

DIAGNOSIS OF THE ECOSYSTEM IMPACT OF FISHING AND TROPHIC INTERACTIONS BETWEEN FLEETS: A MAURITANIAN APPLICATION

Beyah Meissa ⁽¹⁾, Didier Gascuel ⁽²⁾, Sylvie Guénette ⁽³⁾

(1) Institut Mauritanien de Recherches Océanographiques et des Pêches (IMROP), BP: 22, Nouadhibou, Mauritania

(2) Université Européenne de Bretagne, Agrocampus Ouest, UMR985 Ecologie et santé des écosystèmes, 65 rue de Saint Briec, CS 84215, 35042 Rennes cedex, France

(3) EcOceans, St Andrews, NB, Canada

ABSTRACT

Based on the Mauritanian case study, this presentation shows how the EcoTroph model (Gascuel et al., 2011) can be used to build global diagnosis of the ecosystem impact of fishing, and to analyze interactions between fleets targeting various compartments of the ecosystem. We used a preexisting EwE model, which includes 51 trophic groups and covers the whole Mauritanian continental shelf (Guénette et al., 2014). The model, initially fitted on catches and survey time series over the 1991-2006 period, was first updated based on recent stock assessment results (Meissa, 2013). Then, starting from the 2010 Ecopath model, simulations of increasing or decreasing fishing efforts were performed, using the ET-Diagnosis routine of the EcoTrophR package (Colléter et al., 2013). Multipliers of the current fishing mortality, ranking from zero (no fishing) to five (strong increase in the fishing pressure), were applied, either to the whole fisheries or fleet by fleet in order to analyse fisheries interactions (Gasche and Gascuel, 2013).

Compared to the pristine conditions, the current exploitation is estimated to lead to a 25 % decrease in the total ecosystem biomass (for all animals), and to a 65 % and 70 % decrease for the biomass of exploited species, and top predators (TL > 4), respectively.

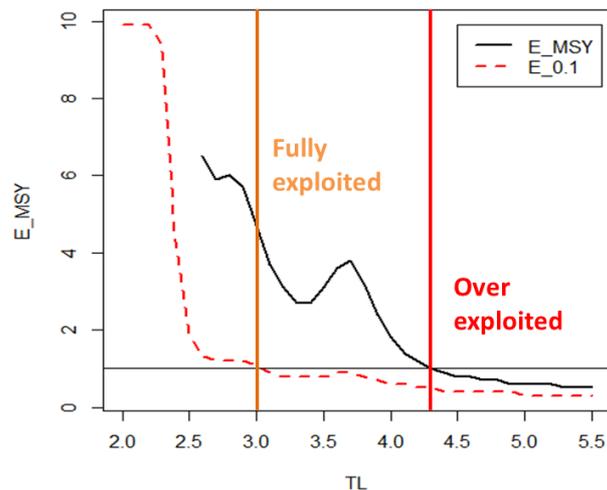


Figure 1. Global diagnosis of the ecosystem impact of fishing in the Mauritanian continental shelf ecosystem. Indicators E_{msy} and $E_{0.1}$ are the fishing mortality multipliers which allow reaching F_{msy} and $F_{0.1}$, the reference values for full and overexploitation respectively

Two indicators can be used to build a global diagnosis of the fishing impact at the scale of the entire food web (Figure 1). The E_{msy} indicator is the fishing mortality multiplier that allows obtaining the maximum sustainable yield of a given trophic class. Therefore, if E_{msy} is lower than 1, the related trophic class is overexploited (and conversely, underexploited for E_{msy} higher than 1). The $E_{0.1}$ indicator is commonly used in single species stock assessments, in order to define the starting point of the full exploitation (i.e. the lowest value of the fishing mortality characterised by a flat yield curve, with catch values close to MSY). Therefore, $E_{0.1}$ values smaller than 1 characterise fully or overexploited situations, while values higher than 1 relate to underexploited trophic classes.

These indicators show that all trophic levels higher than 4.3 are currently overfished, while those between 3.0 and 4.3 are fully exploited. In addition, trophic levels between 2.6 and 3.0 are

close to full exploitation, only lowest trophic levels being currently under-exploited.

As an example, we show here results of simulations related to interactions between the industrial foreign fishery (IPF) targeting pelagics (mainly sardinella), and the small scale coastal fishery (SSCF), targeting a wide range of species including small pelagics, demersal fish and octopus (Figure 2). In these simulations, other fleet segments (i.e. industrial demersal fisheries) remained constant. Results demonstrated the strong interactions between the two fisheries. An increase in the fishing effort of the industrial pelagic fishery would lead to an increase in total catch but to a significant decrease in the whole ecosystem biomass, in the catch of the small scale fishery, and in the mean trophic level of ecosystem biomass and catches. The impact results from both direct and indirect effects, because the industrial pelagic fishery targets species that also targeted by the small scale fishery and prey for demersal fish exploited by the small scale fishery.

Conversely, increasing the fishing effort of the small scale fishery would have limited quantitative impacts (on the whole ecosystem biomass and catch) and limited qualitative impacts (on mean trophic levels). Other simulations (not shown) also suggested interactions between the small scale and the industrial demersal fisheries. Each one has a limited quantitative impact on the other (i.e. on total biomass and catch), but higher qualitative impact, where increasing fishing effort would lead to a depletion in high trophic levels abundance, and therefore to a decrease in the mean trophic level of biomass and catch.

Such EcoTroph simulations finally demonstrated that fisheries management depends on highly political choices. The development of the small scale coastal fishery in Mauritania would imply to reduce the fishing effort of foreign fleets. Interactions between fleets do result not only from the target of the same species, but also from indirect effects propagating from one fishery to the other through the food web. In particular, industrial fisheries targeting small pelagics have large impacts on the whole food web, thus impacting all local fisheries.

REFERENCES

- Colleter M., Guittou J., Gascuel D., 2013. An Introduction to the EcoTrophR package: analyzing aquatic ecosystem trophic network. *The R Journal*, 5(1): 98-107.
- Gasche L., Gascuel D., 2013. EcoTroph: a simple model to assess fisheries interactions and their impacts on ecosystems. *ICES Journal of Marine Sciences*, 70: 498–510.
- Gascuel D, Guénette S, Pauly D., 2011. The trophic-level based ecosystem modelling approach: theoretical overview and practical uses. *ICES Journal of Marine Sciences*, 68: 1403–1416.
- Guénette S, Meissa B, Gascuel D., 2014. Assessing the Contribution of Marine Protected Areas to the Trophic Functioning of Ecosystems: A Model for the Banc d'Arguin and the Mauritanian Shelf. *PLoS ONE*, 9(4): e94742.
- Meissa O.B., 2013. Dynamique des ressources démersales dans l'écosystème marin mauritanien : vulnérabilité des ressources et impacts de la pêche. Thèse Agrocampus Ouest, mention écologie, 234 p.

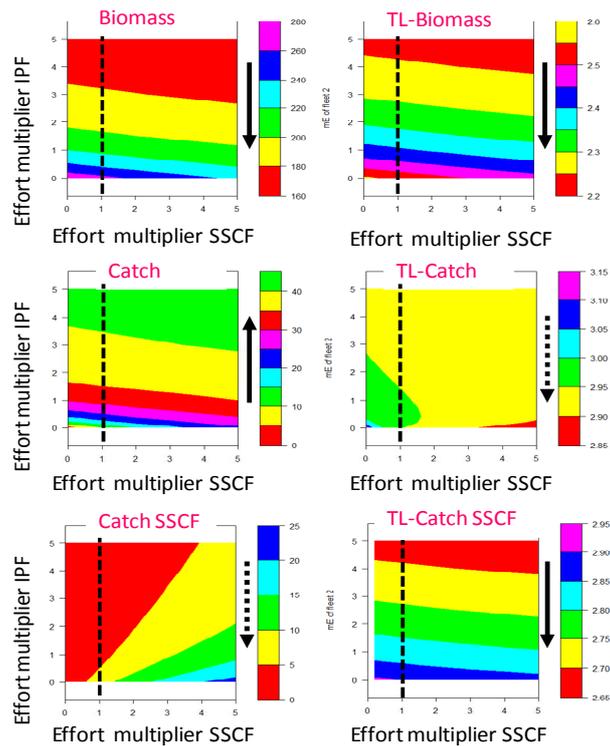


Figure 2. Simulation of biomass, total catch and catch of the small scale fishery, as a function of the fishing mortality multiplier of the small scale fishery (x-axis) and the industrial small pelagics fishery (Y-axis). Left column refers to the variable of interest (in tons per km²), while right column refers to the mean trophic level of the same variable. Dash line refers to the current small scale fishing effort, while arrows indicate trends.