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Working group report

WG 5. Integrating food web dynamics from end to end

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Introduction:
The overarching theme of this WG is the development of the ability to predict the future behaviour of marine ecosystems and their emergent properties (e.g. elemental cycling, fisheries production, biodiversity). We accept that humans are a key influence on every ecosystem on earth and that we need to address the impact of the human influence (e.g. pollution, fisheries, fish farming, coastal impacts, transportation, introductions of exotic species) on the current and future state of marine ecosystems and their emergent properties. Furthermore we assume that ecosystem structure encompasses all trophic levels and their diversity (e.g. genetic, species). For a global change program, state estimation is not sufficient. Prediction must be a primary goal.

Overarching themes:

Theme 1 To quantify the oceans' role, as mediated by the biota, in determining elemental flux (C, N, Si, S, O, P, Fe, Mn, Cd, Zn) between global compartments (AIR/OCEAN/LAND).

Q1.1 Identify the key species/functions/ processes.

Q1.2 Assess the utility of fixed ratios as the currency of transfer of biomass and elemental flux e.g. (e.g. Redfield stoichiometry, carbon:chlorophyll ratios) between trophic compartments

Q1.3 Identify the processes controlling the temporal and geographic distribution of different types of food webs and key species?

Q1.4 Quantify the importance of the continental shelf to global and regional biogeochemical cycles

Q1.5 Understand and reconstruct past states of the ocean.

Theme 2. To determine the nature of changes in ecosystem state and develop techniques to monitor/predict them?

Q2.1 How do climate cycles and elemental cycles select for life cycles? (the resulting dominant species then affect the elemental cycles and the climate).

Q2.2 What are the effects of global change on exchange between ocean compartments (e.g. benthic/pelagic coupling, shelf/ocean coupling)?

Q2.3 What is the role of biodiversity for function and adaptability of the systems?

Q2.4 Can we quantify and predict the past, current and future behavior of the biological component of elemental cycles in their "average" state, their time-dependent dynamics and their un-expected sources of biogenic variability?

Q2.5 How do large and small perturbations of an ecosystem by human activities affect food webs, their emergent properties and the time-scale of return to the previous or a new ecosystem state?

Q2.6. How important are fisheries as a top-down control on the food web from end to end and what are the implications for elemental cycling?

Theme 3. What is the role of adaptation for global change and what are the effects on ecosystem dynamics?

Q3.1 How do communities respond to environmental changes?

- What are the "genetic options" for organism adaptation (e.g. microbes) in response to environmental conditions?
- Can groups adapt phenotypically?

- What are the implications of species replacement (e.g. from a cryptic species, introduced species) and system replacement (e.g. microbial loop versus diatom food web). Are there time lags for responses that are related to generation times? **Q3.2** How important are biodiversity and the persistence of rare species for future surprises in an ecosystem?

Q3.3 What controls whether an ecosystem responds to external stresses by changing its geographic distribution or community composition.

Theme 4. How does the nature of empirical and modeling aggregation influence our ability to understand and predict the dynamics of an ecosystem and elemental fluxes?

Q4.1 What is the impact of arbitrary definitions of taxonomic level and functional grouping? (The definition of "functional groups" or "levels of aggregation" depends on the question asked (e.g., carbon sequestration; fisheries production). Food webs are structured by species (key players) – but the primary "actors" are individuals.)

Q4.2 How much complexity in the food-web model is required to provide an adequate representation and to capture all the feedback loops (internal and external) that are relevant to the space and time scales of interest. **Q4.3.** What are the methods required to identify flexible functional groups (regionally variable?) and to test validity of these functional groups. **Approaches / Strategies**

- Natural experiments observations on perturbed systems (monitoring)
- Real experiments (in situ manipulations, mesocosms)
- Better observations of physiological changes with respect to changes in biotic and abiotic conditions
- We are not suggesting that we can model everything from viruses to whales in a single model. We need to explore new modeling options (*e.g.* nested approaches, complex dynamical models, flexible functional groups). Development of molecular methods to look at key processes as well as to identify organisms and functional biodiversity.New and emerging technologies for automated observations systems for monitoring abundance of organisms and key ecosystem functions are to be encouraged. The wide spread use of such systems is essential. Research on life history and physiology of organisms will be needed to address many of the above items. However this work needs to be justified in terms of its potential role in ecosystem function and/or mediating elemental fluxes.Design and implement monitoring programs in regions susceptible to global change. We need to fill the information gaps in our current understanding of ecosystem structure and function as it relates to biogeochemical cycles. This includes the biology and biodiversity of the lower trophic levels, the microbial-zooplankton linkages and the interactions between species (such as symbiosis and other not predator-prey interactions).
- The field of complex dynamical systems is emerging as an exciting new technique. This field has a lot to teach us about the functioning of food webs and ecosystems. The idea that community structure and nutrient fluxes are emergent properties resulting from the interactions of an ever-changing collection of individuals has the potential to change how we think about food webs.

Links to SOLAS