Name of indicator	2.11 Depth distribution of selected perennial macroalgae
Type of Indicator	State indicator
Author(s)	Ari Ruuskanen
Description of the indicator	The indicator is a multimetric indicator comprising of a set of four perennial macroalgae indicator species, the red algae *Furcellaria lumbricalis*, *Polysiphonia fucoides*, *Phyllophora pseudoceranoides* and *Rhodomela confervoides*. These species belong to the natural flora of the coastal area of south-western Finland MARMONI FIN3 study area and the indicator can be used in the whole study area except in the innermost bays. The indicator describes the long-term changes in water quality through measurements of the lower depth limit of a coverage of ≥ 0,1% of the indicator species. It has been shown that human-based eutrophication has an effect on the vertical depth distribution of macroalgae by decreasing water transparency and thus light penetration in the water column (Torn *et al*. 2006). Furthermore, the natural variation of the indicator species' occurrence and abundance are strongly related to the geographical location, sea bottom structure, and wave exposure (Rinne *et al*. 2011). When these sources of natural variation are known and taken into account, effects of human-based eutrophication can be detected.
Relationship of the indicator to marine biodiversity	The indicator red algae species *Furcellaria lumbricalis*, *Polysiphonia fucoides*, *Phyllophora pseudoceranoides* and *Rhodomela confervoides* are dominant in the sublittoral zones of Finnish coastal waters (SYKE macrophyte data base). They make up most of the diversity in terms the number of species and the number of individuals. The sublittoral invertebrate fauna is strongly associated to these species (Koivisto 2011). The most common zoobenthos taxa are blue mussel (*Mytilus trossulus*), gastropods (*Hydrobia* spp.) and gammarids (*Gammarus* spp). Thus, canopies of the indicator species maintain zoobenthos diversity in hard bottoms, and a decrease in the abundance of the indicator species means a decrease in total biodiversity (Koivisto 2011).
Relevance of the indicator to different policy instruments	The present indicator can be connected to the Water Framework Directive (EC 2000/60/EC) compliance Finnish Macrophyte Index. The indicator has been agreed as a Core Indicator in the HELCOM CORESET of Biodiversity indicators (HELCOM 2012). descriptor 1, criteria 1.1 Species distribution, 1.1.1 Distributional range descriptor 5, criterion 5.1 Direct effects of nutrient enrichment descriptor 6, criterion 6.1 Kind and size of relevant biogenic substrata HELCOM Baltic Sea Action Plan (BSAP): Ecological objectives "Natural distribution and occurrence of plants and animals" (Eutrophication) and "Thriving communities of plants and animals" (Nature conservation).
Relevance to commission decision criteria and indicator	1.1. Species distribution 1.1.1. Distributional range
Method(s) for obtaining indicator values	Data sampling is performed by a trained SCUBA diver. The diver measures the depth of the lower growth limit of a coverage of ≥0,1 % of the indicator species with an accuracy of 10 cm. At least four sites per studied water area must be sampled, and three of the four indicator species are needed for attaining a reliable indicator value; the use of too low number of species does not give a reliable result. The diver performing the investigation must have good species identification skills. The depth values measured for each indicator species is converted to EQR (Ecological Quality Ratio) values, by a method obtained from the WFD (EC 2000/60/EC). The EQR is a numerical expression of a function of observed values divided by the reference depth (Table 1). The EQR value is expressed as a number between zero and one, where one represents reference conditions and zero extremely bad conditions. Since each indicator species have different reference depths, the use of EQR makes it possible to compare values. For the calculation of the index, for a water body (or water type or given water site), the average of the EQRs of all indicator species found at the site is calculated.
Documentation of relationship between indicator and pressure	General eutrophication has an effect on the vertical depth distribution of macroalgae by decreasing water transparency and thus light penetration in the water column; the more eutrophied the area is, the lower (shallower) the depth distribution of macroalgae. The indicator species' occurrence and abundance, expressed here as their vertical depth distribution, are furthermore strongly related to the geographical location, sea bottom

structure, and wave exposure.

If we know the natural conditions mentioned above, and the minimum light requirements of a species for growth in pristine conditions, it is possible to determine the potential maximum growth depth of the indicator species, i.e. the reference value. If the indicator species do not meet this potential maximum growth depth, we can assume that water transparency has decreased, perhaps due to anthropogenic reason.

By analysing existing data sets of maximum vertical depth limits of the percentage coverage of ≥ 0,1% of the indicator species, and data sets on Secchi depths, we found that there was a relationship between the vertical depth distribution of the indicator species and Secchi depth (i.e. water transparency). Secchi depth in turn has been shown to correspond with general eutrophication; a lower Secchi depth being indicative of eutrophication.

Geographical relevance of indicator

Regional

How Reference Conditions (target values/thresholds) for the indicator were obtained?

The expected lower growth depth values, i.e., reference values, were determined through laboratory experiments, by using published literature, by analysing data available in the data base of the Finnish Environment Institute SYKE, and by doing additional field works and laboratory experiment to fill gaps in knowledge.

The laboratory experiment set up was as follows (Figure 1). As an example, specimens of *Furcellaria lumbricalis* were placed in a net basket so that they were situated in their natural position. The basket was placed in an aquarium containing autoclaved natural seawater and was exposed to various intensities of light. The light quality (wave length and colour) was adjusted according to the Rosco light conversion sheets (Kraufvelin *et al.* 2012) (#89 Moss green) to be equal to light prevailing at the depth of 15–20 meters (the estimated lower growth limit of given species). By increasing and decreasing the light intensity it was possible to determine a compensation point of photosynthesis activity, i.e. the production of the specimen, measured as the oxygen production. The change in oxygen production was measured from the aquarium water with a YSI 6000 sond at 10 minute intervals. To make ensure that plankton production did not affect oxygen production, a S:CAN fluorometer was included to detect the presence of plankton. The temperature was kept at 12 ºC, the mean temperature at approximately 15 meters depth during the growth season.

As a result, the compensation point of light intensity, expressed as oxygen production, was for *Furcellaria lumbricalis* between 5–7 μE/m^2/sec (Figure 2). In other words, the compensation point equals the theoretical lower growth depth, i.e., the depth where the amount of light is 5–7 μE/m^2/sec. By using under water light measurement device in the field, the equivalent depth for a light amount of 5–7 μE/m^2/sec was determined to be 16–14 meters in the study area.

Method for determining GES

In the present work, we define GES as a deviation of 21% from the reference value. This means that GES is EQR = 0,79. To determine reference conditions, historical data, modelling and expert judgment was used. The reference depths or values of the indicator species are shown in table 1. In order to take natural variation in depth limit caused by wave action in to account, the archipelago is divided into more exposed and more sheltered parts. The final EQR is calculated as follow: After the sampling of a given water site (a water body, a water type or a given water site), the average of the EQRs of the all indicator species is calculated.

Table 1. The reference depths of the indicator species.

	More exposed archipelago	More sheltered archipelago
Indicator species	Reference depth (m)	Reference depth (m)
Furcellaria lumbricalis	18	15
Polysiphonia fucoides	15	13
Phyllophora pseudoceranoides	21	18
Rhodomela confervoides	15	13

An example of the use of the present indicator is shown in Figure 3. The data from the coastal area of south-western Finland MARMONI study area (Hanko peninsula) from the years 2002-2013 was obtained from the data base of the Finnish Environment Institute SYKE. According to the indicator, the water quality does not meet GES during this period.

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Illustrative material for indicator documentation

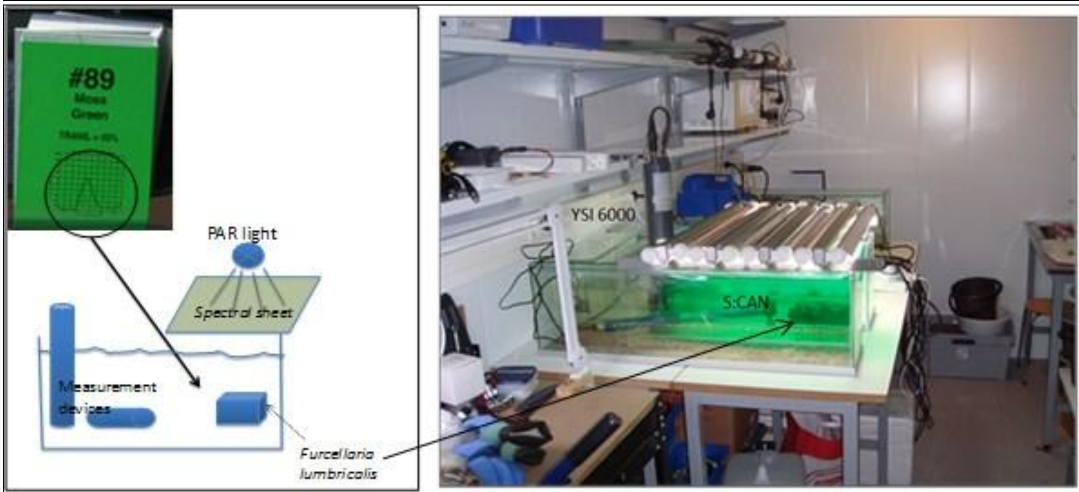


Figure 1. A schematic and authentic presentation of the laboratory experiment set up.

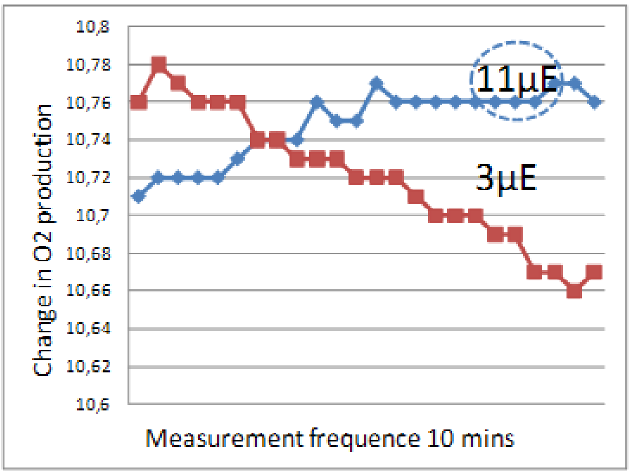
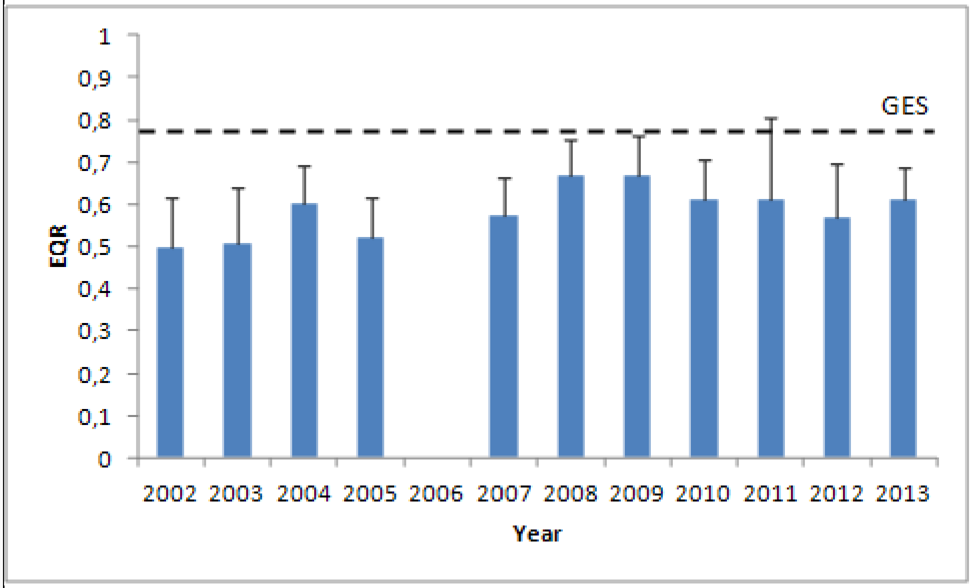


Figure 2. The change in oxygen production of *Furcellaria lumbricalis* at 11 µE/m^2/sec and 3 µE/m^2/sec light exposures. At the light exposure of 3 µE/m^2/sec there was no oxygen production, only respiration. At the light exposure of 11 µE/m^2/sec oxygen production took place. The measurement period (marks) was 10 minutes.

	 Figure 3. Changes in EQR of the present indicator species (average of all) in the coastal area of south-western Finland in 2002-2013. No sampling was performed in the year 2006. The GES limit is indicated as a dashed line; according to the indicator, the water quality does not meet GES.