COUNTRY: PERU

Project Title:
Dynamics of the Peruvian Upwelling Ecosystem

Source of Information:
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National Representative/Contact:
Renato Guevara-Carrasco rguevara@imarpe.gob.pe
Instituto Del Mar Del Peru (IMARPE)
Esq.Gamarra y Gr. Valle
Chucuito
Callao
Peru

Project Description:
The importance of the Peruvian upwelling ecosystem, subjected to strong environmental variability (as El Niño and La Niña events, interdecadal changes, etc.), and large fluctuations of its main populations allows us to propose a large national project. The duration of the project will be several years, consisting of detailed monitoring of the abiotic environment, planktonic and benthic communities, pelagic and demersal populations.

In some upwelling systems, anchovy and sardine populations have been alternating mutually as dominant species in different periods of time. Kawasaki (1983) proposed the synchrony in fluctuations of three sardine populations in the Pacific Basin, and by 1988, during a Workshop in La Paz, Baja California, Mexico, synchronous changes in abundance of pelagic resources were described as manifestations of "regime shifts" which had global manifestations in the fishery (Lluch-Belda, *et al*, 1989).

Similarly, these changes have also been observed in the Peruvian upwelling ecosystem. Until the early 1970´s, the Peruvian industrial fishery was dominated by anchovy (*Engraulis ringens*) which represented, in times of maximum abundance, close to 98% of catches in Peru and more than 15% of the world catches. In the following two decades an alternation took place in the domain. Although sardine catches did not reach the same level as anchovy catches, it took place an increase of sardine stock levels during the mid 1970s and 1980s. Inversely during the 1990´s an increase of anchovy stock levels was observed. This situation was accentuated at the beginning of the 2000 decade, indicating to us that the stock balance of "anchovy-sardine" in the Peruvian sea is currently in the similar to the 1960´s. It is an interesting scientific phenomenon, and one of maximum importance for the Peruvian industrial fishery (Csirke *et al*, 1994). Recently, Ayón, *et al*. (2004) have shown long term fluctuation of zooplankton volumes off Peru from 1960 – 2001, in a quasi similar trend of the anchovy fluctuation.

For understanding the causes and mechanisms of these fluctuations, we consider that not only the pelagic resources but also the ecosystem interactions should be investigated within a national GLOBEC program. This program will allow us to understand those processes with the purpose of a better management of the ecosysytem in the future.

This study is only possible because of the IMARPE´s capacity to monitor the main environmental and biological variables through an intensive sampling program along the year, in parallel to fisheries monitoring. In fact, this is the approach of its annual working plan.

System Types Studied:
The study area is the Peruvian sea between 03º23´ - 18º20´ S and 72 - 84ºW, including the surface and subsurface circulation and the continental margin. This area presents very particular features, partly originated by the complex system of surface and subsurface currents. The whole system responds to coastal upwelling which is forced by the southeasterly trade winds. The usual moderate wind stress coupled with low-latitude location, aperiodic El Niño events, among other processes, may explain the very high productivity of the ecosystem, enabling the existence of great stocks of small

pelagic species. At the same time, local high production of organic matter and large-scale circulation result on the existence of a shallow well-developed oxygen minimum zone whose temporal variability and influence on the living cycles of pelagic and marine resources has not been studied enough. In turn, high organic sedimentation rates, bottom water oxygen deficiency and low terrigenous dilution have enabled the preservation of high-resolution sedimentary records of the past variability of the ecosystem, probably through the last 2000 years.

Target Organisms:
The program will focus on the following biological groups:

- Pelagic fauna (Anchovy *Engraulis ringens*, sardine *Sardinops sagax*, jack mackerel *Trachurus murphyi*, Pacific mackerel *Scomber japonicus*, longnose anchovy *Anchoa nasus* and giant squid *Dosidicus gigas*.
- Demersal fishes: hake (*Merluccius gayi peruanus*) and gurnard (*Prionotus stephanophrys*)
- Large predators: Sea lion (*Otaria flavescens*), fur seal (*Arctocephalus australis*), cormorants (*Phalacrocorax bougainvilli*), gannets (*Sula variegata*) and pelicans (*pelecanus thagus*).
- Zooplankton and phytoplankton communities
- Benthic communities

Physical Processes Examined:
- The main currents off Peru come from subtropical, tropical, equatorial and sub-antartic regions. The Peruvian current is divided into a coastal and oceanic component.
- Coastal upwelling, the essential mechanism of the high biological production which is particularly intense in the 4°-5° S, 7°-8° S, 11°-12° S and 14°-15° S regions.
- Presence of two events of opposite features: “El Niño” and “La Niña” that happen alternately, with different intensity and duration (ENSO).
- Propagation of Kelvin and Rossby waves
- Dynamics of the Peruvian undercurrent and link with the Cromwell undercurrent

Key Questions, Hypotheses and Issues:
- How does coastal upwelling interact with the ENSO equatorial dynamics, e.g. weakening or reinforcing the development of El Niño conditions off the Peruvian coast?
- What is the meso - and macroscale spatial and temporal variability of the circulation off the Peruvian coast?
- How does remote forcing (equatorial or Antarctic) influence the subsurface dynamics, specifically the oxygen minimum zone?
- How do environmental fluctuations modulate inter-annual changes of pelagic biomass (anchovy, sardine, jack mackerel, and Pacific mackerel) and what is the role of the La Niña and El Niño events on them?
- What are the direct and indirect effects of the physical environment on the reproductive success (encompassing fecundity success, spawning success and larval survival) and other biological parameters of the main pelagic species?
- How do large predators (seabirds and marine mammals) respond to their environment and food availability, mainly anchovy?
- Can we quantify the trophodynamics of the Peruvian upwelling ecosystem?
- Can we use remote sensing techniques to direct or/and predict fishing effort?
- What is the role of the Peruvian undercurrent on the dispersion and recruitment success of the benthodemersal populations?
- How do the dynamics of the oxygen minimum zone constrain the living cycles and population dynamics of pelagic and bentho-demersal communities?
- Is there evidence of regime shifts in the Peruvian Upwelling Ecosystem in the past and how can they be characterized using an ecosystem approach?

Participating Institutions:
Instituto del Mar del Perú (IMARPE)

Number of Scientists:
36

Duration:
This will be an ongoing project.

Funding Agency:
Peruvian Government
International Cooperation

Budget:
US $5,000,000 per year