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The importance of predator–prey overlap—predicting North Sea cod recovery with a multispecies assessment model

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Extended abstract:

The Ecosystem Approach to Fisheries (EAF), nowadays worldwide on political agendas, takes into account ecosystem knowledge, considers multiple external influences and looks at the broader impact of fisheries on the entire ecosystem (FAO, 2003), rather than trying to manage fish stocks singly. Specifically, it deals with effects of fishing on ecosystems, effects of ecosystems on fisheries and the manipulation of ecosystems, such as setting harvest levels for one stock to achieve a particular state in another ecosystem component (O'Boyle *et al*., 2008). This requires that multispecies interactions via predation or competition must be taken into account when evaluating management decisions in an ecosystem context.

The overlap between predator and prey is known as a sensitive parameter in multispecies assessment models for fish and its parameterization is notoriously difficult. Overlap indices were derived from trawl surveys and used to parameterize the North Sea Stochastic Multispecies model SMS (Lewy and Vinther 2004). The effect of time-invariant and year- and quarter-specific overlap estimates on the historical (1991–2007) and predicted trophic interactions, as well as the development of predator and prey stocks, was investigated. The focus was set on a general comparison between single-species and multispecies forecasts and the sensitivity of the predicted development of North Sea cod for the two types of overlap implementation.

The spatial–temporal overlap between cod and its main predators was found to increase with increasing temperature, indicating that food web processes might reduce the recovery

potential of cod during warm periods. Multispecies scenarios were highly influenced by assumptions on future spatial overlap, but they predicted a considerably lower recovery potential than single-species predictions did. In addition, a recovery of North Sea cod had strong negative effects on its prey stocks.

The results demonstrated two major drawbacks in standard single species evaluations of management plans. First, density-dependent processes, such as an increasing rate of cannibalism with increasing stock size and direct, as well as indirect predation effects from other species, for example, grey gurnard and whiting, have not been taken into account. Our results demonstrated clearly that SS forecasts overestimate the likely level to which North Sea cod might recover, as well as give a false idea of the time-frame when a target biomass might be reached. This could easily result in wrong conclusions on whether a certain fishing mortality is sufficient to recover the stock with high probability. In principle, cannibalism could be incorporated with relative ease in single-species models and it does not require a full multispecies model. Density-independent direct and indirect predation processes, however, are hard to incorporate in a single-species evaluation framework, except by including stochastic variations in natural mortalities to test the robustness of management plans. As long as predation mortalities vary without trend, this might be sufficient, but in case of a future trend, serious bias could be introduced. The second shortcoming is that the consequences of a recovery of North Sea cod for other species have not been evaluated, although the EAF requires that the entire ecosystem should be able to sustain the effects of management decisions (FAO, 2003; Garcia *et al.*, 2003). To meet this requirement, the target fishing mortalities in long term management plans for dependent prey species would have to be revised in case of a substantial recovery of cod.

The limitations of the single-species approach to guide management decisions on recovering stocks and maximizing yield from individual species, irrespective of the consequences on other stocks, are not novel (Sissenwine and Daan, 1991; Pope, 1991). Because of predator–prey interactions, it is impossible to reach all MSY targets as defined by single-species assessments simultaneously (ICES, 2008). This is particularly relevant in an overexploited ecosystem, where interactions between different components reflect the exploited, rather than the undisturbed system. In such a case, trying to recover one major predator stock could result in unexpected and disappointing effects on the target species and quite harmful effects on others.

For further information see: Kempf, A., Dingsør, G. E., Huse, G., Vinther, M., Floeter, J., and Temming, A. 2010. The importance of predator–prey overlap—predicting North Sea cod recovery with a multispecies assessment model. – ICES Journal of Marine Science, 67: doi:10.1093/icesjms/fsq114.

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