PROPOSAL FOR SEAFOAM - SCOR WG

Submitted to: Dr. Edward Urban, Executive Secretary, Scientific Committee for Oceanic Research (SCOR)

Submitted by: Dr. Robert Y. George, President, George Institute for Biodiversity and Sustainabilty (GIBS), 1320 Vanagrif Ct., Wake Forest, North Carolina.

Date of Submission: April 29, 2015.

SEAFOAM

SEAmount **F**aunal vulnerabilty to impacts of **O**cean **A**cidification and **M**ining

Summary/Abstract (250 words)

We propose a new SCOR Working Group (2016 to 2018) that seeks to assess new impacts on seamount ecosystems from ocean acidification (OA) and deep-sea mining for cobalt crusts. The WG seeks to re-evaluate and augment the science priorities defined in 2012 by the Census of the Marine Life, but taking into account the new threats. The WG would initiate the first conference session focussed on OA impacts and deep-sea ecosystems as part of The Fourth Symposium on Oceans in a High CO_2 World, in Hobart, 2016 and plans to work with Dr. Richard A. Feeley with whom Dr. George conducted an international OA Workshop in Florida in 2008) The WG plans to develop a follow-on capacity building workshop in Fiji to address commercial deep-sea mining on seamounts, which will start in the region in 2016. In 2017, the WG will meet for three days at North Carolina State University to generate two open-access publications; 1) the first global assessment of OA on deep-sea fauna, and 2) a blueprint for monitoring mining impacts on seamount ecosystems. In 2018, the WG will meet for 3 days at Oxford University, UK, hosted by Prof. Alex Rogers (SEAFOAM WG) to produce a peer-reviewed publication on conservation objectives for seamounts in the face of multiple human impacts. As a follow-up, WG members will go to Ghent University, Belgium, to work with Prof. Ann Vanreusel (SEAFOAM WG) on 'Capacity Building' in developing nations on deep ocean ecosystem management. The culmination of the WG will be the long-time archiving of information on selected seamounts as "Seamount Data Pool" (SDP) to complement Data Banks on Seamounts at Scripps and University of British Columbia.

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Scientific Background and Rationale (1250 words)

Deep-Sea Overview:

It is essential to recognize that there are fundamental links between the deep ocean and the rest of the Earth System. It has been demonstrated that deep-sea ecosystems, their biodiversity and ecosystem functioning, can change quickly and significantly because of direct (e.g. bottom trawling, deep-water oil spills) and indirect (e.g. climate variation) human impacts (Smith et al,

2009). In addition to these known impacts, two new pressures have been recognized in recent years; 1) ocean acidification, including the effects of changing pH on shell-bearing planktonic and benthic organisms, and 2) the rapid development of deep-sea mining with its potential to disturb exceptionally large areas of the seabed. There is an urgent need to consider how deep-sea ecosystems will respond to these new pressures and whether there will be significant feedbacks to other parts of the Earth System. In particular, deep-sea seamounts are considered to be especially vulnerable (Consalvey et al, 2010).

This proposal is timely owing to: (1) the increasing interest of "Oceans in the High Carbon World" and (2) the new licenses (2013 –2015) issued by International Seabed Authority (ISA) for the exploration of cobalt-rich crusts on seamounts. The proposed work is truly global in scale encompassing Exclusive Economic Zones (EEZs), Extended Continental Shelves and the High Seas (Areas Beyond National Jurisdiction). Owing to the cross jurisdictional nature of seamount research, and the need for generic strategies for seamount management, a SCOR WG is probably the only way to approach the growing problem facing seamounts and generate good science to guide management decisions. Seamounts are underwater mountains and occur throughout the world's oceans. There are as many as 100,000 seamounts at least one kilometer in height. However, of these, less than 200 have been studied in any detail and their biodiversity is still poorly known. Depending on the height of the summit they may have particularly high productivity and may serve as migratory stopovers for whales and other pelagic species. Seamounts are heterogeneous habitats, often spanning a great depth range (Pitcher et al., 2007; Consalvey et al., 2010; Clark et al., 2010).. Their topography interacts with a wide variety of physical processes including internal waves and tides. As a result seamounts may support highly varied and patchy benthic communities. As for all deep-sea species the seamount fauna generally has long generation times and therefore seamount communities are particularly sensitive to physical impacts, such as bottom trawling and mining. As sampling of seamounts increases, previously held views of seamounts as having a high proportion of endemic species on individual seamounts are challenged (Rowden et al., 2010; Clark et al. 2012). It is now known that many species are shared with other deep-sea habitats, such as continental slopes and banks, although seamounts may have communities with a different structure (Rowden et al., 2010). Historically, seamounts have been poorly sampled owing to their complex topography.

It is only now with the greater availability of Remotely Operated Vehicles (ROVs) and the rapid development of genetic techniques that many issues relating to seamount ecosystems can be resolved. The lack of comprehensive data has led to generalizations about seamounts as a whole. Very often, however, the generalisations apply only to a subset of seamounts, depending also on the biogeographical province and depth band in which they occur (McCain, 2007; Kvile et al., 2013). A concerted effort on studying seamounts is needed, and possible.

Apart from global warming threats on coral reefs in shallow seas through coral bleaching and the increasing spread of deoxygenation by creating hypoxic or anoxic zones in ocean areas off river deltas, ocean acidification (OA) threatens ocean health through effects on plankton (e.g. pteropods) and benthic shell-bearing animals (corals and molluscs) which in some cases are deep-water habitat engineers.. Increasing CO_2 input is expected to decrease ocean pH by 0.3 to 0.5 by 2100, thus lowering the carbon ion concentration of surface waters. This rapid and dramatic scenario of ocean acidification has the potential to have serious effect on calcification

of marine organisms. Since industrialization, there has been a substantial increase in CO_2 flux into the oceans from atmosphere. It is cautioned that by 2100, if this flux is not reduced by shifting gear to renewable energy, irreversible damage may occur to our ecosystems and may diminish ecological services.

There has been an exponential increase in the number of publications on biological effects of OA and several recent reviews have covered this topic. However, few studies cover the benthic realm. The importance of the combined, and frequently interactive, impacts of multiple stressors (such as temperature, low oxygen and pollutants) is now recognized, as well as the potential for multi-generational adaptation. Experimental research confirms that survival, calcification, growth, development and abundance can all be negatively affected by acidification, but the scale of response can vary greatly for different life stages, between taxonomic groups and according to other environmental conditions, including food availability. Volcanic CO_2 vents can provide useful proxies of future OA conditions allowing studies of species responses and ecosystem interactions across CO_2 gradients. Studies at suitable vents in the Mediterranean Sea and elsewhere show that benthic marine systems respond in consistent ways to locally-increased CO_2. At the shelf-edge, the ongoing shoaling of carbonate-corrosive waters (with high CO_2 and low pH) threatens cold-water corals, in particular *Lophelia pertusa*, in the North East Atlantic Ocean..

In upwelling areas of the Northeast Pacific Ocean, shoaling of the Aragonite Saturation Horizon (ASH) has reduced hard-coral ecosystems dominated by scleractinian corals. The ASH is located much deeper in the other regions of the deep sea. This led, in part, to Tittensor et al. (2010) postulating that OA threat is really confined to continental margins (continental slopes and plateaus) and that mid-ocean seamounts may not be impacted adversely by OA. However, this thesis needs urgent clarification particularly in polar seas and in areas affected by cold water out-flows. A concerted study of seamounts is required in relation to OA threats and other human impacts, such as trawling, mining and OA threats.

Cobalt-rich ferro-manganese crusts are formed by the precipitation of manganese and iron from cold seawater coating the rocky slopes and summits of seamounts in a layer up to 25 cm thick at ocean depths typically between 800 and 2500 m (Baker and Beudoin, 2013). The crusts form very slowly (e.g. only a few mm every one million years). There are about 1,200 seamounts and guyots which may be of commercial interest in the western Pacific Ocean alone, some of which have been licensed in the last 3 years by the UN International Seabed Authority (ISA) for cobalt crust exploration. In addition, the ISA is in the process of agreeing to an extensive exploration license for cobalt crusts on the Rio Grande Rise in the SW Atlantic Ocean.

Mining crusts involves removing the relatively thin layer of ore from the underlying rocky surface. Removing the crust will destroy all the sessile organisms. It is not known how long it will take to recolonize impacted areas, but there is evidence that corals on seamounts at depths where mining may occur may be as old as 2300 years (Carreiro-Silva et al., 2013). Recovery may take a long time. A number of biological issues arise, for instance: 1) How connected are seamounts with other deep-sea habitats such as continental slopes and banks? 2) What population sizes are required in areas of biodiversity conservation to ensure connected and long-

lasting reproductive populations? 3) What are the possible cumulative impacts of mining? (Baker and Beaudoin, 2013).

Terms of Reference (ToRs)(250 words)

1. Ocean acidification impacts of pH change on deep-water coral reefs on continental margin and seamount communities above and below the Aragonite Saturation Horizon (ASH) and Calcite Saturation Horizon (CSH).
2. Influence of physical disturbance and mine tailing releases from deep-sea mining for cobalt crusts on seamounts).
3. Connecting ongoing global deep-sea conservation activities to assess the influences of cumulative human impact on seamount ecosystems and biodiversity of seamount ecosystems.

Work Plan – details of the Terms of Reference (1000 words)

ToR 1. Ocean Acidification

The working group will build upon previous initiatives by organizing a follow-up workshop at the 'Ocean in a High CO2 World' conference in Hobart in April 2016, hosted by Dr. Ron Thresher of CSIRO of Australia (WG member and the nominal chair of the international planning committee. The research presented will be used to produce a peer-reviewed publication detailing a 10-years research plan for studying the OA impacts on seamounts in the world oceans (Deliverable #1). This document will be finalized at the second SEAFOAM WG meeting in North Carolina in 2017.

Background for SCOR WG: The Hobart session on deep-sea ecosystems and ocean acidification builds on two previous "Ocean Acidification workshops" led by Dr. Bob George (SEAFOAM Chair), one held at Ft. Lauderdale, Florida during the 11th International Coral Reef Symposium (July 7 –11, 2008) and another held at Wellington, New Zealand during the 4th International Deep-Sea Coral Symposium (Dec. 1-5, 2008). The recommendations from the Florida workshop were submitted through Dr. Shirley Pomponi of the NAS 'Ocean Studies Board' to US National Academy of Sciences (NAS) to increase budget allocation for OA research for both NSF sand NOAA through Congressional appropriations.

.**ToR 2. Mining Impacts**

SEAFOAM will seek to stimulate coordinated international research on seamount ecosystems and mining issues, building on the scientific community created through the Census of Marine Life (CoML, 2000-2010) (Consalvey et al. 2010).

A workshop will be organized at North Carolina State University in 2017 to produce: (1) a peer-reviewed publication detailing a 10 year research plan for studying OA impacts on seamounts in the world oceans (Deliverable ToR # 1) and (2) a publication detailing the science behind the first regional environmental management plan for a cluster of seamounts, balancing the needs of resource exploitation with the conservation of regional biodiversity (no species

loss). The workshop will focus on the western equatorial Pacific Ocean where a large number of seamounts within a region have been licensed for the exploration of cobalt crusts (Deliverable ToR #2). The workshop will set the proposed management plans within the context of long-term climate change scenarios (e.g. Gehlen et al., 2014).

Capacity building funding will be sought from the ISA (drawn from direct funding of contractors to the ISA, and from the ISA Endowment Fund) for Master's level students to attend and participate in the workshop, especially those from south west Pacific Ocean island states. Additional funding for capacity building will be sought from the South Pacific Commission (SPC) which is coordinating deep-sea mining issues within Exclusive Economic Zones in all island states within the region.

ToR 3. Conservation of Seamount Ecosystems

In 2014 the UN Convention on Biological Diversity (CBD), in collaboration with UNEP, updated the impacts of OA in a report on "A Updated Synthesis on the Impacts of Ocean Acidification Impacts on Marine Biodiversity" (Hennige, Roberts and Williamson (2014). Dr. Braulio Dias, Executive Director CBD, gave a succinct summary of this report with recommendations for future OA research and monitoring. In this proposal to SCOR for creating a WG, we have taken the advice from these recommendations. We also realize that thus far we have focused more in the Atlantic and Pacific Oceans and have not included the Indian Ocean. Therefore, we have included an expert from National Institute of Oceanography in Goa, India (Dr. V. K. Banakar). To bring together these many disparate strands a workshop will be organized in Oxford, UK, (2018), building on the results of the two previous workshops, to produce an open access publication on the conservation and management of deep-sea seamounts, including a forward-looking 10-year international research plan (Deliverable ToR#3).

Deliverables:

In addition to the 3 deliverables related to the ToR detailed above, SEAFOAM will prepare a multi-authored comprehensive science paper on potential impact of ocean acidification with emphasis on shell-bearing fauna in the seamounts such as scleractinian coral species. This paper will include the following research questions: (1) How ASH and CSH will behave in different geographic regions, upwelling zones on the eastern parts of world oceans vs non-upwelling zones on western parts of the world oceans, (2) Which deep-sea coral species have inherent genetic adaptability to be resilient in low pH conditions (and what shore-based OA study facilities are called for in order to conduct long-term experiments on chosen deep-sea corals and (3) What recommendations should be developed to International Seabed Authority for designation Marine Protected Areas (MPAs) in the seamounts that are targets of seafloor industries in the cobalt mining in the coming decade.

Capacity Building Plan (500 words)

Much of capacity building and training in marine science, conservation and management is focused on coastal systems. The marine training portal www.marinetraining.eu, as a measure of international opportunities, shows only a very limited number of courses targeting human

impacts and deep-water systems. Searching the keywords “ocean acidification” and “deep-sea mining” provides only a negligible number of records. The importance and scale by which OA and mining may impact biodiversity and ecosystem functioning in deep-water have not been reflected in training programs that have been organized to date. This is of concern as developing countries start to utilize offshore resources within their Exclusive Economic Zones (EEZs). The cross boundary causes and consequences of OA, the international framework in which mining operations occur, and the global distribution of seamounts within and beyond EEZs, requires international awareness and action. Therefore, building knowledge and training capacity on OA and deep-sea mining in developed and developing countries, including fast growing nations such as India, and Brazil is a major objective for SEAFOAM.

We aim to inform and educate young scientists on the threats, research needs and management tools for the conservation of biodiversity and resource exploitation on seamounts. We aim to conduct three new capacity building activities related to SEAFOAM.

First, we will contribute expert knowledge to a workshop for developing countries planned for Namibia in 2016 (http://www.indeep-project.org/wg/population-connectivity) by WG 3 of the INDEEP Project. The topic is “Biodiversity and connectivity of deep-sea ecosystems in areas targeted by deep-sea mining” in relation to management and decision making. The plan is to have a 10 day workshop with 18-20 participants.

Second, we will time the third SEAFOAM workshop in Oxford in 2018 to allow a follow up course on seamount ecology and human impacts at Ghent University as part of their international Masters of Oceans and Lakes (www.oceansandlakes.be). This course educates 30 students each year, in a two-year course, complete with project work on a topic of direct importance to the student’s country of origin. Students from 30 developing countries have attended at the Master’s level todate. Many students have gone on to Ph.D. studies or to environmental management roles in their home country. A special course will be offered with a certificate awarded for attendance.

Third, over the next 4 years new contractors to the International Seabed Authority for exploration of cobalt crusts on seamounts are required to provide at sea training opportunities and fellowships (http://www.isa.org.jm/training). SEAFOAM will work with the students selected to act as role models for future capacity building.

In addition to these initiatives SEAFOAM will search for funding from agencies (e.g. UNESCO) and foundations (e.g. Packard, Sloan, Total) to provide scholarships for people from developing countries to attend targeted workshops. In particular, SEAFOAM will work with the South Pacific Commission (SPC) to provide a training program in Polynesia on seamounts and environmental management to follow on from the WG’s meeting in Hobart in 2016.

Funding support, especially in relation to capacity building in developing nations will be sought from private philanthropic foundations concerned about biodiversity loss in the oceans such as the Sloan Foundation and the Packard Foundation.

Relationship to other SCOR WGs and International Programs:

SEAFOAM seeks to interact with the following ongoing efforts that emphasize the need to resolve OA threats to marine ecosystems and biodiversity. Apart from work on seafloormapping and ocean observatories, SCOR has had little focus on benthic ecosystems in the world's oceans in the past. SEAFOAM builds on interests in SCOR on oceans in a high CO2 world and ocean acidification to fill a important gap in SCOR's past and present work.

International programs that will benefit directly from SEAFOAM and which have produced reports calling for research produced by SEAFOAM are:

1. 2014 Recommendations from Convention for Biological Diversity (CBD) Report

2. SCOR WG will interact with Prof. Alex Rogers, Professor of Zoology at Oxford, UK and will use his consultant service on seamount ecosystem research..

3. Dr. Maria Baker of National Oceanography Centre and the University of Southampton UK has consented help as liaison between the SCOR WG and INDEEP and DOSI (Deep-Ocean Stewardship Initiatives) that have made significant progress under the leadership of Prof. Lisa Levin of Scripps Institution of Oceanography and Prof. Elva Escobar of UNAM, Mexico to assemble concerned deep-ocean scientists to address issues such as:

    (A) Deep-Sea Mining (Prof. Craig Smith, University of Hawaii)
    (B) Global Ocean Assessment (Dr. Tony Koslow, Scripps Institution of Oceanography)
    (C) Ocean Conservation (Dr. Jeff Ardron, Commonwealth Secretariat, London)
    (D) Collaborations with Developing Nations (Dr. Christian Neumann)
    (E) High Sea and Sargasso Sea Commission (Dr. Kristina, Gjerde, IUCN)
    (F) Networking (Dr. Maria Baker, NOC, University of Southampton, UK)
    (G) Deep-Sea Fisheries (Dr. Les Watling, University of Hawaii)
    (H) Legal Issues and Mining Tailings (Dr. Eva Ramirez, NIVA, Norway)
    (I) Oil and Gas Explorations and Drilling (Dr. Eric Cordes, Temple University, Philadelphia, USA)).

4. The SCOR WG will also interact with Dr. Tim Shank who will host the 2016 Deep-Sea Coral Symposium. Note: the first International deep-sea coral symposium in USA was coordinated by Prof.. Robert Y. George (GIBS) and Dr. Robert Brock (NOAA) at the University of Miami in 2005). Dr. George co-edited this symposium proceedings with Dr. Stephen Cairns of Smithsonian Institution in two volumes, one entitled :"Conservation and Adaptive Management of Deep-Sea coral and seamount ecosystems."

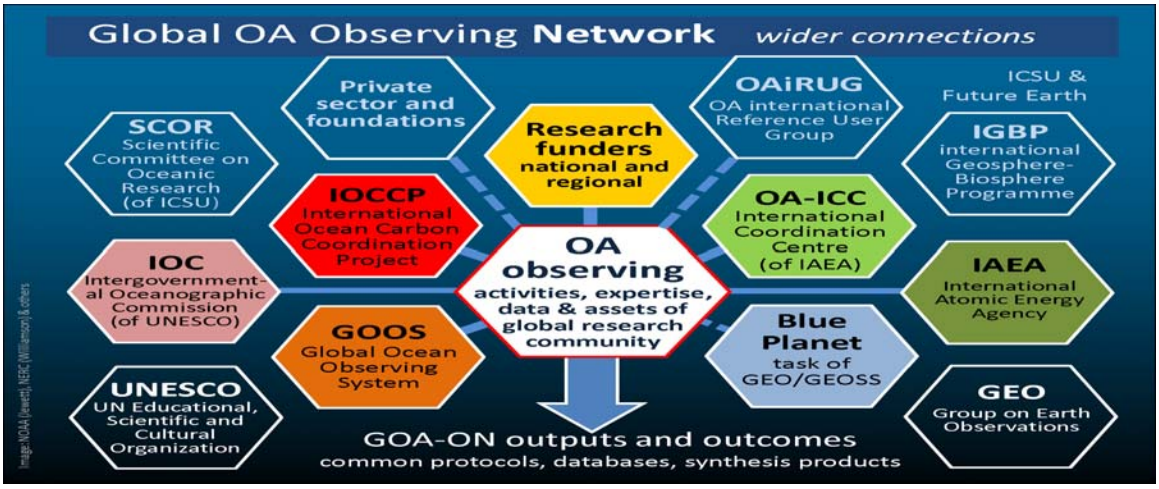
5. The results of the SCOR WG will find ready application in the environmental management of cobalt-rich crusts on seamounts, through the International Seabed Authority, Kingston, Jamaica, which is seeking to expand work on regional Strategic Environmental Assessments (SEA) in relation to deep-sea mining (International Seabed Authority, 2014). SCOR results will be provided through links of the SCOR WG to the

ISA Secretariat and ISA Legal and Technical Commission (LTC), an expert group that advises the ISA Council in its decision making (www.isa.org.jm). Dr Billett (SEAFOAM WG) is a member of the current ISA LTC.

6. To bring together these many disparate strands a workshop will be organized in Oxford, UK, (2018), building on the results of the two previous workshops to produce an open access publication on the conservation and management of deep-sea seamounts, including a forward-looking 10-year international research plan

7. Global Ocean Acidification Network (GOAN)

We are also aware of the existing "Global Ocean Acidification Network" , with a vast number of scientists and managers from many nations, actively involved in OA research and monitoring efforts in the world ocean with Dr. Libby Jewett of NOAA as a coordinator of this activity, as illustrated below. The Scientific Committee for Oceanic Research (SCOR) is one of many participants in this ongoing network



8. The Brazilian Ocean Acidification Research Group (BrOA; www.broa.furg.br) was created in December 2012, as an action arising out of the workshop "Studying Ocean Acidification and its Effects on Marine Ecosystems" (Dec. 4-6, 2012, Cananéia, Brazil), which was organized by the International Geosphere-Biosphere Program, University of São Paulo, Brazilian Council of Scientific Research and Development and Brazil's National Institute for Space Research. In March 2015, BrOA identified: (A) National ocean acidification projects and learning how they have integrated field and laboratory experimentations (B) Scientific collaboration between Brazil and other countries in the context of ocean acidification research.

COLLABORATION WITH GOA-ON, NOAA AND OA EXPERTS

Dr. Sam Dupont at the Department of Biological and Environmental Sciences of Gothenburg University and Sven Loven Center for Marine Sciences, Kristineberg, Sweden, has offered to help SEA FOAM and will participate in the first meeting of SEASFOAM WG for SCOR on May 7, 2016 in Hobart, soon after the 4th High Carbon Ocean Symposium. Dr. Dupont is a member of Executive Council of Global Observatory Network for Ocean Acidification (GOA-ON) and he is leader of the Biology WG of GOA-ON). Dr. Dupont is also a member of the International Coordination Center for Ocean Acidification. We will also invite Dr. Sam Dupont (Sweden), Dr. Richard A, Feely (NOAA) Dr. Libby Jewett (NOAA) and also Dr. Jean-Pierre Gattuso (University of Pierre-et-Marie Curie) who chairs the 'Ocean in the High Carbon World' symposium in Hobart (May 3-6, 2016) to participate in the SEAFOAMWG meeting on May 7, 2016.

SCOR WG SEAFOAM (Seamounts Ocean Acidification and Mining)

Full Members (no more than 10, please identify chair(s))

Name	Gender	Place of work	Expertise relevant to proposal
1 Prof.Robert Y. George (CHAIR)	Male	Raleigh, North Carolina	Deep-Sea Ecology. Ocean Acidification
2 Dr. David Billett (VICE_CHAIR)	Male	Southampton, UK	Deep-Sea Mining and Benthic communities
3 Prof. Billie J. Swalla	Female	Univ. of Washington, Washington State	Ocean Acidification Research Facility
4 Prof. Alex Rogers	Male	Oxford University, UK	Seamounts Ecology
5 Dr. Anna Metaxas	Female	Dalhousie University, Canada	Deep-Sea Ecosystems
6 Dr. Ron Thresher	Male	CSIRO, Hobart, Tasmania, Australia	High Carbon Oceans
7 Prof. Marco Taviani	Male	Marine Geology Institute, Italy	Deep-Sea Geology and deep-sea Corals
8 Dr. Marcelo Kitahara	Male	Sao Paola, Brazil	Deep-Sea Hard Corals
9 Prof. Ann Vanreusel	Female	University of Ghent Belgium	Deep-Sea seeps and nematode biodiversity
10 Dr. V. K. Banakar	Male	NIO, Goa, India	Deep Sea Minerals

Associate Members (no more than 10)

Name	Gender	Place of work	Expertise relevant to proposal
1 Dr. Jason Hall-Spencer	Male	Univ. of Plymouth, UK	Deep-sea conservation and Ocean Acidification
2 Dr. Thomas Hourigan	Male	NOAA, USA	Deep-Sea Corals
3 Prof. Robert S. Carney	Male	LSU, USA	Deep-Sea Ecology
4 Dr. David Eggleston	Male	CMST, North Carolina State University, NC	Marine Ecosystem Services/Conservation
5 Dr. Myriam Sibuet	Female	Institut Oceanographique, Paris, France	Deep-Sea Ecology
6 Dr. Alison Swaddling	Female	Suva, Fiji	Deep-Sea Mining and Ecology
7 Dr. Eva Ramirez	Female	NIVA, Oslo, Norway	Marine Ecology
8 Dr. Ashley Rowden	Male	NIWA, Wellington, New Zealand	Seamount Ecology/Fisheries
9 Dr. Robert H. Byrne	Male	University of South Florida,.	High Carbon Ocean/ pHMonitoring
10 Dr. Telmo Morato	Male	University of Azores	Seamount Ecology

Brief CVs of each Full Member

1. Dr. Robert Y. George (GIBS) – Chair

Dr. Robert Y. George was Professor of Biological Oceanography for 30 years (1972-2002) at UNC-Wilmington, North Carolina, USA and he taught a graduate course on deep-sea biology. Dr. George conducted original deep-sea research for 40 years off North Carolina Coast, Puerto Rico Trench, Blake Plateau Coral Ecosystems, Sargasso Sea (Beaufort – Bermuda Transect), Arctic and Antarctic deep-sea. Since 2002, Dr. George has been the President and CEO of the George Institute for Biodiversity and Sustainability, a Non-Profit 501-C-3 organization in North Carolina. Dr. George now serves as NOAA delegate to ICES (International Council for Exploration of Seas) Deep-Sea Working Group, since 2005, and organized with NOAA the 3rd international deep-sea coral symposium at the University of Miami.

2. Dr. David Billett, (NOC, Southampton, Visiting Research Fellow, UK) Vice-Chair/Rapporteur

David Billett is a Visiting Research Fellow at the National Oceanography Centre, Southampton and a deep-sea biologist with over 38 years of experience of mid-ocean ridges, abyssal sediments, seamounts, coral mounds, submarine canyons, continental slopes. Dr Billett has a particular interest in 1) the effects of climate change on deep-sea ecosystems, 2) distinguishing between natural and man-made change, and 3) the environmental management of offshore deep-water fisheries, oil and gas production and mineral mining, working on the expert advice group, the Legal and Technical Commission, for the UN International Seabed Authority.

3. Dr. Billie J. Swalla, Director, Friday Harbor Laboratories, UW

Dr. Swalla is an expert on sessile tunicates with several papers on molecular taxonomy. She is also involved in the operation of 'Ocean Acidification Research Facilty", funded by US National Science Foundation. Dr. Swalla holds summer courses to train graduate students both American and from abroad to offer research skills in the areas of marine biodiversity conservation and ocean acidification impact on shell-bearing invertebrates in the sea.

4. Dr. Anna Metaxas (Dalhousie University, Canada)

Dr. Anna Metaxas is professor at the Department of Oceanography in Dalhousie University, Nova Scotia, Canada. Dr. Metaxas teaches 'Deep Sea Biology' and she also participates in the International Ocean Institute Training Program in Dalhousie University. She is the chair of the INDEEP working group on "Population Connectivity" and is spearheading the capacity-building workshop in Namibia. She is also chair of the INTERRidge working group on "Ecological Connectivity and Resilience. Her research expertise encompasses a wide variety of interests that include octocoral larval ecology, hydrothermal vent system associated with seamounts and deep water gorgonian corals. Dr. Metaxas does field-oriented research on cruises, laboratory research experiments on both larval and adult deepwater corals and prediction models..

5. **Dr. Ronald Thresher (CSIRO, Australia)**

Dr Ron Thresher is a senior scientist at the Australian Commonwealth Scientific and Industrial Research Organization with a focus on deep-sea oceanography/communities, in particular deep-sea corals, studying long-term oceanic records for the Southern Ocean to complement modern instrumental records, threats posed by climate change and ocean acidification on deep-sea reefs. He has examined options for mitigating the impacts of climate change on seamount communities and investigated the potential application of pH and other environmental proxies in the ecology of deep-sea corals, including links to regional oceanographic features at intermediate depths. Ron is also the Chair of the international scientific steering committee for the planned 2016 "Oceans in the High CO2 World", to be held in Australia, which directly dovetails with the proposed WG work plan.

6. Prof. Ann Vanreusel (University of Gent) –Coordinator for Capacity Building
Prof Ann Vanreusel is head of the research group Marine Biology of Ghent University (Belgium) with extensive expertise in structural and functional biodiversity research in shallow-water and deep-sea benthic ecosystems. Prof. Vanreusel has focused her research on the ecology of extreme marine environments including the canyons, cold water corals, polar seas and cold seeps. Recently much of her research has focused on CO_2 seeps to understand impact of long term extreme acidification on biota.

7. Dr. Marco Taviani (Italian Marine Institute)

Dr Marco Taviani is Research Director at the Insititute of Marine Sciences (ISMAR)-CNR, Bologna, Italy, with an interest in bio-sedimentology (biogenic carbonate factories, hydrocarbon-imprinted carbonates, deep water coral ecosystems), Cenozoic-Recent marine extreme environments (polar, cold seeps), carbonate geochemistry, paleoclimatology and paleoceanography (Antarctica, Mediterranean, Red Sea, Western Indian Ocean). He has carried out over 40 oceanographic missions (Mediterranean, Red Sea, Atlantic Ocean and Antarctica) often as chief-scientist, onboard Italian, German, French and US research vessels, including ROV operations, manned submersibles, rotary drilling, scientific SCUBA diving for the study of cold-water corals to assess their biodiversity and unravel their paleoclimatic potential.

8. Dr. V. K. Banakar (National Institute of Oceanography, Goa, India)
Dr. Banakar has three decades of research experience in the field of deep-sea mineral exploration and paleoceanography/palaeoclimate working on marine mineral deposits particularly manganese nodules, seamount crusts and hydrothermal sulfides.

9. Dr. Marcelo Kitahara (University of Sao Paulo, Brazil)
Dr Kitahara is a deep-sea coral molecular biologist at the University of Sao Paulo, Brazil, using molecular approaches in addition to morphology (microarchitecture, and macro and microstructure of the skeleton), fossil data, and bioinformatics to study the evolutionary history of scleractinian corals and related groups, such Corallimorpharia. This research is showing how scleractinians have survived climate change and OA events in the past and shedding light on how corals of ecological and economic importance will cope with increasing modern anthropogenic pressures.

10. Dr. Alex Rogers (Oxford University)

Dr. Rogers is an expert on seamount ecosystems with focus on cold-water coral. He employs molecular tools and traditional taxonomy to study seamount ecosystems in spatial and temporal scales. Dr. Rogers has worked with International Seabed Authrities (ISA), IUCN and UN Division of Laws of the Seas. He has guided Ph.D research pf more than 2 dozen doctoral scholars.

Five key references for each Full Member

1. Dr. Robert Y. George (GIBS) – Chair

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ASSOCIATE MEMBERS

The Associate members play a key roles in two relevant areas (1) Teaching training courses for students from developing nations concerning deep sea biodiversity and resources as well as (2) advising the SCOR-SEAFOAM WG.on areas of their expertise. For example, (A) Dr.Telmo Morato (Azores) will advise on seamount fisheries, (B) Dr.Myriam Subuet (France) will be an asset as Associate Member wit vast experience in deep-sea ecosystem service, (C) Dr. Alison Swaddlng in Fiji will provide guidelines on deep sea mineral explorations, based on her

experience in in Fiji. Papa New Guinea and Tonga. (D) Dr. Ashley Rowden (New Zealand) will help SEAFOAM with his knowledge on biodiversity, habitat heterogeneity and seamount fisheries.(E) Dr. Tom Hourigan (NOAA, USA) has authored a comprehensive report on the status of cold water corals of
the world in 2008 and is now heading the habitat conservation program focusing on deep-sea corals. Dr. Hourigan, in collaboration with Dr. Peter Etnoyer of NOAA, is currently preparing a summary report on status of the deep-sea coral ecosystems in continental margins and seamounts within US EEZ and this report will be published online in 2016 and will become a valuable resource for the proposed SCOR WG – SEAFOAM.(F) Dr. Bob Byrne of University of South Florida is well-known for his research on climate change on carbon chemistry of the ocean and (G) Dr. Bob Carney was director of NSF Biological oceanography program is renowned scholar on deep-sea zonation and biodiversity.

PROPOSED BUDGET

1. 2016 SCOR WG Delegates for participation High Carbon Ocean conference and workshop in Tasmania	$ 12,000
2. 2017 SCOR WG Annual meeting workshop at NC State. University (Cost for travel plus hotel/per diem for 9 members of WG, George as host)	$ 15,000
3. 2018 SCOR WG Final Conference at Oxford, UK (Travel/hotel cost at flat rate of $ 2,000 for five WG members)	$,14,000
4.Travel cost for chair and vice-chair (Final Report Preparation)	$ 4, 000
TOTAL FUNDS REQUESTED FROM SCOR	$ 45,000

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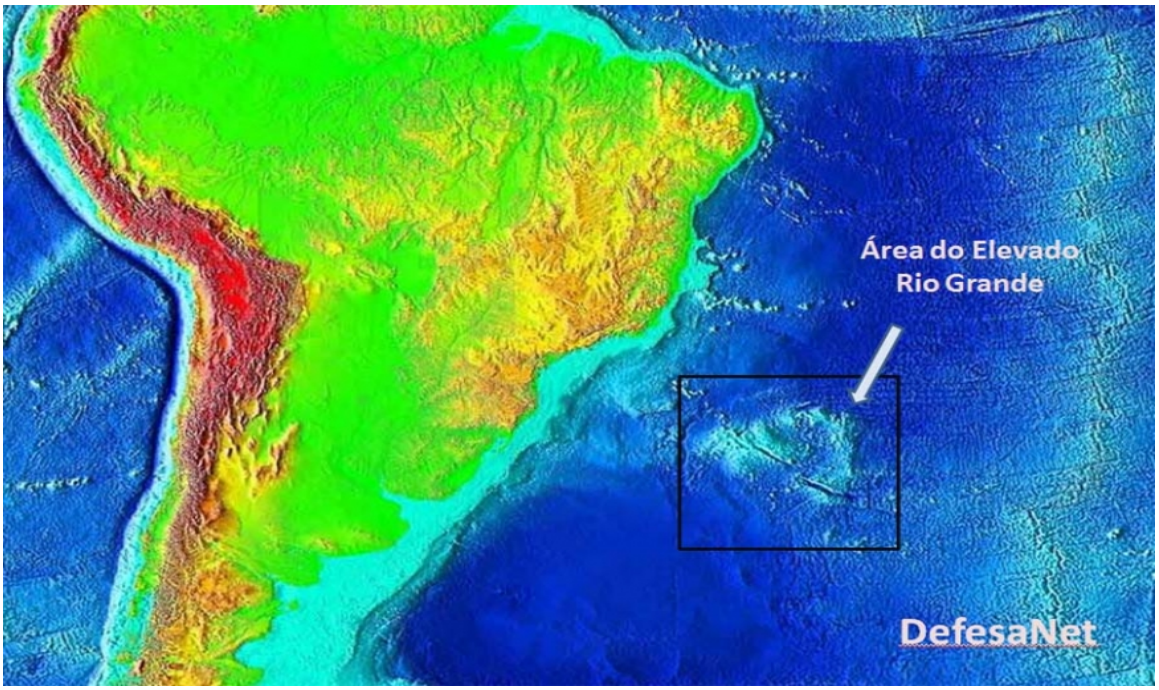
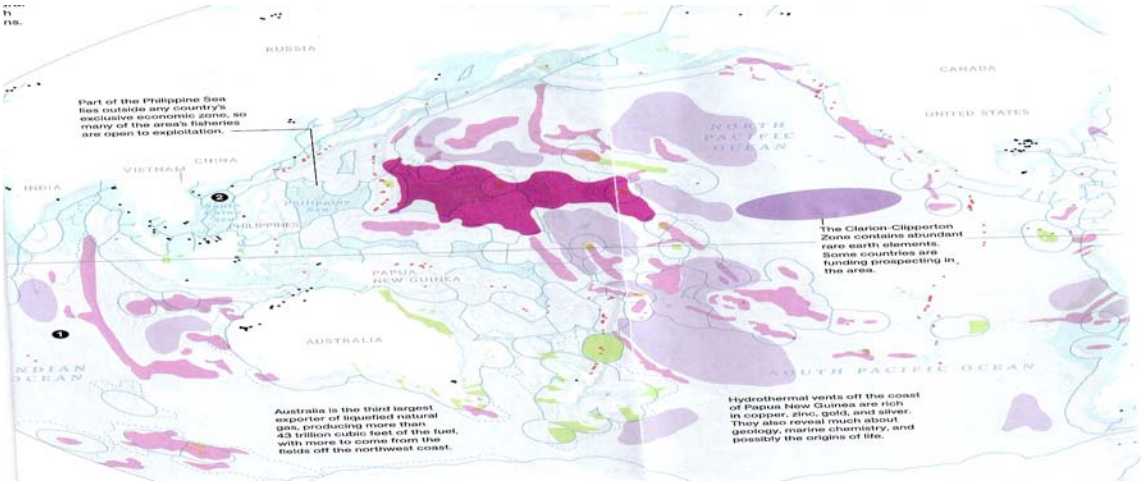
Figure 1. RIO GRANDE RISE: COBALT MINING ZONE



Location of RIOGRANDE RISE

FIGURE 2. MINERAL RESOURCES ON DEEP-SEA FLOOR IN PACIFIC



Mineral deposits in Deep-Sea (Source: National Geographic). Dark Pink-reddish is Cobalt; Violet is Copper and Nickel and Black Dots are Oil and Gas Explorations.