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ON STOCK STATUS AND ASSESSMENT OF A POSSIBLE COMMERCIAL WITHDRAWAL OF PELAGIC *SEBASTES MENTELLA* IN THE IRMINGER SEA

by

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Abstract

In June/July 2001, the international trawl-acoustic survey (TAS) on stock assessment of *Sebastes mentella* in the area of the Irminger Sea and adjacent waters of the Labrador Sea was carried out.

The analysis of accuracy of *Sebastes mentella* stock assessments obtained during TAS 2001 by both acoustic and trawl methods is presented. Besides, the acoustic assessment of *S. mentella* stock was performed by the Russian party at layers deeper 500 m.

Results of assessment and forecast of stock status of *S. mentella*, as well as possible size of a commercial withdrawal in 2002, carried out by means of standard soft wares accepted in the ICES.

On the basis of the carried out analysis, the status of pelagic *S. mentella* stock is assessed as stable one. It was concluded that the obtained during TAS 2001 the assessment of *S. mentella* stock of 2 132 thou. t is the low border of the real stock value. To our mind, total value of *S. mentella* in the whole water column 0-1 000 m in the surveyed area was within the range of 2.1 –3.4 mill. t of which 0.7 – 2.1 mill. t were distributed inside of the sound scattering layer (SSL). Biomass of *S. mentella* assessed by the classic acoustic method outside the SSL in layers higher 500 m constituted 0.7 – 0.8 mill. t, whereas deeper 500 m it was about 0.6 mill. t.

Analysis of status of *S. mentella* commercial stock and carried out calculations of a possible size of commercial withdrawal let us consider TAC of 95 thou. t based on estimations of TAC for 1999 as understated. To achieve rational exploitation of *S. mentella* stock we propose to discuss the possibility to increase TAC for 2002 at the level not less than 120 thou. t.

Introduction

The international trawl-acoustic survey (TAS) on stock assessment of pelagic *S. mentella* in the area of the Irminger Sea and adjacent waters was carried out by Germany, Iceland, Russia and Norway in June/July, 2001, in the area of total square about 420 thou. mile^2. *S. mentella* biomass assessed by the traditional acoustic method in layers higher 500 m constituted 715 thou. t. Redfish biomass assessed by the trawl method constituted as follows: in layers 0-500 m – 1 075 thou. t, deeper than 500 m – 1057 thou. t, total biomass of redfish was estimated as 2 132 thou. t. In addition, the Russian party performed by data of four vessels the acoustic estimation of redfish stock deeper than 500 m where redfish biomass constituted 608 thou. t. The obtained estimation of total biomass and biomass of redfish in the upper 500-m layer is higher

than that obtained during the international TAS of 1999 (Sigurdsson et al., 1999). The analysis of accuracy of obtained in TAS 2001 assessments of redfish stock by both acoustic and trawl methods is given in the paper.

In addition to what was mentioned above, we performed calculations with the use of standard soft wares accepted in the ICES in order to estimate and forecast stock status and possible size of the commercial withdrawal.

Materials and methods

Method of assessment of *S. mentella* abundance and biomass during the international TAS was described in detail in "Draft Report on the Joint German/Icelandic/Norwegian/Russian Trawl-Acoustic Survey on Pelagic Redfish in the Irminger Sea and Adjacent Waters in June/July 2001" (Sigurdsson et al., 2001).

Mathematical calculations of assessment and forecast of *S. mentella* stock and possible size of the commercial withdrawal were done with the use of standard soft wares accepted in the ICES. Stock assessment of *S. mentella* in the Irminger Sea was performed by the Extended Survivors Analysis method (XSA). Forecast of the stock status and possible size of the commercial withdrawal were done by two ways, namely: by the MFDP programme and reproduction model ASPIC.

Calculations by XSA and MDPF were carried out in the age range 8 – 22+ which, to our opinion, covers fully the commercial part of *S. mentella* stock. Age composition of catches includes the international catch by years. Fishing indices are standardized by vessels of STM type (effort, catch per effort). Coefficient of natural mortality by all age groups is accepted as stable and equal to 0.1, although we did the calculation using either the variable values of natural mortality coefficients calculated by the Tretyak's method (Tretyak, 2000).

Results

Classic acoustic assessment in the layers higher than 500 m (i.e. above the SSL)

By results of acoustic estimation carried out by Icelandic scientists, redfish biomass in layers higher 500 m constituted 715 thou. t (Table 1). However it should be accounted that the reliability of acoustic data of R/V "W. Herwig III" gives rise to some doubt. As it is seen from Figs. 1 and 2 the average densities in series of squares between 57°00' and 57°45'N, corresponding to the tack of the German vessel along 57°15'N, are approximately 1.5-2 times lower than values of densities in the adjacent series of squares surveyed by R/V "AtlantNIRO" and "A. Fridriksson". If one assumes that acoustic data of "W. Herwig" are really underestimated 1.5-2 times, then due to the approximate calculation, the total biomass was underestimated by about 50-100 thou. t. Considering this, the total value of redfish stock assessed by acoustic method in layers higher 500 m (i.e.above the SSL) should constitute about 800 thou. t.

Acoustic estimation deeper than 500 m (i.e. under SSL)

Acoustic assessment of redfish abundance and biomass deeper than 500 m was carried out in PINRO on the basis of SA values for redfish (H > 500 m) along tacks of four vessels (R/V "AtlantNIRO", "B. Saemundsson", "A. Fridriksson" and "G. O. Sars") by the same method and with averaging of data by the same statistic squares which were used at acoustic assessment of redfish stock in layers higher than 500 m (Fig. 3). Since in the exchanged materials

from the R/V "W. Herwig" there were no acoustic data for redfish deeper than 500 m, values of density distribution by squares surveyed by this vessel were interpolated by values of density in the adjacent squares surveyed by other vessels.

As a result, the acoustic estimate of biomass of redfish deeper 500 m constituted 608 thou. t at the abundance of 786 mill. spec. (Table 2). It should be mentioned that these data agree satisfactorily with results of Russian experimental investigations of the previous years: by results of acoustic surveys of PINRO in the Irminger Sea onboard of R/V "Atlantida" in 1995 and 1997, redfish biomass at depths lower than 500 m assessed by exclusively acoustic method varied within the range 400-900 thou. t (Sigurdsson, 2001).

Redfish stock assessment by trawl method

It was decided to use in the joint paper for ICES on TAS-2001 the linear regression of a kind SA=K*Catch obtained during trawlings of "pure" concentrations of redfish for each vessel separately as an algorythm of recalculation of catches into equivalent values SA_{tr}. Values K with the coefficient of correlation R^2 were accepted as follows:

Walter Herwig-III: K = 0.1322, R^2 = 0.91 – 0.94 (trawlings of types 1, 2, 3)

AtlantNIRO: K = 0.2568, R^2 = 0.75 (trawlings of types 1, 2, 3)

Bjarni Sæmundsson: K = 0.2621, R^2 = 0.6 – 0.8 (trawlings of types 1, 2, 3)

Árni Friðriksson: K_1 = 2.5493, R_2 = 0.35 (trawlings of a type 1)

Árni Friðriksson: K_2 = 0.2621 (trawlings of a type 2, 3)

As a result, total biomass of redfish in layers 0-500 m estimated by the trawl method constituted 1 075 thou. t, and that in layers deeper than 500 m was 1 057 thou. t (Tables 3 and 4). Redfish distribution densities assessed by results of trawlings are in Figs. 4 and 5.

The most reliable data from the point of view of a regression analysis of catches and acoustic values SA dependencies were obtained onboard of R/V "AtlantNIRO" and "W. Herwig", i. e. for subareas D, E and F (Sigurdsson, 2001). Nevertheless, if acoustic data of R/V "W. Herwig" are really underestimated, as it was mentioned above, then it will lead to underestimation of used in calculations coefficient K in the regression dependence between catch value and acoustic SA. For example, if to consider data of R/V "W. Herwig" as underestimated 2 times, it will lead to the value of regression coefficient K = 0.2644 instead of the used K = 0.1322 for this vessel (in this case the value K for R/V "W. Herwig" is practically identical to K = 0.26 for R/V "AtlantNIRO" and "B. Saemundsson", that looks like natural, since all vessels used in the cruise the trawls of the same kind). As a result, as the calculation shows, if to use K = 0.2644 for R/V "W. Herwig", then total redfish stock in layers higher 500 m assessed by the trawl method will constitute 1240 thou. t (instead 0f 1075 thou. t), whereas deeper than 500 m – 1210 thou. t (instead of 1057 thou. t).

As it was mentioned in the report on TAS-2001 (Joint Report…), the regression dependencies between catches and values SA for Icelandic R/V "A. Fridriksson" and " B. Saemundsson", on the basis of which the calculations of abundance and biomass of redfish was done by the trawl method for subareas A, B and C, are very approximate ones. In particular for R/V "B. Saemundsson", when estimating the dependence SA on catches (and, correspondingly, for

trawlings of types 2 and 3 of R/V "A. Fridriksson"), both linear regression SA = 0.2621*Catch (R^2 = 0.6 – 0.8) and ascending regression SA = 1.366*Catch$^{0.5087}$ (R^2 = 0.534) can be applied with a close probability from the statistical point of view. It should be mentioned that from our point of view the power regression with power < 1, to compare with the linear one, reflects more accurately the real dependence between SA and catches: the catchability of trawl, due to the experience, increases very often at the increase of the volume density of fish distribution. In the case of usage of the mentioned above power regression dependence between catches and SA for R/V "B. Saemundsson" and "A. Fridriksson" total estimate of redfish biomass by the trawl method in layers higher 500 m would constitute 1 235 thou. t, whereas that at depth lower than 500 m- 2 177 thou. t (Tables 5 and 6).

Redfish stock assessment with the use of soft wares

Calculations were carried out with the use of standard soft wares accepted for exploitation at the ICES Working Groups. Although XSA method is not used for *S. mentella* stock assessment at the ICES Working Groups we used traditionally this method in our calculations coming from the concept of the single *S. mentella* stock. We decided to use making parallel calculation on the productive model ASPIC which is recent time more preferred at the Working Groups.

Due to the obtained results, *S. mentella* stock is at the stable high level. Due to calculations done with the use of XSA and MDPF, redfish abundance in the year 2001constituted 2 946 thou. spec. and biomass was 1 412 thou. t, and those for the year 2002 are calculated as 2 989 thou. spec and 1 438 thou. t, correspondingly. The size of the possible withdrawal in 2002 can constitute 119 thou. t. The production model gives for 2002 the similar estimate of biomass 1 387 thou. t and more careful estimate of the possible catch of 105,4 thou. t.

The obtained results can be considered as mutually complementary. For example, analysis of the stock situation obtained by the production model illustrates the stable stock status registering the low level of its exploitation (Appendix 1). Due to ASPIC, maximum stable yield (MSY)of *S. mentella* of the Irminger Sea constitutes 375 thou. t at F_{msy} = 0.5 and B_{msy} = 751 thou., i. e. the biomass value mentioned above is 1.85 times higher than that level. Considering this and understanding that the exploitation level of the stock F_{msy} is just the reference point, it is also possible, following the Working groups practice, to introduce one more reference point F_{pa} ($2/3F_{msy}$) equal to 0.33 at which the catch can constitute 250 thou. t.

The calculation with the use of XSA and MFDP points to the fact that a catch upto 148 thou. t lets the total biomass of 1 412 thou. t and spawning biomass of 105 thou. t be unchangeable in years 2002-2003 (Appendix 2).

Conclusion

In general, analysing results of a trawl-acoustic survey carried out in June-July 2001 we should admit that the presented in the report (Sigurdsson et al., 2001) stock assessment of *S. mentella* from the Irminger Sea (2 132 thou. t) is the low border of the real value of the stock. From our point of view coming from ideas mentioned above the total value of *S. mentella* stock in the whole depth column 0 -1 000 m in the surveyed area in 2001 was within the range 2,1 – 3,4 mill. t of which 0,7 – 2,1 mill. t were distributed inside the SSL. Biomass of *S. mentella* assessed by the classic acoustic method outside the SSL, constituted in layers higher 500 m 0,7 – 0,8 mill. t, whereas in layers deeper than 500 m – about 0, 6 mill. t. Thus, stock status of *S. mentella* can be evaluated as stable. To our opinion, during the previous international TAS in 1999 a sufficient underestimation of *S. mentella* took place because of re-distribution

of fish into the SSL and lower layers inaccessible for stock assessment by the traditional acoustic method. Report on the international TAS-2001 (Sigurdsson et al., 2001) says: " The estimated abundance derived from the trawl data should be treated with great caution". We think that biomass of redfish estimated at 2 132 thou. t is the low border of the real size of the stock and agrees well with results of Russian investigation in the 1990's whenthe estimated redfish biomass constituted 1,9 – 2,6 mill. t (Shibanov et al., 1994; Shibanov et al., 1996; Melnikov et al., 1998).

The analysis of *S. mentella* commercial stock and the carried out investigations of the possible size of the commercial withdrawal let us consider TAC of 95 thou. t based on TAC-1999 values as underestimated. In order the exploitation of *S. mentella* stock be rational, we propose to discuss the possibility of TAC increase for 2002 to not less than 120 thou. t.

References

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Table 1

The Redfish Abundance Estimation Results by the Acoustic Method at the Depthes above 500 m (Icelandic Data).
(TS = 20LgL - 71.3)

Subarea	Area, sq.nm	Mean SAac, sq.m/sq.nm	Mean Density, tonn/sq.nm	Mean Length, cm	Mean Weight, g	Abundance, 10^6 sp	Biomass, 10^3 tonn
A	126179	1.29	0.70	34.7	524	168	88
B	106502	4.24	2.07	35.2	546	403	220
C	25616	1.59	1.17	36.5	601	50	30
D	76052	7.17	3.51	34.7	522	512	267
E	52840	3.00	1.95	33.3	467	221	103
F	34481	0.53	0.20	31.4	403	17	7
Total	421671	3.27	1.70	34.6	522	1370	715

Table 2

The Redfish Abundance Estimation Results by the Acoustic Method at the Depthes below 500 m (Russian Data).
(TS = 20LgL - 71.3)

Subarea	Area, sq.nm	Mean SAac, sq.m/sq.nm	Mean Density, tonn/sq.nm	Mean Length, cm	Mean Weight, g	Abundance, 10^6 sp	Biomass, 10^3 tonn
A	126179	6.58	3.61	39.7	806	565	455
B	106502	2.07	1.12	39.1	768	155	119
C	25616	0.25	0.13	37.6	691	5	3
D	76052	0.23	0.12	35.2	603	15	9
E	52840	0.71	0.34	32.9	479	37	18
F	34481	0.24	0.11	31.8	433	9	4
Total	421671	2.66	1.44	39.1	774	786	608

Table 3

The Redfish Abundance Estimation Results by the Trawl Method at the Depthes above 500 m (Trawlings type 1 and 2).
(TS = 20LgL - 71.3)

Subarea	Area, sq.nm	Mean SAtr, sq.m/sq.nm	Mean Density, tonn/sq.nm	Mean Length, cm	Mean Weight, g	Abundance, 10^6 sp	Biomass, 10^3 tonn
A	80982	2.17	1.03	34.6	530	158	84
B	103579	5.63	2.70	35.3	555	503	280
C	8464	6.60	3.14	36.5	592	45	27
D	62897	14.44	7.46	34.7	581	808	469
E	69000	6.17	2.96	33.3	497	411	204
F	32470	0.83	0.37	31.1	406	30	12
Total	357392	6.09	3.01	34.5	550	1955	1075

NOTE: Linear Regr: SAtr = 0.2621*Catch for “B.Saemundsson” (Tr.type 1-3) and “A.Fridriksson” (Tr.type 2-3)

Table 4

The Redfish Abundance Estimation Results by the Trawl Method at the Depthes below 500 m (Trawlings type 3).
(TS = 20LgL - 71.3)

Subarea	Area, sq.nm	Mean SAtr, sq.m/sq.nm	Mean Density, tonn/sq.nm	Mean Length, cm	Mean Weight, g	Abundance, 10^6 sp	Biomass, 10^3 tonn
A	125975	7.80	4.27	39.7	806	669	539
B	127125	4.75	2.56	39.1	768	424	326
C	28934	1.82	0.96	37.6	691	40	28
D	62897	2.49	1.30	35.2	603	135	82
E	69000	1.97	0.93	32.9	479	134	64
F	32470	1.28	0.59	31.8	433	44	19
Total	446401	4.42	2.37	38.2	731	1446	1057

NOTE: Linear Regr: SAtr = 0.2621*Catch for “B.Saemundsson” (Tr.type 1-3) and “A.Fridriksson” (Tr.type 2-3)

Table 5

The Redfish Abundance Estimation Results by the Trawl Method at the Depthes above 500 m (Trawlings type 1 and 2).
(TS = 20LgL - 71.3)

Subarea	Area, sq.nm	Mean SAtr, sq.m/sq.nm	Mean Density, tonn/sq.nm	Mean Length, cm	Mean Weight, g	Abundance, 10^6 sp	Biomass, 10^3 tonn
A	80982	3.84	1.83	34.6	530	279	148
B	103579	6.28	3.01	35.3	555	561	312
C	8464	17.22	8.19	36.5	592	117	69
D	62897	14.74	7.62	34.7	581	825	479
E	69000	6.47	3.11	33.3	497	431	214
F	32470	0.82	0.37	31.1	406	30	12
Total	357392	7.02	3.45	34.6	550	2244	1235

NOTE: Power Regr: SAtr = 1.366*Catch^0.5087 for “B.Saemundsson” (Tr.type 1-3) and “A.Fridriksson” (Tr.type 2-3)

Table 6

The Redfish Abundance Estimation Results by the Trawl Method at the Depthes below 500 m (Trawlings type 3).
(TS = 20LgL - 71.3)

Subarea	Area, sq.nm	Mean SAtr, sq.m/sq.nm	Mean Density, tonn/sq.nm	Mean Length, cm	Mean Weight, g	Abundance, 10^6 sp	Biomass, 10^3 tonn
A	125975	17.17	9.41	39.7	806	1472	1186
B	127125	10.11	5.45	39.1	768	902	692
C	28934	7.56	3.97	37.6	691	166	115
D	62897	3.22	1.68	35.2	603	175	106
E	69000	1.83	0.87	32.9	479	125	60
F	32470	1.28	0.59	31.8	433	44	19
Total	446401	9.04	4.88	38.7	755	2884	2177

NOTE: Power Regr: SAtr = 1.366*Catch^0.5087 for “B.Saemundsson” (Tr.type 1-3) and “A.Fridriksson” (Tr.type 2-3)

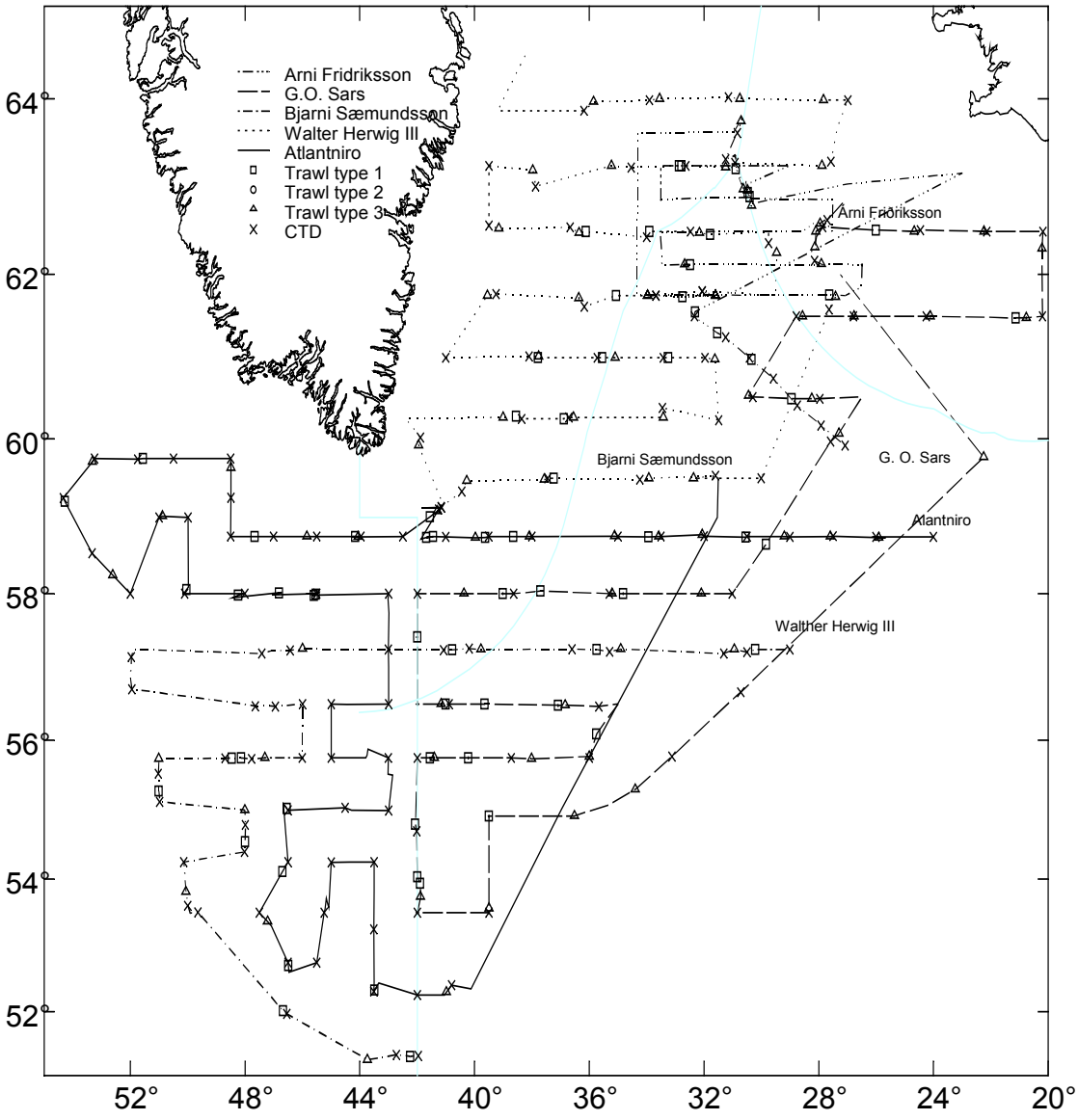

Fig. 1. Cruise tracks and stations taken in the joint international redfish survey in June/July 2001

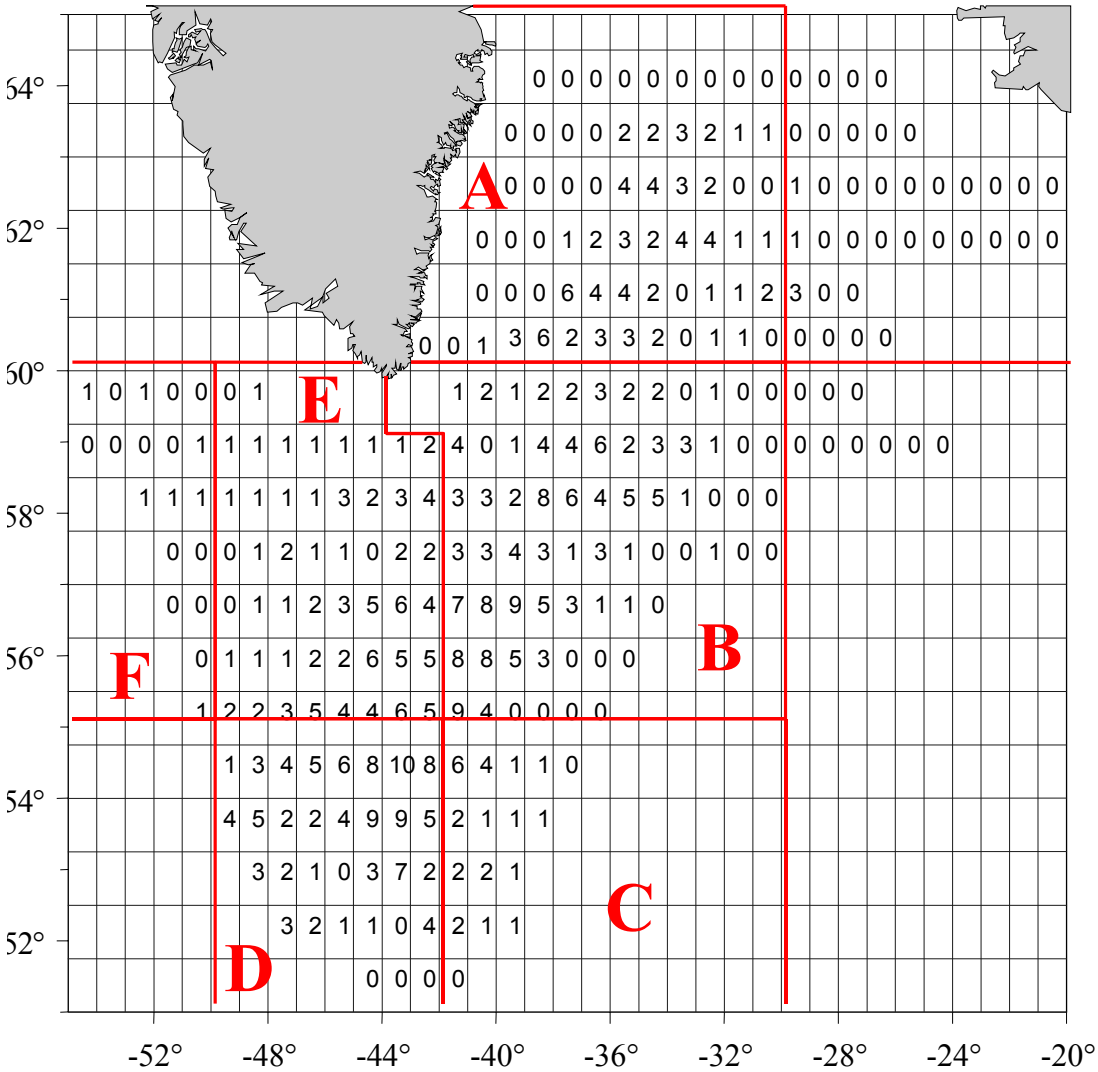

Fig. 2. Mean density for redfish (tonn/sq.nm) per rectangles in layer 0-500 m

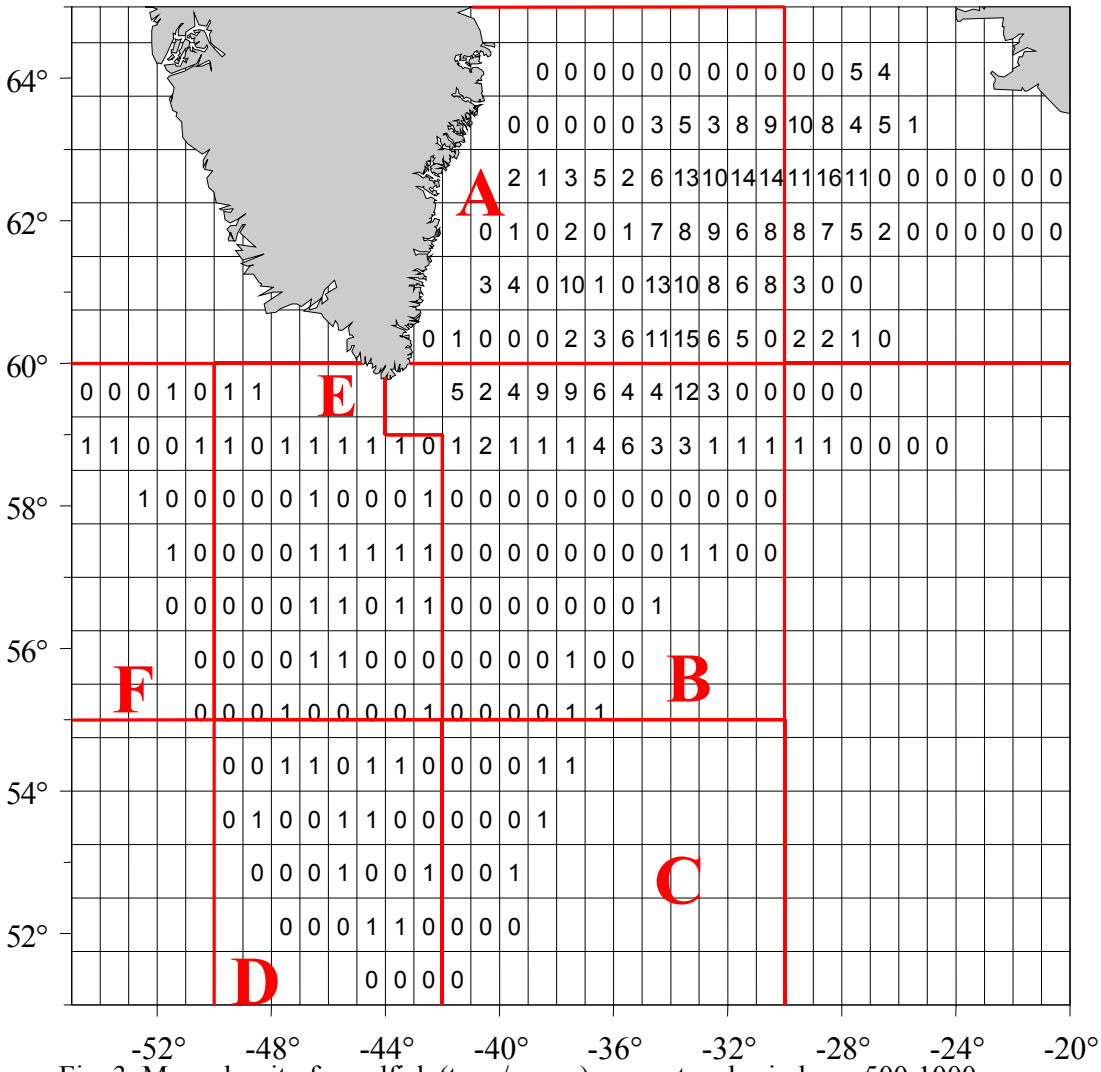

Fig. 3. Mean density for redfish (tonn/sq.nm) per rectangles in layer 500-1000 m

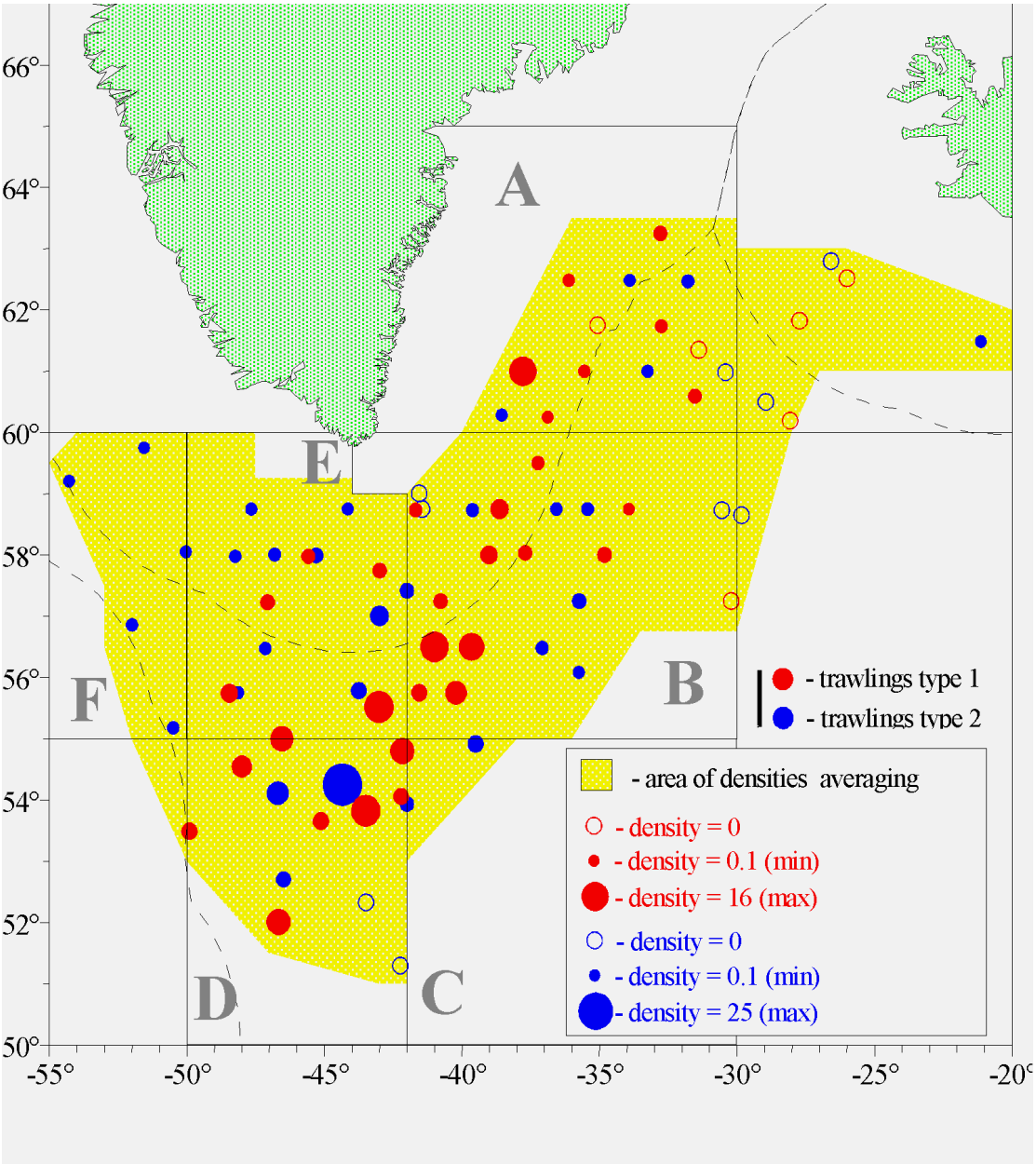

Fig. 4. Calculated redfish densities (tonn/sq.nm) above 500 m, obtained from trawl catches

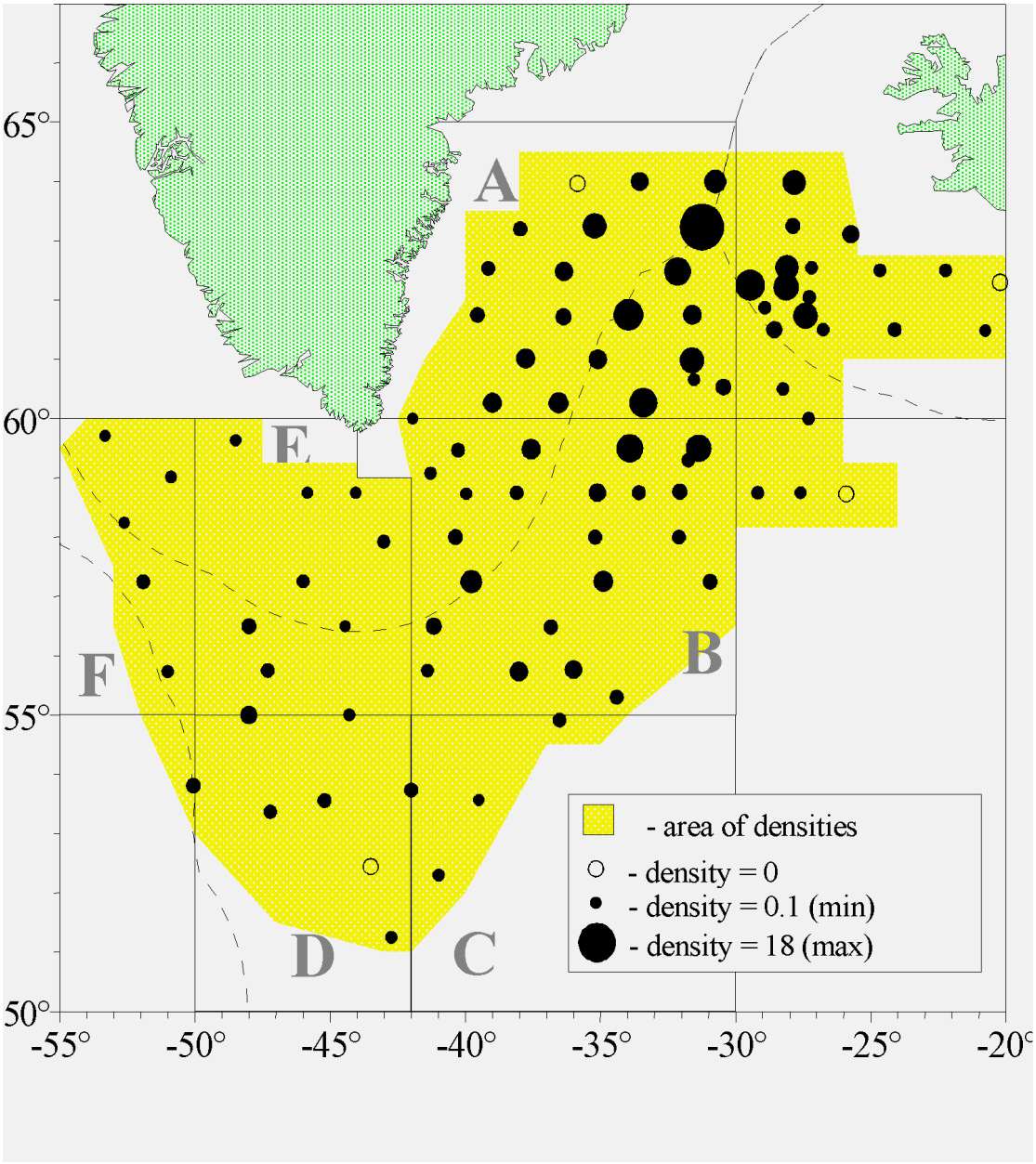

Fig. 5. Calculated redfish densities (tonn/sq.nm) bellow 500 m, obtained from trawl catches

Appendix 1

ASPIC 3.6x Sample Input File (ASPIC.inp) Page 1
08 Apr 2002 at 11:58.35
ASPIC -- A Surplus-Production Model Including Covariates (Ver. 3.82) FIT Mode

Author: Michael H. Prager; NOAA/NMFS/S.E. Fisheries Science Center
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ASPIC User's Manual is available gratis from the author.

Ref: Prager, M. H. 1994. A suite of extensions to a nonequilibrium surplus-production model. Fishery Bulletin 92: 374-389.

CONTROL PARAMETERS USED (FROM INPUT FILE)

Number of years analyzed:	12	Number of bootstrap trials:	0
Number of data series:	1	Lower bound on MSY:	2.000E+04
Objective function computed:	in effort	Upper bound on MSY:	5.000E+05
Relative conv. criterion (simplex):	1.000E-08	Lower bound on r:	3.000E-01
Relative conv. criterion (restart):	3.000E-08	Upper bound on r:	1.000E+00
Relative conv. criterion (effort):	1.000E-04	Random number seed:	9126738
Maximum F allowed in fitting:	8.000	Monte Carlo search mode, trials:	1 3000

PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS) code 21

ERROR: Estimate of r is at or near maximum constraint, 1.000E+00
Solution may be trivial--examine carefully.

GOODNESS-OF-FIT AND WEIGHTING FOR NON-BOOTSTRAPPED ANALYSIS

Loss component number and title	Weighted SSE	N	Weighted MSE	Current weight	Suggested weight	R-squared in CPUE
Loss(-1) SSE in yield	0.000E+00					
Loss(0) Penalty for B1R > 2	0.000E+00	1	N/A	0.000E+00	N/A	
Loss(1) Sample Effort & Catch, Table 21	2.832E+00	12	2.832E-01	1.000E+00	1.000E+00	0.193
TOTAL OBJECTIVE FUNCTION:	2.83191321E+00					

Number of restarts required for convergence: 6
Est. B-ratio coverage index (0 worst, 2 best): 1.6064 < These two measures are defined in Prager
Est. B-ratio nearness index (0 worst, 1 best): 1.0000 < et al. (1996), Trans. A.F.S. 125:729

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Starting guess	Estimated	User guess
B1R	Starting biomass ratio, year 1990	2.540E-01	1.000E+00	1	1
MSY	Maximum sustainable yield	3.753E+05	2.000E+05	1	1
r	Intrinsic rate of increase	1.000E+00	6.000E-01	1	1
.....	Catchability coefficients by fishery:				
q(1)	Sample Effort & Catch, Table 21	6.627E-03	1.267E+02	1	0

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Formula	Related quantity
MSY	Maximum sustainable yield	3.753E+05	Kr/4	
K	Maximum stock biomass	1.501E+06		
Bmsy	Stock biomass at MSY	7.505E+05	K/2	
Fmsy	Fishing mortality at MSY	5.000E-01	r/2	
F(0.1)	Management benchmark	4.500E-01	0.9*Fmsy	
Y(0.1)	Equilibrium yield at F(0.1)	3.715E+05	0.99*MSY	
B-ratio	Ratio of B(2002) to Bmsy	1.848E+00		
F-ratio	Ratio of F(2001) to Fmsy	1.583E-01		
F01-mult	Ratio of F(0.1) to F(2001)	5.687E+00		
Y-ratio	Proportion of MSY avail in 2002	2.809E-01	2*Br-Br^2	Ye(2002) = 1.054E+05
.....	Fishing effort at MSY in units of each fishery:			
fmsy(1)	Sample Effort & Catch, Table 21	7.545E+01	r/2q(1)	f(0.1) = 6.791E+01

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

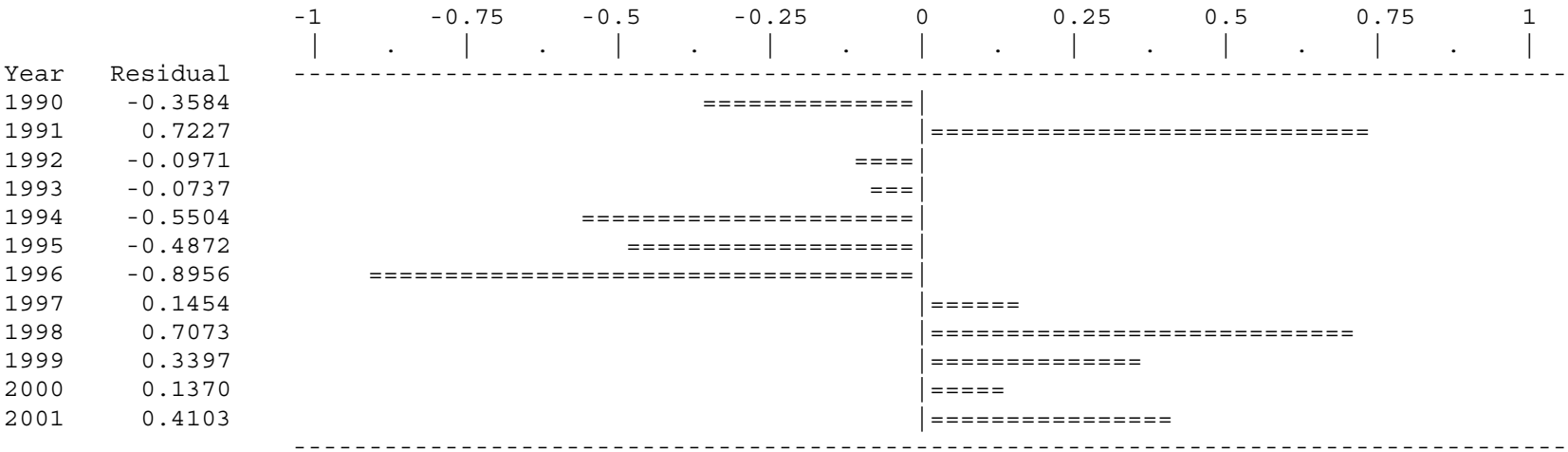
Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1990	0.113	1.907E+05	2.793E+05	3.152E+04	3.152E+04	2.252E+05	2.257E-01	2.540E-01
2	1991	0.047	3.844E+05	5.351E+05	2.496E+04	2.496E+04	3.388E+05	9.328E-02	5.121E-01
3	1992	0.077	6.982E+05	8.522E+05	6.596E+04	6.596E+04	3.634E+05	1.548E-01	9.303E-01
4	1993	0.103	9.957E+05	1.095E+06	1.132E+05	1.132E+05	2.945E+05	2.069E-01	1.327E+00
5	1994	0.122	1.177E+06	1.221E+06	1.487E+05	1.487E+05	2.274E+05	2.436E-01	1.568E+00
6	1995	0.135	1.256E+06	1.270E+06	1.712E+05	1.712E+05	1.958E+05	2.696E-01	1.673E+00
7	1996	0.127	1.280E+06	1.290E+06	1.633E+05	1.633E+05	1.811E+05	2.531E-01	1.706E+00
8	1997	0.076	1.298E+06	1.328E+06	1.004E+05	1.004E+05	1.530E+05	1.513E-01	1.729E+00
9	1998	0.066	1.351E+06	1.368E+06	9.028E+04	9.028E+04	1.210E+05	1.320E-01	1.799E+00
10	1999	0.063	1.381E+06	1.390E+06	8.787E+04	8.787E+04	1.029E+05	1.264E-01	1.840E+00
11	2000	0.072	1.396E+06	1.395E+06	1.006E+05	1.006E+05	9.848E+04	1.442E-01	1.860E+00
12	2001	0.079	1.394E+06	1.390E+06	1.100E+05	1.100E+05	1.028E+05	1.583E-01	1.858E+00
13	2002		1.387E+06						1.848E+00

RESULTS FOR DATA SERIES # 1 (NON-BOOTSTRAPPED) Sample Effort & Catch, Table 21

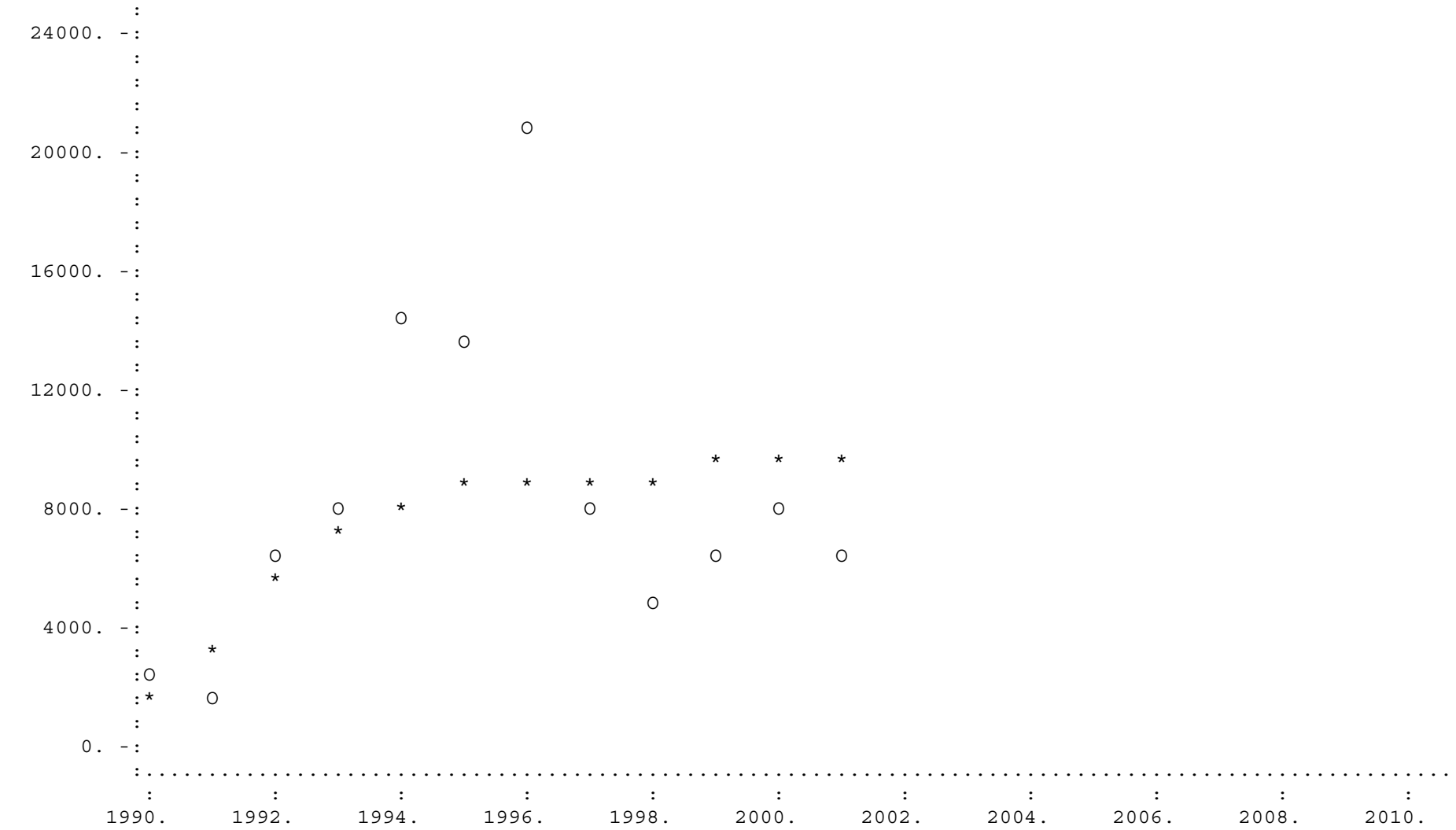
Data type CE: Effort-catch series Series weight: 1.000

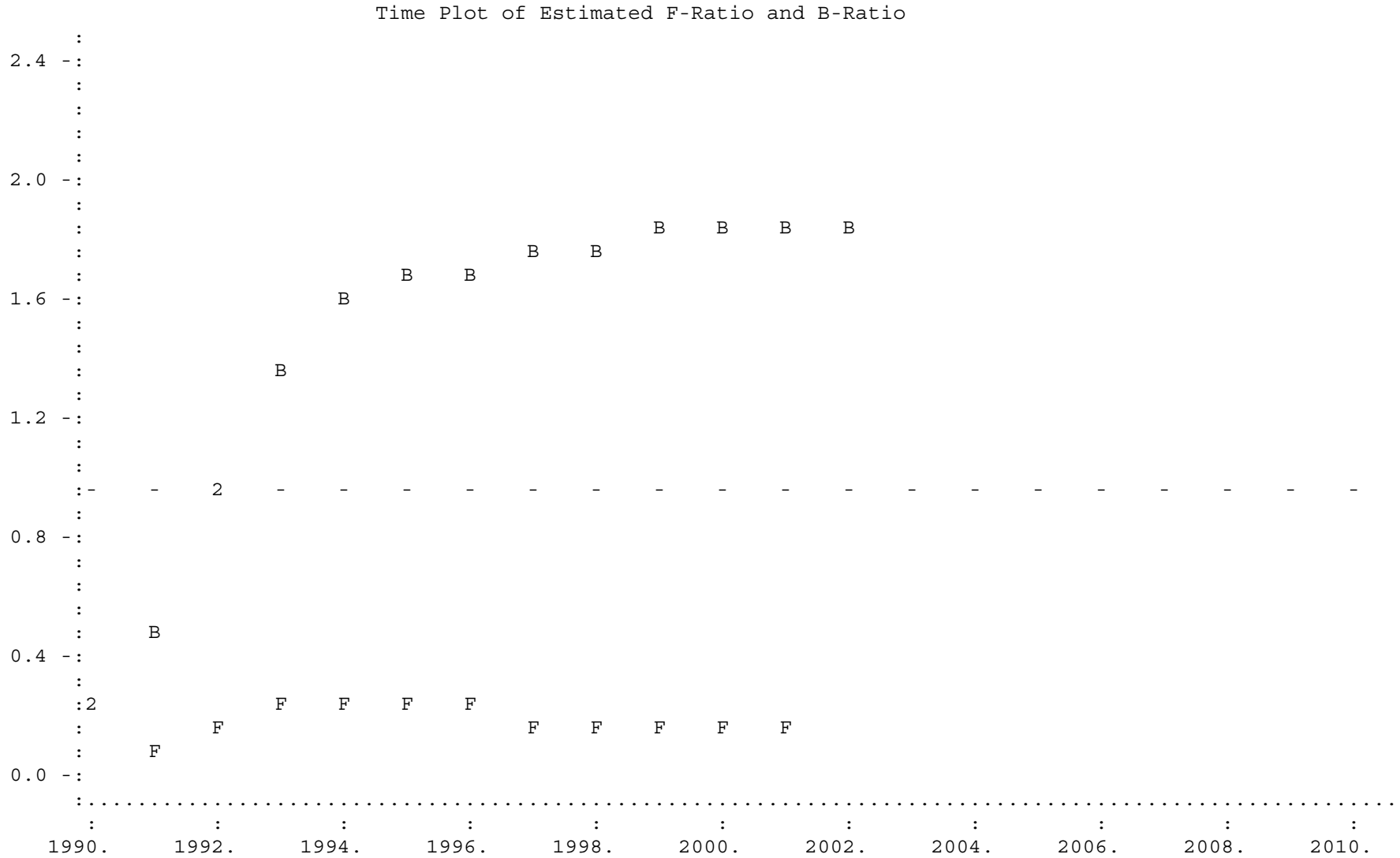
Obs	Year	Observed CPUE	Estimated CPUE	Estim F	Observed yield	Model yield	Resid in log scale	Resid in yield
1	1990	2.648E+03	1.851E+03	0.1128	3.152E+04	3.152E+04	-0.35841	0.000E+00
2	1991	1.721E+03	3.546E+03	0.0466	2.496E+04	2.496E+04	0.72274	0.000E+00
3	1992	6.223E+03	5.647E+03	0.0774	6.596E+04	6.596E+04	-0.09710	0.000E+00
4	1993	7.809E+03	7.254E+03	0.1034	1.132E+05	1.132E+05	-0.07369	0.000E+00
5	1994	1.403E+04	8.092E+03	0.1218	1.487E+05	1.487E+05	-0.55037	0.000E+00
6	1995	1.369E+04	8.413E+03	0.1348	1.712E+05	1.712E+05	-0.48715	0.000E+00
7	1996	2.094E+04	8.550E+03	0.1266	1.633E+05	1.633E+05	-0.89557	0.000E+00
8	1997	7.609E+03	8.800E+03	0.0756	1.004E+05	1.004E+05	0.14540	0.000E+00
9	1998	4.470E+03	9.066E+03	0.0660	9.028E+04	9.028E+04	0.70730	0.000E+00
10	1999	6.558E+03	9.211E+03	0.0632	8.787E+04	8.787E+04	0.33974	0.000E+00
11	2000	8.061E+03	9.245E+03	0.0721	1.006E+05	1.006E+05	0.13703	0.000E+00
12	2001	6.111E+03	9.211E+03	0.0791	1.100E+05	1.100E+05	0.41031	0.000E+00

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 1



Observed (O) and Estimated (*) CPUE for Data Series # 1 -- Sample Effort & Catch, Table 21




Time Plot of Estimated F-Ratio and B-Ratio
2.4
2.0
1.6
1.2
0.8
0.4
0.0
1990.
1992.
1994.
1996.
1998.
2000.
2002.
2004.
2006.
2008.
2010.

Appendix 2

"MFDP version 1a"
"Run: 222"
"TestProjection index file 15/02/02."
"Time and date: 13:58 15.02.02"
"Fbar age range: 10-19"

2001
"Biomass","SSB","FMult","FBar","Landings"

"1411549","1048510","0.9310","0.0950","110000"

2002,,,,,2003
"Biomass","SSB","FMult","FBar","Landings","Biomass","SSB"
"1438330","1078702","0.0000","0.0000","0","1568298","1200018"
".","1078702","0.1000","0.0102","11574","1556134","1188232"
".","1078702","0.2000","0.0204","22989","1544140","1176612"
".","1078702","0.3000","0.0306","34245","1532314","1165156"
".","1078702","0.4000","0.0408","45347","1520653","1153861"
".","1078702","0.5000","0.0510","56297","1509155","1142724"
".","1078702","0.6000","0.0612","67096","1497816","1131743"
".","1078702","0.7000","0.0714","77747","1486636","1120916"
".","1078702","0.8000","0.0816","88253","1475610","1110240"
".","1078702","0.9000","0.0918","98616","1464737","1099713"
".","1078702","1.0000","0.1020","108837","1454014","1089332"
".","1078702","1.1000","0.1122","118920","1443439","1079096"
".","1078702","1.2000","0.1224","128866","1433010","1069001"
".","1078702","1.3000","0.1326","138678","1422724","1059046"
".","1078702","1.4000","0.1428","148356","1412579","1049229"
".","1078702","1.5000","0.1530","157905","1402573","1039547"
".","1078702","1.6000","0.1632","167325","1392703","1029998"
".","1078702","1.7000","0.1735","176619","1382968","1020580"
".","1078702","1.8000","0.1837","185788","1373366","1011292"
".","1078702","1.9000","0.1939","194834","1363894","1002130"
".","1078702","2.0000","0.2041","203760","1354550","993094"

"Input units are thousands and kg - output in tonnes"

```
"*****  Results  *****"
"*****  Interim years  *****"
"Year","FMult","Fbar","Yield","Biomass","SSB"

2001,.93098919936,9.49888280107008E-02,110000.012313175,
1411549.30366667,1048510.21930357


"*****  Projection year  *****"
2002,0,0,0,1438329.52085362,1078701.89146832
2002,.1,.010203,11574.2636150183,1438329.52085362,1078701.89146832
2002,.2,.020406,22988.5928975099,1438329.52085362,1078701.89146832
2002,.3,.030609,34245.4911934489,1438329.52085362,1078701.89146832
2002,.4,.040812,45347.4200568373,1438329.52085362,1078701.89146832
2002,.5,.051015,56296.7999784789,1438329.52085362,1078701.89146832
2002,.6,.061218,67096.0111016197,1438329.52085362,1078701.89146832
2002,.7,.071421,77747.3939246984,1438329.52085362,1078701.89146832
2002,.8,.081624,88253.2499914457,1438329.52085362,1078701.89146832
2002,.9,.091827,98615.8425685656,1438329.52085362,1078701.89146832
2002,1,.10203,108837.397311227,1438329.52085362,1078701.89146832
2002,1.1,.112233,118920.102916596,1438329.52085362,1078701.89146832
2002,1.2,.122436,128866.111765619,1438329.52085362,1078701.89146832
2002,1.3,.132639,138677.540553285,1438329.52085362,1078701.89146832
2002,1.4,.142842,148356.470907577,1438329.52085362,1078701.89146832
2002,1.5,.153045,157904.949997311,1438329.52085362,1078701.89146832
2002,1.6,.163248,167324.991129082,1438329.52085362,1078701.89146832
2002,1.7,.173451,176618.574333505,1438329.52085362,1078701.89146832
2002,1.8,.183654,185787.646940961,1438329.52085362,1078701.89146832
2002,1.9,.193857,194834.124147029,1438329.52085362,1078701.89146832
2002,2,.20406,203759.889567798,1438329.52085362,1078701.89146832


"*****  Projection year + 1  *****"
2003,"","","",1568298.22242501,1200018.10886827
2003,"","","",1556133.7021931,1188231.89155113
2003,"","","",1544139.75171566,1176611.96471675
2003,"","","",1532313.67411575,1165155.6982173
2003,"","","",1520652.81791905,1153860.50618611
2003,"","","",1509154.57625617,1142723.84625976
2003,"","","",1497816.38607959,1131743.21881429
2003,"","","",1486635.72739466,1120916.16621523
2003,"","","",1475610.12250463,1110240.27208124
2003,"","","",1464737.13526928,1099713.16056109
2003,"","","",1454014.37037705,1089332.4956237
2003,"","","",1443439.4726303,1079095.98036109
2003,"","","",1433010.12624346,1069001.35630388
2003,"","","",1422724.05415396,1059046.40274917
2003,"","","",1412579.01734554,1049228.93610062
2003,"","","",1402572.8141838,1039546.80922035
2003,"","","",1392703.27976373,1029997.91079268
2003,"","","",1382968.28526909,1020580.16469919
2003,"","","",1373365.73734321,1011291.52940517
2003,"","","",1363893.57747129,1002129.99735709
2003,"","","",1354549.78137364,993093.594390929
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