System Formulation

Part 2: Running the model

ExtendSim Model with input and ouput

The SPICOSA SSA 7.6, Søndeledfjorden, Norway
Version 1.20 (19 July 2009)

Erlend Moksness[1], Jakob Gjøsæter[1], Inga Wigdahl Kaspersen[2], Eirik Mikkelsen[3], Håkan T. Sandersen[5] and Jon Helge Vølstad[1]

1) Institute of Marine Research, Flødevigen Marine Research Station, 4817 His, Norway
2) University of Tromsø, Department of Economics and Management, 9037 Tromsø, Norway
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 Lagaillarde, 1point2, France

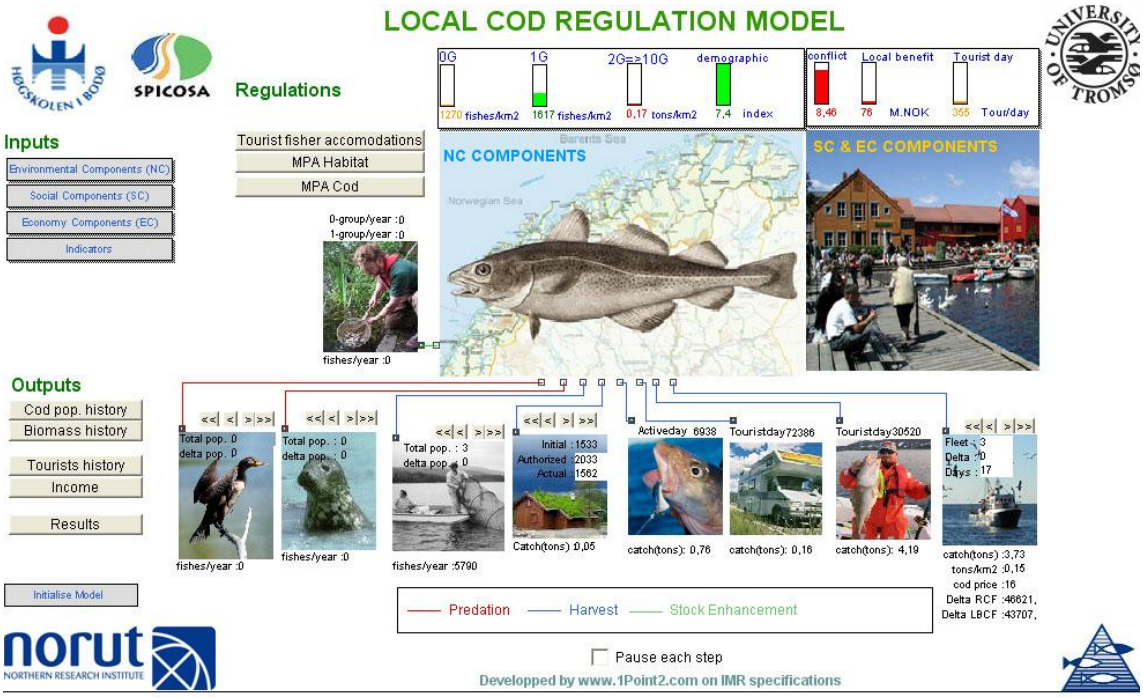


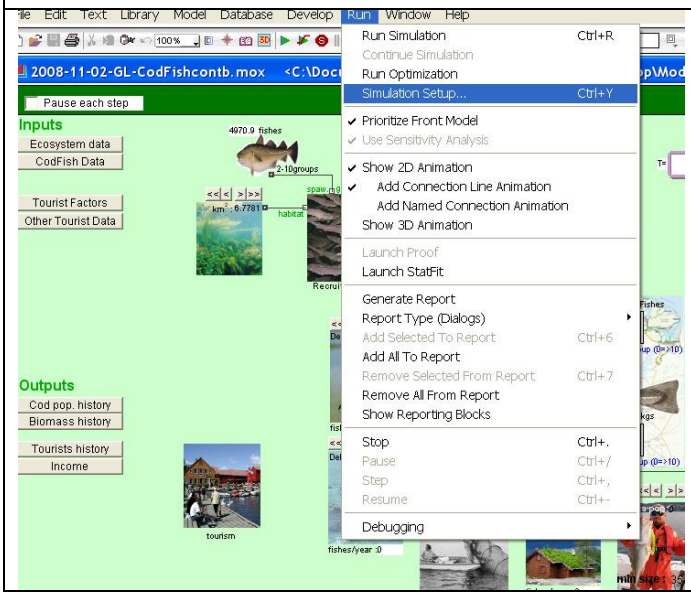
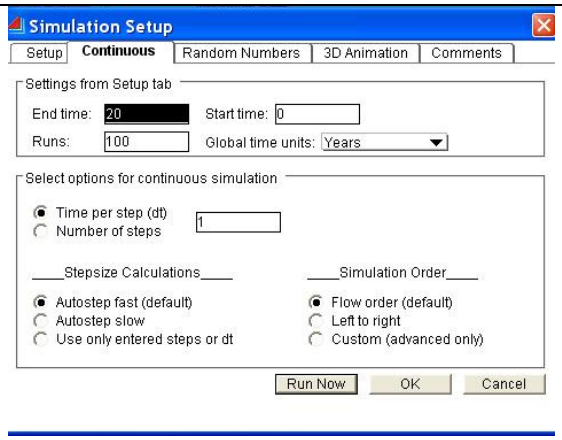
Table of Content

Page

1. What you need

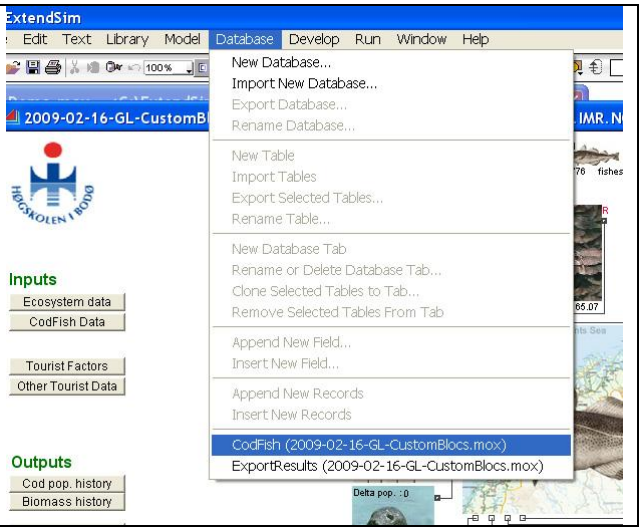
Make sure you have the following files in the same folder: - The ExtendSim Model - CodFish.lix - ExportedData.xls	

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.



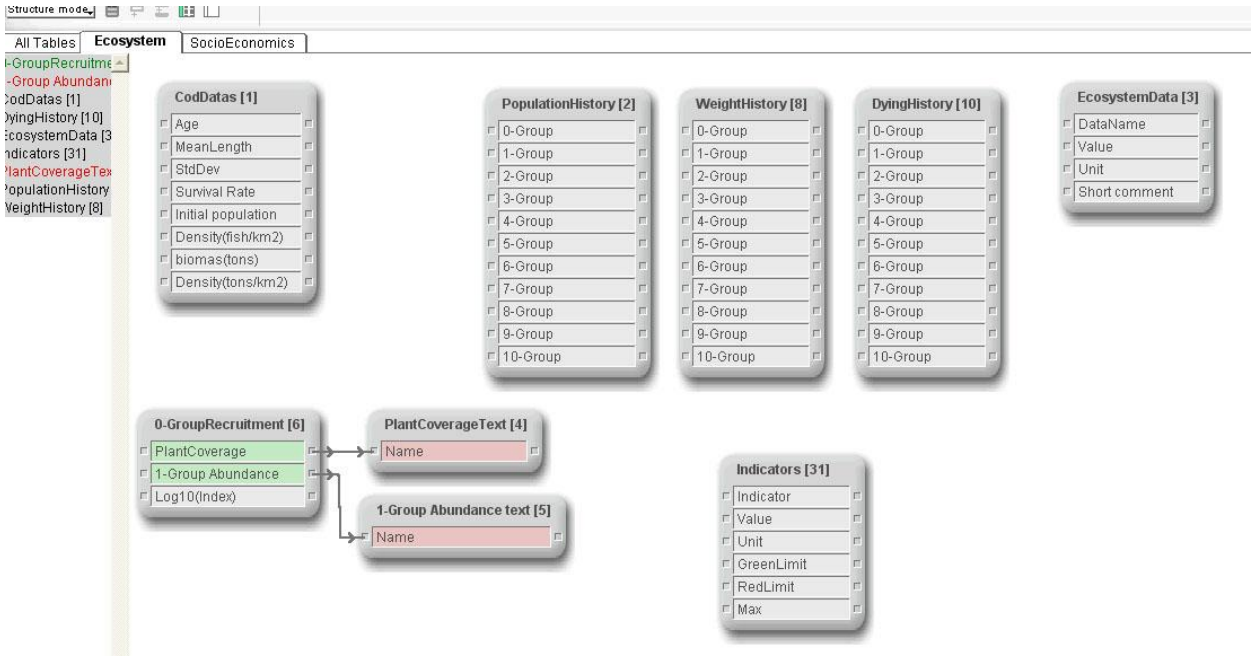
2.1 Environmental component (NC)

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	
0-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	

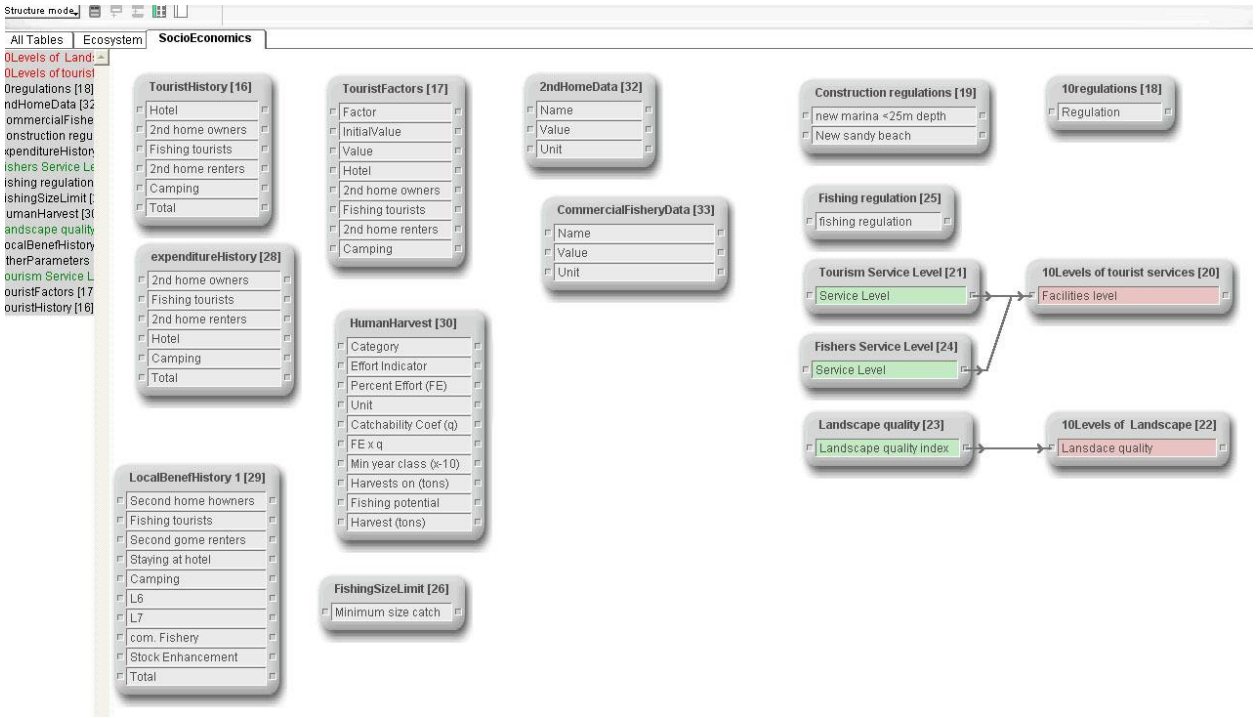


1.2 Social component

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".

Input Tables	**Content Table**	**Corresponding table in Part 1**
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
CommersialFisheryData (31)	Contain default price for cod	Chapter 3.3
2ndHomeData (32)	Default economical parameters	Chapter 3.2
Output Tables		
TouristHistory (16)	Number of tourist-days in the different categories	
ExpenditureHistory (28)	Cost in the different categories	
LocalBenefHistory (29)	Income from the different categories	

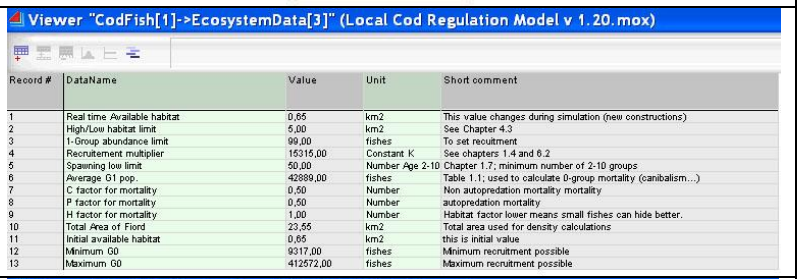
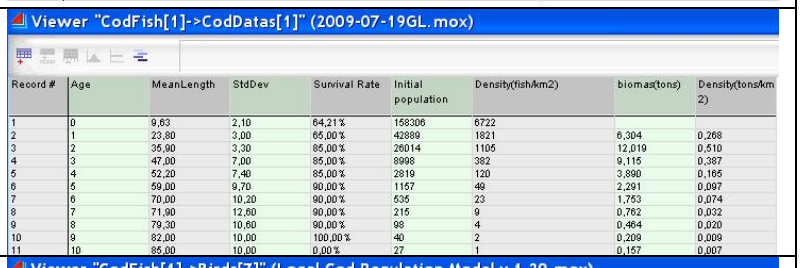
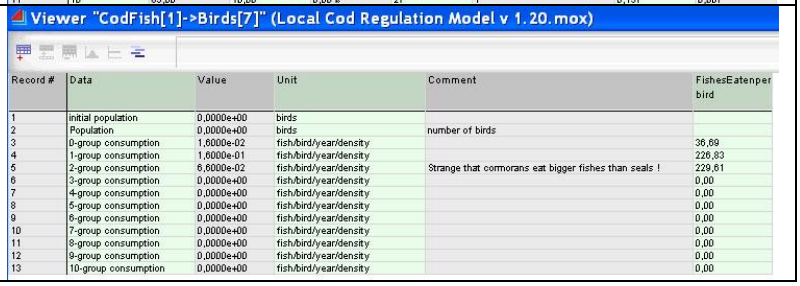
3. Changing Input parameters

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.	

3.2 Environmental components (NC)

Input data for the ecosystem model

Four option	
Ecosystem data	
Codfish data	
Birds data	

Viewer "CodFish[1]->EcosystemData[3]" (Local Cod Regulation Model v 1.20.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	Recruitement 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 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

Viewer "CodFish[1]->CodDatas[1]" (2009-07-19GL.mox)

Record #	Age	MeanLength	StdDev	Survival Rate	Initial population	Density(fish/km2)	biomass(tons)	Density(tons/km2)
1	0	9,63	2,10	64,21%	158306	6722		
2	1	23,80	3,00	65,00%	42889	1821	6,304	0,268
3	2	35,90	3,30	85,00%	26014	1105	12,019	0,510
4	3	47,00	7,00	85,00%	8998	382	9,115	0,387
5	4	52,20	7,40	85,00%	2819	120	3,890	0,165
6	5	59,00	9,70	90,00%	1157	49	2,291	0,097
7	6	70,00	10,20	90,00%	535	23	1,753	0,074
8	7	71,90	12,60	90,00%	216	9	0,762	0,032
9	8	79,30	10,60	90,00%	98	4	0,464	0,020
10	9	82,00	10,00	100,00%	40	2	0,209	0,009
11	10	85,00	10,00	0,00%	27	1	0,157	0,007

Viewer "CodFish[1]->Birds[7]" (Local Cod Regulation Model v 1.20.mox)

Record #	Data	Value	Unit	Comment	FishesEatenperbird
1	initial population	0,0000e+00	birds		
2	Population	0,0000e+00	birds	number of birds	
3	0-group consumption	1,6000e-02	fish/bird/year/density		36,69
4	1-group consumption	1,6000e-01	fish/bird/year/density		226,83
5	2-group consumption	6,6000e-02	fish/bird/year/density	Strange that cormorans eat bigger fishes than seals !	229,61
6	3-group consumption	0,0000e+00	fish/bird/year/density		0,00
7	4-group consumption	0,0000e+00	fish/bird/year/density		0,00
8	5-group consumption	0,0000e+00	fish/bird/year/density		0,00
9	6-group consumption	0,0000e+00	fish/bird/year/density		0,00
10	7-group consumption	0,0000e+00	fish/bird/year/density		0,00
11	8-group consumption	0,0000e+00	fish/bird/year/density		0,00
12	9-group consumption	0,0000e+00	fish/bird/year/density		0,00
13	10-group consumption	0,0000e+00	fish/bird/year/density		0,00

Seals data

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	1,0900e-01	fish/seal/year/density		249,95
4	1-group consumption	4,0100e-01	fish/seal/year/density		568,48
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

Eel fishers

Viewer "CodFish[1]->EelFishers[11]" (Local Cod Regulation Model v 1.20.mox)

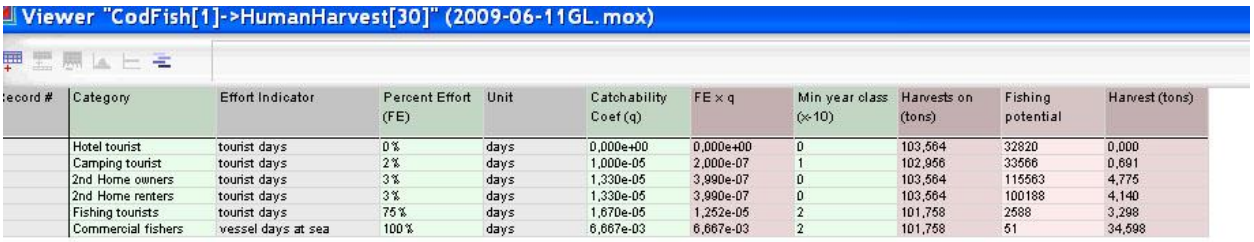
Record #	Data	Value	Unit	Comment	FishesEatenPer Fisher
1	Initial Eal fishers	3,0000e+00	fishers	Number of fishers	
2	Delta	0,0000e+00	fishers	Number of fishers	
3	0-group consumption	3,7200e-01	density multiplyier		853,06
4	1-group consumption	5,4900e-01	density multiplyier		778,30
5	2-group consumption	6,3300e-01	density multiplyier		2202,20
6	3-group consumption	0,0000e+00	density multiplyier		0,00
7	4-group consumption	0,0000e+00	density multiplyier		0,00
8	5-group consumption	0,0000e+00	density multiplyier		0,00
9	6-group consumption	0,0000e+00	density multiplyier		0,00
10	7-group consumption	0,0000e+00	density multiplyier		0,00
11	8-group consumption	0,0000e+00	density multiplyier		0,00
12	9-group consumption	0,0000e+00	density multiplyier		0,00
13	10-group consumption	0,0000e+00	density multiplyier		0,00

Net fishing data

Viewer "CodFish[1]->NetFishing[15]" (Local Cod Regulation Model v 1.20.mox)

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	Commercial fleet	
4	0-group consumption	0,0000e+00	fish/year		0,00
5	1-group consumption	0,0000e+00	fish/year		0,00
6	2-group consumption	2,7859e+04	fish/year		13,07
7	3-group consumption	1,2260e+03	fish/year		1,34
8	4-group consumption	1,5677e+03	fish/year		2,30
9	5-group consumption	3,5176e+03	fish/year		7,50
10	6-group consumption	1,6796e+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

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)”.



ecord #	Category	Effort Indicator	Percent Effort (FE)	Unit	Catchability Coef (q)	FE x q	Min year class (x-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	102,956	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	34,698

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	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 accomodation

** 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)

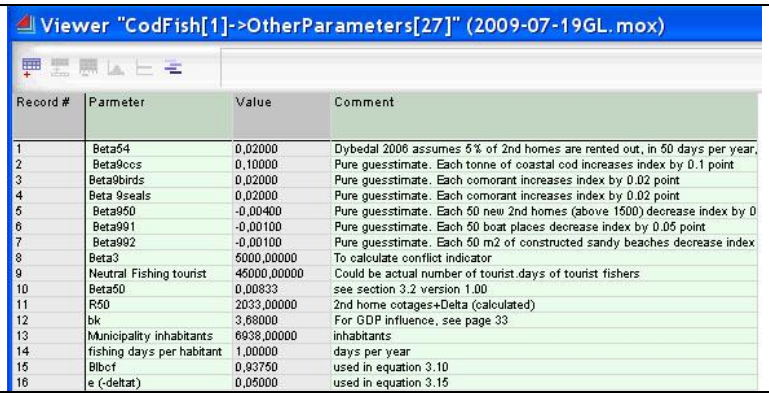
Three option

Tourist Factors

Cod price

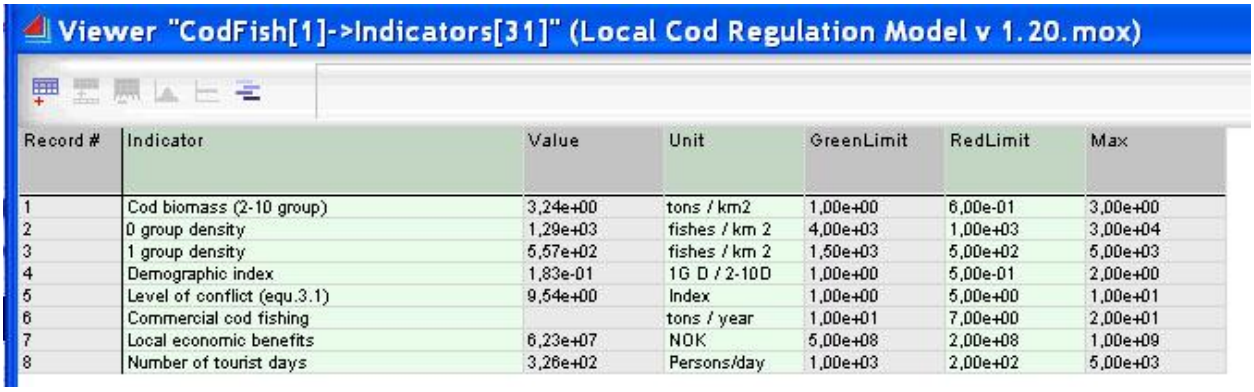
Record #	Name	Value	Unit
1	Cod Price	16,00	NOK/ kg

Economy Comp



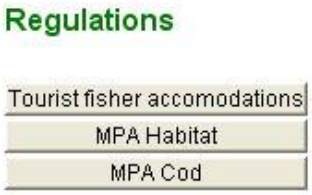
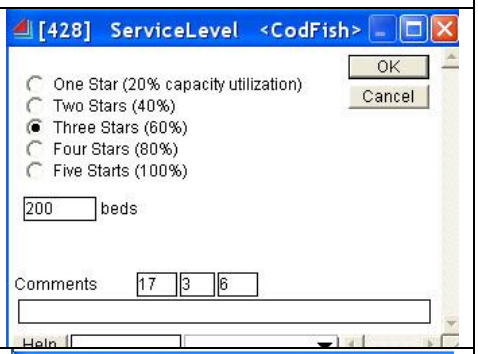
Record #	Parmeter	Value	Comment
1	Beta54	0,02000	Dybedal 2006 assumes 5% of 2nd homes are rented out, in 50 days per year,
2	Beta9ccs	0,10000	Pure guesstimate. Each tonne of coastal cod increases index by 0.1 point
3	Beta9birds	0,02000	Pure guesstimate. Each cormorant increases index by 0.02 point
4	Beta 9seals	0,02000	Pure guesstimate. Each cormorant increases index by 0.02 point
5	Beta950	-0,00400	Pure guesstimate. Each 50 new 2nd homes (above 1500) decrease index by 0
6	Beta991	-0,00100	Pure guesstimate. Each 50 boat places decrease index by 0.05 point
7	Beta992	-0,00100	Pure guesstimate. Each 50 m2 of constructed sandy beaches decrease index
8	Beta3	5000,00000	To calculate conflict indicator
9	Neutral Fishing tourist	45000,00000	Could be actual number of tourist.days of tourist fishers
10	Beta50	0,00833	see section 3.2 version 1.00
11	R50	2033,00000	2nd home cotages+Delta (calculated)
12	bk	3,68000	For GDP influence, see page 33
13	Municipality inhabitants	6938,00000	inhabitants
14	fishing days per habitant	1,00000	days per year
15	Blbof	0,93750	used in equation 3.10
16	e (-deltat)	0,05000	used in equation 3.15

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	
Tourist fisher accommodation 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 http://www.fisketurisme.no). 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). Number of dedicated beds for tourist fishers can be changed.	
MPA habitat **Option 1: Non** **Option 2:** No new sandy beaches Option 3: No new sandy beaches and marinas over depths less than 25 m	
MPA cod **Option 1: Non** **Option 2:** No fishing during spawning period (3 months) with nets **Option 3**: No fishing during spawning period (3 months) with nets and hooks **Option 4:** No fishing of cod through the whole year with nets and trawl **Option 5**: No fishing of cod through the whole year with nets, trawl and hooks	

Eel-fishers

The default number of eel fishers is set to 3.	

2nd homes

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

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.	

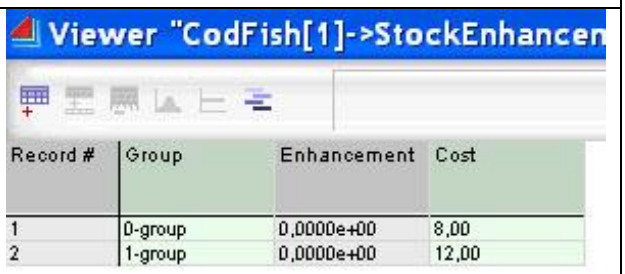
Tourist fishers

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

Commercial fishers

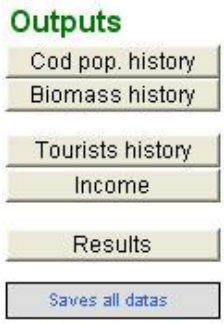
The numbers of commercial fishers are are set directly.	

Stock enhancement

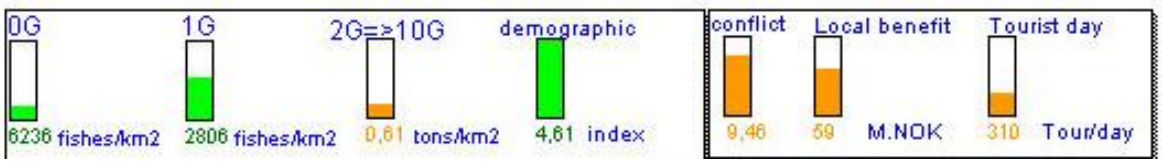
0-group and 1-group cod can be produced artificially for release. This option gives the possibility to produce and release both year-classes.	
Double click on the picture and double click on "stock enhancement" bottom	
You are now able to change the number of 0- and 1-group cod and the production cost for these	

5. Output and export of data

5.1 General

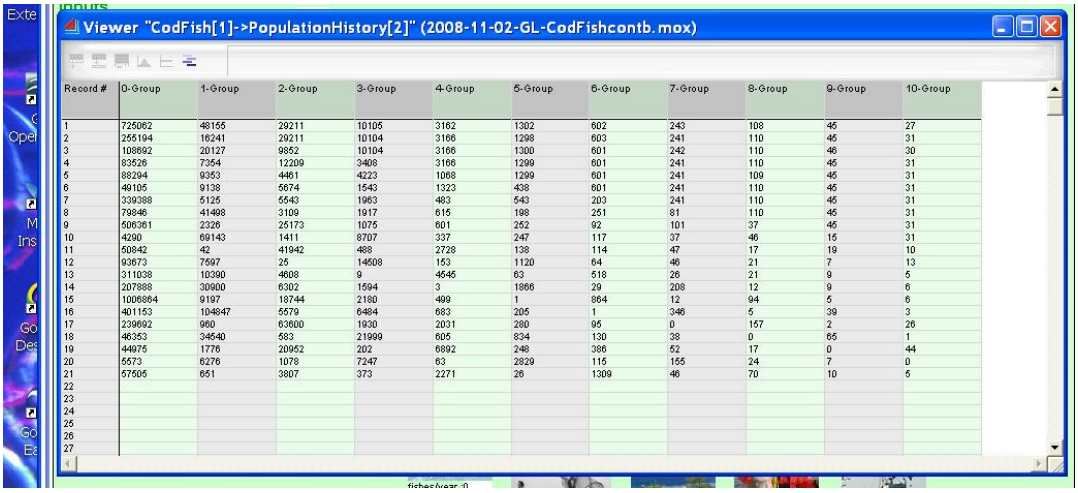
When running the model you can view the output values by selecting the four tables in the lower left corner of the front page of the model (circled in red). These tables are the same as in the database described under section 1. At present he values given are only from the last run of the model.	

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



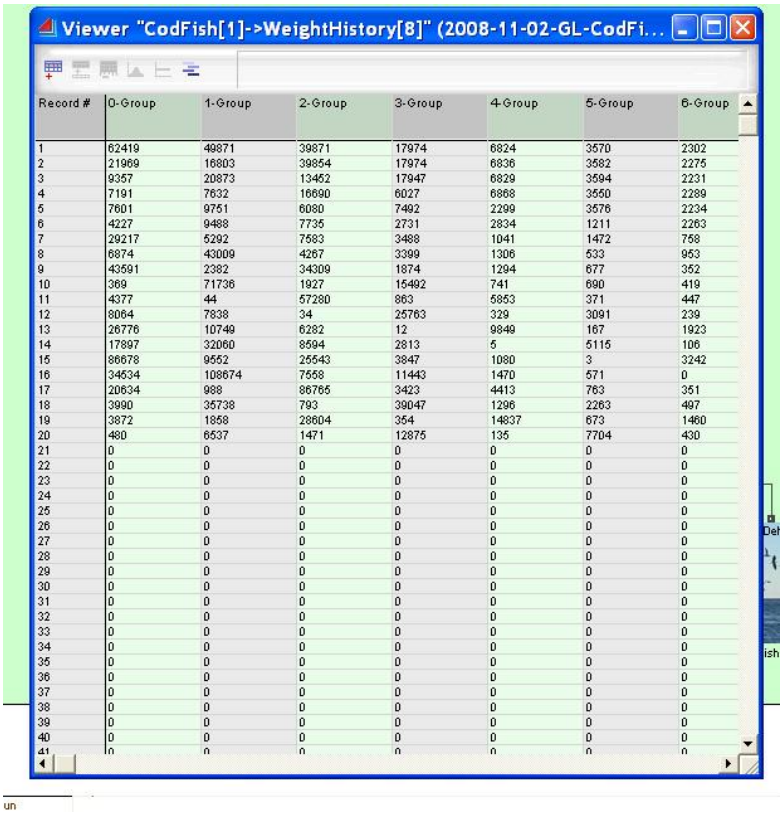
5.2 Environmental (Cod population)

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	45	27
2	265194	16241	29211	10104	3166	1298	603	241	110	45	31
3	108692	20127	9852	10104	3166	1300	601	242	110	46	30
4	83526	7354	12209	3408	3166	1299	601	241	110	45	31
5	88294	9353	4461	4223	1068	1299	601	241	109	45	31
6	49105	9138	5674	1543	1323	438	601	241	110	45	31
7	339388	5125	5543	1963	483	543	203	241	110	45	31
8	79846	41498	3109	1917	615	198	251	81	110	45	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	93673	7597	25	14508	153	1120	64	46	21	7	13
13	311038	10390	4608	9	4545	63	518	26	21	9	5
14	207888	30900	6302	1594	3	1866	29	208	12	9	6
15	1006864	9197	18744	2180	499	1	864	12	94	5	6
16	401153	104847	5579	6484	683	205	1	346	5	39	3
17	239692	960	63600	1930	2031	280	95	0	157	2	26
18	46353	34540	583	21999	605	834	130	38	0	65	1
19	44975	1776	20952	202	6892	248	386	52	17	0	44
20	5573	6276	1078	7247	63	2829	115	155	24	7	0
21	57505	651	3807	373	2271	26	1309	46	70	10	5
22											
23											
24											
25											
26											
27											

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



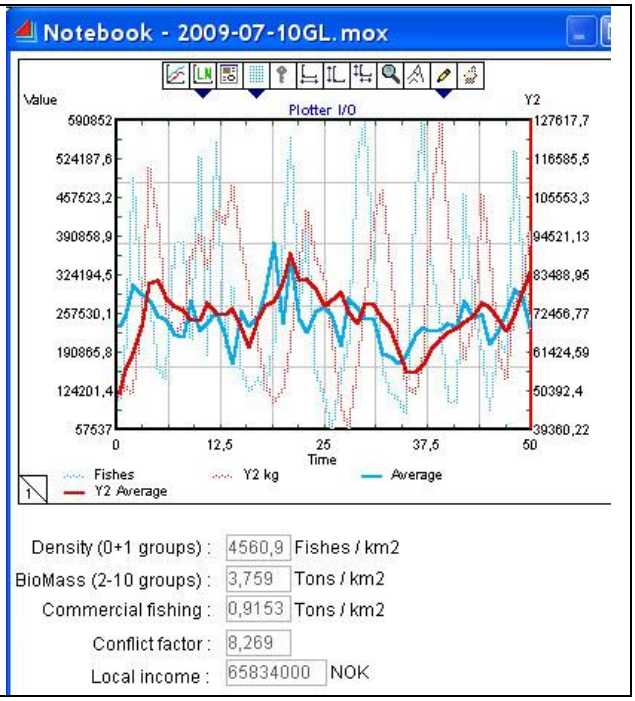
Record #	0-Group	1-Group	2-Group	3-Group	4-Group	5-Group	6-Group
1	62419	49871	39871	17974	6824	3570	2302
2	21969	16803	39854	17974	6836	3582	2275
3	9357	20873	13452	17947	6829	3594	2231
4	7191	7632	16690	6027	6868	3550	2289
5	7601	9751	6080	7492	2299	3576	2234
6	4227	9488	7735	2731	2834	1211	2263
7	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	108674	7558	11443	1470	571	0
17	20634	988	86766	3423	4413	763	351
18	3990	35738	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	0	0	0	0	0	0	0

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 km^{-2})
- Biomass (2-10 yrs) (ton km^{-2})
- Commercial fishing (2-10 yrs) (ton km^{-2})
- Conflict Factor
- Local income

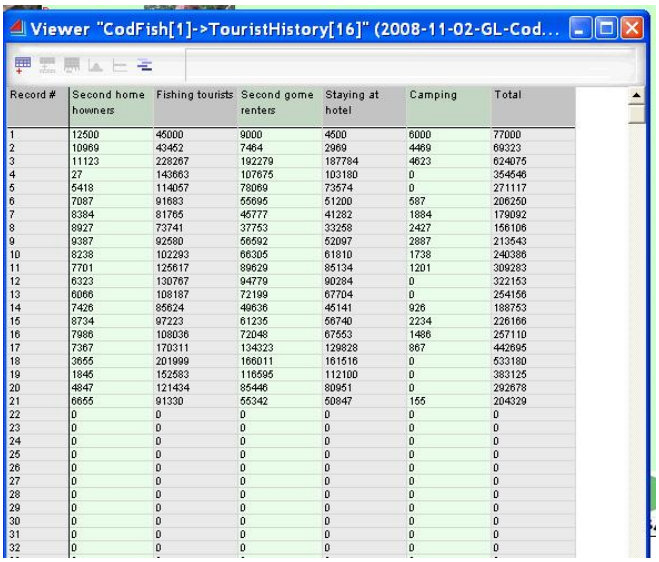
are given below and present output values from the model.



5.3 Economic

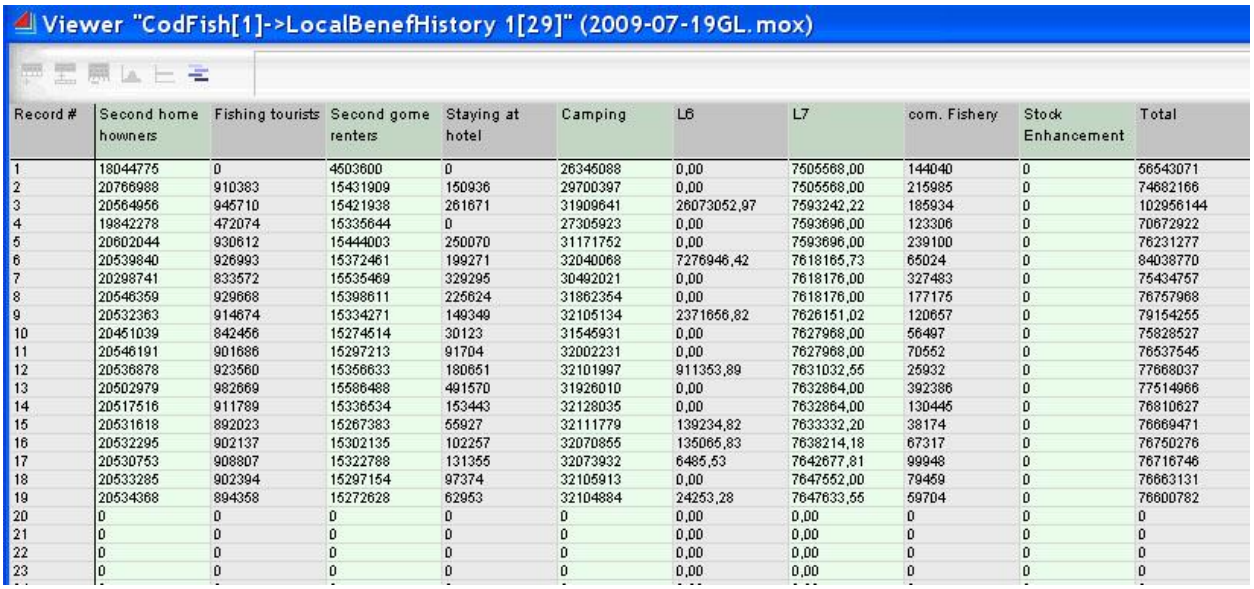
The results from the economic run will be displayed and exported similar to the ecosystem data (Not available yet)

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.


Viewer "CodFish[1]->TouristHistory[16]" (2008-11-02-GL-Cod...

Record #	Second home howners	Fishing tourists	Second gome renters	Staying at hotel	Camping	Total
1	12500	45000	9000	4500	6000	77000
2	10969	43462	7464	2969	4469	69323
3	11123	228267	192279	187784	4623	624075
4	27	143663	107675	103180	0	354546
5	5418	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	240386
11	7701	125617	89629	85134	1201	309283
12	6323	130767	94779	90284	0	322153
13	6066	108187	72199	67704	0	254156
14	7426	85624	49636	45141	926	188753
15	8734	97223	61235	56740	2234	226166
16	7986	108036	72048	67553	1486	257110
17	7367	170311	134323	129828	867	442695
18	3655	201999	166011	161516	0	533180
19	1845	152583	116595	112100	0	383125
20	4847	121434	85446	80951	0	292678
21	6655	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.


Viewer "CodFish[1]->LocalBenefHistory 1[29]" (2009-07-19GL.mox)

Record #	Second home howners	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	15431909	150936	29700397	0,00	7505568,00	215985	0	74682166
3	20564956	945710	15421938	261671	31909641	26073052,97	7593242,22	185934	0	102956144
4	19842278	472074	15335644	0	27305923	0,00	7593696,00	123306	0	70672922
5	20602044	930612	15444003	260070	31171752	0,00	7593696,00	239100	0	76231277
6	20539840	926993	15372461	199271	32040068	7276946,42	7618165,73	65024	0	84038770
7	20298741	833572	15535469	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	2371656,82	7626151,02	120657	0	79154255
10	20461039	842456	15274514	30123	31545931	0,00	7627968,00	56497	0	75828527
11	20546191	901686	15297213	91704	32002231	0,00	7627968,00	70552	0	76537545
12	20536878	923560	15356633	180651	32101997	911353,89	7631032,55	25932	0	77668037
13	20502979	982669	15586488	491570	31926010	0,00	7632864,00	392386	0	77514966
14	20517516	911789	15336534	153443	32128035	0,00	7632864,00	130445	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	908807	15322788	131355	32073932	6485,53	7642677,81	99948	0	76716746
18	20533285	902394	15297154	97374	32105913	0,00	7647552,00	79459	0	76663131
19	20534368	894358	15272628	62953	32104884	24253,28	7647633,55	59704	0	76600782
20	0	0	0	0	0	0,00	0,00	0	0	0
21	0	0	0	0	0	0,00	0,00	0	0	0
22	0	0	0	0	0	0,00	0,00	0	0	0
23	0	0	0	0	0	0,00	0,00	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) 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:

- Number and weight of each year-class (0-10) of cod
- 2nd Home owners
- Commercial fishing
- Density 0-gr (number km^{-2})
- 2nd Home renters
- Hotel
- Camping
- Density 1-gr (number km^{-2})
- Density (2-10 yrs) (number km^{-2})
- Biomass (2-10 yrs) (ton km^{-2})
- Cod demographic index: E1 = N1/ N(2-10); N1 = Density 1-gr, N(2-10) = Density (2-10 yrs)
- Conflict Factor
- Number of 2nd homes (absolute numbers, and total number allowed (R50).

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.

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

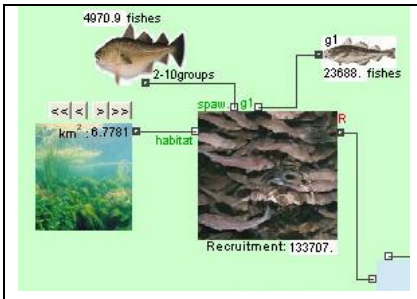
The model can easily be adapted to other fjord systems and their cod stock. You have to change the parameters given chapter 2.

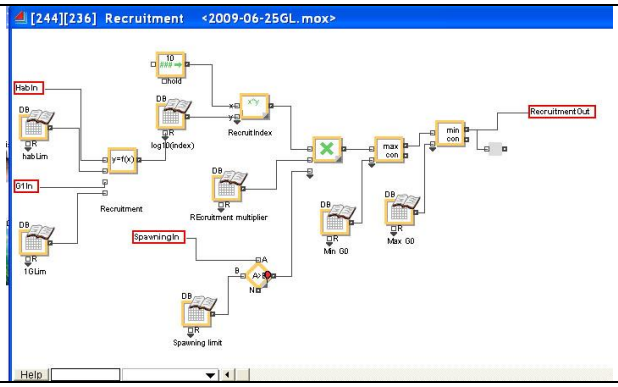
7 Calculations

7.1 Cod population

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

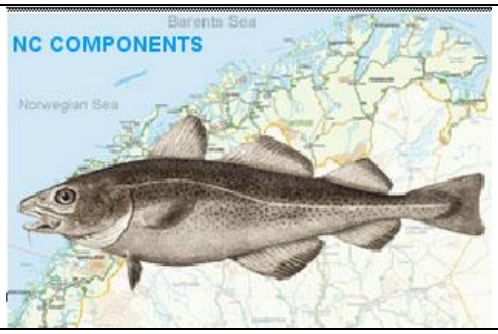
The left figure shows where the annual recruitment is calculated in the model and the right figure shows the content of the recruitment box. The abundance of the 0-group cod in the population is modeled as a function of the area of suitable habitats (eelgrass etc; at present the default value is 1) for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

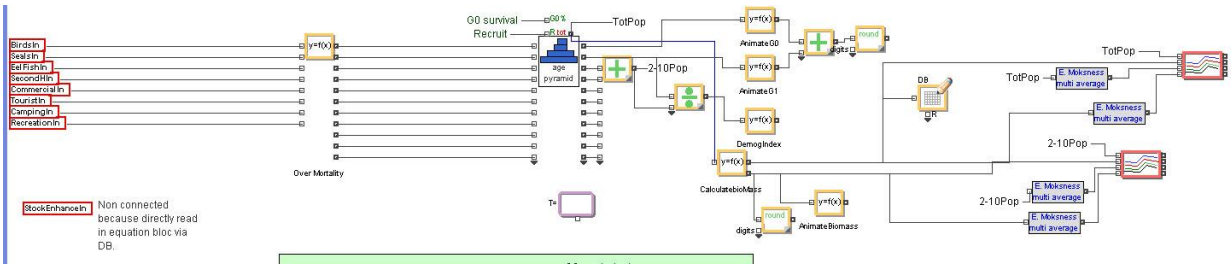




7.1.2 Estimating cohort sizes over the chosen time frame

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

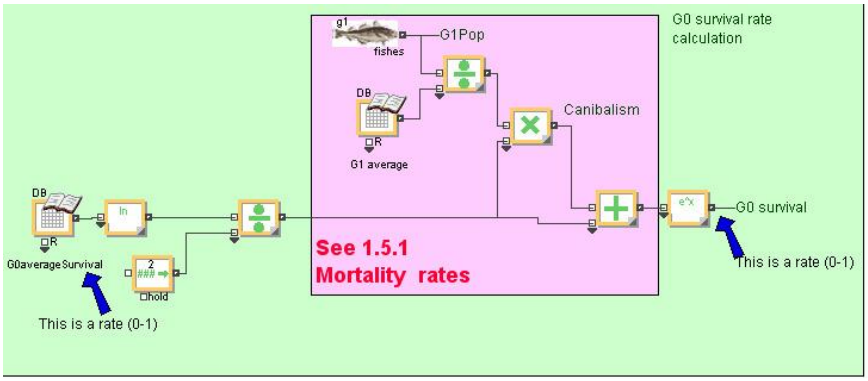
The mortality caused by 1-group cod on the 0-group cod can be changed by entering this input-table and changes the value in the last line.

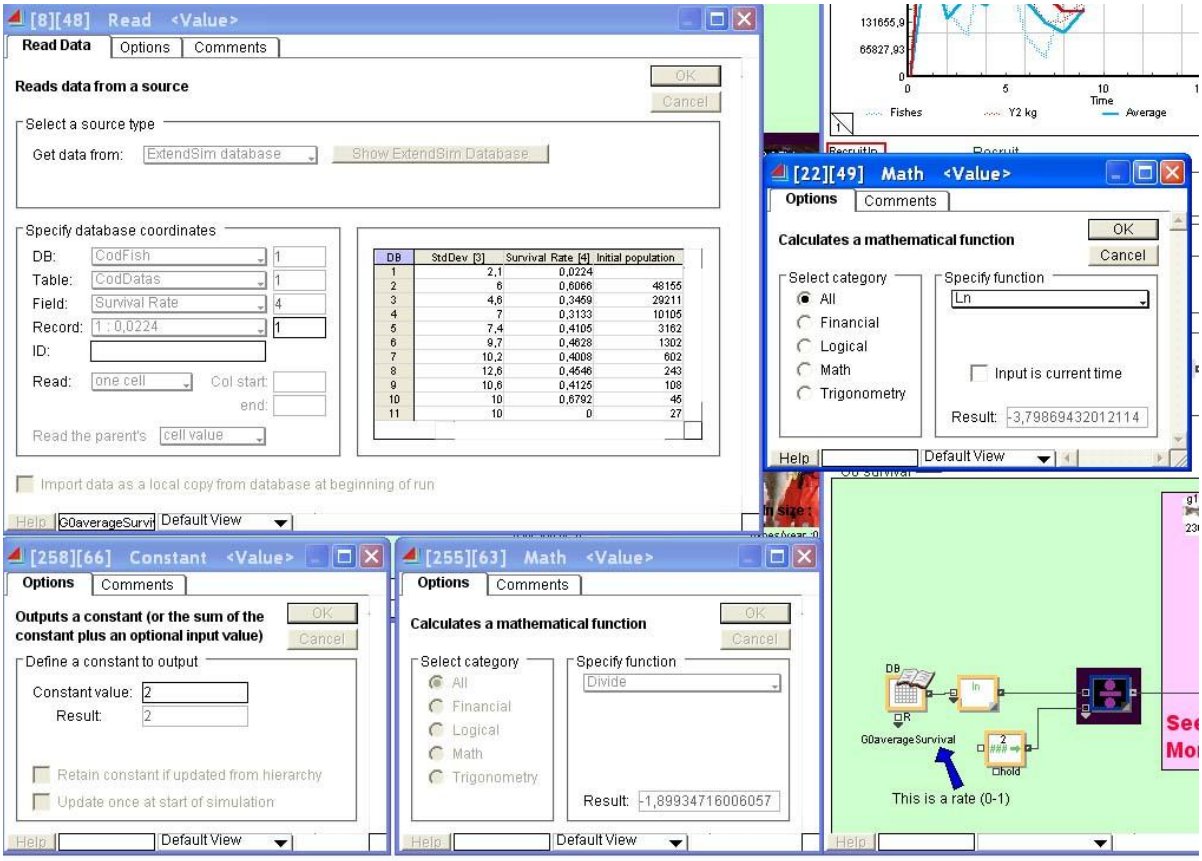
Viewer "CodFish[1]->EcosystemData[3]" (2009-06-25GL.mox)

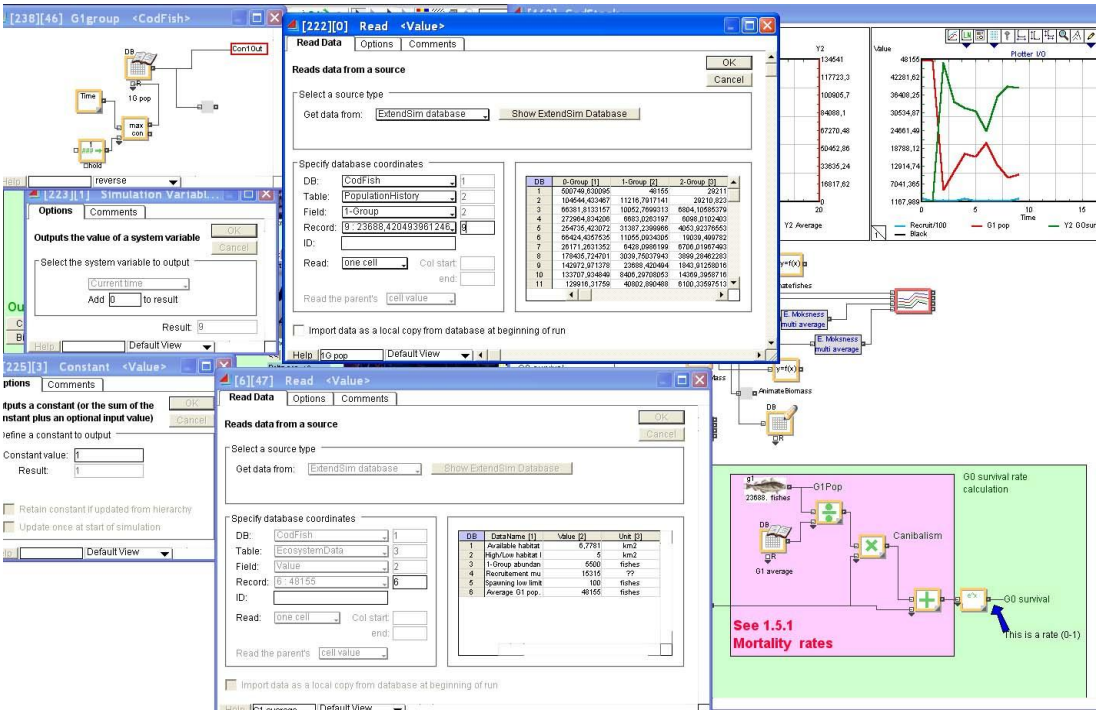
Recruitement multiplier

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 recuitment
4	Recruitement 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 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.



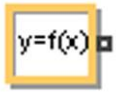

[8][48] Read <Value>
Read Data
Options
Comments
Reads data from a source
OK
Cancel
Select a source type
Get data from:
ExtendSim database
Show ExtendSim Database
Specify database coordinates
DB:
CodFish
Table:
CodDatas
Field:
Survival Rate
Record:
1 : 0,0224
ID:
Read:
one cell
Col start:
end:
Read the parent's
cell value
Import data as a local copy from database at beginning of run
Help
G0averageSurvi
Default View
DB StdDev [3] Survival Rate [4] Initial population
1 2,1 0,0224
2 6 0,6066 48155
3 4,6 0,3459 29211
4 7 0,3133 10105
5 7,4 0,4105 3162
6 9,7 0,4628 1302
7 10,2 0,4008 602
8 12,6 0,4546 243
9 10,6 0,4125 108
10 10 0,6792 45
11 10 0 27
131655,9
65827,93
0
0
5
10
Time
Fishes
Y2 kg
Average
[22][49] Math <Value>
Options
Comments
Calculates a mathematical function
OK
Cancel
Select category
All
Financial
Logical
Math
Trigonometry
Specify function
Ln
Input is current time
Result:
-3,79869432012114
Help
Default View
[258][66] Constant <Value>
Options
Comments
Outputs a constant (or the sum of the constant plus an optional input value)
OK
Cancel
Define a constant to output
Constant value:
2
Result:
2
Retain constant if updated from hierarchy
Update once at start of simulation
Help
Default View
[255][63] Math <Value>
Options
Comments
Calculates a mathematical function
OK
Cancel
Select category
All
Financial
Logical
Math
Trigonometry
Specify function
Divide
Result:
-1,89934716006057
Help
Default View
DB
In
R
G0averageSurvival
2
hold
This is a rate (0-1)
Help


[238][46] G1group <CodFish>
ConfOut
DB
R
Time
10 pop
max con
hold
reverse
Help
[222][0] Read <Value>
Read Data
Options
Comments
Reads data from a source
OK
Cancel
Select a source type
Get data from:
ExtendSim database
Show ExtendSim Database
Specify database coordinates
DB:
CodFish
Table:
PopulationHistory
Field:
1-Group
Record:
9 : 23688,420493961246
ID:
Read:
one cell
Col start:
end:
Read the parent's
cell value
Import data as a local copy from database at beginning of run
Help
60 pop
Default View
[223][1] Simulation Variabl...
Options
Comments
Outputs the value of a system variable
Select the system variable to output
Current time
Add
0
to result
Result:
9
Default View
[225][3] Constant <Value>
Options
Comments
Retain constant if updated from hierarchy
Update once at start of simulation
Default View
[6][47] Read <Value>
Read Data
Options
Comments
Reads data from a source
OK
Cancel
Select a source type
Get data from:
ExtendSim database
Show ExtendSim Database
Specify database coordinates
DB:
CodFish
Table:
EcosystemData
Field:
Value
Record:
6 : 48155
ID:
Read:
one cell
Col start:
end:
Read the parent's
cell value
Import data as a local copy from database at beginning of run
Default View
DB DataName [1] Value [2] Unit [3]
1 Available habitat 6,7781 km2
2 High/Low habitat 5 km2
3 1-Group abundan 5500 fishes
4 Recruitement mu 15315 ??
5 Spawning low limit 100 fishes
6 Average G1 pop. 48155 fishes
Value
Plotter I/O
Y2
Y2 Average
Recruit/100
G1 pop
Y2 G0sur
Time
E Meksness multi average
AnimateBiomass
G1
23688. fishes
G1Pop
DB
R
G1 average
Canibalism
G0 survival rate calculation
G0 survival
This is a rate (0-1)
See 1.5.1
Mortality rates

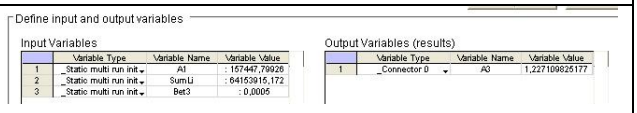
7.2 Social calculations

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.

<table>
<tr>
<td>The calculation of the Conflict indicator is found i the block as shown to the right.</td>
<td> 

->


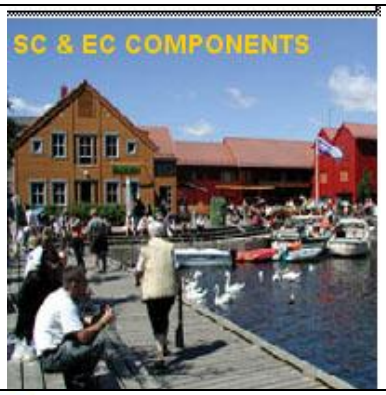
Calculate A3</td>
</tr>
<tr>
<td>The equation in the model with input and output value is given to the right.

From Part 1, Chapter 2.6:
Conflict indicator:
$$A3 = \beta_3 \frac{A_1}{\sum_{1}^{5} L_{i_{t-1}}}$$
Equa (2.1): Let β3=1000; L_i refer to the total sum in Equa (3.6).</td>
<td> 

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);</td>
</tr>
</table>

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) $A1=\sum_{i=1}^{5} T_i$