Impact of trophic interactions on production functions and on the ecosystem response to fishing: A simulation approach

A simulation model is developed to analyse the variability of production functions in an exploited virtual ecosystem. We assume that a complex food web can be represented by a set of trophic components interacting through predation. Each component has a set of recruitment, growth, and survival models, a catch level and trophic preference function. Prey are consumed according to their abundance and predators' trophic preference functions are estimated in a pristine system. A parameter for the food consumption per unit biomass describes foraging for each trophic component. The FishBase database is used to parameterise some of the major processes in a generic model. A commercial fishery targets mostly high trophic levels through a set selectivity function. Some key ecosystem features are assessed in simulations: the intensity of top-down and of bottom-up controls, and the degree of trophic opportunism. Top-down control is the regulation of lower food-web components by one or several upper-levels predators. Bottom-up control is the regulation of trophic components by their prey. Results show that biological production functions are highly dependent on predation parameters and vary differently according to trophic level. Fishing activity modifies the biomass distribution between components and strongly affects higher trophic levels more sensitive to exploitation. Trophic dynamics within the system are altered through the rates of predation mortality. In systems where predation mortality is high, top-down control dominates and fishing affects all food web components. These “fishing-controlled” systems display compensatory mechanisms through a released predation control. We also show that systems where productivity is dependent on prey abundance are more “environment-controlled” and seem more sensitive to overexploitation, particularly the higher trophic levels. Trophic opportunism tends to dampen the propagation of top-down or bottom-up controls through the food web and thus stabilizes the ecosystem. Trophic relationships are therefore essential ecosystems characteristics that determine production and response to exploitation. Their routine analysis is a key part of the ecosystem approach.

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