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Editorial

MODELLING THE NORTHERN HUMBOLDT CURRENT ECOSYSTEM
MODELADO DEL NORTE DEL ECOSISTEMA DE LA CORRIENTE DE HUMBOLDT

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The Humboldt Current Ecosystem extends along the west coast of South America, from northern Peru to southern Chile. Traditional management has led to overfishing of main fishery resources, due in part to the complexity of environmental factors and of multiple interactions among species. Ecosystem complexity requires new conceptual and technical approaches. In order to ensure sustainability, the holistic "ecosystem approach to fisheries" (EAF) has been proposed. United Nations (2002) encouraged countries to apply this EAF by 2010. Simulation models are suitable tools to deal with ecosystem complexity; however, they need high performance computational equipments.

Simulation models can be used for 4 main purposes: (i) understand present scenarios, (ii) assess hypothetical scenarios, (iii) forecast future scenarios, and (iv) optimize future scenarios.

At the Instituto del Mar del Perú (IMARPE), the Oceanographical and Fishery Biological Modelling Research Center (CIMOBP), in cooperation with the Institute of Research for Development (IRD, France) and other collaborators, has implemented models to simulate physical, chemical and biological processes of the Northern Humboldt Current Ecosystem (NHCE).

The physical processes have been modeled with the Regional Oceanic Modeling System (ROMS). The oceanic model simulated the climatological and interannual variation of temperature, salinity and currents (Penven et al. 2005). Fig. 1 shows a climatological simulation of sea surface temperature of Peru, emphasizing cold waters from coastal upwelling and warm waters from the north and offshore. This model will be used as boundary conditions for nested models of several bays along the Peruvian coast, in order to assess the ecotoxicological effects of anthropogenic pollutants.

The biogeochemical processes are simulated using the outputs of the physical ROMS model, coupled to the Pelagic Interaction Scheme for Carbon and Ecosystem Studies (PISCES) biogeochemical model, which includes several components such as nutrients, phytoplankton, zooplankton, detritus, etc. (Aumont et al. 2003).

In turn, the outputs of the biogeochemical model can be used to feed a biological Individual Based Model (IBM) such as ICHTHYOP (Previmer 2008, Brochier et al. 2008). These models can simulate the influence of El Niño event on reducing nutrient concentrations, primary production, and consequently, affecting early life stages of pelagic fishes.

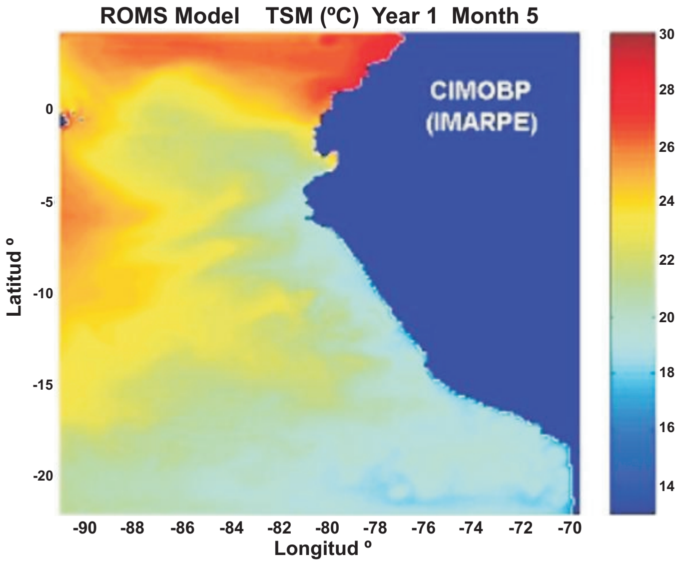

Figure 1. Simulation of sea surface temperature with the ROMS model.

Monospecific synthetic models have been used to estimate a maximum viable yield (MVY) of fishery resources, within the framework of viability theory (De Lara & Doyen 2008, Oliveros & Tam 2008), in cooperation with CERMICS (France). Viability theory does not consider an optimal solution but instead provide all possible evolutions of a dynamical system under given constraint. This theory will be used with analytical models including environmental scenarios under uncertainty, in order to apply a management strategy evaluation approach.

On the other hand, multispecific ecotrophic models were used, in cooperation with the Center for Tropical Marine Ecology (ZMT, Germany), to simulate the reduction of total throughput and ecosystem organization, in terms of energy flows, during an El Niño event (Tam et al. 2008, Taylor et al. 2008).

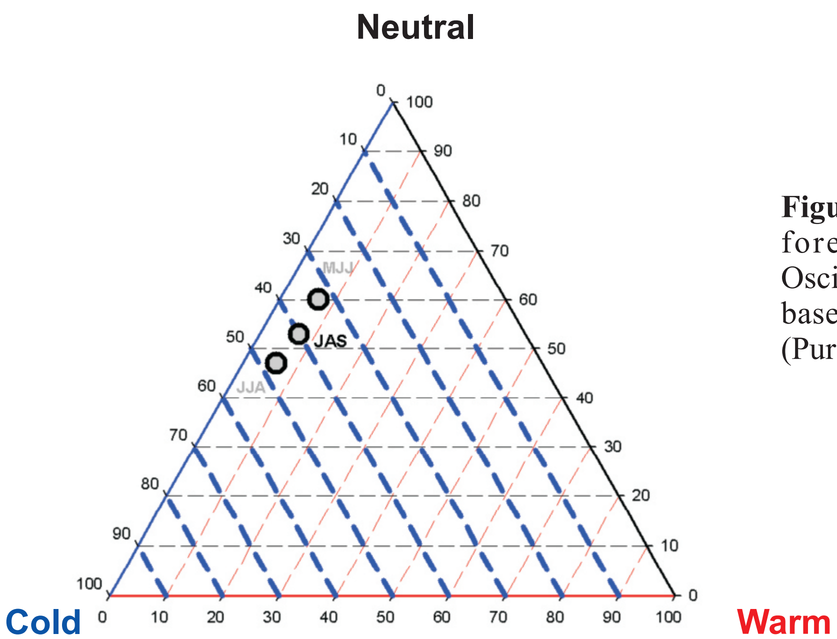

Figure 2. Seasonal probabilistic forecast of the Peruvian Oscillation Index from a model based on contingency table (Purca *et al.* 2007).

Future research would involve the effect of interdecadal climate changes on the dynamics of multispecies interactions.

Short and medium-term forecasts of the effects of El Niño Southern Oscillation (ENSO) on the NHCE are carried out with statistical models: autoregressive models (Quispe & Purca 2007), probabilistic models based on contingency tables (Purca et al. 2007), and an empirical model based on the warm water volume (Matellini et al. 2007). Fig. 2 shows a seasonal probabilistic forecast in a triangular diagram indicating cold-neutral temperatures for 2007 winter. Long-term forecasts will be possible with the development of a Southeastern Pacific model receiving feedback from an Equatorial Pacific model, such as a coupled ocean-atmosphere model of intermediate complexity (Dewitte 2000).

System analysis of the NHCE is performed in order to synthesize the information of several marine stations along the Peruvian coast. A Peruvian Oscillation Index (POI) was defined as the first empirical orthogonal function of sea surface temperatures time series along the Peruvian coast (Purca 2005). Wavelet analyses of the POI and the Pacific Decadal Oscillation (PDO) showed higher variance in the band period of 2-6 years (Purca et al. 2005), suggesting that ENSO overshadows decadal oscillations over the subtropical Pacific.

In summary, several models are being used to simulate the physical, chemical and biological processes of the NHCE, and these models will contribute to society with the application of the ecosystem approach to fisheries, as a warning and prediction system in face of uncertain global climatic changes.

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