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Putting marine scientific research on a sustainable footing at hydrothermal vents

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Abstract

Marine scientific research (MSR), involving the study of hydrothermal vent systems and their associated biological communities, is of some of the most exciting scientific work currently being undertaken. It is generally recognised that the discovery of chemosynthetic-based ecosystems at hydrothermal vents on the deep seabed was one of the most important findings in biological science in the latter half of the 20th century. Hydrothermal vents—underwater water circulatory systems driven by sub-surface volcanic activity—are primarily concentrated along the earth's Mid-oceanic Ridge, a 60,000 kilometre seam of geological activity. Their warm, chemical-laden, waters support some of the planet's most productive and densely populated marine biological communities, despite extreme conditions of high pressure, toxicity and darkness. Though deep sea hydrothermal vents are typically low in biodiversity at the macro-organism level, they tend to exhibit high endemism at taxonomic levels higher than species. In contrast, they host one of the highest levels of microbial diversity on the planet. It is thought that hundreds if not thousands of hydrothermal vent sites may exist along the Mid-oceanic Ridge. But they are extremely hard to find and only approximately 100 sites have been documented by researchers to date. Of these, perhaps only about 12 sites—located within and beyond the limits of national jurisdiction in the International Seabed Area (the Area)—are regularly visited for MSR purposes, primarily because of their proximity to land-based facilities and their relative ease of accessibility. Despite the appearance of physical isolation and their apparent inaccessibility under thousands of metres of water, the more accessible deep sites are potentially threatened by human activities. The activities most likely to involve hydrothermal vents and their biological communities are seabed mining for associated polymetallic sulphide deposits, submarine-based tourism and MSR. Of these, ironically, MSR poses the most immediate threat to the most visited hydrothermal vent systems and their associated biological communities. As a natural resource-based activity MSR needs to be placed on a sustainable footing in order to conserve biodiversity and maintain the scientific value of the most accessible sites. This article will focus on the tools available to place MSR on a more sustainable footing at hydrothermal vents located within and beyond the limits of national jurisdiction. A code of conduct for MSR activities at hydrothermal vents will be proposed.

Keywords: Marine scientific research; Hydrothermal vents; Mid-oceanic Ridge; International Seabed Area; Code of conduct

1. Introduction

Marine scientific research (MSR), involving the study of hydrothermal vent systems and their associated biological communities, is of some of the most exciting scientific work currently being undertaken. It is generally recognised that the "discovery of chemosynthetic-based ecosystems at hydrothermal vents… [on the deep seabed]…was one of the most important findings in biological science in the latter half of the 20th century [1]."

Hydrothermal vents—underwater water circulatory systems driven by sub-surface volcanic activity—are primarily concentrated along the earth's Mid-oceanic Ridge, a 60,000 km seam of geological activity. Their warm, chemical-laden, waters support some of the planet's most productive and densely populated marine biological communities, despite extreme conditions of high pressure, toxicity and darkness [1].

Though deep-sea hydrothermal vents are typically low in biodiversity at the macro-organism level, they tend to exhibit high endemism at taxonomic levels higher than species [2]. In contrast, they "host one of the highest levels of microbial diversity on the planet [3]".

Micro-organisms provide the biological interface between the vents' physical and chemical environments.

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Some act as the basis of a chemosynthetic food web that supports crustacea, polychaetes, echinoderms, coelenterates, fish and molluscs.

It is thought that hundreds if not thousands of hydrothermal vent sites may exist along the Mid-oceanic Ridge. But they are extremely hard to find and only approximately 100 sites have been documented by researchers to date [2]. Of these, perhaps only about 12 sites[1]—located within and beyond the limits of national jurisdiction in the International Seabed Area (the Area)—are regularly visited for MSR purposes, primarily because of their proximity to land-based facilities and their relative ease of accessibility.

Despite the appearance of physical isolation and their apparent inaccessibility under thousands of metres of water, the more accessible deep sites are potentially threatened by human activities. The activities most likely to involve hydrothermal vents and their biological communities are seabed mining for associated polymetallic sulphide deposits, submarine-based tourism and MSR.

Of these, ironically, MSR poses the most immediate threat to hydrothermal vent systems and their associated biological communities.[2] As a natural resource-based activity MSR needs to be placed on a sustainable footing in order to conserve biodiversity and maintain the scientific value of the most accessible sites [4].

This article focuses on the tools available to place MSR on a more sustainable footing at hydrothermal vents located within and beyond the limits of national jurisdiction. Section 2 briefly describes MSR and the threats posed to hydrothermal vents. Section 3 describes the international legal basis for conserving hydrothermal vents and provides two case studies of national approaches that involve creating marine protected areas (MPAs). Section 4 proposes a code of conduct for MSR activities at hydrothermal vents.

[1] Five or six vent sites are visited at a once per year frequency. These include Endeavour and Axial Volcano in the northeast Pacific, 9° North on the East Pacific Rise, Lucky Strike, Rainbow and possibly Menez Gwen on the Mid-Atlantic Ridge. There are probably at least as many again that are visited every 2 or 3 years.

[2] Mining for polymetallic sulphide crusts poses the greatest potential physical threat to hydrothermal vents and their biological communities. Direct adverse impacts may include direct physical damage and destruction. Indirect adverse impacts may include sedimentation and disrupted water circulation systems.

An informal WWW survey indicates that submarine-based marine tourism is taking place along the mid-Atlantic Ridge at the Rainbow site off the Azores in the Area. The Russian Academy of Sciences has partnered with Deep Ocean Expeditions, a tour operator, to offer non-scientists the opportunity to participate in and help financially support scientific research cruises. Biological and geological samples are collected using the Russian Mir submersibles. The tours appear to be limited to once a year. See generally the Deep Ocean Expeditions WWW site (site visited on 25 November 2002) ⟨http://www.deepoceanexpeditions.com/default.cfm?loadlevel=2&loadindex=27⟩.

2. MSR at hydrothermal vents

Commentators have noted that one aspect of the threat MSR poses originates from a shift in research priorities from exploration and discovery to those emphasising temporal processes through observation [2,5]. According to Mullineaux et al., the resulting "concentration of sampling, observation and instrumentation at a small number of well known hydrothermal sites" has led to the discovery "that certain activities are incompatible, and that even more cooperation and coordination will be required to resolve potential conflict [5]".

A growing problem is the conflict between observational monitoring activities that depend upon vent sites remaining in an undisturbed state and those activities that involve manipulating or collecting biological or geological samples from a particular area. Furthermore, Mullineaux et al., assert that "disturbance by researchers can have a substantial impact on vent systems" and that "anthropogenic changes in distribution and occurrence of vent fluid flows and of associated vent communities have been well-documented at vents along the East Pacific Rise, on the Juan de Fuca Ridge and at the TAG field on the Mid-Atlantic Ridge.

This view was echoed by the InterRidge Workshop on the Management and Conservation of Hydrothermal Vent Ecosystems (28–30 September 2000, Sidney, British Colombia, Canada). The workshop was "the first formal consideration by the international scientific community of the threat to isolated hydrothermal vent 'oasis' ecosystems from human activities [1]."

The participants found that "[m]ost scientific activity is concentrated at a relatively small number of vent… [fields]…that are visited repeatedly." Concentrated sampling and instrument deployments have resulted in use conflicts between biologists with different research approaches and biologists and geologists.

Frequently, more concentrated sampling puts pressure on vent biological communities. This is compounded by the relatively small areas that animals tend to occupy on the surfaces of and below the surface of the venting structures. Vent fields, which tend to be small, sometimes measuring only in the tens or hundreds of square metres, are also subject to more general environmental impacts from MSR.[3]

Two other workshop conclusions are worth noting. First, participants agreed that criteria were needed to

[3] Direct impacts include chimney removal, environmental manipulation, clearing fauna, faunal transplantation between sites, instrument placement and boring, observation, submersibles' thrust and light.

Second order impacts include decreased population numbers, local extinction, regional or global extinction, structural changes to biological communities, disrupted water circulatory systems and the introduction of alien species riding on underwater vehicles and equipment.

identify "critically important" sites—those that are ecologically sensitive or scientifically important.[4]

Second, participants concluded that the management of all hydrothermal vent sites was not only unnecessary but unrealistic. Instead efforts should focus on the most visited sites whether within or beyond the limits of national jurisdiction.

3. Possible legal and institutional tools

MSR is generally viewed as a valuable activity contributing to human knowledge. It is an activity that needs to be encouraged. At the same time, MSR needs to be undertaken sustainably. For these reasons a primary issue is how to ensure conservation, sustainable use and fewer use conflicts at frequently visited hydrothermal vent sites while not impeding MSR activities unnecessarily?

MSR activities at hydrothermal vents take place both within and beyond the limits of national jurisdiction. Different approaches need to be taken depending on where the activities are located and which sources of law apply.

At the global level, the primary sources of relevant international treaty law are the United Nations Convention on the Law of the Sea (1982) (UNCLOS) and the Convention on Biological Diversity (1992) (CBD). Each treaty's scope of application depends primarily on the nature of the activity and the activity's geographical location.

UNCLOS subjects it Parties to the very general obligations of protecting and preserving the marine environment (art. 192) and protecting and preserving rare or fragile ecosystems (art. 194(5)).[5]

Parties also have obligations to conserve the living resources of their exclusive economic zones (EEZ) (art. 61) and to conserve and manage the living resources of the high seas (art. 117). It is, however, unsatisfying to read into these provisions more than what they were originally intended to apply to: species targeted by fishing activities, especially since the MSR activities at hydrothermal vents do not resemble fishing.

On the other hand, the UNCLOS MSR provisions (Part XIII) are more directly on point and are applicable to activities within and beyond the limits of national jurisdiction. They provide a departure point for managing scientific activities at hydrothermal vents.

States with hydrothermal vents within their jurisdiction could simply regulate MSR through MSR consent procedures typically vetted through the ship clearance procedure. For example, within areas of national jurisdiction, UNCLOS establishes principles for a MSR consent regime overseen by a coastal State (Part XIII, Section 3). Express consent is required within the territorial sea (art. 245), while consent shall be granted in normal circumstances in the EEZ and on the continental shelf (art. 246). In each situation consent can be subject to conditions including those to address environmental considerations (art. 240 (d)).

The situation is less controlled on the high seas and in the Area. All States and competent international organisations have the right to conduct MSR (art. 256) subject to the rights and obligations of other States.

MSR is further qualified in the Area. All MSR within the Area "shall be carried out for the benefit of [hu]mankind as a whole" (art. 143(1)). This standard however has yet to be defined. What's more, even though the International Seabed Authority has a mandate to promote MSR at least with regard to the Area's mineral resources (art. 143 (2)), at present there is no comprehensive international oversight of MSR activities in the Area.

With respect to biodiversity conservation, the CBD fills in some of the gaps left by UNCLOS. The CBD's obligations applied to hydrothermal vents and MSR activities within the limits of national jurisdiction provide an ample framework to justify conservation action by its Parties.

For example, the CBD subjects its Parties to a range of obligations at ecosystem, species and genetic levels such as establishing protected areas, identifying the components of biodiversity and using environmental impact assessment. The requirement for Parties to identify (article 7(c)) and then regulate or manage (article 8(l)) threats to biodiversity, is unique and potentially quite powerful if applied to MSR activities within areas of national jurisdiction (see generally, [6]).

Beyond the limits of national jurisdiction, as with UNCLOS, the situation again becomes less defined and depends on the proactive actions of Parties working alone or together with other Parties and States. Parties are to co-operate on processes and activities that may threaten biological diversity. This provides a basis for action in the Area.

[4] Proposed criteria include whether (1) a high degree of endemism exists; (2) unique species are present; (3) the species affected have restricted geographic distribution or recruitment potential; (4) the site is unusually long-lived; (5) high species or genetic diversity are present; (6) unusually high environmental diversity is present; (7) unique ecological interactions occur; (8) the site has exceptional scientific value; and (8) the site is particularly valuable for education [1].

[5] The general obligation to protect and preserve rare or fragile ecosystems under article 194(5) appears in a section entitled, "Measures to prevent, reduce and control pollution of the marine environment." The intent is to ensure that UNCLOS Parties take into consideration the protection of rare or fragile ecosystems when they take measures to prevent, reduce and control pollution. There is some difficulty reading this as a stand alone obligation to protect rare or fragile ecosystems for reasons other than pollution prevention, reduction and control. Notwithstanding this limitation, the CBD can be interpreted to provide a gap-filling function when States are Party to both instruments.

Importantly, the CBD is more than its obligations. The Conference of Parties (COP) has an elaborate work programme covering a variety of different thematic and cross-cutting areas whose aims are to support the Convention's obligations through, among other things, the development of guidelines. Consequently, the COP has the ability to further define and deepen the Convention's obligations directly or as they are applied within particular contexts. In contrast to UNCLOS's more static nature, this dynamic process makes the CBD adaptable and facilitates its evolution.

Still, the CBD has not yet begun to treat deep-sea biodiversity through the Jakarta Mandate, its marine biodiversity work programme. This however may change.

The Eighth Meeting of the CBD Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA), scheduled to meet in March 2003, will consider a study[6] on the sustainable use of genetic resources in relation to bioprospecting on the deep seabed. It is hoped that this will provide an opportunity to address wider issues of deep seabed ecosystems such as the conservation of hydrothermal vents and sea mounts (For a general overview of the issue see [7,8]).

The greatest number of intersections between UNCLOS and the CBD will likely occur in areas of national jurisdiction, as both treaties have the most detailed provisions covering this geographical area. Importantly, States may already have in place laws implementing these treaties, as well as unrelated but potentially applicable environmental laws.

In contrast, there are no definitive or clear cut applications of either treaty with regard to the Area, especially in terms of conservation and sustainable use of the biological communities associated with hydrothermal vents. From a practical standpoint, hydrothermal vents, their associated biological communities and, with the exception of seabed mining, the activities involving them fall into an international legal crack whose boundaries are ill-defined by high seas freedoms.

There is no specific reference to hydrothermal vents anywhere and the application of international law on biodiversity conservation can only be inferred. This is not necessarily problematic if marine scientific researching States undertaking active hydrothermal vent programmes and party to either, both, or, in the case of the United States, neither, are willing to creatively interpret and apply the treaties' principles. The difficulty lies in getting these States to act.

In areas of national jurisdiction managing physical access to sites important for biodiversity conservation or of scientific interest may be a viable solution to the problem. One possibility already alluded to is for an oversight agency that grants consent to undertake MSR within the EEZ and on the continental shelf, to undertake a screening or clearing house-type function. It could identify potential conflicts and make prospective researchers aware of them before they occur, perhaps when a permit application to undertake research is first submitted.

If the country is particularly advanced, granting permission to undertake activities in an area might be informed by a management plan, especially if the hydrothermal vent area has been established as a marine protected area (MPA). Moving beyond simply managing access through vessel clearance procedures to creating an MPA and an accompanying management plan is really the only way to not only control access but to establish comprehensive protection and active management. This general concept reflects the approach that Canada and Portugal are respectively taking for the Endeavour Hydrothermal Vents Area and Lucky Strike/Menez Gwen, three hydrothermal vent systems located within their jurisdiction.

3.1. The Canadian approach

The Endeavour Hydrothermal Vents Area is one of three known hydrothermal sites in Canadian waters [3]. It lies on the Juan de Fuca Ridge, about 256 km southwest of Vancouver Island. Endeavour is the largest and most diverse area of hydrothermalism on the Juan de Fuca Ridge. Five vent fields of black smokers and cooler vented waters are found there with about 2 km of seabed separating one from the other.

According to Tunnicliffe and Thomsen, a typical Endeavour vent field lies in 2200 m of water [3]. It may include "dozens of sulphide structures or edifices rising tens of metres" high and measure 300 m $\times$ 200 m in area. The size of some of the sulphide structures, such as the 15 storey high "Godzilla", suggests that the some venting taking place has been stable over a long period of time.

Biomass may range up to half a million animals per square metre of vent surface. Twelve species are endemic to Endeavour.

Endeavour's vent fields do not exist in isolation. It is hypothesised that the Endeavour vents influence the biological productivity of the overlying water column.

For example, Tunnicliffe and Thomsen note that a combination of "chemosynthetic bacteria, resuspended detritus from the upper ocean, and other biological products carried upward in the buoyant plumes [of the vents] support a wide range of biological activity in the overlying water column". They continue that "within a radius of about 50 km of the Endeavour Ridge venting region, zooplankton communities consist of both deep- and shallow water species of zooplankton, suggesting

[6] See UN Doc. UNEP/CBD/SBSTTA/8/INF/3 (visited on 4 December 2002) 〈http://www.biodiv.org/doc/meeting.asp?wg=SBSTTA-08〉

that the animals migrate vertically over 2000 m to reach these food rich zones''. Zooplankton predators follow.

Endeavour is visited by one to several MSR expeditions every year [3]. Biological and geological samples are collected and instrumentation is left behind. Commentators have suggested that MSR is exerting low pressure on the Endeavour area and that it is difficult to distinguish between natural variability and MSR-related impacts [3].

However, pressure may grow over the long-term with technological advances and increased scientific and public interest [9]. As usage grows, habitat degradation from physical damage to the vent structures is seen as the primary threat to the Endeavour vent fields.

The Canadians foresaw the need to comprehensively manage the area by creating an MPA. The links between the Endeavour vents and the water column suggested that the MPA would need to include both. The Endeavour Hydrothermal Vents Marine Protected Area is proposed to cover a $100\,km^2$ area of seabed and the overlying water column.

As of December 2002, the Endeavour MPA has yet to be legally established and consultations are on-going. Final establishment is expected in early 2003. The regulatory approach proposed is structured around existing and new legal requirements related to the MPA designation/management and vessel clearance.

The 1996 Oceans Act is the primary Canadian legal authority for designating the MPA. Endeavour is considered to be a unique habitat with unique species and high productivity. It provides unique MSR opportunities while being vulnerable to human pressures [10].

Within the MPA, a new prohibition promulgated by regulation would prevent any person from disturbing, damaging, destroying or removing ''any part of the seabed, including a venting structure, or any part of the subsoil, or any living marine organism or part of its habitat'' without first obtaining the relevant licenses and submitting a research plan (see [11], Sections 2 and 3). Activities within the MPA would need to be for scientific research to conserve, protect and understand the area within the MPA (see [11], Sections 3(a) (1)).

An MPA designation provides the basis to manage the area comprehensively to achieve eight management objectives enumerated in a management plan developed via a stakeholder dialogue process [12]. The plan's primary objectives are to conserve and protect Endeavour's ecological integrity and to monitor and coordinate activities through an Access Authorisation Process. The management plan is being applied on an interim basis prior to the MPA's legal establishment. Users are asked to voluntarily comply with the plan.

Four management areas correspond to the four best known vent fields found within the Endeavour Area. A fifth area, ''Sasquatch'', has been recently discovered and has yet to be integrated into the management plan, though it does fall within the areal boundaries of the MPA [13].

Each management area is managed to achieve different objectives. In effect, Endeavour has been zoned for different uses representing a continuum of intrusiveness. Activities incompatible in one management area can be potentially re-directed to one of the other three management areas if their own management objectives are not contravened.

For example, the ''Salty Dawg'' field has been reserved as an observational research site [14]. Its relatively pristine nature makes it ideal for research on the effects of human activities on hydrothermal vents. Research involving moderate sampling could be redirected from Salty Dawg to the ''Mothra'' or ''Main Endeavour'' vent fields because they are reserved for this type of activity.

In contrast, the ''High Rise'' vent field has been reserved for educational and outreach projects. Intrusive activities can be shifted to Mothra and Main Endeavour, leaving High Rise useful for long-term monitoring.

A multi-pronged information and monitoring mechanism is a central feature of the management plan. An information centre will be developed as one of the MPA management objectives. It will be used to consolidate access to a large number of existing and yet to be developed individual data sources related to Endeavour.

The information centre will among other things help to inform researchers who plan or are carrying out MSR, facilitate information sharing and identify research gaps [15]. It will also provide the basis for information and outreach programmes that are the basis of management objective 8.

Marine environmental quality will be monitored through yet to be developed protocols and indicators in order to eliminate or minimise human impacts [16].[7] This information will then be used to support an evaluation process for each of the management areas, correlated to their management objectives and the number of access requests granted and denied. The overall management plan will be kept under continual informal evaluation by a management committee, with formal re-evaluation taking place every 5 years.

Access restrictions within the MPA would apply equally to Canadian and foreign nationals and vessels. Access to the site would be regulated pursuant to existing regulations governing fisheries [17] and foreign vessel clearance [18]. Applicable authority is determined by whether access is sought by domestic or foreign vessels, respectively.

[7] Some possible monitoring approaches include (1) before and after imaging of the sample site; (2) continuous video taping by submersible and dive operations (for research, education or tourism) when on the sea floor; (3) cruise reports; and (4) on-board observers.

The Fisheries Act (1985) and regulations govern access by domestic vessels. Under this body of law, fishing without a licence is prohibited, as is fishing for scientific purposes. Alteration of fish habitat is prohibited without authorisation. A license issued pursuant to the Fisheries Act would specify conditions for undertaking activities within the MPA [9].

The authority to regulate access by foreign vessels is governed by the Coastal Fisheries Protection Act (1985) and its regulations and the Coasting Trade Act (1992). The former address fishing and access to Canadian ports. The later addresses access to Canadian waters.

The Coasting Trade Act specifies that foreign vessels are prohibited from conducting MSR in Canadian waters. They must first seek and be granted foreign vessel clearance through diplomatic channels from the Department of Foreign Affairs and International Trade (DFIAT) (see [18], Sections 3(2) (a)).

Currently, requests to access Canadian waters for MSR purposes are directed by DFIAT to the Department of Fisheries and Oceans (DFO) for review. DFO then requests DFIAT to condition consent to ensure Canada's interests in the MSR undertaken usually by requesting the participation of a Canadian observer and the submission of a cruise report [9].

This process, with an additional level of review, is already being applied in the Endeavour Area as an interim management measure until the MPA is legally established. Requests to access the Endeavour Area are channelled by DFO to the Endeavour Planning Team. The Planning Team reviews the request for its consistency with the Endeavour Management Plan [12]. DFO decides on access. Once the Endeavour MPA is legally established a multi-stakeholder management committee[8] will be created to take over review and management functions.

3.2. The Portuguese approach

The Azores Triple Junction—the point where the American, Eurasian and African continental plates meet—is the location of four hydrothermal vent fields. Together the four fields stretch in a line along the Mid-Atlantic Ridge to the southwest of the Azores.

Menez Gwen, Lucky Strike, Saldanha and Rainbow lie at different depths (850–2800 m), have different geology and host distinct ecosystems [19]. Their ecosystem diversity is thought in part to derive from their different depths and the quality of vented effluent and gas that characterises each site.

These four vent fields, and four others, are the only known areas of hydrothermal activity in the North-east Atlantic Ocean [20]. Only Menez Gwen and Lucky Strike are found within a State's (Portugal) EEZ.

Menez Gwen is found in 850 m of water, in the cone of a young undersea volcano [21]. Deep water coral reefs are found in the areas away from the active venting.

Lucky Strike, further to the southwest, is considered to be one of the largest known active fields yet discovered anywhere. Its 21 active chimney sites lie in 1700 m of water.

Lucky Strike's vent sites provide habitat for 66 identified species. Its biomass and biodiversity is greater than that of Menez Gwen (with 35 identified species). One species of mussel dominates with up to 600 individuals per square metre observed [20].

The two sites have been the subject of ad hoc MSR activities on a regular basis since their discovery during the 1990s. Though foreign vessels are subject to Portuguese foreign vessel clearance procedures, no site specific management measures have been taken to regulate use and minimise impacts [21]. Since 1998, scientists have recognised the need for a more coordinated approach to biological and geological MSR activities at the Azores Triple Junction vent fields, and developed the MOMAR proposal.[9]

In October 2001, the Azores Regional Government proposed creating MPAs for Menez Gwen and Lucky Strike. The Azores Regional Government sponsored a workshop to vet a draft MPA management plan for the sites in June 2002 [24].

The workshop brought Portuguese and international experts together to share experiences. Working groups (1) developed a preliminary zoning scheme for the two sites; (2) reviewed outstanding legal and institutional issues; and (3) developed possible elements for a code of conduct.

[8] The Management Committee will be responsible for the MPA's overall management. It will be chaired by DFO. It will inter alia (1) identify and evaluate emergent or critical issues involving the use of the MPA's resources; (2) review plans for research and other activities, such as submarine tourism; (3) identify educational opportunities; (4) provide advice to DFO on the MPA's development and evaluation; and (5) twice annually review applications for research and other activities within the MPA. The Committee will have 13 members including Canadian researchers (3), foreign researchers (2), educators (2) and an environmentalist (1) (see [12]).

[9] MOMAR (MOnitoring the Mid-Atlantic Ridge) is an international initiative "to promote international cooperation to establish long-term multi-disciplinary monitoring of the Mid-Atlantic Ridge near the Azores. The MOMAR initiative is envisioned to last 5–10 years with funding primarily from the European Union. It will coordinate observations of biological and physico-chemical activity at hydrothermal vents and observations on geological processes. Permanent seabed-based observatories would be deployed. Submarine cables to transmit power and data and moored buoys are envisioned. To accomplish its scientific goals, MOMAR—through its Steering Committee—will coordinate the setting of instrumentation, repeated sampling, site management and project implementation. The MOMAR region would include the Menez Gwen, Lucky Strike, Saldanha and Rainbow vent fields—sites located within the Portuguese EEZ and within the Area. (See generally, [22,23]).

The participants concluded that both proposed MPAs should be defined by easily identifiable boundaries (boxes) larger than the vent areas themselves. They would include the water column. Each would exclude mining, fisheries and tourism activities. MSR would be the only activities allowed within the MPAs. MSR activities would be regulated and zoned within the vent fields themselves.

The Menez Gwen MPA would comprise two areas: (1) a conservation area (southern sites including the active volcano and the coral reefs) and (2) a "regulated" sampling area (the remaining area). The conservation area would be reserved for non-intrusive observation and non-destructive sampling. The regulated sampling area would be at minimum subject to a code of conduct.[10]

The Lucky Strike MPA would comprise three areas: (1) an integral reserve (two chimneys), (2) a reserve (three chimneys) and (3) a regulated sampling area (remaining area). The integral reserve area would be designated for observational activities only. The natural state of the environment would be respected so that evolutionary processes could be observed. The reserve area would allow observation and monitoring activities. The regulated sampling area would be at minimum subject to a code of conduct.[11]

The second working group looked at the possible legal and institutional basis for creating and accessing the MPAs. An outstanding issue that remains to be clarified by the Portuguese and Azores Governments was which law applied to the MPA's creation [26].

Portuguese law allows two MPA categories to be created: marine parks and marine reserves. Protected areas legislation is under review in the Azores. At the time of the workshop it was unclear whether the Azores Regional Government had the authority to create MPAs beyond the territorial sea, even though it was presumed that the MPAs would be managed at the regional level.

It was agreed, however, that in any case, the MPAs should be formerly established in law and not simply defined by a voluntary arrangement guided by a management plan. It was also agreed that a code of conduct, and perhaps the management plan, could be applied on an interim basis prior to the MPAs' formal legal establishment. The principles embodied in a code of conduct could also provide the basis for permit conditions later on.

Regulating access to the MPAs was also reviewed. Existing foreign vessel clearance procedures, overseen by the Portuguese Foreign Office, could remain in place but the consultation process should be expanded to include the competent authority designated to oversee the MPAs' management.

Domestic research vessels working at Menez Gwen and Lucky Strike, on the other hand, have been largely unregulated in the past. It was foreseen that the access procedures for domestic vessels could be addressed through the national or regional MPAs legislation. Fisheries legislation would apply to fishing activities within the MPAs.

The third working group looked at the concepts behind and the possible elements for a code of conduct for MSR activities and for managing the MPAs.[12] It was

[10] The zonation working group also proposed that the area would be subject to "the indications of the MOMAR Steering Committee" (see [25]). It is not clear at this point what the relationship would be between the MOMAR Steering Committee (see [21]) and governmental regulatory processes over the MPA (whether at the national or regional levels). However, the MOMAR Steering Committee could be envisioned to act as a management committee providing advice to the Portuguese or Azores governments (once the respective governmental competences are established). This governance structure would parallel the Canadian example with the Endeavour Management Committee. (See [12]).

[11] The area would also be subject to "the indications of the MOMAR Steering Committee" (see [24,25]).

[12] In actuality both the code of conduct working group and the zonation working group discussed possible elements for a code of conduct. Elements discussed included: (1) investigators should provide accurate and relevant information to the competent authority managing the MPAs; (2) research proposals should include a statement of possible environmental impacts; (3) scientific equipment proposed for deployment and actually deployed should be reported to the competent authority to avoid use conflicts; (4) activities should not damage or destroy active vents; (5) activities should not pollute the area with materials (inert or otherwise) and the presence of non-natural substances should be reported to the competent authority; (6) sampled materials should not be disposed of at sea outside the area of collection to minimise contamination; (7) biological transplantation should be forbidden within the MPA and discouraged elsewhere to minimise risk of genetic pollution, disease transmission and the introduction of alien species; (8) on-going, already deployed experiments should be respected and not disturbed; (9) zoned MPA areas and authorised activities should be respected; (10) a list of samples should be sent to the competent authority after a cruise; (11) non-target samples not originally approved should be reported to the competent authority; (12) samples should be shared; (13) voucher specimens and reference collections should be deposited with the Azores Natural History Museum; and (14) the code of conduct and its implications should be disseminated among the investigators participating in a cruise (see [25,27]).

With regard to MPA management, the competent authority should: (1) encourage publication of results while protecting unpublished data; (2) maintain a public record of planned and completed research especially to avoid use conflicts; (3) publish an annual summary of research within the MPAs especially directed towards the public; and (4) encourage interdisciplinary research teams (see [27]).

It appears that submarine tourism will be banned within some or all of the areas encompassing the Menez Gwen and Lucky Strike MPAs. Still, the workshop's code of conduct working group proposed possible elements for a code of conduct or management plan to address this tourism: (1) access should be prohibited within defined zones (e.g., experimental areas and highly sensitive sites) depicted on maps; (2) accessible areas should be restricted with regard to inter alia mode of operation, vessel type and size; (3) tour operators should provide on-board ship access to MPA officials for public education and awareness activities, as well as to function as observers to ensure compliance; (4) biological and geological specimen collection should be prohibited; (5) photographic and video imagines should be only for private use; (6)

foreseen that some of the elements proposed could also find more direct application in the MPA management plan itself.

4. Towards a code of conduct

To an observer, the Azores MPA workshop was particularly noteworthy because it represented another example of the scientific community's growing acceptance of the need to regulate access to sites that are valuable to science and for their biodiversity. The workshop also demonstrated that a code of conduct could have a role to play in jurisdictions where MPA or vessel clearance legislation is applied. A code could be applied, either as an intermediate step towards the application of more detailed rules or to supplement the application of existing legislation.

A code of conduct may also be useful in situations where MSR activities involve hydrothermal vents in jurisdictions where no national legislation exists or is planned. By this logic a code's best use, however, would be within the Area.

A code of conduct would be particularly appealing given that the regulatory situation is a lot less structured in the Area: at this time there is no oversight agency for the seabed with a mandate to oversee all MSR activities or biological resources. Without (1) direct measures taken by individual researching states to regulate the conduct of their marine scientific researchers in the Area, (2) a new international treaty or (3) voluntary oversight by the scientific community itself, there is very little that international law and institutions can directly offer at present to minimise the potential use conflicts and the threats MSR may pose to the most visited sites.

A new international treaty between States is unlikely, and intergovernmental processes tend to be time consuming and potentially political. In contrast, voluntary approaches, possibly involving a code of conduct along with self- and peer policing, are the most expeditious way to minimise the conflicts and environmental impacts that MSR activities are posing to hydrothermal vents and their associated biological communities.

Voluntary actions by researchers have been proposed by Mullineaux et al. [5]. This would require greater coordination and collaboration between marine scientific researchers themselves, which will depend upon information sharing, awareness and good will. A coordinating body would be helpful.

A step towards voluntary action was undertaken as a result of a 1995 recommendation by the InterRidge Biological Studies Ad Hoc Committee to demarcate seabed sanctuaries [28]. This was subsequently elaborated upon further in a position paper put forth by Mullineaux et al., whereby a "research reserve system" was proposed that would be "regulated entirely by consensus"[5].

InterRidge—an initiative concerned with facilitating international and multi-disciplinary research associated with mid-ocean ridges—would disseminate information and summarise controversies. To alleviate collecting pressure at the most popular sites researchers would be encouraged to devote dive time to explore new sites for collecting.

To date research reserves have been proposed in the Area for the sites within the East Pacific Rise and for sites within Rainbow. Sites within national jurisdiction have been proposed within Canadian, Portuguese and Russian waters.

As presently practised a research reserve amounts to a researcher posting on the InterRidge WWW site an open request to other researchers asking that they avoid disturbing an experiment. Locational coordinates are provided.[13] The extent to which this service is actually being used is difficult to determine as postings date to 1998 and 1999. Notwithstanding this uncertainty, it is a good example of how consultation between researchers could avoid use conflicts.

Voluntary action by the research community is not a new idea, but the use of a code of conduct adds a new dimension whose legitimacy has been gaining currency over the last 3 years. A code would add a holistic and comprehensive tool that could build on the research reserve concept at least as it is being practised presently in order to address environmental impacts.

The idea for a code of conduct was first introduced in 1999 (see [29]). It was subsequently discussed at an InterRidge workshop on managing and conserving hydrothermal vents in 2000.[14]

Workshop participants agreed with the concept of developing a code of conduct, or statement of best practices, for future research activities at hydrothermal vents. It was foreseen that the code would be limited to MSR activities only.[15]

(*footnote continued*)
professional photographers should be charged a fee, images should be provided to an MPA data bank and credits should include a reference to the MPA; (7) tour operators should submit independently undertaken environmental assessments; (8) tour operators should be licensed with the threat of revocation for non-compliance; and (9) a license fee should be assessed that could contribute to MPA management (see [27]).

[13] InterRidge WWW site (visited on 2 September 2002) ⟨http://triton.ori.u_tokyo.ac.jp/∼intridge/⟩

[14] InterRidge Workshop on the Management and Conservation of Hydrothermal Vent Ecosystems, Sydney, British Colombia, Canada, 28–30 September 2000.

[15] Possible elements included: (1) investigating on-going research activity at a site; (2) notifying InterRidge and national agencies of intended cruise dates, sites of activity and types of activities; (3) contacting other users to gather information and discuss compatible

The concept was again presented to participants at the Second International Symposium on Deep-Sea Hydrothermal Vent Biology, 8–12 October 2001, Brest, France during an open discussion on conservation issues (see [30]).

The Azores MPA workshop and a preceding workshop on MOMAR [31] further advanced the code of conduct concept. Acceptance within MOMAR was important because the vent fields within the MOMAR region will be subject to increased, more focussed scientific activities in the future, especially if funding sources are secured. Furthermore, the MOMAR region extends to vent fields within and beyond the limits of national jurisdiction. Consequently, the MOMAR Steering Committee will have a strong role to play in the oversight of the Menez Gwen, Lucky Strike, Saldanha and Rainbow vent fields.

Promisingly, the MOMAR Steering Committee could influence the application of a code of conduct within the MOMAR region. This in turn could provide the departure point for greater acceptance and application of a code to other vent fields around the world.

In short, MOMAR could make a code of conduct a reality. The various workshops over the past 3 years have contributed possible elements. What is needed now is to review the elements, add to them if necessary, polish them, subject them to a stakeholder process and to implement them.

5. Conclusion

In the absence of State action, voluntary actions by marine researchers would be a timely and expedient way to minimise research conflicts and conserve biodiversity at hydrothermal vents. Such action would be in keeping with the spirit of UNCLOS since UNCLOS applies to MSR within and beyond the areas of national jurisdiction.

Particularly within the Area, the scientific community's voluntary actions would contribute to the conservation and sustainable use of hydrothermal vents and their associated biodiversity and thereby benefit humankind as a whole, helping to add some meaning to UNCLOS article 143 (1). This also would be in keeping with the spirit of the CBD's international cooperation provisions and its declaration that biodiversity conservation is a "common concern of humankind" (preambular para. 3).

With any voluntary system the principles upon which it is based must be known to the participants. A code of conduct would help to guide researchers and to provide a reference point against which they can judge their own conduct and the conduct their peers.

Furthermore, the ultimate success of any voluntary system or instrument such as a code of conduct is intimately related to the process by which it is developed. It is a well-established principle in modern conservation circles that the key stakeholders must be involved in any process whose result may impact upon their activities.

In addition, incentives may need to be provided to encourage application. For example, international steering committees such as that for MOMAR need to condition approval on demonstrable implementation of any future code of conduct. Funding institutions could agree to condition grant money upon the demonstrable application of code of conduct by the grantee. Peer pressure may also play a role in the ultimate success of any voluntary system.

To fully ensure a codes' application, and give it added weight, it may need to be concretised one day by an intergovernmental body such as UNESCO's Intergovernmental Oceanographic Commission. This would ensure oversight of its implementation at the global level and may encourage its voluntary application by States. However, the marine scientific research community does not need to wait for this to happen in order to place their activities on a more sustainable footing. It can act immediately.

(*footnote continued*)

uses; (4) avoiding or minimising activities that (a) cause long-term decline of the resource to the detriment of future users, (b) decrease biodiversity (at ecosystem, species and genetic levels), (c) interfere with other on-going investigations or (d) compromise the safety of underwater vehicles; and (4) maximise sampling efficiency by, for example, (a) minimising waste, (b) developing micro-analytical techniques and alternatives to physical sampling and (c) making productive use of any excess materials [1].

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