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Predicting the Impact of Climate Change on the Distribution of the Key Habitat-Forming Species in the Ne Baltic Sea

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Background

The Baltic Sea is expected to face severe changes in environmental conditions by the end of the 21st Century, caused by ongoing climate change. The Baltic Sea hosts a mixture of aquatic vegetation of marine, brackish and freshwater origin, living often close to their physiological limits and even small changes in the environment can dramatically affect species. Loss or decrease of habitat-forming species severely affects the ecological stability and functioning of marine ecosystems. In the Baltic Sea, such special, structuring species are large perennial macroalgae *Fucus vesiculosus* and *Furcellaria lumbricalis* on hard seabed and eelgrass *Zostera marina* and charophytes on soft seabeds. It is essential to forecast changes in the distribution of valuable species in order to provide data for marine environmental protection and management decisions.

Aims of the study

(1) predict the current and future distribution of key habitat-forming species in the NE Baltic Sea
(2) elucidate which species potentially benefit or are adversely impacted by climate change
(3) assess the contribution of environmental variables in predicting the distribution for the species

Methods

The study was conducted in Estonian coastal waters in the NE Baltic Sea. Data from 11,474 benthic sampling sites from years 2005–2015 were used as an input for a mathematical model to predict the occurrence of the studied species. The abiotic environmental variables in this study included water depth, wave exposure, salinity, sediment type and temperature.

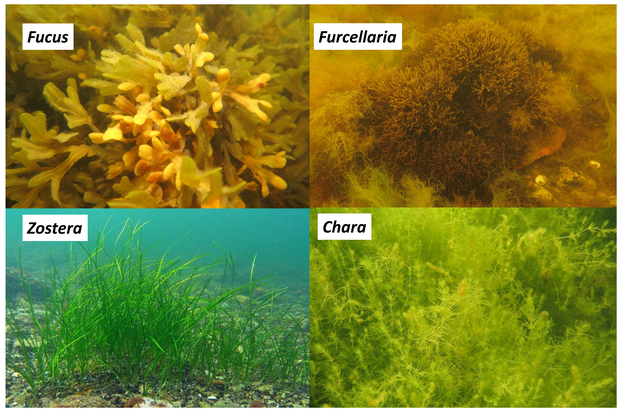
Future climate scenario

- A1B emission scenario, based on an assessment of the future developments and emissions of CO2 and other greenhouse gases (Nakićenović et al., 2000)
- seasonal means for winter and summer water salinity and temperature were used for the period 2070–2099
- uniform 10% increase in annual mean wind speed
- same depth and sediment data was used in the present and future scenario models

Modeling

The predicted distributions of habitat-forming species were modeled using the boosted regression trees (BRT) method. Models with tree complexity of 5 were built, the learning rates of models were set to 0.005 and the bag fraction was set at 0.5. Model predictions were calculated for both, present and future climate scenarios

Studied species



Results

Depth was the most influential environmental variable in predicting the spatial distribution of species (Fig. 1). The distribution extent of all marine species was similar (Fig. 2). Based on the modeling, the climate change will cause a significant reduction of the distribution area of *Zostera* and *Furcellaria* (Fig. 3). Unlike the other species, the distribution area of charophytes will probably increase in the future.

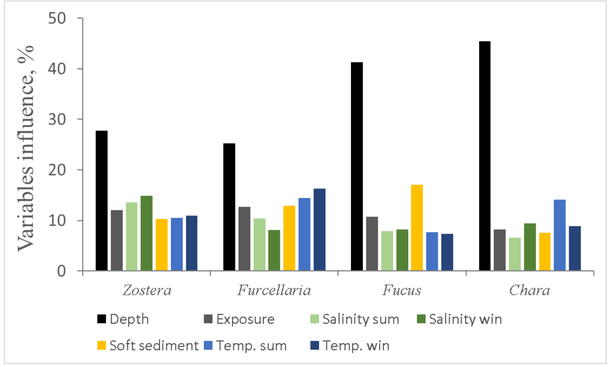


Fig. 1. Influence of environmental variables in predicting species distribution in BRT models. Higher values indicate higher importance. Abbrevations: sum=summer, win=winter, temp=temperature.

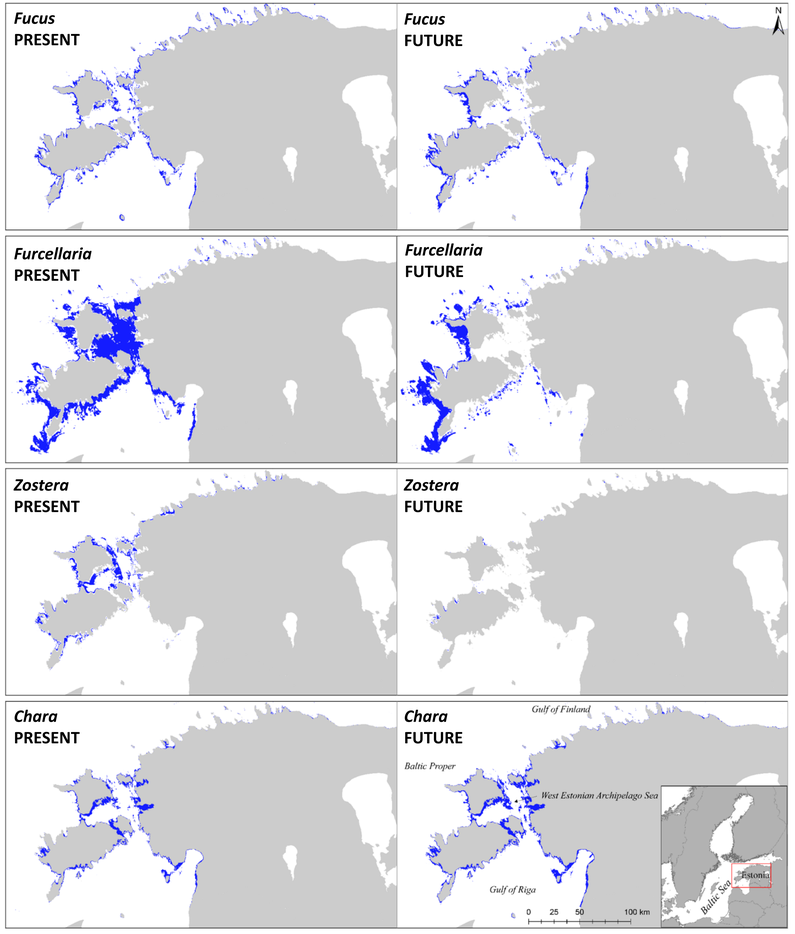


Fig. 2. Distribution of species (blue color) as predicted by the BRT models for present and future climate scenarios in Estonian coastal waters, NE Baltic Sea.

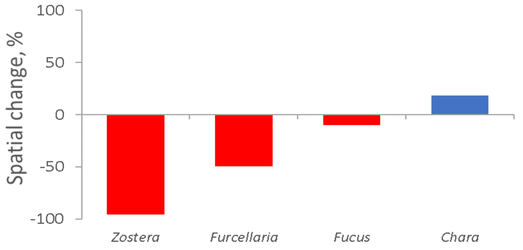


Fig. 3. Change of spatial distribution of habitat-forming species.

Predicted changes in future

- Decrease of salinity:
  - ✓ photic area with salinity over 4 expected to decrease more than 40% in 100 years perspective
  - ✓ possible extinction of the unique loose-lying red algal community dominated by *Furcellaria* in the Baltic Sea
  - ✓ dramatic loss in the occurrence of *Zostera*
- Rising temperature:
  - ✓ elongation of growth season can benefit some species
  - ✓ reduced oxygen concentrations
  - ✓ promoted the dispersal of invasive species

Conclusions

- The climate change may cause a significant reduction of the distribution of valuable habitat-forming species like *Zostera* and *Furcellaria*.
- Charophytes are potential winners by probably increasing their distribution in the future.
- Charophytes are not able to replace the niche of the other key habitat-forming species due to different substrate, wave exposure and salinity preferences.

Acknowledgements

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References

Nakićenović, N.; Alcamo, J.; Davis, G.; DeVries, B.; Fenhann, J.; Gaffin, et al., 2000. Special report on emissions scenarios: a special report of Working Group III of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

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