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Comparing compartment and trait-based models in fisheries management

Nis S. Jacobsen*[1], Tim E. Essington[2], Ken H. Andersen[1]

What are the implications of size-structured vs. food web based interactions?

Introduction

The ecosystem approach to fisheries (EAF) is becoming more recognized as the future of sustainable harvesting. EAF requires models that account for a range of components in an ecosystem.

We studied the differences and similarities between two models used for strategic management of fisheries; Ecopath w. Ecosim (EwE) and a trait based size spectrum model (SSM). The models are conceptually different as EwE is structured in species "compartments", and includes specific food webs, while SSM is a fully size structured model where prey selection is purely size-based.

The models were employed in the California Current and the outcome of different fishing scenarios compared. Secondly, the consequences of employing four different characteristic fleets in the system was investigated.

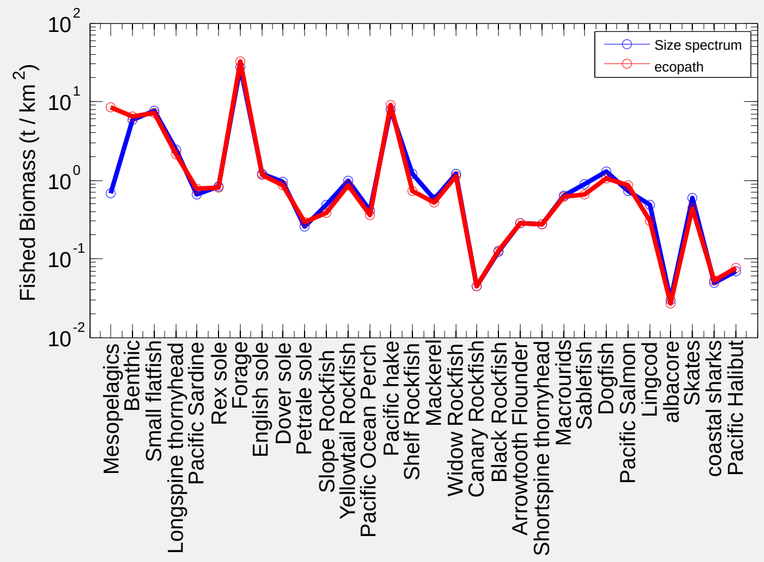


Figure 4) The biomass distribution of Ecopath (red) and the calibrated Size Spectrun Model (b). There is generally good fit, but the large amount of medium sized species does not allow "mesopelagics" to have equally high biomass in SSM as in EwE.

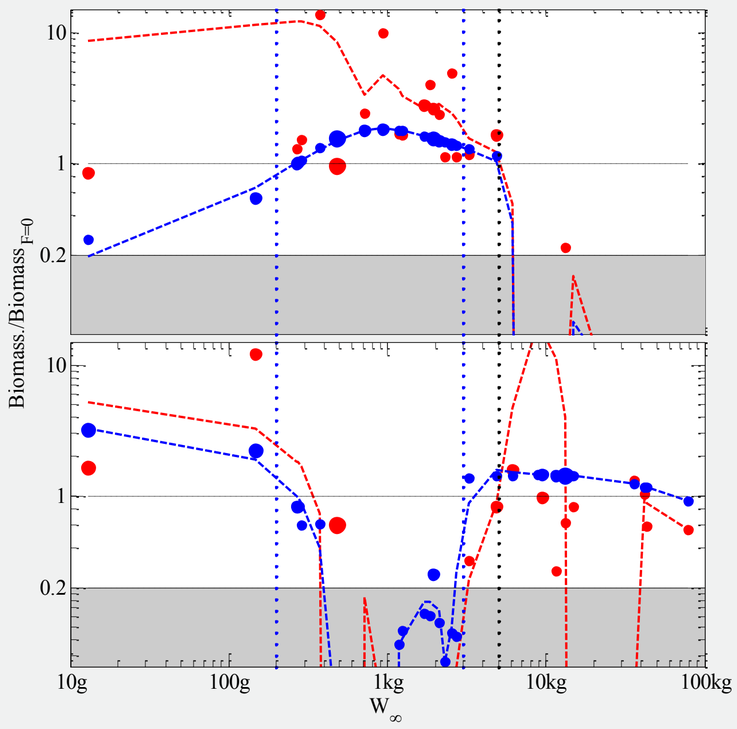


Figure 2) Trait-based comparison of biomass relative to the unfished biomass in Ecopath with Ecosim (red) and Size spectrum model (Blue). Grey area is <20% of the unfished biomass (crashed).Names from figure 1 are changed to asymptotic size (same order).A is when fishing all fish > 5 kg with F = 1, B is when fishing fish 200g > W_∞ > 3 kg- Dots are biomasses, lines are smoothing curves fitted to biomass data

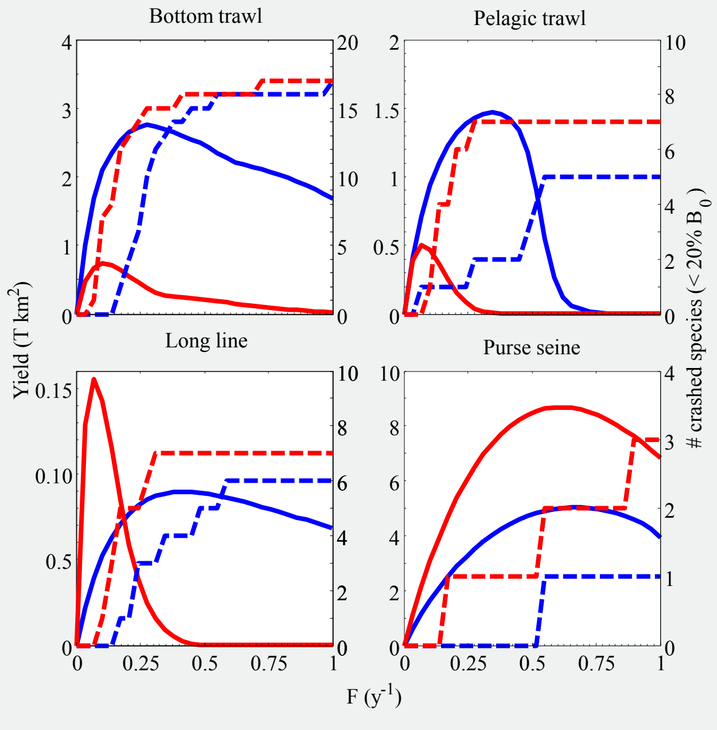


Figure 3) Multispecies maximum sustainable yield from 4 different fleets (full lines) and the corresponding number of crashed species (dotted lines). Red lines represent EwE, blue lines SSM. There is quite large differences between the yields in the two models, but there is no systematic difference, only between fleets. The crashed species are almost equal, with EwE being a little more sensitive to fishing.

Methods

A California Current parameterization of the model described in Hartvig *et al* 2011 was developed using the Ecopath model created by Field *et al* 2006. To parameterize the SSM we

- Found the W_∞ corresponding to the fish species in the Ecopath model
- Fixed the carrying capacity of the background spectrum to produce equal total biomasses in the models
- Find the preferred predator prey mass ratio
- Optimized for the maximum recruitment parameter, so all species are equally abundant in both models
- Calculated the mean maximum food intake and search rates of California current fish species

Fleets were defined by historical fishing patterns in the California Current, and divided into 4 fleets: Bottom trawl, Pelagic trawl, Long line and Purse seine fishery.

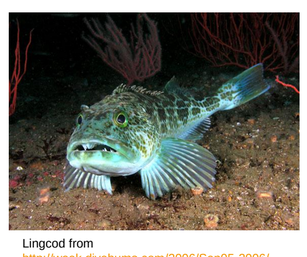
Results/Conclusion

- Both models show trophic cascades , but the responses of individual species are more differentiated among species, when feeding choices are food-web based, compared to size based
- Competition causes larger species to increase in abundance in SSM, when the medium sized species are removed.
- SSM shows secondary cascades to a larger degree than EwE
- The models show quantitative differences in yields from the different fleets, but similar patterns
- Species crash (< 20% B_0) at lower fishing mortalities in EwE

We conclude that food-web structure creates species specific responses to trophic changes, which are not seen when feeding is purely size-based. Although the models show similarities, their differences are great when comparing relative yield of four diverse fleets.

*Corresponding author: nsja@aqua.dtu.dk, tlf: +45 61 77 13 96
1) Centre for Ocean Life, DTU AQUA, Technical University of Denmark, Charlottenlund Slot, Charlottenlund, Denmark
2) School of Aquatic and Fisheries Sciences, University of Washington, 1122 NE Boat St, Seattle, WA 98105

References:
Field, J. C., R. C. Francis, and K. Aydin. "Top-down modeling and bottom-up dynamics: linking a fisheries-based ecosystem model with climate hypotheses in the Northern California Current." *Progress in Oceanography* 68.2 (2006): 238-270.
Hartvig, Martin, Ken H. Andersen, and Jan E. Beyer. "Food web framework for size-structured populations." *Journal of theoretical biology* 272.1 (2011): 113-122.



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