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APPLICATION OF GLOSS METHODOLOGY TO 3NO COD

by

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Introduction

This document reports the application of the G(loss) approach (Cook, 1998) to cod in 3NO. This method calculates the replacement line associated with the lowest observed spawning stock biomass, B(loss), and the probability that a given fishing mortality rate exceeds this replacement line. If the fishing mortality rate exceeds G(loss) then the stock will tend to decline below the lowest observed SSB.

Data

Input data required for the analysis are the time series of SSB, recruitment, catch, fishing mortality and the biological parameters of weight at age, maturity at age, natural mortality and selectivity at age. In the analysis presented here the data are taken from the VPA series (Stansbury, pers comm.). The time series of stock summary statistics are given in Table 1. For the weights at age, etc, a ten year mean from 1985-1994 was used. Table 2 gives the values used and the coefficient of variation (CV) used in the estimation of the distribution of G(loss).

Method

The method is described in Cook (1998) and implemented in the program 'glossh'. Annex 1 describes the program implementation. It was run using the following configuration:

1. The origin was included as an observation
2. Fitted recruitment was not corrected for the log transform
3. SSB estimates were treated as values at the start of the year
4. All the stock recruitment points were included in the lowess smoother.

In addition to the G(loss) analysis, a parametric equilibrium analysis was performed. For this method a Beverton-Holt stock recruitment curve was fitted to the data and the equilibrium SSB and yield curves calculated.

Results

Figure 1 shows the summarised results from the analysis from the program. The stock recruitment plot (top left) shows the fitted lowess line and the 5-95 percentiles of the distribution of G(loss) (vertical shading) and the comparable distribution for the mean fishing mortality for the period 1985-1994, G(F) (horizontal shading). As can be seen, the probability that the observed mean F exceeds G(loss) is approximately 50%. The slope of G(loss) in the analysis may well be optimistic since the slope of the line is determined largely by a period when productivity was high.

The equilibrium SSB is plotted against fishing mortality rate in the top right panel. The equilibrium curve declines sharply as fishing mortality increases and indicates a stock collapse with a fishing mortality close to F=0.5. For more than half the period since 1959 the fishing mortality rate has been above this value which supports the view that fishing mortality rates of this magnitude will reduce the stock to very low levels even in periods of high productivity.

Table 3 gives the results of fitting the Beverton-Holt curve to the stock recruitment data. Figure 2 shows the results of the parametric equilibrium analysis using the fitted curve. The equilibrium curves for SSB and yield are very similar to the results obtained using the non-parametric stock-recruit curve. This analysis suggests that Fcrash is less than 0.5 but similar to the value of F(loss).

With the exploitation pattern (selectivities at age) estimated for the period 1985-1994 the fishing mortality limit needed to ensure a low probability of exceeding G(loss) is estimated as F=0.28. This compares with an Fmed value of 0.34.

Reference

Cook, R.M. (1998). A sustainability criterion for the exploitation of North Sea cod. ICES journal of Marine Science, in press.

Table 1. Stock summary statistics for Cod in 3NO.

Year	Recruits	SSB	TSB	Catch	Mean F
1959	53836.789	91433.13	206826.25	35301	0.4073
1960	52941.623	77321.561	191414.89	41894	0.4174
1961	82277.224	76479.018	184296.77	37557	0.3954
1962	107847.51	72300.054	187562.69	15451	0.3623
1963	78582.853	82074.169	227373.63	30680	0.7236
1964	112438.77	91655.999	257200.75	53875	0.3737
1965	162501.74	119491.23	291063.59	47098	0.9333
1966	209951.19	114192.86	359092.93	67480	1.2965
1967	183217.27	98534.832	403685.16	161654	0.6370
1968	100485.85	89146.781	327373.19	149025	0.6001
1969	127819.37	75196.472	247577.06	64420	0.4928
1970	80366.291	77113.056	237559.08	49848	0.4563
1971	84407.586	84144.51	245343.51	77400	0.4969
1972	62151.002	80525.169	206462.68	54159	0.4830
1973	34817.03	71296.879	181479.55	63064	0.3714
1974	36329.395	66769.189	124706	45356	0.9641
1975	22759.06	32495.212	62664.995	21783	1.7358
1976	27482.841	7021.7774	46241.976	19186	0.3368
1977	45342.338	7077.473	59837.001	8232	0.6593
1978	40121.915	8054.9826	89013.084	9192	0.2747
1979	17370.411	13026.217	98288.318	17149	0.2621
1980	19737.266	21797.521	101561.69	8537	0.1704
1981	27478.613	50659.661	136060.86	8003	0.2384
1982	21445.936	60642.442	150555.41	8953	0.3638
1983	34880.259	68274.538	161225.24	7931	0.2475
1984	41350.603	65291.996	176347.73	8420	0.2942
1985	32204.296	57245.576	161943.46	16986	0.3005
1986	8749.2241	66607.594	149583.34	17772	0.3337
1987	6452.5204	59506.68	128734.61	12069	0.3986
1988	12904.805	55719.287	93344.424	15114	0.5073
1989	12839.828	38510.661	70703.528	11303	0.4290
1990	5132.9829	35692.194	56785.743	13307	0.4652
1991	5731.892	27147.078	38654.204	5957	0.9510
1992	17364.171	11032.855	21674.734	8722	0.6926
1993	6693.9728	5479.7295	15728.197	6360	0.4458
1994	789.18426	2809.0872	10580.657	3928.	0.1363

Table 2. Biological parameters based on the mean 1985-1994. The first number is the nominal value and the second the coefficient of variation assumed.

Selectivities

s3	0.18	1.45
s4	0.38	1.49
s5	0.53	0.55
s6	0.59	0.35
s7	0.53	0.46
s8	0.40	0.22
s9	0.45	0.31
s10	0.48	0.39
s11	0.85	1.47
s12	0.46	0.01

Weight in the catch

wc3	0.47	0.28
wc4	0.84	0.20
wc5	1.35	0.16
wc6	2.02	0.13
wc7	2.92	0.19
wc8	4.59	0.12
wc9	6.30	0.17
wc10	8.24	0.10
wc11	8.99	0.23
wc12	10.90	0.16

Weight in the stock

ws3	0.37	0.34
ws4	0.65	0.20
ws5	1.11	0.13
ws6	1.68	0.10
ws7	2.45	0.14
ws8	3.72	0.10
ws9	5.34	0.10
ws10	7.21	0.09
ws11	8.52	0.15
ws12	10.16	0.10

Natural mortality

m3	0.20	0.21
m4	0.20	0.20
m5	0.20	0.20
m6	0.20	0.20
m7	0.20	0.20
m8	0.20	0.20
m9	0.20	0.20
m10	0.20	0.20
m11	0.20	0.20
m12	0.20	0.20

Maturity at age

MT3	0.01	0.78
MT4	0.01	0.78
MT5	0.03	0.61
MT6	0.15	0.50
MT7	0.48	0.39
MT8	0.81	0.15
MT9	0.96	0.04
MT10	0.99	0.01
MT11	1.00	0.00
MT12	1.00	0.00

Table 3. Results of fitting Beverton-Holt curve to cod 3NO stock recruit data.

Coefficient of determination =, .0964

Parameter, s.d.

1.0492, .6511,
78.5520, 111.8226,

Y/Class,	SSB,	Recruits,	Fit. rct,	residuals,
1959,	91.43,	107.85,	44.33,	.8890,
1960,	77.32,	78.58,	40.88,	.6534,
1961,	76.48,	112.44,	40.66,	1.0172,
1962,	72.30,	162.50,	39.50,	1.4144,
1963,	82.07,	209.95,	42.11,	1.6065,
1964,	91.66,	183.22,	44.38,	1.4178,
1965,	119.49,	100.49,	49.73,	.7035,
1966,	114.19,	127.82,	48.83,	.9623,
1967,	98.53,	80.37,	45.86,	.5610,
1968,	89.15,	84.41,	43.81,	.6557,
1969,	75.20,	62.15,	40.31,	.4330,
1970,	77.11,	34.82,	40.83,	-.1593,
1971,	84.14,	36.33,	42.63,	-.1598,
1972,	80.53,	22.76,	41.72,	-.6060,
1973,	71.30,	27.48,	39.21,	-.3555,
1974,	66.77,	45.34,	37.87,	.1801,
1975,	32.50,	40.12,	24.12,	.5090,
1976,	7.02,	17.37,	6.76,	.9433,
1977,	7.08,	19.74,	6.81,	1.0638,
1978,	8.05,	27.48,	7.67,	1.2767,
1979,	13.03,	21.45,	11.72,	.6040,
1980,	21.80,	34.88,	17.90,	.6670,
1981,	50.66,	41.35,	32.31,	.2466,
1982,	60.64,	32.20,	35.91,	-.1088,
1983,	68.27,	8.75,	38.32,	-1.4771,
1984,	65.29,	6.45,	37.41,	-1.7575,
1985,	57.25,	12.90,	34.74,	-.9904,
1986,	66.61,	12.84,	37.82,	-1.0802,
1987,	59.51,	5.13,	35.52,	-1.9345,
1988,	55.72,	5.73,	34.20,	-1.7862,
1989,	38.51,	17.36,	27.11,	-.4456,
1990,	35.69,	6.69,	25.75,	-1.3472,
1991,	27.15,	.79,	21.17,	-3.2892,

ANNEX 1

GLOSS PROGRAM

Method

The method is described in Cook (1998). Using stock recruitment data, the replacement line at the lowest observed spawning stock biomass, G(loss), is calculated with an associated distribution. The software also calculates the distribution of the replacement line at current fishing mortality, G(F) and the probability that G(F)>G(loss). The program also allows the calculation of a fishing mortality rate which gives a replacement line with a user specified probability of exceeding G(loss). This latter facility is a means of estimating a fishing mortality rate which may be regarded as 'safe' in the sense that it has a low probability of leading the stock down to levels below the lowest observed SSB.

In addition to the G(loss) analysis, the program will calculate the equilibrium SSB and yield from the smoothed stock-recruit data.

Running the program FCRPL3 after GLOSSH will plot the results automatically.

Reference: Cook, R. M. 1998. A sustainability criterion for the exploitation of North Sea cod. ICES journal of Marine Science, to appear.

Input data

The program requires two input data files which contain;

1. the historical series of estimates of recruitment, SSB, catch and mean fishing mortality rate, and

2. The schedules of weight at age, natural mortality, maturity at age and age dependent selectivities. In addition to the point estimates, coefficients of variation for each value are also required.

Typically the above data will be outputs from catch at age analysis such as XSA, ADAPT, etc.
The data files are defined below.

Running the program

The present version of the program is a DOS implementation named GLOSSH. Typing glossh invokes the program and the user is offered a series of prompts. Most of the prompts offer defaults which only require the RETURN key to pressed. The options offered are as follows:

a) Constrain stock-recruit curve through the origin. The option allows the smoothing procedure to use the origin as part of the data set. It will tend to force the smoother towards the origin at the left hand side of the stock-recruitment data. It can be useful to do this of the data are highly scattered, particularly near the left hand end of the series. The default is to include the origin.

b) The next two prompts are for input files. The first is the file containing the age dependent biological parameters described in (2) above. The second is the historical estimates of recruitment, SSB etc. described in (1) above. No default is offered but the program will prompt you if the input file name given cannot be found.

c) The next two prompts request the proportion of annual natural mortality (M) and fishing mortality (F) which occurs before spawning. This is to correct the SSB/R calculations to the time of spawning. The default is zero for species which spawn in the first quarter of the year.

d) In order to fit the smoother to the stock recruitment data using LOWESS, the program needs to know the range of data to use for each smoothed point. The span required must lie in the range 0-1. The maximum, 1, includes all the data for each smoothed value and gives the 'stiffest' line. For general use a value of 0.5 is often recommended. However, for stock-recruit data which are highly scattered a larger value is to be preferred and 1 is offered as the default.

e) In fitting the smoother to the stock-recruit data, the program makes a log transformation. The smoothed value at B(loss) is therefore a geometric mean which is lower than the expected value on the raw (untransformed) scale. The default log correction will inflate the fitted value to the expected value on the raw scale. The effect of doing this is to give a G(loss) value with a higher slope than if no transformation was made. Accepting the log correction is probably better when examining the equilibrium SSB and yield plots. However, if the primary interest is in G(loss) then it may be preferable not to make the log correction. This is because low stock sizes correspond to high Fs and will tend to contain few year classes. These low SSBs will more commonly be close to the geometric mean than the arithmetic mean.

f) The program now runs the bootstrap procedure. At present the program performs 500 iterates and the run number is displayed on the screen. On pentium processors, the progress is rapid, but 486 processors may be fairly slow. Once complete, the final option is to choose the probability level for an F value exceeding G(loss). The default is 0.1. The program iterates to find a solution before terminating.

Output files

The program creates two output files. The main output is included in the .FCR file. This contains distributions of G(loss) etc in ASCII format ready for plotting by FCRPL3. The program also outputs a summary file containing the stock-recruitment data. This has the file extension .REC. The latter file can be used as an input to a parametric stock-recruitment function fitting program, RECREV.

Input File Formats

The program is designed to link with the output from the ICES XSA program and in particular is uses data files created by INSENS which uses the output files from XSA. These files can be created manually but because they are general purpose files, they contain redundant information.

The stock summary file, .SUM is as follows:

title
Number of columns in file (always 12)
Designator for presence of Human Consumption,discard, industrial by catch data. usually 1,0,0
year label
First year , last year
recruitment label
Age of recruitment, units for recruits
SSB label
units for SSB
Total stock biomass label
units for total stock biomass
Total catch label
units for total catch
Human consumption landings label
units for HCL
Discard catch label
units for discard catch
Industrial bycatch label
units for industrial by catch
Total F label
first age in mean F, last age in mean F
H. Cons F label
first age in mean F, last age in mean F
Discard F label
first age in mean F, last age in mean F
Ind bycatch F label
first age in mean F, last age in mean F
year,recruits,SSB,TSB,Catch total, catch hcl, catch dis, catch Ind, Ftotal,Fhc,Fdis,Find
repeated for each year
.
.
.
.
.
.

<End>

SSB/R data file

This data file was designed for use in another catch forecast program and therefore is not optimally suited to gloss. The file has a fixed structure and it will be necessary to use dummy values for some data. Gloss does not use the numbers at age, for example, so any dummy values may be input to pad the file.

Title
lowest age, highest age, first year, 3
Hcons 1/0, discards 1/0, ind bycatch 1/0 [normally 1,0,0]
label, number at lowest age, CV
label, number at next age, CV
etc
label, HC selectivity lowest age, CV
label, HC selectivity next age, CV
etc
include discard selectivity if available
include industrial bycatch if available
label, catch weight lowest age, CV
label, catch weight next age, CV
etc
include discard weights if available
include industrial weights if available
label, stock weight at lowest age, CV
label, stock weight at next age, CV
etc
label, natural mortality at lowest age, CV
label, natural mortality at next age, CV
etc
label, proportion mature at lowest age, CV
label, proportion mature at next age, CV
etc
label, recruitment year t+1, CV (not used by gloss)
label, recruitment year t+2, CV (not use by gloss)
label, HC F multiplier year t, CV
label, HC F multiplier year t+1, CV (not used by gloss)
label, HC F multiplier year t+2, CV (not used bu gloss)
[label, Ind F multiplier, t, CV] omit if not required
[similar for t+1]
[similar for t+2]
label, multiplier on M year t, CV
label, multiplier on M year t+1, CV (not used by gloss)
label, multiplier on M year t+2, CV (not used by gloss)
species label
area label
<end>

PROGRAM FCRPL3

This program plots the results from the Gloss program. All that it required in the .FCR file created by GLOSSH. The program will give a screen display of the data. The display is largely self explanatory. In the stock-recruitment plot the vertical shading shows the 5-95 percentiles of the gloss distribution. The horizontal shading shows the similar distribution for the most recent fishing mortality as specified in the .SEN file.

To clear the screen display press enter. The plot file is saved in an HPGL file called FCRASH.PLT and can be imported into packages such as Word etc for printing. Alternatively the utility PRINTGLD can be used for printing. The latter is shareware.

Problems may be experienced with the axis labelling. The program requires a soft font file, simplexr.chr which should be located in the default directory.

Figure 1. Result of Gloss analysis. COD ,NAFO-3NO

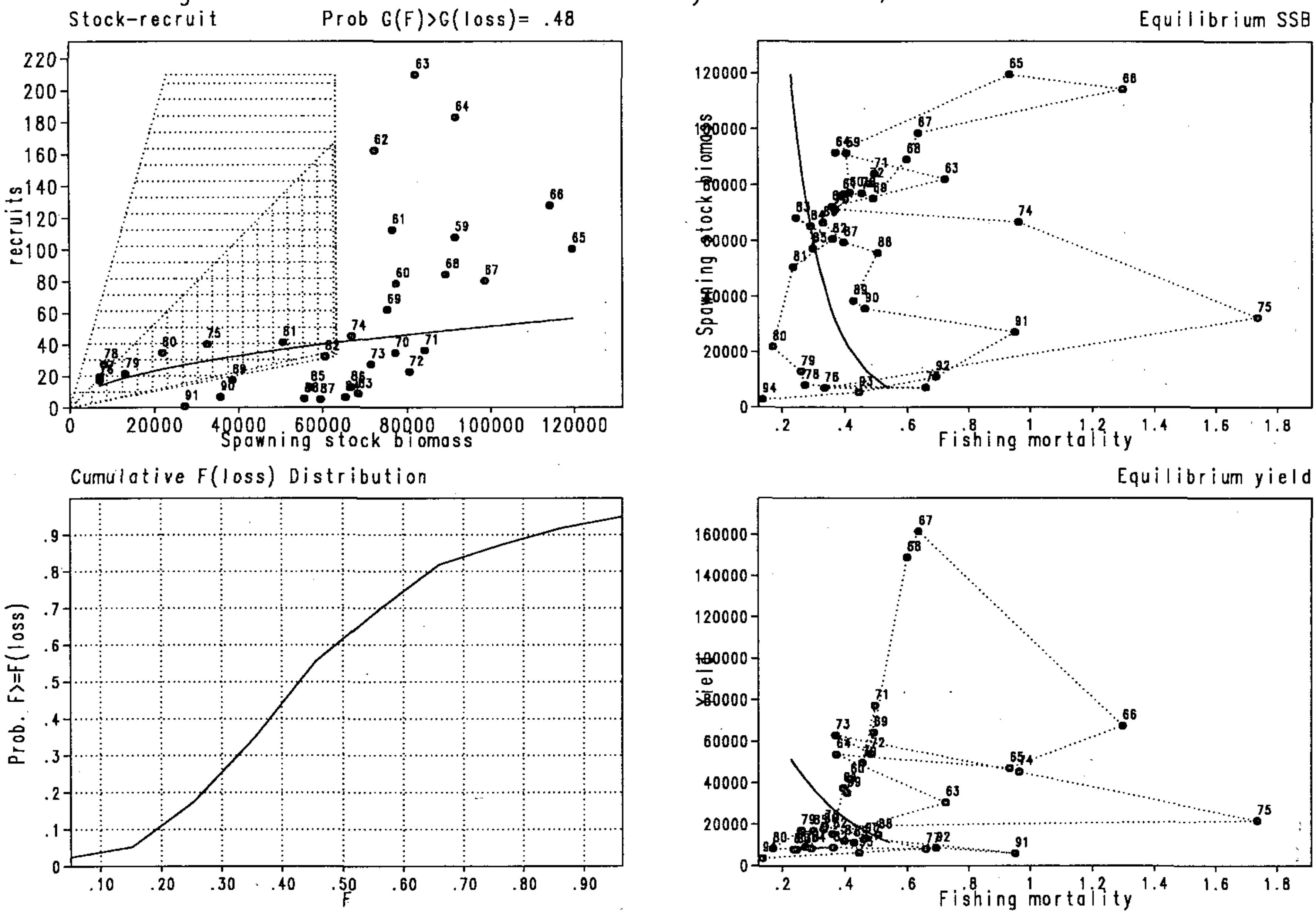
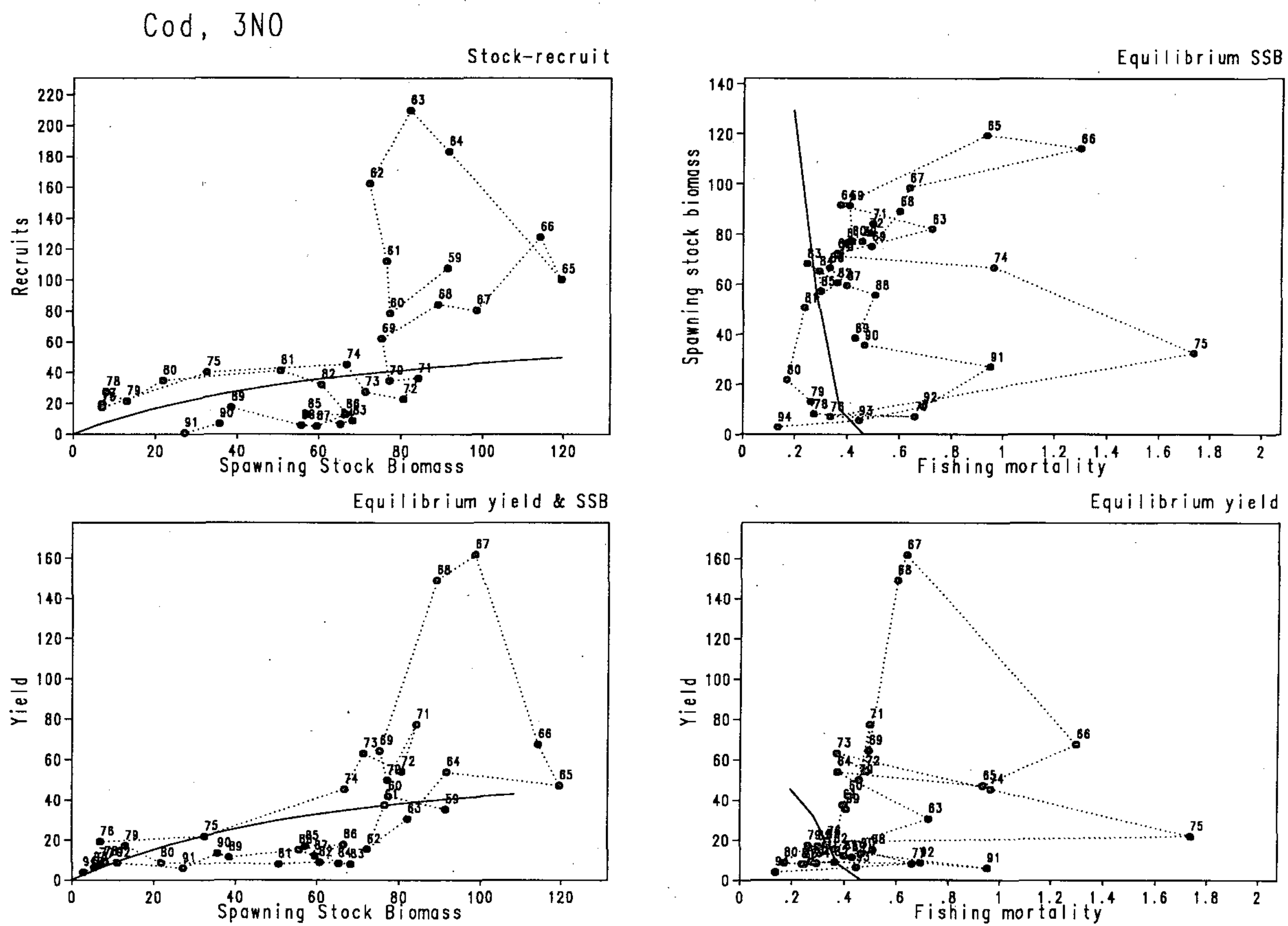


Figure 2


Cod, 3NO
Stock-recruit
Recruits
Spawning Stock Biomass
Equilibrium SSB
Spawning stock biomass
Fishing mortality
Equilibrium yield & SSB
Yield
Spawning Stock Biomass
Equilibrium yield
Yield
Fishing mortality