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BYCATCH OF JUVENILE FISH IN THE SHRIMP FISHERY  
- MANAGEMENT BASED ON BIOECONOMIC CRITERIA.

by

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**ABSTRACT**

The bycatch of juvenile fish can be a major problem in fisheries with small meshed trawls, such as fisheries for shrimp, (*Pandalus borealis*). A sorting grid that effectively removes most of the undersized fish has been developed for shrimp trawls and it is not legal to fish for shrimp in the Barents Sea without the use of this sorting grid. Apart from this, the existing catch-regulation of shrimp fishery in the Barents Sea is closing of shrimp fisheries on fishing-grounds, where the bycatch of juvenile fish exceeds the criteria for allowable bycatch in numbers per ton of shrimp set by The Norwegian - Russian Fishery Commission.

In this paper a new method for calculation of a criteria for closing shrimp fisheries based on both biological and economic considerations is established. This bio-economic approach is an alternative to the existing biological approach. The main concept in the bio-economic approach is that if the expected future value of the bycatch exceeds the value of the shrimp catches, the shrimp fishery should be closed. In this paper a joint criteria for allowable bycatch is developed and calculated, including all the commercially interesting species, (cod; *Gadus morhua*, haddock; *Melanogrammus aeglefinus*, redfish; *Sebastes mentella* and Greenland halibut; *Reinhardtius hippoglossoides*) whose juveniles are caught as bycatch in the shrimp fisheries in the Barents Sea.

3238 / 14 / 5

## INTRODUCTION

In the Barents Sea and adjacent waters, the large-scale intensive fisheries for shrimps, demersal and pelagic species are conducted throughout the year. The bycatch of juvenile fish can be a major problem in fisheries where small meshed trawls are in use, such as shrimp fisheries. *Pandalus borealis*, commonly known as deep-water prawn or pink shrimp, is an important species both economically and ecologically in the Barents Sea. However groundfish, caught as bycatch in the shrimp fishery, are also commercially important species, but when caught at the juvenile stage in a shrimp trawl it are of no commercial value. The species concerned are cod; *Gadus morhua*, haddock; *Melanogrammus aeglefinus*, redfish; *Sebastes mentella* and Greenland halibut; *Reinhardtius hippoglossoides*.

Bycatch of juvenile fish increases the mortality of these species, and through this reduces the stocks size. This calls for management actions, and the first step was taken by The Joint Soviet - Norwegian Fisheries Commission in 1983. In its meeting that year, the Commission imposed a regulation that implies that fishing grounds should be closed if the bycatch of young cod and haddock exceeds 300 specimens per 1 ton of shrimps. This rule has since 1983 been a part of the annual fisheries agreement between Russia (USSR) and Norway. Russia and Norway have later agreed also to restrict the bycatch of Greenland halibut to 300 specimens per 1 metric ton of shrimps. This rule was first introduced July 1. 1992, and have been a part of the annual agreement between Russia and Norway since then. An extensive surveillance program is carried out to monitor the closing and opening of fishing grounds in accordance with the agreed bycatch rules.

To further reduce the bycatch of juvenile fish in shrimp trawls, Russia and Norway took the second step towards an effective management as from January 1. 1993. Since then it has been prohibited to fish for shrimps in the Barents Sea and adjacent waters without the use of a sorting grid, that effectively prevents the catch of fish larger than approximately 18 cm.

Since the sorting grid effectively sorts out most of the bycatch the closing criteria of 300 specimen per 1 metric ton of shrimp is less restrictive when the sorting grid is used. Several fishing grounds in the Barents Sea and adjacent waters have been opened for shrimp fishing because of the general use of the sorting grid.

The existing criteria for allowable bycatch in the shrimp fishery were established on the basis of general biological reasoning; no precise calculation of appropriate level of bycatch was undertaken. In this paper we develop a method for the determination of allowable bycatch in the shrimp fishery based on both biological and economic considerations. This bio-economic approach is an alternative to the existing biological approach. The main concept in the bio-economic approach is that if todays value of the potential future catch of the juveniles caught as bycatch on a shrimp fishing ground exceeds the value of todays shrimp catches, then the shrimp fishing on the fishing ground should be stopped.

In order to have a joint criteria for allowable bycatch including all four commercially interesting species whose juveniles are caught as bycatch in the shrimp fishery, we have developed a joint measure for juvenile fish, called the young cod equivalent. By such a measure juveniles of haddock, Greenland halibut and redfish are given values relative to cod.

## **MATERIAL AND METHODS**

The basic principle is that the present value of expected future catch of all commercially important species that would have been caught as bycatch in the shrimp fishery, in this paper called the protected species, should be compared to the value of the present shrimp catches. The shrimp fishery in the area should be stopped if the present value of expected future catch of protected species exceeds the value of the present shrimp catches.

To make this comparison we need to know the value of the protected species if it is decided to close shrimp fishing on fishing grounds. The juvenile fish has a biological value as a contributor to the future spawning stock, and as prey for other fish. This comes in addition to its value as future catch which is reflected by the future market price of the different species.

The expected future catch (yield) per juvenile fish is calculated using data from "Report of the Arctic Fisheries WG" 1992, (ICES C.M. 1993/Assess. 1). Such calculation requires knowledge of the age of the fish just before it is sorted out of the shrimp trawl by the sorting grid. We call this the juvenile-age. The juvenile age has been estimated on the basis of selectivity test with the sorting grid. With regard to selectivity tests reference is made to Isaksen et al., 1992.

To calculate present value of the future catch of the protected species we also need to know at which age these species are expected to be caught in the future. We presuppose that all the catch from a yearclass are caught at the average catching age, (age at catch, see appendix).

The abundance of yearclasses of the protected species varies. On the basis of surveys made each year, the yearclasses can be classified according to strength and the expected yield per juvenile fish can be estimated. It is concluded in Sundby et al., 1989, that "yearclass-strength is mainly determined before early juvenile stage, and therefore good assessments of early juvenile abundance have a prognostic value." The yearclass-strength can be classified in three groups; poor, medium and rich yearclasses. (Tretyak et al., 1994). These groups have different expected yield per juvenile fish. Average yield per juvenile fish should be estimated for the three groups for all four species. However due to lack of sufficient data the calculations can only be done for cod and haddock. More research has to be done to estimate an average yield per juvenile for redfish and Greenland halibut of different yearclass-strength.

The expected future prices to the fishermen for catch of the different protected species are estimated on the basis on an average price in the period 1986 - 1990 (NOS Fishery Statistics 1990-1991) and the prices obtained in the period 1990 - 1994. It is the relative prices that are important in this context, and not the absolute level. Price for shrimps is set at 9 NOK/kg.

Since there is difference in time between the present catch of shrimp and the future catch of protected fish which the value of the shrimp catches should be compared to, the present value of the expected future catch of the protected species have to be calculated. The present value is the discounted value of the expected future catch of the protected species. In this paper a discount rate of 5% is used. 5% reflects the alternative rate of return when investing in renewable resources.

Closed fishing grounds impose a loss for the shrimp fishermen. How large this loss is depends on the possibility to postpone some of the catch until after the fishing grounds are reopened. The vital question is whether the catch-rate of shrimp is increased after the reopening. If the catch-rate is higher after the closing, then some of the lost catches will be

compensated for.

In the following calculations we have assumed that all shrimp fishing grounds are closed during the period January - April. It will be no catch of shrimps in this period. Shrimps have a natural mortality in this period of approximately 15%. This means that without fishing, 85% of the shrimps survive. The density of shrimps in the fishing grounds in the last 8 months of the year can be expected to be higher compared to a situation without closure. Higher density will entail higher catch-rates, lower catching-costs and higher incomes. It is difficult to estimate how much of the lost catches can be compensated for through higher catch-rates during the last 8 months of the year. Theoretically however one could catch 85% out of the lost catches in the last 8 months of the year. A reasonable guesstimate could be somewhere around 40%. In this paper we presuppose that 40% of the lost shrimp-catches can be regained. The proportion of shrimp catches that cannot be regained later by a higher catch-rate will then be 0.6.

The assumption that bycatch of juvenile fish in the shrimp fishery only imply closing of fishing grounds in the period January - April can be a fairly good approximation if the closing is caused by juveniles of cod or haddock. If however the closing is caused by bycatch of juveniles of Greenland halibut or redfish it may occur any time of the year. The consequences will therefore be that if the closing is caused by bycatch of juveniles of either Greenland halibut or redfish there will be no possibility to regain any of the lost shrimp catches.

The method developed in this paper draws heavily on the method used in Pallsson and Thorsteinsson 1985.

$\delta_p * (P_p * E(Y_p) - C_p) * X_p$  = present value of expected future catch of protected species if fishing ground is closed for shrimp fishing

$(P_s - C_s) * 1000 \text{ kg} * D$  = value of lost shrimp catches if the fishing ground is closed for shrimp fishing

where:

- $\delta_p$  = discount factor =  $1/(1+r)^a$
- $r$  = discount rate
- $a$  = average catching age - juvenile age
- $P_p$  = expected future price for the protected species p where p refers to cod (c), haddock (h), redfish (r) and Greenland halibut (g).
- $E(Y_p)$  = expected yield per juvenile fish where  $Y_p$  refers to yearclass-strength for the various species
- $C_p$  = costs when fishing for the protected species
- $X_p$  = bycatch of protected species in shrimp fisheries
- $P_s$  = price for shrimps = 9 NOK/kg
- $C_s$  = costs when fishing for shrimps
- $D$  = proportion of shrimp catches that cannot be regain later by higher catch rates

The maximum allowable bycatch is the  $X_p$  that balance the present value of expected future catch of the protected species with the value of the shrimp catches. If the bycatch exceeds this  $X_p$  the fishing ground should be closed for shrimp fishing since the bycatch is more valuable than the shrimp-catches. Then  $X_p$  can be found by setting:

$$\delta_p * (P_p * E_p(Y_p) - C_p) * X_p = (P_s - C_s) * 1000\text{kg} * D \quad (1)$$

If the costs per kg catch relative to price per kg catch are equal for shrimp-catches and catches of the protected species, costs can be disregarded in the calculations. If its higher for shrimp than for the protected species the allowable bycatch should be less than if they are equal.

The costs per kg catch relative to price per kg catch depend on what kind of vessels that are used. The vessels that are in use in the fishery for cod, haddock, Greenland halibut and redfish vary from small boats to large trawlers. In this paper we presuppose that the costs per kg catch relative to price per kg catch are equal for shrimpcatches and catches of the protected species. Costs can then be disregarded in the further calculations, and the allowable bycatch,  $X_p$  can be calculated as follows:

$$\delta_p * P_p * E(Y_p) * X_p = P_s * 1000\text{kg} * D \quad (2)$$

$$X_p = (P_s * 1000\text{kg} * D) / (\delta_p * P_p * E(Y_p)) \quad (3)$$

Calculations are made only for the three yearclass-strength for cod. The average yield per juvenile for the three groups are calculated using table A.1 in the appendix. For haddock, redfish and Greenland halibut the calculations are only made for medium yearclass-strength. The yield per juvenile and average catching age (age at catch) are based on a fishing mortality equal to  $F_{med}$ .

Table 1:

Species	Cod	Haddock	G. halibut	Redfish
Juvenile age	1 year	1 year	2 year	4 year
Age at catch	7.6 year	6.1 year	9.2 year	13.2 year
Yield per juvenile				
poor	0.86 kg			
medium	0.79 kg	0.53 kg	0.62 kg	0.20 kg
rich	0.70 kg			
Price	7 NOK/kg	6 NOK/kg	8.5 NOK/kg	3 NOK/kg

If we are able to calculate a joint measure of value of the juvenile fish, it will facilitate closure of the shrimp fishing grounds when the concentration of commercially important juvenile fish are too high, no matter which composition of bycatch of the four species is occurring. In this paper we try to calculate such a measure by asking: What is the value of the juvenile fish measured in terms of "young-cod-equivalents"?

The value of juveniles of haddock, Greenland halibut and redfish are compared to the value of 1 juvenile cod. This calculations shows how many juveniles of haddock, Greenland halibut or redfish that must be protected to give equal value of expected future catch as 1 protected juvenile cod.

1 "young cod equivalent"

= the present value of expected future catch per (protected) juvenile cod

= h \* the present value of expected future catch per (protected) juvenile haddock

= g \* the present value of expected future catch per (protected) juvenile Greenland halibut

= r \* the present value of expected future catch per (protected) juvenile redfish

This gives the following equations:

$$1 * \delta_c * P_c * E(Y_c) = h * \delta_h * P_h * E(Y_h) \quad (4)$$
$$h = (1 * \delta_c * P_c * E(Y_c)) / (\delta_h * P_h * E(Y_h))$$

$$1 * \delta_c * P_c * E(Y_c) = g * \delta_g * P_g * E(Y_g) \quad (5)$$
$$g = (1 * \delta_c * P_c * E(Y_c)) / (\delta_g * P_g * E(Y_g))$$

$$1 * \delta_c * P_c * E(Y_c) = r * \delta_r * P_r * E(Y_r) \quad (6)$$
$$r = (1 * \delta_c * P_c * E(Y_c)) / (\delta_r * P_r * E(Y_r))$$

1 young cod equivalent      = h juvenile haddock  
   = g juvenile Greenland halibut  
   = r juvenile redfish

This provides a method that can be used to calculate a closing-criteria for shrimp fishing grounds based on a maximum number of "young-cod-equivalent", which readily can be converted into maximum number of the other protected species.

This method takes account of different yearclass-strength since yield per juvenile is included in the equations.

Because of the possibility to regain some of the lost shrimp catches if the closing is caused by juveniles of cod or haddock, the young cod equivalents must be adjusted, since there are no possibility to regain any lost shrimp catches if the closing is caused by juveniles of Greenland halibut or redfish.

1 young cod equivalent \* 0.6 = h juvenile haddock \* 0.6  
   = g juvenile Greenland halibut  
   = r juvenile redfish

Because it is convenient to have 1 young cod equivalent as the unit, we divide with 0.6:

1 young cod equivalent      = h juvenile haddock  
   = g juvenile Greenland halibut / 0.6  
   = r juvenile redfish / 0.6

## RESULTS

With this bio-economic method allowable bycatch is calculated using equation (2) and (3). The calculations are done for medium yearclass-strength for haddock, Greenland halibut and redfish. Allowable bycatch of cod in shrimp catches are calculated for poor, medium and rich yearclass-strength. See table A.1 in appendix. The results from the calculations if only one specie is caught as bycatch in the shrimp fishery are presented in table 2 below.

Table 2, Allowable bycatch; juveniles per 1 metric ton of shrimp if only one specie is caught as bycatch:

$X_p$	POOR	MEDIUM	RICH
COD	1238	1347	1521
HADDOCK		2178	
G.HALIBUT		2427	
REDFISH		23498	

However when catching shrimps it is common to catch several groundfish-species as bycatch. Young cod equivalent provides a joint criteria for allowable bycatch. Fishing grounds can then be closed for shrimp fishing if the present value of the expected future catch of the protected juveniles exceeds the value of the shrimp catches, no matter the composition of the bycatch.

Medium yearclass-strength gives an allowable bycatch of 1347 young cod equivalent. The young cod equivalents can be calculated using table 1; medium yearclass-strength and equations (4) - (6):

$$\begin{aligned}
 1 \text{ young cod equivalent} &= 1.6 \text{ juvenile haddock} \\
 &= 1.8 \text{ juvenile Greenland halibut} \\
 &= 17.4 \text{ juvenile redfish}
 \end{aligned}$$

To illustrate the use of the method some examples are given with different bycatch of the various species.

### Example 1:

If the yearclass-strength is medium for all the species concerned and the bycatch consist of:

$$\begin{aligned}
 500 \text{ juvenile cod} &= 500 \text{ young cod equivalent} \\
 + 500 \text{ juvenile haddock} &= 500/1.6 \text{ young cod equivalent} \\
 + 500 \text{ juvenile Greenland halibut} &= 500/1.8 \text{ young cod equivalent} \\
 &= \underline{1090} \text{ young cod equivalent}
 \end{aligned}$$

giving 1090 young cod equivalent which would not imply closing of the fishing ground.

Example 2:

If the bycatch in example 1 in addition consist of 5000 juvenile redfish and yearclass-strength of redfish is medium, then the bycatch would exceed 1347 young cod equivalent and the fishing ground should be closed.

500 juvenile cod	= 500 young cod equivalent
+ 500 juvenile haddock	= 500/1.6 young cod equivalent
+ 500 juvenile Greenland halibut	= 500/1.8 young cod equivalent
+ 5000 juvenile redfish	= 5000/17.4 young cod equivalent
	= <u>1378</u> young cod equivalent

Example 3:

If the bycatch in example 1 consist of 800 instead of 500 juvenile cod, then the bycatch would exceed 1347 young cod equivalent and the fishing ground should be closed.

800 juvenile cod	= 800 young cod equivalent
+ 500 juvenile haddock	= 500/1.6 young cod equivalent
+ 500 juvenile Greenland halibut	= 500/1.8 young cod equivalent
	= <u>1390</u> young cod equivalent

Example 4:

If the cod yearclass is poor and haddock, Greenland halibut and redfish are medium yearclasses, the cod equivalent would be:

1 young cod equivalent = 1.8 juvenile haddock = 2.0 juvenile Greenland halibut = 19.0 juvenile redfish.

If the cod yearclass is poor then the bycatch in example 3 would be:

800 juvenile cod	= 800 young cod equivalent
+ 500 juvenile haddock	= 500/1.8 young cod equivalent
+ 500 juvenile Greenland halibut	= 500/2.0 young cod equivalent
	= <u>1328</u> young cod equivalent

giving 1328 young cod equivalent, which would imply closing of the fishing ground since the allowable bycatch is 1238 young cod equivalent when the cod yearclass is poor, (see table 2).



## DISCUSSION

Even with a poor yearclass of cod the allowable bycatch is calculated to be more than 4 times higher than the existing criteria.

In Tretyak et al. 1994 total bycatch of young fish from any yearclass is accepted as allowed if the yearclass will remain within the limits of the confidential interval of the general mean abundance of its own group to the age of recruiting the commercial stock. Annual allowed bycatch is calculated for cod, haddock and *Sebastes mentella* during the trawl fishery for shrimp, cod and haddock.

The method used in Tretyak et al. 1994, is a statistical method, which do not take economic considerations into account. Calculated allowed bycatches of young cod and haddock during shrimp fishery for 1994 turned in Tretyak et al. 1994 out to be 5 times higher than the existing criteria set by the Joint Russian-Norwegian Fisheries Commission. If economic consideration are taken into account, the criteria would probably be somewhat lower. In addition to making economic considerations, the bioeconomic method provides a joint criteria for allowable bycatch.

In both the method used in Tretyak et al. 1994 and the bio-economic method used in this paper, yearclass-strength have to be determined and calculations needs to be made every year.

According to Pallsson and Thorsteisson 1985, the management guideline in Iceland has been 1900 - 3300 gadoids per 1000kg shrimp in the period 1979 - 1985, which is higher than allowable bycatch calculated in this paper.

\*

In the calculations in this paper we have made some assumptions. In this section we ask how changes in these assumption affect the calculated criteria for allowable bycatch. Medium yearclass-strength and bycatch of cod are used as a basis for the sensitivity analyses.

### Assumptions:

- Instantaneous Natural Mortality,  $M = 0.3$  for ages 1 and 2,  $M = 0.2$  for older fish.
- Instantaneous Fishing Mortality is assumed to be  $F_{med} = 0.46$
- We disregard the predation-aspect.
- We have set the discount rate to 5%.
- We assume that the relative prices are constant.
- We disregard costs in both shrimp-fishery and in the groundfish-fishery.
- We assume that 40% of the lost shrimp catches can be regained if the closing of the fishing grounds are caused by juvenile cod or haddock.

### Natural mortality

It is assumed that the natural mortality for 1 and 2 year old cod are  $M = 0,3$ . This gives a survival of 55% of a yearclass at the age of 3. It is difficult to give a reliable estimate of the natural mortality in this period. We have therefore calculated the criteria for allowable bycatch with different assumptions regarding the natural mortality for 1 and 2 year old cod:

M	% Survival	Closing criteria
0,2	67%	1097
0,3	55%	1347
0,4	45%	1638
0,5	37%	2008

As the table above shows, the calculated criteria for allowable bycatch are as we can see, sensitive to changes in M. A high M indicates a less strict criteria. However if M = 0,2 the calculated criteria for allowable bycatch would still be more than 3 times higher than the existing criteria for allowable bycatch. See table A.2 in appendix.

### Fishing mortality

We have used  $F_{med}$  as a basis for the calculations, what if  $F_{low}$  or  $F_{high}$  are to be used instead? Yield per juvenile cod is changed very little, but the catching age varies from 6,6 year to 8,3 year. The criteria are however just slightly altered from 1347. With  $F_{low}$  the criteria are calculated to be 1394 juvenile cod per metric ton of shrimp.  $F_{high}$  gives a criteria for allowable bycatch equal to 1352 juvenile cod per metric ton of shrimp. See table A.3 in appendix.

### Discounting

When discounting a rate of 5% is used. 5% reflects the alternative rate of return when investing in renewable resources. We have calculated the criteria using a discount rate of 2%, this gives a criteria equal to 1113 young cod equivalent per 1 metric ton of shrimp instead of 1347.

### Predation

The total biomass of cod will increase if we protect juvenile cod. Cod is a predator, and predate among other species on shrimp. Protection of juvenile cod will therefore decrease the total biomass of shrimps because of the increased predation on shrimp. A reduction of the biomass of shrimp can imply higher catching-cost for shrimptrawlers.

How important shrimp will be as food for cod depends on the availability of alternative food sources. An increase in the biomass of capelin, Norwegian spring spawning herring and redfish would probably decrease the need for shrimp as food for cod.

A criteria for allowable bycatch should from a bioeconomic point of view take the predation aspect into consideration. This implies need for knowledge about aspect of optimal size of the stocks of shrimp and cod simultaneously. There is however a need for more research to be done before the aspect of predation can be taken into consideration.

### Prices

In the calculations estimated prices are used.

If the price for cod increases with 1 NOK and the other prices are unchanged, then the closing criteria will decrease from 1347 to 1179 young cod equivalent per metric ton of shrimp.

If the price for shrimp increases with 1 NOK and the other prices are unchanged then the closing criteria will increase from 1347 to 1497 young cod equivalents per metric ton of shrimp.

Similar calculations can be made for the other species.

#### Lost shrimp catches - possibility to regain catch

On some shrimp fishing grounds where there are problems with ice, it can be difficult to regain shrimp catches by increased catch-rates because shrimp fishing grounds can be covered with ice soon after reopening.

If only 20% of the lost shrimp catches can be regained, then the closing criteria would change from 1347 to 1797 young cod per metric ton of shrimp. The young cod equivalent would change to 1 cod equivalent = 1.6 juvenile haddock = 1.4 juvenile Greenland halibut = 13.1 juvenile redfish.

### **CONCLUSIONS**

We have developed a new method for calculating allowable bycatch in shrimp fisheries. This bio-economic method provides a joint criteria for commercially interesting species whose juveniles are caught as bycatch.

From the calculations in this paper it can be concluded:

- the existing criteria for allowable bycatch of cod and haddock in the Barents Sea shrimp fishery is too strict.
- depending on yearclass-strength a bio-economic criteria for allowable bycatch is calculated to be in the range of 1238 - 1521 young cod equivalent per ton of shrimp. This level of allowable bycatch is comparable to, but still below, levels suggested by other works, (Tretyak, 1994, Pallsson and Thorsteinsson 1985).
- in practical management a frequent change in the criteria for allowable bycatch is not preferable, however a recalculation should be done if yearclass-strength or other parameters change substantially.

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## APPENDIX

Here is given data used in the calculations for cod in this paper. Yield per juvenile is the yield given using  $F = 0.46$  if other values are not stated. Average stock and average spawning stock is the stock generated if one individual recruited every year. Average weight is the arithmetic mean weight in stock and catch from this stock. Age at catch is the age times catch in weight at each age divided by total catch.

Table A.1 Yield, stock size and weight per juvenile in different yearclasses. Units are kg, except age is year.

Yearclass	1978	1979	1980	1981	1982	1983	1984
Yield per juvenile	0.90	0.94	0.88	0.84	0.75	0.70	0.73
Age at catch	7.6	7.6	7.6	7.6	7.6	7.7	7.7
Average weight in stock	1.98	2.01	1.81	1.67	1.58	1.27	1.35
Average weight in catch	3.90	4.07	3.81	3.65	3.27	3.03	3.16
Average stock	3.72	3.77	3.41	3.15	2.97	2.39	2.53
Average spawning stock	1.57	1.59	1.21	1.19	1.25	1.18	1.45
Yearclass-strength	Poor	Poor	Poor	Medium	Medium	Rich	Poor

Table A.2 Natural mortality of ages 1 and 2 varying for 0.2 - 1.0 giving different values for some of the parameters.

Natural mortality, M	M = 0.2	M = 0.3	M = 0.4	M = 0.5	M = 0.7	M = 1.0
% survival to age 3	67%	55%	45%	37%	25%	14%
Yield per juvenile	0.97	0.79	0.65	0.53	0.36	0.28
Average stock	3.74	3.06	2.51	2.05	1.38	0.76
Average spawning stock	1.67	1.37	1.12	0.92	0.62	0.34

Table A.3 Fishing mortality varying gives different values for the other parameters.

Fishing mortality	$F_{low} = 0.32$	$F_{med} = 0.46$	$F_{high} = 0.78$
Yield per juvenile	0.79	0.79	0.75
Average weight in stock	1.93	1.63	1.29
Average weight in catch	3.96	3.43	2.74
Average stock	3.91	3.06	2.17
Average spawning stock	2.13	1.37	0.63
Age at catch	8.3	7.6	6.6