

SCOR Working Group Proposal

(max. 6000 words, excluding Appendix)

1. **Title:** Building a coral reef marine biodiversity observation network

2. **Acronym:** CoralMBON

3. **Summary/Abstract (max. 250 words)**

Coral reefs are among the most biodiverse, socio-economically important and threatened ocean ecosystems, facing a potential global collapse under the combined local and global threats imposed by the worlds' growing population. The working group's aim is to provide the technical foundation for identifying Essential Variables (EVs) that describe the status and trends of coral reefs, and build capacity in the Global Coral Reef Monitoring Network (GCRMN) to provide regionally and globally consistent data and indicators on reefs. This will help to consolidate and advance research on reef processes and futures, and support management and decision-making to conserve reefs from local to global levels.

The working group will identify and refine EVs across the six Essential Biodiversity Variable classes set by GEOBON (starting with live coral cover), and provide guidance for the GCRMN to become a mature observing system and part of the international marine Biodiversity Observation Network (MBON). By integrating this work with ongoing reporting on reefs by GCRMN regions, the working group will build capacity in the monitoring teams and regional networks of developing countries. Outputs will include specification sheets and manuals that define EVs and how to produce them, and papers in open access journals. By working within the institutional framework of the GCRMN and the International Coral Reef Initiative, the working group will leave a lasting legacy. The working group will facilitate improved reporting of coral reef health relevant to Aichi Target 10 on climate vulnerable ecosystems, and thereafter of relevance to the Sustainable Development Goals.

4. **Scientific Background and Rationale (max 1250 words)**

The vulnerability of coral reefs to the current combination of local and global stressors, including climate change, is very high (Spalding and Brown 2015), and the societal need and priority level for conserving reefs is high. Coral reefs occupy less than 0.25 % of the ocean, host > 25% of all known marine fish species, and 32 of the 34 recognised animal Phyla. Coral reefs are found in 109 countries, all tropical and mostly developing, with more than 450 million people living within 60 kilometres of them. A healthy reef can yield up to 15 tonnes of fish and other seafood per km² each year, and benefits lost from degraded reefs are estimated as high as US\$137,000-1,200,000 over a 25-year period. Yet human pressures have driven 27% of the world's coral reefs into severe decline, and if present rates of destruction continue, 60% of the world's coral reefs will be destroyed over the next 30 years. The importance of coral reefs is highlighted in their prominence in the Strategic Plan for Biodiversity of the Convention of Biological Diversity (Aichi Target 10), the recent decision by COP12 on Priority Actions for Coral reefs (<https://www.cbd.int/doc/publications/cbd-aichi-target-10-en.pdf>) and in the UNFCCC's recognition of coral reefs as an indicator ecosystem of the first irreversible impacts of climate change on planetary biota (Gatuso 2014).

A number of initiatives are converging on the need to establish a global and robust observing and reporting system for coral reefs, which will serve to report on success or failure in reversing the decline of coral reefs and help identify necessary actions to achieve societal and national goals with respect to coral reefs. The Global Ocean Observing System (GOOS) Biology and Ecosystems Panel, considering among other things the societal drivers and pressures requiring sustained observation

of biological ocean variables, has identified “live coral cover” in the top two of nine priority Essential Ocean Variables. The Global Coral Reef Monitoring Network (GCRMN), hosted by the International Coral Reef Initiative (ICRI, <http://www.icriforum.org>), has generated global and regional reports on coral reef status and trends since 1998 and is poised to revitalize and upgrade its approach following a regional report completed for the Caribbean (Jackson et al. 2014). Historically done through writing teams aggregating from national to global levels (e.g. Wilkinson 2008), the GCRMN is ready to put in place a more robust regional analytical process (ICRI 2015). Further, while coral cover is recognized as the prime variable for reporting reef status, and is justifiably proposed as one of the first EOVs (see above), on its own it provides a very narrow picture of the status of such a diverse and complex ecosystem (Hughes 2010); the identification of other variables (see Jackson et al. 2014) across the full range of Essential Biodiversity Variable (EBV) classes (Pereira 2013, <http://geobon.org/essential-biodiversity-variables/ebv-classes-2/>) would provide an immeasurably stronger basis for decision-making on coral reefs, from local to global scales.

As in many sciences, focused effort and investment is needed to open up existing communities of practice and bridge gaps across them. The GCRMN has paved the way for standardization, but debates persist about methods and focus (see Jackson et al. 2014), particularly with emerging challenges and threats such as climate change. Further, rapidly emerging technologies that are revolutionizing methods and data collection, need to be considered to maintain long time series of data that provide appropriate pre-impact baselines for assessing change. Practices developed in the climate and open ocean observing communities (through the Global Climate Observing System and GOOS-OOPC), in terrestrial biodiversity fields (in GEOBON) and in other marine systems under the GEOBON MBON umbrella (see UNESCO 2012, GEOBON undated) provide templates to streamline the next stage of development of the GCRMN.

A SCOR WG provides an unparalleled opportunity to bring these communities of practice together, combining the expertise and approaches across different global science communities, and integrating the experience gained by different field-based scientific and monitoring groups. SCOR funds target such scientific innovation and integration with observing systems, where other funding sources focus on primary research or conservation outputs. The emerging focus on Essential Variables (Bojinski 2014, Pereira 2013), which address the scientific output and societal benefit of a monitoring programme, provides a clearer path to integration across different contributors that is relevant for coral reefs. The SCOR WG will contribute to ocean science by a) identifying and developing mature Essential Ocean/Biodiversity Variables (EVs) for coral reefs that comply with the GOOS and GEOBON criteria (UNESCO 2012, GEOBON undated), and b) building capacity at regional and global levels in a coral reef observing network, for EV generation, data use and access, and interoperability. In doing so, the group will set a new foundation for longer term collaboration in the coral reef observing and reporting communities, and provide direction for the next steps in fundamental science supporting this development.

The urgency for this working group’s outputs is high, both from push and pull factors. Currently, coral reefs are experiencing a global coral bleaching event that began in 2015, and is impacting the Caribbean, parts of the Pacific, the Great Barrier Reef and the Indian Ocean. This global event highlights the need for a strengthened observing system that incorporates forecasting to anticipate major threats, and to measure their impact. The broader beneficiary community that will use improved coral reef observations and reporting extends from the national to global reporting frameworks for biodiversity and organs relating to them (including the Convention on Biological Diversity (CBD) and the IPBES), to the biodiversity and natural resource management and conservation communities aligned through the International Union for the Conservation of Nature

(IUCN) (including states, non-government organizations and communities/stakeholders). Already, the GCRMN is the de facto reporting mechanism used by these groups, such as in the Global Biodiversity Outlook 4, and in IUCN Red Listing for coral reef species. Yet its lack of standards and procedures for data quality and processing, and aggregation to higher levels undermine the reliability of the outputs (GBO 4, Tittensor 2014). Providing standards that raise confidence and credibility in these outputs will be a key contribution of the SCOR WG to both science and societal goals.

Work will focus at regional scales, matching the driving forces and large-scale dynamics of coral reef systems, and strengthening existing processes. The UNEP Regional Seas programme was designed around the regional oceanographic processes that control coral reefs, and provides a template on which ICRI and the GCRMN operate. The working group will work with the GCRMN's existing regional reporting processes. Currently, reporting is underway or planned in the Western Indian Ocean (2015-16) Pacific (2016-17), Eastern Tropical Pacific (2016-17) and Southeast Asia, and the goal is to complete reporting in all coral reef regions by 2020 and contribute a global update to assess achievement of the CBD's Aichi Target 10. The regional approach will enhance sustainability of actions after the end of SCOR support, and will also provide a platform for addressing emerging research questions at the regional scale (e.g. on disease, invasive species and cascading effects of climate change and global resource (fish) extraction).

While social science and socio-economic monitoring are necessary to develop effective management and interventions to maintain coral reef health (see GCRMN's SocMon programme – <http://www.socmon.org/>), they are beyond the scope of this first stage of work. They will thus not be covered by the working group, but recommendations for applying the lessons learned from this WG to socio-economic monitoring will be considered at the conclusion of this group.

5. Terms of Reference (max. 250 words)

1. Define and publish guidance on coral cover as an Essential Ocean/Biodiversity Variable (EV) in an EV specification sheet and a community methods paper in an open access journal.
2. Identify concept & pilot EVs for coral reefs and prepare time-bound workplans led by a WG member to develop and describe them as mature EVs.
3. Strengthen the Global Coral Reef Monitoring Network to become a mature ocean observing platform supplying coral reef Essential Variables to the global community, and link this to the international MBON under GEO BON (i.e. develop a crMBON)
4. Establish open data, reporting and dissemination principles and mechanisms that facilitate access to and use of coral reef EVs for decision-support tools (e.g. IUCN Red Lists, UN World Ocean Assessment, IPBES) and reporting on coral reef health (e.g. CBD Aichi Target 10).
5. Establish a portal for coral reef EVs linked to OBIS, facilitating open access to EVs and to the science and monitoring community that provides them.
6. Build capacity in regional observing and reporting networks (the nodes of GCRMN) as the primary mechanism for sustaining coral reef EV generation.
7. Expand GCRMN communications and publications to support regional capacity building and reporting, EV development and communications relevant to decision-makers.

6. Working plan (logical sequence of steps to fulfil terms of reference, with timeline. Max. 1000 words)

Part I, EVs – Draft specifications for live coral cover, and supporting EVs are being developed by GOOS-BioEco in 2016. These will be expanded through scientific consultations in 2016 providing a first set of variables for the WG to classify as concept, pilot or mature (UNESCO 2012, GEOBON undated), and subsequently identify how to move each one up the maturity scale. Each EV will be classified through the following steps:

- A. Institutional relationships: describe the current state, and necessary improvements for an oversight group, expert teams and implementation communities.
- B. Methods and data provision: describe the current state of monitoring using the DPSIR framework of the FOO:
 1. inputs –the requirements for observations, focused on scientific and societal priorities;
 2. processes – the monitoring teams, their methods and the variables that they produce, and processing steps to generate coral reef EVs.
 3. outputs – using EVs to calculate further output variables, accessibility of the EV to user communities from local to global levels, reporting and products that will benefit both science and society, and the needs identified in 1).
- C. Score A and B into the three levels of maturity: concept (ideas are articulated and peer-reviewed), pilot (aspects of the system are tested and made ready), and mature (the system is scaled and reliable, is a sustained part of the global ocean observing system). Each of these have 3 sub-levels defined (UNESCO 2012) – use these to facilitate identification of manageable steps to upgrade each component of the observing system.

The GCRMN use field-based monitoring methods, which can contribute to certain EVs and EBV classes, for example coral cover as measure of ecosystem structure (EBV class 6). The WG will distinguish those EVs that can be supplied by the GCRMN, from those requiring different methods (e.g. genetics). Tools already available in BON in a Box will be used and developed to support analyses.

For the GCRMN-compatible EVs:

- identify/select the mature EVs to update the scope of the GCRMN, and identify targets to upgrade regional GCRMN programmes to full maturity;
- for EVs in a concept or pilot phase, identify steps to improve them to mature status, providing guidance for implementation teams and regional networks to build capacity;
- write a community methods paper in an open access journal consolidating the description of the EVs and their input variables and methods, with a component on improvements and innovations that currently do, or soon may, improve data provision.
- obtain certification for the GCRMN as an operational observing system under GOOS, and as a coral reef BON under the broader Marine BON.

For the non-GCRMN EVs, WG members active in those fields will form sub-groups (co-opting new members if needed) to identify key research and prepare workplans to advance the EVs to mature status, and organized as the coral reef component of MBON (i.e. crMBON). The responsibility to raise additional resources for these sub-groups will be theirs, leveraged by their status on the SCOR WG. Publications by these sub-groups will be specified in their workplans.

Workshop 1 will be held early in year 1, to establish common ground for the WG members, focus on the EVs for which the above work will be undertaken, and confirm planned actions for years 2 and 3. A potential venue may include Fiji, aligned with the First Triennial Oceans and Seas Global Conference (June 2017), in a GCRMN region undergoing its reporting process, or coinciding with an ICRI General Meeting.

Part II, Open data – there is no common or open access data system for key coral reef variables that are critical for management and decision-making. Based on open data principles, data publishing and Creative Commons standards, the WG will identify mechanisms to make coral reef EVs open access and available through an online resource/portal (to be resourced separately). Past and existing systems (Reefbase, Coral Triangle Initiative, COREMO, and a new French database, BD-ROI) will be assessed to inform this process. Synergies would be clear with portals such as the Ocean

Biogeographic Information System (OBIS), and a proposed coral reef portal under the CBD Secretariat to support Decision XII/23 on Priority Actions for Coral Reefs. To further enhance access to the data and its use by decision-makers (e.g. in national government or regional institutions), score cards will be developed for GCRMN teams to report on their data, presenting only the higher-level results/outcomes based on the small set of EVs.

The data system and processing tools, requirements for a portal and completing EV work from Part I will be the focus of Workshop II, to be held in the middle of Year 2. Similar criteria will apply to selecting a venue for workshop II, and/or the 4th World Conference on Marine Biodiversity (WCMB) in Montreal, Canada (May 2018) will provide access to global representation of scientists and students, and to the Secretariat of the CBD.

Part III, Dissemination & Publications – the WG will strengthen the publication series of the GCRMN producing the outputs listed in the deliverables section (#7). Some of these publications will be built up in years 1 and 2 and output progressively, while the full publications/output plan will be completed in year 3 and workshop 3, though publication of some items will take longer. The online data portal (Part II) will assist by maintaining all publications in one place, as well as on www.icriforum.org, and may have capability for data enquiry and output of simplified, user-generated score cards.

Workshop 3 will be held in 2019, in conjunction with a Chapman Conference, or another major international conference. It will project the findings of the WG to the global policy domain, and will be held in an influential country providing high level support for the work in ICRI (and/or the CBD). It will be used to prepare a global report on coral reef status for release in 2020, to coincide with reporting on CBD Aichi Target 10.

7. Deliverables (state clearly what products the WG will generate. Should relate to the terms of reference. Max 250 words). A workshop is not a deliverable. Please note that SCOR prefers that publications be in open-access journals.

Deliverables will be published on the WG's online portal (as well as on the GOOS and relevant GEOBON websites, and CBD coral reef portal where relevant) as well as through additional channels specified for each one.

- a) Essential Variable (EV) specification sheets, focused on the EVs produced by different monitoring systems, and addressing the inputs, monitoring elements and outputs for each. From a global template (Part I), the WG will work with regional nodes to prepare regional EV specification sheets, revealing explicit steps to upgrade each region;
- b) Community methods papers specifying the main EVs, their supporting EVs, and the families of methods currently accepted/used to supply them. Starting in year 1, we will propose a special topic in *Frontiers in Marine Science* under which the full series of peer-reviewed publications of the GCRMN and SCOR WG can be published, planned to continue the series/topic into the future.
- c) A GCRMN/SCOR/GOOS/GEOBON technical series, building on the existing GCRMN reports (global and regional), focused on implementation of methods and upgrading regional GCRMN networks to mature level. These form a grey literature tier below the peer-reviewed publications in b) above.
- d) Communications products targeted at end-users, such as score cards for decision makers, facilitating their access to key information useful in their contexts.
- e) Policies and manuals for EV production adopted under the institutional umbrella of the GCRMN and the International Coral Reef Initiative, and accredited by GOOS and GEOBON.

8. Capacity Building (How will this WG build long-lasting capacity for practicing and understanding this area of marine science globally. Max 1500 words)

Regions are the primary geographic scale at which coral reef policy and implementation mechanisms are most coherent, and are the priority scale for GCRMN implementation and reporting (ICRI 2015). Many coral reef regions lack scientific and analytical capacity; the FOO/GEOBON criteria and standards established in this WG will enable step by step improvements to build more mature regional monitoring systems, and to build scientific and analytical capacity. Capacity building will be targeted under two themes of the WG – one focused on GCRMN monitoring structures to improve their outputs as observing systems (FOO criteria), and the second focused on building broader scientific capacity in the technical areas required for producing non-GCRMN EVs.

The main vehicles for capacity building will be:

- Workshops 2 and 3 (criteria for selection of the locations will include opportunities for inclusion of additional participants, additional activities such as WG members participating in training events, giving lectures, etc., and the location of a Chapman Conference if one is approved);
- Targeted outputs of the working group (EV spec sheets, guidelines for implementation/upgrading of a GCRMN monitoring teams (observing elements) and regional networks;
- Embedding of the WG in regional and global mechanisms that sustain networking and capacity building (GCRMN, GEOBON, GOOS/UNESCO-IOC, CBD at global levels, and regional mechanisms such as the Nairobi Convention's Coral Reef Task Force and Indian Ocean Commission's Reef Network in the Western Indian Ocean).
- Online materials will be developed in Parts II and III, and the potential for a MOOC to be developed can be explored. A coral reef portal mandated by the Convention on Biological Diversity's Decision on Priority Actions for Coral reefs may provide a venue for capacity building materials (<https://www.cbd.int/doc/publications/cbd-aichi-target-10-en.pdf>).

GCRMN EVs – GCRMN implementation teams operate within countries, often under a national network which itself is part of a regional GCRMN node or network. The WG outputs will address standards relevant to all of these levels (i.e. dealing with inputs/objectives, monitoring elements and outputs/publications), and will assist the GCRMN in training team members at all levels of the network. Regional and key national leaders within regional GCRMN teams will be invited to participate in the WG workshops, collaborate with different WG members and/or participate in ICRI General Meetings and other events (e.g. ITMEMS). Taking advantage of their active engagement, workshops 2 and 3 will also be held in regions actively undertaking GCRMN reporting. One of the tasks of the ICRI representative(s) in the WG will be to coordinate this capacity building function and identify further support to sustain it.

Non-GCRMN EVs – the sub-groups leading the development of new coral reef EVs will generally be focused in developed or emerging country research institutions and/or their primary field locations where their active research is focused. Capacity building will target extending this capacity for research to coral reef regions that don't yet have this capacity, and through this, extend the geographic range over which the EV can be supplied. This may occur through promoting collaborations across regional boundaries (e.g. through graduate students and post-docs) to build research capacity. This will broaden and deepen the coral reef biodiversity observation network in coming years, as capacity grows.

Specific outputs from the working group that focus on capacity building will include the following:

- EV specification sheets, as these will provide globally standardized information on complementary and supporting variables to the EOVs, their requirements, observing networks and elements, data and information management, and readiness for global implementation.
- Monitoring manuals, expanding on the methods described in the scientific publications of the WG, building on the existing GCRMN series of manuals. These will also be targeted with other supporting capacity building networks in mind – at global levels (UNESCO-IOC, POGO, ITMEMS), and regional levels (e.g. for the Western Indian Ocean, the ODINAFRICA regional network, the International Indian Ocean Expedition 2, and the Western Indian Ocean Marine Science Association (WIOMSA) are all relevant regional mechanism supporting science capacity building. Similar mechanisms will be identified for other GCRMN regions, with a focus on those undertaking reporting for the GCRMN).
- Online data tools and a portal that holds all the above. The specifications for this will be identified in Part II.

Workshop II and III will be structured around the following options:

- Working group meeting – 2-3 days
- Monitoring methods workshop for national/regional team members, offered by 2-3 of the WG members, for 2-3 days before or after the WG meeting
- Participation in a larger conference (e.g. Chapman Conference) around which the WG meeting is planned, to present findings of the WG to a broader community. This could include at least one presentation on the WG itself, and potentially more presentations by WG members on their own contributions around GCRMN strengthening and/or EV development.
- ICRI General Meeting, or an ITMEMS – participation by some WG members and key national/regional leaders that attend the trainings.

9. Working Group composition (as table).

Full members

1. David Obura (chair)	Male	CORDIO East Africa, Kenya	Reef ecologist, focused on coral biogeography, bleaching and recovery; experience in monitoring and methods development; involvement in science-policy processes
2. Aldo Cróquer	Male	Simón Bolívar University, Venezuela	15 years working on coral reef monitoring programs in Venezuela and across the wider Caribbean. Selection of essential variables for observing and/or reporting trends of coral reef decline & recovery at local and regional scales. Delivering scientific evidence to managers and policy makers in the wider Caribbean.
3. Claire Bissery	Female	IFRECOR, France	Marine ecologist, specialised in data processing and management. Experience in Reef Monitoring data analysis and MPA effectiveness.
4. Jörg Wiedenmann	Male	Coral Reef Laboratory, University of	Full professor, working on nutrient effects on reef corals and the interactions with environmental stress, linking molecular mechanisms to

		Southampton, UK	changes at the ecosystem level.
5. Joshua Madin	Male	Macquarie University, Australia	Leader of the Coral Trait Database; work in quantitative ecology and ecological informatics
6. Maria Dornelas	Female	University of St Andrews, UK	Biodiversity quantification, eco-informatics, big data, coral diversity
7. Mark Eakin	Male	US National Oceanic and Atmospheric Administration, USA	Coral reef ecology, especially environmental remote sensing of coral reefs, the impact of climate change on coral reefs, coral bleaching, ocean acidification, oil spills, coral paleoclimatology, and the behavior of marine organisms
8. Mary Donovan	Female	University of Hawaii, Honolulu HI USA	Analysis of monitoring data, development of databases, participation and knowledge of GCRMN networks, background in resilience, tipping points, indicator development
9. Rohan Arthur	Male	Nature Conservation Foundation, India	Marine Ecologist with an interest in social-ecological systems and system resilience to climate change and other stressors.
10. Vivian Lam	Female	University of Queensland, Marine Spatial Ecology Lab (to end 2016) (Hong Kong)	Previous deputy coordinator of the Global Coral Reef Monitoring Network and IUCN Marine Programme Officer (2010-2013), involving collating data from contributors, workshop organization, and compiling the Caribbean regional report.

Associate members

1. Elizabeth Mcleod	Female	The Nature Conservancy, USA	Impact of climate change on coral reef ecosystems, climate modeling, resilience assessments, coral bleaching, coral reef resilience, ocean acidification, blue carbon, developing tools and guidance for managers to address climate impacts and other stressors on reefs
2. Francis Staub	Male	France and UK	Consultant with 15 years of experience working for ICRI and its networks. Strong network with the coral reef stakeholders (International Development Agencies, governments, NGOs, donors...). Currently providing technical assistance to the French and Madagascar governments, as co-chairs of the ICRI Secretariat.
3. Frank Muller-Karger	Male	University of South Florida, USA	Marine biodiversity and ecology, in situ and remote sensing of coral reefs including geomorphological mapping using medium resolution satellite imagery and coarse resolution multidisciplinary observations (ocean color, temperature,

			winds, etc.) and evaluations of coral reef health.
4. Hugh Sweatman	Male	Australian Institute of Marine Science	A broad interest in coral reef ecology and extensive experience with collecting and interpreting reef monitoring data and communicating to reef managers
5. Jerker Tamelander	Male	UNEP Coral Reef Unit, Thailand	Research focused on reef recovery and resilience, role with UNEP and previously with IUCN supporting and promoting applied research, marine and coastal management and policy development at international as well as national level, for conservation and sustainable use of coral reefs that benefits dependent people and economic sectors.
6. Karen Chong-Seng	Female	Seychelles Islands Foundation (until 30th April 2016)	Ecological structure and processes on disturbed coral reefs, evaluating the coral reef monitoring programme for Aldabra Atoll World Heritage Site.
7. Ruth Gates	Female	University of Hawaii, USA	My research group focuses on defining biological traits driving differences in performance among corals and reefs. Our goal is to contribute new knowledge and discuss how this can translate to solutions that can help preserve, manage and conserve reefs.
8. Serge Planes	Male	CRIOBE, Moorea, French Polynesia	Reef ecologist with expertise on evolution and genetics, and fish monitoring. Director of coral reef monitoring programs and observatory.

10. Working Group contributions (max. 500 words)

Detail for each Full Member (max. 2 sentences per member) why she/he is being proposed as a Full Member of the Working Group, what is her/his unique contribution?

David Obura developed this concept to strengthen GCRMN as a mature ocean observing system that responds to societal needs expressed in local management and convention terms. Will contribute on aspects of coral species, cover and resilience; in the overarching goals and integration of the group across different EBV classes; and institutionalizing outcomes in the GCRMN/ICRI.

Aldo Cróquer 15 years experience on bleaching, disease, trends of decline, recovery and/or stability, across the Caribbean. Has cooperated with the GCRMN to produce annual reports on the status of coral reefs in the South Tropical Americas, and have coordinated local monitoring programs in Venezuela joining efforts with regional and global programs such as CARICOMP and GCRMN

Claire Bissery working with the French coral reef network (IFRECOR) to assure data entry in the national database (BD Récifs), data analysis and definition of indicators to evaluate the coral reef status. As France is ICRI's Secretariat for the 1st two years of the WG, will provide a supporting role to the group, embedding its contribution in ICRI and GCRMN institutional processes, and in regional GCRMN assessments in which France is involved.

Jörg Wiedenmann His research has produced paradigm-changing insights into the nutrient physiology of reef corals and how disturbance of the nutrient environment can increase the vulnerability of coral reefs to stress imposed by global warming. His molecular work has yielded high-content biomarkers to monitor nutrient stress in corals.

Joshua Madin will contribute in developing Essential Biodiversity Variables for coral reefs based on species-level traits, and bring analytical and database expertise to the working group.

Maria Dornelas has led the assembly of the largest assemblage level biodiversity time series database (BioTIME) and has expertise at quantifying and modelling coral biodiversity.

Mark Eakin has been involved with the GCRMN since its start, including as past Chair of its Scientific and Technical Advisory Committee. As Coordinator of NOAA's Coral Reef Watch, He leads the team that monitors ocean temperatures that cause coral bleaching around the world as well as other environmental stresses to coral reefs.

Mary Donovan will bring my experience from GCRMN reporting in the Caribbean, as well as expertise in database design for coral reef monitoring, and analysis of complex data streams. Will also contribute knowledge of coral reef social-ecological systems, including experience developing indicator variables that are relevant to ecosystem and resilience-based management.

Rohan Arthur will contribute a perspective from some of the most vulnerable low-lying atolls in the Indian Ocean, and is keenly interested in understanding how reef resilience can be maintained in even the most heavily populated reef regions. Is interested in exploring how local, governmental and non-governmental management can work together to enhance reef resilience in developing-world scenarios.

Vivian Lam Experience in gathering data for the Caribbean GCRMN and co-editor of the report, and will support the East and Southeast Asia GCRMN regional reporting on returning to Hong Kong after her PhD. My skills are in monitoring data analysis using a multivariate state-space approach to analyse key drivers in long term data.

11. Relationship to other international programs and SCOR Working groups (max. 500 words)

The relationship of the working group to the International Coral Reef Initiative (ICRI) and its monitoring network, the Global Coral Reef Monitoring Programme (GCRMN) has been highlighted in the proposal text. The working group will provide the technical expertise and direction for strengthening the GCRMN and upgrading it to standards developed under the GOOS Biology and Ecosystems Panel (GOOS-BioEco) and GEOBON's Working Group 5 on Oceans, and in particular the Marine Biodiversity Observation Network (MBON). Representatives from each of these institutions are in the working group, and many of the working group meetings will be aligned with ICRI General Meetings in particular, as well as with meeting of GOOS BioEco and GEOBON WG5/MBON. Support for this integration is recorded in meeting minutes from each of these programmes, such as in the ICRI General Meeting minutes from December 2015 (ICRI 2015).

No direct relation to existing SCOR working groups

12. Key References (max. 500 words)

Bojinski, S., M. Verstraete, T. C. Peterson, C. Richter, A. Simmons, and M. Zemp. 2014. The concept of essential climate variables in support of climate research, applications, and policy. *American Meteorological Society* 95, 1431–1443.

Gattuso, J.-P., O. Hoegh-Guldberg, and H.-O. Pörtner, 2014: Cross-chapter box on coral reefs. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the IPCC* [Field, C.B., et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 97-100.

GBO 4 (2014) Global Biodiversity Outlook 4. Secretariat of the Convention on Biological Diversity. www.cbd.int/GBO4 (ISBN- 92-9225-540-1)

GEOBON (undated) National, regional and thematic Biodiversity Observation Networks (BONs): Background and criteria for endorsement

Hughes TP, Graham NAJ, Jackson JBC, Mumby PJ, Steneck RS (2010) Rising to the challenge of sustaining coral reef resilience. *Trends Ecol Evol* 25:633–642

ICRI (2015) Minutes of the 30th ICRI General Meeting, Pattaya, Thailand, 1- 4 December 2015.

Jackson, JBC, Donovan M, Cramer K, Lam V. (2014) Status and Trends of Caribbean Coral Reefs: 1970-2012. GCRMN/ICRI/UNEP/IUCN. Pp. 245.

Pereira HM, Ferrier S, Walters M, Geller GN, Jongman RHG, et al. (2013) Ecology. Essential biodiversity variables. *science* 339: 277–278. doi:10.1126/science.1229931

Spalding MD and Brown BE (2015) Warm-water coral reefs and climate change. *Science* 350, 769-771. DOI: 10.1126/science.aad0349

Tittensor D.P., et al. (2014) A mid-term analysis of progress toward international biodiversity targets. *Science*, 346, 241–244

UNESCO (2012) A Framework for Ocean Observing. By the Task Team for an Integrated Framework for Sustained Ocean Observing, UNESCO 2012, IOC/INF-1284, doi: 10.5270/OceanObs09-FOO

13. Appendix

SECTIONS IN APPENDIX

- A. MEMBER PUBLICATIONS
- B. NOTE AND CONTRIBUTIONS OF ASSOCIATE MEMBERS
- C. LIST OF ACRONYMS

A) MEMBER PUBLICATIONS

Arthur

Alonso D, Pinyol-Gallemí A, Alcoverro T, Arthur R (2015) Fish community reassembly after a coral mass mortality: higher trophic groups are subject to increased rates of extinction. *Ecol Letters* 18:451–461

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B) ASSOCIATE MEMBERS

The roles and key publications for the associate members are also given here, as they a) will contribute equal expertise in the technical work of the group, and/or b) play a key role in participating institutions, serving to anchor the work of the group on those institutions for sustainability

ASSOCIATE ROLES (2 sentences, as for full members)

Francis Staub has been involved in technical support to all ICRI Secretariats since 1999, am a member of the GCRMN Management Group (in ICRI), and provide technical assistance to the secretariat of the UNEP-RSCAP Global Coral Reef Partnership (one of its objectives being to strengthen the GCRMN reporting through the UNEP Regional Seas programme). Thus, he will connect the work of the WG to other projects and supporting institutions, and focus on institutionalizing WG outcomes in GCRMN and ICRI.

Frank Muller-Karger is a member of both GEOBON WG5 and GOOS Bio-Eco working groups, and lead the Marine biodiversity Observation Network under GEO BON (MBON), which includes coral reefs will provide a technical base for the GCRMN strengthening, with ongoing work to identify essential variables for biodiversity observation in the oceans. He have led the CARIACO Oceanographic Time-Series program since 1996 with the goal of observing and understanding ecological and biogeochemistry changes in the Atlantic Ocean and the connection between surface oceanography and the flux of elements to the ocean bottom that preserves climate signals.

Jerker Tamelander will provide technical inputs on indicators, variables and reporting relevant to countries, Regional Seas Conventions and Action Plans and other international reporting processes that can also support management on the ground, based on extensive professional experience, current work at UNEP and with the Regional Seas. And institutional support from UNEP's Coral Reef Unit and Global Coral Reef Partnership to the working group in relation to UN processes, including the SDG indicator framework and the CBD Strategic Plan on Biodiversity (Aichi Targets), as well as on the role of the working group within ICRI, based on experience in GCRMN's Management Group and supporting strategic development of GCRMN.

Karen Chong-Seng has substantial experience working on coral reef monitoring, and assessing their condition – including using quantitative analyses. Moreover, has extensive experience in the Western Indian Ocean, with a focus on the inner granitic Seychelles and the outer, more isolated Aldabra Atoll.

Elizabeth Mcleod has worked building the capacity of reef managers to address climate change for fourteen years. She is the science lead for the Reef Resilience (RR) Network (www.reefresilience.org) which provides the latest guidance to help coral reef managers address climate change impacts and local threats and was instrumental in developing the RR toolkit and trainings which have trained nearly 1,500 reef managers in more than 75 countries. Has led resilience trainings across the Asia-Pacific region and modeled climate impacts on coral reefs across Indonesia and the Pacific.

Ruth Gates will bring her lab's experience in an "omics" approach (metabolomics, gene expression and transcriptomics, epigenetics, genomics), looking at coral response at scales from ecological to cellular, which helps us to better determine the extent to which corals will be able to adapt and acclimatize to climate change, to identification and development of Essential Biodiversity/Ocean Variables for coral reefs. She is the President of the International Society for Reef Studies, am organizing committee of the 13th International

Coral Reef Symposium, and has participated in or is currently leading a variety of International Synthesis efforts to improve connectivity among the coral reef science, agencies and stakeholder groups that will be networked with the work of the WG and GCRMN.

Hugh Sweatman has 20 years' involvement with the AIMS Long-Term Monitoring Program on the Great Barrier Reef, one of largest and longest running of such programs. This has necessarily involved issues of quality control, reassignment of effort to different questions, and program reviews, and he is currently involved in the development of an integrated monitoring program for the GBR.

ASSOCIATE PUBLICATIONS

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C) LIST OF ACRONYMS

- CBD: Convention on Biological Diversity
 EBV: Essential Biodiversity Variable
 ECV: Essential Climate Variable
 EOVS: Essential Ocean Variable
 EV: Essential Ocean/Biodiversity Variable
 FOO: Framework for Ocean Observing
 GCOS: Global Climate Observing System
 GCRMN: Global Coral Reef Monitoring Network
 GEOBON: Group on Earth Observations – Biodiversity Observation Network
 GOOS-OOPC: Global Ocean Observing System – Ocean Observations Panel for Climate
 GOOS: Global Ocean Observing System
 ICRI: International Coral Reef Initiative
 IPBES: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
 ODINAFRICA: Ocean Data and Information Network for Africa
 UNEP: United Nations Environmental Program
 UNESCO-IOC, POGO, ITMEMS), and regional levels (e.g. for the Western Indian Ocean, the ODINAFRIC
 UNFCCC: United Nations Framework Convention on Climate Change
 WIOMSA: Western Indian Ocean Marine Science Association