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MARINE AND COASTAL BIOLOGICAL DIVERSITY

Status and trends of, and threats to, deep seabed genetic resources beyond national jurisdiction, and identification of technical options for their conservation and sustainable use

Note by the Executive Secretary

EXECUTIVE SUMMARY

The present document has been written in response to paragraph 54 of decision VII/5. It presents information on the methods for the identification, assessment and monitoring of genetic resources in the deep seabed beyond the limits of national jurisdiction; compiles and synthesizes information on the status and trends of, and threats to such genetic resources, and proposes technical options for their protection. The document notes the highly expensive technology required to access deep seabed extreme environments, but also the potentially high scientific rewards and commercial profits from deep sea exploration. It also notes that a very small proportion of the deep seabed has been explored thus far, and that the potential for discovery of new species is very high. The lack of knowledge about deep seabed biodiversity provides an opportunity to discover novel organisms of potential use to biotechnology. Organisms in deep sea environments, such as hydrothermal vents and cold seeps are subjected to extremes of pressure and temperature, presenting conditions in which biota have evolved unique characteristics for survival. These two ecosystems have a high degree of endemism, and are mainly threatened by marine scientific research and are likely threatened by future activities like mining. Seamounts, cold water coral and sponge reefs are also of potential interest to biotechnology due to their high diversity and endemism. These ecosystems are highly threatened by destructive fishing practices. Because of the lack of information and uncertainty associated with deep seabed biodiversity, there is a potential for human activities to cause unforeseen damage, including extinctions of entire groups of organisms that are still undiscovered.

The technical options for protection of deep seabed genetic resources beyond national jurisdiction include (i) the use of codes of conduct, guidelines and principles; (ii) management of threats through permits and environmental impact assessments; and (iii) the area-based management uses,

* UNEP/CBD/SBSTTA/11/1.

including through establishment of marine protected areas. At the present time, a legal/regulatory gap exists regarding commercially oriented activities relating to deep seabed genetic resources beyond national jurisdiction. The equitable sharing of benefits arising from the utilization of such genetic resources also needs to be considered within any regulatory regime.

SUGGESTED RECOMMENDATIONS

The Subsidiary Body on Scientific, Technical and Technological Advice may wish to

1. *Welcome* the assessment of status and trends of, and threats to, deep seabed genetic resources beyond national jurisdiction contained in section III of this document, and the summary thereof provided in the annex to this document;

The Subsidiary Body on Scientific, Technical and Technological Advice may wish to recommend that the Conference of the Parties

2. *Notes* that deep seabed ecosystems beyond the limits of national jurisdiction, including hydrothermal vent, cold seep, seamount, cold water coral and sponge reef ecosystems, contain genetic resources of great interest for scientific research and of major importance for present and future commercial applications;

3. *Recognizes* that given the vulnerability and general lack of knowledge of deep seabed biodiversity, there is an urgent need to provide for the conservation and sustainable use of these genetic resources in the context of the precautionary approach;

4. *Requests* that the Executive Secretary make available this information on status and trends of, and threats to, deep seabed genetic resources to the Ad Hoc Open-ended Informal Working Group to study issues related to the conservation and sustainable use of marine biodiversity beyond areas of national jurisdiction established by the General Assembly through its resolution 59/24;

5. *Concerned* about the threats to genetic resources in the deep seabed beyond national jurisdiction, *requests* that Parties, having identified activities and processes under their jurisdiction and control which may have significant adverse impacts on deep seabed ecosystems and species in these areas, as requested in decision VII/5 paragraph 56, take measures to urgently manage such practices in vulnerable deep seabed ecosystems in a sustainable manner, and report on measures taken as part of the national reporting process;

6. *Also requests* that Parties report on research activities related to deep seabed genetic resources beyond the limits of national jurisdiction, and ensure that the results of marine scientific research and analysis are effectively disseminated through international channels as appropriate, in accordance with UNCLOS, article 143.

7. *Takes note* of the technical options identified for protection of deep seabed genetic resources beyond national jurisdiction including (i) the use of codes of conduct, guidelines and principles; (ii) management of threats through permits and environmental impact assessments; and (iii) area-based management of uses, including through establishment of marine protected areas;

6. *Agrees* that there is an urgent need to clarify, within competent bodies, the status of and nature of activities relating to genetic resources in the deep seabed beyond national jurisdiction, within the framework of UNCLOS and other relevant international legal instruments, and based on scientific information.

I. BACKGROUND

1. In its decision VII/5, paragraph 54, the Conference of the Parties requested the Executive Secretary, in consultation with Parties and other Governments and the International Seabed Authority, and in collaboration with international organizations, such as the United Nations Division for Ocean Affairs and the Law of the Sea, the United Nations Environment Programme, and the Intergovernmental Oceanographic Commission of the United Nations Educational, Cultural and Scientific Organization, if appropriate, to compile information on the methods for the identification, assessment and monitoring of genetic resources of the seabed and ocean floor and subsoil thereof, in areas beyond the limits of national jurisdiction; compile and synthesize information on their status and trends including identification of threats to such genetic resources and the technical options for their protection; and report on the progress made to the Subsidiary Body on Scientific, Technical and Technological Advice.

2. In response to this request, and in order to assist SBSTTA in assessing status and trends of and threats to deep seabed genetic resources, and in identifying technical options for their conservation and sustainable use, the Executive Secretary, in collaboration with the United Nations University, has compiled the information contained in this document. The information is based on a study undertaken by the United Nations University. Review comments were provided by a number of international organizations including the United Nations Division for Ocean Affairs and the Law of the Sea, the Intergovernmental Oceanographic Commission of the United Nations Educational, Cultural and Scientific Organization and the IUCN, as well as experts in the field of deep sea exploration.

3. The information presented in this document provides a follow-up to previous work on this topic undertaken in the context of the Convention. In its decision II/10, the Conference of the Parties requested a joint study to be conducted by the secretariats of the CBD and UNCLOS on the conservation and sustainable use of genetic resources on the deep seabed in areas beyond national jurisdiction. This study (see document UNEP/CBD/SBSTTA/8/INF/3/REV1) was considered by the eighth meeting of SBSTTA and subsequently by the seventh meeting of the COP, leading to paragraphs 54-56 of decision VII/5. The joint study concluded that whereas the provisions of the two conventions are complementary and mutually supportive regarding the conservation and sustainable use of marine and coastal biodiversity, neither UNCLOS nor the CBD provides a specific legal regime for commercially-oriented activities relating to marine genetic resources in the Area (the deep seabed, ocean floor and subsoil thereof beyond the limits of national jurisdiction).

4. In addition to requesting the Executive Secretary to provide the information contained in this document (paragraph 54 of decision VII/5), the COP also invited Parties to raise their concerns regarding the issue of conservation and sustainable use of genetic resources in the deep seabed beyond national jurisdiction at the next meeting of the General Assembly, and invited the General Assembly to further coordinate work on this topic (paragraph 55). The COP also invited Parties and other States to identify activities and processes under their jurisdiction and control which may have significant adverse impact on deep seabed ecosystems and species beyond the limits of national jurisdiction, in order to address Article 3 of the Convention.

5. The issue of genetic resources in the deep seabed beyond national jurisdiction has also been addressed by the United Nations General Assembly (UNGA) and the UN Open-ended Informal Consultative Process on Oceans and Law of the Sea (ICP). The need to clarify the legal status and the nature of activities relating to marine genetic resources in the deep seabed was noted by the UN Secretary-General in his annual reports to the 58^{th} and 59^{th} sessions of the UNGA in 2003 and 2004 (A/58/65, A/59/62 and A/59/62/Add.1).

6. The fourth and fifth meetings of the ICP also considered issues relating to genetic resources in the deep seabed beyond national jurisdiction in the broader context of the protection of vulnerable marine ecosystems and the conservation and management of the biological diversity of the seabed in areas beyond national jurisdiction (the reports of the meetings are contained in documents A/58/95 and A/59/122). The fifth meeting of the ICP recommended that the UNGA welcome decision VII/5 of the Conference of the Parties. The ICP identified genetic resources as an issue that might benefit from further work by the UNGA. In accordance with the recommendations of the fifth meeting of the ICP, UNGA at its 59th session reaffirmed the need for States and competent international organizations to urgently consider ways to integrate and improve, on a scientific basis and in accordance with UNCLOS and related agreements and instruments, the management of risks to the marine biodiversity of seamounts, cold water corals, hydrothermal vents and certain other underwater features. States and international organizations were also called upon to urgently take action to address, in accordance with international law, destructive practices that have adverse impacts on marine biodiversity, including seamounts, hydrothermal vents and cold water corals.

7. Significantly, the 59th UNGA decided to establish an Ad Hoc Open-ended Informal Working Group to study issues related to the conservation and sustainable use of marine biodiversity beyond areas of national jurisdiction. The Working Group, expected to convene in early 2006, will survey past and present activities of the United Nations and other relevant international organizations with regard to the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction; examine the scientific, technical, economic, legal, environmental, socio-economic and other aspects of these issues; identify key issues and questions where more detailed background studies would facilitate consideration by States of these issues; and it will indicate, where appropriate, possible options and approaches to promote international cooperation and coordination for the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction.

8. Finally, it should also be noted that substantial related work on marine protected areas in marine areas beyond the limits of national jurisdiction has been carried out as part of decision VII/28 on protected areas. In particular, two studies undertaken for the Convention's Ad Hoc Open-ended Working Group on Protected Areas also contributed to the present document. These were a study of scientific information on biodiversity in marine areas beyond the limits of national jurisdiction (UNEP/CBD/WG-PA/1/INF/1), and a study of the international legal regime concerning the conservation and sustainable use of biodiversity in marine areas beyond the limits of national jurisdiction (see document UNEP/CBD/WG-PA/1/INF/2). While the focus of these studies was on marine protected areas, they also provide valuable information for conservation and sustainable use of deep seabed genetic resources.

9. The information presented in this document should therefore be viewed as one component of a wider effort to address conservation and sustainable use of deep seabed genetic resources beyond national jurisdiction, and the scientific and technical information contained in this document provides context for the broader policy debate. Section II of this document reviews methods for the identification, assessment and monitoring of deep seabed genetic resources. Section III reviews the status and trends of, and threats to, genetic resources in the deep seabed, while section IV identifies technical options for their protection in areas beyond the limits of national jurisdiction. It should be noted that the distinction between technical options and legal and policy options can, at times, be difficult, as the implementation of technical options requires a policy and legal framework. For example, while marine protected areas can be considered technical tools for the conservation and sustainable use of biodiversity, the establishment and management of marine protected areas requires the appropriate policy and legal instruments to be in place.

II. METHODS FOR IDENTIFICATION, ASSESSMENT AND MONITORING OF DEEP SEABED GENETIC RESOURCES

10. Article 2 of the Convention on Biological Diversity (CBD) defines genetic resources as genetic material of actual or potential value. Genetic material is defined as any material of plant, animal, microbial or other origin containing functional units of heredity. It follows that marine genetic resources are marine plants, animals and microorganisms, and parts thereof containing functional units of heredity that are of actual or potential value. This definition applies to deep seabed organisms. It is noteworthy that photosynthetic organisms are not found in deep seabed ecosystems as a result of the absence of solar light.

11. The exploration of deep seabed areas started at the end of the nineteenth century with the British research vessel *Challenger* (1872-1876). However, it was not until 1977 that hydrothermal vents were discovered with the help of the submersible *Alvin* during a survey of the Galapagos Rift in the Eastern Pacific Ocean at depths of more than 1,000 meters. Today, a host of exploration activities are undertaken by universities and research institutions to study the ecology, biology and physiology of deep seabed ecosystems and species[1]. While most of these activities are of an exploratory nature, and are not directly commercially oriented, they help to generate the scientific information necessary for bioprospecting and future commercial application of deep seabed genetic resources. Some are funded, at least in part, by private, commercial companies.

12. Despite these programmes, very little of the deep sea has been explored thus far. Less than 0.1% of abyssal plains have been subject to scientific study, and less than 200 of the estimated 30,000 seamounts have been sampled. The reason for this lies primarily in the vast expense associated with deep seabed research. Reaching deep seabed extreme environments and maintaining alive the sampled organisms, as well as culturing them, requires sophisticated and expensive technologies. For example, the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), one of the leading institutions conducting deep seabed research, has an annual budget of $300 million.

13. Typically, the technology associated with research on deep seabed genetic resources involves: oceanographic vessels equipped with sonar technology, manned or unmanned submersible vehicles; *in situ* sampling tools; technology related to culture methods; molecular biology technology and techniques; and technology associated with the different steps of the commercialization process of derivates of deep seabed genetic resources. With the exception of basic molecular biology techniques, most of the technology necessary for accessing the deep seabed and studying and isolating its organisms is owned by research institutions, both public and private. To date, only very few countries have access to these technologies. The following section describes the steps involved in identification, assessment and monitoring of deep seabed genetic resources.

A. Identification of deep sea topography

14. Prior to sampling with submersibles, an accurate picture of the topography of the deep seabed area needs to be developed. This is done through the use of sonar technology, where a research ships moving along the surface will bounce and receive sound waves from the ocean floor. In some cases, towed sonar vehicles are also used. The technologies used include single beam echo sounders that send a cone of sound down to the seafloor; the more sophisticated multibeam bathymetry incorporating several sound beams; and side-scan sonar, which sends out beams of sound waves sideways from the ship's course to map the seabed topography in broad swaths. The time taken for the sound to travel through the ocean and back is used to calculate water depths and to give information about softness of the seafloor sediment.

1/ Further information is available in the InterRidge MOR&BAB Cruise Database at http://www.interridge.org.

B. Assessment, identification and monitoring using submersibles

15. Once the seafloor has been mapped, a submersible operation can be planned and executed. Submersibles can be manned or unmanned. Unmanned submersibles are commonly referred to as Remotely Operated Vehicles (ROVs). ROVs include towed imaging and mapping vehicles, carrying video and still cameras and acoustic sensors. Such unmanned submersibles can be used to provide video footage of the seabed, and can therefore be useful for species identification and habitat characterization. Rapid assessment methods, including using taxon richness as a surrogate for species richness, can be applied to assess deep seabed communities. Autonomous underwater vehicles (AUVs), programmed to operate without pilot or tether, are meeting scientists' frequent need to monitor areas over long periods of time, or to explore an area of seafloor in fine detail.

16. Manned submersibles come in different sizes and with differing capabilities. A limited number of institutions worldwide own or operate vehicles that are able to reach areas deeper than 1,000 meters below the oceans' surface, and can therefore be actively involved in deep seabed research. A larger number of institutions operate vehicles that are capable of reaching shallower depths. A small-sized deep submersible may carry one navigator and one scientist, but some larger ones operate as much as 6,000m below the ocean's surface and carry a five-person crew. A typical dive to 4,500 meters on the Woods Hole Oceanographic Institution's submersible Alvin takes approximately eight hours, four of which are spent travelling to and from the surface. Submersibles are commonly equipped with lights, hydraulic manipulator arms, video and still cameras, and various collecting devices. They can accommodate specialized instruments for measuring various environmental conditions, including temperature and sediment characteristics. These research vehicles can be used to investigate the nature of hydrothermal vents, bottom sediments, submarine canyons and seamounts, mineral deposits on the ocean floor, and submarine volcanoes. Samples of deep seabed resources can be collected using a variety of collecting devices. Because hydrothermal vents have been the focus of much deep sea scientific research, many new tools and techniques have been developed for the purpose of studying these ecosystems. For example, new sophisticated tools have been produced in order to sample vent fluids at temperature and pressure values as high as 420°C and 600 bar. These techniques also allow maintaining samples at original pressure values *ex situ*.

17. It is evident from the above that developing and operating deep sea technology requires extensive investments of time and money. Many institutions, which own or operate deep sea vehicles and associated technologies, such as pressurized aquaria to maintain sampled organisms at original pressure conditions, are publicly owned. Partnering with private companies interested in possible commercial applications of deep sea genetic resources is common in order to ensure that the costs of deep sea expeditions are adequately covered.

C. Technology related to culture methods and molecular biology technologies and techniques

18. The molecular biologist begins his or her research when samples of marine organisms reach the surface. Techniques used include more conventional techniques, such as culturing sampled micro-organisms, and newer techniques, such as DNA sequencing and hybridization techniques for determining microbial community composition. A combination of such techniques may need to be applied when studying the properties and potential applications of deep seabed genetic material. Traditional taxonomy is also a vital component of this work, but the lack of trained taxonomists remains a major impediment.

19. Marine invertebrates are hosts to a large community of micro-organisms including bacteria and fungi. These symbiotic microbes produce chemicals with the potential to fight disease, and are therefore a valuable resource for drug discovery. Other commercial applications are also possible. These bacteria and fungi must be cultured before they can be studied, a process that starts at sea and continues for many months after return to the laboratory. Innovative devices, such as JAMSTEC's Deep Bath, allow the

maintenance and culturing of deep seabed organisms at *in situ* conditions of extreme pressure and temperature. Microbiologists take a small sample of each organism for culturing, and use different types of growth media depending on the type of micro-organism that will be isolated. Eventually, through a process of extraction, a pure culture containing a single type of micro-organism is obtained and preserved as part of a collection. These pure cultures can then be grown and tested for their biological activity.

20. Studies of DNA can be used to characterize species, and delineate populations. The techniques now being employed include DNA extraction, RNA extraction, the use of agarose gel electrophoresis to visualize DNA and RNA, polymerase chain reaction (PCR), and sequencing of genes of interest. As a result of ocean exploration and research, genomic libraries can be created to preserve all of the genes (DNA) found in marine organisms. From genomic libraries, a gene that makes an important biomedical compound can be cloned and expressed as a chemical compound in an artificial system. Emerging techniques such as that of DNA Barcoding may soon be available on a large scale and help study deep seabed ecosystems and organisms.

D. Commercial uses of deep sea organisms

21. Deep seabed resources hold enormous potential for many different types of commercial applications, including in the health sector, for industrial processes or bioremediation. A brief search of selected Patent Office Databases revealed that compounds from deep seabed organisms have been used as basis for potent cancer fighting drugs, commercial skin protection products providing higher resistance to ultraviolet and heat exposure, and for preventing skin inflammation, detoxification agents for snake venom, anti-viral compounds, anti-allergy agents and anti-coagulant agents, as well as industrial applications for reducing viscosity.

22. Assessing the type and level of current uses of genetic resources from the deep seabed proves relatively difficult for several reasons. First, patents do not necessarily provide detailed information about practical applications, though they do indicate potential uses. Moreover, information regarding the origin of the samples used is not always included in patent descriptions. However, the commercial importance of marine genetic resources is demonstrated by the fact that all major pharmaceutical firms have marine biology departments. The high cost of marine scientific research, and the slim odds of success (only one to two percent of pre-clinical candidates become commercially produced) is offset by the potential profits. Estimates put worldwide sales of all marine biotechnology-related products at US $100 billion for the year 2000.

23. As technology develops and becomes more widely available, scientific research in these extreme environments is likely to increase. Not only will this allow expanding our knowledge of extreme ocean ecosystems in order to improve their conservation and sustainable use, it will also provide opportunities to discover valuable resources and compounds of potential application to industry. Such an increase in research should also provide opportunities for technology transfer.

III. STATUS AND TRENDS OF, AND THREATS TO, DEEP SEABED GENETIC RESOURCES BEYOND NATIONAL JURISDICTION

24. The deep seabed contains several distinct ecosystems. Most of the ocean floor consists of broad, relatively flat abyssal plains, where the slopes coming down from the continental margins even out at depths ranging between 3 and 6 km below sea level. Abyssal plains are covered in a thick layer of sediment, and their flatness is punctuated by rugged low abyssal hills and high seamounts. Seamounts, isolated island chains beneath the surface of the sea, are distributed throughout the world's oceans. The abyssal plains are separated by a couplet of mid-ocean ridges, an immense underwater mountain range that stretches for 64,000 km and covers nearly one-quarter of the earth's surface, forming a significant part of the deep-sea floor. `

25. This document is concerned primarily with those areas of the world's oceans that are known to be home to unique genetic resources. They include hydrothermal vents and cold seeps, both of which support chemosynthetic ecosystems. Although the ecological and biological characteristics of cold seeps are different from those of hydrothermal vents, they create similar scientific and commercial interest since their inhabitant species are adapted to thriving in extreme conditions of depth and toxicity. Of particular biological interest are also seamounts, cold water coral and sponge reefs. Each of these ecosystems contain high levels of endemism and diversity, and are sources of novel genetic resources with potential commercial applications.

26. The deep sea harbours vast numbers of species, most of which are still unknown. Global estimates of marine species vary between 500,000 and 10 million. Since there is no inventory of the fauna of even a single ocean basin, extrapolation of total species numbers of the global abyssal fauna is impossible or at best very speculative. Not surprisingly, new oceanic species, including deep sea species, are continuosly being discovered. However, this figure could be much larger because of the uncertainty associated with patterns of species discovery. It has been estimated that the probability of a new record being a new species is about 50:50 in the deep sea.

27. Because deep seabed biodiversity in general is not well known, there is a potential for human activities to cause unforeseen damage, including extinctions of entire groups of organisms that are still undiscovered. Our current knowledge of deep seabed ecosystems and species suggests that they may be particularly sensitive to human disturbance and exploitation. The slow growth rate of species in certain types of deep seabed ecosystems make them potentially vulnerable to changes in the surrounding environment. In addition, slight changes in environmental conditions might significantly influence key biological processes of species, such as reproduction. Some deep sea ecosystems, including cold seeps and seamounts, are particularly sensitive to disturbances. Concern has grown over the impacts of both pure and applied scientific research in deep seabed areas, and seamount ecosystems are particularly threatened by high impact fishing activities. While it is impossible to quantify the damage caused by research on the deep seabed environment, threats include destruction of habitats, unsustainable collection, alteration of local hydrological and environmental conditions, and different forms of pollution. As more products derived from deep seabed genetic resources move into the testing and development phases, the increased demand for these resources could result in their unsustainable collection. Moreover, the same activities can have very different impacts in various deep sea ecosystems. Cumulative impacts over time, such as those associated with deep sea trawling, may have already resulted in the extinction of species. There is also concern about the effects of climate change on deep sea species.

28. The following presents in additional detail the characteristics of each of the deep seabed ecosystems of particular interest for their genetic resources: hydrothermal vents, cold seeps, seamounts and cold water coral and sponge reefs. The threats to these ecosystems are also described.

A. Hydrothermal vents

29. Hydrothermal vents are found along mid-ocean ridges, where magma from deep parts of the earth emerges. A vent is typically formed when seawater penetrates the crust, is heated by the magma, and surges back into the ocean through a hot vent, bringing with it mineral substances. Hydrothermal vents typically support abundant biological populations, fuelled by chemosynthesis. The discovery of chemosynthetic-based ecosystems at hydrothermal vents in the deep ocean was arguably one of the most important findings in biological science in the latter quarter of the twentieth century. Hydrothermal vent systems are thought to have played an important role in the development of life on Earth, and the differentiation of a common ancestor into Bacteria and Archaea (an evolutionary branch that is separate from those of Bacteria and Eukarya). There is evidence that life has existed around hydrothermal vents for more than 3 billion years. Recent research also indicates that hydrothermal activity is more abundant

than originally thought in locations where there is volcanic activity and magma is close enough to the surface to heat the fluids. These areas include active spreading ridges, subduction zones, fracture zones and seamounts.

30. More than 500 new animal species, most of which are endemic to vents, have been described from this environment. These animal species have adapted to exploit the extreme physio-chemical conditions found at vents, and range from tiny chemosynthetic bacteria to tube worms, giant clams, and ghostly white crabs. Micro-organisms, which are the basis of the vents' trophic chains, and subsequently the functioning of the whole vent ecosystem, have adapted to the extreme temperature and toxicity of their environment. Other hydrothermal vent species also show such adaptations. Because of their unusual physiological characteristics, hydrothermal vent organisms are subject to both scientific and commercial interest. For example, the genomes of hydrothermal vent bacteria hold great importance for evolutionary biologists seeking insight into the earliest life on Earth. They are also of great interest to the modern biotechnology industry because of the economic potential of enzymes and biochemical processes which occur in these extreme environments.

31. The major current anthropogenic threat to hydrothermal vent systems is from marine scientific research. This specific threat to hydrothermal vents has also been identified by the UN Secretary-General in his report to the 58th session of the UNGA. Research may entail physical disturbance or disruption, for example the removal of parts of the vent physical infrastructure or associated fauna. Current research efforts concentrate on temporal changes at individual sites, which often involves repeated sampling, observation and instrumentation of a small number of well-known hydrothermal vent sites. Introducing light into an ecosystem that is naturally deprived of it may also be a cause of disturbance. Already, effects of biological and geological sampling operations on vent faunal communities have been documented. As vent sites become the focus of intensive, long-term investigation, it will become essential to introduce mitigative measures to avoid significant loss of habitat or oversampling populations. Bioprospecting, mining of polymetallic sulphide deposits associated with vent systems, and high-end tourism present potential future threats to vent ecosystems.

B. Cold seeps

32. Cold seeps are deep soft-bottom areas where oil or gases seep out of the sediments. "Seepage" encompasses everything from vigorous bubbling of gas from the seabed to the small-scale emanation of microscopic bubbles or hydrocarbon compounds in solution. Seep fluids contain a high concentration of methane. This methane can have a biological origin from the decomposition of organic matter by microbial activity in anoxic sediments, or a thermogenic origin from fast transformation of organic matter caused by high temperatures. Another important factor in some cold seeps is a high concentration of sulfide in the sediments, produced by the reduction of sulfates. Both, methane and sulfide play a major role in sustaining highly productive cold seep communities.

33. Deep water cold seeps occur in both passive and active continental margins, at depths ranging between 400 and 8000 m. Passive continental margins are non-seismic margins, and cold seeps here are usually associated with oil and gas reservoirs. Active continental margins are associated with subduction zones. Subduction occurs where an oceanic plate collides with another oceanic plate or with a continental plate. When this happens, one of the plates bends and sinks under the other, forming an oceanic trench.

34. Cold seeps support abundant biological populations, fuelled by chemosynthesis. The chemoautotrophic bacteria of cold seeps are found both free living and in symbiotic associations with invertebrates such as tube worms, mussels and clams. The fauna are highly specialized, of relatively low diversity, but high endemism. The large majority of seep fauna are endemic to single seep sites and to the seep ecosystem. Of the 211 species reported thus far, only 13 occur at both seeps and hydrothermal vents.

35. Methane hydrates are in certain instances found associated with cold seeps. Methane hydrates are solid crystals made of methane and surrounded by water molecules. These crystals are a potential source of energy, and a buffer to methane, which is a powerful greenhouse gas. Deep seabed methane systems are also considered to support thriving biological communities in the surrounding area.

36. Seeps have high biotechnology potential as many new species have been discovered in these habitats over the past 20 years. Bacteria from seeps contain novel genes, which may be useful to the biotechnology industry. For example, applications such as bioremediation and oil pollution may be of particular interest.

37. Seepages are potentially threatened from prospecting by the petroleum industry. Seepages may also become subject to direct exploitation in the future, if high-grade mineral-laden fluids expelled from the deep seabed can be tapped. Several patents exist for the direct harvest of seepage minerals from point sources on the seabed.

C. Seamounts

38. Seamounts are isolated islands or island chains beneath the surface of the sea. They are millions of years old, and the remains of past geologic activity. More than 30,000 seamounts over 1000 meters high are estimated to exist in the world's oceans. As deep currents sweep past seamounts they swirl, which serves to concentrate plankton and carry nutrients up from deeper water layers. This upwelling turns these features into important feeding sites for a wide variety of bottom-dwelling and pelagic species. Many seamounts support dense assemblages of suspension feeding species such as corals (gorgonian, scleratinian and antipatharian), crinoids, hydroids, ophiuroids, and sponges. Orange roughy, pelagic armourhead, and oreos are some of the commercially important deep water fish species known to aggregate at seamounts to feed. Frequent pelagic visitors to seamounts include swordfish, tuna, sharks, turtles and whales (see UNEP/CBD/WG-PA/1/INF/1 and UNEP/CBD/COP/7/INF/25).

39. Although relatively few (less than 200) seamounts have been comprehensively sampled, research has shown that seamounts are hot spots for the evolution of new species, refuges for ancient species, and stepping-stones for species to spread across ocean basins. Rates of endemism are considered very high, ranging from 35% on seamounts off Tasmania, 36% for seamounts on the Norfolk Ridge; 31% on the Lord Howe Island seamounts, and 44% for fishes and 52% for invertebrates on the Nasca and Sala-y-Gomez chain off Chile. Adjacent seamounts in New Caledonia have been found to share an average of just 21% of their species, and seamounts on separate ridges approximately 1000 km apart in the Tasman and Coral Seas have only 4% of their species in common (See UNEP/CBD/WG-PA/1/INF/1 and UNEP/CBD/COP/7/INF/25). These studies indicate that the number of seamount species yet-to-be-discovered is much higher than those that have already been discovered.

40. Of all the ecosystems described here, seamount ecosystems (and the cold water coral communities associated with them) are under the most acute and serious threat. This threat does not come from scientific research, but from destructive fishing activities, such as bottom trawling. The biological characteristics of most deep-sea species associated with seamount ecosystems render them particularly sensitive to human disturbance and exploitation. The slow growth, longevity, late sexual maturity, and restricted distribution of many of these species (for example, deep-sea corals, sponges and fish) make them particularly vulnerable to human impacts and the risk of extinction. Concerns over the impact of fishing and the potential loss of this biodiversity are amplified by the limited information about the taxonomy, biology and ecology of most of the species found in deep ocean areas. Destructive fishing activities in these areas could bring about extinctions of entire groups of organisms that are still undiscovered (UNEP/CBD/WG-PA/1/INF/1 and UNEP/CBD/COP/7/INF/25). The immediate and urgent need to manage risks to marine biodiversity of seamounts and cold water coral reefs, through, e.g. elimination of destructive fishing practices, has been highlighted by the seventh meeting of the

Conference of the Parties, and by a number of other international forums, including the Fourth and Fifth Meetings of the United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea, and the 3rd informal consultation of States Parties to the Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks. Because of their high diversity and endemism, seamount ecosystems are also host to unique genetic resources, and thus of potential interest for bioprospecting activities.

D. Cold water coral and sponge reefs

41. Cold-water coral reefs grow in dark deep waters, and, unlike tropical corals, do not have light-dependent symbiotic algae in their tissues. Because of this, they depend solely on current-transported particulate organic matter and zooplankton (animal plankton) for their food. They grow slowly, at only a tenth of the growth rate of tropical corals. Many of them produce calcium carbonate skeletons that resemble bushes or trees, and provide habitat for associated animal communities. Cold-water corals can exist as small, scattered colonies of no more than a few metres in diameter to vast reef complexes measuring several tens of kilometres across. Some living banks and reefs are up to 8000 years old. Cold water coral systems can be found in almost all the world's oceans and seas: in fjords, along the edge of the continental shelf, and around offshore submarine banks and seamounts. In areas beyond national jurisdiction, cold water corals are generally associated with seamounts.

42. Sponge reefs, which are formed by glass sponges with three-dimensional silica skeletons, are built in a manner similar to coral reefs, by new generations growing on previous ones. Although glass sponges are found throughout the world's oceans between the depths of 500 and 3000 meters, reef-forming species occur mainly in cold, northern Pacific waters. The reefs grow at a rate of 2 to 7 cm per year and are long-lived. A 5-meter thick sponge reef in the Queen Charlotte Sound of British Columbia, Canada, is estimated to be nearly 6000 years old.

43. Cold-water coral reefs and sponge reefs support rich and diverse assemblages of marine life, and are home to thousands of other species, in particular animals like sponges, polychaetes (bristle worms), crustaceans (crabs, lobsters), echnoderms (starfish, sea urchins, brittle stars, feather stars), bryozoans (sea moss) and fish. For example, *Lophelia pertusa* coral reefs in cold waters of the Northeast Atlantic provide habitat for over 1,300 species of invertebrates. Marine scientists have observed large numbers of commercially important but increasingly uncommon groupers and redfish among the sheltering structures of deep-sea coral reefs, indicating their importance as habitat.

44. Because cold water coral and sponge reefs are long-lived, slow growing and fragile, they are especially vulnerable to physical damage. Damage from bottom trawling is also reported to be the main threat to both cold-water coral and sponge reefs, resulting in mechanical damage, which breaks up their structure. Recent surveys of cold-water coral reefs have shown that, in many locations, the reefs have already been destroyed or damaged. Similar damage has been observed on sponge reefs. In addition, sponge reefs present high potential for bioprospecting, particularly for pharmaceuticals.

IV. TECHNICAL OPTIONS FOR THE PROTECTION OF DEEP SEABED GENETIC RESOURCES BEYOND NATIONAL JURISDICTION

45. While science and technology evolve at a fast pace, as described in section II above, the management framework lags behind. Ideally, a management framework would address all major threats to deep seabed genetic resources beyond national jurisdiction in the context of the ecosystem approach and the precautionary approach. In accordance with section III above, these threats are either commercial in nature (bioprospecting, prospecting by the petroleum and mining industries, as well as potential future mining and tourism operations) or arise from scientific research. It should be noted that in practice the

differences between marine scientific research 2/ and bioprospecting, 3/ which resides mainly in the intent and purpose of the activities, are sometimes difficult to establish, particularly in the context of research carried out in the deep seabed. In addition to these threats, seamounts, cold water corals and sponge reefs are threatened by fishing activities, in particular bottom trawling. Finally, climate change may present a future threat to some deep seabed ecosystems.

46. The range of technical options available to address these threats includes (i) the use of codes of conduct, guidelines and principles; (ii) management of threats through permits and environmental impact assessments; and (iii) the area-based management of uses, including through establishment of marine protected areas. Some of these options are more suited to a address particular type of threat than others, but collectively they should add up to a management regime that promotes the conservation and sustainable use of deep seabed genetic resources, and the equitable sharing of benefits arising from their utilization. Each of these options is discussed below in more detail. As noted in the background section of this document, implementation of technical options requires a policy and legal framework. Therefore, a brief summary of the policy context is provided for each technical option.

A. Codes of conduct, guidelines and principles

Technical description

47. Certain uses of genetic resources in the deep seabed can be regulated through appropriate codes of conduct, principles or guidelines, which provide for conservation and sustainable use of biodiversity. This option is particularly relevant to scientific and commercial uses of the deep seabed, including tourism operations. Principles are basic facts that guide or influence thought or action. As is the case with the Addis Ababa Principles and Guidelines for Sustainable Use of Biodiversity, guidelines can be put in place to provide practical advice on the application of the principles. Principles are relatively general in nature, while guidelines can provide additional detail. Principles and guidelines can be operationalized through a code of conduct relating to a specific activity or sector. Codes of conduct can be very detailed, and set out international standards of behaviour for responsible practices with a view to ensuring conservation and sustainable use of biodiversity. Ideally, such codes of conduct can minimize conflicts and environmental impacts.

48. Codes of conduct to address the impacts of marine scientific research in the deep seabed are being developed by the scientific community. For example, InterRidge, an initiative by scientists to facilitate international and multi-disciplinary research associated with mid-ocean ridges, is developing a Code of Conduct for the Scientific Study of Marine Hydrothermal Vent Sites. The Code aims to minimize the impacts of scientific research, and maximize its efficiency. The Code would apply to organizations and affiliated individuals undertaking marine scientific research and submarine-based tourism activities at hydrothermal vents located beyond the limits of national jurisdiction. However, the Code has long been under development and is not yet adopted, and there is some concern that it may not address impacts associated with all types of scientific research. Moreover, research in other deep sea ecosystems is not covered by this code of conduct, and development of similar codes to cover all relevant ecosystems and resources could be encouraged, perhaps through other mechanisms. It would be important that the codes of conduct cover potential adverse impacts of research and collection related to

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2/ Document UNEP/CBD/SBSTTA/8/INF/3/REV1 noted that “in the absence of a formal definition, marine scientific research could be defined as an activity that involves collection and analysis of information, data or samples aimed at increasing mankind’s knowledge of the environment, and is not undertaken with the intent of economic gain.”

3/ There is currently no internationally agreed-upon definition of the term “bioprospecting”. However, a note prepared by the CBD Secretariat (UNEP/CBD/COP/5/INF/7) defined bioprospecting as “the exploration of biodiversity for commercially valuable genetic and biochemical resources” and further as “the process of gathering information form the biosphere on the molecular composition of genetic resources for the development of new commercial products.”

deep seabed genetic resources, and the availability and dissemination of research results as appropriate. There may be a need for a central clearinghouse of information relating to research undertakings.

49. Although related to biological resources found within national jurisdiction, codes of conduct have also been developed to support implementation of the CBD provisions on access and benefit sharing. An example is the Micro-Organisms Sustainable Use and Access Regulation International Code of Conduct (MOSAICC), addressing access to and benefit sharing regarding microbial resources. The Code, which is the result of a consensus between public and private sector representatives, recognizes that monitoring the transfer of microbial genetic resources is necessary to identify the individuals or groups that are entitled to be scientifically or financially rewarded for their contribution to the conservation and sustainable use of the resources. Such a code could be considered for access to, and sharing of benefits stemming from, deep seabed genetic resources beyond national jurisdiction.

50. Because codes of conduct are often voluntary, incentives may be needed to encourage scientists and other resource users to comply with them. Regarding scientific research, national funding institutions could agree to demonstrated compliance with a code of conduct as a pre-requisite for further funding. In addition to the examples mentioned here, further codes of conduct, guidelines or principles could be developed, in particular for scientific research in other deep seabed ecosystems besides hydrothermal vents, and for commercial uses of genetic resources.

Policy framework

51. Codes of conduct, guidelines and principles can be voluntarily developed by an interest group. They can acquire soft law status if they are adopted by an international process, and their use can also be made mandatory through competent international processes. Relevant international processes might include, as appropriate, the CBD, the Intergovernmental Oceanographic Commission (IOC) of UNESCO, or the UN General Assembly. For example, the UN General Assembly could decide to adopt a resolution containing guidelines or principles on deep seabed bioprospecting beyond the limits of national jurisdiction. The Informal Consultative Process on Oceans and Law of the Sea or the UN AD HOC WORKING GROUP on biodiversity beyond national jurisdiction might prepare such guidelines and principles. The guidelines could be used as a temporary framework until a binding regime, if desirable, is developed. Since it might be easier to get agreement on non-binding guidelines or principles, this approach could accommodate the need to take urgent action. The adoption of guidelines or principles by the General Assembly would also reflect broad governmental support.

52. The Bonn Guidelines on Access and Benefit-Sharing, although not applicable beyond national jurisdiction, could be used as a starting point to develop a regime for access to deep seabed genetic resources and sharing of the benefits arising out of their utilization. If a regime similar to that of the Area’s mineral resources is contemplated, a body such as the International Seabed Authority (ISA) could be mandated to negotiate access and benefit-sharing arrangements, keeping in mind the requirements stemming from the principle of common heritage of humankind.

B. Permits and environmental impact assessments

Technical description

53. Undertaking an environmental impact assessments prior to permitting a new activity to proceed presents an option that is particularly suited to address threats arising from commercial uses of deep seabed genetic resources. As described in decision VI/7, environmental impact assessment is a process of evaluating the likely environmental impacts of a proposed project or development, taking into account inter-related socio-economic, cultural and human-health impacts, both beneficial and adverse. An environmental impact assessment (EIA) would provide an objective and recognized basis for developing

a management plan for deep seabed sites, or for deciding on the need for management or restricted access. Any EIA undertaken in relation to new initiatives at vulnerable deep seabed sites should include standard criteria used in EIAs in other marine habitats, such as characterization of the type of disturbance, estimation of the percent loss of seafloor habitat, and identification of affected seafloor organisms. An EIA for planned activities in the deep seabed should be designed to be an instrument, which appraises and evaluates various alternatives and then makes recommendations.

54. The Antarctic Treaty Protocol provides an example of the use of an EIA. The treaty has classified activities in the Antarctic environment according to the potential degree of impact as follows: a) less than a minor a transitory impact; b) a minor or transitory impact; or c) more than a minor or transitory impact. Only activities classified under a) can be carried out immediately. An activity classified under c) requires an EIA. The EIA includes an assessment of both direct and indirect environmental impacts, as well as alternatives and possible ways to minimize the identified impacts. Each Party to the Antarctic Treaty is allowed to carry out the planned activities only after a complete assessment of environmental impacts has been performed, and will also have to monitor the activity in question.

55. However, environmental effects of various activities may be hard to predict, given the lack of experience in deep seabed activities and the relative paucity of information about the deep ocean. The International Seabed Authority has identified five critical questions on which it believes further research is needed. These are (i) the geographical ranges of species, (ii) their response to an event that disturbs the seafloor, (iii) the point at which the repetition of such an event might produce chronic effects, (iv) the speed at which animal communities might recover, and (v) how those communities vary over space and time. More research relating to these questions may be needed prior to implementation of an effective system of EIAs relating to deep seabed genetic resources beyond the limits of national jurisdiction.

Policy framework

56. Environmental impact assessments can be performed voluntarily by those seeking to undertake new activities relating to genetic resources in the deep seabed beyond national jurisdiction. Relevant international and regional processes could also encourage their use, or they could be made mandatory by the competent authorities. Some regional agreements, such as the Antarctic Treaty, already contain requirements for environmental impact assessments. However, the framework of UNCLOS provides the only mechanism under which environmental impact assessments could be considered for all activities potentially impacting deep seabed genetic resources beyond the limits of national jurisdiction.

57. UNCLOS requires States, as far as practicable, to observe, measure, evaluate and analyse, by recognised scientific methods, the risks or effects of pollution of the marine environment. In particular States must keep under surveillance the effects of activities under their control (both within or beyond national jurisdiction) and determine whether they are likely to pollute the marine environment (article 204). The results so obtained must be published at appropriate intervals to the competent international organization, which should make them available to States (article 205). Furthermore, when States have reasonable grounds for believing that planned actions under their jurisdiction or control may cause substantial pollution or significant and harmful changes to the marine environment, they shall, as far as practicable, assess the potential effects of such activities and report the results of such assessments (article 206). These provisions may be used as a basis for the requirement of environmental impact assessments in the case of activities relating to genetic resources of the deep seabed beyond national jurisdiction.

58. Under UNCLOS, the seabed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction have been designated as “the Area” (article 1.1.1). Part XI of UNCLOS and the 1994 Agreement relating to the Implementation of Part XI of UNCLOS (the Part XI Agreement) specifically

define the legal regime for the Area. The Area and its resources are the common heritage of mankind (article 136). Resources are defined in article 133 to mean “all solid, liquid and gaseous mineral resources *in situ* in the Area at or beneath the seabed, including polymetallic nodules.” The International Seabed Authority (ISA) is the organization through which States organize and control all activities of exploration for and exploitation of the resources of the Area (article 1 (1) (3)), particularly with a view to administering mining activities in the Area (article 157). Activities must be carried out for the benefit of mankind as a whole and the ISA must provide for the equitable sharing of financial and other economic benefits derived from activities in the Area (article 140). Under article 145 of UNCLOS, which provides for the protection of the marine environment from harmful effects, which may arise from activities in the Area, the ISA must adopt measures, including on the protection and conservation of the natural resources of the Area and the prevention of damage to the flora and fauna of the marine environment of the Area.

59. To fulfil its mandate under article 145, the ISA has adopted regulations on prospecting and exploration for polymetallic nodules in the Area and has undertaken cooperative scientific projects, which address the harmful effects which may arise from activities in the Area, including harmful effects on biodiversity (the Regulations are contained in document ISBA/6/A/18). These regulations could be used as a model to develop regulations addressing the impacts of bioprospecting activities in the Area

60. Under the regulations, prospective miners are required to submit a plan of work for approval of the Council of the ISA, which has to be accompanied by an assessment of the potential environmental impacts of the proposed activities (regulation 31). Monitoring of compliance with work plans is also part of the mandate of the ISA.

61. There have been proposals to expand the ISA’s mandate to include activities related to genetic resources in the Area. While this would require amending UNCLOS and entail a time-consuming and complex process, the advantage of such an option would be to build on an existing institutional framework and regulations addressing benefit sharing, sustainable use, as well as conservation needs.

C. Area-based management of uses, including through marine protected areas

Technical description

62. Area-based regulation can be used to address multiple threats and to zone various uses. This option has the advantage of being able to provide protection against most of the threats detailed in section III, including scientific research, commercial exploitation, and destructive practices. In addition, the removal of stresses will enhance the resilience of deep seabed ecosystems to cope with potential future threats arising from climate change. Area-based regulation can be accomplished through the prohibition of detrimental or destructive practices in a vulnerable area, and through the establishment of marine protected areas. Action can be taken voluntarily by several countries, in the framework of a regional treaty, or in the context of a global instrument. These options are discussed in additional detail under the policy framework section.

63. Marine protected areas provide a framework within which uses can be regulated in an ecosystem and precautionary context. In its decision VII/5, the Conference of the Parties agreed that marine protected areas are one of the essential tools and approaches in the conservation and sustainable use of marine and coastal biodiversity. Furthermore, the COP agreed that there is a need for international cooperation and action to improve conservation and sustainable use of biodiversity in marine areas beyond the limits of national jurisdiction, including the establishment of further marine protected areas consistent with international law, and based on scientific information, including areas such as seamounts, hydrothermal vents, cold-water corals and other vulnerable ecosystems.

64. Marine protected may accommodate multiple uses and degrees of protection. In its decision VII/5, the Conference of the Parties agreed that an effective marine and coastal biodiversity management framework would comprise of sustainable management practices over the wider marine and coastal environment, including integrated networks of marine and coastal protected areas consisting of: (a) marine and coastal protected areas, where threats are managed for the purpose of biodiversity conservation and/or sustainable use and where extractive uses may be allowed; and (b) representative marine and coastal protected areas where extractive uses are excluded, and other significant human pressures are removed or minimized, to enable the integrity, structure and functioning of ecosystems to be maintained or recovered. Scientific reference areas provide an example of the latter category.

65. Criteria may need to be developed to identify priority areas for protection. Such criteria would likely identify sites that are of critical importance or are particularly sensitive to disturbance. They would also likely take into account the need to protect representative areas. Many Governments and some regional organizations already have such criteria. In addition, the second meeting of the Convention’s Ad Hoc Open-Ended Working Group on Protected Areas (Montreal, Canada, 5-9 December 2005) will be considering such criteria as part of its agenda item on options for cooperation for the establishment of marine protected areas beyond the limits of national jurisdiction.

Policy framework

66. Action to refrain from destructive practices in vulnerable areas can be taken unilaterally by a country or a group of like-minded countries. Such action can be made formal and legally binding through, for example, a decision of the CBD Conference of the Parties or a resolution of the UN General Assembly. A marine protected area can be established using regional or international legal instruments, and will have the added benefit of protecting an area from multiple threats while taking into account the needs of a diverse group of users. A comprehensive review of international legal regime of the high seas and the seabed beyond the limits of national jurisdiction as it relates to the establishment of marine protected areas was undertaken in document in document UNEP/CBD/WG-PA/1/INF/2. The reader is therefore referred to this document for further information on the legal and policy framework.

67. Progress towards establishment of marine protected areas has already been made under regional instruments. The Pelagos Sanctuary for Mediterranean Marine Mammals, initially established by a tripartite agreement among France, Italy and Monaco in 1999, was accepted as a specially protected area of Mediterranean interest in 2001. Approximately 53 per cent of its 87,000 km^2 lies in international waters, and includes a variety of underwater habitats, including continental slope and deep canyons. In addition, the recent meeting of the Intersessional Correspondence Group on Marine Protected Areas (ICG-MPA) of the OSPAR Convention decided to take forward as a test case a proposal to nominate the Rainbow Hydrothermal Vent Field, located beyond national jurisdiction, to the OSPAR network.

Annex

SUMMARY OF STATUS AND TRENDS OF AND THREATS TO GENETIC RESOURCES IN THE DEEP SEABED BEYOND NATIONAL JURISDICTION

Deep-sea habitat	**Status**	**Trend and immediate threats**	**Potential threats**
Seamounts	Less than 200 seamounts have been studied; high endemism on studied seamounts; some seamounts are heavily exploited for fisheries resources, trawling damages benthic habitats.	High seas fishing on seamounts continues, especially in the Southern Ocean; impacts are not monitored; it is anticipated that heavily exploited stocks will be threatened with over exploitation. Vulnerable benthic habitats are threatened by trawling.	Mining of ferromanganese oxide and polymetallic sulphides, climate change
Deep-water coral and sponge reefs	Limited knowledge, they may be more widespread than currently known, and often associated with seamounts; high diversity, easily damaged by trawling, but spatial extent unknown	Fishing on coral and sponge reefs or adjacent to them with consequential damage still occurs, especially in areas beyond national jurisdiction. As fisheries continue to move further offshore and into deeper waters the threat to these habitats beyond national jurisdiction will continue.	Biotechnology, bioprospecting and climate change; gas and oil platforms can damage corals
Hydrothermal vents	Limited disturbances – currently due to limited research on vents, low number of species, but high endemism and high abundance.	Research community is initiating self-policing activities regarding impact of research activities so it is anticipated in the short-term that impacts from research may decline; in the long-term commercial exploitation is a concern and may drive unsustainable collection of species.	High potential for biotechnology, mining, energy and high-end tourism
Cold seeps	Limited knowledge; high endemism; limited disturbances except for Gulf of Mexico (trawling and oil exploitation) or research sites	As fishing and gas and oil operations continues to go further offshore and deeper, disturbances will likely increase.	Biotechnology and mineral exploitation

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