CLIMATE CHANGE IMPACTS ON DEEP-SEA HABITATS, FISH AND FISHERIES

Aug. 26-27, 2017. Woods Hole Oceanographic Institution, Woods Hole MA, USA

A group of scientific experts and RFMO representatives with expertise in the fields of climate change and deep-sea environmental science and modeling, marine benthic ecology, fish biology, fisheries management and biodiversity conservation met at Woods Hole Oceanographic Institution to discuss climate change impacts on deep-sea habitats, fish and fisheries. The meeting was a collaborative effort between the FAO and the Deep Ocean Stewardship Initiative (DOSI) Climate Change Working group. There were 19 participants present from 12 countries from the America, Europe and Asia.

The overarching objective of the project is the analysis of potential impacts of climate change on deep-sea ecosystems and the implications for the management of deep-sea fisheries. Key goals are to:

* Establish spatio-temporal scenarios for major climate change stressors on the deep seabed and its biodiversity
* Examine the impacts on the functioning of deep ocean ecosystems
* Assess how climate impacts might affect deep-sea fish and fisheries.
* Identify regions and fisheries that might be most vulnerable.
* Identify which VME indicator species are most vulnerable (and locations, depths) and anticipate spatial planning to ensure efficient protection
* Determine what essential ocean variables (EOVs) are important to monitor those changes in order to assess the risks to deep-sea species and communities due to climate change.

The workshop began on Day 1 with a brief introduction to the project objectives, deliverables and approaches by L. Levin. This was followed by participant introductions with a description of expertise, and a discussion of FAO needs and goals relevant to the project by T. Thompson. M. Gianni then gave a report on the UN General Assembly Resolutions and international guidelines relevant to deep-sea fisheries, Vulnerable Marine Ecosystems, and climate change. The workshop discussions then moved to the projection of climate change stressors at depths ranging from 200 to 2000m (including warming, ocean acidification, ocean deoxygenation and POC flux). C.L. Wei compiled a series of future climate projections in the form of kmz files, including average, standard deviation, hazard exposure to Thetao, O2, pH, and POC flux, and presented examples including examples of regional and habitat assessments. There was group discussion of projection scale and methods for extrapolating POC flux. W. Cheung presented a framework for assessing vulnerability to climate change based on IPCC SREX and AR5 approaches that combine hazard and exposure to evaluate risk of climate impacts. He presented a fuzzy logic approach to evaluating species –level and community vulnerability, and the group discussed issues and challenges. N. Le Bris presented how climate-change disturbances propagate rapidly to the deep sea via seasonal and short-term oceanographic features on regional-scales and meso-scales, including upwelling and downwelling, deep convection, eddies, and dense shelf-water cascading. The need to consider how such processes, driven by the wind and sea-ice regime, will change the mixed layer depth climatology and influence DOM and POM export fluxes, both in quantity and quality, was discussed.

Turning to benthic habitats, L. Levin with input from A. Colaco and M. Silva gave an overview of VME criteria, indicators and functions, as well as examples of warming, acidification and deoxygenation reaching the deep ocean. Biodiversity tipping points, modes of climate influence, and vulnerabilities of corals and sponges were discussed. L. Watling presented the interaction of fish and benthic habitats, particularly VMEs. Following a group lunch on site, T. Morato presented on species distribution and habitat suitability modeling, the environmental variables that are most closely associated with deep-sea species distributions, and the challenges arising. W. Cheung then focused on the application of fuzzy logic modeling to assess vulnerability via sensitivity and adaptive capacity assessment, and then the combination of vulnerability with exposure to hazard metrics to arrive at risk of impact. The group discussed how best to apply this approach (to whom and where).

The final portion of Day 1 were spent outlining the elements of the report that follows and engaging authors in specific components. There was agreement that the report should focus on what we know now, provide examples of modeling approaches, and provide a platform for future work on the subject. Leads were selected to coordinate writing of each section. At the end of the day we spent some time addressing the question *Are existing RFMO measures appropriate under climate change scenarios?* including issues related to VME guidance, feedback management, marine protected areas, time scales, and non-VME organisms and systems.

The first half of Day 2 was spent in a plenary session of the Deep-Ocean Stewardship Initiative, which reviewed past activities of DOSI including the progress of 11 working group. The DOSI –FAO project was introduced and participants met in an expanded Climate Change working group in the afternoon, engaging WG members and young scientists that attended the DOSI meeting. There was further discussion of the report outline and addition of new expertise not present the previous day, to yield an expanded co-author list. The discussions also led to several other working group projects relevant to this report, including a technical paper on mechanisms underlying climate change in the deep sea, to be led by N. LeBris, expansion of a Zotero-based deep-ocean climate change bibliography, which will be open access. These were reported on in a final DOSI plenary at the end of the day.