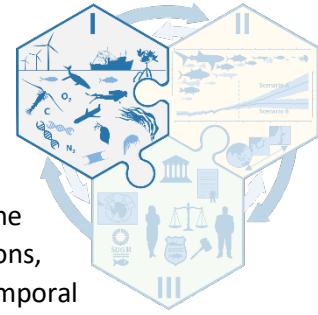# Grand Challenge I

Understanding and quantifying the state and variability of marine ecosystems

The Challenge: To develop a system-level understanding of marine ecosystems including complex biogeochemical cycles and human interactions, their structure and functioning, and the scales of their spatial and temporal variability.

The SCOR review of IMBeR was completed in December 2021 and has endorsed a Grand Challenge I focus on three research priorities with key deliverables to be achieved by the IMBeR community.

Grand Challenge l Priorities – 2022-2025

1. *Evaluate and predict the cumulative effect of multiple stressors*
2. *Integration of climate change and climate variability*
3. *Impacts on society – preparation for a changed future*

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1. *Evaluate and predict the cumulative effect of multiple stressors*

The cumulative effect of multiple stressors such as warming, deoxygenation, ocean acidification, pollution, etc. will be addressed through research within the regional programmes and working groups, and contribute to model development and prediction under GCII, and human responses under GCIII. Coastal areas are the location of most human activities, and hence the most stressors on marine ecosystems and services. Nutrient runoff, sediment transport, habitat loss, and warming in coastal seas all combine to change the balance of ecosystem structure and function. These stressors can result in emergent new system states, such as coastal eutrophication. In collaboration with Future Earth Coasts and the Continental Margins Working Group, this objective will describe the multiple eutrophication pathways evident in coastal seas around the world. This will also involve studying the combination of stressors and cumulative impacts in these coastal ecosystems, and the changes on key environmental variables.

Key deliverables include
1. Eutrophication pathways described for coastal seas around the world
2. The combination of stressors and cumulative impacts investigated in ecosystems (key environmental variables e.g. $SST/O_2/pH$)

2. *Integration of climate change and climate variability*

IMBeR science achievements so far suggest that studies of climate change and climate variability have been largely separate. However, it is now clear that climate change and variability are linked, particularly through the emergence of extreme events (e.g., marine heatwaves). We will pursue research which endeavours to integrate change and variability. Examples include upwelling regions, utilising new connections between observations and modelling at a range of time scales, with case studies in the Indian Ocean which assess the impact of variability and change on ecosystem function and fisheries. In addition to upwellings, ICED, ESSAS and SIBER will continue to focus on impacts of climate variability and change on polar regions and the Indian Ocean. Integrated consideration of

variability and change will better allow the resilience of ecosystems to be described, and the potential for ecosystem service disruption predicted, linking to the objectives for GCII and GCIII.

Key deliverables include

3. Impact on upwelling regions quantified
4. Resilience of ecosystems can be described, and potential for ecosystems service disruption predicted

3. *Impacts on society – preparation for a changed future*

The IMBeR regional programmes have all had a major focus on interactions between ecosystem structure, fisheries and to a lesser extent, humans. By 2024, we will renew the focus on elucidating the linkages between humans and society, and changes in the ocean, and broaden the scope from fisheries to a wide range of human uses, including recreation, energy generation, tourism, and aquaculture. In particular, we will work to develop observation and prediction systems for extreme events (e.g., marine heatwaves, coastal flooding), and use these to improve the preparation and options for maintaining socio-ecological systems (linking with GCIII). The non-stationarity in marine ecosystems due to climate change and human population pressures also mean that past management practices may no longer be suitable, and so approaches such as scenario testing (GCII) and foresighting will be increasingly important to consider alternative pathways and outcomes for the ocean.

Key deliverables include:

5. Extreme events can be predicted, and socio-ecological systems prepared
6. Determine how we can better prepare for, and consider, non-stationarity in ecosystems and management (beyond fisheries)

Progress to these three priorities

The interplay between multiple drivers will be progressed through interaction with COBS, while we have developed a new Innovation Challenge on climate interventions (IC5).
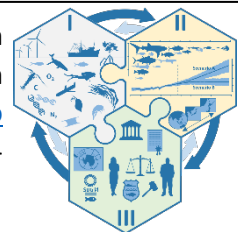
> **Innovation Challenge 5 – Interventions to change the course of climate impacts**
>
> This activity is in the planning stage and seeks to address one focal question: **How can human intervention reduce the impacts of climate change on ocean life and human well-being?**

Challenge connections and delivery

This Grand Challenge is linked to the other IMBeR Grand Challenges, which guide activity in the four IMBeR Regional Programmes and thematic Working Groups. See GC I Fact sheet #1 for other links.

IMBeR is an international network that facilitates interdisciplinary marine research within three interconnected Grand Challenges in order to achieve sustainable ocean governance for the benefit of society. Sign up to IMBeR via http://www.imber.info to benefit from networking, mentoring and collaborative opportunities with world-class natural and social scientists, practitioners and researchers.

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