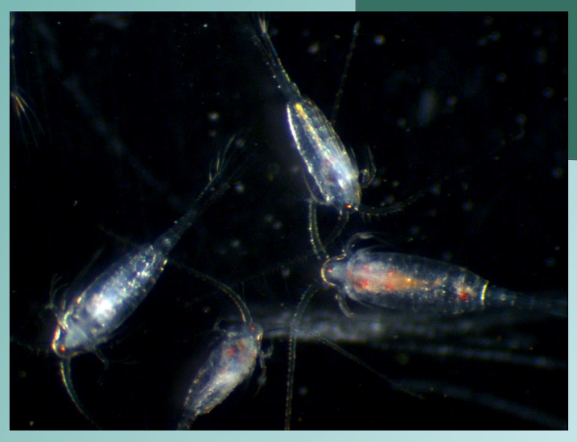
EVALUATING ZOOPLANKTON INDICATORS USING SIGNAL DETECTION THEORY



Picture: Maiju Lehtiniemi

Susanna Jernberg*, Maiju Lehtiniemi, Laura Uusitalo

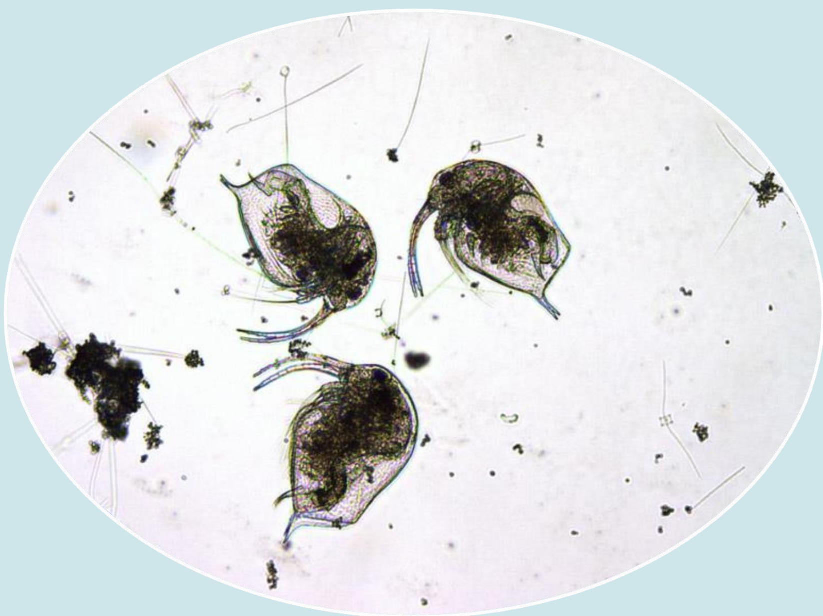
Finnish Environment Institute (SYKE)

***contact: susanna.jernberg@ymparisto.fi**

INTRODUCTION

Indicators of the state of the marine ecosystem are used to help managers conserve biodiversity and guarantee the sustainable use of marine resources. Good indicators are scientifically valid, ecologically relevant, respond to pressures, and it is possible to set target levels for them.

Zooplankton mean size and total abundance has been proposed as a food web indicator in the Baltic Sea [1]. Zooplankton are an important link in the food web, transferring energy from primary producers to fish (ecological relevance). Eutrophication increases the abundance of smaller zooplankton, thus affecting the abundance and size of the zooplankton, which, in turn, affect their grazing efficiency and desirability as food items to fish (scientific validity). In this study, we used signal detection theory [2] to evaluate the Indicator's response to pressures and ability to set meaningful targets.



Picture: Siru Tasala

Picture: Pro Kala

METHODS

The zooplankton data has been collected during the HELCOM Combine program (years 1979-2014). Herring weight-at-age and chlorophyll *a* were used as a references or "gold standard" for the good state of the environment. The performance of the zooplankton mean size and total abundance were tested in relation to the set references using signal detection theory (SDT). ROC (receiver operating characteristics) curves were drawn and AUC (area under curve) values were calculated for the analysis. Thresholds were proposed for indicator parameters with acceptable AUC value.

If the environment is in a bad condition, the indicator gives an "alarm", a positive signal, and if the environment is in a good condition, the signal is negative (Table 1.). SDT helps to evaluate these properties of an indicator and the following values help to evaluate the indicator performance:

Sensitivity (true positive rate):
TP/(TP+FN)

Specificity (true negative rate):
TN/(TN+FP)

Positive predictive value (PPV):
TP/(TP+FP)

Negative predictive value (NPV):
TN/(TN+FN)

Table 1. The matrix about indicator outcome (predicted) in relation to real environmental state. Each cell would include the number of observations falling into that class.

	Predicted POSITIVES	Predicted NEGATIVES
Real POSITIVES (bad state)	true positives **TP**	false negatives **FN**
Real NEGATIVES (good state)	false positives **FP**	true negatives **TN**

RESULTS AND DISCUSSION

Indicator performance was considered acceptable when AUC exceeded 0.7 and excellent when AUC was 0.8. Our results suggest that the zooplankton mean size is able to reflect the herring weight-at-age status in three out four study areas (fig. 1). The proposed threshold of good environmental status of the zooplankton mean size for each study area with acceptable AUC are presented in table 2. NPV and PPV were also calculated for the thresholds; for example in the Bothnian Bay, the PPV is 78 % which means that if the mean size indicates bad environmental condition, the actual environmental condition is bad with the probability of 78 %.

Zooplankton abundance response to set references was more difficult to evaluate because eutrophication increases the abundance of zooplankton but on the other hand, fish predation decreases it. So there are contradicting pressures which cannot be distinguished by the signal detection theory.

Table 2. Proposed thresholds of zooplankton mean size for the areas that reached the acceptable AUC value. Prevalence of the bad environmental status, the specificity, sensitivity, and positive and negative predictive values are also shown.

Zooplankton mean size (mg)						
Area	Threshold	Prevalence	Specificity	Sensitivity	NPV (%)	PPV (%)
Bothian Bay	0.051	0.66	0.56	0.95	83	78
Åland Sea	0.012	0.79	0.83	0.83	56	95
Gulf of Finland	0.011	0.71	0.80	0.67	50	89

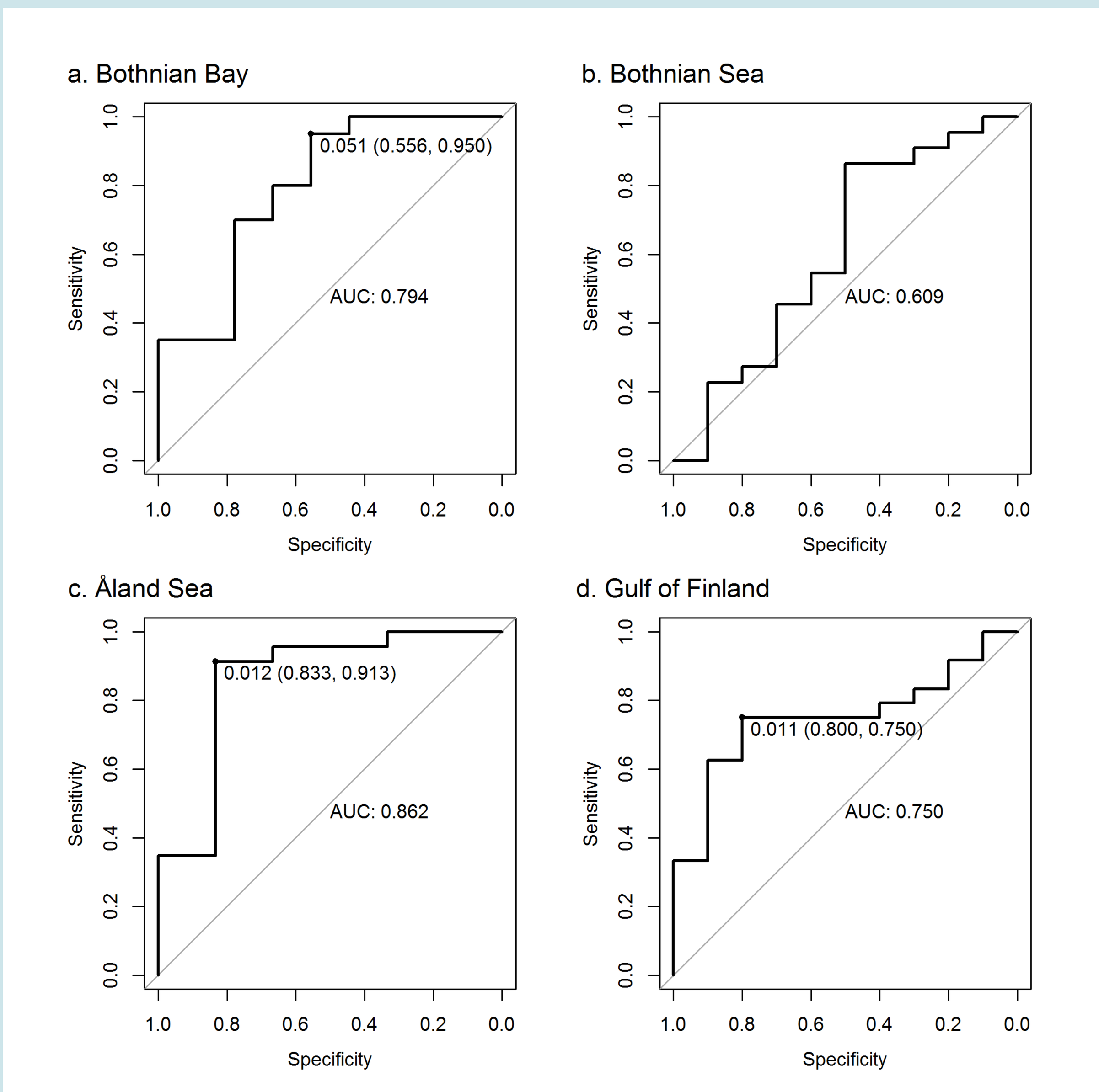


Fig. 1. ROC curves of zooplankton mean size response to herring weight-at-age reference. Proposed thresholds for mean size indicating good environmental status are printed in the figures where the AUC value is considered acceptable (>0.7).

CONCLUSIONS

Our study suggests that the zooplankton mean size is able to reflect the status of the food web in the northern Baltic Sea. Zooplankton abundance did not respond clearly to the set references, probably due to pressures that affect the abundance both positively and negatively. Therefore, it is possible to set meaningful target values for the mean size, but setting them for the zooplankton abundance is not as straightforward.

References:
1. Gorokhova, E., M. Lehtiniemi, L. Postel, G. Rubene, C. Amid, J. Lesutiene, L. Uusitalo, S. Strake, and N. Demereckiene. 2016. Indicator Properties of Baltic Zooplankton for Classification of Environmental Status within Marine Strategy Framework Directive. PLoS ONE 11:e0158326.
2. Murtaugh, P. A. 1996. The Statistical Evaluation of Ecological Indicators. Ecological Applications 6:132-139

Aknowledgements: This study was partly funded by Maj and Tor Nessling foundation and DEVOTES (DEVelopment Of innovative Tools for understanding marine biodiversity and assessing Good Environmental Status) project funded by the European Union under the 7th Framework Programme, 'The Ocean of Tomorrow' Theme (Grant Agreement No. 308392), www.devotesproject.eu.
The poster was also granted ICES travel fund. This work was also partly supported by the BONUS BIO-C3 project that were supported by BONUS (Art 185), funded jointly by the EU, and Academy of Finland.