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Recommendations for the guidance of contractors for the assessment of the possible environmental impacts arising from exploration for polymetallic nodules in the Area[1]

Issued by the Legal and Technical Commission

I. Introduction

1. On 13 July 2000, the International Seabed Authority adopted the Regulations on Prospecting and Exploration of Polymetallic Nodules in the Area ("the Regulations") (ISBA/6/A/18). The Regulations require the Authority to establish and keep under periodic review environmental rules, regulations and procedures to ensure effective protection for the marine environment from harmful effects which may arise from activities in the Area. They also provide that every contract for exploration for polymetallic nodules shall require the contractor to gather environmental baseline data and to establish environmental baselines against which to assess the likely effects of its programme of activities under the plan of work for exploration on the marine environment and a programme to monitor and report on such effects. The contractor shall cooperate with the Authority and the sponsoring State or States in the establishment and implementation of such monitoring programmes. The contractor shall report annually on the results of its environmental monitoring programmes. Furthermore, when applying for approval of a plan of work for exploration, each applicant is required to provide, inter alia, a description of a programme for oceanographic and environmental baseline studies in accordance with the Regulations and any environmental rules, regulations and procedures established by the Authority that would enable an assessment of the potential environmental impact of the proposed exploration activities, taking into account any recommendations issued by the Legal and Technical Commission, as well as a preliminary assessment of the possible impact of the proposed exploration activities on the marine environment.

[1] Adopted by the Legal and Technical Commission on 27 April 2010 on the understanding that annex I is adopted provisionally pending further consideration by the Commission.

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2. Pursuant to the Regulations, the Legal and Technical Commission may from time to time issue recommendations of a technical or administrative nature for the guidance of contractors to assist them in the implementation of the rules, regulations and procedures of the Authority. Under article 165, paragraph 2 (e), of the 1982 United Nations Convention on the Law of the Sea, the Commission shall also make recommendations to the Council on the protection of the marine environment, taking into account the views of recognized experts in that field.

3. In June 1998 the Authority convened a workshop on the development of environmental guidelines. The outcome of the workshop was a set of draft guidelines for the assessment of possible environmental impacts from exploration for polymetallic nodules. The workshop noted the need for clear and common methods of environmental characterization based on established scientific principles and taking into account oceanographic constraints. The draft guidelines were considered by the Legal and Technical Commission at its meetings in August 1999 and July 2000. The Commission was mindful of the need to provide simple and practical recommendations to assist contractors in carrying out their obligations under the Regulations to establish environmental baselines. This document was issued in 2002 as "Recommendations for the guidance of the contractors for the assessment of the possible environmental impacts arising from exploration for polymetallic nodules in the Area" (ISBA/7/LTC/1/Rev.1**). The Commission felt that, given the technical nature of the recommendations and the limited understanding of the impact of exploration activities on the marine environment, it was vital to provide, as annex I to the document, an explanatory commentary on the technical recommendations. The explanatory commentary is supplemented by a glossary of technical terms contained in annex II to document ISBA/7/LTC/1/Rev.1**.

4. As the recommendations contained in document ISBA/7/LTC/1/Rev.1** were based on the current scientific knowledge of the marine environment and the technology to be used at the time they were prepared, it was noted that they might require revision at a later date, taking into account the progress of science and technology. In accordance with the Regulations, the Legal and Technical Commission may from time to time review the present recommendations, taking into account the current state of scientific knowledge and information. It is recommended that such a review be carried out preferably at intervals of five years. To facilitate the review, it is recommended that the Authority convene a workshop in which the members of the Legal and Technical Commission, contractors and recognized experts from the scientific community are invited to participate.

5. The present document is an update of the previous recommendations issued by the Commission in 2002 that takes into account relevant information from the workshops held in 2001 and 2004. In 2001, the Authority held a workshop on the standardization of environmental data. In 2004, the workshop was designed to produce suggestions for environmental recommendations with regard to human activity related to polymetallic sulphides and cobalt-rich crusts. While some of the recommendations of the 2004 workshop are not relevant to polymetallic nodules as a consequence of the different environmental setting of the resources, others may be relevant as they are a result of increased knowledge and improved technology since the 1998 workshop.

II. Scope

A. Purpose

6. These recommendations for the guidance of contractors describe the procedures to be followed in the acquisition of baseline data, and the monitoring to be performed during and after any activities in the exploration area with potential to cause serious harm to the environment. Their specific purposes are:

(a) To define the biological, chemical, geological and physical components to be measured and the procedures to be followed by contractors to ensure effective protection for the marine environment from harmful effects which may arise from the contractors' activities in the Area;

(b) To facilitate reporting by contractors;

(c) To provide guidance to potential contractors in preparing a plan of work for exploration for polymetallic nodules in conformity with the provisions of the Convention, the 1994 Agreement relating to the implementation of Part XI of the United Nations Convention on the Law of the Sea, and the Regulations.

B. Definitions

7. Except as otherwise specified in the present document, terms and phrases defined in the Regulations shall have the same meaning in these recommendations for the guidance of contractors. A glossary of technical terms is contained in annex II to the present document.

C. Environmental studies

8. Every plan of work for exploration for polymetallic nodules shall take into consideration the following phases of environmental studies:

(a) Environmental baseline studies;

(b) Monitoring during and after testing of collecting systems and equipment.

III. Environmental baseline studies

A. Baseline data requirements

9. To set up the environmental baseline in the exploration area as required under regulation 31, paragraph 4, the contractor, utilizing the best available technology, shall collect data for the purpose of establishing the spatial and temporal variability, including:

(a) For physical oceanography:

(i) Collect information on the oceanographic conditions, including, inter alia the current, temperature and turbidity regimes, along the entire water column and particularly near the sea floor;

(ii) Adapt the measurement programme to the geomorphology of the seabed where appropriate;

(iii) Adapt the measurement programme to the regional hydrodynamic activity in the upper water column and at the sea surface where appropriate;

(iv) Measure the physical parameters at the depth of the forecasted discharge during the testing of collecting systems and equipment;

(v) Measure the particle concentration to record distribution along the water column;

(b) For geology: produce Geographic Information System regional maps with high quality bathymetry to show major geological and geomorphological features to reflect the heterogeneity of the environment;

(c) For chemical oceanography (including geochemistry): collect information on the water-column chemistry, including the water overlaying the nodules;

(d) For sediment properties: determine the basic properties of the sediment, including measurement of soil mechanics, to adequately characterize the surficial sediment deposits which are the potential source of deep-water plume; sample the sediment taking into account the variability of the sediment;

(e) For biological communities, using regional maps to plan biological sampling strategy taking into account the heterogeneity of the environment:

(i) Gather data on biological communities, taking samples representative of the variability of bottom topography, sediment characteristics, abundance and types of nodules;

(ii) Collect data on the sea floor communities specifically relating to megafauna, macrofauna, meiofauna, microfauna, nodule fauna and demersal scavengers;

(iii) Assess pelagic communities;

(iv) Record levels of trace metals found in dominant species;

(v) Record sightings of marine mammals, other near-surface large animals (such as turtles and fish schools) and bird aggregations, identifying the relevant species where possible;

(vi) Establish at least one station within each habitat type or region, as appropriate, to evaluate temporal variations;

(f) For bioturbation: gather data on the mixing of sediments by organisms;

(g) For sedimentation: gather data on the flux of materials from the upper water column into the deep sea.

10. In addition to an analysis of the data, raw data should be provided in annual reports where relevant to obtain a better understanding of the region that enables effective environmental protection.

IV. Environmental impact assessment

11. The best available technology for sampling should be used in establishing baseline data for environmental impact assessments.

A. Activities not requiring environmental impact assessment

12. The following activities, which have no potential for causing serious harm to the marine environment, do not require environmental impact assessment:

(a) Gravity and magnetometric observations and measurements;

(b) Bottom and sub-bottom acoustic or electromagnetic profiling of resistivity, self-potential or induced polarization, or imaging without the use of explosives;

(c) Water, biotic and sediment sampling for environmental baseline study:

(i) Sampling of small quantities of water, sediment and biota;

(ii) Mineral sampling of a limited nature, such as that using grab or bucket samplers;

(iii) Sampling by box core, small diameter core or grab;

(d) Meteorological observations and measurements, including the setting of instruments;

(e) Oceanographic, including hydrographic, observations and measurements, including the setting of instruments;

(f) Video and still photographic observation and measurements;

(g) Shipboard mineral assaying and analysis;

(h) Positioning systems, including bottom transponders and surface and subsurface buoys filed in Notices to Mariners;

(i) Towed plume-sensor measurements (chemical analysis, nephelometers, fluorometers, etc.);

(j) In situ metabolic measurements (for example, sediment oxygen consumption);

(k) DNA screening of biological samples.

B. Activities requiring environmental impact assessment

13. The following activities require prior environmental impact assessment, as well as an environmental monitoring programme to be carried out during and after the specific activity, in accordance with the recommendations contained in paragraphs 17 and 18. It is important to note that these baseline, monitoring and impact assessment studies are likely to be the primary inputs to the environmental impact assessment for commercial mining:

(a) Sampling with epibenthic sled, dredge or trawl, to collect nodules for on-land studies for mining and/or processing if the sampling area of any one sampling activity exceeds 10,000 m^2;

(b) Use of specialized equipment to study the effect of artificial disturbances that may be created on the sea floor;

(c) Testing of collection systems and equipment.

14. The prior environmental impact assessment and the information set out in the recommendation contained in paragraph 16 and the relevant environmental monitoring programme is to be submitted by the contractor to the Secretary-General at least one year before the activity takes place.

15. Each contractor should include in its programme specification of events that could cause suspension or modifications of the activities owing to serious environmental harm if the effects of the events cannot be adequately mitigated.

C. Information to be provided by the contractor

16. The contractor is to provide the Secretary-General with some or all of the following information, depending on the specific activity to be carried out:

(a) Nodule collection technique (passive or active mechanical dredge, hydraulic suction, water jets, etc.);

(b) Depth of penetration into the seabed;

(c) Running gear (skis, wheels, caterpillars, Archimedes screws, bearing plates, water cushion, etc.) which contacts the seabed;

(d) Methods for separation on the sea floor of the nodules and the sediment, including washing of the nodules, volume of the discharge of sediment mixed with water, concentration of particles in the discharged mixture, height of discharge above the sea floor, etc.;

(e) Nodule crushing methods;

(f) Methods for transporting the nodules to the surface;

(g) Separation of the nodules from the fines and the sediment on the surface vessel;

(h) Methods for dealing with the abraded nodule fines and sediment;

(i) Volume and depth of overflow discharge, concentration of particles in the discharged water and chemical and physical characteristics of the discharge;

(j) Location of the mining test and boundaries of the test area;

(k) Probable duration of the test;

(l) Test plans (collecting pattern, area to be perturbed, etc.).

D. Observations and measurements to be made while performing a specific activity

17. The contractor is to provide the Secretary-General with some or all of the following information, depending on the specific activity to be carried out:

(a) Width, length and pattern of the collector tracks on the sea floor;

(b) Depth of penetration in the sediment, lateral disturbance caused by the collector;

(c) Volume of sediment and nodules taken by the collector;

(d) Ratio of sediment separated from the nodule on the collector, volume of sediment rejected by the collector, size and geometry of the discharged plume, behaviour of the plume behind the collector;

(e) Area and thickness of re-sedimentation by the side of the collector tracks to the distance where re-sedimentation is negligible;

(f) Volume of overflow discharge from the surface vessel, concentration of particles in the discharged water, chemical and physical characteristics of the discharge, behaviour of the discharged plume at the surface, in mid-water or at the seabed.

E. Observations and measurements to be made after the performance of a specific activity

18. The Contractor is to provide the Secretary-General with some or all of the following information, depending on the specific activity to be carried out:

(a) Thickness of re-deposited sediment by the side of the collector tracks and over the area affected by the resettled sediment from a plume caused by the mining test activity and the discharge plume;

(b) Abundance, diversity and, where possible, the behaviour of the different types of benthic fauna subjected to re-sedimentation;

(c) Changes in the abundance and diversity of benthic fauna in the collector tracks, including rates of recolonization;

(d) Possible changes in the benthic fauna in adjacent areas apparently not perturbed by the activity;

(e) Changes in the characteristics of the water at the level of the discharge from the surface vessel during the mining test, and possible changes in the behaviour of the corresponding fauna;

(f) For mineral deposits, post-test-mining maps of the mined area, highlighting changes in geomorphology at the finest scale practicable;

(g) Levels of trace metals found in dominant benthic fauna subjected to resettled sediment from the discharge plume.

V. Data collection, reporting and archival protocol

A. Data collection and analysis

19. The types of data to be collected, the frequency of collection and the analytical techniques in accordance with the present recommendations should follow the best available methodology and the use of an international quality system and certified operation and laboratories.

B. Data archival and retrieval scheme

20. The following obligations should be met:

(a) Cruise report with station list, list of activities and other relevant metadata to be submitted to the International Seabed Authority Secretariat within one year of the completion of the cruise;

(b) Raw sample data to be submitted to the International Seabed Authority Secretariat.

C. Reporting

21. Assessed and interpreted results of the monitoring shall be periodically reported to the Authority in the prescribed format.

D. Transmission of data

22. All data relating to the protection and preservation of the marine environment, other than equipment design data, collected pursuant to the recommendations contained in paragraphs 17 and 18 should be transmitted to the Secretary-General to be freely available for scientific analysis and research within four years of the completion of a cruise, subject to confidentiality requirements as contained in the Regulations.

23. The contractor should transmit to the Secretary-General any other non-confidential data in its possession which could be relevant for the purpose of the protection and preservation of the marine environment.

VI. Cooperative research and recommendations to close gaps in knowledge

24. Cooperative research may provide additional data for the protection of the marine environment and may be cost-effective for contractors.

25. It implies interaction between multiple oceanographic disciplines and can be useful in closing gaps in knowledge resulting from contractors working individually. The Authority can give support in the coordination and dissemination of the results of such research, in accordance with the Convention.

Annex I

Explanatory commentary

1. The aim of the recommendations for the guidance of contractors is to define the biological, chemical, geological and physical components to be measured and the procedures to be followed by the contractor to ensure the effective protection of the marine environment from harmful effects which may arise from its activities in the Area, and to provide guidance to prospective contractors in preparing plans of work for exploration for polymetallic nodules.

2. It was considered that there was a need to clearly define the various stages of exploration. The scale of tests of collecting systems is crucial for the assessment of their environmental consequences. Any plan of work for exploration will take into consideration the following phases of environmental studies:

(a) Environmental baseline studies;

(b) Monitoring during and after testing of collecting systems and equipment.

3. The purpose of environmental baselines is to ensure that measures can be taken to evaluate the impact of exploration activities on the marine environment. Although the actual technology that will be used for some exploration activities, namely the one which will be embodied in the collecting systems and equipment, is not currently known, and current knowledge of the deep-sea environment is insufficient to predict the real impacts of tests of such technology, the environmental disturbances may be forecast to some extent, based on the experience and knowledge gathered from previous activities carried out by the registered pioneer investors and by the scientific community. The main impacts are expected to occur at the sea floor. The nodule collector will disturb the semi-liquid sediment-surface layer and will create a near-bottom plume. The nodule collector will compress, break up and squeeze the harder underlying sediment layer. For predicting the effects of the activities and for managing them in such a way as to prevent serious harm to the environment, the critical issues are the following:

(a) The dose-response function for the sediment communities for a single deposition event. The dose-response and modelling of the amount of sediment that would settle in a particular area would help predict the impacts;

(b) The chronic disturbance effect, i.e. the disturbance effect of multiple sediment depositions in a given area, which would yield information on how frequently a plume is produced in an area that yields a small amount of sedimentation, without having a negative impact upon the ecosystem;

(c) The time scale of community recovery after a very intense disturbance. The sediment transported to the surface with the stream of polymetallic nodules may be discharged into the ocean together with nodule fines. Disposal in the surface waters would possibly interfere with primary productivity by increasing the nutrient levels and decreasing light penetration into the ocean, or enter the food chain and disturb vertical migration. The discharge may occur below the thermocline layer and the oxygen-minimum zone, and preferably at the seabed. Since the thermocline and the oxygen-minimum zones vary regionally and to some extent seasonally, environmental studies must:

(i) Determine the depth range of the thermocline and the oxygen-minimum layer at each mining area;

(ii) Concentrate on the oceanographic properties around the discharge depth;

(iii) Include oceanographic parameters in the upper-water layer because of the potential for accidental discharge.

4. Part III deals with the baseline data requirements. The contractor, utilizing the best available technology, shall set up the environmental baseline in the exploration area. The baseline data requirement shall take into consideration seven groups of data: physical oceanography, chemical oceanography, sediment properties, biological communities, bioturbation, sedimentation and geological properties.

5. The first baseline data group (physical oceanography) is a general requirement targeted at collecting the physical data prior to any disturbance in order to model and to value the potential influence on the physical environment. Information on the physical oceanography is required to estimate the potential influence of the mining plume. This information includes the current conditions, temperature and turbidity regimes above the sea floor. At the depth of discharge, measurements of the currents and particulate matter are required as basic information to predict the behaviour of the discharge plume. At the upper layers, these studies are required to characterize the baseline environmental conditions. Surface oceanographic structure is measured by conductivity-temperature-depth (CTD) systems studies. Temporal aspects of the surface structure need to be addressed. The CTD profiles and sections should be performed from the surface to the bottom, to characterize the stratification of the entire water column. Current and temperature field structures can be inferred by the long-mooring data and from supplementary acoustic Doppler current profilers (ADCP) and other current measurement methods. The number and location of the moorings need to be appropriate for the size of the area to adequately characterize the current regime. The recommended sampling resolution is based on World Ocean Circulation Experiment and CLIVAR standards, with station spacing not exceeding 50 km. In regions of large lateral gradients (for example, in boundary currents and near major geomorphologic structures), the horizontal sampling spacing should be decreased in order to allow resolution of the gradients. The number of current metres on a mooring is dependent upon the characteristic scales of topography of the area studied (difference in heights from the bottom). The suggested location should be as close as possible to the sea floor, normally 1 m to 3 m. The location of the upper current metre should exceed the highest element of the topography by a factor of 1.2 to 2. Along with this, the basic levels of the current metres should be 10 m, 20 m, 50 m, 100 m and 200 m above the seabed. A satellite-data analysis is recommended for understanding synoptic-scale surface activity in the area and for larger-scale events.

6. The second baseline data group (chemical oceanography) is a specific requirement targeted at collecting data prior to any discharge in the water, including the water overlying the nodules. The data gathered are important for assessing the possible influence on biological activity of the modification of the water composition by the mining tests of collecting systems. Samples should be collected at the same locations as indicated for physical oceanography measurements. The water overlying the nodules and the pore water in the sediments should be characterized chemically where possible to evaluate processes of chemical exchange between the sediment and the water column. The chemical parameters to be

measured and the suggested protocols are listed in chapter 23 of the International Seabed Authority report entitled *Standardization of Environmental Data and Information: development of guidelines*. In the same report, table 3 lists the specific parameters that should at least be measured (phosphate, nitrate, nitrite, silicate, carbonate alkalinity, oxygen, zinc, cadmium, lead, copper, mercury, total organic carbon). Once details of the proposed test-mining techniques are known, the parameter lists should be extended to include any potentially hazardous substances that may be released into the water column during test mining. All measurements must be accurate in conformance with accepted scientific standards (for example, CLIVAR, JGOFS and GEOSECS).

7. Characterization of the water-column chemistry is essential for assessing background conditions prior to any discharge in the water. In order to allow for later analysis of additional parameters, water samples suitable for analysis of dissolved and particulate matter should be collected and archived in a repository accessible for future study.

8. Vertical profiles and temporal variation also need to be addressed in the field measurement programme.

9. A general scheme for physical and chemical oceanographic baselines includes:

(a) Collection of water-column hydrographic and light-transmission data of sufficient resolution to characterize the dominant patterns, taking into account the characteristics of the geomorphology of the seabed at the exploration site, where appropriate;

(b) Collection of data appropriate for assessing the horizontal and vertical advective and eddy-diffusive dispersal potential of dissolved and particulate matter on the environmentally relevant time and space scales;

(c) Set-up and validation of a numerical circulation model that covers the temporal and spatial scales important for dispersal, and the carrying out of experiments, for example to investigate the potential impact of accidental spills.

10. The time scales for the environmental impact of each test-mining by-product must be modelled. Both advective and eddy-diffusive contributions to the dispersal potential should be assessed. Before test mining is to begin, the dispersal potential must be assessed at all levels where environmentally significant test-mining by-products are to be released into the water column and where accidental spills are considered most likely. In regions of geomorphologic relief near the test-mining site, horizontal and vertical resolutions should be increased to allow dynamical structures associated with deep-sea topography (e.g. boundary currents, trapped eddies, overflows) to be resolved. In order to complete an assessment of the dispersal potential, a three-dimensional hydrodynamic numerical model that covers the temporal and spatial scales important for dispersal must be constructed.

11. Modelling will assist in extrapolating from test mining to commercial-scale mining.

12. The third baseline data group (sediment properties, including pore water chemistry) is targeted at collecting the basic information to predict the behaviour of the discharge plume and the effect of test-mining activity on sediment composition. In this context, the following parameters should be measured: specific gravity, bulk density, shear strength and grain size as well as the sediment depth of change from

oxic to suboxic conditions. Additionally, organic as well as inorganic carbon in the sediment, other elements (iron, manganese, zinc, cadmium, lead, copper, mercury), nutrients (phosphate, nitrate, nitrite and silicate), carbonate (alkalinity) and the redox system in the pore water should be measured to 20 cm depth. The geochemistry of the pore water and sediments should be determined as far down as 20 cm. Recommended protocols are listed in tables 1 and 2 of chapter 23 of the International Seabed Authority report entitled *Standardization of Environmental Data and Information: development of guidelines*.

13. The fourth baseline data group (biological communities) is targeted at collecting the "natural" data, including "natural variability" to evaluate the effects of the activities on the benthic and pelagic fauna.

14. Seabed mining will have its greatest impact on the sea floor biological community. The test of components (engineering tests) will provide a first indication of this impact. Subsequent integrated tests will yield a deeper knowledge of this impact.

15. Geographic Information System mapping tools are recommended as a means to place habitat and sample information in spatial contexts.

16. Standard practices for the preservation of organisms should be followed, including: discrete sampling of sub-habitats into separate sample containers (preferably insulated) with closed lids to prevent washing on recovery; recovery of samples within 12 hours of collection to obtain quality material; and immediate processing and preservation of samples on deck or maintenance in cold rooms for durations of no more than six hours before preservation (or less where molecular assays are planned).

17. Multiple preservation methods should be used, including: preservation in formalin for taxonomic studies; freezing or preservation in 100 per cent ethanol for molecular studies; drying of whole animals and/or selected tissues for stable isotope analyses; and freezing of whole animals and/or selected tissue for trace metal and biochemical analyses.

18. Colour photographic documentation of organisms should be obtained whenever possible (organisms in situ and/or fresh material on deck to document natural coloration). These photographs should become part of an archival collection.

19. All samples and sample derivatives (e.g. photographs, preserved material, gene sequences) should be linked to relevant collection information (the minimum requirement is date, time, method of sampling, latitude, longitude, depth).

20. Identification and enumeration of samples at sea and in the laboratory should be complemented by molecular and isotopic analyses, as appropriate. Species-abundance and species-biomass matrices should be standard products wherever practical.

21. Specimens must be archived for comparison with taxonomic identifications from other sites and to understand the details of changes in the composition of species over time.

22. Standardization of methodology and reporting of the results is extremely important. Standardization should include: instruments and equipment; quality assurance in general; sample collection; treatment and preservation techniques;

determination methods and quality control on board vessels; analytical methods and quality control in laboratories; and data processing and reporting.

23. Collection and analytical techniques must follow best practices, such as those developed by the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization, and available at World Data Centres and Responsible National Oceanographic Data Centres, or those established or recommended by the Authority.

24. Spatial variation in the biological community must be evaluated prior to test mining.

25. Different kinds of sampling equipment can be used depending upon the size of the fauna to be collected. The use of multiple corers allows the distribution of different sampling tubes from the same station among the specialists that used different techniques for fauna identification and counting. However, it should be stressed that the diameter of the tubes must be adjusted to avoid excessive disturbance of the sediment or obstruction by the nodules. The data to be collected and the corresponding methodology for the various classes/sizes of seabed fauna should be as follows:

Megafauna. Data on megafauna abundance, biomass, species structure and diversity are to be based on photographic transects. Photographs need to have a sufficient resolution in order to identify organisms greater than 2 cm in their smallest dimension. The width covered by the photographs should be at least 2 m. As for sampling stations, the pattern of the photographic transects should be defined taking into account the different features of the bottom, such as topography, variability of the sediment characteristics and abundance and type of nodules. Species identification should be confirmed by collection of specimens at the site. Sampling efforts should be used to characterize the less abundant but potentially key megafauna in the system (including fish, crabs and other motile organisms). Representative samples of those organisms should be preserved for taxonomic, molecular and isotopic analyses.

For infauna:

Macrofauna. Data on macrofauna (>250µm) abundance, species structure, biomass, diversity and depth distribution (suggested depths: 0-1, 1-5, 5-10 cm) are to be based on box cores (0.25 m^2).

Meiofauna. Data on meiofauna (<250µm, >32µm) abundance, biomass, species structure and depth distribution (suggested depths: 0-0.5, 0.5-1.0, 1-2, 2-3, 3-4 and 4-5 cm) are to be based on cores. One tube per station of a multiple corer-sampling pattern could be devoted for this purpose.

Microfauna. Microbial metabolic activity should be determined using adenosine triphosphate (ATP) or other standard assay for 0-1 cm intervals of cores. One tube per station of a multiple corer-sampling pattern could be devoted for this purpose. Suggested intervals for sampling are 0-0.5, 0.5-1.0, 1-2, 2-3, 3-4, 4-5 cm.

Nodule fauna. Abundance, biomass and species structure of the fauna attached to the nodules should be determined from selected nodules taken from the top of box corers.

Demersal scavenger. A time-lapse baited camera should be installed at the study area for at least one year to examine the physical dynamics of surface sediment and to document the activity level of surface megafauna and the frequency of re-suspension events. Baited traps may be used to characterize the community species composition.

26. If there is potential for surface discharge, the plankton community in the upper 200 m of the water column should be characterized. The pelagic community structure around the depth of the plume and in the benthic boundary layer need also to be assessed prior to test mining. Measurements should be made of phytoplankton composition, biomass and production, zooplankton composition, and biomass and bacterial plankton biomass and productivity. Temporal variation of the plankton community in the upper surface waters on seasonal and inter-annual scales should be studied. Remote sensing can be used to augment field programmes. Calibration and validation of remote-sensing results are essential.

27. Trace metals should be assessed in muscle and target organs of dominant benthic and benthopelagic fish and invertebrate species. This should be done at least four times before test-mining operations begin (to measure natural variability) and thereafter at least annually to monitor possible changes due to test-mining activity. A combination of monitoring and shipboard and laboratory experimentation may be necessary to resolve completely, prior to test mining, the issues of impacts on phytoplankton and zooplankton if there is surface discharge, and the effects of trace metals.

28. Temporal variation must be evaluated for at least one potential test mining site and the preservation reference site for the test-mining activity (ideally, once every year for three years; minimally, twice — once at the beginning and once at the end of a single year). This temporal study should be reviewed by the Authority prior to the start of test mining. The temporal evaluation must include a video and/or photographic survey of subhabitat distribution, in addition to baseline data, including species abundance, biomass and community structure.

29. Taxonomic standardization should be addressed and, in order to facilitate identification, there should be an exchange of identification codes, keys, drawings and sequences at major laboratories and collections that carry out taxonomic studies of marine organisms.

30. Information from samples, photographs, video or other sources will assist in determining impact on the benthos. Such information will help to resolve questions about the significance of the impact and may assist in developing any appropriate mitigation strategies for commercial recovery operations. Information on the faunal succession that follows the test mining will help to determine the potential for the recovery of the benthic population from the effects of such mining. Data should include samples from the immediate test area before and after test mining, from selected distances away from the mined area to determine the effect of the benthic plume, and at selected times after test mining. Such impact experiments can be conducted collaboratively.

31. Information on other effects of the plume on the mid-water biota can be gathered by making observations of unusual events, such as fish kills and unusually large concentrations of fish, marine mammals, turtles and birds.

32. The vertical distribution of light directly affects primary productivity in the euphotic zone. If there is surface discharge, vertical light-intensity profiles will show the effect of discharged particles on light attenuation and spectral bands over time, depth and distance from the mining ship. Those values can be used to detect any accumulation of the suspended particles at the pycnocline.

33. The fifth baseline data group (bioturbation) is targeted at collecting the "natural" data, including "natural variability" to model and to value the effects of the activities (bottom plume). Rates of bioturbation, i.e., the mixing of sediments by organisms, must be measured to analyse the importance of biological activity prior to a mining disturbance and can be evaluated from profiles of excess Pb-210 activity from cores, taking into account the variability in the sediment. Excess Pb-210 activity should be evaluated on at least five levels per core (suggested depths are 0-0.5, 0.5-1.0, 1-1.5, 1.5-2.5 and 2.5-5 cm). Rates and depth of bioturbation are to be evaluated by standard advection or direct diffusion models.

34. The sixth baseline data group (sedimentation) is targeted at collecting the "natural" data, including "natural variability" to model and to evaluate the effects of the activities (mid-water plume). It is recommended that deployment of moorings with sediment traps on a mooring line should be undertaken, with one trap below 2,000 m to characterize the particulate flux from the euphotic zone and one trap approximately 500 m above the sea floor to characterize the flux of materials reaching the sea floor. The bottom trap must be high enough above the bottom so as not to be influenced by sediment re-suspension. Sediment traps should be installed for a suitable period of time, with samples collected monthly to examine the seasonal flux and to evaluate inter-annual variation, particularly between climatic event years (for example, El Niño, La Niña). The trap installation may share the same mooring as the current metres described above. As the flux of materials from the upper-water column into the deep sea is ecologically significant in the food cycle of bottom-dwelling organisms, an adequate characterization of the material flux in the mid-water and flux to the sea floor is necessary for a comparison with the effect of the tailings discharge.

35. The seventh baseline group (geological properties) is targeted at determining the heterogeneity of the environment and assisting the placement of suitable sampling locations.

36. High-resolution (at least 200 m horizontal, 10 m vertical), high-quality bathymetric data should be collected over the area where the dispersal of test-mining by-products is expected to significantly affect the environment, that is, over the entire region covered by the numerical circulation model.

37. As part of the high-resolution baseline survey, a suite of representative pre-mining cores of the sea floor sediment (including the top few centimetres, which can be lost when standard corers are used) around the target area should be collected and stored in a suitable repository, which is available for appropriate scientific study, while respecting the commercial implications for the contractor. A reasonable sampling strategy would consist of sediment cores taken at 1 km intervals starting at the margin of the deposit and extending at least 10 km along the four cardinal points.

38. Part IV of the recommendations for guidance deals with environmental impact assessment. Certain activities have no potential for causing serious harm to the

marine environment and therefore do not require environmental impact assessment. Such activities are listed. In regard to activities that require environmental impact assessment, a monitoring programme is needed during and after a specific activity. Two kinds of operations are involved. The first is the observation and measurement of parameters that must be carried out during the performance of the activity in order to determine the extent of the disturbances created by that activity. The second is the periodic observation and measurement of parameters after the performance of the specific activity in order to determine the effects of the activity on the biological activities, including the recolonization of the disturbed areas.

39. The environmental studies during exploration will be based on a plan proposed by the contractor and reviewed by the Legal and Technical Commission for completeness, accuracy and statistical reliability. The plan would then be incorporated into the programme of activities under the contract. The environmental studies to be conducted during exploration will include, among other things, the monitoring of environmental parameters so as to confirm the findings that activities not expected to cause serious environmental harm do not in fact cause harm. The studies will be devoted primarily to the collection of data which can address concerns of the potential for serious environmental harm, in respect of benthic, mid-water and upper-water column impacts, resulting from the use of the proposed technologies.

40. Tests of collecting systems are viewed as an opportunity to examine the environmental implications of mining. The contractor will submit to the Authority a plan of such testing at least one year in advance. Preliminary descriptions of such tests, if they exist, should be submitted to the Authority with the application for approval of a plan of work for exploration; the details for monitoring the environment during the test mining shall be submitted at least one year before testing begins. A plan for testing of collection systems shall include provision for monitoring of those areas impacted by the contractor’s activities which have the potential to cause serious environmental harm, even if such areas fall outside the proposed test site. The programme will include, to the maximum extent practicable, specification of those activities or events that could cause suspension or modification of the tests owing to serious environmental harm if the specified activities or events cannot be adequately mitigated. The programme will also authorize refinement of the test plan prior to testing and at other appropriate times, if refinement is necessary to reflect proposed operations accurately or to incorporate recent research or monitoring results. The plan for testing of collecting systems will include strategies to ensure that sampling is based on sound statistical methods, that equipment and methods are scientifically accepted, that the personnel who are planning, collecting and analysing data are scientifically well qualified and that the resultant data are submitted to the Authority in accordance with specified formats.

41. During the mining tests of collecting systems, delineation of the impact reference zone and preservation reference zone is recommended. The impact reference zone should be selected based on the area being representative of the environmental characteristics, including the biota, of the site where testing will take place. The preservation reference zone should be carefully located and be large enough so as not to be affected by the natural variations of local environmental conditions. The zone should have species composition comparable to that of the test area. The preservation reference zone should be outside the test area and areas influenced by the plume.

42. The monitoring programme proposed by the contractor must provide the means to assess the importance of the perturbations created by its activities. This information is essential for assessing the effects of such activity on the environment and predicting the effects of similar activities in the future, including at the time of commencement of a commercial operation. It must be noted that some of the observations or measurements are beyond the capabilities of currently available technology. Consequently, the present proposals will have to be adjusted depending upon the improvements in the technology at the time of the activity.

43. Part V of the recommendations deals with data collection and reporting. It is recommended that collection and analytical techniques should follow best practices such as those developed by the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization and available at World Data Centres and Responsible National Oceanographic Data Centres, or those established or recommended by the Authority. An inventory of the data holdings from each contractor should be accessible on the World Wide Web Metadata that will detail the analytical techniques, error analyses, descriptions of failures, techniques and technologies to avoid. Comments on sufficiency of data and other relevant descriptors should also be included, in addition to the actual data.

44. A data archival and retrieval scheme could assist all contractors in the search for environmentally significant indicator elements. The environmental baseline studies and the monitoring programmes represent an important source of data and knowledge. Synthesis of such data and experience can work to the advantage of all contractors. As an example, synthesized data on bathymetry, currents, winds, salinity and temperature fields can form critical inputs for the modelling of regional- or basin-scale oceanographic processes. Models can be validated and fine-tuned by these sea truth data and can then partially supplement costly data-collection exercises. Increased data accessibility increases the likely accuracy of models and will assist in:

(a) Identification of best practices;

(b) Development of a common approach to an acceptable database;

(c) Multilateral exchange of views and data leading to international cooperation;

(d) Savings of time, effort and costs in alerting the community to failures;

(e) Savings through reduction of measurement of some parameters.

45. Some claim areas may lie adjacent to or in the vicinity of other claims, providing further justification for data accessibility and joint efforts in modelling, so that the impact of activities in neighbouring areas can be evaluated without repeating all aspects of environmental assessment.

46. Part VI of the recommendations for the guidance of contractors deals with cooperative research and recommendations to close gaps in knowledge. Recent years have witnessed a revolution in the development of knowledge and technology in the deep-sea sciences. A number of research institutes around the world are carrying out extensive research programmes. Those institutions have considerable biological and scientific expertise.

47. Cooperative research can facilitate the establishment of baselines of natural variability on the basis of geological, biological and other environmental records acquired in selected areas.

48. A partnership between scientific community and contractors may result in voucher collection repositories, a gene sequence database repository, stable isotope analysis and interpretation and a photographic library of species/specimens. The basic scientific information acquired in partnership should result in the cost-effective acquisition of information that will assist in development planning and decision-making, and the timely recognition of any significant environmental effects or issues prior to and during test mining. This information can be used to find solutions with a minimum conflict approach.

49. The risk of extinction for a significant fraction of a community of fauna within a potential test mine site will depend largely on how localized or widespread the species are distributed. Assessment will require syntheses of the biogeography of the fauna. This assessment should be facilitated by collaboration among contractors and with the scientific community.

50. Modelling studies should be undertaken collaboratively and linked closely to the field studies, to assess extinction risks under various management strategies, including various options for the design of protected areas. Overall conservation strategies need to take into account non-test mining impacts on faunal communities.

51. The contractors should work together with the Authority on cooperative research programmes to maximize the assessment of environmental impact and minimize the costs of these assessments.

52. In accordance with the Convention, the Authority shall promote and encourage the conduct of marine scientific research in the Area, and shall coordinate and disseminate the results of such research and analysis when available.

Annex II

Glossary of technical terms

ATP	Adenosine triphosphate, a complex organic compound which serves for short-term energy storage and conversion in all organisms. The amount of ATP present can be used as a measure of total microbial biomass in the sediment, as it corresponds to the number of active cells, most of which are bacteria.
Bathypelagic	Pertaining to open-ocean environments at depths greater than 3,000 m, deeper than the mesopelagic zone.
Benthic	Pertaining to the ocean bottom.
Benthic boundary layer	Pertaining to the layer of water immediately above the ocean bottom water layer/sediment interface.
Benthopelagic	Pertaining to the zone very close to, and to some extent having contact with, the sea floor of deeper portions of the open ocean.
Benthos	The forms of marine life that live on, or in, the ocean bottom.
CLIVAR	Climate variability and predictability, a component of the World Climate Research Programme.
CTD	Pertaining to a system for measuring conductivity (indicator of salinity), temperature and depth (defined from pressure measurements). The first two parameters are essential in oceanographic observations and the depth profile is required to delineate the vertical structure of the ocean. Additional parameters, such as pH and dissolved oxygen concentration, can be measured if optional sensors are installed.
Diel	Involving a 24-hour period that usually includes a day and the adjoining night.
Embolism	The blood and tissues of fish contain dissolved gases. If fish from the deep ocean are brought to the surface, the decrease in pressure allows the dissolved gas to expand in the form of bubbles (embolism), causing disfiguration and protrusion of the internal organs through the mouth and other orifices.
Epifauna	Animals that live on the bottom, either attached to the sea floor or freely moving over it.
Epipelagic	Referring to the upper region of the ocean depths, above the mesopelagic and generally below the oxygen-minimum zone.

Euphotic zone	The upper section of the ocean which receives sufficient light for photosynthesis. In clear oceanic waters, the euphotic zone can extend to a maximum water depth of 150 m.
GEOSECS	Geochemical Ocean Sections Study.
Halocline	A layer of water in which there is a steep gradient in salinity.
Hydrodynamic	Referring to any event relevant to the movement of sea water.
Infauna	Organisms that live within the sediment.
JGOFS	Joint Global Oceans Flux Study (Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization).
Macrofauna	Animals large enough to be seen by the naked eye, up to 2 cm long.
Megafauna	Defined as animals large enough (larger than 2 cm) to be determined in photographs, proposed as key taxon (see taxonomy) for environmental impact assessment in deep-sea mining.
Meiofauna	Animals of the benthic community that are intermediate in size between macrofauna and microfauna. Operationally defined as >32µm and <250µm.
Mesopelagic	Referring to the portion of the oceanic province that is below the epipelagic and above the bathypelagic, usually corresponding to the dimly lit ocean or “twilight zone”.
Microfauna	Organisms invisible to the naked eye, smaller than meiofauna. Operationally defined as <32µm.
Nekton	Fish, squids, crustaceans and marine mammals that are active swimmers in the open ocean environment.
Nematoda	The class of roundworms; a dominant meiofauna constituent.
Oxygen minimum	A water layer present in all oceans at depths between 400 and 1,000 m, caused by the sinking and degrading by bacteria of organic matter produced in the surface ocean. The oxygen scarcity can cause particulate metals to dissolve.
Pelagic	Pertaining to the open ocean environment.
pH	A measure of acidity or alkalinity.

Photosynthesis	The biological synthesis of organic material using light as energy source. Plants convert carbon dioxide and water, in the presence of chlorophyll and light energy, into carbohydrate food and oxygen.
Phytoplankton	Microscopic plants that are primary producers in the oceans.
Plankton	Passively drifting or weakly swimming organisms.
Plume	A plume is a dispersion of seawater that contains dense sediment particles. Benthic plume is a stream of water containing suspended particles of sea floor sediment, abraded manganese nodules and macerated benthic biota that emanates from the mining collector as a result of collector disturbance of the sea floor and spreads in a zone close to the sea floor. The far-field component of the benthic plume is termed the “rain of fines”. Surface plume is a stream of water containing suspended particles of sea floor sediment, abraded manganese nodules and macerated benthic biota resulting from the separation, on board the mining ship, of the nodules from the water carrier and spreads in a zone closer than benthic plume to the ocean surface.
Pore water	The water present within the spaces between sediment particles; also called “interstitial water”.
Pycnocline	A layer of water in which there is a steep gradient in density with depth. It separates the well-mixed surface waters from the dense waters of the deep ocean. Density of the water is a function of temperature, salinity and, to a lesser extent, pressure.
Rain of fines	Far-field component of the “benthic plume” that consists mainly of fines; sedimentary particles which drift with the bottom current and slowly settle to the sea floor, generally outside the specific mining area.
Redox system	One essential chemical reaction is oxidation (giving electron) and reduction (removing electron). The chemical tendency (environmental strength) of oxidation can be expressed by redox potential (mv) that can be measured by an Eh/Ph meter. Eh is strongly correlated to the dissolved oxygen concentration in the sediment.
Scavenger	An animal that eats waste products and dead remains of other animals and plants that they did not kill themselves.

Spatial scales	Scales characteristic of dimensions in space, as of oceanic phenomena, for example, the diameter of an eddy or the length of a wave. Also pertains to the geographical arrangement of sampling stations.
Synoptic scales	Scales of hydrodynamic variability or events encompassing temporal scales ranging from one to two weeks to one to two months and spatial scales of one to several hundred kilometres. A typical feature is synoptic eddies 100-200 km in diameter passing through the north-east tropical Pacific from east to west and often penetrating to the sea floor.
Taxonomy	Orderly classification of animals or plants according to their presumed natural relationship.
Thermocline	A layer of water in which there is a rapid change of temperature with depth.
Transect	The vertical plane (reference for all the measures and sampling taken during the survey) from surface to sea bottom, of the route of a survey oceanographic vessel, from point A to point B.
Transmissometer	Device used to measure the attenuation of light through a given path, such as of water. Data can be correlated to the amount of particles present.
Zooplankton/ animal plankton	Unlike phytoplankton, these organisms cannot produce organic matter on their own and thus feed on other organisms.