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Upwelling Systems

Upwelling ecosystems are characterised by an upward movement to the surface of deeper cold and nutrient-rich waters. Thus upwelling ecosystems located at the eastern boundaries of the Pacific and Atlantic oceans are among the most productive regions of the world. They account for more than 20% of the total worldwide catches of marine species, while representing only 3% of the ocean surface.

The four major upwelling ecosystems are located in the eastern boundary current systems of the oceans and include the Canary (including the Iberian Peninsula and NW Africa), the Benguela (SW Africa), the Humboldt (SW America), and the California (NW America).

Upwelling ecosystems are particularly relevant for the study of the impact of climate and anthropogenic forcing on pelagic ecosystems, because they support important fishing activities and display important inter-annual and inter-decadal fluctuations of the biomass corresponding to small pelagic fishes (sardines, anchovies). Moreover their different geographical locations and ecosystem structure makes it possible and promising to use a comparative approach – a major tool in disciplines such as fisheries science in which experiments are hard to perform.

EUR-OCEANS will focus mainly on three upwelling ecosystems (Canary, Benguela and Humboldt). However, the California ecosystem will be dealt with through co-operation with US scientists, and comparative studies.

Recent developments in modelling and computer sciences make it possible to couple physical and biological process models, which will lead to a better understanding of how ecosystems function and respond to climate and anthropogenic forcing. This should lead to the development of new (ecosystem-oriented) tools for a better management of marine resources.

In the Upwelling Systems we will couple physical, biogeochemical and ecological generic models to study the functioning of upwelling ecosystems. The modelling approach will include the use of:

- Productivity models, such as 3D NPDZ (Nutrient-Phytoplankton-Detritus-Zooplankton models);
- Early life history models, such as IBM (individual-based models);
- Ecosystem trophic models or dynamic and size-structured models, such as ECOPATH, ECOSYM and OSMOSE

The NPDZ will be coupled with the hydrodynamical ROMS model (Regional Ocean Modeling System) to produce distributions of temperature, salinity, currents and food.

IBM and ecosystem models will make use of the output of NPZD models under present, past and – as far as possible – predicted forcing to study the functioning of pelagic ecosystems (e.g., types of production control – bottom-up, top-down, wasp-waist; fish distributions).

In situ and/or *in vitro* experiments will be conducted to validate models outputs, fulfil missing information and verify new hypotheses arriving from modelling studies. Some examples of these experiments are:

- Release of Lagrangian markers in spawning areas to validate the 3D hydrodynamical model simulations.
- Mesocosms experiments on phyto- and zooplankton growth and survival rates according to environmental conditions in order to improve the parameterisation of NPDZ models

This System involves about 26 Principal Investigators (PIs) belonging to 17 Member Organisations from 13 European and non-European countries, such as Chile, Morocco, Peru and South Africa, which will contribute with local expertise and unique databases.

Memoranda of Understanding were already signed with USA in the context of GLOBEC regional programme on Small Pelagics and Climate Change (SPACC) and with Namibia in the frame of the Benguela Environment Fisheries Interaction and Training Programme (BENEFIT). A general Agreement with the Scripps Institution of Oceanography (USA) was also celebrated.

Finally, from a total of 19 PhD fellowships already selected in the frame of EUR-OCEANS, 3 of them will focus specifically on upwelling ecosystems.