

## **Theme Session F**

**(ICES/EUROCEANS co-sponsored session):**

### **How does fishing alter marine populations' and ecosystems' sensitivity to climate?**

**Conveners: Benjamin Planque and Miguel Bernal**

Spatio-temporal fluctuations in marine populations are modulated by a number of drivers, which can be generally classified into climate drivers, human effects and internal dynamics. The relative influence of the different classes of drivers varies across populations, due to factors such as geographical distribution, population structure and fishery characteristics. However, there is increasing evidence that the different effects may not be independent/additive, but rather interrelated/multiplicative, and therefore cannot be fully disentangled.

The objective of Theme Session F was to analyse the interactions between the different groups of drivers, in particular the interactions between human effects, climate and internal drivers. A range of approaches, from empirical analysis to modeling and simulation was expected, and one of the main scopes was to evaluate if new evidence (empirical or theoretically based) could be provided to support or falsify the hypothesis that exploited marine systems are more sensitive to climate than less exploited ones.

An overview of the climate-fishing-internal controls and the dilemma between additive and multiplicative approaches was presented in an introductory talk by the session conveners (Figure 1; two panels with the three classes of drivers in an additive or interactive fashion). The rest of the presentations (a total of eight) in general addressed interactions between two or three of the groups presented in Figure 1. Empirical evidence of interactions between human effect, internal dynamics and climate drivers was presented at least in two of the presentations (Hidalgo et al., 2009; Nye and Link, 2009) using either an extended version of stock-recruitment model that includes environmental drivers for a number of North Atlantic fish species (Nye and Link, 2009; Figure 2) or spectral analysis techniques on environmental and fisheries time series data in Mediterranean hake (Hidalgo et al., 2009; Figure 3).

Also, theoretical support and a set of hypotheses that relate fluctuations due to interactions between internal dynamics and human effects alone, without climate modulation, were presented (Daan et al., 2009). Under the scenario presented in that work, changes in internal dynamics induced by human exploitation play an important role in stock fluctuation, and can lead to misleading signals in stock assessment and in analysis trying to link stock fluctuation with climate variability, without having into account interactions with human and internal dynamics.

Some empirical evidence on the effect of human and climate drivers at community level were also presented, for case studies on the Bay of Biscay (Guénette et al., 2009), and the Barent sea (Aschan et al., 2009). Reduction of

upper trophic levels biomass in relation to lower trophic levels biomass (Guénette et al., 2009), as well as a reduction in the demersal *vs* pelagic species ratio (Aschan et al., 2009) was observed in those communities as a result of both human and climate drivers, although synergies between the drivers were not directly investigated. Alterations in the composition of the benthic fish community in the North Sea under current human pressure scenarios and a changing climate scenario were also predicted, driven by food competition and changes in food availability, based in a mixture of some empirical evidence and a set of theoretical assumptions (Van der Zoon et al., 2009).

Two more presentations addressing the combined environmental, fisheries and biological data available to pursue climate, human and internal drivers effects studies (Pinto et al., 2009) and the effects in human societies of climate-human driven population fluctuations completed the session (Charles, 2009).

## **Discussion**

A number of issues were raised in the brief discussions between presentations and at the end of the session. One of the first things raised was that the topic of the Theme Session generated a relatively high interest, judged by the high attendance, but the amount of presentations received was relatively low. Together with the fact that only very recent literature is available on the topic with a small body of empirical evidence and a lack of general hypothesis in this field, suggested that the proposed theme is at an early stage of development, especially in the ICES community. Controversy on the degree of interactions among drivers and their relative influence emerge from some of the presentations and from recent literature. Theoretical and empirical support for interactions between human and climate drivers on population dynamics are available in the literature and were presented in this session (e.g. Hidalgo et al., 2009), but opposite conclusions also exist in the mainstream literature (e.g. Anderson et al., 2009). Theoretical support for strong interaction between internal dynamics (density dependence and growth rates) and human effects, without the need for environmental control, were also presented in the session for some specific cases in which the population is on the verge of collapse (Daan et al., 2009). These apparent contradictions may indicate that conclusions on the relative influence of each group of drivers, as well as the relative influence of the interaction between them may be high case-specific.

Different difficulties on the progression of research in this area were foreseen during the discussion. First, the requirements for long data series of both biological and environmental parameters are quite high to obtain the necessary contrast in the analysis. Existing time series, data recovery and accessible databases are therefore crucial for the development of scientific approaches to analyse climate, human and internal dynamics effects on marine systems. Climate and ocean simulation were also cited as a general requirement to advance in the field. However, those tools were not much used in the presentations included in the session, and were expected to be covered by some of the other Climate oriented Theme Sessions of this Annual Science Conference. One specific problem that was discussed in this session is the scale problem; how to mix fishery data with environmental and climate data and ultimately with impacts on the society. No clear solution was proposed, although downscaling, and upscaling within model simulations was expected to provide some solutions.

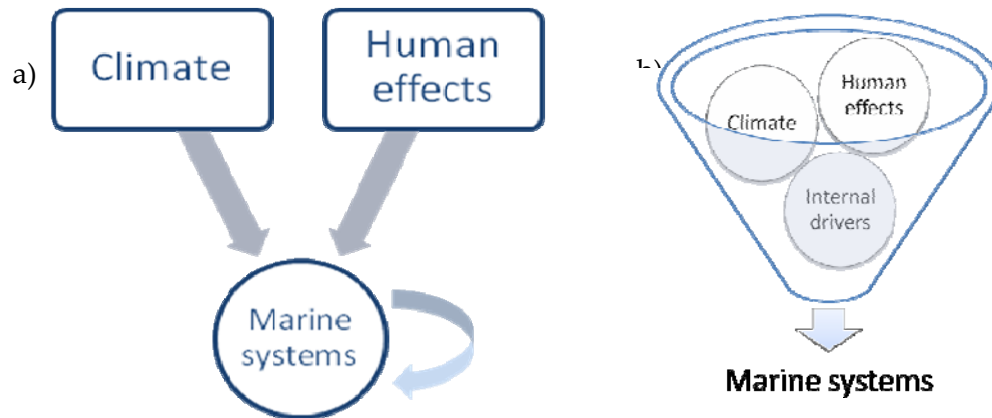
The joint study of climate-fishing-internal controls on marine populations, communities and ecosystems was therefore described in this session as a complex area, which requires the integration of various sources of data, at different scales, and a broad spectrum of science branches. We expect that some time will be required before adequate models are available that provide reliable tools for investigating the consequences of possible management options for particular marine systems. Parallel robust management strategies that recognize the high uncertainty in predictability and the low controllability of marine systems under variable climate and human exploitation scenarios must therefore be developed while this area of science develops.

(For a list of presentations, please check the conference site:

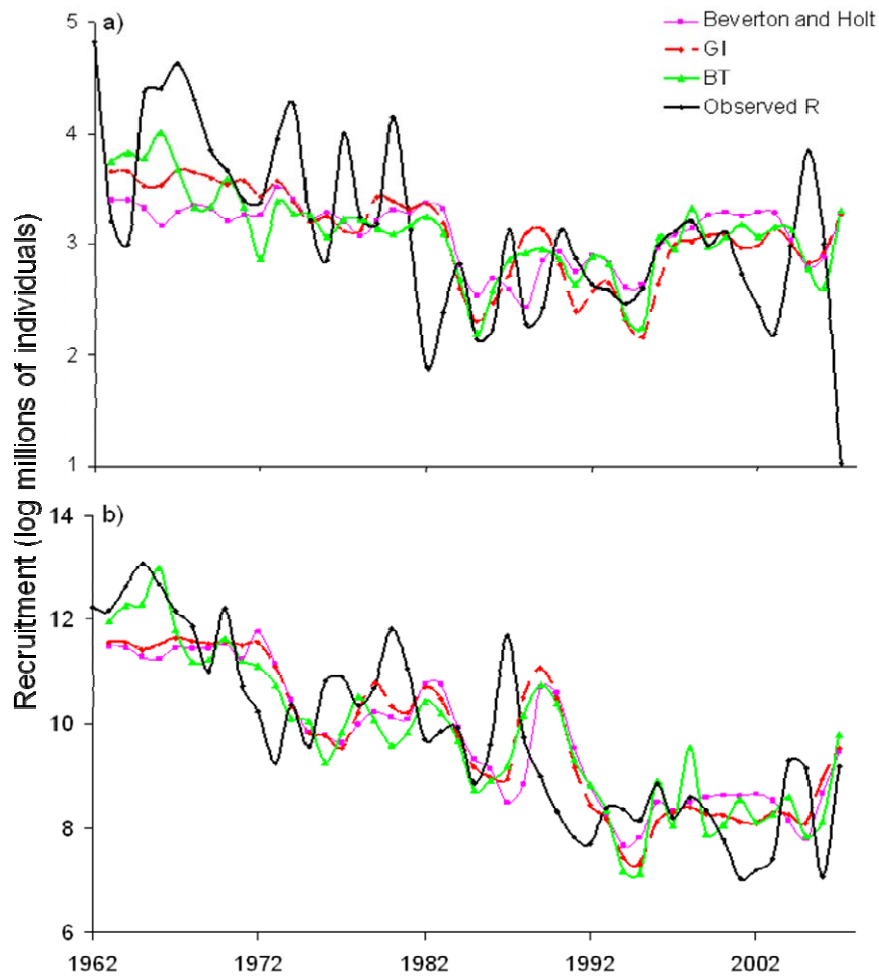
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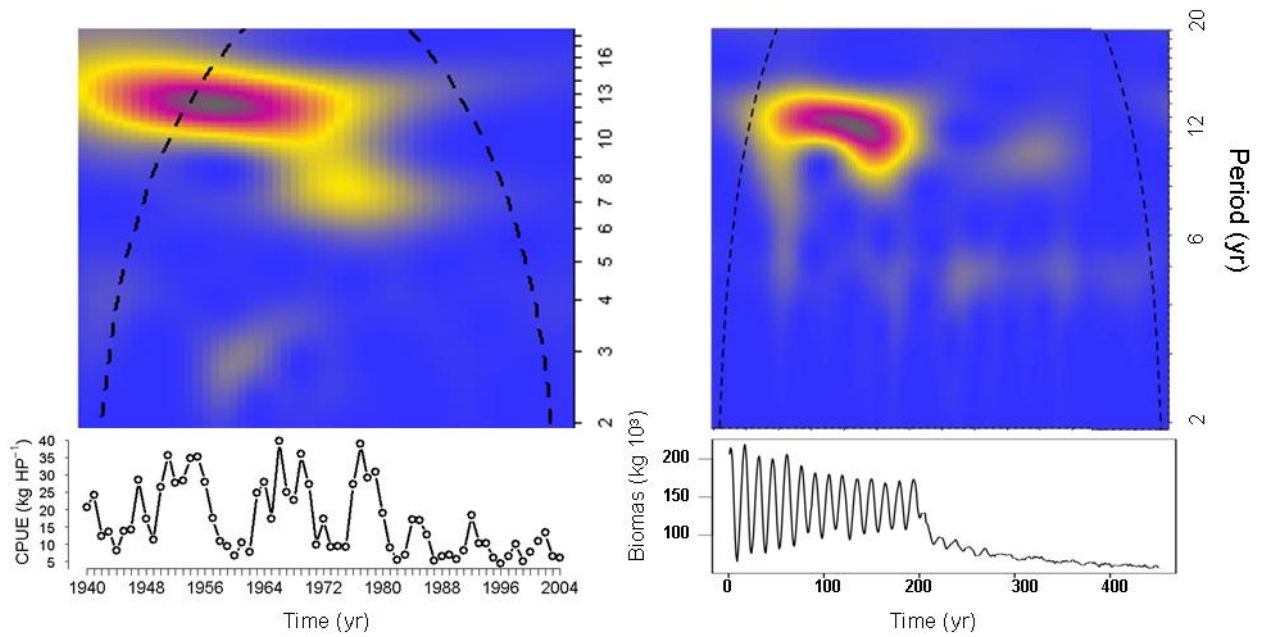
C. N. K. Anderson, Hsieh, S. A. Sandin, R. Hewitt, A. Hollowed, J. Beddington, R. M. May, and G. Sugihara. 2008. Why fishing magnifies fluctuations in abundance. *Nature*, 452:835–839.



**Figure 1:** Schematic classification of drivers affecting marine systems fluctuations (climate, human effect and internal drivers). Left panel (a) summarises the analysis made in most works (additive/independent effects of the different classes of drivers). Right panel (b) indicates a framework in which the different classes of drivers interact with each others, producing non-linear multiplicative effects.



**Figure 2:** Comparison of observed and predicted recruitment of two stocks of North East Atlantic yellowtail flounder ( a - George Bank stock; b – Southern part of the stock) from Beverton and Holt stock-recruitment relationships in which only SSB was incorporated (pink) and where the Gulf Stream Index (GI - red) and bottom temperature (BT - green) were incorporated as additional explanatory variables. The incorporation of environmental indexes on the stock-recruitment analysis provided an increase in explanatory power (from Nye et al., 2009).



**Figure 3:** Change in the frequency of hake observed CPUE (left panel) and simulated biomass fluctuations (right panel). Bottom panels show the time series while upper panels show the spectral analyses. Fluctuations periodicity of the observed CPUE was different before and after a regional change in climatic conditions in the Mediterranean Sea in the early eighties (left panel). The time series spectrum of the hake population simulated biomass (upper right panel) was recreated by an age-structured stochastic simulation model which includes environmental forcing and age-selectivity removal (natural and fishery induced). A combined synergic effect of climate and human exploitation on fluctuation frequency was concluded from this analysis (Hidalgo et al., 2009)