Name of indicator	2.1 Accumulated cover of perennial macroalgae
Type of Indicator	State indicator
Author(s)	Nicklas Wijkmark
Description of the indicator	This indicator reflects quantity of the perennial macroalgae community measured as accumulated cover, thus indicating biodiversity quantity as the amount of a diverse community of algae and species living on and among the algae. It indicates biodiversity quantity on shallow hard bottoms and may be used simultaneously with a vascular plant indicator for shallow soft bottoms. The measured unit is accumulated % cover and the assessment unit is the total aggregated accumulated cover within a predefined monitoring area. Since the abundance of ephemeral species varies considerably both seasonally and between years (e.g. Kiirikki and Lehvo 1997), only perennial species are included in this indicator. It is similar to the indicator "Total cover of erect macroalgae" developed as an indicator of water quality for the WFD in Denmark (Carstensen *et al*. 2005), but in accumulated cover the cover of each species are summed including all layers and overlapping species. The indicator is intended for use in the entire Baltic Sea, but establishment of new reference values are needed when using the indicator in a new area. The indicator may also be used in the Gulf of Bothnia by including bryophytes when calculating accumulated cover.
Relationship of the indicator to marine biodiversity	This indicator reflects the amount of the perennial macroalgae community, thus indicating biodiversity quantity of perennial macroalgae and associated species. Macroalgae form habitats for a range of other species in the Baltic Sea (e.g. Bucas 2009; Råberg and Kautsky, 2006; Wikström and Kautsky, 2007; Salovius and Kraufvelin, 2004).
Relevance of the indicator to different policy instruments	MSFD descriptors: Mainly relevant for MSFD descriptor 1 "Biological diversity is maintained". May also be of relevance for descriptor 5 "Eutrophication" HELCOM BSAP: Relevant for BSAP segment 4: "Towards favourable conservations status of Baltic Sea biodiversity" by providing data of important communities and habitat building species. Habitats Directive**:** May provide relevant data for habitats such as 1170 (reefs).
Relevance to commission decision criteria and indicator	1.5.2. Habitat volume 1.6. Habitat condition 1.6.1. Condition of the typical species and communities 1.6.2. Relative abundance and/or biomass, as appropriate
Method(s) for obtaining indicator values	Suggested sampling method is drop-video which is a time efficient method for covering large areas (Svensson *et al*. 2011). Methods such as diving may also be used. Geographical aggregation – Sampling may be performed in different ways. An example applicable to drop-video is a randomized stratified sampling in monitoring areas in order to cover important gradients such as depth and wave exposure. Both soft and hard substrates can be sampled, thus also providing data for the vascular plant indicator within the same survey. However, indicator values for this indicator are only calculated for hard bottoms. Stations with both soft and hard substrates can provide data for both indicators. Monitoring areas can be natural such as coastal basins, or artificial such as administrative units. Temporal aggregation – Repeated sampling and modelling of perennial macroalgae cover in monitoring areas within a monitoring programme provides temporal trends of the quantity of this community. Sampling is performed once during a monitoring year. This is typically performed in summer or early autumn.
Documentation of relationship between indicator and pressure	Eutrophication is suggested as the main anthropogenic pressure for this indicator. Accumulated cover of perennial macroalgae was negatively related to mean CHLa in a random Forest analysis of the data from the Hanö Bight study area, supporting eutrophication and the resulting reduced transparency as main "anthropogenic" pressure. Mixed pollutants from environmentally hazardous activities also had a negative effect on the indicator values. The similar indicator "Total cover of erect macroalgae" (Carstensen *et al*. 2005) is related to water transparency and eutrophication in offshore areas, a higher cover indicating better water quality and clearer water.
Geographical relevance of indicator	4. Baltic Sea wide
How Reference	Reference conditions were established by spatial modelling and prediction with

Conditions (target values/thresholds) for the indicator were obtained?	environmental layers adjusted to reference conditions (e.g. adjusted predictor layers where effects of anthropogenic pressures have been removed). Adjusted environmental layers were CHLa, Secchi depth, proximity to environmentally hazardous activities, marine traffic and urban developments. This was performed with data from the Hanö Bight study area in Sweden. Predicted reference values accumulated cover were higher than actual accumulated cover at depths below 3 meters and lower at shallower depths.
Method for determining GES	GES-levels were set as 25 % acceptable deviation from the modelled reference conditions in 2 m depth intervals. See Table 1 for values.
References	Bucas, M. 2009. Distribution patterns and ecological role of the red alga *Furcellaria lumbricalis* (Hudson) J.L. Lamouroux off the exposed Baltic Sea coast of Lithuania. Doctoral dissertation, Klaipeda 2009. Carstensen J, Krause-Jensen, D, Dahl, K, Middelboe AL. 2005. Development of macroalgal indicators of water quality In Petersen, J.K., Hansen, O.S., Henriksen, P., Carstensen, J., Krause-Jensen, D., Dahl, K., Josefson, A.B., Hansen, J.L.S., Middelboe, A.L. & Andersen, J.H. 2005. Scientific and technical background for intercalibration of Danish coastal waters. National Environmental Research Institute, Denmark. 72 pp. - NERI Technical Report No. 563. http://technical-reports.dmu.dk Kautsky L., Wibjörn C., Kautsky H. 2007. Bedömningsgrunder för kust och hav enligt krav i ramdirektivet vatten – makroalger och några gömfröiga vattenväxter. Rapport till Naturvårdsverket 2007-05-25. 50 pages. In Swedish with English summary. Kiirikki, M. and Lehvo, A. 1997. Life strategies of filamentous algae in the northern Baltic Proper. Sarsia 82, 259-267. Råberg, S., Kautsky L., 2006. A comparative biodiversity study of the associated fauna of perennial fucoids and filamentous algae. Estuarine, Coastal and Shelf Science 73, 249-258. Salovius, S. and Kraufvelin, P., 2004. The filamentous green alga *Cladophora glomerata* as a habitat for littoral macro-fauna in the Northern Baltic Sea, Ophelia,Vol. 58, Iss. 2, 2004. Sandén, P. and Håkansson, B. 1996. Long-term trends in Secchi depth in the Baltic Sea. Limnol. Oceanogr. 31: 909-926. Svensson J. R., Gullström, M., Lindegarth, M. 2011. Dimensionering av uppföljningsprogram: komplettering av uppföljningsmanual för skyddade områden. Havsmiljöinstitutet, Göteborgs Universitet (Swedish). Wikström, S. A. and Kautsky, L. 2007. Structure and diversity of invertebrate communities in the presence and absence of canopy-forming *Fucus vesiculosus* in the Baltic Sea. Estuarine, Coastal and Shelf Science 72, 168-172.
Illustrative material for indicator documentation	Table 1. Reference conditions and GES for accumulated cover of perennial macroalgae in depth intervals suggested. The first meter below the surface should be excluded from the assessment.

Predicted RefCond and GES-levels (mean % acc. cover)		
Depth (m)	**GES value**	**Reference condition**
1-3	42	56
3-5	39	52
5-7	36	48
7-9	34	45
9-11	22	30
11-15	21	28

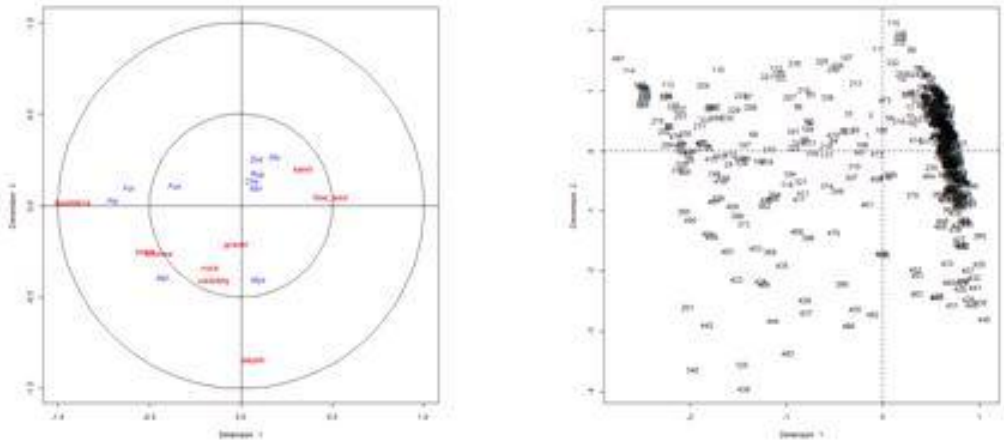

Figure 1. CCA-plot illustrating abundant macroalgae and vascular plant species in the Hanö Bight in relation to natural environmental variables. Accumulated cover of perennial macroalgae and Accumulated cover of vascular plants will together indicate biodiversity quantity in two important coastal communities.

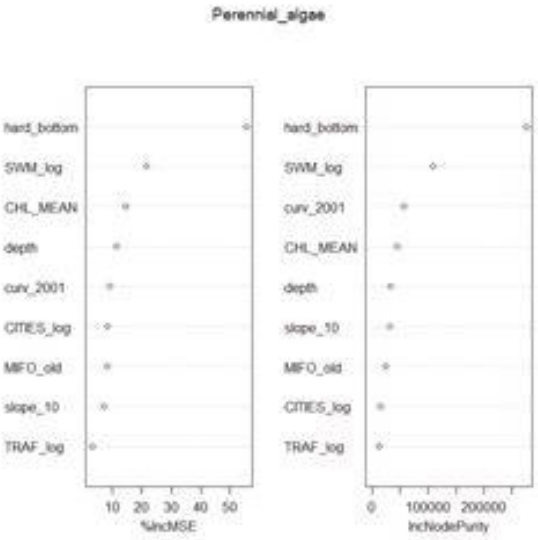

Figure 2. rF variable importance measures for accumulated cover of perennial macroalgae. Mean chlorophyll is the most important of the four "anthropogenic" or "semi-anthropogenic" environmental variables included in the analysis. (MIFO is the density of environmentally hazardous activities, CITIES is the density of populated places and TRAF is shipping).