Understanding and quantifying the state and variability of marine ecosystems

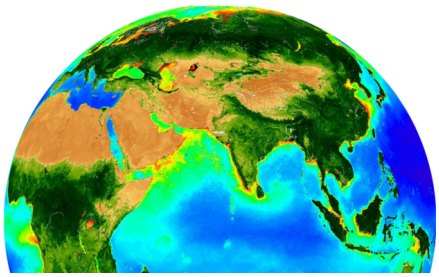
***The Challenge**: To develop a system-level understanding of marine ecosystems, including complex biogeochemical cycles and human interactions, their structure and functioning, and the scales of their spatial and temporal variability.*

A rapidly changing ocean complicates whole-system understanding

The interconnected nature of the global ocean, including interactions with the atmosphere and land, means that changes can have impacts over wide and disparate areas. Humans are part of the ocean ecosystem. They derive benefits from the ocean and contribute to stressors, such as marine pollution and climate change. Humans and other organisms are also impacted by ocean changes. Research in recent years has emphasised that regional differences exist in the combination of ocean stressors, the expression of impacts, and the likely solutions to help mitigate or avoid these impacts. New tools, models, and observing systems provide novel insights. New tools, from satellites to micro-sensors, remotely operated ocean vehicles, electronic animal tags, drifting floats with new sensors, and the "omics" revolution, provide researchers with new views of nutrient cycling, acidification, oxygen concentration, biodiversity change, and effects of temperature on metabolism. All of these vary on different time and space scales. We have discovered changing upwelling patterns, trends in extreme events, and the role of climate drivers on ice dynamics. Changes in the distribution, abundance and physiology of species from microbes to whales are changing food web structure, with consequences for human well-being. The rapid pace of climate change complicates our understanding, and so we must go faster and further into understanding marine ecosystems.

IMBeR case study: Variability in Indian Ocean boundary currents influences trophic connections

The unique, seasonally reversing and regionally contrasting Indian Ocean boundary currents have recently been shown to have remarkable ecological and biogeochemical consequences. These range from adaptive changes in food webs - from plankton communities to the behaviour, reproductive cycles and catches of higher-trophic level species - to extreme hypoxia and mass fish mortality. Activities within the Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER) regional programme advances this area.



Future efforts will require interdisciplinary approaches

Substantial gaps in our understanding of ecosystems still exist. These gaps often centre on the linkages and feedbacks between ecosystems (e.g. surface waters and the deep ocean, coastal and oceanic waters), between focal areas (e.g. physics, biogeochemistry, and ecology), and between humans and ecosystem services. Even within a system, we often struggle to fully characterize carbon flow and other biogeochemical processes. Quantifying the role of environmental variability, biodiversity,

ecology (including animal behaviour and trophic interactions), and humans in these processes is a challenge. Additionally, biodiversity loss and change are being observed in many systems when we have the capability to monitor the diversity of life. Such capabilities are currently limited to few regions and, within these regions, few taxonomic groups.

IMBeR looks to increase work on animals and system-level processes, building on knowledge gained about phytoplankton and other microbes. Technological and methodological capabilities for the detection and attribution of impacts will continue to be a major focus of future IMBeR work, as will disseminating this information to stakeholders. Finally, the role of humans in ecosystems, including the impacts on them and feedbacks from them, will continue to be a high priority research area.

IMBeR amplifies the value chain from ocean observation to prediction by addressing ocean processes important to environmental conservation and societal benefits

Policy and management require measurements of the status and trends of key metrics about the sea to sustain the benefits we get from the marine environment. Many of these benefits are related to how the diversity, distribution, and abundance of life in the sea changes due to events, between seasons, and over longer periods of time. Two synergistic frameworks, the Essential Ocean Variables (EOVs) of the Global Ocean Observing System (GOOS), and the marine Essential Biodiversity Variables (EBVs) of the Group on Earth Observations Biodiversity Observation Network (GEO BON), support reporting against such metrics, including those needed for internationally agreed conventions and treaties. IMBeR provides the understanding of how natural and human processes are linked and develops the forecasting framework, using scientific methods and research based on these essential observations.

The Challenge cannot be addressed in isolation: 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. IMBeR endorses projects funded by different academic, government and private sector groups to increase exposure and enhance relevance to other international groups. The Working Groups link IMBeR with several global research projects, such as Future Earth Coasts, the Global Carbon Project, International Ocean Carbon Coordination Project and the Surface Ocean–Lower Atmosphere Study. Other partners include the International Council for the Exploration of the Sea (ICES) and the North Pacific Marine Science Organization (PICES). IMBeR science activities include contributions to the Global Ocean Observing System, the Marine Biodiversity Observation Network (MBON), the United Nations Sustainable Development Goals, the World Ocean Assessment and the Decade of Ocean Science for Sustainable Development.

IMBeR is an international network that facilitates interdisciplinary marine research guided by three interconnected Grand Challenges 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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