



**Model developers input for MEECE Deliverables:**  
**D2.1: Report on system specific key species, feedbacks and forcings (M9, R, PU, Resp UHAM);**  
**T2.2 Creation of Module library**

**1. General Information**

**Developer contacts:**

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**Model name:**

SMS (Stochastic Multi Species model)

**MEECE Area of implementation (choose as many as applicable):**

SMS has been implemented for the North Sea and the Baltic Sea.

**Model Schematic (please attach an image of the model structure)**

No image available

**Model description, key publications:**

**Overview of the SMS model**

SMS (Stochastic Multi-Species model) (Lewy and Vinther, 2004) is a fish stock assessment model including biological interactions estimated from a parameterised size dependent food selection model. The model includes also fish predation from seabirds and marine mammals. SMS can also be used in forecast mode and includes extended possibilities for evaluating scenarios based on new and existing long term management plans. For the fish eating species the model will be extended with a dynamic model for mean weight at age and sexual maturation, where food consumption and growth will be dependent of sea temperature and the available food estimated within the model. Dependent on the outcome from other projects, SMS will also incorporate the effect of availability of zooplankton (from external models) on growth of plankton eating species. Recruitment success for all species included and available food and growth of prey fish like sandeel and herring will be obtained through linkage to NPDZ models as well as allowing the assessment of top down controls of zooplankton populations and hence trophic cascades.

**SMS model code, manual & interfacing**

The SMS code and manual are open to sharing and can be obtained via the Model Library on the MEECE Project website ([www.meece.eu](http://www.meece.eu)) or requested from Morten Vinther [mv@aqu.dtu.dk](mailto:mv@aqu.dtu.dk). SMS is AdModel Builder program and requires the ADMB library to compile and link. ADMB can freely be downloaded from <http://admb-project.org/>.

With respect to the "interface variables description" the only possibility today (Nov 2009), is offline. Right now SMS reads and write data on a simple ASCII formats, and this could be used for exchange of data with other programs. It will require a considerable effort to implement an XML interface to SMS, however according to our local ADMB expert, it would be possible.

**SMS historical analysis and parameter estimation**

SMS is used to estimate historical stock sizes, fishing and predation mortalities from a parameterised age based separable fishing mortality model for and an age-size model for predation. Parameters are fitted by maximum likelihood technique from observations of total catches, survey CPUE and stomach contents.

Main input to the historical parameters:

- Total international Catch at age numbers
- Residual natural mortality at age
- Catch per unit effort at age by survey

- *Stomach contents (diet) by predator and prey length group*
- *Ration (amount food eaten) by predator age and sea temperature*
- *Age-length-keys to split abundance by age to abundance by size class*
- *Stock size of "other predators" for which there is no analytical assessment*
- *NPDZ model output applicable for stock recruitment models and "other prey"*

*Main output*

- *Historical stock size, predation and fishing mortality*
- *Parameters for separable fishing mortality model*
- *Parameters for stock-recruitment relation*
- *Parameters for predation model*
- *Parameter for growth in relation to available food (dependent on other projects)*

**SMS forecast analysis**

*SMS is a forward running model and as such easy to use for scenario testing. The model has included a series of generic and species specific harvest control rules which can be evaluated with or without taking the uncertainties of stock assessment into account. The model operates with quarterly time steps and can be configured to exchange data with other models for each time step.*

*Main input*

- *Initial stock size of assessed species*
- *Stock sizes of "other predators"*
- *All the parameters estimated from the historical analysis*
- *Sea temperature*
- *NPDZ model output applicable for stock recruitment models and "other prey"*

*Main output*

- *Stock size, predation mortality (eaten biomass) and fishing mortality and yield*
- *Performance of harvest control rules (i.e. the ability to reach the defined targets)*

1. Lewy and Vinther, 2004. ICES C.M. 2004, FF:20, pp 1-33. <http://www.ices.dk/products/CMdocs/2004/FF/FF-2004.pdf>
2. Koster *et al.*: Biological Reference Points of Eastern Baltic Cod J. Northw. Atl. Fish. Sci. , Vol 41. <http://journal.nafo.int/41/koster/18-koster.html>
- 3.

## **2. Technical & Driver Information**

### **Programming language:**

*SMS is implemented using the AD Model-Builder software which is a tool for rapid development and fitting of general nonlinear statistical models. AD Model Builder provides a template-like approach to code generation using C++ and the AUTODIF C++ class library. AUTODIF combines an array language with the reverse mode of Automatic differentiation supplemented with precompiled adjoint code for the derivatives of common array and matrix operations. The AD Model Builder package is freely available.*

*Executable usually invoked on command line with options as arguments. Designed to be platform independent and has been tested under DOS/Windows and Linux.*

*All input and output to SMS are simple ASCII files. Data processing of output is done by separate scripts using the freely available R package.*

### **Specific Setups**

#### **Spatial and vertical resolution:**

*The model assumes one homogeneous area. Time variable specific predator prey overlap can be used in both hind- and forecast mode.*

#### **Temporal resolution (time step range):**

*SMS can be used with annual or quarterly time steps.*

### **Details of current / planned simulations:**

*Input data are available from 1963 (the North Sea) or 1974 (the Baltic Sea) to present. There are no limitations on the periods for forecast scenarios.*

### **Purpose for development (i.e. original rationale for model development)**

*SMS was developed with the purpose to provide stock assessment/forecast for commercial important fish species talking predation mortality into account. SMS can be seen as a stochastic version of the deterministic model "Multi Species Virtual Population Analysis (MSVPA)" previously used by ICES multispecies assessment working groups.*

### **Source of External Forcing (climate runoff)**

*Not relevant.*

### **How is the model initialised?**

*SMS in hindcast mode produces stock numbers and parameter estimates which are used in forecast mode. Future recruitment is based on the historical stock recruitment relationship an estimated parameters. Scenario fishing mortality is kept constant or changed dynamically according to specified Harvest Control Rule.*

## **3. Model detail:**

### **Key species of your model:**

*Baltic Sea: Cod, herring sprat and "other food"*

*North Sea: Cod, haddock, whiting, saithe, mackerel, horse mackerel, grey gurnards, Raja radiata, nine species of seabirds, grey seals, herring, sprat, Norway pout, sandeel and "other food".*

### **Life history driven distribution ...i.e. life history closure**

*Not applicable*

**Model parameters, input and output:**

AB	available prey biomass for a predator
ALK	proportion at size for a given age group. Input
C	observed catch in numbers. Input
CPUE	catch in numbers per unit of effort. Input
F	instantaneous rate of fishing mortality.
g	coefficient of prey size preference for a predator eating a prey. Parameter
Impred	mean size of size class lpred. Input
Imprey	mean size of size class lprey. Input
M1	instantaneous rate of residual natural mortality. Input
M2	instantaneous rate of predation mortality estimated in the model
N	stock number
OF	Biomass of other food for a predator. Input
Q	catchability, proportion of the population caught by one effort unit. Parameter
R	recruitment, number of the youngest fish entering the model. Parameter
RA	food ration, biomass consumed by a predator. Input
S	coefficient of suitability of a prey entity as food for a predator entity
S1,S2	mesh selection parameters.
SSB	spawning stock biomass
STOM	weight proportion of prey i found in the stomach of predator j. Input
U	sampling intensity of stomachs. Input
V	variance of diet observations in relation to sampling intensity. Parameter
W	body weight. Input
Z	instantaneous rate of total mortality
a	alfa in stock recruitment relation. Parameter
a2	food ration coefficient. Input
$\beta$	beta in stock recruitment relation. Parameter
$\beta_2$	food ration exponent. Input
?PREF	natural logarithm of the most suitable relative prey size for a predator. Parameter
?MIN	observed minimum relative prey size for a predator species. Input
?MAX	observed maximum relative prey size for a predator species. Input
?	spatial overlap between predator and prey species in season q. Mainly input
?	coefficient of species vulnerability. Parameter
sCATCH	standard deviation of catch observations. Parameter
sPREF	parameter expressing how particular a predator is about the size of its prey. Parameter
sSR	standard deviation of stock recruitment estimate. Parameter
sSTOM	standard deviation of stomach content observations. Parameter
sSURVEY	standard deviation of survey CPUE observations. Parameter

**Principle methods & data sets to calibrate your model**

SMS uses maximum likelihood technique for parameter estimation for fitting the model to observations of total catch at age, Catch per unit effort and stomach contents.

**Principle data sets currently used for evaluation**

Catch at age numbers and CPUE data available from ICES. Stomach contents data (50000 stomachs from the Baltic Sea and 300000 stomachs from the North Sea) from international coordinated sampling programs

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