Name of indicator	3.5 Phytoplankton trait- and dendrogram based functional diversity index (FD)
Type of Indicator	State indicator
Author(s)	Sirpa Lehtinen and Riina Klais
Description of the indicator	The indicator aims to describe the trait-based functional diversity of phytoplankton with a functional diversity index (FD), which is calculated based on the dendrogram method (Mouchet *et al*. 2008). The 11 functional traits considered here, including for example traits like motility and ability to fix nitrogen, are described in Klais *et al*. (in prep.). Within the framework of the MARMONI project, we tested the usability of this trait- and dendrogram-based index as a biodiversity indicator. This is not the only way to calculate a phytoplankton functional diversity index (see e.g. Mouchet *et al*. 2010), and there are also different possibilities to select traits. At present, the index is not ready to be utilized as an indicator. In order to get comparable FD index results, the microscopy methods and the level (accuracy) of species identification must be the same in all samples. To obtain a trait-based functional diversity index which could be used as a simple biodiversity indicator, further studies are needed to determine (1) which trait composition is the most useful for describing phytoplankton functional diversity, (2) which method is the most useful to calculate the functional diversity index, and (3) how functional diversity and various traits relate to different ecological processes.
Relationship of the indicator to marine biodiversity	The trait-based functional diversity index aims to describe the functional diversity of Baltic Sea phytoplankton. The hypothesis is that a more functionally diverse phytoplankton community is more stable and thus more resistant to different pressures. Previously it has been shown that taxonomic diversity predicts stability in natural phytoplankton communities (Ptacnik *et al*. 2008). The index was tested with natural phytoplankton community data from two stations (Seili and Längden, located in the coastal area of south-western Finland in the MARMONI FIN area) and by re-analysing an existing experimental data set (from six mesocosm experiments, performed also in the MARMONI FIN area). The aim of the testing was to obtain a target value above which FD would indicate a relatively stable phytoplankton community, and below which FD would indicate a relatively unstable community, if exposed to pressures. The re-analysis of the existing experimental data set supported somewhat the hypothesis by indicating stability in FD if the initial FD was high. However, the results from long-term data and re-analysis of experimental data showed non-comparable levels of the FD index. This was probably due to differences in analysing methods and changes in the accuracy of species identification. The conclusion is that the FD index is sensitive to changes relating to microscopy methods and the accuracy of species identification. Long-term data showed an increasing trend in the FD index which was difficult to interpret with current scientific knowledge. It is however worth noting that the observed increase in FD is in line with recent studies showing an increase in the Baltic Sea phytoplankton taxonomic diversity (Olli *et al*. 2014). Olli *et al*. (2014) found that phytoplankton taxonomic diversity has increased in the Baltic Sea, and concluded that this might indicate a long-term change in the species inventory of the Baltic Sea, potentially reflecting a delayed long-term response to the anthropogenic fertilization. We conclude that the tested method of calculating the FD index cannot be taken into use as a phytoplankton biodiversity indicator at the moment, since a complete ecological base study is needed to understand the ecosystem processes connected to phytoplankton functional diversity.
Relevance of the indicator to different policy instruments	MSFD descriptor 1: Biodiversity, 1.7. Ecosystem structure, 1.7.1. Composition and relative proportions of ecosystem components (habitats and species). HELCOM BSAP
Relevance to commission decision criteria and indicator	1.7. Ecosystem structure 1.7.1. Composition and relative proportions of ecosystem components (habitats and species)
Method(s) for obtaining indicator values	The functional diversity of a phytoplankton sample is calculated based on species specific microscopy results and a table, where each taxon is categorized based on the functional traits that it possesses. The microscopy results are obtained by quantitative analysis of conventional monitoring samples. A detailed phytoplankton species composition analysis requires good species identification skills. In order to get comparable FD index results, the microscopy methods and the accuracy of species identification must be the same in the

	whole investigated data set. For this functional diversity index, functional diversity is determined by using a clustering dendrogram method (Mouchet *et al.* 2008, Mouchet *et al.* 2010, Litchman *et al*. 2010).
Documentation of relationship between indicator and pressure	The index was tested as an ecosystem structure indicator, and thus the aim was not to find relationships between the index and pressures. Instead, the aim was to find a target value to indicate stability of the community when it is exposed to pressures. The relationship between phytoplankton community diversity and stability has been shown earlier by e.g. Ptacnik *et al*. (2008).
Geographical relevance of indicator	2. Regional
How Reference Conditions (target values/thresholds) for the indicator were obtained?	Long-term and experimental data were used in an attempt to obtain reference conditions and target values/thresholds. Based on this data and due to gaps in the current scientific knowledge it was not possible to obtain reference conditions and target values or thresholds.
Method for determining GES	A target value (lower limit) to indicate stability of the community when it is expressed to pressures (Ptacnik *et al*. 2008) was sought. Based on testing performed using long-term data and experimental data, we conclude that currently a target level for this index cannot be defined. In the future projects, further studies will be undertaken to determine which trait composition is the most useful for describing phytoplankton functional diversity, which method is the most useful to calculate the functional diversity index, and how functional diversity and various traits are connected to different ecological processes.
References	Klais, R., Lehtinen, S., Olli, K., Trikk, O., Tamminen, T. (In prep.). Functional diversity of Baltic Sea phytoplankton. Litchman, E., de Tezanos Pinto, P., Klausmeier, C.A., Thomas, M.K., Yoshiyama, K. (2010). Linking traits to species diversity and community structure in phytoplankton. Hydrobiologia 653: 15-28. Mouchet, M., Guilhaumon, F. Villéger, S., Mason, N.W.H. Tomasini, J.-A., Mouillot, D. (2008). Towards a consensus for calculating dendrogram-based functional diversity indices. Oikos 117: 794-800. Mouchet, M., Villéger, S., Mason, N.W.H., Mouillot, D. (2010). Functional diversity measures: an overview of their redundancy and their ability to discriminate community assembly rules. Functional Ecology 24: 867-876. Olli, K., Ptacnik, R, Andersen, T., Trikk, O., Klais, R., Lehtinen, S. & Tamminen, T. (2014). Against the tide: Recent diversity increase enhances resource use in coastal ecosystems. Limnol. Oceanogr. 59 (1): 267-274. Ptacnik, R. Solimini, A.G., Andersen, T., Tamminen, T., Brettum, P., Lepistö, L., Willén, E., Rekolainen, S. (2008). Diversity predicts stability and resource use efficiency in natural phytoplankton communities. PNAS vol. 15, no. 13: 5134-5136.