Development of zooplankton indicators for implementation of MSFD in the Baltic Sea

2010-2013: Discussions at CORESET I and ZEN meetings on indicator properties of zooplankton, with particular focus on Baltic communities

2012-2013: Gathering data sets around the Baltic Sea (only HELCOM monitoring data!) for testing. Meetings and remote work.

2013-2015: Defining principle for setting reference conditions and evaluating indicator performance. CORESET II, remote work, writing.

2013-2016: ZOOIND project: evaluation of Swedish data, defining reference conditions and targets.

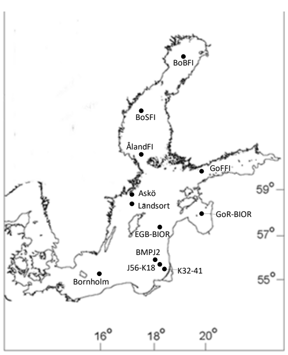
Elena Gorokhova (*elena.gorokhova@su.se*)

Putative indicators evaluated in ZEN-QAI project

- •Total abundance,
- •Total biomass
- •Copepod abundance
- •%Copepod abundance
- •Copepod biomass
- •%Copepod biomass
- •Microphagous species biomass
- •%Microphagous species biomass
- •Cladocera/Copepoda ratio
- •(Rotifera+Cladocera)/Copepoda ratio
- •**Mean size**
- •Zooplankton/Phytoplankton

Some were found useful in all areas, some - as SUPPORTING indicators in specific areas!

Metadata used for indicator evaluation



Long-term data for:

BB, BS, GoF - Finland
NBP - Sweden
GoR, GB - Latvia
SEB - Lithuania
SB - Germany
K - Sweden

PLOS | ONE

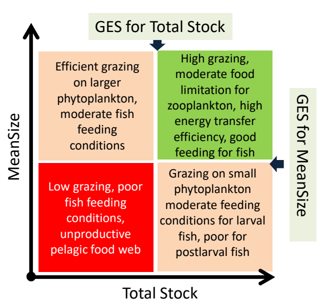
RESEARCH ARTICLE

Indicator Properties of Baltic Zooplankton for Classification of Environmental Status within Marine Strategy Framework Directive

Elena Gorokhova[1]*, Maiju Lehtiniemi[2], Lutz Postel[3], Gunta Rubene[4], Callis Amid[1], Jurate Lesutiene[5], Laura Uusitalo[2], Solvita Strake[6], Natalja Demereckiene[7]

- Results of evaluation (11 indicators)
- Data sources
- Concept for MSTS

MSTS: Zooplankton mean size and total stock



- combination of **scores** for mean body size in zooplankton community and total ZP stock;
- **discriminate** relatively well between reference and stressed conditions
  ► PLS-DA, GLM;
- ecologically **meaningful** (mechanisms of responses can be explained);
- are **not redundant** with each other.

Indicator assessment: main steps

Data inventory
- Zooplankton data (monitoring programs, recipient control programs, historical data, etc.).

Reference periods?

- EQR (or Chlorophyll data)
  - ✓ HELCOM Assessment of Eutrophication status in the Baltic Sea, local data
- Sprat or herring body condition index (WAA or Fulton index)
  - ✓ ICES reports, local data

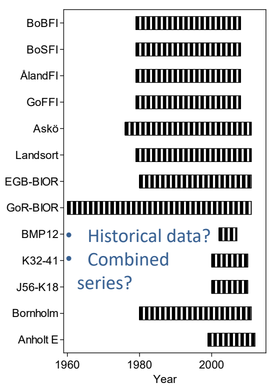
Data requirements: SAMPLING

- HELCOM-guided zooplankton monitoring
  - ✓ WP2, 90-100 µm
- Several sampling occasions during June-September
  - ✓ Several stations can be combined (if reasonable);
  - ✓ Summer dynamics of major groups and species contributing >5% on the abundance or biomass basis should be covered;
  - ✓ Low-frequency sampling (1-2 samples/year) will result in high uncertainty
- Depth-resolved sampling is currently not incorporated into the indicator assessment
  - ✓ Average value for the water column based on depth-specific TZA and TZB

Data requirements: ANALYSIS

- HELCOM-guided zooplankton analysis
  - ✓ Quality Assurance Practices for zooplankton analysis (accuracy and error assessment, ring tests, etc.)
  - ✓ Species according to ZEN taxa list
  - ✓ Biomass calculations based on individual weights
    - ➢ Hernroth L (1985) Recommendations on methods for marine biological studies in the Baltic Sea. Mesozooplankton biomass assessment. The Baltic Marine Biologists, Publ. 10.
- For indicator calculations, only selected groups/stages should be considered

Time series



- Most – from early 1980-ties

  → >12 years are usable
- The longer – the better?

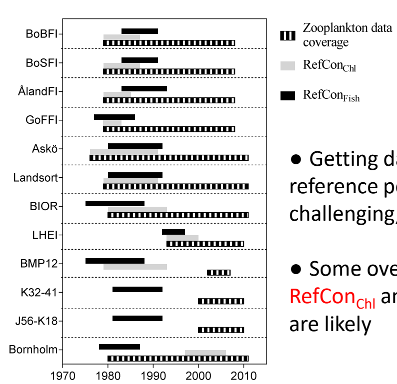
  →Not necessarily

Philosophy for defining reference periods: 2 approaches

(1) all data available (i.e. all years of the monitoring period, including the most recent year) → trend analysis

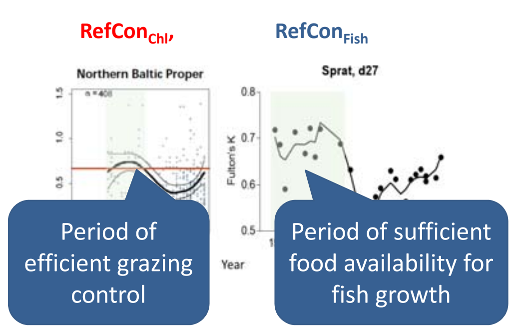
(2) a window of the available data corresponding to the selected reference period, i.e., years representing basin-specific reference conditions for

- **RefCon$_{Chl}$,** defined using a period with environmental quality ratio (EQR) >0.67 and historical data on chlorophyll-a (Figs 2.13; HELCOM 2009); this indicates in-GES state, food webs not measurably affected by eutrophication;
- **RefCon$_{Fish}$** periods of successful foraging in the relevant ICES subdivisions



- Getting data for reference periods is challenging, but possible
- Some overlaps between RefCon$_{Chl}$ and RefCon$_{Fish}$ are likely

Philosophy for defining reference periods: example for Approach 2

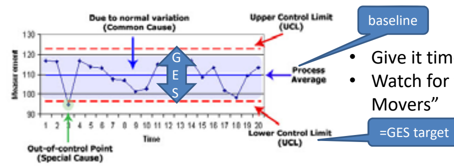


Indicator assessment: main steps

Calculations
- Z-scores (zero mean, unit variance)
- CuSum (Cumulative Sum) statistics
- Determining baseline and in-GES values
- Evaluation of the indicator value in relation to GES

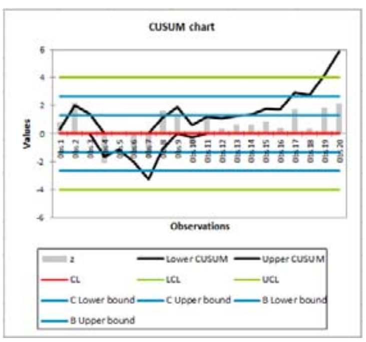
Control charts

What is control chart?

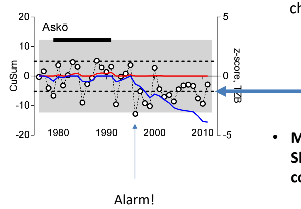


- Give it time!
- Watch for the "Big Movers"

What is CuSum? Accumulated deviations from the baseline

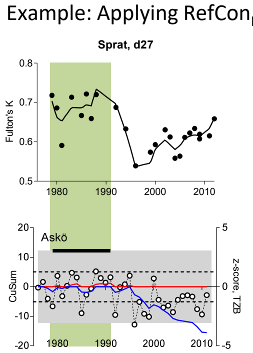


Combined Shewhart and CuSum charts



- Shewhart - sudden shifts
- CuSum – gradual and sustained changes
  - **Out of control periods** were defined as CuSum: ±5*SD for LCL (=SixSigma approach)
- **Most informative when both Shewart and CuSum charts are considered**

Example: Applying RefCon$_{Fish}$ reference period to TZB

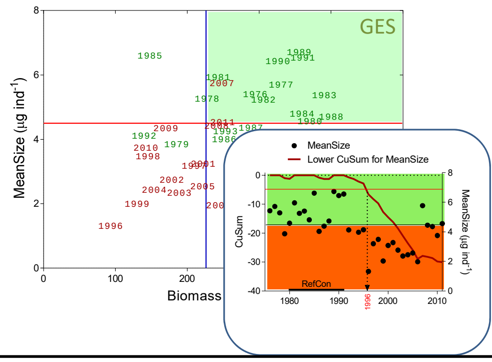


- Sprat Fulton's K for the nearest subdivision.
- Consider also stock dynamics for young herring and sprat (avoid using years with lowest stocks).
- Calculate mean (μ) and σ for TZB using data for 1979-1992.
- Calculate z-scores and CuSum for each observation (including 1979-1992) using μ and σ values obtained in the previous step.
- Plot z-scores and CuSum and examine whether any of the control charts cross their respective limits.

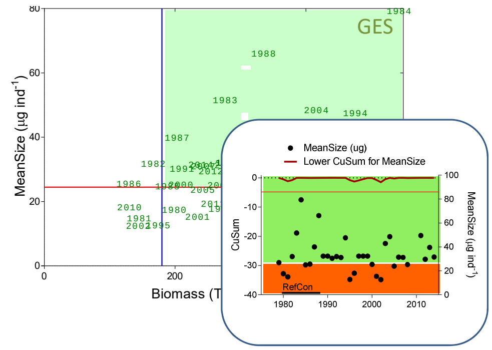
Zooplankton community is in-GES, when

- Lower CuSums of **both** MeanSize and stock (TZA or TZB) are ABOVE their respective LCLs, for **both** RefCon$_{chl}$ and RefCon$_{Fish}$
  - LCL values for RefConChl and RefConFish are compared and the highest is adopted as the target
  - Example: RefConChl: MeanSize - 5 μg, TZB – 200 mg/m^3
  - RefConFish: MeanSize - 8 μg, TZB – 100 mg/m^3
  - LCL is set at 99% CI

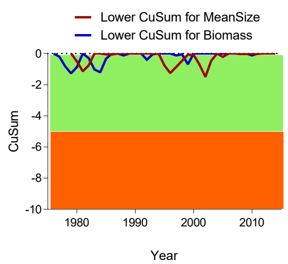
Northern Baltic Proper



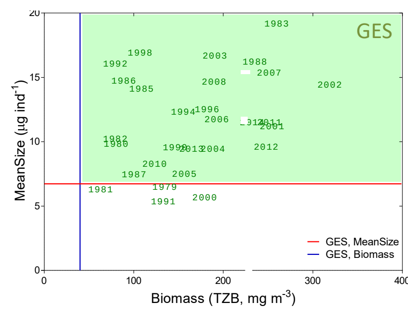
Bothnian Bay



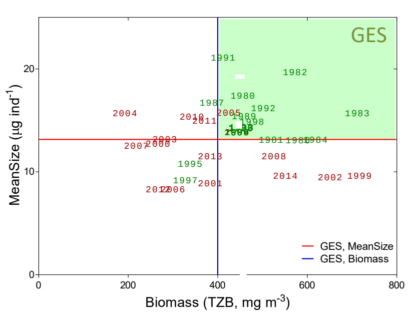
Bothnian Bay: A simplified way to present the outcome



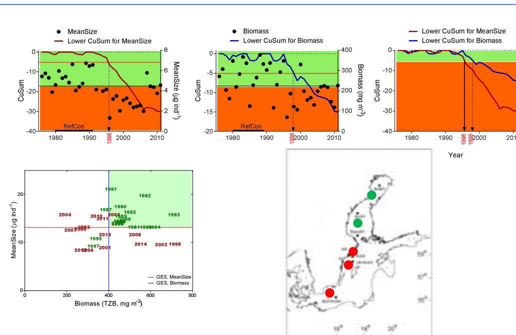
Bothnian Sea



Bornholm



Presentation tools can vary



Metrics used to calculate MSTS: no major adjustments in current monitoring are needed

- **Total zooplankton abundance (TZA)** obligatory
  - HELCOM guidelines
  - Species, stages – business as usual.
- **Total zooplankton biomass (TZB)** obligatory
  - calculated using TZA and individual weights (species- and stage-specific) – revised!
- **Mean zooplankter size (MeanSize)**
  - TZB:TZA ratio

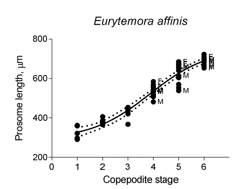
TACK!

- **ALL MONITORING PERSONNEL**
- **HELCOM**
  - HELCOM staff
  - funding
- **ZEN group**
- **NV and HaV**

Biomass validation

- Species table was complemented with individual weights used by different labs
  - One lab is using length measurements and regressions (most problematic results)
- Not all are using standard BMB weight values but the origin of the values used is not documented
- How much of intraspecific variation is actually there?
- Do standard weights provide adequate estimates?

- How much of intraspecific variation is actually there?



- 58 individuals from BP
- Stage-specific measurements, 6 individuals per stage
- $R^2 = 0.94$
- We use groups:
  - CI-III
  - CIV-V
  - M
  - F

Between-stage variability is larger than within-stage, → estimated mean size of pooled stages is negligibly affected

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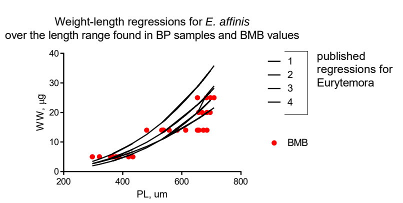
Do standard weights provide adequate estimates?



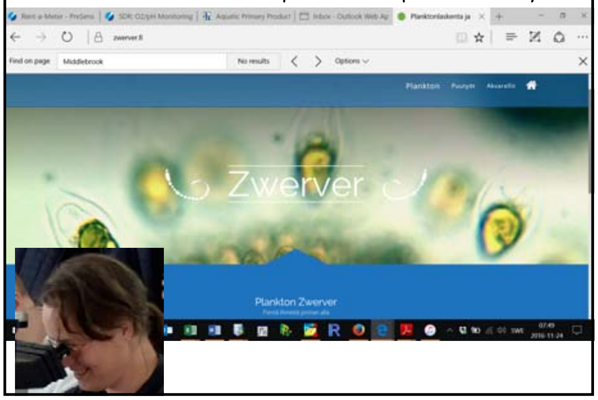
Test-measurements from Satu (BP)

1 Watkins J, et al (2011) Length-weight regressions for zooplankton biomass calculations – A review and a suggestion for standard equations. Cornell Biological Field Station Publications and Reports : 1-17.
2 Hoffmeyer MS, Torres ER (2001) Morphometric variables and individual volume of Eurytemora americana and Acartia tonsa females (Copepoda, Calanoida) from the Bah´ýa Blanca estuary, Argentina. Hydrobiologia 459: 73-82.
3 Ara K (2001) Length-weight relationships and chemical content of the planktonic copepods in the Cananeia Lagoon estuarine system, Sao Paulo, Brazil. Plankton Biol. Ecol. 48: 121-127.
4 Escaravage V, Soetaert K (1993) Estimating secondary production for the brackish Westerschelde copepod population Eurytemora affinis (Poppe) combining experimental data and field observations. Cah. Biol. Mar. 34: 201-214.

Biomass validation

- Species table was complemented with individual weights used by different labs
  - One lab is using length measurements and regressions (most problematic results)
- Not all are using standard BMB weight values but the origin of the values used is not documented
- During the previous discussions, the idea of real differences in ZP body size that exist between areas and that is not sufficiently reflected in BMB values was stressed → let's check.

Satu Zwerver: Consultunt specialized in plankton analysis



Only summer samples

- samples have arrived from
6 countries / 9 institutes

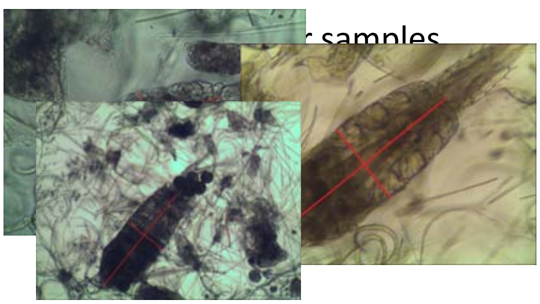
Danmark	Fishlab
Germany	GEOMAR / Leibniz-Institut f. Ostseeforschung Warnermünde
Latvia	Institute for Food Safety, Animal Health and Environment (BIOR)
Lithuania / Latvia	Open access centre for marine research
Sweden	Stockholm university / Umeå marine Science Centre
Finland	SYKE /Turku university

- 87 bottles, some already pooled
  - 58 open sea samples
  - 29 coast samples

- 4000 measurements (length, width)
- Inter-area comparison of body size
- Collection of images for different zooplankton species/stages

Open access materials

r samples



- 4000 measurements (length, width)
- Inter-area comparison of body size
- Collection of images for different zooplankton species/stages

Open access materials

What will be done

Stations/Specis	Total species
Bothnian Bay	5
Bothnian Sea	8
Gulf of Finland	9
Northern Baltic Proper	9
Gulf of Riga	8
Eastern Baltic Proper	10
Southern Baltic Proper	11
Kattegat	9

- Estimated number of species for analysis
- 28 measurements per copepod species covering the ontogenetic size variation
- Size comparisons (with ZEN) among areas
- Calculated individual weights using generic regressions for Copepoda, Bosmina, Keratella, Synchaeta, etc.
- The results will show whether we should continue using BMB values or make new recommendations based on the measured values.

Measuring zooplankton
in the Baltic Sea 2016-2017

February-May
Overall planning

June-October
Samples arriving

October-November
Amount of samples?
Preparing the measurements
- samples
- stages
- cameras

Amount of measurements?

December - January
Measuring

February
Reporting

Company Zwerver Arkadinatie 2, 25700 Kemiö, Finland www.zwerver.fi

HOW to proceed with MSTS calculations now?

- As for now – for MSTS calculations we all should use the last BMB recommendations for biomass assessment of mesozooplankton in the Baltic Sea;
- If a standard weight for a species is missing there (VERY few!), use weights for another species of similar body length
- We can ask Satu to make an additional effort for species not covered by BMB manual
- Reach other ZEN members when setting weights for species absent in the BMB recommendations