ICES CM 2019/F:357

Ecologically Sustainable Exploitation Rates

- A multispecies approach for fisheries management -

Significance
A new statistical method of estimating exploitation levels of interacting fish populations that are sustainable with respect to the state of whole fish communities.

Definition
Exploitation rates associated with a maximum acceptable probability (determined by management) that any interacting species decreases to an unacceptably low population size.

Data requirements
Time series of interacting fish populations, exploitation rates and potentially important environmental covariates.

Methodological approach

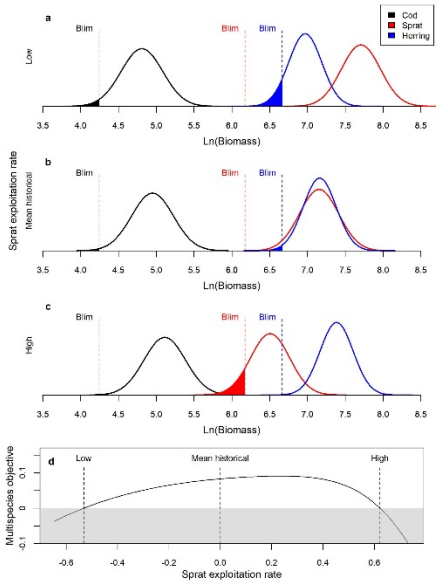


Fig 1. An illustration of the methodological approach of estimating Ecologically Sustainable Exploitation Rates (ESERs). Panels (**a**), (**b**) and (**c**) illustrate marginal stationary distributions of a multivariate autoregressive model of biomasses of the interacting fish species cod, sprat and herring, subjected to (**a**) low, (**b**) mean historical or (**c**) high mean exploitation rates on sprat, and mean historical exploitation on cod and herring. The filled areas in (**a**)-(**c**) represent the marginal probability that a species biomass goes below its critical biomass limit (Blim). These marginal probabilities make up the core of the multispecies objective function shown in (**d**). The y-axis in (**d**) represents the difference between a predefined maximum acceptable probability that any species goes below its Blim, and the probability for this to occur given a set of mean exploitation rates. Exploitation rates associated with positive values of the objective function represents Ecologically Sustainable Exploitation Rates. Exploitation rates are represented as anomalies, i.e. as the number of standard deviations above or below mean historical levels (here 1988-2014).

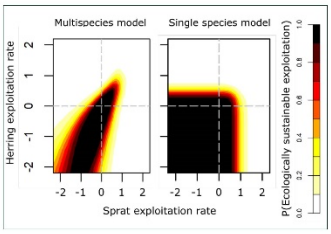
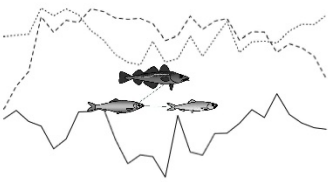


Fig 2. The probability of ecologically sustainable exploitation is more constrained in a multispecies as compared to a single-species setting.

Application
The probability of ecologically sustainable exploitation is more constrained in a multispecies as compared to a single-species setting.

Implications
The statistical approach of estimating ESERs of interacting fish populations is framed around a simple and accessible objective at the community level. This makes analytical derivation of ESERs an applicable complement to conventional single-species stock assessment.



Torbjörn Säterberg
torbjorn.saterberg@slu.se
https://www.slu.se/cv/torbjorn-saterberg/

Michele Casini
michele.casini@slu.se
https://www.slu.se/cv/michele-casini/

Anna Gårdmark
anna.gardmark@slu.se
https://www.slu.se/annagardmark/

SCIENCE AND EDUCATION FOR SUSTAINABLE LIFE

Ecologically Sustainable Exploitation Rates – a multispecies approach for fisheries management

Authors: Torbjörn Säterberg, Michele Casini, Anna Gårdmark

Abstract text:
Fisheries management is slowly evolving from its traditional single species focus to a more holistic ecosystem based approach. Yet, limits for exploitation are almost always set based on single species models, treating species as isolated entities. This is problematic since the sustainability of a fishery hinges on its effects on the exploited community as a whole. Here, we develop a novel analytical approach of estimating exploitation rates that are sustainable with respect to the state of whole fish communities. Our approach simultaneously addresses species interactions, environmental covariates and natural variability of population sizes, yet it is framed around a simple and accessible objective. We derive Ecologically Sustainable Exploitation Rates, i.e. exploitation rates associated with a maximum acceptable probability (determined by management) that any interacting species decreases to an unacceptably low population size. Using models fitted to an exploited fish community we show how accounting for species interactions constrains the possibilities for ecologically sustainable exploitation. The conventional omission of species interactions may thus result in overestimated exploitation limits. Moreover, our application rendered a counterintuitive result: it suggests that the exploitation of one species should increase, as compared to mean historical levels, for the purpose of conservation of the community as a whole. Such insights could impossibly be gained using single species approaches, illustrating the need to adopt multispecies models in fisheries management. Analytical derivation of Ecologically Sustainable Exploitation Rates offers a mean to do so.

Keywords:
Multispecies exploitation, Multispecies objective, Reference points, Stock assessment, Viability modeling

Contact author:
Torbjörn Säterberg, Swedish University of Agricultural Sciences, Department of Aquatic Resources, Skolgatan 6, SE-74242 Öregrund, Sweden;
Email: torbjorn.saterberg@slu.se;
Phone: +46 10 478 41 61