


## I. ANNEX

# ISA Contract for Exploration – Public Information Template

	Type of resource: Polymetallic Nodules
	Name of Contractor: Federal Institute for Geosciences and Natural Resources (BGR)
	Contract Start: 19 July 2006
Sponsoring State: Germany	Contract End: 18 July 2026
	Location: Clarion-Clipperton Zone

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## Introduction

The information contained in this ISA Contract for Exploration – Public Information Template is made available to the public in response to the request by the Council of the ISA to make contracts publicly available, subject to restrictions on confidential information, industrial secrets and proprietary data.

The content of the present template is in accordance with the Regulations on Prospecting and Exploration for [*Polymetallic Nodules in the Area*] [*ISBA/19/C/17*] (the “Regulations”).

## 1. Contract Information

Annex III of the Regulations.

<b>Type of resource</b>	Polymetallic Nodules
<b>Name of Contractor</b>	Federal Institute for Geosciences and Natural Resources (BGR)
<b>Contract Start</b>	19 July 2006
<b>Contract End</b>	18 July 2026
<b>Location</b>	Clarion-Clipperton Zone
<b>Contract Area (km<sup>2</sup>)</b>	74,724

## 2. Coordinates and Illustrative Chart of the Exploration Area

Schedule 1 of Annex III of the Regulations.

The exploration area is shown in red on the map below and located between

### W1: western part of the contract area

Starting Point 1: N 13°30' / W 138°22'

E to 2: N 13°30' / W 137°32'

S to 3: N 12°30' / W 137°32'

W to 4: N 12°30' / W 137°50'

S to 5: N 11°38' / W 137°50'

W to 6: N 11°38' / W 138°22' return

N to Starting Point 1: N 13°30' / W 138°22'

### E1: eastern part of the contract area

Starting Point 1: N 13°17' / W 119°25'

E to 2: N 13°17' / W 118°00'

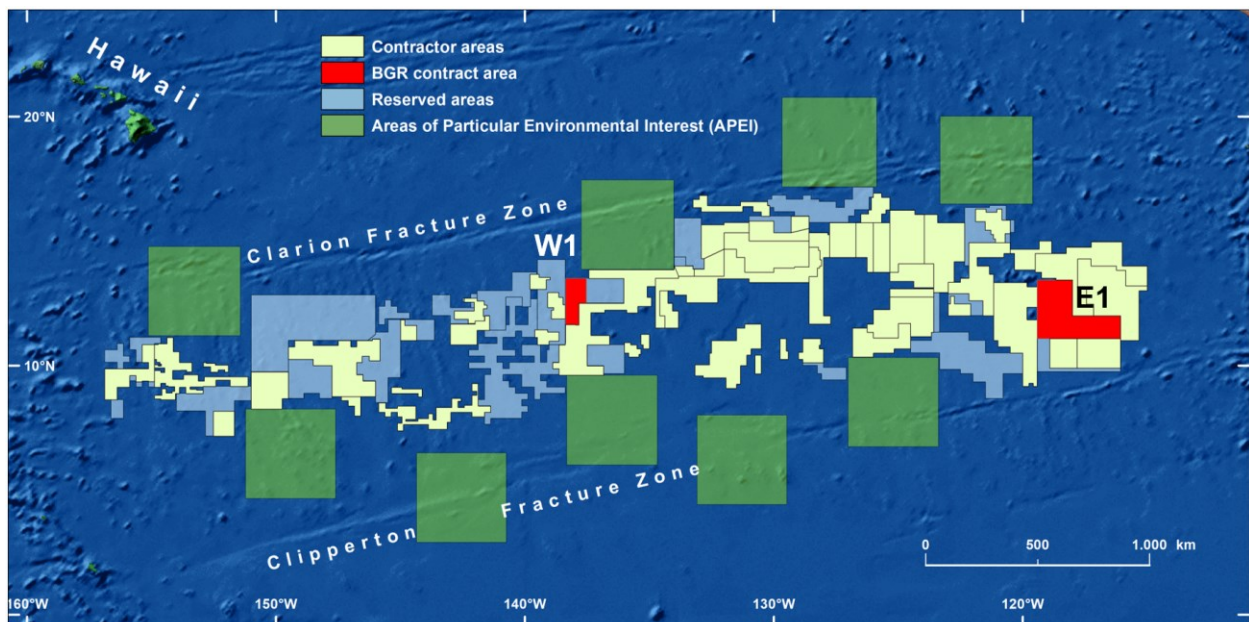
S to 3: N 12°00' / W 118°00'

E to 4: N 12°00' / W 116°04'

S to 5: N 11°05' / W 116°04'

W to 6: N 11°05' / W 119°25' return

N to Starting Point 1: N 13°17' / W 119°25'



### 3. Plan of work

Summary of Plan of Work for Exploration including the Programme of Activities for the first 15-year period and the current 5-year extension period (Regulation 18).

#### **Year 1 (starting 07/2006) – Start of first 5-year plan**

- Data extraction from archived files that BGR inherited from the Preussag AG (analogue seafloor photos, analogue echo-sounder readings)
- Preparation of proposal for BMBF-funded cruise to carry out (1) multibeam bathymetry and backscatter mapping with vessel-based swath sounding systems and side-scan sonar, (2) seafloor sampling, and (3) investigation of benthic communities (taxonomy, composition of assemblages, biodiversity)
- Planned expenditure in total: 191,000 EUR

#### **Year 2 (2007)**

- Continuation of data extraction from archived Preussag AG files (evaluation of seafloor photos; determination of nodule abundance, analogue 3.5-kHz sub-bottom echo-sounder readings)
- Integration of data from the Preussag files and research cruises (sediment characteristics and sampling data, mapping data)
- Planned expenditure in total: 195,000 EUR

#### **Year 3 (2008)**

- Exploration cruise to the contract area (swath bathymetry, side-scan sonar, sediment sampling and biological baseline sampling)
- Data processing, compilation and evaluation (bathymetry, sediment and nodule samples)
- Planned expenditure in total: 1,595,000 EUR

#### **Year 4 (2009)**

- Analysis and interpretation of data and samples from 2008 cruise (bathymetry and backscatter, nodule chemistry and coverage, biology)
- Identification of prospective areas based on acoustic data and seafloor samples
- Planned expenditure in total: 588,000 EUR

#### **Year 5 (2010)**

- Development of a nodule distribution model
- Selection of prospective mining areas from the contract area
- Planned expenditure in total: 180,000 EUR

**Year 6 (2011) – Start of second 5-year plan**

- Analysis and integration of samples and data obtained during cruises in 2008, 2009 and 2010 including:
  - geochemical analysis (ICP-OES/MS, XRF) of major, minor and trace elements of nodules
  - mineralogical analysis of nodules (XRD, XANES)
  - age-dating of sediments and selected nodules using radiogenic isotopes
  - investigation of environmental parameters such as organic carbon content of sediments, pore water and water column chemistry (salinity, temperature, redox potential)
  - biological baseline data
  - development of artificial neuronal networks software for automated analysis of HD seafloor photos
  - analysis of seafloor photos to determine nodule coverage
- Implementation of a GIS-based data base and project for data handling
- Preparation of exploration cruise in 2012 including call for tender
- Preparation of proposal for BMBF-funded cruise to investigate potential hydrothermal influence on nodule formation
- Technical upgrade of BGR-owned video sledge (high-resolution photo/video, ADCP current meter, CTD, O<sub>2</sub> and chlorophyll sensors)
- Planned expenditure in total: 455,000 EUR

**Year 7 (2012)**

- Exploration cruise to the contract area with a focus on nodule samples, seafloor video mapping, CTD and ADCP measurements; side-scan sonar mapping; deployment of ADCP moorings; dredge hauls for nodule mass samples (ca. 25 workdays)
- Work in home labs: analysis of geological and biological samples, photo and side-scan sonar data, CTD and ADCP data analysis obtained during cruises from 2008 to 2011
- Lab experiment for metallurgical processing route
- Preparation of an exploration cruise in 2013
- Planned expenditure in total: 1,850,000 EUR

**Year 8 (2013)**

- Exploration cruise to the contract area with a focus on nodule sampling, seafloor video mapping, CTD and ADCP measurements; side-scan sonar mapping; deployment of ADCP moorings; dredging of nodule mass samples (ca. 25 workdays)
- Work in home labs: continuation of analysis of geological and biological samples, photo and side-scan sonar, CTD and ADCP data obtained during cruises from 2008 to 2012
- Lab experiment for metallurgical processing route
- Extension of the GIS-based data base and project with new data and information
- Preparation of a cruise in 2014
- Planned expenditure in total: 1,655,000 EUR

**Year 9 (2014)**

- Geochemical analyses of nodules from cruise in 2013 (300 samples; ICP-OES/MS; XRF)
- Analysis of extensive video (approx. 100 hours) and still photo data (approx. 30,000 pictures) gathered during the cruise in 2013 with specially developed software to obtain information on nodule coverage
- Analysis of high-resolution bathymetric AUV data mapped during cruise in 2013
- Oceanographic data interpretation of near-bottom current data, simulation of sediment cloud distribution during nodule mining
- Metallurgical experiments with nodules to increase recovery of main metals (Cu, Ni, Co, Mn) and to investigate potential recovery of rare metals (Mo, Li, REE)
- Preparation of exploration cruise in 2015 to the western part of the contract area using a vessel of opportunity. Focus of this cruise will be sampling of Mn nodules, extensive video mapping of nodule fields and mapping of geological structures using the BGR-owned side-scan sonar in the western part of the contract area
- Planned expenditure in total: 265,000 EUR

**Year 10 (2015)**

- Exploration cruise to the western part of the contract area with a focus on nodule sampling, video mapping of the seafloor, side-scan sonar mapping, installation of ADCP moorings for long-term measurement of near-bottom currents, dredging of nodule mass samples (ca. 25 workdays)
- Geochemical analysis of nodules
- Video/photo interpretation (approx. 30.000 pictures) for nodule coverage
- Analysis of side-scan sonar data and development and adaptation of analytical software
- Environmental data interpretation including CTD and ADCP data and benthic biodiversity
- Continuation of metallurgical experiments with polymetallic nodules to increase recovery of main metals (Cu, Ni, Co, Mn) and to investigate potential recovery of rare metals (Mo, Li, REE)
- Planned expenditure in total: 1,720,000 EUR

**Year 11 (2016) – Start of third 5-year plan**

- Exploration cruise to the eastern part of the contract area with a focus on nodule sampling, video mapping of the seafloor and the acquisition of high-resolution multibeam data / seafloor topographic data within an area of high economic potential (PA-1), dredging of nodule mass samples, biodiversity and sediment sampling in the previously defined Preservation Reference Zone (PRZ), deployment of ADCP moorings for one year
- Geochemical analysis of nodules
- Video/photo interpretation (approx. 30,000 pictures) for nodule coverage and megafauna
- Analysis of high-resolution multibeam bathymetry and backscatter data to identify natural and artificial obstacles on the seafloor for a nodule collector and to determine potential correlation between backscatter and nodule coverage
- Environmental data interpretation of CTD and ADCP data

- Biodiversity studies including the phytoplankton community, the analysis of spatial and temporal similarities of the benthic fauna in the Impact Reference Zone (IRZ) and PRZ situated ca. 60 km apart, and the genetic connectivity and demography of predominant macrofaunal taxa
- Compilation of oceanographic and climatological data to characterise climate variability and the regional hydrodynamic structure of the upper water column based on data available in scientific literature and databases as well as BGR-owned oceanographic data
- Continuation of metallurgical experiments with polymetallic nodules to increase recovery of main metals (Cu, Ni, Co, Mn) and to investigate potential recovery of rare metals (Mo, Li, REE)
- Study on Ga, Ge, Sb contents in manganese nodules
- Preparation of an exploration cruise in 2017
- Planned expenditure in total: 3,850,000 EUR

#### **Year 12 (2017)**

- Exploration cruise to the eastern part of the contract area with a focus on nodule sampling, video mapping of the seafloor and the acquisition of high-resolution multibeam data / seafloor topographic data within an area of high economic potential (PA-1), dredging of nodule mass samples, biodiversity and sediment sampling in the previously defined PRZ. Deployment of ADCP moorings for one year. Deployment of sediment traps and current meters for the analysis of natural particle fluxes in the water column for a time period of several weeks
- Geochemical analysis of nodules
- Video/photo analysis for the interpretation of nodule coverage and megafauna distribution
- Analysis of high-resolution multibeam bathymetry and backscatter data to identify natural and artificial obstacles on the seafloor for a nodule collector and to determine potential correlation between backscatter and nodule coverage
- Interpretation of CTD and ADCP data
- Biodiversity studies including the phytoplankton community, the analysis of spatial and temporal similarities of the benthic fauna in the IRZ and PRZ situated ca. 60 km apart, and the genetic connectivity and demography of predominant macrofaunal taxa. Focus will be on the analysis of spatial faunal communities of the PRZ and the suitability of the PRZ as protected area and source area for recolonisation of impacted areas
- Continuation of metallurgical experiments with polymetallic nodules to increase recovery of main metals (Cu, Ni, Co, Mn) and to investigate potential recovery of rare metals (Mo, Li, REE)
- Development of a GIS-based database system to store, organise and process all geoscientific and biological data, photos, videos, reports, etc. that have been collected, developed and analysed during the exploration period
- Determination of sinking velocities, flocculation potential, suspended particle matter size distributions, erosion and resuspension potential of CCZ sediments in order to deliver input parameters for a sediment-transport model for plume dispersion
- Planned expenditure in total: 4,100,000 EUR

**Year 13 (2018)**

- Biodiversity studies with a focus on the analysis of spatial faunal communities of the PRZ and the suitability of the PRZ to serve as a protected area and source area for the recolonisation of impacted areas. Comparison of biological data from distant regions to understand species ranges and dispersal on the scale of ocean basins
- Video/photo interpretation for nodule coverage and megafauna
- Continuation of metallurgical experiments with polymetallic nodules to increase recovery of main metals (Cu, Ni, Co, Mn) and to investigate potential recovery of rare metals (Mo, Li, REE)
- Expansion of the GIS-based database and project with new data and information
- Preparation of an exploration cruise to the western area in 2019
- Planned expenditure in total: 800,000 EUR

**Year 14 (2019)**

- Exploration cruise to the western part of the BGR contract area with a focus on nodule sampling, video mapping of the seafloor and the acquisition of high-resolution multibeam data of seafloor topography, dredging of nodule mass samples, sampling for environmental and biodiversity studies. Deployment of ADCP moorings and sediment traps
- Geochemical analyses of nodules
- Video/photo interpretation for nodule coverage and megafauna
- Analysis of high-resolution multibeam bathymetry and backscatter data
- Biodiversity studies on samples from the western BGR contract area with a focus on species ranges and dispersal on the scale of ocean basins, including comparison with the eastern area and other distant regions
- Continuation of metallurgical experiments with polymetallic nodules to increase recovery of main metals (Cu, Ni, Co, Mn) and to investigate potential recovery of rare metals (Mo, Li, REE)
- Development of a GIS-based database system to store, organise and process all geoscientific and biological data, photos, videos, reports, etc. that have been collected, developed and analysed during the exploration period
- Lab experiments to determine sinking velocities and flocculation potential, suspended particle matter size distributions, and erosion and resuspension potential of CCZ sediments to deliver the input parameters for a sediment-transport model for plume dispersion
- Planned expenditure in total: 3,380,000 EUR

**Year 15 (2020)**

- Compilation and cumulative assessment of all data regarding geology, nodule and resource potential, and environmental conditions in the entire BGR contract area in order to prepare reports on resource estimations, a mining concept and an Environmental Impact Assessment. In particular BGR will develop:
  - a model for the distribution of nodule coverage and metal grades as well as the inferred tonnages
  - studies on market trends and land-based mining developments



- a mining concept
- an evaluation of all environmental data for an Environmental Impact Assessment
- Planned expenditure in total: 1,650,000 EUR

#### **Year 16 (2021) – Start of 5-year extension period**

- Exploration cruise to the eastern part of the BGR contract area to monitor the environmental impacts caused by the testing of GSR’s pre-prototype collector vehicle Patania II. An ROV for megafauna and sediment sampling, monitoring of the sediment plume, photographic analysis of blanketing and the manual distribution and recovery of tripod oceanographic sensors, micro-profilers and recolonization frames will be chartered with the ship. Comprehensive monitoring equipment of the Contractor and all involved research partners (MiningImpact) will be on board, including AUV, photo sledge, CTD-Rosette, bottom water sampler and 40 – 50 oceanographic and sediment transport sensors and cameras in the form of tripods or moorings
- Oceanographic evaluation of baseline conditions as well as impact and post-impact physical conditions (particle fluxes, plume dispersion) close to the seafloor in association with the collector test (long- and short-term data from ADCPs and sediment traps; analysis of the spread and intensity of the sediment plume; implications for industrial-scale mining)
- Geochemical analysis and evaluation of baseline and impact-affected bottom water obtained in 2020 and 2021 (trace metal distribution; investigation of particulate matter, including the mineralogical and geochemical characterisation of sediment plume material). Together with new data for baseline and post-impact benthic pore water fluxes, these investigations aim at understanding the geochemical processes controlling mobilisation and fate of potentially toxic trace metals at the sediment-seawater interface and within mining-induced sediment plumes in the water column. Studies with passive samplers as potential monitoring tools to assess trace metal bioavailability will be continued
- Development of deep-towed ultrasound technology for the volumetric analysis and determination of nodule abundance on the seafloor; ex-situ testing to test the feasibility of the technology as a potential seafloor resource assessment tool
- Further development of the GIS-based database system in order to store, organise and process all geoscientific and biological data, photos, videos, reports, etc. that have been collected, developed and analysed during the exploration period
- Laboratory-scale leaching study as part of the development of the metallurgical zero-waste process to assess the efficiency of recovering various metals using different nodules: (synthetic) pyrite mixtures and sulphuric acid as a leaching agent
- Preparation of an exploration/monitoring cruise with a vessel-of-opportunity in 2022 to monitor the impacts of the collector test one year after the disturbance
- Planned expenditure in total: 5,415,000 EUR

#### **Year 17 (2022)**

- Exploration cruise to the eastern part of the BGR contract area to monitor the environmental impacts caused by the testing of GSR’s pre-prototype collector vehicle Patania II ca. one year after the disturbance. For these purposes, the Contractor will participate in a research campaign

on the German research vessel SONNE, scheduled to revisit the GSR and BGR collector test sites for post-impact monitoring. Although this campaign is not organised by the BGR (led by the German GEOMAR institute) and funded by the German Federal Ministry of Education and Research, the monitoring obligations set out in BGR's EIA for the test will be complied with

- Chemical oceanography and sediment biogeochemistry: Ongoing analyses and evaluation of water and surface sediment samples obtained in 2021 and 2022 for the impact assessment one year after the collector test, focus on impact monitoring at the sediment-seawater interface
- Development of a numerical reactive transport model integrating chemical reaction kinetics into a hydrodynamic plume dispersal model. The coupling of chemical reactions (such as dissolution/precipitation, surface complexation, reduction/oxidation, sorption/desorption) with mass transport and fluid dynamics is needed to understand the transport and mobility of potentially toxic trace metals in sediment plumes and to predict their dispersal in space and time. The model will use published thermodynamic datasets and integrate empirical results from laboratory experiments addressing trace metal reaction kinetics in sediment plumes. Field data on trace metal concentrations and their physical and chemical speciation will be used for model validation
- Analysis of baseline data and impact-related data on benthic faunal distribution and density as well as recovery (all faunal size classes), including differences in respiration and ecosystem functioning between non-impacted and impacted areas to determine gradients of harm associated with the collector test. Implications for environmental monitoring and management will be assessed. The baseline analysis of the pelagic realm (whole water column) will be continued
- Designation of PRZ(s) and IRZ(s): the results on habitat mapping, faunal distributions, resource potential, connectivity of taxa/species and expected drift and sedimentation of a mining-induced sediment plume will be used to designate appropriate PRZs and IRZs in the contract area
- Continuation of metallurgical experimentation to improve our knowledge on "zero-waste" processing techniques for manganese nodules with respect to increasing the efficiency of recovery of the main metals (Cu, Ni, Co, Mn) and for investigating possible techniques for the recovery of rare metals (Mo, Li, REE). The pyrometallurgical route of the zero-waste metallurgical concept for the processing of manganese nodules will be finalised (i.e., the production of ferromanganese, silicomanganese and a final mineral product), including proof for its industrial applicability and economic viability as well as the incorporation of products that comply with international standards. Upscaling of the hydrometallurgical processing of the metal alloy produced during the large-scale pyrometallurgical trials is planned for proof of its industrial-scale applicability in a similar way to the pyrometallurgical route
- Enhancement of the GIS-based database system to store, organise and process all geoscientific and biological data, photos, videos, reports, etc. that have been collected, developed and analysed during the exploration period
- Initial scoping exercise to identify the main activities and impacts relevant to a potential mining project in the contract area: Development of an initial desktop study of the current

environment, identification of all possible impacts through a qualitative (Level 1) Risk Assessment (e.g., risk matrix). The Contractor assumes that the experiences and results obtained from the collector test will form the primary inputs of this risk assessment. The ERA should emphasise the activities of high risk but will also identify elements of low risk. This exercise should help to identify the key environmental issues and terms of reference for a potential future project-related EIA/EIS and will help focus sampling goals and strategies for further environmental baseline analyses

- Preparation of an exploration/monitoring cruise with a vessel-of-opportunity in 2023 to monitor the impacts of the collector test two years after the disturbance and to continue the exploration of the western contract area
- Planned expenditure in total: 3,570,000 EUR

#### **Year 18 (2023)**

- Exploration cruise to the eastern and western part of the BGR contract area to monitor the environmental impacts caused by the testing of GSR's pre-prototype collector vehicle Patania II ca. two years after the disturbance and to continue exploration in the western contract area (resource assessment of a prospective area using a box corer, video sledge; environmental baseline analysis, biodiversity studies, oceanographic data acquisition (CTD, sediment traps, ADCPs)
- Geochemical analyses of Mn nodules (ICP-OES/MS; XRF); approximately 200 analyses
- Analysis and evaluation of water column and pore water geochemistry in the western contract area: spatial variability of particle fluxes and trace metal speciation (chemical and physical speciation), characterisation of biogeochemical conditions in surface sediment. Evaluation of geochemical data obtained in the eastern contract area two years after disturbance will be used to identify indicator variables for impact monitoring
- Collection of baseline data on benthic and pelagic faunal distribution and density, with a special emphasis on using metabarcoding for more rapid community assessment. The results are expected to shed more light on the connectivity of species across the CCZ region as detailed comparisons between the eastern and western contract areas as well as with other contractor areas can be made that will also help validate or adjust area-wide predictions of taxon abundances and distribution. Such results can greatly contribute to inform spatial management issues and the implementation of the Environmental Management Plan for the CCZ in line with Decision of the Council of the ISA relating to the review of the environmental management plan for the Clarion-Clipperton Zone, ISBA/26/C/58
- Completion of GIS-based database system to store, organise and process all geoscientific and biological data, photos, videos, reports, etc. that have been collected, developed and analysed during the exploration period
- Planned expenditure in total: 3,470,000 EUR

#### **Year 19 (2024)**

- Final metal resource assessments: based on all available data, a final model for the distribution of nodule coverage and metal grades as well as the inferred tonnage and tonnage distribution will be developed. Methods of neuronal networks and conventional geostatistics that enable the

inclusion of all kinds of relevant data such as bathymetry, seafloor properties, video analyses, metal contents, sediment characteristics, environmental properties, etc. will be utilised

- Feasibility study: Based on the assumption that the at-sea exploration work will have been successfully completed and that the zero-waste metallurgical processing concept delivers robust cost predictions, an initial mining feasibility study will be outlined utilising the most recent data. If this preliminary feasibility assessment leads to positive conclusions, further conceptual and design work will be devoted to the mining process
- Study on useful management tools for the contract area (e.g., final designation of IRZs and PRZs) based on habitat mapping, biodiversity, connectivity and knowledge on spatial ranges of mining-related impacts
- Preparation of an exploration/monitoring cruise with a vessel-of-opportunity in 2025. Focus of the cruise will be on water column geochemistry (with focus on trace metals) and the geochemistry of artificially created in-situ sediment plumes using ultra-clean CTD, Rosette samplers, in-situ pumps, bottom water samplers and passive sampling techniques. Additionally, the impacts of the collector test four years after the disturbance will be monitored
- Planned expenditure in total: 500,000 EUR

#### **Year 20 (2025/2026)**

- Exploration cruise to the eastern part of the BGR contract area to carry out a detailed geochemical assessment of the water column (trace metals) and of the benthic boundary layer including respective spatial variability, both as baseline and because of the artificial mobilisation of sediments in seafloor sediment plumes. An ultra-clean, metal-free CTD/Rosette and a metal-free cable (Kevlar) will be required and will form part of the ship charter. Further equipment for in-situ flux measurements and time-resolved sampling at the sediment-seawater interface needs to include in-situ pumps, a bottom water sampler, benthic chambers, micro-profilers, passive sampler deployments. The collector test area will also be monitored four years after disturbance
- Characterisation of the baseline water column and surface sediment biogeochemistry in the eastern contract area based on data obtained between 2021 and 2025, with a focus on spatial variability. Data will be used for a holistic assessment of chemical parameters throughout the water column and their vertical and spatial variability, including POC flux and POC lability, oxygen, nutrients, carbonate system, radioisotopes, trace metal concentration and speciation. Data derived between 2021 and 2025 in the collector test area will be used to assess the biogeochemical conditions in surface sediments up to 4 years after impact
- Conduct of an ecotoxicological study to quantify the potential eco-toxicological risk of operational and discharge plumes. Integration of field data for trace metal physical and chemical speciation, baseline concentrations of metals and potential organic contaminants in key benthic, abysso- and bathypelagic species recovered from the IRZs and PRZs, and sediment physico-chemical properties; bioaccumulation of metals in indicator species; sub-lethal effects/biomarkers in indicator species; and laboratory eco-toxicological bioassays. Together with model results for plume dispersal (see Year 17), these parameters feed into Weight of Evidence (WoE) models for risk assessment. A coupled experimental assessment of trace metal

speciation and bio-uptake will be used to better constrain the bioavailability/toxicological risk of chemical species and to identify useful techniques to monitor fluxes of potentially toxic metal fractions in mining areas

- Environmental Risk and Impact Assessment: The qualitative ERA carried out in Year 17 will be supplemented by results obtained from the environmental baseline studies in the contract area as well as published results from relevant studies carried out in the wider region of the CCZ to develop a comprehensive and (semi-) quantitative ERA, taking all relevant ISA regulations, recommendations and guidelines into consideration. The analysis of all possible site-specific and mining-related ecological and environmental impacts and possible mitigation measures as well as possible management and monitoring strategies will be completed
- Development of a mining concept: Once final data processing has been completed and evaluation of cruise and archive data is completed, and the feasibility study of Year 19 has come to a positive conclusion, a mining concept will be developed considering all relevant data. The relevant data includes nodule coverage, grade, extent of feasible mining areas, water depths, topographic elements, extent and severity of environmental impacts (results ERA), potential locations of IRZs and PRZs, suggested mitigation strategies, etc. These are prerequisite for the development of an integrated mining concept, provided that information on feasible mining technology is available at this stage
- A study on market trends / land-based mining developments will be undertaken
- Planned expenditure in total: 4,350,000 EUR

**Total cost estimate for first 15-year exploration period: 22,474,000 EUR**

**Total cost estimate for 5-year extension period: 17,305,000 EUR**

**Total estimated cost PMN exploration according to Plans of Work: 39,779,000 EUR**

## 4. Programme of Activities and Exploration Expenditure

Section 4.1 of Annex IV of the Regulations and Schedule 2 of Annex III of the Regulations.

### I. Agreed 5-year Programmes of Activities

5-year Programme of Activities	First	Second	Third	Extension
General Objectives	Objective		Description	
<b>Year 1 Data compilation and assessment</b>	Compilation and evaluation of archived data from the PREUSSAG AG		Data were extracted from archived Preussag AG files that BGR had inherited. These included analogue seafloor photos of sampling sites. Photos were compiled from the archive, digitalised / scanned and subsequently evaluated in terms of nodule abundance and seafloor characteristics as well as megafaunal distribution and abundance. Archive files were also scanned for information on depth soundings from ship tracks and sampling stations to improve the information available on bathymetry as acquired during exploration activities in the 1970ies and 1980ies	
	Submission of a research cruise proposal		A proposal for a research project / cruise to the contract area was prepared and submitted for review to the German Federal Ministry of Education and Research (BMBF) as third-party funding organisation ("Formation of manganese nodules and biodiversity in the NE Pacific")	
	Additional activity: Certification of polymetallic nodule reference material		For geochemical analytical quality control of polymetallic nodule material, nodules powders were developed as certified reference material (end 2007)	
<b>Year 2 Data compilation; nodule laboratory certification; cruise planning</b>	Compilation and evaluation of archived data from the PREUSSAG AG (continued)		Work continued on archived data: evaluation of seafloor photos, determination of nodule abundance, cross-check and calibration of data from seafloor sampling with photographic	

		results, re-evaluation of data from all sources
	Review of additional archived survey data (e.g. from past research cruises)	Further relevant data from past research cruises was extracted, and integrated with Preussag data
	<i>Additional activity:</i> Geochemical analyses of nodules	Nodules derived from the Preussag archive
	<i>Additional activity:</i> Certification of polymetallic nodule reference material	For geochemical analytical quality control of polymetallic nodule material, nodules powders were developed as certified reference material (continued from 2006)
	<i>Additional activity:</i> Acquisition of sampling gear for exploration	Dredge for nodule sampling
	<i>Additional activity:</i> Preparation for an exploration cruise in 2008	Tender for a ship-of-opportunity; collection of adequate exploration equipment
<b>Year 3</b> <b>First exploration cruise; multibeam analyses</b>	Exploration cruise MANGAN 2008 (RV Kilo Moana)	First exploration cruise to the eastern and western contract area, with focus on the acquisition of swath bathymetry (EM120) and sediment sampling
	Analysis and interpretation of data and samples from MANGAN 2008	Data on acoustic reflectivity of the seafloor were extracted from digital acoustic data and compiled; digital data was processed and interpreted. Reliable bathymetric maps for parts of the contract area were developed.
	<i>Additional activity:</i> Certification of polymetallic nodule reference material	For geochemical analytical quality control of polymetallic nodule material, nodules powders were developed as certified reference material (continued from 2006)
	<i>Additional activity:</i> Preparation for an exploration cruise in 2009	Tender for a ship-of-opportunity
<b>Year 4</b> <b>Second exploration cruise; analysis of data; prospective nodule areas</b>	<i>Additional activity:</i> Exploration cruise MANGAN 2009 (RV Kilo Moana)	Second exploration cruise to the eastern and western contract area, with focus on the acquisition of swath bathymetry (EM120) & side-scan sonar data

	Integration of existing and new bathymetric datasets; identification of prospective areas	Interpretation of acoustic reflectivity data; compilation of facies maps including all available data (digital and archived data, sampling data); identification of prospective areas in terms of nodule coverage
	<b>Additional activity:</b> Preparation for a research cruise in 2010	Organisation of/with partner institutions; exchange with BMBF (third-party funded)
<b>Year 5 Third cruise (research cruise to study nodule formation and biodiversity); development of a nodule distribution model</b>	<b>Additional activity:</b> Research cruise SO205 (RV Sonne)	A research cruise to the eastern contract area took place after the research cruise proposal submitted in Year 1 was positively evaluated. Focus was on the acquisition of biological and other env. data, seafloor-photo profiles, sampling for calibration and ground-truthing, and additional detailed high-resolution swath bathymetry
	<b>Additional activity:</b> Acquisition of exploration equipment	Side-scan sonar, video sledge, USBL positioning system
	Development of a nodule distribution model	Correlation between bathymetric data, sediment characteristics and nodule coverage; integrative evaluation to produce a general nodule distribution model for the contract area
	Selection of prospective mining areas in the contract area	Reasonably-sized prospective areas were defined based on all data types gathered; these function as target areas for further detailed exploration work
	<b>Additional activity:</b> Resource assessments	Nodule geochemical analyses; photo analyses
	<b>Additional activity:</b> Development of a concept for a state-of-the-art nodule collector	Subcontracted to Aker-Wirth



General Objectives	First	Second	Third	Extension
	Objective		Description	
<b>Year 6 Interpretation of available data</b>	Analyses and evaluation of cruise data and samples obtained in 2008, 2009, 2010		Processing of data (photos), analyses of cruise samples (trace metals, selective leaching), interpretation of results (resource & environment)	
	Implementation of a GIS-based database and project for data handling		Postponed to 2017 (start of development)	
	Submission of a research cruise proposal		A proposal for a research project / cruise to the contract area was prepared and submitted for review to the German Federal Ministry of Education and Research (BMBF) as third-party funding organisation to investigate potential hydrothermal influence on nodule formation	
	Technical upgrade of BGR-owned video sledge and side-scan sonar		High-resolution photo/video, ADCP current meter, CTD, O <sub>2</sub> and chlorophyll sensors	
	Biological investigations on the benthic fauna		Morphological and genetic analyses of macrofauna and meiofauna to determine distribution ranges, biodiversity, gene flow	
	Preparation for an exploration cruise in 2012		Tender for a ship-of-opportunity; discussions with IFREMER to jointly charter RV L'Atalante	
<b>Year 7 Fourth exploration cruise; further resource and env. analyses</b>	Exploration cruise BIONOD 2012 (RV L'Atalante)		Joint French-German cruise to both the FR and the eastern BGR contract areas. Focus on biodiversity studies, but also included nodule sampling, seafloor video mapping, CTD and ADCP measurements. Deployment of moorings and side-scan sonar postponed to 2013	
	Analyses in home laboratories		Analysis of obtained geological and biological samples, photo evaluation and analysis	

	Additional activity: Acquisition/maintenance of survey and lab equipment	Current meters (ADCP, RCM), penetrometer, mills
	Metallurgical experimentation	Postponed to 2013 and subsequent years
	Preparation for an exploration cruise in 2013	Tender for a ship-of-opportunity
<b>Year 8</b> <b>Fifth exploration cruise; resource and env. analyses in a prospective area (PA1) and in a PRZ</b>	Exploration cruise MANGAN 2013 (RV Kilo Moana)	Cruise to the eastern contract area: sampling in a prospective area (PA1) and in a PRZ, seafloor video mapping, resource assessments, CTD and ADCP measurements; side-scan sonar mapping; deployment of long-term ADCP moorings; biological sampling (time series analysis started). High-resolution AUV bathymetric mapping and dredge hauls postponed to 2016
	Analyses in home laboratories	Analysis of obtained geological and biological samples, photo and env. data; evaluation of potential mining areas
	Metallurgical processing route	Metallurgical lab experiments on bioleaching; concept for a zero-waste processing technique
	Additional activity: Acquisition of exploration equipment	Extra-large dredge; spares for video sledge; mooring releasers; large mooring buoys
	GIS-based database	Postponed to 2017 (start of development)
	Preparation for an exploration cruise in 2014	Tender for a ship-of-opportunity
<b>Year 9</b> <b>Sixth exploration cruise; resource and env. analyses in a second prospective area (PA2) and in a PRZ</b>	Additional activity: Exploration cruise MANGAN 2014 (RV Kilo Moana)	Cruise to the eastern contract area: sampling in two prospective areas (PA1 and PA2) and in a PRZ, seafloor video mapping, high-resolution AUV bathymetric mapping, dredge hauls, resource assessments. CTD and ADCP measurements; deployment of long-term ADCP moorings; biological sampling (time series analysis cont'd)

	Analyses in home laboratories	Analysis of obtained geological and biological samples (all benthic faunal classes, phytoplankton), env. data (oceanography, sediment physical properties, sediment sinking characteristics, geochemistry); evaluation of potential mining areas, evaluation of the bottom current regime
	Geochemical analyses	ICP-OES/MS; XRF
	Automated image analysis	Analysis of extensive video (> 100 hours) and still photo data (> 30,000 pictures) gathered during previous cruises with specially developed software to obtain information on nodule coverage
	High-resolution bathymetry	Postponed to 2016
	Additional activity: Acquisition of exploration equipment	Camera equipment, box corer spares, mooring spares
	Metallurgical processing route	Metallurgical lab experiments on bioleaching
	Preparation for a research cruise in 2015	Organisation of/with partner institutions; exchange with BMBF (third-party funded)
<b>Year 10 Seventh cruise (research cruise FLUM – hydrothermal influences on nodule formation)</b>	Modified activity: Research cruise SO240 on RV Sonne	Third-party funded research cruise to the eastern part of the contract area, with a focus on potential hydrothermal influences on the formation of nodules (project FLUM: “Fluid fluxes and Mn nodules”). Several research partners involved. Work also included oceanography (moorings; yoyo and tow-yo CTD)
	Geochemical analyses of collected nodules	ICP-OES/MS; XRF
	Automated image analysis	Analysis of extensive video and still photo data gathered during past cruises with specially developed software to obtain information on nodule coverage

	Analysis of side-scan sonar data		Replaced by deep-towed multibeam mapping in 2016. The side-scan sonar acquired in 2010 and deployed in 2013 never produced good data	
	Environmental data interpretation		CTD and ADCP data; benthic biodiversity analyses (main focus on connectivity and seamounts as potential refuges for megafauna; further analyses of time series)	
	Additional activity: Acquisition of exploration equipment		Camera equipment, spares, mooring releasers and accessories	
	Metallurgical processing route		Postponed to 2016 and subsequent years	
	Additional activity: Preparation for an exploration cruise in 2016		Tender for a ship-of-opportunity	
<b>General Objectives</b>	<b>First</b>	<b>Second</b>	<b>Third<sup>1</sup></b>	<b>Extension</b>
	<b>Objective</b>		<b>Description</b>	
<b>Two exploration cruises in Years 11 and 13 (eighth and ninth cruises)</b>	Exploration cruises MANGAN 2016 (RV Kilo Moana) and MANGAN 2018 / SO262 (RV Sonne)		Two exploration cruises to the eastern part of the BGR contract area were carried out in 2016 and 2018 (instead of 2016, 2017 and 2019 as originally planned). The cruise that was set to revisit the western contract area was shifted into the extension phase. The cruise planned for 2019 was replaced by BGR's participation in the third-party funded research cruise SO268 (RV Sonne) led by the MiningImpact consortium ("Environmental impacts and risks of deep-sea mining"). A cruise in 2020 was planned but had to be postponed to 2021 (extension phase) due to the COVID-19 pandemic. Topics of focus during the two exploration cruises were: high-resolution seafloor topography mapping in areas of high economic value using the BGR	

<sup>1</sup> Organised per topic instead of per year as many tasks were carried out inter-annually from year to year

		<p>deep-towed multibeam HOMESIDE, the acquisition of nodule samples using box corer and dredge, and video mapping of the seafloor. A new prospective area was sampled (PA3). The environmental programme included deployment of moorings for long-term measurement of near-bottom currents and particle fluxes, geochemical sampling of bottom sediments and bottom waters, analyses of particles / aggregation in the water column, and detailed biological analyses (benthic and pelagic biodiversity, metabarcoding of meiofauna and zooplankton, analysis of scavengers, continuation of time series) in the PRZ and PAs</p>
<b>Participation in a research cruise in Year 14</b>	<p><b>Additional activity:</b> BGR participation in JPIO MiningImpact research cruise SO268 (RV Sonne) to the GSR B4 contract area and the BGR E1 contract area</p>	<p>Third-party funded cruise (BMBF) organised and lead by GEOMAR. BGR participated with 2 persons. This cruise was planned to monitor the env. impacts of GSR's Patania II collector tests. Due to technical failures in the power supply to the collector, trails could not be carried out. Baseline samples for the postponed tests as well as a small-scale dredge monitoring experiment were carried out instead</p>
	<p><b>Additional activity:</b> Acquisition and maintenance of exploration and lab equipment</p>	<p>Camera equipment, spares, mooring releasers, ADCPs, LADCPs, 3 sediment traps and accessories, transponders, Bottom Water Sampler, multicorer, seaFAST sample introduction system for seawater analysis</p>
<b>Mineral resource estimations</b>	<p>Geochemical analyses of nodules</p>	<p>Analyses of nodule geochemistry and mineralogy for the determination of average metal contents and the crystal structure of nodules in order to further develop the metallurgical processing route</p>

	Image analyses for nodule abundance	The combination of box core samples and photo transects continued to provide data on nodule abundances and coverage as the basis for resource assessment and modelling
	Analyses of high-resolution multibeam bathymetry	The BGR deep-towed multibeam HOMESIDE obtained high-resolution bathymetry in an area of ca. 100 km <sup>2</sup> in PA1
	Evaluation of potential mining areas; Resource assessments and classifications	Economic assessments of the deposit were carried out (nodule abundance per square meter; topographic conditions in the three PAs)
<b>Biodiversity analyses</b>	Biodiversity studies	Biodiversity studies focussed on the benthic faunal community (community structure, standing stocks, geographic distribution, gene flow), the diversity of near-bottom scavengers and the pelagic fauna (diversity and distribution). Faunal analyses integrate taxonomic, genetic (barcoding, metabarcoding) and habitat / species distribution modelling (R-forest) approaches
<b>Physical oceanography</b>	Compilation and interpretation of oceanographic and climatologic data	Analysis of climate conditions (frequency of storms and hurricanes, seasonal fluctuations of wave height and direction, ocean currents strength and direction) based on BGR-owned data and data from publicly accessible databases
	Currents and particle fluxes in the water column	Analysis of background bottom water currents and their spatial and temporal variability; particle fluxes in the water column (sediment traps)
<b>Sediment characteristics; plume modelling</b>	Determination of sinking velocities, flocculation and resuspension potential of CCZ sediments (plume dispersal)	Characterisation of the natural, dynamic behaviour of seafloor sediments under in-situ conditions based on laboratory studies (particle size distributions, settling velocities, concentration and turbulence-dependent flocculation)

		potential (aggregation), erosion and resuspension potential). These parameters are essential as input values for numerical plume modelling exercises. Modelling was carried out in cooperation with the European MIDAS project (SAMS) and the MiningImpact project (University of Bremen)
<b>Chemical oceanography; sediment geochemistry</b>	Determination of trace metal concentrations and their speciation in bottom waters and pore waters; sediment and water particle mineralogy	Characterisation of metal concentrations and how they are bound/fractionated (dissolved, colloidal, particulate); different routes of potential toxicity during mining activities (sediment plume); testing of DGT passive samplers as indicators for bioavailable (toxic) trace metals
<b>Submission of an Environmental Impact Assessment (EIA) for testing of a nodule collector</b>	<b>Additional activity:</b> Development of an EIA for testing of GSR's Patania II collector in the eastern BGR contract area	An EIA was carried out for a test area in the north-eastern eastern BGR contract area (submitted to ISA in March 2018; originally for the test to occur in 2019). The test did not occur until May 2021
<b>Metallurgical processing route</b>	Metallurgical experiments for the development of processing routes at sub-industrial scales	Testing and analysis of a "zero waste" pyrometallurgical extraction technique for Ni, Cu and Co recovery; production of a saleable ferromanganese and/or silicomanganese product and a Ca-Si product. Produced slags should meet environmental and quality requirements, e.g. toxic metal concentrations must remain below pre-defined thresholds. A "zero waste" process conceptualised and partly realised in the third project phase. Further analysis and testing shifted into the extension phase
<b>GIS-based data management system</b>	Development of a GIS-based data management system	Measurement, observation and analysis data on the order of several TB per year are collected during exploration cruises, in completely different formats. A data management system (metadata and exploration data) is required to manage these

		exploration data and to carry out overarching geological, oceanographic and biological analyses and has been developed consecutively		
<b>Compilation and cumulative assessment of all available resource data</b>	Development of a report on resource estimations in the contract area		Distributions of nodule coverage, metal grades, indicated / inferred / measured tonnages in the entire area as well as in the PAs were determined	
	Studies on market trends and land-based mining developments		Postponed to the extension phase	
	Development of a mining concept		Postponed to the extension phase	
	Evaluation of all available env. data for an Environmental Impact Assessment (EIA)		Postponed to the extension phase	
<b>General Objectives</b>	<b>First</b>	<b>Second</b>	<b>Third</b>	<b>Extension</b>
	<b>Objective</b>		<b>Description</b>	
<b>Year 16 Tenth exploration cruise; independent scientific env. monitoring of the Patania II collector tests</b>	Exploration cruise MANGAN 2021 (MV Island Pride); partners of the European research project MiningImpact were invited to join this cruise for a joint monitoring of test mining activities		Cruise to the B4 GSR contract area and to the eastern BGR contract area (E1). One test of 40 h (31,000 m <sup>2</sup> ) and one test of 24 h (23,400 m <sup>2</sup> ) occurred in each area, respectively. Env. monitoring occurred with state-of-the-art monitoring tools of all MiningImpact partners involved (ROV, AUV, oxygen microprofilers, sensor platforms, moorings, CTD, multicorer, boxcorer, larvae pumps)	
	Oceanographic evaluation of baseline, impact and post-impact conditions		Sensor data collected during and after the collector tests have been calibrated and evaluated (plume dispersion and blanketing: Gazis et al., subm.). Sediment trap analyses	
	Geochemical analysis and evaluation of baseline and impact-affected bottom water obtained in 2020 and 2021		Analyses of trace metal distribution; mineralogical and geochemical characterisation of particulate matter of the sediment plume. Studies with passive samplers as potential monitoring	



		tools to assess trace metal bioavailability were continued
	Development of deep-towed ultrasound technology for the volumetric analysis and determination of nodule abundance on the seafloor	Ultrasound technology was tested ex-situ to determine the feasibility of the technology as a potential seafloor resource assessment tool
	<b>Additional activity:</b> Acquisition/maintenance of survey and lab equipment	Floats for moorings, seaFAST sample introduction system for seawater analysis, Milli-Q ultrapure water purification system, spare parts, iridium service
	Further development of a GIS-based data management system	Storage, organisation and processing of all geoscientific and biological data, photos, videos, reports, etc. that have been collected, developed and analysed during the exploration period
	Metallurgical experiments for the development of processing routes at sub-industrial scales	The zero-waste pyrometallurgical processing technique suffered setbacks and postponements due to the COVID-19 pandemic. A laboratory-scale leaching study to assess the efficiency of recovering various metals using different nodules was carried out instead: using (synthetic) pyrite mixtures and sulphuric acid as a leaching agent
	Preparation for an exploration cruise in 2022	Tender for a ship-of-opportunity. Failed as no offers were received for the tender
<b>Year 17 independent scientific env. monitoring of the Patania II collector tests 1.5 years after impact</b>	BGR contribution to the research cruise SO295 on RV Sonne (MiningImpact / successor project NoduleMonitoring 2) to the GSR B4 contract area and the BGR E1 contract area	Third-party funded research cruise organised and lead by GEOMAR, with BGR participation of 4 persons. The aim was to monitor the impacts of the collector tests 1.5 years after the tests with ROV, AUV, oxygen micro-profilers, multicorer, boxcorer, CTD, video sledge, moorings
	Chemical oceanography and sediment biogeochemistry	Analyses and evaluation of water and surface sediment samples obtained before and in 2021 for the baseline and impact

		assessment before/during the collector tests; focus was on impact monitoring at the sediment-seawater interface
	Development of a numerical reactive transport model integrating chemical reaction kinetics into a hydrodynamic plume dispersal model	<b>Postponed</b> to 2024 as the execution requires field data on trace metal concentration and their physical and chemical speciation, that are still being gathered and analysed at the moment
	Analysis of baseline data and impact-related data on benthic faunal distribution and density as well as recovery (all faunal size classes)	As impact-related biological data were collected within the framework of the MiningImpact (NoduleMonitoring 2 Projects, BGR contracted INES to quantitatively analyse spatial and temporal patterns of macrofaunal density and community structure from box core material. This allows habitat and species modelling of all faunal classes which aids in the designation of PRZs. Water column zooplankton morphological data were obtained and compared to genetic data obtained in 2018
	Designation of PRZ(s) and IRZ(s)	<b>Postponed</b> to 2023 as the data on spatial macrofaunal distributions were required (see above)
	<b>Additional activity:</b> Acquisition/maintenance of survey and lab equipment	Spare parts, maintenance, iridium service
	Further development of a GIS-based data management system	Storage, organisation and processing of all geoscientific and biological data, photos, videos, reports, etc. that have been collected, developed and analysed during the exploration period
	Metallurgical experiments for the development of processing routes at sub-industrial scales	The zero-waste pyrometallurgical concept for the processing of nodules could still not be finalised due to technical problems with the furnaces. An upscaling of the hydrometallurgical processing of the metal alloy produced necessarily had to be postponed to

		2024. Experiments involving leaching with pyrite were continued. A study on the potential of solid-state chlorination for the treatment of nodules was started
	Initial scoping exercise to identify the main activities and impacts relevant to a potential mining project	<b>Postponed</b> to 2024 as the results of the SO295 cruise are deemed necessary and to form the primary inputs of risk assessments
	Preparation for an exploration cruise in 2023	Tender for a ship-of-opportunity
<b>Year 18 Eleventh exploration cruise; resource and biological assessments</b>	Exploration cruise MANGAN 2023 (RV Kilo Moana)	Cruise to the eastern and western BGR contract area. Aims are resource and env. baseline characterisation of a N-S transect in the western contract area; ground-truthing of spatial habitat and faunal distribution models in the eastern contract area by biologically sampling less prospective areas scattered throughout the area; continuation of time series analyses; mooring work; deployment of passive samplers; sampling of a potential new PRZ for PA1 as defined by habitat modelling

**II. Results achieved during reported year [#]: [year]**

Annual objectives and activities			
Year	No.	Agreed Objectives	Objective: Completed, Modified, Postponed or Replaced
2006	1	Compilation and evaluation of archived data from the PREUSSAG AG	Completed Expenditure: 54,956 EUR
2006	2	Preparation and submission of a research cruise proposal	Completed Expenditure: 28,872 EUR
2006	3	Certification of polymetallic nodule reference material	Additional activity (not included in the original plan of work), started Expenditure: 20,160 EUR
2007	1	Continued data extraction from Preussag archive and integration with data from previous research cruises	Completed Expenditure: 48,424 EUR
2007	2	Geochemical analyses of Mn nodules	Additional activity, completed Expenditure: 44,388 EUR
2007	3	Certification of polymetallic nodule reference material	Additional activity, continued Expenditure: 63,338 EUR
2007	4	Preparation for cruise in 2008	Additional activity, completed Expenditure: 89,931 EUR
2007	5	Acquisition of sampling gear for exploration	Additional activity, completed Expenditure: 28,751 EUR
2008	1	Exploration cruise MANGAN 2008 to the eastern and western parts of the BGR contract area incl. multibeam data processing	Completed Expenditure: 2,196,512 EUR
2008	2	At-sea training (4 trainees)	Completed Expenditure: 12,694 EUR
2008	3	Preparation for cruise in 2009	Additional activity, completed Expenditure: 31,000 EUR
2008	4	Certification of polymetallic nodule reference material	Additional activity, completed Expenditure: 26,200 EUR
2009	1	Exploration cruise II to the eastern and western parts of the BGR contract area incl. multibeam data processing	Additional activity, completed Expenditure: 2,064,617 EUR
2009	2	Analysis of data and samples from 2008 cruise incl. identification of prospective areas	Completed Expenditure: 517,509 EUR
2009	3	Training in the BGR labs (4 trainees)	Completed Expenditure: 16,300 EUR
2009	4	Preparation for cruise in 2010	Additional activity, completed Expenditure: 32,692 EUR
2010	1	Research cruise SO205 to the eastern part of the BGR contract area	Additional activity, completed Expenditure: 1,923,652 EUR

Annual objectives and activities			
Year	No.	Agreed Objectives	Objective: Completed, Modified, Postponed or Replaced
2010	2	Acquisition of exploration equipment (side-scan sonar, video sledge, positioning system)	Additional activity, completed Expenditure: 1,397,367 EUR
2010	3	Concept of state-of-the-art nodule collector	Additional activity, completed Expenditure: 610,000 EUR
2010	4	Nodule geochemistry, processing of multibeam data, photo analyses	Additional activity, completed Expenditure: 350,000 EUR
2010	5	Development of nodule distribution model, selection of prosp. mining areas	Completed Expenditure: 403,371 EUR
2011	1	Analysis and interpretation of samples and data obtained in 2008, 2009 and 2010	Completed Expenditure: 1,992,565 EUR
2011	2	Implementation of a GIS-based data base system	Postponed to 2017 (start of development)
2011	3	Preparation of exploration cruise in 2012	Completed Expenditure: 106,200 EUR
2011	4	Preparation of proposal for a BMBF-funded research cruise	Completed
2011	5	Technical upgrade of video sledge and side-scan sonar	Completed Expenditure: 549,381 EUR
2011	6	Biological investigations on benthic faunal communities	Completed Expenditure: 197,400 EUR
2012	1	Exploration cruise BIONOD 2012: joint French-German cruise to both contract areas, focus on biodiversity research	Modified Expenditure: 1,176,110 EUR
2012	2	Geochemical analyses of nodules	Completed Expenditure: 422,100 EUR
2012	3	Evaluation of potential mining areas for nodule abundance (ArcGIS)	Completed Expenditure: 477,750 EUR
2012	4	Photo analyses for nodule abundance	Completed Expenditure: 473,120 EUR
2012	5	Selective leaching geochemistry	Additional activity, completed Expenditure: 396,870 EUR
2012	6	Metallurgical experiment for the development of processing route	Postponed to 2013 and subsequent years
2012	7	Acquisition/maintenance of survey and lab equipment	Additional activity, completed Expenditure: 126,615 EUR
2012	8	Biological investigations on benthic faunal communities; env. data assessment	Completed Expenditure: 345,770 EUR
2012	9	Preparation of an exploration cruise in 2013	Completed Expenditure: 127,590 EUR

Annual objectives and activities			
Year	No.	Agreed Objectives	Objective: Completed, Modified, Postponed or Replaced
2013	1	Exploration cruise MANGAN 2013 to the eastern part of the BGR contract area	Modified Expenditure: 2,379,669 EUR
2013	2	Geochemical analyses of nodules	Completed Expenditure: 1,055,692 EUR
2013	3	Evaluation of potential mining areas for nodule abundance (ArcGIS)	Completed Expenditure: 699,675 EUR
2013	4	Photo analyses for nodule abundance	Completed Expenditure: 546,917 EUR
2013	5	Acquisition/maintenance of survey and lab equipment	Additional activity, completed Expenditure: 156,024 EUR
2013	6	Biological investigations on the benthic faunal communities; env. data assessment	Completed Expenditure: 391,639 EUR
2013	7	Metallurgical experiment for the development of processing route	Completed Expenditure: 83,549 EUR
2013	8	Extension of GIS-based data base and project with new data and information	Postponed to 2017 (start of development)
2013	9	Preparation of a cruise in 2014	Completed Expenditure: 242,683 EUR
2014	1	Exploration cruise MANGAN 2014 to the eastern part of BGR contract area	Additional activity, completed Expenditure: 2,292,096 EUR
2014	2	Geochemical analyses of nodules	Completed Expenditure: 718,479 EUR
2014	3	Evaluation of potential mining areas for nodule abundance (ArcGIS)	Completed Expenditure: 536,751 EUR
2014	4	Photo analyses for nodule abundance / automated image analysis	Completed Expenditure: 479,339 EUR
2014	5	Acquisition/maintenance of survey and lab equipment	Additional activity, completed Expenditure: 53,474 EUR
2014	6	Biological investigations of the benthic faunal communities and phytoplankton; env. data assessment	Completed Expenditure: 379,713 EUR
2014	7	Metallurgical experiment for the development of a processing route	Completed Expenditure: 102,580 EUR
2014	8	At-sea training & at BGR (2 persons)	Completed Expenditure: 10,429 EUR
2014	9	Preparation of a cruise in 2015	Completed Expenditure: 169,715 EUR
2015	1	Research cruise SO240 (FLUM) to the eastern part of the BGR contract area	Modified Expenditure: 257,872 EUR
2015	2	Geochemical analyses of nodules	Completed Expenditure: 557,063 EUR

Annual objectives and activities			
Year	No.	Agreed Objectives	Objective: Completed, Modified, Postponed or Replaced
2015	3	Evaluation of potential mining areas for nodule abundance (ArcGIS)	Completed Expenditure: 367,680 EUR
2015	4	Photo analyses for nodule abundance	Completed Expenditure: 189,555 EUR
2015	5	Analysis of side-scan sonar data and development and adaptation of analytical software	Replaced by deep-towed multibeam mapping in 2016
2015	6	Acquisition/maintenance of survey and lab equipment	Additional activity, completed Expenditure: 273,813 EUR
2015	7	Biological investigations on the benthic faunal communities; env. data assessment	Completed Expenditure: 264,294 EUR
2015	8	Metallurgical experiment for the development of a processing route	Postponed to 2016
2015	9	Preparation of a cruise in 2016	Additional activity, completed Expenditure: 168,371 EUR
2016	1	Exploration cruise MANGAN 2016 to the eastern part of the BGR contract area	Completed Expenditure: 2,631,338 EUR
2016	2	Geochemical analyses of nodules	Completed Expenditure: 416,035 EUR
2016	3	Study on Ga, Ge, Sb contents in polymetallic nodules	Postponed to 2017
2016	4	Evaluation of potential mining areas for nodule abundance (ArcGIS), incl. analysis of high-resolution multibeam data	Completed Expenditure: 464,616 EUR
2016	5	Photo analyses for nodule abundance	Completed Expenditure: 232,259 EUR
2016	6	Acquisition/maintenance of survey and lab equipment	Additional activity, completed Expenditure: 444,259 EUR
2016	7	Biological investigations on benthic faunal communities; env. data assessment	Completed Expenditure: 588,368 EUR
2016	8	Compilation and interpretation of oceanographic and climatologic data from climate databases and BGR-owned CTD and ADCP data	Completed Expenditure: 29,783 EUR
2016	9	Metallurgical experiments for the development of a processing route	Completed Expenditure: 241,297 EUR
2016	10	Preparation of a cruise in 2017	Postponed to 2017 for 2018
2017	1	Exploration cruise to the eastern part of the BGR contract area	Postponed to 2018

Annual objectives and activities			
Year	No.	Agreed Objectives	Objective: Completed, Modified, Postponed or Replaced
2017	2	Geochemical analyses of nodules	Completed Expenditure: 236,601 EUR
2017	3	Evaluation of potential mining areas for nodule abundance (ArcGIS)	Completed Expenditure: 45,000 EUR
2017	4	Analysis of high-resolution multibeam bathymetry and backscatter data	Completed in 2016
2017	5	Acquisition/maintenance of survey and lab equipment	Additional activity, completed Expenditure: 251,080 EUR
2017	6	Biological investigations on benthic faunal communities; env. data assessments	Completed Expenditure: 521,190 EUR
2017	7	Interpretation of CTD and ADCP data	Completed in 2016
2017	8	Development of a GIS-based database system (start)	Completed Expenditure: 89,489 EUR
2017	9	Determination of sinking velocities, flocculation and resuspension potential of CCZ sediments	Completed Expenditure: 59,514 EUR
2017	10	Metallurgical experiment for the development of a processing route	Completed Expenditure: 253,193 EUR
2017	11	Co-organisation of the joint ISA/UBA/BGR international workshop on an environmental management strategy for the Area	Additional activity, completed Expenditure: 75,668 EUR
2017	12	Preparation of a cruise in 2018	Completed
2018	1	Exploration cruise MANGAN 2018 / SO262 to the eastern part of the BGR contract area	Shifted from 2017; Completed Expenditure: 3,075,801 EUR
2018	2	Geochemical analyses of nodules	Additional activity, completed Expenditure: 267,551 EUR
2018	3	Evaluation of potential mining areas, mineral resource assessment	Completed Expenditure: 31,916 EUR
2018	4	Photo analyses for nodule abundance	Completed Expenditure: 31,877 EUR
2018	5	Expansion of the GIS-based database system	Completed Expenditure: 93,721 EUR
2018	6	Acquisition/maintenance of survey and lab equipment	Additional activity, completed Expenditure: 622,147 EUR
2018	7	Biological investigations on benthic fauna, scavengers and zooplankton	Completed Expenditure: 371,359 EUR
2018	8	Determination of sinking velocities, flocculation and resuspension potential of CCZ sediments	Completed Expenditure: 92,377 EUR



Annual objectives and activities			
Year	No.	Agreed Objectives	Objective: Completed, Modified, Postponed or Replaced
2018	9	Environmental studies (oceanography, sediment geochemistry)	Additional activity, completed Expenditure: 67,463 EUR
2018	10	Environmental impact assessment for GSR collector test in BGR contract area	Additional activity, completed Expenditure: 62,045 EUR
2018	11	Metallurgical experiment for the development of a processing route	Completed Expenditure: 287,892 EUR
2018	12	At-sea training & in BGR (2 persons)	Completed Expenditure: 51,780 EUR
2018	13	Preparation of a cruise in 2019	Postponed to 2019 (for 2020) due to BGR's participation in the MiningImpact SO298 research cruise to the CCZ in 2019
2019	1	Participation in JPIO MiningImpact research cruise SO268 to the eastern part of the BGR contract area	Modified Third-party funded. Expenditure for personnel & transports: 111,298 EUR
2019	2	Geochemical analyses of nodules	Completed Expenditure: 282,796 EUR
2019	3	Photo analyses for nodule abundance	Completed Expenditure: 57,312 EUR
2019	4	Evaluation of potential mining areas, mineral resource assessment	Completed Expenditure: 115,371 EUR
2019	5	Further development of a GIS-based database system	Completed Expenditure: 132,489 EUR
2019	6	Acquisition/maintenance of survey and lab equipment	Additional activity, completed Expenditure: 479,952 EUR
2019	7	Biological investigations on benthic faunal communities & zooplankton	Completed Expenditure: 196,845 EUR
2019	8	Determination of sinking velocities, flocculation and resuspension potential of CCZ sediments	Completed in 2018
2019	9	Environmental studies (oceanography, sediment geochemistry)	Additional activity, completed Expenditure: 165,997 EUR
2019	10	Metallurgical experiment for the development of a processing route	Completed Expenditure: 417,312 EUR
2019	11	Preparation of a cruise in 2020	Additional activity, completed Expenditure: 35,490 EUR
2020	1	Exploration cruise in 2020 (shifted from 2019)	Postponed to 2021 (extension phase) due to the COVID-19 pandemic and for alignment with GSR's Patania II collector tests
2020	2	Development of a report on resource estimations in the contract area	Completed Expenditure: 91,218 EUR

<b>Annual objectives and activities</b>			
<b>Year</b>	<b>No.</b>	<b>Agreed Objectives</b>	<b>Objective: Completed, Modified, Postponed or Replaced</b>
2020	3	Acquisition/maintenance of survey and lab equipment	Additional activity, completed Expenditure: 663,083 EUR
2020	4	Development of summary studies on biological distribution patterns, biodiversity and abundance in the BGR contract areas and the wider CCZ	Completed Expenditure: 395,535 EUR
2020	5	Oceanography, bottom water currents, ocean chemistry, sediment geochemistry	Completed Expenditure: 469,496 EUR
2020	6	Metallurgical experiment for the development of a processing route	Completed Expenditure: 708,585 EUR
2020	7	Further development and maintenance of the GIS-based database system MAREX	Completed Expenditure: 204,112 EUR
2020	8	Formulation of an application for extension of the PMN exploration license by 5 years	Additional activity, completed Expenditure: 67,488 EUR
2020	9	Development of a mining concept	Postponed to 2025 to integrate further resource and env. information
2020	10	Study on market trends and land-based mining developments	Postponed to 2025
2020	11	Evaluation of all env. data for an EIA	Postponed to 2025
2020	12	Preparation of a cruise in 2021	Completed Expenditure: 155,358 EUR
2021	1	Exploration cruise MANGAN 2021 to the B4 GSR contract area and the eastern part of the BGR contract area	Completed Expenditure: 5,377,629 EUR
2021	2	Acquisition/maintenance of survey and lab equipment	Additional activity, completed Expenditure: 362,894 EUR
2021	3	Development of an ultrasound sonar system for nodule detection (ex-situ)	Completed Expenditure: 116,267 EUR
2021	4	Sediment geochemistry	Completed Expenditure: 79,774 EUR
2021	5	Oceanography, ocean chemistry, sediment trap studies	Completed Expenditure: 286,840 EUR
2021	6	Metallurgical experiment for the development of a processing route (leaching with pyrite)	Partly completed/replaced Expenditure: 75,632 EUR
2021	7	Further development and maintenance of the GIS-based database system MAREX	Completed Expenditure: 181,396 EUR

Annual objectives and activities			
Year	No.	Agreed Objectives	Objective: Completed, Modified, Postponed or Replaced
2021	8	Preparation of a cruise in 2022	Completed Expenditure: 16,976 EUR
2021	9	At-sea training & in BGR (2 persons)	Postponed to 2023 due to pandemic
2022	1	Participation in BMBF research cruise SO295 (NoduleMonitoring2) to the BGR E1 and GSR B4 contract areas	Completed. Third-party funded. Expenditure for personnel & transports: EUR 286,490
2022	2	Acquisition/maintenance of survey and lab equipment	Additional activity, completed Expenditure: EUR 246,237
2022	3	Chemical oceanography and geochemistry analyses	Completed Expenditure: EUR 431,040
2022	4	Biological investigations on benthic macrofaunal communities & zooplankton	Completed Expenditure: EUR 178,230
2022	5	Development of a numerical reactive transport model	Postponed to 2024
2022	6	Designation of PRZ(s) and IRZ(s)	Postponed to 2023
2022	7	Initial scoping exercise	Postponed to 2024 (results of the SO295 cruise are necessary)
2022	8	Metallurgical experiment for the development of a processing route (leaching; solid-state chlorination)	Partly completed/replaced Expenditure: EUR 64,233
2022	9	Further development and maintenance of the GIS-based data management system MAREX	Completed Expenditure: EUR 142,176
2022	10	Preparation of a cruise in 2023	Completed Expenditure: EUR 80,178
2023	1	Exploration cruise MANGAN 2023 to the eastern and western BGR contract areas	ongoing
2023	2	At-sea training & in BGR (4 persons)	ongoing
2023	3	Training in ISA's Deep Dive e-learning platform (4 persons)	ongoing

**Total cost for first 15-year exploration period: 45,114,633 EUR + 565,635 EUR administrative costs + 5,437,792 EUR overhead costs = 51,118,060 EUR**

**Total cost for 5-year extension period up to end 2022: 7,925,992 EUR + 456,744 EUR administrative costs + 358,859 EUR overhead costs = 8,741,595 EUR**

**Total cost PMN exploration 2006-2022: 59,859,655 EUR**

## 5. Training Programme

Schedule 3 of Annex III of the Regulations.

### I. Training Programme

Type of training	At sea & home lab training I	At sea & home lab training II	ISA's Deep Dive e-learning program
<b>Institutions</b>	BGR/DZMB	BGR/DZMB	ISA
<b>Duration</b>	10 weeks	13 weeks	2 weeks
<b>Scope</b>	Mapping, resource & biology of the deep sea	Mapping, resource & biology of the deep sea	Aspects of deep-sea mining
<b>Fields</b>	Geology, geophysics, biology	Geology, geophysics, biology	Legal, technical & scientific
<b>Qualification required</b>	MSc; sufficient English	MSc; sufficient English	BSc; 5 years professional experience; sufficient English; age under 45
<b>Financing</b>	BGR financing	BGR financing	BGR financing

### II. Trainings conducted up to reported year [#]: [year]

Start year	End Year	Name of Trainee	Nationality	Gender	Type of Program	Duration
2008	2009	Yaya M. Djire	Mali	male	At sea & home lab training I	6 weeks on-board training, 4 weeks training at BGR
2008	2009	Suzan Mohamed El Gharapaw	Egypt	female	At sea & home lab training I	6 weeks on-board training, 4 weeks training at BGR
2008	2009	Heliarivonjy Rakotondramano	Madagascar	male	At sea & home lab training I	6 weeks on-board training, 4 weeks training at BGR
2008	2009	Nesha Nurse	Barbados	female	At sea & home lab training I	6 weeks on-board training, 4 weeks training at BGR
2014	2014	Khaled Sayed Sinoussy Mohamed	Egypt	male	At sea & home lab training I	6 weeks on-board training, 4 weeks training at BGR
2014	2014	Daniel Armando Perez-Calderon	Mexico	male	At sea & home lab training I	6 weeks on-board training, 4 weeks training at BGR

2018	2018	Christine Mae Edullantes	Philippines	female	At sea & home lab training II	9 weeks on-board training, 4 weeks training at BGR/DZMB
2018	2018	Abner Nhgoongoloka	Namibia	male	At sea & home lab training II	9 weeks on-board training, 4 weeks training at BGR
2023		Laura Florez	Argentina	female	At sea & home lab training I	6 weeks on-board training, 4 weeks training at BGR/DZMB
2023		Walter Obuya	Kenya	male	At sea & home lab training I	6 weeks on-board training, 4 weeks training at BGR
2023		Frankline Oketch	Kenya	male	At sea & home lab training I	6 weeks on-board training, 4 weeks training at BGR
2023		Roshaun Brown	Jamaica	male	At sea & home lab training I	6 weeks on-board training, 4 weeks training at BGR
2023		tbd	tbd	tbd	Deep Dive	2 weeks
2023		tbd	tbd	tbd	Deep Dive	2 weeks
2023		tbd	tbd	tbd	Deep Dive	2 weeks
2023		tbd	tbd	tbd	Deep Dive	2 weeks

### III. Completed Trainings per Year

	At sea & home lab training / Deep Dive
Year 1 (2006)	
Year 2 (2007)	
Year 3 (2008)	
Year 4 (2009)	4
Year 5 (2010)	
Year 6 (2011)	
Year 7 (2012)	
Year 8 (2013)	
Year 9 (2014)	2
Year 10 (2015)	
Year 11 (2016)	
Year 12 (2017)	
Year 13 (2018)	2
Year 14 (2019)	
Year 15 (2020)	
Year 16 (2021)	

Year 17 (2022)	
Year 18 (2023)	4 <sup>a</sup> + 4*
Year 19 (2024)	
Year 20 (2025/2026)	4*

<sup>a</sup> in progress at the time of writing; \* planned

## 6. Standard clauses

Annex IV of the Regulations.