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Legion Analysis Game and Simulation Program (LAGS)

by

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Abstract

L.A.G.S. is a computer program on Legion Analysis (or Multispecies VPA combined with a multifleet model in the prognostic mode). L.A.G.S. is a user oriented program, which should (in its simplest form) be run by users with no experience in computers, or modelling. L.A.G.S. contains a number of obtions on the users choice, e.g. it can be used for stochastic simulation studies on recruitment.

It may be applied for simulation studies only, but if the users wishes so, it can be used as a game as well. In this case each "player" has to manage a fleet. A "move" consists in taking annual decisions on effort, mesh sizes and directivity of fishing effort. L.A.G.S. contains a (simple) submodel on the economics of the fleets. The player who obtains the highest profit during, say, a ten years simulation run, wins the game.

L.A.G.S. has been implemented in various versions in FORTRAN (for a larger computer) and in BASIC (for a micro computer).

CONTENTS.

1. Introduction

The computer program "LAGS" is based on the multispecies, multi fleet fishery model "Legion Analysis" (Sparre, 1980). The present version of Legion Analysis may be considered as the prognosis version of multispecies VPA (Pope, 1979 and Helgason & Gislason, 1979, Beyer and Sparre, 1983).
As far as the biological aspects are concerned, this model is in fact a simplified version of the Andersen and Ursin model, (1977).

LAGS may be used for two purposes:

1. As an educational tool by which most of the mechanisms in Legion Analysis can be examplified and illustrated.
2. As a game, (which may also be used to illustrate the "psychology of overfishing").

The program works interactively by asking questions to the user (or the players) via a screen display and receiving the answers via the screen. The user (or the players) may as well ask question to LAGS. In fact, the user has the possibility to ask a large number of questions to LAGS. LAGS may be run in three different modes named:

1. slow mode
2. fast mode
3. very fast mode.

In the "slow mode" every step and question is explained in details on the screen, and it should be possible for a beginner to run LAGS in the slow mode without any introductory explanations.
If certain options are omitted it should in fact be possible for the socalled "man in the street" to run the program without any introduction. However, this version is supposed to be used for eduction on a university level and thus contains a number of obtions, the utilization of which requires a certain background.

The fast mode is qualitatively equivalent to the slow mode.
The only difference is that most explanations given on the screen in the slow mode are omitted in the fast mode. These two modes are used when running LAGS as a game or as a simulation.
The "very fast mode" is used only for simulation purposes. In this mode a simulation of the system dynamics for, say 50 years, with display of yearly results may be performed in 5-10 minutes depending on the number of result tables displayed. The present version of LAGS (implemented on the RC8000-computer at the Danish Institute for Fisheries and Marine Research) contains an option for output on the line printer, an option which is especially useful in connection with the simulation application.

2. The basic elements of the game

This section is a coarse description of LAGS. More detailed explanations will be given in the subsequent sections.
The underlying model assumes a homogen sea area from which no fish emigrate or immigrate. The sea area is assumed to contain only three major fish stocks (or groups of fish stocks).
There is one predator, in the following named "cod" and two prey-species named "plaice" and "herring".
Only cod acts as a predator, as illustrated in Figure 2.1.

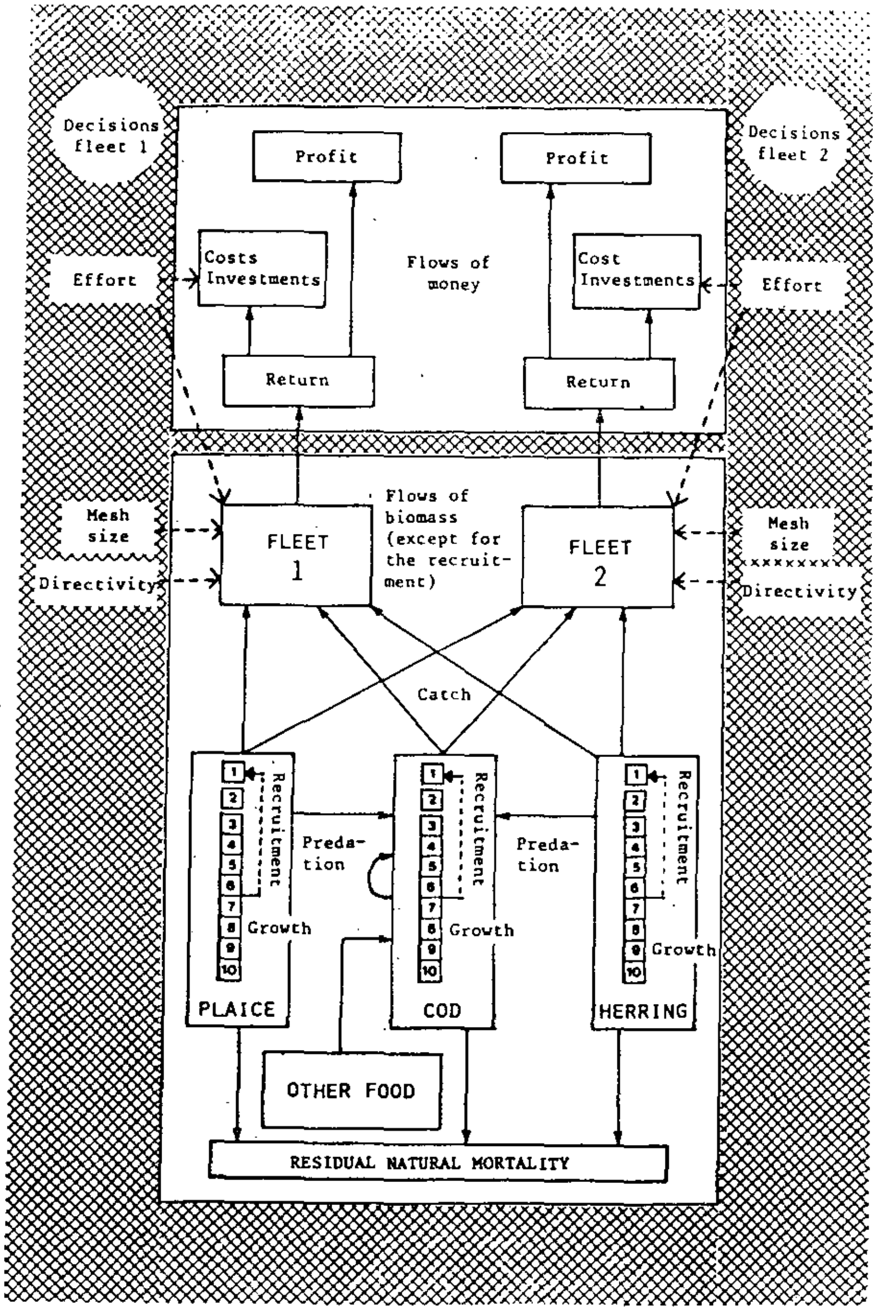


Figure 2.1. Static description of LAGS.

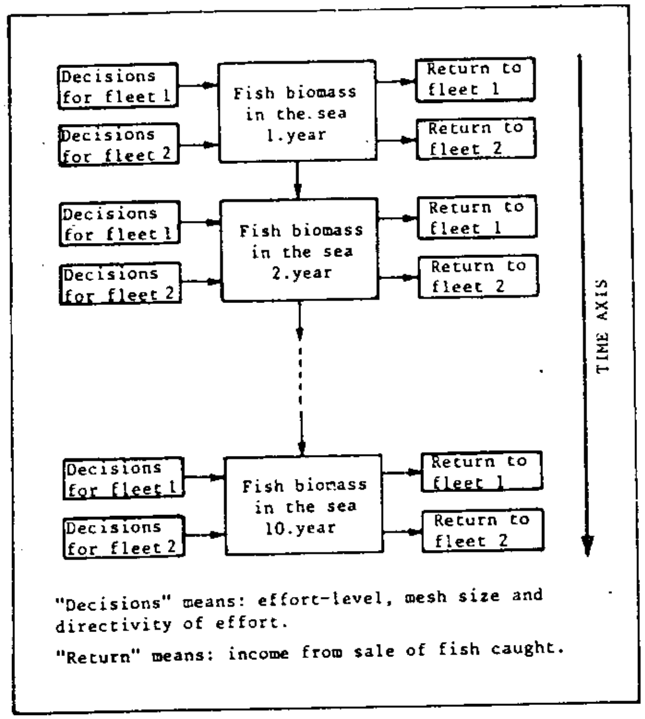
Figure 2.1 gives a static illustration of the basic elements of LAGS where as Fig. 2.2 illustrates the basic dynamic aspects. In each stock 1o age groups are considered. Recruitment (to the 1-group) occurs discontinously once per year (at the beginning of the year). The number of recruits depends of the parent stock biomass (age group 3 and older fish). Production of fish biomass (per fish) due to body growth remains constant from year to year. Recruitment and body growth constitute the two first elements of the list of factors controlling the dynamics of fish biomass in the sea. The list is:

1. production:	1.1 Recruitment
	1.2 Body growth
2. decay:	2.1 Fishing
	2.2 Predation (by cod)
	2.3 "Other" natural mortality

Items 2.2 and 2.3 will be discussed in section 4. **Here**, we shall only look at the decay caused by fishing. The amount of fish deads due to fishing depends on the decisions taken by the user (or players). The game runs on a yearly basis and decisions always apply to a time span of one year. Thus within a year the fishing pattern and the level of fishing remain constant, but it may vary between years. The annual nature of the dynamics is illustrated in Figure 2.2

In this version of the game there can only be two players, namely one player for each fleet. The game runs over ten years and every year each player has to make a "move". A "move" consists in three "decisions" which are:

1. Decision about the effort (e.g. the number of fishing hours) to be exerted by his fleet during the next year.
2. Decision about the mesh size to be used by his fleet. (All vessels in a fleet use identical gears, and a gear is assumed to be a trawl).
3. Decision about the "directivity" of the effort, i.e. the player can decide that, say, 3o % of the effort is used to catch cod, 5o % of the effort is used to catch plaice, and the remaining 2o % of the effort is used to catch herring, or he could decide any other split of the effort between the three species he wishes.



"Decisions" means: effort-level, mesh size and directivity of effort.

"Return" means: income from sale of fish caught.

Figure 2.2. Dynamic description of LAGS.

Thus, in total, each player has to take 4o decisions during the lo years period.
Depending on the decisions taken each player gets a catch which he sells (to a fixed price). From the income of sale the cost of fishing is subtracted to give the profit. At the beginning of the game each player has a fleet of a certain size. If a player wants to put more effort into the fishery he has to invest in extra vessels and consequently take loans, for which he has pay instalments and interests in the following years.
The player which obtain the highest profit during the ten years wins the game.
Figure 2.2 illustrates the time table of the game. For beginners a game may last from 2o minutes to more than an hour, depending on the number of question to be answered by LAGS.
Actually, one does not need to know anything about population dynamic or fishery-models to play the game. However, to become a master of this game, one has to understand the underlying model, and to be able to utilize the possibility to ask questions to LAGS.

3. An example of a run with LAGS in the slow mode

The following list of screen displays illustrates a run with LAGS. **Figures in boxes, e.g.**

[15]

are the input from the user (or players). This, of course, is not shown on the screen, as the characters given as input are shown on the screen.
The list of possible questions to LAGS are arranged into two "menues", the "small menu" and the "large menu" The small menu offer "courses" consisting of VPA-tables, i.e., number caught, number of survivors, fishing mortality and predation mortality.
The large menu contains only such information which can be understood without a scientific background.
As the game is supposed to be self-explanatory the game will be explained by a serie of screen display. The displays are separated with lines. A screen desplay contains at maximum 24 lines of maximum 8o characters.
The players can use as much time as they like to study the single screen displays.

If LAGS is used as a game it is recommended that the players shift order of decision making, i.e. first year, say, player no. 1 takes his decisions before player no. 2, second year player no. 2 make his decisions before player no. 1 ..etc. If, say, player no. 2 is always last, he is certain to win if he just once is ahead of player no. 1. The only thing he then has to do is to take exactly the same decisions as his adversary in the remaining years and he will keep the lead. For simplicity, player no. 1 is first all years in the example given below.
In the testrun, the first two years , 1982 and 1983, are past without use of the menues. After the third year the large menu is demonstrated. After the last year, 1991, the small menu is demonstrated.

```
Do you run this program for the first time ? (yes=1, no=RETURN) [1]
```

```
WELCOME TO THE FISHERY GAME

This game contains three fish stocks : Cod, plaice and herring
Cod acts as a predator to plaice, herring and (smaller) cod
Number of age groups and average body weight for each age
group are shown on the table below :

   Mean weight at age (Kg.)
```

age	Cod	Plaice	Herring
1	0.49	0.09	0.06
2	1.66	0.17	0.10
3	3.40	0.28	0.14
4	5.45	0.39	0.17
5	7.59	0.52	0.19
6	9.67	0.64	0.21
7	11.59	0.76	0.23
8	13.30	0.88	0.24
9	14.78	0.99	0.25
10	16.06	1.09	0.25

```
To continue - press "RETURN" [RETURN]
```

```
There are two fishing fleets in the game - one for each player
Each year you must decide the "fishing strategy", i.e. in each
year you must decide the number of fishing effort units to be
used by your fleet, which mesh size you want and the "direc-
tivity" of your effort on the three species.
The game runs over ten years, and the player who obtain the
highest profit during the ten years becomes the winner of the
game.
If a player does not invest and fish in a sensible way, he may
get ruined, and thus loose the game
To continue - press "RETURN" [RETURN]
```

```
Return from fisheries is determined by

Kg-prices of fish
```

age	Cod	Plaice	Herring
1	1.71	1.71	1.43
2	4.00	4.00	3.33
3	5.45	5.45	4.55
4	6.46	6.46	5.38
5	7.20	7.20	6.00
6	7.76	7.76	6.47
7	8.21	8.21	6.84
8	8.57	8.57	7.14
9	8.57	8.57	7.14
10	8.57	8.57	7.14

```
To continue - press "RETURN" [RETURN]
```

```
When the game starts in year 1982 there are the following
Number of survivors at the beginning of 1982
```

age	Cod	Plaice	Herring
1	10000	200000	600000
2	6065	121306	363918
3	3679	73576	220728
4	2231	44626	133878
5	1353	27067	81201
6	821	16417	49251
7	498	9957	29872
8	302	6039	18118
9	183	3663	10989
10	282	5647	16940
Biomass (tons)	74890	123609	171993
Spawning stock biomass (tons)	59922	84874	96946

```
(biomass of age 3 and older fish)
To continue - press "RETURN" [RETURN]
```

```
When starting the game (year 1982) you have a
fishing fleet which at maximum fishing intencity corresponds to
  200 fishing effort units. If you want more effort units
you must invest in new vessels

Cost per effort unit    300 Dkr.
Instalment amonuts to 1/5 of the investment per year
Rate of interest is  10.0 percent per year
Investment for one extra effort unit amounts to   1000 Dkr.
You are ruined if your accumulated profit comes below  -150000 Dkr.
and more than 3 years have elapsed since we started
In last year all remaining loans are paid back
Do you want the introduction one more time (yes=1,no=RETURN)[RETURN]


HERE WE GO - WE START IN YEAR 1982
```

```
GIVE MESH SIZES FOR EACH FLEET IN YEAR 1982
-----------------------------------------------------------------
mesh size of fleet 1 (mm) .Last years decision :      0 [80]
mesh size of fleet 2 (mm) .Last years decision :      0 [30]
```

```
GIVE NUMBER OF EFFORT UNITS FOR EACH FLEET IN YEAR 1982
-----------------------------------------------------------------
Number of effort units of fleet 1 .Last years decision :   0 [250]
You have now invested in     50 extra effort units
-----------------------------------------------------------------
Number of effort units of fleet 2 .Last years decision :   0 [250]
You have now invested in     50 extra effort units
-----------------------------------------------------------------
```

```
GIVE DIRECTIVITY FOR EACH OF THE 3 STOCKS , IN YEAR 1982
-----------------------------------------------------------------
Directivity are expressed in percentage. The sum of the three
directivity figures must thus be 100. Percentages should be
given for cod and plaice only - I calculate the percentage for
herring


Directivity of fleet no.  1
Percentage for Cod           .Last years decision :   0 [80]
Percentage for Plaice        .Last years decision :   0 [20]
percentage for Herring                                   0


Directivity of fleet no.  2
Percentage for Cod           .Last years decision :   0 [0]
Percentage for Plaice        .Last years decision :   0 [30]
percentage for Herring                                   70
```

```
The following decisions were taken in year 1982

                          fleet 1  fleet 2
--------------------------------------------
Mesh size                   80       30
Number of effort u.        250      250
Investments (ef.u.)         50       50
Directivity Cod             80        0
Directivity Plaice          20       30
Directivity Herring          0       70
--------------------------------------------
Is input for year 1982 ok ? (yes=RETURN, no=1)
(Or should fleet 1 take decisions after fleet 2 ?) [RETURN]
```

```
Accumulated profit
   2453 I 2
        I
        I
        I
        I
        I
        I
   1970 I------------------------------
        I
        I
        I
        I
        I
   1487 I 1
      --I--I--I--I--I--I--I--I--I--I
        82 33 84 85 86 87 88 89 90 91
To continue - press "RETURN"            [RETURN]
```

```
Catch (tons) and total biomass (tons) of Cod
(biomass is the average biomass during a year)
  56628 I B
        I
        I
        I
        I
        I
        I
  41697 I-----------------------------
        I
        I
        I
        I
        I
  26765 I C
      --I--I--I--I--I--I--I--I--I--I
        82 83 84 85 86 87 88 89 90 91
To continue - press "RETURN"            [RETURN]
```

```
Catch (tons) and total biomass (tons) of Plaice
(biomass is the average biomass during a year)
  96880 I B
        I
        I
        I
        I
        I
        I
  61759 I-----------------------------
        I
        I
        I
        I
        I
  26637 I C
      --I--I--I--I--I--I--I--I--I--I
        82 83 84 85 86 87 88 89 90 91
To continue - press "RETURN"            [RETURN]
```

```
Catch (tons) and total biomass (tons) of Herring
(biomass is the average biomass during a year)
 122052 I B
        I
        I
        I
        I
        I
        I
  87706 I-----------------------------
        I
        I
        I
        I
        I
  53559 I C
      --I--I--I--I--I--I--I--I--I--I
        82 83 84 85 86 87 88 89 90 91
To continue - press "RETURN"            [RETURN]
```

```
Do you want the small or the large menue ?
(small=1, large=2, none=RETURN) [RETURN]
```

```
GIVE MESH SIZES FOR EACH FLEET IN YEAR 1983
----------------------------------------------------------------
By using the "RETURN" key, the decision of this year
becomes the same as last years decision
mesh size of fleet 1 (mm) .Last years decision :    80 [120]
mesh size of fleet 2 (mm) .Last years decision :    30 [RETURN]
```

```
GIVE NUMBER OF EFFORT UNITS FOR EACH FLEET IN YEAR 1983
----------------------------------------------------------------
By using the "RETURN" key, the decision of this year
becomes the same as last years decision
Number of effort units of fleet 1 .Last years decision :   250 [RETURN]
Number of effort units of fleet 2 .Last years decision :   250 [RETURN]
```

```
GIVE DIRECTIVITY FOR EACH OF THE 3 STOCKS , IN YEAR 1983
----------------------------------------------------------------
Directivity are expressed in percentage. The sum of the three
directivity figures must thus be 100. Percentages should be
given for cod and plaice only - I calculate the percentage for
herring

By using the "RETURN" key, the decision of this year
becomes the same as last years decision


Directivity of fleet no.  1
Percentage for Cod              .Last years decision :   80 [RETURN]
Percentage for Plaice           .Last years decision :   20 [RETURN]
percentage for Herring                                    0


Directivity of fleet no.  2
Percentage for Cod              .Last years decision :    0 [RETURN]
Percentage for Plaice           .Last years decision :   30 [RETURN]
percentage for Herring                                   70
```

```
The following decisions were taken in year 1983

                         fleet 1  fleet 2
----------------------------------------------
Mesh size                  120       30
Number of effort u.        250      250
Investments (ef.u.)          0        0
Directivity Cod             80        0
Directivity Plaice          20       30
Directivity Herring          0       70
----------------------------------------------
Is input for year 1983 ok ? (yes=RETURN, no=1)
(Or should fleet 1 take decisions after fleet 2 ?)  [RETURN]
```

```
Accumulated profit
   4454 I    2
        I
        I
        I
        I
        I
        I
        I
   2971 I-----------------------------
        I
        I  2
        I     1
        I
        I
        I
   1487 I 1
      --I--I--I--I--I--I--I--I--I--I
        82 83 84 85 86 87 88 89 90 91
To continue - press "RETURN"             [RETURN]
```

```
Catch (tons) and total biomass (tons) of Cod
(biomass is the average biomass during a year)
  56628 I B
        I    B
        I
        I
        I
        I
        I
  38893 I-----------------------------
        I
        I
        I
        I
        I C
  21157 I    C
      --I--I--I--I--I--I--I--I--I--I
        82 83 84 85 86 87 88 89 90 91
To continue - press "RETURN"             [RETURN]
```

```
Catch (tons) and total biomass (tons) of Plaice
(biomass is the average biomass during a year)
  98953 I B  B
        I
        I
        I
        I
        I
        I
  60172 I-----------------------------
        I
        I
        I
        I
        I
  21390 I C  C
      --I--I--I--I--I--I--I--I--I--I
        82 83 84 85 86 87 88 89 90 91
To continue - press "RETURN"             [RETURN]
```

```
Catch (tons) and total biomass (tons) of Herring
(biomass is the average biomass during a year)
 122052 I B
        I
        I
        I
        I    B
        I
        I
  82821 I-----------------------------
        I
        I
        I
        I
        I C
  43589 I    C
      --I--I--I--I--I--I--I--I--I--I
        82 83 84 85 86 87 88 89 90 91
To continue - press "RETURN"             [RETURN]
```

```
Do you want the small or the large menue ?
(small=1, large=2, none=RETURN) [RETURN]
```

```
GIVE MESH SIZES FOR EACH FLEET IN YEAR 1984
-------------------------------------------------------------
By using the "RETURN" key, the decision of this year
becomes the same as last years decision
mesh size of fleet 1 (mm) .Last years decision :   120 [50]
mesh size of fleet 2 (mm) .Last years decision :    30 [50]
```

```
GIVE NUMBER OF EFFORT UNITS FOR EACH FLEET IN YEAR 1984
-------------------------------------------------------------
By using the "RETURN" key, the decision of this year
becomes the same as last years decision
Number of effort units of fleet 1 .Last years decision :   250 [300]
You have now invested in     50 extra effort units
-------------------------------------------------------------
Number of effort units of fleet 2 .Last years decision :   250 [RETURN]
```

```
GIVE DIRECTIVITY FOR EACH OF THE 3 STOCKS , IN YEAR 1984
-------------------------------------------------------------
Directivity are expressed in percentage. The sum of the three
directivity figures must thus be 100. Percentages should be
given for cod and plaice only - I calculate the percentage for
herring

By using the "RETURN" key, the decision of this year
becomes the same as last years decision


Directivity of fleet no.  1
Percentage for Cod             .Last years decision :   80  [50]
Percentage for Plaice          .Last years decision :   20  [50]
percentage for Herring                                       0


Directivity of fleet no.  2
Percentage for Cod             .Last years decision :    0  [RETURN]
Percentage for Plaice          .Last years decision :   30  [RETURN]
percentage for Herring                                      70
```

```
The following decisions were taken in year 1984
                           fleet 1  fleet 2
--------------------------------------------------
Mesh size                     50       50
Number of effort u.          300      250
Investments (ef.u.)           50        0
Directivity Cod               50        0
Directivity Plaice            50       30
Directivity Herring            0       70
--------------------------------------------------
Is input for year 1984 ok ? (yes=RETURN, no=1)
(Or should fleet 1 take decisions after fleet 2 ?) [RETURN]
```

```
Accumulated profit
 5849 I      2
      I
      I
      I
      I
      I    2  1
      I
 3668 I--------------------------------
      I
      I
      I
      I 2
      I     1
 1487 I 1
    --I--I--I--I--I--I--I--I--I--I
     82 83 84 85 86 87 88 89 90 91
To continue - press "RETURN"            [RETURN]
```

```
Catch (tons) and total biomass (tons) of Cod
(biomass is the average biomass during a year)
 59328 I        B
       I B
       I    B
       I
       I
       I
       I
 40243 I------------------------------
       I
       I
       I
       I
       I C
 21157 I    C  C
     --I--I--I--I--I--I--I--I--I--I
      82 83 84 85 86 87 88 89 90 91
To continue - press "RETURN"            [RETURN]
```

```
Catch (tons) and total biomass (tons) of Plaice
(biomass is the average biomass during a year)
 98953 I B  B
       I
       I        B
       I
       I
       I
       I
       I
 60172 I------------------------------
       I
       I        C
       I
       I
       I
 21390 I C  C
     --I--I--I--I--I--I--I--I--I--I
      82 83 84 85 86 87 88 89 90 91
To continue - press "RETURN"            [RETURN]
```

```
Catch (tons) and total biomass (tons) of Herring
(biomass is the average biomass during a year)
122052 I B
       I
       I
       I     B
       I
       I
       I        B
       I
 74892 I------------------------------
       I
       I
       I
       I C
       I    C
 27731 I       C
     --I--I--I--I--I--I--I--I--I--I
      82 83 84 85 86 87 88 89 90 91
To continue - press "RETURN"            [RETURN]
```

```
Do you want the small or the large menue ?
(small=1, large=2, none=RETURN)  [2]
```

```
SELECT A COURSE FROM THE LAEGE MENU :
-------------------------------------
1   : Mean weight at age in the three stocks
2   : Mean lenghts at age in the three stocks
3   : Kg-prices at age and species
4   : Cost per effort unit, interest and instalment
5   : Fishing effort and investments in the foregoing years
6   : Mesh sizes used in the foregoing years
7   : Directivities used in the foregoing years
8   : Number of survivors in each stock
9   : Number caught from each stock
10  : Number caught by each fleet
11  : Weight and value of the catch of each fleet
12  : Percentage fish died due to fishing
13  : Percentage fish died due to the predator (the cod)
14  : Year class strenghts and spawning stock biomasses
15  : Costs, income and profit (book-keeping for a single year)
16  : Food selection of cod (food suitabilities)
17  : Grafical display
18  : Relative stomach content of cod
RETURN : Stop displaying results - return to the game  [1]
```

```
   Mean weight at age (Kg.)
age        Cod         Plaice        Herring
---------------------------------------------
 1          0.49        0.09          0.06
 2          1.66        0.17          0.10
 3          3.40        0.28          0.14
 4          5.45        0.39          0.17
 5          7.59        0.52          0.19
 6          9.67        0.64          0.21
 7         11.59        0.76          0.23
 8         13.30        0.88          0.24
 9         14.78        0.99          0.25
10         16.06        1.09          0.25
Back to the large menu : RETURN   [RETURN]
```

```
SELECT A COURSE FROM THE LAEGE MENU :
-------------------------------------
1   : Mean weight at age in the three stocks
2   : Mean lenghts at age in the three stocks
3   : Kg-prices at age and species
4   : Cost per effort unit, interest and instalment
5   : Fishing effort and investments in the foregoing years
6   : Mesh sizes used in the foregoing years
7   : Directivities used in the foregoing years
8   : Number of survivors in each stock
9   : Number caught from each stock
10  : Number caught by each fleet
11  : Weight and value of the catch of each fleet
12  : Percentage fish died due to fishing
13  : Percentage fish died due to the predator (the cod)
14  : Year class strenghts and spawning stock biomasses
15  : Costs, income and profit (book-keeping for a single year)
16  : Food selection of cod (food suitabilities)
17  : Grafical display
18  : Relative stomach content of cod
RETURN : Stop displaying results - return to the game  [2]
```

```
   Mean length (cm) at age
age        Cod         Plaice        Herring
---------------------------------------------
 1         36.54       18.12         18.51
 2         55.00       22.56         21.66
 3         69.81       26.38         23.94
 4         81.70       29.67         25.60
 5         91.23       32.50         26.81
 6         98.89       34.94         27.68
 7        105.03       37.04         28.32
 8        109.96       38.84         28.78
 9        113.92       40.40         29.11
10        117.10       41.74         29.36
Back to the large menu : RETURN   [RETURN]
```

```
SELECT A COURSE FROM THE LAEGE MENU :
-------------------------------------
1   : Mean weight at age in the three stocks
2   : Mean lenghts at age in the three stocks
3   : Kg-prices at age and species
4   : Cost per effort unit, interest and instalment
5   : Fishing effort and investments in the foregoing years
6   : Mesh sizes used in the foregoing years
7   : Directivities used in the foregoing years
8   : Number of survivors in each stock
9   : Number caught from each stock
10  : Number caught by each fleet
11  : Weight and value of the catch of each fleet
12  : Percentage fish died due to fishing
13  : Percentage fish died due to the predator (the cod)
14  : Year class strenghts and spawning stock biomasses
15  : Costs, income and profit (book-keeping for a single year)
16  : Food selection of cod (food suitabilities)
17  : Grafical display
18  : Relative stomach content of cod
RETURN : Stop displaying results - return to the game  [5]
```

NOTE:

In the slow mode the menu-list will be displayed on the video before any course is displayed. We have now seen the menu-list three times, and in the following pages you will only see it once again, in order to reduce the number of pages in this report.

You can surpress the video display of the menu-list by selecting the fast mode as will be demonstrated later.

Courses 3 and 4 have already been shown in the introductory shreen displays and they are not repeaded here.

[5]

Number of effort units and investments

year	fleet 1 effort u.	fleet 1 invest.	fleet 2 effort u.	fleet 2 invest.
1982	250	500	250	500
1983	250	0	250	0
1984	300	500	250	0

Back to the large menu : RETURN

[6]

Mesh size (mm) in each year

year	fleet 1	fleet 2
1982	80	30
1983	120	30
1984	50	50

[7]

Directivity of effort (percentage) in each year

Yr	Cod fleet 1	Cod fleet 2	Plaice fleet 1	Plaice fleet 2	Herring fleet 1	Herring fleet 2
1982	80	0	20	30	0	70
1983	80	0	20	30	0	70
1984	50	0	50	30	0	70

[8]

Which year do you want ? (default : 1984)
default : RETURN, no more year : type "0" [82]

Number of survivors at the beginning of 1982

age	Cod	Plaice	Herring
1	10000	200000	600000
2	6065	121306	363918
3	3679	73576	220728
4	2231	44626	133878
5	1353	27067	81201
6	821	16417	49251
7	498	9957	29872
8	302	6039	18118
9	183	3663	10989
10	282	5647	16940
Biomass (tons)	56628	96880	122052
Spawning	41660	58145	47006

stock biomass (tons) (biomass of age 3 and older fish)

Which year do you want ? (default : 1984)
default : RETURN, no more year : type "0" [RETURN]

Number of survivors at the beginning of 1984

age	Cod	Plaice	Herring
1	9789	205294	467033
2	7694	122205	254746
3	5385	75957	136597
4	1895	46881	83910
5	1103	28385	51969
6	670	17373	32114
7	408	10644	19765
8	247	6496	12121
9	150	3961	7411
10	231	6166	11530
Biomass (tons)	59328	59241	87608
Spawning	41753	49879	32091

stock biomass (tons) (biomass of age 3 and older fish)
Which year do you want ? (default : 1984)
default : RETURN, no more year : type "0" [0]

[9]

Which year do you want ? (default : 1984)
default : RETURN, no more year : type "0" [1983]

Total number of fish caught in year 1983

age	Cod	Plaice	Herring
1	57	29600	164309
2	885	18311	88169
3	1077	11391	53845
4	739	7171	33159
5	458	4728	20398
6	279	3176	12511
7	169	2108	7653
8	103	1368	4671
9	62	869	2846
10	96	1387	4406
Catch (tons)	21157	21390	43589

Which year do you want ? (default : 1984)
default : RETURN, no more year : type "0" [RETURN]

Total number of fish caught in year 1984

age	Cod	Plaice	Herring
1	2773	71385	50397
2	2265	46241	59184
3	1600	29253	38734
4	565	18282	25197
5	329	11174	15946
6	200	6887	9955
7	122	4242	6162
8	74	2600	3792
9	45	1590	2324
10	69	2481	3621
Catch (tons)	22239	49512	27731

Which year do you want ? (default : 1984)
default : RETURN, no more year : type "0" [0]

[10]

Which year do you want ? (default : 1984)
default : RETURN, no more year : type "0" [RETURN]

Number of fish caught by each fleet in year 1984

age	Cod fleet 1	Cod fleet 2	Plaice fleet 1	Plaice fleet 2	Herring fleet 1	Herring fleet 2
1	2773	0	47590	23795	0	50397
2	2265	0	30828	15414	0	59184
3	1600	0	19502	9751	0	38734
4	565	0	12188	6094	0	25197
5	329	0	7449	3725	0	15946
6	200	0	4592	2296	0	9955
7	122	0	2828	1414	0	6162
8	74	0	1733	867	0	3792
9	45	0	1060	530	0	2324
10	69	0	1654	827	0	3621
catch (tons)	22239	0	33008	16504	0	27731

Which year do you want ? (default : 1984)
default : RETURN, no more year : type "0" [83]

Number of fish caught by each fleet in year 1983

age	Cod fleet 1	Cod fleet 2	Plaice fleet 1	Plaice fleet 2	Herring fleet 1	Herring fleet 2
1	57	0	84	29517	0	164309
2	885	0	197	18114	0	88169
3	1077	0	371	11021	0	53845
4	739	0	558	6613	0	33159
5	458	0	689	4039	0	20398
6	279	0	695	2481	0	12511
7	169	0	587	1521	0	7653
8	103	0	437	931	0	4671
9	62	0	301	569	0	2846
10	96	0	503	885	0	4406
catch (tons)	21157	0	2838	18552	0	43589

Which year do you want ? (default : 1984)
default : RETURN, no more year : type "0" [0]

[11]

Catch in tons and value of catch each year

	fleet 1 tons	fleet 1 value (Dkr)	fleet 2 tons	fleet 2 value (Dkr)
1982	35239	2337	71522	3303
1983	23995	1692	62141	2891
1984	55247	3295	44235	2275

[12]

Which year do you want ? (default : 1984)
default : RETURN, no more year : type "0" [RETURN]

Percentage fish dead due to fishing in year 1984

age	Cod	Plaice	Herring
1	28.32	34.77	10.79
2	29.43	37.84	23.23
3	29.71	38.51	28.36
4	29.81	39.00	30.03
5	29.84	39.37	30.68
6	29.85	39.64	31.00
7	29.85	39.85	31.18
8	29.85	40.02	31.29
9	29.85	40.14	31.36
10	29.85	40.24	31.40

Which year do you want ? (default : 1984)
default : RETURN, no more year : type "0" [0]

[13]

Which year do you want ? (default : 1984)
default : RETURN, no more year : type "0"

Percentage of fish dead due to predation (by cod) in year 1984

age	Cod	Plaice	Herring
1	7.88	14.56	17.47
2	2.40	12.41	15.65
3	0.80	10.23	14.25
4	0.25	8.39	13.32
5	0.05	6.96	12.66
6	0.00	5.88	12.18
7	0.00	5.06	11.83
8	0.00	4.38	11.58
9	0.00	3.91	11.40
10	0.00	3.54	11.27

Which year do you want ? (default : 1984)
default : RETURN, no more year : type "0"

[14]

Year class strength (number of 1 year old fish)
and spawning stock biomass (3 year and older fish) on 1. January.

year	Cod Yr. cl.	Cod S.S.B.	Plaice Yr. cl.	Plaice S.S.B.	Herring Yr. cl.	Herring S.S.B.
1932	10000	59922	200000	84874	600000	96946
1983	9461	53795	198838	83894	532049	77222
1984	9789	57450	205294	89490	467033	61773

[15]

Which year do you want ? (default : 1984)
default : RETURN, no more year : type "0" [RETURN]

Costs, income and profit in year 1984

	fleet 1 catch (tons)	fleet 1 value of catch (Dkr)	fleet 2 catch (tons)	fleet 2 value of catch (Dkr)
Cod	22239	1352	0	0
Plaice	33008	1943	16504	972
Herring	0	0	27731	1303
Total	55247	3295	44235	2275
Costs of fishery		900		750
Instalm.+Interest		230		130
profit		2395		1525
Accumulated profit		4454		5849

Which year do you want ? (default : 1984)
default : RETURN, no more year : type "0" [0]

[16]

Food selection of cod
Which age group do you want ? (RETURN if you do not want more age grc
food preference of 2 years old cod [2]

age	Cod	Plaice	Herring
1	0.007	0.047	0.059
2	0.000	0.026	0.042
3	0.000	0.016	0.033
4	0.000	0.010	0.027
5	0.000	0.007	0.024
6	0.000	0.005	0.021
7	0.000	0.004	0.020
8	0.000	0.000	0.019
9	0.000	0.000	0.018
10	0.000	0.000	0.017

"other food" 0.600
yearly food consumption of 2 years old cod : 7.5 kg.
Biomass of "other food" : 300000 tons

Food selection of cod
Which age group do you want ? (RETURN if you do not want more age gr
food preference of 10 years old cod [10]

age	Cod	Plaice	Herring
1	0.039	0.048	0.042
2	0.016	0.051	0.049
3	0.007	0.048	0.051
4	0.003	0.043	0.051
5	0.002	0.038	0.051
6	0.000	0.034	0.051
7	0.000	0.030	0.050
8	0.000	0.027	0.050
9	0.000	0.025	0.049
10	0.000	0.023	0.049

"other food" 0.070
yearly food consumption of 10 years old cod : 46.1 kg.
Biomass of "other food" : 300000 tons
[RETURN]

[17]

WHICH GRAPH DO YOU WANT TO SEE ?
1 : Accumulated profit
2 : Profit
3 : Total catch (tons)
4 : Costs (number of effort units)
5 : Income
6 : Investments
7 : Catch and total biomass of cod
8 : Catch and total biomass of plaice
9 : Catch and total biomass of herring
10 : Spawning stock biomass and recruitment of cod
11 : Spawning stock biomass and recruitment of plaice
12 : Spawning stock biomass and recruitment of herring
RETURN : I do not want to see more curves [2]

```
Profit
 2453 I 2
      I
      I         1
      I
      I    2
      I
      I
 1628 I-----------------------------
      I
      I 1
      I         2
      I
      I
      I
  802 I    1
      --I--I--I--I--I--I--I--I--I--I
       82 83 84 85 86 87 88 89 90 91
To continue - press "RETURN"   [RETURN]
```

```
WHICH GRAPH DO YOU WANT TO SEE ?
 1 : Accumulated profit
 2 : Profit
 3 : Total catch (tons)
 4 : Costs (number of effort units)
 5 : Income
 6 : Investments
 7 : Catch and total biomass of cod
 8 : Catch and total biomass of plaice
 9 : Catch and total biomass of herring
10 : Spawning stock biomass and recruitment of cod
11 : Spawning stock biomass and recruitment of plaice
12 : Spawning stock biomass and recruitment of herring
RETURN : I do not want to see more curves
```

3

```
Catch (tons)
  71522 I 2
        I
        I
        I     2
        I
        I        1
        I
  47759 I-----------------------------
        I        2
        I
        I
        I  1
        I
  23995 I    1
        --I--I--I--I--I--I--I--I--I--I
         82 83 84 85 86 87 88 89 90 91
To continue - press "RETURN"
```

RETURN

NOTE: Before any graph is displyed the list of graphs is displayed on the video. In the following these displays are omitted.
Graphs 1, 7, 8 and 9 are those displayed automatically after every year, so they are not shown here.

4

```
Costs
   300 I        1
       I
       I
       I
       I
   275 I---------------------------
       I
       I
       I
       I
   250 I12 12  2
       --I--I--I--I--I--I--I--I--I--I
        82 83 84 85 86 87 88 89 90 91
To continue - press "RETURN"
```

5

```
Income
  3303 I 2      1
       I
       I
       I    2
       I
  2498 I---------------------------
       I 1      2
       I
       I
       I
  1692 I    1
       --I--I--I--I--I--I--I--I--I--I
        82 83 84 85 86 87 88 89 90 91
To continue - press "RETURN"
```

6

```
Investments
   500 I12      1
       I
       I
       I
       I
       I
       I
       I
       I
       I
     0 I   12  2
       --I--I--I--I--I--I--I--I--I--I
        82 83 84 85 86 87 88 89 90 91
To continue - press "RETURN"
```

10

```
Spawning stock biomass (age 3 and older) and recruitment (number of 1
of Cod         .  min. biomass =   3711  min. recruitment =     9461
                  max. biomass =   4533  max. recruitment =    10000
        0 I S
          I
          I
          I
          I
          I
          I R
        0 I----S--R--------------------
          I
          I
          I     R
          I
          I
          I
        0 I        S
         --I--I--I--I--I--I--I--I--I--I
          82 83 84 85 86 87 88 89 90 91
To continue - press "RETURN"
```

11

```
Spawning stock biomass (age 3 and older) and recruitment (number of
of Plaice      .  min. biomass =   6157  min. recruitment =   198838
                  max. biomass =   6724  max. recruitment =   205294
        0 I        S
          I
          I
          I
          I
          I        R
          I
        0 I-----------------------------
          I
          I R   S
          I     R
          I
          I
          I
        0 I S
         --I--I--I--I--I--I--I--I--I--I
          82 83 84 85 86 87 88 89 90 91
```

12

```
Spawning stock biomass (age 3 and older) and recruitment (number of
of Herring     .  min. biomass =   2917  min. recruitment =   467033
                  max. biomass =   4285  max. recruitment =   600000
        0 I S
          I
          I R
          I
          I
          I
        0 I----R------------------------
          I    S
          I
          I
          I
          I        R
        0 I        S
         --I--I--I--I--I--I--I--I--I--I
          82 83 84 85 86 87 88 89 90 91
```

```
WHICH GRAPH DO YOU WANT TO SEE ?
 1 : Accumulated profit
 2 : Profit
 3 : Total catch (tons)
 4 : Costs (number of effort units)
 5 : Income
 6 : Investments
 7 : Catch and total biomass of cod
 8 : Catch and total biomass of plaice
 9 : Catch and total biomass of herring
10 : Spawning stock biomass and recruitment of cod
11 : Spawning stock biomass and recruitment of plaice
12 : Spawning stock biomass and recruitment of herring
RETURN : I do not want to see more curves [RETURN]

Back to the large menu : RETURN [RETURN]
```

18

```
Which year do you want ? (default : 1984) [RETURN]
default : RETURN, no more year : type "0"
```

Relative cod-stomach content*10000 of Cod in year 1984

prey age / cod age	1	2	3	4	5	6	7	8	9	10
1	0	1	6	17	28	41	43	46	47	48
2	0	0	3	10	21	34	40	46	50	53
3	0	0	0	0	10	18	23	27	30	33
4	0	0	0	0	0	0	6	7	8	9
5	0	0	0	0	0	0	0	0	0	4
6	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0

[RETURN]

Relative cod-stomach content*10000 of Plaice in year 1984

prey age / cod age	1	2	3	4	5	6	7	8	9	10
1	0	31	83	158	204	249	232	219	210	202
2	0	20	66	143	203	265	260	255	252	248
3	0	12	45	108	165	226	230	233	234	235
4	0	6	28	73	117	167	174	180	184	187
5	0	3	16	45	76	112	119	125	130	133
6	0	2	9	28	48	72	78	83	87	90
7	0	1	5	17	29	45	50	54	57	59
8	0	0	3	10	18	28	31	34	36	38
9	0	0	1	6	11	17	19	21	22	23
10	0	0	2	9	17	27	30	33	36	38

[RETURN]

Relative cod-stomach content*10000 of Herring in year 1984

prey age / cod age	1	2	3	4	5	6	7	8	9	10
1	0	75	180	317	390	459	416	385	363	345
2	0	44	122	237	312	386	363	345	332	321
3	0	24	73	150	207	264	254	247	240	235
4	0	14	47	103	145	190	185	182	179	176
5	0	9	30	68	98	130	128	127	126	124
6	0	5	19	44	64	86	85	85	84	84
7	0	3	12	27	41	55	55	55	55	55
8	0	2	7	17	25	35	35	35	35	35
9	0	1	4	10	16	21	22	22	22	22
10	0	1	7	16	25	34	34	35	35	35

Relative cod-stomach content*10000 of "other food" in year 1984

Cod age	1	2	3	4	5	6	7	8	9	10
1	10000	9739	9219	8378	7721	7029	7075	7109	7135	7156

Which year do you want ? (default : 1984)
default : RETURN, no more year : type "0" [0]

SELECT A COURSE FROM THE LAEGE MENU :

1 : Mean weight at age in the three stocks
2 : Mean lenghts at age in the three stocks
3 : Kg-prices at age and species
4 : Cost per effort unit, interest and instalment
5 : Fishing effort and investments in the foregoing years
6 : Mesh sizes used in the foregoing years
7 : Directivities used in the foregoing years
8 : Number of survivors in each stock
9 : Number caught from each stock
10 : Number caught by each fleet
11 : Weight and value of the catch of each fleet
12 : Percentage fish died due to fishing
13 : Percentage fish died due to the predator (the cod)
14 : Year class strenghts and spawning stock biomasses
15 : Costs, income and profit (book-keeping for a single year)
16 : Food selection of cod (food suitabilities)
17 : Grafical display
18 : Relative stomach content of cod
RETURN : Stop displaying results - return to the game [RETURN]

GIVE MESH SIZES FOR EACH FLEET IN YEAR 1985

By using the "RETURN" key, the decision of this year
becomes the same as last years decision
mesh size of fleet 1 (mm) .Last years decision : 50 [RETURN]
mesh size of fleet 2 (mm) .Last years decision : 50 [RETURN]

NOTE: Al causes of the large menu have now been shown and we are back in the game. To reduse the size of the report the full display for the years 1985 - 1990 are not shown. Next page shows the resumes of the decisions taken in this period and then we continue with the last year, 1991.

The following decisions were taken in year 1985

	fleet 1	fleet 2
Mesh size	50	50
Number of effort u.	300	250
Investments (ef.u.)	0	0
Directivity Cod	50	20
Directivity Plaice	50	50
Directivity Herring	0	30

The following decisions were taken in year 1986

	fleet 1	fleet 2
Mesh size	50	50
Number of effort u.	300	250
Investments (ef.u.)	0	0
Directivity Cod	50	30
Directivity Plaice	50	50
Directivity Herring	0	20

The following decisions were taken in year 1987

	fleet 1	fleet 2
Mesh size	50	20
Number of effort u.	300	250
Investments (ef.u.)	0	0
Directivity Cod	70	30
Directivity Plaice	30	20
Directivity Herring	0	50

The following decisions were taken in year 1988

	fleet 1	fleet 2
Mesh size	50	20
Number of effort u.	300	250
Investments (ef.u.)	0	0
Directivity Cod	70	30
Directivity Plaice	30	20
Directivity Herring	0	50

The following decisions were taken in year 1989

	fleet 1	fleet 2
Mesh size	20	20
Number of effort u.	300	250
Investments (ef.u.)	0	0
Directivity Cod	20	20
Directivity Plaice	30	20
Directivity Herring	50	60

The following decisions were taken in year 1990

	fleet 1	fleet 2
Mesh size	20	20
Number of effort u.	300	250
Investments (ef.u.)	0	0
Directivity Cod	20	20
Directivity Plaice	30	20
Directivity Herring	50	60

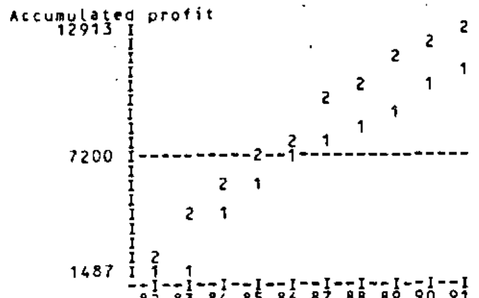
```
GIVE MESH SIZES FOR EACH FLEET IN YEAR 1991
-------------------------------------------------------------------
By using the "RETURN" key, the decision of this year
becomes the same as last years decision
mesh size of fleet 1 (mm) .Last years decision :    20 [RETURN]
mesh size of fleet 2 (mm) .Last years decision :    20 [RETURN]
```

```
GIVE NUMBER OF EFFORT UNITS FOR EACH FLEET IN YEAR 1991
-------------------------------------------------------------------
By using the "RETURN" key, the decision of this year
becomes the same as last years decision
Number of effort units of fleet 1 .Last years decision :   300 [RETURN]
Number of effort units of fleet 2 .Last years decision :   250 [RETURN]
```

```
GIVE DIRECTIVITY FOR EACH OF THE 3 STOCKS , IN YEAR 1991
-------------------------------------------------------------------
By using the "RETURN" key, the decision of this year
becomes the same as last years decision

Directivity of fleet no.  1
Percentage for Cod          .Last years decision :   20 [RETURN]
Percentage for Plaice       .Last years decision :   30 [RETURN]
percentage for Herring                               50

Directivity of fleet no.  2
Percentage for Cod          .Last years decision :   20 [RETURN]
Percentage for Plaice       .Last years decision :   20 [RETURN]
percentage for Herring                               60
```

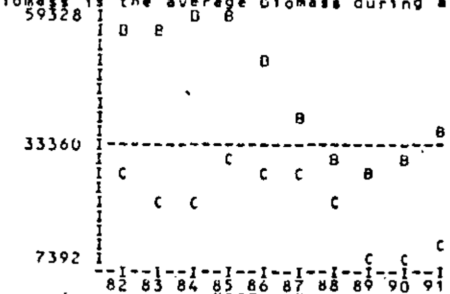
```
The following decisions were taken in year 1991
                        fleet 1   fleet 2
-------------------------------------------------
Mesh size                  20        20
Number of effort u.       300       250
Investments (ef.u.)         0         0
Directivity Cod            30        20
Directivity Plaice         30        20
Directivity Herring        40        60
-------------------------------------------------
Is input for year 1991 ok ? (yes=RETURN, no=1)
(Or should fleet 1 take decisions after fleet 2 ?) [RETURN]
```

Accumulated profit



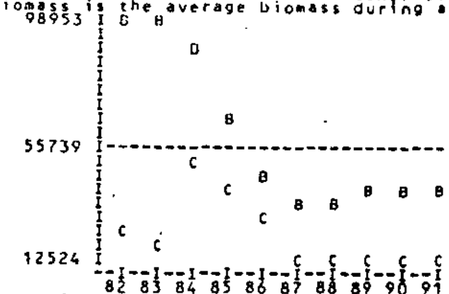
To continue - press "RETURN" [RETURN]

Catch (tons) and total biomass (tons) of Cod
(biomass is the average biomass during a year)



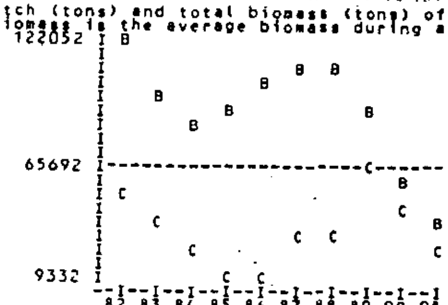
To continue - press "RETURN" [RETURN]

Catch (tons) and total biomass (tons) of Plaice
(biomass is the average biomass during a year)



To continue - press "RETURN" [RETURN]

Catch (tons) and total biomass (tons) of Herring
(biomass is the average biomass during a year)



To continue - press "RETURN" [RETURN]

```
Do you want the small or the large menue ?
(small=1, large=2, none=RETURN) [1]
```

```
SELECT A COURSE FROM THE SMALL MENU :
1 : Number of survivors
2 : Total number caught
3 : Total fishing mortality
4 : Predation mortality
5 : Number caught by each fleet
6 : Fishing mortality by each fleet
RETURN : Stop displaying results - return to game [1]
```

which species do you want ? (cod=1,plaice=2,herring=3,none=RETURN) [1]

Number of survivors :

Cod age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	10000	9461	9789	10305	9715	8765	7172	5810	6497	7329
2	6065	7074	7694	5501	5077	4528	3583	3002	3779	4183
3	3679	3249	5385	4641	2923	2538	1959	1560	2029	2546
4	2231	1997	1895	3315	2521	1492	1116	865	1066	1385
5	1353	1220	1103	1175	1814	1296	660	494	592	731
6	821	742	670	685	644	935	575	293	340	407
7	498	450	408	417	376	332	415	255	201	233
8	302	273	247	253	229	194	147	184	175	138
9	183	166	150	154	139	118	86	65	126	121
10	282	255	231	237	214	182	133	97	112	164

[RETURN]

which species do you want ? (cod=1,plaice=2,herring=3,none=RETURN) [2]

Number of survivors :

Plaice age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	200000	198838	205294	175706	134549	101913	102393	106631	111884	115606
2	121306	120703	122205	90032	67730	52904	56191	59219	61144	62796
3	73576	72532	75957	52542	33704	25732	29148	32281	34374	34850
4	44626	43187	46881	33730	20361	13204	14533	17035	19043	19980
5	27067	26325	28385	21415	13477	8203	7624	8627	10190	11256
6	16417	16213	17373	13249	8758	5548	4818	4581	5217	6103
7	9957	9978	10644	8240	5513	3664	3301	2922	2794	3155
8	6039	6123	6496	5110	3474	2335	2202	2016	1793	1702
9	3663	3749	3961	3149	2176	1485	1414	1352	1243	1099
10	5647	5839	6166	4959	3491	2448	2402	2358	2300	2186

[RETURN]

which species do you want ? (cod=1,plaice=2,herring=3,none=RETURN) [3]

Number of survivors :

Herring age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	600000	532049	467033	427121	475959	526035	524871	523956	406070	297626
2	363918	284433	254746	297439	289314	335846	295030	308601	201416	152716
3	220728	172867	136597	136738	187880	194735	188630	173713	118835	75897
4	133878	105978	83910	68535	84588	124991	110262	111684	67193	45072
5	81201	64957	51969	41515	42460	56472	71349	65654	43422	25646
6	49251	39734	32114	25714	25875	28521	32451	42681	25633.	16659
7	29872	24255	19765	15938	16119	17476	16473	19481	16717	9873
8	18118	14782	12121	9841	10038	10935	10132	9915	7648	6457
9	10989	8997	7411	6051	6220	6832	6357	6110	3899	2961
10	16940	13920	11530	9485	9856	10980	10385	10117	6394	3993

which species do you want ? (cod=1,plaice=2,herring=3,none=RETURN) [RETURN]

```
SELECT A COURSE FROM THE SMALL MENU :
1 : Number of survivors
2 : Total number caught
3 : Total fishing mortality
4 : Predation mortality
5 : Number caught by each fleet
6 : Fishing mortality by each fleet
RETURN : Stop displaying results - return to game [2]
```

which species do you want ? (cod=1,plaice=2,herring=3,none=RETURN) [1]

Number of fish caught :

Cod age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	1178	57	2773	3669	3798	4108	3396	1299	1445	1995
2	2220	885	2265	2038	2060	2184	1734	683	859	1167
3	1376	1077	1600	1737	1197	1233	953	357	464	715
4	838	739	565	1245	1036	727	544	198	244	390
5	509	458	329	442	746	632	322	113	136	206
6	309	279	200	258	265	456	280	67	78	115
7	187	169	122	157	155	162	202	59	46	66
8	114	103	74	95	94	95	72	42	40	39
9	69	62	45	58	57	58	42	15	29	34
10	106	96	69	89	88	89	65	22	26	46

[RETURN]

```
which species do you want ? (cod=1,plaice=2,herring=3,none=RETURN) [RETURN]

SELECT A COURSE FROM THE SMALL MENU :
1 : Number of survivors
2 : Total number caught
3 : Total fishing mortality
4 : Predation mortality
5 : Number caught by each fleet
6 : Fishing mortality by each fleet
RETURN : Stop displaying results - return to game [3]
```

```
which species do you want ? (cod=1,plaice=2,herring=3,none=RETURN) [1]
```

Fishing mortalities :

Cod age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.139	0.007	0.373	0.497	0.559	0.709	0.709	0.275	0.275	0.350
2	0.492	0.143	0.375	0.500	0.562	0.712	0.712	0.275	0.275	0.350
3	0.500	0.429	0.375	0.500	0.562	0.712	0.712	0.275	0.275	0.350
4	0.500	0.491	0.375	0.500	0.562	0.712	0.712	0.275	0.275	0.350
5	0.500	0.498	0.375	0.500	0.562	0.713	0.713	0.275	0.275	0.350
6	0.500	0.500	0.375	0.500	0.562	0.713	0.713	0.275	0.275	0.350
7	0.500	0.500	0.375	0.500	0.562	0.713	0.713	0.275	0.275	0.350
8	0.500	0.500	0.375	0.500	0.562	0.713	0.713	0.275	0.275	0.350
9	0.500	0.500	0.375	0.500	0.562	0.713	0.713	0.275	0.275	0.350
10	0.500	0.500	0.375	0.500	0.562	0.713	0.713	0.275	0.275	0.350

```
which species do you want ? (cod=1,plaice=2,herring=3,none=RETURN) [RETURN]
```

```
SELECT A COURSE FROM THE SMALL MENU :
1 : Number of survivors
2 : Total number caught
3 : Total fishing mortality
4 : Predation mortality
5 : Number caught by each fleet
6 : Fishing mortality by each fleet
RETURN : Stop displaying results - return to game [4]
```

```
which species do you want ? (cod=1,plaice=2,herring=3,none=RETURN) [3]
```

Predation mortalities :

Herring age	1982	1983	1964	1985	1986	1987	198R	1989	1990	1991
1	0.210	0.200	0.217	0.232	0.210	0.166	0.118	0.106	0.128	0.151
2	0.207	0.196	0.210	0.226	0.207	0.164	0.117	0.105	0.126	0.148
3	0.196	0.185	0.197	0.212	0.195	0.156	0.112	0.100	0.119	0.140
4	0.186	0.175	0.185	0.200	0.185	0.148	0.106	0.095	0.113	0.132
5	0.177	0.167	0.176	0.190	0.176	0.142	0.101	0.091	0.108	0.126
6	0.171	0.161	0.169	0.182	0.169	0.136	0.098	0.087	0.104	0.121
7	0.166	0.156	0.164	0.177	0.164	0.133	0.095	0.085	0.101	0.118
8	0.163	0.153	0.161	0.173	0.161	0.130	0.093	0.083	0.099	0.115
9	0.160	0.150	0.158	0.170	0.158	0.128	0.092	0.082	0.098	0.114
10	0.158	0.149	0.156	0.168	0.156	0.126	0.091	0.081	0.096	0.112

```
which species do you want ? (cod=1,plaice=2,herring=3,none=RETURN) [RETURN]
```

```
SELECT A COURSE FROM THE SMALL MENU :
1 : Number of survivors
2 : Total number caught
3 : Total fishing mortality
4 : Predation mortality
5 : Number caught by each fleet
6 : Fishing mortality by each fleet
RETURN : Stop displaying results - return to game [5]

which fleet do you want ? (1 or 2) [1]
```

```
which species do you want ? (cod=1,plaice=2,herring=3,none=RETURN) [1]

FLEET NO.  1

Number of fish caught :
```

Cod age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	1178	57	2773	2752	2532	3022	2498	708	788	1283
2	2220	885	2265	1529	1373	1610	1277	373	468	750
3	1376	1077	1600	1303	798	909	702	195	253	460
4	838	739	565	934	690	536	401	108	133	251
5	509	458	329	331	497	466	237	62	74	132
6	309	279	200	193	177	336	207	37	42	74
7	187	169	122	118	103	119	149	32	25	42
8	114	103	74	71	63	70	53	23	22	25
9	69	62	45	43	38	42	31	8	16	22
10	106	96	69	67	59	66	48	12	14	30

```
which species do you want ? (cod=1,plaice=2,herring=3,none=RETURN) [2]

FLEET NO.  1

Number of fish caught :
```

Plaice age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	1245	84	47590	38548	29767	15682	16100	18403	19123	19563
2	4041	197	30828	21414	16209	8932	9668	10277	10524	10716
3	5336	371	19502	12727	8202	4409	5073	5644	5969	6010
4	4034	558	12188	8278	5015	2286	2548	2997	3332	3477
5	2594	689	7449	5308	3350	1431	1344	1525	1794	1973
6	1606	695	4592	3309	2192	974	853	813	923	1075
7	983	587	2828	2069	1387	646	586	520	496	556
8	600	437	1733	1289	878	413	392	360	319	302
9	365	301	1060	797	551	263	252	242	222	195
10	564	503	1654	1258	887	435	429	422	411	389

```
which species do you want ? (cod=1,plaice=2,herring=3,none=RETURN) [RETURN]
```

```
SELECT A COURSE FROM THE SMALL MENU :
1 : Number of survivors
2 : Total number caught
3 : Total fishing mortality
4 : Predation mortality
5 : Number caught by each fleet
6 : Fishing mortality by each fleet
RETURN : Stop displaying results - return to game [6]

which fleet do you want ? (1 or 2) [1]
```

```
which species do you want ? (cod=1,plaice=2,herring=3,none=RETURN) [1]

FLEET NO.  1

Fishing mortalities :
```

Cod age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.139	0.007	0.373	0.373	0.373	0.522	0.522	0.150	0.150	0.225
2	0.492	0.143	0.375	0.375	0.375	0.525	0.525	0.150	0.150	0.225
3	0.500	0.429	0.375	0.375	0.375	0.525	0.525	0.150	0.150	0.225
4	0.500	0.491	0.375	0.375	0.375	0.525	0.525	0.150	0.150	0.225
5	0.500	0.498	0.375	0.375	0.375	0.525	0.525	0.150	0.150	0.225
6	0.500	0.500	0.375	0.375	0.375	0.525	0.525	0.150	0.150	0.225
7	0.500	0.500	0.375	0.375	0.375	0.525	0.525	0.150	0.150	0.225
8	0.500	0.500	0.375	0.375	0.375	0.525	0.525	0.150	0.150	0.225
9	0.500	0.500	0.375	0.375	0.375	0.525	0.525	0.150	0.150	0.225
10	0.500	0.500	0.375	0.375	0.375	0.525	0.525	0.150	0.150	0.225

```
which species do you want ? (cod=1,plaice=2,herring=3,none=RETURN) [2]

FLEET NO.  1

Fishing mortalities :
```

Plaice age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.008	0.001	0.340	0.340	0.340	0.204	0.204	0.225	0.225	0.225
2	0.043	0.002	0.374	0.374	0.374	0.224	0.224	0.225	0.225	0.225
3	0.094	0.006	0.375	0.375	0.375	0.225	0.225	0.225	0.225	0.225
4	0.116	0.016	0.375	0.375	0.375	0.225	0.225	0.225	0.225	0.225
5	0.123	0.032	0.375	0.375	0.375	0.225	0.225	0.225	0.225	0.225
6	0.124	0.052	0.375	0.375	0.375	0.225	0.225	0.225	0.225	0.225
7	0.125	0.072	0.375	0.375	0.375	0.225	0.225	0.225	0.225	0.225
8	0.125	0.088	0.375	0.375	0.375	0.225	0.225	0.225	0.225	0.225
9	0.125	0.099	0.375	0.375	0.375	0.225	0.225	0.225	0.225	0.225
10	0.125	0.106	0.375	0.375	0.375	0.225	0.225	0.225	0.225	0.225

which species do you want ? (cod=1,plaice=2,herring=3,none=RETURN) [3]

FLEET NO. 1

Fishing mortalities :

Herring age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.375	0.375	0.300
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.375	0.375	0.300
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.375	0.375	0.300
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.375	0.375	0.300
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.375	0.375	0.300
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.375	0.375	0.300
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.375	0.375	0.300
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.375	0.375	0.300
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.375	0.375	0.300
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.375	0.375	0.300

which species do you want ? (cod=1,plaice=2,herring=3,none=RETURN) [RETURN]

mesh	80	120	50	50	50	50	50	20	20	20
effort	250	250	300	300	300	300	300	300	300	300
1 byc.	80.00	80.00	50.00	50.00	50.00	70.00	70.00	20.00	20.00	30.00
2 byc.	20.00	20.00	50.00	50.00	50.00	30.00	30.00	30.00	30.00	30.00
3 byc.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00	50.00	40.00

[RETURN]

SELECT A COURSE FROM THE SMALL MENU :
1 : Number of survivors
2 : Total number caught
3 : Total fishing mortality
4 : Predation mortality
5 : Number caught by each fleet
6 : Fishing mortality by each fleet
RETURN : Stop displaying results - return to game [RETURN]

Do you want the small or the large menue ?
(small=1, large=2, none=RETURN) [RETURN]

GAME IS FINISHED

	Fleet 1	Fleet 2
Accum. profit	10851	12913
Loans not paid	0	0
Ac. prof.-loan	10851	12913

! FLEET NO 2 WON THE GAME !

To continue - press "RETURN" [RETURN]

SELECT A COURSE FROM THE LAEGE MENU :
1 : Mean weight at age in the three stocks
2 : Mean lenghts at age in the three stocks
3 : Kg-prices at age and species
4 : Cost per effort unit, interest and instalment
5 : Fishing effort and investments in the foregoing years
6 : Mesh sizes used in the foregoing years
7 : Directivities used in the foregoing years
8 : Number of survivors in each stock
9 : Number caught from each stock
10 : Number caught by each fleet
11 : Weight and value of the catch of each fleet
12 : Percentage fish died due to fishing
13 : Percentage fish died due to the predator (the cod)
14 : Year class strenghts and spawning stock biomasses
15 : Costs, income and profit (book-keeping for a single year)
16 : Food selection of cod (food suitabilities)
17 : Grafical display
18 : Relative stomach content of cod
RETURN : Stop displaying results - return to the game [RETURN]

NOTE:

This bringe us to the end of the testrun.

4. The model behind LAGS

This section contains a concentrated presentation of "Legion Analysis". All equations of Legion Analysis are presented and based on this section it is possible for an experienced modelmaker to see through everything that happens in LAGS.

The following indices are used

y:	index of year	y = 1982, 1983, ...
s:	index of species	s = 1, 2, 3.
e:	index of fleet	e = 1, 2.
a,b:	index of age group	a = 1,2, ... lo

4.1 Number of survivors and number caught

The number of survivors at the beginning of year y, of species s and agegroup a is

$$N(y,s,a) \quad \text{(unit: 1000 fish)}$$

The total mortality coefficient is

$$Z(y,s,a) \quad \text{(unit: years}^{-1}\text{)}$$

The number of survivors at the end of year y (or at the beginning of year y + 1) are given by

$$N(y+1,s,a+1) = N(y,s,a)\ \exp\ (-Z(y,s,a))$$

Z is assumed to remain constant during the year. Thus, Legion Analysis is based on difference equations.

The recruitment, i.e. N(y,s,1) will be explained in next subsection. The oldest age group (lo-group) is a plusgroup, i.e.

$$N(y+1,s,10) = N(y,s,9)\ \exp(-Z(y,s,9)) + N(y,s,10)\exp(-Z(y,s,10))$$

The average number of survisors during year y is

$$\bar{N}(y,s,a) = N(y,s,a)(1-\exp(-Z(y,s,a)))/Z(y,s,a)$$

The total number caught is given by

$$C(y,s,a) = F(y,s,a)\ \bar{N}(y,s,a)$$

where F(y,s,a) is the total fishing mortality coefficient.

The number of species s caught by fleet e is

$$C(y,e,s,a) = F(y,e,s,a)\ \bar{N}(y,s,a)$$

where F (y,e,s,a) is fishing mortality caused by fleet e.

$$C(y,s,a) = \sum_e C(y,e,s,a)$$

$$F(y,s,a) = \sum_e F(y,e,s,a)$$

The model for F(y,e,s,a) is given in subsections 4.4 and 4.5. The total mortality is split into three major terms

$$Z(y,s,a) = F(y,s,a) + M2(y,s,a) + M1$$

Where M2 is the predation mortality coefficient caused by cod and M1 is the natural mortality coefficient caused by other natural factors (disease, old age, spawning stress,etc) M1 is assumed to remain constant from year to year, from species to species and from age group to age group. The derivation of M2 is given in sub-section 4.8.

The number devoured by cod is determined by:

$$D(y,s,a) = M2(y,s,a)\ .\ \bar{N}(y,s,a)$$

4.2 Recruitment

LAGS allowes for two stock/recruitment models of users choice. The two models are both of the Beverton and Holt type:

$$N(y,s,1) = \frac{NOMAX(S)}{1+ HALFSAT(S)/SSB(y,S)}$$

where $SSB(y,s) = \sum_{a \geq 3} N(y,s,a) \cdot W(s,a)$

is the spawning stock biomass

W(s,a) is the average weight of an a years old fish (unit:kg).

Thus, in this model fish mature at the age of 3 years.

NOMAX(S) is the maximum recruitment (see Figure 4.2.1)and

HALFSAT is the SSB-value which produces NOMAX/2 recruits.

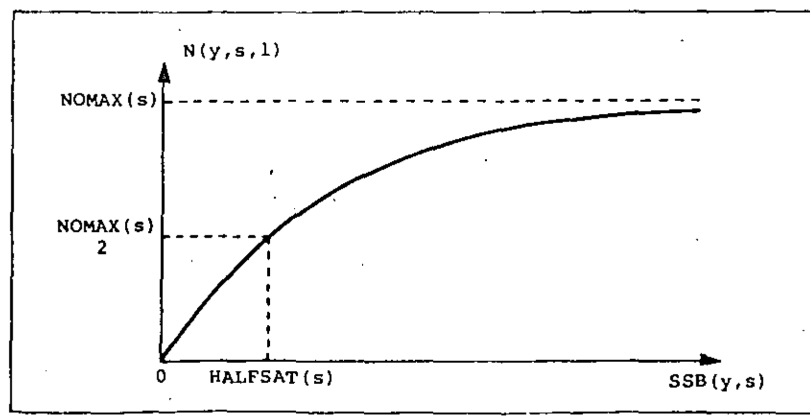


Figure 4.2.1. Stock/recruitment model.

One of the two alternative models, the deterministic model, is defined by the expression for N(y,s,1) given above. The other model, the stochastic model, is defined by:

$$N(y,s,1) = \frac{NOMAX(S)}{1 + HALFSAT(S)/SSB(y,s)} \cdot EBS$$

where EBS is a stochastic term. The actual values of EBS are drawn by aid of a random number generator. In this model EBS can take at most ten different values. Which values EBS is allowed to take can be specified by the user if he wishes so, and also the probability of each possible EBS value can be chosen by the user. (**How to do this is explained in subsection 4.2**).

4.3 Growth

Body weight and length growth are assumed to remain constant from year to year, and the average length of an a years old species s fish is given by the von Bertalanffy growth equation

$$LGT(S,a) = L8(S)\left[1-\exp\left\{-KBER(S)\cdot(a+0.5-TO(S))\right\}\right]$$

(unit:cm)

where L8(s) is the asymptotic length of species s, KBER(s) and TO(s) are the von Bertalanffy growth parameters. Body weight is determined by

$$W(S,a) = CONF(S)\cdot LGT(S,a)^3 \qquad \text{(unit .kg)}$$

where CONF(s) is the condition factor of species s.

4.4 Mesh selection

Both fleets are treated as if they used trawls. A certain proportion of the fish entering the gear is assumed to escape through the meshes. This proportions depends on the length, and thus also of the age, of the fish. The length of the fish at which 5o % of the fish escape, when entering the gear of fleet e is determined by

$$L5o(y,e,s) = MESH(y,e)\cdot SELFAC(s)$$

(unit of mesh: mm, unit of L5o: cm)

where MESH(y,e) is the mesh size used by fleet e in year y, and SELFAC is the selection factor of species s.

The selection range, i.e.

$$\frac{L75(y,e,s)}{L5o(y,e,s)}$$

is assumed to be a constant (selection range = 1.1)

The selection curve, i.e.

$$\text{Prob.}\left\{\text{the fish is retained} \mid \text{the length is LGT}\right\}$$

is given by:

$$GSEL(y,e,s,a) = \left[1+\exp\left\{-LGT(s,a)-L5o(y,s,a))\frac{1o.986}{L5o(y,s,a)}\right\}\right]^{-1}$$

$$\frac{1o.986}{L5o(y,s,a)} = \frac{\log(3)}{L75(y,s,a)-L5o(y,s,a)} \qquad \text{(see Figure 4.4)}$$

(**For a discussion of this model, see Hoydal *et. al.*, 1982**)

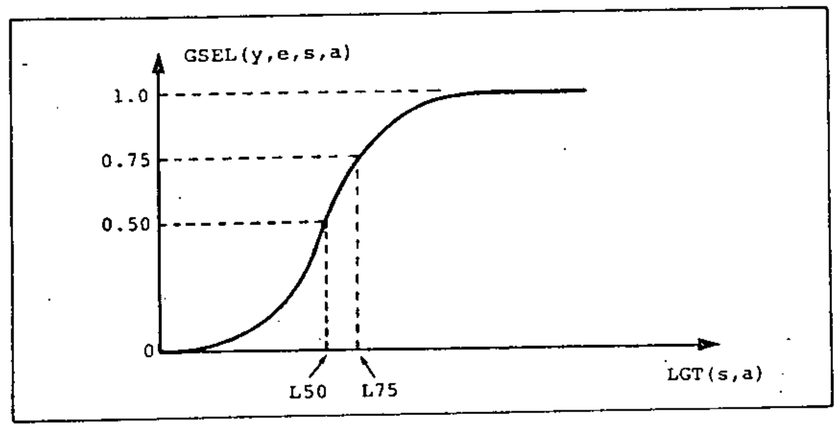


Figure 4.4. Gear selection curve.

4.5 Fishing mortality

Fishing mortality on species s, age group a caused by fleet e is given by

$$F(y,e,s,a))=BYC(y,e,s)EF(y,e)\cdot GSEL(y,e,s,a)\cdot ECON.$$

where EF(y,e) = number of effort units used by fleet e in year y.

BYC(y,e,s) ="directivity" of fleet e against species s.

ECON : a constant

BYC(y,e,s) determines the fraction of EF which is directed against species s. Thus,

$$\sum_{s=1}^{3} BYC(y,e,s) = 1.0$$

4.6 Catch in weight and income from sale of catch

The yield in weight of species s age group a caught in year y by fleet e is

$$YIELD(y,e,s,a)=C(y,e,s,a)\cdot W(s,a) \qquad \text{(unit: tonnes)}$$

And the return from that yield is

$$RETURN(y,e,s,a)=YIELD(y,e,s,a)\cdot PR(s,a)\cdot 1000$$

where PR is the kg price of fish species s age group a.
(unit of PR:D.kr.)
PR is a fixed price, independent of supply of fish to the market.

Total return to fleet e from the fishery in year y, thus becomes

$$RETURN(y,e) = \sum_{s=1}^{3}\sum_{a=1}^{10} RETURN(y,e,s,a)$$

4.7 Cod's food selection

The model of cod's food selection is in essence that of Andersen and Ursin, (1977).
In the present application, food selection is assumed to be a function of the ratio

$$\frac{\text{weight of the cod}}{\text{weight of prey}}$$

as far as fish prey is concerned.

Let SPREF be the logarithm of the preferred (the optimum) predator/prey weight ratio of cod.

Then

$$SIZEP(b,s,a) = \exp\left[-\frac{\left(\ln\frac{W(1,b)}{W(s,a)} - SPREF\right)^2}{SVAR}\right].$$

is used as a measure of "food suitability" of prey of size W(s,a) as food for cod of weight W(1,b) (see Figure 4.7)

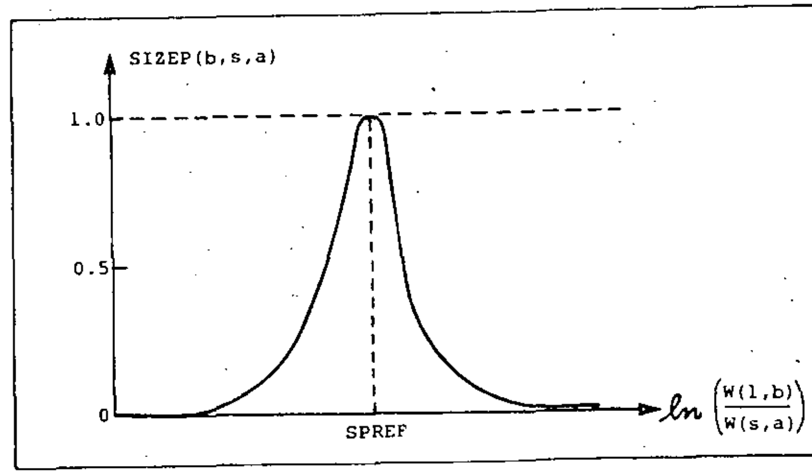


Figure 4.7. Size preference of cod.

SVAR (which corresponds to $2\sigma^2$ in normal distribution) is a measure for how particular the cod is in its food selection.

In addition to cod, plaice and herring the cod also have the opportunity to eat "other food". "Other food" is a somewhat artificial compartment introduced in the model to avoid inconsistencies. In the model the cod always gets the food it need (which is a consequense of the assumption of constant growth). If then fish prey becomes scarce there must be something else the cod can eat, and for that purpose the compartment other food has been invented. Other food consist in one "species" of body weight 1 kg and only one age group.

The suitability of "other food" as food for cod must be given as imput, as well as the biomass of other food must be specified by the user. The higher values of suitability indexes or biomass of other food, the smaller will the predation pressure on the fish be.
Let SUIT(b,s,a) be the suitability coefficient of species s age group a as food for cod of age b.

Then SUIT(b,4,1) is the suitability of "other food" (here given the species index:s=4)

SUIT(b,4,1) has to be specified by the user and the remaining suitability coefficients are calculated by:

$$\mathrm{SUIT}(b,s,a) = \frac{\mathrm{SIZEP}(b,s,a)}{\sum_{j}\sum_{d}\mathrm{SIZEP}(b,j,d)}\,(1-\mathrm{SUIT}(b,4,1))$$

where SUIT(b,4,1) $\leq$ 1.0. **It follows that**

$$\sum_{s=1}^{4}\sum_{a}\mathrm{SUIT}(b,s,a) = 1.0$$

Thus, the SUIT's are generated by the 12 parameters SIZEPREF, SVAR, SUIT(1,4,1), SUIT(2,4,1), ... SUIT(10,4,1).

4.8 Predation mortalities

The "available" biomass of food for b years old cod in year y is defined

$$\mathrm{AVAIL}(y,b) = \sum_{s=1}^{4}\sum_{a}\bar{N}(y,s,a)W(s,a)\mathrm{SUIT}(b,s,a)$$

i.e. the biomass of food weighted by it's suitability.

The yearly food consumption of age group b cod is given by

$$\mathrm{FOOD}(b) = \mathrm{HF}\cdot W(1,b)^{\mathrm{MFOOD}}$$

where HF and MFOOD are constant parameters.

The relative stomach content of prey s age a in the stomach of b-group cod is given by

$$\mathrm{STOC}(y,b,s,a) = \frac{\bar{N}(y,s,a)\mathrm{SUIT}(b,s,a)}{\mathrm{AVAIL}(y,b)}$$

The total consumption (in tonnes) of prey s age a thus becomes

$$\sum_{b}\bar{N}(y,1,b)\mathrm{FOOD}(b)\cdot\mathrm{STOC}(y,b,s,a)$$

and the number devoured by cod is obtained by dividing with W(s,a).

The predation mortality then becomes

$$M2(y,s,a) = \frac{1}{\bar{N}(y,s,a)W(s,a)}\sum_{b=1}^{10}\bar{N}(y,1,b)\mathrm{FOOD}(b)\cdot\mathrm{STOC}(y,b,s,a)$$

The calculation of M2 has to be made by an iterative process, as M2 is required to calculate $\bar{N}$, and $\bar{N}$ is required to calculate M2.

This procedures works as follows:

A: Give an intitial guess on M2(y,s,a)

B: $M2_{old} := M2_{new}$

C: Calculate $\bar{N}(y,s,a)$

D: Calculate AVAIL(y,b)

E: Calculate $M2_{new}$ (by the formula given above)

F: If $\sum_{s=1}^{3}\sum_{a=1}^{10}(M2_{new}(y,s,a)-M2_{old}(y,s,a))^2 > 0.0001$ **then goto B.**

FINIS:

There are two alternative hypothesis about "other food" of the user's choise.

These are:

1. The biomass of "other food" remains constant (Helgason and Gislason, 1979)
2. The biomass of "other food" plus biomass of fish remains constant (Sparre, 1980)

If hypothesis two above is chosen the iterative procedure is modified, by inserting an extra point between C and D:

C1: calculate the biomass of "other food"

$$\bar{N}(y,4,1) = (\text{total biomass}) - \sum_{s=1}^{3}\sum_{a=1}^{10}\bar{N}(y,s,a)W(s,a)$$

where "total biomass" is a constant.

4.9 Other natural mortality

Other natural mortality (old age, diseases, spawning, stress etc)

$$M1 = Z - F - M2$$

is assumed to remain constant for all species all age groups in all years.

4.lo Costs, investments and interests

The cost of fishing (salaries, oil, maintenance etc) pr unit of effort is a constant parameter in the present model. Thus the cost of fishing in year y of fleet e becomes

$$EF(y,e) \cdot ECOST \qquad \text{(unit: d.kr.)}$$

where ECOST is the cost of fishing pr unit of effort (e.g. pr fishing year of, say, lo trawlers).

When starting the game each player has a fleet which at maximum can fish with an effort of ESTART effort units pr year. If EF exceeds ESTART for a fleet this means that there has been invested in new vessels. The investments are determined by

$$INV(y,e) = \max\left\{ EF1(y,e) - \max_{i \leq y} \left\{EF1(i,e)\right\}, 0 \right\}$$

where $EF1(y,e) = EPR \max\left\{EF(y,e) - ESTART, o\right\}$

EPR is the price of new vessels corresponding to one effort unit. (see Figure 4.1o.1)

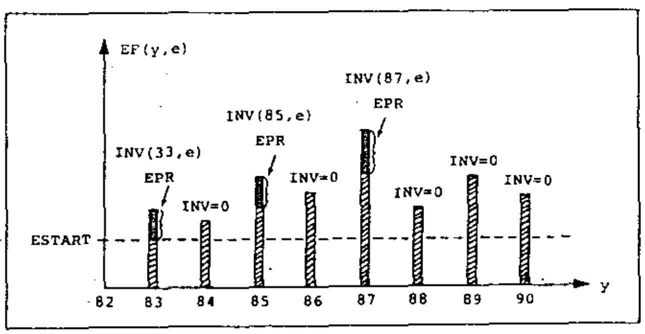


Figure 4.10.1. Investments as a function of year and EF(effort).

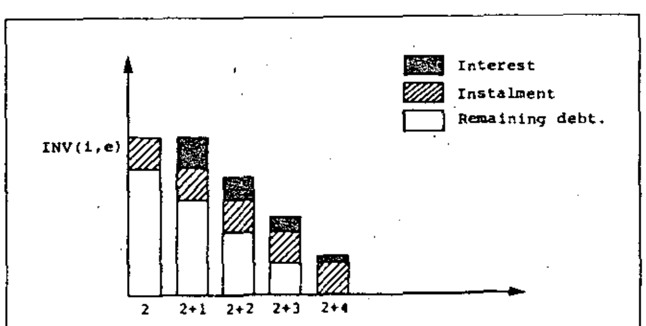


Figure 4.10.2. Instalments, interests and remaining debt.

Investments are based on loans the yearly instalments of which constitutes 2o % of the initial loan and the rate of interest amounts to INTE.

Thus it takes five years to pay back the loan. If there remains a debt in the last year (lo years after the start) the total remaining debt has to be paid.

Thus, for years earlier than the last year we have

$$\text{instalment} = o.2 \cdot INV(y,e)$$

where y is the investment year.

Interest in year y thus becomes

$$INV(y,e) \cdot INTE\ (1-(y-i) \cdot o.2)$$

where i is the investment year

$$(i+1 \leq y < i+5) \qquad \text{(see Figure 4.1o.2)}$$

Finally, total costs in year y of fleet e are

$$COST(y,e) = EF(y,e)\,ECOST + \sum_{i=y-4}^{y} INV\left[o.2 + (1+o.2(y-i)) \cdot INTE\right] + o.2\ INV(y,e)$$

4.11 Profit

If y is not the last game year the profit for that year is

$$PROFIT(y,e) = RETURN(y,e) - COST(y,e)$$

For last year, say, 1991 the profit is

$$PROFIT(1991,e) = RETURN(1991,e) - COST(1991,e) - \sum_{i=1986}^{1991} INV(i,e)\ (1-(1991-i)o.2)$$

The accumulated profit (in case 1982 is the first year) is

$$ACCP(y,e) = \sum_{i=1982}^{y} PROFIT(i,e)$$

and the player who obtain the highest accumulated profit in the last year wins the game.

The limit for ruin is defined by

$$ACCP(y,e) < MINACCP \text{ and } y \geq 3$$

where MINACCP is the lower limit for an acceptable economy of a fleet. In case a fleet is ruined, this player is out of the game and his competitor can continue alone.

When ten years have elapsed, the game is over. However, if the players want they can continue for as many ten years periods as they wish. Every new game will start with the stocks left from the foregoing ten years period, but the bookkeeping starts with zero profit and all investments from foregoing ten years period are lost. The option for continueing the game is primary made to make LAGS suitable for simulation studies.

4.12 Survey of parameters

LAGS contains an option for changing parameter values or the initial value of stock numbers, N.
Each parameter is given a number, and when changing the parameter values via the screen the parameter must be indentified by it's number.

The parameters are :

parameter 1: If the biomass of "other food" is assumed to remain constant the value of this parameter is the biomass of "other food". If the total biomass (fish + other food) is assumed to remain constant, the value of 1. parameter is the total biomass.

parameters 2-11 : SUIT(a,other food) or SUIT(a,4,1) for cod ages a = 1,2,...,10.

parameter 12 : MFOOD.

parameter 13 : HFOOD. Parameters 12 and 13 are the food consumption parameters of cod : $\mathrm{FOOD}(a) = \mathrm{HFOOD}\ W(1,a)^{\mathrm{MFOOD}}$

parameter 14 : SPREF.

parameter 15 : SVAR. Parameters 14 and 15 are the food selection parameters of cod :

$$\mathrm{SUIT}(b,s,a) \propto \exp\left\{-\frac{(\ln(W(1,b)/W(s,a) - \mathrm{SPREF})^2}{\mathrm{SVAR}}\right\}$$

parameters 16 - 18 : KBER(s) for cod, plaice and herring resp.
parameters 19 - 21 : L8(s) for cod, plaice and herring resp.
parameters 22 - 24 : TO(s) for cod, plaice and herring resp.
parameters 25 - 27 : CONF(s) for cod, plaice and herring resp.

Parameters 16 - 27 are the growth parameters :

$$\mathrm{LGT}(s,a) = \mathrm{L8}(s)\cdot(1 - \exp(-\mathrm{KBER}(s)(a+0.5-\mathrm{TO}(s))))$$

$$W(s,a) = \mathrm{CONF}(s)\cdot\mathrm{LGT}(s,a)^3 \qquad s = 1,2,3.$$

parameter 28 : M1. Residual natural mortality coeff. (all three species)
parameters 29 - 31 : NOMAX(s) for cod, plaice and herring resp.
parameters 32 - 34 : HALFSAT(s) for cod, plaice and herring resp.

Parameters 29 - 34 are the stock/recruitment parameters

$$N(y,s,1) = \frac{\mathrm{NOMAX}(s)}{1 + \mathrm{HALFSAT}(s)/\mathrm{SSB}(y,s)}$$

where $\mathrm{SSB}(y,s) = \sum_{a=3}^{10} N(y,s,a)\ W(s,a)$

parameters 35 - 37 : SELFAC(s) for cod, plaice and herring resp. (gear selection factor)

parameter 38 : ECOST. Cost of fishing with one effort unit.
parameter 39 : INTE. Rate of interest.
parameter 40 : ESTART. Initial number of effort unite available to each fleet.
parameter 41 : MINACCP. Minimum allowable accumulated profit (limit of ruin).
parameter 42 : EPR. Investment price for vessels corresponding to one effort unit.

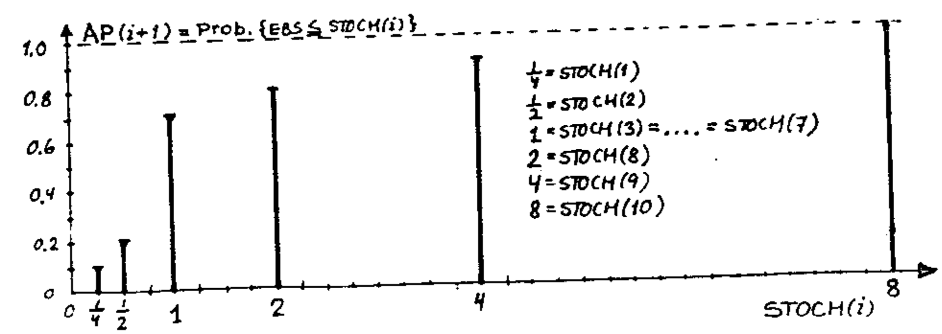
parameters 43 - 52 : PR(1,a). Kg price for cod a = 1,2,...,10.
parameters 53 - 62 : PR(2,a). Kg price for plaice a = 1,2,...,10.
parameters 63 - 72 : PR(3,a). Kg price for herring a = 1,2,...,10.
Initial values 73 - 82 : N(1982,1,a). Initial number of cod a=1,2,...,10.
Initial values 83 - 92 : N(1982,2,a). Initial number of plaice a=1,2,...,10.
Initial values 93 -102 : N(1982,3,a). Initial number of herring a=1,2,...,10.
parameters 103 - 112 : AP(i). Accumulated probability function for the stochastic stock/recruitment model (explained below). i=1,2,...,10.
parameters 113 - 122 : STOCH(i). Possible values of the stochastic term, EBS in the model

$$N(y,s,1) = \frac{\mathrm{NOMAX}(s)}{1 + \mathrm{HALFSAT}(s)/\mathrm{SSB}(y,s)}\ \mathrm{EBS}$$

where the stochastic factor EBS has the distribution :

$$\mathrm{Prob.}\{\mathrm{EBS} = \mathrm{STOCH}(i)\} = \mathrm{AP}(i+1) - \mathrm{AP}(i)$$

EBS can at most take 10 different values. In the example below EBS can take 6 different values.



In Appendix B a list of the parameters, as shown on the video screen is given. This list is considered more suitable as an aid to memory when changing parameters.

5. AN EXAMPLE OF A RUN WITH LAGS IN THE FAST MODE.

Several options were not demonstrated in the "beginners mode" in Section 3. These options are available also in the slow mode. They have been removed from the beginners mode, because beginners might easily get confused. The utilization of these options (e.g. the option to change parameters) requires a certain knowledge in the theory of Legion Analysis.

In beginners mode the following options are chosen by LAGS :

1. The biomass of "other food" is a constant parameter.
2. Deterministic stock/recruitment model.
3. All parameters have the default value (cf. App. B.).
4. Slow mode.

If you do not choose the beginners mode, LAGS will ask you the following introductory questions :

```
Do you run this program for the first time ? (yes=1, no=RETURN)  [RETURN]

Do you want total biomass of the ecosystem to remain constant give input : 0
If you want "other food" to remain constant input : 1  [0]

Do you want stochastic stock/recruitment ? (yes=1, no=RETURN) [1]

Which version do you prefer ? (slow=0, fast=1, very fast=2)  [1]


Do you want to change parameters (yes=1,no=RETURN) [1]

Give the number of the parameter you want to change
If you do not want more changes : RETURN [RETURN]
```

Param. no.	Param. value
1	2000000
2	1.000000
3	0.600000
4	0.300000
5	0.150000
6	0.100000
7	0.070000
8	0.070000
9	0.070000
10	0.070000
11	0.070000
12	0.800000
13	5.000000
14	4.600000
15	4.600000
16	0.220000
17	0.150000
18	0.320000
19	130.000000
20	50.000000
21	30.000000
22	0.000000
23	-1.500000
24	-1.500000
25	0.000010
26	0.000015
27	0.000010
28	0.100000
29	20000.0
30	400000.0
31	1200000.0
32	59921.7
33	84874.5
34	96946.6
35	5.000000
36	5.000000
37	4.000000
38	3.000000
39	0.100000
40	200.0
41	-1500.0
42	10.000000
43	0.017143
44	0.040000
45	0.054545
46	0.064615
47	0.072000
48	0.077647
49	0.082105
50	0.085714
51	0.085714
52	0.085714
53	0.017143
54	0.040000
55	0.054545
56	0.064615
57	0.072000
58	0.077647
59	0.082105
60	0.085714
61	0.085714
62	0.085714
63	0.014286
64	0.033333
65	0.045455
66	0.053846
67	0.060000
68	0.064706
69	0.068421
70	0.071429
71	0.071429
72	0.071429
73	10000.0
74	6065.3
75	3678.8
76	2231.3
77	1353.4
78	820.8
79	497.9
80	302.0
81	183.2
82	282.5
83	200000.0
84	121306.1
85	73575.9
86	44626.0
87	27067.1
88	16417.0
89	9957.4
90	6039.5
91	3663.1
92	5646.7
93	600000.0
94	363918.4
95	220727.7
96	133878.1
97	81201.2
98	49251.0
99	29872.2
100	18118.4
101	10989.4
102	16940.1
103	0.000000
104	0.100000
105	0.200000
106	0.300000
107	0.400000
108	0.500000
109	0.600000
110	0.700000
111	0.800000
112	0.900000
113	0.250000
114	0.500000
115	1.000000
116	1.000000
117	1.000000
118	1.000000
119	1.000000
120	2.000000
121	4.000000
122	8.000000

NOTE: In this run the following options are chosen :

[0] Total biomass of the ecosystem is assumed to remain constant.

[1] There is a stochastic stock/recruitment relationship.

[1] The fast mode is chosen.

[1] If you only want a display of the parameters, answer [1] to the first queestion and [RETURN] to the next one. Thus in this case we get a listning of the parameters on the screen!

NOTE:

Suppose we want to change the parameters :

	old value (default)	new value
Total biomass	2000000	2500000
SUIT(8,4,1)	0.07	0.06
SUIT(9,4,1)	0.07	0.05
SUIT(10,4,1)	0.07	0.04
HFOOD	5.0	6.0
NOMAX(2)	400000	600000
NOMAX(3)	1200000	1500000

the following input should be given

```
Do you want to change parameters (yes=1,no=RETURN)  [1]

Give the number of the parameter you want to change
If you do not want more changes : RETURN      [1]
Give the new parameter value [2500000]

Give the number of the parameter you want to change
If you do not want more changes : RETURN [9]
Give the new parameter value [0.06]

Give the number of the parameter you want to change
If you do not want more changes : RETURN [10]
Give the new parameter value [0.05]

Give the number of the parameter you want to change
If you do not want more changes : RETURN [11]
Give the new parameter value [0.04]

Give the number of the parameter you want to change
If you do not want more changes : RETURN [13]
Give the new parameter value [6.0]

Give the number of the parameter you want to change
If you do not want more changes : RETURN [30]
Give the new parameter value [600000]

Give the number of the parameter you want to change
If you do not want more changes : RETURN [31]
Give the new parameter value [1500000]

Give the number of the parameter you want to change
If you do not want more changes : RETURN [RETURN]
```

NOTE : For the interpretation of the parameters, see Section 4.12 or Appendix B.

When terminating the changing of parameters with RETURN you will get a list of the corrected parameter set on the video :

Param. no.	Param. value	
1	2500000	← total biomass
2	1.000000	
3	0.600000	
4	0.300000	
5	0.150000	
6	0.100000	
7	0.070000	
8	0.070000	
9	0.060000	← SUIT(8,4,1)
10	0.050000	← SUIT(9,4,1)
11	0.040000	← SUIT(10,4,1)
12	0.800000	
13	6.000000	← HFOOD
14	4.600000	
15	4.600000	
16	0.220000	
17	0.150000	
18	0.320000	
19	130.000000	
20	30.000000	
21	30.000000	
22	0.000000	
23	-1.500000	
24	-1.500000	
25	0.000010	
26	0.000015	
27	0.000010	
28	0.100000	
29	20000.0	
30	600000.0	← NOMAX(2)
31	1500000.0	← NOMAX(3)
32	59921.7	
33	84874.5	
34	96946.4	
35	1.000000	
36	3.000000	
37	4.000000	
38	3.000000	
39	0.100000	
40	200.0	
41	-1500.0	
42	10.000000	
43	0.017143	
44	0.040000	
45	0.054545	
46	0.064615	
47	0.072000	
48	0.077647	
49	0.082105	
50	0.085714	
51	0.085714	
52	0.085714	
53	0.017143	
54	0.040000	
55	0.054545	
56	0.064615	
57	0.072000	
58	0.077647	
59	0.082105	
60	0.085714	
61	0.085714	
62	0.085714	
63	0.014286	
64	0.033333	
65	0.045455	
66	0.053846	
67	0.060000	
68	0.064706	
69	0.068421	
70	0.071429	
71	0.071429	
72	0.071429	
73	10000.0	
74	6065.3	
75	3678.8	
76	2231.3	
77	1353.4	
78	820.8	
79	497.9	
80	302.0	
81	183.[illegible]	
82	[illegible]	
83	200000.0	
84	121306.1	
85	73575.9	
86	44626.0	
87	27067.1	
88	16417.0	
89	9957.4	
90	6039.5	
91	3663.1	
92	[illegible]	
93	600000.0	
94	363918.4	
95	220727.7	
96	133878.1	
97	81201.2	
98	49251.0	
99	29872.2	
100	18118.4	
101	10989.4	
102	[illegible]	
103	0.000000	
104	0.100000	
105	0.200000	
106	0.300000	
107	0.400000	
108	0.500000	
109	0.600000	
110	0.700000	
111	0.800000	
112	0.900000	
113	0.250000	
114	0.500000	
115	1.000000	
116	1.000000	
117	1.000000	
118	1.000000	
119	1.000000	
120	[illegible]	
121	4.000000	
122	[illegible]	

NOTE:

In case we don't want to change more parameters the answer RETURN starts the game without any introduction. The fast mode contains all the options of the slow mode - the only difference is that several explanations given in the slow mode are surpressed in the fast mode. The four graphs automatically displayed in the slow mode can still be displayed in the fast mode, but in that case you will have to give a request.

The procedure works as follows :

```
Do you want to change parameters (yes=1,no=RETURN) [RETURN]
mesh size of fleet 1 (mm) .Last years decision :        0 [20]
mesh size of fleet 2 (mm) .Last years decision :        0 [100]
Number of effort units of fleet 1 .Last years decision :  0 [100]
Number of effort units of fleet 2 .Last years decision :  0 [200]

Directivity of fleet no.  1
Percentage for Cod              .Last years decision :  0 [0]
Percentage for Plaice           .Last years decision :  0 [30]
percentage for Herring                                     70

Directivity of fleet no.  2
Percentage for Cod              .Last years decision :  0 [60]
Percentage for Plaice           .Last years decision :  0 [40]
percentage for Herring                                     0
```

```
The following decisions were taken in year 1982
                    fleet 1   fleet 2
-----------------------------------------
Mesh size              20       100
Number of effort u.   200       200
Investments (ef.u.)     0         0
Directivity Cod         0        60
Directivity Plaice     30        40
Directivity Herring    70         0
-----------------------------------------
 1 fish biom.     301068 other food     2198932

Do you want the small or the large menu ?
(small=1, large=2, none=RETURN)  [RETURN]
```

NOTE : When choosing the option of constant total biomass the program will display the biomass of fish and the biomass of other food in every year. In case the parameters are chosen so that the biomass of other food becomes negative (and that may well happen) the results become absurd and the execution of LAGS is stopped.

NOTE : As the fast mode is very much like the slow mode there is little reason in demonstrating all the details and we jump forward to the last year, 1991. and demonstrate how to display courses from the large menu. As an example it is shown how to display information about spawning stock biomass and recruitment (recall that the option stochastic stock/recruitment was chosen). To aid memory concerning the contents of the menu lists Appendix C should be consulted.

Give course no. on large menu [14]

Year class strength (number of 1 year old fish)
and spawning stock biomass (3 year and older fish) on 1. January.

year	Cod Yr. cl.	Cod S.S.B.	Plaice Yr. cl.	Plaice S.S.B.	Herring Yr. cl.	Herring S.S.B.
1982	10000	59922	200000	84874	600000	96946
1983	5285	67162	2548144	96042	750364	97040
1984	11419	79746	173359	116185	383340	101357
1985	22299	75486	251000	434768	6330988	108267
1986	5701	79455	492220	387612	1472937	93510
1987	12565	101259	477118	329546	1193165	384839
1988	46190	81865	468302	301803	1150821	319515
1989	5524	73944	460028	278945	1085652	254013
1990	6573	114924	226654	262280	8186872	208146
1991	12294	95598	447361	248754	3858659	174721

Give course no. on large menu [17]

Give graph no. [10]

```
Spawning stock biomass (age 3 and older) and recruitment (number of 1-years)
of Cod           .  min. biomass =    4073  min. recruitment =     5285
                    max. biomass =    5677  max. recruitment =    46190
        0 I                   R
          I
          I
          I
          I
          I
          I
          I
          I
          I
        0 I-----------------------------
          I
          I          R
          I
          I                S
          I    S  S  S  S     S
          I S     R        R     S  S SR
          I R
        0 I    R        R        R  R
          --I--I--I--I--I--I--I--I--I--I
           82 83 84 85 86 87 88 89 90 91
```

Give graph no. [11]

```
Spawning stock biomass (age 3 and older) and recruitment (number of 1-years)
of Plaice        .  min. biomass =    6157  min. recruitment =  173359
                    max. biomass =    7108  max. recruitment = 2548144
        0 I    R
          I
          I
          I
          I
          I
          I
          I
          I
          I
        0 I-----------------------------
          I
          I
          I
          I
          I
          I S  S  S  S  S  S  S  S  S  S
          I             R  R  R  R     R
        0 I R     R  R              R
          --I--I--I--I--I--I--I--I--I--I
           82 83 84 85 86 87 88 89 90 91
```

Give graph no. [12]

```
Spawning stock biomass (age 3 and older) and recruitment (number of 1-years)
of Herring     .  min. biomass =    2954  min. recruitment =   583340
                  max. biomass =    4554  max. recruitment = 3186872
        0 I                                R
          I
          I
          I
          I         R
          I
          I
          I
          I
        0 I-----------------------------
          I                              R
          I
          I
          I  S  S  S  S  S
          I              S  S
          I                    S  S
          I           R          S
          I              R  R  R
        0 I  R  R  R
          --I--I--I--I--I--I--I--I--I--I
           82 83 84 85 86 87 88 89 90 91
Give graph no. RETURN
Give course no. on large menu RETURN
```

```
GAME IS FINISHED

                    Fleet 1      Fleet 2
Accum. profit        71469        42537
Loans not paid           0            0
------------------------------------------
Ac. prof.-loan       71469        42537

------------------------------
! FLEET NO 1 WON THE GAME    !
------------------------------

Give course no. on large menu  RETURN

Do you want to continue ? (yes=1, no=0)  1

Which version do you prefer ? (slow=0, fast=1, very fast=2)  2
```

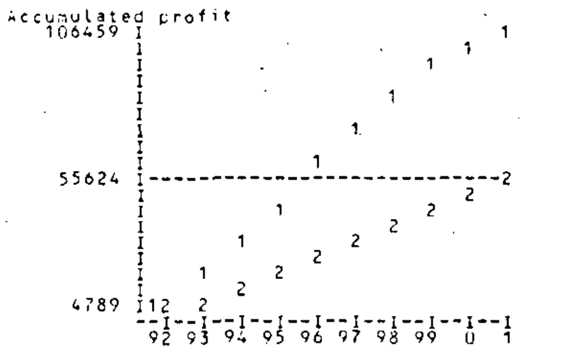
NOTE : When terminaring the game for a ten years period, there is an option for continuation in the next decade, i.e. 1992 - 20001. The players may continue for as many decades as they want, but due to limited capacity of the computer only results for the current decade is kept and available for display. The stock numbers in 1992 will be those at the end of 1991.
In this example the option for continuation is chosen, and as can be seen, the mode has been shiftet from the fast mode to the very fast mode. The continuation will be dealt with in next section.

6. AN EXAMPLE OF A RUN WITH LAGS IN THE VERY FAST MODE.

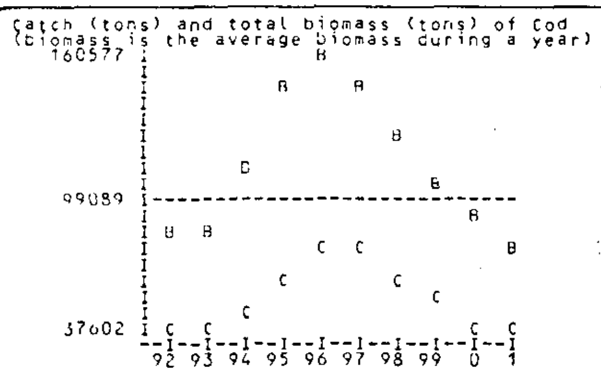
This example continues the example of Section 5. Thus we start in year 1992 with the stock left at the end of 1991.
In the very fast mode the decisions for the first year applies to all ten year, and can not be changed during the decade. In the present case it will be the decisions taken in year 1991, which apply to the years 1992 - 2001.
In case we started in 1982 we would have to give the decisions as input (in exactly the same manner as for the fast mode).
In this case where total biomass is assumed to remain constant the output during the execution of the decade calulations will be :

```
Do you want to change parameters (yes=1,no=RETURN) [RETURN]
 1 fish biom.       1006320 other food       1493680
 2 fish biom.        930293 other food       1569707
 3 fish biom.        850317 other food       1649683
 4 fish biom.       1189096 other food       1310904
 5 fish biom.       1172529 other food       1327471
 6 fish biom.       1024517 other food       1475483
 7 fish biom.        869316 other food       1630684
 8 fish biom.        740525 other food       1759475
 9 fish biom.        645503 other food       1854497
10 fish biom.        580486 other food       1919514

Do you want the small or the large menu ? (small=1, large=2, none=RETURN) [2]

Give course no. on large menu [17]

Give graph no. [1]
```

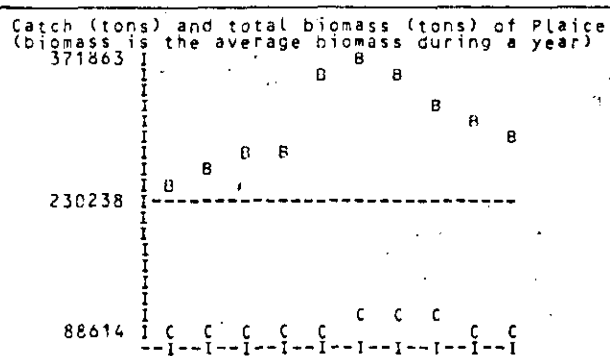
NOTE : Calculations terminated. Some courses from the large menu are displayed.



Give graph no. [7]

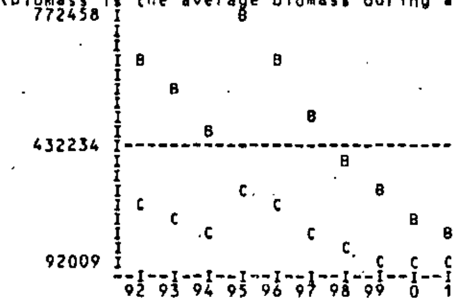


Give graph no. [8]



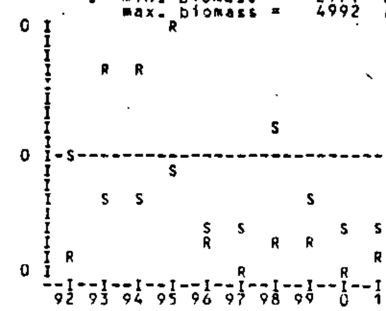
```
Give graph no. [9]
```

Catch (tons) and total biomass (tons) of Herring
(biomass is the average biomass during a year)



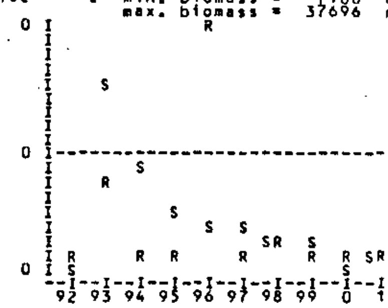

```
Give graph no. [10]
```

Spawning stock biomass (age 3 and older) and recruitment (number of 1-years)
of Cod . min. biomass = 2171 min. recruitment = 6282
max. biomass = 4992 max. recruitment = 51793



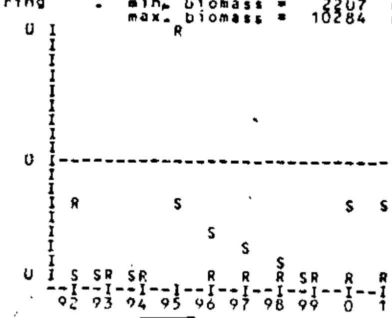

```
Give graph no. [11]
```

Spawning stock biomass (age 3 and older) and recruitment (number of 1-years)
of Plaice . min. biomass = 7108 min. recruitment = 424092
max. biomass = 37696 max. recruitment = 1786103




```
Give graph no. [12]
```

Spawning stock biomass (age 3 and older) and recruitment (number of 1-years)
of Herring . min. biomass = 2207 min. recruitment = 953951
max. biomass = 10284 max. recruitment = 9403412




```
Give graph no. [RETURN]
Give course no. on large menu [RETURN]
```

7. EXAMPLES OF SENSITIVITY ANALYSIS ON LAGS.

So far we have concentrated on the game aspect of LAGS. However, when run in the fast mode LAGS is suitable for all kinds of system analysis. We shall look at two examples to illustrate the sort of calculations which can be made in a few minutes with LAGS run in the very fast mode.

In the first example we investigate the development of the system in case of no fishery. If we assume the biomass of other food to remain constant, the stock/recruitment to be deterministic and all the parameters to have default values (cf. App. B.) the prey stocks will be depleted due to predation pressure. This situation is illustrated in Figure 7.1.B. In case the value of the parameter "other food" is increased from the default value 300000 to 2000000 the plaice and herring stock will not suffer so much from the cod because cod will shift it's diet to other food. This is illustrated in Figure 7.1.A.

From this exercise we have learned that the parameter "other food" is a very important one (unfortunately, this parameter is extremely complicated to estimate in practise). Tables 7.1-2 give further details about the predation pattern. As can be seen the predation mortality increases with a factor of about 10 for plaice and hering during the decade. For many reasons, this depletion of the prey stocks when fishing is absence, is not satisfactory and we may be interested in parameter sets which produce more stable systems.

The second example deals with the effect of a mesh change. In this case we have again assumed other food to remain constant and a deterministic stock/recruitment relationship. In Table 7.3 examples of fishing mortality as a function of mesh size is shown for the three species. In the present example fleet no. 1 fish on cod exclusively and fleet no. 2 on plaice and herring exclusively. Figure 7.2.B shows the development of the system when cod are fished with a large mesh size (120 mm). It should be noted that with the large mesh size the cod biomass stabilizes on a level which reduces the prey stocks to half of their initial size. If mesh size for cod is reduced to 20 mm (no selectivity of the trawl) the cod stock will be reduced to less than ten percent of it's initial size, and the prey stocks remain at their initial size. Thus, a change of a mesh size for the predator causes a dramatic change of the entire system.

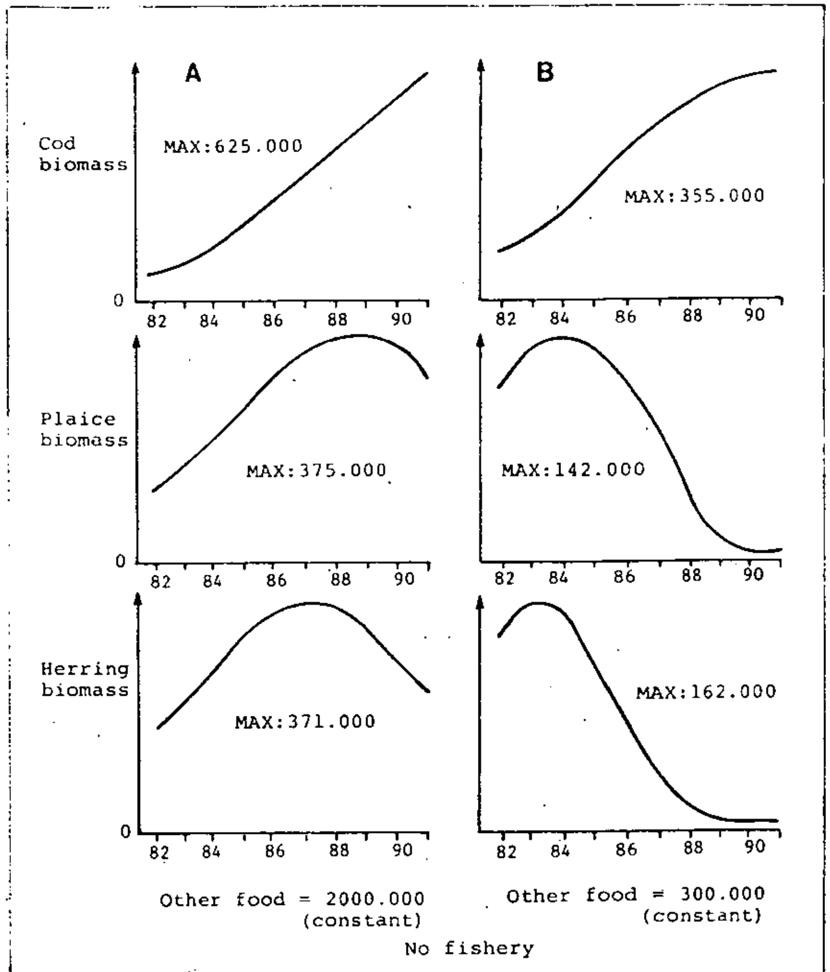


Figure 7.1. The effect of changing the parameter "other food" in case of no fishing (and constant other food) and deterministic stock/recruitment model. The curves are smoothed to the curves displayded by LAGS:

	age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
cod	1	0.129	0.183	0.267	0.397	0.595	0.869	1.178	1.449	1.636	1.737
	2	0.039	0.058	0.081	0.123	0.189	0.284	0.398	0.505	0.587	0.641
	3	0.013	0.019	0.027	0.043	0.068	0.106	0.154	0.200	0.238	0.265
	4	0.004	0.006	0.009	0.013	0.022	0.037	0.058	0.082	0.104	0.122
	5	0.001	0.001	0.002	0.003	0.004	0.007	0.012	0.018	0.028	0.039
	6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
plaice	1	0.254	0.360	0.517	0.744	1.063	1.472	1.890	2.206	2.370	2.407
	2	0.223	0.317	0.457	0.668	0.975	1.379	1.813	2.162	2.371	2.452
	3	0.183	0.261	0.378	0.557	0.824	1.183	1.578	1.909	2.123	2.222
	4	0.150	0.213	0.310	0.459	0.685	0.994	1.339	1.637	1.838	1.941
	5	0.124	0.176	0.256	0.382	0.573	0.838	1.138	1.402	1.585	1.685
	6	0.104	0.148	0.216	0.323	0.487	0.716	0.978	1.212	1.378	1.472
	7	0.089	0.127	0.186	0.278	0.421	0.622	0.854	1.063	1.214	1.302
	8	0.078	0.110	0.162	0.243	0.370	0.548	0.756	0.945	1.083	1.165
	9	0.069	0.098	0.144	0.217	0.331	0.492	0.680	0.853	0.980	1.057
	10	0.063	0.089	0.130	0.197	0.300	0.447	0.620	0.779	0.898	0.971
herring	1	0.255	0.341	0.516	0.736	1.040	1.421	1.802	2.077	2.207	2.220
	2	0.251	0.356	0.511	0.738	1.060	1.473	1.901	2.228	2.404	2.451
	3	0.238	0.337	0.486	0.707	1.024	1.439	1.876	2.221	2.420	2.487
	4	0.225	0.319	0.461	0.673	0.981	1.388	1.822	2.171	2.379	2.459
	5	0.214	0.305	0.441	0.645	0.944	1.341	1.768	2.116	2.329	2.415
	6	0.207	0.294	0.425	0.623	0.914	1.303	1.724	2.069	2.283	2.374
	7	0.201	0.285	0.413	0.607	0.892	1.274	1.689	2.032	2.247	2.340
	8	0.197	0.279	0.405	0.595	0.876	1.252	1.663	2.003	2.218	2.313
	9	0.193	0.275	0.399	0.586	0.864	1.236	1.644	1.982	2.197	2.293
	10	0.191	0.272	0.394	0.580	0.855	1.225	1.629	1.966	2.180	2.278

Table 7.1. Predation mortalities corresponding to Figure 7.1.B. (no fishery, other food = 300 000, other food constant).

age	Cod	Plaice	Herring	year
1	11.91	21.40	21.46	1982
2	3.62	19.05	21.16	
3	1.33	15.97	20.16	
4	0.39	13.25	19.19	
5	0.07	11.08	18.40	
6	0.00	9.42	17.79	
7	0.00	8.19	17.34	
8	0.00	7.17	17.01	
9	0.00	6.39	16.76	
10	0.00	5.77	16.59	
1	42.89	62.85	62.05	1986
2	16.39	59.72	62.72	
3	6.24	53.76	61.50	
4	2.08	47.44	59.96	
5	0.39	41.70	58.58	
6	0.00	36.83	57.45	
7	0.00	32.82	56.58	
8	0.00	29.49	55.92	
9	0.00	26.80	55.43	
10	0.00	24.73	55.07	
1	79.49	88.19	86.28	1991
2	45.25	86.59	88.59	
3	22.18	86.31	88.90	
4	10.95	82.74	88.65	
5	3.64	78.53	88.26	
6	0.00	74.20	87.88	
7	0.00	70.00	87.54	
8	0.00	66.12	87.28	
9	0.00	62.84	87.07	
10	0.00	59.59	86.91	

Table 7.2. Percentage of fish dead due to predation, corresponding to Figure 7.1.B. (no fishery, other food = 300 000, other food constant).

	age	Fishing mortality								BYC	length	Selection factor
cod	1	0.150	0.137	0.042	0.007	0.002	0.001	0.000	0.000	0.20	36.54	5.00
	2	0.150	0.150	0.148	0.112	0.043	0.013	0.005	0.001		55.[illegible]	
	3	0.150	0.150	0.150	0.148	0.129	0.074	0.030	0.005		69.[illegible]	
	4	0.150	0.150	0.150	0.150	0.147	0.129	0.084	0.018		81.[illegible]	
	5	0.150	0.150	0.150	0.150	0.150	0.145	0.124	0.041		91.2[illegible]	
	6	0.150	0.150	0.150	0.150	0.150	0.148	0.140	0.070		98.[illegible]	
	7	0.150	0.150	0.150	0.150	0.150	0.149	0.145	0.095		105.[illegible]	
	8	0.150	0.150	0.150	0.150	0.150	0.150	0.148	0.112		109.9[illegible]	
	9	0.150	0.150	0.150	0.150	0.150	0.150	0.149	0.123		113.[illegible]	
	10	0.150	0.150	0.150	0.150	0.150	0.150	0.149	0.130		117.[illegible]	
plaice	1	0.149	0.078	0.010	0.002	0.001	0.000	0.000	0.000	0.20	18.12	5.00
	2	0.150	0.141	0.051	0.009	0.002	0.001	0.000	0.000		22.56	
	3	0.150	0.149	0.112	0.031	0.008	0.002	0.001	0.000		26.35	
	4	0.150	0.150	0.146	0.070	0.019	0.006	0.002	0.001		29.67	
	5	0.150	0.150	0.147	0.107	0.038	0.012	0.004	0.001		32.50	
	6	0.150	0.150	0.149	0.129	0.063	0.020	0.007	0.002		34.94	
	7	0.150	0.150	0.150	0.139	0.087	0.032	0.011	0.002		37.04	
	8	0.150	0.150	0.150	0.144	0.106	0.046	0.016	0.003		38.84	
	9	0.150	0.150	0.150	0.147	0.119	0.060	0.022	0.004		40.40	
	10	0.150	0.150	0.150	0.148	0.128	0.072	0.029	0.005		41.74	
herring	1	0.382	0.034	0.004	0.001	0.001	0.000	0.000	0.000	0.60	18.51	4.00
	2	0.441	0.115	0.013	0.003	0.001	0.001	0.000	0.000		21.66	
	3	0.448	0.222	0.027	0.005	0.002	0.001	0.000	0.000		23.94	
	4	0.449	0.304	0.045	0.008	0.003	0.001	0.001	0.000		25.60	
	5	0.450	0.352	0.065	0.012	0.003	0.001	0.001	0.000		26.81	
	6	0.450	0.380	0.083	0.015	0.004	0.002	0.001	0.000		27.68	
	7	0.450	0.395	0.099	0.017	0.005	0.002	0.001	0.000		28.32	
	8	0.450	0.405	0.112	0.020	0.005	0.002	0.001	0.000		28.78	
	9	0.450	0.410	0.122	0.022	0.006	0.002	0.001	0.000		29.11	
	10	0.450	0.414	0.129	0.023	0.006	0.002	0.001	0.000		29.36	
mesh size		40	60	80	100	120	140	160	200			

	L8	KBER	TO	CONF
cod	130	0.22	0.0	0.000010
plaice	50	0.15	-1.5	0.000015
herring	30	0.32	-1.5	0.000010

$$\frac{L75\%}{L50\%} = 1.1$$

Table 7.3. Fishing mortality as a function of directivity (BYC) and mesh size (for a single fleet).

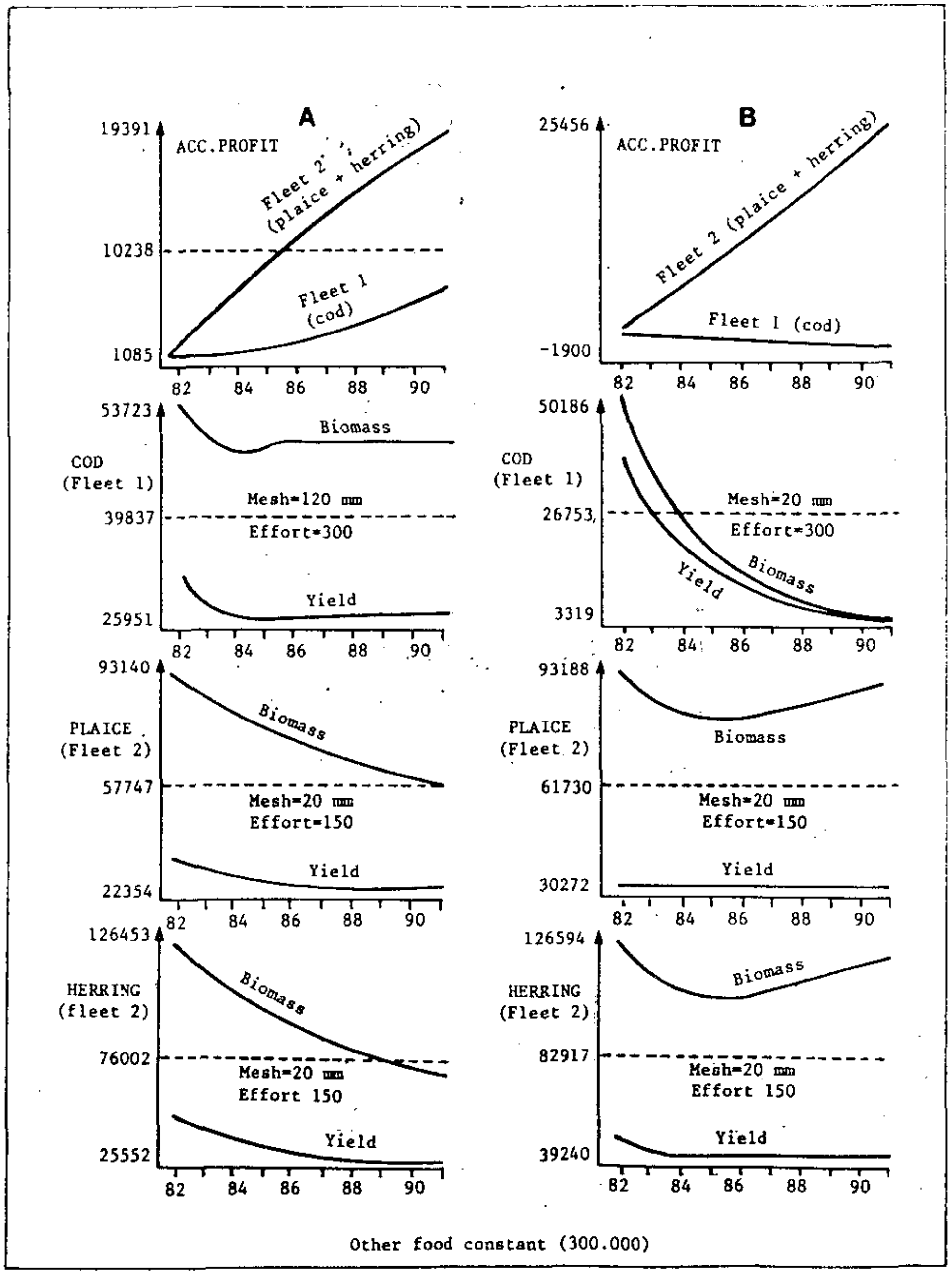


Figure 7.2. Assessing the effect of mesh change for cod on all three species.

References.

Andersen, K.P. and Ursin, E. 1977. A multispecies extension to the Beverton Holt theory of fishing, with account of phosphorus circulation and primary production. Meddr. Danm. Fisk. - og Havunders. N.S. 7: 319-435.

Helgason, T. and Gislason, H. 1979. VPA-analysis with species interaction due to predation. ICES C.M. 1979/G:52 (mimeo).

Hoydal, K., Rørvik, C. J. and Sparre, P. 1982. Estimation of effective mesh sizes and their utilization in assessment. DANA, Vol. 2. pp 69-95.

Pope, John. 1979. A modified cohort analysis in which constant natural mortality is replaced by estimates of predation levels. ICES C.M. 1979/H:16 (mimeo).

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APPENDIX A

List of FORTRAN IV program for the RC8000 computer at the Danish Institute for Fisheries and Marine Research.

```
c ***************************************************
c * FISHERY GAME          Program by Per Sparre      *
c * Danish Institute for Fishery and Marine Resarch  *
c * Charlottenlund Slot  2920 Charlottenlund         *
c *                  Denmark                         *
c ***************************************************
c
      real n(10,3,10),c(10,3,10),biom(10,3),n0max(3),
     *l8(3),kber(3),t0(3),conf(3),l(3,10),w(3,10),
     * mesh(10,3),selfac(3),byc(10,2,3),ef(10,3),
     * ftot(10,3,10),f(10,2,3,10),m(10,3,10),
     * suit(10,3,10),food(10),m1,other,osuit(10),
     * price(3,10),revenu(10,2,3),ton(10,2,3),omk,profit(10,2),
     * mfood,inv(10,2),dist(2,10),repay(10,2),
     * nmean(3,10),avail(10),virb(3),pr(3),efmax(2),aux(10),xt(10,3,10)
     *,efmax1(2)
c
      integer fishn(3,10),tegn(42),
     * y,e,s,a,yfirst,iy,isidst,ifall(2),ttegn(15),ylast
c
      common /name/ fishn,tegn,iskriv,ihurt
      common /clas/ ttegn,xx
c
      common /com1/ n,c,biom,
     * l8,kber,t0,conf,l,w,
     * mesh,selfac,byc,ef,
     * ftot,f,m,avail,
     * suit,food,m1,other,osuit,
     * price,revenu,ton,omk,profit,inv,repay,pr1,rente,accmin,
     * y,yfirst,iy,isidst
c
      data tegn /'IIII','    ','----','****','1111','2222','CCCC','BBBH',
     *'SSSS','RRRR','   y','nnnn',
     *'CCCC','oooo','dddd','    ','    ','    ','    ',
     *'    ','    ',
     *'PPPP','llll','aaaa','iiii','cccc','eeee','    ','    ',
     *'    ','    ',
     *'HHHH','eeee','rrrr','rrrr','iiii','nnnn','gggg','    ',
     *'    ','    '/
     *,ttegn /'   0','   1','   2','   3','   4','   5','   6',
     *'   7','   8','   9','   .','   -','   y','   n','   N'/
c
c space requirement : about 3300 reals and about 100 integeres
c
      do 20 s=1,3
      do 20 i=1,10
      i1=s*10+i+2
   20 fishn(s,i)=tegn(i1)
c
      yfirst=1982
      iyfirst=yfirst
      ylast=1991
      isidst=19
      ihurt=0
      iskriv=0
c
c "other food" parametre :
c
      other=300000.0
      totbio=2000000.0
      osuit(1)=1.0
      osuit(2)=0.6
      osuit(3)=0.3
      osuit(4)=0.15
      osuit(5)=0.1
      do 30 a=6,10
   30 osuit(a)=0.07
c
c food selection and consumption parameters
c
      spref=4.6
      svar=spref
      mfood=0.8
      hfood=5.0
c
c "other" natural mortality
c
      m1=0.1000
c
c selection parameters
c
      selfac(1)=5.0
      selfac(2)=3.0
      selfac(3)=4.0
c
c initial values of some variables
c
      do 80 y=1,10
      do 60 s=1,3
      biom(y,s)=0.0
      do 60 a=1,10
      c(y,s,a)=0.0
      n(y,s,a)=0.0
      ftot(y,s,a)=0.0
      do 59 e=1,2
   59 f(y,e,s,a)=0.0
   60 m(y,s,a)=0.2
      do 78 e=1,2
      do 75 s=1,3
      revenu(y,e,s)=0.0
      byc(y,e,s)=-1.0
   75 ton(y,e,s)=0.0
      mesh(y,e)=-1.0
      ef(y,e)=-1.0
      profit(y,e)=0.0
      inv(y,e)=0.0
   78 repay(y,e)=0.0
   80 continue
c
c von Bertalanffy growth parameters
c
      conf(1)=.00001
      conf(2)=.000015
      conf(3)=.00001
      l8(1)=130.0
      l8(2)=50.0
      l8(3)=30.0
      t0(1)=0.0
      t0(2)=-1.5
      t0(3)=-1.5
      kber(1)=0.22
      kber(2)=0.15
      kber(3)=0.32
c
c recruitment first year
c
      n(1,1,1)=10000.0
      n(1,2,1)=200000.0
      n(1,3,1)=600000.0
c
c recruitment parameters (maximum recruitment)
c
      n0max(1)=2.0*n(1,1,1)
      n0max(2)=2.0*n(1,2,1)
      n0max(3)=2.0*n(1,3,1)
      x1=0.0
      x2=0.25
      do 90 i=1,10
      dist(1,i)=x1
      x1=x1+0.1
      dist(2,i)=x2
      x2=x2*2.0
      if (i .gt. 2 .and. i .lt. 7) x2=1.0
   90 continue
c
c economic parameters
c
      omk=3.0
      pr1=10.00
      accmin=-1500.0
      rente=0.10
      estart=200.0
      do 100 e=1,2
      profit(1,e)=0.0
      efmax(e)=0.0
  100 ifall(e)=0
c
      efmean=400.0
      pr(1)=12.0
      pr(2)=12.0
      pr(3)=10.0
      prhf=3.0
c
```

```
c
c calculation of weight at age and length at age
c prices and HF (=virb)
c
      do 210 s=1,3
      virb(s)=0.0
      biom(1,s)=0.0
c
      do 200 a=1,10
      time=float(a)+0.5
      l(s,a)=l8(s)*(1.0-exp(-kber(s)*(time-t0(s))))
      w(s,a)=conf(s)*l(s,a)**3
      xa=float(a)-0.5
      price(s,a)=0.01*pr(s)*xa/(xa+prhf)
      if (a .gt. 8) price(s,a)=price(s,8)
      if (a .eq. 1) goto 200
      n(1,s,a)=n(1,s,a-1)*exp(-0.5)
      if (a .eq. 10) n(1,s,10)=n(1,s,10)/(1.0-exp(-0.5))
      biom(1,s)=biom(1,s)+n(1,s,a)*w(s,a)
      if (a .gt. 2) virb(s)=virb(s)+n(1,s,a)*w(s,a)
  200 continue
  210 biom(1,s)=biom(1,s)+n(1,s,1)*w(s,1)
c
c
c
c
c
c INTRDUCTORY QUESTIONS :
c ----------------------
c
      write(out,500)
  500 format(2x,'Do you run this program for the first time ?',1x,
     *'(yes=1, no=RETURN)  ')
      call las(i,iskriv)
      ibeg=0
      if (i .ne. 1) goto 611
      ihg=1
      istock=0
      totbio=other
      ifast=0
      ihurt=0
      ibeg=1
      goto 640
c
c
c
      call las(iskriv,0)
  611 write(out,612)
  612 format(/,2x,'Do you want total biomass of the ecosystem to',1x,
     *'remain constant give input : 0 ',/,2x,
     *'If you want "other food" to remain constant input : 1  ')
      call las(ihg,iskriv)
      if (ihg .ne. 1 .and. ihg .ne. 0) goto 611
      if (ihg .eq. 1) totbio=other
      write(out,613)
  613 format(/,2x,'Do you want stochastic stock/recruitment ?',1x,
     *'(yes=1, no=RETURN)  ')
      call las(istock,iskriv)
  615 write(out,620)
  620 format(//,2x,'Which version do you prefer ? (slow=0,',1x,
     *'fast=1, very fast=2)  ')
      call las(ihurt,iskriv)
      if (ihurt .ne. 0 .and. ihurt .ne. 1 .and. ihurt .ne. 2) goto 615
      ifast=0
      if (ihurt .ne. 2) goto 630
      ifast=1
      ihurt=1
  630 continue
      if (ihurt .eq. 1) goto 750
c
c
c
c
c
c
c
  640 write(out,650)
  650 format(///////,2x,'WELCOME TO THE FISHERY GAME',//,2x,
     *'This game contains three fish stocks : Cod, plaice and herring',
     */,2x,'Cod acts as a predator to plaice, herring and (smaller) cod',
     */,2x,'Number of age groups and average body weight for each age ',
     */,2x,'group are shown on the table below :',/)
c
      call menue(-1)
      call vent
c
      write(out,700) yfirst
  700 format(//,2x,'There are two fishing fleets in the game',1x,
     *'- one for each player',/,2x, -
     *'Each year you must decide the "fishing strategy", i.e. in each',/,
     *2x,'year you must decide the number of fishing effort units to be',/,
     *2x,'used by your fleet, which mesh size you want and the "direc-',/,
     *2x,'tivity" of your effort on the three species.',/,2x,
     *'The game runs over ten years, and the player who obtain the',/,2x,
     *'highest profit during the ten years becomes the winner of the',/,2x,
     *'game.',/,2x,
     *'If a player does not invest and fish in a sensible way, he may',/,2x
     *,'get ruined, and thus loose the game')
c
      call vent
      write(out,703)
  703 format(/,2x,'Return from fisheries is detremined by')
      call menue(-3)
      call vent
      write(out,705) yfirst
  705 format(/,2x,'When the game starts in year ',i4,' there are',1x,
     *'the following')
c
      y=1
      iy=yfirst
      call q
      call menue(-8)
      call vent
      write(out,710) yfirst,estart
  710 format(//,2x,'When starting the game (year ',i4,') you have a',/,2x,
     *'fishing fleet which at maximum fishing intencity corresponds to',/,
     *2x,f5.0,' fishing effort units. If you want more effort units',/,2x,
     *'you must invest in new vessels')
c
      call menue(-4)
      write(out,715)
  715 format(2x,
     *'Do you want the introduction one more time (yes=1,no=RETURN)')
      call q
      call las(i,iskriv)
      if (i .eq. 1) goto 640
c
c
c
c
c
c
```

```
c
c option to change parameters in the model
c
      if (ibeg .eq. 1) goto 1800
  750 write(out,780)
  780 format(////,2x,'Do you want to change parameters (yes=1,no=RETURN)')
      call las(i,iskriv)
      if (i .ne. 1) goto 1800
  805 write(out,815)
  815 format(//,2x,'Give the number of the parameter you want to change',
     */,2x,'If you do not want more changes : RETURN ')
      call q
      call las(ip,iskriv)
      if (ip .lt. 0) goto 900
      write(out,820)
  820 format(2x,'Give the new parameter value ')
      call las(j,0)
c
      if (ip .eq. 1 .and. ihg .eq. 1) other=xx
      if (ip .eq. 1 .and. ihg .ne. 1) totbio=xx
      if (ip .ge. 2 .and. ip .le. 11) osuit(ip-1)=xx
      if (ip .eq. 12) mfood=xx
      if (ip .eq. 13) hfood=xx
      if (ip .eq. 14) spref=xx
      if (ip .eq. 15) svar=xx
      if (ip .ge. 16 .and. ip .le. 18) kber(ip-15)=xx
      if (ip .ge. 19 .and. ip .le. 21) l8(ip-18)=xx
      if (ip .ge. 22 .and. ip .le. 24) t0(ip-21)=xx
      if (ip .ge. 25 .and. ip .le. 27) conf(ip-24)=xx
      if (ip .eq. 28) m1=xx
      if (ip .ge. 29 .and. ip .le. 31) n0max(ip-28)=xx
      if (ip .ge. 32 .and. ip .le. 34) virb(ip-31)=xx
      if (ip .ge. 35 .and. ip .le. 37) selfac(ip-34)=xx
      if (ip .eq. 38) omk=xx
      if (ip .eq. 39) rente=xx
      if (ip .eq. 40) estart=xx
      if (ip .eq. 41) accmin=xx
      if (ip .eq. 42) pr1=xx
      if (ip .ge. 43 .and. ip .le. 52) price(1,ip-42)=xx
      if (ip .ge. 53 .and. ip .le. 62) price(2,ip-52)=xx
      if (ip .ge. 63 .and. ip .le. 72) price(3,ip-62)=xx
      if (ip .ge. 73 .and. ip .le. 82) n(1,1,ip-72)=xx
      if (ip .ge. 83 .and. ip .le. 92) n(1,2,ip-82)=xx
      if (ip .ge. 93 .and. ip .le. 102) n(1,3,ip-92)=xx
      if (ip .ge. 103 .and. ip .le. 112) dist(1,ip-102)=xx
      if (ip .ge. 113 .and. ip .le. 122) dist(2,ip-112)=xx
c
      goto 805
c
  900 continue
      if (ihg .eq. 1) totbio=other
      write(out,905) totbio
  905 format(//////,2x,'Param. no. Param. value',/,2x,25(1h-),/,
     *4x,'1 : ',f9.0)
      do 920 a=1,10
      i=a+1
  920 write(out,930) i,osuit(a)
  930 format(2x,i3,' : ',2x,f10.6)
      write(out,930) 12,mfood
      write(out,930) 13,hfood
      write(out,930) 14,spref
      write(out,930) 15,svar
      do 935 s=1,3
      i=s+15
  935 write(out,930) i,kber(s)
      do 940 s=1,3
      i=s+18
  940 write(out,930) i,l8(s)
      call las(j,0)
      do 945 s=1,3
      i=s+21
  945 write(out,930) i,t0(s)
      do 950 s=1,3
      i=s+24
  950 write(out,930) i,conf(s)
      write(out,930) 28,m1
      do 960 s=1,3
      i=s+28
  960 write(out,965) i,n0max(s)
  965 format(2x,i3,' : ',2x,f10.1)
      do 970 s=1,3
      i=s+31
  970 write(out,965) i,virb(s)
      do 980 s=1,3
      i=s+34
  980 write(out,930) i,selfac(s)
      write(out,930) 38,omk
      write(out,930) 39,rente
      write(out,965) 40,estart
      write(out,965) 41,accmin
      write(out,930) 42,pr1
      call las(j,0)
      i=42
      do 1000 s=1,3
      do 1000 a=1,10
      i=i+1
      write(out,930) i,price(s,a)
      if (i .eq. 62) call las(j,0)
 1000 continue
      do 1020 s=1,3
      do 1020 a=1,10
      i=i+1
      write(out,965) i,n(1,s,a)
      if (i .eq. 82) call las(j,0)
 1020 continue
      call las(j,0)
      if (istock .ne. 1) goto 750
      do 1040 j=1,2
      do 1040 a=1,10
      i=i+1
 1040 write(out,930) i,dist(j,a)
      call las(j,0)
      goto 750
 1800 continue
c
c
c
c
c
c
c
c
c
c
c
c calculation of food-suitability coefficients and food consumption
c
      do 1810 s=1,3
      do 1810 a=1,10
      time=float(a)+0.5
      l(s,a)=l8(s)*(1.0-exp(-kber(s)*(time-t0(s))))
      w(s,a)=conf(s)*l(s,a)**3
 1810 suit(1,s,a)=0.0
      do 1900 ib=2,10
      sum=0.0
      do 1860 s=1,3
      do 1860 a=1,10
      x1=w(1,ib)/w(s,a)
      rx=alog(x1)-spref
      if (x1 .gt. 2.0) suit(ib,s,a)=exp(-rx**2/svar)
      if (x1 .le. 2.0) suit(ib,s,a)=0.0
      sum=sum+suit(ib,s,a)
 1860 continue
      sum=sum/(1.0-osuit(ib))
      do 1870 s=1,3
      do 1870 a=1,10
 1870 suit(ib,s,a)=suit(ib,s,a)/sum
      food(ib)=hfood*w(1,ib)**mfood
 1900 continue
      food(1)=hfood*w(1,1)**mfood
c
c
c
c
```

```
c
c
c
      bs=0.0
      iy=yfirst-1
      y=0
c
c-----------------------------------------------------------------------
 2000 iy=iy+1
c-----------------------------------------------------------------------
c
c READ DECISIONS :
c ----------------
c
c
c
      y=y+1
      if (y .eq. 1) goto 2009
      if (ifast .ne. 1) goto 2009
      do 2005 e=1,2
      mesh(y,e)=mesh(y-1,e)
      ef(y,e)=ef(y-1,e)
      do 2005 s=1,3
 2005 byc(y,e,s)=byc(y-1,e,s)
      goto 2150
 2009 continue
      if (ifast .eq. 1 .and. yfirst .gt. iyfirst) goto 2150
      if (y .eq. 1 .and. ihurt .ne. 1) write(out,2010) iy
 2010 format(///////,2x,'HERE WE GO - WE START IN YEAR ',i4,/)
 2015 format(2x,'By using the "RETURN" key, the decision of this year',
     */,2x,'becomes the same as last years decision')
c
      efmax1(1)=efmax(1)
      efmax1(2)=efmax(2)
 2020 continue
      if (ihurt .ne. 1) write(out,2030) iy
 2030 format(///,2x,'GIVE MESH SIZES FOR EACH FLEET IN YEAR ',i4,
     */,2x,63(1h-))
      efmax(1)=efmax1(1)
      efmax(2)=efmax1(2)
      if (y .gt. 1 .and. ihurt .ne. 1) write(out,2015)
      do 2040 e=1,2
      if (y .gt. 1) bs=mesh(y-1,e)
      if (mesh(y,e) .ne. -1.0) bs=mesh(y,e)
 2031 write(out,2033) e,bs
 2033 format(2x,'mesh size of fleet ',i1,' (mm)',1x,
     *'.Last years decision :',f6.0,1x)
      call q
      call las(ii,iskriv)
      if (ii .eq. -10 .and. y .eq. 1 .end. mesh(y,e) .eq. -1.0) goto 2035
      if (ii .ne. -10) mesh(y,e)=ii
      if (ii .eq. -10 .and. mesh(y,e) .eq. -1.0 .and. y .gt. 1)
     *mesh(y,e)=mesh(y-1,e)
      if (mesh(y,e) .gt. 4.99999) goto 2040
 2035 write(out,2037)
 2037 format(2x,'Mesh size must be above 5 mm - try again !')
      call q
      goto 2031
 2040 continue
c
c
c
c
      if (ihurt .ne. 1) write(out,2050) iy
 2050 format(///,2x,'GIVE NUMBER OF EFFORT UNITS FOR EACH',1x,
     *'FLEET IN YEAR ',i4,
     */,2x,63(1h-))
      if (y .gt. 1 .and. ihurt .ne. 1) write(out,2015)
      do 2078 e=1,2
      if (y .gt. 1) bs=ef(y-1,e)
      if (ef(y,e) .ne. -1.0 ) bs=ef(y,e)
 2053 write(out,2054) e,bs
 2054 format(2x,'Number of effort units of fleet ',i1,
     *' .Last years decision :',f6.0,1x)
      call q
      call las(ii,iskriv)
      if (ii .eq. -10 .and. y .eq. 1 .and. ef(y,e) .eq. -1.0) goto 2053
      if (ii .ne. -10) ef(y,e)=ii
      if (ii .eq. -10 .and. ef(y,e) .eq. -1.0 .and. y .gt. 1)
     *ef(y,e)=ef(y-1,e)
      if (ef(y,e) .lt. 0.0) goto 2053
      if (ifall(e) .eq. 0 .or. ef(y,e) .eq. 0.0) goto 2070
      ef(y,e)=0.0
      write(out,2060) e
      call q
 2060 format(2x,'fleet ',i1,' is ruined. Number of effort units is',1x,
     *'given the value zero')
 2070 continue
c
      ef1=(ef(y,e)-estart)*pr1
      inv(y,e)=0.0
      if (ef1 .le. 0.0 .or.  ef1 .lt. efmax(e)) goto 2074
      inv(y,e)=ef1-efmax(e)
      efmax(e)=ef1
      x1=inv(y,e)/pr1
      if (x1 .gt. 0.001) write(out,2072) x1
      call q
 2072 format(2x,'You have now invested in ',f6.0,' extra effort units',
     */,2x,50(1h-))
 2074 continue
c
 2078 continue
c
c
c
c
c
      if (ihurt .ne. 1) write(out,2080) iy
 2080 format(///,2x,'GIVE DIRECTIVITY FOR EACH OF THE 3 STOCKS',
     *1x,', IN YEAR ',i4,/,2x,63(1h-))
      if ( y .le. 3 .and. ihurt .ne. 1) write(out,2081)
 2081 format(2x,
     *'Directivity are expressed in percentage. The sum of the three',/,
     *2x,'directivity figures must thus be 100. Percentages should be',/,2x
     *,'given for cod and plaice only - I calculate the percentage for',/,
     *2x,'herring',/)
      if (y .gt. 1 .and. ihurt .ne. 1) write(out,2015)
 2083 do 2100 e=1,2
      write(out,2085) e
      call q
 2085 format(///,2x,'Directivity of fleet no. ',i2)
      do 2090 s=1 ,2
      if (y .gt. 1) bs=byc(y-1,e,s)
      if (byc(y,e,s) .ne. -1.0) bs=byc(y,e,s)
      write(out,2087) (fishn(s,i),i=1,10),bs
      call q
 2087 format(2x,'Percentage for ',10a1,5x,
     *'.Last years decision :',f6.0,1x)
      call las(ii,iskriv)
      if (ii .eq. -10 .and. y .eq. 1 .and. byc(y,e,s) .eq. -1.0) goto 2091
      if (ii .ne. -10) byc(y,e,s)=ii
      if (ii .eq. -10 .and. y .gt.1.and.byc(y,e,s).eq.-1.0)
     *byc(y,e,s)=byc(y-1,e,s)
 2090 continue
      byc(y,e,3)=100.0-byc(y,e,1)-byc(y,e,2)
      if (byc(y,e,3) .ge. 0.0) goto 2094
 209  write(out,2092)
 209c format(2x,'Erroneous input - try again !')
      call q
      goto 2083
 2094 write(out,2095) (fishn(3,i),i=1,10),byc(y,e,3)
      call q
 2095 format(2x,'percentage for ',10a1,38x,f4.0)
 2100 continue
c
c
c reading of dicisions terminated
c
c
c display review of dicisions
c
      x1=inv(y,1)/pr1
      x2=inv(y,2)/pr1
      write(out,2105) iy,(mesh(y,e),e=1,2),(ef(y,e),e=1,2),
     *x1,x2,((byc(y,e,s),e=1,2),s=1,3)
 2105 format(///////////,2x,
     *'The following decisions were taken in year ',i4,//,
     *22x,'fleet 1  fleet 2',/,2x,42(1h-),/,2x,
     *'Mesh size          ',2(f6.0,3x),/,2x,
     *'Number of effort u.',2(f6.0,3x),/,2x,
     *'Investments (ef.u.)',2(f6.0,3x),/,2x,
     *'Directivity Cod    ',2(f6.0,3x),/,2x,
     *'Directivity Plaice ',2(f6.0,3x),/,2x,
     *'Directivity Herring',2(f6.0,3x),/,2x,42(1h-))
c
      if (ihurt .ne. 1) write(out,2110) iy
 2110 format(2x,
     *'Is input for year ',i4,' ok ? (yes=RETURN, no=1)',/,2x,
     *'(Or should fleet 1 take decisions after fleet 2 ?) ')
      call q
      call las(i,iskriv)
      if (i .eq. 1) goto 2020
c
c
c
c
```

```
c
c
c
c calculation of fishing mortalities for each fleet
c
 2150 do 2200 e=1,2
      f1=ef(y,e)/efmean
      do 2190 s=1,3
      f2=f1*byc(y,e,s)*0.01
      x50=0.1*mesh(y,e)*selfac(s)
      scon=10.986123/x50
      do 2180 a=1,10
      gsel=exp(scon*(l(s,a)-x50))
      gsel=gsel/(1.0+gsel)
      f(y,e,s,a)=f2*gsel
 2180 continue
 2190 continue
 2200 continue
c
c calculation of total fishing mortality
c
      do 2220 s=1,3
      do 2220 a=1,10
      ftot(y,s,a)=0.0
      do 2215 e=1,2
 2215 ftot(y,s,a)=ftot(y,s,a)+f(y,e,s,a)
 2220 continue
c
c calculation of predation mortality
c
      noiter=0
c-------------------------------------------------------------
 2400 noiter=noiter+1
c------------------------------------ NEW ITERATION -----------
      fbio=0.0
      do 2500 s=1,3
      do 2450 a=1,10
      z=ftot(y,s,a)+m(y,s,a)+m1
      nmean(s,a)=n(y,s,a)*(1.0-exp(-z))/z
 2450 fbio=fbio+nmean(s,a)*w(s,a)
 2500 continue
      if (ihg .eq. 1) goto 2600
c
c calculation of other food in the case where total biomass of
c the system is assumed to remain constant
c
      other=totbio-fbio
      if (other .gt. 0.0) goto 2600
      write(out,2550)
 2550 format(//,2x,'OTHER FOOD LESS THAN 0, THE PROGRAM IS STOPPED')
      stop
 2600 continue
c
c
      do 3410 ib=1,10
      avail(ib)=0.0
      do 3400 s=1,3
      do 3400 a=1,10
 3400 avail(ib)=avail(ib)+nmean(s,a)*w(s,a)*suit(ib,s,a)
 3410 avail(ib)=avail(ib)+other*osuit(ib)
c
      sum=0.0
      do 3500 s=1,3
      do 3500 a=1,10
      xm=0.0
      do 3480 ib=1,10
 3480 xm=xm+nmean(1,ib)*food(ib)*suit(ib,s,a)/avail(ib)
      sum=sum+(xm-m(y,s,a))**2
      m(y,s,a)=xm
 3500 continue
c
      if (sum .gt. 0.0001) goto 2400
c-------------------------------------------------------------
c
c calculation of stock numbers at the beginning of next year
c
c
      if (y .eq. 10) goto 3800
      do 3560 s=1,3
      do 3550 a=1,9
      z=ftot(y,s,a)+m(y,s,a)+m1
 3550 n(y+1,s,a+1)=n(y,s,a)*exp(-z)
      n(y+1,s,10)=n(y+1,s,10)+n(y,s,10)*exp(-ftot(y,s,10)-m(y,s,10)-m1)
 3560 continue
c
c calculation of year class strength next year
c
      do 3700 s=1,3
      ssb=0.0
      do 3680 a=3,10
 3680 ssb=ssb+n(y+1,s,a)*w(s,a)
      n(y+1,s,1)=n0max(s)/(1.0+virb(s)/ssb)
 3700 continue
      if (istock .ne. 1) goto 3800
c
c generation of stochastic term in the stock/recruitment model
c "systime" and "random" are routines from the RC8000 library
c "random" generates a random integer between 1 and 8388586
c drawn from a uniform distribution.
c
      call systime(1,0,time)
      ii=time
      do 3740 s=1,3
      call random(ii)
      xr=float(ii)/8388586.0
      do 3730 i=2,10
      if (xr .gt. dist(1,i)) fx=dist(2,i)
 3730 continue
      n(y+1,s,1)=n(y+1,s,1)*fx
 3740 continue
 3800 continue
c
c calculation of numbers caught and total average biomass
c
      do 4400 s=1,3
      biom(y,s)=0.0
      do 4390 a=1,10
      biom(y,s)=biom(y,s)+nmean(s,a)*w(s,a)
      z=m1+ftot(y,s,a)+m(y,s,a)
 4390 c(y,s,a)=ftot(y,s,a)*n(y,s,a)*(1.0-exp(-z))/z
 4400 continue
c
c calculation of catch in tons and revenu
c
      do 4500 e=1,2
      profit(y,e)=0.0
      do 4455 s=1,3
      ton(y,e,s)=0.0
      revenu(y,e,s)=0.0
      do 4450 a=1,10
      x1=0.0
      if (ftot(y,s,a) .gt. 0.0)
     *x1=w(s,a)*c(y,s,a)*f(y,e,s,a)/ftot(y,s,a)
      ton(y,e,s)=ton(y,e,s)+x1
      revenu(y,e,s)=revenu(y,e,s)+x1*price(s,a)
 4450 continue
      profit(y,e)=profit(y,e)+revenu(y,e,s)
 4455 continue
 4500 continue
c
c calculation of profit
c
      do 4600 e=1,2
      profit(y,e)=profit(y,e)-ef(y,e)*omk
      if (y .gt. 1) profit(y,e)=profit(y,e)+profit(y-1,e)
 4600 continue
c
c calculation of interest and repayment of investments
c
      i1=1
      if (y-4 .gt. 1) i1=y-4
      i2=y-1
      do 5000 e=1,2
      sum=inv(y,e)*0.2
      if (y .eq. 1) goto 4980
      do 4950 i=i1,i2
 4950 sum=sum+inv(i,e)*(0.2+(1.0-float(y-i)/5.0)*rente)
 4980 repay(y,e)=sum
      profit(y,e)=profit(y,e)-repay(y,e)
 5000 continue
      if (ihg .ne. 1) write(out,5100) y,fbio,other
 5100 format(2x,i2,' fish biom. ',f11.0,' other food ',f11.0)
      if (ifast .eq. 1 .and. y .lt. 10) goto 2000
c
c -------------------------------------------------------------
c calculations for the year finished. Display of results :
c -------------------------------------------------------------
c
```

```
c
c
c
c
c
c
c display of four graphs on the screen
      if (ihurt .eq. 1) goto 5300
c
      call graf(-1)
      do 5500 s=1,3
      ix=-6-s
 5500 call graf(ix)
c
c display of menues on the screen
c
 5300 write(out,5550)
 5550 format(/,2x,'Do you want the small or the large menu ?',1x,
     *'(small=1, large=2, none=RETURN)  ')
      call las(i,iskriv)
      if (i .eq. 1) goto 5600
      if (i .ne. 2) goto 5800
      call menue(1)
      goto 5800
c
c display of the small menue
c
 5600 continue
c
      call q
      if (ihurt .ne. 1) write(out,5605)
 5605 format(//////,2x,
     *'SELECT A COURSE FROM THE SMALL MENU :',/,2x,
     *'1 : Number of survivors',/,2x,
     *'2 : Total number caught',/,2x,
     *'3 : Total fishing mortality',/,2x,
     *'4 : Predation mortality',/,2x,
     *'5 : Number caught by each fleet',/,2x,
     *'6 : Fishing mortality by each fleet',/,2x,
     *'RETURN : Stop displaying results - return to game',/)
      if (ihurt .eq. 1) write(out,5610)
 5610 format(2x,'Give course no. on small menu ')
c
      call las(iopt,iskriv)
c
c
      if (iopt .lt. 0 .or. iopt .gt. 6) goto 5300
      goto (5620,5625,5630,5635,5640,5640),iopt
c
c
c
 5620 call tabel(n,1,0,yfirst)
      goto 5600
 5625 call tabel(c,2,0,yfirst)
      goto 5600
 5630 call tabel(ftot,3,0,yfirst)
      goto 5600
 5635 call tabel(m,4,0,yfirst)
      goto 5600
c
c display of numbers caught by each fleet
c
 5640 write(out,5645)
 5645 format(2x,'which fleet do you want ? (1 or 2)  ')
      call las(e,iskriv)
      if (e .ne.1 .and. e .ne. 2) goto 5640
      if (iopt .eq. 6) goto 5650
      do 5760 s=1,3
      do 5760 a=1,10
      do 5760 j=1,10
      xt(j,s,a)=0.0
      if (ftot(j,s,a) .gt. 0.0) xt(j,s,a)=c(j,s,a)*f(j,e,s,a)/ftot(j,s,a)
 5760 continue
      call tabel(xt,2,e,yfirst)
c
      goto 5600
c display of fishing mortality by each fleet
c
 5650 do 5770 s=1,3
      do 5770 a=1,10
      do 5770 j=1,10
 5770 xt(j,s,a)=f(j,e,s,a)
      call tabel(xt,3,e,yfirst)
      write(out,5780) (mesh(j,e),j=1,10)
      write(out,5785) (ef(j,e),j=1,10)
      do 5772 s=1,3
 5772 write(out,5773) s,(byc(j,e,s),j=1,10)
 5773 format(2x,i1,' byc. ',10f7.2)
 5785 format(2x,'effort ',10f7.0)
 5780 format(2x,77(1h-),/,2x,'mesh',3x,10f7.0)
c
      goto 5600
c
 5800 continue
c
c
c
c
c
      if (y .le. 3) goto 2000
      do 6000 e=1,2
      if (ifall(e) .eq. 1) goto 6000
c
c check of ruins
c
      if (profit(y,e) .ge. accmin) goto 6000
      ifall(e)=1
      ie=1
      if (e .eq. 1) ie=2
      write(out,5900) e,accmin,e
      call q
 5900 format(//,2x,'FLEET NO. ',i1,' HAS BEEN RUINED',/,2x,
     *26(1h=),/,2x,'Acc. profit is below the lower limit',1x,
     *': ',f7.0,' (Fleet ',i1,' is out of the game')
      if (ifall(ie) .eq. 1) goto 5955
      write(out,5950) ie
 5950 format(/,2x,'Fleet ',i1,' can continue alone')
      goto 6000
 5955 write(out,5960)
 5960 format(///,2x,'Both fleets are ruined - game is over',/,2x,
     *'dont behave that stupid next time you play with me !')
      call vent
      call menue(1)
      goto 5955
 6000 continue
c
      if (y .lt. 10) goto 2000
c
c TERMINATION of the game
c
      do 8210 e=1,2
      sum=0.0
      do 8200 i=7,10
 8200 sum=sum+inv(i,e)*(float(i)/5.0-1.0)
      aux(e)=sum
 8210 aux(2+e)=profit(10,e)-sum
c
      write(out,8300) (profit(10,e),e=1,2),(aux(e),e=1,4)
      call q
 8300 format(//,2x,'GAME IS FINISHED',///,15x,
     *'  Fleet 1       Fleet 2',/,2x,
     *'Accum. profit ',2(2x,f6.0,5x),/,2x,
     *'Loans not paid',2(2x,f6.0,5x),/,2x,36(1h-),/,2x,
     *'Ac. prof.-loan',2(2x,f6.0,5x))
c
      ivin=1
      dif=aux(3)-aux(4)
      if (dif .lt. 0.0) ivin=2
      if (abs(dif) .lt. 0.01) ivin=3
      if (ivin .ne. 3) write(out,8320) ivin
      call q
 8320 format(//,2x,
     *'-------------------------------',/,2x,
     *'! FLEET NO ',i1,' WON THE GAME   !',/,2x,
     *'-------------------------------')
      if (ivin .eq. 3) write(out,8325)
 8325 format(2x,
     *'----------------------------',/,2x,
     *'! GAME ENDED IN A DRAW    !',/,2x,
     *'----------------------------')
```

```
      call vent
      call menue(1)
c
      if (ibej .eq. 1) stop
c
c option for continuation of the game
c
 8990 write(out,9000)
 9000 format(///,2x,'Do you want to continue ?',1x,
     *'(yes=1, no=0)   ')
      call las(i,iskriv)
      if (i .ne. 1 .and. i .ne. 0) goto 8990
      if (i .ne. 1) stop
      yfirst=yfirst+10
      ylast=ylast+10
      do 9010 s=1,3
      do 9005 e=1,2
 9005 byc(1,e,s)=byc(10,e,s)
      do 9010 a=1,10
 9010 n(1,s,a)=n(10,s,a)
      do 9015 e=1,2
      mesh(1,e)=mesh(10,e)
 9015 ef(1,e)=ef(10,e)
      goto 615
      end
c
```

```
c
      subroutine menue(iopt)
      external in,out; zone in,out
c
c *************************************************************
c *    T H E     L A R G E     M E N U                        *
c *                                                           *
c * display of results and parameters (no calculations)       *
c *************************************************************
c
      real n(10,3,10),c(10,3,10),biom(10,3),
     * l8(3),kber(3),t0(3),conf(3),l(3,10),w(3,10),
     * mesh(10,3),selfac(3),byc(10,2,3),ef(10,3),
     * ftot(10,3,10),f(10,2,3,10),m(10,3,10),
     * suit(10,3,10),food(10),m1,other,osuit(10),
     * price(3,10),revenu(10,2,3),ton(10,2,3),omk,profit(10,2)
     * ,inv(10,2),repay(10,2),
     * aux(10),avail(10)
c
      integer fishn(3,10),tegn(42),
     * y,e,s,a,yfirst,iy,isidst,stoc(10),b
c
      common /name/ fishn,tegn,iskriv,ihurt
c
      common /com1/ n,c,biom,
     * l8,kber,t0,conf,l,w,
     * mesh,selfac,byc,ef,
     * ftot,f,m,avail,
     * suit,food,m1,other,osuit,
     * price,revenu,ton,omk,profit,inv,repay,pr1,rente,accmin,
     * y,yfirst,iy,isidst
c
      jy=iy
      i3=jy-yfirst+1
c
      if (iopt .lt. 0) goto 310
      if (ihurt .ge. 1) goto 150
  100 write(out,130)
  130 format(/,2x,'Give course no. on large menu ')
      goto 250
c
  150 write(out,200)
      call u
  200 format(///////,2x,
     *'SELECT A COURSE FROM THE LAEGE MENU :',/,2x,40(1h-),/,2x,
     *'1  : Mean weight at age in the three stocks',/,2x,
     *'2  : Mean lenghts at age in the three stocks',/,2x,
     *'3  : Kg-prices at age and species',/,2x,
     *'4  : Cost per effort unit, interest and instalment',/,2x,
     *'5  : Fishing effort and investments in the foregoing years',/,2x,
     *'6  : Mesh sizes used in the foregoing years',/,2x,
     *'7  : Directivities used in the foregoing years',/,2x,
     *'8  : Number of survivors in each stock',/,2x,
     *'9  : Number caught from each stock',/,2x,
     *'10 : Number caught by each fleet')
      write(out,202)
      call u
  202 format(2x,
     *'11 : Weight and value of the catch of each fleet',/,2x,
     *'12 : Percentage fish died due to fishing',/,2x,
     *'13 : Percentage fish died due to the predator (the cod)',/,2x,
     *'14 : Year class strenghts and spawning stock biomasses',/,2x,
     *'15 : Costs, income and profit (book-keeping for a single year)'
     *,/,2x,
     *'16 : Food selection of cod (food suitapilities)',/,2x,
     *'17 : Grafical display',/,2x,
     *'18 : Relative stomach content of cod',/,2x,
     *'RETURN : Stop displaying results - return to the game',/,2x)
  250 call las(iopt,iskriv)
      if (iopt .eq. -10) return
  300 format(i2)
  310 continue
      iopt1=iopt
      if (iopt .lt. 0) iopt=-iopt
      iy1=yfirst
      if (1 .le. iopt .and. iopt .le. isidst) goto 500
      write(out,350) iopt
  350 format(2x,'Course mo. ',i2,' is not on the menue -',1x,
     *'try again')
      goto 150
  500 continue
```

```
c-----------------------------------------------------------------------
c              1    2    3    4    5    6    7     8     9    10    11    12    13
      goto (600,600,850,880,800,900,1000,1100,1100,1100,1400,1100,1100
     *,1700,1100,1900,2000,1100), iopt
c        14   15   16   17   18
c-----------------------------------------------------------------------
c 1-2-1-2-1-2-1-2-1-2-1-2-1-2-1-2-1-2-1-2-1-2-1-2-1-2-1-2-1-2-1-2-1-2-1-2
  600 continue
      if (iopt .eq. 1) write(out,610)
  610 format(5x,'Mean weight at age (Kg.)')
      if (iopt .eq. 2) write(out,620)
  620 format(5x,'Mean length (cm) at age')
      call hoved
      ia=1
      do 670 a=1,10
      if (iopt .eq. 1) write(out,665) ia,(w(s,a),s=1,3)
      if (iopt .eq. 2) write(out,665) ia,(l(s,a),s=1,3)
  665 format(2x,i2,3x,3(3x,f8.2,2x))
      ia=ia+1
  670 continue
      goto 9000
c
c 5-5-5-5-5-5-5-5-5-5-5-5-5-5-5-5-5-5-5-5-5-5-5-5-5-5-5-5-5-5-5-5-5-5-5
  800 continue
      write(out,810)
  810 format(///,2x,'Number of effort units and investments',/,2x,
     *'year          fleet 1                fleet 2',/,10x,
     *2('effort u.  invest.',2x),/,2x,45(1h-))
      iy1=yfirst
      do 830 i=1,y
      write(out,820) iy1,ef(i,1),inv(i,1),ef(i,2),inv(i,2)
  820 format(2x,i4,4(6x,f4.0))
  830 iy1=iy1+1
      goto 9000
c
c 3-3-3-3-3-3-3-3-3-3-3-3-3-3-3-3-3-3-3-3-3-3-3-3-3-3-3-3-3-3-3-3-3-3-3
  850 write(out,851)
  851 format(/,2x,'Kg-prices of fish')
      call hoved
      do 860 a=1,10
      do 855 s=1,3
  855 aux(s)=price(s,a)*100.0
  860 write(out,665) a,(aux(s),s=1,3)
      goto 9000
c
c 4-4-4-4-4-4-4-4-4-4-4-4-4-4-4-4-4-4-4-4-4-4-4-4-4-4-4-4-4-4-4-4-4-4-4
  880 aux(1)=omk*100.0
      aux(2)=rente*100.0
      aux(3)=pr1*100.0
      aux(4)=accmin*100.0
      write(out,885) (aux(i),i=1,4)
  885 format(//,2x,'Cost per effort unit',f6.0,' Dkr.',/,2x,
     *'Instalment amonuts to 1/5 of the investment per year',/,2x,
     *'Rate of interest is ',f5.1,' percent per year',/,2x,
     *'Investment for one extra effort unit amounts to ',f6.0,
     *' Dkr. ',/,2x,
     *'You are ruined if your accumulated profit comes below ',f8.0,
     *' Dkr.',/,2x,'and more than 3 years have elapsed since we started',
     */,2x,'In last year all remaining loans are paid back')
      goto 9000
c
c 6-6-6-6-6-6-6-6-6-6-6-6-6-6-6-6-6-6-6-6-6-6-6-6-6-6-6-6-6-6-6-6-6-6-6
  900 continue
      write(out,910)
  910 format(////,2x,'Mesh size (mm) in each year',/,2x,
     *'year     fleet 1    fleet 2',/,2x,28(1h-))
      iy1=yfirst
      do 930 i=1,y
      write(out,920) iy1,mesh(i,1),mesh(i,2)
  920 format(2x,i4,2(3x,f4.0,3x))
  930 iy1=iy1+1
      goto 9000
c
c 7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7-7
 1000 continue
c
      write(out,1010) ((fishn(s,i),i=1,10),s=1,3)
 1010 format(//,2x,'Directivity of effort (percentage) in each year',
     */,12x,3(3x,10a1,3x),/,2x,'år',4x,3('fleet 1 fleet 2',2x),
     */,2x,56(1h-))
      iy1=yfirst
      do 1080 i=1,y
      do 1050 s=1,3
      j=2*s
      aux(j-1)=byc(i,1,s)
 1050 aux(j)=byc(i,2,s)
      write(out,1060) iy1,(aux(j),j=1,6)
 1060 format(2x,i4,6(1x,f6.0,1x))
      iy1=iy1+1
 1080 continue
      goto 9000
c
c 8-9-10-12-15---8-9-10-12-15---8-9-10-12-15---8-9-10-12-15---8-9-10-1
 1100 continue
c
c-----------------------------------------------------------------------
      jy=iy
      if (iopt1 .lt. 0) goto 1107
      write(out,1104) iy
      call q
 1104 format(2x,'Which year do you want ? (default : ',i4,')',/,2x,
     *'default : RETURN, no more year : type "0"  ')
      call las(jy,iskriv)
      if (jy .eq. 0) goto 9000
      if (yfirst-1900 .le. jy .and. jy .le. iy-1900) jy=jy+1900
      if (jy .lt. yfirst .or. jy .gt. iy) jy=iy
c
 1107 continue
      i1=iopt-7
      i3=jy-yfirst+1
      if (iopt .eq. 18) goto 2100
      goto (1108,1200,1300,1400,1500,1600,1800,1800) ,i1
c              1    2    3    4    5    6
c-----------------------------------------------------------------------
c
c 8-8-8-8-8-8-8-8-8-8-8-8-8-8-8-8-8-8-8-8-8-8-8-8-8-8-8-8-8-8-8-8-8-8-8-
 1108 continue
      if (iopt1 .gt. 0) write(out,1109)
 1109 format(//////////,2x)
      write(out,1110) jy
 1110 format(2x,'Number of survivors at the beginning of ',i4)
      call hoved
      do 1150 a=1,10
      write(out,1140) a,(n(i3,s,a),s=1,3)
 1140 format(2x,i2,6x,3(2x,f6.0,5x))
 1150 continue
      write(out,1160) (biom(i3,s),s=1,3)
 1160 format(2x,43(1h-),/,2x,'Biomass  ',3(1x,f7.0,5x),/,4x,'(tons)')
      do 1162 s=1,3
 1162 aux(s)=biom(i3,s)-w(s,1)*n(i3,s,1)-w(s,2)*n(i3,s,2)
      write(out,1165) (aux(s),s=1,3)
 1165 format(2x,43(1h-),/,2x,'Spawning ',3(1x,f6.0,6x),/,2x,
     *'stock biomass (tons) (biomass of age 3 and older fish)')
      if (iopt1 .lt. 0) return
      goto 1100
c
c 9-9-9-9-9-9-9-9-9-9-9-9-9-9-9-9-9-9-9-9-9-9-9-9-9-9-9-9-9-9-9-9-9-9-9
 1200 continue
      write(out,1210) jy
 1210 format(///,2x,'Total number of fish caught in year ',i4)
      call hoved
      do 1250 a=1,10
      write(out,1240) a,(c(i3,s,a),s=1,3)
 1240 format(2x,i2,6x,3(2x,f6.0,5x))
 1250 continue
      do 1255 s=1,3
      aux(s)=0.0
      do 1255 e=1,2
 1255 aux(s)=aux(s)+ton(i3,e,s)
      write(out,1260) (aux(s),s=1,3)
 1260 format(2x,43(1h-),/,2x,'Catch',2x,3(2x,f6.0,5x),/,2x,'(tons)')
      if (iopt1 .lt. 0) return
      goto 1100
c
```

```
c 10-10-10-10-10-10-10-10-10-10-10-10-10-10-10-10-10-10-10-10-10-10
 1300 continue
      write(out,1310) jy,((fishn(s,i),i=1,10),s=1,3)
 1310 format(/,2x,'Number of fish caught by each fleet in year ',i4,/,
     *8x,3(8x,10a1),3x,/,2x,' age ',3x,
     *3('fleet 1  fleet 2  '),/,2x,61(1h-))
      do 1350 a=1,10
      do 1320 s=1,3
      i1=2*s-1
      i2=i1+1
      aux(i1)=0.0
      aux(i2)=0.0
      if (ftot(i3,s,a) .le. 0.0) goto 1320
      x1=c(i3,s,a)/ftot(i3,s,a)
      aux(i1)=f(i3,1,s,a)*x1
      aux(i2)=f(i3,2,s,a)*x1
 1320 continue
      write(out,1330) a,(aux(s),s=1,6)
 1330 format(2x,i2,4x,6(3x,f6.0))
 1350 continue
      write(out,1360) ((ton(i3,e,s),e=1,2),s=1,3)
 1360 format(2x,61(1h-),/,2x,'catch',6(3x,f6.0),/,2x,'(tons)')
      if (iopt1 .lt. 0) return
      goto 1100
c
c 11-11-11-11-11-11-11-11-11-11-11-11-11-11-11-11-11-11-11-11-11-11-11
 1400 continue
      write(out,1402)
 1402 format(/,2x,'Catch in tons and value of catch each year',/,11x,
     *'fleet 1',13x,'fleet 2',/,2x,43(1h-),/,9x,
     *2('tons          value',5x),/,7x,2(12x,'(Dkr)',3x),/,2x,43(1h-))
      iy1=yfirst
      do 1410 i=1,y
      aux(1)=ton(i,1,1)+ton(i,1,2)+ton(i,1,3)
      aux(3)=ton(i,2,1)+ton(i,2,2)+ton(i,2,3)
      aux(2)=revenu(i,1,1)+revenu(i,1,2)+revenu(i,1,3)
      aux(4)=revenu(i,2,1)+revenu(i,2,2)+revenu(i,2,3)
      write(out,1405) iy1,(aux(j),j=1,4)
 1405 format(2x,i4,4(2x,f6.0,2x))
 1410 iy1=iy1+1
      if (iopt1 .lt. 0) return
      goto 9000
c
c 12-12-12-12-12-12-12-12-12-12-12-12-12-12-12-12-12-12-12-12
 1500 continue
c
      write(out,1510) jy
 1510 format(///,2x,'Percentage fish dead due to fishing in year ',i4)
      call hoved
      do 1530 a=1,10
      do 1515 s=1,3
 1515 aux(s)=100.0*c(i3,s,a)/n(i3,s,a)
      write(out,1520) a,(aux(s),s=1,3)
 1520 format(2x,i2,6x,3(2x,f6.2,5x))
 1530 continue
      if (iopt1 .lt. 0) return
      goto 1100
c
c 13-13-13-13-13-13-13-13-13-13-13-13-13-13-13-13-13-13-13-13-13-13
 1600 continue
      write(out,1610) jy
 1610 format(/,2x,'Percentage of fish dead due to predation',1x,
     *'(by cod) in year ',i4)
      call hoved
      do 1630 a=1,10
      do 1615 s=1,3
      z=m1+ftot(i3,s,a)+m(i3,s,a)
 1615 aux(s)=100.0*m(i3,s,a)*(1.0-exp(-z))/z
      write(out,1520) a,(aux(s),s=1,3)
 1630 continue
      if (iopt1 .lt. 0) return
      goto 1100
c
c 14-14-14-14-14-14-14-14-14-14-14-14-14-14-14-14-14-14-14-14-14-14-
 1700 continue
      write(out,1710) ((fishn(s,i),i=1,10),s=1,3)
 1710 format(//////,2x,'Year class strength (number of 1 year old fish)',
     */,2x,'and spawning stock biomass (3 year and older fish) on',1x,
     *'1. January.',/,2x,'year',
     *3x,3(6x,10a1,1x),/,13x,3('Yr. cl.  S.S.B. ',1x),/,2x,63(1h-))
      do 1730 i=1,y
      do 1715 s=1,3
      aux(s)=0.0
      do 1715 a=3,10
 1715 aux(s)=aux(s)+n(i,s,a)*w(s,a)
      write(out,1725) iy1,(n(i,s,1),aux(s),s=1,3)
 1725 format(2x,i4,3x,6(2x,f7.0))
 1730 iy1=iy1+1
      goto 9000
c
c 15-15-15-15-15-15-15-15-15-15-15-15-15-15-15-15-15-15-15-15-15-15-15
 1800 continue
      do 1805 i=1,10
 1805 aux(i)=0.0
      write(out,1810) jy
 1810 format(////,2x,'Costs, income and profit in year ',i4,/,19x,
     *'fleet 1',15x,'fleet 2',/,14x,
     *2('catch     value of ',3x),/,14x,
     *2('(tons)    catch (Dkr)',3x),/,2x,55(1h-))
      do 1820 s=1,3
      write(out,1815) (fishn(s,i),i=1,10),ton(i3,1,s),revenu(i3,1,s),
     *ton(i3,2,s),revenu(i3,2,s)
 1815 format(2x,10a1,4(f6.0,5x))
      aux(1)=aux(1)+ton(i3,1,s)
      aux(2)=aux(2)+revenu(i3,1,s)
      aux(3)=aux(3)+ton(i3,2,s)
      aux(4)=aux(4)+revenu(i3,2,s)
 1820 continue
      write(out,1830) (aux(i),i=1,4)
 1830 format(2x,55(1h-),/,2x,'Total',5x,4(f6.0,5x))
      aux(5)=ef(i3,1)*omk
      aux(6)=ef(i3,2)*omk
      write(out,1835) aux(5),aux(6)
 1835 format(2x,'Costs of fishery   ',3x,2(f6.0,16x))
      write(out,1836) (repay(i3,e),e=1,2)
 1836 format(2x,'Instalm.+Interest',4x,2(f6.0,16x))
      aux(7)=aux(2)-aux(5)
      aux(8)=aux(4)-aux(6)
      write(out,1840) aux(7),aux(8)
 1840 format(2x,'profit',5x,2(10x,f6.0,6x))
      write(out,1850) (profit(i3,e),e=1,2)
 1850 format(2x,'Accumulated profit',3x,2(f6.0,16x))
      if (iopt1 .lt. 0) return
      goto 1100
c
c 16-16-16-16-16-16-16-16-16-16-16-16-16-16-16-16-16-16-16-16-16-16
 1900 continue
 1910 write(out,1920)
 1920 format(//////,2x,'Food selection of cod',/,2x,
     *'Which age group do you want ?',1x,
     *'(RETURN if you do not want more age groups)  ')
      call q
      call las(ib,iskriv)
      if (ib .le. 0 .or. ib .gt. 10) goto 9000
      write(out,1930) ib
 1930 format(/,2x,'food preference of ',i2,' years old cod')
      call hoved
      do 1940 a=1,10
 1940 write(out,1945) a,(suit(ib,s,a),s=1,3)
 1945 format(2x,i2,6x,3(3x,f6.3,4x))
      write(out,1950) osuit(ib),ib,food(ib),other
 1950 format(2x,'"other food"',f6.3,/,2x,
     *'yearly food consumption of ',i2,' years old cod : ',f6.1,
     *' kg.',/,2x,
     *'Biomass of "other food" : ',f8.0,' tons')
      goto 1910
c
c 17-17-17-17-17-17-17-17-17-17-17-17-17-17-17-17-17-17-17-17-17-17
 2000 call graf(1)
      goto 9000
```

```
c 18-18-18-18-18-18-18-18-18-18-18-18-18-18-18-18-18-18-18-18-18-18
 2100 continue
c
c
c calculation of available food
c
      do 3200 b=1,10
      avail(b)=0.0
      aux(b)=0.0
      do 3000 s=1,3
      do 3000 a=1,10
      z=ftot(i3,s,a)+m(i3,s,a)+m1
      xn=n(i3,s,a)*(1.0-exp(-z))/z
 3000 avail(b)=avail(b)+xn*w(s,a)*suit(b,s,a)
 3200 avail(b)=avail(b)+other*osuit(b)
c
c
      do 3500 s=1,3
      write(out,3300) (fishn(s,i),i=1,10),jy,(b,b=1,10)
 3300 format(//,2x,'Relative cod-stomach content*10000 of ',10a1,
     *'   in year ',i4,/,1x,
     *'prey    / cod age',/,1x,'age',10(2x,i2,2x),/,
     *1x,63(1h-))
      do 3400 a=1,10
      z=ftot(i3,s,a)+m(i3,s,a)+m1
      xn=n(i3,s,a)*(1.0-exp(-z))/z
      do 3350 b=1,10
      xs=10000.0*xn*w(s,a)*suit(b,s,a)/avail(b)
      aux(b)=aux(b)+xs
      stoc(b)=xs
 3350 continue
      write(out,3360) a,(stoc(b),b=1,10)
 3360 format(1x,i2,10(1x,i5))
 3400 continue
      call las(j,0)
 3500 continue
c
      write(out,3600) jy,(b,b=1,10)
 3600 format(/,2x,'Relative cod-stomach content*10000 of "other food"',
     *1x,' in year ',i4,
     */,6x,'Cod age',/,4x,10(2x,i2,2x),/,1x,63(1h-))
      do 3620 b=1,10
      i=aux(b)
      stoc(b)=10000-i
 3620 continue
      write(out,3360) 1,(stoc(b),b=1,10)
      call las(j,0)
      goto 1100
c
 9000 continue
      call q
c
      if (iopt1 .lt. 0) return
      if (ihurt .ne. 1) write(out,9010)
 9010 format(/,2x,'Back to the large menu : RETURN')
      call q
      read(in,300) i
      call r
c
      if (ihurt .eq. 1) goto 100
      goto 150
      end
c
c
c
c
c
c
c
c
c
      subroutine hoved
c ****************************************
c *  "head" for tables with 3 species     *
c ****************************************
      external in,out; zone in,out
      integer s,fishn(3,10),tegn(42)
      common /name/ fishn,tegn,iskriv,ihurt
      write(out,100) ((fishn(s,i),i=1,10),s=1,3)
  100 format(/,2x,' age ',3x,5(3x,10a1))
      write(out,200)
  200 format(2x,44(1h-))
      call q
      return
      end
```

```
      subroutine graf(ix)
c ************************************
c * graphical output (no calculations) *
c ************************************
c
       external in,out; zone in,out
c
      real n(10,3,10),c(10,3,10),biom(10,3),
     * l8(3),kber(3),t0(3),conf(3),l(3,10),w(3,10),
     * mesh(10,3),selfac(3),byc(10,2,3),ef(10,3),
     * ftot(10,3,10),f(10,2,3,10),m(10,3,10),
     * suit(10,3,10),food(10),m1,other,osuit(10),
     * price(3,10),revenu(10,2,3),ton(10,2,3),omk,profit(10,2),
     * inv(10,2),repay(10,2),
     * x(10,2),avail(10)
c
      integer fishn(3,10),y,e,s,a,yfirst,iy,ylast,tegn(42)
c
      common /name/ fishn,tegn,iskriv,ihurt
c
      common /com1/ n,c,biom,
     * l8,kber,t0,conf,l,w,
     * mesh,selfac,byc,ef,
     * ftot,f,m,avail,
     * suit,food,m1,other,osuit,
     * price,revenu,ton,omk,profit,inv,repay,pri,rente,accmin,
     * y,yfirst,iy,isidst
c
      if (ix .lt. 0) goto 50
    1 continue
      if (ihurt .ne. 1) goto 5
      write(out,2)
    2 format(/,2x,'Give graph no. ')
      goto 30
    5 write(out,10)
      call q
   10 format(///////,2x,'WHICH GRAPH DO YOU WANT TO SEE ?',/,2x,
     *'  1 : Accumulated profit',/,2x,
     *'  2 : Profit',/,2x,
     *'  3 : Total catch (tons)',/,2x,
     *'  4 : Costs (number of effort units)',/,2x,
     *'  5 : Income',/,2x,
     *'  6 : Investments',/,2x,
     *'  7 : Catch and total biomass of cod',/,2x,
     *'  8 : Catch and total biomass of plaice',/,2x,
     *'  9 : Catch and total biomass of herring',/,2x,
     *' 10 : Spawning stock biomass and recruitment of cod',/,2x,
     *' 11 : Spawning stock biomass and recruitment of plaice',/,2x,
     *' 12 : Spawning stock biomass and recruitment of herring',/,2x,
     *'RETURN : I do not want to see more curves  ')
   30 call las(iopt,iskriv)
      if (iopt .le. 0 .or. iopt .ge. 13) return
      write(out,40)
   40 format(///,2x)
c
   50 continue
      ylast=yfirst+y-1
      if (ix .lt. 0) iopt=-ix
      goto (100,200,300,400,500,600,650,650,650,900,900,900) ,iopt
c             1   2   3   4   5   6   7   8   9   10  11  12
c
  100 continue
      write(out,102)
  102 format(//,2x,'Accumulated profit')
      call kurve(profit,yfirst,ylast,5,6)
      if (ix .eq. -1) return
      goto 9000
c
  200 continue
      do 210 e=1,2
      do 205 i=2,y
  205 x(i,e)=profit(i,e)-profit(i-1,e)
  210 x(1,e)=profit(1,e)
      write(out,220)
  220 format(/,2x,'Profit')
      call kurve(x,yfirst,ylast,5,6)
      goto 9000
```

```
  300 continue
      do 310 e=1,2
      do 310 i=1,y
      x(i,e)=0.0
      do 310 s=1,3
  310 x(i,e)=x(i,e)+ton(i,e,s)
      write(out,320)
  320 format(/,2x,'Catch (tons)')
      call kurve(x,yfirst,ylast,5,6)
      goto 9000
c
  400 continue
      write(out,410)
  410 format(2x,'Costs')
      call kurve(ef,yfirst,ylast,5,6)
      goto 9000
c
  500 continue
      do 510 e=1,2
      do 510 i=1,y
      x(i,e)=0.0
      do 510 s=1,3
  510 x(i,e)=x(i,e)+revenu(i,e,s)
      write(out,520)
  520 format(/,2x,'Income')
      call kurve(x,yfirst,ylast,5,6)
      goto 9000
c
  600 continue
      write(out,610)
  610 format(/,2x,'Investments')
      call kurve(inv,yfirst,ylast,5,6)
      goto 9000
c
c
  650 continue
      s=iopt-6
      do 660 i=1,y
      x(i,1)=ton(i,1,s)+ton(i,2,s)
  660 x(i,2)=biom(i,s)
      write(out,680) (fishn(s,i),i=1,10)
  680 format(/,2x,'Catch (tons) and total biomass (tons) of ',10a1,/,2x,
     *'(biomass is the average biomass during a year)')
      call kurve(x,yfirst,ylast,7,8)
      goto 9000
c
  900 continue
      s=iopt-9
      sum1=0.0
      sum2=0.0
      do 910 i=1,y
      x(i,1)=0.0
      do 905 a=3,10
  905 x(i,1)=n(i,s,a)*w(s,a)
      x(i,2)=n(i,s,1)
      sum1=sum1+x(i,1)
  910 sum2=sum2+x(i,2)
      xm1=0.0
      xm2=0.0
      do 920 i=1,y
      if (xm1 .lt. x(i,1)) xm1=x(i,1)
      if (xm2 .lt. x(i,2)) xm2=x(i,2)
  920 continue
      xmin1=xm1
      xmin2=xm2
      do 921 i=1,y
      if (xmin1 .gt. x(i,1)) xmin1=x(i,1)
      if (xmin2 .gt. x(i,2)) xmin2=x(i,2)
  921 continue
      do 922 i=1,y
      x(i,1)=x(i,1)/sum1+0.01
  922 x(i,2)=x(i,2)/sum2+0.01
      write(out,930) (fishn(s,i),i=1,10),xmin1,xmin2,xm1,xm2
  930 format(/,2x,'Spawning stock biomass (age 3 and older) and',
     *1x,'recruitment (number of 1-years)',/,2x,
     *'of ',10a1,' .',
     *2x,'min. biomass = ',f6.0,'  min. recruitment = ',f7.0,/,
     *19x,'max. biomass = ',f6.0,'  max. recruitment = ',f7.0)
      call kurve(x,yfirst,ylast,9,10)
c
c
 9000 continue
      call q
      if (ix .lt. 0) return
c
      if(iopt .ne. -1) goto 1
      return
      end
```

```
      subroutine kurve(x,yfirst,ylast,ib1,ib2)
c
c *********************
c * Curve-drawing     *
c *********************
      external in,out;  zone in,out
      real x(10,2)
      integer yfirst,ylast,y,e,yy(10,2),bog(32),fishn(3,10),tegn(42)
c
      common /name/ fishn,tegn,iskriv,ihurt
c
      islut=ylast-yfirst+1
      xmax=-10.0e6
      xmin=-xmax
      do 200 e=1,2
      do 200 i=1,islut
      if (xmax .lt. x(i,e)) xmax=x(i,e)
      if (xmin .gt. x(i,e)) xmin=x(i,e)
  200 continue
      range=xmax-xmin
      if (range .le. 0.000001) range=1.0
c
      do 300 e=1,2
      do 300 i=1,islut
      y1=(x(i,e)-xmin)/range
      y1=y1*18.0+0.5
      ii=y1
      if (ii .eq. 0) ii=1
      if (ii .eq. 19) ii=18
  300 yy(i,e)=ii
c
      xnul=0.0
      nul=-1
      y1=-xmin/range
      if (xmin*xmax .lt. 0.0) nul=18.0*y1+0.49999
      if (nul .eq. 18 .or. nul .eq. 1) nul=-10
      mean=-1
      xmean=0.5*(xmin+xmax)
      y1=(xmean-xmin)/range
      if (xmin*xmax .gt. 0.0 ) mean=18.0*y1+0.49999
      if (mean .ne. -1) nul=-10
c
      bog(1)=tegn(1)
      call q
      j=19
c ---------------------------------------------------
      do 1000 j1=1,18
      j=j-1
c
      do 320 k=2,30
      bog(k)=tegn(2)
      if (j .eq. nul .or. j.eq. mean) bog(k)=tegn(3)
  320 continue
c
      do 500 i=1,islut
      ik=3*i
      if (j .eq. yy(i,1)) bog(ik)=tegn(ib1)
      if (j .eq. yy(i,2)) bog(ik)=tegn(ib2)
      if (j .eq. yy(i,1) .and. j .eq. yy(i,2)) bog(ik-1)=tegn(ib1)
  500 continue
c
      if (j1 .eq. 1) write(out,600) xmax,(bog(k),k=1,30)
  600 format(5x,f6.0,1x,32(a1))
      if (j1 .eq. 18) write(out,600) xmin,(bog(k),k=1,30)
      if (j .eq. nul) write(out,600) xnul,(bog(k),k=1,30)
      if (j .eq. mean) write(out,600) xmean,(bog(k),k=1,30)
      if (j1 .ne. 1 .and. j1 .ne. 18 .and. j .ne. nul .and.
     * j .ne. mean) write(out,620) (bog(k),k=1,30)
  620 format(12x,32a1)
 1000 continue
c----------------------------------------------------
      call q
      i1=yfirst-1901
      do 1100 y=1,10
      i1=i1+1
      if (i1 .ge. 100) i1=i1-100
 1100 bog(y)=i1
      write(out,1200) (bog(y),y=1,10)
 1200 format(12x,10(3h--I),/,12x,10i3)
      call q
      call vent
      return
      end
```

```
c
      subroutine r
      external in; zone in
      logical setposition
      call setposition(in,0,0)
      return
      end
c
c
      subroutine q
      external out; zone out
      logical setposition
      call setposition(out,0,0)
      return
      end
c
c
      subroutine vent
c *********************
c * "waiting"-routine *
c *********************
      external in,out; zone in,out
      integer fishn(3,10),tegn(42)
      common /name/ fishn,tegn,iskriv,ihurt
c
      if (ihurt .ne. 1) write(out,100)
  100 format(2x,'To continue - press "RETURN"')
      call q
      read(in,200) i
  200 format(i4)
      call r
      return
      end
c


      subroutine tabel(x,iopt,e,iyf)
c
c ***********************************************************************
c * Display of VPA-tables. Used for the small menu                      *
c ***********************************************************************
c
      external in,out; zone in,out
      real x(10,3,10)
      integer fishn(3,10),tegn(42),e,s,a,y
      common /name/ fishn,tegn,iskriv,ihurt
c
      call q
  100 write(out,200)
  200 format(///,2x,'which species do you want ?',1x,
     *'(cod=1,plaice=2,herring=3,none=RETURN)  ')
      call las(s,iskriv)
      if (s .lt. 0 ) return
      if (s .ne. 1 .and. s .ne. 2 .and. s .ne. 3) goto 100
c
      if (e .gt. 0) write(out,300) e
  300 format(/,2x,'FLEET NO. ',i2)
      if (iopt .eq. 1) write(out,410)
  410 format(/,2x,'Number of survivors :')
      if (iopt .eq. 2) write(out,420)
  420 format(/,2x,'Number of fish caught :')
      if (iopt .eq. 3) write(out,430)
  430 format(/,2x,'Fishing mortalities :')
      if (iopt .eq. 4) write(out,440)
  440 format(/,2x,'Predation mortalities :')
c
      iyf1=iyf+9
      write(out,500) (fishn(s,i),i=1,10),(y,y=iyf,iyf1)
  500 format(/,2x,10a1,/,2x,' age ',3x,10(2x,i4,1x),/,2x,77(1h-))
      do 900 a=1,10
      if (iopt .le. 2) write(out,520) a,(x(y,s,a),y=1,10)
  520 format(4x,i2,3x,10f7.0)
      if (iopt .gt. 2) write(out,540) a,(x(y,s,a),y=1,10)
  540 format(4x,i2,3x,10f7.3)
  900 continue
      call las(j,0)
      goto 100
c
      return
      end
```

```
      subroutine las(tal,iopt)
c ***************************
c * format-free reading     *
c ***************************
      external in,out; zone in,out
      integer x(20),tal,ttegn(15)
      common /clas/ ttegn,xtal
c
      call q
      read(in,100) (x(i),i=1,20)
  100 format(20a1)
      call r
      jx=0
      sign=1.0
      idec=-1
      icif=0
c ------------------------------------------------------
      do 200 i=1,20
      ixx=x(i)-8224
        do 150 j=1,10
      if (ixx .ne. ttegn(j)) goto 150
      icif=icif+1
      x(icif)=j-1
      goto 200
  150 continue
      if (ixx .ne. ttegn(11)) goto 160
      idec=icif
      goto 200
  160 continue
      if (ixx .ne. ttegn(12)) goto 200
      sign=-1.0
  200 continue
c
      if (icif .gt. 0) goto 400
      tal = -10.0
      if (iopt .eq. 1) write(out,380)
  380 format(2x,'RETURN <== ')
      call q
      return
  400 xtal=0.0
      x10=1.0
      do 500 i=1,icif
      xij=float(x(icif+1-i))*x10
      xtal=xtal+xij
  500 x10=x10*10.0
      tal=0
      if (xtal .lt. 8300000.0) tal=xtal
c
      if (idec .eq. -1) goto 580
      idec=icif-idec
      xtal=xtal/10.0**idec
  580 xtal=xtal*sign
c
      if (iopt .eq. 1) write(out,600) tal
  600 format(2x,i8,' <==')
      call q
      return
      end
```

APPENDIX B.

List of parameters as displayed on the video screen.

(default values)

Species	Param. no.	Age	Param. value	Description
cod only	1		300000	biomass of other food or total biomass of the ecosystem (depending on which option is chosen) default total biomass of ecosystem: 2000 000
cod only	2	1	1.000000	SUIT(a, other food)
cod only	3	2	0.600000	SUIT(a, other food)
cod only	4	3	0.300000	SUIT(a, other food)
cod only	5	4	0.150000	SUIT(a, other food)
cod only	6	5	0.100000	SUIT(a, other food)
cod only	7	6	0.070000	SUIT(a, other food)
cod only	8	7	0.070000	SUIT(a, other food)
cod only	9	8	0.070000	SUIT(a, other food)
cod only	10	9	0.070000	SUIT(a, other food)
cod only	11	10	0.070000	SUIT(a, other food)
cod only	12		0.800000	MFOOD — food consumption
cod only	13		5.000000	HFOOD — food consumption
cod only	14		4.600000	SPRET — food selection
cod only	15		4.600000	SVAR — food selection
cod	16		0.220000	KBER (growth parameters)
plaice	17		0.150000	KBER (growth parameters)
herring	18		0.320000	KBER (growth parameters)
cod	19		130.000000	L8 (growth parameters)
plaice	20		50.000000	L8 (growth parameters)
herring	21		30.000000	L8 (growth parameters)
cod	22		0.000000	TO (growth parameters)
plaice	23		-1.500000	TO (growth parameters)
herring	24		-1.500000	TO (growth parameters)
cod	25		0.000010	CONF (growth parameters)
plaice	26		0.000015	CONF (growth parameters)
herring	27		0.000010	CONF (growth parameters)
	28		0.100000	M1 residual nat. mort.
cod	29		20000.0	NOMAX (stock/recruitment parameters)
plaice	30		400000.0	NOMAX (stock/recruitment parameters)
herring	31		1200000.0	NOMAX (stock/recruitment parameters)
cod	32		59921.7	HALFSAT (stock/recruitment parameters)
plaice	33		84874.5	HALFSAT (stock/recruitment parameters)
herring	34		96946.4	HALFSAT (stock/recruitment parameters)
cod	35		5.000000	SELFAC (gear selection)
plaice	36		3.000000	SELFAC (gear selection)
herring	37		4.000000	SELFAC (gear selection)
	38		3.000000	cost of 1 effort unit.
	39		0.100000	rate of interest t/100
	40		200.0	"free" number of effort u.
	41		-1500.0	ruin-limit of acc. profit.
	42		10.000000	price of 1 extra effort u.
	43	1	0.017143	kg. price of cod /100
	44	2	0.040000	kg. price of cod /100
	45	3	0.054545	kg. price of cod /100
	46	4	0.064615	kg. price of cod /100
	47	5	0.072000	kg. price of cod /100
	48	6	0.077647	kg. price of cod /100
	49	7	0.082105	kg. price of cod /100
	50	8	0.085714	kg. price of cod /100
	51	9	0.085714	kg. price of cod /100
	52	10	0.085714	kg. price of cod /100
	53	1	0.017143	kg. price of plaice/100
	54	2	0.040000	kg. price of plaice/100
	55	3	0.054545	kg. price of plaice/100
	56	4	0.064615	kg. price of plaice/100
	57	5	0.072000	kg. price of plaice/100
	58	6	0.077647	kg. price of plaice/100
	59	7	0.082105	kg. price of plaice/100
	60	8	0.085714	kg. price of plaice/100
	61	9	0.085714	kg. price of plaice/100
	62	10	0.085714	kg. price of plaice/100
	63	1	0.014286	kg. price of herring/100
	64	2	0.033333	kg. price of herring/100
	65	3	0.045455	kg. price of herring/100
	66	4	0.053846	kg. price of herring/100
	67	5	0.060000	kg. price of herring/100
	68	6	0.064706	kg. price of herring/100
	69	7	0.068421	kg. price of herring/100
	70	8	0.071429	kg. price of herring/100
	71	9	0.071429	kg. price of herring/100
	72	10	0.071429	kg. price of herring/100

(age)

food consumption $FOOD(cod) = HFOOD \cdot W(1,a)^{MFOOD}$

food selection $SUIT(b,s,a) \propto \exp\left[-\frac{\{\ln(W(1,b)/W(s,a)) - SPREF\}^2}{SVAR}\right]$ (b: cod age; s, a: prey)

growth parameters: $LGT(s,a) = L8(s)(1.0 - \exp(-KBER(a+0.5-TO)))$, $W(s,a) = CONF(s) \cdot LGT(s)^3$

stock/recruitment parameters: $N(y,s,1) = \frac{NOMAX(s)}{1 + HALFSAT(s)/SSB(y,s)}$ where $SSB(y,s) = \sum_{a=3}^{10} N(y,s,a)W(s,a)$

(continued)

Param. no.	Age	Param. value	Description
73	1	10000.0	n(1982, a, cod)
74	2	6065.3	n(1982, a, cod)
75	3	3678.8	n(1982, a, cod)
76	4	2231.3	n(1982, a, cod)
77	5	1353.4	n(1982, a, cod)
78	6	820.8	n(1982, a, cod)
79	7	497.9	n(1982, a, cod)
80	8	302.0	n(1982, a, cod)
81	9	183.2	n(1982, a, cod)
82	10	282.[illegible]	n(1982, a, cod)
83	1	200000.0	n(1982, a, plaice)
84	2	121306.1	n(1982, a, plaice)
85	3	73575.9	n(1982, a, plaice)
86	4	44626.0	n(1982, a, plaice)
87	5	27067.1	n(1982, a, plaice)
88	6	16417.0	n(1982, a, plaice)
89	7	9957.4	n(1982, a, plaice)
90	8	6039.5	n(1982, a, plaice)
91	9	3663.1	n(1982, a, plaice)
92	10	5646.7	n(1982, a, plaice)
93	1	600000.0	n(1982, a, herring)
94	2	363918.4	n(1982, a, herring)
95	3	220727.7	n(1982, a, herring)
96	4	133878.1	n(1982, a, herring)
97	5	81201.2	n(1982, a, herring)
98	6	49251.0	n(1982, a, herring)
99	7	29872.2	n(1982, a, herring)
100	8	18118.4	n(1982, a, herring)
101	9	10989.4	n(1982, a, herring)
102	10	16940.1	n(1982, a, herring)

initial stock numbers.

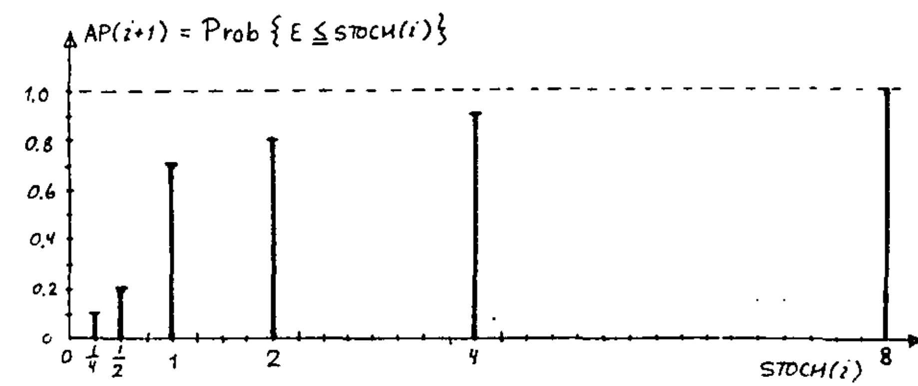
only used in case of stochastic stock/recruitment:

Param. no.	Param. value	Description
103	0.000000	AP(i)
104	0.100000	AP(i)
105	0.200000	AP(i)
106	0.300000	AP(i)
107	0.400000	AP(i)
108	0.500000	AP(i)
109	0.600000	AP(i)
110	0.700000	AP(i)
111	0.800000	AP(i)
112	0.900000	AP(i)
113	0.250000	STOCH(i)
114	0.500000	STOCH(i)
115	1.000000	STOCH(i)
116	1.000000	STOCH(i)
117	1.000000	STOCH(i)
118	1.000000	STOCH(i)
119	1.000000	STOCH(i)
120	2.000000	STOCH(i)
121	4.000000	STOCH(i)
122	8.000000	STOCH(i)

$N(y,s,1) = \frac{NOMAX(s)}{1 + HALFSAT(s)/SSB(y,s)} \cdot E$

where: $Prob\{E = STOCH(i)\} = AP(i+1) - AP(i)$

STOCH can at maximum take 10 different values.



APPENDIX C.

MENU LISTS (to be used when running the fast mode)

```
SELECT A COURSE FROM THE SMALL MENU :
1 : Number of survivors
2 : Total number caught
3 : Total fishing mortality
4 : Predation mortality
5 : Number caught by each fleet
6 : Fishing mortality by each fleet
RETURN : Stop displaying results - return to game
```

```
SELECT A COURSE FROM THE LAEGE MENU :
-----------------------------------------
1  : Mean weight at age in the three stocks
2  : Mean lenghts at age in the three stocks
3  : Kg-prices at age and species
4  : Cost per effort unit, interest and instalment
5  : Fishing effort and investments in the foregoing years
6  : Mesh sizes used in the foregoing years
7  : Directivities used in the foregoing years
8  : Number of survivors in each stock
9  : Number caught from each stock
10 : Number caught by each fleet
11 : Weight and value of the catch of each fleet
12 : Percentage fish died due to fishing
13 : Percentage fish died due to the predator (the cod)
14 : Year class strenghts and spawning stock biomasses
15 : Costs, income and profit (book-keeping for a single year)
16 : Food selection of cod (food suitabilities)
17 : Grafical display
18 : Relative stomach content of cod
RETURN : Stop displaying results - return to the game
```

```
17

WHICH GRAPH DO YOU WANT TO SEE ?
 1 : Accumulated profit
 2 : Profit
 3 : Total catch (tons)
 4 : Costs (number of effort units)
 5 : Income
 6 : Investments
 7 : Catch and total biomass of cod
 8 : Catch and total biomass of plaice
 9 : Catch and total biomass of herring
10 : Spawning stock biomass and recruitment of cod
11 : Spawning stock biomass and recruitment of plaice
12 : Spawning stock biomass and recruitment of herring
RETURN : I do not want to see more curves
```