EXECUTIVE SUMMARY

At the tenth session of the International Seabed Authority, held in May 2004, the Legal and Technical commission presented "Draft regulations on prospecting and exploration for polymetallic sulphides and cobalt-rich ferromanganese crusts in the Area" to the Council for its consideration at the eleventh session.[1] The document comprised 43 regulations and 4 annexes. Annex 1 was entitled "Notification of intention to engage in prospecting," annex II was on "Application for approval of a plan of work for exploration to obtain a contract," annex III was entitled "Contract for exploration," and annex IV contained standard clauses for exploration contracts. Of the 43 regulations, 9 concerned the protection and preservation of the marine environment from activities in the Area. These were: regulation 5 in part II (Prospecting), regulations 20 and 22 in part III (Applications for approval of plans of work for exploration in the form of contracts), regulations 33, 34, 35, 36 and 38 in part V (Protection and preservation of the marine environment), and regulation 41 in part VI (Confidentiality). Of these, regulation 33 (Protection and preservation of the marine environment), regulation 34 (Environmental baselines and monitoring) and regulation 41 (Recommendations for the guidance of contractors) were most pertinent to the objectives of the workshop discussed in this publication.

Article 165, paragraph 2 (e) of the Convention requires the Commission to make recommendations to the Council on the protection of the marine environment, taking into account the views of recognized experts in this field. This workshop, the seventh convened by the Authority, entitled "Polymetallic sulphides and cobalt-rich ferromanganese crusts: Their environments and considerations for the establishment of environmental baselines and an associated monitoring programme for exploration" was convened to address that requirement.

Although the workshop was scheduled to be held from 6 to 10 September 2004, it ended on 9 September, owing to threats posed by hurricane Ivan. The workshop was attended by 40 participants from 18 countries, 16 of whom made presentations. One of the invitees to the workshop, Mr. David Heydon, Chief Executive Officer of Nautilus Minerals Limited, a company that had been active in the development of polymetallic sulphides in the territorial waters of Papua New Guinea, was unable to attend. However, Mr. Heydon sent two presentations to help in the discussions on impact and technology for polymetallic sulphides development. These were entitled "Exploration for and pre-feasibility of mining seafloor polymetallic sulphides – a commercial study" and "Mining on land vs. the seafloor - a case study."

The objectives of the workshop were:

1. To increase understanding of the potential impact of exploring for and mining these resources;

[1] ISBA/10/C/WP.1

2. To determine what was required for baseline studies;

3. To ascertain the relevance of current or past research programmes;

4. To design a monitoring programme to be carried out during exploration for, and mining of these resources;

5. To determine any potential collaborations in applicable research in order to reduce costs for potential contractors, and

6. To propose guidelines to be submitted to the Legal and Technical Commission to facilitate its work in establishing environmental baselines at potential sulphides and cobalt-rich crusts mines, and for subsequent environmental monitoring.

One of the working groups (chaired by Dr. Andreas Thurnherr) considered chemical and physical baseline requirements at deposits of both resources; the second (chaired by Professor Cindy-Lee Van Dover) considered the biological baseline requirements at polymetallic sulphides deposits; and the final group (chaired by Dr. Anthony Koslow) considered the biological baseline requirements at cobalt-rich ferromanganese crusts deposits. The schedule was such that the working groups were to discuss their recommendations at the workshop, but the impending hurricane made this impossible.

On the first day of the workshop, following welcoming remarks by the Secretary-General, participants saw a movie entitled *"Volcanoes of the Deep Sea"* by Professor Peter Rona of the Institute of Marine and Coastal Sciences of Rutgers University that illustrated the environment of deposition of polymetallic sulphides deposits. After that, the Chairman of the Legal and Technical Commission, Mr. Albert Hoffman, made a presentation on the environmental provisions contained in the draft regulations. Subsequently, two presentations that highlighted the technologies that might be involved when commercial activities (exploration and mining) occurred at polymetallic sulphides and cobalt-rich ferromanganese crusts deposits were made by Professor Steven Scott of the University of Toronto and Dr Rahul Sharma of the Indian National Institute of Oceanography. These presentations were essential to ensure that all participants understood the impact of the potential technologies for exploration and mining on the physical, chemical and biological components of the in situ environments that characterize these resources.

In his presentation utilizing an IMAX film entitled *"Volcanoes of the Deep Sea"*, Professor Peter Rona informed workshop participants that the movie clearly illuminated, for the first time, the environmental setting for deep-sea polymetallic sulphides deposits and their associated ecosystems. He also informed participants that the Executive Producer had been James Cameron, the Producer of the blockbuster film, "Titanic", and that Stephen Lowe, the award-

winning IMAX Director, had directed the film. Subsequently, Professor Rona highlighted some points from the film that he thought were relevant to the workshop

Professor Rona said that, in the film, it was possible to see a sealing of a lava flow, with the flow destroying the vent ecosystem, which was composed primarily of giant tubeworms and other fauna. He stated that one of the important questions was how long it would take to re-establish the community following lava flows and how often the lava flows occurred. With regard to lava flows, Professor Rona noted that eruptions on fast-spreading ridges in the Pacific were quite frequent, and that they could occur on a timescale of up to tens of years. He suggested that some people might use the re-establishment of communities as evidence that it was possible to disregard the effects of destroying the ecosystem by marine mining because the system was resilient and biodiversity would recolonize the area. However, Professor Rona stated that this was not true, because when lava flow destroys an ecosystem, all the seeds of rejuvenation (the heat and organisms) are still present. He emphasized that this situation differed from destroying a system by tearing the bottom out with mining equipment.

Professor Rona concluded his presentation by pointing out that, if scientists learnt how to explore for larger deposits, they would probably find ancient deposits on the seabed away from the ecosystems found at active ridge crests. He noted that current knowledge indicates the discovery of many more deposits in the future. Considering this, he suggested that the environmental guidelines should remain flexible to incorporate research emanating from such discoveries.

Mr. Hoffman, the Chairman of the Legal and Technical Commission of the Authority made a presentation on "The Authority's draft Regulations for prospecting and exploration for polymetallic sulphides and cobalt-rich ferromanganese crusts in the Area". He observed that his task was to present the draft Regulations emphasizing those provisions of the draft regulations relating to the protection and preservation of the marine environment, including the data and information requirements that were relevant to the objectives of the workshop.

Mr. Hoffman said that, at the tenth session of the International Seabed Authority held in 2004, the Legal and Technical Commission completed new draft Regulations for Prospecting and Exploration for Polymetallic Sulphides and Cobalt-rich Ferromanganese Crusts in the international seabed area ("the Area"). The Legal and Technical Commission submitted the draft Regulations to the Council at that session. Mr. Hoffman said that the Council decided to continue examination of the draft Regulations at the eleventh session in 2005, to allow Council members time to study the document and consult with their respective Governments. He said that the draft Regulations were the product of more than two years of deliberations within the Legal and Technical Commission. He noted that these new regulations followed on the earlier elaboration of Regulations for Prospecting and Exploration for Polymetallic Nodules in the Area by the Legal and Technical Commission. He informed participants that the Assembly eventually adopted those regulations, in July of 2000. With regard to these new regulations, Mr Hoffman said that

the Legal and Technical Commission had completed its deliberations on them on the general understanding that, as far as practicable, the new regulations should follow the framework of the regulations for polymetallic nodules. More importantly, he said that the Commission agreed that the regulations should be in conformity with the provisions of the Convention and the Agreement related to part XI.

Nevertheless, according to Mr. Hoffman, significant adjustments had to be made, in order to reflect not only the differences in the nature and distribution of nodule deposits from those of crusts and sulphides deposits, but also the fact that each of the latter deposits differed from the other. He also noted that different political and economic considerations applied.

Mr. Hoffman observed that the most significant differences in the new regime related to the definition of blocks, the sizes of areas for exploration, and subsequent relinquishment. He also proposed that, because of the different distribution of these resources on the seafloor, in addition to the site banking system, the contractor could elect to participate in an equity interest, joint venture, or production-sharing arrangement with the Authority. Based on these discussions, Mr Hoffman said that the Legal and Technical Commission felt that despite differences in geometry and dimensions of the two types of deposits, the size of the exploration areas made available to contractors would be the same for both types of deposits.

Most of Mr. Hoffman's presentation was dedicated to outlining the various sections of the draft regulations, with particular reference to those which were relevant to the environment, and hence, the workshop. Mr. Hoffman felt that it was noteworthy that, of the 43 regulations, nine concerned the protection and preservation of the marine environment from activities in the Area.

In his presentation on "Proposed exploration and mining technologies for sulphides", Professor Steven Scott, Professor and Chairman of the Department of Geology of the University of Toronto in Canada noted that, while the technology required for exploration for hydrothermal deposits was non-intrusive, evaluating these deposits for the mineral resources and mineral reserves that they contained would be a challenging process. In this regard, he said that evaluating sulphides deposits required a carefully arrayed series of samples obtained by drilling holes into the deposits. He said that even though the exploitation of sulphides resources in the Area remained unproven, two companies (Nautilus Minerals and Neptune Resources) had begun to explore for sulphides reserves in the territorial waters and exclusive economic zones (EEZs) of Papua New Guinea and New Zealand. He stated that set-up costs for a marine mineral operation are higher than for a land-based operation. He suggested, however, that operational costs may be lower and that, although the technology for mining polymetallic sulphides was not currently available, it was expected that the methods used would be adaptations of those already used for offshore diamond mining and those proposed for polymetallic nodule mining. He informed participants that it is not cost-effective to mine the deposits by extracting the metals from

hydrothermal fluids (active vents). He noted that it is better to let nature accumulate the minerals from the fluids and recover the minerals from the deposits formed from the fluids.

Professor Scott reminded the participants that even geologists used the term "ore" loosely. Professor Scott defined "ore" as naturally occurring material from which one or more metals of economic value could be extracted at a reasonable profit. Professor Scott said that while it was possible to have something that looked like a rich deposit, when all of the costs associated with its recovery were considered (exploration, mining, enironmental protection, processing, shipping, sales and dividends for investors), the material may not be profitable enough to make its recovery viable. Therefore, it was questionable whether some of the known deposits were indeed ores.

According to Professor Scott, the advantages of ocean mining include movable mining platforms, lower shipping costs and less pollution when compared with land-based mining. Professor Scott noted that the biggest problems created for the environment by land-based mining were acid drainage (rainfall on iron sulphides makes sulphuric acid) and the fact that the product of mining was not aesthetically pleasing. He pointed out that none of these problems would occur from ocean mining. He did note, however, that there were other problems, as ocean mining would degrade the seabed. In this regard, he said that there would be degradation of bottom waters, because of the release of toxic elements. He also said that it appeared there would also be a loss of habitat, as the animals associated with the deposits would be in a toxic environment. Nevertheless, the animals around active vents had been thriving in that environment, so Professor Scott did not see where toxic elements produced by mining would have a big effect on the animal community. According to Professor Scott, mining would not occur in hydrothermally active areas; because it would destroy the equipment. He therefore said that inactive deposits that would be the targets for mining. He noted however, that mining would have an impact on the organisms associated with inactive deposits.

In his presentation on "Proposed exploration and mining technologies for cobalt-rich crusts," Dr. Rahul Sharma, a scientist at India's National Institute of Oceanography in Dona Paula, Goa said that exploration for crusts deposits was similar to sulphides exploration, with the exception that cobalt-rich crusts tended to occur on the sides of seamounts. He said that the slopes of seamounts often had an incline of greater than 15%, which had implications for mining technology. He noted that suspended sediments produced as part of the commercial recovery of crusts were expected to have the same effect as those produced by polymetallic nodule mining but added that the areas where crusts and sulphides were found were often associated with lower than normal amounts of sediment cover. Therefore, he said that the effect of sediments on the environment in these areas might be of less concern than that produced from polymetallic nodule mining.

Dr. Sharma stated that, in his opinion, the Hawaiian Marine Mining plan was the most detailed study on a possible mining scenario for cobalt-rich crusts.[2] He noted that the report contained chapters covering all activities including prospecting, exploration, mining and processing. He further noted that the report estimated that the Hawaiian Archipelago and Johnston Island had a mean coverage of crusts on seamounts of 40%, creating a deposit of about 350 million tons with varying compositions and quantities of different metals.

According to Dr. Sharma, there are many unanswered questions, including the choice of a mining system. As such, Dr. Sharma said it was not possible to determine the impacts of mining on the environment in the absence of knowledge of the processes that would be involved. Dr Sharma informed participants that various groups had conducted a number of experiments to assess the impact of crusts mining on the environment. He noted, however, that these experiments were at scales significantly less than commercial mining scale. He concluded that experiments to monitor the impact of mining cobalt-rich ferromanganese crusts on the environment should simulate the activity at the scale at which mining would occur. In this connexion, he further noted that it would not be possible to extrapolate all the "what ifs", until the scale of the experiment is relevant to the environmental disturbance created.

A full day was devoted to polymetallic sulphides deposits. Presentations made included the physical and biological environments of these deposits, along with presentations by the Census of Marine Life and InterRidge, two international bodies promoting cooperation in marine scientific research related to hydrothermal systems that are often associated with polymetallic sulphides.

In his presentation on "An Introduction to hydrothermal vents and associated polymetallic sulphides deposits in the area with a special emphasis on the chemical environment", Professor Peter Herzig, Director of IFM-GEOMAR in Kiel, Germany emphasized that the magma chamber not only drove the seafloor spreading process, but that it also drove seawater hydrothermal convection systems. Professor Herzig said that the magma chamber is a large circulation system responsible for the formation of massive sulphides deposits and hydrothermal systems, at and beneath the seafloor. He said that a lot of sulphur in massive sulphides is from hydrothermal fluids leaching it from the surrounding rocks. Sulphur and other metals would be transported in solution up to the seafloor, together with hydrogen sulphide. There, these materials would form iron sulphides, copper sulphides, zinc sulphides and lead sulphides in response to the mixing of this high temperature hydrothermal fluid with ambient seawater. The product was sulphides mineralization below the seafloor. Professor Herzig described the process as stockwork remineralization, and said that mixing also created massive sulphides at the seafloor.

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[2] Hawaii. Department of Planning and Economic Development. Business and Industrial Development Division. Ocean Resources Branch. *Mining Development scenario for cobalt-rich manganese crusts in the exclusive economic zones of the Hawaiian archipelago and Johnston Island*. Honolulu: 1987.

Professor Herzig stated that the mineralogical composition of seafloor massive sulphides deposits was relatively simple, with base metals occurring as sulphides of zinc, copper, lead and iron. In some areas, Professor Herzig said that exotic elements and minerals, such as native mercury and gold are associated with the sulphides deposits. He pointed out that from a commercial perspective, the revenue to support the operation would come from the base metals; the gold would be a valuable by-product. Professor Herzig noted that recently discovered deposits in the Southwest and West Pacific Ocean were extremely interesting with regard to their metal content. He said that in both Oceans, these deposits contain relatively high amounts of lead and zinc sulphides and, in places, a relatively high amount of gold. He further noted that these deposits were most similar to the massive sulphides currently mined on land.

Professor Herzig informed participants that, of the known deposits, only two, a large seamount on the East Pacific Rise and the TAG deposits, were located in the Area. However, there was significant potential for further discoveries, particularly in the Area, highlighting a clear role for the International Seabed Authority to play. Professor Herzig said that there are large areas of oceanic ridges that have not been scientifically examined thus far, in particular, in the Southeast Pacific Rise, the South Atlantic and in the Indian Ocean outside the 200-nautical-mile zone, which would be under the jurisdiction of the Authority.

In his presentation on "The physical environment of polymetallic sulphides deposits, the potential impact of exploration and mining on this environment, and data required to establish environmental baselines in exploration areas", Dr. Andreas Thurnherr, Doherty Associate Research Scientist at Columbia University, informed participants that the physical environment in the vicinity of polymetallic sulphides deposits was the typical deep ocean environment. He described the environment as dark, cold and characterized by high pressure. Dr. Thurnherr said that in this environment, the instantaneous velocity of water was generally in the order of a few centimetres per second with mean flow velocities a few millimetres per second over weeks and months. He stated that no effects on the the physical environment of sulphides deposits were expected by mining operations beyond the scales of mining. He noted that the exception would be with blasting techniques. He further noted that in this case, the scales would depend entirely on the amount and size of explosives.

Dr. Thurnherr noted that there were other possible indirect large-scale effects if density anomalies were introduced into the water column. For example, if large amounts of fresh water were pumped down to the seabed, some type of connected plumes would be formed and these would have the potential to drive large-scale circulations. Dr. Thurnherr felt that it was very important to consider larger scales than the physical scales of mining, because anything released into the water column during mining or during transport to the surface would be dispersed in the ocean by physical processes that would be larger than the scales of mining.

Dr. Thurnherr was of the view that the physical environment could be expected to have more impact on mining than vice versa, as complex physical processes associated with the

deposits would affect how far any effects of the activity would spread. With regard to determining the effect of currents on the area of impact, Dr. Thurnherr said that a combination of current meter moorings and tracer dye experiments would be needed to fully assess dispersal, as one type of measurement could be misleading without the other.

In her presentation on "The biological environment of polymetallic sulphides deposits, the potential impact of exploration and mining on this environment, and data required to establish environmental baselines in exploration areas", Professor Cindy-Lee Van Dover of the Biology Department, College of William & Mary in Virginia explained that there were two types of polymetallic sulphides deposits - active and inactive. She said that their biological environments were different. Professor Van Dover pointed out that the major biological difference between the two deposits was that communities at inactive sites were relatively unknown and, as such, predicting any impacts of exploration and mining on them would be difficult.

Professor Van Dover noted that, when considering the impact of mining on the environment, it was necessary to identify the seafloor area where activities would cause impacts and to determine the response of animals to plume fallout. In this regard, she also noted that it was necessary to know the distribution of the habitat, the species composition, community structure and basic biology of the species. She said that it would be necessary to know something about the heavy metals that could affect the animals. Professor Van Dover informed participants that it was not necessary to know the full range of all organisms of a species, but stated that it was necessary to know whether any species were endemic to a region. Professor Van Dover said information on community structure was necessary, as was as the age of the sulphides deposit, because fossils in the deposits would give an insight into the history of some of the vents. In this regard, she said that although scientists could follow active vent fields for 10 to 15 years, the 100,000 to 200,000-year fossil record in the sulphides deposits might be lost during mining. She suggested that there might be a way of studying the fossil record during mining or protecting deposits that were rich in fossils that might require protection. She also suggested modelling as a means to determine the effects of scaling as exploitation increased.

Professor Van Dover stated that in addition to the sulphides deposits themselves, impact assessment studies should also include surrounding areas that might be affected by the fallout resulting from the physical regime around the deposits. She recommended that preservation zones be established, since the organisms at hydrothermal sites may have biotechnological importance.

In his presentation on 'The work of InterRidge and its potential relevance to the establishment of environmental baselines, including the voluntary code of conduct for scientific research at hydrothermal vents, and potential collaborations with the Authority", Professor Colin Devey, Chairman of InterRidge introduced the organization as an international and interdisciplinary group. He said that InterRidge is concerned with all aspects of mid-ocean

ridges, where polymetallic sulphides deposits are to be found. Professor Devey said that InterRidge comprised 27 member countries. He also said that financing for the activities of InterRidge is through contributions from its member countries. Professor Devey informed participants that InterRidge has a little less than 2,800 researchers from the 27 member countries; adding that not all of the researchers were Western Europeans or North Americans. He said that InterRidge is actively trying to involve countries that might not have the resources to do expensive research but that probably needed to do it. Professor Devey said that this was especially true in the context of the discussions at the workshop. In this regard, he noted that for example, while the back-arc basins in the West Pacific Ocean are areas that people were interested in exploiting, many of the countries close to them did not have the resources to do so.

Professor Devey said that in order to get many people working together, there needed to be community building. He said that InterRidge supported this process through a newsletter it published and which it made available to all interested parties. Professor Devey said that the newsletter contains information about the work of InterRidge, and that it is not a scientific publication.

Professor Devey informed participants that InterRidge is also involved with science policy and representation. He stated that InterRidge tries to be a mouthpiece for all researchers, adding that this was quite an important role. With regard to some of the other activities of InterRidge, Professor Devey said that in 2000, InterRidge convened a workshop on the management and conservation of hydrothermal vent ecosystems in Canada. He noted that the biological working group of InterRidge was responsible for this workshop as well as the "Code of Conduct for the conduct of scientific research on Marine Hydrothermal Vent Sites".

Dr. Lúcia de Siqueira Campos of the Institute of Biology, Department of Zoology, of the Federal University of Rio de Janeiro, Brazil informed the workshop that the Biogeography of Chemosynthetic Ecosystems (ChEss) project was part of the Census of Marine Life (CoML) programme. By way of introduction, she said that CoML was a "growing global network of researchers in more than 70 nations engaged in a ten-year initiative to assess and explain the diversity, distribution and abundance of marine life in the oceans".

According to Dr. Campos, the main objectives of CoML are to document diversity, distribution and abundance of marine organisms. She said that experts in different fields from over 70 nations around the globe assisted CoML in meeting its objectives. Dr. Campos said that CoMl had identified several key questions to meet its objectives, and is conducting research to address them over the next 10 years.

Dr. Campos said that the ChEss project is concerned with determining the biogeography of chemosynthetic communities found in various ocean areas, including at hydrothermal vent sites. She informed participants that chemosynthetic communities are often associated with polymetallic sulphides deposits. Dr Campos also told participants that ChEss is

creating a database of chemosynthetic communities, including species found at each site, which would facilitate the determination of species ranges of organisms associated with polymetallic sulphides deposits. She pointed out that this information would be vital when establishing impact and preservation zones, as well as during monitoring programmes. Dr. Campos stated that ChEss is a very useful advisory body.

The following day was devoted to cobalt-rich feromanganese crusts deposits. Presentations were given on the chemical, physical and biological environments, along with a presentation by the relevant group from the Census of Marine Life.

The first presentation on the environment of deposition of cobalt-rich ferromanganese crusts deposits was on "The physical environment of cobalt-rich ferromanganese crust deposits, the potential impact of exploration and mining on this environment, and data required to establish environmental baselines". During his presentation, Professor Aike Beckmann of the Division of Geophysics, University of Helsinki in Finland noted that the physical conditions around seamounts vary, depending on the geometry and topography of the seamount and the ambient physical regime of the area. Through the use of a series of models, Professor Beckmann indicated how different conditions could produce very different current patterns. He said that the ingredients for physical environments at seamounts were the same, but that the relative contribution of each of these depended on many parameters related to the seamount, such as its geometry, the smoothness of topographic features and other parameters, such as the direction of the incident flow relative to a non-symmetric seamount. However, Professor Beckmann pointed out that general physical factors were the same at most seamounts and that seamounts were often associated with low levels of sedimentation, strong upward and downward mixing along the slope, and boundary currents which may prevent impacts on the seamount spreading to other seamounts. He said that the negative effect of these physical factors was that any sedimentation and pollution would not be diluted and would increase the localized impact. He noted that surrounding seamounts should not be affected.

Professor Beckmann noted that more knowledge of seamount geometry and a good way of describing the shape, height and steepness of the slopes of seamounts is required. In this regard, he pointed out that while it is easy to describe the geographical latitude of the seamount, information on the stratification of the water column and ambient ocean currents is required. Professor Beckmann informed participants about numerical methods, which had been available for ten years that are useful to determine, from selected short-term simulations, what the typical physical environment would be at a given seamount. In addition, he said that the numerical model is useful to determine the consequences of flow fields, such as where transport occurred, and to determine whether particles would be retained in the near field, and the amount of vertical upwelling. Professor Beckmann said that this information would provide a good basis for establishing baselines for the physical environment around seamounts.

In his presentation on "The chemical environment of cobalt-rich ferromanganese crust deposits, the potential impact of exploration and mining on this environment, and data required to establish environmental baselines in the exploration areas", Professor Huaiyang Zhou of the Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, People's Republic of China focussed on the chemical composition of crusts and the methods used for crusts exploration. Professor Zhou said that the methods used to explore for crusts were similar to those used for sulphides. He pointed out that the major impacts from crusts exploitation would be sediment plumes, and the accumulation of crusts fragments and debris at the base of the seamounts and in the surrounding abyssal plains. He also noted that mining may result in increased dissolved nutrients in the water column, which could have a positive impact if it occurred in areas where low concentrations of trace metals limited primary productivity.

In his presentation on "The biological environment of cobalt-rich ferromanganese crust deposits, the potential impact of exploration and mining on this environment, and data required to establish environmental baselines", Dr. Anthony Koslow, Senior Principal Research Scientist at CSIRO Marine Research, Wembley, Western Australia pointed out the limitations of available studies. He explained that, while there had been some work done to investigate the biological environment of seamounts, there had been no faunal studies undertaken on crust communities. He therefore stressed the need for such investigations. Dr. Koslow said that, as a result of this deficiency, a major assumption was that communities found on crusts were the same as those found on seamounts. He pointed out that, due to enhanced currents associated with seamounts and their topographic isolation, endemism is very high, with the result that the species found on a region of a single seamount may be limited to that region.

Dr. Koslow showed a map highlighting about 250 sites of sampled seamounts. He compared the 250 sites with the thousands of seamounts known in the oceans, particularly in the Pacific Ocean, and concluded that a great deal of further sampling is necessary. With regard to the sampled seamounts, Dr. Koslow said that the map was misleading, in that adequate sampling has not occurred since more often than not, the concerned investigator had only been interested in one item, such as fish. With regard to the most likely geographic area of interest for cobalt-rich crusts in the Equatorial Pacific, Dr. Koslow said that it was for this reason that there are no biological data.

Dr. Koslow stated that, in some studies, no species were found in common between seamount chains and there was a much higher level of endemism than had been previously thought. This had led scientists to refer to seamounts as "The Galapagos of the Deep".

Dr. Koslow discussed the potential impact of crusts mining on the environment. He said that mining crusts would result in stripping large areas of a seamount, and the loss of epifauna. He also noted the potential impact of enhanced sedimentation or the release of metals, which could have an effect on the benthic fauna of regions adjacent to the seamount, and on water column processes, such as primary productivity. Dr. Koslow thought that this was a key

issue because if the crusts turned out to have relatively poor fauna, if there were richer fauna above the crusts, mining could have an impact on them.

Dr. Koslow believed that the key questions were the risk of extinction of endemic seamount species and the timescale for recovery, both for mined portions of seamounts and adjacent areas.

Dr. Koslow said that it was unclear what the potential impacts on the water column might be. There were a number of potential pluses and minuses. There could be enhanced micronutrients, such as iron, which could enhance primary productivity. On the negative side, Dr. Koslow said that bringing up a lot of material and releasing it in the upper water column could decrease the light available for primary productivity and interfere with grazers. In addition, he said that there would be a mix of trace metals released in the water. He noted that some of trace metals might enhance primary productivity; others might poison it.

Dr. Malcolm Clark, Principal Scientist, Deepwater Fisheries, National Institute of Water & Atmospheric Research in Wellington, New Zealand, made a presentation on a proposed CoML programme on seamounts, called CenSeam. Dr. Clark noted that, while the oceanographic definition of seamounts was quite specific with smaller protrusions from the seafloor called "knolls" or "pinnacles", more recently, "seamounts" is the term given to all three types of features. He said that for environmental coniderations the definition used has to be clear. On the basis of the traditional definition, Dr. Clark said that there were approximately 50,000 seamounts in the world's oceans. If the more general term was used, he said, the number rose to the millions. Dr. Clark said that the general term was also more appropriate when referring to crusts, as they were not restricted by the size of the "seamount". He pointed out that the CenSeam programme had closely followed the questions that had been posed during the workshop and that they would be addressed by the programme.

Dr. Clark said that other aspects of the CenSeam programme were to increase collaboration with other organizations, and to produce databases. He also said that the programme was a potential link between scientific research, the needs of the Authority in determining baseline information, and the strong international component and global overview offered by CenSeam.

In addition to the presentations outlined above, scientists from concerned countries made additional presentations on other programmes of relevance to the establishment of baselines, to the development of appropriate databases and to an increased understanding of the natural variability of polymetallic sulphides and cobalt-rich crusts ecosystems.

Professor Elva Escobar-Briones, Professor and Head, of the Biological Oceanography, Biodiversity and Deep-Sea Department of the Autonomous University of Mexico presented relevant work by the University on polymetallic nodules, polymetallic sulphides and cobalt-rich

crusts in the Mexican exclusive economic zone. Other topics of relevance were also discussed, including the establishment of priority marine areas in Mexican waters and national marine conservation strategies. At the request of some participants, Dr. Escobar provided information on known marine mineral resources in the Gulf of Mexico.

Professor Escobar-Briones informed participants that Mexican scientists had documented transects along the abyssal plain and into venting sites in collaboration with IFREMER. Specimens of communities occupying the inactive structures had been collected and the research revealed that bacteria colonized some of the residual minerals and components of the inactive venting structures. Another result of the research is that invertebrates, such as shrimp, feed on the bacteria.

According to Professor Escobar-Briones, implementation of Mexico's national conservation strategies is by a Mexican conservation agency called CONABIO. Dr Escobar said that with the support of a foundation, Mexican authorities have designated a priority mining area within Mexico's marine jurisdiction. She said that the implementation of conservation strategies for hydrothermal vents, polymetallic nodule bearing areas and seeps is by different agencies of the Mexican Government. She said that the purpose of the conservation agency is to preserve biological diversity in different environments including terrestrial and aquatic habitats.

Dr. Baban Ingole, a Scientist in the Biological Division of the National Institute of Oceanography in Dona Paula in India stated that, Indian scientists had mapped seamounts, which had the potential for cobalt-rich crusts deposits, and the mid-ocean ridge system, which had potential for hydrothermal sulphides in the Indian Ocean. He said that for the past 20 years, there had been studies of areas in the abyssal basin, but that research on the ridges was relatively recent and with sampling of the seamounts in the planning stages.

Dr. Tomohiko Fukushima, a researcher at the Ship and Ocean Foundation in Tokyo, Japan stated that Japan had been conducting a survey of deep-sea mineral resources in its exclusive economic zone as a part of the Japanese International Technical Cooperation Project. The survey, initiated in 1985, is ongoing. It had produced various results related to polymetallic nodules, cobalt-rich crusts and polymetallic sulphides. He noted the use of deep-sea cameras by Japanese scientists during prospecting for marine mineral resources. He further noted that the still photographs and video recordings could be used for other purposes, such as megabenthos observation.

Dr. Fukushima presented participants with the differences observed in megafaunal communities at polymetallic nodule deposits, polymetallic sulphides deposits and cobalt-rich crusts deposits. He pointed out the need for intercallibration between researchers and contractors.

Dr. Fukushima stated that Japanese work in polymetallic nodules took place between 1975 and 1999, and said that environmental research took place from 1990 to 1997. He said that research on cobalt-rich ferromanganese crusts is underway and noted that while prospecting for polymetallic sulphides commenced in 1985, the associated environmental research is yet to start.

After all the presentations had been made, the participants divided themselves into three working groups to consider the main aim of the workshop, which was to prepare suggestions for the Legal and Technical Commission regarding the information that should be acquired by contractors for cobalt-rich ferromanganese crusts and polymetallic sulphides exploration to establish environmental baselines for a monitoring programme. Following a few hours of discussion within the working groups, all the participants met again in plenary, so that each working group could present the results of its deliberations and obtain feedback from the other working groups. Since some participants had already departed, owing to the threat of the impending hurricane, no one met on the fifth day of the workshop. In this regard, a decision was taken that the working groups should carry out the remainder of their work via email and presents their final recommendations to the Legal and Technical Commission through the Secretariat.

When the reports of the three working groups were completed, the Authority convened a meeting with the three working group chairpersons and David Heydon, the Chief Executive Officer of Nautilus Minerals, who had been unable to attend the workshop. At that meeting, working group leaders compared the reports of their respective groups and, based on these, a single document, entitled "Recommendations of the workshop on polymetallic sulphides and cobalt crusts: their environment and considerations for the establishment of environmental baselines and an associated monitoring programme for exploration" was produced and presented to the Legal and Technical Commission for its consideration in August 2005, as document ISBA/11/LTC/2.