Potential Climate Change Effects on Coastal Small-scale Fisheries and on the Exploited Biodiversity in French Guiana

Efecto Potencial del Cambio Climático en la Pesca Costera Artesanal y en la Biodiversidad Explotada en la Guayana Francesa

Scénario D'impact du Changement Climatique sur la Pêche Côtière et la Biodiversité Halieutique en Guyane

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EXTENDED ABSTRACT

Introduction

At the global scale, considering biodiversity loss and erosion because of overexploitation, habitat alteration, climate change, pollution, and invasive species, there is an urgent need to develop an ecosystem based fisheries management. In French Guiana, the long term increase of the demand for sea food due to the population growth, the population will be multiplied by two in 20 years, and the impacts of climate change yet observed for marine biodiversity, question the ecosystem capacity to insure food security and economic viability of the coastal small-scale fisheries without alteration for the next generations. To bring some answers to this question, a bio-economic model has been developed.

Material and Methods

We used the ADHOC bio-economic model developed by Cissé et al. (2013, 2015). ADHOC contains the population dynamics of the 13 main species exploited (*Cynocion acoupa*, *C. virescens*, *Sciades parkeri*, *S. proops*, *Centropomus undecimalis*, *Epinephelus itajara*…) their trophic interactions and fishing mortalities according to the various coastal fleets. To better tackle long terms scenarios, an impact of the temperature on population growth has been added here. We have considered that the minimal, maximal and mean SST observed within the distribution area of the species are respectively representative of the minimal, maximal tolerance and the optimal temperature (Figure 1). The species considered are demersal ones but live between 0 and 20-30 meter depth, in a well mixed water layer with homogeneous temperatures, so that SST can be used. Knowing these SST values for each species i considered here from fishbase, we defined a theoretical model of population reaction $\alpha_i(\theta_t)$ to temperature variations (Equation 1). Then the Equation 2 were introduced in the model as a multiplying factor of the biomass at the preceding time step.

$$\alpha_i(\theta_t) = -a\theta_t^2 + b\theta_t + c \qquad \text{Equation (1)}$$

$$\gamma_i(\theta_t) = \frac{\alpha_i(\theta_{t+1})}{\alpha_i(\theta_t)} \qquad \text{Equation (2)}$$

In order to test ecological and economic performance of management, or economic development scenarios, indicators are computed from the model outputs such as the species richness, the trophic marine index, the total income.

The model was calibrated using the landings and fishing efforts observed daily on all the coastal fisheries landing points since 2006 by Ifremer, the IUU fishing efforts observed by the French National Marine and data from literature. Illegal, unreported and unregulated (IUU) foreign fisheries has actually been assessed in French Guiana, and should be twice high as the legal national fleet (Levrel 2012). A foreign IUU fleets has then be added in the model. A warming has been simulated considering the annual rate that have been observed from the NOAA SST remote sensing data set from 1986 to 2014.

The model was used to test the impact of climate change and/or the impact of IUU fishing, considering various fishing effort scenarios. We present here only the *business as usual scenario* to test the ecological sustainability of the fishing effort observed during the last years in terms of impact on the species richness.

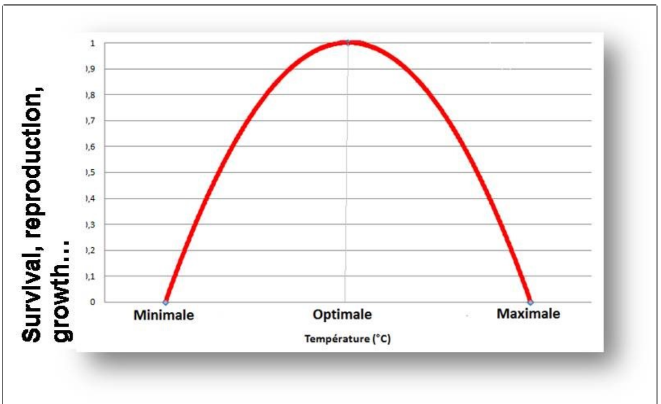

Figure 1. Theoretical model of population response to temperature variations. Minimal, maximal temperature are respectively the minimal and maximal SST observed within the distribution area of the considered species in the west-Atlantic Ocean. The optimal temperature is the mean SST value.

Results and Discussion

The simulations (Figure 2) with or without climate change showed that the fishing effort observed is not sustainable as three species are lost. With the uncertainties, considering the business as usual fishing scenarios without climate change, a first species loss may be observed from 2021, and a third loss may be observed up to 2039. When the impact of IUU fishing is added, a first loss may be observed from 2017 and the third loss up to 2033. When climate change is added to IUU fishing, a first loss may be observed from 2017 and the third loss up to 2031. Climate change accelerates the fishing impacts, and conversely.

LITERATURE CITED

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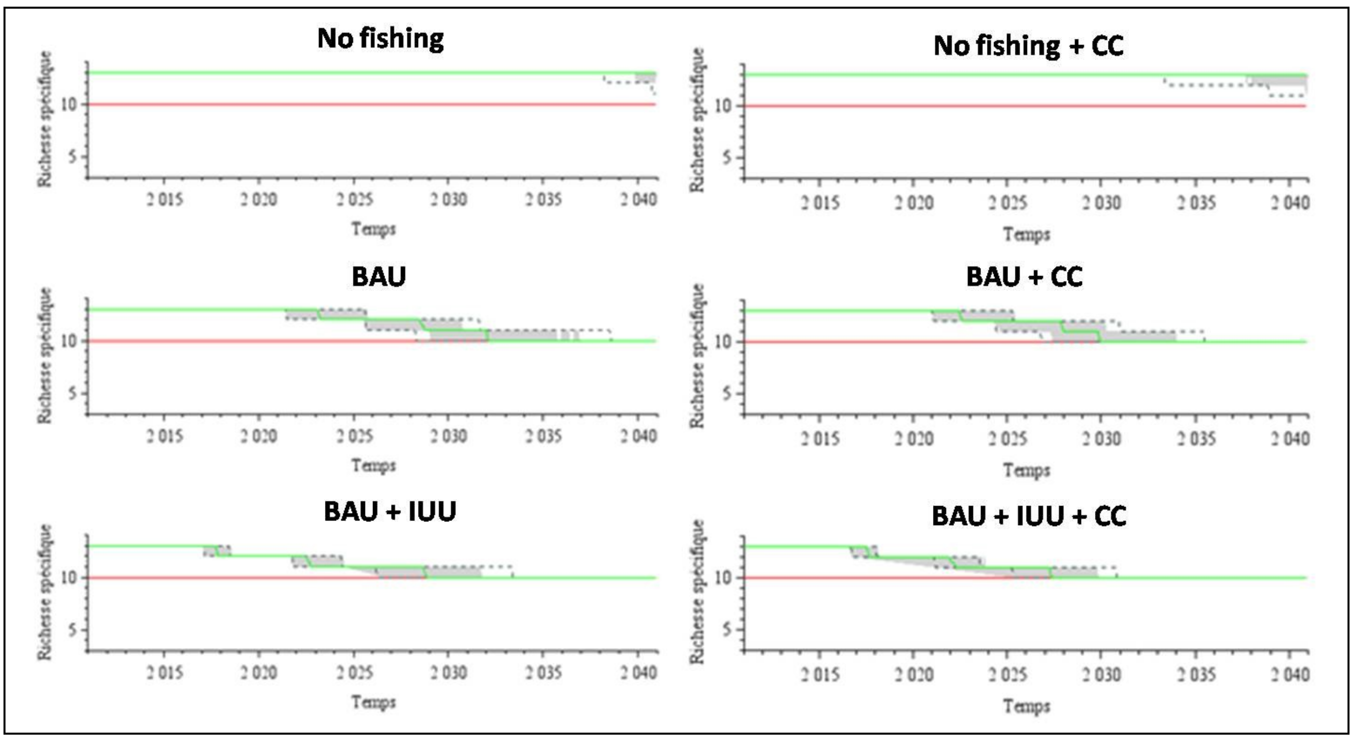

Figure 2. Left panel: potential long term impact of fishing on the exploited species richness (number of species in the trophic network), with a stable fishing effort (BAU "business as usual" scenario of fishing effort), and with illegal fishing (IUU) without climate change (CC). Right panel: potential long term impact of climate change on the exploited species richness, with a stable fishing effort (BAU), and with illegal fishing (IUU).