

# System Formulation

## Part 2: Running the model

ExtendSim Model with input and ouput

### The SPICOSA SSA 7.6, Søndeledfjorden, Norway Version 1.3 (21 February 2010)

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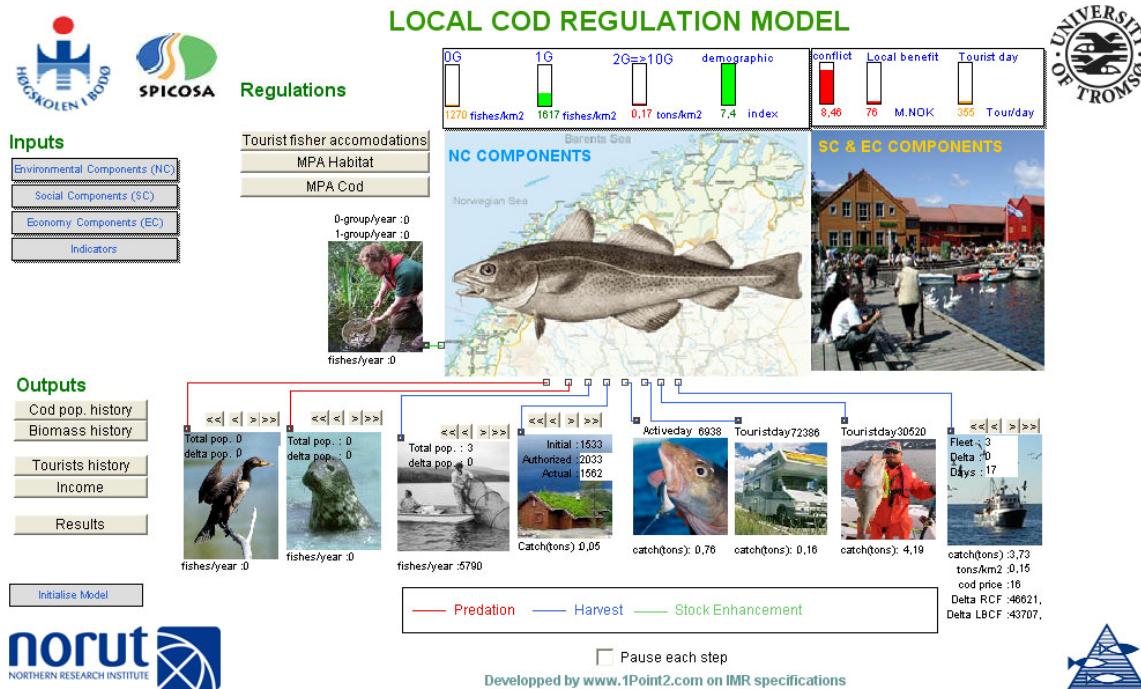
3) Norut AS, Postboks 6434 Forskningsparken, 9294 Tromsø, Norway

4) Institute of Marine Research, 5817 Bergen, Norway

Bodø University College, Dep. of Social Science, 8049 Bodø, Norway

### ExtendSim Model developer

Guillaume Lagaillardé, 1point2, France



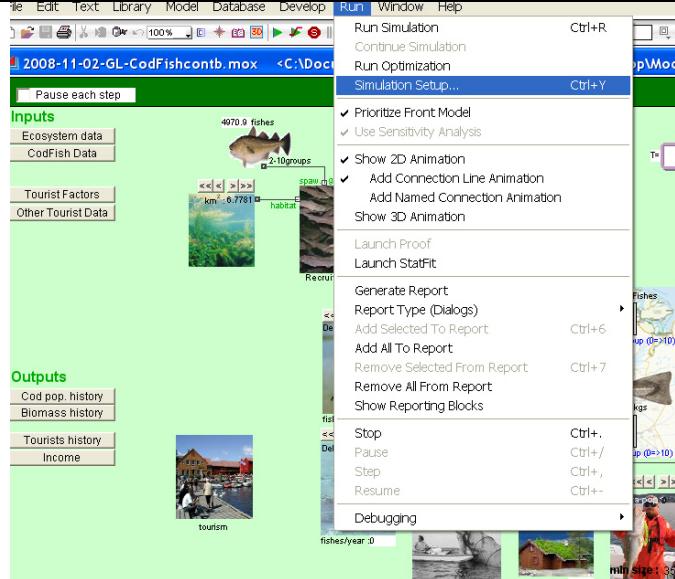
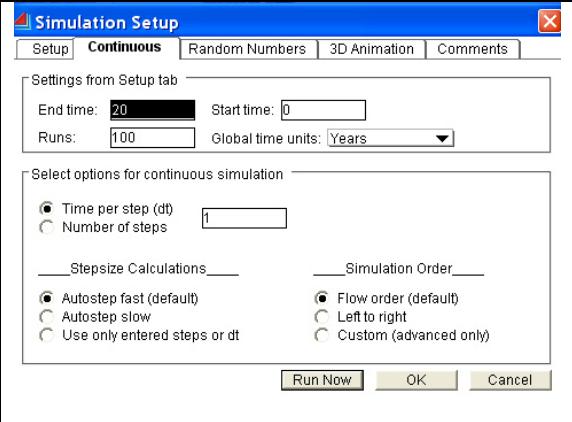
## Table of Content

	Page
<b>1. What you need .....</b>	<b>3</b>
<b>2. General description .....</b>	<b>4</b>
2.1 Environmental component (NC) .....	4
2.2 Social component (SC) .....	6
2.3 Economic component (EC).....	7
<b>3. Changing Input parameters .....</b>	<b>8</b>
3.1 General.....	8
3.2 Environmental component (NC) .....	8
3.3 Social component (SC) .....	9
3.4 Economic component (EC).....	11
3.5 Indicators .....	12
<b>4. Regulations and scenarios .....</b>	<b>13</b>
<b>5. Output and export of data .....</b>	<b>16</b>
5.1 General.....	16
5.2 Environmental (cod population).....	16
5.3 Economic.....	18
5.4 Export of data to MS Excel.....	19
<b>6. Adopting the model to other local cod stocks and fjord systems .....</b>	<b>21</b>
<b>7 Calculations .....</b>	<b>21</b>
7.1 Ecosystem (Cod population) .....	21
7.1.1. Estimating annual recruitment (Number of 0-group cod).....	21
7.1.2. Estimating cohort sizes over the chosen time frame .....	21
7.1.3. Estimating survival from 0-group to 1-group cod.....	22
7.2 Social .....	24
7.3 Economic.....	25

## 1. What you need

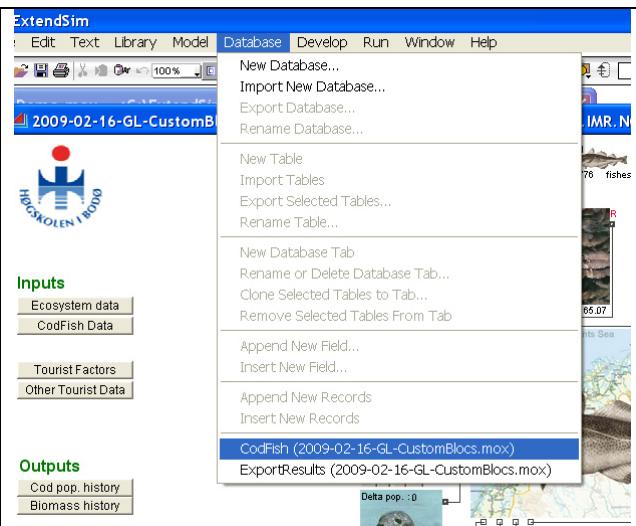
Make sure you have the following files in the same folder:	 Local Cod Regulation Model v 1.20.mox ExtendSim Model
- The ExtendSim Model - CodFish.lix - ExportedData.xls	 CodFish.lix ExtendSim Library 1 307 KB

It is possible to set simulation duration up to 50 years. You can run up to 100 simulations.

First select "Simulation setup" from the "Run" menu.	Secondly enter the number years for the run (maximum 50 years) and the total number of simulations ("Runs") (unlimited). Then you can select "Run simulation" from the "Run" menu.
	

## 2. General description

The model consists of several tables that contain input and output data. The different tables can be viewed by selecting the codfish model from the Database menu, as showed in the figure to the right.



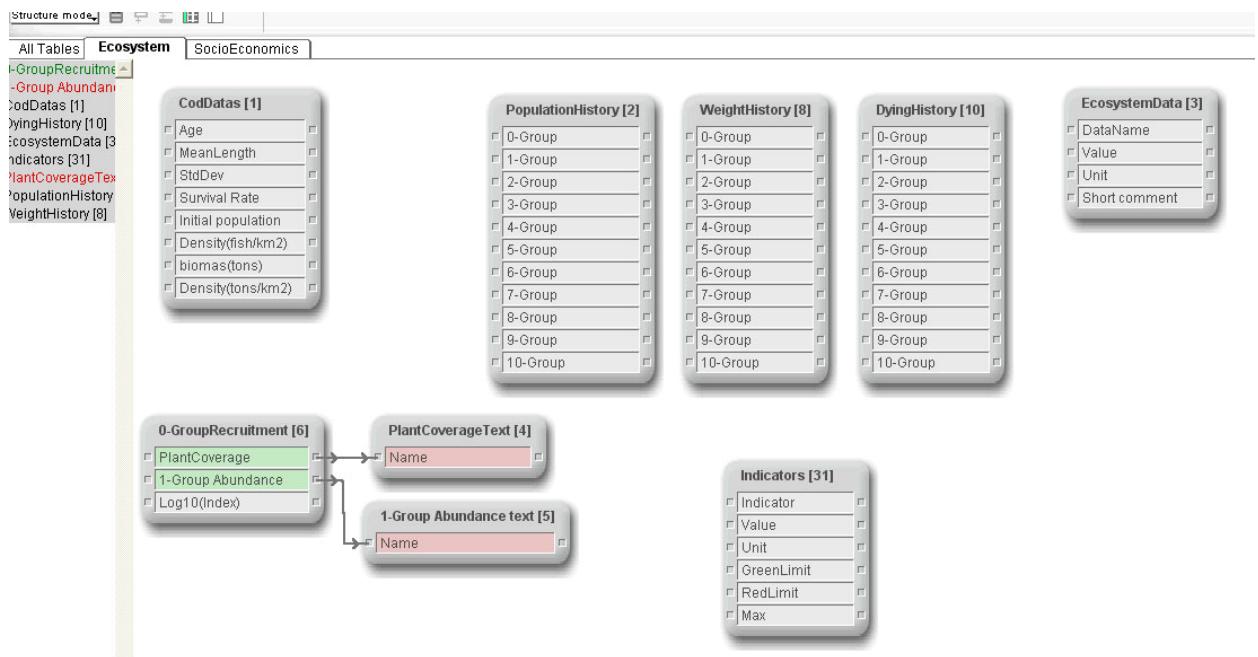
### 2.1 Environmental component (NC)

The ecosystem model is a demographic model that projects the abundance of the coastal cod (*Gadus morhua*) population in SSA 7.6 (Søndeledfjorden, Norway) in numbers by age (0 - 10 years age groups) forward in time.

- The model is running with yearly time-steps over a period of 1-50 years.
- Recruitment of 0-group cod are randomly picked by the model from a distribution of historical data.
- The total population size and the strength of the different year-classes of cod is a function of natural predators (as birds and mammals) and fishing mortality (caused by tourists and commercial) and other human activities (Eco-tourists etc).
- The cod spawning stock (SS) consists of age-groups 4-10.
- The default fishable stock consists of age-groups 2-10, however, will vary between user groups
- Several policy instruments influence the dynamics of the cod population: TAC (total allowable catch on each year-class per year), amount of bottom habitat occupied by marinas, and the number of predators (birds and mammals) which can be controlled by hunting.

In the following tables and figures you can view the different tables used in the ecosystem component in the model.

Input Tables	Content Table	Corresponding table in Part 1
CodDatas (1)	Default values on the cod population	Table 1.1 and Table 1.5
EcosystemData (3)	Default values for different input parameters	
O-GroupRecruitment (6)		
Indicators (31)	Values for the different indicators (traffic lights)	
Output Tables		
PopulationHistory (2)	Numbers of cod in the different year-classes	
WeigthHistory (8)	Lengths and weights of cod in the different year-classes	
DyingHistory (10)	Cod dying in the different year-classes	

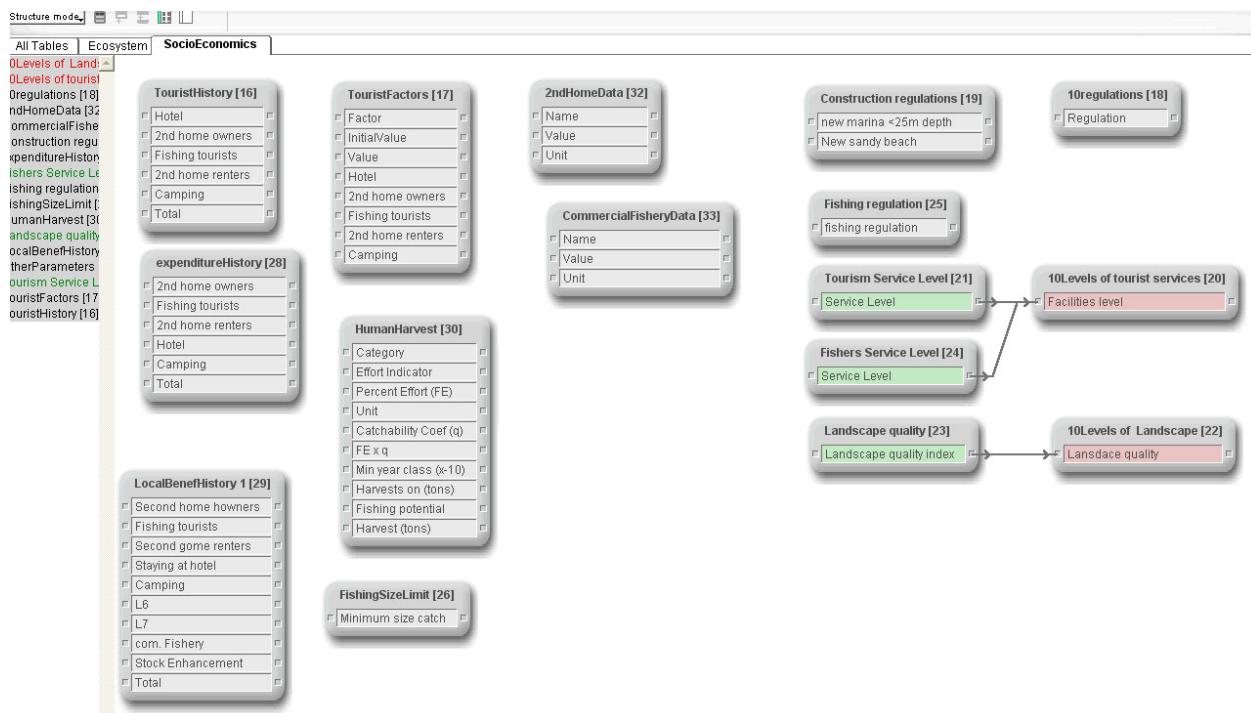


## 1.2 Social component

Several policy instruments influence the dynamics of the cod population: TAC (total allowable catch on each year-class per year), amount of bottom habitat occupied by marinas, and the number of predators (birds and mammals) which can be controlled by hunting. (The model reflects the 2008 situation without any regulations).

In the figure below are given the different tables used in the social component in the model. The input tables are given in the table below with corresponding tables in "Part 1- Description".

Input Tables	Content Table	Corresponding section in Part 1
Construction regulations (19)	Boat marinas construction	Section 2.5.2.1
	Sandy beaches construction	
Tourist Service Level (21)	Used to calculate FisherTourist	Section 4.2
Landscape quality (23)	Landscape quality index	
Fishers Service Level (24)	Used to calculate FisherTourist	Section 4.2



### **1.3 Economic component**

The main aim of economic component is to estimate (net) local economic benefits from tourism in the Søndeledfjord area. This is set equal to Risør municipality in our case. The economic benefits/costs related to tourism that we consider come from 1) expenditures from tourists visiting the area (except 2nd home building and maintenance), and multiplicator effects of those expenditures, 2) the building and maintenance of 2nd homes + multiplicator effects, 3) changed income in commercial fishery due to changes in the coastal cod stock due to tourism (fishing + habitat changes), and 4) net local costs of coastal cod stock enhancement.

In the figure below are given the different tables used in the economic component in the model. The input and output tables are given in the table below with corresponding tables in "Part 1- Description".

<b>Input Tables</b>	<b>Content Table</b>	<b>Corresponding table in Part 1</b>
Touristfactors (17)	Contain default values of parameters	Table 3.3
OtherParameter (27)	Contain default values of parameters	Table 3.4
HumanHarvest (30)	Contain default values of parameters	Table 1.3
CommercialFisheryData (31)	Contain default price for cod	Chapter 3.3
2ndHomeData (32)	Default economical parameters	Chapter 3.2
<b>Output Tables</b>		
TouristHistory (16)	Number of tourist-days in the different categories	
ExpenditureHistory (28)	Cost in the different categories	
LocalBenefHistory (29)	Income from the different categories	

### 3. Changing Input parameters

#### 3.1 General

When running the model you can change the input values by selecting the four tables in the upper left corner of the front page of the model. These tables are the same as in the database described under section 1.

**Inputs**

- Environmental Components (NC)
- Social Components (SC)
- Economy Components (EC)
- Indicators

#### 3.2 Environmental components (NC)

Input data for the ecosystem model

Four option	<input type="checkbox"/> Ecosystem data <input type="checkbox"/> CodFish Data  <input type="checkbox"/> Birds data <input type="checkbox"/> Seals data																																																																																																												
<b>Ecosystem data</b>	<p>Viewer "CodFish[1]-&gt;EcosystemData[3]" (Local Cod Regulation Model v 1.20.mox)</p> <table border="1"> <thead> <tr> <th>Record #</th> <th>DataName</th> <th>Value</th> <th>Unit</th> <th>Short comment</th> </tr> </thead> <tbody> <tr><td>1</td><td>Real time Available habitat</td><td>0,65</td><td>km2</td><td>This value changes during simulation (new constructions)</td></tr> <tr><td>2</td><td>High/Low habitat limit</td><td>5,00</td><td>km2</td><td>See Chapter 4.3</td></tr> <tr><td>3</td><td>1-Group abundance limit</td><td>99,00</td><td>fishes</td><td>To set recruitment</td></tr> <tr><td>4</td><td>Recruitment multiplier</td><td>150,00</td><td>Constant K</td><td>See chapters 4.4 and 8.2</td></tr> <tr><td>5</td><td>Species lower limit</td><td>50,00</td><td>Number</td><td>Number Age 2-10, Number 11-17, minimum number of 2-10 groups</td></tr> <tr><td>6</td><td>Average G1 pop</td><td>42889,00</td><td>fishes</td><td>Table 1.1; used to calculate 9-group mortality (canibalism...)</td></tr> <tr><td>7</td><td>C factor for mortality</td><td>0,50</td><td>Number</td><td>Non autoreproduction mortality</td></tr> <tr><td>8</td><td>P factor for mortality</td><td>0,50</td><td>Number</td><td>autoreproduction mortality</td></tr> <tr><td>9</td><td>H factor for mortality</td><td>1,00</td><td>Number</td><td>Habitat factor lower means small fishes can hide better.</td></tr> <tr><td>10</td><td>Total Area of Fjord</td><td>23,55</td><td>km2</td><td>Total area used for density calculations</td></tr> <tr><td>11</td><td>Initial available habitat</td><td>0,65</td><td>km2</td><td>this is initial value</td></tr> <tr><td>12</td><td>Minimum GG</td><td>9317,00</td><td>fishes</td><td>Minimum recruitment possible</td></tr> <tr><td>13</td><td>Maximum GG</td><td>412572,00</td><td>fishes</td><td>Maximum recruitment possible</td></tr> </tbody> </table>	Record #	DataName	Value	Unit	Short comment	1	Real time Available habitat	0,65	km2	This value changes during simulation (new constructions)	2	High/Low habitat limit	5,00	km2	See Chapter 4.3	3	1-Group abundance limit	99,00	fishes	To set recruitment	4	Recruitment multiplier	150,00	Constant K	See chapters 4.4 and 8.2	5	Species lower limit	50,00	Number	Number Age 2-10, Number 11-17, minimum number of 2-10 groups	6	Average G1 pop	42889,00	fishes	Table 1.1; used to calculate 9-group mortality (canibalism...)	7	C factor for mortality	0,50	Number	Non autoreproduction mortality	8	P factor for mortality	0,50	Number	autoreproduction mortality	9	H factor for mortality	1,00	Number	Habitat factor lower means small fishes can hide better.	10	Total Area of Fjord	23,55	km2	Total area used for density calculations	11	Initial available habitat	0,65	km2	this is initial value	12	Minimum GG	9317,00	fishes	Minimum recruitment possible	13	Maximum GG	412572,00	fishes	Maximum recruitment possible																																						
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Viewer "CodFish[1]->Seals[9]" (Local Cod Regulation Model v 1.20.mox)					
Record #	Data	Value	Unit	Comment	FishesEatenper Seal
1	Initial population	0.0000e+00	seals	Number of seals	
2	Population	0.0000e+00	seals	Number of seals (delta)	
3	0-group consumption	1.0000e-01	fish/seal/year/density		249.95
4	1-group consumption	4.0100e-01	fish/seal/year/density		569.48
5	2-group consumption	0.0000e+00	fish/seal/year/density		0.00
6	3-group consumption	0.0000e+00	fish/seal/year/density		0.00
7	4-group consumption	0.0000e+00	fish/seal/year/density		0.00
8	5-group consumption	0.0000e+00	fish/seal/year/density		0.00
9	6-group consumption	0.0000e+00	fish/seal/year/density		0.00
10	7-group consumption	0.0000e+00	fish/seal/year/density		0.00
11	8-group consumption	0.0000e+00	fish/seal/year/density		0.00
12	9-group consumption	0.0000e+00	fish/seal/year/density		0.00
13	10-group consumption	0.0000e+00	fish/seal/year/density		0.00

### 3.3 Social component (SC)

Two option	<p>The screenshot shows the SocieComp software interface. At the top, it displays "[693] SocieComp". Below the title bar are two buttons: "Eel fishers" and "Net fishing data". At the bottom of the window is a "Help" button.</p>																																																																																										
Eel fishers	<p>The screenshot shows a data viewer titled "Viewer "CodFish[1]-&gt;EelFishers[11]" (Local Cod Regulation Model v 1.20.mox)". The table has columns: Record #, Data, Value, Unit, Comment, and FishesEatenPer Fisher. The data includes initial values and consumption rates for different groups of eel fishers.</p> <table border="1"> <thead> <tr> <th>Record #</th><th>Data</th><th>Value</th><th>Unit</th><th>Comment</th><th>FishesEatenPer Fisher</th></tr> </thead> <tbody> <tr> <td>1</td><td>Initial Eel fishers</td><td>3.0000e+00</td><td>fishers</td><td>Number of fishers</td><td></td></tr> <tr> <td>2</td><td>Delta</td><td>0.0000e+00</td><td>fishers</td><td>Number of fishers</td><td></td></tr> <tr> <td>3</td><td>0-group consumption</td><td>5.7200e-01</td><td>density multiplier</td><td></td><td>85.05</td></tr> <tr> <td>4</td><td>1-group consumption</td><td>6.4000e-01</td><td>density multiplier</td><td></td><td>776.39</td></tr> <tr> <td>5</td><td>2-group consumption</td><td>6.3300e-01</td><td>density multiplier</td><td></td><td>2202.20</td></tr> <tr> <td>6</td><td>3-group consumption</td><td>0.0000e+00</td><td>density multiplier</td><td></td><td>0.00</td></tr> <tr> <td>7</td><td>4-group consumption</td><td>0.0000e+00</td><td>density multiplier</td><td></td><td>0.00</td></tr> <tr> <td>8</td><td>5-group consumption</td><td>0.0000e+00</td><td>density multiplier</td><td></td><td>0.00</td></tr> <tr> <td>9</td><td>6-group consumption</td><td>0.0000e+00</td><td>density multiplier</td><td></td><td>0.00</td></tr> <tr> <td>10</td><td>7-group consumption</td><td>0.0000e+00</td><td>density multiplier</td><td></td><td>0.00</td></tr> <tr> <td>11</td><td>8-group consumption</td><td>0.0000e+00</td><td>density multiplier</td><td></td><td>0.00</td></tr> <tr> <td>12</td><td>9-group consumption</td><td>0.0000e+00</td><td>density multiplier</td><td></td><td>0.00</td></tr> <tr> <td>13</td><td>10-group consumption</td><td>0.0000e+00</td><td>density multiplier</td><td></td><td>0.00</td></tr> </tbody> </table>	Record #	Data	Value	Unit	Comment	FishesEatenPer Fisher	1	Initial Eel fishers	3.0000e+00	fishers	Number of fishers		2	Delta	0.0000e+00	fishers	Number of fishers		3	0-group consumption	5.7200e-01	density multiplier		85.05	4	1-group consumption	6.4000e-01	density multiplier		776.39	5	2-group consumption	6.3300e-01	density multiplier		2202.20	6	3-group consumption	0.0000e+00	density multiplier		0.00	7	4-group consumption	0.0000e+00	density multiplier		0.00	8	5-group consumption	0.0000e+00	density multiplier		0.00	9	6-group consumption	0.0000e+00	density multiplier		0.00	10	7-group consumption	0.0000e+00	density multiplier		0.00	11	8-group consumption	0.0000e+00	density multiplier		0.00	12	9-group consumption	0.0000e+00	density multiplier		0.00	13	10-group consumption	0.0000e+00	density multiplier		0.00						
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Net fishing data	<p>The screenshot shows a data viewer titled "Viewer "CodFish[1]-&gt;NetFishing[15]" (Local Cod Regulation Model v 1.20.mox)". The table has columns: Record #, Data, Value, Unit, Comment, and Catch(tons). The data includes initial fleet values and consumption rates for different groups of net fishing boats.</p> <table border="1"> <thead> <tr> <th>Record #</th><th>Data</th><th>Value</th><th>Unit</th><th>Comment</th><th>Catch(tons)</th></tr> </thead> <tbody> <tr> <td>1</td><td>Initial Fleet</td><td>3.0000e+00</td><td>Boats</td><td>Commercial fleet</td><td></td></tr> <tr> <td>2</td><td>DeltaFleet</td><td>0.0000e+00</td><td>Boats</td><td>Commercial fleet</td><td></td></tr> <tr> <td>3</td><td>Days at sea</td><td>1.7000e+01</td><td>days</td><td></td><td></td></tr> <tr> <td>4</td><td>0-group consumption</td><td>0.0000e+00</td><td>fish/year</td><td></td><td></td></tr> <tr> <td>5</td><td>1-group consumption</td><td>0.0000e+00</td><td>fish/year</td><td></td><td>0.00</td></tr> <tr> <td>6</td><td>2-group consumption</td><td>2.7899e+04</td><td>fish/year</td><td></td><td>13.07</td></tr> <tr> <td>7</td><td>3-group consumption</td><td>1.2280e+03</td><td>fish/year</td><td></td><td>1.24</td></tr> <tr> <td>8</td><td>4-group consumption</td><td>1.5677e+03</td><td>fish/year</td><td></td><td>2.30</td></tr> <tr> <td>9</td><td>5-group consumption</td><td>3.5176e+03</td><td>fish/year</td><td></td><td>7.60</td></tr> <tr> <td>10</td><td>6-group consumption</td><td>1.8796e+02</td><td>fish/year</td><td></td><td>0.59</td></tr> <tr> <td>11</td><td>7-group consumption</td><td>2.0706e+02</td><td>fish/year</td><td></td><td>0.80</td></tr> <tr> <td>12</td><td>8-group consumption</td><td>1.6116e+02</td><td>fish/year</td><td></td><td>0.83</td></tr> <tr> <td>13</td><td>9-group consumption</td><td>4.4200e+00</td><td>fish/year</td><td></td><td>0.02</td></tr> <tr> <td>14</td><td>10-group consumption</td><td>6.8000e+00</td><td>fish/year</td><td></td><td>0.04</td></tr> </tbody> </table>	Record #	Data	Value	Unit	Comment	Catch(tons)	1	Initial Fleet	3.0000e+00	Boats	Commercial fleet		2	DeltaFleet	0.0000e+00	Boats	Commercial fleet		3	Days at sea	1.7000e+01	days			4	0-group consumption	0.0000e+00	fish/year			5	1-group consumption	0.0000e+00	fish/year		0.00	6	2-group consumption	2.7899e+04	fish/year		13.07	7	3-group consumption	1.2280e+03	fish/year		1.24	8	4-group consumption	1.5677e+03	fish/year		2.30	9	5-group consumption	3.5176e+03	fish/year		7.60	10	6-group consumption	1.8796e+02	fish/year		0.59	11	7-group consumption	2.0706e+02	fish/year		0.80	12	8-group consumption	1.6116e+02	fish/year		0.83	13	9-group consumption	4.4200e+00	fish/year		0.02	14	10-group consumption	6.8000e+00	fish/year		0.04
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In addition the fishing effort, coefficients in the Schaffer model and minimum fish size (represented by minimum year-class) (Table 1.3 in the document “Part 1: ExtendSim Model description”) can be changed Extend input table “HumanHavest (30)”.

Viewer "CodFish[1]->HumanHarvest[30]" (2009-06-11GL.mx)										
Record #	Category	Effort Indicator	Percent Effort (FE)	Unit	Catchability Coef(q)	FE × q	Min year class (<10)	Harvests on (tons)	Fishing potential	Harvest(tons)
	Hotel tourist	tourist days	0 %	days	0,000e+00	0,000e+00	0	103,564	32820	0,000
	Camping tourist	tourist days	2 %	days	1,000e-05	2,000e-07	1	102,958	33566	0,691
	2nd Home owners	tourist days	3 %	days	1,330e-05	3,990e-07	0	103,564	115563	4,775
	2nd Home renters	tourist days	3 %	days	1,330e-05	3,990e-07	0	103,564	100188	4,140
	Fishing tourists	tourist days	75 %	days	1,670e-05	1,252e-05	2	101,758	2588	3,298
	Commercial fishers	vessel days at sea	100 %	days	6,667e-03	6,667e-03	2	101,758	51	34,598

Table 1.3 in the document “Part 1: ExtendSim Model description”.

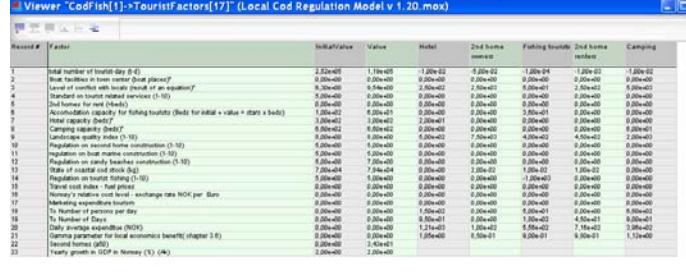
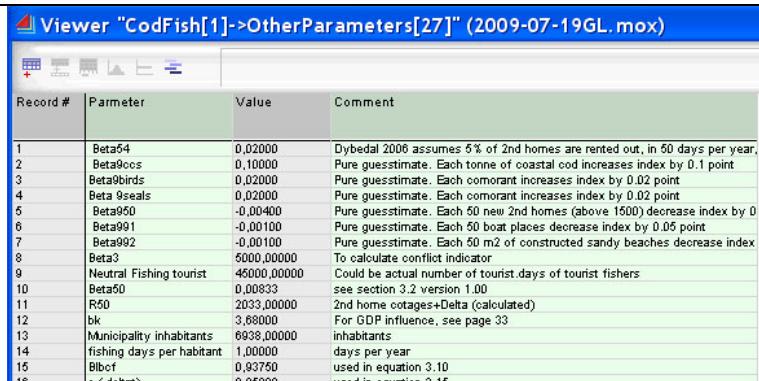
Category	EI - Effort Indicator	FE - Fishing effort as proportion of EI	Fishing effort unit	q - Catchability coefficient	Catch per unit effort indicator, per cod stock unit (= FE * q)	Year-classes harvested on	Example EI value	"Normal" cod stock biomass (tonnes)	Example harvest tonnes biomass
								30	
Hotel tourists	Tourist days	0	days		x	x	32 000		0,00
Camping tourists*	Tourist days	2 %	days	1,00E-05	0,0000002	1-10	35 000		0,21
2nd home owners	Tourist days	3 %	days	1,33E-05	0,0000004	0-10	115 000		1,38
2nd home renters*	Tourist days	3 %	days	1,33E-05	0,0000004	0-10	100 000		1,20
Fishing tourists**	Tourist days	75 %	days	1,67E-05	0,0000125	2-10	4 000		1,50
Recreational fishers	Active days	75 %	days	1,67E-05	0,0000125	2-10	4 000		1,50
Commercial fishers***	vessel days at sea	100 %	vessel days	0,006666667	0,006666667	2-10	50		10,00
							Sum harvest tonnes		
									15,79

\* Not counting Fishing tourists, even though they may be staying at this type of accommodation

\*\* Each boat with fishing tourist catches 1,5 kg cod per day, and have ca 3 tourists per boat on average (Volstad 2009, prelim results survey)

\*\*\* Commercial fishermen catch about 10 tonnes cod per year in the Søndeledfjord system. We assume with 50 vessel days.

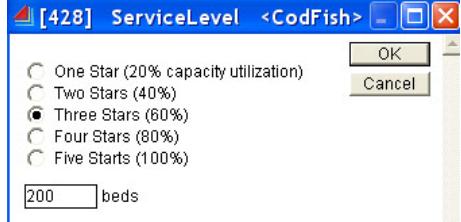
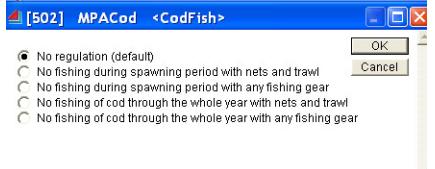
### 3.4 Economic component (EC)

Three option	
Tourist Factors	
Cod price	
Economy Comp	

### 3.5 Indicators

Record #	Indicator	Value	Unit	GreenLimit	RedLimit	Max
1	Cod biomass (2-10 group)	3,24e+00	tons / km2	1,00e+00	6,00e-01	3,00e+00
2	0 group density	1,29e+03	fishes / km 2	4,00e+03	1,00e+03	3,00e+04
3	1 group density	5,57e+02	fishes / km 2	1,50e+03	5,00e+02	5,00e+03
4	Demographic index	1,83e-01	1G D / 2-10D	1,00e+00	5,00e-01	2,00e+00
5	Level of conflict (equ.3.1)	9,54e+00	Index	1,00e+00	5,00e+00	1,00e+01
6	Commercial cod fishing		tons / year	1,00e+01	7,00e+00	2,00e+01
7	Local economic benefits	6,23e+07	NOK	5,00e+08	2,00e+08	1,00e+09
8	Number of tourist days	3,26e+02	Persons/day	1,00e+03	2,00e+02	5,00e+03

## 4 Regulations and Scenarios

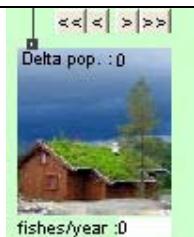
Three options	Regulations
<p><b>Tourist fisher accommodation</b></p> <p>The standard is indicated by number of stars (1-5 – worst to best), according to NHO's (The Confederation of Norwegian Enterprises) classification system for fishing tourism accommodation, see <a href="http://www.fisketurisme.no">http://www.fisketurisme.no</a>). We assume that beds in premises with 5 stars are utilized 100% for the 180 day season. 1 star gives only 20% capacity utilization (36 days).</p> <p>Number of dedicated beds for tourist fishers can be changed.</p>	
<p><b>MPA habitat</b></p> <p><b>Option 1: Non</b></p> <p><b>Option 2:</b> No new sandy beaches</p> <p>Option 3: No new sandy beaches and marinas over depths less than 25 m</p>	
<p><b>MPA cod</b></p> <p><b>Option 1: Non</b></p> <p><b>Option 2:</b> No fishing during spawning period (3 months) with nets</p> <p><b>Option 3:</b> No fishing during spawning period (3 months) with nets and hooks</p> <p><b>Option 4:</b> No fishing of cod through the whole year with nets and trawl</p> <p><b>Option 5:</b> No fishing of cod through the whole year with nets, trawl and hooks</p>	

### Eel-fishers

<p>The default number of eel fishers is set to 3.</p>	
---	---

## **2<sup>nd</sup> homes**

The present numbers of 2<sup>nd</sup> homes in the study area is 1523. Over the next years it might expand to nearly 2000. The effect of each 2<sup>nd</sup> home is that the available 0-group cod habitat is reduced with 50m<sup>2</sup>.



## **Recreational fishers**

The numbers of recreational fishers are dependent of number of municipal inhabitants



## **Camping tourists**

The numbers of camping tourists are dependent on parameters given in the economical component.



## **Tourist fishers**

The present numbers of tourist fishers are dependent on the number of beds available and quality of the facilities



## **Commercial fishers**

The numbers of commercial fishers are set directly.

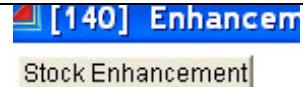


## Stock enhancement

0-group and 1-group cod can be produced artificially for release. This option gives the possibility to produce and release both year-classes.



Double click on the picture and double click on "stock enhancement" bottom



You are now able to change the number of 0- and 1-group cod and the production cost for these

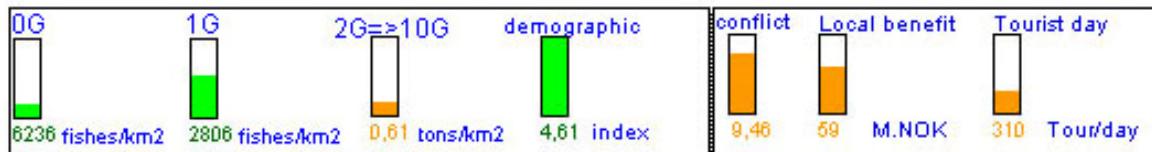
Viewer "CodFish[1]->StockEnhancem"			
Record #	Group	Enhancement	Cost
1	0-group	0,0000e+00	8,00
2	1-group	0,0000e+00	12,00

## 5. Output and export of data

### 5.1 General

<p>When running the model you can view the output values by selecting the four tables in the lower left corner of the front page of the model (circled in red). These tables are the same as in the database described under section 1.</p> <p>At present the values given are only from the last run of the model.</p>	<p><b>Outputs</b></p> <p>Cod pop. history Biomass history Tourists history Income Results Saves all data</p>
---	--

In addition the model shows the changes in fisheries and a set of indicators as the model progress.



### 5.2 Environmental (Cod population)

This table gives the number of cod by age-groups over a 1-50 years period.

Record #	0-Group	1-Group	2-Group	3-Group	4-Group	5-Group	6-Group	7-Group	8-Group	9-Group	10-Group
1	725062	48155	29211	10105	3162	1302	602	243	108	46	27
2	255194	16241	29211	10104	3166	1298	603	241	110	46	31
3	109692	20127	10104	9852	3166	1300	601	242	110	46	30
4	255194	73564	12200	30183	3166	1299	601	241	110	46	31
5	882994	9330	4481	4223	1069	1299	601	241	109	46	31
6	49105	9138	6874	1543	1223	438	601	241	110	46	31
7	239398	5126	6543	1063	483	543	203	241	110	46	31
8	79846	41498	3109	1917	615	198	251	81	110	46	31
9	506361	2326	25173	1075	601	252	92	101	37	46	31
10	4290	69143	1411	8707	337	247	117	37	46	15	31
11	50842	42	41942	488	2728	138	114	47	17	19	10
12	93970	7597	25	14608	153	1120	64	46	21	7	13
13	31103	18340	4658	6	4546	63	518	26	21	9	5
14	207388	30900	6302	1594	3	1606	20	208	12	9	6
15	1006894	9197	18744	2180	499	1	864	12	94	5	6
16	401153	104947	5579	6484	683	205	1	346	5	39	3
17	239692	960	63600	1930	2031	280	95	0	157	2	26
18	46533	34540	583	21999	605	834	130	38	0	65	1
19	44075	1776	20952	202	6892	248	386	52	17	0	44
20	5573	6276	1078	7247	63	2829	115	155	24	7	0
21	67605	651	3807	373	2271	26	1309	46	70	10	5

This table gives the weight of the cod by age-groups over a 1-50 years period.

Viewer "CodFish[1]->WeightHistory[8]" (2008-11-02-GL-CodFi...)

Record #	0-Group	1-Group	2-Group	3-Group	4-Group	5-Group	6-Group
1	62419	49871	39871	17974	6824	3570	2302
2	21969	16803	39854	17974	6836	3582	2275
3	9357	20973	13462	17947	6829	3594	2231
4	7191	7632	16690	6027	6868	3550	2289
5	7601	9751	6080	7492	2299	3576	2234
6	4227	9488	7735	2731	2834	12111	2263
7	29217	5292	7583	3488	1041	1472	758
8	6874	43009	4267	3399	1306	533	953
9	43591	2382	34309	1874	1294	677	352
10	369	71736	1927	15492	741	690	419
11	4377	44	57280	863	5853	371	447
12	8064	7838	34	25763	329	3091	239
13	26776	10749	6282	12	9849	167	1923
14	17897	32060	8594	2813	5	5115	106
15	86678	9552	25543	3847	1080	3	3242
16	34534	108874	7558	11443	1470	571	0
17	20634	998	86765	3423	4413	763	261
18	3990	36738	793	39047	1296	2263	497
19	3872	1858	28604	354	14837	673	1460
20	480	6537	1471	12875	135	7704	430
21	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0
41	n	n	n	n	n	n	n

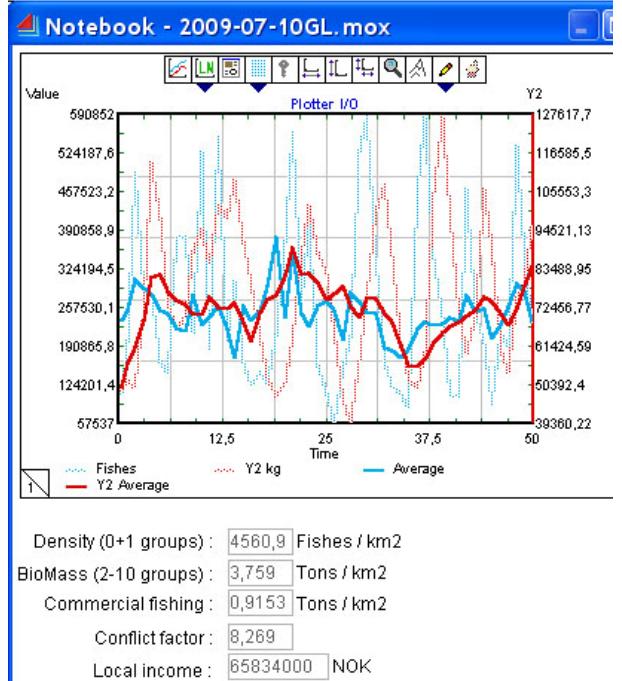
un

By choosing results the below figure will appear. The figure shows the average number (solid blue) and weight (solid red) of cod + the same values from the last run as stippled

In addition the values for:

- Density 0-1-gr (number  $\text{km}^{-2}$ )
- Biomass (2-10 yrs) (ton  $\text{km}^{-2}$ )
- Commercial fishing (2-10 yrs) (ton  $\text{km}^{-2}$ )
- Conflict Factor
- Local income

are given below and present output values from the model.



## 5.3 Economic

The results from the economic run will be displayed and exported similar to the ecosystem data (Not available yet)

This table gives the number of person pr day ( $T_0$ ) over a time period (1-50 years) selected. The same Table as TouristHistory in Databases. Corresponds to Table 3.3 and 3.5.

Record #	Second home owners	Fishing tourists	Second gome renters	Staying at hotel	Camping	Total
1	12500	45000	9000	4500	6000	77000
2	10999	43452	7464	2969	4469	69323
3	11123	228287	192279	187784	4023	624075
4	27	143683	107975	103180	0	354546
5	6418	114057	78069	73574	0	271117
6	7087	91683	55695	51200	587	206250
7	8384	81765	45777	41282	1884	179092
8	8927	73741	37753	33258	2427	156106
9	9387	92580	56592	52097	2887	213543
10	8238	102293	66305	61810	1738	240388
11	7701	125617	89629	85134	1201	309283
12	96323	130767	94779	90284	0	322163
13	40666	108187	72198	67704	0	254166
14	7439	8924	40255	40111	928	133333
15	8734	9723	61235	56740	2234	228166
16	7908	160036	72048	67553	1488	257110
17	7387	170311	134233	120928	867	442805
18	3655	201999	166011	161516	0	533180
19	1845	162583	116595	112100	0	383125
20	4847	121434	85446	80951	0	292678
21	6665	91330	55342	50847	155	204329
22	0	0	0	0	0	0
23	0	0	0	0	0	0
24	0	0	0	0	0	0
25	0	0	0	0	0	0
26	0	0	0	0	0	0
27	0	0	0	0	0	0
28	0	0	0	0	0	0
29	0	0	0	0	0	0
30	0	0	0	0	0	0
31	0	0	0	0	0	0
32	0	0	0	0	0	0

This table gives the income over 1-50 years period.

Record #	Second home owners	Fishing tourists	Second gome renters	Staying at hotel	Camping	L6	L7	com. Fishery	Stock Enhancement	Total
1	18044775	0	4503600	0	26345088	0,00	7505568,00	144040	0	56543071
2	20766988	910383	16431909	150936	29700397	0,00	7506568,00	215985	0	74682166
3	20564956	946710	15421938	261671	31909641	26073052,97	7593242,22	186934	0	102956144
4	19842278	472074	15335644	0	27305923	0,00	7593696,00	123306	0	70672922
5	20602044	930612	15444003	250070	31171752	0,00	7593896,00	239100	0	78231277
6	20539840	926993	15372461	199271	32040068	7276946,42	7618166,73	65024	0	84038770
7	20298741	833572	15635469	329295	30492021	0,00	7618176,00	327483	0	75434757
8	20546359	929668	15398611	225624	31862354	0,00	7618176,00	177175	0	76757968
9	20532363	914674	15334271	149349	32105134	2371666,82	7626151,02	120657	0	79154255
10	20451039	842466	15274514	30123	31546931	0,00	7627968,00	56497	0	75828527
11	20546191	901686	15297213	91704	32002231	0,00	7627968,00	70552	0	76537546
12	20536878	923660	15356633	180651	32101997	911353,89	7631032,55	25932	0	77668037
13	20502979	982669	15688488	491570	31926010	0,00	7632864,00	392386	0	77514966
14	20517516	911789	15336534	153443	32128035	0,00	7632864,00	130446	0	76810627
15	20531618	892023	15267383	55927	32111779	139234,82	7633332,20	38174	0	76669471
16	20532295	902137	15302135	102257	32070855	135065,83	7638214,18	67317	0	76750276
17	20530753	909807	15322788	131355	32073932	6485,53	7642677,81	99448	0	76716746
18	20533285	902394	15297154	97374	32105913	0,00	7647552,00	79459	0	76663131
19	20534368	894358	15272628	62963	32104884	24253,28	7647633,55	59704	0	76600782
20	0	0	0	0	0,00	0,00	0	0	0	0
21	0	0	0	0	0,00	0,00	0	0	0	0
22	0	0	0	0	0,00	0,00	0	0	0	0
23	0	0	0	0	0,00	0,00	0	0	0	0

## 5.4 Export of data to MS Excel

The data from each run are automatically saved in a Excel spreadsheet named (Exportresults.xls)	 ExportedData.xls Microsoft Office Excel 97-2003 Work... 462 KB
Remember to save the excel file with a new name if you like to keep the data.	

The following data are exported and listed in the following order:

- Local benefit from commercial fishery
- Local benefit from building 2<sup>nd</sup> homes
- Local benefit from maintenance 2<sup>nd</sup> homes
- Local benefit from stock enhancement activity
- Total weight of cod eaten by birds
- Total weight of cod eaten by seals
- Total weight of cod fished by eel fishers
- Total weight of cod fished by 2<sup>nd</sup> home owners fishers
- Total weight of cod fished by commercial fishers
- Total weight of cod fished by tourist fishers
- Total weight of cod fished by Camping tourists
- Total weight of cod fished by recreational fishers
- Number and weight of each year-class (0-10) of cod
- 2<sup>nd</sup> Home owners
- Commercial fishing
- Density 0-gr (number km<sup>-2</sup>)
- 2<sup>nd</sup> Home renters
- Hotel
- Camping
- Density 1-gr (number km<sup>-2</sup>)
- Density (2-10 yrs) (number km<sup>-2</sup>)
- Biomass (2-10 yrs) (ton km<sup>-2</sup>)
- Cod demographic index: E1 = N1/ N(2-10); N1 = Density 1-gr, N(2-10) = Density (2-10 yrs)
- Conflict Factor
- Number of 2<sup>nd</sup> homes (absolute numbers, and total number allowed (R50).
- Tuning-Cod stock Average
- Tuning-Economic average

One row in the excel sheet represents one simulation (1-50 years; columns) and there is room for up to 100 simulations (row 3 to row 102). Between row 104 and row 111 are the calculated minimum (Min), maximum (Max); median, average, number of simulations (Count), standard deviation (Stdev), 5%-percentile and 95%-percentile values over the number of simulations chosen for each of the year in the simulation.

This table explanation of content of the different sheets in the excel-file "ExportedData.xls"

Sheet name	Content 1	Content 2
LocBenCommFishery	Local benefit from commercial fishery	
LocBenConstruction	Local benefit from building 2 <sup>nd</sup> homes	
LocBenMaintenance	Local benefit from maintenance 2 <sup>nd</sup> homes	
LocBenStkEnhance	Local benefit from stock enhancement activity	
BirdsEating	Total weight of cod eaten by birds	
SealsEating	Total weight of cod eaten by seals	
EelFishersEating	Total weight of cod fished by eel fishers	
SecondHEating	Total weight of cod fished by 2 <sup>nd</sup> home owners fishers	
NetFishersEating	Total weight of cod fished by commercial fishers	
TouristFishersEating	Total weight of cod fished by tourist fishers	
CampinFishersEating	Total weight of cod fished by Camping tourists	
RecretaionFishersEating	Total weight of cod fished by recreational fishers	
Group0	Number of fishes	Biomass of fishes (kg)
Group1	Number of fishes	Biomass of fishes (kg)
Group2	Number of fishes	Biomass of fishes (kg)
Group3	Number of fishes	Biomass of fishes (kg)
Group4	Number of fishes	Biomass of fishes (kg)
Group5	Number of fishes	Biomass of fishes (kg)
Group6	Number of fishes	Biomass of fishes (kg)
Group7	Number of fishes	Biomass of fishes (kg)
Group8	Number of fishes	Biomass of fishes (kg)
Group9	Number of fishes	Biomass of fishes (kg)
Group10	Number of fishes	Biomass of fishes (kg)
SecondHomeOwn	Number of Touristdays	Expenditure (NOK)
Fishing	Number of Touristdays; <b>Fishing tourists</b>	Expenditure (NOK)
SecondHomeRent	Number of Touristdays	Expenditure (NOK)
Hotel	Number of Touristdays; <b>tourists staying at hotels</b>	Expenditure (NOK)
Camping	Number of Touristdays; <b>Camping tourists</b>	Expenditure (NOK)
0Gdensity	0-group cod; density (number/km2)	

1Gdensity	1-group cod; density (number/km2)	
2-10Gdensity	Sum of 2-10 group cod; density (number/km2)	
2-10Gbiomass	Sum of 2-10 group cod biomass (kg)	
DemogIndex	Demographic Index = OG/(2-10G); OG = Number of 0-group cod; (2- 10G) sum of Number of 2-10 group cod	
ConflictFactor	See Chapter 2.8 (Description document)	
Number2ndHomes	Total number of 2 <sup>nd</sup> Homes	
Tuning-Cod stock Average	Excel sheet to help in tuning the ecological component	
Tuning-Economic average	Excel sheet to help in tuning the economic component	

## 6. Adopting the model to other local cod stocks and fjord systems

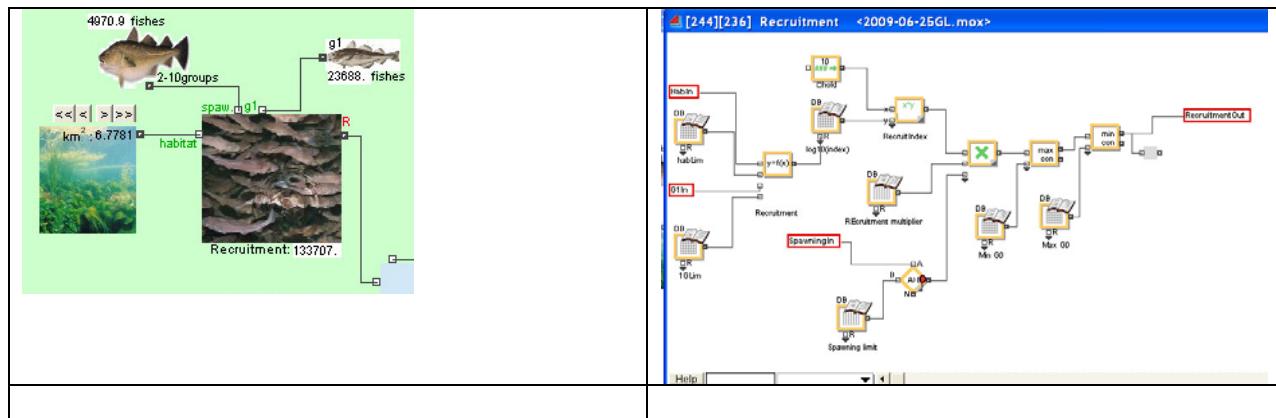
The model can easily be adapted to other fjord systems and their cod stock. You have to change the parameters given chapter 2.

## 7 Calculations

### 7.1 Cod population

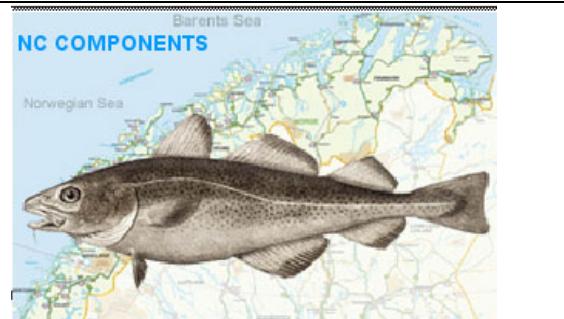
#### 7.1.1 Estimating annual recruitment (Number of 0-group cod)

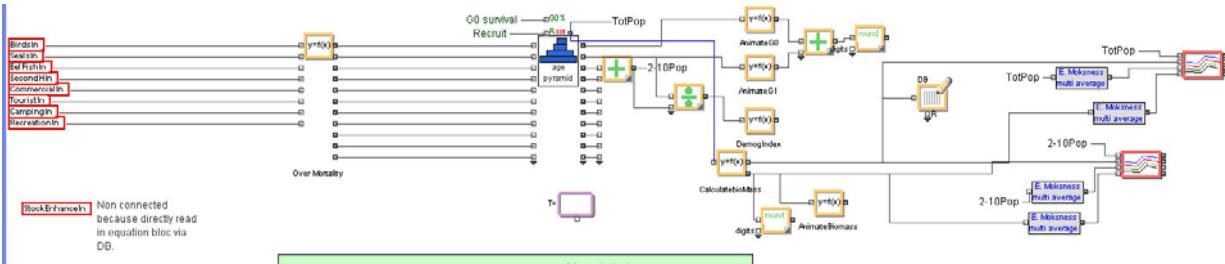
The left figure shows where the annual recruitment is calculated in the model and the right figure shows the content of the recruitment box. The abundance of the 0-group cod in the population is modeled as a function of the area of suitable habitats (eelgrass etc; at present the default value is 1) for recruitment, the strength of the 1-group cod and that the spawning stock (year-classes 4-10) consist of more than 100 cod.



#### 7.1.2 Estimating cohort sizes over the chosen time frame

The calculations in the ecosystem model take place in the block shown to the right. When open it the structure will be seen as below. Average numbers of code in the different year-classes of cod are calculated in the different “multi average” boxes.



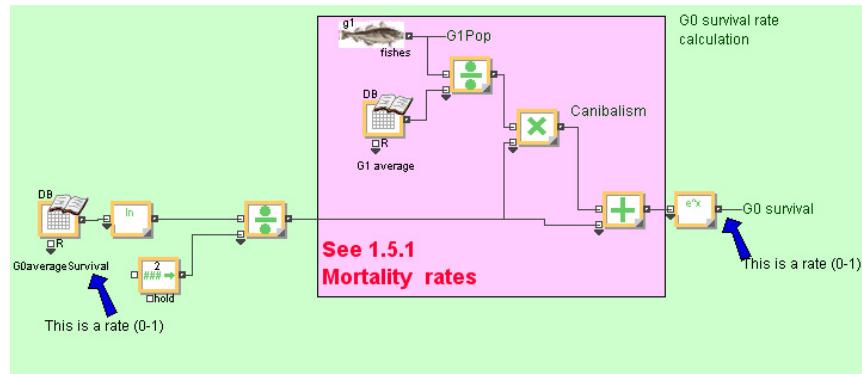


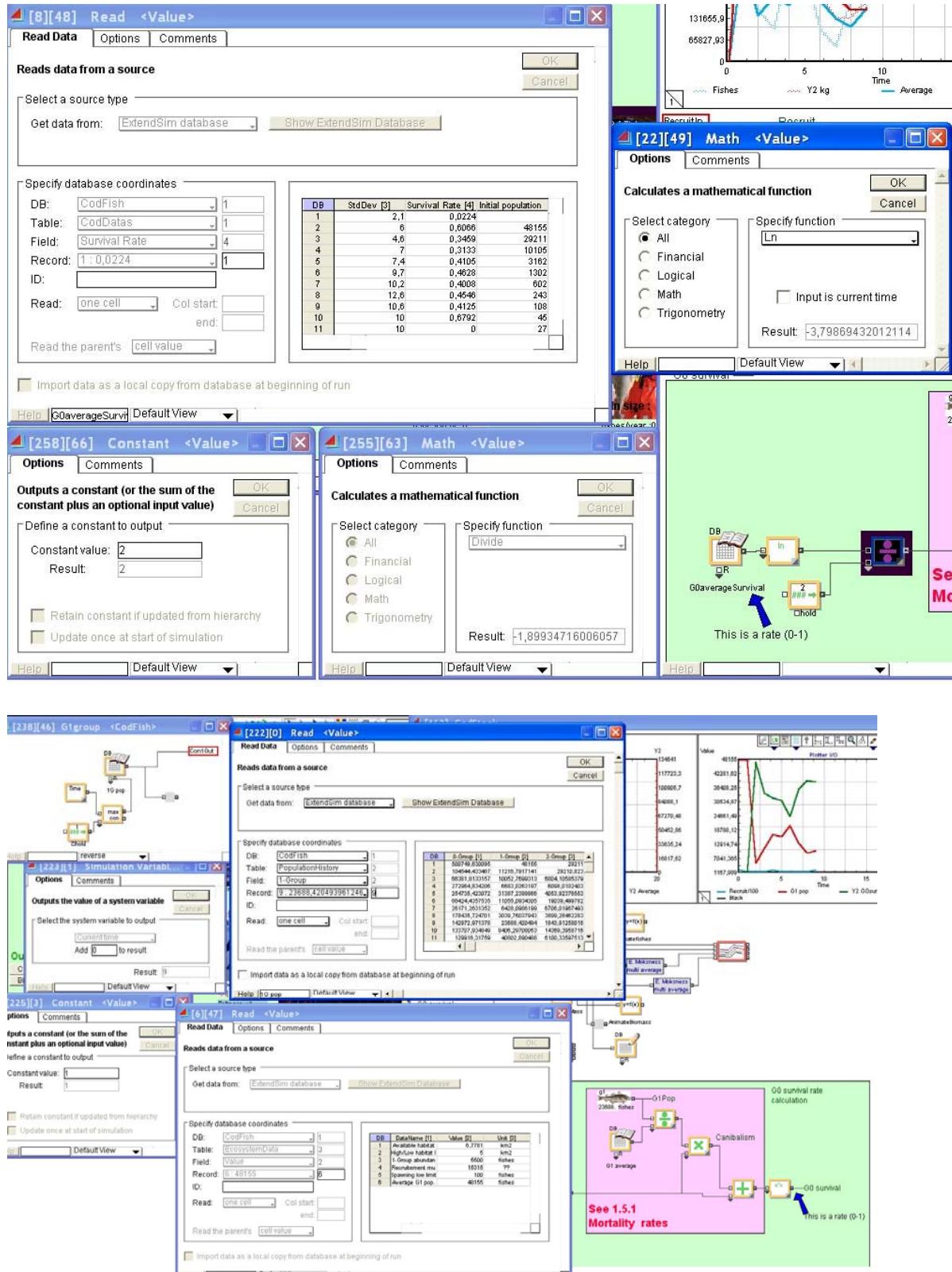
### 7.1.3 Estimating survival from 0-group to 1-group cod

The mortality caused by 1-group cod on the 0-group cod can be changed by entering this input-table and changes the value in the last line.

Viewer "CodFish[1]->EcosystemData[3]" (2009-06-25GL.mox)				
Record #	DataName	Value	Unit	Short comment
1	Real time Available habitat	0,65	km2	This value changes during simulation (new constructions)
2	High/Low habitat limit	5,00	km2	See Chapter 4.3
3	1-Group abundance limit	99,00	fishes	To set recruitment
4	Recruitment_multiplier	15315,00	Constant K	See chapters 1.4 and 6.2
5	Spawning low limit	50,00	Number Age 2-10	Chapter 1.7; minimum number of 2-10 groups
6	Average G1 pop.	42889,00	fishes	Table 1.1; used to calculate 0-group mortality (canibalism...)
7	C factor for mortality	0,50	Number	Non autopredation mortality
8	P factor for mortality	0,50	Number	autopredation mortality
9	H factor for mortality	1,00	Number	Habitat factor lower means small fishes can hide better.
10	Total Area of Fiord	23,55	km2	Total area used for density calculations
11	Initial available habitat	0,65	km2	this is initial value
12	Minimum G0	9317,00	fishes	Minimum recruitment possible
13	Maximum G0	412572,00	fishes	Maximum recruitment possible

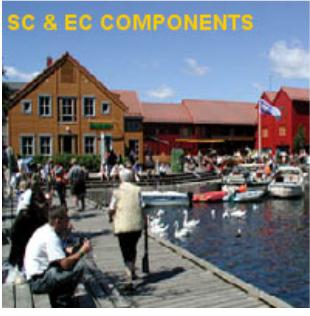
The survival from 0-group cod to 1-group cod are calculated in the three figures shown below.



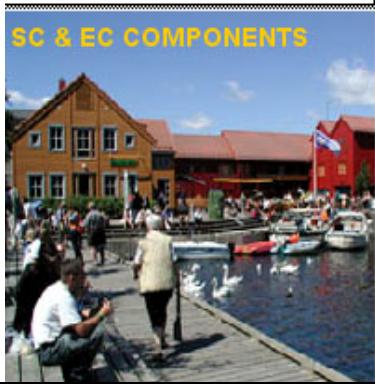


## 7.2 Social calculations

As avoiding/limiting the level of conflict between locals and tourists is a definitive objective in the policy issue, it would be useful to have this indicator as an output of the model. In addition, it is an input to the function determining how attractive the area is for tourists.

<p>The calculation of the Conflict indicator is found in the block as shown to the right.</p>	 <p><math>y=f(x)</math></p> <p>-&gt; Calculate A3</p>																		
<p>The equation in the model with input and output value is given to the right.</p> <p>From Part 1, Chapter 2.6:  <i>Conflict indicator:</i></p> $A3 = \beta_3 \frac{A_1}{\sum_{i=1}^5 L_{i-1}}$ <p>Equa (2.1): Let <math>\beta_3=1000</math>; <math>L_i</math> refer to the total sum in Equa (3.6).</p>	<p>Define input and output variables</p> <table border="1"> <thead> <tr> <th>Variable Type</th> <th>Variable Name</th> <th>Variable Value</th> </tr> </thead> <tbody> <tr> <td>Static multi run int</td> <td>A1</td> <td>157447.79926</td> </tr> <tr> <td>Static multi run int</td> <td>SumLi</td> <td>64163916.172</td> </tr> <tr> <td>Static multi run int</td> <td>Bet3</td> <td>0.0005</td> </tr> </tbody> </table> <table border="1"> <thead> <tr> <th>Variable Type</th> <th>Variable Name</th> <th>Variable Value</th> </tr> </thead> <tbody> <tr> <td>Connector</td> <td>A3</td> <td>1,227109825177</td> </tr> </tbody> </table> <pre> A1=DBDataGetAsNumber(1,16,6,currenttime); //Total number of tourists. SumLi=DBDataGetAsNumber(1,28,6,currenttime); //Total earnings. Bet3=DBDataGetAsNumber(1,27,2,8); A3=Bet3*A1/SumLi;  DBDataSetAsNumber(1,17,2,3,A3); </pre>	Variable Type	Variable Name	Variable Value	Static multi run int	A1	157447.79926	Static multi run int	SumLi	64163916.172	Static multi run int	Bet3	0.0005	Variable Type	Variable Name	Variable Value	Connector	A3	1,227109825177
Variable Type	Variable Name	Variable Value																	
Static multi run int	A1	157447.79926																	
Static multi run int	SumLi	64163916.172																	
Static multi run int	Bet3	0.0005																	
Variable Type	Variable Name	Variable Value																	
Connector	A3	1,227109825177																	

### 7.3 Economic calculations

The economic calculations take place in the bloc shown on the left. The different calculations are taken place in the blocs shown below	
Calculate total number of tourists (Part 1, Table 3.2) $A1 = \sum_{i=1}^5 T_i$	