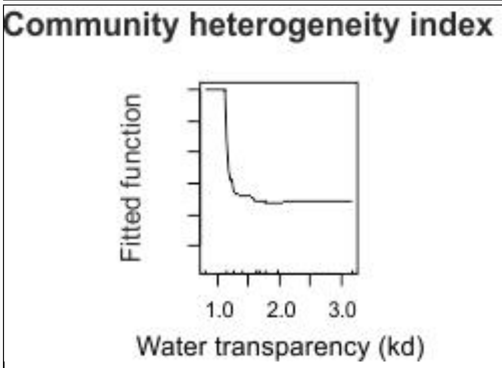
Name of indicator	2.12 Community heterogeneity (CH)
Type of Indicator	State indicator
Author(s)	Jonne Kotta, Merli Pärnoja
Description of the indicator	The index analyses heterogeneity of communities at the landscape scale. In order to do so we quantify the relative importance of scale-specific variability of macroalgal and benthic invertebrate communities. Using multivariate data analyses dissimilarities between pairs of samples are calculated using a zero-adjusted Bray-Curtis coefficient (e.g. using PRIMER software package). The coefficient is known to outperform most other similarity measures and enables samples containing no organisms at all to be included. Then the geographical distances between the studied sites are calculated and the distances are related to the dissimilarity matrices of biota. The ratio between the distance-based mean dissimilarities and its standard deviation is used as a proxy of the community heterogeneity at landscape scale. As such the index estimates the complexity of the spatial patterns of benthic communities with higher values of the statistic indicating more distinct and less variable (i.e. potentially less disturbed) communities at the studied spatial scale.
Relationship of the indicator to marine biodiversity	The development of this diversity index is based on the evidence that various stressors operate at different spatial scales. The index allows estimating simultaneously the relative contribution of different stressors operating at various spatial scales. The CH index quantifies the diversity of seascapes i.e. beta diversity.
Relevance of the indicator to different policy instruments	There is a potential to use the indicator for assessment of MSFD descriptors 1, 2, 4, 5, 6 and in the frame of the Habitats Directive.
Relevance to commission decision criteria and indicator	1.6. Habitat condition 1.7. Ecosystem structure 1.7.1. Composition and relative proportions of ecosystem components (habitats and species)
Method(s) for obtaining indicator values	The equation of a zero-adjusted Bray-Curtis coefficient is: $dBCC\,(i,j) = \frac{\sum_{k=0}^{n-1}\lvert yi,k - yj.k\rvert}{[2 + \sum_{k=0}^{n-1}(yi,k + yj,k)]}$ In the equation dBCC is the Bray-Curtis dissimilarity between the objects i and j; k is the index of a variable and n is the total number of variables y. A zero-adjusted Bray-Curtis coefficient includes a virtual dummy variable being 1 for all objects. Consequently, the result is not undefined, when the variables among two objects are entirely 0. In the numerator this variable subtracts to zero and in the denominator it sums to 2. The equation of the scale-specific community heterogeneity is: $CHi = \frac{mean(dBCCi)}{stdev(dBCCi)},$ where mean(dBCCi) is the mean zero-adjusted Bray-Curtis dissimilarity coefficient and stdev (dBCCi) is a standard deviation of this mean at a predefined spatial scale i. Although response variables can be manifold such as number of species, abundances, biomasses of species, functionality of community etc., in this study benthic species biomasses were used.
Documentation of relationship between indicator and pressure	The CH index responded differentially to the studied environmental variables. The links between environmental variables and index were always the strongest at 5 km spatial scale. At smaller spatial scales the index reflected changes to local ice conditions and/or coastal topography. At 5 km spatial scale, however, the index followed the variability in coastal eutrophication. Thus, this is the scale where eutrophication processes are likely to have the largest effects on coastal environment and at which the impacts of eutrophication on coastal biota should be assessed. The CH index decreased with elevating eutrophication i.e. kd values. However, the relationship was not very strong. An explanation of the observed relationship is as follows. The CH index reflects patchiness in the seascape. It is known that an increased eutrophication tends to homogenize the seascape patchiness by increasing the cover of filamentous algae irrespective of physical water properties and local topography. Besides, eutrophication impoverishes underwater light conditions and therefore further reduces overall biological diversity as in such a low-light environment only a few algal and associated invertebrate species can be found. Consequently, an inverse relationship between

	eutrophication and CH is expected (Kotta *et al*. 2013).
Geographical relevance of indicator	2. Regional
How Reference Conditions (target values/thresholds) for the indicator were obtained?	Due to the lack of historical data of required spatial resolution and extent, the reference condition was set at the upper tail (95th percentile) of the natural variability of the index value in the MARMONI pilot area. This expert judgement is based on the current status of the marine coastal ecosystems and on the established probability distribution of the index value.According to these criteria the reference condition of CH index was set at 18.0.
Method for determining GES	GES was determined using the the European Union Water Framework Directive classification scheme for water quality in the Estonian coastal areas. Specifically, among the eutrophication related variables water transparency was best related to the CH index. Thus, in order to set GES value, a functional relationship between pressure levels (e.g. kd values) and index values was established (the BRT modelling). Then, the existing boundary of water transparency between moderate and good water quality class was used to define the GES boundary of CH index. According to the established criteria the GES value of CH index was 9.0.
References	Kotta, J., Orav-Kotta, H., Pärnoja, M. 2013. Role of physical water properties and environmental disturbances on the diversity of coastal macrophyte and invertebrate communities in a brackish water ecosystem. WIT Transactions on Ecology and the Environment, WIT Press, 77 – 88.
Illustrative material for indicator documentation	 Supplementary figure. The Boosted Regression Tree model on the functional relationship between eutrophication variable and the index calculated at 5 km spatial scale. As a proxy of eutrophication we used the MODIS satellite derived water transparency (kd). The frequency of satellite observations was generally weekly over the whole ice-free period, however, several observations were discarded due to cloudiness. The spatial resolution of satellite data was 1 km. In general, increasing eutrophication is associated with elevated Kd values in our study area.