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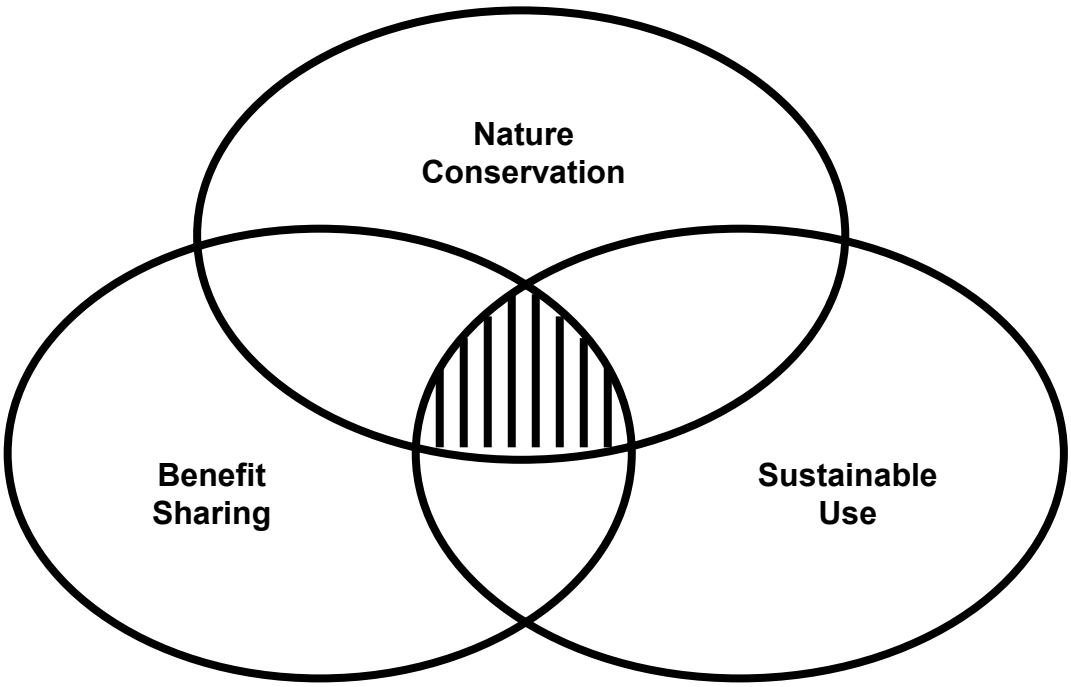

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List of acronyms

CBD	Convention on Biological Diversity
CHH	Common Heritage of Humankind
COP	Conference of the Parties
CRAMRA	Convention on the Regulation of Antarctic Mineral Resource Activities
CSD	Commission on Sustainable Development
DNA	Desoxyribonuclein Acid
DOMES	Deep Ocean Mining Environmental Study
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EPR	East Pacific Rise
FAO	Food and Agriculture Organization
GMO	Genetically Modified Organisms
IMO	International Maritime Organization
IOC	International Oceanic Commission
IPR	Intellectual Property Rights
IRA	Impact Reference Area
ISA	International Seabed Authority
IUCN	International Union for Conservation of Nature and Natural Resources
MAR	Mid-Atlantic Ridge
MPA	Marine Protected Area
NeMo	New Millennium Observatory
NEPTUNE	Northeast Pacific Time-integrated Undersea Networked Experiments
NM	Nautical Mile
NOAA	National Oceanic & Atmospheric Administration
OSPAR	Convention for the Protection of the Marine Environment of the North-East-Atlantic
PCR	Polymerase Chain Reaction
PMS	Polymetallic Sulfide Deposit
PRA	Preservational Reference Area
PSSA	Particularly Sensitive Sea Area
RNA	Ribonuclein Acid
SBSTTA	Subsidiary Body on Scientific, Technical and Technological Advice
SPA	Science Priority Area
Taq	Thermos aquaticus
TRIPS	Agreement on Trade-Related Aspects of Intellectual Property Rights
UNCED	United Nations Conference on Environment and Development

UNCLOS	United Nations Convention on the Law of the Sea
UNDOALOS	United Nations Division for Ocean Affairs and the Law of the Sea
UNEP	United Nations Environmental Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNICPOLOS	United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea
USPA	Unique Science Priority Area

Introduction

It is only in the last few decades that the importance of the enormous area of open ocean beyond the 200 mile limit has been recognised, not only due to its role in the regulation of global climate but also because of its natural resources. In the deep-sea an even greater amount of species may be found than in all the other environments of the Earth together.[1] The unsuspected high diversity of the deep-sea floor[2] defeated the theory of a desert-like environment. This was supported by the overwhelming wealth of different habitats like seamounts, deep-sea trenches, reef-forming corals, submarine canyons, cold seeps and pockmarks. Especially the discovery of deep-sea hydrothermal vents and their unique biological communities was one of the most important findings in biological science in the latter half of the 20th century. This text therefore will focus on these deep-sea habitats. But some suggestions may be valuable for other habitats as well.

Unusual symbioses between invertebrates and chemolithautotrophic bacteria are producing concentrations of biomass at hydrothermal vent sites that is similar to the most productive ecosystems on Earth. The existence of chemoautotrophic and hyperthermophilic microbes in the hydrothermal waters has promoted new theories of the origin of life on Earth.[3] The unbelievable high number of over 500 new animal species and the high endemism rate at vents[4] has provided a great impetus to marine conservation measures on the high seas. Biodiversity as a term which can be used on all levels of biological organisation, ranging from a measure of the genetic variability of one population to the diversity of major ecosystem-types . In recent years long-term and large-scale researches of the deep-sea environment has begun and the commercial sector is now able to operate in water depths of at least 2,000 m.[5] So far exploitation is concentrated in areas within national jurisdiction.

The deep-sea environment with its ecological processes remains poorly studied and understood. There are no complete catalogues of the species or habitats in these environments, not even at regional scale. A fact which does not facilitate efforts to ensure a sustainable use management or the establishment of marine protected areas.

Hydrothermal vent science is now in its third decade and shifting to time series observations and long-term studies. Concentrations of sampling, bioprospecting and observation at some vent sites show already effects on vent faunal communities. Thus, it is important to co-ordinate research to help resolving and avoiding conflicts between different types of investigation. Vent scientists are concerned about species conservation and environmental stewardship and are proposing some protection measures.

The multiple-use interests of the industry and the scientific community on the undersea oases present a challenge to design a comprehensive conservation and management regime. While science and technology evolve very quick, legal and policy regimes tend to lag behind. This gap is particularly evident in the deep ocean. Although there is the understanding that international legal paradigms like the common heritage principle are evolving, the precautionary approach is emerging. The Earth's rapidly shrinking pool of

1 GAGE, J.D. & R. M. MAY (1993): A dip into the deep seas, Nature 365. 609-610.
2 HESSLER,R.R. & H. L. SANDERS (1967): Faunal diversity in the deep sea. Deep-Sea research I, 14, 65-78.
3 InterRidge, p. 2.
4 TUNNICLIFFE, V.; MCARTHUR,A.G. & D. MCHUGH (1998): A biogeographical perspective of the deep-sea hydrothermal vent fauna, Adv Mar. Biol., 34: 353-442.
5 CROOK, J. (2000): Roncador – the World's deepest field. Petroleum Review 54: 14-16; MERRETT, N.R. & R.L. HAEDRICH, (1997): *Deep-sea demersal fish and fisheries.* London, Chapman & Hall.

biological diversity has to be conserved and to be used sustainable before irreversible lesses occur. The existing international legal regime is still inadequate to meet the urgent needed conservation and management measures for the deep-sea vent fields in the next decades.

This text seeks to summarise the legal proposals with respect to access to and use of deep-sea hydrothermal vent sites and resources. In addition, conservation and management measures adapted to the multiple-use conflicts are presented. Therefore, part 1 describes briefly the nature of vents and their biological communities. Part 2 continues with the existing and expected uses and threats to these habitats. The existing legal regime with regard to hydrothermal vents on the outer shelf or deep seabed is described in part 3 while part 4 focuses on the legal issues in the context of the classification of vents and their living and genetic resources as well as on the legal status of vent research activities under the United Nations Convention on the Law of the Sea and the Convention on Biological Diversity. Part 5 provides possible management and protection measures for seabed vents.

PART 1
Characteristics of the deep-sea-vents

The oceans cover seventy percent of the Earth's surface with its greatest part below 300 m. Light penetration is insufficient to support sunlight-driven photosynthesis. Hydrostatic pressure increases with increasing depths, one atmosphere for every 10 m of depth. The temperature is decreasing, below 1000 m under 5°C. Furthermore, the deep sea is a food-limited environment with an organic content of about 0.5 % in the sediment beneath productive water. Oxygen concentration is near saturation.[6]

In 1977, scientists discovered the first deep-sea hydrothermal vents two hundred miles northwest of Ecuador's Galapagos Rift. The densely with divergent (to the surrounding fauna populated vents were located along a rift in the East Pacific Rise at a depth of about 2,500 m).[7] In the meantime, many other vent systems have been found in the northeast Pacific (e.g. *Endeavour, Gorda Ridge, Eyplorer Ridge*), the western Pacific (e.g. *Okinawa, Mariana, Manus*), the East Pacific (e.g. *Guaymas Basin Southern East Pacific Rise*) and along the Mid-Atlantic Ridge.[8] Biologists so far have studied vents mainly in the eastern Pacific or the north-central Atlantic because of the expenses and difficult logistics of the expeditions and the countries involved. However, the abundance of vents is unknown and only 10 % of the ridge system has been explored so far. It has been presumed that there may exist about 500 vents worldwide.[9]

1 Geology

The vent systems are mainly located on mountain ranges, so called mid-ocean ridges. As a surficial expression of ocean crust formation, plate separation and global heat loss, they girde the globe along 75,000 km and at an average width of about 2 km.[10] A combination of geologic processes and sedimentation from organic and inorganic sources has shaped the planets basins. These processes can be explained by the theory of plate tectonics having already been formulated by Alfred Wegener in the early twentieth century.[11] The symmetry of magnetic anomalies about ridge axes and the corresponding anomaly caused by magnetic reversals led to the acceptance of the theory in 1963.[12] The theory of plate tectonics includes sea-floor spreading and continental drift. Thereby the earth's relatively cool outer layer floats on the planet's hot inner core. Combined with volcanism[13] these activities permanently reshape the seafloor.

On rifts along the mid-ocean range molten basalt forms the crust that lies under the ocean basis. These spreading centres are located on divergent plate boundaries. Thereby spreading rates can be divided into slow (10-50 mm yr^{-1}), medium (50-90 mm yr^{-1}) and fast variants (> 90 mm yr^{-1}).[14] Nearly 50 % of the active ridges are slow spreading like the Mid-Atlantic Ridge. The only active fast spreading centre at present is the East Pacific Rise. Interestingly, more than 50 % of the ocean crust was formed at fast sprea-

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[6] DOVER,L. VAN: The Ecology of Deep-Sea Hydrothermal Vents, pp. 4-5 (2000, Princeton University Press, New Jersey).

[7] JANNASCH,, H.W.: Neuartige Lebensformen an den Thermalquellen der Tiefsee, p. 9 (1994, Opladen: Westdeutscher Verlag).

[8] DOVER, L. van: The Ecology of Deep-Sea Hydrothermal Vents, supra note 6, figure 2.1, p. 26; see also H. W. Jannasch, supra note 7, figure 3, p. 14.

[9] WWF/IUCN/WCPA: The status of natural resources on the high-seas, p. 15 (2001, Gland, Switzerland).

[10] Id., pp. 25-26.

[11] WEGENER, A.L.: The Origin of Continents and Oceans, chapter 2 (1921).

[12] DOVER, L. van: The Ecology of Deep-Sea Hydrothermal Vents, supra note 6, pp. 28-29.

[13] Submarine volcanism totals more than 75 % of the planet's volcanism, see L. van Dover, supra note 6, p. 25.

[14] DOVER, L. van: supra *note 6*, p. 29.

ding rates. With the spreading rate (and thus with the underlying magma) not only the morphology of ridge axes varies dramatically but also the forms of segmentation, tectonic fabric of the crust and spacing of hydrothermal vent habitats.[15]

Hydrothermal vents have also been found at convergent plate boundaries where the outer layer subduces under the abutting continental landmass forming submarine trenches.[16] Hot springs on the seafloor are found not only at spreading centres and island-arc systems but occur wherever sufficient heat for hydrothermal convection is available. Therefore they are also found on seamounts, in subduction and fracture zones.[17]

2 Chemistry

Since the spare organic substances derived from photosynthetic processes are not sufficient for the survival of the rich vent fauna there must be another source of energy. High pressure and heat, primarily from magma within the Earth's crust, provide this energy since they drive the hydrothermal circulation responsible for the vents. After penetrating into the seafloor through fissures at spreading centres, the dense seawater is circulating through the oceanic crust along several kilometres. Close to the surface of the ocean crust it is heated when percolating into magma chambers and reacts with the surrounding minerals. When expelled through fissures at the seafloor at so-called hydrothermal vent sites, the heated water is now less dense and enriched in reduced chemical compounds, dissolved gases as hydrogen sulphide, hydrogen and carbon dioxide. Furthermore, the fluids are acidic, have highly variable salinity and seem to contain microbes that live in the sub seabed.[18]

There are two characteristic types of springs at the seafloor. Where the hot water emerges unmixed with the cold seawater it has very high flow rates (1-3 m/sec) and temperatures can reach 400°C. As the mineral-rich water is cooled the metal sulphide precipitate in form of black plumes, building large chimneys. They are therefore called "black smokers". The polymetallic sulphide deposits contain iron, copper and zinc sulphide as well as other minerals like gold and silver (sometimes in high concentrations).[19] If the heated water appears as diffuse flow around the vent field, the fluids are of lower temperatures (around 25°C) and slower flow rates (1-3 m/min) without forming chimneys. These vents have the highest biological activity and most dense animal populations.[20] They were first discovered on the Juan de Fuca Ridge in 1995.[21]

[15] Id., supra note 6, pp. 29, 35-36.
[16] See generally in respect to geological processes: S. E. HUMPHRIS, Hydrothermal Processes at Mid-Ocean Ridges, http://earth.agu.org/revgeiophys/humphr01/humphr01.html (last visited June 2001).
[17] DOVER, L. van: supra note 6, p. 37; WWF/IUCN/WCPA, supra note 9, p. 15.
[18] H. W. JANNASCH, supra note 7, pp. 11-12 and figure 2, p. 11; L. van Dover, supra note 6, chapter 2.5, pp. 47-65; TUNNICLIFFE, V.; MCARTHUR, A.G. & D. MCHUGH, A biogeographical perspective of the deep-sea hydrothermal vent fauna. Advances in Marine Biology 34, pp. 355-442 (1998).
[19] JANNASCH, H.W..:supra note 7, table 1, p. 13.
[20] Id., p. 12.
[21] M. J. MOTTL, G. WHEAT, E. BAKER, N. BECKER, R. DAVIS, A. FEELY, D. GREHAN, M. KADKO, G. LILLEY, C. MASSOTU, C. MOYER, F. SANSONE, Warm springs discovered on 3.5 Ma oceanic crust, eastern flank of the Juan de Fuca Ridge. Geology 26, pp. 51-54 (1998).

While the vent fields can have a size between a few hundred up to a few million square meters, vent fauna and sulphide deposits mainly cover very small areas (about 25%) of the field.[22] Due to the different geological processes the temperature and chemical composition of the vent fluids vary over time within a field and from field to field.[23]

The episodic nature of the underlying hydrologic and geologic processes in combination with continuous settlement of minerals cause the rapid change and final extinction of most seabed vents within a vent field particularly in the Northeast Pacific and along the East Pacific Rise.[24] Above all at the sites of an eruption the effects on surrounding biotic life is dramatic and drives the community dynamics and succession.[25] Thus the individual vent's activity is estimated for a period of time between 10 and 100 years. With the cease of the vent's water discharge (its sulphur-flow) or the disruption of the underlying geologic pattern, the biological community is extinguished or altered, and the mineral deposits oxidize and crumble. Since the rates of sulphide deposition is rapid and the vent organisms are closely associated to those sites, fossilization of vestimentiferan tubeworms or polychaetes is not unusual. But the fossil record does not always perfectly prove the origins of major vent groups.[26]

3 Biology and Ecology

3.1 Chemo synthesis

Above all the sulphide of the vent fluids support the unique vent ecosystem. Specially adapted micro organism relying on chemo synthesis are the primary producers. In contrast to photosynthesis which relies on light energy, chemo synthesis is possible by using chemical energy provided by sulfur from the vent hydrogen sulphide emissions.[27] The microbes have the ability to use the reduced inorganic compounds in the vent fluids for the synthesis of organic matter. Chemo synthesis occurs also under anaerobic conditions with methane as end product.[28] In analogy to hydrothermal vents, cold seep communities rely on chemo syntheticchemo synthetic bacteria as primary producers. But here methane is the primary substance for the chemo synthesis processes.[29]

Scientists are still uncertain about the origin of these chemoautotrophic microbes. They seem to exist in enormous numbers within the Earth's crust.[30]

3.2 Food Web

The special conditions at hydrothermal vents have created a totally different fauna to the surrounding deep-sea benthos. The consumers within the vent community depend exclusively on these primary producers. Thus they have developed several ways to exploit the microbes' production of organic carbon:

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[22] MOTTL, M.J. & W. E. SEYFRIED: *Geologic Setting and Chemistry of Deep.Sea Hydrothrmal Vents*, in: The Microbiology of Deep-Sea Hydrothermal Vents, p. 4 (David M. Karl,ed. 1995).
[23] Id., pp. 9-11.
[24] JANNASCH,, H.W.: *supra note 7,* p. 10.
[25] DOVER, L. VAN: supra note 6, chapter 10; therein the description of eruptions at 9° North and other sites.
[26] Id., p. 324.
[27] ZIERENBERG, R.A.; ADAMS, M.W. & A.J. ARP: *Life in extreme environments: Hydrothermal vents,* p. 12961, PNAS, vol. 97, no. 24, Nov. 2000.
[28] Id., p. 12961; H. W. JANNASCH, *supra note 7*, pp. 15-16; WWF/IUCN/WCPA, *supra note 9*, p. 15; L. VAN DOVER, *supra note 6*, pp. 115-120.
[29] M. J. MOTTL, W. E. SEYFRIED, *supra note 22*, p. 2.
[30] R. A. KERR, *Life Goes to Extremes in the Deep Earth-and Elsewhere*, 276 SCIENCE 703 (1997).

Some live in symbiosis with the microbes and remarkable anatomical, physiological and biochemical adaptation of hosts to support their microbes have been discovered. One example are the endosymbiotic tubeworms of the *Vestimentifera* phylum. Some worms of this phylum like *Riftia* and *Ridgeia* have no eyes, are mouth less, gutless, immobile and reach a length of up to 2 meters. They provide the microbes with shelter and support them with their nutrient acquisition and synthesis while on the other hand, they consume energy and organic compounds produced by the microbes.[31] Exceptional is the capability of vent communities to survive in an environment of heavy metals, radioactive elements and toxins. It is now known that they are able to inhabit sulphide-rich habitats because they developed detoxification mechanisms that involve microbial symbionts. Besides chemo synthetic vestimentiferans also vesicomyid clams are able to detoxificate sulphide, binding it to blood-borne components. This mechanism is well characterized for the tubeworm *Riftia pachyptila*.[32] Vesicomyid clams are supported by abundant microbial symbionts located in their gills. An exception to the model of vent invertebrate biomass supported by endosymbionts are shrimps discovered at vents on the Mid-Atlantic-Ridge. They feed on chemoautotrophic episymbiotic bacteria which are essential for the nutrition of the adult animals.[33] Other marine invertebrates that have no sulphide binding protein seem to rely on sulphide oxidation.[34]

It is important to note that these associations between chemoautotrophic, symbiotic micro organism and their macro invertebrate hosts distinguishes them from shallow-water and terrestrial hydrothermal ecosystems.[35]

One step higher in the food web, zooplankton in the surrounding water of the vent fluids feed on free-living chemo synthetic microbes and are filtered themselves by clams and mussels. Benthic worms, molluscs and other grazing fauna rely on microbes living in mats. All these organisms are preyed on and scavenged by shrimp, crabs, lobster, fish and even octopus.[36]

3.3 Biogeography

Besides the unique adaptation to the extreme environment of the vents, the species diversity , the composition of the communities and their uniqueness in time and space attract special attention. Vent communities represent a mosaic of species coming from a regional pool and reflecting habitat availability and temporal progression through the venting cycle. Thus, some species are common to more than one site, some have so far only been found on one site. Mussels, for example, are the dominant invertebrates near the equator on the Galapagos Spreading Centre. But at the northern end of the East Pacific Rise no mussels were found. Scientists therefore presume that somewhere north of 13°N on the East Pacific Rise there is a major bio geographic “filter” that excludes mussels but not clams and tubeworms.[37] Furthermore, only a half-dozen of the 70 species known from northeast Pacific vents (Explorer, Juan de Fuca and Gorda Ridges) occur at East Pacific Rise vents. But at the same time there are more than 20 shared genera. This raises the question how such a differentiation is possible. Looking back into geological history of the two

[31] L. VAN DOVER, *supra note 6*, pp. 146-149.
[32] H. W. JANNASCH, *supra note 7,* pp. 30-32 and figure 7, p. 31.
[33] L. VAN DOVER, *supra note 6*, p. 151.
[34] R. A. ZIERENBERG, M. W. ADAMS, *supra note 27*, p. 12962.
[35] L. VAN DOVER, *supra note 6*, p. 145.
[36] H. W. JANNASCH, *supra note 7,* p.28; see also figure 5, p. 27.
[37] L. VAN DOVER, *supra note 6*, p. 331.

sites, the split of a vent-faunal assemblage seems to have produced two assemblages millions of years ago subsequently diverging.[38]

While the Galapagos and east Pacific Rise faunas are most similar, the largest difference in faunas is between the ocean basins of the Atlantic and the Pacific.[39] Tubeworms have so far been found only at the Pacific Basin sites while north-central Atlantic Ridge sites are dominated variously by mussels and shrimps. The explanation for the observation could be the fundamental differences between fast- and slow-spreading centres. The Mid-Atlantic Ridge has always been slow spreading with low frequency, long wavelength and broad, deep rift valleys. Thus, there is a potential for pooling and horizontal exchange of a water column in contrast to the low relief environment of the fast-spreading centre of the East Pacific Rise. There, species are quite unlimited by physical barriers and populations are consequently well mixed. The dominance of shrimp species at Mid-Atlantic Ridge vents supports this theory since under slow-spreading conditions taxa with broad distributions are privileged. Shrimp have a nonpassive dispersal as adults and a dissemination during their larval and juvenile development. On the other hand colonization opportunities are quite rare at slow-spreading centres and the regional diversity is lower.[40]

The Arctic Ocean seems to contain the most isolated ridge systems and fauna since this basin did not open until about 65-70 million years ago. [41] Consequently, e.g. the Mohn's Ridge and ridge systems further north in the Arctic host a fauna most distinct from other hydrothermal vent systems.[42]

However, it is not yet clear how new vent sites are colonized by the highly specialized fauna.

Gene flow along the hydrothermal systems could happen through "isolation by distance" when organisms have a limited dispersal and a declining gene flow with increasing distance. The "island" model applies to species with long-distance dispersal.[43] Furthermore, there arises the question whether the sea-floor hydrothermal vents may serve as "interocean faunal highways".[44] In this respect it is important to know more about possible interruptive impacts on those highways, for example, by seabed mining.

3.4 Endemism and species diversity

Hydrothermal vents as isolated islands contain around 90 % endemic species. Since the extreme physico-chemical conditions at vents require a high specialization and adaptation, this high endemism rate at vent sites is no surprise.[45] But this aspect is important concerning possible extinctions of vent communities due to anthropogenic activities.

In contrast to the very high productivity of vents compared with the soft-sediment deep-sea environment, diversity at hydrothermal vents is low. Approximately 450 invertebrate species have been identified to generic level and it became obvious that three phyla dominate the vent fauna (90%): molluscs, annelids and arthropods.[46] Also about 32 octopus and fish species have been found in and around vents. Impor-

[38] Id., pp. 332-333.
[39] Id., figure 11.13, p. 339.
[40] Id., pp. 340-341.
[41] L. VAN DOVER, *Ecology of Mid-Atlantic Ridge hydrotheermal vents*, in: L. M. PARSON, C. L. WALKER AND D. R. DIXON (eds.). Hydrothermal Vents and Processes. Geol. Soc. Spec. Publ. 87: 257-295 (1995).
[42] L. VAN DOVER, *supra note 6,* p 339.
[43] Id., p. 344.
[44] L. VAN DOVER, *Vents at Higher Frequency*, 395 NATURE 437 (1998).
[45] WWF/IUCN/WCPA, *supra note 9*, p. 16; L. van Dover, *supra note 6*, p. 313.
[46] V. TUNNICLIFFE, A. G. MCARTHUR, D. MCHUGH, supra note 18, pp. 355-442.

tantly, over 75% of vent species occur at one site only and no single species has been observed at all sites.[47]

The highest concentrations of life is found in the zone where the hydrothermal vent fluids are mixing with ambient seawater. There environmental conditions are extremely variable with temperatures up to 50°C.[48]

However, not all hydrothermal vent sites have large populations of extraordinary faunal assemblages. "The Lost City" field, for example, at 700 m on the Mid-Atlantic Ridge found in the year 2000 has no obvious mega- and macro fauna. Specialized vent fauna has been discovered so far only at depth greater than 400 m.[49]

3.5 Hyperthermophile Archeae

In respect to the extreme thermal environments of deep-sea vents, considerable attention has been given to hyperthermophilic micro organisms especially for economic reasons. Vent communities may be an important source for biotechnological applications (see part 2). This involves genetic resources including such from hyperthermophile or even superthermophile organisms.

Hyperthermophiles can be defined as micro organisms able to grow at 90°C and above. Until now about 20 different types of such organisms are known.[50] They live within the walls of black smokers, where the hydrothermal vent fluids mix with the surrounding seawater. Classification of hyperthermophiles allows new insights into evolution and the origin of life.[51]

Most marine hyperthermophiles belong according to their genetic distinction (16S ribosomal RNA) to the Archaea. In addition to the bacteria, they belong to the second domain of prokaryotic life but seem to be more closely related to eukarya (the third domain) than to bacteria.[52] Since they are the most slowly evolving archaea within their domain, it has been suggested that life may have first evolved when the earth was much hotter.[53]

Their tolerance to ("of" stimmt) high temperatures raises many questions how life can thrive and about the biochemical characteristics of these organisms. Most microbes and all eukaryotic cells are lost at temperatures much above 50°C. But most enzymes from hyperthermophiles are extremely stable and show optimal catalytic activity above 100°C. Thereby they consist of the same 20 amino acids as enzymes of "conventional" organisms. Furthermore, sequence comparisons of analogous proteins from hyperthermophilic and "conventional" organisms are basically identical.[54] It has therefore been suggested that "very subtle, synergistic and co-operative intramolecular interactions"[55] are the reason for the extended protein stability at 100°C. Until now the protein of hyperthermophiles seems to have unknown solutions to the problem.[56]

[47] Id.
[48] WWF/IUCN/WCPA, *supra note 9*, p. 16.
[49] Id., p. 17.
[50] K. O. STETTER, FEMS Microbiological Rev. 18, 149-158 (1996).
[51] R. A. ZIERENBERG, M. W. ADAMS, *supra note 27*, p. 12961; H. W. Jannasch, *supra note 7*, p. 34.
[52] L. VAN DOVER, supra note 6, p. 122; see also figure 8 in: H. W. Jannasch, supra note7, p. 35.
[53] R. A. ZIERENBERG, M. W. ADAMS, *supra note 27*, p. 12961.
[54] Id., p. 122962; see also www.tigr.org (last visited July 2001).
[55] Id., p. 12962.
[56] Id., p. 12962.

There is also evidence of superthermophiles in fluids collected from black smokers with temperatures at 150°C and higher. Some argue that life in water at such extreme temperatures may be only possible where pressure precludes boiling.[57]

3.6 Cognate Communities

Cognate communities can be found at seeps, pockmarks and whale skeletons.[58]

3.6.1 Cold seeps and pockmarks

Soon after the discovery of chemoautotrophic communities at hydrothermal vents, dense animal life in a cold-water "seep" environment was found. The perspective for the industry to find offshore-petroleum resources promoted seep research and subsequently non-pockmarked seepage areas have been discovered with new biological communities. For example, the first cold seep that was found along the base of the Florida Escarpment in the Gulf of Mexico at a depth of 3000 m, has hyper saline cold sulphide fluids and is covered by fauna on an area which is some 30 m wide and about 1,500 m long. Seabed seepages, i.e. hydrocarbon-seep or pockmarks, occur on continental shelves, in the deep ocean and on the intervening slope.[59]

Many of the invertebrates in the seep communities are taxonomically related to those of hydrothermal vents (at species level only infrequently). Chemoautotrophic processes provide here also the nutritional basis for the high biomass. Although sulphide may also play a prominent role, methane-rich fluid of thermogenic and/or biogenic origin is the main source of energy for the associate biological communities. Thereby biogenic fluids are produced in anoxic sediment layers by the decomposition of microbial organic matter.[60] Interestingly, many genera and some higher taxonomic groups are only known from cognate communities and not from hydrothermal vents.[61]

Seeps are related to geological active sites like petroleum or natural gas escapes. High-fluid pressures are caused by tectonically processes or sediment slumps and slides. Thus, seep fluids are of hydrocarbon, hydrothermal or volcanic origin and continuous, intermittent, localised or diffuse.[62]

Pockmarks are formed by fluid seepage through some sediment types and were first discovered at a continental shelf off Nova Scotia. The North Sea is cratered also heavily with these formations.[63]

Large bivalves are the dominant seep species (families Vesicomyidae and Mytilidae). About 30% of the discovered species (about 65) belong to the symbiont-bearing macro fauna and rely on methane or sul-

[57] L. VAN DOVER, supra note 6, p. 125.

[58] For example, figure. 12.1 in: L. van Dover, *supra note 6*, p. 356, shows in a "deep-sea triangle" the estimated numbers of shared and endemic species from vents, seeps, and the non-vent deep sea including whale skeletons.

[59] A global distribution of seeps can be found at http://www.Ideo.columbia.edu/margins/seeps_workshop.html#fig1; however most seepage areas are not known to date; WWF/IUCN/WCPA, *supra note 9*, p. 46

[60] M. SIBUET, K. OLU, *Biogeography, biodiversity and fluid dependence of deep-sea cold-seep communities at active and passive margins.*Deep Sea Research II 45(1-3): 517-567 (1998); H. SAHLING, D. RICKERT, P. LINKE, E. SUESS, R. W. LEE, *Macrofaunal community structure and sulfide flux at gas hydrate deposits from the Cascadia convergent margin*, Forschungszentrum für marine Geowissenschaften, submitted to Marine Ecology Progress Services (Jan. 2001), p. 2.

[61] L. VAN DOVER, *supra note 6*, p. 355.

[62] M. SIBUET, K. OLU, *Biogeography, biodiversity and fluid dependence of deep-sea cold-seep communities at active and passive margins.*Deep Sea Research II 45(1-3): 517-567 (1998).

[63] M. HOVLAND, A.G. JUDD, *Seabed Pockmarks and Seepages. Impact on Geology, Biology and the Marine Environment.* Graham and Trotham, London. 293 pp. (1988).

phide oxidation or both with the help of chemoautotrophic endosymbiont bacteria. Also dense communities of polychaete worms (Hesionidae) on methane hydrates in the Gulf of Mexico and of mussels around gas hydrates on a passive margin off North Carolina at depths of 2000 m have been found.[64]

The large majority of seep fauna is endemic to the seep-ecosystem and even to single seep sites. So far, only 13 species occur at seeps as well as at vent sites. Barriers to larval migration or slower methane seepage rates may be the reason for the absence of bathymodiolid mussels in the Pacific. In general, the higher diversity of seep communities could be explained by the sediment habitat, fluid flow duration, less extreme habitat and seep evolution.[65]

Similar to the bacteria at vent sites, seeps may contain novel genes useful to the biotechnology industry, e.g. the bioremediation of oil pollution. Furthermore, seepages are of interest to the petroleum industry and patents already exist for the harvest of seepage minerals on the seabed. Thus, potential and actual threats to these exceptional ecosystems come from benthic trawling or destructive scientific research.[66]

3.6.2 Whale skeletons

Scientists using the deep-sea submersal "Alvin" discovered by accident the skeletal remains of a 20-m-long baleen whale. The organic enrichment of this kind of organism can be compared with 10^{10} calories. Since microbial degradation generates sulphide apart from sulphate reduction also from putrefaction of the lipid-rich organic material, mats of sulphide-oxidizing bacteria and more than 40 invertebrate species could be found at the whale bones of which more than 95% are rare or absent in the surrounding sediment.[67] It has been suggested that the whale-bone community is composed of "core" (when they are specifically adapted to the sulphide-rich habitat) and "satellite" (when they are only marginally able to survive in this habitat) species.[68]

Interestingly, at higher taxonomic levels, the core species of whale-bone communities are obviously related to vent and seep faunas of the eastern Pacific with its bivalves and polychaetes.[69] And since the list of shared species between whale skeletons and other deep-sea reducing habitats grows, the whale skeletons may serve as stepping-stones for the dispersal of certain vent and seep taxa.[70]

[64] C. K. PAULL, W. USSLER, W. S. BOROWSKI, F. N SPIESS, *Methane-rich plumes on the Carlina continental rise: Associations with gas hydrates.* Geology 23(1): 89-92 (1995).
[65] M. SIBUET, K. OLU, *Biogeography, biodiversity and fluid dependence of deep-sea cold-seep communities at active and passive margins.*Deep Sea Research II 45(1-3): 517-567 (1998).
[66] WWF/IUCN/WCPA, *supra note 9*, p. 47; M. HOVLAND, A.G. JUDD, *SEABED Pockmarks and Seepages. Impact on Geology, Biology and the Marine Environment.* Graham and Trotham, London. 293 pp. (1988).
[67] L. VAN DOVER, *supra note 6*, pp. 385-386.
[68] B. A. BENNETT, C. R. SMITH, B. GLASER, AND H. L. MAYBAUM. *Faunal community structure of a chemoautotrophic assemblage on whale bones in the deep northeast Pacific Ocean*. Mar. Ecol. Prog. Ser. 108:205-223 (1994).
[69] Id.
[70] C. K. SMITH, H. KUKERT, R. A. WHEATCROFT, P. A. JUMARS, AND J. W. DEMING, *Vent fauna on whale remains.* Nature 341:27-28 (1989); L. van Dover, *supra note 6*, pp. 387-388; see also table 12.5, p. 387.

PART 2
Exploitation of Hydrothermal Vent Sites and Threats to Vent Ecosystems

1 Potential use conflicts

Although it is not yet possible to predict the economic value of the oceans[71] and the majority of hydrothermal vents have still to be discovered, they are coming under increasing pressure by human activities. Potential market uses of hydrothermophilic bacteria have been estimated to be worth $3 billion annually.[72] A threat to a vent ecosystem can be defined as an activity that will undermine sustainable use of the system, or affect the use or value of the resource.[73]

First, the most accessible will be threatened by marine scientific research, submarine cable and pipeline laying, seabed mining, oil and gas exploration, geothermal exploitation, waste disposal, tourism and bioprospecting. Technological developments will enable humans to more intensive ventures into the deep sea. Thus pressures upon these ecosystems are likely to increase. And, notwithstanding the immense technical and financial[74] obstacles, the vent fields are already multifariously used. This can lead to conflicts between activities of

- exploration/exploitation of polymetallic sulphide deposits and prospecting for genetic resources
- oil and gas exploitation and research/resource exploration activities
- observation and biological sampling within the scientific community.

The following is a brief survey of the different threats to vent sites.

2 Marine Scientific Research

Since the deep ocean floor is one of the least known ecosystems of the world[75], scientists try to bring light into such phenomena as heat loss, global plate tectonics, marine biodiversity and ecology, the origin and evolution of life, and the possible existence of a deep microbial biosphere within the Earth. Therefore so far marine scientific research is the most frequent activity at hydrothermal vent systems.

Some examples of scientific research:

- the National Oceanic and Atmospheric Administration's (NOAA) program (1984) tries to get more information about submarine volcanoes and hydrothermal vents in the northeast Pacific.[76]

[71] One estimation: US $21 trillion per year, in: R. Constanza et al, *The Value of the World's Ecosystem Services and Natural Capital*, 387 NATURE 253, tbl. 2 (1997).
[72] D. ANTON, *Law for the Sea' Biological Diversity*, in: Columbia Journal of Transnational Law 36, p. 349 (1996).
[73] InterRidge: *Management and Conservation of Hydrothermal Vent Ecosystems*. Report from an InterRidge Workshop. p. 6.: Institute of Ocean Sciences, Sidney, B.C. Canada (2000).
[74] One estimation: up to US $30,000 per day for a deep-ocean scientific expedition, in: U.N. Environment Programme, *Bioprospecting of Genetic Resources of the Deep Sea-Bed:* Report by the Subsidiary Body on Scientific, Technical and Technological Advice, 44, UNEP/CBD/SBSTTA/2/15 (1996).
[75] U.N.: *Oceans and the Law of the Sea*, in: Report of the Secretary-General , U.N. GAOR, 54th Session, Agenda Items 40(a) & (c), at 78, 509, U.N. Doc. A/54/429 (1999), available at http://www.un.org/Depts/los/a54_429.htm (last visited April 17, 2001).
[76] http://www.pmel.noaa.gov/vents/ (last visited June 20, 2001)

- the New Millennium Observatory (NeMO) gives the opportunity for a monitoring and sampling program on the summit of an active seabed volcano throughout the year (location: in depth of 1500 meters, 300 miles off the Oregon-Washington coast).[77]
- the NEPTUNE project (Northeast Pacific Time-integrated Undersea Networked Experiments) plans to establish a system of submarine fibre-optic cables to connect

remote sites with laboratories and classrooms on land along the west coast of the United States and Canada.[78]

Scientists are collecting seabed, water, mineral, and biological samples during seafloor dives by submersibles (manned and unmanned). Information about some of the samples taken from the vents are available in a database provided by InterRidge.[79]

Despite the benefits and necessity of scientific studies, they are the most immediate threat to the ocean and seabed.[80] In addition, the main conflict arises between observational and other research activities like manipulating or collecting biological and geological samples.

Substantial impacts on vent systems are well documented at certain sites on the East Pacific Rise, the Northeast Pacific and the Mid-Atlantic Ridge where activities are concentrated:[81]

- Removing chimneys and rocks for geological and chemical sampling.[82]
- Drilling and other environmental manipulations, which can change fluid flow pathways.
- Clearing fauna
- Transplanting fauna
- Placement of instrument packages
- Damage to photosensitive organisms through light-spots.
- Damage to fauna and flora by landing submersibles and their thrusters.

These above listed activities can cause second order biological effects:[83]

- Decrease in population numbers
- Local, regional or global extinction of species
- Change in community structure
- Introduction of alien species

[77] http://newport.pmel.noaa.gov/nemo/ (last visited May 4, 2001)
[78] http:/www.neptune.washington.edu/(last visited June 20, 2001); David Malakoff, *Academy Panel Backs Sea-Floor Observatories*, 289 SCIENCE 522 (2000).
[79] http://triton.ori.u-tokyo.ac.jp/~intridge/index.html (last visited April 24 2001)
[80] D. CHRISTIE*, Life on the RIDGE*, 10 RIDGE EVENTS No. 1, pp. 2, 4 (1999).
[81] L. MULLINEAUX et al., *Deep-sea Sanctuaries at Hydrothermal Vents*: A Position Paper, InterRidge News, April 1998, pp. 15-16.
[82] For example, a joint U.S.-Canada expedition removed four black smoker chimneys from the Endeavor Segment of the Juan de Fuca Ridge (1998). Three of the chimneys now can be seen in the American Museum of Natural History, http://amnhohnline.org/expeditions/black_smokers.html (last visited April 24 2001).
[83] InterRidge*, supra note 73* , p. 6.

Therefore more co-operation and co-ordination will be required.[84] The exchange of knowledge of population size, of structures and interactions will be needed for management measures (see part 5, Threat Management).

3 Seabed Mineral Mining

3.1 The most important deep-sea minerals of interest to mining companies are polymetallic (manganese) nodules, cobalt crusts, and polymetallic sulphide (PMS) deposits. Sources of each are located within and beyond areas of national jurisdiction. Engineers are believing that marine technology has improved to a stage that mining machines can be constructed to work at several thousand meters depth. And there may be advantages, for instance

- environmental: no acid mine drainage
- financial: mobility of the large mining ships saves costs
- legal: less problems of tenure.[85]

3.2 Timing

Currently 99 % of extracted minerals are coming from onshore areas. It is predicted that land deposits of the same minerals as in the deep-sea last for the next century.[86] Therefore, mining activity in the Area is not expected in the near future.[87] Nevertheless, there are already mining interests and activities mainly in Back Arc areas and within the Exclusive Economic Zones (EEZs).

3.3 Minerals of interest

3.3.1 Polymetallic (Manganese) Nodules

They are found at depths of 4000 to 6000 meters precipitating from seawater over a period of millions of years. Mineral components include economically valuable manganese, cobalt, nickel, and copper.[88] In the Clarion-Clipperton Fracture Zone between Mexico and Hawaii (where active hydrothermal vent sites have been discovered in the vicinity), some U.S.-consortia have already conducted research. Several pioneer investors from other nations have the approval of the International Seabed Authority (ISA) for research in the same area.[89] There are also activities within the EEZ, for example at the Cook Islands through a Norwegian consortium.[90] Conflicts between manganese nodule mining and hydrothermal vent research are likely to grow.

3.3.2 Methane Hydrates

These ice-like hydrates have been found on the seabed (100-1200 meters) and in the seabed (up to 3000 meters). Beside the hydrates, also methane, a greenhouse gas, is believed to be an important energy

[84] L. MULLINEAUX et al., *supra note 81*, p. 15.
[85] InterRidge, *supra note 73*, p. 7.
[86] C. A. HODGES, *Mineral Resources, Environmental Issues, and Land Use*, 268 SCIENCE 1305 (1995).
[87] generally: HANDBOOK OF MARINE MINERAL DEPOSITS (DAVID S. CRONAN, ed,. 2000).
[88] A. L. HAMMOND, *Manganese Nodules: Mineral Resources of the Deep Seabed* (pt. 1), 183 SCIENCE 502 (1974).
[89] ISA/5/A/1, International Seabed Authority, Report of the Secretary-General of the International Seabed Authority under article 166, para. 4, of the United Nations Convention on the Law of the Sea (third annual report), (July 1998 to July 1999). http://www.un.org/Depts/los/Docs/Agencies/isa.htm (last visited July 4, 2001).
[90] U.N. Secretary-General *Report on Oceans & Law of the Sea*, *supra note 75*, p. 337.

source. The supply of methane in gas hydrates worldwide is estimated to be equivalent of 10.000 gigatons of carbon, twice as much as all fossil fuels on the planet.[91] In areas with methane hydrates, hydrothermal and cold seep biotic communities have been found, because the hydrates feed some chemo synthetic-based ecosystems.[92] Therefore, again conflicts may arise caused by hydrate research and exploitation.

3.3.3 Polymetallic Sulphide Deposit (PMS)

These deposits may create most obviously conflicts. They have been documented at many active and extinct vent sites. Around active vent sites massive sulphide deposits like zinc, copper, silver and gold have been found up to hundreds of cubic meters. When the deposits of the sites expire, they eventually oxidize and crumble.

There is a growing international interest in mining seabed PMS deposits although the technology has not yet been developed.[93] Despite legal and technical problems, activities at two potential sites within national jurisdiction are developing.[94] At the Papua-New Guinea site, ironically a coral reef of extraordinary bio-diversity has been documented.[95] Other sites of interest are the Okinawa Trough, the Bonin area, the Atlantis II Deep and the Explorer Ridge.[96]

3.4 Environmental effects on vent sites

A number of environmental studies predict substantial impacts of seabed mining activities on the surrounding ecosystems (in geographically limited areas):

- recommendations from an ISA-workshop[97]
- Deep Ocean Mining Environmental Study (DOMES) by NOAA[98]
- an international workshop in Papua-New Guinea focusing on the Bismarck Sea[99]

At the moment, it is not clear how rapidly sites may recover from mining operations. Long-lived vent fields host the largest mineral deposits and are likely to exhibit the greatest biodiversity.

Possible environmental damages caused by the extraction of polymetallic sulphide deposits[100]:

- selective removal of the substratum
- production of a particulate plume
- some organisms will be killed directly by mining machinery
- others may be smothered by plume-material

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[91] U.S.Department of Interior, Minerals Management Service, *An Assessment of the Undiscovered Hydrocarbon Potential of the Nation's Outer Continental Shelf: A Resource Evaluation Program Report*, MMS 96-0034 (1996).

[92] K. KRAJICK, *The Crystal Fuel,* 106 NAT. HIST. 30 (1997).

[93] U.N. SECRETARY-GENERAL *Report on Oceans & Law of the Sea*, *supra note 75*, p. 338.

[94] at the Gorda Ridge PMS mining site and the Papua-New Guinea PMS mining site NAUTILUS Mineral Cooperation); see e.g.: U.S. Department of Interior, Minerals Management Services, *Draft Environmental Impact Statement: Proposed Polymetallic Sulfide Minerals Lease Offering, Gorda Ridge Area Offshore Oregon and Northern California* (Dec. 1983)

[95] J. D. THOMAS, *Using Marine Invertebrates to Establish Research and Conservation Priorities*, in Biodiversity II: Understanding and protecting our biological resources 357, pp. 363-66 (M. L. REAKA-KUDLA et al., eds. 1997).

[96] Inter Ridge*, supra note 73*, p. 7.

[97] International Seabed Authority, Legal and Technical Commission, *Recommendations from the Workshop to Develop Guidelines for the Assessment of the Possible Environmental Impacts Arising from Exploration for Polymetallic Nodules in the Area,* Annex, ISA/5/LTC/1 (1999).

[98] U.S. DEPARTMENT OF COMMERCE, NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION, *Deep seabed Mining, Final Programmatic Environmental Impact Statement*, (1981) (EIS Order 810762).

[99] U.N. SECRETARY GENERAL *Report on Oceans & Law of the Sea*, *supra note 75*, pp. 340-342.

[100] InterRidge, *supra note 73*, p. 7.

- replacement of hard substrata by soft particulates
- hindrance of hydrothermal conduits by particulates
- changes of the subsurface hydrology beneath the vent openings could stop hydrothermal fluid flow
- releasing high concentrations of sulphides into upper water levels could diminish the level of oxygen necessary for the biota
- toxicosis of free sulphides, particularly hydrogen sulphide, at low levels to most fish, crustaceans, polychaetes
- sonic "pollution" caused by submarine mining might affect the behaviours of sound-sensitive organisms

Possible mining methods to reduce effects of PMS mining:

- pulverisation of the sulphide deposits on the seabed and separating the ores magnetically (technology does not yet exist)[101]
- limitation of mining operations at the sulphide deposits at extinct vent sites to avoid negative impacts for the biotic communities found at active sites (advantage: less temperature and corrosion problems
- disadvantage: difficulty in locating inactive deposit sites; even inactive sites may provide unique ecosystems, but more extensive sampling is required)[102]

In addition to the mining code[103], the ISA is developing at the request of the Russian government a mining code for polymetallic sulphide deposits and cobalt crusts.[104]

A report of the U.N. Secretary General[105] concludes that before commercial mining production on the seabed starts, there is the opportunity to apply the precautionary approach to the environmental impacts of these commercial activities. Furthermore, the pre-mining period is a chance to develop a comprehensive legal regime for the vent fields and their resources, and gives time for the ISA to fulfil its obligations to protect the marine environment (see part 3).

4 Oil and Gas Exploitation

Offshore exploitation of oil and gas is already carried out at depths of more than 2500 meters.[106] When these industries are shifting more seaward, potential conflicts with deep-sea-researchers and seabed mining companies will increase.

5 Geothermal Exploitation

It is possible that large-scale hydrothermal fluid extraction can reduce the flow of the natural fluids important for vent organisms. In consequence, this could cause a premature ageing of vents in contrast to the rapid habitat loss through mining.[107]

[101] S. D. SCOTT, *Deep ocean mining*, Geoscience Canada (2001).
[102] InterRidge, *supra note 73*, pp. 7-8.
[103] International Seabed Authority*, Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area,* ISA Doc. ISA/6/A/18 (2000) [hereinafter *ISA Mining Code for Nodules*].
[104] Third Report of the ISA, *supra note 89*, p. 46.
[105] U.N. SECRETARY GENERAL *Report on Oceans & Law of the Sea*, *supra note 75*, pp. 342-343.
[106] U.N. SECRETARY GENERAL Report on Oceans & Law of the Sea, *supra note 75*, pp. 325-326.
[107] InterRidge, *supra note 73*, p. 8.

6 Bioprospecting and Biotechnology

The discovery of hyperthermophilic Bacteria and Archaea, which are adapted to the extreme conditions at hydrothermal vents, opens new ways for biotechnology. The ability of their enzymes to work under high temperatures and high/low pH values, makes them interesting for molecular biology to food and chemical processing, pharmaceutical production, and toxic waste reduction.[108] Well-known is the production of DNA-parts for the Polymerase Chain Reaction (PCR).[109] Microbes have been identified that live in benzene and kerosene.[110]

The Taq (Thermus aquaticus) DNA polymerase enzyme, first found in terrestrial hot springs in Yellowstone National Park, is now used worldwide in molecular biology with an estimated annual market of $500 million per year.[111] Other DNA polymerase enzymes from hydrothermal organisms are presently being marketed. This commercial value now raises considerable attention.[112] Forecasts say that the market for biotechnology enzymes derived from extremophiles grows at 15-20 % per year.[113]

But similar to the potential mining activities, biological prospecting causes problems with access rights and environmental impacts involving a variety of international and national laws. For example, under U.S. law, genetically engineered microbes are always patentable. This includes hydrothermal vent fauna.[114] On the other hand, a federal court suspended the agreement between the U.S. government and a California biotechnology company over bioprospecting rights within Yellowstone National Park.[115]

There are already some public agencies in several countries to manage the exploitation of their resources. Papua New Guinea's BioNet for instance, sent an observer to a just concluded bioprospecting operation (ODP Leg 193) in Manus Basin and wants to control future cruises in the area.[116] But the risks associated with sampling and genetically modified organisms (GMO's) are still unknown and have to be evaluated. Therefore it is necessary to act in time since there are important economic and ecologic arguments for conserve the poorly known biodiversity and its genetic potential.

7 Tourism

Although private submersibles will not pose significant threats on the vents in the near future, unregulated diving by tour companies could disrupt research activities or have negative impacts on the organisms living there.

Russia has already taken tourists to the Rainbow vent site on the Mid-Atlantic Ridge.[117]

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[108] Bacterial bioremediation of waste sulphides for industrial purposes has already be developed in laboratories. Bacterial biomass of this process can be used for aquaculture and in the production of synthetic fuels; see WWF/IUCN/WCPA, *The status of natural resources on the high-seas*, (Gland, Switzerland, 2001), p. 17.

[109] H. JANNASCH, *Neuartige Lebensformen an den Thermalquellen der Tiefsee*, in: Tiefsee und Höhlen (F. Uiblein, ed., 2000), p. 87.

[110] F. S. MEYERS & A. ANDERSON, *Microbes from 20,000 Feet Under the Sea*, 255 SCIENCE 28 (1992), about the Deep-Sea Environment Exploration Program: Suboceanic Terrane Animalcule Retrieval (DEEPSTAR).

[111] InterRidge, *supra note 2*, p. 8.

[112] C. HOLDEN, *Money for Extremophiles*, 275 SCIENCE 623 (1997).

[113] WWF/IUCN/WCPA, *supra note 9*, p. 17.

[114] See DIAMOND V. CHAKRABARTY, 447 U.S. 303 (1980): patents to persons who invent or discover "any" new or useful "manifacture".

[115] C. MACILWAIN, *Court Suspends Pioneering Gene Deal in Yellowstone,* 398 NATURE 358 (1999).

[116] InterRidge, *supra note 73*, p. 8.

[117] L. MULLINEAUX, *Biology Working Group Update*, 8.2 INTERRIDGE NEWS 10 (Spring 1999).

Bringing tourists to the vent sites in the deep-sea could support public education needs and greater concern for these sensitive ecosystems. The Russian example of mixing tourists and science could be adopted by other nations, or the "teacher at sea programmes". But those offers must not be a "fig leaf" for the exploitation-focused economy. In addition, there are many endangered ecosystems on the planet with easier access, providing educational success of the same importance. Virtual tourism may be therefore even more useful.

Nevertheless, an access regime for vents should include tourism-uses as well.

Part 3
The legal framework for seabed vent sites

The legal framework for deep seabed vents beyond national jurisdiction consists principally of the following legal authorities and soft law instruments. They will be the basis for the legal classification of the vent's resources and activities:

- the United Nations Convention on the Law of the Sea[118]
- the Convention's Part XI Implementation Agreement[119]
- the rules promulgated by the International Seabed Authority
- the Rio Declaration of Principles[120]
- the Agenda 21[121]
- the Convention of the Biological Diversity[122]
- customary law.

1 The United Nations Convention on the Law of the Sea (UNCLOS)

The United Nations Convention on the Law of the Sea entered into force 1994 and seems to be the most comprehensive international law project ever completed up to the year 2001. 132 states are parties, the United States set not because of the convention's deep seabed mining regime.

Since the Convention does not offer solutions to all traditional and future problems of the seas and oceans, the drafters referred to international instruments, international organisations and customary law. In addition, the 1994 Part XI Agreement, the 1995 Fish Stock Agreement and the established United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea (UNICPOLOS) support this process.

1.1 The regime for the conduct of marine scientific research

To promote a better knowledge of the oceans and their processes, Part XIII of the UNCLOS offers a balanced regime for the conduct of marine scientific research.[123] In this context it is important to notice that some developing nations view marine scientific research as an exclusive right of a few industrial nations including the deriving benefits.[124] Thus, the UNCLOS articles on marine scientific research try to balance

[118] United Nations Convention on the Law of the Sea, U.N. Doc. A/CONF.62/122 (1982), 1833 U.N.T.S. 397, reprinted in BGBl., 1994 II, pp. 1798; http://www.un.org/Depts/los/unclos/contents.htm (last visited July 2001).
[119] Agreement Relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea of 10 December 1982, G.A. RES. 263, U.N. GAOR, 48th Sess. Supp. No. 49A, at 7, U.N. Doc. A/RES/48/263/ Annex (1994).
[120] Report of the United Nations Conference on Environment and Development (Rio de Janeiro, June 1992), U.N. Doc. A/CONF. 151/27 (1992).
[121] Agenda 21: Programme of Action for Sustainable Development, in Annex II to the Report of the United Nations Conference on Environmental and Development (Rio de Janeiro, June 1992), U.N. Doc. A/CONF. 151/26 (Vol. I-III) (1992).
[122] Convention on Biological Diversity, June 1992, U.N. Doc. DPI/130/7 (1992), Treaty Doc. 20, 103d Cong. 1st Sess. (1993); entered into force Dec. 29, 1993.
[123] UNCLOS, *supra note 118*, part XIII; A.A.H. Soons, *Marine scientific research and the law of the sea* (1992).
[124] R.R. CHURCHILL & A.V. LOWE, *The Law of the Sea*, pp. 403-404, 3rd ed. 1999.

between encouragement of the researchers and the engagement of states when marine scientific research activities are practiced in coastal waters or on their continental shelves.

States have to support marine scientific research and to further international co-operation.[125] Since the UNCLOS provides a zonal approach for marine scientific research, the obligations of states vary according to the location of the activities. Above all, marine scientific research activities have to follow the marine environment protection and preserving provisions laid down in Part XII. In conjunction with Part XIV of the Convention, states have to co-operate for a development and transfer of marine science and technology[126] as well as to promote standards for marine technology transfer.[127] The UNESCO Intergovernmental Oceanographic Commission's International Oceanographic Data and Information Exchange System facilitates theses tasks.[128] In the waters beyond national jurisdiction, marine scientific research is recognised as a high seas freedom (article 87) restricted through the Parts VI and XII.

It is doubtful whether Part XIII of the UNCLOS and the Convention on Biological Diversity limit international property rights of marine scientific research in areas beyond national jurisdiction.[129] Questions are also arising with respect to "pure" and "applied" research, terms not used in the UNCLOS but of direct significance for the distinctions between research carried out "exclusively for peaceful purposes and in order to increase scientific knowledge of the marine environment for the benefit of all mankind"[130] and marine scientific research activities that are of "direct significance for the exploration and exploitation of natural resources".[131] It is also not clear whether "bioprospecting"[132] falls within the marine scientific research regime or within the articles governing the exploration and exploitation of living marine resources. These questions will be soon examined further in **Part 4 B**.

1.2 The regime for non-living marine resources beyond national jurisdiction

Activities beyond national jurisdiction are governed by Part XI of the Convention, the 1994 Implementation Agreement.

The "Area" is defined as the seabed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction.[133] Part XI places the Area and its resources under the "Common Heritage of Humankind" principle.[134] But there exists no definition of this concept. The resources of the Area include "all solid, liquid or gaseous mineral resources *in situ* in the Area at or beneath the seabed, including polymetallic nodules".[135] Living marine resources are not included. But the Authority "shall adopt appropriate rules,

[125] UNCLOS, *supra note 118*, arts. 239, 242.
[126] Id., art. 266.
[127] Id., art. 271.
[128] See http://ioc.unesco.org/iode/ (last visited July 2001).
[129] I. WALDEN, Preserving Biodiversity*: The Role of Property Rights*, in: Intellectual property rights and the Biodiversity Convention, p. 176 (Timothy Swanson ed., 1995).
[130] UNCLOS, *supra note 118*, art. 246(3).
[131] Id., art. 246(5).
[132] Id., Annex III, art. 2.
[133] Id., art. 1(1).
[134] Id., art. 136.
[135] Id., art. 133(a).

regulations and procedures for inter alia[136] the prevention of damage to the flora and fauna of the marine environment".[137]

Article 137(1), (3) provides that no state may claim or exercise sovereignty or sovereign rights over any part of the Area or its resources, nor may any state or private entity appropriate any part of the Area or its resources, except as provided by the Convention. Activities within the Area are "all activities of exploration for, and exploitation of these resources of the Area.[138] They are under the jurisdiction of the International Seabed Authority

(ISA) according to Article 1(2) and shall be carried out for the common benefit of all mankind[139] and exclusively for peaceful purposes.[140]

The ISA has to develop rules to implement the deep seabed mining regime established by Part XI of the Convention.[141] Until now the ISA has prepared and approved regulations for prospecting and exploration for polymetallic nodules, which include guidelines for the assessment of environmental impacts.[142] These guidelines are reviewed periodically to assist contractors in preparing a plan of work for environmental monitoring. In July 2001 recommendations for the guidance of the contractors for the assessment of the possible environmental impacts arising from exploration for polymetallic nodules in the Area have been added.[143] Also considerations relating to the regulations for prospecting and exploration for hydrothermal polymetallic sulphides and cobalt-rich ferromanganese crusts in the Area[144] have been made after beginning those preparations earlier **(see Part 4 B)**.[145]

It must be kept in mind that a state may extend its continental shelf claim beyond the presumptive 200 NM limit if the geologic continental margin extends more than 200 NM from the baseline.[146] But in this case the coastal state has

- to share the fruits of the exploitation with the international community[147]
- to consent to marine scientific research on the shelf beyond 200 NM when the project is of direct significance for the exploration and exploitation of natural resources[148]

and all activities fall within the Convention's high seas freedoms.[149]

1.3 The regime for living marine resources

With respect to access to and conservation of living marine resources, there is a zonal approach under the UNCLOS. However, living marine resources mean only those traditionally harvested and certain "sedentary species". Microbes, such as vent bacteria or archaea are not directly addressed.

[136] Id., art. 145; U. BEYERLIN, Umweltvölkerrecht, p. 127 (München: Beck, 2000).
[137] UNCLOS, *supra note 118*, art. 145(b).
[138] Id., art 1(3).
[139] Id., art. 140.
[140] Id., art, 141.
[141] Part XI Implementation Agreement, *supra note 119*, Annex, § 1, 5(f), 5(g), 15.
[142] ISBA/6/W/18 (July 2000).
[143] ISBA/7/LTC/1/Rev.1 (July 2001).
[144] ISBA/7/C/2 (July 2001).
[145] U.N. Secretary General Report on Oceans and the Law of the Sea, *supra note 75*, p. 341 (1999).
[146] UNCLOS, *supra note 118*, art. 76(2)-(10).
[147] Id., art. 82.
[148] Id., art. 246(6).
[149] Id., art. 78(1).

a) *Within national jurisdiction* sedentary species are governed by the continental shelf regime.[150] All other living marine resources fall under the high seas or Exclusive Economic Zone (EEZ) articles.[151] Article 56, for example, ensures the right of coastal states over the living and non-living natural resources within their EEZ including the seabed, subsoil and superjacent waters. In addition, the states have to manage and conserve their living marine resources and grant other states access.[152] The coastal state's duties concerning those resources within the continental shelf are quite contrary. There exist no obligations to conserve or grant access according to Article 77(2) where it is provided "that if the coastal State does not explore the continental shelf or exploit its natural resources, no one may undertake these activities without the express consent of the coastal State". Furthermore, the coastal state has not to share returns from living marine resource proceedings beyond the 200 NM extension of their continental shelf as provided for non-living resources.[153] In this context it is very important to note that a coastal state may only claim rights over living marine resources on continental shelves beyond the 200 NM limit when such resources fall within the definition of sedentary species. It is therefore a key question whether hydrothermal vent communities in these areas can be classified as sedentary species **(see Part 4)**.

b) The provisions of the UNCLOS for living marine resources *of the high seas* improve the use-orientated Geneva Convention regime[154] but still provides no comprehensive conserving and managing concept. And although "fishing" is one of the traditional high seas freedoms[155] the conventions define neither fish nor fishing. But Articles 117 to 119 seem to widen the term "living marine resources" to a class more than fish. It will therefore be analysed in **Part 4 A** whether those provisions can be applied to research and exploitation of vent living marine resources.

   As seen before mineral resources of the deep seabed fall under the common heritage of humankind principle and can only be explored in accordance with Part XI of the UNCLOS. By contrast, living marine resources can be freely captured and appropriated, limited only by the obligations to respect the rights of other nations. Since this practice can soon lead to the severe threat or extinction also of vent community organisms some argue that the common heritage principle should include sedentary species and genetic resources of the deep sea[156] **(see Part 4 A)**.

1.4 The regime for the protection of the marine environment

According to Article 192 states have "the obligation to protect and preserve the marine environment". They have the duty to co-operate in establishing rules and standards governing pollution from national seabed activities and ocean dumping.[157] Supported by an (in comparison to the CBD) weak ecosystem

[150] Id., art. 77(4).
[151] Sedentary species are expressly excluded because they fall within the continental shelf regime, see art. 68.
[152] Id., arts. 61, 62.
[153] Id., art. 82.
[154] Convention on the High Seas (1958), 450 U.N.T.S. 82; Convention on Fishing and Conservation of the Living Resources of the High Seas (Geneva 1958), 559 U.N.T.S. 285; U. BEYERLIN, *supra note 136*, p. 112, fn. 327.
[155] H. GROTIUS, MARE LIBERUM (1609); Convention on the High Seas (1958), *supra note 154*, art. 2(2); UNCLOS, *supra note 118*, arts. 87, 116-120.
[156] E. MANN-BORGESE, *The Oceanic Circle: Governing the seas as a global resource,* United Nations University Press, (1998), pp. 188, 198.
[157] UNCLOS, *supra note 118*, arts. 208(5) and 211(1).

approach[158], the parties have to preserve and protect rare or fragile ecosystems and the habitat of depleted, threatened, or endangered species or other forms of marine life. Consequently, coastal states can outline standards for particularly sensitive sea areas (PSSAs) to prevent pollution from vessels[159] and complement this with a broader marine protected area (MPA) system.[160] The question whether MPA's can be established on the high seas beyond national jurisdiction will be briefly examined in **Part 5**.

Under the Convention, "particular attention" is required to protect the marine environment from harm by activities in the Area such as drilling, dredging, excavation, disposal of waste, construction and operation or maintenance of installations, pipelines and other devices related to activities.[161] The ISA has to adopt rules to prevent pollution and protect natural resources of the Area. Thus, any plan of work by a seabed miner has to consider the potential environmental impacts of the proposed activities.[162] Recommendations for an improved assessment of the possible environmental impacts have been made recently.[163] This aspect and the authority of the ISA to disapprove areas for exploitation when there is a risk of serious harm to the marine environment will be examined in **Part 4 B**.

2 The United Nation's Conference on Environment and Development and its instruments

The instruments of the United Nation's Conference on Environment and Development (UNCED)[164] can help to implement conservation and management measures for seabed vent resources.

2.1 The Rio Declaration of Principles on Environment and Development

These Principles are considered soft law and "carry a strong moral obligation".[165] Although not binding, they commit to sustainability, equity and integration of environmental protection into the development process.[166] Principle 7 requires the co-operation of all nations in order to "conserve, protect and restore the health and integrity of the Earth's ecosystem". And like under the UNCLOS[167], a purpose of the Principles is the strengthening of capacity-building for sustainable development through the exchange of scientific and technology knowledge.[168] It is of importance that the Principles support the precautionary approach. Thus, the lack of scientific knowledge can not be a reason to refuse measures for the preventation of environmental damages.[169]

[158] Id., art. 194(5).
[159] Id., art. 211(6).
[160] IUCN, *A Global Representative System of Marine Protected Areas, (1999).*
[161] UNCLOS, *supra note 118*, art. 145(a).
[162] 1994 Part XI Implementation Agreement, *supra note 119*, §1, 7.
[163] See ISA/5/LTC/1, International Seabed Authority, Legal and Technical Commission, *Recommendations from the Workshop to Develop Guidelines for the Assessment of the Possible Environmental Impacts Arising from Exploration for Polymetallic Nodules in the Area,* Annex, (1999).
[164] Rio de Janeiro, 1992; generally: U. Beyerlin, *supra note 136, pp. 136*; *The Earth Summit: The United Nations Conference on Environment and Development (UNCED)*, S.P. Johnson (ed.), (1992).
[165] Report of the United Nations Conference on Environment and Development, *supra note 164* , Introduction at 3.
[166] Id., principles 3, 8; 4, 17.
[167] UNCLOS, *supra note 118*, Part XIV.
[168] Report of the UNCED*, supra note 164*, principle 9.
[169] Id., principle 15.

2.2 The Agenda 21

This program of action for sustainable development and environmental protection is soft law but its principles are constantly incorporated into new international agreements and decisions.[170] Chapter 17 of the Agenda 21 provides a comprehensive catalogue of recommendations for the protection and conservation of the marine environment and its living resources. It can be seen as the link between the UNCLOS and the UNCED process and tries to push the development of the marine environmental protection program.[171] Chapter 17 recognizes the provisions and obligations of the UNCLOS. Although it does not directly mention seabed vent resources it can support the implementation of the relevant UNCLOS articles. Furthermore, while calling for new approaches Chapter 17 can complement the framework of the UNCLOS.[172]

Chapter 8 of Agenda 21 is also relevant to the seabed vent fields since there is an integration of environmental considerations into decision-making and an effective use of economic incentives is demanded.

2.3 The Convention on Biological Diversity (CBD)

The CBD puts no obligations on non-contracting parties as settled down in the Vienna Convention.[173] And it does not impose any obligations on individuals since they are only bound by the laws and regulations enacted for the implementation of the CBD.

a) This agreement tries to consider all aspects of biological diversity, including genetic resources, species, and ecosystems. Its regime consists of three pillars which are

- the conservation of biological diversity
- the sustainable use of its components
- the fair and equitable sharing of the benefits, arising from the use of genetic resources.[174]

According to Article 2 “genetic resources” are defined as “genetic material of actual or potential value”. “Genetic material “ includes “any material of plant, animal, microbial or other origin containing functional units of heredity.” The conservation of biological diversity is a “common concern of humankind” and must always be taken into account during the development process.[175] However, the CBD does not provide a preservationist regime since those resources not endangered can be used.[176]

An important principle is the sovereign right of all states to exploit their own resources.[177] Article 15 ensures for the source states an equitable share of the benefits resulting from the use of genetic resources.

To achieve fairness and equity, the CBD provides scientific and technical co-operation, access to genetic resources, and the transfer of technologies.[178]

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[170] Principles of sustainable development and the precautionary approach can be find, for example, in art. 5 of: The Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, U.N. Doc. A/CONF. 164/37 (1995) or 34 I.L.M. 1542 (1995); see also U. BEYERLIN, *supra note 136*, pp. 129-130.

[171] U. BEYERLIN, *supra note 136*, pp. 111, 113; E. MANN-BORGESE, Ocean Governance and the United Nations, p. 23 & chapter 3 (2nd ed. 1996).

[172] Agenda 21, *supra note 121,* chapter 17.1.

[173] Vienna Convention on the Law of Treaties, U.N. Doc. A/CONF.39/27 (1969), 1155 U.N.T.S. 331, art. 34.

[174] Convention on Biological Diversity, *supra note 122*, art. 1.

[175] Id., preamble, para. 3.

[176] For example, see preamble, para. 20.

[177] Convention on Biological Diversity, *supra note 122*, art. 7.

According to Article 4(a) of the CBD the provisions with respect to the components of biological diversity apply throughout the limits of national jurisdiction for each contracting party. (The "components" of biological diversity mean the biological resources, which "include genetic resources, organisms or parts thereof, populations, or any other biotic component of ecosystems with actual or potential use or value for humanity".[179]) The provisions therefore extend to the EEZ and continental shelf and all activities carried out under the jurisdiction of any party fall within the CBD ambit regardless whether conducted within or beyond national jurisdiction and where their effects occur.[180] Questions therefore arise with respect to a party's marine scientific research obligations and when operating as a flag state for vessels outside national waters **(see Part 4).**

b) Recognizing the need to protect marine biological diversity as well as terrestrial biodiversity, the Second CBD Conference of Parties (COP) adopted the "Jakarta Mandate on Marine and Coastal Biological Diversity".[181] It provides five issues for CBD implementation in marine and coastal areas:

- Integrated marine and coastal area management
- Marine and coastal protected areas
- Sustainable use of marine and coastal living resources
- Mariculture
- Alien species.[182]

The CBD Secretariat co-operates with the Intergovernmental Oceanographic Commission, to take advantage of the IOC's expertise on subjects relevant to marine biodiversity.[183]

Although the COP chose the coastal and ocean sector as its priority for the CBD implementation, little progress has been made. With respect to the vent biodiversity, the future will show possible impacts of the CBD on its conservation and management.

3 Conflicts between the UNCLOS and the CBD

The two conventions provide a complementary, but still incomplete regime concerning access to and conservation of the resources of deep-sea vents. Both conventions require nations to co-operate to conserve living resources and preserve free marine scientific research on those resources beyond national jurisdiction.[184] Although complementary, there exist also conflicting provisions in the context of seabed vents like

- neither convention addresses access to genetic resources on the high seas or in the Area[185] directly

[178] Id., arts. 16, 19. These articles have risen controversy whether intellectual property rights are concerned; K. Ten Kate & S.A. Laird, *The Commercial Use of Biodiversity: Access to genetic resources and benefit sharing* (1999).
[179] Convention on Biological Diversity*, supra note 122*, art. 2.
[180] Id., art. 4(b).
[181] UNEP, CBD Conference of Parties, Decision II/10: *Conservation and Sustainable Use of Marine and Coastal Biological Diversity*, in: Report of the second Meeting of the COP to the Convention on Biological Diversity, Annex II, Decision II/10, U.N. Doc. UNEP/CBD/COP/2/19 (1995).
[182] See U.N. Doc. UNEP/CBD/COP/4/5 (1998); http://www.biodiv.org/FinalReports/index.html (last visited July 2001).
[183] http://ioc.unesco.org/iochtm/gwio04/doc12/12.htm (last visited July 2001).
[184] UNCLOS, *supra note 118*, arts. 87(f), 143; CBD, *supra note 122*, arts. 5, 17-18, 22.
[185] P. KRANIOTIS & R. B. GRIFFIS, *International Law: Implications for Exploitation of Deep-Sea Benthic Biodiversity*, 9 OCEANOGRAPHY 100, 101 (1996).

- the two conventions adopt different approaches to conservation and management and create different processes which undermine integrated management
- the CBD tries to conserve also the diversity of genetic resources while the UNCLOS is only concerned about the conservation of species or particular stocks[186]
- the CBD supports an "ecosystem" approach to conservation[187] while the UNCLOS does not mention it directly and accentuated [188] .
- The CBD incorporates a precautionary principle, only discreetly mentioned in the UNCLOS
- The CBD requires a "prior informed consent"[189] while marine scientific research is a high seas freedom under the UNCLOS

In case of a conflict, the rules codified in the Vienna Convention on the Law of Treaties provide guidance with the *pacta sunt servanda* norm. According to Article 26, a party to both conventions must perform their obligations under both in good faith. In addition, Article 30(1) provides the subsidiary of an earlier treaty in cases of conflict, when a treaty is "not to be considered as incompatible with" this earlier treaty. Examining the CBD and UNCLOS with respect to their application to living resources of the high seas and deep seabed, it has been concluded, that in the case of a conflict the UNCLOS takes precedence over the CBD.[190] Support finds this by Article 22 of the CBD. There, it is provided that the CBD is to be implemented "consistently" with "the rights and obligations of states under the law of the sea". And Article 311(2) of the UNCLOS ensures the application of other compatible treaties as long as they are not changing the rights and obligations of parties to the UNCLOS.

However, the COP of the Biodiversity Convention does not necessarily accept the subordinance of the CBD to the UNCLOS with respect to vent resources. The Secretariat of the CBD asked "whether, or how, UNCLOS, or the common heritage principle, applies to the genetic resources of the deep seabed" and stressed the necessity of a "in depth study on how to best address the use of these resources".[191] Informal discussions between the CBD Secretariat and UNDOALOS (U.N. Division for Ocean Affairs and the Law of the Sea) about the control over access to genetic resources in the Area including bioprospecting for deep-sea resources began in 1999.[192] In the same year, the U.N. General Assembly installed a new procedure for co-operation on law of the sea issues. After a continuous intergovernmental review by the Commission on Sustainable Development (CSD) of marine environmental aspects[193], now all members

[186] UNCLOS, *supra note 118*, art. 119(1)(b).
[187] CBD, supra note 122, preamble, para. 10.
[188] Only article 119 of the UNCLOS requires that measures for conservation of living marine resources of the high seas have to consider "the effects on species associated with or dependent upon harvested species"; but this seems no true ecosystem approach.
[189] CBD, *supra note 122*, art. 15.
[190] L. GLOWKA et al., *A Guide to the Convention on BiologicalDiversity,* (1994), p. 109; D. ANTON, *Law for the Sea's Biological Diversity*, in: Columbia Journal of Transnational Law 36, (1996), p. 357.
[191] SBSTTA, Second Meeting, Bioprospecting of genetic resources of the deep sea-bed, UNEP/CBD/SBSTTA/2/15 (1996), the working paper was addressed to the U.N. Division for Ocean Affairs and the Law of the Sea (UNDOALOS); Jakarta Mandate, CBD, Conference of the Parties II/10, *Conservation and sustainable use of marine and coastal biological diversity* (1996); the Fourth COP adopted a Programme of Work to realize the goals of the Mandate in: COP Decision IV/5, Conservation and Sustainable Use of Marine and Coastal Biological Diversity, Including a Programme of Work, U.N. Doc. UNEP/CBD/COP/4/5 (1998).
[192] Report by the Executive-Secretary, *Progress Report on the Implementation of Programmes of Work on Thematic Areas: Inland Water, Marine and Coastal, Agricultural, and Forest Biological Diversity*, U.N. Environmental Programme, 29, UNEP/CBD/SBSTTA/4/3 (1999).
[193] G.A. Res. S-19/2, 19th Special Session, at 36, U.N. Doc. A/RES/S-19/2 (1992).

review the Secretary-General's annual report on oceans and the law of the sea and establish action priorities.[194]

[194] G.A. Res. 54/33, U.N. GAOR, 54th Session, U.N. Doc. A/RES/54/33 (2000).

PART 4 A
Classification of deep-sea vent resources under the UNCLOS

The UNCLOS defines the rights and obligations of the parties concerning vent access, conservation, and management. The CBD regime depends to a certain extent on these provisions to establish the underlying sovereign rights and jurisdiction of the member States. Sovereign rights of the States over resources of the oceans and their jurisdiction are determined by the UNCLOS, contracting parties directly through conventional law, non-contracting parties through international customary law.

An examination of the legal status 1) of the seabed's vent fields and 2) their non-living and 3) living resources may clarify the momentary status.

1 The distinctions between the status of the seabed and the subsoil

a) For the analysis of seabed vent fields located near or astride national and international jurisdiction lines, the dispute over continental shelf/Area boundary determinations may be important. When a coastal State pushes its boundary seaward or raises late claims to continental shelves beyond 200 NM[195], claims on a vent field on a ridge beyond 200 NM, but on the coastal State's continental margin, might ask for clearance about Article 76(3) within the community of States. There, claims to "the deep ocean floor with its oceanic ridges or the subsoil thereof" are precluded.

Furthermore the question about the relationship between high seas freedoms and coastal State jurisdiction and control of the oceans where continental shelves extend geologically more than 200 NM[196] has to be regarded. In this context the possibility to share vent fields exists according to Articles 78(2), 208, 214, 256-257 and 300. All these questions are covered by a document of the U.N. Division for Ocean Affairs and the Law of the Sea.[197]

b) Beyond national jurisdiction, about sixty percent of the seabed lies within the Area. Scientists have concluded that the majority of the vent fields of research interest are situated in the Area.[198] (Of course there are also important fields within national jurisdiction as for instance on the Juan de Fuca Plate within the Canadian EEZ.) Therefore, the legal status of seabed and subsoil is important for vent access.

The "Common Heritage of Humankind" (CHH) articles[199] include not only the resources in the Area (as stated in Article 136), but also the Area itself. Seabed and subsoil are included and therein vent fields located on the seabed within the Area as well. Some support the argument that the CHH has already ripened into a rule of customary international law (see point 5).

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[195] U.N. Convention on the Law of the Sea: Report of the 10th Meeting of States Parties (New York, May 2000), para. VI.C, U.N. Doc. SPLOS/60 (2000); http://www.un.org/Depts/los/Docs/SPLOS/SPLOS_60.htm (last visited July, 2001).

[196] About ten percent of the oceans.

[197] U.N. Division for Ocean Affairs and the Law of the Sea, The Law of the Sea: Definition of the Continental Shelf: An examination of the relevant provisions of the UN Convention on the Law of the Sea, U.N. Sales No. E. 93V.16 (1993).

[198] L. V. DOVER, The ecology of deep-sea hydrothermal vents, *supra note 6*, tbl.2.

[199] UNCLOS, *supra note* 119, Part XI, arts. 136-149. The roots of the CHH-principle lay in the 1970 U.N. General Assembly resolution on the Declaration of Principles Governing the Sea Bed and Ocean Floor, and the Subsoil Thereof, Beyond the Limits of National Jurisdiction, G.A. Res. 2749(XXV), U.N. GAOR, 25th Session, Supp. No. 28, U.N. Doc. A/8028 (1970).

Unfortunately, the CHH regime does not clarify the relations of conflicting activities within the Area (**see Part 4 B**). Actually, it is similar to the inclusive use articles in respect to the high seas freedoms.[200]

The main problem of the CHH regime in respect to conservation and management of deep-sea vent resources/activities is the unforeseen possibility to establish conservation and management measures, pollution prevention or control systems. No State has the right to establish those measures in the Area. **In Part 5** it will be shortly examined whether the establishment of marine protected areas in the high seas would be possible. The ISA jurisdiction exists only in regard to mining activities. On the other hand, it is doubtful whether a consensus-based management is effective enough to conserve common resources.[201]

Here lies the *tragedy of the commons*: this principle wants to avoid unilateral exercise of sovereignty by a State, at the same time, it does not provide sufficient measures to protect threatened vent fields against unsustainable use through the international community.[202]

2 Classification of non-living vent resources under the UNCLOS

In the final text of the 1982 UNCLOS the term "resources" within Part XI and its CHH regime is limited to mineral resources.[203] Originally, when using the unprecise term resources all natural resources might have been included.[204]

It has to be noticed that the "resources" of Article 133(a) of the Area are less extended than the "natural resources" of the continental shelf defined in Part VI. There[205], "natural resources referred to in this Part consist of the mineral and other non-living resources of the sea-bed and subsoil together with living organisms belonging to sedentary species". In contrast, the definition of "resources" of the Area does not mention non-living resources others than minerals. Furthermore, neither "sedentary species" nor other living resources are included in the CHH regime of Part XI.

3 Classification of living vent resources under the UNCLOS

A fundamental challenge to the UNCLOS is the classification of vent living and genetic resources within the Area. The disputes about the boundaries between continental shelves and the Area (see 1a) raise the question in this regard as well. Although the biological communities have been discovered (1977) before

[200] UNCLOS, *supra note 118*, arts. 88, 89, 301.
[201] R.W. PARKER, *The Use and Abuse of Trade Leverage to Protect the Global Commons: What we can learn from the tuna-dolphin conflict*, 12 Geo. International Environmental Law Review pp.3, 9, 99 & 100 (1999).
[202] Interestingly, Resolution 15 of the World Peace through Law Conference (Geneva, July 1967) suggested to establish the Common Heritag of Humankind regime for the Area and the high seas but failed with this proposal. Then the United Nations would have been the owners of ocean resource.; see text: "Whereas, new technology and oceanography have revealed the possibilitiy of exploitation of untold resources of the high seas,, and the bed thereof beyond the continental shelf; and, more than half of mankind find itself underprivileged, underfed and underdeveloped; and, that the high seas are the common heritage of all mankind, resolved, that the World Peace through Law Center (1) Recommend to the General Assembly of the United Natons the issuance of a proclamation declaring that the non fishery resources of the high seas, outside the territorial waters of any state, and the bed of the sea beyond the continental shelf, appartain to the United Nations and are subject to its jurisdiction and control."
[203] UNCLOS, *supra note 118*, art. 133(a).
[204] Declaration of the Principles Governing the Sea-Bed and the Ocean Floor, and the Subsoil Thereof, Beyond the Limits of National Jurisdiction, G.A. Res. 2749(XXV), U.N. GAOR, 25th Session , Supp. No. 28, U.N. Doc. A/8028 (1970), para. 1; 10 I.L.M. 220 (1971).
[205] UNCLOS, *supra note 118*, art. 77(4).

UNCLOS III was concluded (1982) the drafters did not pay attention to the vent's existence and were obviously unaware of their value.

To determine those resources there is a) a factual (physical characteristics) and b) a legal analysis necessary. Thereby interpretations have to be "broad not narrow, flexible not rigid, and adaptive in orientation, not fixed on the past".[206] If there is a fractured regulatory approach to the conservation and management of microbes and other organisms at the vent sites, this could cause a divided, different classification what is against the uniformity of the ecosystem.

3.1 Sedentary species

Sedentary species and other living marine resources lying on a coastal state's continental margin beyond 200 NM can lead to two different regimes: access to sedentary species will be governed by the continental shelf regime, access to all other living marine resources fall under the high seas freedom. To avoid severe problems regarding the management, a uniformal classification of vent organisms is necessary. Thus, the phrase sedentary species of Article 77[207] has to be analysed.

To fall within the sedentary species classification, an organism must be at the harvestable stage (1) immobile on the seabed or subsoil, or, (2) if mobile, capable of movement only in constant physical contact with the seabed or subsoil. Unfortunately, this definition neglects the needs of biological taxonomy and the relation between an organism and its ecosystem.

With respect to the living marine resources of seabed hydrothermal vents, their physical characteristics could be subdivided as follows:

- they are transient migrants, e.g. they arrive at the fields by special routes[208]
- some vent organisms travel across the sea-floor
- some may be carried from one vent to another in spinning whirlpools[209]
- some have a free living-larval stage
- some microbes seem to originate in the subseabed biosphere.[210]

Many of the vent organisms are therefore oceanic voyagers whereby the whole food web is fuelled by chemical energy coming from the seafloor. Those primary producers seem to originate from the subseabed. A possible classification of vent fauna according to the seabed and subsoil could therefore be categorized after

- the dependence on the seabed for location and movement
- the dependence on the seabed for physiological functioning
- the dependence on the seabed for nutritional purposes
- the dependence on the seabed for reproduction.[211]

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[206] W. T. BURKE, *State Practice, New Ocean Uses, and Ocean Governance Under UNCLOS,* in: OCEAN GOVERNANCE – Strategies and approaches for the 21st century, p. 222 (T. A. MENSAH, ed., 1996).

[207] Art. 77 defines the natural resources within the continental shelf regime as " the mineral and other non-living resources of the seabed and subsoil together with living organisms belonging to sedentary species, that is to say, organisms which, at the harvestable stage, either are immobile on or under the sea-bed or are unable to move except in constant physical contact with the sea-bed or subsoil."

[208] L. VAN DOVER, *The Ecology of Deep-Sea Hydrothermal vents*, *supra note 6*, chapter 11.

[209] R. C.. VRIJENHOEK, *Gene Flow and Genetic Diversity in Naturally Fragmented Metapopulations of Deep-Sea Hydrothermal Vent Animals*, 88 J. Hered. 285 (1997).

[210] See http://www.newscientist.com/ns/981212/plume.html (last visited July 2001).

[211] D. P. O'CONNELL, *The International Law of the Sea*, pp. 502-503 (I. A. Shearer, ed., 1982).

The classification system of Article 77 is therefore far too short for the complicated relations within the food web of hydrothermal vent organisms. The same could be said for living marine resources at other deep-sea ecosystems like cold seeps.

Furthermore, the term *"at harvestable stage"*[212] is inappropriate for vent organisms which are not harvested commercially like oysters or clams. On the other hand it could be argued with respect to the genetic material of vent organisms that they are harvestable when they can be collected for later study and exploitation. This broad view can lead to an harvestable stage at any point of their life cycle.

The term *"mobility"* requires distinct studies of the fauna's development stages that effect their mobility. Problematic again is the unclear legal classification of this term since organisms can move by themselves or with the help of outside forces. This has caused a continuous disagreement between states even for well-studied species like scallops.[213] Thus, a reasonable classification for vent organisms is at least for the near future quite unrealistic.

V*ent macrofauna*, fish and octopus for instance, fails to meet the term "immobile" or "mobile in constant physical contact with the seabed". On the other hand sessile anemones, tubeworms, molluscs, and polychaetes seem to fall within the sedentary species definition when they are harvestable (i.e. in their adult stage).[214]

The legal classification as sedentary species of *vent microbes* is even more complicated since far less is known about their origin and life cycle. While they could fall within the class of "living marine resources" of the Parts V and VII, they have never been formally classified under the law of the sea. Thus, as a first step, the vent microbes could be classified into four groups after their habitats from which they could be collected:[215]

- the free-living microbes around the upwelling vent fluids
- the microbes living within the hydrothermal vent water plumes
- the free-living microbes that grow on the rocks and chimneys constantly exposed to vent water
- the symbiotic microbes associated with vent macrofauna

Some of them can move by themselves, others remain immobile throughout their life cycle.

Those living in mats on the seabed or other substrate could be classified under the term "unable to move except in constant physical contact with the seabed." Thus, some of the microbes at vents would meet the definition of sedentary species. Even those who live in mats on organisms could be considered as sedentary if the organisms themselves (e.g. tubeworms, polychaetes) are sedentary. Consequently, the law of the sea would treat microbes found in other collected marine resources similar to zooxanthellae living in coral polyps.

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[212] The term is not defined in the UNCLOS.

[213] See the dispute between the United States and Canada over the classification of sea scallops: Is their movement made in "constant physical contact" with the seabed ? J. M. VAN DYKE, *Modiying the 1982 Law of the sea convention: New Initiatives on Governance of High Seas Fisheries Resources: the Straddling Stocks Negotiations*, 10 International Journal of Marine and Coastal Law 219, 221-222 (1995).

[214] L. VAN DOVER, The Ecology of Deep-Sea Hydrothermal vents, *supra note 6* , chapter 9.

[215] See D. M. KARL, *Ecology of Free-Living Hydrothermal Vent Microbial Communities*, in: The Microbiology of Deep-Sea Hydrothermal Vents, p. 60 (D. M. Karl, ed., 1995); L. van Dover, *The Ecology of Deep-Sea Hydrothermal Vents*, *supra note 6*, § 5.2.1 and figure 5.2.

In contrast thereto, microbes living in the water column in or near vent sites are non-sedentary species. Accordingly, access to those microbes would be governed by the EEZ or high seas provisions.

It is obvious that the present regime leads to a fractured regulatory approach regarding management and conservation of vent field resources since many organisms fall outside the sedentary species definition. This means a severe obstacle when creating an effective management and conservation concept. A second impediment is the unclear legal regime for vent microfauna in the Area or on the high seas.

3.2 Two conflicting claims in respect to access

There exist two conflicting claims in respect to access to vent living resources on or under the seabed within the Area. First, industrial countries, biotechnology interests and access minded marine scientists take the position that access to these resources falls within the high seas freedoms in Part VII of the UNCLOS, or the freedom to conduct marine scientific research in the Area under Part XI. Therefore, the resources can be collected and captured by any private or governmental entity according to the freedom of the high seas only in regard to the interests of other States[216] and the conservation and environmental provisions in Parts VII and XII.[217]

The second claim comes from developing countries. Their argument is that the living and genetic resources of seabed vent sites within the Area should be treated as the common heritage of humankind. Consequently, all benefits are for the international community and to be shared equally.

A third argumentation supports the position that all the access and conservation issues fall outside of the existing conventional and customary law, and that customary law or new international agreements have to be developed.[218]

3.2.1 Are vent living resources beyond national jurisdiction "living marine resources" under part VII, falling under the high seas universal use principle? Or are they "resources" under Part XI falling under the common heritage regime ?

Article 87 lists the high seas freedoms valid for all States, whether coastal or landlocked. It includes the freedom of navigation, fishing, and scientific research. However, the UNCLOS does not define "fishing" or "marine scientific research".

The "inter alia" clause of Article 87 and the broad interpretations of the terms "fish" and "fishing"[219] could lead to the conclusion that vent microbe collections are included in the freedom of fishing (although States might not have had them in mind when ratifying the Convention).

Article 133(a) defines "resources" of the Area as mineral resources – no living marine resources are included. This limitation is made although Article 136 provides that the Area and *its resources* fall within

[216] UNCLOS, *supra note 118*, art. 87.
[217] Id., arts. 116-119.
[218] L. GLOWKA, Testing the Waters: Establishing a Legal Basis to Conserve and Sustainably Use Hydrothermal Vents and their Biological Communities, p. 45, InterRidge News 45 (1999).
[219] The Convention on Fishing and Conservation of the Living Resources of the High Seas (1958) extends the term of "fishing" to the harvest of fish and "other living marine resources", arts. 1, 3-5, 7.
In the United States the definition of "fish" includes all forms of marine animal and plant life other than marine mammals and birds (MSFCMA, 16 U.S.C. § 1802(7) (Supp. IV 1998); even krill has been "fished", U.N. Food and Agriculture Organization, Review of the State of the World's Fisheries: Marine Fisheries: "Southern Ocean", FAO Fisheries Circ. No. 920, available at http://www.fao.org/fi/publ/circular/c920/areax8tf.asp#AREAX8 (last visited July 2001).

the common heritage regime of Part XI. Furthermore, Article 133 does not provide an extension since no "inter alia" clause is established. A strict textual approach therefore supports the conclusion that no living marine resources fall within the common heritage regime of the UNCLOS. Nevertheless, the rules of interpretation provided by the Vienna Convention on the Law of Treaties require the analysis to go beyond the text and to examine the treaty's context and its purpose.[220]

Such an examination could help to clarify the construction of the common heritage principle.

Textual examination

When interpreting a treaty, the "context" includes the treaty's preamble.[221] The preamble to the UNCLOS supports an expansive interpretation of the CHH regime. There, an "equitable" utilization of the seas' resources[222] is desired and adds that the Convention "will contribute to the realization of a just and equitable international economic order which takes into account the interests and needs of mankind as a whole and, in particular, the special interests and needs of developing countries".[223] Referring to mineral resources, the UNCLOS certainly did that. But, interestingly, the preamble cites the Declaration of Principles resolution by the U.N. General Assembly, where "the resources" are neither defined nor limited.[224] Thus, it could be argued, that by citing the Declaration of Principles, the parties wanted to incorporate *all* of the resources into the UNCLOS. But on the other hand, while the Convention limits the CHH regime to mineral resources, it seems to be obvious, that this extent represents the consensus of the parties. This is supported by the structure of the Convention and the position of the limited CHH regime in Part XI without any direct provisions for conservation and management. A stretching of the term "resources" to living marine resources would place those resources under a regime without conservation provisions. (For the ISA exist only indirect possibilities to protect natural resources in the Area, **see Part 4 – seabed mining.**) In contrast, Part VII provides an admittedly insufficient framework for access, conservation and management of living marine resources beyond national jurisdiction.[225]

Thus, an interpretation of the text to include living resources in the common heritage of humankind regime does not seem to be correct.

Contextual arguments

Nevertheless, there are some contextual arguments for and against an expansive interpretation of the common heritage of humankind principle.

a) Are vent living resources beyond national jurisdiction "living marine resources" under part VII, falling under the high seas universal use principle?

1) The inter alia clause of Article 87 makes it difficult to exclude from the activity of "fishing" the collection of living marine resources (from vents within the Area or in the surrounding waters of the high seas) by marine scientist, or the harvest by bioprospectors. Those activities may be embraced by the freedom to capture, study, and use the living resources beyond national jurisdiction. Until now no State protested against sampling of organisms from the chimneys, and even their later biotechnological commercialisation. But it must be underlined that during the last years the

[220] Vienna Convention, *supra note 174*, art. 31.
[221] Id., art. 31(2).
[222] UNCLOS, *supra note 118*, preamble, para. 4.
[223] Id., para. 5.
[224] Id., para. 6; Declaration of Principles, *supra note 204*, paras. 1, 7 and 11(b).
[225] UNCLOS, *supra note 118*, arts. 116-119.

scientific community itself became aware how strong the impacts of their activities on vent communities are (see Part 5, management).[226]

2) Some argue that "because new technology is constantly developing, the freedoms of the high seas cannot be exhaustively listed".[227] Since in Article 87 not all ocean uses are listed, there must be an analysis whether the use is "compatible with the status of the high seas".[228] As long as the use interferes not unreasonable with the rights of others on the high seas and is not expressively excluded by the Convention, the use should be allowed as a high seas freedom.

3) To support the position living marine resources fall under the high seas freedom it could also be argued that until now no nation has restricted the right of its vessels or individuals to sample from vent sites because these resources are governed by the common heritage of humankind principle.

4) The argument that deep-sea mineral resources are exhaustible is not transferable to living resources since they appear to be renewable. But this opinion is to be handled cautiously because it refers to single collecting activities. Repeated collection of genetic material is likely to damage the variability of vent sites with their high endemism.

5) The originally broad definition of "resources" was rejected by the participants of the UNCLOS III process.[229]

6) Living marine resources collection activities at present seem not to require exclusive rights for scientists as for authorized miners with their preemptive claims to mining sites. Again it could be objected that special marine scientific resources activities like observation depend on exclusive, undisturbed zones **(Part 5, Management).**

7) Finally, the view of a positivist [230] takes the position that any expansion of the common heritage of humankind concept to living marine resources is in opposition to the long tradition of broad high seas freedoms. Only a voluntary action by States to limit the scope of those freedoms is thinkable and could produce a binding norm.

b) Contextual arguments for an expansive construction of the common heritage of humankind principle

In contrast to opinion a), the historical freedom of the high seas with regard to living marine resources is classified as wrong. A hint may be the unregulated freedom of vessels to explore and exploit high seas resources other than those dictated by the flag State. But the fifty-plus treaties instruments (conventional and customary law) for the protection of the marine environment underline "a break on unrestrained freedom".[231]

1) Preamble, paragraph 6, desires to "develop the principles embodied in" the Declaration of Principles. One writer therefore argues that the micro-organisms of the vents fall within the common heritage of humankind concept.[232]

2) The need to bring all related deep seabed resources exploration and exploitation activities under a single comprehensive regime to avoid uncertainty **(see Part 4 B)**.

3) It is questionable whether the "inter-alia"-clause of the common use principle of the high seas[233] is still up to date.

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[226] L. Mullineaux, S. K. Juniper, D. Desbruyères, *Deep-Sea Sanctuaries at Hydrothermal Vents*, p. 15, InterRidgeNews, vol. 7(1) (1998).
[227] CHURCHILL & LOWE, *The Law of the Sea* (3rd ed. 1999), p. 205.
[228] Id., p. 206.
[229] A. PARDO, *An Oppurtinity Lost*, in: The Law of the sea: U.S. Policy Dilemma 13, 22 (B. H. OXMAN, ed., 1983).
[230] What is not prohibited by positive law is permitted.
[231] D. K. ANTON, *supra note 190*, p. 361.
[232] E. MANN-BORGESE, *Governance and the United Nations*, supra note, p. 48.
[233] UNCLOS, *supra note 118,* art. 87.

4) The 1970 UN Declaration of Principles resolution extends the common heritage of humankind concept to a broader meaning of resources than the Articles 133 and 136 of the UNCLOS arguing that "there is still a place for morality in ocean politics".[234] However, there is no definition which "resources" fall within the concept. It can only be speculated that common heritage of the humankind proponents had no limitation of the term "resources" in mind. But of course, the Declaration is not enforceable law but merely a recommendation and not a binding law.[235]

5) Some argue that the common heritage of humankind concept is now a peremptory norm under international law[236], e.g. it can not be derogated by a treaty.[237] This position can be supported by Article 311(6), in which the parties of the UNCLOS state "that there shall be no amendments to the basic principles relating to the common heritage of mankind set forth in article 136…" But it is not clear how Article 311(6) promotes an expansive definition of "resources" of the Area beyond "mineral" resources (Article 136). Also the severe amendments with regard to the application of the common heritage of humankind regime through the 1994 Part XI Implementation Agreement and its support by the ratifying states weakens the argument for a peremptory norm.

3.2.2 What does the UNCLOS offer for the genetic resources of the vent organisms ?

The high risks and costs of vent site access let the public and private interests focus more likely on the genetic codes and biochemical processes of the organisms than on the biological resources directly.

But the UNCLOS provides no distinct regime for the genetic resources to govern access to exploration and exploitation nor a distinction between living marine resources and their genetic material within the Area.

The UNCLOS uses the term "living resources" only in the fisheries or conservation sense including the Area's fish and invertebrate communities existing there. Thus, it could be argued that it is broad enough to include the free living and symbiotic micro-organisms as well. Consequently, their genetic material might be included as sub-set and freely accessible as a part of the high seas regime.[238]

But there are several arguments against this conclusion which shows that the analogy is unsatisfying**:**

- The acquisition and subsequent use of these resources is different to fishing with respect to the technique, equipment or nature.
- Unlike fish, the microbial genetic resources of the Area are not harvested for consumptive uses. Instead, they are sampled, for example as part of marine scientific research in small quantities
- The micro-organisms have to be isolated and cultured before it is possible to study them. Only after substantial financial investments, research and marketing the organism and its genetic material may become economically valuable.
- In case the adequate technical, financial and human resource are available, both, the micro-organism and its genetic material, may be reproduced. Then, the Area's microbial genetic resources are not finite like fisheries. They may be used perpetually without reducing availability to other bioprospectors and commercial or non-commercial applications.[239]

[234] B. THORNE-MILLER, *The Living Ocean: Understanding and Protecting Marine Biodiversity, p. 60 (2nd edition 1999).*
[235] R. WOLFRUM, *Die Internationalisierung staatsfreier Räume*, Beiträge zum ausländischen öffentlichen Recht und Völkerrecht, Band 85, p. 345.
[236] E. MANN-BORGESE, The Ocean Circle, *supra note 156*, p. 117.
[237] Vienna Convention, *supra note 174,* art. 53.
[238] L. GLOWKA, The Deepest of Ironies: Genetic Resources, Marine Scientific Research and the International Deep Sea-bed Area, IUCN Environmental Law Centre (Paris, 4 September 1995), p. 14.
[239] Id., p. 14.

Thus, further intergovernmental review is necessary since it is questionable whether the international community wants the maintenance of the genetic material's status within the high seas legal regime.

4 Options to create a legal regime for the Area's genetic resources

The inclusion of the Area's genetic resources under the common heritage of humankind principle could secure the interests of all humanity in the Area's genetic resources. Although there exists no definition of this principle it can be described as follows:

- non-appropriation of the Area
- shared management of the Area
- active benefit sharing from mineral resource exploitation in the Area
- exclusive dedication of the Area to peaceful purposes.[240]

Besides positive aspects of such a legal regime like the insurance of the legal status of the Area's genetic resources and its conservation, there are also negative aspects like hindering marine scientific research or creating unreasonable obstacles to commercial biotechnological development.[241]

There are four options with respect to the Area's genetic resources:[242]

4.1 **To do nothing** would mean that the living marine resources remain unregulated and freely available to all exploration and exploitation interests.

a) Access minded parties may think that only without an agreement economic interests and freedom of marine scientific research would be ensured for the future. This position could be underlined by the conclusion that the present lacunae do not justify the prohibition of collection activities until a new regime is established since those activities have been conducted for decades.

b) On the other hand it is doubtful whether the industry based on the high seas freedom can exploit biological resources without international regulations. It can instead be assumed that with the start of exploitation there will be a request to the U.N. General Assembly to declare these resources as common heritage of humankind. Consequently, there will begin negotiations on an international agreement to regulate exploration and exploitation and a moratorium for their exploitation will be established as long as negotiations last.[243] Such a moratorium could cause interruptions of exploration enterprises and delay exploitation. Furthermore, additional pressure on industries is possible to make concessions without being able to observe the financial risks through prolonged interruptions.[244]

c) At the same time unregulated access might provide incentives to discover the wealth of marine biological diversity more quickly.[245] Unlimited opportunities for science, medicine and economy could be the consequence. But at the same time the risk of irreversible loss of diversity will dra-

[240] L. GLOWKA, The Deepest Of Ironies, *supra note 238*, p. 16.
[241] Id., p. 15.
[242] See D. K. ANTON, *supra note 190*, p. 367; Report of the Second Meeting of the COP to the Convention on Biological Diversity, Annex II,, Decision II/10, U.N. Doc. UNEP/CBD/COP/2/19 (Nov. 30, 1995).
[243] J. KOCH, The political-legal framework required for exploration and responsible exploitation of marine biodiversity on the high seas and in the Area, p. 1 (Entwurf), in: Ladenburger Diskurs "Marine Biodiversität/ Marine Biodiversity" (Feb. 2001).
[244] Id., p. 1.
[245] D. K. ANTON, *supra note 190*, p. 367.

matically increase. Following the precautionary approach states should establish norms for conservation before interests have vested which would make it much harder to create a legal regime. To do nothing would also "undermine any sort of interpretation of biological diversity beyond the limits of national jurisdiction as falling within the common heritage of humankind".[246]

4.2 An amendment to Article 133 of the 1982 UNCLOS, which would add both sedentary species and genetic resources of the deep seabed to the definition of "resources" of the Area.[247] This would mean the establishment of new law.

Advantages of an amendment of the UNCLOS:

- the UNCLOS provides a framework for environmental protection in Part XII
- there is already a structure for an international supervision of the conservation and sustainable use of resources
- the International Agreement Relating to Part XI of the UNCLOS can be used as a model; this "would not waste effort on reinventing the wheel"[248]
- compatible with the benefit-sharing approach contained in the CBD and the UNCLOS

Disadvantages:

- artificial separation from the terrestrial biodiversity
- an amendment could raise conflicts between the CBD and the UNCLOS
- co-ordination problems between the administrative bodies of both conventions
- amendment means the establishment of new law which takes time and needs strong efforts until the final ratification by the parties (see the negotiations on the exploration and exploitation of the mineral resources of the deep seabed and its subsoil which started 1967 and lasted until 1994)

For many parties it might therefore be easier to **adopt an annex** on the protection and sustainable use of the living and genetic marine resources within the Area. Although a new annex has also be signed and ratified by the parties like the original treaty (Article 39 of the Vienna Convention on the Law of Treaties) it might be an advantage to negotiate only about this special issue and define it anew instead of amend parts within the already existing Convention.

Above all, it has to be kept in mind that a consensus or qualified majority of the COP enables indeed the pass of an annex. But legal force by international law is only given for those States who have ratified.

4.3 A protocol to the CBD (Article 28 CBD) for the preservation and sustainable use of such resources is another alternative. Possible is a two-step framework convention and protocol approach.[249]

More difficult would be an amendment of the Convention according to Article 29.

Advantages can be:

- a unified approach to biological diversity with the possibility to oversee and manage the interactions between land and open ocean ecosystems.
- avoids two different sets of rules (CBD/UNCLOS)

[246] Id., p. 368.
[247] E. MANN-BORGESE, The Oceanic Circle, *supra note 156*, pp. 170-171.
[248] D. K. ANTON, *supra note 190*, p. 368.
[249] D. K. ANTON, *supra note 190*, p. 369.

- one administrative body
- already existing benefit-sharing provisions could be extended and adopted to the area of marine biological diversity beyond national jurisdiction

Disadvantages:

- competition to and co-ordination problems with the ISA and IMO
- takes time and needs strong efforts
- possible opposition by the United States and other states with similar interests which would be a severe obstacle to the whole process.[250]

4.4 A new agreement could be an advantage not only for interested industries.

a) International rules on the exploration and exploitation of marine biological resources provide a reliable legal basis for commercial activities. The pharmaceutical and chemical industries can adjust its plans to the rules.[251] Furthermore, an agreement could avoid emotions as raised during the negotiations on the exploration and exploitation of the mineral resources of the deep seabed and its subsoil.

b) Of course, the elaboration of the rules has to reflect the interests of the developing countries to avoid confrontations as it did in the Third U.N. Law of the Sea Conference on Deep Sea Mining.[252] Therefore, a new agreement should support the development of the common heritage of humankind concept into a customary rule of law.

Furthermore, the new agreement has to take into account the conservation and sustainable use provisions provided by the CBD regardless whether the resources are terrestrial or marine. Then an artificial separation of the biological resources can be avoided. Fundamental support comes from the environmental provisions of Part XII of the UNCLOS.

c) Administrative and institutional aspects have to deal with the subjects of a new agreement and the institutional framework.

(1) Proposals for the regulation of exploration and exploitation of biological resources have been made:[253]

- The collector of small amounts of biological resources has to inform the competent authority of their intention.
- In case the biological resources serve for the commercial development of synthesized derivates, the competent authority may be interested to participate.
- A permit by the competent authority should be necessary if someone intents to collect larger quantities and to use them for commercial purposes. For this, the authority needs sufficient knowledge for the examination of the consequences of the proposed activities.
- When biological resources are used for the production of goods the authority should be participated.
- Other issues like confidentiality of data, protection and preservation of the marine environment, access to biological resources, transfer of technology, handling of biotechnology, financial questions, inspection, enforcement, responsibility/liability/settlement of disputes have also to be addressed in the draft agreement.

Further intense discussions for the creation of regulations of exploration and exploitation of the biological resources will be necessary.

[250] Id., pp. 370-371.
[251] J. Koch, *supra note 243*, p. 1.
[252] Id., p. 2.
[253] Id., pp. 2-3.

(2) Additionally, an institutional framework has to be created for the implementation of those provisions. Three proposals have been made:[254]

- Member States have to regulate the exploration and exploitation of the biological resources of the high seas and the Area by natural or legal persons under their jurisdiction. Model: Articles 2 and 7 of the Draft Convention on the Regulation of Antarctic Mineral Resource Activities of 1988 (not in force). A commission, a scientific, technical and environmental advisory committee and a secretariat serve as inter-governmental bodies of the regime. The advantage of this alternative is that all administrative tasks are left to administrative institutions of the member States. The international institution has only to supervise the actions of the member States and, if necessary, to adopt additional rules. The main disadvantage could be the variability of ensuring compliance with the international rules between the member States caused by different administrative practices.
- The establishment of an international authority to carry out all administrative functions for the regulation and supervision of the relevant activities as well as for the enforcement of compliance with the provisions of the agreement. This model requires "an elaborated international structure capable of performing all legislative and administrative tasks necessary for the execution of the regime".[255] Advantageous would be the uniform administrative practice with respect to all operators. A disadvantage are the high costs when establishing an new international authority even though it gets fees and financial contributions from operators.
- A mixed system which provides the regulatory and administrative power to the international institution with the purpose to ensure and enforce compliance to the international institution as well as to the relevant member State. Model: Articles 139(1), 153(1) and (4) of the UNCLOS and Article 4 (4) of annex III. The International Seabed Authority (ISA) may serve as a model since it has a complete international structure with an assembly, a council, a finance committee, a legal and technical commission and a secretariat.

(3) For all three proposals an international institution is needed to implement the new agreement. Therefore, it has to be questioned whether it is possible to entrust this task to an already existing international organization. This could save money and avoid more bureaucratic weight. Two international organizations may be able to fulfil these tasks:

First, the institutions created by the CBD consist of a Conference of Parties, a Secretariat and of a Subsidiary Body on Scientific, Technical and Technological Advice. These institutions are already dealing with the subjects foreseen by the new agreement. A disadvantage is that they are only engaged with issues relating to the biological resources within national jurisdiction and do not have any administrative functions with regard to their exploration and exploitation.

[254] Id.,pp. 3-4.
[255] Id., p. 4.

Second, the ISA should be examined. It already has an organizational structure which can be complemented to be in the position for carrying out additional tasks relating to living marine resources within the Area. The Authority actually performs tasks with respect to exploration and exploitation of the mineral resources of the Area. Therefore, the second solution seems more practicable.[256]

d) There is the fear that the establishment of a new agreement would underline the inability of the parties to create the CBD to an umbrella agreement for conservation and sustainable use of biodiversity, as had been suggested by U.N.E.P.'s Governing Council.[257]

But on the other hand it must be recognized that the CBD as well as the UNCLOS can serve as umbrella agreements and precedents. This promotes the development of conventional and customary international law as has already happened with the fifty plus treaties for the protection of the marine environment. Individual treaties can be far more effective for the regulation of the issue in question.

5 Developing customary law to fill legal gaps

With respect to access to vent living marine resources the UNCLOS leaves gaps. Yet no agreement on the issues within the Convention has been reached. Since the drafters of the document (UNCLOS) recognized that the document did not cover all known legal issues, and much less the unforeseen, there are possibilities to apply other law:

- The preamble provides that general international law will govern issues not regulated by the Convention
- Article 87 provides that the high seas freedoms can be carried out under the conditions of the Convention and by "other rules of international law"[258]
- Article 311 demands for the validity of other treaties the compatibility with the UNCLOS.

A recent example to supplement the Convention is the proposed Convention on the Protection of Underwater Cultural Heritage.[259] Thus, new customary law norms should be developed through claim and response in respect to the living marine resources within the Area. Then the common heritage of humankind concept could ripen into a customary rule of law. This option seems to be more prospective than the amendment of Part XI of the UNCLOS.

6 Global and regional international regulations on the conservation and the sustainable use of hydrothermal vents within the Area

Global as well as regional regulations are desirable to ensure a comprehensive protection of vent sites. The general global regulations can be more specified by agreements at the regional level which can go into the given (political) conditions in the region in more detail. The Convention on the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention)[260] is a good example for this approach. Within the legal framework of the Law of the Sea Convention, the Contracting Parties adopted at

[256] J. KOCH, *supra note 243*, p. 5.
[257] D. K. ANTON, *supra note 243,* p. 370; United Nations Environment Programme, Governing Council: Proceedings Of The Governing Council At Its Fourteenth Session, Annex I, p. 58, U.N. Doc. UNEP/GC.14/26 (1987).
[258] UNCLOS, art. 87(1).
[259] UNESCO, Draft Convention on the Protection of Underwater Cultural Heritage, UNESCO Doc. CLT.98/CONF.202/CLD.5 (1999).
[260] Done in Paris on 22 September 1992 and replaced with its entry into force 1998 the Oslo Convention and the Paris Convention.

a regional level of more stringent measures with respect to the prevention and elimination of pollution of the marine environment and its protection against effects of human activities than are provided for in international conventions or agreements with a global scope. Similar, conventions at regional levels on the conservation and sustainable use of hydrothermal vents and related habitats like cold seeps could be created for instance by a group of Member States to UNCLOS.

PART 4 B
The Legal Status of vent activities under UNCLOS

1 Marine Scientific Research

To get a closer view of the legal status of genetic resources in the deep sea, it might be helpful to define the extent of marine scientific research. At present this activity is the "primary avenue through which the Area's genetic resources are accessed." [261] For that reason a short examination of the nature of marine research activities, their applications and the relevant Convention articles, follows.

As on the high seas, marine scientific research in the Area can be conducted by all States and competent international organisations.[262] Part XIII together with provisions in the EEZ establishes the principles, rights and obligations in respect of marine scientific research. Article 238 provides the "universal use principle" of those activities. In contrast, the Area is ruled by the principle of the benefit of humankind.[263] Differences exist also between areas within and beyond national jurisdiction: In areas under national jurisdiction access for marine researchers is limited and all activities must be in consent with the coastal State.[264] In the Area and the high seas beyond 200 NM a right to access is granted. Article 240 requires the purely peaceful conduct and compliance with all environmental protection regulations.

Since the CBD supports the UNCLOS regime when ruling access to genetic resources, the two conventions have to be taken into account together when examining marine research activities.

1.1 Nature of marine scientific research

Marine scientific research is characterized by openness, data or sample collecting, publication and dissemination of those results. These principles support human scientific knowledge and can therefore benefit humankind.[265]

In general, vent research activities can be described as follows:

- the findings are reported and easily accessible through international organisations
- they can help to increase our knowledge about geological and evolutionary processes
- they can foster the improvement of the conditions for humans on the planet
- they can support the developments of the environmental impact assessment and protection measures of the new Mining Code of the ISA
- they support the ISA in its obligations under Art. 145 (protection of the marine environment) and Art. 194(5) (identifying rare and fragile ecosystems).

Since deep sea research activities are very expensive and risky, pure scientific research may seldom exist and becomes more and more commercialised. Therefore researchers may primarily come from universities and government agencies but work at the same time for a biotechnology company. Until now no private bioprospecting at vent sites is known. Nevertheless, companies entered into agreements with univer-

[261] L. GLOWKA, *The Deepest of Ironies*, *supra note 238*.
[262] UNCLOS, *supra note 118*, art. 256.; A.C. de Fontaubert& T.S. Agardy, Critical Analysis of the Protocol on Specially Protected Areas and Wildlife to the Cartagena Convention: the Dilemma of Regional Cooperation. University of Miami Inter American Law Review 30: 85-98 (1998).
[263] Id., art. 143(1).
[264] Id. art. 246 (1), (2).
[265] A.H.A. SOONS*, Marine Scientific Research and the Law of the Sea*. pp 6 & 242-243 (1982).

sities and scientific research institutions to pay for samples of organisms collected from the sea.[266] Consequently, vent research activities can also be classified as prospecting for resources under Part XI, or exploring and exploiting living or non-living resources. It always varies with the intent and the nature of the activity.

1.2 Classification

The consequences of these uncertain classifications between pure and applied marine scientific research can be immense:

1. Art. 256 provides freedom to conduct marine scientific research in the Area (and to harvest marine living resources on the high seas and in the seabed of the Area). But mineral resource prospecting, exploration, and exploitation in the Area are controlled by the ISA.[267] Therefore the classification of the activity in the Area decides therefore about the different requirements.
2. Following the principle outlined in Art. 244, States and international organisations have to publish their findings. There is also the demand to disseminate the results of research and analysis through the Authority or other international channels in the Area.[268] But information gained through prospecting, exploring, or exploiting efforts, are generally proprietary and kept confidential.[269] To meet the different interests of the industry and the need of the ISA for data to effectively regulate seabed mining, the Authority shall not disclose data except those of reserved areas.[270]
3. The question of sovereign immunity of State-owned vessels depends on their activities. Only if they are "used on government non-commercial service" their immunity is extended. This status changes when exploring or exploiting resources. [271]
   There are far more examples to underline this aspect.

Problems are increasing since there is no definition of marine scientific research.[272] Historically there was no will of the States for a possible restriction of their activities by a precise definition. [273] Additionally, the term "biological prospecting" does not exist anywhere within UNCLOS.

It might therefore be useful to limit the extent of marine scientific research with the help of the existing regime within national jurisdiction. This could also help to minimize the conflict within the scientific research community in respect to observation and sampling.

- Article 246 provides the **distinction** between research carried out for "*peaceful purposes* and in order to increase scientific knowledge of the marine environment for the benefit of all mankind" and research "having a *direct significance* for the exploration and exploitation of natural resources". Al-

[266] A.C. DE FONTAUBERT & T.S. AGARDY, *Critical Analysis of the Protocol on Specially Protected Areas and Wildlife to the Cartagena Convention: the Dilemma of Regional Cooperation.* University of Miami Inter American Law Review 30: 85-98 (1998).
[267] LOSC, Annex III, arts. 2-3.
[268] UNCLOS, *supra note 118*, art. 143 (3).
[269] Id. Annex III, art. 14.
[270] Id. Annex III, art. 14 (3); see also Mining Code for Nodules, ISBA/6/A/18, Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area, Annex, reg. 6 & Part VI.
[271] UNCLOS, *supra note 118*, art. 96.
[272] See Id. art. 246
[273] U.N. Division for Ocean Affairs and the Law of the Sea, The Law of the Sea: Marine Scientific Research: Legislative History of Article 246 of the United Nations Convention on the Law of the Sea, 1-3, 6-7, U.N. Sales No. E. 94.V.9 (1994).

though the Marine Scientific Research Implementation Guide[274] concluded that marine scientific research *does not include* research having a "*direct significance* for the exploration and exploitation of natural resources"[275], it deleted this conclusion later.[276] But a distinction between marine scientific research and hydrographical surveys (Arts. 19(2)(j), 21(1)(g), 40) as well as between prospecting and exploration activities was accepted.[277]

Consequently, activities of direct significance for the exploration and exploitation of natural resources fall within marine scientific research. But in reality a coastal State can simply refuse access for researchers by defining the planned activities an *exploration for resources.* Exploration can be understood as an activity undertaken in respect to possible future exploitation of those resources.[278] Often it might be not unrealistic to assume that the research relates to exploration. Access has to be granted by coastal States based on the "objective facts submitted in the application" (Art. 248).[279]

It has been tried to solve the difficulties arising out of the unprecise definition of "direct significance" with arguments like:

- classification should be made after the *intent* of the researcher; but this would deny the objective evaluation demanded in the law of the sea.
- research is then of direct significance to exploration and exploitation when the results of the research have *their own, intrinsic value* and are not only of significance for further measures.[280]

Regrettably, the development of laws in respect to marine scientific research access within coastal State EEZs or continental shelves through decisions by international tribunals is not very realistic (Art. 297(2)) and will likely be governed by the unpredictable State practice.

- Also the **distinction** between *pure* and *applied* research is difficult to draw because of the period of time between collection and commercialisation. It is therefore likely that, for instance, sample collecting activities at vent sites fall under prospecting/ exploration/exploitation and not under marine scientific research. As seen within the coastal zone, States may tend to classify most research activities **not** as marine scientific research. It is likely that the same happens in the Area and most activities will not be classified as marine scientific research. To date, however, no conflicts exist between States and the ISA in respect to sampling and prospecting provisions in Part XI. Mineral sample collection seems to be still recognized as marine scientific research. But for the future it can be assumed that mineral sample collection activities fall within the ISA prospecting regime because it generally precedes the resource exploration and exploitation phases.[281]

[274] U.N. Office for Ocean Affairs and the Law of the Sea, Marine Scientific Research: A Guide to Implementation of the United Nations Convention on the Law of the Sea. (1989).
[275] Id. at 3. para. 8.
[276] Id. at 1.
[277] [16] Marine Scientific Research Implementation Guide, supra note, at 1: survey activities, prospecting and exploration are governed elsewhere in the Convention and „"could" therefore fall not under the regime of Part XIII.
[278] A.H.A. Soons*, Marine Scientific Research and the Law of the Sea* (1982), p. 59.
[279] MSR Implementation Guide, *supra note 274*, p. 12.
[280] Soons, *supra note 278*, at 171.
[281] UNCLOS, supra note, Annex III, art. 2; ISA Mining Code for Nodules, *supra note 103*, reg. 1(e).

The **disadvantage** of this development can be the restriction of the freedom of marine scientific research. Its important tasks demand a clear and uncomplicated access regime.

On the other hand the **advantages** could overweigh:

- First, as a result there may be a **distinct definition of sampling** which helps clarifying the conflicts between marine scientific researchers and prospectors. The collection of whole chimneys causes severe damages within the vent community and endemic species could be destroyed before explored by scientists. The positive aspect of a clear definition of sampling and its management by the ISA are clear guidelines for scientific researchers. Additionally, it would strengthen their position. Access would be still undetermined when constituting pure marine research (= observation), whereas mineral sampling activities fall under the ISA regime. Sustainable use of the resources by the scientists could be ensured through management measures and voluntary exchange of data.
- The forthcoming **ISA regulations on prospecting for polymetallic sulphides and cobalt crusts**[282] have the important task to lessen future conflicts between pure marine scientific research and mineral prospecting activities in the Area.[283]

  It is planned to model this new regulatory regime after that for polymetallic nodules. A general problem is the difficulty to compare polymetallic sulphides/cobalt crusts and polymetallic nodules since their nature is very different.[284] Another significant point is the occurrence of polymetallic nodules deposits to be mostly in the Area, whereas the majority of deposits of polymetallic sulphides and cobalt crusts discovered so far are located in areas under national jurisdiction.[285] Thus, potential investors will favour national regimes for prospecting and exploration what makes it "difficult for the Authority to generate interest in exploration in the Area".[286]

  The consequence is the encouragement of prospecting in the Area through the Authority while neglecting environmental issues. The proposed model clauses treat the topics of "prospecting", "size of area and relinquishment", "site-banking" and "overlapping claims". There is still no definition of "prospecting" or "marine scientific research". But to lessen the future conflicts between these two activities, a distinct definition of "pure" marine scientific research is required. Additionally, this would be far more easier than to introduce a definition into UNCLOS. Furthermore, there may be some points to be worked into the model clauses:

  - Encouragement of the position of the marine scientific researchers. The model clauses of "overlapping claims", for instance, relate only to prospecting.
  - Classification of "applied" marine scientific research under the regulations of the new code would help to solve the unclear legal status of multi-purpose research vessels. It

[282] ISA: *Considerations relating to the regulations for prospecting and exploration for hydrothermal polymetallic sulphides and cobalt-rich ferromanganese crusts in the Area*, ISBA/7/C/2 (July 2001).
[283] U.N., International Seabed Authority, Report of the Secretary-General of the International Seabed Authority under Article 166, para. 4 of the United Nations Convention on the Law of the Sea, pp. 52-54, ISA 6/A/9 (2000).
[284] ISA: *Considerations relating to..*, *supra note 282*, III.12.
[285] Id., III.13 and II.A.5 notifying that "many of the potential known mine sites are in areas under national jurisdiction, including those of Canada, Ecuador, Fiji, Japan, Papua New Guinea and Tonga. The potential known sites in the Area are located in the East Pacific Rise at 0°-13° north latitude and in the Atlantic Ocean at the Mid-Atlantic Ridge from 12° to 28° north latitude."
[286] Id., III.13.

would help to clarify positions of observers and collectors and regulate unsustainable prospecting measures.

- Enforcement of the co-operation between marine scientific research and industry/State agencies to support funding mechanisms. Only intense scientific work can generate the evaluation of impacts of mineral resource exploration on the vent ecosystems to develop and improve environmental impact assessments.
- Since there are high endemism rates at vents and since organisms will be directly killed by machinery and smothered by material settling, the establishment of marine protected areas is needed which could be laid down in the new code. In this context it has to be realized that "the long-lived vent fields that host the largest mineral deposits are likely to be the most ecologically stable and have the highest biodiversity".[287]
- Promotion of voluntary exchange of data and findings. To do so could help to lessen the fundamental conflict within the marine scientific community between openness in regard to research results and secrecy/confidence.

- The remaining problem of **sampling living marine resources in the Area** could be solved when including those resources in the already existing ISA regime **(see Part 3)**. The authority has the duty to encourage and regulate prospecting in the Area.[288] Therefore, while controlling mineral production and progresses of the prospectors, it is in the position to oversee necessary conservation and management measures of living marine resources. Those resources can be endangered when they are impacted by mining activities. The prospectors must inform the ISA of the location of the activity and submit a written undertaking.[289] They are allowed to recover a "reasonable quantity" of minerals for later testing.[290] The inclusion of living marine resources would also solve the increasing conflicts within the marine scientific research community in respect to observation and sampling biological resources. All sample activities would automatically fall within the ISA regime and be regulated according to sustainable guidelines developed by the ISA. Observers would know which rights samplers have and call for clearance in the case of conflicts. This would mean an extension of, for example, the provisions of responsibility and liability of contractors under the ISA Mining Code for Nodules.[291] This approach could be supported by the establishment of deep-sea Science Priority Areas (SPA's) independent of species, habitat or community protection[292] **(see Part 5).**

- The analysis of the nature of sampling could also help to solve the uncertainty about the **distinction between marine scientific research and harvesting living marine resources.**

  Harvesting living marine resources falls within the right to conduct marine scientific research on the high seas or in the Area. Within the Area harvesting from the seabed is free and only limited by the provisions to show consideration for the interests of other States.[293] The activity must fol-

[287] S.K. Juniper, *Background paper on Deep-Sea Hydrothermal Vents*, High Seas MPA Expert Workshop, International Academy for Nature Conservation, Isle of Vilm, Germany (Feb. 2001).
[288] UNCLOS, Annex III, art.2. The term "prospecting" has never been applied to living marine resources under UNCLOS.
[289] UNCLOS, *supra note 118*, Annex III, art. 2(1)(b).
[290] ISA Mining Code for Nodules, *supra note 103*, reg. 2(4).
[291] Id., Annex 4, Section 16.
[292] H. Thiel, *Unique Science and Reference Areas on the High Sea,* p. 98-100, in: Managing Risks to Biodiversity and the Environment on the High Sea, Including tools such as Marine Protected Areas – Scientific Requirements and Legal Aspects – (eds. H. Thiel & A. Koslow, 2001, BfN-Skripten 43).
[293] UNCLOS, Art. 87(2).

low peaceful purposes only and be carried out for the benefit of humankind.[294] The first principles for marine scientific research activities stress also the peaceful purposes of marine scientific research[295] and applies to all uses in the Area equally.[296]

Conflicts may arise out of the requirement that the research has to benefit humankind as a whole. One step towards the fulfilment of this principle, which is not defined in the convention, is laid down in Article 244 where publication or dissemination of research results is required. The researchers as part of humankind are therefore not automatically precluded from the deriving benefits.

It must nevertheless be clarified whether the findings of seabed living marine researchers after application can be claimed for intellectual property rights.

- **Intellectual property rights (IPR's)** limit the society's right to use findings and its application. Article 241 of UNCLOS seems to exclude this possibility as it provides that "marine scientific research activities shall not constitute the legal basis for any claim to any party of the marine environment or its resources". But it has to keep in mind that this provision was created to hinder exclusive access claims by the marine scientific research community over the seabed and its resources as long as no international regime (i.e. ISA) existed.[297] A second argument against the total exclusion of IPR's over the Area's living marine resources could be that Article 241 adds nothing new to the convention in respect to preclude claims to the Area's resources.[298]

  Industrialized countries try to provide patent protection to micro-organisms which

  - occur naturally
  - can be isolated and purified from their surroundings
  - can be characterized [299].

The TRIPS-agreement offers the opportunity to patent biotechnological inventions when reading Article 27(1) and (3) together.[300]

Article 27(3)(b) provides that member States have to grant patents to non-biological and microbiological inventions and processes.[301] Although there seems no direct conflict caused by the requirement that member States have to benefit humankind, there is a need to examine

- whether incentives for publication of research results or dissemination of biological material from the Area are provided by intellectual property protection

[294] Id., Art. 143(1).
[295] Id., Art. 240(a); R. Wolfrum et al. (G. Klepper, P.T. Stoll, S.L. Franck), Genetische Ressourcen, traditionelles Wissen und geistiges Eigentum im Rahmen des Übereinkommens über die biologische Vielfalt, Schlussbericht des FuE-Vorhabens "Rechtliche Analyse des Übereinkommens über die biologische Vielfalt unter besonderer Berücksichtigung der Fragen des geistigen Eigentums", BfN (Bonn 2001).
[296] Id., Art. 141.
[297] Declaration of Principles, *supra note 204*, para. 10.
[298] Soons, *supra note 278*, pp. 137-139.
[299] L. GLOWKA, *The deepest of Ironies, supra note 238*, p. 19.
[300] R. WOLFRUM & G. KLEPPER & P.T. STOLL & S.L. FRANCK, *Genetische Ressourcen, traditionelles Wissen und geistiges Eigentum im Rahmen des Übereinkommens über die biologische Vielfalt*, Schlussbericht des F&E -Vorhabens "Rechtliche Analyse des Übereinkommens über die biologische Vielfalt unter besonderer Berücksichtigung der Fragen des geistigen Eigentums", BfN (Bonn 2001), pp. 69-70.
[301] Id., p.12; L. Glowka, *The deepest of Ironies, supra note 238,* p. 19.

- how to implicate private intellectual property protection in the international property concept.[302]

Furthermore, to ensure an adequate protection of the micro-organisms at vent sites, there should be efforts to create a system similar to the already existing TRIPS-provisions concerning plant species. There, member States must ensure their protection a) through patents b) through an effective sui generis system or c) by combining these two possibilities.

1.3 Co operation

Since there exists no appropriate system to generate benefits it is necessary to examine whether the UNCLOS and the CBD co-operation-provisions adequately ensure them. This could help to outline future international co-operation provisions concerning the Area's genetic resources. A focal point would be capacity building[303] but this is not enough to ensure benefits and protection.

Both the UNCLOS and the CBD require co-operation with respect to treaty measures on the high seas and in the Area:

the UNCLOS

- Article 63 (stocks occurring…both within the EEZ and in an area beyond and adjacent to it)
- Article 118 (co-operation of States in the conservation and management of living resources)
- Article 143(1) (marine scientific research)
- Article 242 (promotion of international co-operation)
- Article 270 (ways and means of international co-operation)

the CBC

- Article 5 (co-operation of States in respect to conservation and sustainable use of biodiversity)

But in the context of seabed vent access and use, it is not clear

- what scope the duty to co-operate has and
- what kind of findings/incidents impose the duty to co-operate on all parties.

The duty to attend at conferences is not enough. A new agreement about international co-operation rules and sharing the benefits of living marine resources in the deep-sea could fill the gap. It is doubtful, however, whether an agreement could be established in time to prevent severe damages to the ecosystems in the deep-sea. Nevertheless, a recent decision by the International Tribunal for the Law of the Sea[304] may introduce a new approach of the duty to co-operate under the law of the sea. Therein the *refusal to agree* on conservation measures amounts to the *failure to co-operate* under Article 118.

1.4 The urgent need for conservation measures

The lacking of an area-based jurisdiction makes it necessary to take direct and effective measures to avoid severe damages to the biodiversity of deep-sea vents. It is doubtful whether States which are aware of the value of those vents want to rely on flag State jurisdiction which already causes severe conflicts in regard to pollution and fishing. New measures could schedule the establishment of marine protected areas, the

[302] L. GLOWKA, *The deepest of Ironies, supra note 238*, p. 19.
[303] Id., p. 20.
[304] Southern Bluefin Tuna (Australia & N.Z. vs. Japan), Order on Provisional Measures, pp. 28(1)(d), 29(1)(D), International Tribunal for the Law of the Sea (Aug. 27, 1999).

licensing of restrictions or the promotion of voluntary co-operation within the scientific and international community. These topics will be further elaborated in **part 5.**

2 Seabed Mining

Environmental studies, although incomplete, show that the impacts of seabed mining activities on the surrounding ecosystems can be substantial **(see Part 2)**.

Article 145(a) of the UNCLOS requires "particular attention" to avoid damaging effects of activities in the Area such as drilling, dredging, excavation, disposal of waste, construction and operation or maintenance of installations, pipelines and other devices related to activities.

The Regulations on Prospecting and Exploration of Polymetallic Nodules in the Area[305]

- require the ISA to establish and develop environmental rules, regulations and procedures to ensure reliable protection for the marine environment from harmful effects of activities in the Area
- provide that every contract for exploration shall require the contractor to gather environmental baseline data
- provide that the contractor establishes environmental baselines to reduce the likely effects of his activities under the plan of work for exploration on the marine environment and a programme to monitor on such effects
- require the contractor to co-operate with the Authority and the sponsoring State in the establishment/implementation of such monitoring programmes
- require applicants for approval of a plan of work for exploration to describe a programme for oceanographic and environmental baseline studies to enable an assessment of the potential environmental impact.[306]

To develop these insufficient procedures and to be better able to predict and manage effects on the activities, the Legal and Technical Commission prepared draft guidelines for the assessment of the possible environmental impacts arising from exploration of polymetallic nodules in the Area:[307]

a) Six groups of baseline data requirements expect the contractor to set up the environmental baseline in the exploration area.[308] Thereby it is realized that the seafloor biological community is most impacted by seabed mining.[309]

b) For activities which cause serious harm to the marine environment an environmental impact assessment (EIA) is required.[310] A monitoring programme during and after the activity is planned. It is doubtful, however, whether these obligations are sufficient to prevent serious harm to vent communities. The EIA process seems to start too late and could therefore be ineffective when decisions have been reached tentatively only. And as long as EIA's only react to and never avoid activities there is a need to provide precautionary measures at least for selected vent sites **(see Part 5).**

It is therefore important to notice that the ISA has the authority to disapprove areas to be exploited "in cases where substantial evidence indicates the risk of serious harm" [311] to the environment and to issue

[305] ISBA/6/A/18 (July 2000).
[306] Part XI Implementation Agreement, supra note, § 1, 7 (1994).
[307] ISBA/7/LTC/1/Rev.1 (July 2001).
[308] Id., part III and Annex I.4.
[309] Id., Annex I.9.
[310] Id., part IV.B.10 and Annex I.12.
[311] UNCLOS, *supra note 118*, art. 162(2)(w)(x).

emergency orders, which may include orders for the suspension or adjustment of operations. Although the phrase "only in cases where substantial evidence indicates the risk of serious harm" can be read as a refusal of the precautionary approach, the ISA Mining Code expressly incorporates this approach.[312] Furthermore, because active vent sites are "rare and fragile ecosystems" [313], it should not be too difficult to prove "substantial evidence" of "the risk of serious harm" of exploitation activities. When reading the Articles 145, 162 and 194(5) together, there seems to be a strong obligation to the ISA to place active vent sites outside mining exploration and exploitation activities in case of substantial evidence of endangering the vent community. This would be an easy and effective way to protect special vent sites.

A problem may arise concerning the most interesting sites for commercial uses. Because of their size and long-term genesis they often posses the highest biodiversity rates. It will be very challenging for the UNCLOS regime (for protection of the marine environment) to react to the increasing marine biotechnology applications.

[312] ISA Mining Code for Nodules, *supra note 103*, reg. 31,2, s.1: "In order to ensure effective protection for the marine environment from harmful effects which may arise from activities in the Area, the Authority and sponsoring States shall apply *a precautionary approach*, as reflected in principle 15 of the Rio Declaration, to such activities."

[313] UNCLOS, *supra note 118*, art. 194(5).

Part 4 C
The Legal Status of vent resources and activities under the Convention on Biological Diversity

The CBD is designed to „enhance and complement existing international arrangements, including UNCLOS, for the conservation of biological diversity and the sustainable use of its components“.[314]

A component of biological diversity are genetic resources with “actual or potential value”.[315] However, their legal status within the Area is neither defined nor changed by the CBD. Parties have no right to implement Convention provisions applicable to the components of biological diversity. According to Art. 4 (a) CBD exist therefore in areas beyond national jurisdiction no obligations concerning access and sharing of benefits similar for use of areas under national jurisdiction.

Two approaches of the CBD could help to explain its application to vent resources and the harmonization with UNCLOS: First, the ecosystem approach, second the zonal perspectives and the resulting different treatment of issues. A fundamental problem when observing the CBD provisions is the narrow economic view in respect to the value of the biological diversity. Only preamble 1 is expressing consciousness “of the intrinsic value of biological diversity and of the ecological, genetic, social, economic, scientific, educational, cultural, recreational and aesthetic values of biological diversity and its components”. To this approach far more attention has to be paid when examining access and benefit sharing of the living marine resources.

1 Ecosystem approach

The ecosystem approach of the CBD implies to find a balance between the three objectives of the convention: Conservation, sustainable use and sharing of the benefits. All of the three following aspects should therefore be taken into account equally.

1.1 Conservation

According to Art. 2, the CBD intends to conserve diversity within species, among different species, and of ecosystems. The vent communities are unique ecosystems since they vary in genesis, extent and community composition. Until now there is little known about diversity among vent species. It is estimated that up to ninety percent of those species are endemic.[316] Especially these species have to be protected consequently. This endemism together with the precautionary principle of the CBD requires to adopt a conservative approach to the living marine resources of vent fields.

Furthermore the genetic diversity particularly within microbial species is largely unknown. Therefore in-situ and ex-situ conservation measures are needed. As happened with terrestrial hydrothermal microorganisms, they are often the only source for research purposes and commercialisation when cultured and banked.[317] However, data or genetic material collections for scientific purposes are often incomplete or

[314] CBD, *supra note 122*, pmbl, para. 22.
[315] Id. , art. 2.
[316] VAN DOVER, *Ecology of vents*, *supra note 6*, p. 313.
[317] L. M. WARREN, The Role of Ex Situ Measures in the Conservation of Biodiversity, in: International law and the conservation of biodiversity (1999), pp. 129, 135.

badly managed.[318] Since marine scientists at the moment are most frequently active at vent sites they are already aware of the importance of conservation initiatives. The aim must be a full implementation of data and sample sharing programs after the model of InterRidge and other organizations. Better access to vent resource banks and cultured micro organisms for scientists could limit the uncontrolled collecting and bioprospecting activities. Problematic in this respect is the lack of funding for the implementation work within the marine scientist community.

1.2 Sustainable use of the vent living and genetic marine resources

Marine scientific research and collection activities at vent sites should be sustainable. Since we have small knowledge about colonization and the role of vent fields as faunal "highways", sustainable use of biological resources is urgently required. The international community must be able to survey the consumptive and non-consumptive uses of vent fields to evaluate their impacts. Until now, sustainability is not ensured since the technology to synthesize metabolites or cultivate micro-organisms is not far developed. Unsustainable harvests and the threat of whole ecosystems are the consequences. Therefore, parties must examine the effect of the precautionary principle of the CBD preamble. So far as long as there is uncertainty about the possible impacts of activities to vent biodiversity, it can be a justification for parties to take no measures to minimize them.

1.3 Fair and equitable access to vent living and genetic marine resources

The SBSTTA Bioprospecting Report stated that in the United States more than half of the scientific research institutions collaborated with companies. In Japan up to eighty percent of marine biotechnology is supported by private industry.[319] This linkage between the public and private sector and the increasing possibility of commercial applications of living marine resources, demonstrate the importance of the fair and equitable access provisions incorporated in the CBD.

To protect their living or genetic resources many coastal States will implement the prior informed consent regime including benefit sharing.[320] This will exceed the consent regime for marine scientific research of UNCLOS which only applies to "pure" research (Art. 252). Accordingly, within coastal zones or on continental shelves, researchers will have to modify their intentions to get access to the resources. Since in the Area no such regime exists direct measures like new agreements or voluntary management by the community are necessary.

2 The zonal approach

This approach provides nations sovereignty over genetic resources within national jurisdiction (Art. 15(1) CBD). States can therefore limit access and use of those resources.

1. Within national jurisdiction the CBD is applicable to

- the components of biological diversity and
- the processes and activities which may affect biological diversity.

[318] Conservation of Biological Diversity Background and Issues: *Report of the Secretary General*, U.N. GAOR, 3rd Session, U.N. Doc. A/CONF.151/PC/66.

[319] *SBSTTA Bioprospecting Report*, Second Meeting, *Bioprospecting of genetic resources of the deep seabed*, UNEP/CBD/SBSTTA/2/15 (1996), p. 40 (therein. R.A. ZILINSKAS et al., *The Global Challenge of Marine Biotechnology : A Status Report on the United States, Japan, Australia, and Norway).*

[320] CBD, supra note 122, art. 15 (4), (5).

The CBD offers no defined distinction between "components" and "processes and activities".[321] Components of biological diversity can for instance be plants, animals, microbial organisms, their genetic material and the ecosystems. Marine "activities" are limited to those activities which (possibly) have significant impacts on biodiversity.[322] Included may therefore be vessel navigation, marine scientific research, prospecting, exploration, exploitation, dumping and tourism **(see Part 2)**. The CBD does not refer directly to these activities, not even scientific research or sampling. Instead, UNCLOS governs access to coastal State waters for marine scientific research or living marine resource collections. Only as far as these activities touch the CBD's provisions for fair and equitable access to genetic resources, the two conventions must be read in conjunction. Since there is no reference to marine activities, there exists no, for example the most urgent needed, distinction between marine scientific research and bioprospecting in the CBD.

2. In respect to "processes and activities", the CBD extends the obligations of the parties beyond national jurisdiction (Art. 4(b) CBD) where the contracting party has jurisdiction and control. Therefore they have to ensure, for example, that activities within their jurisdiction and control cause no environmental damages to other States or areas beyond their jurisdiction.[323]

Article 4(b) raises issues concerning activities of vessels of flag States outside of national waters. As provided in UNCLOS[324], flag States have exclusive jurisdiction over such vessels. Expansive interpretations of the CBD-Article argue that "processes and activities" funded by a government or supported by a license and carried out under the "control "of a State, fall automatically within State's control. In case of government funded research activities with their vessels in the Area, the State could then claim property rights over the living marine resource findings ignoring the common heritage principle. States, which have a very extended view of their jurisdiction over vessels on the high seas[325] could tend to interpret the jurisdictional frame of the CBD in waters beyond national jurisdiction even broader. There is therefore urgent need to develop international law to protect marine biodiversity outside national jurisdiction, particularly at seabed vent fields in the Area.

Possibilities to develop customary law and precedents as well as measures to ensure sustainable use and protection of living marine resources and their ecosystems will be examined in **part 5**.

3. In this context the CBD issue of "fair and equitable" sharing of the benefits from potential exploitation of the components of biodiversity is of interest. The declaration of genetic resources as "common heritage" of humankind was rejected and instead biodiversity declared as "common concern".[326] Furthermore, the provisions of access to genetic resources (Art. 15 CBD) are limited to resources within national juris-

[321] D. ANTON, *supra note 190*, pp. 356-357.
[322] L. GLOWKA, Deepest of Ironies, *supra note 238*, p. 171; art. 7 of the CBD.
[323] CBD, *supra note 122*, art. 3.
[324] UNCLOS, *supra note 118*, art. 92 (1).
[325] For example the United States with its High Seas Fishing Compliance Act, 16 U.S.C. § 5502(10) (1994 & Supp. IV 1998) and MSFCMA, 16 U.S.C. § 1802(44) (1994) adopting the broad definition of jurisdiction over vessels in the Maritime Drug Law Enforcement Act, 46 U.S.C. § 1903(c) (1994).
[326] CBD, *supra note 122*, preamble, para. 3; L. GLOWKA, F. BURHENNE-GUILMIN, H. SYNGE, *A guide to the Convention Biodiversity Diversity,* Environmental Policy and Law Paper No. 30, IUCN (1994), p. 3.

diction. Since no State has sovereignty over living marine resources of the high seas or in the Area, there is no basis to force any State to share benefits.[327]

The SBSTTA commented that "it is unclear whether, or how, UNCLOS, of the common heritage principle, applies to the genetic resources of the deep seabed" and that "there needs to be an in-depth study on how to best address the use of these resources".[328] Since the UNCLOS regime for the Area's resources is very precise and both conventions offer very little to minimize potential use conflicts and threats, it could be assumed, that the SBSTTA prefers a revision to Part XI of UNCLOS including living and genetic resources of the Area in the "common heritage" regime.

[327] L. GLOWKA, Testing the Waters, *supra note 218*, p. 50; D. Anton, supra note, p. 360.
[328] SBSTTA Bioprospecting Report, *supra note 319*, p. 1.

Part 5
Management and Protection of hydrothermal vent sites

1 Threat management

There exist several potential and even actual threats to the biodiversity of the vent fauna and their habitats through human activity (see part 2). Effects and damages on these ecosystems have already been reported[329] and the extinction of some species could become realistic. Thus, immediate measures have to be taken to manage activities at, exploitation of and access to the vents sites. However, the management of all of the world's hydrothermal vent sites in the oceans is not achievable. Moreover, legal measures have to be established and special sites have to be identified to ensure the reasonable (sustainable) use of sites and at least a profound conservation of some of them. To reach this goal, further knowledge of the exceptional ecosystems at vent sites, their populations and spatial scales, ecological dynamics and life cycles has to be gained. Consequently, scientific research has to be supported but at the same time proper managed regimes for the conservation of the sites have to be ensured. In general, a long-term decline in diversity due to human activities has to be strongly prevented.

1.1 Environmental Impact Assessment

An Environmental Impact Assessment (EIA) can provide an objective and controllable basis in respect to the development of a management plan. Furthermore, it can make the decision easier whether management is needed or access has to be restricted. Meanwhile the ISA is drafting a code of conduct for environmental assessment in areas where polymetallic sulphides and cobalt crusts are expected.[330] In general an EIA with respect to new initiatives at hydrothermal vent sites should include standard criteria similar to other EIAs of marine habitats, like:

- Characterisation of the type of disturbance
- Estimation of the percent loss of seafloor vent habitats. Further information about the nature and biodiversity of these habitats is required.
- Identification of affected seafloor organisms. Especially species with a narrow distribution have to be managed more carefully to ensure their survival.
- Dose-response characteristics of plume fallout has to be determined since especially sessile vent organisms can be severely disturbed by particular plumes and sediment fallout.[331]

In addition, science, mining or tourist activities could be divided after their impact. The Antarctic Treaty Protocol on Environmental Protection[332], for example, identifies in Article 8(1) the activities on the Antarctic environment as having:

a) less than a minor or transitory impact;

b) a minor or transitory impact; or

[329] L. MULLINEAUX, S. K. JUNIPER, D. DESBRUYÈRES, *Deep-Sea Sanctuaries at Hydrothermal Vents: A Position Paper*, p. 15, InterRidge News, Vol. 7(1) (1998).

[330] ISBA/7C/2, Considerations relating to the regulatons for prospecting and exploration for hydrothermal polymetallic sulphides and cobalt-rich ferromanganese crusts in the Area (July 2001).

[331] InterRidge, *Management of Hydrothermal Vent Ecosystems,* p. 9, in: Report from an InterRidge Workshop, Institute of Ocean Sciences, Sidney (Victoria), B.C., Canada, (28-30 September, 2000).

[332] Text in: BGBl. 1994 II, 2478; ILM 30 (1991). The 25 members to the protocoll (in 1999) are all parties to the Antarctic Treaty (1959), text in: UNTS 402, 71.

c) more than a minor or transitory impact.

Only activities of step a) can be carried out immediately. An activity with an impact described under c) requires an EIA (Article 3 of Annex 1). There, direct and non direct environmental impacts have to be included as well as alternatives and possible measures to minimize those impacts. Each party is allowed to carry out the planned activities only after a complete assessment of the environmental impacts (Article 4 of Annex 1) and has to supervise the effects of the activity in question. Thus, the procedures set out in Annex 1 of this protocol provide measures for a substantial planning and management process.

Consequently, an EIA for human activities at hydrothermal vent sites (as well as at cold seeps and pock-marks) could be designed to be an instrument of preventive environmental protection which appraises and evaluates various alternatives and then makes recommendations. Nevertheless, besides this instrument strict liability provisions have to be adopted since in reality an EIA only reacts and seldom can prevent severe damages caused by human activities. In EIA-procedures also cumulative effects of smaller projects should be taken into account. When developing the legal framework for EIA it should also be made sure that large projects cannot be divided into several smaller ones, each individually being of minor impacts and thus not requiring extensive EIA or mitigation measure

1.2 Environmental liability provisions

Until now, international law rarely provides a contractual regime of environmental liability. In case of border passing environmental damages liability is a question between the causing and the victim State or between the private operator and the private injured party on the basis of civil law endangerment liability.

Concerning the Area regulated by the common heritage of humankind regime the question arises what kind of liability regime should be established since no State may claim property rights. An example can be the Convention on the Regulation of Antarctic Mineral Resource Activities (CRAMRA).[333] Article 8(2) provides a civil law endangerment liability of the operator in case of not only insignificant environmental damages. Furthermore, the sponsor State is liable when there is proof that its neglected in duties with respect to the damages caused by an operator.[334] Unfortunately it is doubtful whether this convention will ever come into force.[335]

One step further goes the regime on environmental liability of the draft "Annex on Environmental Liability" to the Antarctic Treaty Protocol on Environmental Protection. Here the operator is obliged to precautionary measures to prevent damages. In case of a significant environmental damage, the operator is liable after the principles of endangerment liability. Are there "unrepaired damages" the operator has to pay a compensation in a fond. Is it not possible to get compensation by the operator, the State has to pay for the environmental damage when he neglected its duties of supervision of the operator active in the Antarctic.

With respect to the (potential) human activities at the sensible hydrothermal vent sites similar environmental liability provisions should be developed.

[333] CRAMRA, June 1988; text in: ILM 27, 1988, 868.
[334] Id., art. 8(3).
[335] R. WOLFRUM, C. LANGENFELD, Umweltschutz durch internatonales Haftungsrecht (1999), p. 96.

1.3 The identification of critical and sensitive sites

Since the management or protection of all hydrothermal vent sites seems to be unrealistic, criteria for the identification of sites that are

- of critical importance or
- particularly sensitive to disturbance because of their scientific value or their significance for species survival

were developed.[336]

The following questions shall thereby help to recognize the need for management or restriction of human activities in a vent field using the terminology from the UNCLOS and the CBD:

Concerning threatened and endangered species

- Is there a high degree of endemism ?
- Are there unique species present ?
- Do the affected species have restricted geographic distribution or recruitment potential ?

An endangerment to endemic species or unique biological and evolutionary traits can argue more strongly for taking measures to avoid species extinction.

Concerning rare and fragile ecosystems:

- Is the site unusually long-lived ? Since hydrothermal vents are relatively short-lived, long-lived vent sites are rare ecosystems. But there is evidence that biodiversity is greatest at larger and older hydrothermal sites.[337] At the same time, these sites may have large accumulations of sulphide deposits and will therefore be prime targets for mining.
- Is there high species diversity ? Unusual species diversity implies more interactions within the ecosystem. It is still not clear whether this makes an ecosystem more or less vulnerable to disturbance. However, unusually diverse and complex vent ecosystems can be considered as rare.
- Is there high genetic diversity ? In this context it has to be noted that studies are still too incomplete to permit a ranking of vent sites according to the genetic diversity of even their most common species.
- Is there unusually high environmental diversity ? Higher species diversity is often a result of an exceptional diversity of habitat in a vent field.
- Are there unique ecological interactions ? Besides the unusual interactions between prokaryotes and macrofauna and geochemical features, there are sites with truly unique interactions. An example is the diverse bacterial mat growth on the hydrocarbon rich sediments of the Guaymas Basin vents in the Gulf of California.[338]

Other criteria:

- Is the site of exceptional scientific value ?
- Is the site particularly valuable for education ?

[336] InterRidge, *supra note 6*, p. 10.
[337] V. TUNNICLIFFE, A. G. MCARTHUR, D. MCHUGH, *A biogeographical perspective of the deep-sea hydrothermal vent fauna.* Adv. Mar. Biol. 34, 353-441 (1998).
[338] InterRidge, *supra note 6*, p. 11.

1.4 The management of scientific activities (deep-sea sanctuaries)

Biological research at deep-sea hydrothermal vents made remarkable discoveries like new sites, novel organisms and unusual adaptations. But at the same time the third decade of biological research shows that certain research activities are incompatible, and that more co-operation and co-ordination will be required in order to resolve potential conflicts. The main issue is the incompatibility of monitoring at undisturbed vents with the study of processes by manipulating the system or collecting parts of it.[339]

Since the management of research activities at vent sites in the near future will be voluntary, mechanisms are required to facilitate communication and encourage participation at all levels. The need for a central clearing-house for information about research plans is prior to management and conservation. It was proposed that the InterRidge Office could fill this gap since with its membership and infrastructure it reaches the majority of the ridge scientists.[340]

Furthermore, it could contact regularly national ridge research programmes, vessel operators and, in case of the establishment of marine protected areas, management committees. Agencies and scientists should constantly provide new information to the clearing-house to ensure its actuality and an effective voluntary management. Of course, here arises the conflict between the free exchange of research information and the motives of other scientists who do not share their discoveries due to their combating goals. Moreover, the effect to promote ridge crest research through international co-operation as provided by the InterRidge Office (or another clearing-house) could support a voluntary management database without the need for substantial new resources. However, "the greatest challenge will be to obtain community co-operation in keeping the database up to date, and in respecting any management guidelines, zoning or reporting requirements that might be developed."[341]

In addition, voluntary participation in management programmes should be realized through the following three approaches to combine the interests of observers, experimentalists and collectors[342]:

- Exclusive use

  Some scientists favour the concept of deep-sea hydrothermal vent sanctuaries for long-term observations. Especially studies of the relationship between community dynamics and post-eruptive or longer-term evolution of vent systems are sensitive to anthropogenic disturbances. As long as the research community is small, e.g. at the vent sites at 13°N and 9°50'N, both at the East Pacific Rise, informal communication and co-operation is easy. But the successful management of the majority of vent sites requires a global network of sites and formal mechanisms for protecting observational studies. Thus, the research community recommends ways to facilitate a fair and equitable process for establishing ecological reserves regulated entirely by consensus:[343]

  - Investigators should make a formal proposal to the community, e.g. through the InterRidge Steering Committee (and the InterRidge web site), for temporary exclusive use of a

[339] L. MULLINEAUX, S. K. JUNIPER, D, DESBRUYÈRES, *Deep-Sea Sanctuaries at Hydrothermal Vents : A Position Paper,* in: InterRidge News, vol. 7(1), p. 15 (1998).
[340] InerRidge, *supra note 6*, p. 23.
[341] Id., p. 23.
[342] Id., pp. 23-24.
[343] L. MULLINEAUX, S. K. JUNIPER, D, DESBRUYÈRES, *supra note 340*, pp. 15-16 ; see also the hydrothermal vent sanctuaries web page: http://www.lgs.jussieu.fr/~intridge/sanct.htm

site. The research community would then comment on the proposal and a formal recognition by the Committee could follow.[344]

- Pressure on the popular vent sites can be relieved by identification of new vents in form of exploratory dives during cruises near the protected areas. Then, fresh material for physiological and biochemical studies could be provided.

- Pilot Management and Zonal Projects

  The establishment of pilot management plans for frequently used areas, e.g. Lucky Strike or 9°N EPR, would include a zoning of different research activities. A positive effect could be an improved communication between researchers and groups through site-specific workshops.[345]

- Sample Redistribution

An international sample-sharing programme would reduce the high costs of obtaining samples and the impact of sampling on vent communities. However, until now voluntary reporting of sample collections or laboratory inventories is very low. Therefore it was suggested to publish "wish lists" of scientists to enable the investigators to make greater use of the collected material. New collaborations could particularly support those scientists who are not participating in oceanographic expeditions.[346]

Furthermore, to prevent disposals of waste products in one or more scientific high intensity areas, the designation of Unique Science Priority Areas (USPAs) has been made for the Northeast Atlantic.[347] This category would complete the IUCN concept of Preservational Reference Areas (PRAs) and Impact Reference Areas (IRAs).[348]

1.5 Further recommendations for the management of vent sites

- According to the UNESCO Biosphere Reserve approach, the zoning of hydrothermal vent systems could be envisioned. The three zones could be:
  - A strict protection area available only for non-invasive observational research
  - A buffer zone where research and activities with insignificant impacts could take place
  - A transition zone where seabed mining could take place
- The Russian example of mixing tourism with science could be encouraged. Those "teacher at sea" programmes may increase public awareness without having great environmental impact.[349] So far this type of activity is rare because costs involved are prohibitively high. Some journalists or other prominent "multipliers" may also be brought to the sites to get more public attention. But before extensive increase of such activities occur, an EIA should be performed and made available in the public.
- A "*code of conduct*" for users could be an effective measure to minimize conflicts concerning environmental impacts. At the national level incentives for marine scientists or peer pressure may encourage to comply with this code. The International Oceanographic Commission should adopt

[344] InterRidge, *supra note 6*, p. 24.
[345] Id., p. 24,
[346] Id., p. 24.
[347] H. THIEL, *Unique Science and Reference Areas on the High Sea,* p. 98-100, in: Managing Risks to Biodiversity and the Environment on the High Sea, Including tools such as Marine Protected Areas – Scientific Requirements and Legal Aspects – (eds. H. THIEL & A. KOSLOW, 2001, BfN-Skripten 43).
[348] PRAs serve as a reference area for the natural community development in undisturbed regions. In IRAs the community development after severe disturbance by polymetallic nodule mining is monitored.
[349] Id., p. 25.

the code to emphasise its international significance. The code might include recommendations/requests like[350]:

- The investigation of on-going research before starting new research activities
- The information to international and national agencies about cruise dates
- The contact to other users
- The avoidance of activities that cause the decrease of biodiversity or the long-term decline of resources
- The co-ordinated use with other researchers
- The insurance of the efficiency in sampling.

2 High-seas marine protected areas (MPAs)

Marine protected areas are emerging as flexible, targeted alternative to traditional management measures.[351] They provide a framework in which uses can be regulated. Additionally, within a single MPA different uses and levels of use can be organised (see for example the largest MPA, the Great Barrier Reef Marine Park). Thus, a whole ecosystem can be managed instead of a single species or a mineral resource and vulnerable habitats like the hydrothermal vents could be protected. MPAs can also help the precautionary principle to emerge, a new principle of international law whose implementation is somewhat at random. It can be interpreted as follows:

- The absence of scientific information is no excuse for inaction in curtailing harmful activities, and
- the new user of a resource has to prove that the intended uses will not cause severe damages to the resources.[352]

Through the restriction or prohibition of uses the MPAs provide for the protection of the resources even when clear impacts can not be identified or when it is not sure what use would be sustainable. On one hand an MPA would restrict the use of a high sea resource but at the same time it would conserve the resource. On the long term the conservation measures impact will out weight the short benefits from unrestricted and uncontrolled resource use.

To date, MPAs have only in exceptional cases established on the high-seas. The reason for this is the inherent nature of international law, thus, no State is bound to restrictive regulations on the high-seas unless it is willing to do so. Beyond national jurisdiction, no single State or authority can designate a MPA, adopt and enforce management measures. This would always be an interference with the regime of the high-seas, unless tolerated by all States.[353] Nevertheless, a number of States are interested in exploring the possibilities of MPAs on the high-seas because they are aware of the failure of traditional measures. But because MPAs tend to provoke negative reactions of some States, MPAs should be the ultimate means to protect certain features and "shall be requested only, if other measures, such as fisheries management, pollution control, rules, regulations and procedures adopted by the International Seabed Author-

[350] Id., p. 26.
[351] See generally: T. S. AGARDY, *Marine Protected Areas and Ocean Conservation,* Environmental Intelligence Unit, Academic Press (1997).
[352] WWF/IUCN/WCPA*, supra note 9*, p. 74
[353] R. PLATZÖDER, *The United Nations Convention on the Law of the Sea and Marine Protected Areas on the High Seas,* in: Proceedings of of the Expert Workshop held at the International Academy for Nature Conservation; Isle of Vilm, Germany (27 February – 4 March 2001), p. 139.

ity, or an envisaged Code of Conduct for Marine Scientific Research, would be ineffective or would not serve the purpose otherwise".[354]

In October 2000, IUCN adopted the Amman Resolution on the High-Seas MPAs with the purpose to conserve marine biodiversity. Therein, the creation of a representative system of marine protected areas at regional and global scales is demanded.[355] However, only the action and co-operation of some States willing to restrict their own uses on the high-seas, will support the evolution of the existing regime and the fuller incorporation of the precautionary principle and the ecosystem approach. But the positive effects of those actions will always be severely limited unless the main users in the area do co-operate.

2.1 The current international legal regime of MAPs

The conventional international law instruments and soft law principles concerning marine protected areas are diverse, inconsistent and ambiguous. Several papers on this subject were presented at the Vilm Meeting of Experts on High-seas MPAs.[356] Therefore in the following only a listing of the instruments and principles is given:

- World Conservation Union (IUCN) principles
- UNCLOS provisions
- Chapter 17 of the Report of the United Nations Conference on Environment and Development (UNCED) – Agenda 21
- Convention on Biological Diversity (CBD)
- International Maritime Organisation (IMO) Guidelines for the Designation of Special Areas and the Identification of Particularly Sensitive Sea Areas

Besides these instruments of globular scope, regional approaches such as the UNEP's Regional Seas Programmes have evolved.

Furthermore, the development of customary international law shows the willingness of States to set wide areas of the high seas aside in order to restrict at least some activities. For example, under the International Whaling Commission, two sanctuaries were designated on the high-seas with the idea to restrict a single use (whaling) or ban it completely. Of course, it has to be noted that some States expressed their refusal. On the other hand it stresses the possibility that a community of nations bind itself under international law even if not all States share the intention.[357]

Notwithstanding the diverse content of conventional law instruments and soft law principles, there is ample support for the general concept of marine protected areas both within and beyond national jurisdiction. The protection of marine areas beyond national jurisdiction by means of international co-operation is contemplated in Chapter 17 of Agenda 21. The Convention of Biological Diversity stresses the establishment of protected areas as the principal measure for conserving biodiversity within national jurisdiction. Beyond national jurisdiction, Contracting Parties are not explicitly obliged to co-operate to establish

[354] Id., p. 140.
[355] WWF/IUCN/WCPA, *supra note 9,* p. 76.
[356] H. THIEL, J. A. KOSLOW (eds.), *Managing Risks to Biodiversity and the Environment on the High Sea, Including Tools such as Marine Protected Areas –Scientific Requirements and Legal Aspects-,* in: Proceedings of the Expert Workshop held at the International Academy for Nature Conservation; Isle of Vilm, Germany (27 February – 4 March 2001)*;* see for instance the papers submitted by V. KOTLIAR, R. PLATZÖDER, R. WARNER.
[357] WWF/IUCN/WCPA, *supra note 9*, p. 86.

such areas. Article 5 of the Convention only requires to co-operate for the conservation and sustainable use of biological diversity in areas beyond national jurisdiction. At the regional and national level, the implementation of MPAs and the accommodation of protective measures with other ocean uses may offer precedents. The IMO Guidelines for the Identification of Particularly Sensitive Sea Areas provide a template for international endorsement of protected areas of ocean space. It is important to note that the application of the criteria is not limited to areas within national jurisdiction. Above all, the designation of marine protected areas should be consistent with the Law of the Sea. In this context it has to be noted that the UNCLOS regime is not static and could be build upon (the 1995 Fish Stocks Agreement, various Regional Seas Conventions) or even amended (the 1994 Agreement on deep-sea mining) when it is inadequate.

2.2 A future international legal framework for MPA's beyond national jurisdiction

At present no single conventional law instrument or set of soft law principles exists which defines the international law basis for declaring marine protected areas beyond national jurisdiction or provides a system for global identification for such areas and mechanisms to implement their protection.[358] To achieve this objective, elements from different law sources have to be drawn together and amplified. This would result in an global agreement which implements the relevant provisions of the CBD and is consistent with the framework of the UNCLOS. It is suggested that upon this a network of subsidiary agreements is built. Therein States together with regional organisations could manage particular areas beyond national jurisdiction.[359] The IMO Guidelines provide a vehicle for the implementation of such an instrument if they would be extended to areas beyond national jurisdiction. Regional governments close to environmentally sensitive areas beyond national jurisdiction could propose those areas for identification by IMO and enforce protective measures at the regional level. Furthermore, the collaboration between IMO and, for example, the International Seabed Authority, the International Whaling Commission and FAO should be examined to expand the protective measures.

Furthermore, a legal and scientific challenge will be the clear and comprehensive definition of MPAs with respect to hydrothermal vents. Although definitions of MPAs[360] and Particularly sensitive sea areas[361] exist already, the lack of knowledge about hydrothermal vent fields and the difficulty of an exact classification of the fauna and their genetic components (see part 3) are obstacles for a satisfactory definition. Thus, understanding how new vent fields are colonized, and the possible role vent fields may play as "highways" for the oceanic seabed fauna, will be essential for a sustainable management of vent field

[358] R. WARNER, *Marine Protected Areas Beyond National Jurisdiction – Existing Legal Principles and Future Legal Frameworks,* in: Managing Risks to Biodiversity and the Environment on the High Sea, Including tools such as Marine Protected Areas – Scientific Requirements and Legal Aspects – (eds. H. THIEL & A. KOSLOW, 2001, BfN-Skripten 43), p. 167.

[359] Id., p. 167.

[360] See D. CZYBULKA, *The Convention on the Protection of the Marine Environment of the North-East Atlantic,* in*:* Managing Risks to Biodiversity and the Environment on the High Sea, Including tools such as Marine Protected Areas – Scientific Requirements and Legal Aspects – (eds. H. THIEL & A. KOSLOW, 2001, BfN-Skripten 43), p. 183-184; this definition is based on Art. 192, 194 para. 5 UNCLOS, and Art. 6 and 8 CBD as well as on Art. 2 para.1 in connection with Annex V of the OSPAR Convention.

[361] R. WARNER*, supra note 359*, p. 160: "areas which need special protection through action by IMO because of their significance for recognized ecological or socio-economic or scientific reasons and which may be vulnerable to damage by maritime activities."

resources. For instance, it is suggested to define MPAs by water circulation patterns where larvae are transported by the component currents.[362] Other proposals may follow.

2.3 Political obstacles

Since there exists no centralised, overarching jurisdictionally authority that could impose measures on States on the high-seas, States that had traditionally the most advantages of the freedom of the high-seas will be concerned when the designation of MPAs is in question. Therefore, approaches that will meet on consensus or quasi-consensus are needed. For example it does seem necessary to focus initially on resources that are under direct or actual threat to increase the sense of urgency. Furthermore, the costs and benefits of MPAs on the high-seas - also in respect to future generations - have to be kept in mind. Conservation measures on the high seas might not be so extensive as in the coastal area as long as their resources are not highly appreciated. Last but not least, action may be required even if a State is still against any amendment or strengthening of the existing regime. Once measures have been taken, this could have a significant, positive impact and could even promote the establishment of a sub-regime among co-operating States.[363]

2.4 Current and proposed marine protected areas for specific hydrothermal areas

While an international regime has still to be developed, proposals for marine protected areas for specific hydrothermal areas have already been made. The Canadian Oceans Act of 1997, for example, allowed the introduction of integrated management plans for areas within the EEZ. In December 1998 two pilot offshore marine protected areas were designated: the Bowie Seamount and the Endeavour Segment of the Juan de Fuca Ridge which is the largest and most diverse of several hydrothermal sites on the ridge. They are part of a national system of MPAs initiated by the Canadian government. Other proposals are the Kraternaya Bight at the Yankich Island in the Kuriles, the Dom João de Castro Seamount in the Azores or an area at Lucky Strike, on the Mid-Atlantic Ridge within the Portuguese EEZ.[364] Also a so-called "Seamount Experiment" has been made to prove that a voluntary MPA scheme can work beyond national jurisdiction.[365] Unfortunately, attention has to be paid to the possibility that the designation of a MPA could be a signal to distant water fleets that valuable resources are found around the area. This has to be taken into account when evolving an international regime for the establishment of marine protected areas on the high seas.

[362] B. THORNE-MILLER, The Living Ocean: Understanding and Protecting Marine Biodiversity, p. 105 (2nd edition 1999), p. 113.
[363] WWF/IUCN/WCPA, *supra note 9*, p. 88-89.
[364] InterRidge, *supra note 6*, p. 13-14.
[365] WWF/IUCN/WCPA, *supra note 9*, p. 89.

Conclusion

Deep-sea hydrothermal vent fields offer an exceptional biodiversity. Because of their high endemism rates and the unique nature of many of the species found there they are very vulnerable. Although difficult to reach, human impact on these ecosystems will increase in the future. Several sites are already under potential threats from intensive scientific exploitation or future mining activities. To mediate among the conflicting interests a conservation and management regime must be comprehensive and it must incorporate criteria for establishing priorities between the uses. Thereby, the still poor knowledge of these ecosystems demands a conservative and precautionary approach to ensure a sustainable use of those very special living marine resources.

At present the main problems when designing special management regimes are the absolutely free access to the high sea and the deep sea living marine resources, and the fragmented responsibility of States for conservation and management of resources beyond national jurisdiction. While the International Seabed Authority regulates mineral mining in the Area, there are still conflicting claims in respect to vent living resources between the high seas freedoms and common heritage regime. Even when research and biological specimen collection in the Area fall under the "common heritage of humankind regime" as a matter of customary law, the UNCLOS and the CBD offer little to regulate access. The CBD articles on sharing of benefits from the use of genetic resources do not apply explicit to collection activities on the high seas or in the Area. In addition, Part XI of the UNCLOS deals only with non-living resources. Marine scientific research activities and exploitation fall outside this regime, also. Vessels engaged in those activities fall under the jurisdiction of their flag State only. At the moment, only the ISA could place active vent sites off limits to mining activities according to the precautionary principle.

Several proposals have been made to establish a legal regime in respect to the Area's living and genetic resources ranging from the broadening of Part XI of the UNCLOS over a protocol to the CBD to a new agreement. The positive effect would always be to have a legal status of the living resources of the Area and their conservation since harvested vent organisms on the deep seabed and the superjacent waters of the high seas are considered to be "fish". At least they can be classified as "living marine resources" described in Articles 116-119 of the UNCLOS. In addition, the freedom of the high seas in respect to collecting those resources beyond any nation's continental shelf allows for unrestricted exploitation. But it is important to note that all contracting parties to the UNCLOS are obliged under Part VII to co-operate in the conservation and management of vent living marine resources. A new regime could provide the difficult but necessary distinction between marine scientific research and harvesting living marine resources and even offer intellectual property rights. However, to fill the gaps in the present regime with customary law or a new agreement has great normative appeal.

Although contracting parties to the CBD and the UNCLOS have the duty to protect and preserve the marine environment and rare or fragile ecosystems and to use the components of biological diversity sustainable, the avoidance of severe damages to the vents is not ensured. On the contrary, as economic advantages are prognosticated, direct and effective measures have to be taken before the "run starts". Since the establishment of a new legal regime would obviously need too much time, it is desirable to designate a management and protection system as soon as possible. Herein belong Environmental Impact Assessments, Environmental liability provisions and the identification of critical and sensible sites for the establishment of deep-sea sanctuaries to manage scientific activities. Also a code of conduct should be envis-

aged. Within their EEZ, Canada has designated a pilot marine protected area for a frequently visited vent field. Exporting this approach to the international commons, high-seas marine protected areas for selected vent fields on the deep-seabed are advocated.

Above all, the ethical aspect of the conservation of the unique hydrothermal vent resources has to be stressed. At present, the foundation of an Earth Commission to ensure the necessary long-term thinking for environmental protection and the guarantee of the rights and interests of future generations as well as to give new impulses to science and political actors is only a vision.[366] The intrinsic value of all components of nature in contrast to the pure anthropogenic view have, however, always to be kept in mind.[367] This aspect may once perhaps be introduced into environmental law supporting efforts for a comprehensive conservation and management regime. Notwithstanding, we have already now the opportunity and the great demand to design a responsible approach to human activities at the hydrothermal vent fields.

[366] Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen, *Welt im Wandel – Neue Strukturen globaler Umweltpolitik*, Springer-Verlag (2001), p. 179.

[367] See for instance: T. L. S. SPRIGGE, *Gibt es in der Natur instrinsische Werte ?*, in: Ökophilosophie (ed. D. BIRNBACHER), Reclam-Verlag (1997), p. 60f.; P. W. TAYLOR, *Die Ethik der Achtung für die Natur*, in: Ökophilosophie (ed. D. BIRNBACHER), Reclam-Verlag (1997), p. 77f.; A. KREBS (ed.), *Naturethik – Grundtexte der gegenwärtigen tier- und ökoethischen Diskussion*, suhrkamp-Verlag (1997).

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