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Feeding and growth potential of Atlantic cod in the Baltic Sea in the wake of climate change

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Abstract
An abrupt decrease in the frequency of inflow events renewing the bottom water has led to increasing hypoxic bottom areas in the he eastern part of the semi-enclosed Baltic Sea. This, in turn, has limited the scope for benthic productivity. We addressed the question how the main demersal predator, cod, is impacted by the increased hypoxia. Five decades of stomach content data gave detailed insight into changes in diet composition and energy uptake of cod during the period of decreased benthic productivity. This way, we could identify mechanisms by which climate change has altered the susceptibility of this species to density-dependent competition. As hypoxia progressed, the abundance of benthic food in the diet of small cod decreased and benthic diversity changed from high energy to lower energy prey organisms. As a consequence, growth of young cod is severely inhibited and they are forced to initiate piscivory at an earlier stage of their lives. Preceding the climatically induced drop in inflow frequency, large cod had the lowest feeding levels and hence were most sensitive to density-dependent competition. The originally negative trend in feeding levels during life-history has been reversed. Nowadays, small cod are susceptible to density-dependent food limitation. Besides the economically important decrease in cod growth, the change in size-dependent density dependence illustrates how large scale climatic changes can have severe regional scale implications for population structure and species interactions.

Keywords: Baltic cod, feeding, growth, density-dependence, climate change

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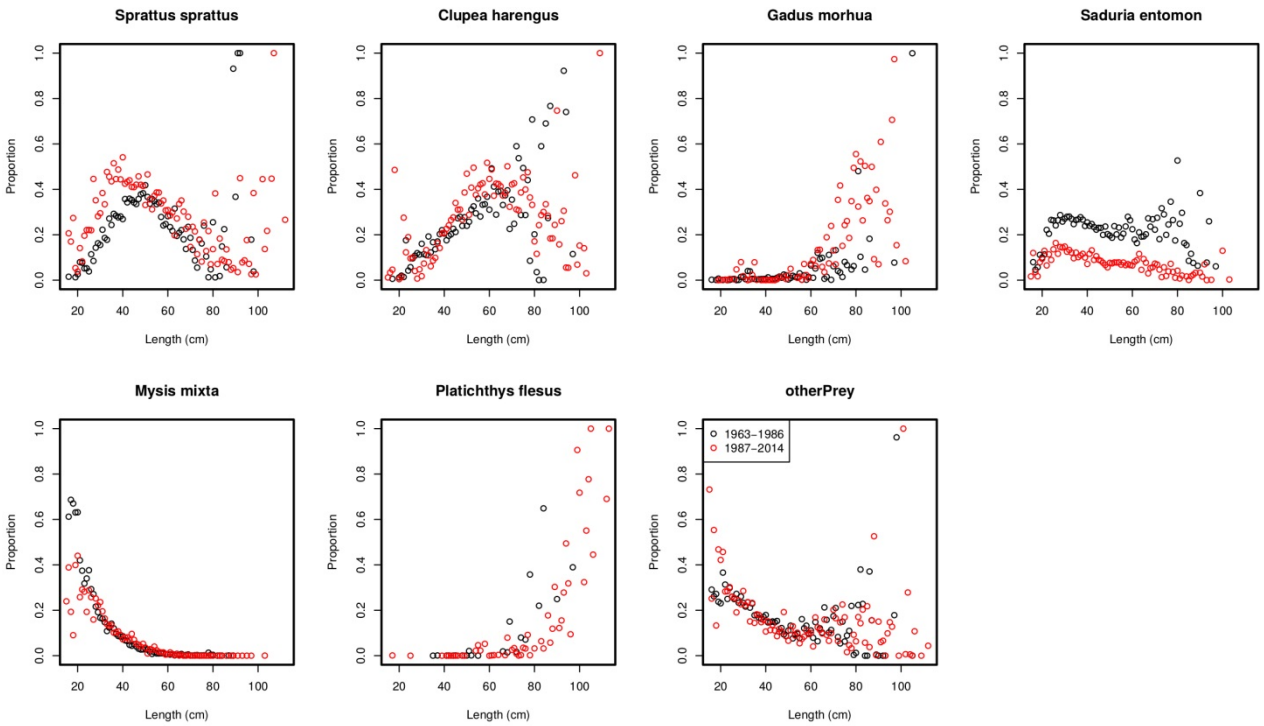

Figure 1. Plot of the proportional contribution in weight of different prey items in the cod stomachs in relation to cod size, separately for the period before (1963-1986) and after (1987-2014) the regime shift in the Baltic.

-change x-axis to log scale
-change time period to before and after 1985
-change weight fraction to energy fraction
-ad plot on weight at length (log-log?) or energy intake versus length (log-log)
-sprat in consumed earlier during life
-herring, too, but still later than sprat
-energy due to cannibalism has increased (NB: not necessarily rate of predation mortality, other paper)
-Saduria went down
-Mysids went down
-other prey increased (what is that made of?)
- run same analysis for Bornholm Baisn only)

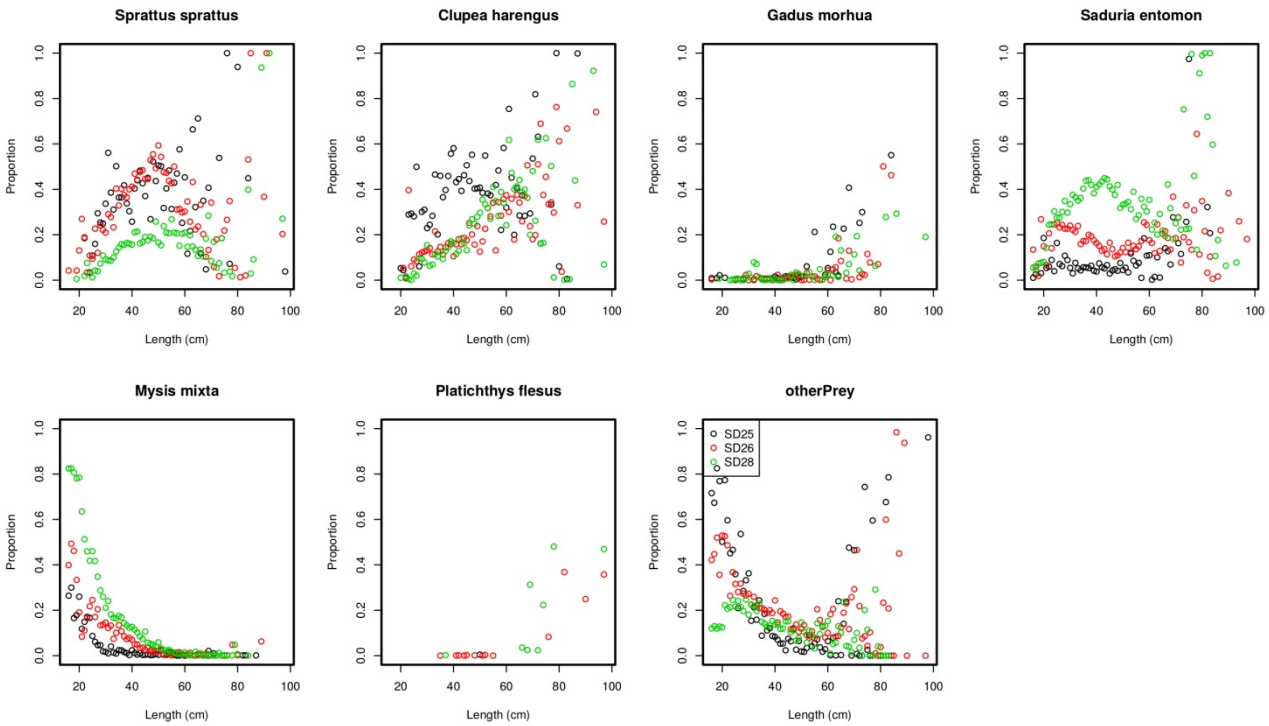

Figure 2. Plot of the proportional contribution in weight of different prey items in the cod stomachs in relation to cod size, separately for the ICES subdivisions 25, 26, 28 over the time period 1963-2014. Green 28, red 26 and black 25.

-is the change in sprat in F1 due to food availability, or becuase sprat has alsways been high in SD25, and in the second period most of hte cod arte in this area?
-same for Saduriaa, just thee other way around
-what happened to the diet and energy intake per SD? → make this plot for the two periods, start with this!

--IS IT BENTHIC PELAGIC RATIO, OR SMTH ELSE?

Four panels with feeding levels over size. Focus on 15-(30 or 40 cm afterwards?) – check thee sd thing first!

Visualize benthic/pelagic ratio over (a) over time for sd's in the identified length range, and (b) over size

Estimate growth?