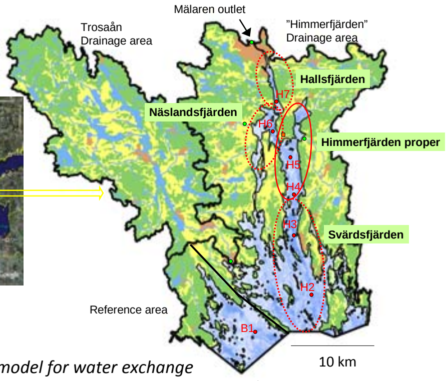
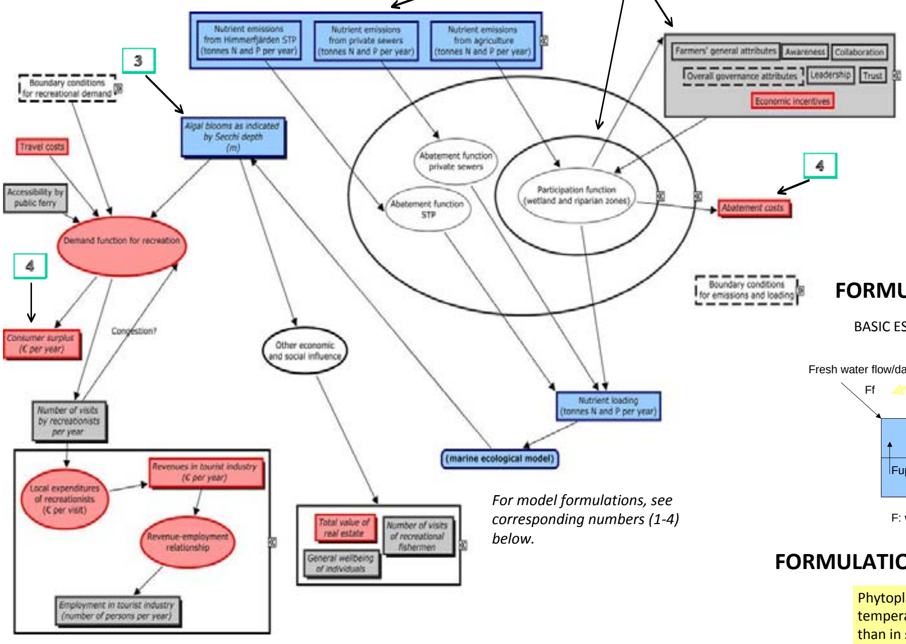
SSA No. 04 - HIMMERFJÄRDEN

- The policy issue is "ALGAL BLOOMS", defined as increased algal biomass due to increased nutrient loads.
- One main aim is to identify a cost-effective mix of measures to reduce nutrient loads from the major sewage treatment plant, agriculture and private sewers, in order to achieve a given reduction in phytoplankton biomass and increase in Secchi depth (water transparency). In addition, the recreational benefits of an improved water quality are estimated.

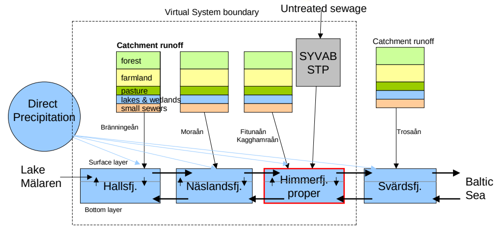


OVERALL CONCEPTUAL MODEL



For model formulations, see corresponding numbers (1-4) below.

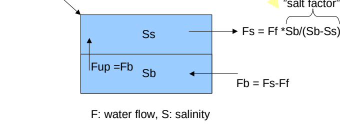
Conceptual model for water exchange



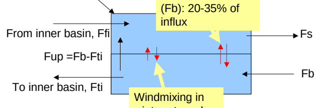
FORMULATIONS – WATER EXCHANGE

BASIC ESTUARINE CIRCULATION

The water exchange is based on "salt factors" from measurements, and known fresh water inputs



MODIFIED ESTUARINE CIRCULATION



Downward flux in relation to influx (Fb): 20-35% of influx

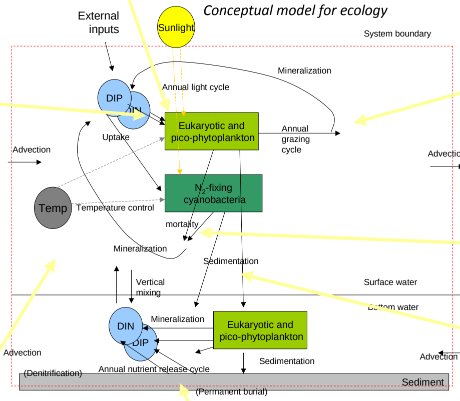
Windmixing in winter at weaker thermocline

FORMULATIONS – ECOLOGY

Phytoplankton **growth** is dependent on the cell-quota of nitrogen and phosphorus, and temperature and light. The temperature optimum is assumed to be lower in spring than in summer. [PhytoGrowth= MIN((1/(C:Nmax-C:Nmin)*C:N+1+C:Nmin/(C:Nmax-C:Nmin)), ((1/(C:Pmax-C:Pmin)*C:P+1+C:Pmin/(C:Pmax-C:Pmin)))*Light/(Light+Ks light)*1.1^(Temp-TempOptimum)*PhytoMaxGrowthRate]
The simpler Monod kinetics (with half-saturation constant for growth), resulted in unrealistically high dissolved inorganic nitrogen concentrations in summer.

Phytoplankton **nutrient** uptake is controlled by the external concentration of dissolved inorganic nutrients (Monod kinetics). When maximal cell-quota is reached, uptake is zero. [PhytoDINuptake = cDIN/(cDIN+KsDIN) *PhytoMaximumUptake Rate*PhytoBiomass]

Conceptual model for ecology



Phytoplankton **loss due to grazing** is a function of zooplankton relative seasonal abundance and zooplankton grazing rate (as % of phytoplankton biomass)

Phytoplankton **mortality** is a proportion of biomass, and higher at low nutrient status of the phytoplankton.

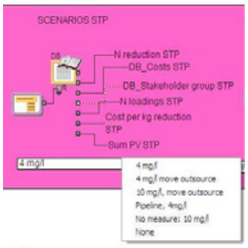
Phytoplankton **sedimentation** is a proportion of mortality, and higher in spring

Secchi depth will be modeled by empirical relationsships with chlorophyll

Sediment **nutrient release** is dependent on season, with maximum in September. [Release = max release rate per m^2 * seasonal relative release rate (0-1) * bottom area]
In the current model there is no coupling between organic matter inputs and nutrient release.

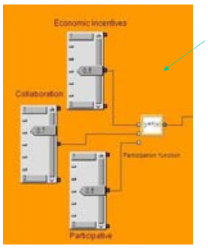
FORMULATIONS – SOCIAL SCIENCE, ECONOMIC AND ESE LINKAGES

1. SCENARIO BLOCK WITH POLICY OPTIONS



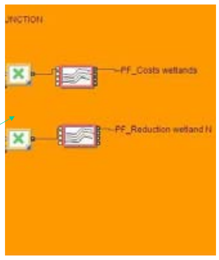
Section from Scenario block in EXTEND model. The policy option for HSTP (Himmerfjärden Sewage Treatment Plant) is chosen in the drop down menu. There are menus for the other human activities (HAs) as well, which means that it is possible to run one policy option for each HA at the same time. Data for costs, nitrogen loadings, stakeholder group involved etc. for chosen policy option are collected from databases, except for Wetland scenario (see Participation funtion below).

2. PARTICIPATION FUNCTION

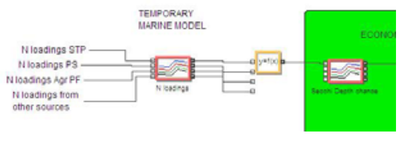


a. Section from Participation Function block. The variables that determine the probability for land owner to participate in wetland project are set in sliders.

b. ESE linkage: The Participation Function block gives the total amount of nitrogen retained by wetlands created, providing the levels of variables (chosen in a.) plus the total cost for creating these wetlands.



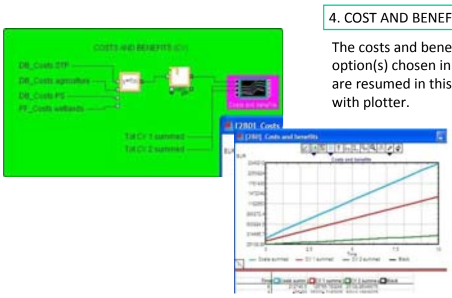
3. TEMPORARY MARINE MODEL



ESE linkage: The change in total nitrogen loading from human activities in the selected scenario affects Secchi depth, which in turn is assumed to affect people's wellbeing and the demand for recreation in Himmerfjärden. The change in wellbeing is measured as the change in consumer surplus and is an estimate of the benefits of the chosen scenario. This temporary model will later on be replaced by the ecological model.

4. COST AND BENEFIT CALCULATIONS

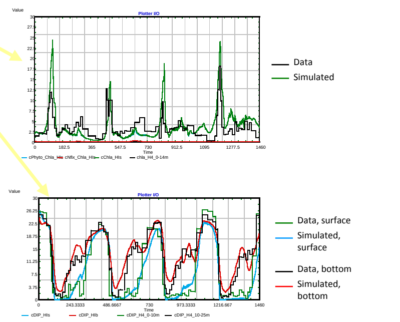
The costs and benefits of the policy option(s) chosen in the Scenario block are resumed in this block and illustrated with plotter.



CALIBRATION OF PARAMETERS

Chlorophyll *a* in Himmerfjärden proper.

Dissolved inorganic nitrogen in surface and bottom water of Himmerfjärden proper



Parameter	Value	Unit
Phyto_max_growth (rate)	1.5	day^{-1}
DIN_Ks (Phyto)	5	µg l^{-1}
DIP_Ks (Phyto)	4	µg l^{-1}
Light_Ks	10000	kJ m^{-2} h^{-1}
Phyto_max_growth_temp	15 - 25	°C
Phyto_CNmin	4	weight ratio
Phyto_CNmax	12	weight ratio
Phyto_CPmin	35	weight ratio
Phyto_CPmax	200	weight ratio
Phyto_DIN_max_uptake_rate	0.2	g N g C^{-1} day^{-1}
Phyto_DIP_max_uptake_rate	0.1	g P g C^{-1} day^{-1}
Phyto_loss_rate_high_Droopfactor	0.05-0.1	day^{-1}
Phyto_loss_rate_low_Droopfactor	0.35	day^{-1}
Phyto_sed_fraction	0.25-0.8	day^{-1}
PhytoC_to_Chla_ratio	40	g C g Chl^{-1}
Nfix_max_growth_rate	0.7	day^{-1}
DIP_Ks_Nfix	15	µg l^{-1}
Nfix_max_growth_temp	25	°C
Nfix_loss_rate_high_Droopfactor	0.04	day^{-1}
Nfix_loss_rate_low_Droopfactor	0.04	day^{-1}
NfixC_to_Chla_ratio	40	g C g Chl^{-1}
Nfixers_CN_ratio	5.9	weight ratio
Nfix_CPmin	30	weight ratio
Nfix_CPmax	200	weight ratio
Nfix_DIP_max_uptake_rate	0.1	g P g C^{-1} day^{-1}
Nfix_sed_factor	0.5	day^{-1}

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SPICOSA
SIXTH FRAMEWORK PROGRAMME