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Recent change in the long-term dynamics of copepods influence the pelagic food web structure in the Gulf of Riga

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BACKGROUND

Copepods are functionally significant organisms in the Gulf of Riga as they provide the basic linkage between the autotrophs and the main plankton eater – herring *Clupea harengus*. In the result of the other research, it was determined that the long-term dynamics of copepod *Eurytemora affinis* – the main prey species for herring – is mostly regulated by the water temperature and the predators. The large copepod *Limnocalanus macrurus* are regarded as the high-energy food item for planktivorous fish, but in the 1990s, the species almost disappeared from the Gulf of Riga. The increase of biomass could only be observed in the last decade. Some recent studies suggested that the species probably is the preferred food item for planktivorous fish (Livdāne et al. 2016). However, the main regulating factors of *L.macrurus* dynamics still remain unclear.

Our research objectives:

1) To clarify the dynamics and shifts of prey copepods (*E.affinis* and *L.macrurus*) in spring within the recent decades (1990-2014);
2) To model the influence of the abiotic (temperature, salinity, oxygen) and biotic factors (biomass of 1-year-old herring and 2-8-year-old herring) upon the species dynamics in various periods;
3) To determine the changes in the food web structure by analysing the long-term dynamics of copepod mean individual weight. The mean weight or size is developed as the indicator which could describe the predator-prey balance in the food web (Gorokhova et al. 2016).
4) To analyze the possible impact of the copepod May biomass and size structure in the herring larvae survivor and growth.

CONCLUSIONS

✓ The significant changes in the zooplankton cenosis in past 25 years have been observed in the Gulf of Riga: the biomass of *E.affinis* decreased, but *L.macrurus* increased. The observed changes in the composition and biomass have been accompanied by an increase in mean copepod weight and the changes probably imply increased prey quality for planktivorous fish.

✓ The multiple linear regression analysis revealed that 1-year-old herring was the main factor influencing the biomass of both copepods in the spring.

✓ The study also suggested that the changes in copepod structure probably could make an impact on the survivor and growth of herring larvae in the spring, which should be taken into account, for example, when forecasting herring recruitment dynamics.

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RESULTS

Significant shifts in copepod long-term dynamics

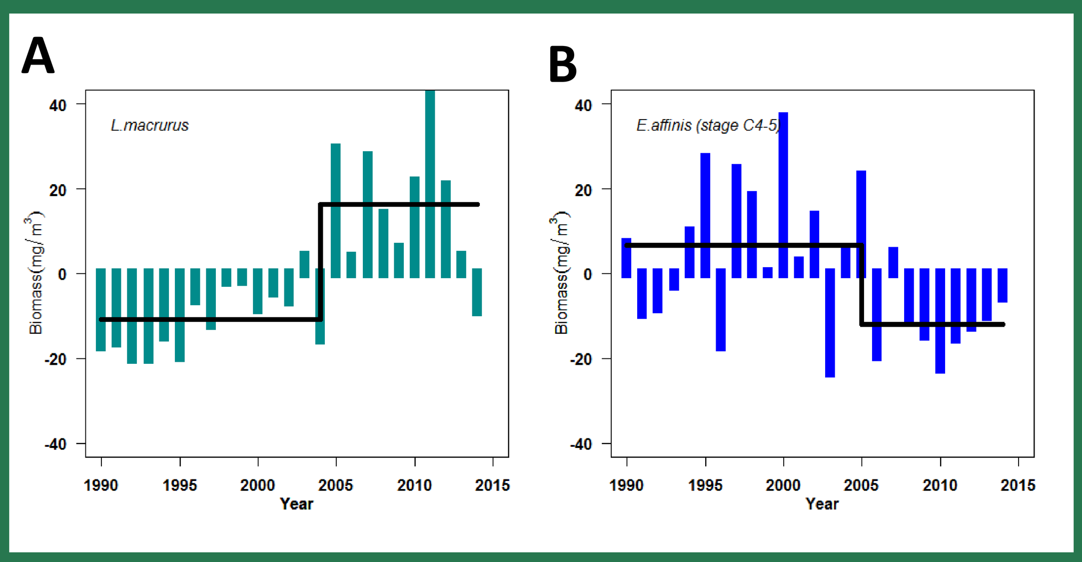


Fig.1. We established the significant shifts in the spring biomass of A) *L.macrurus* in 2004 (p<0.001) and B) *E.affinis* copepodites (C4-5) in 2005 (p=0.026). Overall, the biomass of *L.macrurus* has increased (Kendall score (S) = 171, p<0.0001), but total biomass of *E.affinis* has declined (non-significant) since the beginning of the1990s.

Top-down or bottom-up stresses?

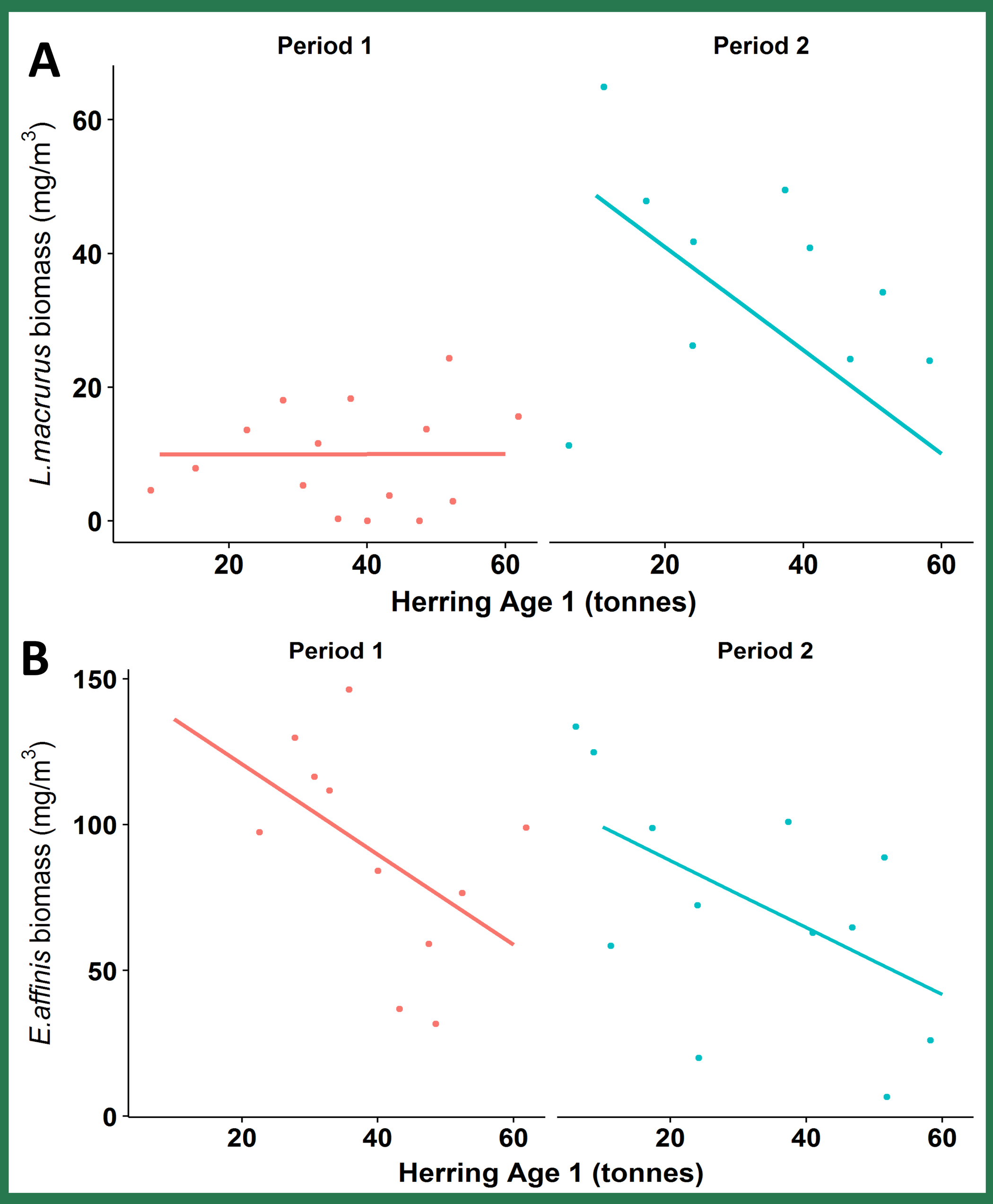
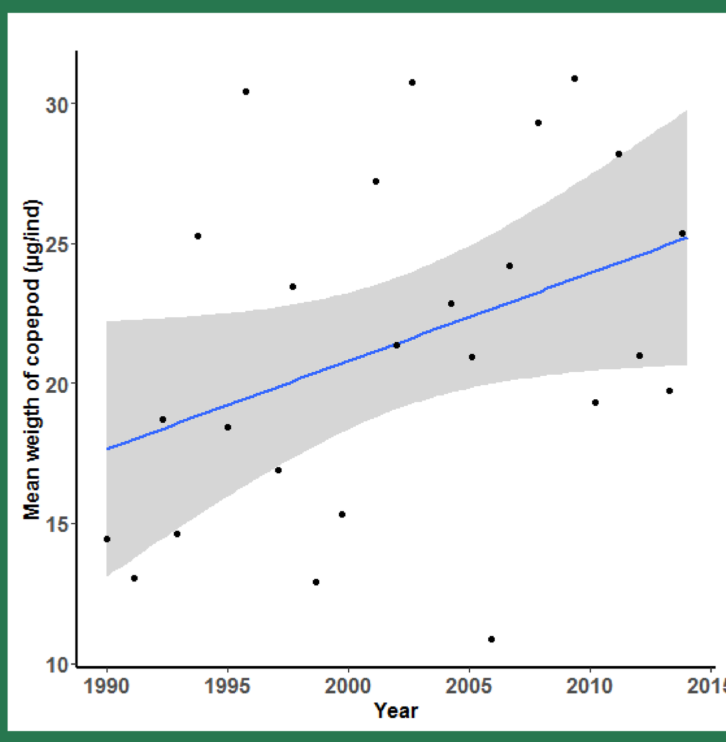


Fig2. In the result of statistical analysis, we determined that the spring abundance of
A) ***L.macrurus*** **was affected by herring eating (mostly by young, 1-year-old fish) in last decade;**
B) ***E.affinis*** **in both periods was affected by herring eating. Overall, the multiple linear regression models explained 72% of *L.macrurus* variation (p<0.001) and 49% of *E.affinis* variation (p= 0.028). However, none of the statistical analyses showed a significant impact of hydrological factors.**

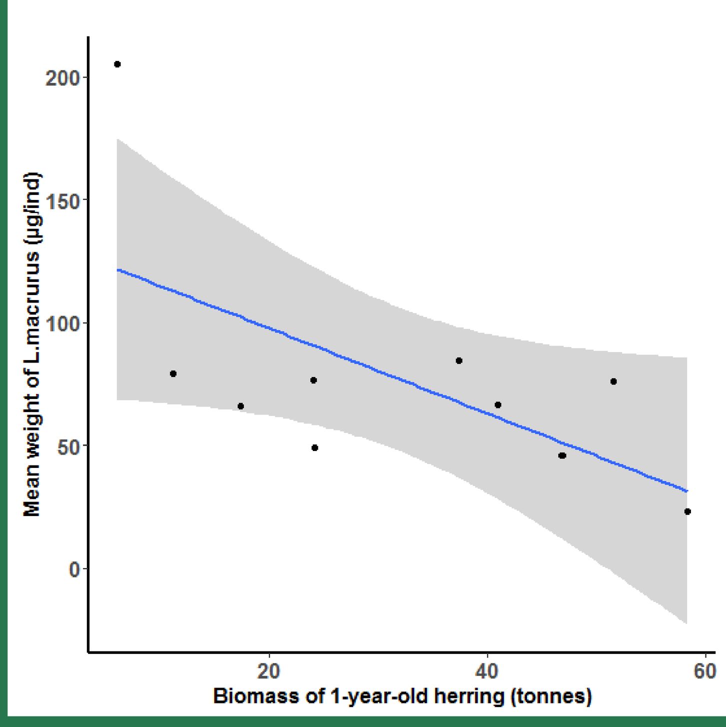
Do the changes in copepod biomass has affected the copepod mean individual weight?

Fig.3. Changes in zooplankton cenosis over the past 25 years have contributed to the increase in the average individual weight (µg/ind) of copepods (Kendall score (S) = 82, p=0.05).



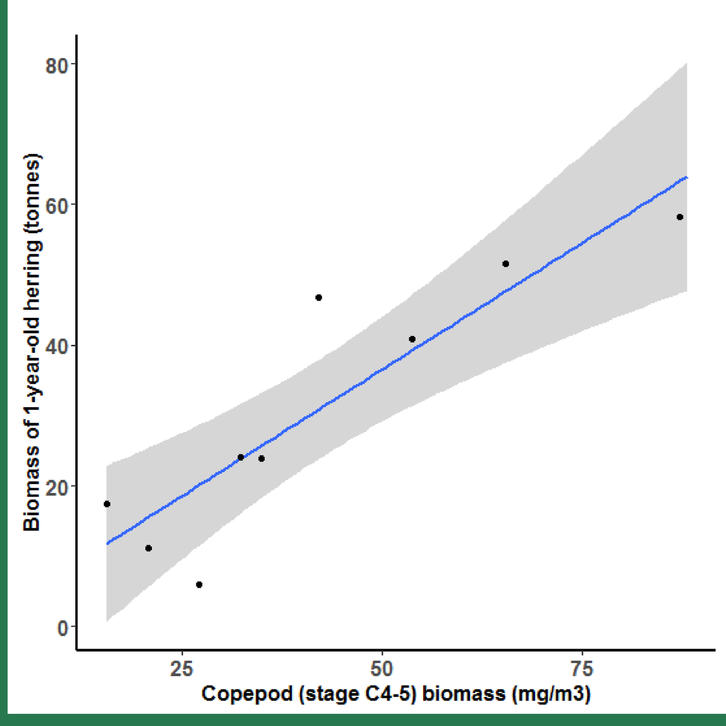
Does predation affects copepod mean individual size?

Fig.4. Results of linear regression analysis suggested that 1-year-old herring could control the average individual weight of *L.macrurus* in the most recent period (2005-2014), as it probably could selectively eat up the largest specimens (R^2=0.4, p=0.049).



How copepod biomass could influence the year-class herring biomass in the successive year?

Fig.5. The study suggested that the potential role of *L.macrurus* in herrings' diet increased in the second half of the observation period. The species in combination with a reduced biomass of *E.affinis* probably became an important factor also in the survival of the herring larvae. The results of linear regression analysis showed that the copepod *E.affinis* and *L.macrurus* biomass together (particularly older copepodites) could explain up to 80% of the variation in 1-year-old herring biomass in the successive year (p=0.0011).



MATHERIAL AND METHODS

✓ To identify recent changes in the long-term copepod biomass dynamics in the Gulf of Riga, we used May data from 1990 till 2014, which were obtained from the research institute's BIOR database, but herring biomass data were derived from the Gulf of Riga herring stock assessment (ICES 2015).

✓ Monotonous changes in copepod long-term dynamics were determined by performing the non-parametric Mann-Kendall test.

✓ In order to identify shifts in mean biomass of copepods, we performed analysis using "changepoint" package (Killick and Eckley 2014) in R software version 3.1.3. In addition, we performed a Wilcoxon test to obtain p-values, which would describe the statistical significance of the shifts.

✓ To ascertain the effect of various factors (e.g. water temperature, salinity, oxygen, 1-year-old herring, 2-8 year-old herring) on the dynamics of copepod species, we performed multiple linear regression analysis, which included the above-mentioned factors and the year of the changes.

✓ In order to specify the structural changes in copepod community and food web, we analysed the dynamics of mean individual weight (B/N) and determined the possible predator-prey interactions using linear regression analyses in different time periods.

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