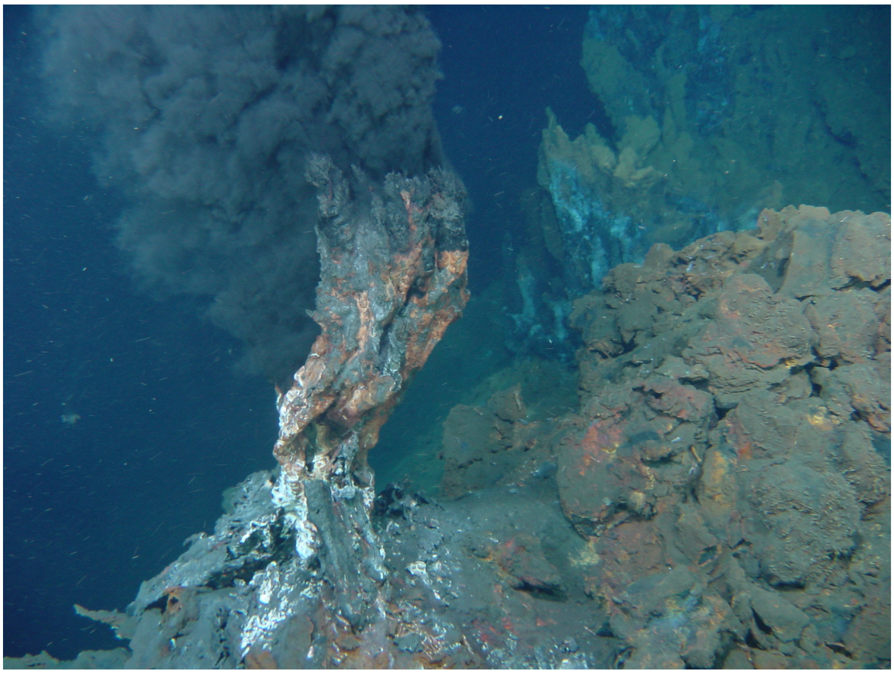
OSPAR COMMISSION

Background Document for Oceanic ridges with hydrothermal vents/fields



Biodiversity Series

2010

OSPAR Convention

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention") was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. It has been ratified by Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Sweden, Switzerland and the United Kingdom and approved by the European Community and Spain.

Convention OSPAR

La Convention pour la protection du milieu marin de l'Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d'Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998. La Convention a été ratifiée par l'Allemagne, la Belgique, le Danemark, la Finlande, la France, l'Irlande, l'Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni de Grande Bretagne et d'Irlande du Nord, la Suède et la Suisse et approuvée par la Communauté européenne et l'Espagne.

Acknowledgement

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Photo acknowledgement

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Contents

Background document for Oceanic ridges with hydrothermal vents/fields

Executive Summary

This background document on oceanic ridges with hydrothermal vents/fields has been developed by OSPAR following the inclusion of this habitat on the OSPAR List of threatened and/or declining species and habitats (OSPAR agreement 2008-6). The document provides a compilation of the reviews and assessments that have been prepared concerning this habitat since the agreement to include it in the OSPAR List in 2003. The original evaluation used to justify the inclusion of oceanic ridges with hydrothermal vents/fields in the OSPAR List is followed by an assessment of the most recent information on its status (distribution, extent, condition) and key threats prepared during 2009-2010. Chapter 7 provides recommendations for the actions and measures that could be taken to improve the conservation status of the habitat. In agreeing to the publication of this document, Contracting Parties have indicated the need to further review these proposals. Publication of this background document does not, therefore, imply any formal endorsement of these proposals by the OSPAR Commission. On the basis of the further review of these proposals, OSPAR will continue its work to ensure the protection of oceanic ridges with hydrothermal vents/fields, where necessary in cooperation with other competent organisations. This background document may be updated to reflect further developments or further information on the status of the habitat which becomes available.

Récapitulatif

Le présent document de fond sur les dorsales océaniques comportant des sources/champs de sources hydrothermales a été élaboré par OSPAR à la suite de l'inclusion de cet habitat dans la liste OSPAR des espèces et habitats menacés et/ou en déclin (Accord OSPAR 2008-6). Ce document comporte une compilation des revues et des évaluations concernant cet habitat qui ont été préparées depuis qu'il a été convenu de l'inclure dans la Liste OSPAR en 2003. L'évaluation d'origine permettant de justifier l'inclusion des dorsales océaniques comportant des sources/champs de sources hydrothermales dans la Liste OSPAR est suivie d'une évaluation des informations les plus récentes sur son statut (distribution, étendue et condition) et des menaces clés, préparée en 2009-2010. Le chapitre 7 fournit des propositions d'actions et de mesures qui pourraient être prises afin d'améliorer l'état de conservation de l'habitat. En se mettant d'accord sur la publication de ce document, les Parties contractantes ont indiqué la nécessité de réviser de nouveau ces propositions. La publication de ce document ne signifie pas, par conséquent que la Commission OSPAR entérine ces propositions de manière formelle. A partir de la nouvelle révision de ces propositions, OSPAR poursuivra ses travaux afin de s'assurer de la protection des dorsales océaniques comportant des sources/champs de sources hydrothermales le cas échéant avec la coopération d'autres organisations compétentes. Ce document de fond pourra être actualisé pour tenir compte de nouvelles avancées ou de nouvelles informations qui deviendront disponibles sur l'état de l'habitat.

1. Background information

Nomination

Oceanic ridges with hydrothermal vents/fields

EUNIS code: A6.94

National Marine Habitat Classification for UK & Ireland code: Not defined

Definition for habitat mapping

Hydrothermal vents occur along spreading ridges (such as the mid-Atlantic ridge), , fracture zones and back-arc basins (Gage & Tyler, 1991). They are produced by seawater penetrating the upper levels of the Earth crust through channels formed in cooling lava flows, reacting chemically with hot basalt inside the crust and then rising back to the sea-bed to vent as superheated water containing compounds such as sulphides, metals, CO_2 and methane (Tunnicliffe *et al.*, 1998 in Gubbay, 2002). The water may trickle out from cracks and crevices on the seabed as hot springs (5-250°C), or as highly concentrated jets of superheated water (270-380°C). As these concentrated jets of water cool, minerals dissolved in the water precipitate out in black clouds, giving them their common name of 'black smokers'. At lower temperatures, sulphides are mostly precipitated within the rocks, making the venting fluids appear cloudier. These are known as 'white smokers' (Gage & Tyler, 1991). Generally hydrothermal vent fields cover relatively small areas of the seabed in water depths of 850–4000 m. However shallower vents can occur between 100 and 500 metres as in Iceland or even shallower as in the D. João de Castro Bank (20m depth; Azores). The biological communities associated with hydrothermal vents are unusual as they are able to derive energy under conditions where photosynthesis is not possible. These habitats contain a huge diversity of chemo-autotrophic bacteria, which form the basis of the trophic structure around the vent. Characteristic species at the deep-sea Mid-Atlantic Ridge vents in the OSPAR Region V include the mussel *Bathymodiolus azoricus* and its commensal worm *Branchipolynoe seepensis*, the shrimps *Mirocaris fortunata, Chorocaris chacei* and *Rimicaris exoculata* (this last one being dominant on the southern vent fields of Lucky Strike), the crab *Segonzacia mesatlantica*, the polychaete *Amathys lutzi*, the amphipod *Luckia strike* and the limpet *Lepetodrilus atlanticus*. The vents at the OSPAR Region I are dominated by microbes with no evident vent fauna with the exception of the recent discovered vent field at 73ºN (see text below).

2. Original Evaluation against the Texel-Faial Selection Criteria

List of OSPAR Regions and Dinter biogeographic zones where the habitat occurs

OSPAR Regions; I, V

Biogeographic zones: Hydrothermal Vents/Fields, Arctic subregion; Atlantic subregion (North Atlantic provinces)

List of OSPAR Regions where the habitat is under threat and/or in decline

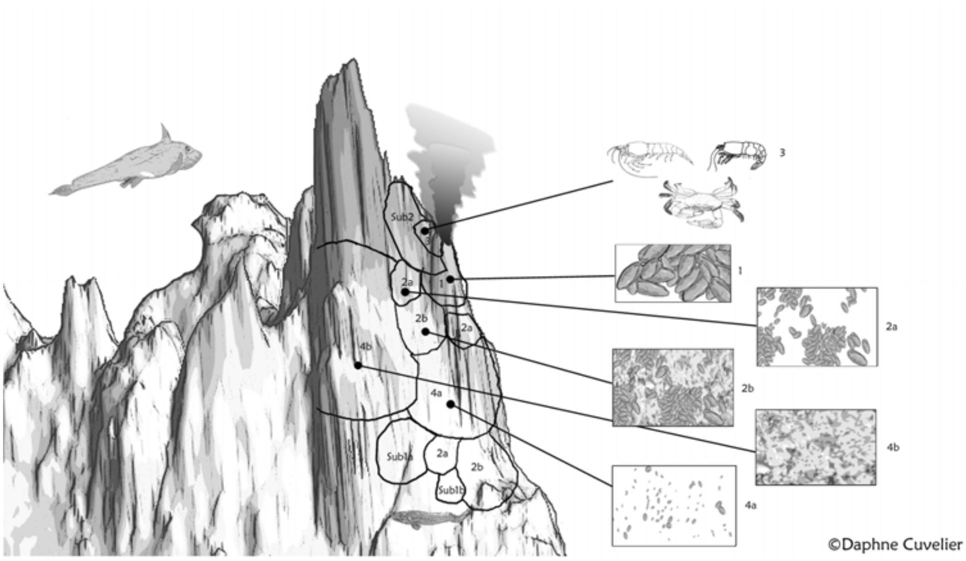
The OSPAR List recognises hydrothermal vent/fields on mid-ocean ridges as under threat in Region V. Similar threats may be relevant in Region I as knowledge increases on the location of this habitat.

General

Hydrothermal vents/fields have been found in areas of shallow and deep-sea tectonic activity in the Pacific, Indian and Atlantic Oceans. In the Atlantic they are associated with the Mid-Atlantic Ridge (MAR).

The hydrothermal vents are indirectly related with seafloor spreading and are located at the ridge axes. Hydrothermal vents form when hot, mineral rich water flows into the ocean floor through volcanic lava on a mid-ocean ridge volcanoes formed by sea-floor spreading.

The hydrothermal activity around vents is caused by seawater penetrating the upper layers of the Earth crust through channels formed in cooling lava flows. The tall chimneys formed around the vents and the surrounding sediments are almost pure metallic sulphides and are a unique geological feature of hydrothermal vents (Tunnicliffe *et al.,* 1998). Sulphide minerals crystallise from hot water directly onto the volcanic rocks at the same place where hot mineral rich water flows from out of the ocean floor. Hydrothermal vents are the interface between the hot, anoxic up flow zone and cold, oxidised seawater. When hot fluids mix with cold seawater, many hydrothermal minerals precipitate within seconds to form the dense particle plumes characteristic of black smokers. The particles are predominantly a mixture of sulphides (e.g. pyrrhotite FeS, sphalerite ZnS, chalcopyrite $CuFeS_2$, etc.) and sulphates (anhydrite $CaSO_4$, barite $BaSO_4$). Some of these minerals become part of chimney structures that build up on the sea-bed, while others form plumes that disperse through the water (Colaço, 2001). Around these structures highly rich and diverse animal communities occur frequently. One of the most striking features of the exotic animal communities that are found at hydrothermal vents is that they are sustained by chemo-autotrophic bacteria. Until the discovery of hydrothermal vents, photosynthesis had been the best known metabolic process for the sustaining life on earth. Photosynthesis uses light as the source of energy and CO_2 as the inorganic source of carbon. In chemo-autotrophy, the source of carbon is again inorganic (CO_2), but the source of energy is chemical, obtained from sulphide or methane. Vent organisms, in particular the anaerobic microorganisms are therefore independent of sunlight and, (vent organisms still depend from the Oxygen produced on the upper layers for oxidation processes), for this reason it has been suggested that hydrothermal vents could have been the location for the origin of life on our planet. The associated animal communities are particularly unusual as the species derive energy under conditions where photosynthesis is not possible, tolerate great extremes and variability in the temperature and the chemical composition of the surrounding water, and cope with potentially toxic concentrations of various heavy metals.



A conceptual model representing biological zonation of assemblages and substratum distribution at Eiffel Tower (Lucky Strike). Patches occupied by assemblages and substrata are positioned on the structure in such a way that their proportions and position one to another and to the fluid exit is respected. Mean patch sizes are in proportion as well as the relative distance to the fluid exit. Faunal assemblages are represented by a detailed inset (1, 2a, 2b, 3, 4a, 4b), substrata are named on the patch itself (Sub 1a, Sub 1b, Sub 2). Some predators are represented as well; a *Cataetyx laticeps* (Pisces) is lying at the bottom of the structure, and a *Hydrolagus pallidus* (Pisces) is passing by left of the sulphide structure. The presence of the crab, *Segonzacia mesatlantica*, is mostly driven by the presence of a food source that is why it is positioned in the proximity of Assemblage 3. © Cuvelier *et al*. (2009)

Biological Importance: Deep-sea hydrothermal vent biology has received scientific interest and attention since their discovery, the result being a better knowledge of vent organisms and ecosystems on a range of biological scales (namely sub cellular, physiological, whole animal and ecological) than about almost any other biological component in the deep-sea environment. Deep-sea vents are also a special example of a biological community that is intimately linked to sub-surficial, geological processes. Given this dependence on the underlying geology and the vent chemistry, vent biota have been assumed to be isolated from processes elsewhere in the ocean. However, the recent demonstration that energy derived from photosynthesis through the food-web is important to maintain Mid-Atlantic Ridge macrofaunal populations living on the vent sites (Dixon *et al*., 2002) has forced a review of the trophic ecology of hydrothermal vent communities.

At the shallow water vents (100 to 106 m depth) reported at the subpolar Atlantic off Kolbeinsey on the Jan-Mayen ridge, a new type of animal community has been found near hot vents. In contrast to deep-sea vent sites of the Mid-Atlantic and other oceans, the Kolbeinsey macro- and meiofauna consists of species reported from non-vent areas in the boreal Atlantic and adjacent polar seas (Fricke *et al*., 1989). The shallow water vent field Dom João de Castro Bank in the Azores presents the same type of communities were the macroalgae and macrofauna are similar to those found in coastal waters (Cardigos *et al*., 2005; Santos *et al*., 2010).

Original Evaluation against the Texel-Faial criteria for which the habitat was included on the OSPAR List

Deep-sea hydrothermal vents/fields were nominated in a joint submission by three Contracting Parties citing regional importance, decline, rarity, and sensitivity, with information also provided on threat. The nomination was for Region V.[1]

Regional importance: Hydrothermal vents are most commonly found where the Earth plates are actively spreading but only occupy a small portion of the spreading ridges. The habitat is therefore only present at irregular intervals, the intervening distances depending on the nature of both the volcanism and tectonics of the ridge. At the time of the submission only four vent fields were known in the OSPAR area. These fields were located to the south-west of the Azores and were named Menez Gwen, Lucky Strike, Saldanha and Rainbow.

Decline: The extent and distribution of active hydrothermal vents in the MAR is not fully known and will, in any case, change with time over a variety of scales. As many of these sites only cover a small geographic area and include relatively fragile structures, they can be under considerable exploration pressure. At some sites this has already reached a point where man-induced changes in the distribution and occurrence of vent fluid flows and of associated vent communities have been documented (Mullineaux *et al.,* 1998).

Rarity: At the time of the submission it was considered that most, of the hydrothermal vent fields in the OSPAR Maritime Area occurred in Region V. They covered very small areas in relatively shallow

[1] Hydrothermal vents on mid-ocean ridges were nominated in 2001 for inclusion in the OSPAR List by Iceland, Portugal and the United Kingdom.

depths (from 840m to 2300m) compared to fields outside the OSPAR area (depths>3000m). These factors have made them a rare habitat in the area under consideration.

Rarity should also be considered in relation to the animal communities associated with hydrothermal vents. At the Lucky Strike vent field, for example, the assemblage is dominated by dense beds of a new species of mussel of the genus *Bathymodiolus* (*B. azoricus*), besides supporting a totally novel amphipod fauna including a new genus, and the echinoderm *Echinus alexandri*. These vent communities have a sufficiently unique fauna that can be considered to represent a biogeographic hydrothermal province different to those previously described (Van Dover *et al.,* 1996).

Sensitivity: The specialised adaptations which allow organisms to exploit vent habitats include major reorganisation of internal tissues and physiologies to house microbial symbionts, biochemical adaptations to cope with sulphide poisoning, behavioural and molecular responses to withstand high temperature, presence of metal-binding proteins and development of specialised sensory organs to locate hot chimneys (Tunnicliffe *et al.,* 1998). The result has been specialised faunas, which are rarely found in other environments. They are also not a very diverse group of species but because they can exploit an abundant energy source around vents they are often present in very high densities (Childress & Fisher, 1992). Vent species are therefore not as sensitive to fluctuations in environmental conditions as many other deep sea fauna but are specially adapted to these extreme conditions. They may also be sensitive to factors that have still to be studied such as blinding due to extensive use of lights and flash photography and damage to the vent chimneys

Threat: The main threats to hydrothermal vent systems and their associated biological communities are from unregulated scientific research (including collecting), seabed mining, tourism and bioprospecting (InterRidge, 2000). The unusual nature of the marine communities that occur around hydrothermal vents makes them a focus for deep-sea research. There are regular expeditions to the well-known sites to make observations and measurements, deploy instruments, and collect specimens of the marine life, seawater and rocks. As many of these sites only cover a small geographic area and include relatively fragile structures they can be under considerable exploration pressure (Mullineaux *et al.,* 1998).

Apart from research expeditions, it can be expected that hydrothermal vents will also be subject to pressures from other activities. The first tourist trips to deep sea hydrothermal vents took place in the OSPAR Maritime Area in 1999, at the Rainbow vent site, and are already reputed to have caused some damage to vent chimneys. The vent system on the Dom João de Castro Bank in the Azores is in shallow waters and subject to some tourist use.

Seabed mining is a potential threat with mining companies seriously investigating the possibility of mining metal sulphide deposits. An exploration licence for such activity has been granted to one company already, although outside the OSPAR Maritime Area (Butler *et al.,* 2001). Bioprospecting and microbial sampling in particular are additional threats. This usually causes less habitat destruction than many other types of sampling, but the ecological impact of redistribution micro-organisms between sites remains to be evaluated (InterRidge, 2000).

Relevant additional considerations

Sufficiency of data: Hydrothermal vents and their associated animal communities were discovered in the late 1970’s. Given the relatively short history of research, and the difficulties of conducting such research in the deep sea, it is clear that the study of vent habitat and faunas is at a relatively early stage. This relates to both the extent of active vents in the OSPAR Maritime Area and knowledge of the associated communities. The situation is different for particular vents, such as those to the south of the Azores, which have been the focus of intensive research programmes funded at national, international and EU levels. It is also the work in these locations that has led to concerns about threats to vent habitats and their associated communities.

As a result of these cruises, the detailed bathymetry of the ridge, its geophysical signature, the composition of erupted basalts, and the large-scale distribution of chemical anomalies in the water column are well known within Region V of OSPAR in what is known as the MoMAR area (south of the Azores). The main objectives of these programmes were to locate hydrothermal sites and to study their physical, chemical and biological characteristics. These objectives were remarkably successful as five active hydrothermal sites have been discovered in the OSPAR-Azores area since 1992 and up to now: the Menez Gwen site at 37°45'N, the Lucky Strike site at 37°15'N, the Saldanha site at 36°34'N, and the Rainbow site at 36°13.8'N, and the Ewan site at 37°17.28' N / 32°16.49' W. These five sites differ by (i) their depth (from 850m to 2800m), (ii) the composition of their host rocks (mantle-derived serpentinized peridotite or basalt), (iii) the nature of associated volcanism (explosive at depths shallower than 900m, effusive at greater depths), and (iv) their tectonic setting (in the centre of ridge segments, or within axial discontinuities). The ecosystems they associate with are also distinct at least in four sites, the biodiversity and biomass being greatest at the Lucky Strike site (Desbruyères et al., 2001a).

Changes in relation to natural variability: Hydrothermal vents are most commonly found where ridges of the Earth plates are actively spreading. On fast spreading ridges, such as the East Pacific Rise at 13° N vent sites appear to have a short lifetime (generally no longer than about 100 years) and the zone of hydrothermal activity shifts along the ridge. On slow spreading ridges such as the Mid-Atlantic Ridge, the hydrothermal activity is spatially more focused and stable over the long term, even if the lifetime of an individual vent site is similar to that on fast spreading ridges (Comtet & Desbruyères, 1998).

Vents and their associated communities are transient and variable not only at short time scales of days and seconds but also over decades. Variability in the hydrothermal discharge causes changes in the animals communities associated with vents. As a consequence, the vent fauna must adapt to unstable environmental conditions and nutrient supply by rapidly colonising new vents (Comtet & Desbruyères, 1998). Evidence for the longer term variability can be seen in accumulations of dead giant bivalve shells which, as they are known to only persist for about 15yrs before being dissolved, must indicate quite recent change in conditions. Geophysical and geochemical evidence suggests that bursts of hydrothermal activity are short and last decades or less. The habitat is neither permanent nor contiguous; dispersal and migration are the major links between neighbouring vents (Tunnicliffe *et al.,* 1998).

Expert judgement: There is ample information to confirm the unique nature of hydrothermal vents and their associated community, and a good basis for considering them to be a rare habitat in the OSPAR Maritime Area. The threats to these habitats have been observed in particular locations and have led to calls by scientists for the co-ordination and management of research programmes to avoid damage. This has been taken up by the Regional Government of the Azores in particular, who are preparing a management plan for the first hydrothermal vent Marine Protected Area in the Atlantic. A combination of research data and expert judgement therefore suggests that hydrothermal vents/fields should be on the OSPAR list of threatened and/or declining species and habitats.

ICES evaluation: The ICES review of the nomination for this habitat agreed that there is no empirical evidence to suggest that hydrothermal vents are in decline (ICES, 2002). In relation to threat, ICES consider that this habitat has not been proven to be under threat from present-day human activities and that potential future threats such as mining and bioprospecting will be localised and of relatively low impact.

This assessment needs to be viewed in context, as the habitat itself is relatively localised. The limited extent of current and potential threats could therefore still cause serious damage to vent fields and associated communities, and have a significant impact. The threats to hydrothermal vents have been described above and are believed to be a realistic description of human activities, which can have an impact on this habitat.

3. Current status of the habitats

Distribution in OSPAR Maritime Area

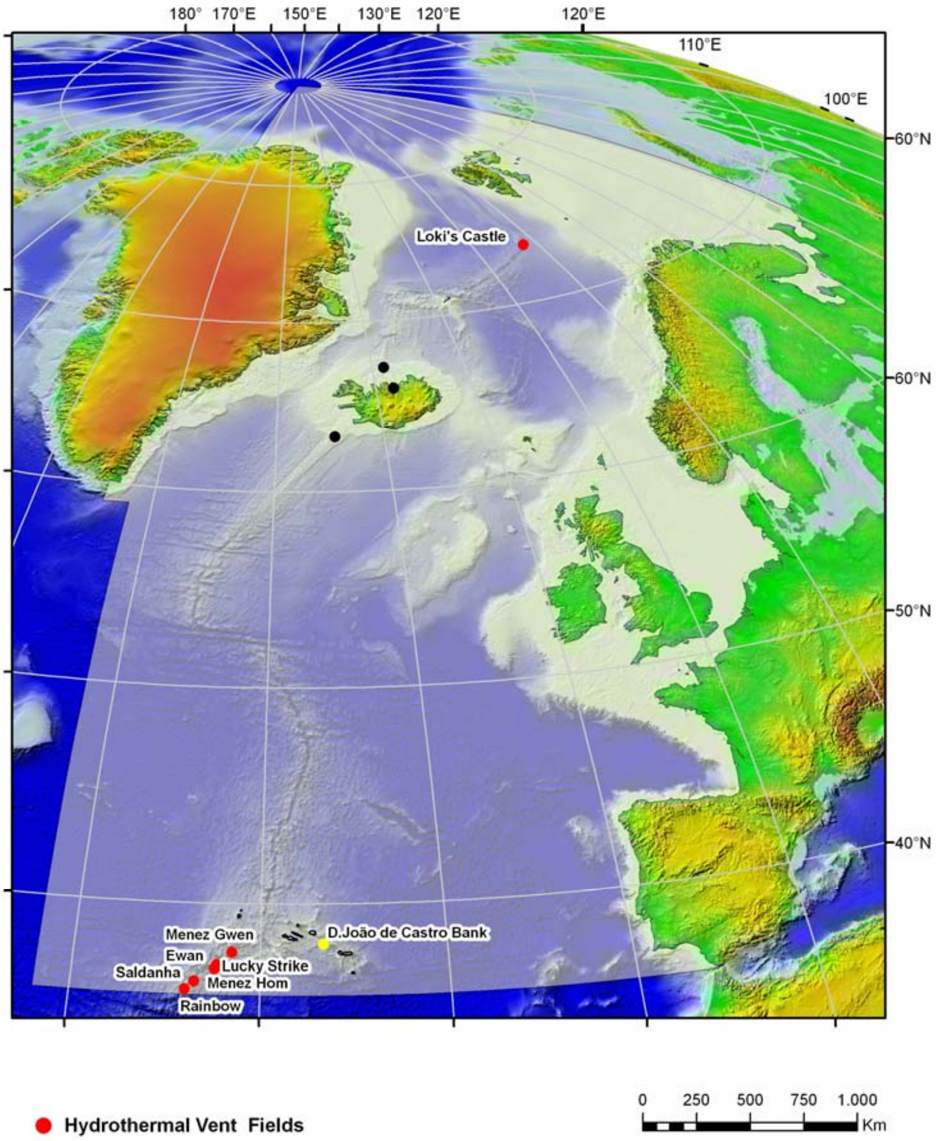


Figure 1. Main chemosynthetic hydrothermal vents (red). In yellow shallow water (-40 metres) vent at D. João de Castro. In black hydrothermal vent sites (two at -100 to -200 and one at -200 to -500 metres deep) where no chemosynthetic associated macrofauna is known.

The hydrothermal vents in the OSPAR Maritime Area lie along the Mid-Atlantic Ridge (MAR) (Figure 1). However, it should be emphasized that the actual number of hydrothermal vents in the

OSPAR area and its locations are still unknown. Two new vent fields discovered in 2005 are located around 71° N latitude on a part of the Arctic Ridge system called the Mohns Ridge at 500 – 700 m depth. The first field is located right in the middle of the Mohns Ridge fault zone. It contains several tens of chimneys that vent fluids with temperatures as high as 250 °C. Amphipods, anemones and bacterial mats dominated the organisms associated to the vents. A type of hydroid was also observed both on the vent structures as well as on the surrounding areas. A second extensive vent field was located on top of a volcanic ridge about 5km south of the first field. It was roughly 100 – 200 m in size and much denser than the first field. The chimneys were so dense in some areas that it was difficult to get the ROV into the field.

In August 2006 a new field was discovered on the southern flank of the Lucky Strike volcano which has been named Ewan.

In 2008, vents were found along the northerly Arctic portion of Mid-Atlantic Ridge at 73°N, about 300km from the nearest land, Bear Island. The first black smoker found is associated to a chimney that is around 11 m in height. Within a radius of around 100 m from the first chimney another five black smokers were also found. The field has been named Loki's Castle because the many hundreds of turrets and small chimneys of the field appear like a fantasy castle. Loki is a Norwegian god who is renowned for trickery: an appropriate name for a field that was so difficult to locate. The Loki's Castle smokers are located on mounds of mineral-rich material that has precipitated out when the mineral-rich, super-heated vent water met the very cold waters of the deep sea. Researchers speculate that, based on preliminary examination, the field's mineral deposits are significant, perhaps one of the largest yet discovered, and may have been building up over 100 kyrs. Surrounding the chimneys researchers found a rich ecosystem based on chemosynthesis. Preliminary observations suggest that the ecosystem around these northerly vents is diverse and interestingly appears to be different from the vent communities observed elsewhere. Samples have been collected for study. The hydrothermal field is located on top of a linear deep-sea volcano, one of the many thousand that are found along the Mid-Atlantic Ridge. The water emerging from the smokers measured over 300 ºC.

Extent (current/trends/future prospects)

Hydrothermal vents are highly dynamic, heterogeneous and ultimately ephemeral deep-sea environments. Vent organisms can experience variations in the temperature and chemistry of their environment on the timescale of seconds as a result of turbulent mixing of hydrothermal fluids and ambient seawater, typically overlaid on longer-period tidal variations (Johnson *et al*., 1988; Scheirer *et al*., 2006).

Over longer time scales, volcanic events at mid-ocean ridges can disturb vent communities directly (Lutz *et al*., 1994), while tectonic events can disrupt the subsurface plumbing of hydrothermal systems (Johnson *et al*., 2000).

On a fast spreading ridge like the East Pacific Rise (EPR) the life time of a hydrothermal vent field might be 12 years, while on a slow spreading ridge (the case of the oceanic ridges in the OSPAR area) the lifetime is expected to be much longer. Expeditions to 9°N (EPR) have recorded the early stages of vent community development following a volcanic eruption in 1991 that destroyed part of an established community (Shank *et al*., 1998a). At 21°N (EPR), however, community composition and venting patterns demonstrate temporal stability at a decadal scale (Hessler *et al*., 1985; Desbruyères, 1998). Meanwhile on the Galapagos Rift, decadal-scale variation has been noted in the vent community at Rose Garden (Hessler *et al*., 1988) despite an apparent lack of fluctuations in venting over the period of visits (Desbruyères, 1998), implying ecological change mediated by biological interactions.

However, vents at the Mid-Atlantic Ridge were just recently discovered (during the 80's). Compared with fast spreading ridges hydrothermal vents, the OSPAR ones have not change since they were discovered. At Lucky Strike and Menez Gwen communities are dominated by the vent mussel with high percentage cover, and at the Rainbow vent field the communities are dominated by swarms of the shrimp *Rimicaris exoculata*. There are micro-variations in terms of percentage cover which is the subject of an ongoing study (Cuvelier *et al.*, 2009). A recent work by Copley *et al*. (2007) showed that on deeper vents at the MAR, there was decadal-scale invariance in dominance, distribution and abundance of species which contrasts with the dynamics established for many East Pacific hydrothermal vent communities.

The frequencies of tectonic and volcanic events that can disrupt the pathways for vent fluids are lower on the slow-spreading Mid-Atlantic Ridge, resulting in greater temporal stability in the location and activity of vent sites (Copley *et al*., 2007). This way, major changes in population size or habitat extent are not expected, unless a major geological phenomenon happens or vent fluid activity changes.

Condition (current/trends/future prospects)

Not applicable to this type of habitat.

Limitations in knowledge

Due to the difficulties and costs of exploring and studying the hydrothermal vents at the Mid-Atlantic Ridge, there are a few gaps in knowledge that the scientific community are trying to fill. This passes by biomass studies, trends in biomass changes, relation of percentage cover, population size, habitat extent with physiological stages and life cycle of the species. Studies on the dispersal of the key species, biogeography phenomena, and variability at different time scales are lacking.

4. Evaluation of threats and impacts

Threat and link to human activities

Relevant human activity: mineral extraction, research, bio-prospecting, tourism. *Category of effect of human activity:* Physical – substratum removal, visual disturbance. Biological – physical damage to species, displacement of species, removal of target and non-target species, changes in population or community structure, introduction of microbial pathogens or parasites.

Unregulated scientific research around hydrothermal vents can cause physical damage to the habitats and associated organisms through sampling programmes, accidental damage and monitoring techniques. Tourist trips to hydrothermal vents and commercial mining activity are other potential threats that would be a result of human activity.

Activities with potential impact

The activities identified are (Santos *et al*., 2003):

- Unregulated scientific research
- Potential bioprospecting
- Potential mining
- Fishing activities
- Tourism
- Shipping

5. Existing Management Measures

Creation of the Azorean Marine Park (RAA, 2007); the Interidge code of conduct; the OSPAR Code of Conduct for responsible marine scientific research in the deep and high seas of the OSPAR maritime area (OSPAR other agreement 2008-1). Lucky Strike, Menez Gwen and Rainbow were proposed by Portugal to be part of the OSPAR network of Marine Protected Areas. This was accepted by the parties. A management plan is already proposed waiting for the publication of the regulatory Law Decree of the Azorean Marine Park. InterRidge promotes interdisciplinary, international studies of oceanic spreading centres by creating a global research community, planning and coordinating new science programmes that no single nation can achieve alone, exchanging scientific information, and sharing new technologies and facilities. Most of the scientists that work on Mid Oceanic Ridges and vents are members of Interridge. By approving and promoting the Code of Conduct, InterRidge creates regulated scientific activities and promotes an awareness of the impacts of unregulated activities.

6. Conclusion on overall status

There are potential threats, however, management measurements are being established, and the scientific community has been successful in regulating themselves in order to maintain as far as possible the natural conditions of these special habitats. Just recently, temporal evolution studies of these habitats have started, so we cannot make inferences about their decline or recovery.

7. Action to be taken by OSPAR

Action/measures that OSPAR could take, subject to OSPAR agreement

As set out in Article 4 of Annex V of the Convention, OSPAR has agreed that no programme or measure concerning a question relating to the management of fisheries shall be adopted under this Annex. However where the Commission considers that action is desirable in relation to such a question, it shall draw that question to the attention of the authority or international body competent for that question. Where action within the competence of the Commission is desirable to complement or support action by those authorities or bodies, the Commission shall endeavour to cooperate with them

Research protocols, co-ordinated studies and protected areas are amongst the ideas being taken forward by scientists working on hydrothermal vents and their associated biological communities. Similar measures may also be required to manage future tourist activities while issues concerning seabed mining will need to be raised with the International Seabed Authority if they are to be implemented beyond Exclusive Economic Zones. Measures such as these can be supported by OSPAR to address concerns that the ecological quality of the hydrothermal vent habitats in OSPAR Region V might significantly decline if no protection or management measures are taken.

Brief summary of the proposed monitoring system

Hydrothermal ecosystems are strongly dependent on the characteristics of local hydrothermal fluxes: flow rates, temperature and chemistry. The deep-sea hydrothermal vent community composition and structure are affected (1) by linking and isolating mechanisms between vent fields (Hessler & Lonsdale, 1991; Tunniclife, 1991), (2) by local conditions (chemistry and particle content of fluids and substrate patterns) (Johnson *et al*., 1988), and (3) by instability of venting, which induces an extinction-colonization dynamics (Cann *et al*., 1994; Desbruyères, 1998; Chevaldonne *et al*., 1997). Biological monitoring should therefore pay particular attention to inter and intra-specific interactions. It will be necessary to maintain the time series monitoring programme over the scale of years. Three goals should guide the work supplying data to the assessment of the habitat status in the OSPAR area:

1. Assessment of the distribution of hydrothermal vents in OSPAR area;
2. Assessment and monitoring the number of species inhabiting individual hydrothermal vents in the OSPAR area;
3. Monitor hydrothermal vent communities or species in order to assess their status in space and time and the potential impacts of human activities.

Annex 1: Detailed description of the proposed monitoring and assessment strategy

Rationale

Hydrothermal ecosystems are strongly dependent on the characteristics of local hydrothermal fluxes: flow rates, temperature and chemistry. The deep-sea hydrothermal vent community composition and structure are affected (1) by linking and isolating mechanisms between vent fields (Hessler & Lonsdale, 1991; Tunniclife, 1991), (2) by local conditions (chemistry and particle content of fluids and substrate patterns) (Johnson *et al*., 1988), and (3) by instability of venting, which induces an extinction-colonization dynamics (Cann *et al*., 1994; Desbruyères, 1998; Chevaldonne *et al*., 1997). Biological monitoring should therefore pay particular attention to inter and intra-specific interactions. It will be necessary to maintain the time series monitoring program over the scale of years.

Three goals should guide the work supplying data to the assessment of the habitat status in the OSPAR area:

1. Assessment of the distribution of hydrothermal vents in OSPAR area;
2. Assessment and monitoring the number of species inhabiting individual hydrothermal vents in the OSPAR area;
3. Monitor hydrothermal vent communities or species in order to assess their status in space and time and the potential impacts of human activities.

Use of existing monitoring programmes

At present there are no monitoring programmes established for *hydrothermal vents*. Records of change have been gathered *ad hoc* from a series of scientific research surveys. However, there is an international effort to establish an observatory at the Azores region with a node at the Lucky Strike hydrothermal vent site. Several efforts have been made in terms of EU, Portuguese and USA programs to survey the area and develop instrumentation to study this special habitat and implement the observatory, namely the ESONET Network of Excellence; the MRTN MoMARNET the STREP-EXOCET-D, the re-equipment programmes of the Portuguese and Azores Region Science Foundation.

Synergies with monitoring of other species or habitats

Deep-sea surveys are usually expensive due to their remote location. As far as we know no synergies have yet been established. The proximity of these environments with some coral gardens may offer the opportunity to create synergies.

Assessment criteria

Three goals should guide the work supplying data to the assessment of the habitat status in the OSPAR area:

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Visual surveys need to quantify the amount of live and dead vents and its associated sessile macrofauna to the vent habitats in the areas selected. For example if the vents are subject to unregulated scientific sampling using destructive techniques the surveys need to monitor extent of damage and recovery of sampled areas; if the vents are adjacent to mineral exploitation then the effects of mining cuttings, sediment disturbance and infrastructure should be targeted. If the vents are sampled for biotechnology exploitation using destructive or polluting techniques, then the effects of this activity shall be inspected. As regards the impacts of ocean acidification, aragonite saturation states and any associated changes in vent fauna skeletal growth and bioerosion need to be recorded at high latitude vents. The physiological changes that ocean acidification might cause need also to be studied.

Techniques/approaches

In situ monitoring is required. Hydrothermal ecosystems are strongly dependent on the characteristics of local hydrothermal fluxes: flow rates, temperature and chemistry. The deep-sea hydrothermal vent community composition and structure are affected (1) by linking and isolating mechanisms between vent fields (Hessler & Lonsdale, 1991; Tunniclife, 1991), (2) by local conditions (chemistry and particle content of fluids and substrate patterns) (Johnson *et al*., 1988), and (3) by instability of venting, which induces an extinction-colonization dynamics (Cann *et al*., 1994; Desbruyères, 1998; Chevaldonne *et al*., 1997). Biological monitoring should therefore pay particular attention to inter and intra-specific interactions. It will be necessary to maintain the time series monitoring program over the scale of years.

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The specific research required to achieve each goal is summarized in the following tasks.

Task 1 – Assessment of the distribution of hydrothermal vents in OSPAR area

To achieve this task there is a need to explore the ridge to discover new vents. To do this there are several steps:

Track hydrothermal vent plumes through surface research vessels. The vent fluids can be detected because they have different physical properties and chemical composition from the surrounding seawater. For example they differ in temperature (hotter), pH (more acidic), turbidity (higher), O_2 content (generally lower), Mg and SO_4 (lower) and He, Fe, H_2S, Mn (higher). Some of these differences are still discernible at 100’s of km (or in the case of He, 1000’s of km) away from the vent field. There are methods for measuring and mapping hydrothermal plumes based on the detection of temperature and particle anomalies. Scientists can use a CTD (an instrument that measures conductivity, temperature and density) to locate hydrothermal vents and track the dispersing plume. Additional sensors can be added to measure water chemistry and turbidity. (http://www.odp.usyd.edu.au/odp_CD/volcis/viindex.html).

After tracking the plume a probability of where the hydrothermal vent field is situated is estimated. After that the submersibles and ROV's will dive to the bottom of the ocean and explore the area in order to observe and describe the hydrothermal vent field. The description will be made through video imagery and high-resolution mapping of the area using swath systems such as multibeam and side-scan sonars. Species description needs to be made by regulated sampling of the area, due to the small size of the species and because part of the fauna is generally new to science. More recent, AUV as ABE's can track redox differential in the plume using *in situ* sensors (Eh, optical backscatter) and detect the core of the plumes and the vents. This method was used to discover the southern Atlantic vents (German et al, 2008).

Task 2 - Assessment and monitoring the number of species inhabiting individual hydrothermal vents in OSPAR area

A detailed catalogue of species occurring on hydrothermal vents is the deliverable of this task. Some international programmes have been conducting this task such as the initiative ChEss from the Census of Marine Life Program.

Task 3 – Monitor hydrothermal vent communities or species in order to assess their status in space and time and the potential impacts of human activities

Data-mining of video footage is one of the tools to study population trends and thereby monitor vent communities and species, as well as the potential impacts of human activities. The data will be used to compare between sites and years. A few studies have been reported to date to hydrothermal vent systems in the Atlantic. One at the Azores Triple Junction (Desbruyères *et al*., 2001b) and one at Broken Spur (Copley *et al*., 1997) and important media banks exist in IFREMER and other European institutions.

A new concept to monitor the seafloor is fast emerging. Seafloor observatories will be used in the future to monitor the ecosystem not only from a biological point of view but also from a geochemical, geological and geophysical perspective. An international initiative to monitor the Mid-Atlantic Ridge (MoMAR) is in course (Santos *et al*., 2002; Escartin & Santos, 2004). More recently a Network of Excellence for European Seas Observatories (ESONET) has been developing. The aim is to create an organization capable of implementing, operating and maintaining a network of multidisciplinary ocean observatories in deep waters around Europe from the Arctic Ocean to the Black Sea.

Selection of monitoring locations

The MoMAR initiative to monitor the Mid Atlantic Ridge, already selected the south of the Azores hydrothermal vents as targets to be monitor. The Lucky Strike vent field will be the main target, with the Rainbow site as a comparative location due to distinct geological, geochemical and dominant vent fauna differences. With the implementation of this observatory, choosing the same vents for OSPAR habitat monitoring will be an advantage in terms of data and resource optimization.

Timing and frequency of monitoring

Monitoring ideally shall be at least yearly, or each two years during the summer cruises, unless a benthic observatory is established.

Data collection and reporting

The Principal Investigator responsible for each cruise shall inform the appropriate authorities about the sample collection, and guarantee that copies of images of the dives with geo-referencing information are sent to the management authorities. The later should then be responsible for using the images to monitor visually some of the criteria stated in point 4.

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