System Formulation

Part 1: ExtendSim Model description

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

ExtendSim Model developer

Guillaume Lagaillarde, 1point2, France

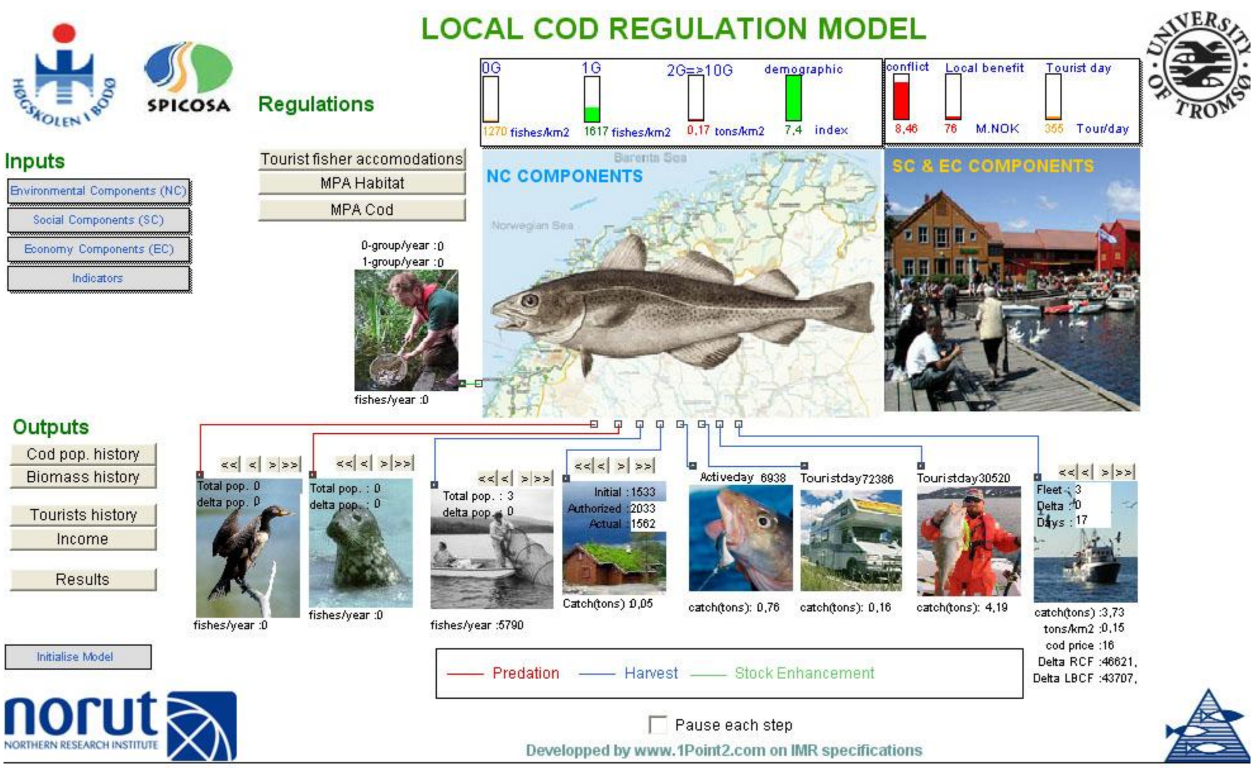


Table of Content

I. Introduction

In this model the status of the local cod (*Gadus morhua*) population the study area is the indicator of the status of the ecosystem. The cod population in the model is affected by top predators (birds and seals), change in available habitat (2^{nd} homes), fishing (eel-fishers, commercial fishers, recreational fishers and tourist fishers), aquaculture and stock enhancement. The effect from each of the above mentioned drivers can be regulated and the economical output is calculated.

The model can easily be adapted to other fjord systems. To change parameters, please see: "System Formulation; Part 2: Running the model".

II. About the Model

This model generates the local cod population in the study area over a 1-50 years period. The cod population are affected by annual recruitment at 0-group stage (September every year) and mortality rates between year-classes. The model can do between one and 100 simulations over the 1-50 years and the results from the different runs are saved in a MS Excel sheet. In the cases with more than one simulation, the excel sheet will calculate average numbers with confidence interval.

The environmental component model is a demographic model that projects the abundance of the coastal cod population in numbers by age (0 - 10 years age groups) forward in time. The body length of the individual cod in each year-class for each year in the 1-50 years run is drawn randomly from an observed normal distribution for each year-class, except for the 0-group where average length is used. The corresponding weights for each individual cod are calculated from the known length-weight relationship. The total weights of the population each year are calculated by summing the weight of all the cod. For more details on the environment component, please see chapter 1.

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 ecosystem model reflects the 2008 situation without any regulations). For more details on the social component, please see chapter 2 of this document.

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 value-added in the commercial fishery due to changes in the coastal cod stock, 4) Aquaculture production, including effect on wild cod stock (not ready yet), and 5) net local costs of coastal cod stock enhancement (not ready yet)**.** For more details on the economic component, please see chapter 3 of this document.

III. The Policy Issue

Increase local economic benefits from tourism, while minimizing negative impacts on local coastal cod stock, and conflicts with local users of the fjord system.

The aim of the modeling is to make a tool that can help policy-makers and regulators by revealing connections between factors and trade-offs between objectives.

This SSA 7.6 ExtendSim model interconnects three separate components:

1. Environment component (NC)
2. Social component (SC)
3. Economy Component (EC)

1. The environment component (NC)

Jakob Gjøsæter, Eirik Mikkelsen, Erlend Moksness and Jon Helge Vølstad

1.1 Introduction

The environment component 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 abundance of the 0-group cod in the population is modeled as a function of the area of suitable habitats (eelgrass etc) for recruitment and the strength of the 1-group cod.
- 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.

1.2 Starting date

1 September is the starting date. This is the time of the year when 0-group cod have settled in the eelgrass areas and yearly beach seine surveys are conducted to estimate the year-class strength.

As the fish pass 1 January each year it will increase it age with one year. An example: 0-group cod will become 1-group cod from 1 January.

1.3 Starting population

The demographic model is initiated with a starting population of cod (numbers by age for the first year) provided in the table 1.1 (For explanation see Chapter 4.1). The first year of the simulation starts with a fixed numbers at age for year classes 1+. The number of 0-group, however, will be generated every year, including for the first year, as given in **chapter 1.4 "Annual recruitment"**. In addition the table 1.1 contains natural mortality (M) for each year-class, both as M-values (exponential) and expressed as percentage survival from one year-class to the next.

$S = N_t/N_0 = e^{-M}$, where S = survival, N_t =number at time t, N_0 = number at time zero (start), and M = natural mortality; ln S = -M.

The total biomass of cod (2-10 years old) is equal to 30.7 tons (density equal to 1.3 ton km^{-2} (see chapter 1.7)

Table 1.1. Starting population of coastal cod in Søndeledfjorden. Age = group or year-class, N = number of individual cod in each year-class, CCS_0 = Initial biomass, M = natural mortality (exponential value), S = percentage survival from one year-class to the next. Number of 0-group (see chapter 1.4) and mortality between 0-group and 1-group cod will be estimated in the model (see chapter 1.5.1).

Age	N	N km^{-2}	CCS_0 (tons)	CCS_0 (tons) km^{-2}	S (%)	Reference
0	156 513	6 645				Tab 6.3b
1	42 889	1 821	6,304	0,268	65	
2	26 014	1 105	12,019	0,510	85	
3	8 998	382	9,115	0,387	85	
4	2 819	120	3,890	0,165	85	
5	1 157	49	2,291	0,097	90	
6	535	23	1,753	0,074	90	
7	215	9	0,762	0,032	90	
8	98	4	0,464	0,020	90	
9	40	2	0,209	0,009	100	
10	27	1	0,157	0,007	0	
1-10	82 792	3 515	36,963	1,569		
2-10	39 903	1 694	30,659	1,302		Fishable stock
4-10	4 891	208	9,526	0,405		Spawning stock

1.4 Annual recruitment (0-group cod)

The annual recruitment (measured as a relative abundance index for 0-group cod in September every year) for each of the years 1919 to 2006 (historical data), is given Chapter 6.2 and Table 6.3a.

Annual recruitment (number of 0-group cod) in the model is randomly picked from a list of historical data (see Table 6.3a. The number of recruits (age 0; 0-group cod) for year t is selected as follows:

1. Select a random number (logr) from the log-normal distribution fitted for historical data
2. Back-transform the number logr to get a 0-group index: r= exp(logr +(σ^2)/2) where σ^2 is the variance of the mean of log-transformed recruitment indices
3. Total number 0-group cod = r * **15315**
4. If estimated number is less than **9317**, it is set to 9317 (equal to 10% percentile (see Table 6.3a)
5. If estimated number is higher than **412 572**, it is set to 412 572 (equal to 90% percentile (see Table 6.3a)

We assume that ln(x) is normally distributed, and fit the normal-distribution, N(mean(ln(x)), var(mean(lnx)) to the log-transformed recruitment indices. Ln(x) can have negative values. It is thus x (recruitment) that is assumed to be log-normally distributed, and x will not have negative values. X is obtained after back-transformation with the formula above. The below entry in Wikipedia is consistent with standard reference books such as Balakrishnan and Nevzorov, A primer on Statistical Distributions. Wiley. (http://en.wikipedia.org/wiki/Log-normal_distribution). The recruitment distributions for fish are generally skewed. The fact that the normal distribution is not rejected for the raw recruitment data in our case is likely due to low sample sizes.

1.5 Mortality

Annual natural mortality rate (M) and survival rate between year-classes is given in table 1.1. *The survival rates, except for the mortality between 0-group and 1-group cod (see chapter 1.5.1 below), are used in the ExtendSim model.*

The annual recruitment (number of 0-group cod) will also be modeled as a function of the area covered by eelgrass (area with eelgrass and of the size and numbers of marinas. The annual recruitment and mortality rates (or survival) between year-classes (age 0-10) will be affected by several possible interactions with human activities. Possible interactions are illustrated in the conceptual model given in Figure 1.1. All the interactions in the ExtendSim model (NC, SC and EC) are discussed in chapter 5.

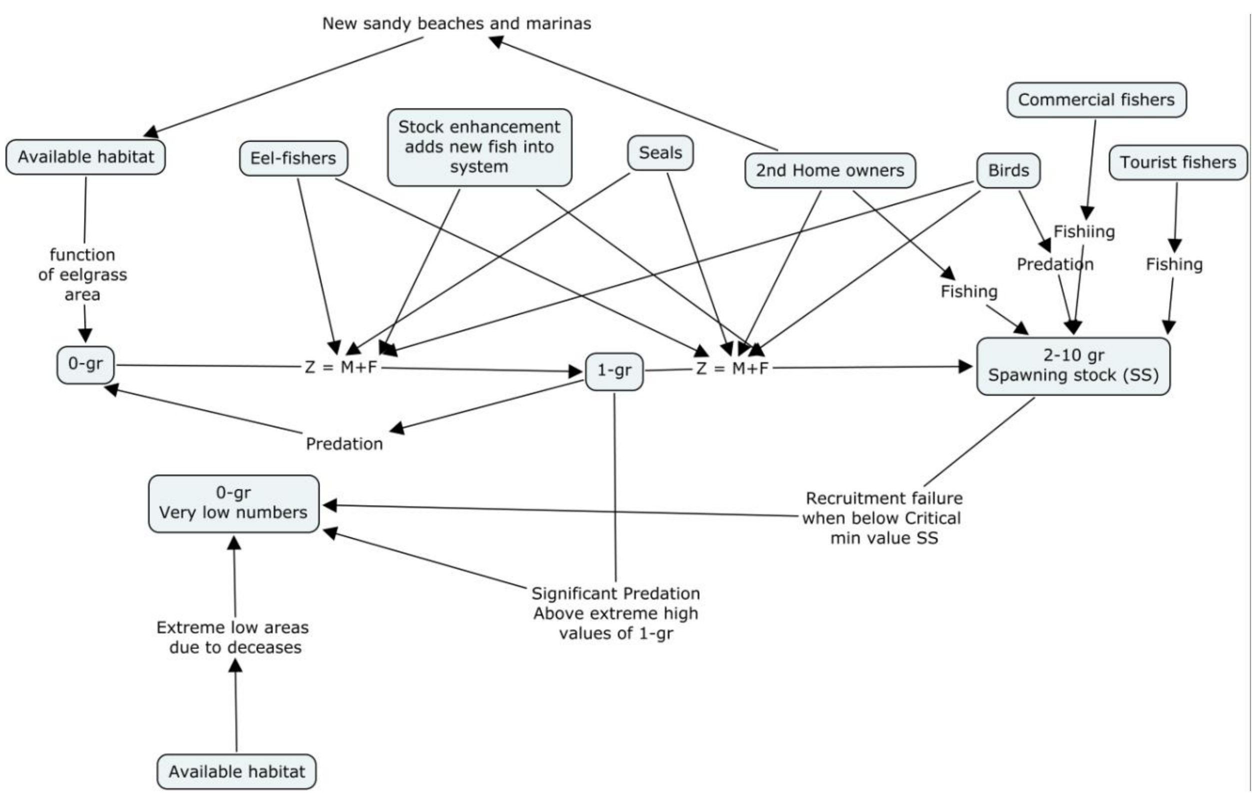


Figure 1.1. Conceptual model of the cod life history, with the main factors affecting mortality. Z = total mortality, M = natural mortality, F = fishing mortality.

1.5.1 Mortality rates between 0-group and 1 group cod

The mortality of 0-group fish is normally high (M = 3.8; see Julliard et al.; 2001), and cannibalism is a significant part of this mortality, and could explain up to 50% of the mortality in cases with high abundance with 1-group cod. In the model it is included a “basic mortality” of 1.9 and regulate the remaining 1.9 of the natural mortality according to number of 1-group, e.g. by making additional mortality a linear function of number of 1 group, so that it is zero at 1-gr =0, and 1.9 at average stock size. (Maybe the suitability of habitat should be taken into consideration so that the slope is steep when there are few hiding places and low when there are few).

Equa (1.1): $M = exp*(p*(2,824+0,281*Log(X_0)) + (1-p)*(2,496+0,381*Log(X_1)))*H;$

Where: M = natural mortality in %; p = proportional natural mortality (value between 0 and 1); X_0 = number of 0-group cod; X_1 = number of 1-group cod; H = index for habitat

At present the index for habitat (H) should be set = 1. In the future a variable H might be included depending if the area or quality of the available habitat is increased or decreased.

1.5.2 Stock enhancement

Stock enhancement studies have taken place in the study area and the results indicate that release of 0- and 1 group cod can have a significant impact on the total cod population in the study area (Danielssen and Gjøsæter, 1994). A marine hatchery for juvenile cod and Atlantic halibut is located in study area. It has the capacity to produce both 0-group and 1-group cod. The production cost of cod is given in table 3.10. The release of 0-group cod will normally take place in September, and the release of 1-group cod will normally take place in March - April.

1.5.3 Fish consumption by harbour seals, *Phoca vitulina*.

Harbour seals consume from 3.4 (juvenile females) to 5.7 (adult females) kg fish per seal per day (Bjørge et al.2002). The composition of the diet is highly variable, and varies with the species available. The proportion of cod has been observed to vary between 2 and 35 %. Most of the fish taken is less than 30 cm long. (Olsen og Bjørge 1995; Berg *et al*. 2002). Assuming a food consumption of 4 kg pr day, a proportion of cod in the diet of 10%, and a average size of the cod eaten of 20 cm (100 g), one seal will eat 4 cod a day. Number of cod eaten per year is given in Table 1.2.

Table 1.2. Number of harbour seal and cormorant in the starting population and the estimated number of cod (by age group) predated by each harbour seal and cormorant per year.

		age group cod	age group cod	age group cod
	Starting number	0	1	2
Harbour seal	6	730	730	0
Cormorants	50	108,5	292	73

It is assumed that the predation on cod depends on the density of cod at any time. It is further assumed that the published predation rates reflect a average cod population with the following densities of 0 and 1 group cod:
Density of 0-group cod = 6722 km^{-2} (see table 1.1 and 6.3a)
Density of 1-group cod = 1821 km^{-2} (see table 1.1)

For harbor seal the following relationships between cod densities and predation from each harbor seals are used:
Equa (1.5): Y = 0,109 * X; where Y = number of 0-group cod eaten and X = Density 0-gr (number km^{-2}).
Equa (1.6): Y = 0,401 * X; where Y = number of 1-group cod eaten and X = Density 1-gr (number km^{-2}).

1.5.4 Fish consumption by cormorants, *Phalacroax carbo sinensis*.

Barrett *et al*. (1990) found that cormorants eat 660 g fish a day and that most of this was small cod and sandeels. Measuring of otoliths showed that most of the cod consumed measured from 60 – 340 mm, and belonged to the 0- I- and II-group. Off the Koster islands Härkönen (1988) found that cod constituted 24 % the stomach contents (in weight), while Skarprud (2003) found that cod constituted ca. 20 % of the food in the Øra area in Østfold. Assuming a food consumption of 660g pr day, a proportion of cod in the diet of 20%, and a average size of the cod eaten of 20 cm (100 g), one cormorant will eat 1.3 cod a day. Number of cod eaten per year is given in Table 1.2.

It is assumed that the predation on cod depends on the density of cod at any time. It is further assumed that the published predation rates reflect an average cod population with the following densities of 0, 1, and 2 group cod:
Density of 0-group cod = 6722 km^{-2} (see table 1.1 and 6.3a)
Density of 1-group cod = 1821 km^{-2} (see table 1.1)
Density of 2-group cod = 1105 km^{-2} (see table 1.1)

For cormorants, the following relationships between cod densities and predation from each cormorant are used:
Equa (1.7): Y = 0,016 * X; where Y = number of 0-group cod eaten and X = Density 0-gr (number km^{-2}).
Equa (1.8): Y = 0,16 * X; where Y = number of 1-group cod eaten and X = Density 1-gr (number km^{-2})
Equa (1.9): Y = 0,066 * X; where Y = number of 2-group cod eaten and X = Density 2-gr (number km^{-2}).

1.5.5 Human harvest of cod

It is not easy to obtain precise and accurate figures for the annual yield from the commercial cod fishery in the study area because not all of the catches are sold at the local buyer. To get an idea of the annual catches of cod in the study area, an interview was made with the leader of the local buyer, Mr. Yngvar Aanonsen at Risør Fiskemottak (http://www.fiskemottaket.no/). His background is as a commercial fisher in the area and he had the following description of the cod fishery and an estimate of annual catches. Normally the commercial fishery take place with nets and the best fishery was during spring with annual catches between 3-4 ton for each boat. In addition, herring fishers normally catch high number of cod in their fishery. His overall estimate was that the annual yield commercial fishery varies between 12 to 15 ton. This corresponds to catches between 0.5 – 0.6 ton km^{-2}. These numbers a very similar to estimated yield in the North Sea cod fishery.

In addition he informed about a very active recreational and tourist fishery in the area, and expected a reasonable high yield of cod in this fishery as well.

Recreational and commercial fishers, and tourists in the different tourists groups harvest cod. It is assumed that the amount harvested depends on the fishing effort by the different groups, but also the size of the cod stock. The bigger the cod stock is, the more catch can be expected for a given amount of fishing effort. In other words, the catch per unit effort (CPUE) depends on the stock size. In addition the fishing effort or effectiveness depends on regulations. See section 2.2.2.2 (Fishing regulations for cod/MPA-cod) on limitations of fishing period and use of gears. The formulas below must be adjusted in accordance with descriptions in 2.2.2.2.

Schaefer (1957) established a simple harvest function for fisheries that have been much used in bioeconomics (Eide et al 2003) when biomass models of the stock are used:

Equa (1.10): $h = q E^{\alpha} X^{\beta}$; E = fishing effort, X = stock biomass, h = harvest, q = catchability coefficient.

It gives a relationship between fishing effort E, stock biomass X and the harvest h. The coefficient q is referred to as the catchability coefficient, and is a constant specific for fish species/stock and fishing gear, as is the coefficients α and β. In the simplest form of the Schaefer harvest function α and β are 1, and then there is a purely linear relationship between harvest and fishing effort, and harvest and stock biomass.

Based on the Schaefer harvest function we model fish mortality from fishing pressure both from the different groups of tourists and commercial fishers. We will calculate harvest in biomass, and then relate it to number of individuals harvested in each year-class. This will be based on the age structure of the cod stock, included the fractions of the biomass in each year-class, which we have data on from the ecological model component.

1.5.5.1 Cod mortality due to tourists

Fishing effort by tourists is measured as fishing days per year, based on number of tourist days per year for each tourist category. For each tourist category, the number of fishing days for a given number of tourist days will be different. Further, they will have different catchability coefficients, and their catch will be made up of different year-classes of cod, as they have different fishing gear and fishing locations. For example, the fishing by 2^{nd} home owners is different from the one performed by fishing tourists. The category 2^{nd} home owners have a very different demographic composition than fishing tourists, and include both adults and children. Children may fish very near shore, with tackle that mainly gives fish of the youngest year-classes. Fishing tourists typically have coarser tackle and fish at larger depths, on older year-classes.

How harvest depends on tourist days for the different categories of tourists is given in the table 1.3.

1.5.5.2 Cod mortality due to commercial fishers

In interviews with local fishermen/fish buyers it is estimated that a normal annual cod harvest from the Søndeledfjord system by commercial fishers is 10-15 tonnes (see box above). It is estimated in the ecological component of the model that a “normal” standing biomass for the cod stock is approximately 30 tonnes (year-classes 2-10). We will assume that commercial fishermen catch 1/3 of the standing biomass annually. This will naturally vary with economic factors like prices on cod, prices on other fish species, fuel prices, and more. However, as a first approximation, we will assume that commercial fishermen catch 1/3 of the standing biomass annually, even when the standing biomass changes. To prepare for possible later refinements to the model, allowing for profit maximising behaviour by commercial fishermen, we will use a similar Schaefer harvest function as for the tourists. We assume that the three registered vessels in Risør together fish 50 days in the Søndeledfjord system, and then get a catch of 10 tonnes given a 30 tonnes standing biomass. The corresponding catchability coefficient, and other data, is given in the table 1.3 below.

For example:
The harvest by camping tourists should be calculated in the following way:

Equa (1.11): Harvest as biomass = Tourist days by camping tourists * Catch per unit effort indicator per cod stock unit * Cod stock biomass

With tourist days= 35 000 and Cod stock biomass = 30 tonnes, Harvest as biomass = 35 000 * 0,0000002 * 30 = 0,21 tonnes.

As camping tourists target year-classes 1-10, the relative distribution of biomass among these year-classes is calculated, and 0,21 tonnes is distributed accordingly among the year-classes. Depending on the average weight of a fish in each year class, a specific number of fishes are removed from each year-class.

Table1.3. Effort indicator and relation to annual catch for different categories of tourists, and for commercial fishermen.

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	100 %	days	1,67E-05	0,0000167	2-10	4 000		2,00
Commercial fishers***	vessel days at sea	100 %	vessel days	0,006666667	0,006666667	2-10	50		10,00
							Sum harvest tonnes		16,29

* 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.

**** Active fishing days = «total number of inhabitants in Risør municipality» * «average number of fishing days in Søndeledfjord by each inhabitant»

Total number of inhabitants in Risør municipality = 6938

Average number of fishing days in Søndeledfjord by each inhabitant = 0,1

1.5.5.3 Cod mortality due to eel fishers

The eel fishing take place mainly during the summer months and the estimated numbers of cod in the different year-classes caught are given in Table 1.4. In the Risør area there is one very active and 2 – 3 periodically active eel fishermen harvesting eel. One fisherman has about 100 ell pots in this area. (Unpublished information).

Nedreaas et al. (2008) collected some information about by-catches in the eel fishery. In the Risør area they found that number of cod pr pot varied from 0.7 to 1.6 with an average of 1.1 cod pr haul (Lekve *et al*. 2006). These values are slightly higher than in Østfold, but lower than in western Norway.

The length distribution of the cod caught in experimental fishing with eel pots in Risør varied from 5 - 50 cm (Fig 1.2)

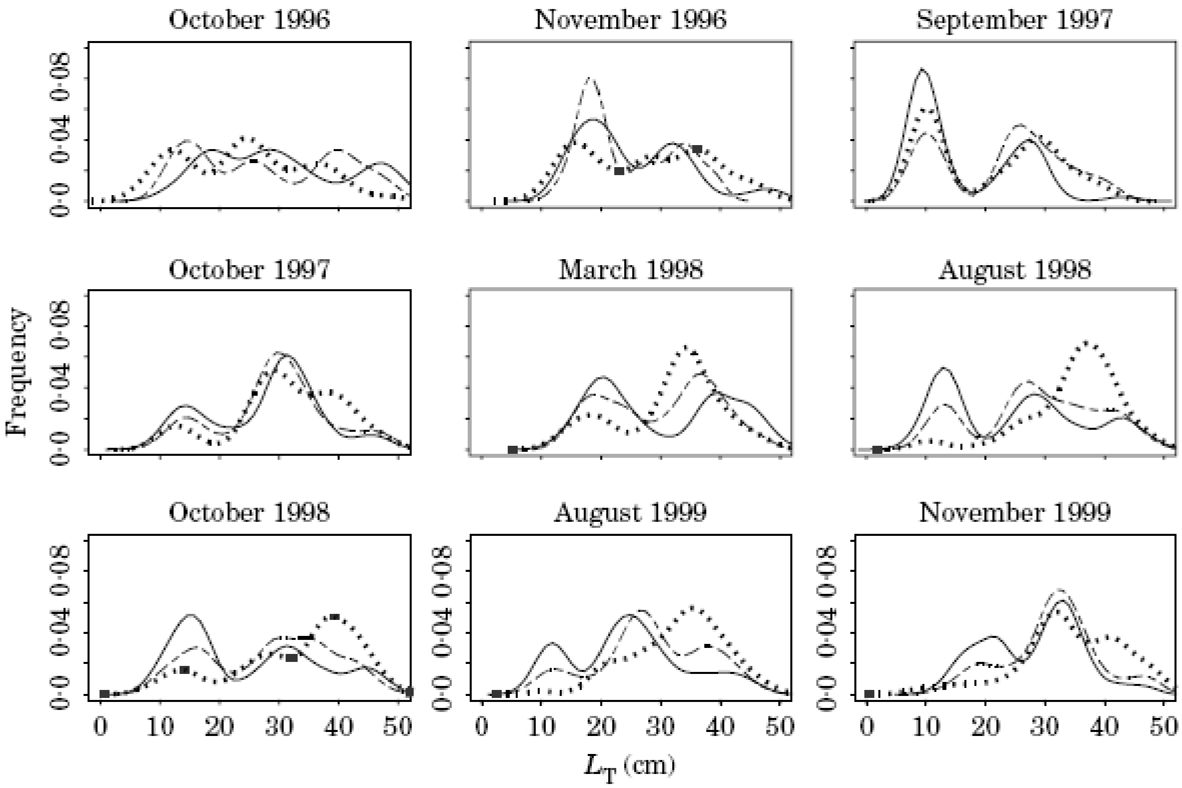
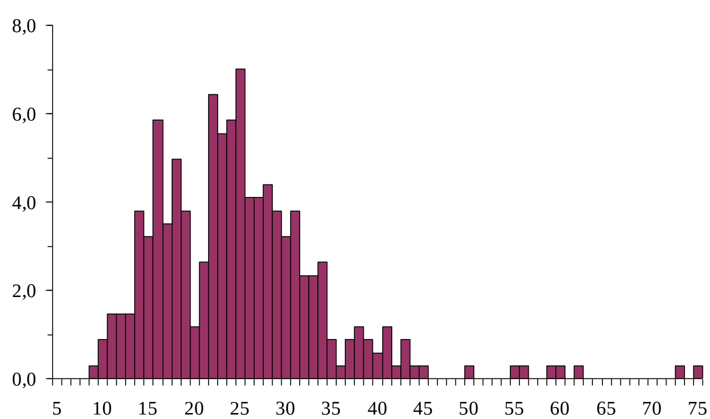


Figure 1.2. The smoothed distributions of cod total length frequencies for the three areas [the Skerries (–), the outer fjord (- -) and the the inner fjord (. . .)]. The graphs are produced by a Gaussian kernel in S-plus (Venables and Ripley, 1997). The number of cod caught in 1996 was very low (Table I), and was interpreted with care. (from Lekve et al. 2004)

Size distribution of cod caught in eel pots in the Bjørnefjord, western Norway (Agnalt et al. 2007) show a similar pattern (Fig. 1.3)



Figur 1.3. Length distribution of cod caught in eel pots in Bjørnefjorden (Hordaland) 1995–2006 (from Agnalt *et al.* 2007).

Table 1.4. Estimated annual reduction in number of cod in the different age-groups caught by eel fishers.

Age-group	Eel-fishers (per year)	Equation number	Y = number of 0-group cod caught and X = Density x-gr (number km^{-2}).
0	2500	1.13	Y = 0,372 * X
1	1000	1.14	Y = 0,549 * X
2	700	1.15	Y = 0,633 * X

1.5.5.4 Cod mortality due to recreational fishers

The local inhabitants of Risør municipality also fish in the Søndeledfjord system. Cod mortality is modeled similarly as for the other groups, with a Schaefer harvest function.

1.6 Growth

Growth from one year to the next for each cohort of age 1+ will be modeled by selecting the lengths of all individuals in a year class randomly from expected length distributions as given in Table 1.5 below. The mean length and standard deviation for each age group are estimated from data for the cod population in Søndeledfjorden. This simple approach ensures that the projected population in numbers by age will have an expected length distribution in each age group that is consistent with empirical data, and is an alternative to the selection of von Bertalanffy growth curves for each cohort.

Change in size (length, weight) from one year to the next for each individual fish in a cohort is calculated from a table of mean size (μ) and the associated standard deviation (σ) by age group as calculated from empirical data. The length of each individual fish in an age group, x(i), is randomly selected from a normal distribution, N(μ, σ). The weight of each fish is then determined by a length-weight equation (see equation (1.2)).

Table 1.5. Average length (cm) of cod in each age group (year-class) with Standard deviation (SD) (Age 3-10 comes from Gjøsæter and Danielssen (In prep)) and average wet weight (g) with standard deviation (Age 3-10 is calculated using equation 1.2). N = number of observations.

Age	Average length (cm)	SD	Average weight (g)	SD	N	Reference
0	9,63	2,10			➢ 1000	Own data
1	23,8	3,0	147	73	991	Own data
2	35,9	3,3	462	150	70	Kristoffersen et al (In prep)
3	47,0	7,0	1013	NA	302	
4	52,2	7,4	1380	NA	112	
5	59,0	9,7	1980	NA	34	
6	70,0	10,2	3276	NA	27	
7	71,9	12,6	3545	NA	13	
8	79,3	10,6	4732	NA	6	
9	82	10	5222	NA	60	
10	85	10	5806	NA	60	

1.6.1 Calculation of individual cod weight

The weight (kg) of each individual in an age-group estimated from the length-weight equation (1.2) given below. Total biomass by age group is obtained by summing the individual weight (after back-transformation from log 10-scale; equation (1.3) over all individuals.

Equa (1.2): lg W = 2.946892916 lg L - 1.921950107; where lg = log 10, w = weight (kg) of cod, L = length (cm) of cod

Equa (1.3): $W = 10^{(\lg W)}$, where lgW is from Equa 1.2

1.6.2 Calculation of total cod biomass

Total biomass by age group is obtained by summing the individual weight calculated in equation (1.3) over all individuals.

Equa (1.4): Total weight by age group (kg) = sum of all individual weights (W) in the age group

1.7 Spawning stock (SS) of cod

The spawning stock (SS) of the coastal cod in SSA 7.6 (Søndeledfjorden) consists of age-groups 4-10. If the spawning stock comes below 50 cod (age-group 4-10), it is below a minimum critical value and will result in a recruitment failure and the number of 0-group cod will be equal to zero.

The starting population of cod (age 1-10) is given in Table 1.1 The spawning stock (age-group 4-10) consist of 4.891 individuals representing a total biomass of 9.5 ton. The density of the spawning stock is calculated to 0.405 ton km^{-2} (total area = 23.52 km^2).

1.8 Cod stock indicator

To assess the "health" of the cod stock a simple indicator is needed. One option is to use exploitation rate or similar indicators (e.g. Pitcher and Hart, 1982) but we have decided to use a more easily measurable indicator i.e. the number of recruits age 1 (N_1) as proportion of the adult stock size ($N_{(2-10)}$).

Equa (1.12): $E = N_1 / N_{(2-10)}$; N_1 = Density 1-group cod, $N_{(2-10)}$ = Density (2-10 group cod)

1.9 Habitats for 0-group cod

Suitable habitats for 0-group cod are above a depth of 25 meters and consist of eel-grass, macroalge, muddy areas. In the period 1933-1937 the eel-grass suffered high mortality due to diseases and resulted in very low biomass in the area and thereby a significant reduction in suitable habitats for the 0-group cod. In these years the recruitment of 0-group cod was at a very low level. It is assumed that all area above 25 m depth is productive areas for 0-group cod (see table 1.6 and chapter 6.3.1).

Table 1.6. Calculated productive volume (from tab. 6.6) and calculated area (for depth less then 25m; from tab. 6.4a) in the Søndeledfjord system.

Basins	Calculated Volume (m^3)	Calculated Area (m^2)
Nordfjorden	798.693.797	6.263.157
Sørfjorden	130.896.705	4.457.576
Total Søndeledfjorden	929.590.502	10.720.733

1.10 Habitats for 1-10 group cod

Suitable habitats for 1-group and older cod are the total area and volume with suitable 0_2 content in the water column (See table 1.7 and 6.6). In the present model, it is assumed that volume available for cod is constant. A separate Maritime spatial planning (MSP) are given in chapter 6.4.

Table 1.7. Calculated productive volume (from tab. 6.6) and calculated area (from tab. 6.4b) in the Søndeledfjord system.

Basins	Calculated Volume (m^3)	Calculated Area (m^2)
Nordfjorden	798.693.797	15.732.236
Sørfjorden	130.896.705	7.819.964
Total Søndeledfjorden	929.590.502	23.552.200

1.11. Aquaculture

To be added later

1.11.1 Mussel

To be added later

1.11.2 Finfish (Salmon and cod)

To be added later

2. The Social component (SC)

Håkan T. Sandersen and Eirik Mikkelsen

Normally the fishery along the Norwegian coast is difficult to regulate as this fishery is regulated as an open "free for all" in accordance with the "The Free Access Right" (Allemannsretten). However, some restrictions apply: There is no charge for fishing in the sea, and Norwegian citizens can engage in sports fishing with handheld line, fishing rod and one motorized trolling-line, fishing nets with collected length of no more than 210 meters, lines with no more than 300 hooks, and up to 20 traps, fish pots or lobster pots. These types of equipment can be used together in the outlined quantities. However, the limitation applies to the vessel and not per person. A recreational fisher can sell up to 2000 kg cod pr. year (Directorate of Fisheries 2008).

2.1 Fishing pressure – user groups

There is a long history of fisheries on cod in the fjord; however, the local cod stock has declined over the past 10 years. The local cod stock in the fjord can be divided in two components, a slow growing and smaller cod in the inner part and a faster growing and bigger cod in the outer part, both belonging to the same stock and use the same spawning area. The fishery pressure are different on these two components, where owners of second-homes normally will fish more on the cod in the inner part, while tourist fishers will fish mainly on the cod in the outer part. Over the past 10 years the numbers of tourist fishers has more than doubled (Sørlandets Feriesenter; pers comm.; Figure 2.1 and 2.2), and are visiting the area outside the summer months, while the second-home owners are normally using the area during the summer months. At present there are **1523** second homes in the area, and there are plans to expand this within the next five years to approximately 1900, an increase of approximately 27%. A significant proportion of existing and planned second homes are for rent-out. The construction activities in the coastal zone may cause habitat destruction (e.g. *Zostra marina*), by dredging, dumping, fillings and artificial beaches, reduced value of fishing and trawling grounds because of cables, pipelines and marine installations. Some mussel plants are located in the fjord-system and these may hinder sailing and leisure fishing and enhance local biodiversity and production.

The present impact in Søndeledfjorden is the decline in coastal cod abundance. An obvious management challenge is to ensure an increase in local economic benefits from tourism, while minimizing negative impacts on local coastal cod stock, and conflicts with local users of the fjord system.

Table 2.1. Overview of starting numbers of different user groups

User group	Starting number	Comments
second homes	1523	May 2009
Eel fishers	3	May 2009
Commercial fishers	3	May 2009

Figure 2.1. Homepage for Sørlandets Feriesenter, hosting tourist fishers.

Figure 2.2. The Sørlandets Feriesenter.

2.2 Residents, Tourists and Second homes

The Skagerak coast is very popular for summer holidays and the population along the coast increases at least two or three fold during the summer months. Both visitors and the owners of the great number of second homes want access to the sea, moorings, buoys, floating piers, marinas, and other boat related facilities. In many cases these are established in productive areas, like mud- and eel-grass habitat, important habitats for juvenile cod. Besides boating, the tourists want sandy beaches along the coast for playing, sunbathing, swimming etc.. To increasing numbers of such artificial beaches contributes to the deterioration of other important habitats for living marine resources. However, tourists and second home owners bring money and revenue to the coastal municipalities, and accounts for an increasing part of the regional and local economy. While entrepreneurs have plans for many more second homes, the municipality administration hopes for larger economic benefits from tourism without large negative ecological effects or conflicts with local residents/industry. How can increased revenue and benefits to the region take place while actually reducing the negative impacts? An increase in the number of tourist can in itself obviously not be the answer. Tourism brings income to the Risør/Søndeledfjord area in several ways. Sales of goods and services to 2nd home residents or the “occasional” tourist are probably the most important part, whereas construction of second homes, or other types of accommodation are somewhat less important. However, it seems to be the case that those making most money from this so far have been from other areas/regions. The municipality mayor has put forward the ambition of increasing the numbers of high-paying tourist with well-developed ecological awareness to the Risør area. Selling services of high quality related to this seems to be a natural part of such a scheme. The municipalities also have tax revenues from second homes.

For the residents in the Risør area Søndeledfjorden represent an important source for recreation, and in addition regularly provide many household with fresh fish. Also for visitors, either on an occasional visit or seasonally returning as owner of a second home, fishing is often an important leisure and recreational activity. The number of visitors is then likely to affect the fishing pressure in the fjord. The main conflicts between local residents and tourist are related to the seasonal over-crowding of most part of the coast and the coastal towns. The locals claim that “the tourists have invaded us”. There are also conflicts between boaters and second home owners/local residents over the access to coastal areas. The local authorities want to further increase the numbers of visitors to the area, but by extending the summer season in both ends. In Risør there are entrepreneurs planning to develop scarce industrial areas to second homes. However, the Risør municipality is, through the Planning and Building Act in charge of the physical planning in the area, and has well-developed tool for dealing with area- and space-related conflicts. The Act provides the municipality with tools for physical planning in both the terrestrial and marine parts of the territory. Included in the act is also a general (national) prohibition of building within the 100 meter zone from the watermark, but the municipality may exempt from this.

The Søndeledfjorden has a few blue mussel rigs located north and west of Barmen, the island in the centre of the fjord system (see fig. 6.1 and 6.3). These are not too welcomed by the second-home owners due to limiting the boat traffic and they perceive these installations are deteriorating the esthetical qualities of the area. On the other hand these installations could increase the food production for fish, and they provide habitats where fish can feed and hide.

2.3 Living resources, tourist fishers and second home owners

Norwegian coastal waters contain plentiful and valuable resources that contribute to the well being and economy of the people living along the coast. Fishing for household consumption has always been a legal right for Norwegian citizens and this fishery is considered rather stable. Hallenstvedt and Wulff (2004) estimated that the total Norwegian non-commercial catch in 2003 was approximately 10,000 tons (round weight) in each of the regions in Eastern Norway, Western Norway and mid-Norway (Møre and Romsdal, South Trøndelag, North Trøndelag); and 18,000 tons in Northern Norway (Nordland, Troms, Finnmark); altogether 48,000 tons. During the 1990's tourist fishing became an important part of the Norwegian tourist market (license for sport fishing in Norwegian coastal waters is not required). It has been estimated that the economic value generated by a fish caught by a tourist is ten times higher than when caught by a commercial fisher (CGE&Y 2003). Motivated by this observation, the Ministry of Fisheries and Coastal Affairs has suggested recently that it may be advantageous to assign part of the Norwegian commercial quota to tourist fishing companies. At present there are no precise statistics on how many tourists fish along the coast or how much and which species they catch. The most recent report (2003) on tourist fishing in Norway is by the consultant company Cap Gemini Ernst & Young (CGE&Y). CGE&Y estimated that the tourists catch about 6,000-9,000 tons (round fish) each year. In comparison, Hallenstvedt and Wulff (2001) estimated the total catch by tourists at between 12,000 and 15,000 tons per year. According to CGE&Y about 17% of the tourist catches are caught in southern Norway. CGE&Y concludes that these estimates are very uncertain, and there is a strong need for more comprehensive research to achieve better catch estimates and information on species and size composition. According to St.meld. no. 19 (March 2005), the Norwegian government ("Stortinget") desires to make tourist fishing a significant component of the tourist industry in Norway. To achieve this goal, the Government will ensure that tourists can fish along the Norwegian coast and regulate the fishery so that it is sustainable. In addition, recently several new laws and regulations have been introduced to ensure the sustainable utilization of coastal resources and to prevent unnecessary conflicts among stakeholders. Reliable regional knowledge about species composition, size and seasonal variation is crucial to manage the resources in a sustainable way, to obtain a sound balance between resources and harvest, and to formulate laws and regulations that fit the actual conditions along the coast.

2.4 User groups and impact

2.4.1 Commercial cod fishing

Commercial cod fisheries are here defined as fishing carried out as an occupation on a commercial basis. Net-fishing is very efficient but also quite selective. Minimum mesh size in Norway is 35 cm, which generally means that 2 year old cod and larger are caught. Some fishers also do line-fishing, but that is quite rare, and does not account for much of the volume landed.

2.4.2 Aquaculture

To be added later.

2.4.3 Eel fishing

Eel fishing are an important user group because as cod are caught in high numbers as by-catch. Eel (*Anguilla anguilla*) is fished mainly in the fjord system, and the surveys and general knowledge about the system indicates that by-catch of cod is substantial in this fishery. Given the recruitment problems and the limited cod resources in the inner fjord, reduction of eel fishing may contribute to the overall improvement of the general abundance of cod. Reducing or stopping the eel fishery can primarily be done through regulations in accordance to the Salt Water Fishing Act by the national and/or regional fisheries authorities. However, the municipality may, at least theoretically; also buy out the few local fishers involved in this fishing, but the municipality has no legal power to stop anyone to (re)enter the fishery. There are only a handful of fishers within the case area involved in eel fisheries, and these are generally retired people getting some income while carrying out their hobby. The eel fishers are generally not selling their cod by-catch, as they often do with the eel. The cod is mainly used for household consumption and often given to neigbours, friends etc.

2.4.4 Recreational fishing

Recreational fishing is fishing carried out by local residents or people occasionally passing by the coastal areas by boat or car, thus cabin-owners with cabins along the case area are not included in this group. The importance of this fishery is difficult to assess, but the volume is generally believed to be high. Some of the local residents are in possession of nets and thus represent a potential high fishing pressure. However, these fishers generally fish only for their own household consumption, and it is unlikely that this potential fishing pressure is heavily utilized.

2.4.5 Tourist fishing

Tourist fishing is fishing where anglers are coming to designated cabin/hotel facilities to stay while fishing, and where boats and other type of infrastructure are provided by the tourist fishing company. These fishers varies from team-building groups that happened to chose fishing as their arena, to dedicated trophy anglers chasing only the big ones, and to those quantity seekers who fish to fill their freezers with cod fillets. This type of fisheries is carried out through the tourist enterprise, and they facilitate and administer the activities with their own guides and boats etc. Foreigners may engage in sports fishing with hand held tackle, but not with fixed equipment like pots, lines and nets. Further, they cannot sell their catch. Also an export quota applies, and it is currently not allowed to bring more than 15 kg of fish, plus one trophy fish, out of the country. Freshwater species are not subject to this regulation.

With support from cost-benefit analyses and so on, the authorities can, again theoretically speaking, channel the cod to the user group that provides the largest economic and social benefit for the municipality or the region or country as a whole. However, this assumes that a certain amount of fish can easily be allocated to the targeted user-groups, and that each of them has the capacity to actually land the allocated amount of cod. This is most likely not the case. The model will distribute the costs and benefits between the user groups and may thus also be an indicator of resource conflicts. If the commercial fishers get more on the expense of tourist fishers, it is likely that the tourist fishing operators and anglers interest groups will mobilize and start media campaigns etc. to change the decision in their favour.

2.4.6 Second Home owners

The 2^{nd} Home owners can be considered as a subgroup of the Recreational fishing group discussed above. However, we see the fishing pressure presented by the 2^{nd} Home-owners as a rather fixed share of the numbers of cabins along the coast. Thus, the fishing pressure from this group may to some extent depend on the numbers of cabins in the coastal areas. And the number of 2^{nd} Homes is largely under the control of the municipality through spatial planning in accordance with the Planning and Building Act. This means that the municipality to some extent indirectly may influence the increase in fishing pressure in the case area. We suggest three alternatives:

- Alt 1: No further increase in second home developments in Risør municipality
- Alt 2: Some local restrictions in second home developments, indicated by increasing numbers (but a lower increase than Alt 3)
- Alt 3: No local restrictions in second home developments, indicated by increasing numbers

2.4.7 Eco-tourism

There are many definitions on ecotourism. Some put emphasis on that development and management of tourism takes place in such a way that the environment is preserved, and that the income from tourism adds to the investment into landscape conservation (Colvin, J. 1994). Some definitions also state that ecotourism should appeal to the ecologically and socially conscious, and also contribute to such consciousness. Often are local culture, local heritage and local nature in the centre of attention. This form of tourism put emphasis on leaving as little "footprints" and other negative impacts as possible.

To some extent the local authorities can facilitate or allow eco-tourism development at the dispense of non-eco tourism/ordinary tourist fishing developments. It is, however, doubtful whether rather small increases in the abundance of cod in the local waters of Risør will significantly improve the chances for further eco-tourism development.

2.5 Regulations

2.5.1 Minimum cod size

To reduce the fishing pressure a minimum size of 35 cm (13.78 inches = 2 year) on fished cod already applies for the commercial fisheries. This measure could also be expanded to and introduced in the tourist and sport fisheries, as it is quite likely that many of these fishers often land fish under this minimum size. The minimum size can also be changed in the model and will affect both commercial and sport/tourist fisheries. The option in the model is to change the minimum year-class (age-group) the different users can fish on.

2.5.2 MPA (Marine protected areas)

The definition of a marine protected area (MPA) adopted by IUCN and other international and national bodies is:
"Any area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment". (Kelleher and Kenchington, 1992).

A protected area is: **"A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values". IUCN 2008**

IUCN 2008 differs between:

1) a) Strict nature reserve, and b) Wilderness area,
2) National park,
3) Natural monument or feature,
4) Habitat/species management area,
5) Protected landscape/seascape,
6) Protected area with sustainable use of natural resources.

In our case only 4, 5 or 6 may apply.

There is, theoretically, possible to close the study area for all kind of fishing by introducing a MPA. There is already a lobster reserve established along the Risør town waterfront. However, to establish a MPA covering large part or all of the study area is highly unlikely, both in terms of practicality and political support and legitimacy. There would also be difficult to justify such strong measures vis-à-vis the national fisheries authorities, and it will most likely also require changes in the fisheries legislation.

2.5.2.1 MPA-habitat

In the present version of the model the estimated effect of each new 2nd home is that each will contribute to reduce available habitat for 0-group cod with 50 m^2. However, three levels of regulations are included, which will affect the available habitat for 0-group cod.

Table 2.2. Regulations that affect establishing new sandy beaches and marinas.

Option	Regulation	The estimated effect of each new 2nd home is that each will contribute to reduce available habitat for 0-group cod with:
1 (Default)	Non	50 m^2
2	No new sandy beaches	25 m^2
3	No new sandy beaches and marinas over depths less than 25 m	0 m^2

Calculation of available habitat for 0-group cod as a function of existing 2nd homes and new 2nd homes:

Equa (2.1): New available habitat = available habitat – (2nd homes)*50 – (Delta)*(option; 1=50; 2=25; 3=0);

2.5.2.2 MPA-cod / Fishing regulations

In the present version of the model the spawning stock of the local cod can be protected by closing the spawning season for fishing and a third option which stop all fishing of cod in the study area.

Table 2.3. Regulations to protect cod and affect tourist and commercial fishers.

Option	Regulation	Effect on Tourist fisher	Effect on commercial cod fishery	Comments
1 (Default)	Non	Non	Non	
2	No fishing during spawning period (3 months) with nets	Non	50 % reduction in fished cod = 5 ton $year^{-1}$	Will affect the ecosystem (table 1.1 with annual survival rate) and economical model
3	No fishing during spawning period (3 months) with nets and hooks	Reduce their available annual fishing period with 30%	50 % reduction in fished cod = 5 ton $year^{-}$	Will affect the ecosystem (table 1.1 with annual survival rate) and economical model (see chapter 3.1.2)
4	No fishing of cod through the whole year with nets and trawl	Non	100 % reduction in fished cod = 10 ton $year^{-1}$	Will affect the ecosystem (table 1.1 with annual survival rate) and economical model
5	No fishing of cod through the whole year with nets, trawl and hooks	No touristfishing – 100% reduction	100 % reduction in fished cod = 10 ton $year^{-1}$	Will affect the ecosystem (table 1.1 with annual survival rate) and economical model (see chapter 3.1.2)

The effect on Tourist Fishers (Option 3 and 5) is through Equa (3.4):

Equa (3.4): $$T_i = \left[T_{i0} + \sum_j b_{ij}(A_j - A_{j_0}) \right] \left[\; 100 + \; b_k \ln(A_k) - 1,3 \quad /100 \right]$$

The MPA-cod will affect equation (3.4) in the following way:

If MPA-cod = 3; the first part of the equation ($\left[T_{i0} + \sum b_{ij}(A_j - A_{j0}) \right]$) should be multiplied with 0.7

If MPA-cod = 5; the first part of the equation ($\left[T_{i0} + \sum b_{ij}(A_j - A_{j0}) \right]$) should be multiplied with 0

The effect on the Commercial cod fishery (Option 2, 3, 4 and 5) is through reducing “Days at sea” with 50% (option 2 and 3) or 100% (option 4 and 5)

2.6 Process (in-put) legitimacy and content (out-put) legitimacy (result)

Legitimacy can in this context consist of either process (in-put) legitimacy (the degree of support and content with the decision-making process) or content (out-put) legitimacy (the degree of support and content with material content of the decision). The important point is that sometimes too little of one can be compensated by more of the other. Also, that more legitimacy is generally better than less legitimacy.

Stakeholder participation in the policy process is thus believed to lead to better and more well-informed decisions, which again will lead to increased support of and compliance to, the regulations agreed upon. Participation ought to be seen as a way to address and reduce the potential for user-conflicts. In addition, participation also has intrinsic values, and is a goal in its own right. Participation is expected to increase the conflicts in the first stages of the decision making processes, but reduce them at the final decision-making stages.

Theoretically, more participation the better. However, participation also has costs, and at some point the benefits will be outweigh by the cost. Thus, to strike the right balance is essential. However, even if the in-put/process legitimacy cannot be directly manipulated, it can be seen as a function of the amount of user-group/stakeholder participation. More participation leads to improved legitimacy. This does not necessarily hold true for all cases, but can be a good enough estimate for use in the model. With a slider this can be illustrated with a slider going from extensive participation to no participation.

2.7 User conflicts/Output-legitimacy

This is a result of the participation and the decision-making and can as such not be treated as a variable that can be directly manipulated. Legitimacy is also a highly complex variable that is very difficult to operationalize. However, it can be measured through indicators such as 1) letters of complaints received by the municipality administration, 2) fisheries and coastal zone related conflicts displayed in the local media, or 3) numbers of cod/coastal zone related conflicts. We doubt these variables easily lend themselves for modelling.

2.8 Conflict-potential indicator

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 the attractiveness of the area for tourists. To set up such an indicator two questions must be answered:

1. What variables are reasonable to include in an indicator of the conflict-potential?
2. How should the variables influence the indicator (functional relationship)?

- The number of tourists in the different categories
  - A higher number of tourists make conflicts over scarce resources more likely, and thus increases the general conflict potential level
  - However, there could be different effects from the different categories of tourists, as they to different degrees contribute to conflicts over resources, external effects, etc.
  - It is thus possible to include the number of tourists in each category, but give them different weight
  - However, we will here just use total number of tourists for simplicity. Last years numbers.
- The economic benefits the tourists give the region
  - If tourists give economic benefits of real significance to the people in the area it reduces the propensity of conflicts for otherwise constant number of tourist days.
  - Will use last year's values here too

Conflict indicator:

Equa (2.2): $$A3 = \beta_3 \frac{A_1}{\sum_{1}^{5} L_{i_{t-1}}}$$ Let $\beta 3=1000$; L_i refer to the total sum in Equa (3.6).

3 The Economic model (EC)

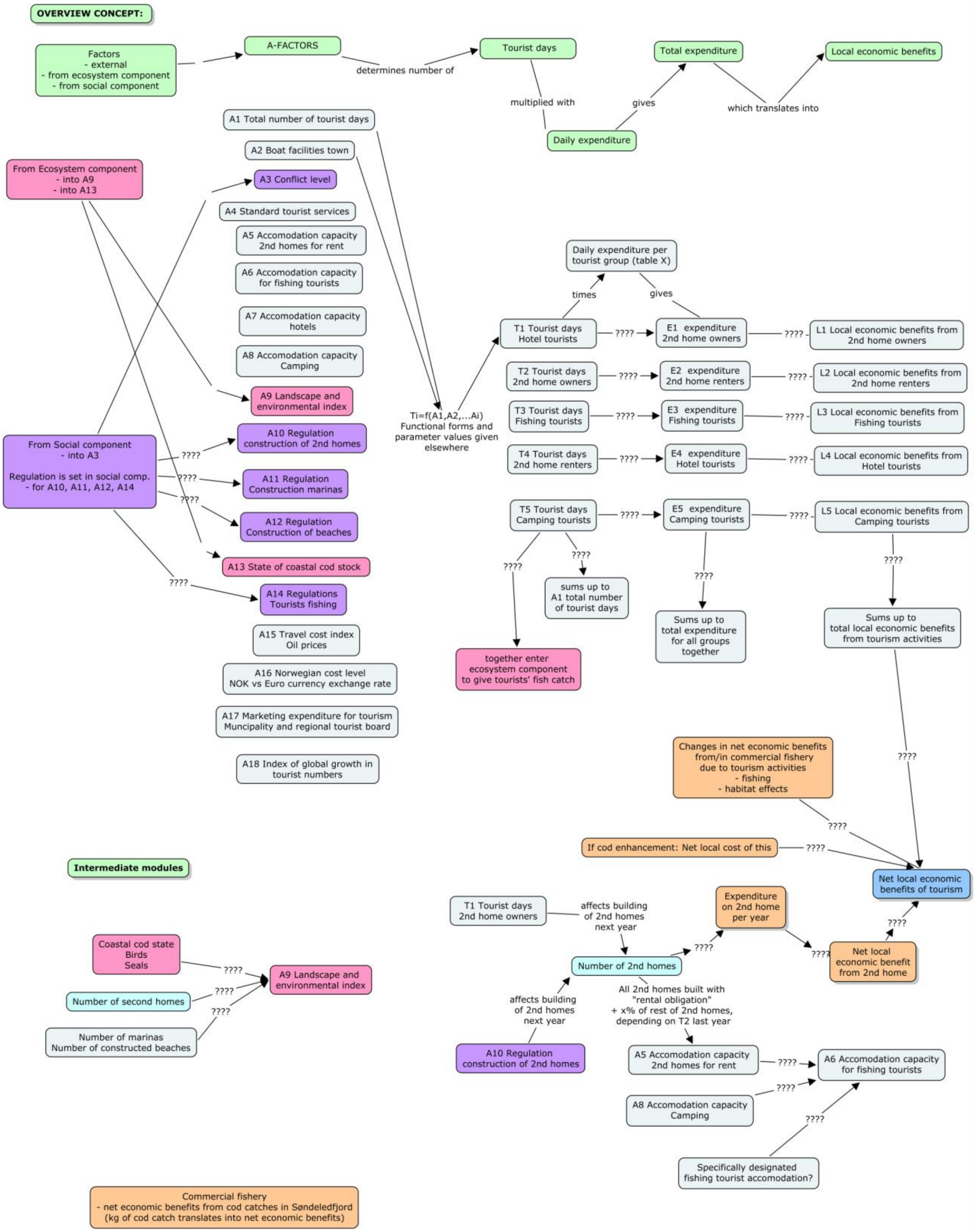


Figure 3.1. Conceptual model for the economic component.

Eirik Mikkelsen and Inga Wigdahl Kaspersen

This present description of the economic model is to show links to ecological and social components of the model, links in the economic component, AND to explicitly give equations and parameters used in the economic model component. The main aim of the 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.

Studies of factors that affect tourism numbers and demand in the literature are for larger regions than a municipality like Risør. Typical geographical areas have been countries or regions of large countries, and they focus on travel costs between regions, relative prices (adjusted for currency changes/purchasing parities), and differences in income growth between countries (Witt and Martin, 1987; Smeral and Witt, 2005; Moshirian, 1993). While these are important determinants of international tourism flows, they are less relevant for our geographical setting and our policy issue. We should look for factors that local authorities can influence, and which may affect tourist-numbers (or tourist-day numbers) to Risør. As the local authorities have stated a wish of attracting high-paying and environmentally conscious tourists, factors that affect such groups of tourists are particularly relevant. The smaller the geographical unit we study is, the less certain will estimates be, and more prone to large fluctuations (in percent/relative to the total number of tourist days) will actual numbers be.

Economic benefits/costs related to tourism that we consider come from:

3 .1 expenditures from tourists visiting the area (except 2nd home building and maintenance), and multiplicator effects[1] of those expenditures

3.2 the building and maintenance of 2nd homes + multiplicator effects

3.3 Changed value-added in the commercial fishery due to changes in the coastal cod stock

3.4 Aquaculture production, including effect on wild cod stock– **Not ready yet**

3.5 net local costs of coastal cod stock enhancement

We use 5 categories of tourists.

- 2nd home owners
- 2nd home renters
- Fishing tourists
- Tourists staying at hotels
- Tourists staying at camping/camping-cabins

The number of tourist-days from each tourist category, multiplied with the average expenditure per tourist-day in that category, gives the total expenditure from that tourist category.

[1] Multiplicator effects: When a person buys goods and services, the ones receiving the money will use it to pay for intermediate goods and wages, and will also get higher income. These will also buy goods and services for them, raising someone else's income, and so on. Some of the money spent will find their way out of the region in each round. This continues until only a negligible amount is "recycled". This way an initial sum of money spent can be "used several times", multiplying up the initial sum.

3.1 Expenditures from tourists visiting the area (except 2nd home building and maintenance), and multiplicator effects of those expenditures

3.1.1 Factors and tourist categories

Local economic benefits are calculated like below, for each group of tourists.

Factors A1-A18 affect number of tourist-days T_i for each tourist group (i=1,5).

Equa (3,1): Ti=f(A1,A2,…,A18)

(*f* just means the variable on the left hand side of the equality sign is a function of the variables/factors in brackets on the right hand side). See Equa 3.4 for a detailed functional relationship.

Factors are below in table 3.1, detailed equations for each tourist-group further below.

Expenditure (E1-E5) from each tourist group is equal to No of tourist-days (T1-T5) multiplied with expenditure per day for this group (from table 3.5).

Equa (3.2): Ei=ei*Ti

Expenditure **Ei** for each tourist group is converted into Local Economic Benefits **Li** from each tourist group.

Equa (3.3): Li=f(Ei)

Table 3.1. Factors/variables Ai that (possibly) affects number of tourist-days Ti for each of the tourist categories.

		Sign?	T1	T2	T3	T4	T5
	Tourist group		**Hotel-tourists**	**2nd home owners**	**Fishing tourists**	**2nd home renters**	**Camping-tourists**
A1	Total number of tourist-days	-	x	x	x	x	x
A2	Boat facilities in town centre *	+	x	x	x	x	x
A3	Level of conflict between tourists and locals	-	x	x	x	x	x
A5	Accomodation capacity 2nd homes for rent	+			x	x	
A6	Accomodation capacity dedicated for fishing tourists	+			x		
A7	Accomodation capacity Hotel	+	x				
A8	Accomodation capacity Camping	+			x		x
A9	Landscape and environmental quality index	+	x	x	X	x	x
A10	Regulation on construction of 2nd homes	-		x			
A13	State of coastal cod stock	+		x	x	x	
A14	Regulations on tourist fishing	-			x		
A17	Marketing expenditure tourism	+	x	x	x	x	x
A19	GDP[2] growth in Norway same year	+	Growth in GDP above a certain level affects the total volume of tourists.				

* Leave out /ignore this factor at this stage (not able to estimate parameters satisfactorily at this stage)

[2] Gross Domestic Product

Table 3.2. Definition of variables.

Aj	Variable name	Base Value (where relevant)	Definition	Formula	Effect
A1	Total number of tourists	250000	Sum tourist-days last year (Sum T1-T5)	A1= $\sum_{i=1}^{5} T_i$	Individual tourists dislikes congestion and high tourists density
A2	Boat facilities in town centre		No of boat places in town centre last year	-leave out?	Better facilities make the area more attractive
A3	Level of conflict between tourists and locals	4,2	Own variable "conflict" last year. See chapter 2.6	From social component	A high perceived level of conflict discourages tourists from coming
A5	Accommodation capacity 2nd home for rent		a_{51}=Number of 2nd homes designated for rent, plus a share of the rest of the 2nd homes, depending on the change in demand for such accommodation last year	A5= $a_{51} + \beta_{54}(T_{4_{t-1}} - T_{4_{t-2}})$ β54=parameter A_{51} = 150 ($T4_{t-1}$ –$T4_{t-2}$) = number of 2nd homes (1373=1523-150) + newly built 2nd homes	The capacity level is an upper limit for the relevant groups of tourists. A higher capacity means it is easier for tourists to find the accommodation that suits them. I assume that accomodation demand is more than met by supply.
A6	Accomodation capacity dedicated for fishing tourists		Particularly designated accommodation for fishing tourists	Should be able to be set in the model, as a combination of number of beds, and their "star"-classification (1-5 stars, see www.fisketurisme.no). A6 = Beds * stars * b_{6i} (see chapter 3.1.2 and Table 3.3)	Designated accommodation capacity for fishing tourists ("rorbu"), including available fishing boats, areas for fish gutting and preparation, etc, attracts more fishing tourists. 5 stars give a 100% capacity utilisation of the beds available for a 180 day season. 1 star gives only 20% capacity utilization (=36 days per year).
A7	Accomodation capacity Hotel	300	Registered beds data SSB	A7 = 300	Same as for A5
A8	Accomodation capacity Camping	660		A8 = 660	Same as for A5

A9	Landscape and environmental quality index	8	A weighted measure of the impact of extra 2nd homes above today's 1523 (a50-1523), boat-marina places a91, coastal cod stock size CCS, number of birds BIRDS and seals SEALS, and area of sandy beaches a92.	A9= β9ccs*CCS + β9birds*BIRDS + β9seals*SEALS + β950*(a50-1523) +β991*a91+β992*a92; BIRDS = set as scenario in extend SEALS = set as scenario in extend	A "higher quality" makes the area attractive for all groups of tourists. More wildlife is better, more 2[nd] homes is a bad, as is boat marinas and sandy beaches See parameter values in Table 3.4
A10	Regulation on construction of 2nd homes	This should be removed, and we use R50 (see equa 3.7) which gives the total number of 2[nd] homes allowed (already existing + accepted for construction)	Number of 2nd homes accepted building plans for		The strictness of regulation affects the rate of growth in number of 2nd homes
A11	Regulation on construction of boat marinas	Should be changed to be used for A9 – will be done later	Strictness of regulation of construction of boat-places in marinas outside town-centre measured as number of boat places compared to number of 2nd homes? Or subjective scale 1-10?	Replaced by MPA-habitat, together with A12	will affect either growth of tourist days for 2[nd] home owners, or rate of construction of new 2[nd] homes Will probably be removed
A12	Regulation on construction of sandy beaches	Should be changed to be used for A9 – will be done later	Strictness of regulation on a subjective scale 1-10?	Replaced by MPA-habitat, together with A11	same as above Will probably be removed
A13	State of coastal cod stock (Sum biomass kg 2-10 year-classes)	30,7 tons	Own variable cod-stock estimate last year yearclasses 2-10	A13=CCS_T	CCS_T = Cod biomass at time T

A14	Regulations on tourist fishing MPA-cod/Regulations on cod fishing	0	Strictness of regulation on a scale 0-5, but only 3 and 5 affect tourist fishers	If the value is 3, number of tourist's fishers should be reduced by 30%, If it is 5, it should be reduced by 100%.	See Chapter 2.2.2.2
A17	Marketing expenditure tourism		Budget for municipality and regional destination company for this?		Marketing attracts more tourists (unless others also increase their marketing effort, but we will ignore the latter effects)
A19=Ak	Yearly growth in GDP in Norway (%)				Tourism is very sensitive to changes in the state of the economy / it's outlook

SSB=Statistics Norway

3.1.2 Calculating tourist-days

As can be seen from Tables 3.1 and 3.2 above, many factors influence the number of tourist days of the different tourist categories. For most factors, the effects on tourist days are calculated using Equa 3.4 below.

A few factors are dealt with differently.

For A6 – (Designated) fishing tourist accommodation:
Designated accommodation for fishing tourists ("rorbu") attracts more fishing tourists, as they include available fishing boats and areas for fish-gutting and preparation, etc. How well the accommodation capacity, measured as number of beds, is utilized over the yearly season of 180 days depends on the standard of the accommodation/premises. 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).

The number of beds available in "rorbu" –(specifically made for fishing tourists), and their average classification (number of stars), are set as a scenario. They increase the annual number of tourist days by fishing tourists in the following way:

Equa (3.11): $A6 = beds * stars * b_{6i}$

b_{6i} is given in table 3.3, and is equal to 36.

The MPA-cod / Fishing regulation (Chapter 2.5.2.2) will affect equation (3.4) in the following way:

If MPA-cod = 3; the first part of the equation ($\left[T_{i0} + \sum_j b_{ij}(A_j - A_{j0})\right]$) should be multiplied with 0.7

If MPA-cod = 5; the first part of the equation ($\left[T_{i0} + \sum_j b_{ij}(A_j - A_{j0})\right]$) should be multiplied with 0

The general formula for calculating the annual number of tourist days for the different categories of tourists:

Calculating number of tourist-days for each category of tourist, i=1,5

Equa (3.4): $T_i = \left[T_{i0} + \sum_j b_{ij}(A_j - A_{j_0})\right]\left[\ 100 + \ b_k \ln(A_k) - 1{,}3 \quad /100\right]$

The number of tourist-days from each tourist category (i=1-5) depends on the base number of tourists (T_{i0}; estimated 2007 numbers). They are adjusted with additions or subtractions due to changed value of some variables (A_j) compared to their 2007 values (A_{j0}). In addition, the total number of tourists is scaled up or down depending on the GDP (Gross Domestic Product) growth rate of Norway (A_k).

For each Ti, i=1,5, the following table 3.3 includes parameter values to the functions above. For the parameters we currently have included in the model, coefficients are different from zero. Those set equal to zero are not currently included in the model, as we have not been able to determine coefficient values satisfactorily, but the variables are expected to be relevant for tourist numbers and for the municipality’s policy options..

The term $b_k \ln(A_k) - 1{,}3$ gives percentage change in tourist numbers given percentage change in GDP (=Ak). The percentage change is given as number of percent change. An input of 2 (Ak=2), meaning a 2% change in GDP from last year, gives a 1,2% change in tourist days, and an output of 1,2.

Table 3.3. Parameters to be used in Equa (3.4). T_{i0} = (Number of persons pr day) * (Number of days)

bji / i	**T1**	**T2**	**T3**	**T4**	**T5**
	Hotel-tourists	**2nd home owners**	**Fishing tourists**	**2nd home renters**	**Camping-tourists**
b1i	-0,01	-0,05	-0,0001	-0,001	-0,01
b2i	-	-	-	-	-
b3i	250,00	2 500,00	50,00	250,00	5 000,00
b4i	-	-	-	-	-
b5i	-	-	-	-	-
b6i	-	-	36	-	-
b7i	20,00	-	-	-	-
b8i	-	-	60,00	-	60,00
b9i	500,00	7 500,00	400,00	450,00	2 000,00
b10i	-		-	-	-
b11i	-		-	-	-
b12i	-		-	-	-
b13i	-	0,02	0,01	0,01	-
b14i	-	-	-1 000	-	-
b17i	-	-	-	-	-
T_{i0}	14250	165002	9000	4500	59400
(T_{i0} - Number of persons pr day)	150,00	3 587,00	50,00	100,00	660,00
(T_{i0} - Number of days)	95,00	46,00	180,00	45,00	90,00
Daily expenditure NOK (Tab 3.5)	1 206,00	100,00	556,00	716,00	396,00

Table 3.4 Other parameters

Parameter	**Value**	**Comment**
β54	0,02	Dybedal 2006 assumes 5% of 2nd homes are rented out, in 50 days per year, with 4 persons per day on average. I assume a growth of demand for 2nd homes for rent of 100 person-days increases supply by 2 2nd homes
β9ccs	0,1	Pure guesstimate. Each tonne of coastal cod increases index by 0.1 point
β9birds	0,02	Pure guesstimate. Each comorant increases index by 0.02 point
β9seals	0,02	Pure guesstimate. Each comorant increases index by 0.02 point
β950	-0,004	Pure guesstimate. Each 50 new 2nd homes (above 1500) decrease index by 0.2 point
β991	-0,001	Pure guesstimate. Each 50 boat places decrease index by 0.05 point
β992	-0,001	Pure guesstimate. Each 50 m^2 of constructed sandy beaches decrease index by 0,05 point
β50	0,00833	β50 = (1 / number of persons pr 2nd home) / number of day in use = (1 / 4) / 30 = 0.00833
βLBCF	0,9375	change in local benefits from the commercial fishery
δ	0,05	discount rate for each year

3.1.3 Tourist-days and expenditure

To get from tourist-days to expenditure: Multiply tourist days by daily expenditure

Equa (3.5): Ei=Ti*ei   i=T1 to T5

The daily expenditures are given in the table 3.5 below. They are based on a Norwegian survey.

Table 3.5. Daily expenditures by tourist group used in our model (NOK – Norwegian kroner; 8 NOK is approx. 1 €):

Tourist group	**T1**	**T2**	**T3**	**T4**	**T5**
Tourist group	**Hotel-tourists**	**2nd home owners**	**Fishing tourists**	**2nd home renters**	**Camping-tourists**
Average daily expenditure e_i	1206	100	556 = (716+396)/2	716	396
T_0 (number of persons pr day)	150,00	3 587	50,00	100,00	660,00
Number of days	95,00	46,00	180,00	45,00	90,00
Tourist-days in all	14250	165000	9000	4500	59400

Of the daily expenditures made by tourists in the different groups, some go to local actors, and some to actors outside the region. Some of the expenditures create large multiplier effects, and other less, depending on the composition of the expenditures into different sectors.

We will estimate total local economic benefits based on total expenditure for each tourist group. They depend on the share of expenditures that go to local actors, and the multiplier effect of these

Equa (3.6): Li = γi*Ei   i=T1 to T5

Table 3.6. Parameters for local economic benefits from tourist expenditure in the different groups. γ**i** = (Local share) * (Mulitiplier)

i	γ**i**	**Local share**	**Multiplier**
T1	1,05	0,7	1,5
T2	0,85	0,65	1,3
T3	0,90	0,6	1,5
T4	0,98	0,7	1,4
T5	1,12	0,7	1,6

Parameters are based on Dybedal 2006 (Table 17 for local share, Table 32 for multipliers)

3.2 The building and maintenance of 2nd homes and economic multiplier effects

The number of 2nd homes in one year depends on last year's number and how many have been built in the last year. The rate of construction of new 2nd homes depends on the demand for tourist-days for 2nd home owners, but is restricted by regulation on construction of 2nd homes. The growth in number of 2nd homes is assumed proportional to growth in demand for tourist days by 2nd home owners, but restricted by how many 2nd homes have been accepted for construction (R50). If the estimated growth would make the total number of 2^{nd} homes larger than R50, the new total number of 2^{nd} homes will be R50. If the number of tourist's days for 2^{nd} home owners goes down, the number of 2^{nd} homes remains at last year's level, as it cannot be reduced.

If there has been a growth in the number of tourist days for 2^{nd} home owners the last two years, this leads to new 2^{nd} homes being built in the current year. The number of 2^{nd} homes constructed is dependent on the rate of growth of tourist days . It is however limited by how many new 2^{nd} homes that are accepted for construction by the planning authorities (R50).

Equation 3.7 gives $a50_t$, the total number of 2^{nd} homes in the current year (t), after new 2^{nd} homes have been constructed in the current year.

Equa (3.7): $$a_{50_t} = \begin{cases} a_{50_{t-1}} + \beta_{50}(T2_{t-1} - T2_{t-2}) & \text{if } a_{50_{t-1}} < a_{50_t} < R_{50} \\ R_{50} & \text{if } a_{50_{t-1}} + \beta_{50}(T2_{t-1} - T2_{t-2}) \geq R_{50} \\ a_{50_{t-1}} & \text{if } a_{50_{t-1}} + \beta_{50}(T2_{t-1} - T2_{t-2}) \leq a_{50_{t-1}} \end{cases}$$

$T2_{t-1}$ = Number of tourist-days last year; $T2_{t-2}$ = Number of tourist-days two years ago

β_{50} = (1 / number of persons pr 2^{nd} home) / number of day in use
β_{50} = (1 / 4) / 30 = 0.00833

Define "DELTAa50" as the number of 2^{nd} homes constructed in the current year.

Equa (3.12): DELTAa50 = $a50_t$ - $a50_{t-1}$

2nd homes create local economic benefits through two mechanisms.

- When they are built **(L6)**
- Maintenance need **(L7)**

The first effect L6 only comes in the year a 2^{nd} home is constructed, while the second effect L7 comes every year, except the year it is constructed.

Dybedal 2006 considers the costs of building and maintenance of 2nd homes in the county where Risør are, and nearby counties. Sale of ground, and costs associated with preparing the ground (water supply, sanitation, electricity and road) is assumed 100% local. For the building costs, we will assume that on average 50% of costs accrue to local actors.

Table 3.7. Per 2nd home constructed: 2006 costs that go to local actors (1000 NOK):

Ground	500
Preparation ground	80
Materials and work	540
SUM	*1120*

Further we assume a multiplicator of 1.3, giving a parameter for calculating net local economic benefits per 2nd home constructed of 1.3 * 1120 000 = 1 456 000 NOK

Local economic benefit in a single year per 2nd home constructed that year = 1 456 000 NOK.

Equa (3.8): L6 = 1 456 000 NOK * $\begin{cases} \beta_{50}(T2_{t-1} - T2_{t-2}) & \text{if} < R_{50} \\ R_{50} & \text{otherwise} \end{cases}$

$T2_{t-1}$ = Number of tourist-days last year; $T2_{t-2}$ = Number of tourist-days two years ago

Maintenance creates local economic benefits. Estimated maintenance costs per 2nd home per year is in Dybedal 2006 in the range 2163-5458 NOK (estimated in NOK for the year 2002), for some other municipalities that Risør. Risør is very attractive with expensive 2nd homes. We use the highest estimate as it is. The local share of this sum is in the same publication estimated between 0,32 to 0,69, for municipalities that are in less densely populated areas than around Risør. We will therefore use the highest local share. Will use a multiplicator of 1,3 again. Net local economic benefits per 2nd home per year is then 1,3 * 0,69 * 5458 NOK = 4896 NOK.

Local economic benefits from maintenance of 2nd homes are 4896 NOK per 2nd home per year. 2nd homes constructed in the current year does not need maintenance in the current year. Hence the number of 2nd homes that need maintenance in the current year is equal to last years' number of 2nd homes. Equa 3.9 gives the local economic benefits from this maintenance.

Equa (3.9): L7=$a50_{t-1}$ * 4896 NOK

3.3 Changed value-added in the commercial fishery due to changes in the coastal cod stock

The vessels that catch cod in the Søndeledfjord system are small coastal vessels of length 8-9.9 m, using conventional fishing gear. In addition, some shrimp trawlers get cod as bycatch. We will concentrate on the vessels of length 8-9.9 m, as they according to interviews with local fishermen and fish buyers are most important for the cod catches in our case-area.

If we assume a linear Schaefer harvest function (Chapter 1.5.5; Equa (1.10): h = q E X, where h is harvest, q is catchability coefficient, E is fishing effort, and X is cod stock in biomass in the fishing area), a larger cod stock will give larger harvest with the same fishing effort. If we further assume that the cod fishery in Søndeledfjord represent only a rather small portion of the vessels' total catches, we can take the vessels' fishing effort as given, without invoking a large error. A vessel of 8-9.9 meters with conventional fishing gear typically catch between 10 and 20 tonnes of cod annually (**reference?**). Thus a doubling of the cod stock in Søndeledfjord would, for the three vessels involved, only represent an extra catch of about 3 tonnes each, in other words between 30 and 15% of the annual catch.

We will therefore for each vessel take effort as given, and hence operating costs as given, independent of the size of the cod stock. The effect on changes in the cod stock will then directly translate into larger operating profits, by the value of the extra catch. Whether this extra profit goes to the vessel owner only, or is shared with the crew as wages, will not matter for our calculation of value added from the commercial fishery.

The average price per kg of cod, paid to the fisherman, has in Norway in 2003-2007 varied between NOK 9.80 and NOK 15.73, with NOK 12.43 as the average price over these years. There has however been a clear trend of increased price over these years. We will therefore use the price **NOK 16/kg** as our basis for calculating extra revenues and hence extra profits/value added.

Table 3.8. Average price per kg cod, paid to fishermen. NOK

2003	2004	2005	2006	2007	Average 2003-07
9,80	11,05	12,25	13,66	15,73	12,43

3.3.1 Changes in profit in the commercial fisheries due to changes in cod stock biomass (year-class 2-10)

The relative deviation of the stock biomass from 30.7 tons gives the relative deviation from total cod catch of 10 tonnes. If the stock biomass is larger than 30.7 tonnes, say 35 tonnes, which is an extra 1/6, the catch will be 1/6 of 10 tonnes larger. This is 10/6 tonnes, 1667 kg. Given a price of NOK 16/kg, this readily translates into an extra value added of NOK 16*1667 = NOK 26 667.

Equa 3.13 below gives DeltaRCF, the change in profit in the commercial fishery due to changes in the local cod stock.

Equa (3.13): DeltaRCF = (Cod price) * 1000 * (CCF_t/CCF_0);

Where CCF_t = Present cod biomass (tons; 2-10 years); CCF_0 = Initial cod biomass (2-10 years; 30,7 tons; Table 1.1)

In this version of the economic component of the model we have chosen a very simple approach to calculate the extra value added. It can be defended as the change in value added due to even relatively large changes in cod stock biomass is very small compared to changes in value added due to changes in tourist numbers of the same relative magnitude. To make the model more general, for example to be useful also in a location where the fishery is relatively more important compared to tourism than in Risør, the modelling of the commercial fishery should be more advanced. The choice of fishing effort could be modelled as a profit-maximising choice depending on the size of the cod-stock. We will leave this as a task for later work. The data below may be useful then.

Data on revenues, operating costs, and other figures related to profitability of vessels 8-9.9 meters can be found here, for 2003-2007 (in Norwegian):
http://www.fiskeridir.no/fiskeridir/content/download/9819/82535/version/3/file/Tidsserie_Fartoygrupper.xls

Table 3.9. Profitability data and catches for fishing vessels 8-9.9 m of length.

Data on catches: (Corrected table from Inga to be inserted here later):

3.3.2 Changes in local economic benefits due to changes in profit in the commercial fishery

A change in the revenues received by commercial fishermen, belonging to the Risør municipality, will affect local expenditure and local economic benefits of this economic activity. We assume that both the owner of a vessel registered in Risør, and any crew on that vessel, live in Risør. Most of these vessels are likely operated only by the skipper for most of the year, so this is a reasonable assumption.

We calculate how changed income for a person living in Risør translates into changed local economic benefits in the following way. We assume a portion of 75% of changed income is spent locally, giving added local economic effects through the multiplier effect. We use a multiplier of 1.25 which results in a constant b_{LBCF} = 0.9375 (Table 3.4), being the product of these two figures.

Equa 3.10 below gives DeltaLBCF, the change in local benefits from the commercial fishery due to changed profit (DeltaRCF).

Equa (3.10): DeltaLBCF=DeltaRCF*b_{LBCF};

Where DeltaRCF is calculated in Equa 3.13; b_{LBCF} = 0.9375 (Table 3.4)

3.4 Aquaculture production, including effect on wild cod stock

To allow for a more general model, we could include a possible fish farm, for salmon or cod or another fish species. Today there is mussel farming at several locations in the Søndeledfjord system. Salmon farming has been attempted. Halibut juveniles have been produced. All of these are examples of fish farming that can generate an economic surplus. However, aquaculture can also have effects on wild fish stocks, or on a fishery (Mikkelsen 2007). Including fish-farming would thus allow for another relevant interaction between economy and ecology in our model. We have the competence to include this in our model, but will postpone it to later.

3.5 Net local costs of coastal cod stock enhancement and resulting change in local economic benefits

A marine hatchery for juvenile cod and Atlantic halibut is located in study area. It has the capacity to produce both 0-group and 1-group cod. The production cost of cod is given in table 3.10. The release of 0-group cod will normally take place in September, and the release of 1-group cod will normally take place in April. Such release of coastal cod juveniles *could* enhance the wild stock, although previous attempts at marine stock enhancement have not been successful (Svåsand et al., 2000). If it would enhance the stock, it would help attract more tourists (more tourist days).

Table 3.10. Production cost per individual for 0-group and 1-group cod (Data from Moksness 2004; Moksness and Støle 1997). 1 EURO = 8 NOK.

Cod	NOK	Euro
C_0 (0-group price)	8	1
C_1 (1-group price)	12	1,5

Equa 3.14 gives the total annual costs of coastal cod stock enhancement.

Equa (3.14): $C_{CCSE}=C_0*N_{SE0}+C_1*N_{SE1}$

Where N_{SE0} and N_{SE1} are, respectively, number of individuals of 0-group and 1-group produced and released under the stock enhancement program; C_0 and C_1 are, respectively, cost of production and release of individuals of 0-group and 1-group under the stock enhancement program

The changes in local economic benefits due to the costs incurred for stock enhancement are not immediately straightforward to estimate. Two major questions must be answered:

1. Who are paying for the stock enhancement? Is it the municipality, perhaps together with local tourism enterprises? In that case, the cost of stock enhancement reduces the expenditure by some local actors in Risør.
2. The second major question is: Who are being paid to do the stock enhancement? If it is a local enterprise, it will result in increased expenditure by actors in Risør. If we assume that both those that bear the cost and those that get paid for stock enhancement are in Risør municipality, it may still lead to changes in local economic benefits. This is since the spending profile across different sectors, and across geography, may be altered.

However, for simplicity, we will assume that both buyers and providers of stock enhancement are local to Risør, and that spending profiles are identical. Then, local economic benefits do not change due to coastal cod stock enhancement being done.

3.6 Present value of local economic benefits

Local economic benefits of different activities vary from year to year. To consider the sum of such effects over the whole period we are considering, it is usual to calculate the present value of these effects (**REF**). Economic effects at different points in time are weighted according to when they occur. Incomes or costs far into the future are weighted less than incomes or costs in the near future.

The present value of the sum of local economic benefits, for each source i, are calculated like this:

Equa (3.15): $PV_{LEBi} = \sum_{t=1}^{N} L_{it} * e^{-\delta t}$

L_{it} is Local economic benefit from source i in year t. N is the number of years we consider into the future.

$e^{-\delta t}$ is a discount rate for each year. δ is the discount factor to be used (Table 3.4), and be set equal to 0,05.

The sum of present value of local economic benefits across all sources is:

Equa (3.16): $PV_{LEB} = \sum_{i} PV_{LEBi}$

4. Regulations and Scenarios

Three types of regulations are included in the model:

- 4.1. Construction regulations
- 4.2. MP-habitat: Table 4.3
- 4.3. MP-cod: Table 4.4

In addition there are seven types of scenarios to choose from

- 4.4. Tourist Fisher Accommodation: See chapter 3.1.2
- 4.5. Stock enhancement
- 4.6. Number of ell fishers
- 4.7. Number of Recreational fishers
- 4.8. Number of commercial fishers
- 4.9. Number of birds
- 4.10. Number of seals

4.1. Construction regulations

Regulated through adding a maximum new number of 2nd Homes allowed.

4.2. MPA- habitat

In the present version of the model the estimated effect of each new 2nd home is that each will contribute to reduce available habitat for 0-group cod with 50 m^2. However, three levels of regulations are included, which will affect the available habitat for 0-group cod. The effect of the present numbers of 2nd home (1523) will reduce the available habitat for 0-group cod with 76.150 m^2 (0,07615 km^2).

Table 2.2. Regulations that affect establishing new sandy beaches and marinas.

Option	Regulation	The estimated effect of each new 2nd home is that each will contribute to reduce available habitat for 0-group cod with:
1 (Default)	Non	50 m^2
2	No new sandy beaches	25 m^2
3	No new sandy beaches and marinas over depths less than 25 m	0 m^2

Calculation of available habitat for 0-group cod as a function of existing 2nd homes and new 2nd homes:

Equa (2.1): New available habitat = available habitat – (number of existing 2nd homes)*50 – (Maximum construction of new 2nd Homes)*(option; 1=50; 2=25; 3=0);

4.3. MPA- Cod

In the present version of the model the spawning stock of the local cod can be protected by closing the spawning season for fishing and a third option which stop all fishing of cod in the study area.

Table 2.3. Regulations to protect cod and affect tourist and commercial fishers.

Option	Regulation	Effect on Tourist fisher, Recreational fishers, camping tourists and 2nd Home owners and renters	Effect on commercial cod fishery	Comments
1 (Default)	Non	Non	Non	
2	No fishing during spawning period (3 months) with nets	Non	50 % reduction in fished cod = 5 ton year^{-1}	Will affect the ecosystem (table 1.1 with annual survival rate) and economical model
3	No fishing during spawning period (3 months) with nets and hooks	Reduce their available annual fishing period with 30%	50 % reduction in fished cod = 5 ton year^{-}	Will affect the ecosystem (table 1.1 with annual survival rate) and economical model (see chapter 3.1.2)
4	No fishing of cod through the whole year with nets and trawl	Non	100 % reduction in fished cod = 10 ton year^{-1}	Will affect the ecosystem (table 1.1 with annual survival rate) and economical model
5	No fishing of cod through the whole year with nets, trawl and hooks	No touristfishing – 100% reduction	100 % reduction in fished cod = 10 ton year^{-1}	Will affect the ecosystem (table 1.1 with annual survival rate) and economical model (see chapter 3.1.2)

The effect on Tourist Fishers (Option 3 and 5) is through Equa (3.4):

Equa (3.4): $$T_i = \left[T_{i0} + \sum_j b_{ij}(A_j - A_{j_0}) \right] \left[100 + b_k \ln(A_k) - 1{,}3 \quad /100 \right]$$

The MPA-cod will affect equation (3.4) in the following way:

If MPA-cod = 3; the first part of the equation ($\left[T_{i0} + \sum_j b_{ij}(A_j - A_k)\right]$) should be multiplied with 0.7

If MPA-cod = 5; the first part of the equation ($\left[T_{i0} + \sum_j b_{ij}(A_j - A_k)\right]$) should be multiplied with 0

The effect on the Commercial cod fishery (Option 2, 3, 4 and 5) is through reducing “Days at sea” with 50% (option 2 and 3) or 100% (option 4 and 5).

4.2. Tourist Fisher Accommodation

The number of beds available in “rorbu” –(specifically made for fishing tourists), and their average classification (number of stars), are set as a scenario. They increase the annual number of tourist days by fishing tourists in the following way:

Equa (3.11): $A6 = beds * stars * b_{6i}$

b_{6i} is given in table 3.3, and is equal to 36.
Number of beds and starts can be changed

4.5. Stock enhancement

Stock enhancement is regulated by added either or both 0-group and 1-group artificial produced cod.

4.6. Number of eel fishers

Number of eel fishers can be added or reduced.

4.7. Number of Recreational fishers

Number of Recreational fishers can be added or reduced.

4.8. Number of Commercial fishers

Number of Commercial fishers can be added or reduced.

4.9. Number of birds

Number of birds can be added or reduced.

4.10. Number of seals

Number of seals can be added or reduced.

5. Interaction between NC, SC and EC components

The present numbers and impact (2008) of the different categories (users) affecting the ecosystem and the local cod population are given in Table 5.1. Reduction or increase in any of these categories will affect the local cod population according to Table 5.3.

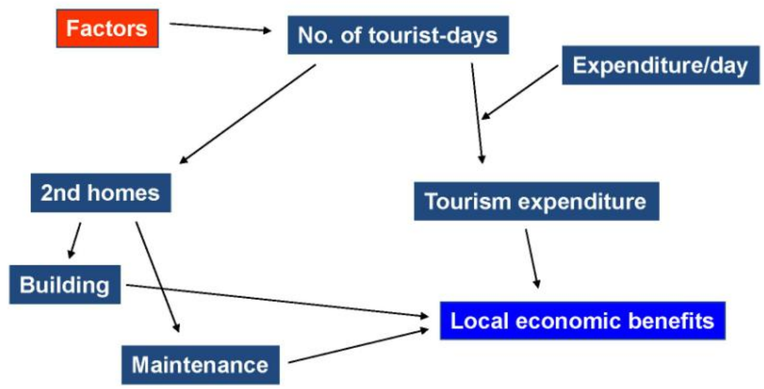
The estimated effect of each new 2nd home is that each will contribute to reduce available habitat for 0-group cod with 50 m^2. The present numbers of 1523 2nd home will affect available habitat for 0-group cod (10.72 km^2) with a loss of 0,076 km^2, representing 0.7 %.

In the present version of the model, affect on the cod populations by other predators (as other fish species in the ecosystem feeding on 0-group cod), food availability or habitat availability for age groups 1-10 of cod, are not included.

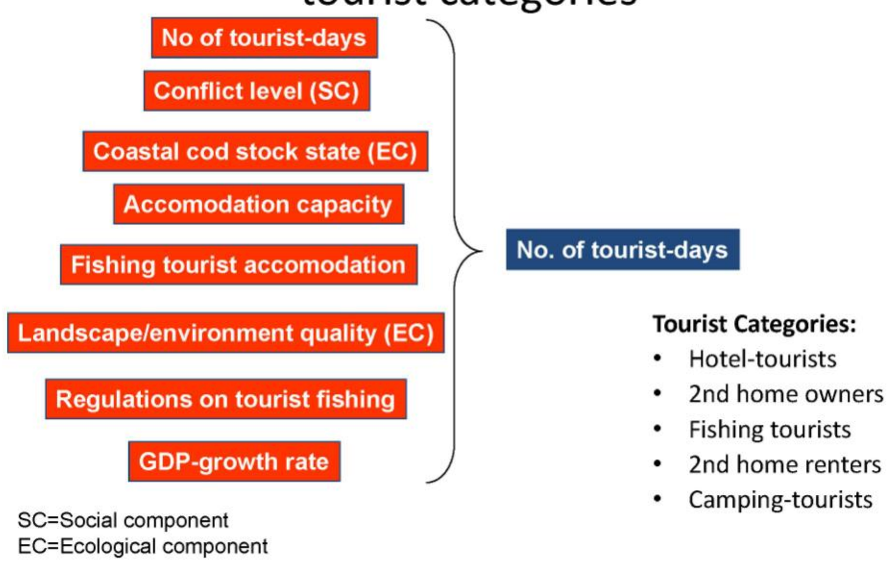
Table 5.1. Expecting fishing activity (by different user groups and presents of predators trough the year.

User	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Des
Cod spawning period		x	x	x								
0-group cod present						x	x	x	x	x	x	x
Hotel tourists	x	x	x	x	x	x	x	x	x	x	x	x
Camping tourists						x	x	x				
2nd homes				x	x	x	x	x				
2nd homes Renters				x	x	x	x	x				
Recreational fishing	x	x	x	x	x	x	x	x	x	x	x	x
Tourist fishers		x	x	x	x	x	x	x	x	x	x	
Eel-fishers					x	x	x	x				
Commercial fishers	x	x	x	x	x	X	X	X	x	x	x	x
Birds (Cormorants)	x	x	x	x	x	x	x	x	x	x	x	x
Seals (Harbour seal)	x	x	x	x	x	x	x	x	x	x	x	x

Schematic of local economic benefits from tourism



Factors affecting number of tourist-days for tourist categories



6. Appendix

6.1 Starting population of cod

The model contains a starting population of cod, which are based on:

- The similarities between in mortality rates of age 2+ cod in the North Sea and Norwegian fjord systems (Svåsand and Kristiansen, 1990).
- Estimated relative strength between age-group 2-10 based on catch data from North Sea cod (ICES 2007; Table 14.1. cont. Nominal landings (in 1000 tons) of cod in IIIa (Skagerrak), IV and VIId, 1987–2006 as officially reported to ICES, and as used by the Working Group (ICES 2007).
- Density (weight km^{-2}) of cod in the study area is similar to observed density in the North Sea. This density vary between 1,0 to 1,83 tons km^{-2} (spawning stock biomass between 0,6 – 1.1 tons over the years 1966 to 1986 (ICES, 2007; area of North Sea = 0,6 Mill Km^{2} (Wikipedia)).

Table 6.1. Catch data from North Sea cod from 19 years of data (periods 1963-1972 and 1985-1993). The relative strength (Ratio) between age groups 2 to 10 are calculated from these data.

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1985	1986	1987	1988	1989	1990	1991	1992	1993	Average	Ratio
1																					
2	42591	22486	51888	62615	70895	83836	22674	33917	155345	187686	118047	32437	1E+05	55330	36358	54290	23456	32059	55272	66814	0,6519
3	7030	20104	17645	29845	32693	42596	31578	18488	17219	48126	18995	34109	9800	43955	18193	11906	16776	8682	11360	23111	0,2255
4	3536	4306	9182	6184	11261	12392	13710	13339	6754	5682	7823	5814	8723	3134	9866	4339	3310	5007	3190	7240	0,0706
5	2788	1917	2387	3379	3271	6076	4565	6297	7101	2726	1377	2993	1534	2557	1002	2468	1390	1060	1577	2972	0,0290
6	1213	1818	950	1278	1974	1414	2895	1763	2700	3201	1265	604	1075	655	1036	310	1053	491	435	1375	0,0134
7	81	599	658	477	888	870	588	961	893	1680	373	556	235	295	251	310	225	329	204	551	0,0054
8	492	118	298	370	355	309	422	209	458	612	173	171	215	66	140	54	139	52	108	251	0,0024
9	14	94	51	126	138	151	147	186	228	390	79	69	55	63	27	60	28	40	18	103	0,0010
10	6	16	83	139	57	134	124	138	171	131	47	63	60	41	41	20	14	26	23	70	0,0007

The relative strength between age groups 2 to 10 are calculated from 19 years of data (periods 1963-1972 and 1985-1993) and given as ratio in Table 6.1. The relative strength between age groups 1 to 10 are estimated based on observed total mortality between 1- to 2 group in the study area, and are given in Table 6.2a. A corresponding relative strength between age groups 2 to 10 are are given in Table 6.2b.

Table 6.2a. Updated ratio based on numbers and biomass respectively between age-groups 1-10 of coastal cod in the Søndeledfjorden.

Age	Ratio based on number	Ratio based on 1-10 group cod biomass
1	0,5180	0,1706
2	0,3142	0,3252
3	0,1087	0,2466
4	0,0340	0,1053
5	0,0140	0,0620
6	0,0065	0,0474
7	0,0026	0,0206
8	0,0012	0,0126
9	0,0005	0,0057
10	0,0003	0,0043
total	1,0000	1,0000

Table 6.2b. Updated ratio based on numbers and biomass respectively between age-groups 2-10 of coastal cod in the Søndeledfjorden.

Age	Ratio based on number	Ratio based on 2-10 group cod biomass
2	0,6519	0,3920
3	0,2255	0,2973
4	0,0706	0,1269
5	0,0290	0,0747
6	0,0134	0,0572
7	0,0054	0,0249
8	0,0024	0,0151
9	0,0010	0,0068
10	0,0007	0,0051
total	1,0000	1,0000

To obtain an estimate on an average total number of different age- groups of cod in the study area, three approaches has been used:

1) Calculated annual recruitment index of 0-group cod over the period from 1919 to 2008 is given in table 6.3. The number of 0-group cod in September each year in the Søndeledfjord system has been estimated to be 156 513 0-group cod on average in September, corresponding to a average density of 6 645 0-group cod km^{-2} (Table 6.3a) (for total area in the Søndeledfjord,

please see Table 6.4 and 6.5). For comparison, Godø et al. (1989) fished with a 50 m long beach seine at the coast of Møre in 1983. They got an average of 15.5 0-group cod pr haul in sheltered areas and 9.9 in semi-exposed areas. This fits well with our catches of 10.3 cod pr haul (table 6.3a) in a 40 m long beach seine in the sheltered fjord area of the Søndeledfjord. These values correspond to an average density of 6 722 0-group cod km^{-2}. Gibb et al. (2007) studied the density of 0-group cod in Scottish waters and at depths less than about 20 m they found average densities around 400 cod km^{-2}. The highest densities were nearly 10 000 0-group cod km^{-2} (see their Fig. 2). Published data on estimated density of 1-group cod in western Norwegian fjord systems (Svåsand et al., 1998), indicate a density between 2 800 to 10 000 cod km^{-2}.

2) In the starting population, the number of 1-group cod is estimated to 42.889 per 1. January. This estimate has been used in this model and is given in Table 1.1. This represents a density of 1823 cod km^{-2}.
3) The initial total number (carrying capacity) of cod in the study site has been estimating in the following way:
    a. It is assumed that the density (weight km^{-2}) of cod in the study area is similar to observed density in the North Sea. The density in the North Sea vary between 1.0 to 1.83 tons km^{-2} (spawning stock biomass between 0.6 – 1.1 tons over the years 1966 to 1986 (ICES, 2007; area of North Sea = 0.6 Mill Km^2 (Wikipedia)), with a mean of 1.47 ton km^{-2}.
    b. The starting population of cod (age 1-10) is given in Table 1.1 and the spawning stock (age-group 2-10) consist of 39 903 individuals representing a total biomass of 30.7 ton. The density of the spawning stock is calculated to 1.3 ton km^{-2} (total area = 23.55 km^2).
    c. The initial density of 1.32 ton km^{-2} corresponds well with calculated densities for the North Sea cod. This is lower than calculated for local cod stocks in fjords in northern Norway (2-3 ton km^{-2}; Pedersen and Pope, 2003a,b) and the Barents Sea, however, higher than calculated density for a low productive fjord in western Norway (Masfjorden, 0.8 ton km^{-2}; Svåsand et al., 2000).

6.2 Annual recruitment in the local cod stock

6.2.1 Historical 0-group Index

The annual recruitment (measured as a relative abundance index for 0-group cod in September every year) during the period from 1919 to 2008 (historical data) is given in table 6.3a. In Table 6.3a these data have been used to calculate to corresponding total sum 0-group cod and 0-group cod densities (number per 1000 m^2) those particular years. These data are established from annual beach seine sampling of 39 stations in the study area (Søndeledfjorden). The annual 0-group index calculated for the study area is based on all 39 stations and express the average number of 0-group cod per sample. The beach seine samples an area of approximately 700 m^2.

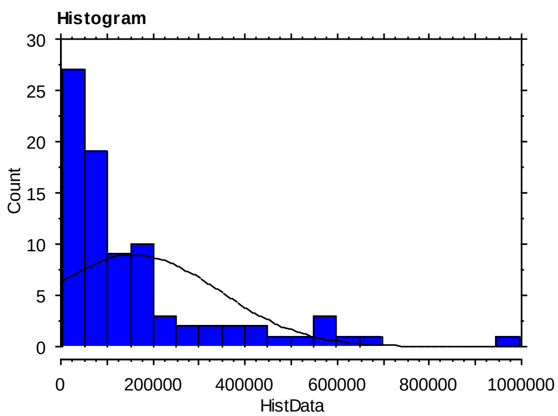
6.2.2 Estimating annual recruitment

In the model the annual recruitment of 0-group cod (in September) in numbers are calculated according to the equation (6.1):

(6.1): Total number 0-group cod = 0-group Index * **K**; where **K** is a constant = **15315**; see below

K is estimated in the following way:

1. Total production area for 0-group cod = 10.720.733 m^2; see table 1.7
2. Area covered by the beach seine = 700 m^2,
3. **K** = 10.720.733 m^2 / 700 m^2 = 15315



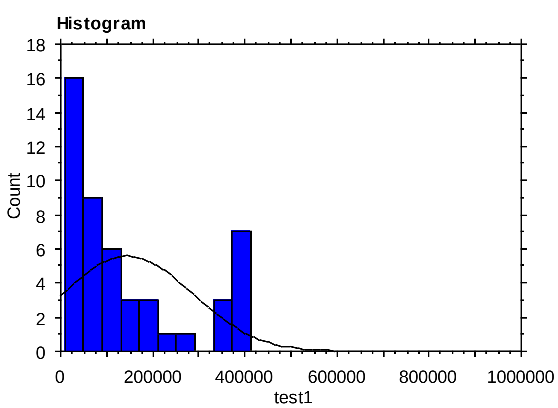


Figure 6.1a. Distribution of calculated number of 0-group cod from the historical data (upper) and estimated number of 0-group cod in the model (lower).

Table 6.3a. The historical data on 0-group coastal cod in the beach seine survey in SSA 7.6 (Søndeledfjorden). Cod/haul (A) = average number of 0-group cod over all 39 stations. Cod km^{-2}; (B) = calculated average number of 0-group cod per km^2 in the areas with depths less than 25 m; B = (A/700)*1.000.000. Sum 0-gr cod (C) = The calculated total number of 0-group cod in the study area; C = B * 10,720733. Cod km^{-2} (D) = Calculated average number of whole study area; D = C / 23,542190.

Year	Cod/haul	log10(A)	Cod km^{-2} Depth < 25m	Sum 0-gr cod Total area	Cod km^{-2} Total area
	A		B	C	D
1919	11,2	1,049218	16 044	172 003	7 303
1920	20,2	1,305351	28 901	309 841	13 155
1921	26,5	1,423246	37 802	405 267	17 207
1922	22,9	1,359835	32 747	351 075	14 906
1923	35,9	1,555094	51 310	550 076	23 356
1924	38,6	1,586587	55 119	590 917	25 090
1925	10,5	1,021189	15 065	161 507	6 857
1926	4,9	0,690196	7 024	75 300	3 197
1927	10,9	1,037426	15 595	167 192	7 099
1928	45,3	1,656098	64 762	694 295	29 479
1929	38,0	1,579784	54 286	581 983	24 710
1930	3,5	0,544068	5 000	53 604	2 276
1931	3,6	0,556303	5 119	54 880	2 330
1932	11,8	1,071882	16 786	179 955	7 641
1933	0,7	-0,1549	952	10 210	434
1934	3,7	0,568202	5 238	56 156	2 384
1935	2,8	0,447158	3 929	42 117	1 788
1936	0,6	-0,22185	833	8 934	379
1937	0,3	-0,52288	476	5 105	217
1938	30,2	1,480007	43 095	462 013	19 617
1939	0,9	-0,04576	1 310	14 039	596
1945	4,3	0,633468	6 190	66 366	2 818
1946	0,6	-0,22185	833	8 934	379
1947	0,0				
1948	2,0	0,30103	2 857	30 631	1 301
1949	1,0	0	1 429	15 315	650
1950	5,2	0,716003	7 381	79 129	3 360
1951	0,4	-0,39794	595	6 381	271
1952	0,7	-0,1549	952	10 210	434
1953	17,9	1,252853	25 595	274 400	11 651
1954	1,7	0,230449	2 381	25 526	1 084

1955	4,3	0,633468	6 190	66 366	2 818
1956	11,8	1,071882	16 905	181 231	7 695
1957	6,1	0,78533	8 690	93 168	3 956
1958	2,1	0,322219	2 976	31 907	1 355
1959	0,2	-0,69897	238	2 553	108
1960	3,6	0,556303	5 119	54 880	2 330
1961	6,0	0,778151	8 571	91 892	3 902
1962	2,2	0,342423	3 095	33 183	1 409
1963	2,7	0,431364	3 810	40 841	1 734
1964	33,9	1,5302	48 413	519 020	22 037
1965	3,0	0,477121	4 286	45 946	1 951
1966	15,2	1,181844	21 667	232 283	9 862
1967	4,5	0,653213	6 429	68 919	2 926
1968	6,2	0,792392	8 810	94 445	4 010
1969	12,0	1,079181	17 143	183 784	7 803
1970	4,9	0,690196	6 939	74 389	3 158
1971	14,3	1,155336	20 408	218 790	9 290
1972	27,1	1,432969	38 776	415 702	17 650
1973	13,3	1,123852	18 980	203 475	8 639
1974	5,3	0,724276	7 551	80 952	3 437
1975	10,9	1,037426	15 510	166 281	7 060
1976	40,0	1,60206	57 143	612 613	26 011
1977	12,9	1,11059	18 367	196 911	8 361
1978	6,1	0,78533	8 776	94 080	3 995
1979	23,0	1,361728	32 857	352 253	14 956
1980	21,6	1,334454	30 816	330 374	14 027
1981	3,3	0,518514	4 694	50 322	2 137
1982	6,3	0,799341	8 980	96 268	4 087
1983	3,0	0,477121	4 286	45 946	1 951
1984	1,9	0,278754	2 653	28 443	1 208
1985	65,0	1,812913	92 857	995 497	42 268
1986	9,4	0,973128	13 469	144 402	6 131
1987	10,3	1,012837	14 667	157 237	6 676
1988	0,1	-1	190	2 042	87
1989	9,8	0,991226	13 968	149 750	6 358
1990	3,1	0,491362	4 429	47 478	2 016
1991	4,4	0,643453	6 349	68 068	2 890
1992	9,4	0,973128	13 393	143 581	6 096
1993	7,0	0,845098	10 000	107 207	4 552

1994	2,5	0,39794	3 571	38 288	1 626
1995	16,9	1,227887	24 107	258 446	10 973
1996	10,9	1,037426	15 536	166 554	7 072
1997	8,4	0,924279	11 964	128 266	5 446
1998	4,6	0,662758	6 607	70 833	3 008
1999	2,3	0,361728	3 214	34 459	1 463
2000	8,3	0,919078	11 786	126 351	5 365
2001	1,9	0,278754	2 653	28 443	1 208
2002	0,6	-0,22185	816	8 752	372
2003	8,7	0,939519	12 449	133 462	5 667
2004	1,6	0,20412	2 245	24 067	1 022
2005	8,1	0,908485	11 633	124 711	5 295
2006	0,7	-0,1549	1 020	10 940	464
2007	0,4	-0,39794	571	6 126	260
2008	0,1	-1	143	1 532	65
Average	10,2	0,685046	14 599	156 513	6 645
SD	12,2	0,615945	17 457	187 150	7 946
Min	0,1	-1	143	1 532	65
Max	65,0	1,812913	92 857	995 497	42 268
5% persentile	0,4	-0,4	575	6 164	262
10% persentile	0,6	-0,2	869	9 317	396
90% persentile	26,9	1,4	38 484	412 572	17 517
95% persentile	37,7	1,576081	53 840	577 197	24 507

6.2.3 Effect of plant coverage and 1-group cod strength on annual recruitment

The estimated numbers of 0-group cod will depend on the size of the 1-group cod the same year and the degree of coverage of marine plants (as eelgrass).

Annual recruitment (number of 0-group cod) can be modeled as a function of the amount of plant habitat and the abundance of predators (1-group cod). We initially classify the historic recruitment indices from survey data into a 2x2 table based on plant coverage (i) and abundance level (j) of 1-group cod (Table 1.2). The yearly 0-group indices from the historic survey are grouped into 2 classes of plant coverage and 2 levels of 1-gr cod (1=below the mean; 2 = equal to or above the mean). We then form the 2x2 table of means and variances of the log-transformed recruitment indices (Table 1.4). The number of recruits (age 0; 0-group cod) for year t is selected as follows:

1. Determine the category of plant coverage (i) and 1-group cod (j)
2. Select mean and variance of log-transformed recruitment indices (ln(x)) for the values associated with cell (i,j) in the recruitment table

3. Create a normal distribution with expected mean[ln(x)] and variance of mean[ln(x)]
4. Select a random number (logr) from the log-normal distribution fitted for cell (i,j)
5. Back-transform the number logr to get a 0-group index: r= exp(logr +(σ^2)/2) where σ^2 is the variance of the mean of log-transformed recruitment indices in the cell (i,j)
6. Total number 0-group cod = r * **15315**

We assume that ln(x) is normally distributed, and fit the normal-distribution, N(mean(ln(x)), var(mean(lnx)) to the log-transformed recruitment indices. Ln(x) can have negative values. It is thus x (recruitment) that is assumed to be log-normally distributed, and x will not have negative values. X is obtained after back-transformation with the formula above.   The below entry in Wikipedia is consistent with standard reference books such as Balakrishnan and Nevzorov, A primer on Statistical Distributions. Wiley. (http://en.wikipedia.org/wiki/Log-normal_distribution). The recruitment distributions for fish are generally skewed. The fact that the normal distribution is not rejected for the raw recruitment data in our case is likely due to low sample sizes.

Table 6.3b. The 2x2 table based on plant coverage (i) and abundance level of 1-group cod (j). (Measured 0-group indexes in each cell (I,j) are given in Table 6.3c).

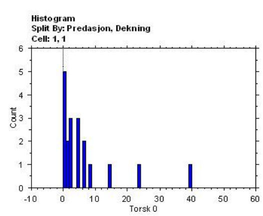
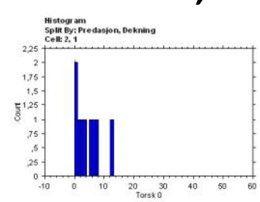
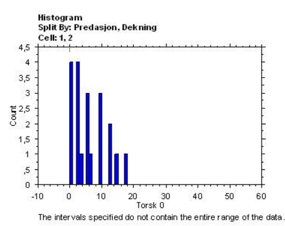
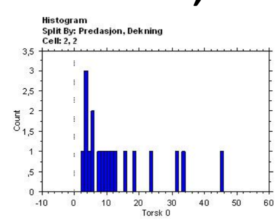
	Below the mean abundance of 1-group cod	Equal or above the mean abundance of 1-group cod
Low plant coverage	**1,1** 	**2,1** 
High plant coverage	**1,2** 	**2,2** 

Table 6.3c. Corresponding 0-group indexes (raw data) to the four cells (I,j) in Table 6.3b.

Cell (I,j)	1,1	1,2	2,1	2,2
	0,22	0,10	0,57	2,67
	0,29	0,33	0,58	3,25
	0,56	0,57	1,00	3,67
	0,80	0,67	2,00	3,88

1,00	2,00	3,00	4,50
1,09	2,17	5,33	5,50
2,30	2,20	6,60	5,50
2,40	2,63	7,10	7,71
2,63	3,20	12,64	8,20
4,20	5,00		9,43
4,60	5,14		10,86
4,67	5,86		11,54
6,50	6,50		12,86
6,50	9,20		15,00
8,00	9,60		18,50
14,29	9,78		23,00
23,67	12,00		31,25
39,11	12,43		33,00
	14,40		45,67
	17,80		
	50,80		
	75,33		

Table 6.3d. Corresponding log-transformed recruitment indices (ln(x)) for the values associated with cell (i,j) in the recruitment table in Table 6.3c, with associated expected mean[ln(x)] and variance of mean[ln(x).

Ln (x)	**ln(x)**	**ln(x)**	**ln(x)**	**ln(x)**	log10(x)	log10(x)	log10(x)	log10(x)
All data	**1,1**	**1,2**	**2,1**	**2,2**	1,1	1,2	2,1	2,2
	-1,514128	-2,3026	-0,5621	0,98208		-1	-0,2441	0,42651
	-1,237874	-1,1087	-0,5447	1,17865	-0,6576	-0,4815	-0,2366	0,51188
	-0,579818	-0,5621	0	1,30019	-0,5376	-0,2441	0	0,56467
	-0,223144	-0,4005	0,69315	1,35584	-0,2518	-0,1739	0,30103	0,58883
	0	0,69315	1,09861	1,50408	-0,0969	0,30103	0,47712	0,65321
	0,0861777	0,77473	1,67335	1,70475	0	0,33646	0,72673	0,74036
	0,8329091	0,78846	1,88707	1,70475	0,03743	0,34242	0,81954	0,74036
	0,8754687	0,96698	1,96009	2,04252	0,36173	0,41996	0,85126	0,88705
	0,9669838	1,16315	2,53687	2,10413	0,38021	0,50515	1,10175	0,91381
	1,4350845	1,60944		2,2439	0,41996	0,69897		0,97451
	1,5260563	1,63705		2,38509	0,62325	0,71096		1,03583
	1,5411591	1,76815		2,44582	0,66276	0,7679		1,06221
	1,8718022	1,8718		2,55412	0,66932	0,81291		1,10924
	1,8718022	2,2192		2,70805	0,81291	0,96379		1,17609
	2,0794415	2,26176		2,91777	0,81291	0,98227		1,26717
	2,65956	2,28034		3,13549	0,90309	0,99034		1,36173
	3,1642084	2,48491		3,44202	1,15503	1,07918		1,49485
	3,6663782	2,52011		3,49651	1,3742	1,09447		1,51851
		2,66723		3,82144	1,59229	1,15836		1,65963
		2,8792				1,25042		
		3,9279				1,70586		
		4,32188				1,87697		
Expected mean	**1,0567815**	**1,47553**	**0,97137**	**2,26459**	0,45895	0,64081	0,42186	0,9835
Variance	2,0667088	2,48938	1,30587	0,70563	0,38981	0,46953	0,2463	*0,13309*
n	18	22	9	19	18	22	9	*19*
Variance of mean	**0,1148172**	**0,11315**	**0,1451**	**0,03714**	0,02166	0,02134	0,02737	0,007

6.3 Appendix 3: Study site description

6.3.1 Description

The SSA 7.6 Søndeledfjorden is situated in the municipality Risør. The Søndeled fjord system is a typical threshold-fjord along the southern coast of Norway, separated from the open Skagerrak by islands and sounds with sills of 30 m or less. Inside the sills are sheltered fjord basins with depth up to more than 180 m, while the shallow areas with eel-grass are important nursery grounds for juvenile cod. Above the sill-level the fjord has an efficient water-exchange with the open Skagerrak, and normally the water in the deeper part of the fjord is renewed every 5-10 years. The deeper parts of the fjord basins may therefore suffer from low oxygen and some of the innermost basins are permanent anoxic. This will to affect space and habitat that are available for the living resources including cod in the fjord. The fjord is considered moderately eutrophicated due to input of nitrogen from local sources as well as long-distance transport with currents from the European continent. The watershed constitutes both urban and rural settings and is about 516 km^2. A river with a mean flow of about 8 m^3s^{-1} enters the innermost basin. In addition about 2 m^3s^{-1} of freshwater enter the fjord-system via brooks and as diffuse run-off. Only 3-4% of the watershed is agriculture fields, while about 70% is forest. The outer part is most urbanized with about 6000 inhabitants, and is also somewhat industrialized.

Table 6.4a. Calculated Total productive volume and area for **0-group cod** in the Søndeledfjord system (Nordfjorden and Sørfjorden; From Tables 6.6 and 6.7).

Area	Area	Volume (m^3)	Ratio (%)	Area (m^2)	Ratio (%)
Nordfjorden	I	798.693.797	85.9	6.263.157	58.4
Sørfjorden	II	130.896.705	14.1	4.457.576	41.6
Total		929.590.502	100.0	10.720.733	100.0

Table 6.4b. Calculated Total productive volume and area for **1-10 group cod** in the Søndeledfjord system (Nordfjorden and Sørfjorden; From Tables 6.6 and 6.7).

Area	Area	Volume (m^3)	Ratio (%)	Area (m^2)	Ratio (%)
Nordfjorden	I	798.693.797	85.9	15.732.236	66.8
Sørfjorden	II	130.896.705	14.1	7.819.964	33.2
Total		929.590.502	100.0	23.552.200	100.0

Table 6.5. Calculated productive volume and area for **0-group cod** in the Søndeledfjord system and nearby systems (From Tables 6.6 and 6.7).

Area	Area	Volume (m^3)	Ratio (%)	Area (m^2)	Ratio (%)
Søndeledfjord system	I + II	929.590.502	50.3	10.720.733	51.8
Risør outer	IV	744.392.699	40.3	6.693.888	32.4
Sandnesfjorden	III	173.975.912	9.4	3.260.889	15.8
Total		1.847.959.113	100.0	20.675.510	100.0

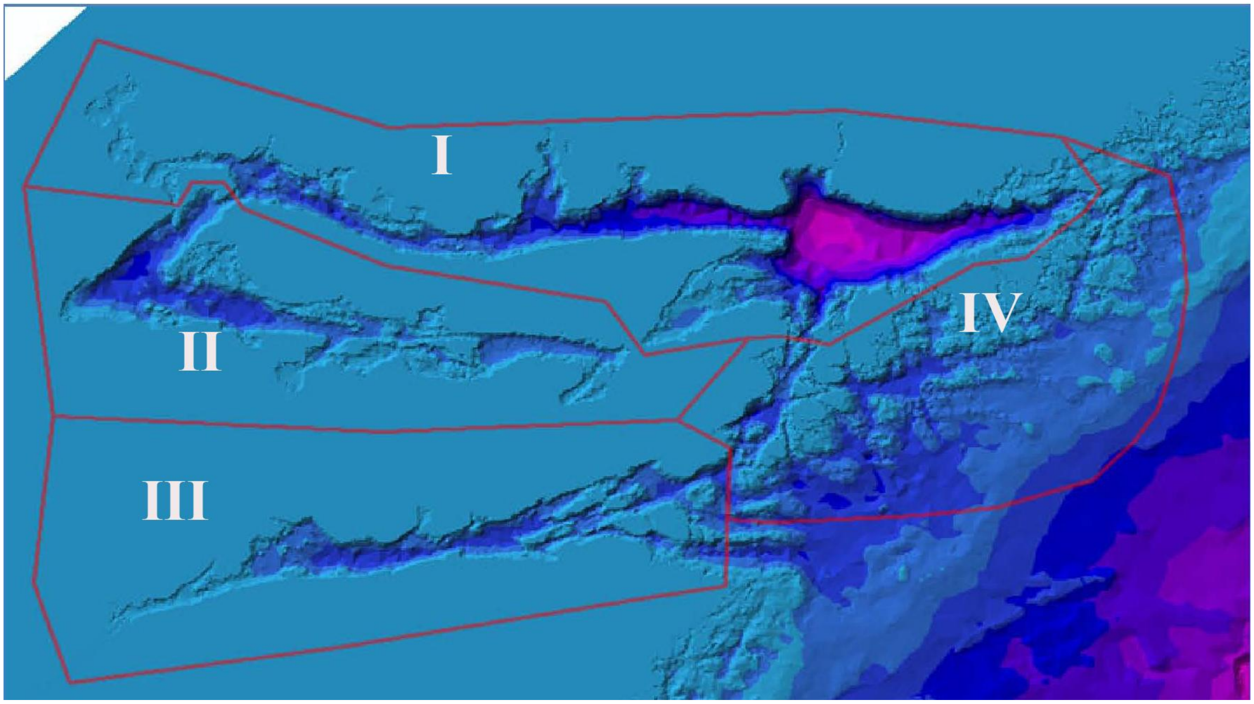


Figure 6.1. Map showing the four (I, II, III and IV) basis in the area, only basin I and II are included in the model. The color purple indicates the deepest part of the basins.

Table 6.6. Productive volume (m^3) in black and no-productive volume (m^3) in red (due to low O_2 content or present of H_2S) in the four basins related to the system.

	Basin I	**Basin II**	**Basin III**	**Basin IV**
Depth range (m)	**Nordfjorden**	**Sørfjorden**	**Sandnesfjorden**	**Risør outer**
0 - 25	286.347.488	130.896.705	118.448.012	455.148.931
25 - 50	183.170.834	54.427.774	50.162.875	242.195.314
50 - 75	122.340.153	13.723.654	5.365.024	46.542.765
75 - 100	89.504.437	169.351		505.690
100 - 125	57.088.090			
125 - 150	39.616.029			
150 - 175	19.011.902			
175 - 200	1.614.864			
Total volume (m^3)	798.693.797	199.217.484	173.975.912	744.392.699
Tot Prod. Vol (m^3)	**798.693.797**	**130.896.705**	**173.975.912**	**744.392.699**

Table 6.7. Total area and calculated productive area (m^2) in black and no-productive area (m^2) in red (due to lack of vegetation) in the four basins within the Søndeledfjord system (Nordfjorden and Sørfjorden) and the two nearby basins.

	Basin I	**Basin II**	**Basin III**	**Basin IV**
Depth range (m)	**Nordfjorden**	**Sørfjorden**	**Sandnesfjorden**	**Risør outer**
0 - 25	6.263.157	4.457.576	3.260.889	6.693.888
25 - 50	3.316.553	2.178.711	2.632.587	10.521.183
50 - 75	1.798.292	1.075.775	799.277	4.254.052
75 - 100	1.448.410	107.902		210.437
100 - 125	1.017.403			
125 - 150	592.250			
150 - 175	942.035			
175 - 200	354.136			
Total area (m^2)	15.732.236	7.819.964	6.692.752	21.679.559
Prod. area (m^2)	**6.263.157**	**4.457.576**	**3.260.889**	**6.693.888**
No- Prod. area (m^2)	**9.469.079**	**3.362.388**	**3.431.863**	**14.985.672**

6.3.2 The local coastal cod population

Coastal cod are distributed along the entire Norwegian coast. These coastal stocks are different from the open sea stocks in that they do not migrate over longer distance, but are rather stationary in the fjord systems or adjacent areas. In recent years it has been documented that each fjord system hold their unique cod stock that are genetically distinguished from stocks in nearby fjords and open sea stocks. For Søndeledfjorden (Risør) and nearby fjords this is shown in Figure 6.2. The Søndeled fjord system is a typical threshold fjord along the southern coast of Norway, separated from the open Skagerrak by islands and sounds with sills of 30 meter or less. Inside of the sills are sheltered fjord basins with depths of up to more than 180 m. The local cod in Søndeledfjorden spawns in the inner (western) part of the area (Figure 6.3), and recent studies shows that the pelagic cod eggs remain in the inner part of the fjord and are thereby protected from the coastal current outside the fjord (Figure 6.4).

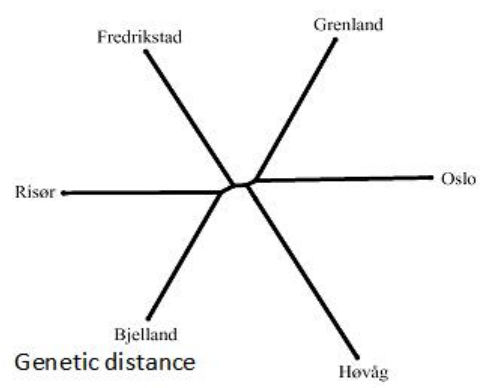
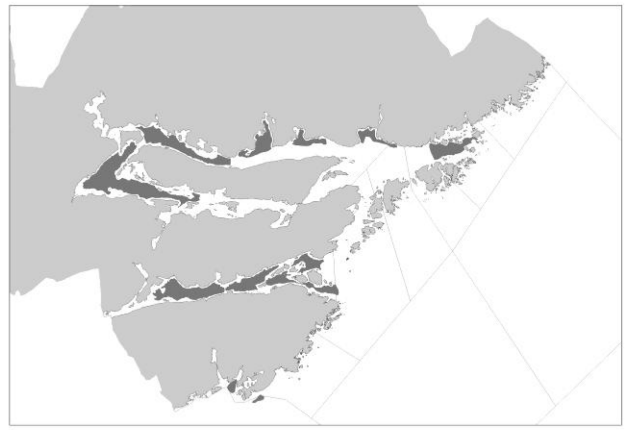
	

Figure 6.2. There is no sign of pattern in the genetic structure of coastal cod along the Skagerrak coast, indicating that all samples are equally different from each other (Knutsen *et al.* 2003).	Figure 6.3. Spawning areas for local cod in the Søndeledfjord and Risør area.

There is a rising concern regarding the condition of the coastal cod stocks along the Norwegian coast, as the long term trend indicates a decreasing yield in the coastal cod fishery, as shown for beach seine surveys in the Søndeledfjord as shown in Figures 6.5a and 6.5b. The reasons for the observed reduction are most likely multiple; however, there is an increased concern that the fishing pressure in both the commercial and recreation fishery in general are too high. Although the recruitment in the Søndeledfjord was good in 2007, the recruitment to 0-group generally has followed the same trend as the Skagerrak coast. The abundance of adult cod the Risør area falls in the transitional zone between eastern Skagerrak where there has been a dramatic decrease in stock size, and the central areas where no such decrease has been observed.

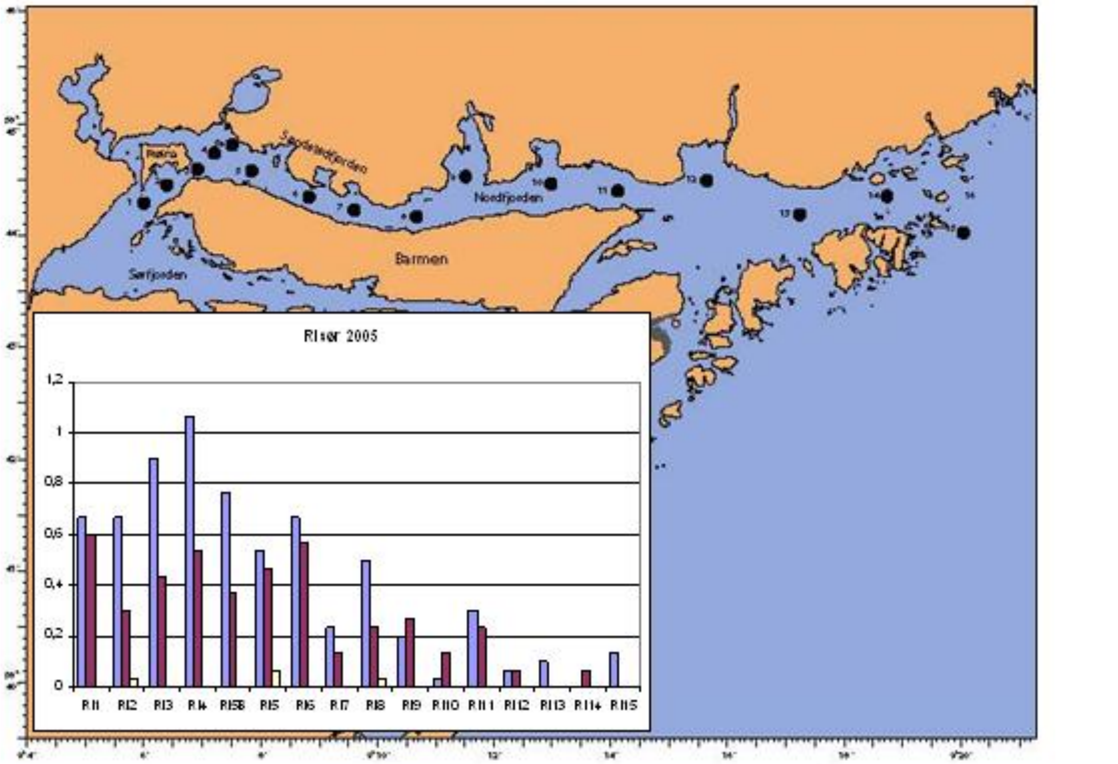


Figure 6.4. The figure is generated from Knutsen et al. (2007) and shows number of cod eggs per m^2 along a transect in Søndeledfjorden. The hatched lines indicate the threshold in the fjord and the blue are immature eggs, the pink is and yellow are older eggs.

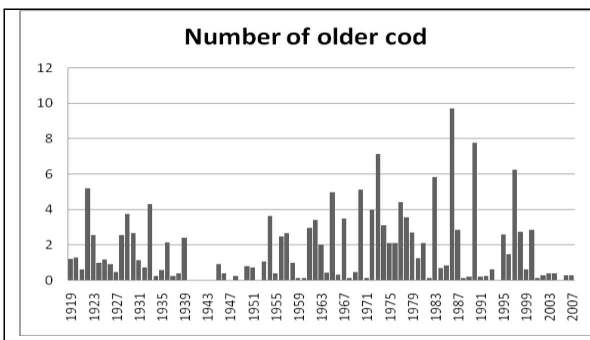


Figure 6.5a. Catches of one year and older local cod in beach seine samples from 1919 to 2007. The figure is an average for all stations each year in the Søndeledfjord.

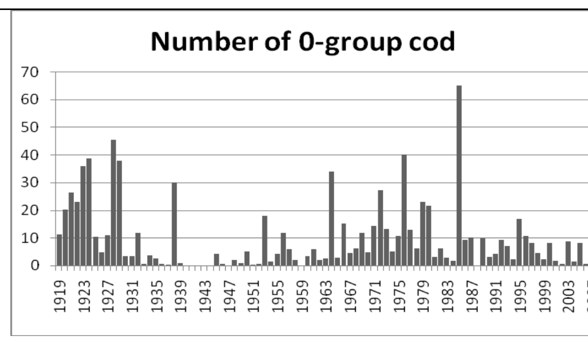


Figure 6.5b. Catches of 0-year local cod in beach seine samples from 1919 to 2007. The figure is an average for all stations each year in the Søndeledfjord.

6.4 Appendix 4: Maritime Spatial Planning (MSP)

Table 6.4.1. Total area and calculated productive area (m^2) in black and no-productive area (m^2) in red (due to lack of vegetation) in the four basins within the Søndeledfjord system (Nordfjorden and Sørfjorden) and the two nearby basins.

	Basin I	**Basin II**	**Basin III**	**Basin IV**
Habitat	**Nordfjorden**	**Sørfjorden**	**Sandnesfjorden**	**Risør outer**
Soft bottom	271.254	215.845	67.948	99.728
Eelgrass	306.491	346.173	116.454	57.967
Kelp-forest	99.439	0	501.970	3.284.861
Cod spawning area	3.504.340	2.855.817	2.638.446	1.838
Cod nursery area	1.688.668	648.033	530.473	1.181.438

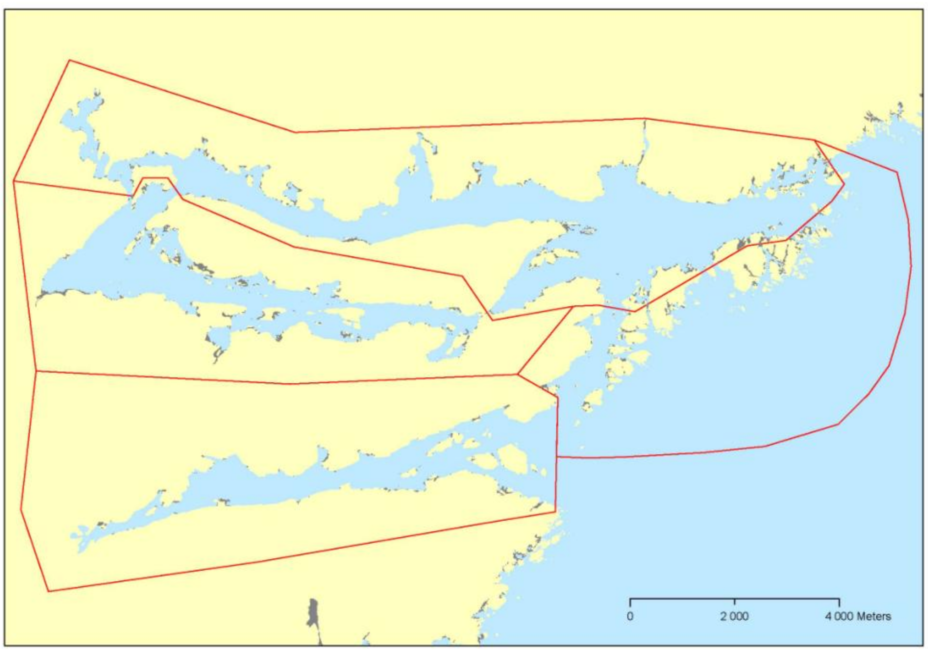


Figure 6.4.1. Soft bottom

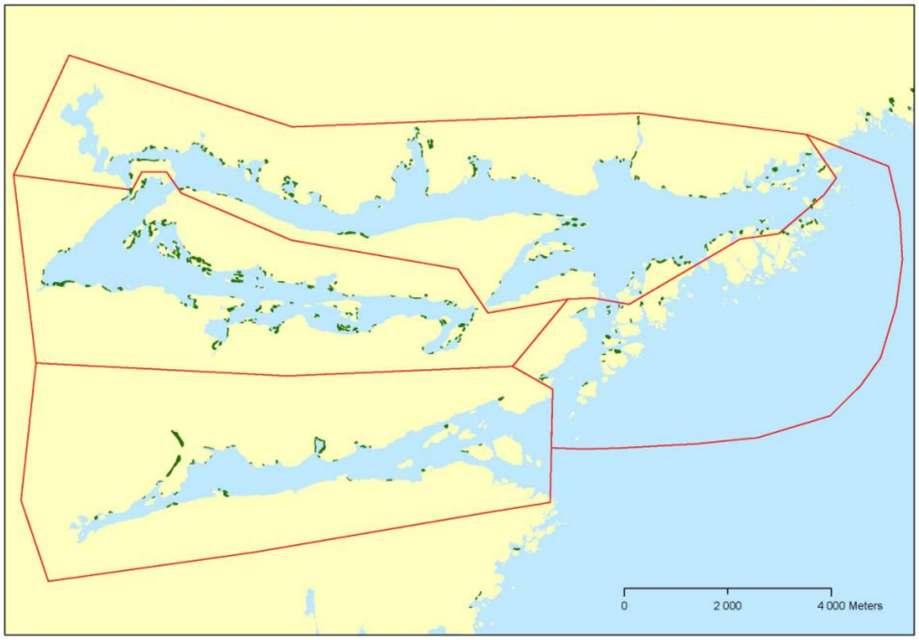


Figure 6.4.2. Eelgrass

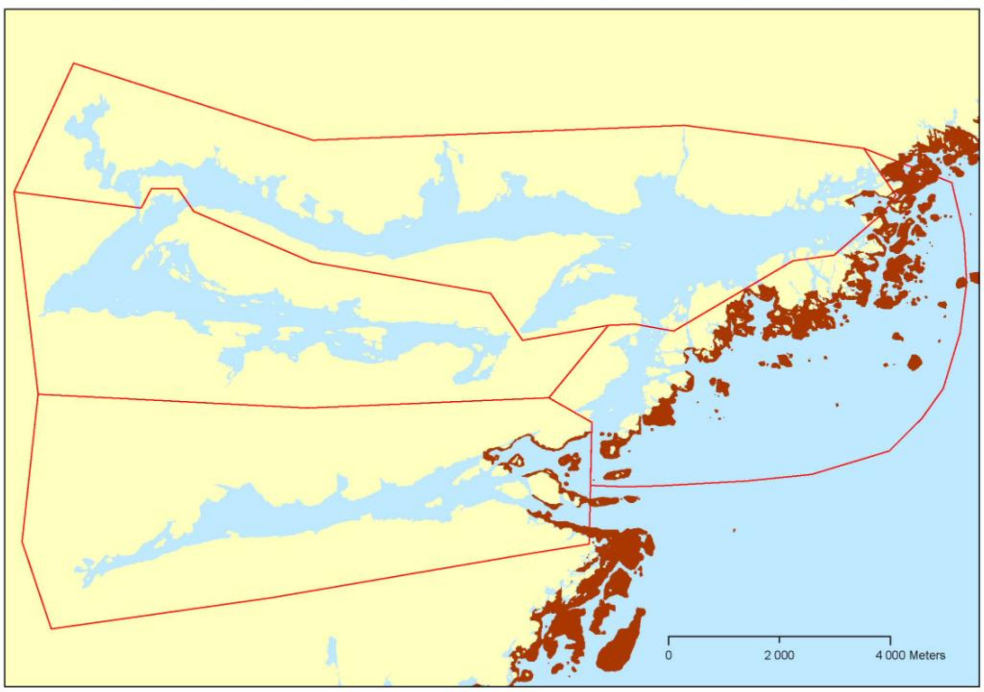


Figure 6.4.3. Kelp-forest

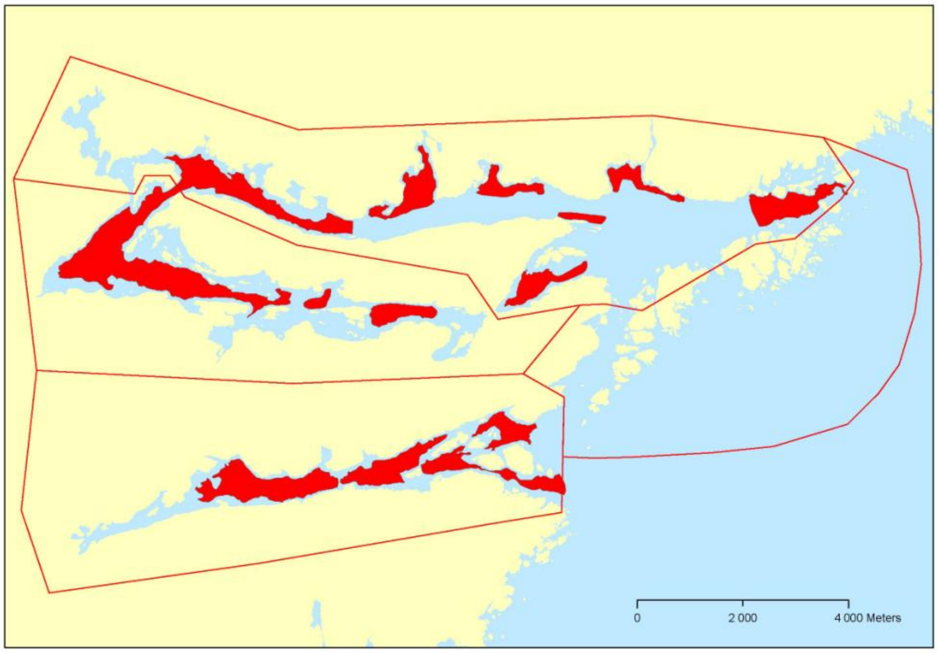


Figure 6.4.4. Spawning area cod

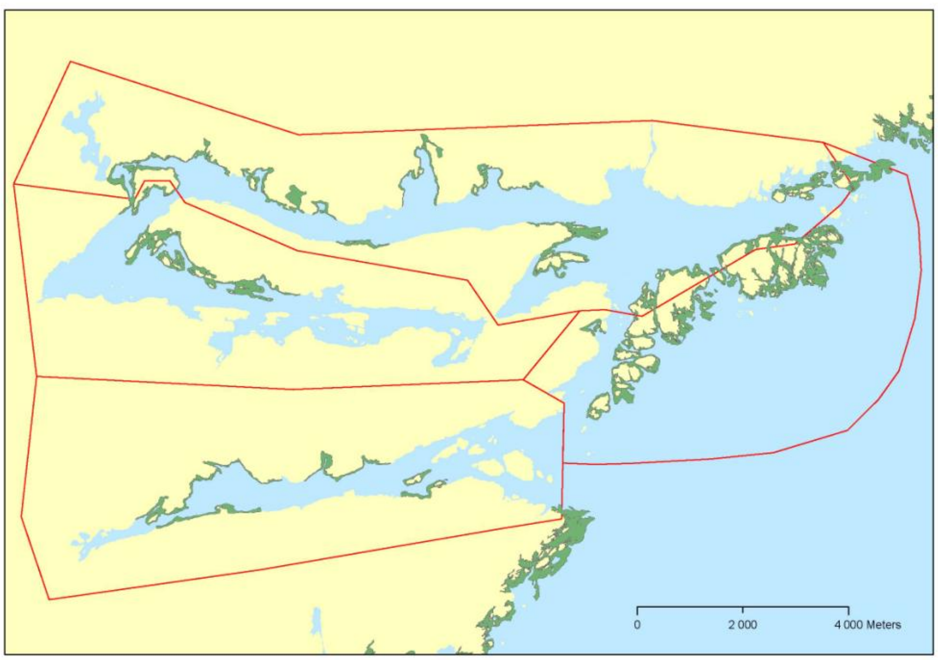


Figure 6.4.5. Nursery area cod

Figure 6.4.6. Location for mussel farming

6.5 Appendix 5: Equations in the model

No	Equation	Model component	Page
1.1	Equa (1.1): M = exp*(p*(2,824+0,281*Log(X_0)) + (1-p)*(2,496+0,381*Log(X_1)))*H	NC	9
1.2	lg W = 2.946892916 lg L - 1.921950107	NC	16
1.3	W = $10^{(\lg W)}$	NC	16
1.4	Total weight by age group (kg) = sum of all individual weights (W) in the age group	NC	16
1.5	Y = 0,109 * X	NC	10
1.6	Y = 0,401 * X	NC	10
1.7	Y = 0,016 * X	NC	10
1.8	Y = 0,16 * X	NC	10
1.9	Y = 0,066 * X	NC	10
1.10	$h = q E^{\alpha} X^{\beta}$	NC	11
1.11	Harvest as biomass = Tourist days by camping tourists * Catch per unit effort indicator per cod stock unit * Cod stock biomass	NC	12
1.12	$E = N_1 / N_{(2\text{-}10)}$	NC	17
1.13	Y = 0,372 * X	NC	15
1.14	Y = 0,549 * X	NC	15
1.15	Y = 0,633 * X	NC	15
2.1	New available habitat = available habitat – (2nd homes)*50 – (Delta)*(option; 1=50; 2=25; 3=0)	SC	25
2.2	*Conflict indicator:* $A3 = \beta_3 \frac{A_1}{\sum_{1}^{5} L_{i_{t-1}}}$	SC	28
3.1	Ti=f(A1,A2,…,A18)	EC	31
3.2	Ei=ei*Ti	EC	31
3.3	Li=f(Ei)	EC	31
3.4	$T_i = \left[T_{i0} + \sum_j b_{ij}(A_j - A_{j_0}) \right] \left[100 + b_k \ln(A_k) - 1{,}3 \quad /100 \right]$	EC	36
3.5	Ei=Ti*ei; i=T1 to T5	EC	38
3.6	Li = γi*Ei i=T1 to T5	EC	38
3.7	$a_{50_t} = \begin{cases} a_{50_{t-1}} + \beta_{50}(T2_{t-1} - T2_{t-2}) & \text{if } a_{50_{t-1}} < a_{50_t} < R_{50} \\ R_{50} & \text{if } a_{50_{t-1}} + \beta_{50}(T2_{t-1} - T2_{t-2}) \geq R_{50} \\ a_{50_{t-1}} & \text{if } a_{50_{t-1}} + \beta_{50}(T2_{t-1} - T2_{t-2}) \leq a_{50_{t-1}} \end{cases}$	EC	39
3.8	L6 = 1 456 000 NOK * $\begin{cases} \beta_{50}(T2_{t-1} - T2_{t-2}) & \text{if } < R_{50} \\ R_{50} & \text{otherwise} \end{cases}$	EC	40
3.9	L7=a50$_{t-1}$ * 4896 NOK	EC	40
3.10	DeltaLBCF=DeltaRCF*b_{LBCF}	EC	42
3.11	A6 = beds * stars * b_{6i}	EC	35

3.12	DELTAa50 = $a50_t - a50_{t-1}$	EC	39
3.13	DeltaRCF = (Cod price) * 1000 * (CCF_t/CCF_0)	EC	41
3.14	$C_{CCSE} = C_0 * N_{SE0} + C_1 * N_{SE1}$	EC	43
3.15	$PV_{LEBi} = \sum_{t=1}^{N} L_{it} * e^{-\delta t}$	EC	44
3.16	$PV_{LEB} = \sum_{i} PV_{LEBi}$	EC	44

6.6 Appendix 6: Databases

Bibliographic databases and information networks like the National Ocean Economics Program's "Non-market Literature Portal" (www.oceaneconomics.org) and the National Oceanic and Atmospheric Administration's Marine Economics website (www.marineeconomics.noaa.gov) now make it possible for researchers to quickly locate relevant studies from the literature

http://www.turistfiske.no/
Contain information on tourist fishing in Norway (only in Norwegian)

http://dnweb12.dirnat.no/nbinnsyn/
Are managed by The Directorate for Nature Management and contain information biodiversity in general and also in marine waters.

7. References

Agnalt, A.-L., Jørstad, K.E., Grefsrud, E.S. 2007. Åleruser - torsk som bifangst. Intern PowerPoint-presentasjon, Havforskningsinstituttet.

Barrett, R.T., Rov, N., Loen, J., Montevecchi, W.A. 1990. Diets of Shags Phalacrocorax aristotelis and Cormorants P. carbo in Norway and possible implications for gadoid stock recruitment. Marine Ecology Progress Series 66: 205–218.

Bjørge, A., Bekkby, T., Bakkestuen, V., Framstad, E. 2002. Interactions between harbour seals, Phoca vitulina, and fisheries in complex coastal waters explored by combined Geographic Information System (GIS) and energetic modelling. ICES Journal of Marine Science, 59: 29–42.

CGE&Y 2003. Vurdering av turistfiske som inntektskilde i Norge - hvilke inntekter gir turistfiske sammenlignet med yrkesfiske? Cap Gemini Ernst & Young, Trondheim, August 2003. 2003-T059-NM. *In Norwegian.*http://www.rbl.no/images/fiskrapport.pdf

Colvin, JG (1994). Ecotourism: a sustainable alternative. NACLA Report on the Americas 28: 9

Dahl, K. & Dannevig, G.M. 1906 Undersøkelser over nytten av torskeutklæking i Østnorske fjorder. *Aarsberetn. Norg. Fisk.* 1-121.

Danielssen, D.S. and Gjøsæter, J. 1994. Release of 0-group cod, *Gadus morhua* L., on the southern coast of Norway in the years 1986-1989. Aquaculture and Fisheries Management 1994. (25), Supplement 1, 129-142.

Dybedal, Petter 2003, Fylkesvise økonomiske virknigner av reiseliv i Finmark, Troms, Nordland og Nord-Trøndelag, TØI rapport 640/2003, Transportøkonomisk institutt, Oslo, Norway.

Eide, A., F. Skjold, F. Olsen, and O. Flaaten. 2003. "Harvest functions: the Norwegian bottom trawl cod fisheries." *Marine Resource Economics* 18:81-93.

Farstad, Eivind and Arne Rideng 2008: Utenlandske turisters forbruk i Norge 2007, TØI Rapport 941/2008, Transportøkonomisk institutt, Oslo, Norway

Gibb FM, Gibb IM, Wright PJ (2007) Isolation of Atlantic cod (Gadus morhua) nursery areas. Mar Biol 151:1185–1194

Gimblett, H.R., Itami, R.M. & Richards M. 2000. Simulating wildland recreational use and conflictin spatial interactions using rule-driven intelligent agents. In: Gimblett, H.R. (ed.). Integrating GIS and agent based modeling techniques for understanding social and ecological processes. Oxford University Press, Oxford.

Gjøsæter, J. 1986. Utsetting av torskeyngel. Naturgrunnlag og mulige virkninger. Flødevigen meldinger, 1986 (3): 1-43.

Godø, O. R., Gjøsæter, J., Sunnana, K. & Dragesund, O. (1989). Spatial distribution of 0-group gadoids off mid-Norway. Rapports et Proce`s-verbaux des Re´unions du Conseil International pour l'Exploration de la Mer 191, 273–280.

Hallenstvedt, Abraham og Ivar Wulff, 2001: Fisk som agn – Utenlandsk turistfiske i Norge. Rapport fra et fellesprosjekt Norges Fiskarlag og Norges Turistråd. NorgesFiskerihøgskole, Universitetet i Tromsø 2001. *In Norwegian.*

Hallenstvedt, Abraham og Ivar Wulff, 2004: Fritidsfiske i sjøen 2003. Norwegian High School for Fisheries/University of Tromsø, June 2004. 66 pp. *In Norwegian.*

Härkönen, T.J., 1988. Food-habitat relationship of harbour seals and great cormorants in Skagerrak and Kattegat. Journal of Zoology 214: 673-681.

ICES 2007, Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, Report 2007

Jakobsen, Jens Kristian Steen 2005: Utenlandske turistfiskeres fiske i saltvann i Norge i 2004, TØI rapport 788/2005, Transportøkonomisk institutt, Oslo, Norway.

Julliard, R., Stenseth, N.C., Gjøsæter, J., Lekve, K., Fromentin, J.-M. & Danielssen, D.S. (2001). Natural mortality and fishing mortality in a coastal cod population: a release-recapture experiment. Ecol. Appl., 11, 540-558

Kristiansen, T.S., H. Otterå and T. Svåsand 2000. Size-dependent mortality of juvenile cod, estimated from recaptures of released cod and tagged wild cod. Journal of Fish Biology 56: 687-712

Kristiansen, T.S. and T. Svåsand 1990. Enhancement studies on coastal cod in western Norway III. Inter-relationships between reared and indigenous cod in a nearly land-locked fjord. *Journal du Conseil international pour l'exploration de la mer* **47**, 23-29.

Lekve, K., Enersen, K., Enersen, S. E., Gjøsæter, J. & Stenseth, N. C. 2006. Interannual variability in abundance and length of young coastal cod in the subtidal zone. Journal of Fish Biology 68, 734–746

Mikkelsen, E. 2007.Aquaculture-Fisheries Interactions. Marine Resource Economics, 22: 287-303

Moksness, E. 2002. Lessons from the Norwegian Sea Ranching Programme (PUSH). Fisheries Science 68:896-899.

Moksness, E. 2004. Stock Enhancement and Sea Ranching as an integrated part of Coastal Zone Management in Norway. In: Stock Enhancement and Sea Ranching; Developments, Pitfalls and Opportunities (Eds. K.M. Leber, S. Kitada, H.L. Blankenship and T. Svåsand) Blackwell Ltd. 2004, 3 – 10

Moksness, E. and R. Støle. 1997. Larviculture of marine fish for sea ranching purposes: is it profitable? Aquaculture 155: 341-353.

Moshirian, F. 1993; Determinants of International Trade Flows in Travel and Passenger Services, The Economic Record, vol 69, 206

Nedreaas, K. Aglen, A. Gjøsæter, J. Jørstad, K., Knutsen, H. Smedstad, O. Svåsand, T. og Ågotnes, P. 2008. Kysttorskforvaltning på Vestlandet og langs Skagerrakkysten Vurdering av status for kysttorsk på strekningen svenskegrensen–Stad med forslag om forvaltningstiltak. Fisken og Havet. 2008 (5), 108 pp

Olsen, M., Bjørge, A. 1995. Seasonal and regional variations in the diet of harbour seal in Norwegian waters. Pp 271-285 in A.S. Blix, L. Walløe and Ø. Ulltang (eds) Whales, seals, fish and man. Elsevier Science, Amsterdam.

Pedersen, T. and J.G. Pope 2003a. Sampling and mortality model of a Norwegian fjord cod (*Gadus morhua* L.) population. Fisheries Research, 63: 1-20.

Pedersen, T. and J.G. Pope 2003b. How may feeding data be integrated into a model for a Norwegian fjord population of cod (*Gadus morhua* L.)? Scientia Marina, 67: 155-169.

Pendleton, Linwood H. and Jaime Rooke 2006: Understanding the Potential Economic Impact of Marine Recreational Fishing: California, University of California, Los Angeles, USA, www.dfg.ca.gov/MLPA/pdfs/binder3di.pdf

Pitcher, T.J. and Hart, P.J.B. 1982 Fisheries Ecology, Springer, ISBN 0412382601, 9780412382604, 414 pp

Schaefer, M. B. 1957. A study of the dynamics of the fishery for yellowfin tuna in the eastern tropical Pacific Ocean. Inter-Am. Trop. Tuna Comm. *Bull* 2:245-285.

Skarprud, M. 2003. Sommerføden til storskarven *Phalacrocorax carbo* i Øra naturreservat, Fredrikstad. Cand.scient.-hovedoppgave Institutt for biologi og naturforvaltning, Norges Landbrukshøgskole, Ås 2003. 43 pp.

Smeral and Witt 2005: Econometric forecasts of Tourism demand to 2005, Annals of tourism research, 23(4),891-907

Svåsand, T. and T.S. Kristiansen 1990. Enhancement studies on coastal cod in western Norway IV. Mortality of reared cod after release. Journal du Conseil international pour l'exploration de la mer **47**, 30-39.

Svåsand, T., Kristiansen, T.S., Pedersen, T., Salvanes, A.G.V., Engelsen, R. og Nødtvedt, M. 1998. Havbeite med torsk – artsrapport. Norges forskningsråd. 78 s.

Svåsand, T., Kristiansen, T.S., Pedersen, T., Salvanes, A.G.V., Engelsen, R., Nævdal, G. and Nødtvedt, M. 2000. The enhancement of cod stocks. Fish and Fisheries, 1: 173-205.

Øines, Torgeir 2000: Økonomiske virkninger av reiselivet. Metoder og muligheter. Arbeidsnotat 1014/00, Nordlandsforskning, Bodø, Norway

Venables, W. N. & Ripley, B. D. 1997. Modern applied statistics with S-PLUS. Springer, New York

Witt and Martin 1987: Econometric models for forecasting tourism demand, Journal of travel research, 25, 23