

Developing a long term field phase for understanding the biogeography of deep-water chemosynthetic ecosystems at the global scale

ChEss steering committee

Background

ChEss is a pilot project within the Census of Marine Life initiative. The main objective of ChEss is to determine the biogeography and biodiversity of deep-water chemosynthetic ecosystems and to understand the processes driving them. For this, ChEss proposes to develop a long-term international field phase for the discovery and exploration of new chemosynthetic sites at key locations.

Since the discovery of hydrothermal vents in 1977, evidence of hydrothermal venting is now available from every ocean basin and at all spreading rates. The mid-ocean ridges form a semi-continuous feature extending for ~60 000 km worldwide. Only a very small fraction of the ridge system has been investigated for the presence of hydrothermal activity to date, but whenever a new systematic search is undertaken, new vent sites are found, from fast spreading ridges such as the East Pacific Rise, to ultraslow spreading ridges such as the Gakkel Ridge in the Arctic (e.g. Tunnicliffe, 1998; Van Dover, 2002; Edmonds et al., 2003).

Cold seeps, discovered in 1984, are now known to occur at both passive and active continental margins, where seepage of cold fluids with high concentrations of methane, and/or sulphide from the underlying sediments are characteristic (Sibuet & Olu, 1998).

Highly reduced sediments supporting chemosynthetically-driven communities also develop in other deep-sea habitats. Whale skeletons release sulphide through microbial reduction of sulphates, sustaining sulphide-oxidising bacteria and communities of invertebrates based on chemosynthetic production (Smith et al., 1989; Smith & Baco, 2003). Accumulations of sunken wood and organic matter as well as areas of low oxygen (Oxygen Minimum Zones, OMZ) intersecting with continental margins or seamounts also create highly reduced habitats where chemosynthetic-based communities can develop (Levin, 2003).

To assess the biogeography and biodiversity of chemosynthetic ecosystems it is essential that all the above systems be studied in combination. Determining the evolutionary and ecological relationships amongst their fauna is crucial to understanding the processes that shape the distribution of species from chemosynthetic ecosystems at the global scale.

Our understanding of the biogeography of chemosynthetic systems is limited to detailed studies of only a small number of sites around the globe. Of these, hydrothermal vent systems are probably the best known. Vent systems have a linear (along-axis) and global-scale distribution, are dynamic and discrete in time and space, have specific physical and chemical parameters and their fauna is constrained to chemosynthetic-based food webs. This combination of properties makes these systems ideal for biogeographic studies and further exploration of new sections of ridge-crest at key locations will certainly provide crucial data leading towards a global understanding of vent species distribution and the processes driving these communities. Cold seeps and other reduced sediment habitats are more open systems and less well understood. Studies on the functional diversity of species, nutritional pathways and evolutionary radiation are essential if we are to understand the relationships amongst all chemosynthetically driven communities.

The present-day distribution of a species reflects vicariant events and the potential of species for dispersal and colonisation. The first phenomenon is geological, the second is ecological and species specific. Dispersal is largely a passive process driven by deep-water circulation and restricted by topographic barriers, though behaviour can play an important role especially at the beginning and end of the dispersal phase. Deep-water circulation is constrained by *Potential Vorticity (PV)*, a variable measured as the ratio between ocean depth and the Coriolis force (Weleander, 1969). Deep-ocean currents tend to follow contours of *PV*, except in western boundaries and areas of turbulent mixing driven by geothermal heating or topographic features. Larvae dispersed within such deep-ocean water masses would be expected to follow these dispersal pathways.

ChEss target areas for exploration

In January 2003, the steering committee of ChEss met at the Scripps Institution of Oceanography (USA). That meeting was convened to identify those major scientific questions which, when answered would provide a more thorough understanding of the biogeography of deep-water chemosynthetic ecosystems. A key outcome of the meeting was the establishment of a hierarchy of future “target” study areas within ChEss. A first priority was two combined areas, the Equatorial Atlantic Belt and the SE Pacific region. Subsequently (June 2003), a region around New Zealand was chosen as a third combined area. Secondly, a further suite of specific locations was identified in key areas where important national/international interests exist. Figure 1 shows the locations of these target areas, endorsed by ChEss for future exploration and research. The detailed rationale leading to their selection is detailed on the following pages.

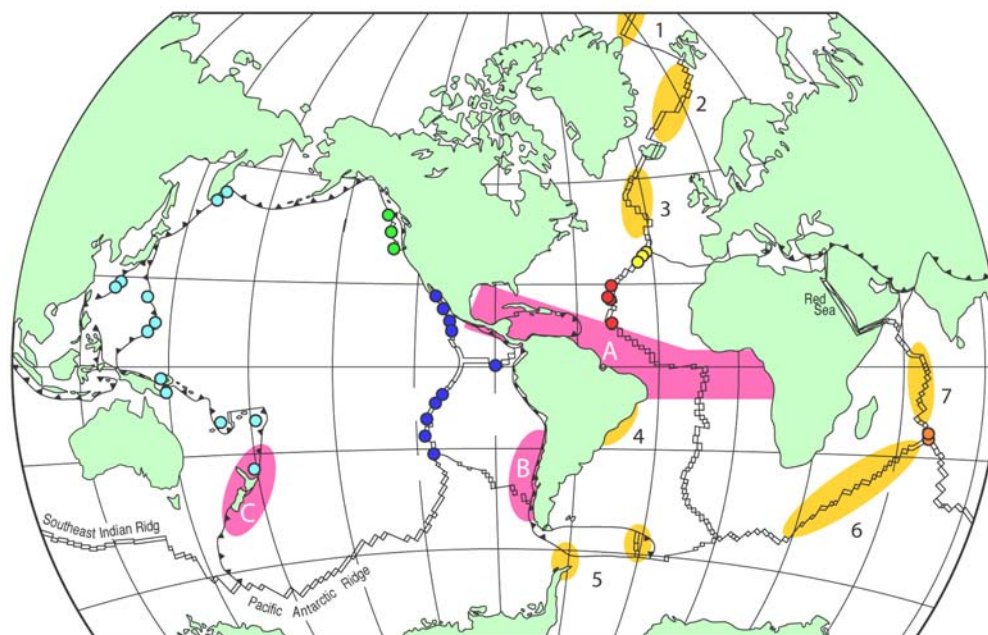


Figure 1. Key target areas for the ChEss field programme. **Category I, combined areas** (pink): Area A: Equatorial Atlantic Belt region - comprising cold seeps off Costa Rica and the Gulf of Mexico, the Cayman Trough spreading centre, the Barbados accretionary prism, the continental margin off north east Brazil including the Amazon outflow, the MAR north and south of the equatorial Fracture Zones and the West African continental margin; Area B: the SE Pacific region - comprising the East Chile Rise; the Peru-Chile trench; the OMZ region of the Chilean continental margin, and coincident whale migration and wood-fall areas; Area C: the New Zealand region – comprising hydrothermal vents (north of NZ extending toward the Lau Basin), cold seeps (immediately north and south of NZ), high concentrations of whale populations (hence whale-falls?) in Kaikoro Canyon and extensive sunken

wood and fjords (west coast, South Island). **Category II, specific areas** (yellow): 1 – the ice-covered Gakkel Ridge, 2 – the (ultra)-slow ridges of the Norwegian-Greenland Sea, 3- the northern MAR between the Iceland and Azores hot-spots; 4 – the Brazilian continental margin, 5 – the East Scotia Ridge and Bransfield Strait, 6 – the SW Indian Ridge, 7 – the Central Indian Ridge.

Category I: Combined areas

These targets are of particular concern to ChEss because their successful investigation will require the highest degree of international collaboration and co-ordination of effort. Each region encloses large areas where different chemosynthetic systems and a number of ecological, geological, evolutionary and topographic parameters are combined. The main purpose to studying these areas is to assess faunal relationships amongst different systems and the processes that drive their distribution. In our first chosen region, various chemosynthetic ecosystems are dispersed widely across an entire ocean basin; in the second, a comparably diverse suite of ecosystems is hypothesised to occur in much closer proximity.

A - Equatorial Atlantic Belt: This area extends on a longitudinal gradient, from Costa Rica to the continental margin off West Africa. The key sites include the Costa Rica cold seeps, the Gulf of Mexico cold seeps, the ultra-slow spreading Cayman Trough, the Barbados Accretionary Prism, Hydrothermal vents on the Mid-Atlantic Ridge (MAR), north and south of the Equatorial (Romanche and Chain) Fracture Zones and cold seeps on the continental margin of west Africa (Angola Basin).

The present mid-ocean ridge pathway between the Atlantic and Pacific Oceans runs via the Indian Ocean and Pacific-Antarctic ridge-systems. Prior to the closure of the Isthmus of Panama, ca. 5 Ma ago a major, low-latitude, deep-ocean gateway existed between these major oceans, albeit with no evident ridge connection (Tunnicliffe et al., 1996). In a generic similarity analysis of cold seeps across this (geologically modern) Central America land-bridge, the Gulf of Mexico and Florida Escarpment fauna clustered with the Oregon Margin seep communities. Also, the only seep-endemic vestimentiferan *Escarpia* sp. is known from the Gulf of Mexico and the California slope. Thus, the limited data available to date suggest a dispersal pathway for seep species between the Pacific and Atlantic via the (now-closed) Panama Isthmus (Tunnicliffe et al., 1996). Further analysis of the cold seep communities from Costa Rica and Caribbean sites would provide data to test this hypothesis of gene flow between these adjacent ocean basins, prior to closure. Further, exploration of the Cayman Trough and first description of its prospective vent-fauna (assuming that hydrothermal fields exist here, as on all other ultra-slow spreading ridges investigated to-date: e.g. Edmonds et al., 2003) would supply data to assess the potential dispersal pathway of vent species between the EPR-Galapagos Rift system and the Mid-Atlantic Ridge. Such studies would also allow to assess taxonomical similarities and evolutionary relationships amongst vent and seep species in close geographical (but not depth) proximity.

The Barbados accretionary prism results from subduction of the Atlantic plate beneath the Caribbean domain (Jollivet et al., 1990). The major groups in the seep community comprise mussels, vesicomid clams and vestimentiferans, but also include a large numbers of sponges, gorgonians and corals (Jollivet et al., 1990). Mud volcanoes and their associated seep fauna - including sponges with methanotroph endosymbionts - also occur in the Barbados Trench at 5000 m depth (Olu et al., 1997). The southward flow of North Atlantic Deep Water (NADW) along the American east coast and its eastward flow along PV contours near the equator might explain the distribution of chemosynthetic species in the NW Atlantic. For example, the vesicomid clam *Calyptogena* aff. *kaikoi* is not only present at the Florida Escarpment seeps and the Barbados Accretionary Prism but is also found at the Logatchev vent site on the MAR

near 15°N (Peek et al., 2000). Similarly, the mussel *Bathymodiolus heckeræ* is found at both North Carolina and Florida Escarpment seeps while closely related species are also found at MAR vent-sites (Van Dover et al., 2002). Further studies on the relationships of fauna amongst chemosynthetic sites in the Caribbean and in the central Atlantic Ocean will provide a better understanding on the effects of deep-water circulation for dispersal and colonisation of vent and seep species.

The Romanche and Chain Fracture Zones, which cross the equatorial MAR, are old (60 Ma) and significant topographic features (4 km high- 935 km ridge offset) that prominently affect both the linearity of the ridge system and large-scale ocean circulation in this region. North Atlantic Deep Water flows south along the East coasts of North and South America as far as the Equator before being deflected east, crossing the MAR through conduits created by these major fracture zones (Speer et al., 2003). Circulation within these fracture zones is turbulent and may provide an important dispersal pathway for species from west to east across the Atlantic (Van Dover et al., 2002). Analysis of species composition and similarities between the Gulf of Mexico communities and the newly-discovered West African margin seep-communities will provide invaluable data to test the hypothesis that these major fracture zones act as important conduits for gene-flow across the Mid-Atlantic Ridge. If the Romanche and Chain Fracture Zones do act as conduits in this latitudinal sense, from West to East, however, they may also act as significant topographic barriers which perturb the dispersal of vent fauna along-axis between the southern and northern MAR (Van Dover, 2000). The potential for dispersal along any ridge-axis, of course, will depend upon the biological and ecological characteristics of the larvae, as well as on the physical parameters (hydrography and bathymetry) created by the presence of, in this case the equatorial fracture zones. Exploration for, and investigation of MAR vent sites and their associated fauna immediately north and south of these fracture zones will also be required, therefore, to test the hypothesis that the southern MAR may represent an entirely new biogeographic province with the implication that other major topographic barriers can also impart significant genomic isolation elsewhere along the global ridge-crest

Implementation

To undertake research in such a broad area, which contains such a variety of habitats and expertise, will require a high degree of international cooperation and collaboration. An important number of cruises are already scheduled to work in different sites of the Equatorial Belt between 2003 and 2005 (see list below and PI contacts and cruise programmes on the ChEss web site). ChEss will act as the umbrella programme, providing a large-scale overview to the research being conducted during each of these cruises, and those to follow, as well as the laboratory-based work to be undertaken in many different laboratories throughout the various ChEss partner-nations. We will plan to coordinate efforts amongst scientists and laboratories from the different countries involved, aiming to join efforts and ensure a maximum return from the ongoing science that will benefit the community as a whole – both through liaison between different parties and through organisation of appropriate symposia at major international meetings. A first important contribution will be an on-line list of upcoming cruises (1st draft presented below), which will be posted on the ChEss web site. Key information will be the dates and location for each cruise plus contact details for the PI and an outline of the research programme for each cruise. This will allow for a better communication between researchers, and may also help identify gaps in sampling effort, hopefully leading to more valuable collaborations and sharing of resources (e.g. wish lists for samples) than might otherwise have been achieved. Daniel Desbruyères (IFREMER, France) will be the lead scientist responsible for coordination of ChEss Equatorial Atlantic Belt studies.

List of upcoming (and potential) cruises in the Equatorial Atlantic Belt

- Costa Rica – Germany – ROV
- Gulf of Mexico – US (Alvin, Johnson Sea-Link) 2003; GEOMAR 2005
- Mid-Cayman Rise – UK – ROV, 2004
- Barbados Prism/Dominica – Germany - 2005
- Amazon Fan – Brazil (Petrobras); ODP Leg 155
- Mid-Atlantic Ridge, 0-15°N – Germany – ROV – 2004/05
- Mid-Atlantic Ridge, 5-15°S – UK/US – TOBI/BRIDGET/ABE - 2005
- Gulf of Guinea – France - Nautile, 2004/05; Germany - ROV, 2005

B- SE Pacific Region: This area has been chosen because it contains almost as wide a diversity of potential sites of interest for ChEss as that observed across the entire Equatorial Atlantic (including Costa Rica) but in much closer geographical proximity. Thus, in comparison with the Equatorial Atlantic Belt, investigation of comparable sites in the SE Pacific will allow an improved understanding of the extent to which inter-community differences reflect “sorting” as a function of dispersal across the scale of ocean basins or, rather, reflects simple inter-ecosystem variations dominated by (perhaps only quite subtle) changes in the local environment between, e.g. vents and seeps; wood-falls and whale carcasses. The area of study we have chosen for this work is that of the SE Pacific Ocean because, here, in close proximity, we find the potential for: hydrothermal vent communities along the East Chile Rise, cold seeps associated with subduction along the Peru-Chile trench, an OMZ abutting the continental margin which extends south along the Peru and Chile margins, significant whale feeding grounds and migration routes along the SW American margin and strong potential for wood-fall from the forests of southern Chile.

The Chile Rise is one of the past geological pathways between the Pacific and Atlantic Oceans, because it was formerly connected to a complex mid-ocean ridge and subduction zone system, which connected across from the SEPR into the Atlantic between the tip of South America and the Antarctic Peninsula (Barker et al., 1991). For the last 10 Ma, however, the Chile Rise has been isolated from the Antarctic ridge system by subduction beneath South America. To date, the only hydrothermal information available on the Chile Rise is evidence of metalliferous input to the sediments in this region (Marienfeld & Marching, 1992). Nevertheless at the intermediate spreading rate observed for this ridge-section it is only to be expected that present-day active venting should be in existence and simply awaits detection and location using well-established techniques. What is also the case is that a significant component of the Antarctic Circumpolar Current passes over this section of ridge-crest before flowing through the Drake Passage, past the Bransfield Strait where the ACC diverges – a significant component continuing East, South of South Georgia where it crosses the East Scotia Ridge. Thus first identifying and describing the hydrothermal fauna of the East Chile Rise and then comparing vent species from the EPR, the East Chile Rise, the Bransfield Strait and the East Scotia Ridge would provide for an excellent investigation of the possibility for chemosynthetic and/or vent-specific gene flow across ocean basins around South America.

The Peru-Chile margin and subduction zone contains hydrate deposits (Victor Gallardo, *pers com*) and seep sites venting methane-rich fluids, although – again - these habitats are largely unexplored along the SW Chile slope. At shallower depth, between 200m and 500m below sea level, the Chile continental margin is intercepted by a well-developed oxygen minimum zone. Where this OMZ impinges on the seafloor, dense mats of sulfur oxidizing bacteria (*Thioploca*) cover the sediments. Isotopic evidence and the occurrence of some symbiont-bearing species indicate that the nutrition of infaunal assemblages in this zone may rely on

chemosynthesis (Levin, 2003). Many species of whales feed in the productive waters of the Peru-Chile margin (including minke, southern right, blue and humpback whales) and migrate through this area, moving between summer and winter feeding and breeding grounds. Community affinities between vent, seep, OMZ and whale-fall communities in close proximity are poorly known and, therefore, remain ripe for novel investigations and discoveries.

Implementation

- Ridge exploration (Sidescan, CTD etc)
 - 1 month of surface ship
- Margin exploration (Sidescan, CTD etc)
 - 1 month of surface ship
- Ridge & Margin investigations
 - 1 month of ship & ROV
- Wood-fall/Whale/Kelp location (cameras) & deployment
 - 2 weeks of surface ship
- Wood-fall/Whale/Kelp investigations
 - 2 weeks of ship & ROV
- OMZ Study - survey and seafloor investigations
 - 4 weeks of ship & ROV together

Total Shiptime Required:

Season 1 = 2.5 months shiptime

- 2 x 1 month seafloor survey & exploration

- 0.5 month for wood/kelp-fall & whale-carcass location/deployment

Season 2 = 2.5 months shiptime with ROV

- 1.5 months @ Ridges/Margins/Wood/Whales/Kelp

1 months for study of OMZ @ 20°S

Chris German (SOC) will be the lead scientist responsible for coordinating ChEss activities in the SE Pacific region. It is anticipated that the field programme for the SE Pacific may be developed in collaboration with a WUN (Worldwide University Network) programme, also coordinated from SOC. A first “implementation” workshop hosted by Victor Gallardo, Director of COPAS (Centre for Oceanographic Research in the Eastern South Pacific), Concepción, Chile is currently proposed, to be co-funded by CoML and WUN, in early 2004.

C – New Zealand region

New Zealand is the third of our ChEss combined study areas. Like the Equatorial Atlantic and the SE Pacific the oceans around New Zealand host a wide variety of chemosynthetic ecosystem niches, all in close geographic proximity. There are known vent sites to the north of New Zealand along the Kermadec volcanic arc that links to the Lau basin (The Lau basin is one of the integrated study sites for the US Ridge 2000 programme). There are also known seep sites on the Hikurangi margin east of North Island and off Otago on the South Island. The fjords of the south-west coast in the South Island are potential target regions for oxygen minima zones, sunken decaying wood and kelp studies. Examinations of wood and kelp environments could equally well be conducted together with whale carcass’ skeleton studies elsewhere in the region. The seas around New Zealand are known as an important whale migration route and whales are particularly abundant in certain areas (as evidenced by popular tourism-based whale-watching), providing the likelihood of important seafloor deposits in these locations. Areas provisionally identified as suitable and accessible for whale skeleton investigations include the Kaikoura canyon (east coast South Island) and the Cook Strait canyons (between the North and South islands). Whale strandings, which are relatively

frequent around New Zealand's coast could provide carcasses for sinking and follow-on re-colonisation experiments.

Implementation

Total Shiptime Required:

Surface-ship \leq 1 month for wood/whales/kelp location and/or deployment

NB: Assumes 1 month GEOMAR (Nth Island) Seeps Survey [UNFORTUNATELY, DIDN'T GET FUNDING]

ROV & Ship = 2.5 months

- 2 weeks on Whale/Wood/Kelp
- 4 weeks on Seeps (2 weeks off Otago; 2 weeks off North Island)
- 4 weeks on deepening vents, north of NZ toward Lau Basin

Amy Baco (WHOI, USA) and Craig Smith (University of Hawaii, USA) will be the lead scientists responsible for coordinating the field programme in the NZ region, in collaboration with scientists at New Zealand's National Institute of Water & Atmospheric Science, Institute for Geological and Nuclear Sciences, and National Museum [if don't want to put names, in and I know it looks heavy – please at least include “in collaboration with interested scientists in New Zealand” – otherwise we have less to ‘trade’ on for our getting monies from within NZ]. Contacts will be made and planning sessions held during the Deep Sea Conference in December 2003 in Queenstown, New Zealand.

Category II - Specific areas

The following represent further key areas, both along the global ridge-crest and on continental margins where there is already interest at the national and/or international level. Each of these sites is also important in our bid to elucidate the biogeographic puzzle of chemosynthetic systems. While they will not require the same degree of complex international coordination for investigation as our Category I areas A and B they, nevertheless, remain important to achieving ChEss goals.

1- Gakkel Ridge: Recent work has revealed evidence for abundant hydrothermal activity on the Gakkel Ridge in the Arctic Ocean (Edmonds et al., 2003). The Gakkel Ridge is an ultra-slow spreading ridge, which lies beneath permanent ice cover within the bathymetrically isolated Arctic Basin. The deep Arctic water is isolated from deep-water in the Atlantic by sills between Greenland and Iceland and between Iceland and Norway. This has important implications for the evolution and ecology of the deep-water Arctic vent fauna. The Atlantic and Pacific were once connected via the open Arctic Ocean, and their vent fauna could have used this pathway to disperse across ocean basins. Identifying which species are found on the Gakkel Ridge and assessing their ecological and phylogenetic relationships with vent species from Pacific and Atlantic vent fauna will allow us to test the hypothesis of a past Arctic Ocean link. Also, exploring the Arctic ridges will enable identification of new species with specific adaptations to unique ecological habitats. Understanding the evolutionary and ecological processes shaping Arctic vent communities will be essential to our understanding of the distribution of vent-fauna across ocean basins.

2- Norwegian-Greenland Sea Ridges: The Knipovich, Mohns and Kolbeinsey ridges extend from the south of Svalbard to the north of Iceland. The first two are ultra-slow spreading ridges, and the Kolbeinsey is a slow spreading ridge. There is evidence for hydrothermal venting at both Kolbeinsey and Knipovich (Pedersen et al., 1999; Connelly and German, 2002) but no information on associated fauna, to-date. These ridges are isolated from the

Gakkel Ridge by shallow sills connecting to the Arctic Basin, but are even more dramatically isolated from the MAR by Iceland, where the ridge is subaerial. Thus, this system offers a natural laboratory for evolution on an isolated section of the ridge.

3- Mid Atlantic Ridge, Azores-Iceland: Despite representing the section of ridge-crest closest to Northern Europe and, indeed, forming an important component of the European tectonic plate boundary, no known vent-sites have yet been located and investigated along this section of the Mid-Atlantic Ridge. Geologically, much of this ridge section should be expected to host hydrothermal activity similar to that found at numerous sites along the northern MAR south of the Azores including variations due to changing lithology (e.g. Logatchev vs Broken Spur) volcano-tectonic setting (e.g. Snake-Pit vs TAG) and decreasing depth toward ocean island hotspots (e.g. Rainbow - Lucky Strike - Menez Gwen). Biologically, it has been shown previously that at decreasing depth there is increasing invasion of local seabed fauna into the known vent-site communities. It is interesting to question, therefore, whether vent-specific fauna may be displaced so effectively that they are completely absent from the shallowest ridge-crest amongst the Azores islands. If so, this shallow section of the ridge may act as a genetic barrier, which isolates the vent-faunal communities south of the Azores from those to the north, rendering these two distinct ridge-sections as genetically isolated biogeographic provinces. Further, the possibility remains that predation in shallow sunlit waters prevents any genetic communication between deep-water hydrothermal communities north and south of the Azores and north and south of Iceland such that this section of the MAR hosts unique vent-fauna isolated between two long-duration hotspots. For that reason, exploration should also continue north of the Azores until depths comparable to Lucky Strike/Rainbow are reached at the Kurchatov Fracture Zone.

4- Continental margin off central Brazil: there is indirect evidence of the existence of cold seeps on the Brazilian continental margin from the collection of a vesicomid shell, *Calypptogena birmani* (Domaneschi & Lopes, 1990). This continental margin is currently under development for extraction of gas and oil by Petrobras and other oil companies, who have acquired a wealth of relevant, but un-published 'commercially sensitive' data. Links and collaboration with industry in this area could be enormously beneficial for both sides. This margin also harbours a resident population of humpback whales and probably falls on a migration route for this and other cetacean species. The potential seep and whale-fall communities of the Brazilian continental margin could be linked to communities on the African continental margin through the eastward flow of NADW via the Rio de Janeiro Fracture Zone and with the southern ocean via whale-falls along SE American margin migration routes.

5- Bransfield Strait/East Scotia Ridge: The Bransfield Strait (BS) and East Scotia Ridge (ESR) are isolated back-arc basins located at the gateway from the Pacific to the Atlantic sector of the Southern Ocean where evidence of hydrothermal activity has been recently identified (German et al., 2001; Klinkhammer et al., 2001). Three hypotheses can be developed to explain the potential faunal colonisation of these sites. If the colonisation of the BS/ESR vents has been driven by hydrography, then the faunal composition would be related to that of Pacific vents, with propagules dispersing with the Antarctic Circumpolar Current from the Southern EPR and/or Chile Rise. If, on the contrary, the colonisation of the BS and ESR vents followed geological controls, then the fauna may have migrated to these sites across the seafloor and more closely resemble those of the southern MAR (always remembering that we have not yet characterised ANY Southern MAR vent-fauna!). The third alternative is that the fauna of the BS and/or the ESR may have evolved quite independently from both the EPR and MAR (German et al., 2001). Certainly, a dispersal pathway from

Pacific to Atlantic via the connection of the Chile Rise, the Antarctic Ridge (Scotia Sea) and the MAR did exist previously, during the Tertiary (Tunnicliffe et al., 1996). The exploration of the BS and ESR and their associated fauna will provide crucial data necessary to understand dispersal and colonisation pathways for vent-species between ocean basins.

6- SW Indian Ridge: The Indian ridges also play an important role in our understanding of the evolutionary dispersal and colonisation of vent sites at the global scale. The only direct modern pathway between the Pacific and Atlantic ridge-systems is via the Pacific Antarctic Ridge, the SE Indian Ridge and the SW Indian Ridge (Tunnicliffe et al., 1998). Of these, the SW Indian Ridge is of particular importance. Like the Gakkel and Knipovich ridges in extreme North, the SWIR is also an ultra-slow spreading ridge. Despite the associated low magmatic flux, recent studies have shown evidence for abundant venting in both volcanic and tectonic terrenes (German et al., 1998; Bach et al., 2001). The question remains, however: is hydrothermal activity present in sufficient abundance to permit significant vent-faunal gene-flow? In 2001, the discovery of the Kairei and Edmond vents at the Rodriguez Triple Junction (where the SE, SW and Central Indian Ridges all meet) showed that while most species at that location have affinities with western Pacific fauna (indicating strong gene flow from the Pacific along the SEIR, the dominant species at the triple junction is the MAR caridean shrimp *Rimicaris* aff. *exoculata* (Van Dover et al., 2001). Is this species also abundant, therefore, along the SWIR and, by inference the southern MAR? First investigation and examination of a hydrothermal community along the SW Indian Ridge is needed to answer this question.

7- Central Indian Ridge: A final specified target for the ChEss programme is the Central Indian Ridge (CIR) north of the Kairei and Edmond hydrothermal fields. If gene-flow is strongly influenced by ridge-spreading rate then vent-sites along the northern CIR should exhibit close similarities to SW Pacific fauna, similar to the Rodriguez Triple-Junction sites. Alternately, however, CIR fauna might define yet another discrete biogeographic province or, indeed, may reflect some residual characteristics dating from connection between the modern-day NW Indian Ocean and the Atlantic/Mediterranean Sea via the now-closed Tethys Ocean.

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