Climate Change Effects for Fisheries Resources: Can We Observe It, Anticipate and Adapt? Discussion from a Case Study in French Guyana

Efectos del Cambio Climático en los Recursos Pesqueros: ¿Podemos Observarlo, Anticiparse y Adaptarse? Discusión de un Caso de Studio en la Guyana Francesa

Effets du Changement Climatique sur les Ressources Halieutiques : Peut-on l'Observer, l'Anticiper et s'Adapter ? Discussion à Partir d'un cas d'Étude en Guyane Française

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ABSTRACT

Marine fish species are subject both to the effects of fishing and climate change that interact. Hence, long-term changes are observed in fish communities but disentangling climate and fishing effects remains challenging. However, there are very few studies of climate nor fishing effects on tropical fish community structure. Within this context, we compared the demersal fish community structure of the shrimp trawling grounds in 1993 - 1994 and in 2006 - 2007 from surveys at sea data sets get in F. Guiana, regarding the temporal variations of the sea surface temperatures and fishing effort changes. We identified an increase in the sea surface temperatures, a decrease of the fishing pressure on the continental shelf and a decrease of the total biomass of the sub-tropical species as compared to tropical ones. Challenge in F. Guiana is food security, facing the growth of the demand of the seafood products due to population growth. We advocate for adding a component to the bio-economic model of the small scale fisheries of F. Guiana previously built up that will relate the growth of population in terms of each species in the model to its biogeographic origin. Hence, we will be able to test scenarios of adaptation.

KEY WORDS: Climate change, tropical fisheries, ecosystem effects of fishing, adaptation, food security

INTRODUCTION

Marine fish species are subject both to the effects of fishing and climate change that interact. Hence, long-term changes are observed in fish communities, but disentangling climate and fishing effects remains challenging. Climate change modify the relative biomass of the species within marine communities (Poulard and Blanchard 2005) and their spatial distribution (Cheung et al. 2009). Moreover, in a first step small species react more rapidly to climate change as compared to large ones (Perry et al. 2005). Ecosystems effects of fishing activities are well documented, unfavouring large long-lived predator species while small short-lived prey species were relatively favoured (Pauly et al. 1998). However, there are very few studies of climate nor fishing effects on tropical fish community structure. Within this context, we investigated the temporal variations of the sea surface temperatures (Reynolds, unpublished data) and fishing effort as forcing factors in the French Guyana shelf and temporal variations of the demersal fish community structure of the shrimp trawling grounds, using data sets from surveys carried out at sea in 1993, 1994, 2006, and 2007.

The challenge in F. Guiana is food security, facing the growth of the demand of the seafood products due to population growth: population will multiply by 2 in 2030. How to satisfy the demand when some species will be (are) unfavoured by climate change; increased fishing effort avoiding over-exploitation, and insure fisher incomes? In perspective, we advocate adding a component to the bio-economic model of the small-scale fisheries of F. Guiana previously built up (Cissé et al. 2013). This component will relate to growth of the population in terms of each species in the model to its biogeographic origin. Hence, we will be able to test scenarios of adaptation.

MATERIAL AND METHODS

Sea surface temperatures were extracted from the NOAA remote sensing data set, and the fishing effort from the Ifremer SIH data set.

First field data surveys were carried out at sea in 1993 and 1994 in May and October, respectively, during the dry and rainy seasons. In October 2006, May and November 2007, the same sampling protocol was applied to carry out new surveys at sea. Samples were collected by ships bottom-trawl. A total of 403 samples were completed.

In order to avoid the influence of rare and occasional fish species, a sub-set of 106 species (corresponding to more than 5% in occurrence) was used for the statistical analyses. Mean biomass (kg/min) per species were then normalised to maximum species-specific biomass. The normalization allows the same weight to be assigned to each species in the following multivariate analysis. These data were used as input in a Correspondence analysis (CA) to check the temporal trends in the fish biomass. The variables (columns) were the years and the individual (rows) were the species. Minimum, maximum, and average temperature encountered by each species within its distribution area was used as a proxy for thermal affinity and were provided by Fishbase (Froese and Pauly 2008) after transformation into a three class nominal variable. This variable was used as additional variables displayed in the data space of analysis but are not included in the CA process of calculation.

RESULTS

A significant increase of the sea surface temperatures is actually observed at about 0.7°C. Temperatures in 2006 - 2007 were higher than in 1993 - 1994 (Figure 1). On the contrary, fishing effort within the concerned area decreased (Figure 2).

The two first axes of CA explain 73,73 % of the total variance. The second axis divides the demersal assemblage into two groups: dominant species in the 1990s on the positive side of this axis and, dominant species in 2006 - 2007 on the negative side (Figure 3). Associated to the years 1993 - 1994, the lower thermal affinity T1, corresponding to sub-tropical species and associated to 2006 - 2007, T2 and T3 corresponding to sub-tropical and tropical species.

DISCUSSION

Some sub-tropical species became less dominant in the recent years, probably unfavoured by the sea warming. This questions the ability of the local fisheries to face the long term growth demand for the sea food product. Actually, how to increase the landings if the biomass of some species (subtropical ones) decreases in F. Guiana? Is the production of the other species able to support increased harvesting?

A bio-economic model of the coastal scmall-scale fisheries of F. Guiana were built to find long term scenarios of fishing effort combination of the fleets (Cissé et al. 2013). The model is multi-species with trophic interactions and multi-fleets. It was possible to find scenarios allowing to satisfy the demand during the next thirty years, without compromising the biodiversity of the system and insuring enough incomes for the fishermen. However, this model does not take into account the impact of climate change on the resources. In order to find sustainable scenarios in the context of warming, a component will be added to the growth population term of the model for each species, according to its biogeographic origin. Hence, the model will be run to find possible combinations of effort from the various fleets that would satisfy the constraints of food security, of necessary incomes, and biodiversity.

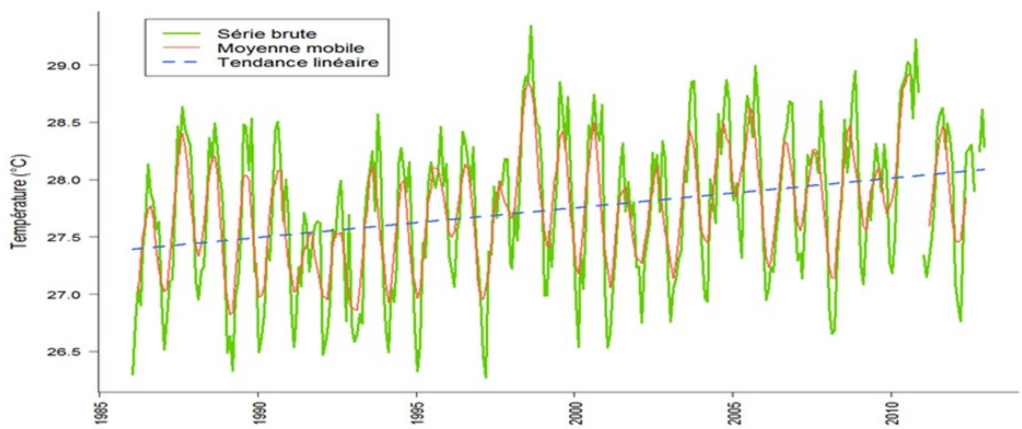

Figure 1. Monthly variations of the sea surface temperatures on the F. Guiana shelf, from NOAA remote sensing data set.

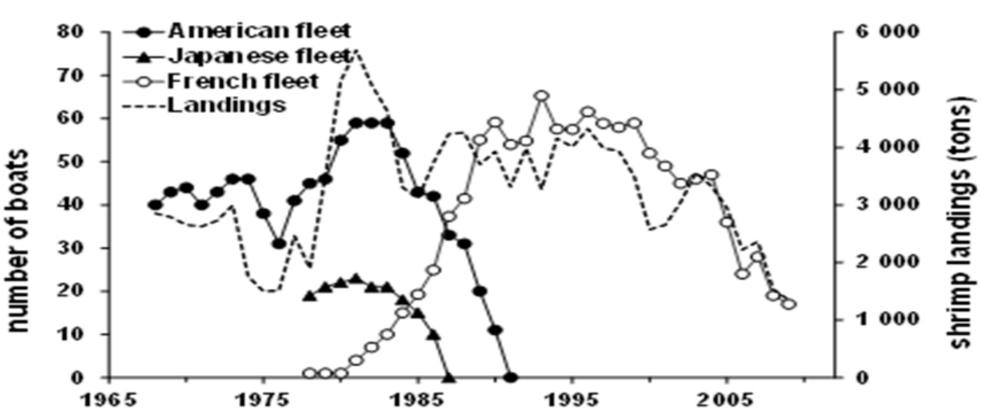

Figure 2. Temporal variations of the fishing effort and landings of the shrimp trawler fleet exploiting the studied area.

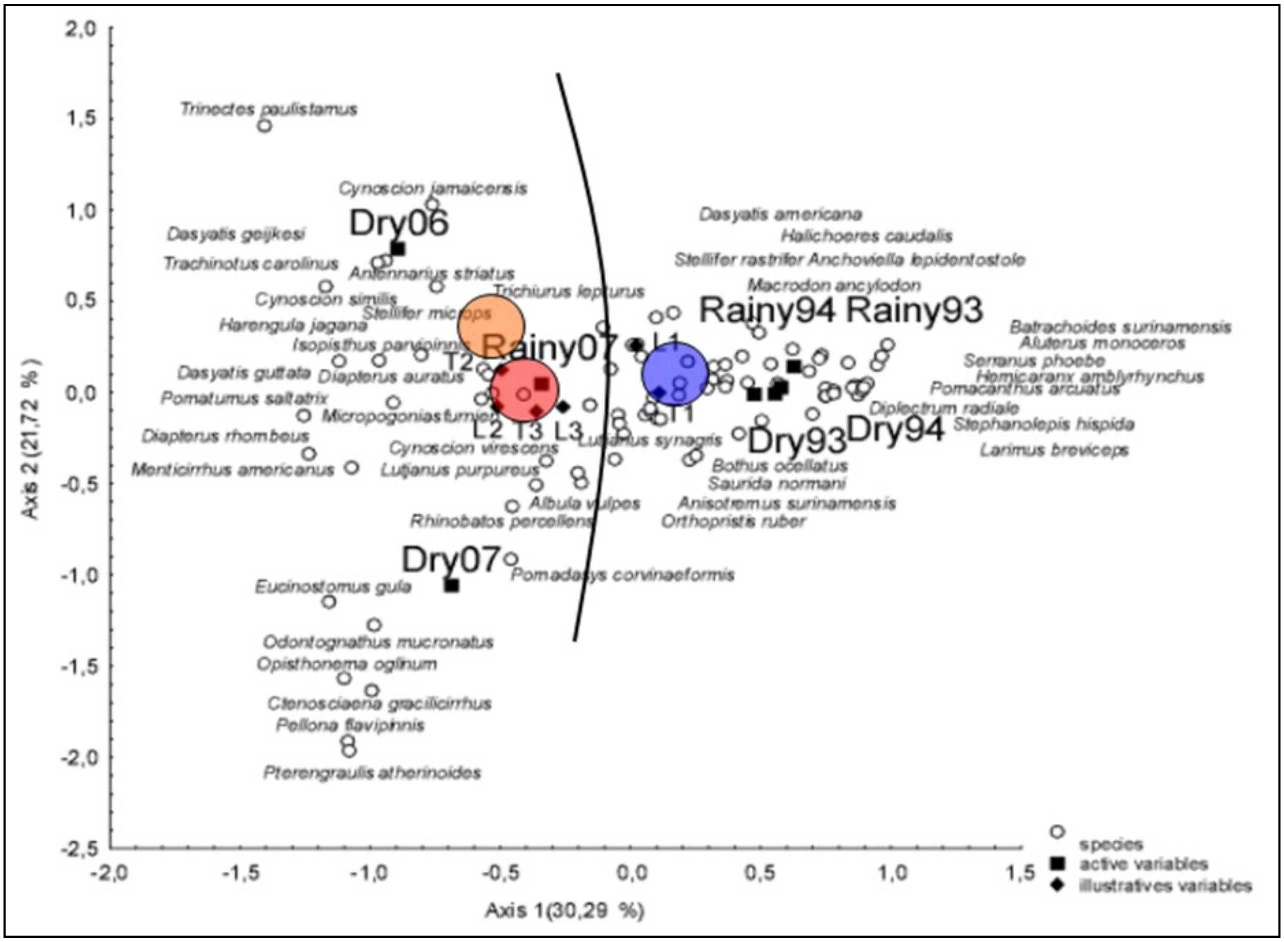

Figure 3. First plan of the CA based on the species standardised biomass sampled in dry and wet season in 1993, 1994, 2006 and 2007, with thermal affinity proxy (T1 for subtropical species with the affinity for the lowest temperatures, T2 and T3 for other subtropical and tropical species).

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