

1. Name of project

COBS Changing Ocean Biological Systems

2. Activities since previous report to SCOR (e.g., virtual or in-person meetings, email discussions, special sessions). Limit 1000 words

We have successfully transitioned from WG149 to the COBS SCOR infrastructural project. In doing so we developed 5 new task teams, each of which are working on working documents. A further fledgling task team that links our COBS activities in natural sciences with those in human systems (socio-ecology, see <https://imber.info/>) in the IMBER programme is being developed.

Details can be found on the recently updated www site <https://scor149-ocean.com/new-page-1>

**COBS management and structure**

As an infrastructural project, COBS has been built around five cross-linked teams. Each task team is currently developing a 2-3 page position analysis to be circulated and discussed at the virtual annual meeting in late July 2021. The revised position analyses will then go to the Advisory panel (initially made up of ex-members of WG149 members Gattuso, Riebesell and Navarro, see <https://scor149-ocean.com/> for feedback. The teams have the following goals and deliverables:

Team 1. Identifying priorities (Havenhand, Collins)

Goals:

Bottom-up evaluation: formulate key scientific questions on Changing Ocean Biological Systems [scientists within SCOR infrastructural project]

Top-down evaluation: identify available and tractable solutions, and constraints [policy/innovation, discussions with UN Decade of Ocean Science, IMBER,]

Deliverables:

- Recommendations on what science is needed to develop/implement solutions. (popular articles, position analysis)

Initial paper draft has started (Collins, Havenhand, Dupont, Hutchins) with a goal of completion by end of year.

Team 2. Promoting action (McGraw, Dupont)

Goals:

Engage all stakeholders (communication)

Teaching and promotion of best practices

Increase engagement with researchers from developing countries

Deliverables:

Targeted multiple driver experimental design (publication)

In-person and virtual) and training tools:

Identification and recruitment of more national advocates for these educational tools

Team 3. Model evaluation (Gehlen, Vichi)

Goal: Scrutinising model projections & parameterisations – are they fit for purpose in the context of COBS?

Deliverables: (scientific articles, position analysis, workshops within the modelling communities)

Team 4. From observations to biological thresholds (Thomas, Dupont, Boyd)

Goal: To expand suites of observations to provide a biological context

Deliverables: Use GOA-ON (Global Ocean Acidification Ocean Network, <http://www.goa-on.org/>) as a test bed for developing and testing new tools (such as seawater omega sensor); (scientific articles, position analysis)

Team 5. Mechanistic understanding (Hutchins, Passow, Ciotti)

Goal: Improved mechanistic understanding (theory, conceptual framework, scientific strategy)

Deliverables: Moving our mechanistic understanding beyond two drivers, exploring compound extremes as test beds for better conceptual understanding (scientific articles, position analysis)

### **Specific activities**

1. The position papers have now been uploaded to our Google document and members are annotating them prior to discussions at our late July annual (virtual) workshop.
2. Sam Dupont has developed an interactive talk, which he presented at the 2021 New Zealand Ocean Acidification Conference (February 2021) and as a GOA-ON webinar (April 2021). Initial responses indicate a surprisingly high number of misconceptions on the wider understanding of drivers and marine life. Such collation of feedback will continue – as seminar opportunities arise – through 2021.
3. In addition to Sam Dupont's "Laboratory experiments for ocean acidification" in the "OCEAN TEACHER GLOBAL ACADEMY - OCEAN ACIDIFICATION COURSE" (below), Christina McGraw has developed the three "Introduction to Ocean Acidification".
4. Despite Covid restrictions, the WG have led online MEDDLE workshops in Norway (Sept 2020) and Scotland (Jan 2021, May 2021). There was also a live workshop in Wellington (Feb 2020). New member Chris Cornwall and Christina McGraw are attempting to organize a workshop at the 2021 NZMSS Conference (July 2021). In addition, we have been in contact with the Oceans in a High CO<sub>2</sub> World (Peru) organizers and confirmed our intention to offer a COBS MEDDLE workshop in 2022. Sam Dupont is exploring IAEA support options for this. MEDDLE is also being added to UNESCO's Ocean Literacy Portal (<https://oceanliteracy.unesco.org>)
5. To facilitate the incorporation of MEDDLE into teaching, lecture slides and a simplified decision support tool were prepared and made available on the website (Sept 2020).
6. Lectures 4-18 December 2020 – Virtual course on "From design to communication: Marine science in a changing world" at Shanghai University had a lecture focusing on multiple stressors. Also the work of the WG is mentioned in a virtual lecture for the "OCEAN TEACHER GLOBAL ACADEMY - OCEAN ACIDIFICATION COURSE" in the module on "Laboratory experiments for ocean acidification". This should be available online during 2021.

7. A task team led by Paul Renaud has recruited ECRs through IMBeR networks, and had an informal virtual discussion with IMBeR representative Carol Robinson, Mike Drexler (Ocean Conservancy) and Sinead Collins, to plan activities moving forward, with an emphasis on integrating activities that would allow for training or workshops in the future.

8. Documents published since previous report to SCOR (e.g., peer-reviewed journal articles, reports, Web pages) and should be limited to publications that resulted directly from project activities and which acknowledge SCOR support.

One of our team Chris is updating our wg149 www to transition it to a SCOR project.

[SCOR Working Group 149 \(scor149-ocean.com\)](http://scor149-ocean.com)

There have been delays in publishing other planned documents (online and publications) due to less free time for members to contribute to COBS during COVID. These include:

Update the of best practices guide, including better links with the MEDDLE resources (to include two new sections on: How to use the resources; How to use the resources in teaching.

Development of a publication on statistical analysis of multi-driver experiments (lead: Havenhand; Experimental Design & Analysis for Multi-Driver Experiments in the Oceans. Havenhand J\*, Boyd PW, Collins S, Dillingham PW, Hurd CL, Gattuso J-P, McGraw CM, Quinn G, Riebesell U, Cornwall CE, mid 2021)

9. Progress toward achieving project's terms of reference. List each term of reference separately and describe progress on each one. Limit 1000 words

1. Develop open-access teaching and learning resources for educators and researchers based on the Best Practice Guide (<https://eprints.utas.edu.au/29392/>) and MEDDLE (<https://meddle-scor149.org/>). These resources will be used to train scientists in multiple driver research in coordination with existing programs, e.g. MSc programmes, summer schools and conference-affiliated training sessions. An online-only program will be developed to reach researchers who cannot attend in-person training.
2. See activities detailed in Section 2.

3. Advocate coordination and harmonisation of experimental approaches by providing data-based guidance through existing structures such as the GRC (Ocean Global Change Biology workshop), IOC (UN Decade of Ocean Science) on how to maximise overlap between different experimental approaches and analysis to allow tighter intercomparison.

The 2020 GRC on Ocean Global Change Biology (to be curated by co-char Sinead Collins) has been delayed to mid 2022. We have had a special session on COBS accepted for the OSM2022 meeting in Hawaii. Sam Dupont and co-chair Philip Boyd have been jointly leading a writing team (via the IOC in Denmark) to provide a Guide for Policy makers on Multiple Stressors and Marine Life. Boyd has also been responsible for jointly leading a section on multiple drivers and marine biota within the IPCC WG2 chapter 3 on Ocean systems.

4. Progress the science towards a more holistic approach to address how multiple drivers will reshuffle marine ecosystems at a decadal scale. To do this, we will develop a strong conceptual framework around a subset of key questions that will be determined by surveying the ocean global change biology community as broadly as possible. This will allow us to bridge disjoints between models, experiments and observations. This framework will be published as a high-profile publication, and survey results will be made available on our website and publicized at meetings.
5. At both the 2020, and the mid 2021 virtual annual meeting each member provided a summary slide on the topics covered with ToR3. A suite of shorter publications will emerge from these collations and the current development of 5 position papers.
6. Publish a series of short articles in both the scientific media and with scientific journalists to disseminate the challenges and opportunities surrounding multiple drivers and ecosystems. Several short articles will emerge from the COBS slide collations and the current development of 5 position papers.
7. Link to societal questions, such as food security, by expanding multiple driver research to include higher trophic levels. This will be done, in part, by engaging with IOC-endorsed and other initiatives to promote an interdisciplinary process-based approach linking observations, models, and experiments within the UN Decade of Ocean Science for Sustainable Development.
8. A fledgling task team – led by Paul Renaud) that links our COBS activities in natural sciences with those in human systems (socio-ecology, see <https://imber.info/>) in the IMBER programme is being developed.

Goals for the end of 2021:

1. Finish the experimental design paper, which was further developed by COBS members in early 2021. Publish the IOC Guide for Policymakers (Dupont, Boyd)
2. Co-ordination with OA-ICC (Sam Dupont) on new training opportunities, including some on multiple stressors (in collaboration with The Ocean Foundation).
3. Christina McGraw will expand the platform for online workshops (which have currently been led by WG members for their research institution) to increase our outreach to underrepresented countries. She will introduce this idea at the Pacific Islands Ocean Acidification Monitoring Dialogue in mid 2021 to gauge interest in a Pacific workshop.
4. Submission of the 5 position analyses to the interim advisory team for feedback, followed by the development of short articles.

11. Is the project having difficulties expected in achieving terms of reference or meeting original time schedule? If so, why, and what is being done to address the difficulties Limit 200 words

COVID has hindered the progress of the SCOR infrastructural project in several ways, including restricting our 3 day annual meeting ( a key opportunity for discussion and development of new ideas and tools) to a series of 1.5 h Zooms using time zone clusters, over a 2 day window, and by limiting the 'band-width' of our members such that they had much less time for inter-sessional activities due to having to develop online resources for example lectures at their home institutions.

Despite these limitations, we were able to successfully transition from W149 to a SCOR infrastructural project. In doing so we developed 5 new task teams each of which are working on working documents.

12. Any special comments or requests to SCOR. Limit 100 words.

We thank SCOR and NSF for their continued support. Thanks to Patricia for ongoing advice and encouragement during these strange times.