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IMBER *Update*

3 - JEAI EMACEP team: Quantitative ecology in the Peruvian upwelling system

Return to TOC

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The Peruvian upwelling system is highly variable in both space and time. It supports the world largest single species fishery and provides employment for both industrial and artisanal fishers. Despite intense research and monitoring by the Peruvian Marine Research Institute (IMARPE) over the past 50 years, there are still gaps in our knowledge about many ecosystem processes. This is due mainly to the limited number of scientists with quantitative ecological knowledge who are able to work on disentangling the complex processes occurring at different scales under climate change and increasing harvesting pressure. It is thus crucial to improve the training of researchers in the use of quantitative ecological tools and to establish teams capable of analysing the abundant information using complex models, in order to provide accurate and timely advice for decision makers.

The Institut de Recherche pour le Développement (IRD, France) provided support to establish a JEAI (Jeunes équipes associées à l'IRD) team, known as EMACEP (Ecología Marina Cuantitativa del Ecosistema de Afloramiento Peruano. This comprises mathematicians, statisticians and economists, as well as biologists and fisheries engineers, and aims to increase quantitative marine ecology skills in the region. The success of this JEAI is due to the multidisciplinarity of the team, and the ongoing collaboration between IMARPE and IRD since 2002. This was strengthened with the launch of the International Joint Laboratory 'Dynamics of the Humboldt Current System' (LMI DISCOH) in 2010, which has produced outstanding results (Gutierrez *et al.* 2011, Bertrand *et al.* 2014).

The research team has 15 permanent members: nine with PhDs (from the IMARPE, the Instituto de Matemática y Ciencias Afines (IMCA), Pontificia Universidad Católica del Perú (PUCP), and Universidad Nacional Agraria La Molina (UNALM)). The team is also fostering three Peruvian PhD students in France, and three Peruvian MSc students based at the Universidad Peruana Cayetano Heredia (UPCH) and the Universidad Nacional Mayor de San Marcos (UNMSM).

The JEAI EMACEP was officially launched at IMARPE on 21 April 2014 (Fig. 22). It focuses on fisheries ecology, oceanography, bioenergetics and ecosystem modelling. Activities are organised around four specific objectives (Fig. 23):

- To use mathematical and statistical tools for the spatial analysis of georeferenced data such as vessel monitoring systems, acoustics, and satellite data (Joo *et al.* 2013, 2014, 2015; Alegre *et al.*, 2015; Grados*et al.* 2016);

- To improve existing bioenergetics, population dynamics and stock assessment models to include environmental variables and uncertainty (Pecquerie *et al.* 2009, Díaz *et al.* 2010, Oliveros *et al.* 2010);

- Application of physical, biogeochemical and biological models at different spatial scales (Tam *et al.* 2008; Brochier *et al.* 2013) to study early and adult stages of the main species (anchovy, scallop, jumbo squid, etc.);

- To develop bio-economic and socio-ecological models to support fisheries management (Ocaña *et al.* 2011, De Lara *et al.* 2012).

Figure 22. Inaugural meeting of the JEAI EMACEP at the Instituto del Mar del Perú (IMARPE). From left to right: Jorge Ramos, Erick Chacón, Enrique Ramos, Abelardo Jordán, Edgar Meza, Vilma Romero, Pepe Espinoza, Eladio Ocaña, Dante Espinoza, Arnaud Bertrand, Avy Bernales, Carmela Nakazaki, Katia Aronés, Patricia Ayón, Rocío Joo, César Fernández, Jorge Tam, Federico Velazco, Cynthia Arellano, Adolfo Chamorro, Josué Díaz, Roberto Quesquén, David Castillo, David Correa, Wilbert Marín, Max Collao.
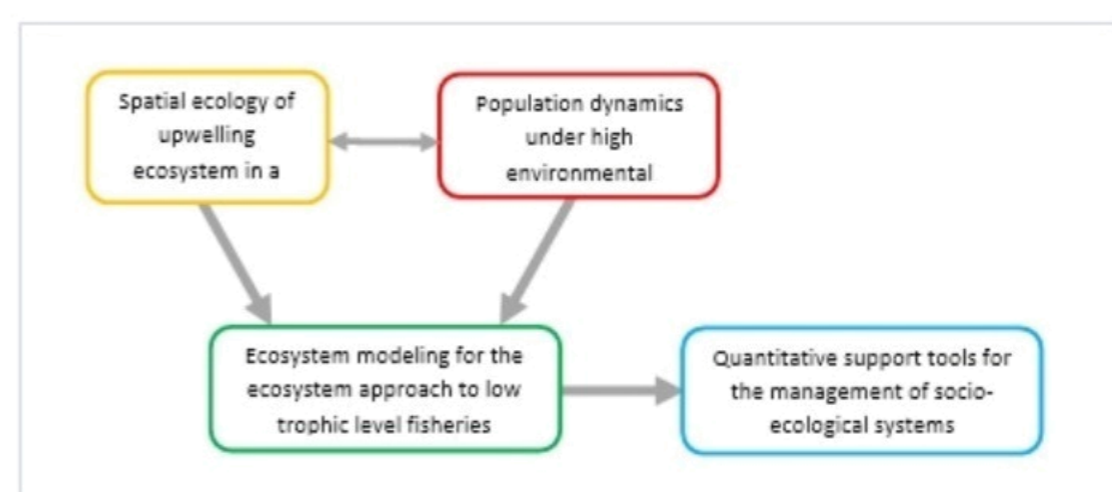

Figure 23. Specific objectives of JEAI EMACEP.

Training of the JEAI EMACEP is undertaken through a variety of courses, *e.g.* Dynamic energy budget (Dr. Laure Pecquerie, IRD), Methods of multivariate analyses (Dr. Sergio Camiz, Sapienza Università di Roma), Basic geostatistics and time series analysis using R (Dr. Rocío Joo and Dr. Daniel Grados, IMARPE). A "Cycle of Conferences on Quantitative Marine Ecology" was convened on 26 February 2016 at IMARPE with 76 participants. Oral presentations covered investigations of statistical analyses of El Niño, scallop larval transport, zooplankton biomass estimations, Silverside morphometric stock identification, epipelagic biodiversity, seabird foraging behaviour, artisanal fishing grounds, classification of anchovy fishery operations, classification of jack mackerel trips and proxies of anchovy biomass.

The JEAI EMACEP is an excellent opportunity for capacity building and to promote multidisciplinary quantitative marine ecological research to address this highly variable and complex upwelling ecosystem. It serves as a natural laboratory to test important hypotheses towards the sustainable development of socio-ecological fisheries communities (Fig. 24). More details about the team are available on the JEAI EMACEP website (in Spanish): http://www.imarpe.pe/imarpe/index.php?id_seccion=I01700403020200100000000.

Figure 24. Activities of JEAI EMACEP (field surveys, lab analyses, trainings and discussions meetings).

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