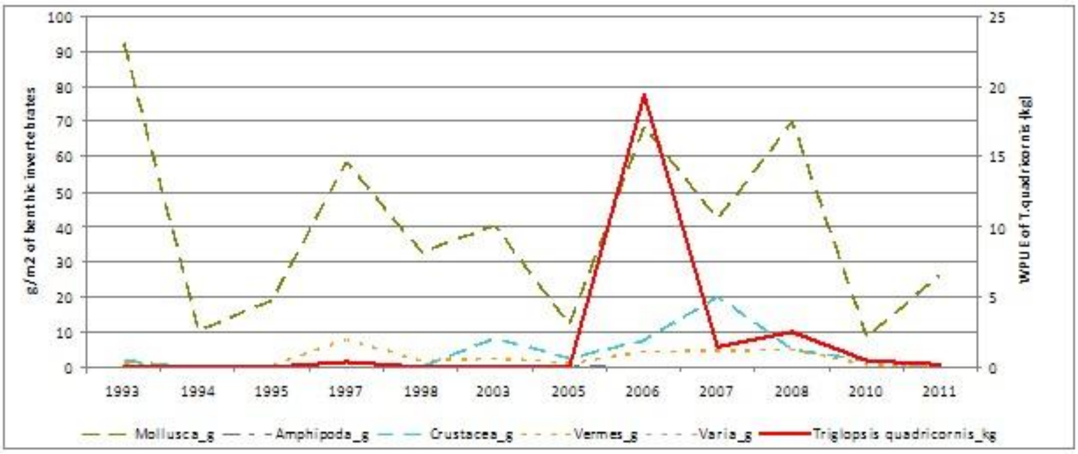
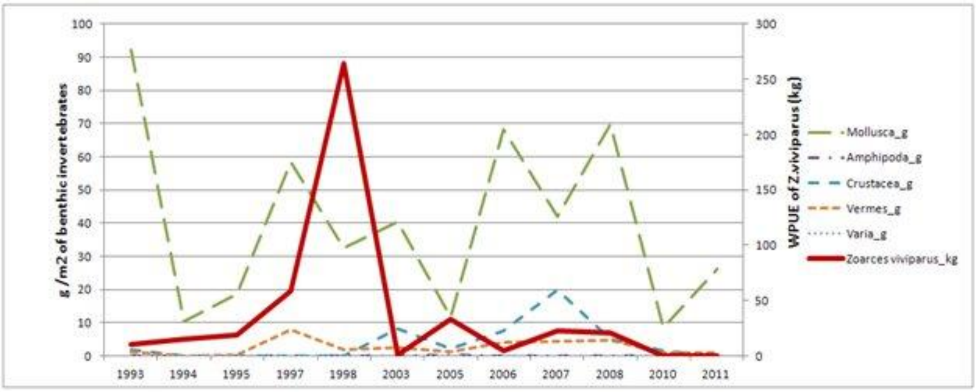
Name of indicator	1.2 Long term abundance and distribution of demersal fish in relation to benthic communities (fourhorn sculpin *Myoxocephalus quadricornis* and eelpout *Zoarces viviparous* example)
Type of Indicator	State indicator
Author(s)	Ēriks Krūze, Atis Minde
Description of the indicator	The indicator demonstrates trophic relationships between demersal fish and benthic fauna. Biomass of fourhorn sculpin (*Myoxocephalus quadricornis*) and eelpout (*Zoarces viviparous*) plotted against biomass of benthic invertebrates. Fourhorn sculpin is thought to be the first fish species that occupied Baltic Sea waters after its forming. Fourhorn sculpin occupies cold brackish and moderately saline water and thus can be an indicator of change in hydrological state of the sea, climate change and increase of eutrophication. For example increased eutrophication can result in lower oxygen concentration that affects food availability for four-horn sculpin and have direct impact as well. Climate change can alter water temperature and fourhorn sculpin being preferably cold water species can be affected by that. Besides, also increase of salinity and predation by cod can have negative impact on abundance of four-horn sculpin. Also high concentrations of heavy metals often observed in the tissue of four-horn sculpins can have negative effects on population level. Therefore distinction of the main factors responsible for particular chages in four-horn sculpin abundance is very important. The indicator is appropriate to use in the Gulf of Riga and other Baltic Sea areas where eelpout is dominant species in the benthic fish community. In the Gulf of Riga there is little fishing pressure on eelpout population because it is targeted only by coastal fishery and fishing intensity is very low. Therefore changes in eelpout abundance are related mostly to environmental factors like food availability and predation by cod and fish eating birds, especially cormorants. To distinguish between effects of decline of habitat quality and other environmental factors, eelpout abundance is plotted against benthic invertebrate biomass. For example low oxygen concentration can decrease the biomass of benthic invertebrates and also fish.
Relationship of the indicator to marine biodiversity	The indicator describes abundance of the key benthic fish species in the Gulf of Riga in relation to benthic invertebrate community. Thus this species could serve as an indicator of good quality of sea environment and is an element of natural biodiversity.
Relevance of the indicator to different policy instruments	Indicator can be applied for reporting on MSFD descriptors 1 and 4. Indicator is related to HELCOM BSAP ecological objective: that habitats, including associated species, show a distribution, abundance and quality in line with prevailing physiographic, geographic and climatic conditions.
Relevance to commission decision criteria and indicator	1.1.1. Distributional range 1.2.1. Population abundance and/or biomass 1.6.1. Condition of the typical species and communities
Method(s) for obtaining indicator values	Sampling of the fish is carried out annually in the Gulf of Riga and Irbe Strait using benthic trawl in fixed survey stations. Biomass of each fish species per m^2 is calculated for each trawling station and an average value from several stations within a geographical region and depth stratum is calculated. The same procedure is applied for biomass data of benthic invertebrates. Benthic invertebrate data come from the National Baltic Sea monitoring programme.
Documentation of relationship between indicator and pressure	Fourhorn sculpin is clearly regarded as a post-glacial relict (Ekman 1940), coldwater species living in brackish waters of the Baltic Sea (http://www.rktl.fi). Although there are no papers documenting direct link between four-horn sculpin abundance and eutrophication level in marine environment, such connection exists regarding closely related species *Myoxocephalus thompsonii* (often considered as a sibling species of fourhorn sculpin) in freshwater lakes in North America (Sheldon *et al*. 2008). In several non-scientific articles eutrophication is mentioned as a threat also for fourhorn sculpin freshwater populations in Sweden. Indicator is related mainly to changes of eutrophication and anoxia in the bottom of the sea. However it could be sensitive to the effects of predation by cod and cormorants. Eelpouts are widely used as a bioindicator of local pollution due to their stationary behavior, but there is little known about links between eelpouts abundance and environmental quality (Hedman *et al*. 2011). As a cold water species abundance and growth rate of eelpouts could indicate rising water temperatures due to climatic changes (Portner *et al*. 2001, Portner and Knust 2007).
Geographical relevance of indicator	2. Regional 3. National waters

How Reference Conditions (target values/thresholds) for the indicator were obtained?	According to literature, there have been at least three systemic regime shifts in the Baltic Sea ecosystem including such subsystems as the Gulf of Riga. Therefore it is still unclear which environmental state can serve as a reference condition. The last ecosystem shift in the Gulf of Riga occured around 1995-1996 and the return of the ecosystem in previous states is discutable. If the current conditions are taken as a reference, then an average abundance of fourhorn sculpin and eelpout since 1995/1996 can be taken as reference value.
Method for determining GES	Indicator can be applicable for Gulf of Riga ecosystem or similar Baltic Sea region. Indicator values need to be calculated preferably for smaller scale geographic regions (for example: West, East, South, Central part of the Gulf of Riga). Ecosystem can be considered being in GES when abundance of fourhorn sculpin and eelpout are within limits of natural yearly variation and there is no decreasing trend of WPUE values coinciding with decrease of benthic invertebrate biomass. Current amount of available data does not allow to properly test this indicator! Precise method for estimation of GES can not be elaborated at this stage.
References	Ekman S. Die Swedishe Verbreitung der glazial-marinen Relikte. Verhandlungen des Internationalen Verein Limnologie. 9:37-58 Commercially exploited fish species in Finland, internet resource http://www.rktl.fi/printview/english/fish/fish_atlas/fourhorn_sculpin/fourhorn_sculpin.html H.O. Portner, B. Berdal, R. Blust, O. Brix, A. Colosimo, B. De Wachter, A. Guiliani, T. Johansen, T. Fischer, R. Knust, G. Lanning, G. Naevdal, A. Nedenes, G. Nyhammer, F. J. Sartoris, I. Serendero, P. Sirabella, S. Thorkildsen, M. Zakhartsev Climate induced temperature effects on growth performance, fecundity and recruitment in marine fish: developing a hypothesis for cause and effect relationships in Atlantic cod (*Gadus morhua*) and common eelpout (*Zoarces viviparus*). Continental Shelf Research. Volume 21, Issues 18-19, December 2001, Pages 1975-1997 Hans O. Portner, Rainer Knust. Climate Change Affects Marine Fishes Through The Oxygen Limitation of Tolerance. Science 5 January 2007: Vol. 315 no. 5808 pp. 95-97 Jenny E. Hedman, Heinz Rudel, Jens Gercken, Sara Bergek, Jakob Strand, Marcus Quack, Magnus Appelberg, Lars Forling, Arvo Tuvikene, Anders Bignert Eelpout (*Zoarces viviparus*) in marine environmental monitoring. Marine Pollution Bulletin. 62(2011)2015-2029 Sheldon, T. A, Mandrak, N. E., Lovejoy, N. R. 2008. Biogeography of the deepwater sculpin (*Myoxocephalus thompsonii*), a Nearctic glacial relict. Canadian Journal of Zoology, Vol.86/2:108-115
Illustrative material for indicator documentation	 Figure 1. Changes in fourthorn sculpin (*Myoxocephalus quadricornis*) abundance in relation to benthic communities

	 Figure 2. Changes in eelpout (*Zoarces viviparous*) abundance in relation to benthic communities