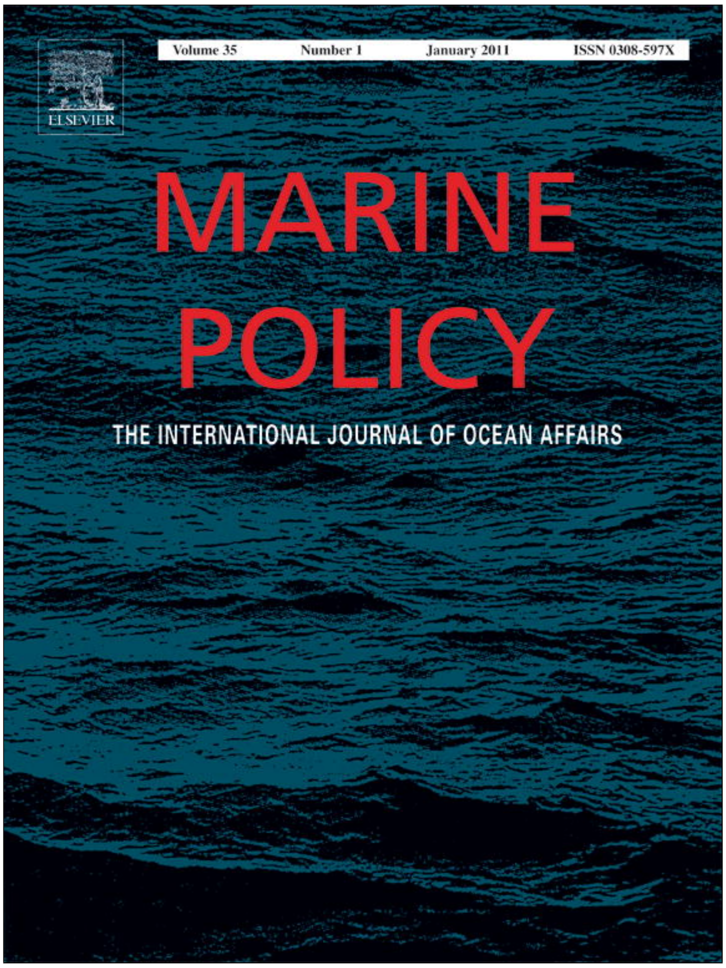

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Designating networks of chemosynthetic ecosystem reserves in the deep sea

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ABSTRACT

From the moment of their discovery, chemosynthetic ecosystems in the deep sea have held intrinsic scientific value. At the same time that the scientific community is studying chemosynthetic ecosystems other sectors are either engaged in, or planning for, activities that may adversely impact these ecosystems. There is a need and opportunity now to develop conservation strategies for networks of chemosynthetic ecosystem reserves in national and international waters through collaboration among concerned stakeholders.

1. Introduction

Chemosynthetic ecosystems are patchy habitats fueled by microbial primary production that uses chemical energy rather than photosynthesis to create organic matter. Examples of these ecosystems on Earth include cold seeps of continental margins and hot-vent ecosystems of mid-ocean ridges and other submarine volcanic systems. From the moment of their discovery, seeps and vents captured the curiosity of the general public and they have since advanced our understanding of ocean chemistry, ore formation, biological adaptations to extreme environments, global biodiversity and biogeography, evolutionary novelty, and cradles for the origin of life on Earth and on other planets and moons [1].

Scientific exploration and discovery continues at chemosynthetic ecosystems, e.g., [2–4]. Simultaneously, other human activities are underway or planned that may adversely affect these ecosystems. These include, but are not limited to, fisheries activities such as trawling that have been known to damage seep habitats, and existing or up-coming extractive industries, such as those that target energy resources at seeps or mineral resources (Cu, Zn, Au, Ag) of seafloor massive sulfides associated with vents. A disconnect exists between multiple activities with cumulative impacts at chemosynthetic ecosystems and governance structures

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that can manage and conserve these ecosystems, especially in international waters.

The jurisdictional basis for the use of maritime space is set out in the 1982 United Nations Convention on the Law of the Sea (UNCLOS). A number of other policy instruments relevant to the conservation of biodiversity and ecosystem function in the marine environment are now integral parts of international, domestic, and customary law. Of these, the Convention on Biological Diversity (CBD) is especially relevant as an international treaty that calls for conservation of all biodiversities and is implemented in the marine environment in a manner consistent with the rights and obligations of the states under UNCLOS. The CBD recognizes that ecosystems, species, and genes may be used for the benefit of present and future generations, and that any activity should be carried out without a long-term loss in biodiversity and irreversible environmental damage. Further, the CBD supports the Precautionary Principle, "*where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation*" [5]. In 2008 the CBD Conference of Parties adopted a set of seven scientific criteria to identify Ecologically or Biologically Significant Areas (EBSAs) in open-ocean waters and deep-seabed habitats (CBD COP 9 Decision IX/20 Annex I), specifically citing chemosynthetic systems as an example of ecosystems meeting EBSA criteria for uniqueness or rarity and for biological productivity. Further, the UN General Assembly (UNGA) has passed multiple resolutions that call for protection of Vulnerable Marine Ecosystems (VMEs) from the damaging effects of bottom fisheries. Hydrothermal vents, together with seamounts and cold-water corals, are cited as examples of VMEs [6], in recognition of "*the immense importance and value of deep-sea ecosystems and the biodiversity they contain*." Based on threats they face from trawling, seeps are now also included as examples of VMEs by the UN Food and Agricultural Organization [7]. Ocean ridges with hydrothermal fields are also a priority habitat of the Oslo–Paris Conventions (OSPAR) for the protection of the marine environment of the northeastern Atlantic, and hydrothermal vents are part of the planned network of OSPAR Marine Protected Areas [8].

2. Management considerations

2.1. Seeps

For seep systems along continental margins, there is a need for integrative, spatially based management of the direct and indirect impacts of on-going fisheries activities and extraction of oil and gas. Additional threats may come from emerging deep-water extraction industries such as mining of slope and shelf phosphates and diamonds. Because seeps are mostly associated with continental margins and are generally in territorial waters and exclusive economic zones, they should be included in existing and emerging marine spatial management plans (examples include the Environment Protection and Biodiversity Conservation Act in Australia; Integrated Management Plan for the North Sea 2015 in the Netherlands; the Provincial Resource Management Plan in the Philippines; the Eastern Scotia Shelf Management Initiative in Canada). To guide national efforts, high-level policy commitments are needed together with an associated legal mandate to conserve and manage chemosynthetic ecosystems on a scientific and precautionary basis. The conundrum created in less-developed countries by limited exploration of their continental margins, lack of deep-water expertise, and need for conservation-based management practices may be met by policies that engender a philosophy of environmental stewardship within new and emerging industries.

2.2. Vents

For vent systems, there is a need to implement scientific and legal measures to minimize impacts of proposed extraction of seafloor massive sulfides [9,10], and to develop a system that provides for proactive conservation. While some hot-vent ecosystems in national waters are partially or fully protected from extractive activities, they are few in number (e.g., Canada: Endeavor Marine Protected Area (MPA); Portugal: Azores Marine Park; Mexico: Guaymas Basin and East Pacific Rise Sanctuary; USA: Mariana Trench National Monument). Marine mineral exploration licenses have either been granted or lodged with a number of countries, including New Zealand, Solomon Islands, and Fiji. These actions, together with the ongoing exploration within the exclusive economic zone of countries such as Tonga and the likely emergence of a new deep-sea mineral extraction industry in territorial waters of Papua New Guinea within the next few years [11], lend special urgency to formulation of a policy that permits development of deep-sea mineral resources in a manner consistent with UNCLOS obligations for protection of the marine environment and with goals of the CBD.

Most hot-vent ecosystems are located in areas beyond national jurisdiction, areas that have received far less protection than any other area on the planet [12]. Beyond areas of national jurisdiction, authority to manage human activities is vested in specific organizations. For example the International Maritime Organization has jurisdiction over shipping and marine pollution caused by ships, and Regional Fisheries Management Organizations managing deep-sea fishing. Despite a number of policy instruments that call for conservation in marine ecosystems outside national waters, no single institution is charged with implementing and enforcing conservation and management across sectors. Many activities that could significantly impact chemosynthetic ecosystems, including cable and pipeline laying, marine scientific research, and bioprospecting, remain largely unregulated. Scientific research on mid-ocean ridges and vents is, however, governed by voluntary codes of conduct (see [1,13]), and the International Marine Minerals Society has developed a comprehensive code for environmental management of marine mining [14].

3. Development of mineral resources: the International Seabed Authority

A special regime, elaborated in Part XI of UNCLOS and a related implementation agreement, deals with the development of mineral resources of the Area Beyond National Jurisdiction (ABNJ; the Area). The International Seabed Authority (ISA) is the institution through which states that are parties to the convention organize and control activities of exploration and exploitation of mineral resources in the Area. The ISA also has a responsibility to adopt and apply regulations for the protection and preservation of the marine environment from the harmful effects of such activities. The ISA recently adopted regulations governing exploration and prospecting for massive sulfides in the area, and is evaluating environmental management plans for manganese nodule fields in the Clarion-Clipperton Zone. Once mineral exploration leases on mid-ocean ridges are granted and large extents of ridge segments are designated for mining interests, it will be much harder to create scientifically defensible networks of chemosynthetic ecosystem reserves. Mining and conservation interests need to work in tandem if networks are to be in place before mining at multiple sites begins. The first applications to the ISA for exploration licenses have been lodged by the China Ocean Mineral Resources Research and Development Association for the Southwest Indian Ridge and by the Russian Federation for the Mid-Atlantic Ridge; these applications will be considered by the ISA in 2011.

Timely action is required to establish regulatory guidelines that promote conservation of biodiversity in chemosynthetic ecosystems while allowing development of mineral resources.

4. Protection of natural resources: the Dinard Guidelines

To move toward conservation of representative chemosynthetic ecosystems in national or international waters, a set of guidelines for establishment of networks of Chemosynthetic Ecosystem Reserves has been proposed (see Box 1: Dinard Guidelines and [15]). The Dinard Guidelines have the conservation goal of protecting natural diversity and the structure, function, and resilience of chemosynthetic ecosystems while enabling their rational use. It is recommended that these guidelines or their derivatives be adopted and implemented by competent agencies at national and international levels to ensure that chemosynthetic resources may be used for the benefit of present and future generations without a long-term decline in biodiversity and irreversible environmental damage.

While the ISA has been proactive in developing rules, regulations, and procedures that incorporate standards for the protection and preservation of the marine environment during exploration and extraction of mineral resources (Annex to Part XI of UNCLOS; Section 1g), its role is essentially sectoral. The ISA is not specifically charged with developing and implementing conservation and management processes relating to EBSAs, VMEs, or networks of Chemosynthetic Ecosystem Reserves even though the majority of member States of the ISA are also parties to the CBD and bound by CBD obligations relating to protection of biodiversity. Under the present regulatory regime, there is a risk that conservation decisions will be driven by exploitation interests rather than by interests in conservation (or sustainable use for other stakeholders) – all uses of the seabed need to be taken into account in the decision-making process.

5. The way forward

In the history of regulation of oil, gas, and fishing activities, conservation management plans have typically been designed and implemented only after the activities had already been initiated, as in the oil and gas industry in the Gulf of Mexico [16], if at all. For seafloor mineral extraction at hydrothermal vents outside national jurisdictions there exists a window of opportunity to establish regulatory frameworks for the conservation of chemosynthetic habitats before the exploitation activities begin, through actions of the ISA [17] or other competent bodies. Gaps in the legal framework for international ocean governance should be filled through new agreements consistent with UNCLOS, within the ISA or another body explicitly tasked with conservation, in a way that separates oversight of licensing activity from environmental regulation and conservation.

For effective management of chemosynthetic ecosystems within EEZs, where valuable fisheries, hydrocarbon resources, and seeps often co-occur, the way forward must involve raised awareness of the value of biodiversity and careful assessment of marine policy options that promote resource sustainability. In some less developed countries where exploitation of margin resources is currently limited but growing exponentially, regulatory opportunities exist but seizing them will require extensive capacity building in scientific, conservation, and policy arenas.

Chemosynthetic ecosystems are just one of a broader array of deep-sea habitats (e.g., seamounts, deep-water coral reefs, submarine canyons, key slope fishing grounds) that require comprehensive management. Regulatory frameworks for chemosynthetic ecosystems that are informed by scientifically sound conservation principles can set an important precedent for conservation priorities in the deep sea, within both national and international waters.

Box 1–Dinard Guidelines for Chemosynthetic Ecological Reserves (CERs) at deep-sea hydrothermal vents and cold seeps, initiated at a June 2010 workshop attended by 31 stakeholders from 14 countries, including scientists, policy makers, and industry representatives, and developed further in the report of the workshop [15].

A) Spatial Design of Chemosynthetic Ecological Reserves (CERs)
- Identify chemosynthetic sites that meet the Convention on Biodiversity criteria for Ecologically and Biologically Significant Areas (EBSAs) or are otherwise of particular scientific, historical, or cultural importance for priority consideration for protection.
- Define the regional framework for protection of biodiversity. Natural management units (biogeographic provinces and bioregions within these) form the ecological framework within which CERs should be established for the protection of chemosynthetic ecosystems.
- Establish the expected distribution patterns of chemosynthetic habitats to provide a spatial framework for capturing representativity.
- Establish CERs and design replicated networks of CERs within bioregions, using guidelines for size and spacing that ensure connectivity and that take into account the pattern of distribution of chemosynthetic habitats, which may vary from semi-continuous to widely dispersed.
- Define human uses and the levels of protection for each CER to achieve the conservation goal.

B) Management Strategies for Chemosynthetic Ecological Reserves
- Use a two-level approach for establishing CERs: (1) select CER sites of extraordinary stand-alone value; (2) fill in the ''gaps'' to establish networks of CERs that, combined, will contribute to the network-level conservation goals while taking into account the spatial demands of human activities.
- Use adaptive management strategies to account for uncertainty and new knowledge.
- Establish CERs in a manner that is consultative and transparent.
- Governance of CERs should be within existing governance regimes wherever possible.
- Where CERs include activities with the potential to cause significant adverse impacts, Environmental Impact Assessments (EIAs) should be required for these activities and should follow best practices.
- Establish monitoring strategies to assess the impacts of cumulative activities in space and time relative to the conservation goal and objectives.
- Use a set of prescriptive criteria, established before multi-use activities begin, to trigger closer monitoring or cessation of activities that jeopardize the conservation goal within a bioregion.

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