

Name of indicator	2.9 Population structure of <i>Macoma balthica</i>
Type of Indicator	State indicator
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Description of the indicator	Deviation from the natural size distribution within the population of a species can be used as an indicator of disturbance in reproduction and/or survival, thus indicating the state of the population. Moreover, size structure can indicate the availability and quality of prey for predators on the species. Long-lived benthic species are suitable as indicators of population structure since they integrate changes in the environment over several years. Different life stages can vary in their sensitivity and response to disturbances, responding with low survival or impaired reproduction (Jahn <i>et al.</i> 1997). This indicator describes the size distribution of <i>Macoma balthica</i>, the dominant, long-lived bivalve species on soft bottoms in the northern Baltic Sea. Occurrence of new recruits, juveniles as well as adults in all year classes in a population of <i>M. balthica</i> indicate that no severe disturbance has taken place and that the population is in a good state. Lack of juveniles or a year class of adults demonstrates adverse conditions. As the natural size distribution of <i>M. balthica</i> varies geographically and also by depth due to variation in growth rates (Segerstråle 1960, Gilbert 1973), targets have to be adjusted to local conditions.
Relationship of the indicator to marine biodiversity	This indicator describes the complexity of benthic habitats and reflects the population condition and abundance/biomass of a dominant long-living benthic species. Large specimens have an important impact on the functioning of the ecosystem and ecosystem services such as energy flow and nutrient cycles (Norkko <i>et al.</i> 2013), thus this indicator also relates to the functional diversity of soft sediment habitats. Additionally, when the indicator value is within the GES limits the <i>M. balthica</i> -population can provide preferred prey-size for predators like common scooter, velvet scooter, flounder and roach (Dunrick <i>et al.</i> 1993, Karlson <i>et al.</i> 2007, Lappalainen <i>et al.</i> 2005).
Relevance of the indicator to different policy instruments	Size distribution of <i>Macoma balthica</i> could be used in describing the following descriptors under the EU Marine Strategy Framework Directive: 1.3 Population condition; 1.6 Habitat condition; 4.3 Abundance/distribution of key trophic groups/species; 6.2 Condition of benthic community. Size distribution of <i>M. balthica</i> also reflects the HELCOM Baltic Sea Action Plan biodiversity goal 'favourable conservation status of Baltic biodiversity' and the ecological objectives for 'thriving and balanced communities of plants and animals'.
Relevance to commission decision criteria and indicator	1.3. Population condition 1.3.1. Population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/ mortality rates)
Method(s) for obtaining indicator values	Data needed for this indicator can be obtained by length measurements of <i>Macoma balthica</i> in samples from e.g. regular monitoring programs. To avoid the high variation caused by variations in the number of settling recruits (Strasser <i>et al.</i> 2001, Beukema <i>et al.</i> 2010), only individuals larger than 5 mm are included in the indicator. This is also roughly the size when maturity occurs in <i>M. balthica</i>, thus all adult year classes are included in the indicator. The indicator value is the median length of <i>M. balthica</i> larger than 5 mm. Since it is typical that strong year classes are not produced every year in <i>M. balthica</i> populations (Strasser <i>et al.</i> 2001, Beukema <i>et al.</i> 2010), it is recommended that a 5-year average of the median length is used as the indicator value. Samples considered to be from the same <i>M. balthica</i> population can be pooled to obtain a more confident evaluation of the population condition and a greater spatial coverage. To obtain a reliable estimate of the population size distribution the density of adult <i>M. Balthica</i> should be at least 100 individuals per square meter.
Documentation of relationship between indicator and pressure	An undisturbed population of <i>Macoma balthica</i> consists of individuals spanning the whole size range (Leppäkoski 1975). Populations disturbed by e.g. eutrophication, harmful substances, or physical disturbance will deviate from this pattern as an effect of increased mortality and failure in recruitment leading to lacking year-classes (Jahn <i>et al.</i> 1997). An indicator value below the GES limit indicates lack of large individuals and occurrence of frequent disturbance, such as seasonal hypoxia, restricting the population to reach old age. On the other hand, an indicator value higher than the GES limit shows that the population consists of only old individuals and that the recruitment is impaired, i.e. not sustainable. Pressures that have an impact on the <i>M. balthica</i> population are illustrated in Fig. 1. Spatial distribution of median length of <i>Macoma balthica</i> in the Gulf of Riga in recent data shows significant relationship with HELCOM Baltic Sea Impact Index (BSII) (Fig. 2).
Geographical relevance of	2. Regional

indicator	
How Reference Conditions (target values/thresholds) for the indicator were obtained?	Reference conditions can be obtained from undisturbed areas, historical data or theoretical population growth models. Reference conditions for MARMONI area FIN, i.e. the coastal area of southwestern Finland were obtained from historical data (Segerstråle 1960) covering a 10-year period (1926-1935) in Tvärminne, SW Finland (Fig. 3). The target value was set by first calculating 5-year mean size distributions for the 10-year period (see fig. 2 for an example). Using these distributions the mean median length and standard deviations of individuals >5 mm were calculated. The mean median length was 11.04 mm, which is considered as the target value. To assess the influence of more eutrophic conditions, the target was also tested by comparing more recent time-series with near-bottom oxygen conditions. Additionally, to serve as a food web indicator, the target was also checked against preferred prey size of predators (common scoter, velvet scoter, flounder and roach) on <i>M. balthica</i>. Preferred mussel prey size for these predators was found to be 10-15 mm (Dunrick <i>et al.</i> 1993, Karlson <i>et al.</i> 2007, Lappalainen <i>et al.</i> 2005), thus well complying with the target set by historical data. Reference conditions for MARMONI area Gulf of Riga were obtained from historical data (BaltNIIH unpublished) covering a 3-year period (1958-1961) (Fig. 4). The mean length of individuals >5 mm from this data was determined to 11.44 mm, which is considered as the target value for the Gulf of Riga.
Method for determining GES	GES is determined through the target value determined through historical data; indicator values falling within two standard deviations of the target value indicate GES. For SW Finland indicator values within the interval 8.6-13.5 mm indicate GES. In turn, for the Gulf of Riga indicator values within the interval 8.6-14.5 mm indicate GES. Due to geographically varying growth rates target values need to be set according to local conditions.
References	Beukema JJ, Dekker R, Philippart CJM (2010) Long-term variability in bivalve recruitment, mortality, and growth and their contribution to fluctuations in food stocks of shellfish-eating birds. <i>Mar Ecol Prog Ser</i> 414:117-130 Dunrick J, Christensen KD, Skov H & Danielsen F (1993) Diet of the common scoter <i>Melanitta nigra</i> and velvet scoter <i>Melanitta fusca</i> wintering in the North Sea. <i>Ornis Fennica</i> 70:215-218. Gilbert MA (1973) Growth rate, longevity and maximum size of <i>Macoma balthica</i> (L.) <i>Biol Bull</i> 145:119:126 Jahn A, Janas U, Theede H, Szaniawska A (1997) Significance of body size in sulphide detoxification in the Baltic clam <i>Macoma balthica</i> (Bivalvia, Tellinidae) in the Gulf of Gdansk. <i>Mar Ecol Prog Ser</i> 154:175-183 Karlson AML, Almqvist G, Skora KE & Appelberg M (2007) Indications of competition between non-indigenous round goby and native flounder in the Baltic Sea. <i>ICES Journal of Marine Science</i> 64:479-486 Lappalainen A, Westerborn M & Heikinheimo O (2005) Roach (<i>Rutilus rutilus</i>) as an important predator on blue mussel (<i>Mytilus edulis</i>) populations in a brackish water environment, the northern Baltic Sea. <i>Marine Biology</i> 147:323-330 Leppäkoski E (1975). Assessment of degree of pollution on the basis of macrozoobenthos in marine and brackish-water environments. <i>Acta Academiae Aboensis, Ser B, Vol 35(2)</i>, 90 p. Norkko A, Villnäs A, Norkko J, Valanko S & Pilditch C (2013) Size matters: implications of the loss of large individuals for ecosystem function. <i>Scientific Reports</i> 3:2646 Segerstråle SG (1960) Investigations on Baltic populations of the bivalve <i>Macoma balthica</i> (L.). Part I: Introduction; Studies on recruitment and its relation to depth in Finnish coastal waters during the period 1922-1959; Age and growth. <i>Commentationes Biologicae Societas Scientiarum Fennica</i> 23. 72 pp Strasser M, Hertlein A, Reise K (2001) Differential recruitment of bivalve species in the northern Wadden Sea after the severe winter of 1995/96 and of subsequent milder winters. <i>Helgol Mar Res</i> 55:182-189

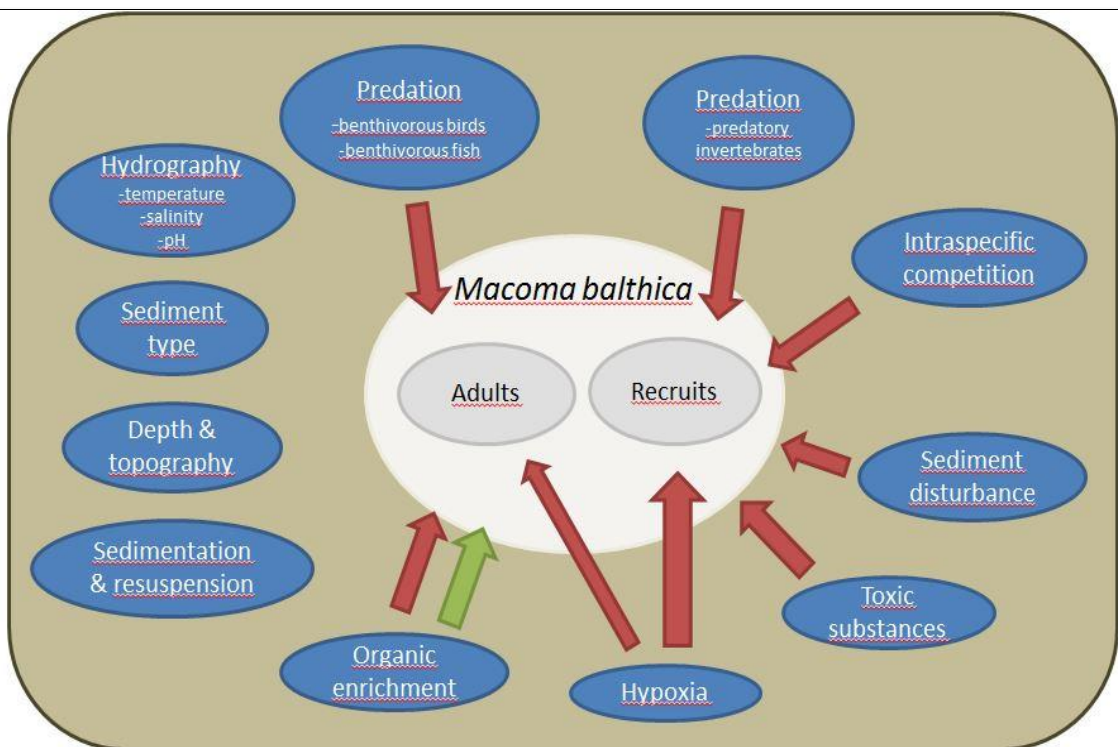


Figure 1. Factors influencing *Macoma balthica* and its population structure. Red arrows indicate a negative effect, whereas the green arrow indicates a positive effect. The abiotic factors on the left represent other habitat structuring factors influencing the occurrence and/or growth rates of *M. balthica*.

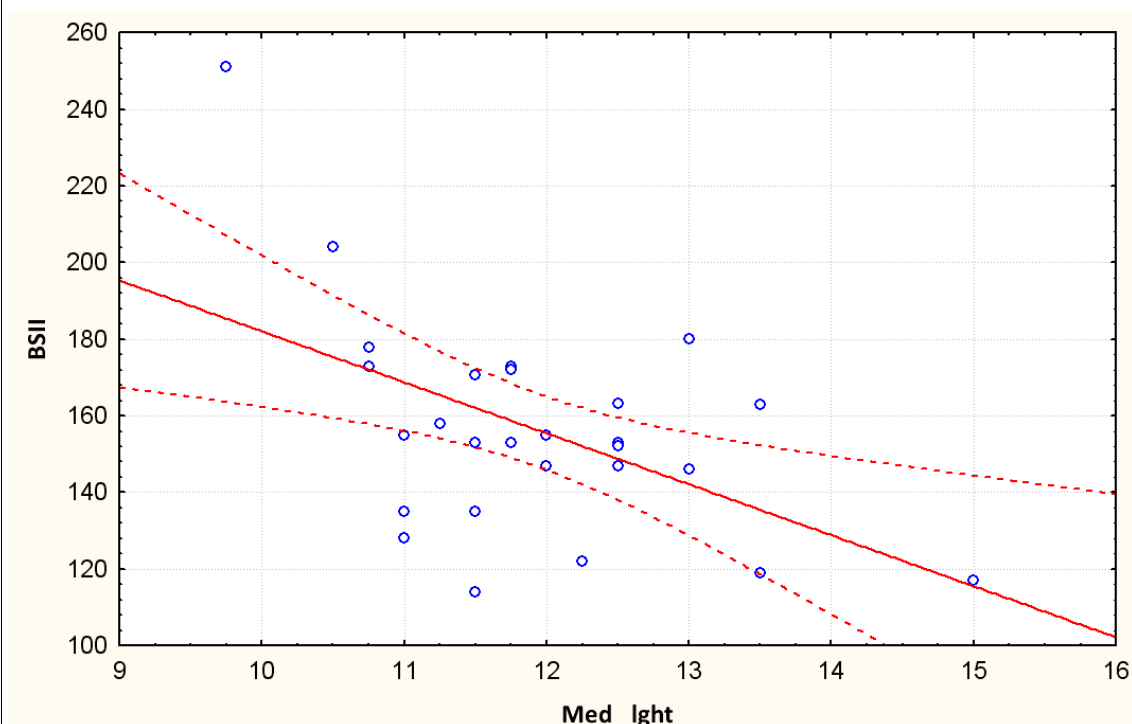


Figure 2. Relationships between Baltic Sea Impact Index (BSII) and median length of *Macoma balthica* >5 mm in the Gulf of Riga in 2010-2011 ($r=0.5138$, $p=0.0052$, $n=28$).

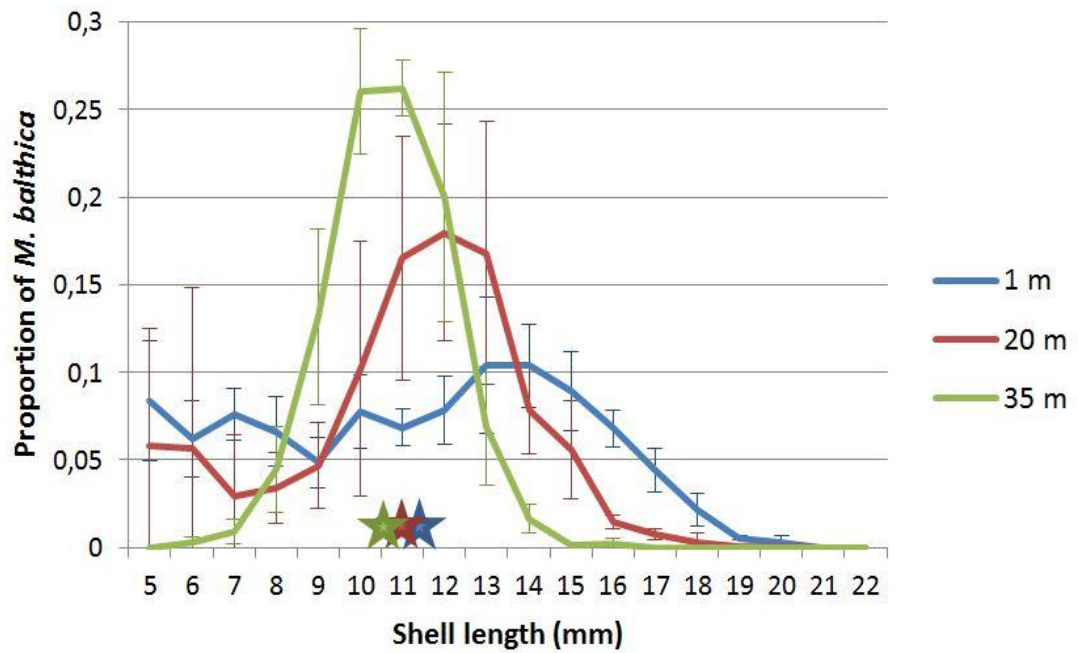


Figure 3. An example of obtaining the indicator value. The lines show historical (1926-1930) 5-year average length distributions ($\pm$ standard deviation) of *M. balthica* at three different depths (based on Segerstråle 1960). The stars indicate the 5-year average median length of *M. balthica* larger than 5 mm at respective depth.

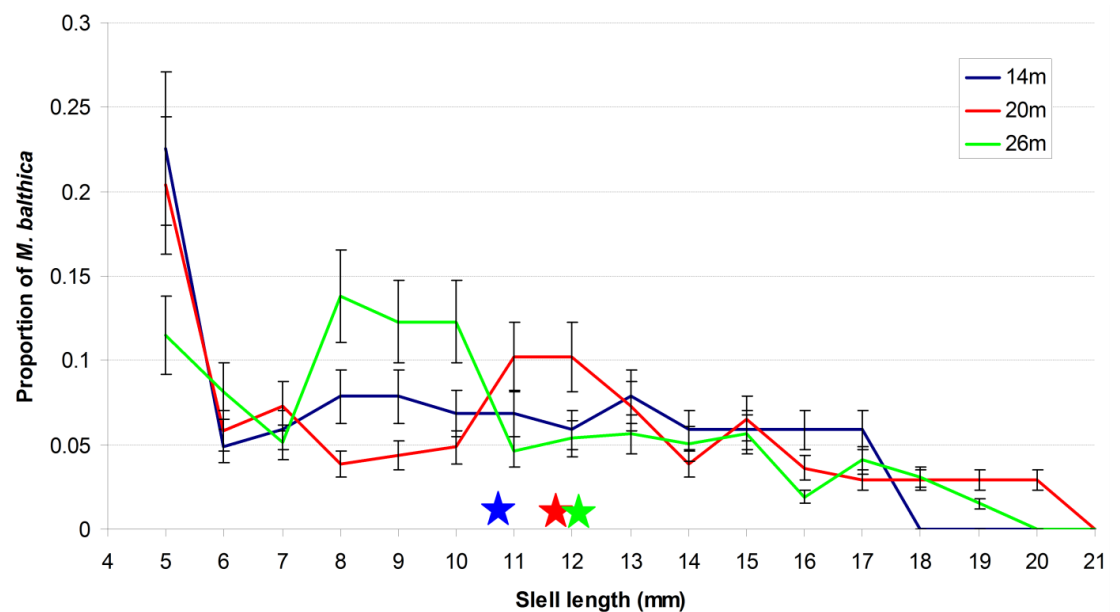


Figure 4. An example of obtaining the indicator value for Gulf of Riga. The lines show historical (1958-1961) 3-year average length distributions ($\pm 20\%$) of *Macoma balthica* at three different depths. The stars indicate the 3-year average median length of *M. balthica* > 5 mm at respective depth.