Food web dynamics off Peru

MODELLING THE ECOSYSTEM DYNAMICS OF THE EASTERN TROPICAL SOUTH PACIFIC

***Y. S. Jose, M. Hill-Cruz, T. Xue, I. Frenger and I. Kriest**, GEOMAR Helmholtz Centre for Ocean Research Kiel*

In Short

- Investigate the ecosystem dynamics and its variability in the Eastern Tropical South Pacific
- Investigate the sensitivity of the ecosystem in the Eastern Tropical South Pacific to environmental changes and fishing pressure.

The Eastern Tropical South Pacific (ETSP) encompasses the Humboldt upwelling system (HUS), one of the productive Eastern Boundary Upwelling Systems (EBUS) [1]. Productivity in the HUS is related to large-scale atmospheric pressure systems that favour along-shore winds, subsequent offshore transport of surface waters, and upwelling of deep nutrient-rich waters. With these characteristics, HUS is the EBUS with the highest fish catch per unit area, contributing with 10% to the global fish catches [1]. Thus, changes in the HUS productivity can have significant socio-economic implications both locally and globally.

The productivity of the HUS is subject to substantial variability. Through its connection with the equatorial region and ocean/atmosphere coupling, the HUS undergoes significant variations due to natural fluctuations [2]. For instance, El Niño Southern Oscillation (ENSO) is known to affect production [3] and oxygen levels [4]. Global warming and associated changes of the ocean stratification and surface winds may affect the upwelling nutrient rich deep waters, and thus production [5]. In addition HUS is strongly affected by the intensity and variability of fishing pressure [6].

Thus, model projections of the future development of productivity in the HUS are affected by many variables. Global climate models disagree in their projections for tropical regions such as the HUS [7]. These uncertainties are linked to the under-representation of local and basin scale variability such as mesoscale eddies and ENSO [7], poorly resolved coastal winds, and for projections of future fish productivity, the actual lack of a representation of higher trophic levels.

The goal of our project is to enhance the mechanistic understanding of the HUS biogeochemical and ecosystem sensitivities, and thus in the broadest sense to serve the conservation and sustainable use of marine resources, by using a model that resolves the regional circulation and ecosystem dynamics well. We use a regional physical-biogeochemical and food web model, calibrated and evaluated against biogeochemical observations, to investigate ecosystem dynamics and to test their sensitivity to idealised anthropogenic forcings and natural variability (e.g., fishing pressure, changing-warming/stratification and extreme events). The end-to-end model configuration is built from the regional ocean circulation model CROCO [8], the biogeochemical model BioEBUS [9], and the higher trophic level (fish) model OSMOSE [10].

CROCO is conceived primarily to resolve the fine scale coastal processes and their interactions with large scale dynamics. It uses a generalized terrain-following vertical coordinate system, which allows a good representation of coastal processes. BioEBUS simulates small and large principal plankton communities, nutrients and oxygen, including representations for both oxic and suboxic conditions (see Figure [1]). OSMOSE is a two-dimensional multi-species and individual based model of fish and other higher trophic levels. For computational efficiency individuals are grouped into schools, i.e. age- and size-structured populations that undergo major processes of organism life cycles (growth, reproduction, predation and starvation, and migration).

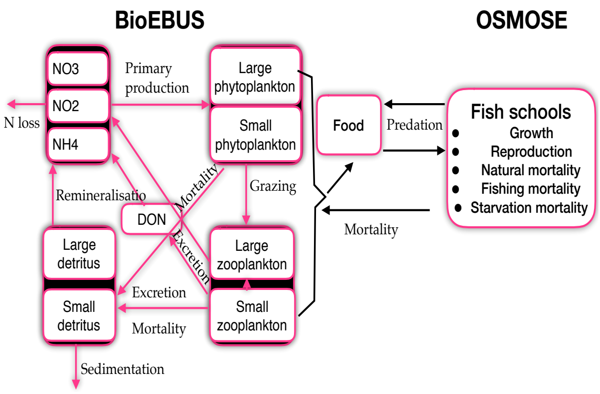

***Figure 1:** Schematic of the 2-way coupled CROCO-BioEBUS-OSMOSE model. Adapted from [9] and http://www.osmose-model.org/modelling-marine-ecosystems*

The CROCO-BioEBUS model is set-up as in José et al. [4], with a domain extending from 10°N to 33°S and 69°W to118°W (Figure [2]), with 1/12° horizontal resolution and 32 vertical levels. The current configuration of OSMOSE for the Humboldt system is based on [11] and simulates 9 higher trophic level groups, namely anchovy, sardine, jack mackerel and chub mackerel (small pelagic fish), hake (demersal predatory fish) and mesopelagic fish, squat lobster, euphausiids and Humboldt squid (pelagic invertebrates).

Coupling OSMOSE to CROCO-BioEBUS will be carried out in an offline (1-way) mode, in which plankton simulated by the latter provides the food for fish in OSMOSE. This mode is useful to test the sensitivities of higher trophic levels to, e.g., changes in stratification (via their impact on plankton production; bottom-up) or to fishing pressure (top-down). In a 2-way (online) coupling, fish predation simulated by OSMOSE modifies plankton mortality in BioEBUS (Figure [1]). This mode is useful to test the effect of higher trophic levels on ocean biogeochemistry (e.g., oxygen deficient zones), or to examine potential nonlinearities of the coupled system.

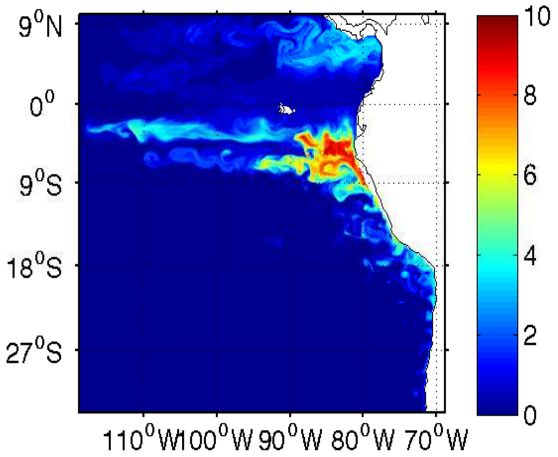

Figure 2: *Visualisation of the spatial extension of the model grid used in this project based on the example of the nitrate distribution in the upper 100 m depth [μmol l^{-1}] from the CROCO-BioEBUS model (averaged from year 1990 to year 2010).*

Within this project we will calibrate the parameters of OSMOSE model, to provide a quantitatively good match to fish observations, carry out 1-way coupled model simulations with OSMOSE to simulate the fish dynamics of the ETSP, and explore the effect of anthropogenic and natural variability on the ecosystem and finally investigate the potential effect of fish on marine biogeochemistry in a 2-way coupling mode.

WWW

http://www.geomar.de/ikriest/

More Information

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