Simple As Necessary approach to the Baltic Sea holistic assessment

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Summary
Linking watershed and offshore ecosystems through data and models, the decision support system Baltic Nest is a natural platform for including environmental, ecological, and societal knowledge in stock and ecosystem assessments. Because a coupling of even simplified representations into holistic description can by itself reveal the emergent properties, the most important is a choice of those conditions and interactions that determine the problem in question. In a suggested development, the simplified ecosystem models are used to simulate the environment, including pelagic and benthic "food" for fish, for the Simple As Necessary Fish model. Being driven by outputs from these models, SANFish plausibly reproduces levels of major fish stanza's biomass, production, and trophic interactions determined by the combined effects of fishery and eutrophication.

Introduction
Since recently, both objective societal demands and subjective fashion trends have given a blooming spreading to invention and development of diverse indicators of variable composition, combining together data and perceptions from variety of approaches and disciplines (*e.g.* Ferreira et al., 2011). The publicly available Baltic Nest (http://nest.su.se) supplements data used for an indicator-estimating with models capable of a dynamical indicator-projecting for a variety of scenarios of changing conditions. For instance, Simple As Necessary Baltic Sea model describes eutrophication status, from hypoxia to productivity, in seven major basins at annual scale. SANBALTS is well validated with available data (Savchuk and Wulff, 2007, 2009) and was used both for reconstruction of the 1900s (Savchuk *et al*., 2008) and, as a component of the Baltic Nest system, for a number of scenarios, including the Baltic Sea Action Plan (Wulff *et al*., 2007; Baker et al., 2010). More detailed is BALTSEM, also realistically describing nutrient biogeochemical cycles, both in the recent history, 1970-2006 (Savchuk *et al*., 2012), and since the middle of 19th century (Gustafsson *et al*., 2012). Fish representations (Harvey *et al*., 2003; Tomczak *et al*., 2012), being aimed at a very detailed food web analysis, are rather vulnerable to a shortage of data on many variables and interactions at a lower ecosystem levels. Therefore, considering both SANBALTS and BALTSEM a plausible representation for abiotic and lower biotic levels of the Baltic Sea ecosystem, we intend to use their results as inputs to fish models.

Materials and methods
SANFish is formulated as age-structured description of fish stocks of sprat, herring, and cod in the Central Baltic and Entrance areas (ICES SD 21-29), and sprat and herring in the gulfs (ICES SD 28.1, 30-32). Clupeids are described with juvenile and adult stanzas, cod – with the juvenile, small adult, and large adult ones. In every basin, the stanza' biomass is determined by reproduction and survival including environmental effects, "ontogenetic transfers" between age categories, growth due to the food consumption, losses due to predation and fishery, and natural mortality due to "other" reasons (diseases and accidents like hits by anchors and mutilating by trawls):

$$\frac{dB_{i,k}}{dt} = Growth_{i,k} + Ontogen_{i,k-1} - Ontogen_{i,k} - Spawn_{i,k} - Predation_{i,k} - Fishery_{i,k} - NatMort_{i,k}$$

where $B_{i,k}$ is a biomass of stanza k in basin i; *Growth* of biomass occurs due to food consumption; *Ontogen* is "ontogenetic transfer" between stanzas *k-1* and *k*; *Spawn* is a transfer of biomass from adult to juvenile stanza; *Predation* is a consumption of stanza *k* by all its predators; *Fishery* is a loss of stanza

k due to operation of the fishermen; *NatMort* is a natural mortality due to "other" reason (including mortality of the adults because of "ageing").

Forcing parameters externally prescribed in the present version of SANFish are fixed biomasses of such food items as zooplankton and benthos that, together with simulated biomasses of forage fish, determine food consumption. In the Baltic Proper basin (ICES SD 24-29) the area of hypoxic zone affects survival of juvenile cod and availability of the deep-water benthos.

Results and discussion

Currently, the SANFish is being calibrated to plausibly respond with a single set of basin-specific parameters in basin-independent parameterizations to four different scenarios of external nutrient loads: corresponding to years 1900 and 2000, agreed under the Baltic Sea Action Plan, and expected under "business as usual" scenario that projects modern tendencies of agricultural, industrial, and demographic development. The results of SANBALTS steady-state solutions corresponding to these scenarios are used for prescription of forcings to SANFish: the hypoxic area is taken directly from the solutions for the Baltic Proper, the basin-wise zooplankton biomasses are estimated from simulated pelagic nitrogen recycling, and the basin-wise biomasses of benthos are calculated from the simulated benthic concentrations of organic nitrogen.

Preliminary results of calibration indicates that within the implemented formulations and set-up, SANFish is capable to plausible reproduce the inter-basin differences in response to different external nutrient loads and fishery losses, both in stanza's biomasses and trophic interactions.

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