W	0	EBS	am Grund	
SO239/024-1	22.03.2015	18:59	11° 51,87' N	116° 59,74' W	0	EBS	vom Grund	
SO239/025-1	22.03.2015	21:40	11° 51,32' N	117° 0,88' W	4120.6	CTD	zu Wasser	Transponder bei SL: 50m
SO 239/029-1	23.03.2015	18:02	11° 43,04' N	116° 36,49' W	0	ROV	auf Tiefe	BoSi: 3000 m
SO239/025-1	23.03.2015	00:25	11° 51,63' N	117° 0,64' W	0	CTD	zu Wasser	Ende Track, Beg. hieven, SL: 4122m
SO239/026-1	23.03.2015	02:55	11° 51,64' N	117° 0,63' W	4121	CTD	zu Wasser	
SO239/027-1	23.03.2015	08:30	11° 50,69' N	117° 3,54' W	0	MUC	am Grund	SLmax: 4151m
SO239/028-1	23.03.2015	10:51	11° 51,72' N	117° 1,92' W	0	AUV	zu Wasser	
SO 239/029-1	24.03.2015	01:55	11° 42,73' N	116° 35,94' W	0	ROV	tauchen auf	
SO 239/031-1	24.03.2015	10:01	11° 51,06' N	117° 3,46' W	0	MUC	am Grund	SLmax: 4143m
SO 239/033-1	24.03.2015	15:27	11° 51,29' N	117° 3,38' W	4126,9	ATC	Ausgelöst	recovered
SO 239/032-1	24.03.2015	13:57	11° 51,28' N	117° 3,38' W	4127	MUC	auf Position	Boko, SL: 4144m

SO 239/034-1	24.03.2015	19:23	11° 50,46' N	117° 3,22' W	0	MUC	auf Position	BOKO - SLmax: 4153m; Hieven - SZmax: 52kN
SO 239/035-1	24.03.2015	22:46	11° 51,09' N	117° 3,05' W	0	MUC	auf Position	BOKO - SLmax: 4143m; Hieven - SZmax: 52kN
SO 239/036-1	25.03.2015	00:35	11° 50,73' N	117° 4,87' W	4126	HS_PS	Beginn Track	rwk: 090°, d: 7sm
SO 239/036-1	25.03.2015	02:28	11° 48,56' N	116° 59,98' W	4142.7	HS_PS	Profil Ende	
SO 239/037-1	25.03.2015	01:30	11° 50,58' N	116° 59,82' W	0	DOS	ausgelöst	DOS
SO 239/038-1	25.03.2015	04:00	11° 51,71' N	117° 1,94' W	4122.7	AUV	zu Wasser	
SO 239/039-1	25.03.2015	08:12	11° 50,47' N	117° 3,50' W	0	MUC	auf Position	BOSI - SL: 4150m
SO 239/039-1	25.03.2015	11:12	11° 50,64' N	117° 3,44' W	4132	MUC	auf Position	Boko, SL: 4150m
SO 239/040-1	25.03.2015	13:15	11° 50,64' N	117° 3,44' W	4131.3	PLA	zu Wasser	
SO 239/040-1	25.03.2015	14:04	11° 50,65' N	117° 3,52' W	4132.5	PLA	auf Tiefe	SL: 500m
SO 239/040-1	25.03.2015	15:03	11° 50,62' N	117° 3,69' W	4134.2	PLA	an Deck	
SO 239/041-1	25.03.2015	19:32	11° 50,55' N	117° 3,46' W	0	ROV	auf Tiefe	BOSI
SO 239/041-1	26.03.2015	02:03	11° 50,47' N	117° 3,47' W	4131	ROV	tauchen auf	
SO 239/044-1	26.03.2015	05:13	11° 51,47' N	117° 0,19' W	4114.6	DOS	zu Wasser	DOS
SO 239/044-1	26.03.2015	07:16	11° 51,44' N	117° 0,18' W	0	DOS	am Grund	DOS
SO 239/046-1	26.03.2015	09:57	11° 41,03' N	117° 21,90' W	4294	HS_PS	Beginn Track	rwK: 270°, d: 14nm
SO 239/046-1	26.03.2015	15:27	11° 53,03' N	117° 36,54' W	4227.6	HS_PS	Profil Ende	
SO 239/047-1	26.03.2015	16:25	11° 49,77' N	117° 31,89' W	4349.5	MOR	zu Wasser	LBL 1
SO 239/047-1	26.03.2015	17:05	11° 47,34' N	117° 31,19' W	4348.2	MOR	zu Wasser	LBL 2
SO 239/048-1	26.03.2015	18:00	11° 49,80' N	117° 31,89' W	0	REL	zu Wasser	Beginn Einmessung LBL 1
SO 239/048-1	26.03.2015	19:57	11° 49,58' N	117° 32,64' W	0	REL	zu Wasser	Ende Einmessung LBL 1
SO 239/048-1	26.03.2015	20:15	11° 47,38' N	117° 32,02' W	0	REL	zu Wasser	Beginn Einmessung LBL 2
SO 239/048-1	26.03.2015	20:57	11° 47,19' N	117° 31,98' W	0	REL	zu Wasser	Ende Einmessung LBL 2
SO 239/049-1	26.03.2015	21:33	11° 48,54' N	117° 32,21' W	0	ATC	zu Wasser	
SO 239/050-1	27.03.2015	02:33	11° 49,92' N	117° 29,31' W	4330.3	EBS	vom Grund	SL: 4285m
SO 239/051-1	27.03.2015	07:21	11° 49,42' N	117° 31,42' W	4347.8	BC	auf dem Grund	SLmax: 4393m, SZmax: 67kN
SO 239/052-1	27.03.2015	10:44	11° 48,65' N	117° 32,54' W	4325	PLA	zu Wasser	
SO 239/052-1	27.03.2015	11:08	11° 48,65' N	117° 32,54' W	4336.5	PLA	auf Tiefe	SLmax: 250m
SO 239/052-1	27.03.2015	11:31	11° 48,65' N	117° 32,54' W	4333	PLA	an Deck	
SO 239/053-1	27.03.2015	12:22	11° 48,65' N	117° 32,54' W	4335	AUV	zu Wasser	
SO 239/054-1	27.03.2015	17:16	11° 41,93' N	117° 27,23' W	3349.9	ROV	auf Tiefe	BoSi bei 3348m
SO 239/054-1	28.03.2015	02:07	11° 40,75' N	117° 27,06' W	2979	ROV	tauchen auf	
SO 239/056-1	28.03.2015	07:12	11° 48,45' N	117° 31,46' W	4368	CTD	zu Wasser	
SO 239/057-1	28.03.2015	12:38	11° 48,45' N	117° 31,46' W	4369.5	BC	auf dem Grund	SLmax: 4399m , SZmax: 68kN
SO 239/058-1	28.03.2015	16:34	11° 49,23' N	117° 32,50' W	0	BC	auf dem Grund	SLmax: 4380m
SO 239/059-1	28.03.2015	20:57	11° 48,22' N	117° 30,42' W	0	EBS	am Grund	SL: 4420m
SO 239/059-1	28.03.2015	23:38	11° 48,55' N	117° 29,03' W	0	EBS	vom Grund	SL: 4270m
SO 239/060-1	29.03.2015	04:18	11° 48,46' N	117° 33,02' W	4324.5	BC	auf dem Grund	SLmax: 4325m
SO 239/061-1	29.03.2015	08:14	11° 47,67' N	117° 32,18' W	4335.1	BC	auf dem Grund	SLmax: 4387m , SZmax: 61kN
SO 239/062-1	29.03.2015	12:26	11° 49,12' N	117° 33,22' W	4312.2	GC	am Grund	SL: 4372m, SZ: 77,1kN

SO 239/063-1	29.03.2015	14:40	11° 48,60' N	117° 32,56' W	4332,6	ATC	Ausgelöst	recovered
SO 239/064-1	29.03.2015	19:15	11° 48,97' N	117° 30,13' W	4346.3	ROV	auf Tiefe	BOSI
SO 239/064-1	30.03.2015	01:53	11° 48,31' N	117° 30,13' W	4355.4	ROV	tauchen auf	
SO 239/065-1	30.03.2015	05:00	11° 48,61' N	117° 32,53' W	4335.7	AUV	zu Wasser	
SO 239/066-1	30.03.2015	10:35	11° 49,13' N	117° 33,13' W	4314.8	MUC	auf Position	BOKO - SLmax: 4353m, Hieven - SZmax: 53kN
SO 239/067-1	30.03.2015	14:26	11° 49,37' N	117° 32,00' W	4347	MUC	auf Position	Boko, SL: 4383m
SO 239/068-1	30.03.2015	19:00	11° 47,40' N	117° 32,72' W	4351.5	MUC	am Grund	SLmax: 4374m
SO 239/069-1	30.03.2015	22:50	11° 47,62' N	117° 31,62' W	4347.9	MUC	auf Position	BOKO - SLmax: 4371m, Hieven - SZmax: 51kN
SO 239/071-1	31.03.2015	03:33	11° 47,88' N	117° 30,62' W	4354.5	MUC	auf Position	SLmax: 4380m
SO 239/074-1	31.03.2015	17:32	11° 4,62' N	119° 39,52' W	4434.5	CTD	zu Wasser	Transponder bei SL 50m
SO 239/075-1	31.03.2015	21:47	11° 3,24' N	119° 35,47' W	4292.7	HS_PS	Beginn Track	rwK: 270°, d: 7nm
SO 239/075-1	31.03.2015	22:54	11° 3,26' N	119° 42,32' W	4385.5	HS_PS	Profil Ende	
SO 239/076-1	31.03.2015	23:31	11° 3,68' N	119° 39,27' W	4419.4	MOR	zu Wasser	LBL 1
SO 239/077-1	31.03.2015	23:53	11° 4,99' N	119° 39,44' W	4403.6	MOR	zu Wasser	LBL 2
SO 239/079-1	01.04.2015	04:52	11° 4,48' N	119° 40,66' W	4414.5	AUV	zu Wasser	
SO 239/080-1	01.04.2015	05:39	11° 3,01' N	119° 41,06' W	4388.9	ATC	zu Wasser	
SO 239/081-1	01.04.2015	09:14	11° 3,97' N	119° 37,67' W	4365.7	EBS	am Grund	SL: 4423m
SO 239/081-1	01.04.2015	11:58	11° 4,29' N	119° 36,29' W	4346.4	EBS	vom Grund	SL: 4330m
SO 239/082-1	01.04.2015	17:11	11° 3,45' N	119° 37,89' W	4363.6	ROV	auf Tiefe	BoSi bei 4355m
SO 239/082-1	02.04.2015	01:27	11° 3,66' N	119° 37,65' W	4366.5	ROV	tauchen auf	
SO 239/084-1	02.04.2015	06:03	11° 4,73' N	119° 39,48' W	4430.8	MUC	am Grund	SLmax: 4465m
SO 239/085-1	02.04.2015	09:21	11° 4,63' N	119° 39,60' W	4433.6	MUC	am Grund	SLmax: 4468m
SO 239/086-1	02.04.2015	13:03	11° 4,52' N	119° 39,81' W	4439.2	MUC	am Grund	SL: 4466m, SZ: 58,2kN
SO 239/087-1	02.04.2015	16:15	11° 4,54' N	119° 39,83' W	4436	GC	am Grund	SLmax: 4475m
SO 239/088-1	02.04.2015	19:42	11° 4,74' N	119° 39,53' W	4432.9	BC	auf dem Grund	SLmax: 4467m, SZmax: 67kN
SO 239/089-1	02.04.2015	23:13	11° 4,55' N	119° 39,65' W	4436.5	BC	auf dem Grund	SL: 4472m, SZ: 67,7kN
SO 239/090-1	03.04.2015	02:35	11° 4,44' N	119° 39,85' W	4433.9	BC	auf dem Grund	SL:4469m, SZ: 68,3kN
SO 239/091-1	03.04.2015	06:00	11° 4,39' N	119° 39,34' W	4418.8	MUC	am Grund	SLmax: 4456m
SO 239/092-1	03.04.2015	09:17	11° 4,38' N	119° 39,35' W	4422.7	MUC	am Grund	SLmax: 4458m
SO 239/093-1	03.04.2015	12:35	11° 4,42' N	119° 39,33' W	4413.5	MUC	am Grund	SL: 4448m
SO 239/094-1	03.04.2015	15:53	11° 4,42' N	119° 39,33' W	4414.4	BC	auf dem Grund	SLmax: 4451m
SO 239/095-1	03.04.2015	19:08	11° 4,41' N	119° 39,35' W	4418.3	BC	auf dem Grund	SLmax: 4456m, SZmax: 69kN
SO 239/096-1	03.04.2015	21:24	11° 2,90' N	119° 41,40' W	4416,5	ATC	Ausgelöst	recovered
SO 239/097-1	04.04.2015	00:58	11° 4,37' N	119° 39,37' W	4420.6	BC	auf dem Grund	SLmax: 4460m
SO 239/098-1	04.04.2015	03:14	11° 4,50' N	119° 40,63' W	4431.9	AUV	zu Wasser	
SO 239/099-1	04.04.2015	06:30	11° 2,28' N	119° 40,89' W	4401.4	EBS	am Grund	SL: 4468m
SO 239/099-1	04.04.2015	09:12	11° 2,61' N	119° 39,52' W	4397.9	EBS	vom Grund	SL: 4390m
SO 239/100-1	04.04.2015	13:25	11° 4,29' N	119° 39,33' W	4427.5	MUC	am Grund	SL: 4459m
SO 239/101-1	04.04.2015	18:04	11° 4,49' N	119° 39,39' W	4444.6	ROV	auf Tiefe	BoSi bei 4443m
SO 239/101-1	05.04.2015	01:39	11° 4,73' N	119° 39,48' W	4411.8	ROV	tauchen auf	
SO 239/103-1	05.04.2015	07:40	11° 4,30' N	119° 39,32' W	4424.9	MUC	am Grund	SLmax: 4456m

SO 239/104-1	05.04.2015	12:16	11° 3,89' N	119° 39,18' W	4424.4	MUC	am Grund	SL: 4457m
SO 239/105-1	05.04.2015	15:45	11° 4,27' N	119° 39,32' W	4423.4	BC	auf dem Grund	SLmax: 4460m
SO 239/106-1	05.04.2015	19:09	11° 4,30' N	119° 39,29' W	4425.3	BC	auf dem Grund	BOKO - SLmax: 4455m, Hieven - SZmax: 69kN
SO 239/107-1	05.04.2015	22:26	11° 4,33' N	119° 39,27' W	4424.7	BC	auf dem Grund	SLmax: 4455m, SZmax: 70kN
SO 239/110-1	07.04.2015	00:36	13° 51,72' N	123° 14,75' W	4511.6	CTD	zu Wasser	
SO 239/111-1	07.04.2015	04:40	13° 52,72' N	123° 15,72' W	4540.1	MOR	zu Wasser	LBL 1
SO 239/112-1	07.04.2015	05:26	13° 50,59' N	123° 15,71' W	4540.5	MOR	zu Wasser	LBL 2
SO 239/113-1	07.04.2015	05:54	13° 52,67' N	123° 16,61' W	4548	HS_PS	Beginn Track	rwK: 360°, d: 10nm
SO 239/113-1	07.04.2015	12:52	13° 50,80' N	123° 19,33' W	4491.8	HS_PS	Profil Ende	
SO 239/115-1	07.04.2015	16:28	13° 51,75' N	123° 16,44' W	4520.1	AUV	zu Wasser	
SO 239/116-1	07.04.2015	17:28	13° 52,32' N	123° 16,36' W	4529.1	ATC	zu Wasser	
SO 239/117-1	07.04.2015	20:03	13° 52,39' N	123° 15,30' W	4496.3	EBS	am Grund	SL: 4550m
SO 239/117-1	07.04.2015	23:08	13° 52,78' N	123° 13,82' W	4513.1	EBS	vom Grund	SL: 4500m
SO 239/118-1	08.04.2015	01:29	13° 52,38' N	123° 15,09' W	4511.7	CTD	zu Wasser	
SO 239/119-1	08.04.2015	08:06	13° 51,55' N	123° 15,16' W	4516.2	BC	auf dem Grund	SLmax: 4550m, SZmax: 64kN
SO 239/121-1	08.04.2015	12:51	13° 51,25' N	123° 15,30' W	4517.7	MUC	am Grund	SL: 4555m
SO 239/122-2	08.04.2015	18:11	13° 51,23' N	123° 15,29' W	4517.7	GC	am Grund	SLmax: 4563m
SO 239/123-1	08.04.2015	19:40	13° 51,22' N	123° 15,30' W	4518,6	ATC	Ausgelöst	recovered
SO 239/124-1	08.04.2015	23:39	13° 51,28' N	123° 14,69' W	4510.8	MUC	am Grund	SL: 4548m
SO 239/125-1	09.04.2015	03:00	13° 51,06' N	123° 14,22' W	4510.8	MUC	am Grund	SL: 4548m
SO 239/126-1	09.04.2015	05:00	13° 50,51' N	123° 14,99' W	4516.3	ATC	zu Wasser	
SO 239/127-1	09.04.2015	06:43	13° 50,66' N	123° 14,76' W	4513.9	BC	auf dem Grund	SL: 4554m
SO 239/128-1	09.04.2015	10:05	13° 51,10' N	123° 15,12' W	4510.7	BC	auf dem Grund	SLmax: 4552m, SZmax: 67kN
SO 239/129-1	09.04.2015	12:05	13° 50,99' N	123° 13,06' W	4485.9	HS_PS	Beginn Track	rwk: 045°, d: 7sm
SO 239/129-1	09.04.2015	13:30	13° 51,58' N	123° 16,36' W	4532.9	HS_PS	Profil Ende	
SO 239/130-1	09.04.2015	15:16	13° 51,68' N	123° 16,37' W	4529.9	AUV	zu Wasser	
SO 239/131-1	09.04.2015	17:47	13° 52,39' N	123° 15,03' W	0	ROV	auf Tiefe	BoSi: 4508m
SO 239/131-1	10.04.2015	02:12	13° 52,44' N	123° 14,88' W	0	ROV	tauchen auf	
SO 239/133-1	10.04.2015	09:55	13° 50,98' N	123° 15,07' W	0	EBS	am Grund	SL: 4550m
SO 239/133-1	10.04.2015	12:29	13° 51,31' N	123° 13,73' W	4507	EBS	vom Grund	SL: 4485m
SO 239/134-1	10.04.2015	15:00	13° 51,76' N	123° 16,46' W	4530.6	AUV	zu Wasser	
SO 239/135-1	10.04.2015	18:21	13° 58,69' N	123° 8,94' W	0	ROV	auf Tiefe	BoSi bei 3912m
SO 239/135-1	11.04.2015	02:13	13° 59,06' N	123° 8,64' W	0	ROV	tauchen auf	
SO 239/137-1	11.04.2015	07:43	13° 51,36' N	123° 14,28' W	4509.7	BC	auf dem Grund	SLmax: 4551m, SZmax: 64kN
SO 239/138-1	11.04.2015	11:16	13° 50,89' N	123° 14,08' W	4503.1	BC	auf dem Grund	SL: 4550m, SZ: 73,0kN
SO 239/139-1	11.04.2015	13:33	13° 52,41' N	123° 16,46' W	4541	ATC	Ausgelöst	recoverd
SO 239/140-1	11.04.2015	16:00	13° 51,71' N	123° 16,46' W	4533.3	AUV	zu Wasser	
SO 239/141-1	11.04.2015	18:16	13° 52,03' N	123° 15,33' W	4506.6	ROV	auf Tiefe	BoSi bei 4510m
SO 239/141-1	12.04.2015	02:14	13° 52,19' N	123° 15,25' W	0	ROV	tauchen auf	
SO 239/145-1	12.04.2015	08:40	13° 50,80' N	123° 14,66' W	4513.3	MUC	am Grund	SLmax: 4548m
SO 239/146-1	12.04.2015	11:59	13° 50,74' N	123° 15,10' W	4511.4	MUC	am Grund	SL: 4549m
SO 239/147-1	13.04.2015	21:20	14° 2,66' N	130° 5,92' W	5028.7	CTD	zu Wasser	

SO 239/148-1	14.04.2015	01:31	14° 3,27' N	130° 6,78' W	4967.2	MOR	zu Wasser	LBL 2
SO 239/149-1	14.04.2015	02:03	14° 1,58' N	130° 6,80' W	4970.9	MOR	zu Wasser	LBL 1
SO 239/150-1	14.04.2015	02:28	14° 2,65' N	130° 4,32' W	5032	HS_PS	Beginn Track	rwk: 270°, d: 5sm
SO 239/150-1	14.04.2015	03:25	14° 2,66' N	130° 10,41' W	4899.8	HS_PS	Profil Ende	
SO 239/152-1	14.04.2015	05:40	14° 2,61' N	130° 7,57' W	4959.6	AUV	zu Wasser	
SO 239/153-1	14.04.2015	06:20	14° 2,75' N	130° 7,93' W	4934.4	ATC	zu Wasser	
SO 239/154-1	14.04.2015	08:21	14° 3,00' N	130° 8,32' W	4889.6	MUC	am Grund	SLmax: 4927m
SO 239/155-1	14.04.2015	11:59	14° 2,97' N	130° 7,85' W	4940	MUC	am Grund	SL: 4975m
SO 239/157-1	14.04.2015	17:27	14° 2,09' N	130° 7,13' W	0	ROV	auf Tiefe	BoSi: 4982m
SO 239/157-1	14.04.2015	23:56	14° 2,19' N	130° 6,82' W	0	ROV	tauchen auf	
SO 239/158-1	15.04.2015	04:58	14° 3,41' N	130° 7,99' W	4946	EBS	am Grund	SL: 5018m
SO 239/158-1	15.04.2015	08:29	14° 3,81' N	130° 6,48' W	4977.3	EBS	vom Grund	SL: 4970m
SO 239/159-1	15.04.2015	13:02	14° 2,94' N	130° 8,06' W	4921	BC	auf dem Grund	SL: 4955m, SZ: 64,8kN
SO 239/160-1	15.04.2015	15:10	14° 2,39' N	130° 5,61' W	5029.8	AUV	zu Wasser	
SO 239/161-1	15.04.2015	19:00	14° 2,07' N	130° 5,60' W	5030.7	ROV	auf Tiefe	BoSi bei 5034m
SO 239/161-1	16.04.2015	02:00	14° 2,41' N	130° 5,72' W	5028.1	ROV	tauchen auf	
SO 239/162-1	16.04.2015	06:19	14° 2,94' N	130° 7,56' W	4950.7	BC	auf dem Grund	SLmax: 4988m
SO 239/164-1	16.04.2015	11:55	14° 3,00' N	130° 7,42' W	4954.9	MUC	am Grund	SL: 4992m
SO 239/165-1	16.04.2015	15:36	14° 2,63' N	130° 8,39' W	4922.7	GC	am Grund	SLmax: 4978m
SO 239/166-1	16.04.2015	18:24	14° 2,62' N	130° 8,39' W	4924.1	AUV	zu Wasser	
SO 239/167-1	16.04.2015	20:14	14° 2,62' N	130° 8,32' W	4918.8	MUC	am Grund	SLmax: 4967m
SO 239/168-1	16.04.2015	23:48	14° 2,60' N	130° 7,82' W	4948.3	MUC	am Grund	SL: 4986m
SO 239/169-1	17.04.2015	03:14	14° 2,53' N	130° 7,64' W	4963.7	BC	auf dem Grund	SLmax: 5000m
SO 239/171-1	17.04.2015	08:00	14° 2,68' N	130° 5,97' W	5030.2	EBS	am Grund	SL: 5060m
SO 239/171-1	17.04.2015	11:04	14° 3,20' N	130° 4,61' W	5015	EBS	vom Grund	SL: 4995m
SO 239/172-1	17.04.2015	13:32	14° 3,20' N	130° 4,61' W	5014.4	AUV	zu Wasser	
SO 239/173-1	17.04.2015	14:03	14° 3,20' N	130° 4,61' W	5016,1	ATC	Ausgelöst	recovered
SO 239/174-1	17.04.2015	18:34	14° 2,44' N	130° 5,10' W	5005.5	GC	am Grund	SLmax: 5052 m
SO 239/175-1	17.04.2015	22:09	14° 2,45' N	130° 5,11' W	5008	MUC	am Grund	SLmax: 5043m
SO 239/176-1	18.04.2015	01:40	14° 2,54' N	130° 5,13' W	5012.3	MUC	am Grund	SL: 5050m
SO 239/180-1	18.04.2015	07:39	14° 2,50' N	130° 8,18' W	4936.4	BC	auf dem Grund	SLmax: 4981m, SZmax: 69kN
SO 239/181-1	18.04.2015	11:03	14° 2,79' N	130° 8,49' W	4896.3	BC	auf dem Grund	SL: 4946m, SZ: 68,9kN
SO 239/182-1	18.04.2015	14:17	14° 2,54' N	130° 7,65' W	4957.3	BC	auf dem Grund	SL: 5001m, SZ: 70,3kN
SO 239/183-1	19.04.2015	13:55	18° 2,39' N	128° 41,91' W	4763	CTD	zu Wasser	
SO 239/184-1	19.04.2015	17:56	18° 3,62' N	128° 41,91' W	4796.9	HS_PS	Beginn Track	
SO 239/184-1	20.04.2015	11:30	18° 45,42' N	128° 22,58' W	0	HS_PS	Profil Ende	
SO 239/185-1	20.04.2015	04:23	18° 46,13' N	128° 21,77' W	4835.5	MOR	zu Wasser	LBL 1
SO 239/186-1	20.04.2015	04:51	18° 48,27' N	128° 21,76' W	4826.9	MOR	zu Wasser	LBL 2
SO 239/188-1	20.04.2015	14:01	18° 47,53' N	128° 22,58' W	4818.2	AUV	zu Wasser	
SO 239/189-1	20.04.2015	17:45	18° 47,80' N	128° 18,53' W	4933.4	ROV	auf Tiefe	BoSi bei 4925m
SO 239/189-1	21.04.2015	02:30	18° 48,13' N	128° 18,20' W	4964	ROV	tauchen auf	
SO 239/191-1	21.04.2015	06:12	18° 46,88' N	128° 19,98' W	4854.7	ATC	zu Wasser	
SO 239/192-1	21.04.2015	09:00	18° 44,81' N	128° 21,87' W	0	EBS	am Grund	SL: 4860m, rwK: 071°

SO 239/192-1	21.04.2015	12:00	18° 45,34' N	128° 20,42' W	0	EBS	vom Grund	SL: 4810m
SO 239/193-1	21.04.2015	14:49	18° 47,52' N	128° 22,56' W	4808.1	AUV	zu Wasser	
SO 239/194-1	21.04.2015	16:46	18° 47,54' N	128° 22,33' W	4815.5	GC	am Grund	SLmax: 4865m
SO 239/195-1	21.04.2015	20:08	18° 47,75' N	128° 21,73' W	4833.4	BC	auf dem Grund	SLmax: 4874m, SZmax: 67kN
SO 239/196-1	21.04.2015	23:33	18° 47,83' N	128° 20,77' W	4847.2	BC	auf dem Grund	SL: 4880m, SZ: 66,3kN
SO 239/197-1	22.04.2015	03:35	18° 48,66' N	128° 22,75' W	4805.5	EBS	am Grund	SL: 4844m, rwk: 073°
SO 239/197-1	22.04.2015	06:30	18° 49,09' N	128° 21,29' W	4822.2	EBS	vom Grund	SL: 4810m
SO 239/199-1	22.04.2015	12:07	18° 47,46' N	128° 22,42' W	4816.6	MUC	am Grund	SL: 4848m
SO 239/200-1	22.04.2015	16:54	18° 49,22' N	128° 25,55' W	4698	ROV	auf Tiefe	BoSi: 4700 m
SO 239/200-1	23.04.2015	02:13	18° 49,60' N	128° 25,48' W	4696.1	ROV	tauchen auf	
SO 239/201-1	23.04.2015	05:00	18° 47,47' N	128° 22,59' W	4807.7	AUV	zu Wasser	
SO 239/202-1	23.04.2015	07:00	18° 47,35' N	128° 21,26' W	4843.7	MUC	am Grund	SLmax: 4881m
SO 239/203-1	23.04.2015	10:23	18° 46,44' N	128° 21,19' W	4843.1	BC	auf dem Grund	SLmax: 4881m, SZmax: 68kN
SO 239/204-1	23.04.2015	13:45	18° 46,40' N	128° 20,17' W	4815.9	BC	auf dem Grund	SL: 4852m, SZ: 63,7kN
SO 239/205-1	23.04.2015	14:11	18° 46,40' N	128° 20,17' W	4817,6	ATC	Ausgelöst	recovered
SO 239/206-1	23.04.2015	17:56	18° 47,23' N	128° 20,24' W	4857	MUC	am Grund	SL: 4891m
SO 239/207-1	23.04.2015	21:33	18° 46,43' N	128° 22,42' W	4825	MUC	am Grund	SLmax: 4860m
SO 239/209-1	24.04.2015	01:54	18° 47,07' N	128° 22,35' W	4819.1	BC	auf dem Grund	SL: 4859m, SZ: 65,1kN
SO 239/210-1	24.04.2015	06:15	18° 49,27' N	128° 25,80' W	4700	EBS	am Grund	SL: 4750m
SO 239/210-1	24.04.2015	09:33	18° 49,92' N	128° 24,40' W	4735.7	EBS	vom Grund	SL: 4725m
SO 239/211-1	24.04.2015	12:22	18° 47,51' N	128° 22,60' W	4806.2	AUV	zu Wasser	
SO 239/212-1	24.04.2015	15:43	18° 32,83' N	128° 44,88' W	1853.1	ROV	auf Tiefe	BoSi bei SL 1873m
SO 239/212-1	24.04.2015	22:09	18° 32,57' N	128° 44,93' W	1713.7	ROV	tauchen auf	
SO 239/213-1	25.04.2015	03:05	18° 46,59' N	128° 20,63' W	4827.6	MUC	am Grund	SL: 4863m

11.2 Summary of deployments

Gear	Code	Number
CTD	CTD	11
Thermistor Mooring	Thst	1
BOBO Lander	BOBO	1
DOS Lander	DOS	2
LBL Mooring	LBL	12
Autonomous Underwater Vehicle	AUV	20
Remote operated vehicle	ROV	15
Boxcorer	BC	35
Gravity Corer	GC	7
Epibenthos sledge	EBS	13
Plankton Net	PLN	2
Multicorer	MUC	37
Amphipod Trap	ATC	7

11.3 List of CTD / rosette water sampling stations

CTD station	Date/ time (UTC)	Location		Sampling purpose	Bottom depth, m	Sampling depth, m	Samples									
							Nutrient[1]	Chl [1]	SPM[1]	Trace elem.[2]	Mn[2]	DOC[2]	Aminoacids[2]	filter 0.2 μ[2]	filter 0.8 μ[2]	Phytoplankton[1]
003	19.03.2015/15:47	11°50.65' N; 116°57.77 'W	German license area, prospective area (PA1)	background conditions;	4102	7	X	X (9)		X	X	X		X		
						29	X	X (9)		X	X	X		X		
						59	X	X (9)		X	X	X		X		
						89	X	X (9)		X	X	X		X		
						142	X	X (9)		X	X	X		X		
						285	X	X (9)		X	X	X		X		
						345	X	X (9)		X	X	X		X		
						719	X			X	X	X		X		
						994	X			X	X	X		X		
						1196	X			X	X	X		X		
						2499	X			X	X	X		X		
						3296	X			X	X	X		X		
						3887	X			X	X	X		X		
						3905				X	X	X		X		
						3925				X	X	X		X		
						3947				X	X	X		X		
						3965				X	X	X		X		
						3987	X			X	X	X		X		
						4007				X	X	X		X		
						4026				X	X	X		X		
						4049				X	X	X		X		
						4063				X	X	X		X		
						4070	X			X	X	X		X		
						4089	X			X	X	X		X		
010	20.03.2015/07:04	11°51.53' N; 117°00.60 'W	German license area, prospective area (PA1)	before EBS disturbance	4117	4091			X (50)	X	X	X	X	X	X (66)	
						4113			X (50)	X	X	X	X	X	X (66)	
025	22.03.2015/21:38	11°51.31' N; 117°00.90 'W	German license area, prospective area (PA1)	after EBS disturbance	4125	4096	X		X (38)	X	X	X	X	X	X (30)	
						4113				X	X	X	X	X	X (30)	
026	23.03.2015/02:53	11°51.63' N; 117°00.64 'W	German license area, prospective area (PA1)	after EBS disturbance	4122	3953	X			X	X	X		X		
						3974				X	X	X		X		
						3985				X	X	X		X		
						4014	X			X	X	X		X		
						4035				X	X	X		X		
						4046				X	X	X		X		
						4055				X	X	X		X		
						4064				X	X	X		X		
						4104				X	X	X		X		
						4118	X		X (36)	X	X	X	X		X (30)	
056	28.03.2015/07:14	11°48.44' N; 117°31.47 'W	German license area, reference area (RA)	Background conditions	4366	9	X	X (10)								
						30	X	X (10)								
						53	X	X (10)								
						81	X	X (10)								
						143	X	X (10)								
						209	X	X (10)								
						652	X									
						1200	X									
						2497	X									
						3295	X									
						4150	X									
						4346	X									
074	31.03.2015/17:33	11°04.61' N; 119°39.53 'W	IOM area	Background conditions	4432	3	X	X (10)								
						29	X	X (10)								
						57	X	X (10)								
						77	X	X (10)								
						118	X	X								

								(10)								
						192	X	X (10)								
						517	X									
						847	X									
						1196	X									
						1397	X									
						2496	X									
						3498	X									
						4416	X									
110	04.04.2015/00:36	13°51.71' N; 123°14.77 'W	Belgian license area	Background conditions; before EBS	4511	4	X	X (9)		X	X	X		X		
						64	X	X (9)		X	X	X		X		
						84	X	X (9)		X	X	X		X		
						109	X	X (10)		X	X	X		X		
						130	X	X (10)								
						166	X	X (10)		X	X	X		X		
						490	X									
						640	X			X	X	X		X		
						997	X									
						1287	X									
						2497	X									
						3545	X									
						4305	X			X	X	X		X		
						4357				X	X	X		X		
						4408	X			X	X	X		X		
						4432				X	X	X		X		
						4456				X	X	X		X		
						4481	X			X	X	X		X		
						4507	X		X (30)	X	X	X	X	X	X (30)	
118	08.04.2015/01:30	13°52.36' N; 123°15.09 'W	Belgian license area	after EBS	4512	4304	X									
						4406	X									
						4481	X									
						4506	X		X (30)	X	X	X	X	X	X (30)	
147	13.04.2015/21:17	14°02.65' N; 130°05.93 'W	French area	Background conditions	5028	4	X	X (10)								X
						23	X	X (10)								X
						91	X	X (10)								X
						136	X	X (10)								X
						158	X	X (10								X
						232	X	X (10)								X
						608	X									
						997	X									
						2497	X									
						3297	X									
						4197	X									
						5009	X									
183	19.04.2015/13:55	18°2.39'N ; 128°41.91 'W	APEI	Background conditions	4768	5	X	X (10)		X	X	X		X		X
						54	X	X (10)								X
						69	X	X (9)		X	X	X		X		X
						109	X	X (10)								X
						141	X	X (10)		X	X	X		X		X
						266	X	X (10)		X	X	X		X		X
						509	X			X	X	X		X		
						601	X									
						1098	X			X	X	X		X		
						1498	X			X	X	X		X		
						2496	X									
						3496	X									
						4562	X			X	X	X		X		
						4664	X			X	X	X		X		
						4683				X	X	X		X		
						4703				X	X	X		X		
						4726				X	X	X		X		
						4739				X	X	X		X		

						4752				X	X	X		X		
						4758	X			X	X	X		X		

[1] – samples collected and/or analyzed by GeoEcoMar
[2] – samples collected/analyzed by Jacobs University Bremen
- within parenthesis - volume of seawater filtered (L)

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