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Appendix 1: The Lowestoft Stock Assessment Suite

Tutorial 1

Data file input and User-defined VPA

by

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Abstract

This document is the first in a series of tutorials that provide an introduction to fitting stock assessment models within the Lowestoft VPA Suite stock assessment software package, and prediction programs that utilise the results. This tutorial takes the user through the input of data files, running a VPA with user defined fishing mortalities and the printing of data and results.

Introduction

This document takes the user through the process of entering data into the Lowestoft VPA suite program and running a "user-defined" traditional VPA (virtual population analysis) using file and keyboard input of terminal F values (the fishing mortality occurring at the oldest cohort age). The tutorial assumes that the user has installed the VPA program described in Darby and Flatman (1994), that the required data files have been placed in a directory c:\vpas\data and that the example assessment index file (Blackfin.ind) contains path names which point to the appropriate input files within that directory.

In the following text **action to be taken by the user** is highlighted in bold. The symbol ↵ is used to represent the Return or Enter key on the keyboard.

Data Input

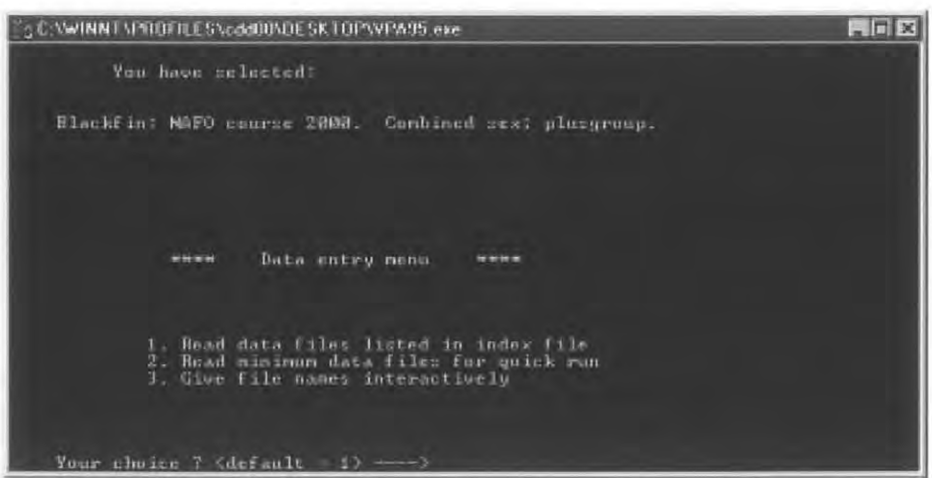
Start the VPA suite from the program file VPA95.EXE or at the windows icon.

The program should open and present the VPA suite introductory screen shown below

If the data files were installed in the recommended directory then

Type in the directory path and index file name C:\VPAS\DATA\BLACKFIN.IND ↲

Otherwise type in the directory in which the data files were placed. The program will then present the data file entry screen.



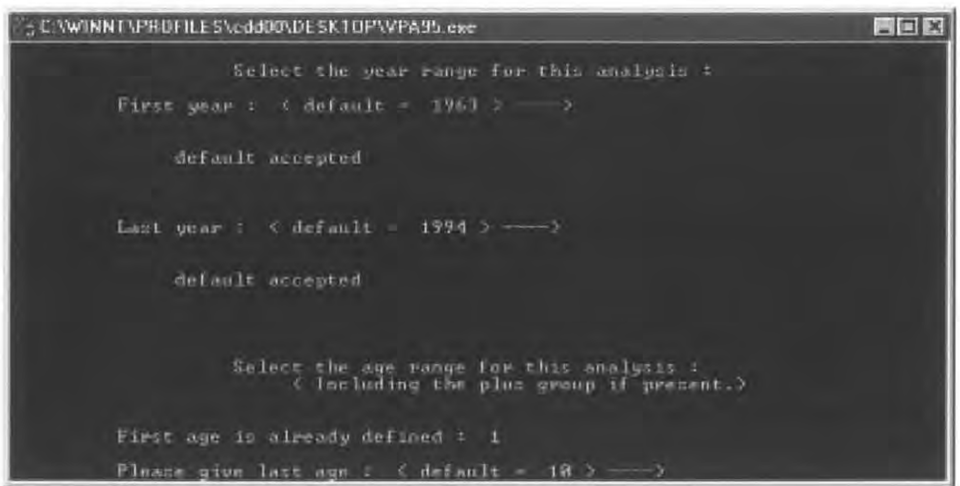
The title from the index file is displayed, for reference, at the top of the screen. Three options are available for input of the data files. Selecting option (1) reads the first eight stock data files from the index file list. Option (2) only reads the catch numbers and natural mortality files from the index file list; the option is used if the other data are not readily available. Runs with this option will only calculate population numbers and fishing mortality rates. Option (3) allows the user to type the path and name of each file interactively; the defaults are taken from the appropriate file name in the index file list.

Type 3 ↵
Type ↵ at each prompt and select the default data files.

Note that the program reads through the list of files provided within the index file list; each is presented so that the user can replace them with alternatives if required. Typing return at each question takes the offered default file.

After selecting the data files that we wish to use in the assessment the program the prompts the user for the selection of the year and age ranges over which the assessment is to be calculated. The subset of data years used for the assessment can be selected from the complete range specified in the data files.

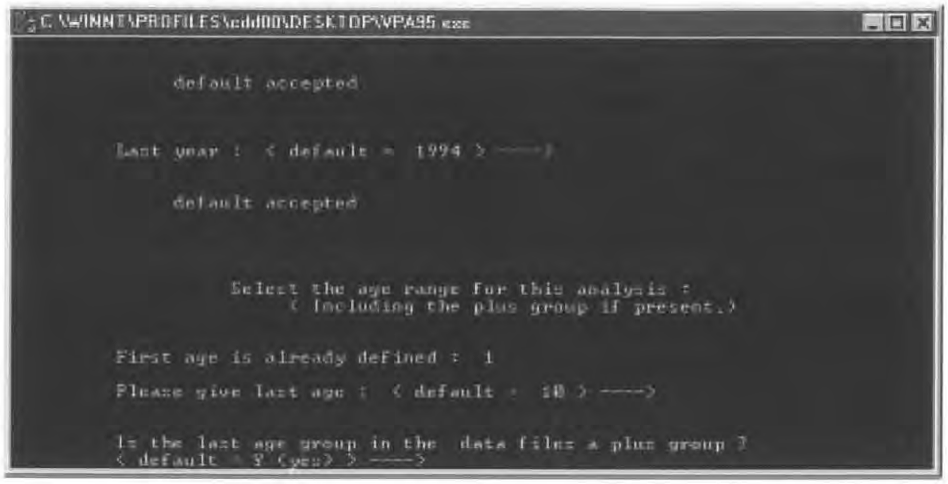
Type ↵ and select the default at each of the year prompts.



When selecting the age range for the assessment, the only restriction imposed on the user is that the first assessment age must be that defined in the data files. If the oldest age selected is less than the oldest defined within the data files, a plus group will be created. The plus group catch weights, stock weights and proportion mature are automatically calculated as catch number weighted means.

The next question defines the use of the oldest age. The program initiates all VPA and Cohort analyses from the oldest **true** age. Stock numbers for the plus group are estimated independently using the plus group catch number and the F on the oldest true age in the same year.

Type ↵ and select the default oldest age.



If the selected age was less than the number of ages in the original data files **the oldest age entered at this prompt will be a plus group**. After selecting the oldest age for the analysis, the user must then inform the program whether the oldest age defined in the data files was created as a plus group. If the oldest age selected by the user is younger than the oldest age defined in the data files, a new plus group is automatically created by summing the catch data of the selected age with the data for older ages. The new plus group catch, stock weights and other data attributes are recalculated as catch-number-weighted means. The age preceding the plus group age becomes the oldest true age for the analysis.

If the user wishes to perform a run without a plus group, the full age range defined within the header section of the original data files **must** be used. The data files should be edited to specify required age range. Data for older ages outside of the range will be ignored. During interactive input, select the default values offered for the age range (the data file values) and answer 'No' to the question asking whether the oldest age in the data files is a plus group.

In this example the original data set listed in the index file does have a plus group at age 10.

Type ↵ to take the default.

We have now completed the specification of the data structures used in the assessment.

Specification of Assessment Summary Table Means

In the next series of selections we define the range of ages used for the fishing mortality and population summary means printed in the result tables when the assessment is completed. This procedure is carried out prior to calculating assessments so that it does not have to be repeated for each assessment run.

Initially we are presented with a screen, shown below, that lists the options available for specifying the summary means.

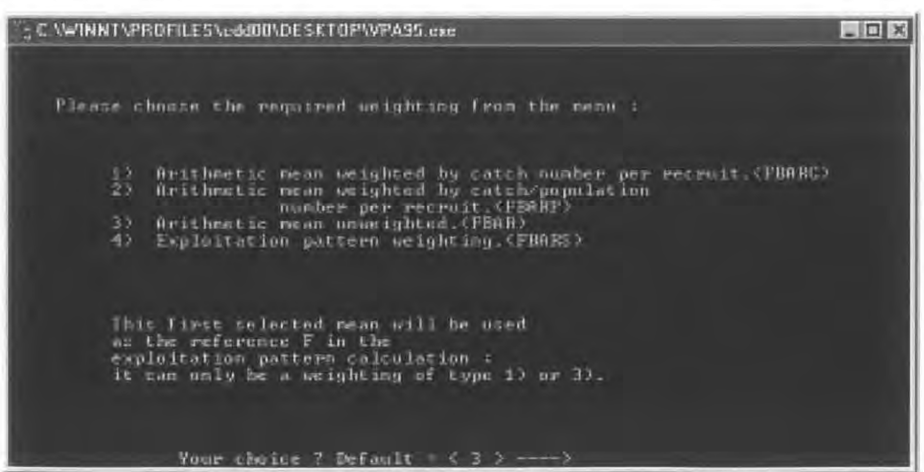
Taking the default option (1) will calculate an unweighted arithmetic mean for each year (across ages). If the number of assessment ages selected by the user is greater than 5, the age range is (firstage +2) to (lastage -2), otherwise the average is calculated over all ages. Row means for each age (across years) are calculated as unweighted arithmetic mean with the year range: (lastyear -2) – last year.

In this example we will define two means for the annual fishing mortality. The first is an arithmetic mean F calculated over ages 3–7. The second is an average in which, at each age, the fishing mortality is weighted by the ratio of the catch numbers to the estimated population numbers.

Type 2 ↵ To select user definition of the fishing mortality column means.

We will specify two means for each column (year) of the output summary table.

Select two means by typing 2 ↵

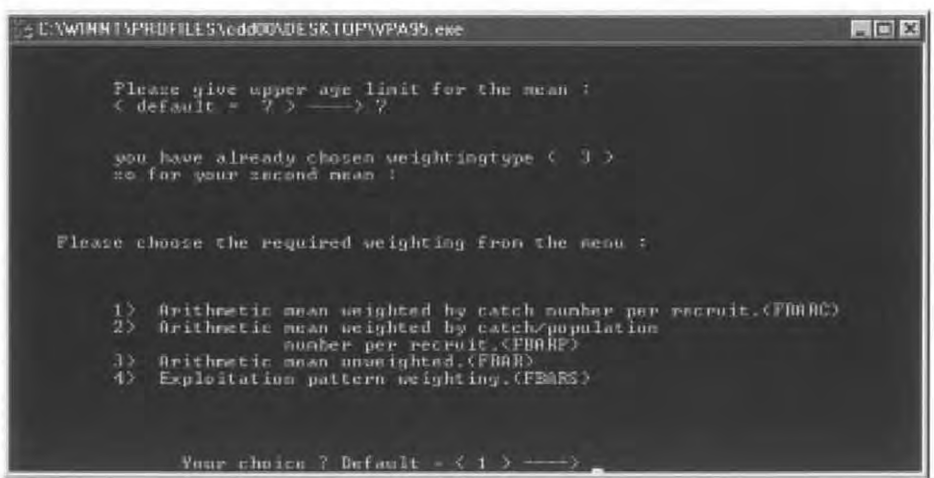


At the next screen we select the format of the first mean.

Type 3 for the arithmetic mean or just press enter for the default.

Select the defaults offered for the range of ages over which the arithmetic mean is to be calculated.

This completes the specification of the unweighted arithmetic mean. We now specify the catch / population weighted mean.



Type 2 for the catch/population weighted mean

The mean is a weighted average of the catch numbers to the population numbers calculated at each age and there is therefore no requirement to specify the age range for the calculations.

This completes the specification of the summary means and brings us to the central menu for the program.

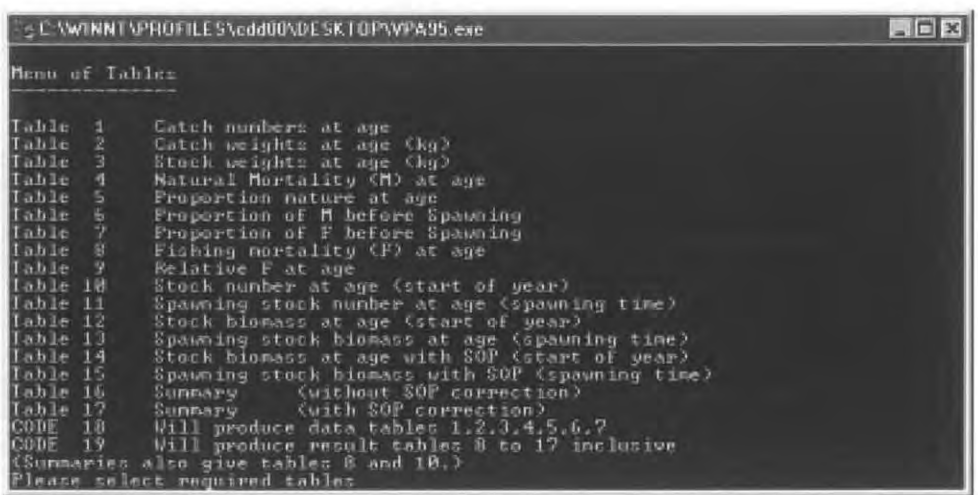
The VPA Suite Central Menu

At the program central menu we can select assessment models and print tables of data or results. After each assessment model has been fitted to a data set, the program will return to this menu. This allows the user to undertake a series of exploratory trials and examine the results of the assessments in an editor or spreadsheet package without having to re-specify the data and summary age or year ranges.

Printing Data and Result Tables

Type 9 ↵

This screen presents a list of the tables available for printing from the program. At the current stage in the tutorial we have not run an assessment model so that there are no results available for printing. We can only print the input data sets 1–7.



Type 1, 2, 3, 4, 5, 6, 7 ↵

Type an output path followed by a file name with a .csv extension ↵

After pressing return you should be back at the central menu. Note the star indicating that we have used the printing section. Examine the results file in a suitable spreadsheet or word processing package; there is no need to close the VPA program. The use of the .csv file extension produces spreadsheets that are automatically formatted when loaded into e.g. Microsoft Excel.

The VPA Suite Input Data Output File Format

Tables 1 – 7 present the Blackfin input data files that are printed as output from the VPA suite. They are:

Table	Contents
1	Catch at age in numbers (thousands)
2	Catch weight at age (kg)
3	Stock weight at age (kg)
4	Natural mortality
5	Maturity ogive
6	Proportion of F before spawning
7	Proportion of M before spawning

Note that for this stock the catch weights have also been used for the stock weights at age. Stock weights at age are used to calculate the spawning stock biomass and ideally should be the values recorded at that time of year.

The first two lines of each output table are consistent between tables. The first line is the run title, taken from the title of the assessment data index file. It is generally used to identify the stock, year and type of data. The second line is the date and time at which the data files were printed.

Table 1 presents the catch numbers at age data used in the assessment model. In this instance the data have been tabulated in thousands, the unit that the program assumes for all calculations. Note however that the output table is formatted for ease of printing and the output unit, as detailed in the first line of each section, may change.

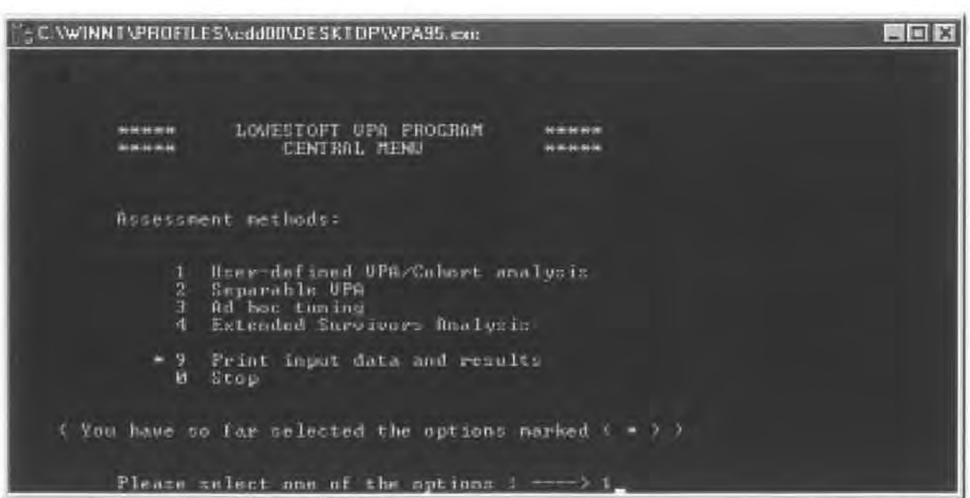
The data are tabulated in columns by year with totals presented for each column. Beneath the total numbers are the landings data time series from the first input file and a sum of products (SOP) cross check. The SOP value indicates the factor, given as a percentage, by which the sum of the products of the catch numbers and catch weights at age has to be raised to match the total landings. In Table 1 the SOP of the catch weights and catch numbers at age for 1963 is 6% lower than the landings weight. The SOP value is taken as an indication of the quality of the sampling used in the estimation of the numbers at age. In many ICES assessment working groups the catch weights are scaled, to correct for the difference, prior to the fitting of the assessment models (this is the case with this data set for recent years). However, if required the correction can be applied within the program during the printing of the results. The SOP value is also presented in Table 2: the catch weight at age data.

Analysis of the dynamics of the population and the characteristics of the fishery does not have to start with the fitting of assessment models. The structure of the catch at age data can be very informative. In the case of the Blackfin example, throughout the time series there has been a change in the peak age of the catch moving towards the youngest ages in the landings. During 1965–69 the distribution of the catch at age peaked at age 4. As the fishery has progressed there has been a gradual reduction in the dominant age towards age 3 in the late 1970's and 1980's to ages 2 and 3 in the most recent years. During the early years there were very few catches recorded at age 1, whereas more recently this age group has formed a substantial proportion of the catch. The pattern could result from high mortalities removing fish before they reach the older ages or from a change in selection by the fishery.

The catch weight at age data demonstrates trends during the available time series. During the period 1967–71 catch weight at age 5 averaged 2.2 kg; it increased during 198–84 to an average of 3.0 kg, and then decreased to less than 2.0 kg during 1987–93. The changes could be the product of the changes in selection by the fishery, such as changes in discard practices, or result from changes in growth rates.

Note that stock weights are a repeat of the catch weights for this fishery. If spawning takes place at a specific time of year catch weights from that time of year or from surveys could be used. Natural mortality is assumed constant at age and invariant through time. Maturity varies with age and is also constant in time. The proportion of fishing mortality and natural mortality that take place before spawning are set to zero so that SSB is calculated at the beginning of the year.

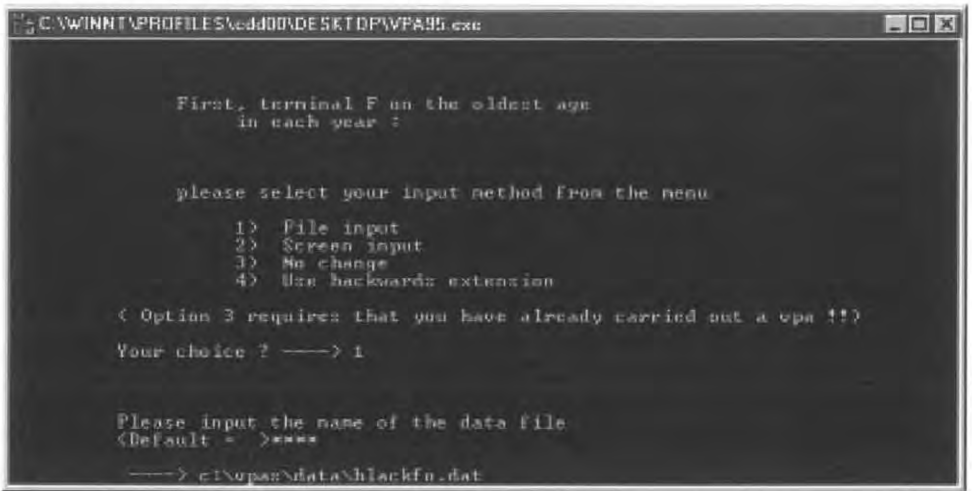
User-Defined VPA



Select Option 1 at the main menu

Four methods are available for the input of terminal fishing mortality values at the oldest age. Option 3 takes F values from a previous run of any of the assessment methods. Option 4 calculates an average of the fishing mortalities at younger ages.

Select option 1 for file input

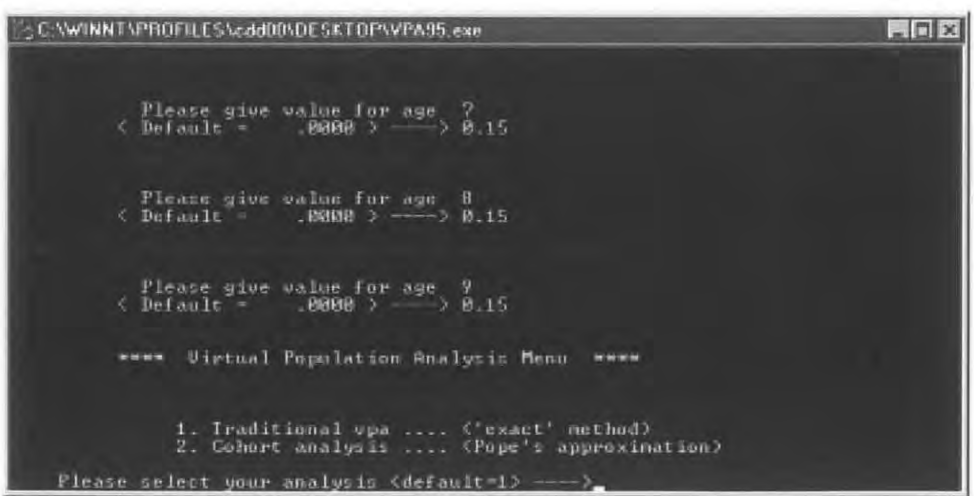


Note the four stars in the default. This indicates that a filename was not specified in the index file and user input is required.

Type the path and file name C:\VPAS\DATA\BLACKFO.DAT ↵

The program reads the fishing mortality values stored in the data file and will use them to calculate population abundance for each of the cohorts terminating at the oldest age prior to the final year.

At the next menu select the "Screen Input" option and type the following values for each successive age (0.01 0.03 0.09 0.10 0.12 0.18 0.15 0.15 0.15).



Select 1 for the Exact VPA method.

After running the VPA we return to the main menu. A star now highlights the user-defined method that we have just used.

The program has now calculated a time series of population abundance and fishing mortality at each age. We can therefore print the time series of spawning and stock biomass and fishing mortalities.

Type 9 and select table 19. Specify a directory path and a file name with a .csv extension.

The VPA Suite Results Output File Format

Tables 8–17 present the output files derived from the previous run and printed using the VPA suite menu option 9.

Table	Contents
8	Fishing mortality at age
9	Relative fishing mortality at age
10	Stock number at age, calculated at the start of the year
11	Spawning stock number at age, calculated at the time of spawning
12	Stock biomass at age, calculated at the start of the year, without SOP correction
13	Spawning stock biomass at age, calculated at the time of spawning, without SOP correction
14	Stock biomass at age, calculated at the start of the year, with SOP correction
15	Spawning stock biomass at age, calculated at the start of the year, with SOP correction
16	The assessment stock summary table without SOP correction
17	The assessment stock summary table with SOP correction

The first line of each table is the run title. It is taken from the title of the assessment data index file and is generally used to identify the stock, year and type of data. The second line is the date and time at which the data files were printed.

Table 8 presents the fishing mortality (F) at age matrix, calculated using the user inputs for the F in the final year, F at the oldest age from the input file, the natural mortality and the catch at age input data. The table layout is similar to the data file tabulation, with columns containing the results for a year and the rows the results for each age. Note that the plus group fishing mortality is defined to be equal to that at the oldest age.

The two fishing mortality means specified by the user are presented in the rows below the results for each age. In this instance we have defined an unweighted average F (FBAR), calculated over the age range 3–7, and a catch/population weighted average calculated across all ages (FBARP). The average values are also presented as time series in summary tables 16 and 17. The final column of the table presents an average fishing mortality for each age calculated over a user-defined range of years. As with the column means, the user can define the type of average and the year range over which it is calculated when specifying the assessment structure.

Pope (1972) has shown that the historic fishing mortality and population numbers calculated using VPA are insensitive to the values used to initiate the cohort calculations if the cumulative fishing mortality back up the cohort is greater than 1.0 (conditional on the value of M); the estimates are considered to be "converged". In Table 8 this generally holds for ages 7 and younger in the years 1963–91. Calibration models fitted to the Blackfin catch at age data set are therefore primarily estimating the level of fishing mortality and population abundance at all ages for the years 1992–94 and at ages 8 and 9 in earlier years.

Table 9 presents the relative fishing mortality at age, that is the ratio of the fishing mortality estimated at each age and the first user defined mean (Fbar 3–7). It is used to detect changes in selection at age such as the increased selection for age 2 and 3 that occurred after 1973.

Table 10 presents the population numbers at age calculated from the VPA transformation of the catch at age data with the two row (age) means. The number of means, the year range and the method of calculation are user defined. In this case the defaults were selected and they are a geometric and arithmetic mean calculated over all years except the final three.

Table 11 presents the spawning stock numbers calculated at spawning time. The populations are brought forward to spawning time using the proportions of fishing and natural mortality that take place before spawning, defined by the user within the input files.

Two tables of stock biomass at age (12, 14) and spawning stock biomass at age (13, 15) are available. The stock biomass is calculated at the beginning of the year, spawning stock biomass at spawning time. Tables 12 and 13 are the biomass without SOP correction and Table 14 and 15 present the biomasses scaled by the SOP factor which corrects for sampling error and which was discussed previously in relation to the catch data.

Two output summary tables are available. Table 16 is not SOP corrected and Table 17 has the SOP corrected biomasses. Both tables present the time series of recruitment to the first age of the assessment, total and spawning stock biomass, landings, yield (landings) / SSB which is a proxy for fishing mortality and the time series of user defined fishing mortality means specified at the start of the run.

References

DARBY, C. D. and S. FLATMAN. 1994. Virtual Population Analysis: version 3.1 (Windows/DOS) user guide. *Info. Tech. Ser.*, MAFF Direct. Fish. Res., Lowestoft, **1**: 85 p.

POPE, J. G., 1972. An Investigation of the Accuracy of Virtual Population Analysis Using Cohort Analysis. *ICNAF Res. Bull.*, **9**: 65–74.

TABLE 1. The VPA suite catch numbers-at-age output table for the Blackfin example data set.

Run title : Blackfin: VPA course. Combined sex; plusgroup.
At 1/02/2002 8:47

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1963	1964
AGE		
1	0	0
2	155	117
3	1483	2136
4	688	2340
5	327	700
6	215	339
7	73	159
8	149	42
9	50	49
+gp	49	93
TOTALNUM	3190	5975
TONSLAND	6594	13596
SOPCOF %	106	105

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE										
1	0	0	0	2	0	0	0	57	350	897
2	231	68	385	49	335	33	382	3973	7753	3374
3	3327	2838	2053	2435	1983	2857	1385	8419	7665	6062
4	3060	4909	2885	2287	4618	2335	4444	3894	5251	2417
5	1757	1220	1934	1197	1498	1805	1891	2256	1946	2158
6	512	693	268	621	507	599	1085	456	883	617
7	271	135	454	148	568	240	465	333	468	949
8	92	39	91	126	106	196	362	160	336	925
9	69	27	44	29	79	41	300	92	199	502
+gp	137	48	75	58	71	122	238	162	472	869
TOTALNUM	9457	9977	8189	6952	9765	8228	10552	19803	25322	18769
TONSLAND	18395	18584	16034	12787	17124	14536	19863	29219	33832	35973
SOPCOF %	98	100	102	98	99	99	98	100	93	97

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
AGE										
1	25	36	160	38	10	46	154	43	35	157
2	2592	2826	1257	4452	1000	1023	2490	1403	3519	3026
3	6672	8274	4680	4278	1836	3351	3932	4633	4761	5590
4	2546	2782	2734	2362	1205	954	1981	1687	2574	2407
5	1328	1806	1687	1306	1181	685	588	1250	834	880
6	873	1122	743	701	724	638	410	574	764	685
7	1013	662	562	293	372	471	341	388	509	302
8	711	518	386	244	157	194	223	247	158	140
9	198	586	290	163	191	91	154	136	105	57
+gp	343	1365	922	1326	757	817	673	461	506	160
TOTALNUM	16300	19979	13421	15163	7433	8270	10947	10824	13765	13404
TONSLAND	30800	41747	27210	31370	21604	22102	23574	23884	28890	21641
SOPCOF %	98	97	96	97	99	100	98	99	102	99

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE										
1	6	232	1	21	22	58	153	28	15	3
2	2288	773	1698	3591	759	1485	1243	861	2511	2408
3	5122	7101	2194	5702	7291	5595	3594	1773	2668	2029
4	3051	8441	6967	3518	5703	3729	2946	3093	2827	1080
5	1459	3787	1928	2627	2255	1194	1175	968	1185	492
6	1230	1399	1359	1051	1400	786	607	354	270	280
7	610	1056	779	892	376	525	424	107	112	109
8	187	470	454	698	258	245	235	61	56	65
9	105	186	261	330	157	132	96	54	43	50
+gp	225	347	210	329	184	157	223	93	83	110
TOTALNUM	14283	23792	15850	18759	18406	13906	10697	7392	9768	6627
TONSLAND	26595	39886	31369	34178	25577	19865	16995	11804	13943	10429
SOPCOF %	99	95	106	99	95	96	101	100	100	99

TABLE 2. The VPA suite catch weights-at-age output table for the Blackfin example data set.

Run title : Blackfin: VPA course. Combined sex; plusgroup.

At 1/02/2002 8:47

Table 2 Catch weights at age (kg)

YEAR	1963	1964
AGE		
1	0	0
2	0.92	0.8
3	1.3	1.45
4	1.769	2.01
5	2.35	2.76
6	3.21	3.76
7	4.17	4.27
8	3.759	5.06
9	5.309	6.26
+gp	7.542	7.297
SOPCOFAC	1.0558	1.0476

Table 2 Catch weights at age (kg)

YEAR	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE										
1	0	0	0	0.48	0	0	0	0.508	0.31	0.309
2	0.74	0.65	1.07	0.63	0.78	0.6	0.65	0.748	0.62	0.589
3	1.16	1.09	1.19	1.19	1.04	1.08	0.95	1.082	1.089	0.973
4	1.68	1.74	1.581	1.68	1.43	1.419	1.26	1.708	1.374	1.607
5	2.47	2.74	2.24	2.19	2.28	1.98	1.79	2.474	2.487	1.716
6	3.85	3.229	3.53	2.989	2.95	2.949	2.74	2.521	3.025	3.522
7	4.48	4.62	3.761	4.05	3.511	3.67	3.51	2.908	3.605	4.519
8	5.431	5.81	5.26	4.47	4.931	4.879	4.701	4.889	4.736	4.985
9	6.791	6.549	5.951	5.28	5.73	6.259	5.28	6.014	6.681	6.012
+gp	7.504	8.069	7.233	7.386	7.578	7.158	7.344	8.088	8.105	8.276
SOPCOFAC	0.9839	0.9952	1.0223	0.9841	0.9873	0.9871	0.9842	1.0037	0.9289	0.9715

Table 2 Catch weights at age (kg)

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
AGE										
1	0.463	0.444	0.459	0.481	0.51	0.415	0.399	0.432	0.38	0.471
2	0.736	0.686	0.659	0.502	0.697	0.65	0.677	0.714	0.674	0.726
3	0.928	1.019	0.844	1.129	1.318	1.165	1.105	1.07	1.251	1.108
4	1.491	1.458	1.396	1.697	1.974	1.928	1.717	1.768	1.841	1.791
5	2.573	2.786	2.252	2.639	2.391	2.645	2.997	2.722	3.089	2.671
6	3.483	3.298	3.259	3.891	3.341	3.552	4.095	3.874	3.656	3.522
7	4.774	4.264	4.339	4.816	4.583	4.555	5.182	5.29	5.04	4.743
8	5.587	5.038	5.132	5.48	5.784	5.533	6.362	6.143	6.315	5.837
9	6.533	5.905	5.946	6.137	6.951	6.525	7.353	7.752	6.985	7.672
+gp	8.554	7.915	7.907	8.572	9.326	9.652	9.944	10.679	10.867	10.877
SOPCOFAC	0.981	0.9737	0.9607	0.9688	0.9936	0.9955	0.9843	0.9895	1.023	0.9853

Table 2 Catch weights at age (kg)

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE										
1	0.403	0.671	0.453	0.56	0.5	0.55	0.564	0.524	0.615	0.632
2	0.702	0.736	0.608	0.7	0.74	0.747	0.865	0.791	0.852	0.939
3	1.047	0.866	0.955	1.034	0.929	0.891	0.969	1.123	1.102	1.168
4	1.67	1.333	1.184	1.344	1.159	1.229	1.235	1.34	1.434	1.612
5	2.61	2.199	1.985	1.706	1.597	1.849	1.797	2.04	1.974	2.322
6	3.23	3.14	3.054	3.21	2.577	2.618	2.366	2.717	2.893	2.998
7	4.301	4.112	4.421	4.414	4.387	3.771	3.249	4.164	3.888	4.377
8	5.979	5.148	5.65	5.545	5.665	5.696	4.64	5.043	4.937	5.381
9	7.352	6.368	7.236	7.176	6.946	6.952	6.536	6.509	6.372	6.397
+gp	11.052	9.469	10.973	9.959	8.75	8.864	8.705	9.744	8.547	8.861
SOPCOFAC	0.9906	0.9478	1.0614	0.9921	0.9481	0.9613	1.0075	1.0019	0.9995	0.995

TABLE 3. The VPA suite weights-at-age output table for the Blackfin example data set.

Run title : Blackfin: VPA course. Combined sex; plusgroup.

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Table 3 Stock weights at age (kg)

YEAR	1963	1964
AGE		
1	0	0
2	0.92	0.8
3	1.3	1.45
4	1.769	2.01
5	2.35	2.76
6	3.21	3.76
7	4.17	4.27
8	3.759	5.06
9	5.309	6.26
+gp	7.542	7.297

Table 3 Stock weights at age (kg)

YEAR	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE										
1	0	0	0	0.48	0	0	0	0.508	0.31	0.309
2	0.74	0.65	1.07	0.63	0.78	0.6	0.65	0.748	0.62	0.589
3	1.16	1.09	1.19	1.19	1.04	1.08	0.95	1.082	1.089	0.973
4	1.68	1.74	1.581	1.68	1.43	1.419	1.26	1.708	1.374	1.607
5	2.47	2.74	2.24	2.19	2.28	1.98	1.79	2.474	2.487	1.716
6	3.85	3.229	3.53	2.989	2.95	2.949	2.74	2.521	3.025	3.522
7	4.48	4.62	3.761	4.05	3.511	3.67	3.51	2.908	3.605	4.519
8	5.431	5.81	5.26	4.47	4.931	4.879	4.701	4.889	4.736	4.985
9	6.791	6.549	5.951	5.28	5.73	6.259	5.28	6.014	6.681	6.012
+gp	7.504	8.069	7.233	7.386	7.578	7.158	7.344	8.088	8.105	8.276

Table 3 Stock weights at age (kg)

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
AGE										
1	0.463	0.444	0.459	0.481	0.51	0.415	0.399	0.432	0.38	0.471
2	0.736	0.686	0.659	0.502	0.697	0.65	0.677	0.714	0.674	0.726
3	0.928	1.019	0.844	1.129	1.318	1.165	1.105	1.07	1.251	1.108
4	1.491	1.458	1.396	1.697	1.974	1.928	1.717	1.768	1.841	1.791
5	2.573	2.786	2.252	2.639	2.391	2.645	2.997	2.722	3.089	2.671
6	3.483	3.298	3.259	3.891	3.341	3.552	4.095	3.874	3.656	3.522
7	4.774	4.264	4.339	4.816	4.583	4.555	5.182	5.29	5.04	4.743
8	5.587	5.038	5.132	5.48	5.784	5.533	6.362	6.143	6.315	5.837
9	6.533	5.905	5.946	6.137	6.951	6.525	7.353	7.752	6.985	7.672
+gp	8.554	7.915	7.907	8.572	9.326	9.652	9.944	10.679	10.867	10.877

Table 3 Stock weights at age (kg)

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE										
1	0.403	0.671	0.453	0.56	0.5	0.55	0.564	0.524	0.615	0.632
2	0.702	0.736	0.608	0.7	0.74	0.747	0.865	0.791	0.852	0.939
3	1.047	0.866	0.955	1.034	0.929	0.891	0.969	1.123	1.102	1.168
4	1.67	1.333	1.184	1.344	1.159	1.229	1.235	1.34	1.434	1.612
5	2.61	2.199	1.985	1.706	1.597	1.849	1.797	2.04	1.974	2.322
6	3.23	3.14	3.054	3.21	2.577	2.618	2.366	2.717	2.893	2.998
7	4.301	4.112	4.421	4.414	4.387	3.771	3.249	4.164	3.888	4.377
8	5.979	5.148	5.65	5.545	5.665	5.696	4.64	5.043	4.937	5.381
9	7.352	6.368	7.236	7.176	6.946	6.952	6.536	6.509	6.372	6.397
+gp	11.052	9.469	10.973	9.959	8.75	8.864	8.705	9.744	8.547	8.861

TABLE 4. The VPA suite natural mortality-at-age output table for the Blackfin example data set.

Run title : Blackfin: VPA course. Combined sex; plusgroup.

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Table 4 Natural Mortality (M) at age

YEAR	1963	1964
AGE		
1	0.2	0.2
2	0.2	0.2
3	0.2	0.2
4	0.2	0.2
5	0.2	0.2
6	0.2	0.2
7	0.2	0.2
8	0.2	0.2
9	0.2	0.2
+gp	0.2	0.2

Table 4 Natural Mortality (M) at age

YEAR	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE										
1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
7	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
9	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
+gp	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 4 Natural Mortality (M) at age

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
AGE										
1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
7	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
9	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
+gp	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 4 Natural Mortality (M) at age

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE										
1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
7	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
9	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
+gp	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

TABLE 5. The VPA suite maturity-at-age output table for the Blackfin example data set.

Run title : Blackfin: VPA course. Combined sex; plusgroup.

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Table 5 Proportion mature at age

YEAR	1963	1964
AGE		
1	0	0
2	0	0
3	0	0
4	0	0
5	1	1
6	1	1
7	1	1
8	1	1
9	1	1
+gp	1	1

Table 5 Proportion mature at age

YEAR	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1
+gp	1	1	1	1	1	1	1	1	1	1

Table 5 Proportion mature at age

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1
+gp	1	1	1	1	1	1	1	1	1	1

Table 5 Proportion mature at age

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1
+gp	1	1	1	1	1	1	1	1	1	1

TABLE 6. The VPA suite proportion of fishing mortality before spawning output table for the Blackfin example data set.

Run title : Blackfin: VPA course. Combined sex; plusgroup.

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Table 6 Proportion of M before Spawning

YEAR	1963	1964
AGE		
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0
6	0	0
7	0	0
8	0	0
9	0	0
+gp	0	0

Table 6 Proportion of M before Spawning

YEAR	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
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
+gp	0	0	0	0	0	0	0	0	0	0

Table 6 Proportion of M before Spawning

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
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
+gp	0	0	0	0	0	0	0	0	0	0

Table 6 Proportion of M before Spawning

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
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
+gp	0	0	0	0	0	0	0	0	0	0

TABLE 7. The VPA suite proportion of natural mortality before spawning output table for the Blackfin example data set.

Run title : Blackfin: VPA course. Combined sex; plusgroup.

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Table 7 Proportion of F before Spawning

YEAR	1963	1964
AGE		
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0
6	0	0
7	0	0
8	0	0
9	0	0
+gp	0	0

Table 7 Proportion of F before Spawning

YEAR	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
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
+gp	0	0	0	0	0	0	0	0	0	0

Table 7 Proportion of F before Spawning

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
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
+gp	0	0	0	0	0	0	0	0	0	0

Table 7 Proportion of F before Spawning

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
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
+gp	0	0	0	0	0	0	0	0	0	0

TABLE 8. The fishing mortality-at-age calculated for the Blackfin stock using Traditional VPA.

Run title : Blackfin: VPA course. Combined sex; plusgroup.
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Traditional vpa using screen input for terminal F

Table 8 Fishing mortality (F) at age

YEAR	1963	1964
AGE		
1	0	0
2	0.0133	0.0052
3	0.148	0.2523
4	0.2404	0.3656
5	0.2208	0.4106
6	0.3218	0.3742
7	0.1649	0.4171
8	0.3774	0.1348
9	0.1582	0.2053
+gp	0.1582	0.2053
FBAR 3- 7	0.2192	0.364
FBARP	0.1061	0.1395

Table 8 Fishing mortality (F) at age

YEAR	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE										
1	0	0	0	0.0001	0	0	0	0.0018	0.012	0.0299
2	0.0162	0.0048	0.0167	0.0029	0.0126	0.0017	0.0133	0.1622	0.3485	0.1528
3	0.199	0.2808	0.1965	0.1394	0.155	0.1414	0.0905	0.4416	0.5319	0.5061
4	0.6903	0.5024	0.5124	0.3491	0.4231	0.2753	0.3391	0.3912	0.5486	0.3166
5	0.5173	0.6624	0.3778	0.4151	0.4065	0.2904	0.3755	0.2883	0.3459	0.458
6	0.6019	0.3961	0.293	0.1992	0.3099	0.2816	0.2843	0.1447	0.1745	0.175
7	0.5837	0.3113	0.4908	0.2605	0.2825	0.2367	0.3682	0.132	0.2167	0.2872
8	0.4553	0.1495	0.3578	0.2421	0.3007	0.1479	0.668	0.2079	0.1909	0.8633
9	0.3433	0.2288	0.255	0.1842	0.2375	0.1808	0.3529	0.3525	0.4304	0.4805
+gp	0.3433	0.2288	0.255	0.1842	0.2375	0.1808	0.3529	0.3525	0.4304	0.4805
FBAR 3- 7	0.5184	0.4306	0.3741	0.2727	0.3154	0.2451	0.2915	0.2796	0.3635	0.3486
FBARP	0.1665	0.1594	0.1454	0.1181	0.1319	0.1071	0.122	0.1816	0.2475	0.207

Table 8 Fishing mortality (F) at age

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
AGE										
1	0.0011	0.0023	0.0095	0.0021	0.0005	0.0016	0.0057	0.0012	0.001	0.004
2	0.1131	0.1653	0.103	0.3874	0.0686	0.061	0.1137	0.0657	0.1296	0.1062
3	0.505	0.6219	0.4493	0.5928	0.2729	0.3412	0.3475	0.3186	0.3285	0.3115
4	0.4132	0.4082	0.4295	0.4304	0.3279	0.2222	0.3474	0.2462	0.294	0.2749
5	0.2879	0.5834	0.4666	0.3759	0.3986	0.3139	0.2077	0.3858	0.1846	0.1543
6	0.3388	0.4209	0.5081	0.36	0.3693	0.3905	0.3144	0.3211	0.4323	0.2275
7	0.4802	0.467	0.386	0.385	0.33	0.4384	0.3743	0.5533	0.5249	0.303
8	0.3627	0.4864	0.5503	0.288	0.3682	0.286	0.3837	0.5116	0.46	0.2645
9	0.4484	0.5774	0.5585	0.4746	0.3835	0.3794	0.386	0.4291	0.4267	0.2951
+gp	0.4484	0.5774	0.5585	0.4746	0.3835	0.3794	0.386	0.4291	0.4267	0.2951
FBAR 3- 7	0.405	0.5003	0.4479	0.4288	0.3397	0.3412	0.3183	0.365	0.3528	0.2542
FBARP	0.1922	0.2254	0.1967	0.2588	0.1542	0.1517	0.1664	0.1559	0.1666	0.1462

Table 8 Fishing mortality (F) at age

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	FBAR 92-94
AGE											
1	0.0003	0.0084	0	0.0011	0.0011	0.0031	0.006	0.0007	0.0002	0.01	0.0036
2	0.0745	0.0484	0.0786	0.1722	0.0475	0.0951	0.0835	0.0418	0.0836	0.03	0.0518
3	0.2627	0.3451	0.188	0.4059	0.621	0.5696	0.3479	0.1643	0.1758	0.09	0.1434
4	0.2793	0.9123	0.6757	0.5158	0.9326	0.7685	0.6789	0.5722	0.425	0.1	0.3657
5	0.267	0.6645	0.5415	0.5893	0.7477	0.5054	0.5913	0.4961	0.4493	0.12	0.3551
6	0.3341	0.442	0.5354	0.6495	0.7365	0.6431	0.525	0.3541	0.2485	0.18	0.2609
7	0.3247	0.5356	0.4745	0.8315	0.5118	0.6916	0.8954	0.1615	0.1793	0.15	0.1636
8	0.3126	0.4471	0.4654	1.0727	0.6161	0.7545	0.7864	0.2988	0.1191	0.15	0.1893
9	0.324	0.5863	0.4804	0.7424	0.7567	0.7601	0.7767	0.4138	0.3502	0.15	0.3047
+gp	0.324	0.5863	0.4804	0.7424	0.7567	0.7601	0.7767	0.4138	0.3502	0.15	
FBAR 3- 7	0.2936	0.5799	0.483	0.5984	0.7099	0.6356	0.6077	0.3496	0.2956	0.128	
FBARP	0.1432	0.2022	0.1764	0.2152	0.2287	0.225	0.2	0.1531	0.1466	0.0755	

TABLE 9. The relative (to the reference mean) fishing mortality-at-age calculated for the Blackfin stock using Traditional VPA.

Run title : Blackfin: VPA course. Combined sex; plusgroup.

At 1/02/2002 8:46

Traditional vpa using screen input for terminal F

Table 9 Relative F at age

YEAR	1963	1964
AGE		
1	0	0
2	0.0605	0.0143
3	0.6752	0.6932
4	1.0966	1.0044
5	1.0075	1.1281
6	1.4683	1.0283
7	0.7523	1.146
8	1.7218	0.3703
9	0.7218	0.5641
+gp	0.7218	0.5641
REFMEAN	0.2192	0.364

Table 9 Relative F at age

YEAR	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE										
1	0	0	0	0.0003	0	0	0	0.0064	0.0329	0.0858
2	0.0313	0.0112	0.0447	0.0107	0.0399	0.0068	0.0456	0.5803	0.9587	0.4384
3	0.3839	0.6521	0.5252	0.5113	0.4915	0.5768	0.3105	1.5797	1.4632	1.4519
4	1.3315	1.1666	1.3697	1.2803	1.3415	1.1234	1.1631	1.3994	1.5091	0.9083
5	0.9977	1.5384	1.01	1.5223	1.2888	1.1849	1.2882	1.0311	0.9517	1.3138
6	1.161	0.9199	0.7831	0.7305	0.9825	1.1491	0.9752	0.5175	0.4799	0.502
7	1.1259	0.723	1.3119	0.9555	0.8957	0.9658	1.263	0.4723	0.596	0.824
8	0.8782	0.3471	0.9565	0.8879	0.9532	0.6036	2.2917	0.7435	0.525	2.4766
9	0.6622	0.5313	0.6816	0.6756	0.753	0.7377	1.2106	1.2609	1.184	1.3785
+gp	0.6622	0.5313	0.6816	0.6756	0.753	0.7377	1.2106	1.2609	1.184	1.3785
REFMEAN	0.5184	0.4306	0.3741	0.2727	0.3154	0.2451	0.2915	0.2796	0.3635	0.3486

Table 9 Relative F at age

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
AGE										
1	0.0027	0.0046	0.0211	0.0048	0.0014	0.0048	0.0179	0.0033	0.0027	0.0159
2	0.2793	0.3304	0.2299	0.9034	0.2018	0.1786	0.3573	0.1799	0.3673	0.4177
3	1.2469	1.2431	1.0031	1.3825	0.8033	0.9998	1.092	0.8728	0.9309	1.2251
4	1.0202	0.816	0.9589	1.0038	0.9651	0.6512	1.0916	0.6744	0.8331	1.0814
5	0.7108	1.1661	1.0418	0.8766	1.1733	0.9198	0.6526	1.057	0.5232	0.6069
6	0.8365	0.8414	1.1345	0.8394	1.0871	1.1444	0.9878	0.8799	1.2252	0.895
7	1.1856	0.9335	0.8617	0.8978	0.9713	1.2848	1.176	1.5158	1.4876	1.1916
8	0.8956	0.9721	1.2287	0.6715	1.0837	0.8381	1.2057	1.4017	1.3037	1.0403
9	1.1071	1.1541	1.2469	1.1068	1.1288	1.1118	1.2129	1.1757	1.2093	1.1608
+gp	1.1071	1.1541	1.2469	1.1068	1.1288	1.1118	1.2129	1.1757	1.2093	1.1608
REFMEAN	0.405	0.5003	0.4479	0.4288	0.3397	0.3412	0.3183	0.365	0.3528	0.2542

Table 9 Relative F at age

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	MEAN 92-94
AGE											
1	0.0009	0.0146	0.0001	0.0018	0.0016	0.0048	0.0098	0.0021	0.0005	0.0781	0.0269
2	0.2538	0.0834	0.1628	0.2878	0.0669	0.1496	0.1374	0.1196	0.2828	0.2344	0.2123
3	0.8949	0.5951	0.3892	0.6783	0.8747	0.8961	0.5725	0.4698	0.5949	0.7031	0.5893
4	0.9516	1.5732	1.3988	0.8619	1.3136	1.209	1.1171	1.6366	1.4379	0.7812	1.2852
5	0.9095	1.1458	1.1211	0.9848	1.0532	0.795	0.973	1.4189	1.52	0.9375	1.2921
6	1.1381	0.7622	1.1085	1.0854	1.0375	1.0117	0.864	1.0128	0.8407	1.4063	1.0866
7	1.106	0.9237	0.9824	1.3895	0.7209	1.0881	1.4734	0.4618	0.6066	1.1719	0.7468
8	1.0648	0.7711	0.9634	1.7925	0.8679	1.187	1.2941	0.8548	0.4031	1.1719	0.8099
9	1.1037	1.011	0.9946	1.2406	1.0659	1.1958	1.2781	1.1836	1.1848	1.1719	1.1801
+gp	1.1037	1.011	0.9946	1.2406	1.0659	1.1958	1.2781	1.1836	1.1848	1.1719	
REFMEAN	0.2936	0.5799	0.483	0.5984	0.7099	0.6356	0.6077	0.3496	0.2956	0.128	

TABLE 10. The population number-at-age calculated for the Blackfin stock using Traditional VPA

Run title : Blackfin: VPA course. Combined sex; plusgroup.

At 1/02/2002 8:46

Traditional vpa using screen input for terminal F

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1963	1964
AGE		
1	30399	19306
2	13025	24888
3	11869	10523
4	3540	8381
5	1815	2279
6	859	1191
7	527	510
8	520	366
9	378	292
+gp	365	551
TOTAL	63296	68288

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE										
1	18969	31238	22737	36038	26343	39047	35655	35364	32388	33584
2	15807	15531	25575	18615	29503	21568	31969	29192	28902	26202
3	20271	12733	12654	20592	15196	23853	17629	25829	20321	16700
4	6695	13601	7873	8512	14665	10655	16955	13184	13597	9774
5	4760	2748	6738	3861	4916	7864	6624	9890	7299	6432
6	1238	2324	1160	3781	2087	2680	4816	3725	6069	4229
7	671	555	1280	709	2537	1254	1656	2967	2639	4173
8	275	306	333	642	447	1566	810	938	2129	1740
9	262	143	216	191	412	271	1106	340	624	1440
+gp	516	260	365	381	367	813	877	600	1477	2493
TOTAL	69464	79438	78931	93322	96474	109571	118095	122029	115446	106767

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
AGE										
1	24954	17320	18737	20363	23306	31208	29894	38984	40439	43073
2	26686	20408	14148	15196	16638	19072	25509	24336	31878	33077
3	18412	19512	14163	10450	8445	12719	14692	18640	18659	22928
4	8243	9098	8577	7399	4729	5263	7404	8497	11098	10999
5	5831	4464	4952	4570	3939	2790	3450	4283	5439	6772
6	3331	3580	2040	2543	2569	2165	1669	2295	2384	3702
7	2906	1944	1924	1005	1452	1454	1199	998	1363	1267
8	2564	1472	997	1071	560	855	768	675	470	660
9	601	1461	741	471	657	317	526	428	331	243
+gp	1039	3400	2356	3843	2605	2835	2305	1446	1595	689
TOTAL	94566	82659	68634	66910	64901	78678	87416	100582	113656	123410

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	GMST 63-92	AMST 63-92
AGE													
1	22048	30484	30508	22052	22043	20945	28479	42159	109779	280	0	27946	28936
2	35123	18046	24748	24977	18035	18027	17096	23179	34492	89866	227	22081	22899
3	24353	26692	14077	18730	17215	14081	13420	12876	18200	25975	71401	16286	16941
4	13748	15332	15476	9550	10219	7575	6522	7759	8945	12498	19436	9240	9831
5	6841	8512	5041	6447	4668	3292	2876	2708	3585	4788	9259	4687	5070
6	4752	4288	3586	2402	2928	1810	1626	1303	1350	1873	3477	2489	2771
7	2414	2785	2257	1719	1027	1148	779	788	749	862	1281	1375	1597
8	766	1429	1335	1150	613	504	471	260	549	513	608	743	890
9	415	459	748	686	322	271	194	175	158	399	361	408	491
+gp	893	855	603	684	378	322	450	301	306	871	894		
TOTAL	111352	108883	98379	88396	77447	67975	71913	91509	178112	137923	106944		

TABLE 11. The spawing stock number-at-age calculated at spawning time for the Blackfin stock using Traditional VPA.

Run title : Blackfin: VPA course. Combined sex; plusgroup.

At 1/02/2002 8:46

Traditional vpa using screen input for terminal F

Table 11 Spawning stock number at age (spawning time) Numbers*10**-3

YEAR	1963	1964
AGE		
1	0	0
2	0	0
3	0	0
4	0	0
5	1815	2279
6	859	1191
7	527	510
8	520	366
9	378	292
+gp	365	551

Table 11 Spawning stock number at age (spawning time) Numbers*10**-3

YEAR	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	4760	2748	6738	3861	4916	7864	6624	9890	7299	6432
6	1238	2324	1160	3781	2087	2680	4816	3725	6069	4229
7	671	555	1280	709	2537	1254	1656	2967	2639	4173
8	275	306	333	642	447	1566	810	938	2129	1740
9	262	143	216	191	412	271	1106	340	624	1440
+gp	516	260	365	381	367	813	877	600	1477	2493

Table 11 Spawning stock number at age (spawning time) Numbers*10**-3

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	5831	4464	4952	4570	3939	2790	3450	4283	5439	6772
6	3331	3580	2040	2543	2569	2165	1669	2295	2384	3702
7	2906	1944	1924	1005	1452	1454	1199	998	1363	1267
8	2564	1472	997	1071	560	855	768	675	470	660
9	601	1461	741	471	657	317	526	428	331	243
+gp	1039	3400	2356	3843	2605	2835	2305	1446	1595	689

Table 11 Spawning stock number at age (spawning time) Numbers*10**-3

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	6841	8512	5041	6447	4668	3292	2876	2708	3585	4788
6	4752	4288	3586	2402	2928	1810	1626	1303	1350	1873
7	2414	2785	2257	1719	1027	1148	779	788	749	862
8	766	1429	1335	1150	613	504	471	260	549	513
9	415	459	748	686	322	271	194	175	158	399
+gp	893	855	603	684	378	322	450	301	306	871

TABLE 12. The stock biomass-at-age calculated at the start of the year (without SOP correction) for the Blackfin stock using Traditional VPA.

Run title : Blackfin: VPA course. Combined sex; plusgroup.

At 1/02/2002 8:46

Traditional vpa using screen input for terminal F

Table 12 Stock biomass at age (start of year) Tonnes

YEAR	1963	1964
AGE		
1	0	0
2	11983	19911
3	15429	15259
4	6262	16845
5	4265	6290
6	2757	4480
7	2200	2177
8	1953	1853
9	2004	1826
+gp	2756	4021
TOTALBIO	49609	72661

Table 12 Stock biomass at age (start of year) Tonnes

YEAR	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE										
1	0	0	0	17298	0	0	0	17965	10040	10378
2	11697	10095	27366	11728	23013	12941	20780	21835	17919	15433
3	23515	13879	15059	24504	15804	25761	16748	27947	22129	16249
4	11247	23666	12447	14301	20971	15119	21363	22519	18683	15707
5	11758	7531	15094	8456	11208	15571	11857	24467	18154	11037
6	4765	7503	4096	11301	6158	7904	13195	9392	18359	14893
7	3006	2564	4815	2870	8906	4601	5812	8629	9515	18860
8	1494	1780	1751	2868	2205	7639	3808	4586	10082	8673
9	1779	935	1286	1006	2363	1696	5837	2045	4168	8658
+gp	3875	2095	2637	2815	2778	5820	6439	4852	11974	20630
TOTALBIO	73135	70049	84549	97147	93404	97052	105839	144236	141023	140518

Table 12 Stock biomass at age (start of year) Tonnes

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
AGE										
1	11553	7690	8600	9795	11886	12951	11928	16841	15367	20287
2	19641	14000	9323	7628	11597	12397	17270	17376	21486	24014
3	17087	19883	11953	11798	11131	14818	16235	19945	23342	25404
4	12290	13264	11974	12556	9335	10147	12712	15023	20431	19700
5	15002	12438	11152	12061	9418	7378	10341	11657	16801	18088
6	11602	11805	6647	9893	8585	7689	6833	8891	8716	13040
7	13875	8287	8347	4838	6656	6623	6215	5277	6869	6008
8	14325	7416	5119	5868	3237	4730	4886	4149	2966	3853
9	3925	8624	4406	2891	4569	2069	3866	3321	2316	1863
+gp	8885	26915	18626	32940	24293	27368	22924	15443	17334	7496
TOTALBIO	128186	130324	96149	110267	100707	106171	113208	117923	135628	139752

Table 12 Stock biomass at age (start of year) Tonnes

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE										
1	8885	20455	13820	12349	11021	11520	16062	22092	67514	177
2	24656	13282	15047	17484	13346	13466	14788	18334	29387	84384
3	25497	23115	13444	19367	15992	12546	13004	14459	20056	30339
4	22959	20438	18323	12836	11843	9309	8055	10397	12827	20147
5	17854	18719	10007	10998	7455	6088	5168	5525	7076	11117
6	15348	13466	10952	7709	7545	4737	3848	3541	3906	5615
7	10384	11453	9977	7587	4505	4328	2530	3280	2912	3774
8	4580	7355	7541	6375	3471	2871	2183	1313	2709	2758
9	3050	2922	5413	4924	2237	1883	1268	1142	1008	2551
+gp	9866	8098	6620	6813	3306	2856	3914	2932	2619	7714
TOTALBIO	143081	139302	111144	106441	80723	69604	70820	83016	150013	168575

TABLE 13. The spawning stock biomass-at-age calculated at spawning time (without SOP correction) for the Blackfin stock using Traditional VPA.

Run title : Blackfin: VPA course. Combined sex; plusgroup.

At 1/02/2002 8:46

Traditional vpa using screen input for terminal F

Table 13 Spawning stock biomass at age (spawning time) Tonnes

YEAR	1963	1964
AGE		
1	0	0
2	0	0
3	0	0
4	0	0
5	4265	6290
6	2757	4480
7	2200	2177
8	1953	1853
9	2004	1826
+gp	2756	4021
TOTSPBIO	15935	20647

Table 13 Spawning stock biomass at age (spawning time) Tonnes

YEAR	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	11758	7531	15094	8456	11208	15571	11857	24467	18154	11037
6	4765	7503	4096	11301	6158	7904	13195	9392	18359	14893
7	3006	2564	4815	2870	8906	4601	5812	8629	9515	18860
8	1494	1780	1751	2868	2205	7639	3808	4586	10082	8673
9	1779	935	1286	1006	2363	1696	5837	2045	4168	8658
+gp	3875	2095	2637	2815	2778	5820	6439	4852	11974	20630
TOTSPBIO	26677	22409	29678	29316	33616	43231	46948	53971	72252	82751

Table 13 Spawning stock biomass at age (spawning time) Tonnes

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	15002	12438	11152	12061	9418	7378	10341	11657	16801	18088
6	11602	11805	6647	9893	8585	7689	6833	8891	8716	13040
7	13875	8287	8347	4838	6656	6623	6215	5277	6869	6008
8	14325	7416	5119	5868	3237	4730	4886	4149	2966	3853
9	3925	8624	4406	2891	4569	2069	3866	3321	2316	1863
+gp	8885	26915	18626	32940	24293	27368	22924	15443	17334	7496
TOTSPBIO	67615	75486	54298	68491	56758	55858	55064	48738	55002	50348

Table 13 Spawning stock biomass at age (spawning time) Tonnes

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	17854	18719	10007	10998	7455	6088	5168	5525	7076	11117
6	15348	13466	10952	7709	7545	4737	3848	3541	3906	5615
7	10384	11453	9977	7587	4505	4328	2530	3280	2912	3774
8	4580	7355	7541	6375	3471	2871	2183	1313	2709	2758
9	3050	2922	5413	4924	2237	1883	1268	1142	1008	2551
+gp	9866	8098	6620	6813	3306	2856	3914	2932	2619	7714
TOTSPBIO	61083	62012	50509	44405	28519	22763	18911	17734	20229	33529

TABLE 14. The stock biomass at age calculated at the start of the year (with SOP correction) for the Blackfin stock using Traditional VPA.

Run title : Blackfin: VPA course. Combined sex; plusgroup.

At 1/02/2002 8:46

Traditional vpa using screen input for terminal F

Table 14 Stock biomass at age with SOP (start of year) Tonnes

YEAR	1963	1964
AGE		
1	0	0
2	12651	20859
3	16290	15985
4	6611	17647
5	4503	6590
6	2911	4693
7	2322	2280
8	2062	1941
9	2116	1913
+gp	2909	4212
TOTALBIO	52376	76120

Table 14 Stock biomass at age with SOP (start of year) Tonnes

YEAR	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE										
1	0	0	0	17024	0	0	0	18031	9327	10082
2	11508	10046	27975	11541	22720	12774	20451	21916	16646	14993
3	23136	13812	15394	24116	15603	25428	16482	28050	20557	15785
4	11066	23552	12724	14074	20705	14924	21024	22602	17355	15259
5	11569	7495	15430	8322	11065	15370	11669	24557	16864	10722
6	4688	7467	4187	11122	6080	7802	12986	9426	17054	14468
7	2957	2552	4922	2825	8792	4541	5720	8661	8838	18322
8	1470	1772	1790	2822	2177	7540	3748	4603	9366	8426
9	1751	931	1314	990	2333	1674	5745	2052	3872	8411
+gp	3812	2085	2696	2770	2742	5745	6337	4870	11123	20041
TOTALBIO	71956	69712	86431	95605	92217	95799	104162	144770	131003	136510

Table 14 Stock biomass at age with SOP (start of year) Tonnes

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
AGE										
1	11334	7488	8262	9489	11810	12893	11740	16665	15720	19989
2	19267	13632	8957	7390	11523	12342	16998	17194	21980	23661
3	16761	19360	11484	11430	11060	14752	15979	19736	23878	25030
4	12056	12916	11503	12164	9276	10102	12512	14866	20900	19410
5	14717	12111	10714	11685	9358	7345	10178	11535	17187	17821
6	11382	11495	6386	9584	8530	7655	6725	8798	8916	12848
7	13611	8069	8019	4687	6614	6594	6117	5222	7027	5920
8	14052	7221	4918	5684	3217	4709	4809	4105	3034	3797
9	3851	8398	4233	2801	4540	2060	3806	3286	2369	1835
+gp	8716	26207	17894	31912	24138	27246	22563	15282	17733	7386
TOTALBIO	125746	126897	92371	106827	100064	105698	111426	116691	138744	137696

Table 14 Stock biomass at age with SOP (start of year) Tonnes

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE										
1	8802	19387	14669	12251	10449	11074	16182	22133	67483	176
2	24424	12589	15971	17345	12653	12944	14898	18369	29374	83959
3	25257	21908	14269	19213	15162	12060	13101	14487	20047	30186
4	22742	19371	19448	12734	11229	8949	8115	10417	12821	20045
5	17686	17742	10621	10911	7068	5852	5206	5535	7073	11061
6	15203	12763	11624	7648	7153	4554	3876	3548	3904	5586
7	10287	10855	10590	7527	4271	4160	2549	3286	2911	3755
8	4537	6971	8004	6324	3291	2759	2199	1316	2708	2744
9	3022	2769	5745	4885	2120	1810	1278	1144	1007	2538
+gp	9773	7675	7026	6759	3135	2745	3943	2938	2617	7675
TOTALBIO	141731	132030	117968	105595	76532	66908	71349	83173	149945	167727

TABLE 15. The spawning stock biomass-at-age calculated at spawning time (with SOP correction) for the Blackfin stock using Traditional VPA.

Run title : Blackfin: VPA course. Combined sex; plusgroup.

At 1/02/2002 8:46

Traditional vpa using screen input for terminal F

Table 15 Spawning stock biomass with SOP (spawning time) Tonnes

YEAR	1963	1964
AGE		
1	0	0
2	0	0
3	0	0
4	0	0
5	4503	6590
6	2911	4693
7	2322	2280
8	2062	1941
9	2116	1913
+gp	2909	4212
TOTSPBIO	16824	21630

Table 15 Spawning stock biomass with SOP (spawning time) Tonnes

YEAR	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	11569	7495	15430	8322	11065	15370	11669	24557	16864	10722
6	4688	7467	4187	11122	6080	7802	12986	9426	17054	14468
7	2957	2552	4922	2825	8792	4541	5720	8661	8838	18322
8	1470	1772	1790	2822	2177	7540	3748	4603	9366	8426
9	1751	931	1314	990	2333	1674	5745	2052	3872	8411
+gp	3812	2085	2696	2770	2742	5745	6337	4870	11123	20041
TOTSPBIO	26246	22301	30338	28851	33189	42673	46205	54170	67118	80391

Table 15 Spawning stock biomass with SOP (spawning time) Tonnes

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	14717	12111	10714	11685	9358	7345	10178	11535	17187	17821
6	11382	11495	6386	9584	8530	7655	6725	8798	8916	12848
7	13611	8069	8019	4687	6614	6594	6117	5222	7027	5920
8	14052	7221	4918	5684	3217	4709	4809	4105	3034	3797
9	3851	8398	4233	2801	4540	2060	3806	3286	2369	1835
+gp	8716	26207	17894	31912	24138	27246	22563	15282	17733	7386
TOTSPBIO	66328	73501	52165	66354	56396	55609	54197	48229	56265	49607

Table 15 Spawning stock biomass with SOP (spawning time) Tonnes

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	17686	17742	10621	10911	7068	5852	5206	5535	7073	11061
6	15203	12763	11624	7648	7153	4554	3876	3548	3904	5586
7	10287	10855	10590	7527	4271	4160	2549	3286	2911	3755
8	4537	6971	8004	6324	3291	2759	2199	1316	2708	2744
9	3022	2769	5745	4885	2120	1810	1278	1144	1007	2538
+gp	9773	7675	7026	6759	3135	2745	3943	2938	2617	7675
TOTSPBIO	60507	58775	53611	44052	27039	21881	19052	17767	20220	33360

TABLE 16. The stock summary table (without SOP correction) for the Blackfin Traditional VPA.

Run title : Blackfin: VPA course. Combined sex; plusgroup.

At 1/02/2002 8:46

Table 16 Summary (without SOP correction)

Traditional vpa using screen input for terminal F

	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3- 7	FBARP
1963	30399	49609	15935	6594	0.4138	0.2192	0.1061
1964	19306	72661	20647	13596	0.6585	0.364	0.1395
1965	18969	73135	26677	18395	0.6896	0.5184	0.1665
1966	31238	70049	22409	18584	0.8293	0.4306	0.1594
1967	22737	84549	29678	16034	0.5403	0.3741	0.1454
1968	36038	97147	29316	12787	0.4362	0.2727	0.1181
1969	26343	93404	33616	17124	0.5094	0.3154	0.1319
1970	39047	97052	43231	14536	0.3362	0.2451	0.1071
1971	35655	105839	46948	19863	0.4231	0.2915	0.122
1972	35364	144236	53971	29219	0.5414	0.2796	0.1816
1973	32388	141023	72252	33832	0.4683	0.3635	0.2475
1974	33584	140518	82751	35973	0.4347	0.3486	0.207
1975	24954	128186	67615	30800	0.4555	0.405	0.1922
1976	17320	130324	75486	41747	0.553	0.5003	0.2254
1977	18737	96149	54298	27210	0.5011	0.4479	0.1967
1978	20363	110267	68491	31370	0.458	0.4288	0.2588
1979	23306	100707	56758	21604	0.3806	0.3397	0.1542
1980	31208	106171	55858	22102	0.3957	0.3412	0.1517
1981	29894	113208	55064	23574	0.4281	0.3183	0.1664
1982	38984	117923	48738	23884	0.49	0.365	0.1559
1983	40439	135628	55002	28890	0.5253	0.3528	0.1666
1984	43073	139752	50348	21641	0.4298	0.2542	0.1462
1985	22048	143081	61083	26595	0.4354	0.2936	0.1432
1986	30484	139302	62012	39886	0.6432	0.5799	0.2022
1987	30508	111144	50509	31369	0.6211	0.483	0.1764
1988	22052	106441	44405	34178	0.7697	0.5984	0.2152
1989	22043	80723	28519	25577	0.8968	0.7099	0.2287
1990	20945	69604	22763	19865	0.8727	0.6356	0.225
1991	28479	70820	18911	16995	0.8987	0.6077	0.2
1992	42159	83016	17734	11804	0.6656	0.3496	0.1531
1993	109779	150013	20229	13943	0.6892	0.2956	0.1466
1994	280	168575	33529	10429	0.3111	0.128	0.0755
Arith. Mean	30566	108445	44524	23125	0.5532	0.3893	0.1691
Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)			

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Appendix 1: The Lowestoft Stock Assessment Suite

Tutorial 2

Separable VPA

by

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Abstract

This document is the second in a series of tutorials designed to assist users of the Lowestoft VPA Suite assessment software and prediction programs that utilise the results. This tutorial takes the user through fitting a Separable VPA model to catch at age data and analysis of the diagnostic output.

Introduction

This tutorial assumes that the user has installed the VPA program described in Darby and Flatman (1994), that the required data files have been placed in a directory c:\vpas\data and that the assessment index file (Blackfin.ind) contains path names which point to the appropriate files.

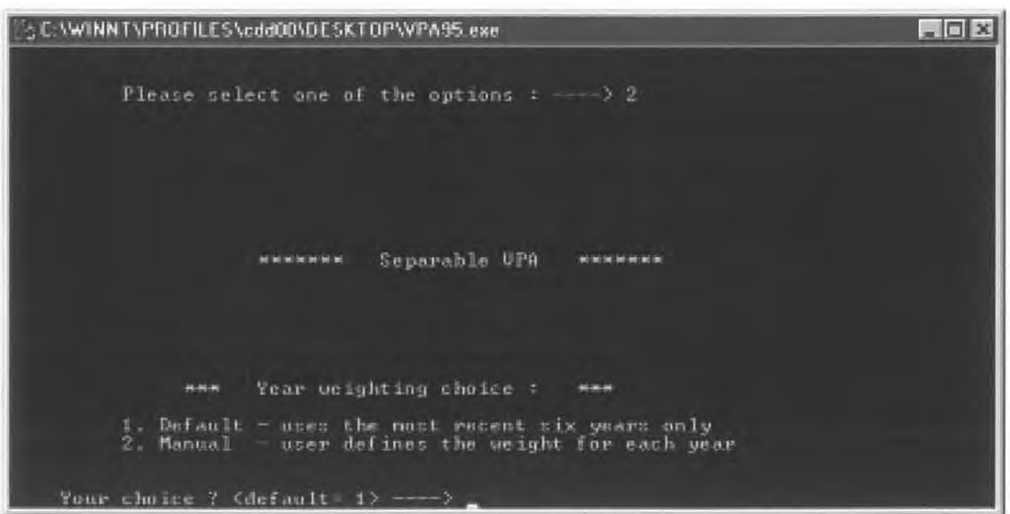
In the following text **action to be taken by the user** is highlighted in bold. The symbol ↵ is used to represent the Return or Enter key on the keyboard.

Separable VPA

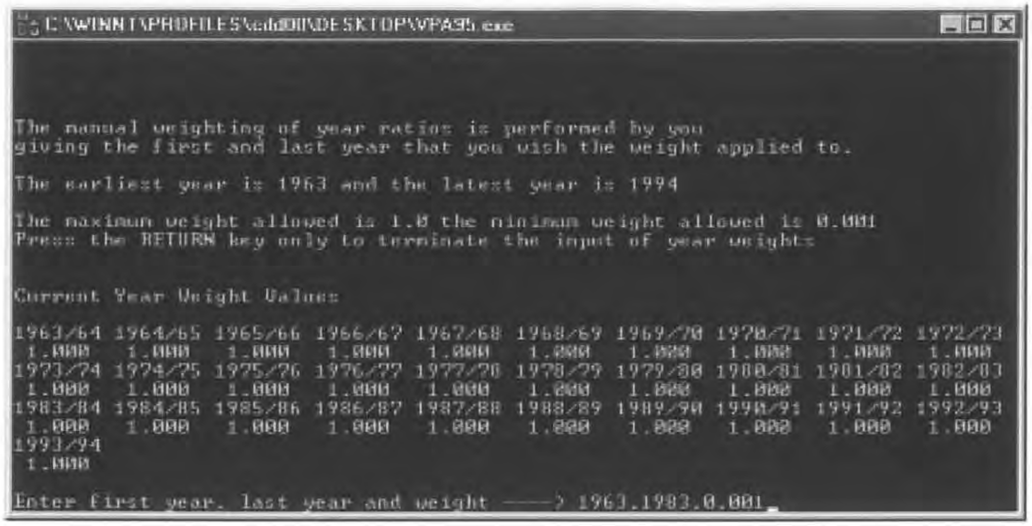
Open the program and read in the index file C:\VPAS\DATA\BLACKFIN.IND. Use the default year, age and summary means settings until the main menu is reached.

At the main menu **Type 2 ↵** to select Separable VPA.

The first input screen is used to define the year weights for the log catch ratios to which the model is fitted. Usually the default settings, which utilise the data from the most recent six years, provide a suitable model for an assessment. However to demonstrate the use of year weighting we shall use the last 11 years.



Type 2 ↵

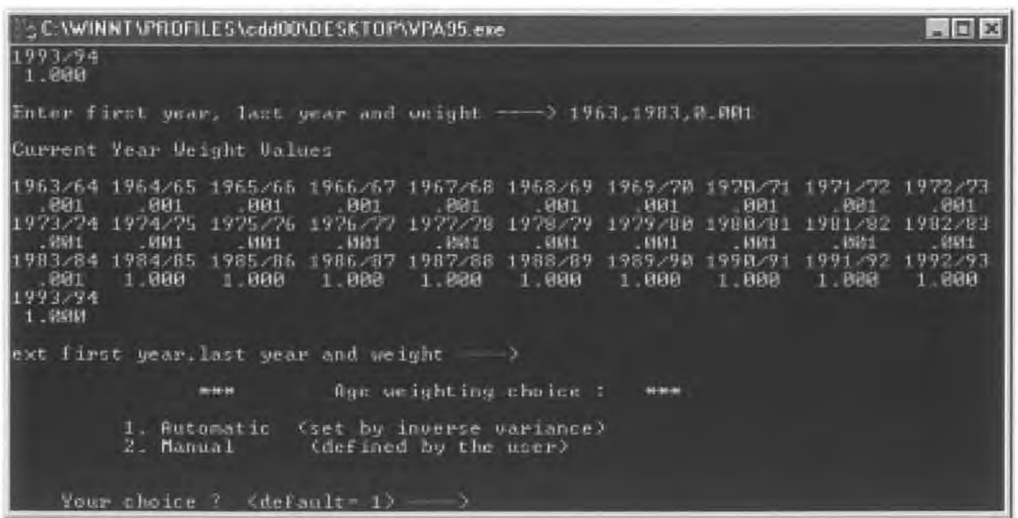


In order to select the most recent years for fitting the model we down-weight data from the early years.

Type 1963, 1983, 0.001↵

This can be repeated until all of the years have been weighted as required.

Type ↵ to exit year weighting.



The next screen presents the options for user-defined age weighting. This would merit a tutorial on its own, and further information on using the option is contained in the referenced user guide. In general it is best left to the program and here we shall take the default and let the program calculate the weights.

Type ↵ To take the default Automatic weighting

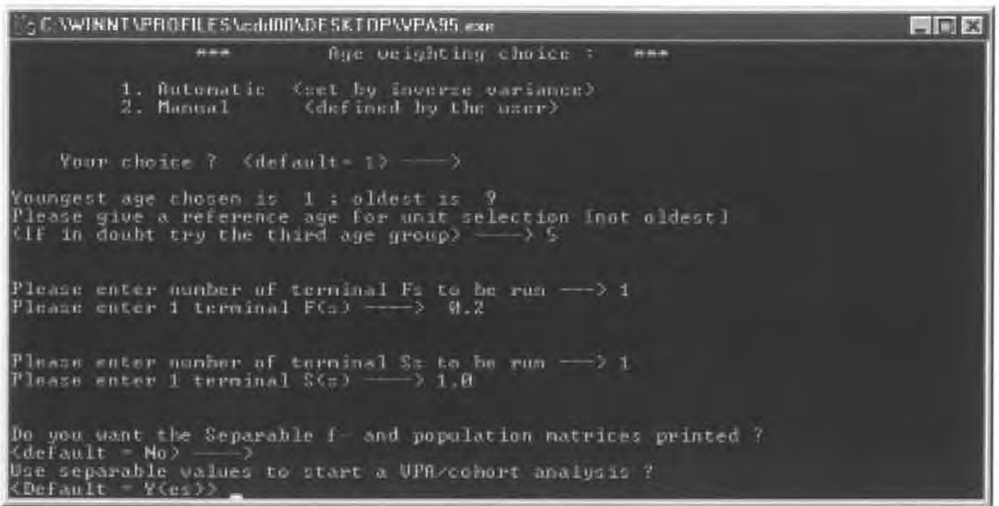
Input is now required for the reference age for unit selection (full recruitment). The selection at each age will be scaled relative to the estimate for this age. The choice as to which age to use is not usually critical and an age in the middle of the range is suitable.

Type 5 ↵

The program allows up to 3 terminal F values to be fitted for each of 3 terminal selection values. Here we shall only run one of each. A terminal F of 0.2 and a selection at the oldest age of 1.0

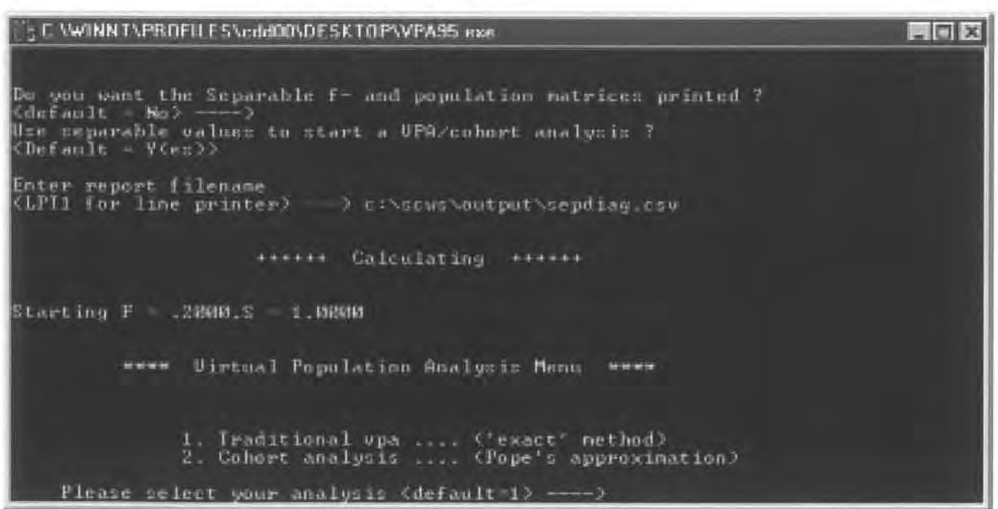
Type 1 ↵ for a single terminal F value
Type 0.2 ↵ the terminal F value to be used in fitting the model

Type 1 ↵ for a single selection value
Type 1.0 ↵ the terminal selection value to be used in fitting the model (make sure it is **1. 0** bug/feature)



Type Y ↵ to print the separable F's and population numbers.
Type ↵ to take default option to use the separable results to start a VPA.

Type a directory path and filename for the Separable VPA diagnostics file ↵
Type↵ to run exact VPA



This completes the fitting of the separable model to the catch at age data and the calculation of a VPA based on the marginal fishing mortalities. To output the SSB and biomass values resulting from the run option 9 must be selected from the main menu.

The Separable VPA Diagnostic File

The separable method produces a diagnostic output file which is listed in Tables 1–5 and illustrated in Figures 1–4. The bracketed numbers within each of the following paragraphs refer to the reference numbers **(x)** added to the tables and figures.

The printed output consists of:

The title, time and date of the run (1), the year and age range of the data and the terminal F and terminal S value for this run (2) (Table 1).

The number of iterations taken to reach the solution (3), and the initial and the final sum of squared **unweighted** residuals (SSQ). This provides a measure of the fit to the separable model and should be reduced in the final solution. For the Blackfin model the sum of squares is reduced from 1160 to 221: a significant reduction on the sum of squares indicating a good fit to the catch data set. The final value can be used to derive the root mean square residual (≡ standard error) of the fit to the log catch ratios, an approximation for the coefficient of variation implied if all the lack of fit were due to uniform random variation in the catch-at-age data.

$$\text{Model RMSE} \equiv \text{catch-at-age data CV} \approx \sqrt{\frac{\text{Final SSQ}}{2((a-1)(y-1)-2}}$$

where a is the number of ages and y the number of years of catch-at-age data. The variance of the fit to the log catch ratios is 2× that of the fit to the catch-at-age data. Often the lack of fit is not due to uniform variation and a few residuals contribute a significant proportion.

The matrix of residuals showing the difference between the observed log catch ratio and the estimated log catch ratio (4). Positive values indicate that the model expects a greater change in the catches between years than observed. Row and column totals of **weighted** residuals are given (5), as is the grand total (6), which the algorithm is attempting to minimize. The row and column totals should be near zero. If they are not the analysis is a poor fit. Row and column weights are printed at the edges of the table.

Often the SSQ value is the result of a few high residuals which indicate poor data for that year and age; these may occur with poorly sampled age groups. The automatic weighting should cope with this adequately, but occasionally it may be necessary to either (i) exclude the age groups by removing younger ages from the analysis or incorporating the older ages in the plus group, or (ii) down-weight specific years manually.

Pattern in the residuals may indicate systematic lack of fit to the model (i.e. a changing selection pattern). Figure 4 illustrates some of the ways in which the residuals can be plotted in order to detect patterns. The figure presents a bubble plots for each age within a year and time series for all ages combines and at each age. Look for year effects running down the columns, age effects across the rows and year class effects which follow the cohort diagonals. If the selection pattern has changed a chequered flag effect can result with positive residuals in diagonally opposed quadrants and negative residuals in the other two.

The fully exploited fishing mortality Fo(y) for each year (7) (Table 2), referred to the reference age, is plotted in Figure 2. The exploitation pattern S(a) for each age (8), referred to unity on the reference age, and set to the user-defined value on the oldest age, is plotted in Fig. 3.

The Separable model fishing mortalities (9) (Table 3) for each cell in the age/year matrix are obtained from the product of the overall fully-exploited fishing mortality for the year, Fo(y), and the selection-at-age value for the particular age S(a). These are the smoothed model estimates of fishing mortality derived from the fit to the log catch ratios.

The Separable VPA populations-at-age (10) (Table 4) are derived by calculating the recruitment (i.e. initial population for each cohort) values that would, using the separable F values, give the best fit to the catch-at-age data over the whole cohort.

After a run with only one value for terminal F and terminal S, the user can choose whether to run a VPA or Cohort analysis. The terminal F starting values for the run are calculated using the raw catch data (including errors), along with the 'smooth', Separable VPA-generated, terminal population abundances (estimated at the start of the year). The F and population numbers tables generated by the VPA or Cohort analysis (Tables 8 and 10 from option 9 of the main menu) are produced by an exact fit to the raw catch data. They will exhibit differences from the 'smoothed' Separable VPA tables ((9) and (10)). The differences in fishing mortality are given in (11) (Table 5), the F residuals ($F_{sep} - F_{vpa}$).

Terminal Fishing Mortality and Selection at the Oldest Age

Each of the user-specified values for the fishing mortality at the reference age in the final year, and selection at the oldest age, result in model fits that are equally good interpretations of the data (as judged by the final sum of squares); each statistically valid. The choice as to which is the appropriate interpretation can only be made using additional information e.g. trends in effort over time, groundfish survey data, assumptions about exploitation patterns, etc. An appropriate example is the Separable VPA assessment carried out for the Western mackerel by Anon. (MS 1993). Spawning stock biomasses (SSB) generated by a Separable VPA were 'tuned' to estimates of SSB derived from triennial egg surveys and the sum of squares between estimated and observed biomasses minimised to find a value for the terminal year fishing mortality. Selection at age was assumed to be constant over the oldest ages.

By definition S on the reference age is 1.0. Using the same value for S on the oldest age, without thought, can lead to: an increasing trend in F with age for the older ages if one has a dome shaped selection pattern (Fig. 1a); or a spuriously domed exploitation pattern if one has selected a reference F at a partially recruited age group (Fig. 1b).

The values of natural mortality-at-age and of selection-at-age are confounded within the separable model. Therefore, the user-defined pattern of natural mortality-at-age can influence the shape of the selection-at-age pattern derived from the analysis. If natural mortality varies with age, the influence of the variation on the selection pattern must be taken into consideration.

The final choice is made on the basis of the user's perception of the most likely shape of the selection-at-age curve. In the absence of any prior information, and if natural mortality is considered to be constant for the oldest ages, it may be prudent to choose a terminal selection value that produces a level exploitation pattern for the oldest ages.

References

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DARBY, C. D. and S. FLATMAN. 1994. Virtual Population Analysis: version 3.1 (Windows/DOS) user guide. Information Technology Series. MAFF Directorate of Fisheries Research, Lowestoft, **1**: 85 p.

POPE, J. G., and J. G. SHEPHERD. 1982. A simple method for the consistent interpretation of catch-at-age data. *ICES J. Cons.*, **40**: 176–184.

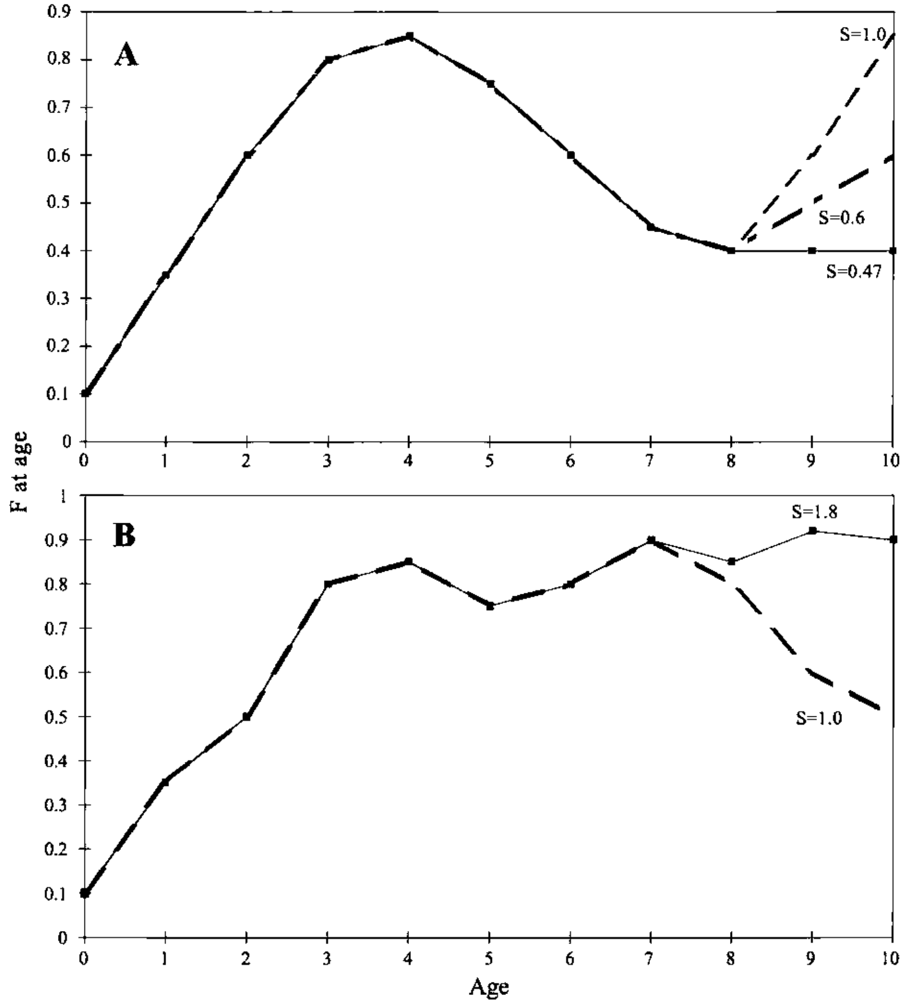

Fig. 1. (**A**) an illustration of the effects on estimated F-at-age of an inappropriate selection for the value of S on the oldest age (Reference age = 4, terminal F = 0.85) and (**B**) an illustration of the effects on estimated F-at-age of an inappropriate selection for the value of S on the oldest age (Reference age = 24, terminal F = 0.5).

TABLE 1. The Separable VPA diagnostic file : model specification and log catch ratio residuals.

```
Title : Blackfin: VPA course. Combined sex; plusgroup.                                   (1)
At  4/02/2002  13:48

Separable analysis                                                                       (2)
from 1963 to 1994 on ages  1 to  9
with Terminal F of  .200 on age  5 and Terminal S of 1.000

Initial sum of squared residuals was  1160.180 and                                       (3)
final sum of squared residuals is      221.386 after 126 iterations

Matrix of Residuals

Years,  1963/64,                                                                         (4)
Ages
1/ 2,  -2.594,
2/ 3,  -1.308,
3/ 4,   -.008,
4/ 5,   -.305,
5/ 6,   -.157,
6/ 7,    .165,
7/ 8,    .441,
8/ 9,   1.108,

TOT ,    .000,
WTS ,    .001,

Years,  1964/65,1965/66,1966/67,1967/68,1968/69,1969/70,1970/71,1971/72,1972/73,1973/74,

1/ 2,  -3.037, -2.718, -3.948, -2.319,  -.717, -1.852, -3.388, -6.398,  -.689,  1.853,
2/ 3,  -1.833, -1.889, -2.279, -1.123, -2.403, -1.366, -2.078, -2.105,   .505,  1.294,
3/ 4,    .253,  -.684,   .224,  -.271,  -.228,  -.266,   .327,  -.992,   .673,  1.212,
4/ 5,    .162,  -.155,   .423,  -.044,   .096,   .079,   .250,  -.053,   .127,   .162,
5/ 6,    .361,   .040,  1.180,   .388,   .702,   .231,   .719,   .878,   .559,   .618,
6/ 7,    .255,   .425,   .072,  -.171,  -.087,   .041,   .447,   .621,  -.417,  -.614,
7/ 8,    .610,  1.076,   .072,   .548,   .189,   .392,  -.185,   .542,  -.365, -1.186,
8/ 9,   -.332,   .481,  -.346,   .520,   .425,   .394,  -.095,   .953,  -.468,  -.799,

TOT ,    .000,   .000,   .000,   .000,   .000,   .000,   .000,   .000,   .000,   .000,
WTS ,    .001,   .001,   .001,   .001,   .001,   .001,   .001,   .001,   .001,   .001,

Years,  1974/75,1975/76,1976/77,1977/78,1978/79,1979/80,1980/81,1981/82,1982/83,1983/84,

1/ 2,   2.886,  -.483,   .425,   .525,   .538,  -.625,   .052,  1.917,  -.390,  -.786,
2/ 3,    .194,   .004,   .367,  -.456,  1.638,  -.244,  -.354,   .446,  -.270,   .167,
3/ 4,    .748,  1.028,   .937,   .432,  1.039,   .663,   .561,   .945,   .562,   .360,
4/ 5,   -.322,  -.286,  -.488,  -.333,  -.338,  -.206,  -.259,  -.217,  -.109,  -.045,
5/ 6,    .186,  -.262,   .112,   .016,  -.241,   .035,  -.040,  -.462,  -.126,  -.729,
6/ 7,  -1.226,  -.164,  -.093,   .059,  -.211,  -.165,   .060,  -.443,  -.510,  -.010,
7/ 8,   -.404,   .269,  -.204,   .003,  -.185,   .094,   .216,  -.140,   .303,   .389,
8/ 9,    .956,  -.105,  -.058,   .141,  -.452,   .093,  -.190,   .136,   .369,   .238,

TOT ,    .000,   .000,   .000,   .000,   .000,   .000,   .000,   .000,   .000,   .000,
WTS ,    .001,   .001,   .001,   .001,   .001,   .001,   .001,   .001,   .001,   .001,      (5)

Years,  1984/85,1985/86,1986/87,1987/88,1988/89,1989/90,1990/91,1991/92,1992/93,1993/94, TOT,  WTS,

1/ 2,   1.447,  -.331,  1.826, -3.592,   .451,  -.201,   .955,  1.680,  -.623, -1.590,  .000, .149,
2/ 3,    .569,   .384,  -.316,   .083,   .148, -1.163,  -.033,  -.044,  -.307,   .693,  .000, .290,
3/ 4,    .777,   .033,  -.286,  -.230,  -.268,   .375,   .356,  -.615,  -.612,   .462,  .000, .537,
4/ 5,   -.089,  -.432,   .344,   .437,  -.677,   .410,   .011,  -.542,   .021,   .518,  .000,1.000,
5/ 6,   -.743,   .012,   .105,   .272,  -.260,   .135,  -.233,  -.221,   .532,   .397,  .000, .694,
6/ 7,   -.307,   .112,  -.343,   .081,   .136,   .059,  -.292,   .311,   .398,  -.153,  .000, .842,
7/ 8,    .085,   .255,  -.042,  -.190,   .396,  -.445,  -.058,   .553,  -.074,  -.483,  .000, .718,
8/ 9,    .008,   .102,  -.189,   .116,   .749,  -.105,   .173,   .198,  -.246,  -.808,  .000, .656,

TOT ,    .000,   .000,   .000,   .000,   .000,   .000,   .000,   .000,   .000,   .000,     -21.683,
WTS ,   1.000,  1.000,  1.000,  1.000,  1.000,  1.000,  1.000,  1.000,  1.000,  1.000,      (6)
```

TABLE 2. The Separable VPA diagnostic file: Fishing mortality at the reference age and selection at age.

Fishing Mortalities (F) **(7)**

,	1963,	1964,								
F-values,	.1445,	.1883,								
,	1965,	1966,	1967,	1968,	1969,	1970,	1971,	1972,	1973,	1974,
F-values,	.3150,	.2106,	.2343,	.1696,	.2190,	.1671,	.3265,	.3269,	.3991,	.4439,
	1975,	1976,	1977,	1978,	1979,	1980,	1981,	1982,	1983,	1984,
F-values,	.4137,	.5330,	.5150,	.4371,	.3531,	.3494,	.3559,	.3958,	.3936,	.2728,
,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	1993,	1994,
F-values,	.3004,	.5460,	.4474,	.6912,	.7091,	.7147,	.7376,	.4003,	.3449,	.2000,

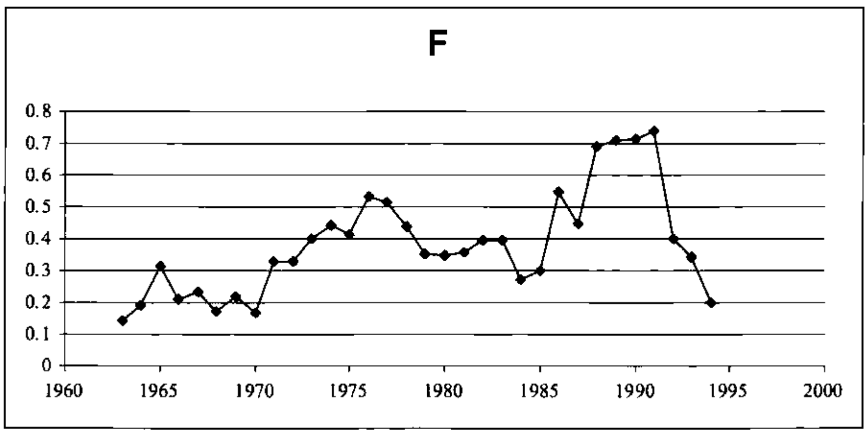

Fig. 2. Fishing mortality at the reference age, by year, for the Blackfin data set as estimated by Separable VPA.

Selection-at-age (S) **(8)**

,	1,	2,	3,	4,	5,	6,	7,	8,	9,
S-values,	.0026,	.1841,	.6919,	1.1884,	1.0000,	.9778,	.9324,	.9099,	1.0000,

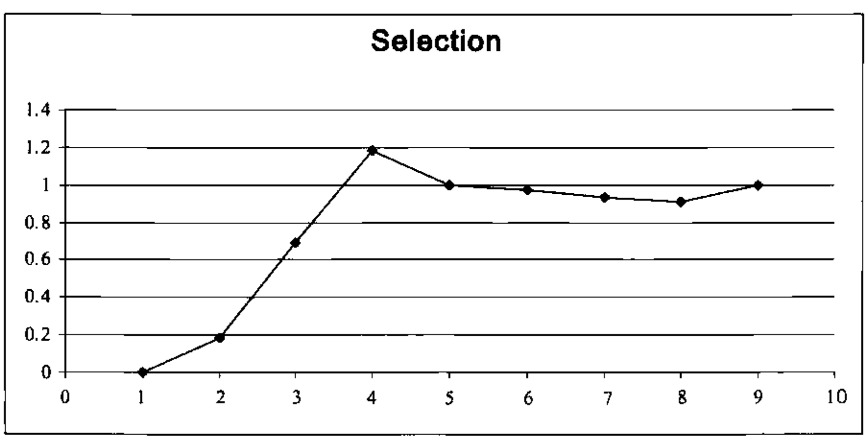

Fig. 3. Selection (y-axis) at age (x-axis) for the Blackfin data set as estimated by Separable VPA.

TABLE 3. The Separable VPA diagnostic file : Separable model estimates of fishing mortality at age.

Run title : Blackfin: VPA course. Combined sex; plusgroup.
At 4/02/2002 13:48

Traditional vpa Terminal populations from weighted Separable populations

SEPARABLY GENERATED FISHING MORTALITIES (9)

YEAR, AGE	1963,	1964,
1,	.0004,	.0005,
2,	.0266,	.0347,
3,	.1000,	.1303,
4,	.1717,	.2238,
5,	.1445,	.1883,
6,	.1413,	.1841,
7,	.1347,	.1756,
8,	.1315,	.1713,
9,	.1445,	.1883,

YEAR, AGE	1965,	1966,	1967,	1968,	1969,	1970,	1971,	1972,	1973,	1974,
1,	.0008,	.0006,	.0006,	.0004,	.0006,	.0004,	.0009,	.0009,	.0010,	.0012,
2,	.0580,	.0388,	.0431,	.0312,	.0403,	.0308,	.0601,	.0602,	.0735,	.0817,
3,	.2179,	.1457,	.1621,	.1173,	.1515,	.1156,	.2259,	.2262,	.2761,	.3072,
4,	.3743,	.2502,	.2785,	.2015,	.2602,	.1986,	.3880,	.3885,	.4743,	.5276,
5,	.3150,	.2106,	.2343,	.1696,	.2190,	.1671,	.3265,	.3269,	.3991,	.4439,
6,	.3080,	.2059,	.2291,	.1658,	.2141,	.1634,	.3192,	.3197,	.3902,	.4341,
7,	.2937,	.1963,	.2185,	.1581,	.2042,	.1558,	.3044,	.3048,	.3721,	.4139,
8,	.2866,	.1916,	.2132,	.1543,	.1993,	.1521,	.2971,	.2975,	.3631,	.4039,
9,	.3150,	.2106,	.2343,	.1696,	.2190,	.1671,	.3265,	.3269,	.3991,	.4439,

YEAR, AGE	1975,	1976,	1977,	1978,	1979,	1980,	1981,	1982,	1983,	1984,
1,	.0011,	.0014,	.0013,	.0011,	.0009,	.0009,	.0009,	.0010,	.0010,	.0007,
2,	.0762,	.0981,	.0948,	.0805,	.0650,	.0643,	.0655,	.0729,	.0725,	.0502,
3,	.2862,	.3688,	.3563,	.3025,	.2443,	.2417,	.2463,	.2738,	.2724,	.1887,
4,	.4916,	.6334,	.6120,	.5195,	.4196,	.4152,	.4230,	.4703,	.4678,	.3241,
5,	.4137,	.5330,	.5150,	.4371,	.3531,	.3494,	.3559,	.3958,	.3936,	.2728,
6,	.4045,	.5211,	.5035,	.4274,	.3452,	.3416,	.3480,	.3870,	.3849,	.2667,
7,	.3857,	.4969,	.4802,	.4076,	.3292,	.3258,	.3319,	.3690,	.3670,	.2543,
8,	.3764,	.4849,	.4685,	.3977,	.3212,	.3179,	.3238,	.3601,	.3581,	.2482,
9,	.4137,	.5330,	.5150,	.4371,	.3531,	.3494,	.3559,	.3958,	.3936,	.2728,

YEAR, AGE	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	1993,	1994,
1,	.0008,	.0014,	.0012,	.0018,	.0019,	.0019,	.0019,	.0010,	.0009,	.0005,
2,	.0553,	.1005,	.0824,	.1273,	.1305,	.1316,	.1358,	.0737,	.0635,	.0368,
3,	.2078,	.3778,	.3096,	.4782,	.4906,	.4945,	.5104,	.2770,	.2387,	.1384,
4,	.3570,	.6489,	.5317,	.8214,	.8427,	.8493,	.8766,	.4757,	.4099,	.2377,
5,	.3004,	.5460,	.4474,	.6912,	.7091,	.7147,	.7376,	.4003,	.3449,	.2000,
6,	.2937,	.5339,	.4375,	.6758,	.6933,	.6988,	.7212,	.3914,	.3373,	.1956,
7,	.2801,	.5091,	.4172,	.6445,	.6612,	.6664,	.6878,	.3733,	.3216,	.1865,
8,	.2733,	.4968,	.4071,	.6289,	.6452,	.6503,	.6711,	.3643,	.3138,	.1820,
9,	.3004,	.5460,	.4474,	.6912,	.7091,	.7147,	.7376,	.4003,	.3449,	.2000,

TABLE 4. The Separable VPA diagnostic file : Separable model estimates of population numbers at age.

Run title : Blackfin: VPA course. Combined sex; plusgroup.

At 4/02/2002 13:48

Traditional vpa Terminal populations from weighted Separable populations

SEPARABLY GENERATED POPULATION NUMBERS **(10)**

YEAR, AGE	1963,	1964,
1,	24065,	15604,
2,	10245,	19695,
3,	11781,	8167,
4,	3641,	8728,
5,	1887,	2511,
6,	1076,	1337,
7,	534,	765,
8,	775,	382,
9,	411,	556,

YEAR, AGE	1965,	1966,	1967,	1968,	1969,	1970,	1971,	1972,	1973,	1974,
1,	14828,	22851,	17496,	33170,	22244,	28525,	27075,	26727,	32305,	33217,
2,	12769,	12130,	18699,	14315,	27145,	18202,	23344,	22148,	21863,	26421,
3,	15576,	9866,	9554,	14663,	11360,	21346,	14451,	17998,	17074,	16632,
4,	5870,	10255,	6982,	6651,	10676,	7993,	15568,	9439,	11752,	10606,
5,	5713,	3305,	6538,	4327,	4452,	6738,	5365,	8647,	5240,	5988,
6,	1703,	3414,	2192,	4234,	2990,	2928,	4667,	3169,	5105,	2878,
7,	911,	1025,	2275,	1427,	2937,	1976,	2036,	2777,	1885,	2829,
8,	526,	556,	689,	1497,	998,	1961,	1385,	1229,	1676,	1064,
9,	263,	323,	376,	456,	1050,	669,	1379,	842,	747,	954,

YEAR, AGE	1975,	1976,	1977,	1978,	1979,	1980,	1981,	1982,	1983,	1984,
1,	23809,	12172,	17935,	20008,	33649,	35767,	29760,	31543,	31867,	42547,
2,	27165,	19472,	9952,	14664,	16362,	27524,	29257,	24343,	25798,	26063,
3,	19934,	20610,	14453,	7411,	11077,	12553,	21131,	22434,	18530,	19645,
4,	10016,	12258,	11670,	8286,	4484,	7104,	8071,	13524,	13968,	11554,
5,	5124,	5016,	5327,	5181,	4035,	2413,	3840,	4329,	6918,	7163,
6,	3145,	2774,	2410,	2606,	2740,	2321,	1393,	2202,	2386,	3821,
7,	1527,	1718,	1349,	1193,	1392,	1588,	1350,	805,	1225,	1329,
8,	1531,	850,	856,	683,	650,	820,	939,	793,	456,	695,
9,	581,	861,	428,	439,	376,	386,	488,	556,	453,	261,

YEAR, AGE	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	1993,	1994,
1,	26575,	29947,	24098,	21306,	23627,	18269,	19298,	33853,	47221,	5329,
2,	34810,	21741,	24483,	19707,	17413,	19308,	14929,	15769,	27687,	38627,
3,	20294,	26967,	16097,	18460,	14207,	12512,	13859,	10671,	11993,	21274,
4,	13318,	13497,	15132,	9671,	9369,	7121,	6247,	6811,	6623,	7734,
5,	6841,	7630,	5775,	7280,	3482,	3303,	2494,	2129,	3465,	3599,
6,	4465,	4147,	3619,	3023,	2986,	1403,	1323,	976,	1168,	2010,
7,	2396,	2725,	1991,	1913,	1259,	1222,	571,	527,	540,	682,
8,	844,	1482,	1341,	1074,	822,	532,	514,	235,	297,	321,
9,	444,	526,	739,	731,	469,	353,	227,	215,	134,	178,

TABLE 5. The Separable VPA diagnostic file : Fishing mortality at age residuals $F_{sep} - F_{vpa}$

Run title : Blackfin: VPA course. Combined sex; plusgroup.

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Traditional vpa Terminal populations from weighted Separable populations

Fishing mortality residuals (11)

YEAR, AGE	1963,	1964,
1,	-.0004,	-.0005,
2,	-.0146,	-.0297,
3,	.0279,	.0943,
4,	.0290,	.0800,
5,	.0428,	.1343,
6,	.0936,	.1175,
7,	.0267,	.0964,
8,	.0998,	-.0398,
9,	-.0001,	-.0770,

YEAR, AGE	1965,	1966,	1967,	1968,	1969,	1970,	1971,	1972,	1973,	1974,
1,	-.0008,	-.0006,	-.0006,	-.0004,	-.0006,	-.0004,	-.0009,	.0009,	.0110,	.0283,
2,	-.0432,	-.0341,	-.0257,	-.0283,	-.0272,	-.0290,	-.0468,	.1067,	.2717,	.0714,
3,	-.0266,	.1068,	.0289,	.0290,	.0034,	.0326,	-.1323,	.2160,	.2777,	.1916,
4,	.2021,	.2250,	.1609,	.1350,	.1913,	.0765,	-.0277,	.0198,	.0755,	-.1908,
5,	.0783,	.2679,	.1129,	.1591,	.1665,	.1519,	.0486,	-.0135,	-.0310,	.0157,
6,	.1070,	.0589,	-.0480,	.0125,	.0109,	.0982,	.0035,	-.1752,	-.1961,	-.2443,
7,	.1271,	-.0142,	.0589,	-.0145,	.0417,	.0025,	.0285,	-.1501,	-.1558,	-.0848,
8,	-.0367,	-.0956,	-.0333,	-.0396,	-.0544,	-.0272,	.0799,	-.1153,	-.1325,	.4567,
9,	.0179,	-.1046,	-.0827,	-.0895,	-.1205,	-.0908,	-.0412,	-.1727,	-.0385,	.1902,

YEAR, AGE	1975,	1976,	1977,	1978,	1979,	1980,	1981,	1982,	1983,	1984,
1,	.0000,	.0009,	.0080,	.0009,	-.0005,	.0007,	.0047,	.0002,	-.0001,	.0033,
2,	.0352,	.0640,	.0076,	.3033,	.0027,	-.0035,	.0473,	-.0081,	.0563,	.0557,
3,	.2204,	.2392,	.0812,	.2857,	.0250,	.0940,	.1001,	.0418,	.0504,	.1202,
4,	-.0877,	-.2230,	-.1983,	-.1063,	-.0957,	-.1967,	-.0833,	-.2252,	-.1775,	-.0556,
5,	-.1004,	.0292,	-.0446,	-.0816,	.0220,	-.0408,	-.1525,	-.0222,	-.2100,	-.1209,
6,	-.0639,	-.0452,	-.0263,	-.0631,	-.0042,	.0157,	-.0409,	-.0744,	.0272,	-.0407,
7,	.1529,	-.0262,	-.0138,	-.0578,	.0065,	.0644,	-.0024,	.1648,	.1367,	.0286,
8,	.0640,	.1049,	.0891,	-.0186,	.0000,	-.0252,	-.0003,	.0623,	.0758,	.0009,
9,	.0322,	.2737,	.2788,	.0480,	.2256,	-.0363,	.0429,	-.0602,	-.0742,	-.0013,

YEAR, AGE	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	1993,	1994,
1,	-.0005,	.0073,	-.0011,	-.0007,	-.0008,	.0017,	.0070,	-.0001,	-.0006,	.0000,
2,	.0189,	-.0520,	-.0009,	.0495,	-.0817,	-.0376,	-.0382,	-.0101,	.0400,	.0320,
3,	.0540,	-.0342,	-.1207,	-.0535,	.1552,	.0974,	-.1675,	-.0806,	.0457,	-.0245,
4,	-.0807,	.2578,	.1391,	-.3023,	.1797,	-.0166,	-.1465,	.0835,	.1354,	-.0599,
5,	-.0415,	.1066,	.0874,	-.1098,	.0475,	-.1022,	-.0419,	.1664,	.0877,	-.0316,
6,	.0337,	-.1107,	.0810,	-.0406,	.0242,	-.0403,	.0209,	.0732,	-.0344,	-.0245,
7,	.0417,	.0102,	.0263,	.1365,	-.1690,	-.0099,	.2553,	-.1015,	-.0620,	.0055,
8,	.0119,	-.0555,	.0355,	.3017,	-.1005,	.0514,	.0365,	-.0362,	-.0904,	.0540,
9,	-.0012,	-.0364,	.0232,	-.0127,	-.1568,	-.1111,	-.0680,	-.0554,	.0545,	.1220,

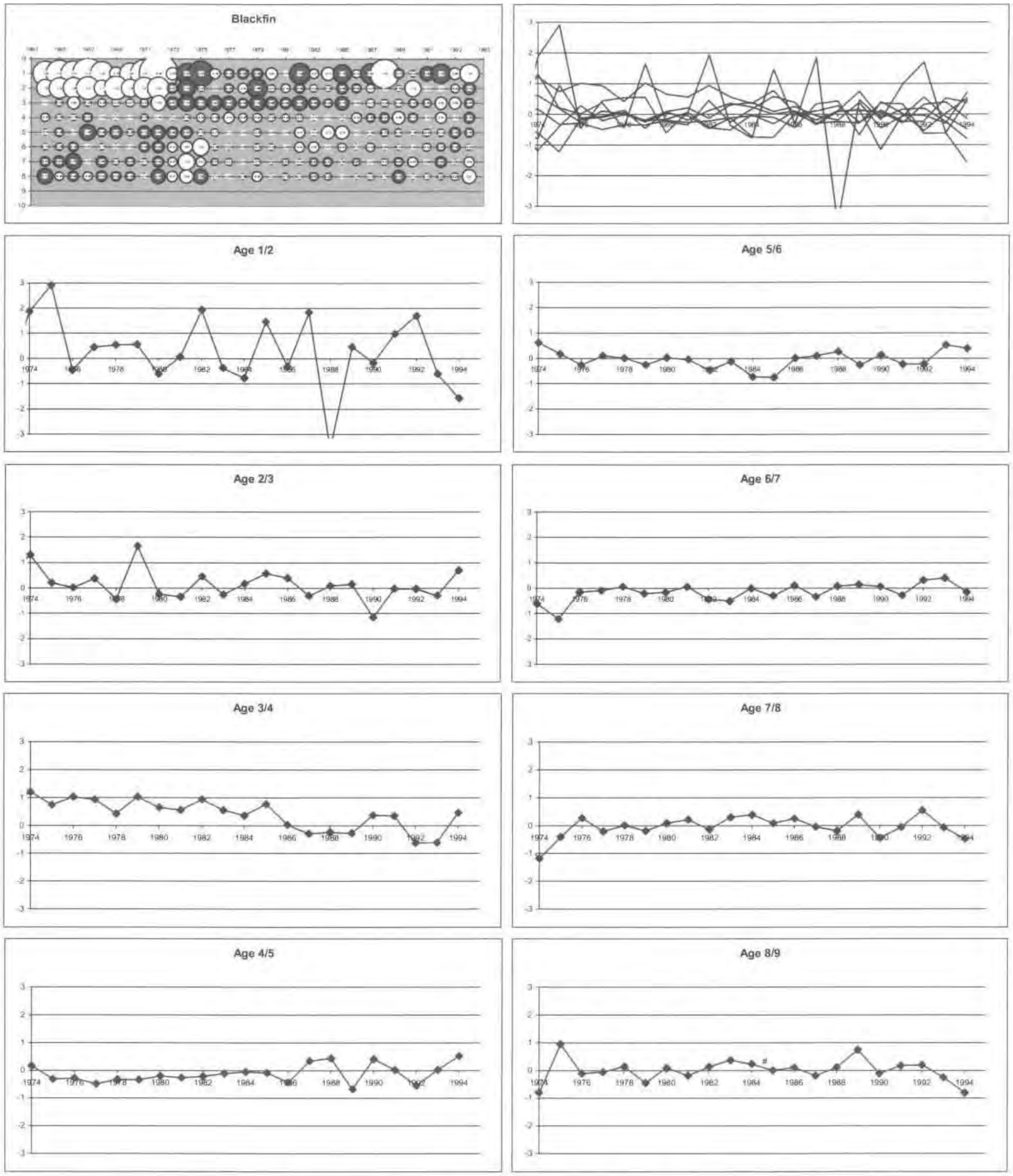

Fig. 4. The Separable VPA log catch ratio residuals illustrated using three diagnostic plotting approaches: bubble plots (solid circles positive) and time series plots of residuals at all ages and each age independently.

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Appendix 1: The Lowestoft Stock Assessment Suite

Tutorial 3

Ad hoc VPA tuning

by

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Abstract

This document is the third in a series of tutorials designed to assist users of the Lowestoft VPA Suite assessment software and prediction programs that utilize the results. The tutorial takes the user through the options required for running the Laurec-Shepherd and Hybrid *ad hoc* VPA tuning algorithms.

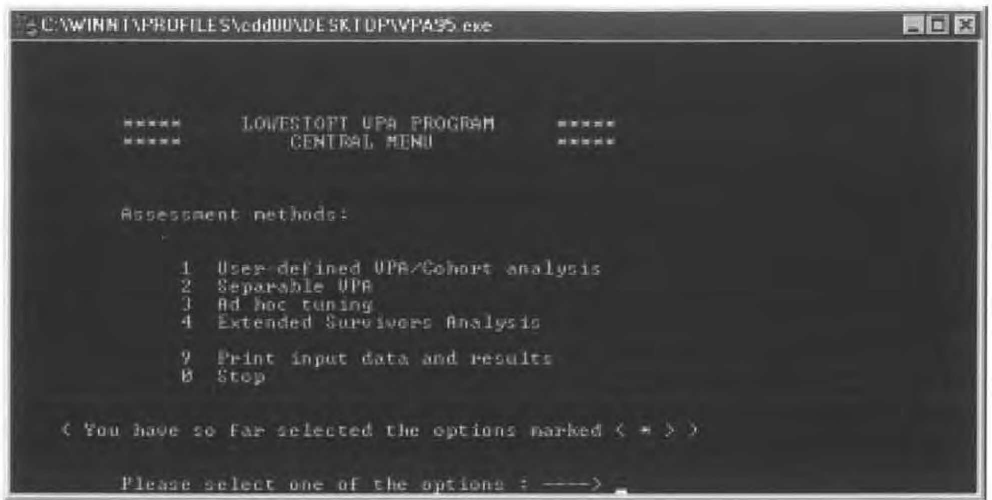
Introduction

This tutorial assumes that the user has installed the VPA program described in Darby and Flatman (1994), that the required data files have been placed in a directory c:\vpas\data and that the assessment index file (Blackfin.ind) contains path names which point to the appropriate files. This tutorial also assumes that the user has either read Tutorial 1which covers reading and selection of input data, or has previous experience of running the program.

In the following text **action to be taken by the user** is highlighted in bold. The symbol ↵ is used to represent the Return or Enter key on the keyboard.

Ad hoc VPA Tuning

Open the program and read in the index file C:\VPAS\DATA\BLACKFIN.IND. Take the default year, age and summary mean settings until the main menu is reached.

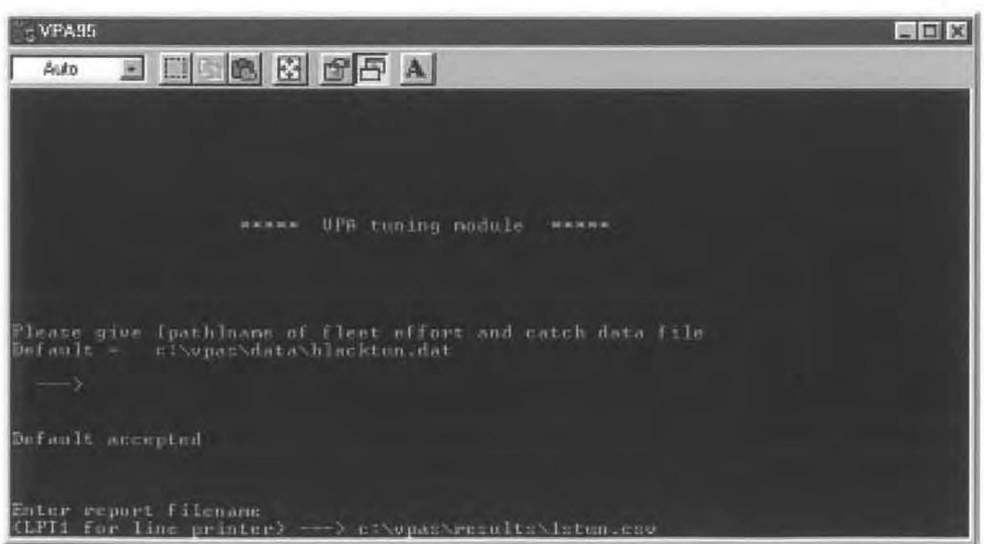


At the main menu **Type 3 ↵** to select *Ad hoc* VPA tuning.

The first two questions require input of the names for the data file containing the catch and effort data that will be used to calibrate the VPA and the diagnostics output file into which will be written the results of the calibration analysis.

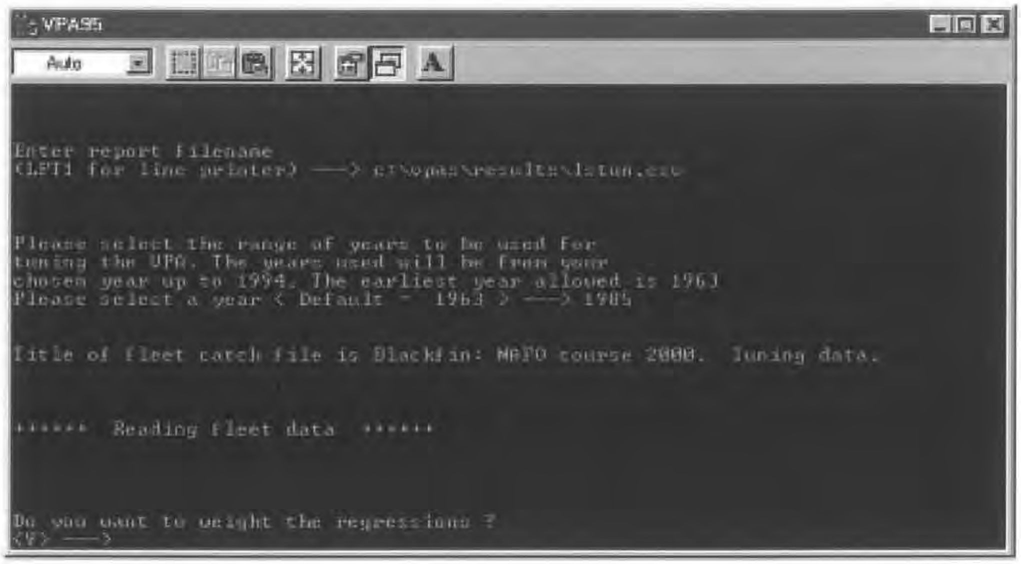
Type ↵ to take the default filename which has been read from the assessment index file

Type a path and filename for the tuning diagnostics output file.



We now have to select the range of data years from the index series to which we wish to fit the VPA. Current "accepted wisdom" is to take the last ten years of data. In general it is expected that catchability will have altered over a longer period.

Type 1985 ↵



The data file title is printed for cross-reference.

We are then asked whether we wish to apply a time series weighting to the model, down weighting the influence of historic tuning data in the fitted model. The models available are discussed in Darby and Flatman (1994). Since we have only taken ten years of tuning data for the calibration model we shall not down-weight historic data.

Type No ↵ , N ↵ or n ↵

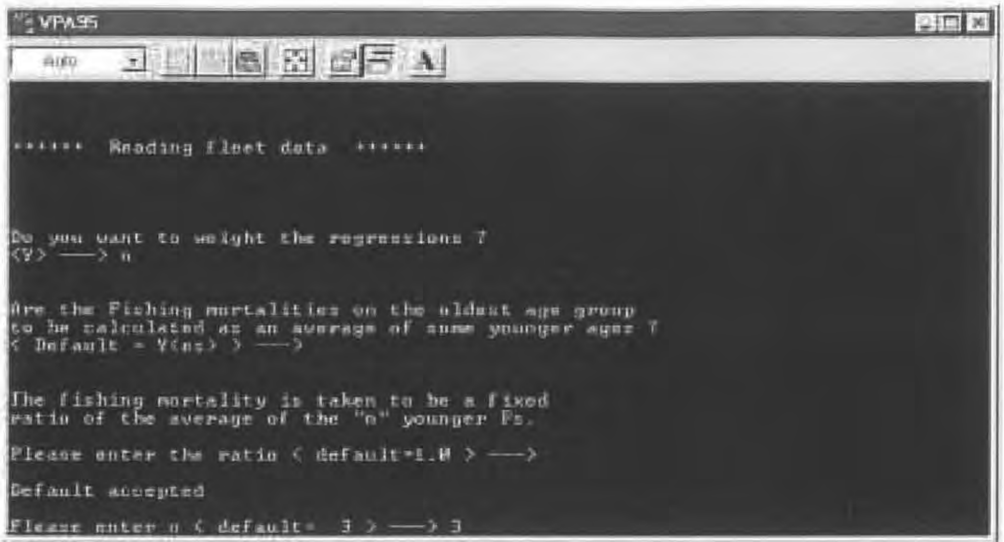
During the selection of the range of ages to be used in the assessment we used the default settings provided by the program, that is ages 1–10+. We have therefore opted for age 9 as the oldest true age.

In order to reduce the number of parameters that are estimated during the calibration of the VPA the *ad hoc* algorithms make the assumption that the fishing mortality at the oldest true age is a function (arithmetic mean) of the values calculated at younger ages in the same year. The program requires the number of ages over which we wish to calculate the average mortality and a scalar multiplier to be applied to that average (for example a value of 0.5 would apply half of the average fishing mortality). In this example we will calculate the fishing mortality at age 9 as the arithmetic mean of the values at ages 6, 7 and 8. Therefore the number of ages is 3 and the multiplier 1.0.

Type Yes ↵, Y ↵ or y ↵ to calculate the fishing mortalities as an average of younger ages

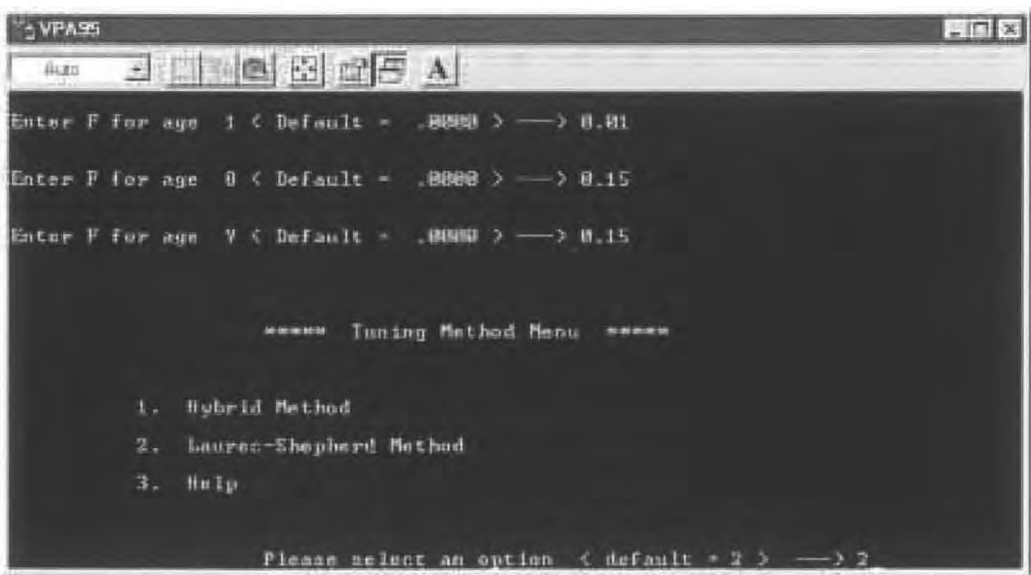
Type 1.0 ↵ for the scalar.

Type 3 ↵ for the number of ages used for the average fishing mortality.



Examination of the calibration data set C:\VPAS\DATA\BLACKFIN\BLACKTUN.DAT reveals that the final year cpue data value at ages 1, 8 and 9 is zero. Zero cpue values are considered to be missing data. Unlike XSA, the *ad hoc* algorithms do not use information from catches taken from the cohort at younger ages in the estimation of the terminal population; only final year cpue values are used. Therefore, in order to estimate the fishing mortality at these ages in the final VPA year, a similar constraint to that at the oldest ages is applied. The algorithm known as shrinkage is described later; but here we are required to supply starting estimates for the fishing mortality at the ages with missing data. The starting values will be replaced by shrinkage estimates in the fitted model.

Type the starting values 0.01 ↵, 0.15 ↵, 0.15 ↵



For the initial run we shall fit the constant catchability Laurec-Shepherd model to the data

Type 2 ↵

The program requires a threshold to be set for the minimum number of non-zero cpue values that are used for the calculation of catchability at each age. If, for any age, the fleet data set contains fewer values than the threshold, the fleet data will not be used in the overall weighted mean for the age. The recommended (default) value for the minimum number of data points is 5. This should prevent the assessment from being dominated by estimates from series with low standard errors, associated with small numbers of data points.

Type ↵ to take the default value for the minimum number of data points

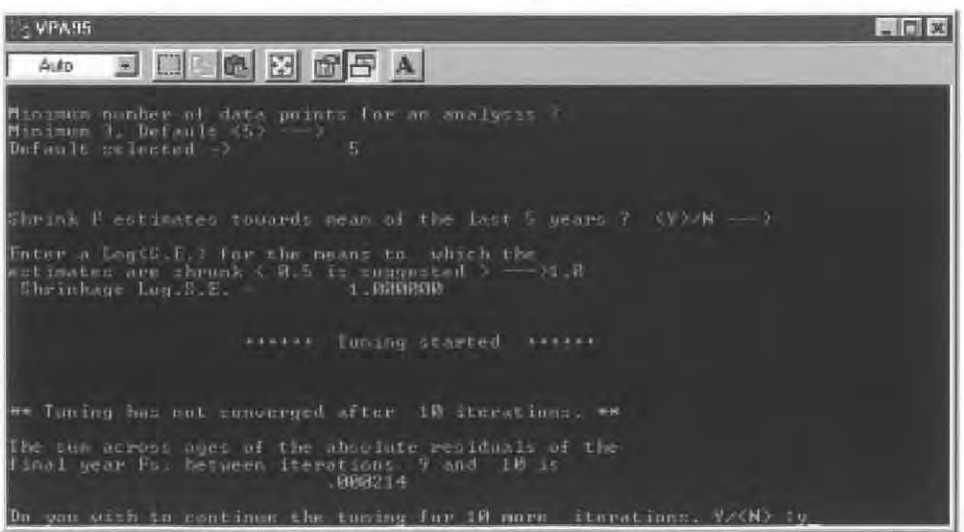
As described previously, we do not have calibration data for the final year at ages 1, 8, 9. Therefore we will use the average fishing mortality calculated over the preceding 5 years for the final year F at those ages, a constraint commonly called shrinkage.

Shrinkage is a constraint on the estimates derived from a time series of observations. The procedure can be described as making the assumption that, if a time series is being used to predict the current value of a particular parameter, e.g. F-at-age, and no major changes are known to have taken place, then as an initial starting value for the estimate, a mean of recent values of the parameter is appropriate. For the ages where we have no calibration information from the cpue series, we can only use the mean of the last few years. This is equivalent to the assumption used to estimate F at the oldest ages as an average of the values at younger ages. A more comprehensive description of the rationale behind shrinkage is given in Darby and Flatman (1994).

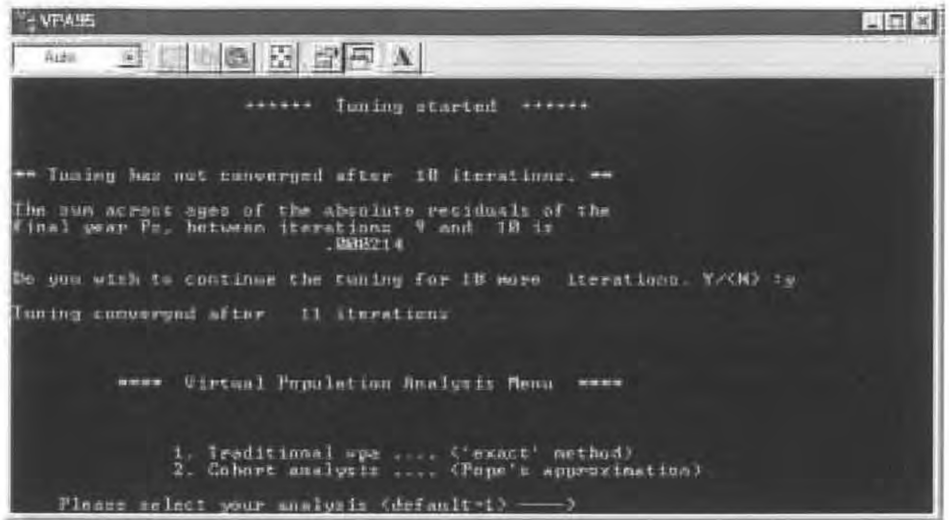
When using shrinkage at ages where fishing mortality estimates from the fleet tuning data series are available, the final year mortality is a weighted average of the estimates from the fleet series and the historic average fishing mortality. The weights for the fleet derived estimates are taken from the inverse of the variance of catchability at that age. The user must enter a weight for the average F. The value is given relative to the standard error of the log catchabilities; an approximation to the c.v. of the catchability. A shrinkage weight of 1.0 is a reasonable value for this data set (a 100% coefficient of variation). The estimate can be refined using retrospective analysis procedures to examine the influence of its magnitude on the consistency of the assessment estimates.

Type y ↵ to use shrinkage
Type 1.0 ↵ for the log standard error weight

This completes the specification of the *ad hoc* tuning algorithm and the program begins to fit the model. The algorithm runs for 10 iterations. If convergence of the final year F values has not been achieved after 10 iterations then the program seeks guidance as to whether to continue further, in batches of 10 iterations.

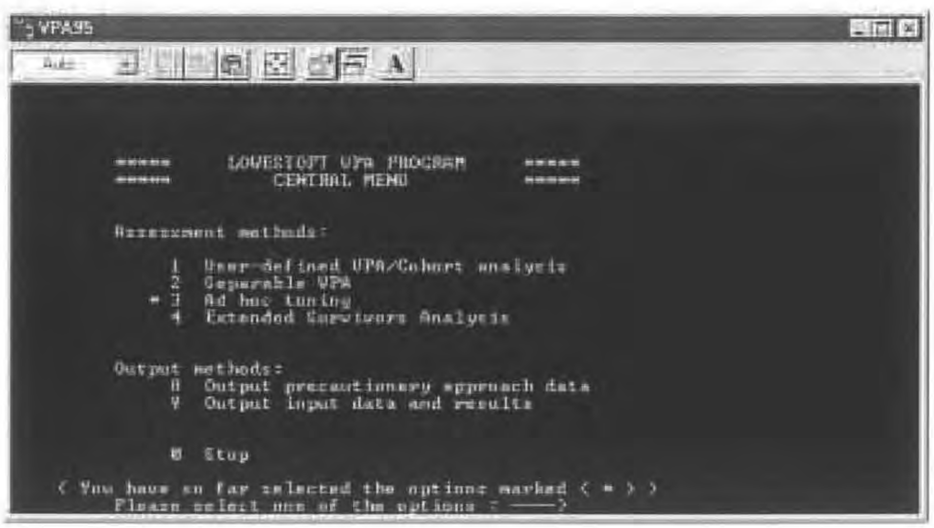


Type Y ↵, y ↵ or yes ↵ to continue the model fitting



There is no change in the terminal year fishing mortality values after 11 iterations and the calibration algorithm is complete. The program now offers a choice as to the method of calculation of the cohort population numbers and fishing mortalities at age: Exact VPA or cohort analysis.

Type y ↵ to use the default Exact VPA.



The program returns to the central menu. Note that we have calibrated the VPA using an *ad hoc* tuning algorithm (denoted by the star) and that we have a tuning diagnostics file for the Laurec-Shepherd method. However, we do not have tables of population numbers, SSB or fishing mortality at age; they are only printed after selecting option 9.

The *Ad hoc* Tuning Diagnostics file

The results from the current run should be in the file c:\vpas\results\lstun.csv. The file can be opened in a text editor word processing or spreadsheet package. The file lists the tuning data file used in the run, the selected range of ages, years and the model options chosen by the user.

Table 1 presents the results for the converged run. In the following text bold numbers **(x)** refer to labels added to the table. The file listing contains the date and time at which the run was performed, the tuning file used for calibrating the VPA **(1)**, a record of the selected assessment options **(2)**, and the convergence results **(3)**. If convergence was not achieved, the final year fishing mortality estimates from the last two iterations are printed. The fishing mortality values will indicate the ages that are varying between iterations and the degree of variation.

Examine the fishing mortality values resulting from the run **(4)**. Check for extreme values, especially those at the older ages that generally result from noise in poor quality catch at age or calibration data. This would indicate that the ages might better be incorporated into the plus group.

Examine the log catchability residuals for each age for all fleets **(5)**. An incidence of 99.99 indicates a missing (zero) fleet catch at age value. The values can indicate changes in the stock – fleet interactions. Look for year effects running down the columns, age effects across the rows and year class effects that follow the cohort diagonals. Recent and sudden changes in catchability may require removal of the fleet from the assessment. For each age, plots of the residuals against time can be used to reveal trends in log catchability. One way to achieve this is to give the tuning output file a comma separated file name extension (.csv) and import it into a spreadsheet package (Fig. 1, 2, 3, 4).

Note: If only one fleet data set is available and the Laurec-Shepherd constant log catchability model is used without shrinkage to the mean, the residuals in the final year will all be 0.0; the terminal F values are generated using the fleet's average catchability for the age. If shrinkage to the mean is selected or the assessment is tuned with more than one fleet, F in the final year is a weighted mean. The estimate of catchability derived for each age will differ from the fleet's mean and the final year residuals will not be zero.

The significance of any trends in time in log catchability noted from the residual tables can be tested using the diagnostics presented in the summary statistics **(6)**. As a quick check, look at the slope of the log catchabilities for each age **(8)**, for each fleet separately. Slopes which exceed twice their standard error consistently, for most of the important age groups, are considered significant and indicate that the assumption of constant catchability used to fit the model may not be correct. Changes in the sign of the slope across ages usually indicate noise in the data.

If there are significant trends in the catchability of the fleets then the use of the Hybrid model could be appropriate. This model allows trends in catchability for selected fleets. If it is used, constant catchability should be maintained for as many fleets as possible. Remember that these are log catchabilities and that a trend with time indicates an exponential trend in catchability.

Examine the mean log catchability (pred. log q) and its standard error for each age and fleet **(7)**. The standard error of the log catchability is an indicator of the quality of the data (a fractional coefficient of variation). Values greater than 0.5 indicate problems with that age for the fleet. High standard errors for the older ages of all fleets indicate that the assessment should probably be re-run with the problem ages incorporated into a younger plus group.

When combining fleet-derived estimates of terminal F at each age, weighting by the inverse of the prediction variance of the log catchability will reduce the influence of poor fleet data. However, if for any fleet, the standard errors of the majority of the important ages are poor, the user may wish to remove the fleet from the analysis altogether.

The estimate of the partial F contributed by the fleet **(9)** and the raised F **(10)** are printed. Raised F's are the individual fleet predictions of overall F: the level that would have been recorded if the fleet had taken the whole of the international catch for that age. The values can be used to identify incompatible predictions from the individual fleet data sets.

For each age, the overall weighted mean terminal F is printed **(11)** along with its internal (SIGMA(int)) and external (SIGMA(ext)) log standard errors. Also given is the overall standard error (SIGMA(overall) **(12)**; it is the larger of the internal and external values.

The internal standard error for an age is calculated from the (prediction) standard errors of the fleet's final year log catchabilities; it corresponds to the within samples variance. The external standard error is calculated from the scatter of the logarithms of the raised F values; it corresponds to the between samples variance (Topping, 1978). If shrinkage to the mean has been selected, the internal and external standard errors include the F shrinkage value.

SIGMA(overall) is a good approximation to the fractional coefficient of variation of the mean F and should be used as a measure of the accuracy of the prediction. If it is large (greater than 0.3) for important age groups, then the assessment should be treated with caution.

If the values of the internal and external standard errors differ significantly, there is a discrepancy between the fleet estimates for overall F (the raised F's **(10)**). The variance ratio **(13)**, $(\text{external s.e.})^2/(\text{internal s.e.})^2$, may be tested as an F statistic with n and n -1 degrees of freedom, where n is the number of fleets contributing a raised F estimate. Values exceeding 3 imply conflicting signals from the fleets. Too small a value implies an unexpected correspondence of the tuning fleets in relation to the inherent noise.

Figures 1–4 present diagnostic plots for the fleets used to fit the Blackfin Laurec-Shepherd calibration model. In each figure the top left hand plot is a bubble plot of the log catchability residuals. This format is useful for looking for year and age effects in the estimates of log catchability. The top right plot presents the log catchability residuals as a time series for all ages together. Individual trends in log catchability at age are separated in the lower plots.

It is relatively obvious from the residual plots that the model assumption of constant catchability in time is being violated by the calibration series used in this fit.

- The Otter trawl residuals show a strong increase in the early period of the time series and a downward trend in recent years.
- The light trawl data are constant in time with no obvious pattern but are noisy.
- The prawn trawl cpue series shows a strong decrease in time.
- The seine data shows a strong increase in catchability in the recent years.

The trends in catchability are carried forward into differences in the estimates of terminal year fishing mortality derived from the four cpue series. Where a fleet has an increasing trend in catchability the assumption of constant catchability induces an under-estimate of the terminal fishing mortality. A downwards trend results in an over estimate of catchability. In the summary diagnostics for each age the difference is clearly illustrated at age 4. The two fleets with strong trends have marked differences in their estimates of the final year fishing mortalities (raised F). Fleet 3, the prawn trawlers, which have a downward trend in q contribute a terminal F estimate of 0.48 to the overall mean. Fleet 4, the seine netters, have an upward trend and F is consequently underestimated (0.05). The trends in residuals result in the estimates from these fleets having a high standard error in log catchability and they are therefore down-weighted in the final inverse-variance weighted estimate of fishing mortality.

In general the fitting of an assessment model to data series that violate the assumptions of the model is not ideal, and the fleets could be excluded from the model fit. Alternatively the Hybrid model, which is also available within the Lowestoft package, can be used to fit trends in time to the log catchability series. If this is carried out the fleet estimates of terminal fishing mortality are more consistent.

References

DARBY, C. D. and S. FLATMAN. 1994. Virtual Population Analysis: version 3.1 (Windows/DOS) user guide. *Info. Tech. Ser.*, MAFF Direct. Fish. Res., Lowestoft, **1**: 85 p.

POPE, J. G., and J. G. SHEPHERD. 1985. A comparison of the performance of various methods for tuning VPA's using effort data. *ICES J. Cons.*, **42**: 129–151.

TOPPING, J. 1978. Errors of observation and their treatment. Chapman and Hall Ltd, London. 119 p.

TABLE 1. The tuning diagnostic file for Laurec Shepherd tuning.

Lowestoft VPA Version 3.1

7/09/2000 23:31

Blackfin: VPA course. Combined sex; plusgroup.

CPUE data from file c:\vpas\data\blacktun.dat (1)

Catch data for 32 years. 1963 to 1994. Ages 1 to 10.

Fleet		First year	Last year	First age	Last age
Otter traw	1	1985	1994	2	6
Light trawl		1985	1994	2	7
Prawn trawl		1985	1994	2	4
Seine		1985	1994	2	5

Disaggregated Qs (2)
Log transformation
The final F is the (reciprocal variance-weighted) mean of the raised fleet F's.

No trend in Q (mean used)
Terminal Fs derived using L/S (with F shrinkage)

Shrinkage Log S.E = 1.000
Tuning converged after 11 iterations (3)

Regression weights

1	1	1	1	1	1	1	1	1	1

Oldest age F = 1.000*average of 3 younger ages.

Missing catch or tuning data at age 1 8 9

Fishing mortalities (4)

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.000	0.008	0.000	0.001	0.001	0.003	0.011	0.001	0.001	0.010
2	0.073	0.047	0.078	0.172	0.048	0.084	0.091	0.076	0.159	0.208
3	0.261	0.339	0.182	0.405	0.621	0.581	0.301	0.181	0.355	0.186
4	0.276	0.900	0.657	0.495	0.927	0.769	0.704	0.459	0.487	0.237
5	0.259	0.652	0.527	0.559	0.692	0.499	0.591	0.530	0.319	0.144
6	0.337	0.424	0.517	0.619	0.667	0.555	0.515	0.354	0.274	0.115
7	0.324	0.544	0.445	0.776	0.471	0.572	0.667	0.157	0.179	0.169
8	0.270	0.447	0.477	0.936	0.539	0.649	0.549	0.185	0.115	0.150
9	0.311	0.471	0.480	0.777	0.559	0.592	0.577	0.232	0.189	0.145

TABLE 1 (Cont'd). The tuning diagnostic file for Laurec Shepherd tuning.

Log catchability residuals **(5)**

Fleet: Otter trawl

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
2	0.91	1.32	-1.01	0.33	-1.12	-1.6	1.14	0.05	0.16	-0.18
3	-1.65	-0.05	-1.52	0.29	0.88	1.38	0.56	0.11	0.08	-0.08
4	-2.4	-1.07	-0.24	0.28	0.61	2.49	1.19	0.08	-1.32	0.38
5	-2.82	-1.4	-1.10	0.67	0.34	2.74	1.63	0.72	-1.26	0.47
6	-1.54	-1.1	-0.56	-0.27	0.65	2.42	0.76	0.43	-0.55	-0.25
7	No data for this fleet at this age									

Fleet: Light trawl

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
2	-0.41	-1.16	0.97	0.32	-0.97	0.05	0.35	0.13	0.6	0.12
3	0.34	0.17	-0.50	-0.36	0.34	0.63	-0.24	-0.35	0.02	-0.04
4	0.47	0.64	-0.87	-0.79	-0.18	0.91	0.59	-0.1	-0.77	0.10
5	-0.80	0.75	-0.47	0.39	-0.40	0.36	1.10	0.15	-1.26	0.17
6	0.17	-0.39	-0.49	-0.65	0.12	0.11	0.49	0.02	0.37	0.26
7	-0.79	-0.01	-0.23	-1.09	-0.10	0.73	0.70	-0.19	0.60	0.37

Fleet: Prawn trawl

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
2	0.84	0.59	0.95	1.12	-1.11	0.29	-0.34	0.00	-0.76	-1.58
3	1.70	2.62	0.54	-1.39	1.46	-0.67	-0.89	-1.36	-1.19	-0.81
4	1.12	0.75	0.06	-1.94	0.19	1.13	0.13	-0.23	-0.49	-0.71
5	No data for this fleet at this age									
6	No data for this fleet at this age									
7	No data for this fleet at this age									

Fleet: Seine

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
2	-2.08	-1.16	0.48	-0.68	-1.43	-1.34	0.75	1.58	1.92	1.96
3	-0.87	-0.28	-1.56	-0.63	-0.29	-0.24	0.49	0.67	1.19	1.52
4	-0.56	0.67	-1.65	-0.82	-0.55	-0.41	0.27	1.48	-0.04	1.61
5	-1.67	1.10	-1.93	0.22	-1.31	-0.13	0.24	1.70	0.26	1.53
6	No data for this fleet at this age									
7	No data for this fleet at this age									

SUMMARY STATISTICS FOR AGE 2 **(6)**

Fleet	Pred **(7)** log q	se (log q)	Partial F **(9)**	Raised F **(10)**	Slope **(8)**	se Slope	Intrcpt	se Intrcpt
1	-14.93	1.041	0.0009	0.2483	-6.44E-02	1.14E-01	-14.928	0.314
2	-16.23	0.702	0.0156	0.1844	8.51E-02	7.21E-02	-16.230	0.212
3	-18.79	0.971	0.0026	1.0100	-2.36E-01	6.88E-02	-18.793	0.293
4	-15.81	1.594	0.0029	0.0294	4.11E-01	1.02E-01	-15.806	0.481

Fbar **(11)**	Sigma(int.)	Sigma(ext.)	Sigma(overall)	Variance ratio
0.208	0.476	0.5	0.5 **(12)**	1.102 **(13)**

TABLE 1 (Cont'd). The tuning diagnostic file for Laurec Shepherd tuning.

SUMMARY STATISTICS FOR AGE 3

Fleet	Pred. log q	se (log q)	Partial F	Raised F	Slope	se Slope	Intrcpt	se Intrcpt
1	-14.10	0.997	0.0021	0.2009	1.49E-01	9.78E-02	-14.099	0.301
2	-15.54	0.386	0.0312	0.1943	-1.87E-02	4.24E-02	-15.538	0.116
3	-19.11	1.536	0.0019	0.4181	-3.60E-01	1.14E-01	-19.107	0.463
4	-15.53	1.002	0.0038	0.0408	2.81E-01	5.08E-02	-15.529	0.302

Fbar	Sigma(int.)	Sigma(ext.)	Sigma(overall)	Variance ratio
0.186	0.331	0.288	0.331	0.757

SUMMARY STATISTICS FOR AGE 4

Fleet	Pred. log q	se (log q)	Partial F	Raised F	Slope	se Slope	Intrcpt	se Intrcpt
1	-14.69	1.439	0.0012	0.1618	1.78E-01	1.47E-01	-14.689	0.434
2	-15.73	0.683	0.0257	0.2136	-2.47E-02	7.55E-02	-15.735	0.206
3	-19.82	0.971	0.0009	0.4832	-1.18E-01	9.97E-02	-19.822	0.293
4	-15.71	1.078	0.0032	0.0475	2.04E-01	9.60E-02	-15.714	0.325

Fbar	Sigma(int.)	Sigma(ext.)	Sigma(overall)	Variance ratio
0.237	0.469	0.397	0.469	0.716

SUMMARY STATISTICS FOR AGE 5

Fleet	Pred. log q	se (log q)	Partial F	Raised F	Slope	se Slope	Intrcpt	se Intrcpt
1	-14.98	1.719	0.0009	0.0895	2.73E-01	1.65E-01	-14.979	0.518
2	-16.31	0.758	0.0145	0.1214	3.67E-03	8.44E-02	-16.307	0.229
3	No data for this fleet at this age							
4	-16.45	1.347	0.0015	0.0313	2.56E-01	1.20E-01	-16.45	0.406

Fbar	Sigma(int.)	Sigma(ext.)	Sigma(overall)	Variance ratio
0.144	0.617	0.326	0.617	0.279

SUMMARY STATISTICS FOR AGE 6

Fleet	Pred. log q	se (log q)	Partial F	Raised F	Slope	se Slope	Intrcpt	se Intrcpt
1	-14.72	1.178	0.0011	0.1473	1.54E-01	1.19E-01	-14.72	0.355
2	-16.46	0.401	0.0124	0.0893	7.31E-02	3.65E-02	-16.46	0.121
3	No data for this fleet at this age							
4	No data for this fleet at this age							

Fbar	Sigma(int.)	Sigma(ext.)	Sigma(overall)	Variance ratio
0.115	0.38	0.143	0.38	0.142

SUMMARY STATISTICS FOR AGE 7

Fleet	Pred. log q	se (log q)	Partial F	Raised F	Slope	se Slope	Intrcpt	se Intrcpt
1	No data for this fleet at this age							
2	-16.54	0.648	0.0115	0.1165	1.28E-01	5.62E-02	-16.541	0.195
3	No data for this fleet at this age							
4	No data for this fleet at this age							

Fbar	Sigma(int.)	Sigma(ext.)	Sigma(overall)	Variance ratio
0.169	0.648	0	0.648	0

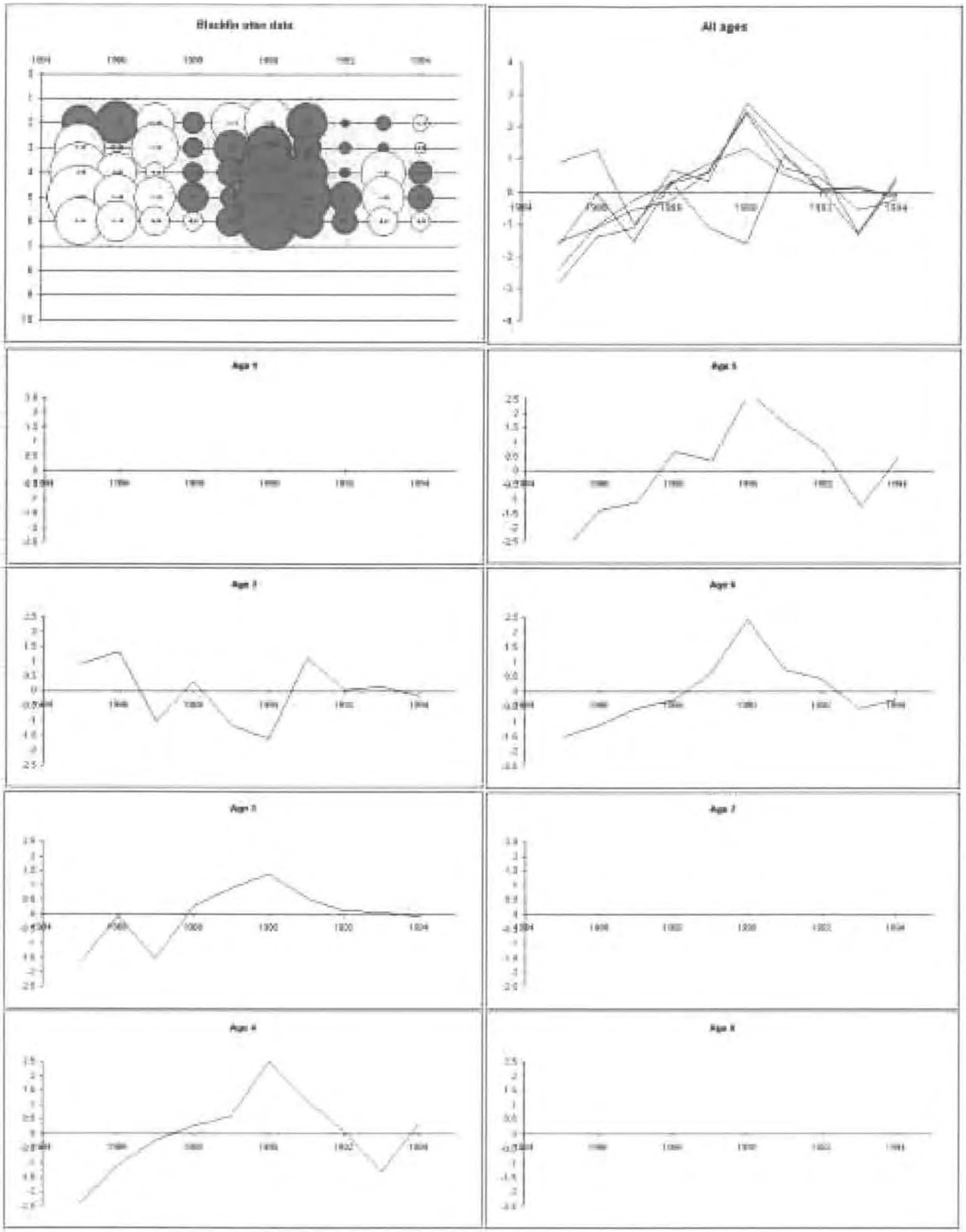


Fig. 1. The log catchability residuals for the Blackfin Otter trawl calibration data set.

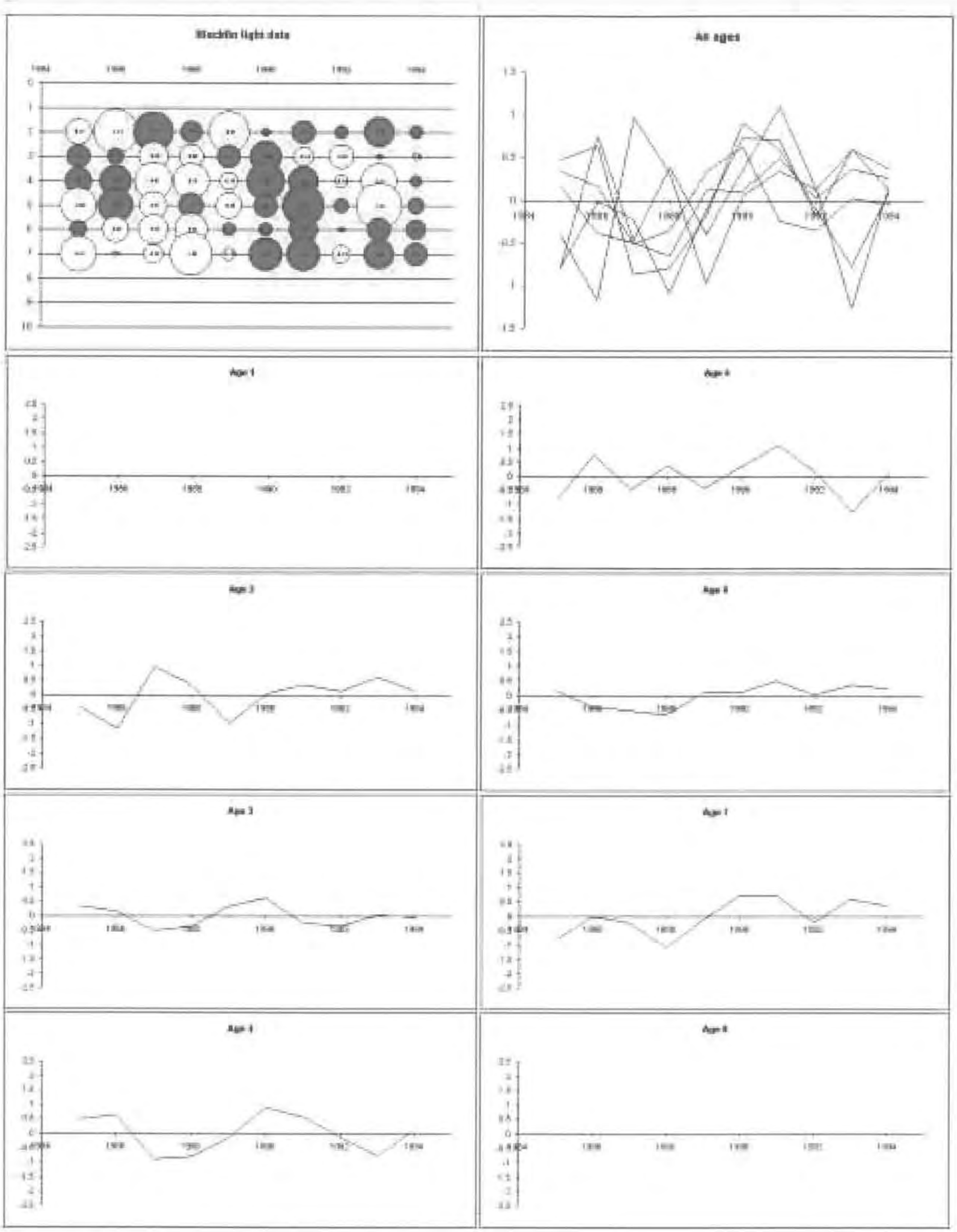


Fig. 2. The log catchability residuals for the Blackfin light trawl calibration data set.

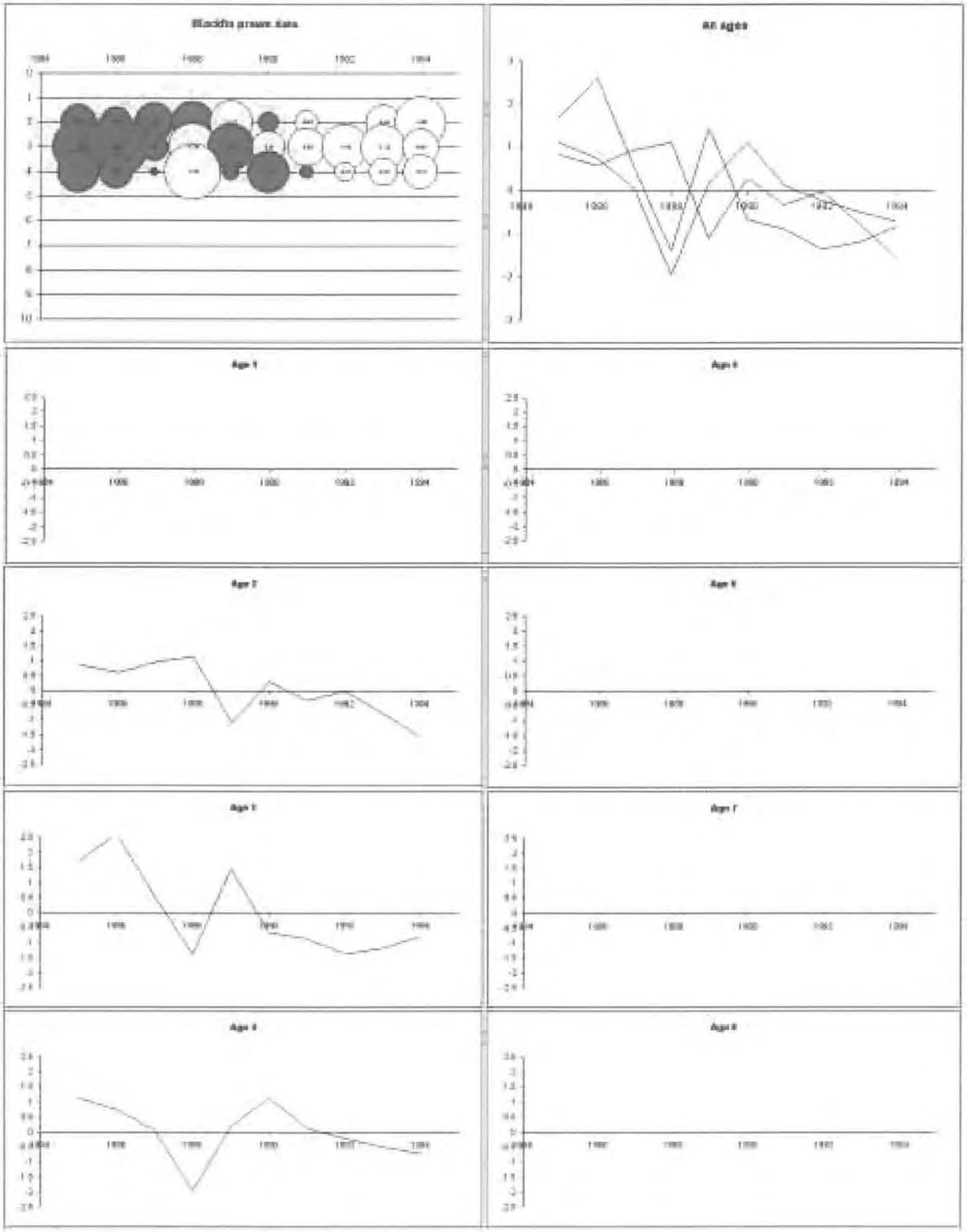


Fig. 3. The log catchability residuals for the Blackfin prawn trawl calibration data set.

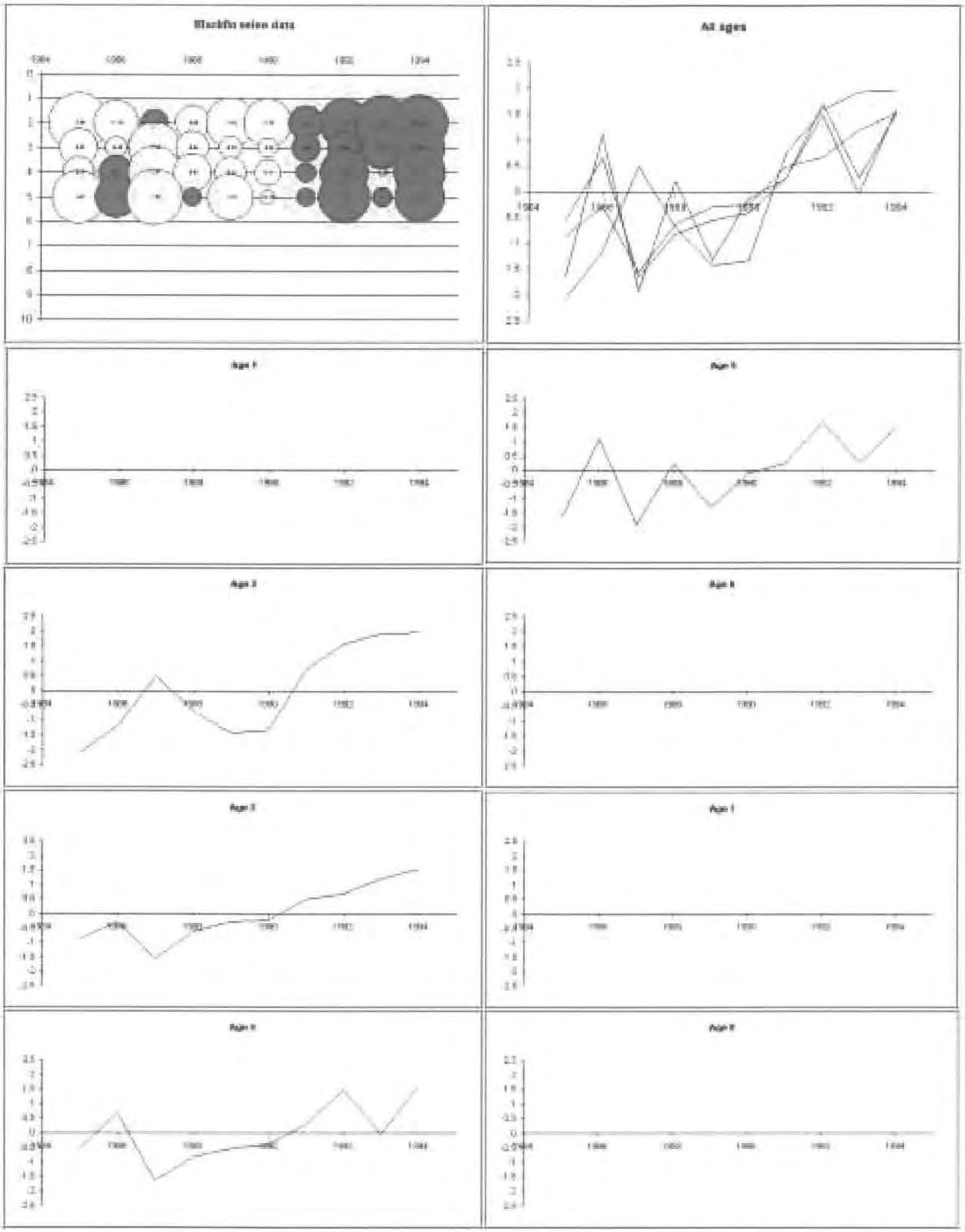


Fig. 4. The log catchability residuals for the Blackfin seine trawl calibration data set.

NAFO Sci. Coun. Studies, 36: 79–102

Appendix 1: Lowestoft Stock Assessment Suite

Tutorial 4

Extended Survivors Analysis (XSA)

by

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Abstract

This document is the fourth in a series of tutorials designed to assist users of the Lowestoft VPA Suite assessment software. The tutorial takes the user through the options required for running the Extended Survivors Analysis (XSA) assessment model.

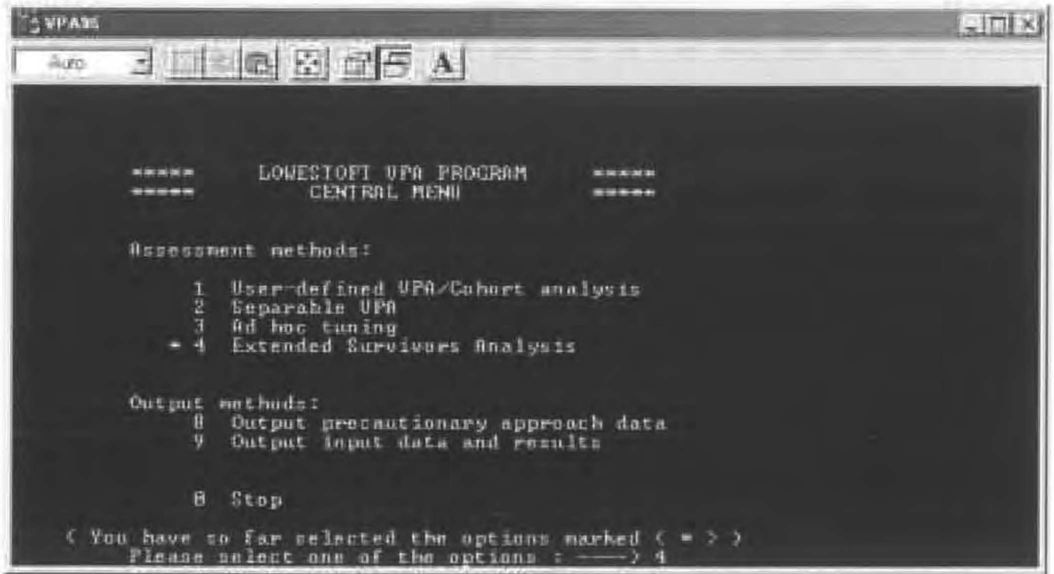
Introduction

This tutorial takes the user through the options required for running the Extended Survivors Analysis (XSA, Shepherd, MS 1992) tuning algorithm. Each of the tutorial series assume that the user has installed the VPA program VPA95.exe, described in Darby and Flatman (1994); that the required Blackfin data files have been placed in a directory c:\vpas\data\, and that the assessment index file (Blackfin.ind) contains path names which point to the appropriate files. This tutorial assumes that the user has either studied Tutorial 1which covers input of the data structures, or has previous experience of running the program.

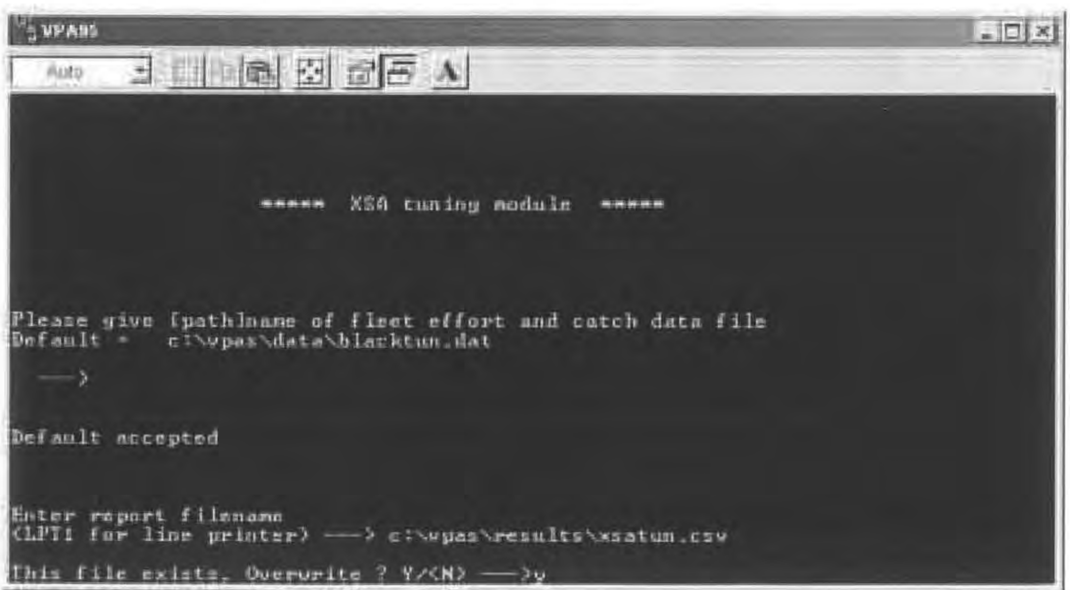
In the following text **action to be taken by the user** is highlighted in bold. The symbol ↵ is used to represent the Return or Enter key on the keyboard.

Extended Survivors Analysis

Open theVPA suite program and read in the index file C:\VPAS\DATA\BLACKFIN.IND. Take the default year, age and summary mean settings until the main menu is reached.

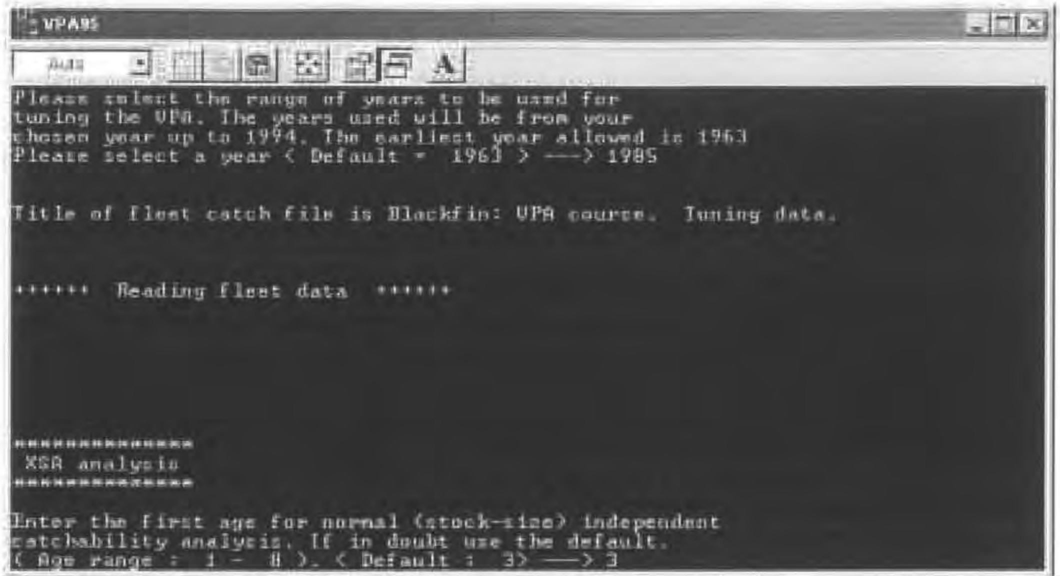


Type 4 ↲ to select the XSA model.
Type ↲ to select the default tuning data file, Blacktun.dat
Type a path and name for the tuning diagnostics output file. If a file of this name is located in the given directory, the program will ask for conformation of replacement.



The program reads the data file and then requires the user to select the range of years of cpue tuning data that will be used for calibrating the VPA. The current fad is to use only the last 10 years of data it is considered that technology creep will not have altered catchability substantially during this time period.

Type 1985 ↵

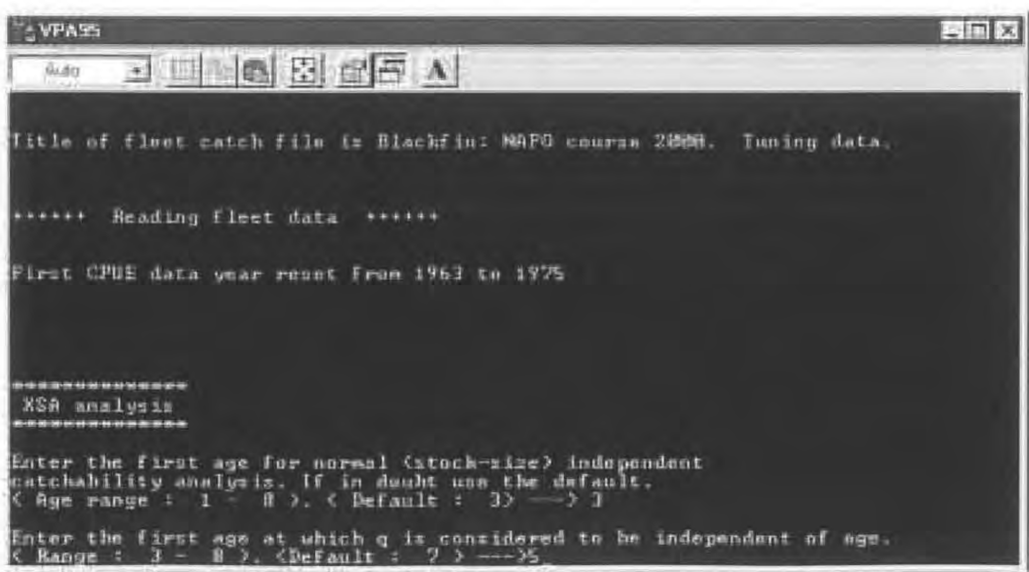


We now select the catchability models for each age. Two models are available:

direct proportionality or constant catchability cpue = q N
and the power model cpue = q N ^{p}

where q is catchability, N is population abundance and p the power coefficient. Unlike most formulations of ADAPT (Gavaris, MS 1988) and ICA (Patterson and Melvin 1996), which allow catchability models to be selected independently for each age within a cpue series, XSA currently fits all series with the specified catchability model at the selected age. If we use a power model at age 2, all calibration series will have this model fitted to the data at that age. In this tutorial we shall fit a power model for catchability at the first age, age 2. Note that the program requires us to input the first age at which the direct proportionality model is to be fitted, age 3.

Type 3 ↵ as the first age for the constant catchability model, that is, age 2 has a power model.



The next model specification required is the age at which we wish to constrain catchability. XSA reduces the number of parameters that are estimated by constraining catchability at the oldest ages to be equal to that at a younger age (the q plateau). Here we shall constrain catchability for ages greater than 5 to be equal to the value estimated at age 5. Once again this applies to all of the indices.

Type 5 ↵ so that catchability at ages older than 5 is set at that estimated at age 5.

The next screen presents the default settings for the XSA time series weights, the estimation of the regression model parameters, shrinkage and the minimum standard error threshold. For this assessment the default settings are not appropriate. We do not require the time series weights as we have reduced the time series for the indices to the data collected during the last 10 years. Also, the range of ages used for the fishing mortality shrinkage mean is also too large, extending into ages that are not fully recruited.

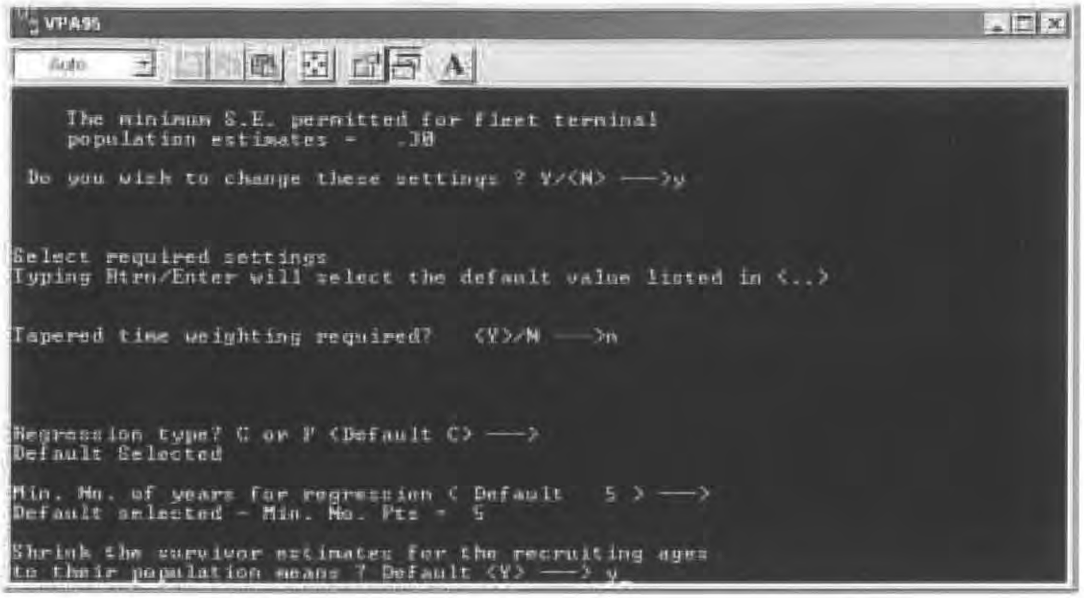
Type Y ↵ in order to change the default settings provided

The first question allows us to set time series weights in order to down - weight older data in the time series. In this example we have only selected the last 10 years and this is not required.

Type N ↵ to use all data in the 10 year time series with equal weight.

We now specify the regression model to be used to estimate the catchability parameters within the power model. We shall use Calibration regression, which assumes that the measurement errors are significantly larger in the survey observations than the estimated population abundance. Setting a minimum for the number of data points to which a regression model is fitted prevents the user from fitting regression models to times series of data that are too short and could therefore exhibit spurious correlation. In this case we can take the default option, as there are 10 years of data. Note that this does not equate to 10 data points in the regression, we could have zero cpue values, which are treated as missing in the analysis.

Type ↵ to take the default calibration regression model
Type ↵ to take the default of a minimum of 5 data points for the fitting of a regression model.



Within XSA two forms of shrinkage are used to provide constrained terminal population estimates. The first form of shrinkage is shrinkage to the population mean. This is described in detail in the user guide. It is only applied to the survivors estimated for the ages at which a power model is fitted. Terminal population estimates (calculated at the end of a year) for age a are shrunk to the time series weighted geometric mean of the population abundance estimates for age $a+1$ (calculated by the preceding VPA iteration, at the beginning of a year). The weight given to the shrinkage mean is the inverse of the variance of the time series weighted geometric mean population at the older age.

Rosenberg *et al.* (1992) have used simulation analysis to show that when estimating year class strength, prediction accuracy can be improved by the use of calibration regression with shrinkage to the population mean. The default settings supply this combination. If predictive regression is used, shrinkage to the population mean is equivalent to a double shrinkage and should be avoided.

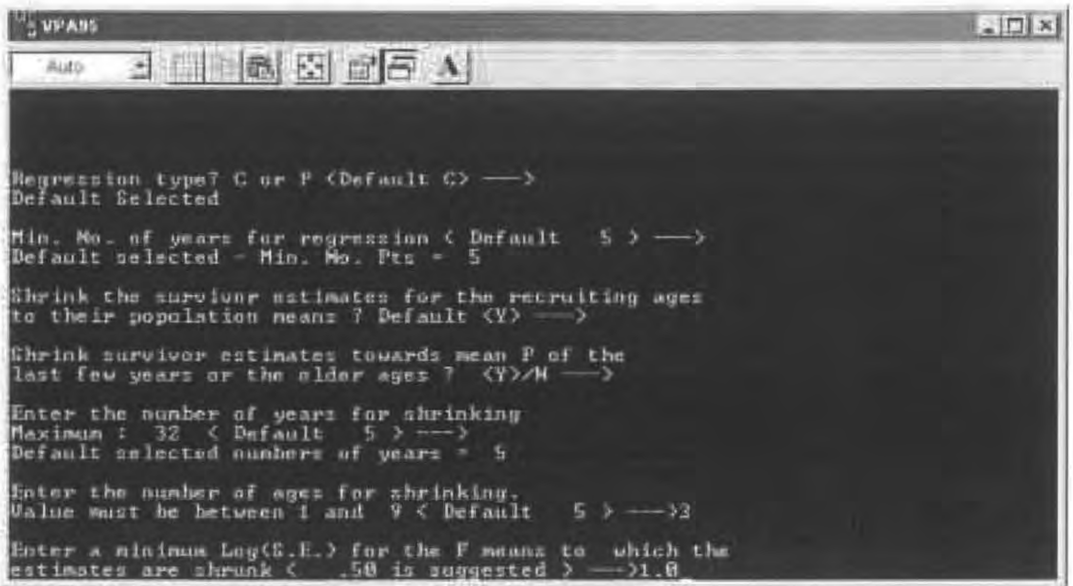
Type ↵ to take the default option of shrinkage to the population mean with the calibration model.

We are then asked whether we wish to use the mean F, calculated over recent years at each age and over the oldest ages to constrain the estimation process (F shrinkage). My personal preference is to start with a low shrinkage weight, allowing the cpue data to determine the survivors. The shrinkage constraint can then be increased later if required. Although it is not required to fit an XSA model, the main reason for keeping the shrinkage option is that we have years of catch data for which we wish to calculate a VPA but have no tuning data. If shrinkage is used, the terminal populations for the oldest age are calculated from the F values at younger ages, a procedure equivalent to the fixed exploitation pattern used within *ad hoc* tuning. By using F shrinkage with a low weight, cohorts without tuning data are initialised by survivor estimates derived from the average fishing mortality. In years for which there is calibration data the high c.v. minimises the influence of the fishing mortality mean. Note that the terminal population estimates are inverse variance weighted averages of the estimates from each cpue series. The weight given to the shrinkage mean (a user supplied value entered as a fractional c.v.) must be chosen relative to the c.v. of the values from the cpue series. A relatively high c.v. of 1.0 may still have a significant weight if the cpue series are noisy.

Type ↵ to take the default of using shrinkage to the mean fishing mortality.

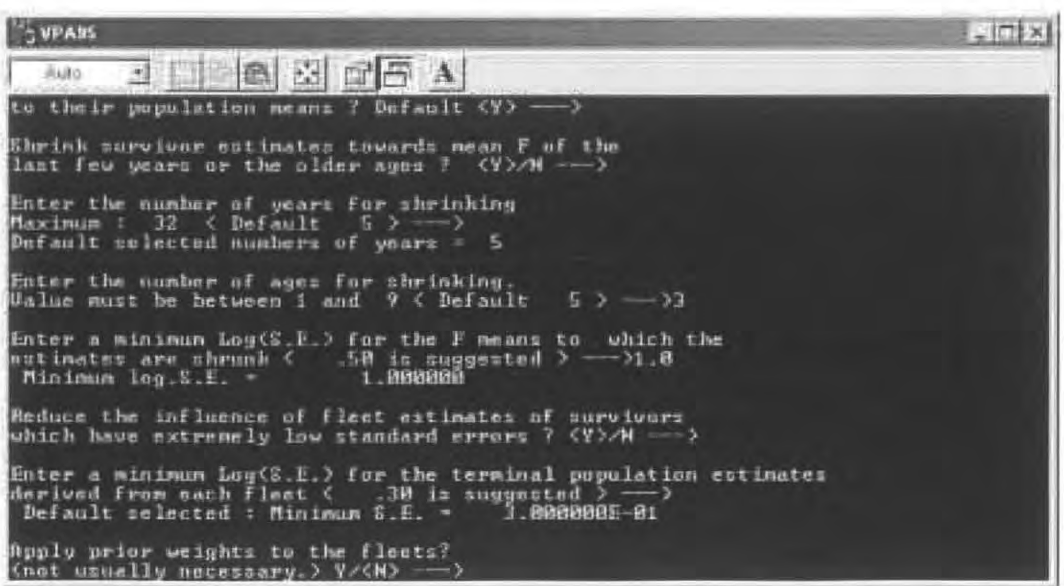
The range of ages over which we are fitting the assessment model is 2–9. The fishing mortality shrinkage mean is calculated over a user-defined range of ages that precede the oldest true age. If the range is too large we will include ages that are not fully recruited to the fishery and could force the assessment to have a dome-shaped selection pattern. We will use a mean taken over three ages.

Type ↵ to use 5 years in the mean across years.
Type 3 ↵ to use 3 ages in the mean across ages.
Type 1.0 ↵ for the weight to be used for the fishing mortality means.



We are using inverse variance weighting within the model fitting procedure. Occasionally one data set can have too great an influence on the fitted assessment and dominate the fit of the model. In order to prevent this we set a maximum for the weight that any observation can take. The weight is specified by entering a minimum for the standard error of any observation. The default value of 0.3 is suitable for this model.

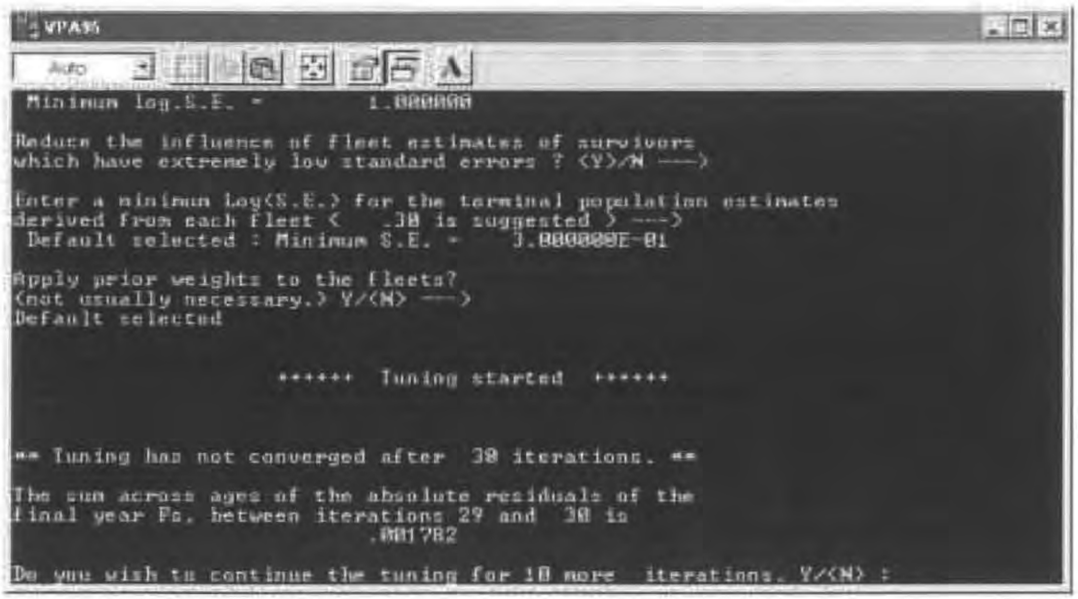
Type ↵ to use a minimum value for the standard error.
Type ↵ to set the minimum to 0.3.



Individual fleet weights can be used to down-weight, usually exclude, some indices from the analysis. In this preliminary run we do not wish to use this.

Type ↵ to take the default option of no individual fleet weighting.

The model now runs the iterative fitting algorithm. Initially 30 iterations are attempted and if convergence is not achieved, measured by the change in final year F values between iterations, then the model asks the user if they wish to run more iterations in batches of 10.



In this example convergence has not been achieved after 30 iterations. We could continue for more but as we are setting up a model it is better to stop the fitting process and examine the diagnostic output file before proceeding.

Once converged or the user has stopped the fitting process, the option is given to print a detailed breakdown of the estimates contributing to the population means. This can be useful in an understanding of which data series contribute most to the fitted model.

Type ↵ to stop the fitting algorithm
Type 1 ↵ to take the full diagnostics output.
Type y ↵ to print adjusted CPUE data.

We return to the main menu and can examine the diagnostics file in a spreadsheet package or text editor. Note that although we have fitted the assessment model we have not calculated the population biomass or printed any results tables. These are created using option 9 at the main menu.

The XSA Tuning Diagnostics File

The results from the current run should be in the file c:\vpas\results\xsatun.csv. The file can be opened in a text editor, word processing or spreadsheet package. The file lists the tuning data file used in the run, the selected range of ages, years and the model options chosen by the user.

Tables 1 - 12 present the results for the converged run; in the following text bold numbers **(x)** refer to labels added to the table. The file listing contains **(1)** the date and time at which the run was performed and the tuning file used for calibrating the VPA. **(2)** The ranges of the catch and calibration index data used to fit the XSA model. **(3)** The specification of the time series weights applied to down-weight older data. **(4)** The specifications for the catchability models. **(5)** The specification of the method for calculating the terminal population estimates. **(6)** The number of iterations performed to reach convergence, or if convergence was not achieved (as in the example), the differences between the final year F values for the last two iterations. **(7)** The time series weights used in down weighting historic data.

Following the model specifications is a selection of the model estimates. The tables are **(8)** the fishing mortality-at-age table for the final ten years of the assessment time series. **(9)** The estimated population numbers-at-age for the last ten assessment years; **(10)** the survivor estimates for the end of the final year (the terminal populations) and **(11)** the taper weighted geometric mean of the final VPA. If the population shrinkage option was selected, the terminal population estimates at the ages at which the power model was fitted were shrunk to the taper-weighted geometric mean population numbers of the next age. In the Blackfin example, the survivors for age 2, estimated at the end of the year, were shrunk to the mean of the population estimates at age 3 (calculated at the beginning of the year). The weight applied to the population shrinkage mean was the reciprocal of the square of the standard error **(12)** of the geometric mean population numbers.

The diagnostics tables from the run are used to examine the fit of the XSA model to the time series of indices at each age; each fleet **(13)** is presented in sequence. The log catchability residuals table **(14)** can be used to examine changes in the fleet – stock interactions (changes in catchability). An incidence of 99.99 indicates a missing (zero) total catch or fleet catch value. Look for year effects running down the columns (e.g. 1987 in the seine residuals), age effects, across the rows and year-class effects that follow the cohort diagonals (e.g. the 1984 cohort at age 2 in 1986 in the light trawl residuals). Recent and sudden changes in catchability may require removal of the fleet from the assessment since departures from the assumptions used in the catchability models can lead to biased estimates of population numbers and exploitation levels.

For the ages with constant catchability with respect to time, examine the log catchability means **(15)** and their standard error **(16)**. The standard error of the log catchability is an indicator of the quality of the data (a fractional coefficient of variation of the fleet's catchability for that age). Values greater than 0.5 indicate problems with that age in the fleet data. High standard errors for the older ages indicate that the assessment should probably be re-run with the problem ages incorporated in a younger plus group.

When combining estimates of terminal population derived from the fleet catches taken at each age, weighting by the inverse of the log catchability variance will reduce the influence of poor quality fleet data. However, if the standard errors of the majority of the important ages for a fleet are poor, the user may wish to remove the fleet from the analysis altogether.

Catchability on the oldest age is poorly determined and, to overcome this, the catchability values for the oldest ages are taken to be equivalent to that of a younger but fully recruited, age. In the initial Blackfin run log catchability at age 6 was constrained to the value at age 5 **(15)**. In order to introduce the greatest possible degree of stability to the assessment, it is necessary to set the age at which catchability is independent of age as low as possible in the fully recruited age range, without affecting the fit of the model at the older ages. The selection of the appropriate age is a process of model refinement. Examine the log catchability values for the ages with constant log catchability with respect to time **(15)** and their standard errors **(16)**. Fig. 2c plots catchability +/- one standard error against age. If, for the oldest ages, catchability does not exhibit large variation from age to age and there are no trends with respect to age, the youngest fully recruited age at which catchability appears to be independent of age is the preferred choice. At the selected age, examine the log catchability standard errors for each fleet; an alternative selection may be required if all of the fleets' log catchabilities, at the selected age, are poorly estimated by the model (s.e.'s >0.5). It is often seen that, if the age at which catchability is held constant is inappropriate, the catchability residuals for the subsequent ages generate blocks of all positive or negative values. Plots such as presented in Figures 2b – 5b aid the detection of problems.

If the log catchability standard errors are acceptable, a series of runs with a stepwise reduction in the age above which catchability is fixed, from the oldest true age-1 to the selected age, can be carried out and the log catchabilities and their standard errors compared with the standard run. Noticeable differences between runs should indicate when to stop.

One reason for choosing the penultimate age for the initial run is that if a trend in catchability with age exists, it is possible to force an inappropriate plateau by selecting too young an age. Also, large variations in catchability for all of the oldest ages in the assessment make it difficult to choose an appropriate age for fixing catchability. In either of these situations it is recommended that the assessment is carried out with catchability for the oldest age determined from the penultimate age. This removes the constraints on the older ages and allows the model to determine the majority of their catchability values independently. In addition, F shrinkage should be used, otherwise the model is badly under-determined and noisy. Due to the increased freedom within the model, the run may require more iterations to achieve a solution.

For each fleet, examine the regression statistics **(17)** for the ages with catchability dependent on year class strength, especially the slope **(18)**, the R square **(19)** and the overall regression standard error **(20)**. The slopes should be tested to see whether they are significantly different from 1.0, if not then catchability is constant with respect to population abundance (direct proportionality). The t-value **(21)** given in the table is derived from t = (slope - 1.0)/ se slope. It can be tested against the t statistic for the required confidence level, obtained from Student's t table with n-2 degrees of freedom – n is the number of data points used for the regression (No Pts) **(22)**.

The XSA algorithm fits the catchability proportional to year class abundance regression to all ages, regardless of whether the results are used within the analysis. This allows an examination of the regression slopes and standard errors for ages fitted with the catchability independent of year class strength model. The column labelled Mean Q **(23)** in the regression diagnostics lists the value of average log catchability derived independently at all ages. Comparison of values with the mean q values listed in **(15)** on the log or un-transformed scale (Fig. 2c–5c) will aid detection of inappropriate values for the age at which catchability is held constant with age.

If requested, XSA will print the final iteration's transformed CPUE values after a run **(40)**. Plotting the log of the CPUE values against the log of the VPA population abundance estimates given in **(9)**, allows an examination of the distribution of the data points about the fitted regression relationships. The graph can be used to examine whether one or two extreme values are dominating the relationships. This practice has also proved useful when examining the fleet CPUE data for ages at which calibration regression generates extreme values that are subsequently weighted out from the tuning process.

For each final year terminal population, the program prints the year class, the age of the cohort in the final year and the model used to derive catchability-at-age **(24)**. If the user selects the long format diagnostics output the program prints the estimate of the terminal population at the end of the final assessment year **(25)** and its raw weight **(26)** estimated for each fleet and each age in the cohort's history. The raw weights are used with the individual estimates of survivors to calculate the fleet-based and overall weighted means. Zero values indicate that the fleet has no data for the age. If the short diagnostics output is selected the individual fleet estimates at age will be omitted and only the following statistics will be tabulated:

A fleet-based weighted mean of the cohort's survivors **(27)**. This is derived from the estimates obtained from the fleet catches at each age in the cohort's history (the raw weights, printed in the long format output, can be used to identify the specific contribution of each estimate).

The internal standard error of the terminal population estimate obtained from a fleet **(28)**. It is derived by combining the standard errors associated with each estimate in the weighted mean and corresponds to the within samples variance of the fleet-based terminal population estimate.

The external standard error of the estimate of survivors obtained from each fleet **(29)**. This is the standard error of the terminal population estimates derived at each age; it corresponds to the between samples variance.

If the values of the internal and external standard errors differ significantly, this indicates a discrepancy between the individual estimates generated by the fleet catches. The variance ratio **(30)**, (external s.e.)^2/(internal s.e.)^2, may be tested as an F statistic with n-1 degrees of freedom. n is the number of estimates of terminal population abundance contributing to the mean, i.e. the number of years in which the fleet removed catches from the cohort. Values exceeding 3 imply that the independent estimates obtained at each age are providing conflicting signals. Too small a value implies an unexpected correspondence of the tuning fleets in relation to the inherent noise.

The scaled weights **(31)** are a measure of the proportional contribution of the fleet's estimates (for all ages) to the overall survivors estimate for the cohort. The weights are not actually used in the derivation of the overall mean, which is a weighted mean (using the raw weights **(26)**) of all the disaggregated (by fleet and age) estimates, including the population and F shrinkage means (if used). The scaled weight is given so that contributions from each fleet can be compared.

The terminal F that would be generated by using the estimate of survivors derived from the fleet to initiate the VPA **(32)** is equivalent to the fleet's raised F generated by the ad hoc tuning procedures. Discrepancies in the signals provided by the fleet data sets can be detected by comparing the F values or the survivor estimates.

If the age is a recruiting age in the assessment and shrinkage to the population mean has been selected, then the estimate of survivors used in the population shrinkage is printed with its standard error, scaled weight and F. The F shrinkage terminal population, the s.e. supplied by the user, scaled weight and F, are also given **(33)**.

The overall weighted geometric mean estimate of survivors at the end of the final year **(34)** is derived by combining all of the estimates of terminal population abundance; the estimates at each age from all fleets and the shrinkage estimates The raw weights used for the overall weighted mean are listed in **(26)**.

The internal standard error **(35)** and external standard error **(36)** of the overall mean, and the variance ratio **(38)** are printed. If the variance ratio exceeds 3, conflicting signals are being given by the disaggregated (by fleet and age) estimates of terminal population. The F test carried out for the individual fleet estimates can be repeated for the overall mean. In this case n is the summation, across fleets, of the number of years in which a fleet removed catches from the cohort. The individual estimates of terminal population abundance **(25)** and the fleet variance ratios **(30)** can be used to identify the fleets and/or ages that are causing problems.

The overall terminal F value for the cohort **(39)** is calculated using the overall weighted mean terminal population and the catch in the final year.

After the diagnostics for each age are printed an optional output of each fleet's corrected CPUE data is tabulated **(40)**. The data are transformed to the beginning of the year using the total fishing mortality values from the final iteration and the alpha and beta values entered in the diagnostics file. The data can be used to examine the distribution of data points about the fitted catchability regressions, as described previously.

The Blackfin example run

The otter trawl fleet cpue series has trends in time in the historic catchability residuals. Catchability increased during the late 1980's then declined during the early 1990's. This is inconsistent with the assumption of constant catchability in time and the large standard errors of log catchability reflect this mismatch. The catchability values are also inconsistent with the proportional to population abundance model, large standard errors and low R square correlation. The high standard errors will result in terminal population estimates from this fleet being heavily down-weighted in the final model estimates and therefore the fleet should be removed from the XSA model. However, the exclusion of the fleet from the model fit on the basis of the lack of correlation between the cpue data and the populations calculated from the catch at age data assumes that the fleet data does not reflect the stock dynamics. If the catch data is biased the VPA estimated populations will be biased and the fleet cpue may reflect the "truth".

The Light trawl cpue series has no trends in log catchability in time. There is a year class effect of low catchability values for the 1984 year class but the values are not extreme relative to the noise in the series. Given that the cohort effect does not reach the final assessment year it will add noise to the terminal population estimates but will not cause any bias. The power model (catchability dependent on population size) is not appropriate for the cpue data at age 2. The t-value indicates that the slope is therefore not significantly different from 1.0 (direct proportionality). The extra parameter fitted in the XSA model is not required. The age (five) at which catchability has been held constant, with respect to age, has resulted in some skew in the residuals calculated for ages 6 and 7 (Fig. 4b). This may be introducing bias at the oldest ages and the sensitivity of the results to this selection should be examined using a re-run with catchability at age seven constrained to that at age six. It would not be expected that the bias has a significant effect on the overall estimates since the catchability values at the older ages are not extremely different from the value at age five (Fig. 4c) and the population numbers at the oldest age are generally low.

The prawn trawl cpue series has pattern in the log-catchability residuals at the oldest ages and consequent high standard errors. Any pattern at the youngest age has been removed by fitting the power model at that age (see also Fig. 4b). The regression model statistics for the fitting of a power model at age 3 are provided even though the model was not used. They indicate that a power or proportional to population abundance model may be appropriate for the cpue at this age (t-value > 2.0, r-square > 0.5, low regression standard error).

The seine trawl cpue has a strong upward trend in catchability during the most recent years. The standard errors are high and for the ages with catchability constant in time have coefficients of variation of greater than 100% indicating that the estimates are poorly determined. Fitting of a power model at age 2 improves the fit of the model and reduces the standard errors through the introduction of the extra parameter. However the level of noise is still substantial. In addition, the slopes of the regression model are all negative, catchability increasing with decreasing population abundance. A clue to the underlying cause of the difficulty in fitting a catchability model is found in the values of R-square, the correlation coefficients for the regression points. The value is very low (close to zero) indicating poor correlation. We therefore have slopes that are potentially significantly different from 1.0 and yet low R-square. This can result from a cloud of data points with outliers that have high leverage, dominating the fitted regression model. Plotting the VPA estimated population abundance against the cpue data corrected to the beginning of the year could help resolve the issue. It would indicate that the data has no signal as to the trends in the stock (as estimated from the catch data) and that the fleet cpue series should not be used in the fitting of the XSA model.

Tables 7–11 present the detailed diagnostic output for the estimation of the terminal populations at the end of the final assessment year. Age 1 in the assessment has catch at age but no calibration or tuning data series. Therefore the estimate of the terminal population at age 2 in the following year is derived from two sources, the time series weighted geometric mean (population shrinkage) and the fishing mortality shrinkage mean. The two estimates of the terminal population differ by two orders of magnitude. This is reflected in the high external variance and the high variance ratio both characteristic of a difference in the estimates from the contributing data sources. The greatest weight (scaled weights) in the final estimate of the terminal population is contributed by the geometric mean. However, even at the low weight given to the fishing mortality shrinkage the very low value has a strong effect on the estimated survivors and raises a question as to the value of including age 1 in the assessment.

At age 2 (Table 7) the final estimate is dominated by the estimate of survivors from the Prawn trawl at age 2 and the population shrinkage geometric mean. This results from the relatively lower standard errors of the two series (Int se). At this age the population shrinkage estimate is higher than all of the fleet estimates and the overall mean is raised by the inclusion of the time series mean. After excluding the noisy fleet cpue series and changing the catchability models, as discussed above, the weighting of the estimates contributed from the series will change and this should be examined here.

Table 8 presents the results for ages 3 and 4. Note that, at these ages, catchability has been modelled as constant in time and therefore the population shrinkage is not used. The summary tables show that the weighted estimates are predominantly derived from the Light trawl and Prawn trawl series and the detailed breakdown shows that the contribution is mostly from ages 2 and 3. The dominance of estimates from separate ages and fleets reflects the poor fit of the catchability models at the youngest ages.

The XSA model should now be re-run and the model parameter and constraint selections altered to the optimum settings for the cpue series. The Otter trawl and seine fleets should be removed from the fitted model. The fastest way of achieving this is to give them a weight of zero using the prior fleet weighting option. In the current XSA program the selection of the age ranges at which the catchability models are applied is specified for all fleets concurrently. However, the most appropriate catchability model for the Light trawl fleet would be the simple proportionality model at all ages, whilst a power model seems appropriate for ages two and three of the Prawn trawl data. In order to fit a model that allows for both options we would go on to fit a power model at the first two ages. For the Prawn trawl fleet this is the required model, for the Light trawl fleet we estimate the slope and intercept rather than forcing them to be one and zero (we waste a parameter). The diagnostics of the new model fit should be examined for the fit of the regression to the Prawn trawl data at age three. Following the examination of the catchability models at the youngest ages, the age at which catchability is held constant with age should be re-evaluated. As noted previously there is a bias in the residuals when age 5 is used as the estimate for ages six and seven. Changes to this assumption should be examined for their effects on residual bias, standard errors and population estimates.

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TABLE 1. The XSA model specification for the Blackfin assessment.

Lowestoft VPA Version 3.1

2/02/2002 11:59 (1)

Extended Survivors Analysis

Blackfin: VPA course. Combined sex; plusgroup.

CPUE data from file c:\vpas\data\blacktun.dat

Catch data for 32 years. 1963 to 1994. Ages 1 to 10. (2)

Fleet	First year	Last year	First age	Last age	Alpha	Beta
Otter trawl	1985	1994	2	6	0	1
Light trawl	1985	1994	2	7	0	1
Prawn trawl	1985	1994	2	4	0	1
Seine	1985	1994	2	5	0	1

Time series weights : (3)

Tapered time weighting not applied

Catchability analysis : (4)

Catchability dependent on stock size for ages < 3

Regression type = C
Minimum of 5 points used for regression
Survivor estimates shrunk to the population mean for ages < 3

Catchability independent of age for ages >= 5

Terminal population estimation : (5)

Survivor estimates shrunk towards the mean F
of the final 5 years or the 3 oldest ages.

S.E. of the mean to which the estimates are shrunk = 1.000

Minimum standard error for population
estimates derived from each fleet = .300

Prior weighting not applied

Tuning had not converged after 30 iterations

Total absolute residual between iterations (6)
29 and 30 = .00178

Final year F values

Age	1	2	3	4	5	6	7	8	9
Iteration 29	0.0001	0.1885	0.2254	0.219	0.1901	0.1541	0.1489	0.1175	0.1368
Iteration 30	0.0001	0.1884	0.2253	0.2188	0.1898	0.1538	0.1487	0.1173	0.1365

Regression weights (7)

1	1	1	1	1	1	1	1	1	1

TABLE 2. The XSA estimates of fishing mortality and population numbers at age during the final 10 years of the assessment time series.

Fishing mortalities **(8)**

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0	0.008	0	0.001	0.001	0.004	0.01	0.002	0.001	0
2	0.072	0.047	0.077	0.168	0.047	0.091	0.102	0.072	0.186	0.188
3	0.26	0.334	0.18	0.401	0.604	0.569	0.332	0.207	0.335	0.225
4	0.279	0.914	0.645	0.49	0.923	0.729	0.68	0.534	0.595	0.219
5	0.267	0.668	0.539	0.541	0.683	0.491	0.533	0.496	0.401	0.19
6	0.35	0.444	0.539	0.645	0.629	0.54	0.501	0.3	0.247	0.154
7	0.376	0.578	0.478	0.85	0.504	0.513	0.638	0.15	0.145	0.149
8	0.293	0.563	0.528	1.109	0.641	0.738	0.457	0.172	0.11	0.117
9	0.342	0.532	0.716	0.962	0.817	0.828	0.742	0.178	0.173	0.136

XSA population numbers (Thousands) **(9)**

	AGE								
YEAR	1	2	3	4	5	6	7	8	9
1985	2.30E+04	3.63E+04	2.47E+04	1.39E+04	6.88E+03	4.61E+03	2.15E+03	8.16E+02	4.00E+02
1986	3.10E+04	1.88E+04	2.76E+04	1.56E+04	8.59E+03	4.31E+03	2.66E+03	1.21E+03	4.99E+02
1987	3.14E+04	2.52E+04	1.47E+04	1.62E+04	5.11E+03	3.60E+03	2.27E+03	1.22E+03	5.64E+02
1988	2.23E+04	2.57E+04	1.91E+04	1.00E+04	6.95E+03	2.44E+03	1.72E+03	1.15E+03	5.90E+02
1989	2.30E+04	1.82E+04	1.78E+04	1.05E+04	5.04E+03	3.31E+03	1.05E+03	6.03E+02	3.11E+02
1990	1.74E+04	1.88E+04	1.42E+04	7.96E+03	3.40E+03	2.08E+03	1.45E+03	5.19E+02	2.60E+02
1991	1.68E+04	1.42E+04	1.41E+04	6.60E+03	3.14E+03	1.70E+03	9.93E+02	7.09E+02	2.03E+02
1992	2.00E+04	1.36E+04	1.05E+04	8.26E+03	2.74E+03	1.51E+03	8.46E+02	4.30E+02	3.68E+02
1993	1.90E+04	1.64E+04	1.04E+04	6.96E+03	3.96E+03	1.37E+03	9.15E+02	5.96E+02	2.96E+02
1994	2.00E+04	1.55E+04	1.11E+04	6.07E+03	3.14E+03	2.17E+03	8.73E+02	6.48E+02	4.37E+02

Estimated population abundance at 1st Jan 1995 **(10)**

0.00E+00	1.64E+04	1.05E+04	7.27E+03	4.00E+03	2.13E+03	1.53E+03	6.17E+02	4.73E+02

Taper weighted geometric mean of the VPA populations: **(11)**

2.68E+04	2.17E+04	1.62E+04	9.34E+03	4.80E+03	2.58E+03	1.42E+03	7.84E+02	4.23E+02

Standard error of the weighted Log(VPA populations) : **(12)**

0.2871	0.2954	0.3078	0.3797	0.4307	0.5088	0.6226	0.6843	0.7408

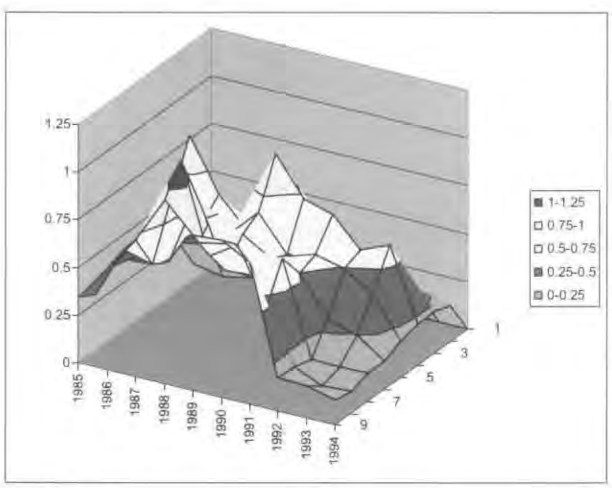

Fig. 1. Fishing mortality-at-age by year as estimated by XSA, note the very strong change in selection at the oldest ages in the most recent years.

TABLE 3. The Otter trawl log catchability residuals at age, the estimated log catchability and the power model regression diagnostics.

Log catchability residuals.

Fleet : Otter trawl **(13)**

(14)

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
2	0.77	1.21	-0.98	0.25	-1.06	-1.42	1.17	0.02	0.3	-0.25
3	-1.68	-0.09	-1.56	0.25	0.82	1.32	0.63	0.22	-0.01	0.09
4	-2.4	-1.08	-0.27	0.25	0.58	2.42	1.13	0.21	-1.14	0.29
5	-2.82	-1.42	-1.11	0.6	0.29	2.69	1.49	0.61	-1.06	0.72
6	-1.28	-0.83	-0.29	-0.01	0.82	2.61	0.96	0.49	-0.42	0.27
7	No data for this fleet at this age									

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	3	4	5	6	
Mean Log q	-14.0782	-14.6821	-14.954	-14.954	**(15)**
S.E(Log q)	0.9547	1.3325	1.6025	1.1215	**(16)**

Regression statistics : **(17)**

Ages with q dependent on year class strength

Age	Slope **(18)**	t-value **(21)**	Intercept	RSquare **(19)**	No Pts **(22)**	Reg s.e **(20)**	Mean Log q
2	0.93	0.067	14.56	0.1	10	0.98	-14.92

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q **(23)**
3	5.63	-0.875	34.59	0	10	5.45	-14.08
4	-1.16	-1.641	2.76	0.07	10	1.42	-14.68
5	-0.62	-2.376	4.34	0.21	10	0.81	-14.95
6	-6.23	-1.472	-35.17	0.01	10	6.41	-14.72

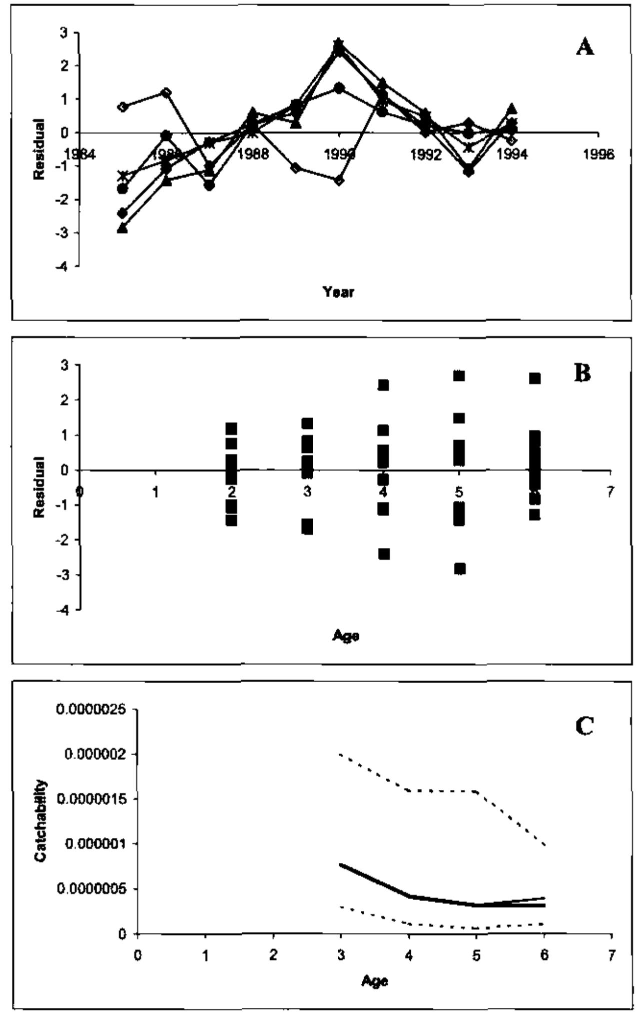

Fig. 2. The Otter trawl log catchability residuals plotted against (**A**) time and (**B**) age and (**C**) estimated catchability +/- one standard deviation.

TABLE 4. The Light trawl log catchability residuals at age, the estimated log catchability and the power model regression diagnostics.

Fleet : Light trawl

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
2	-0.4	-1.44	1.21	0.41	-1.23	0.13	0.49	0.01	0.87	-0.04
3	0.31	0.12	-0.54	-0.39	0.28	0.58	-0.17	-0.25	-0.06	0.12
4	0.46	0.63	-0.9	-0.81	-0.21	0.83	0.53	0.04	-0.59	0.01
5	-0.8	0.74	-0.48	0.32	-0.45	0.31	0.96	0.05	-1.06	0.42
6	0.02	-0.54	-0.64	-0.8	-0.13	-0.11	0.28	-0.33	0.09	0.36
7	-0.91	-0.22	-0.43	-1.28	-0.3	0.35	0.38	-0.5	0.13	-0.02

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	3	4	5	6	7
Mean Log q	-15.5176	-15.7286	-16.2817	-16.2817	-16.2817
S.E(Log q)	0.3457	0.6204	0.6706	0.4326	0.6058

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
2	1.21	-0.22	17.58	0.12	10	0.89	-16.22

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
3	0.81	0.688	14.39	0.62	10	0.29	-15.52
4	1.24	-0.324	17.33	0.18	10	0.81	-15.73
5	1.28	-0.364	18.44	0.18	10	0.9	-16.28
6	1.49	-1.114	20.67	0.4	10	0.57	-16.46
7	2.07	-1.334	26.54	0.16	10	1.05	-16.56

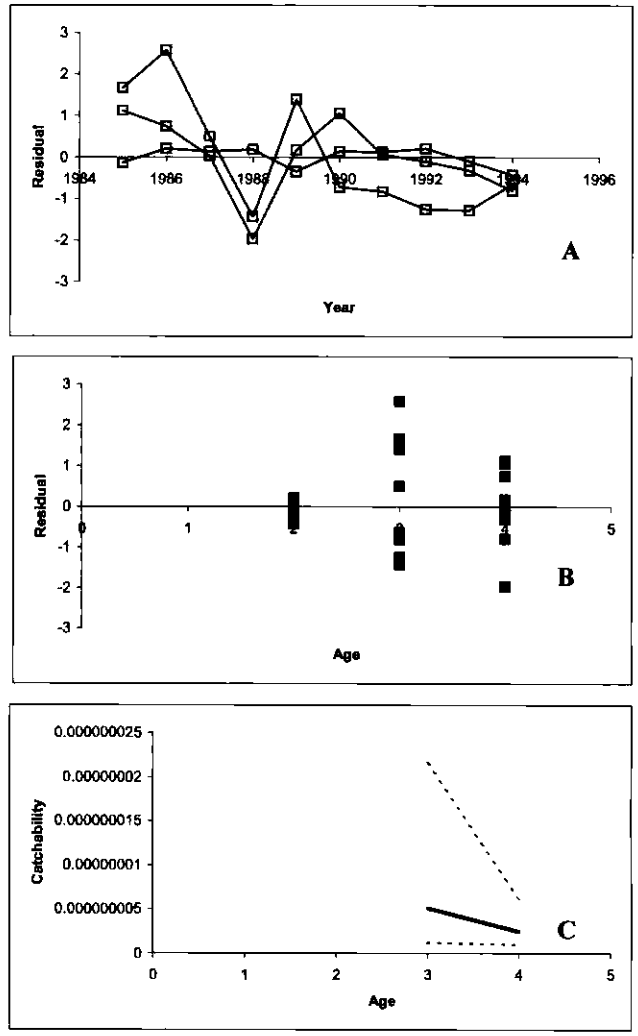

Fig. 3. The Light trawl log catchability residuals plotted against (**A**) time and (**B**) age and (**C**) estimated catchability +/- one standard deviation

TABLE 5. The Prawn trawl log catchability residuals at age, the estimated log catchability and the power model regression diagnostics.

Fleet : Prawn trawl

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
2	-0.14	0.21	0.14	0.18	-0.35	0.14	0.13	0.21	-0.09	-0.42
3	1.67	2.58	0.5	-1.43	1.4	-0.72	-0.82	-1.25	-1.28	-0.64
4	1.12	0.74	0.03	-1.97	0.17	1.06	0.07	-0.1	-0.31	-0.8
5	No data for this fleet at this age									
6	No data for this fleet at this age									
7	No data for this fleet at this age									

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	3	4
Mean Log q	-19.0864	-19.8161
S.E(Log q)	1.4344	0.9164

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
2	0.34	2.446	12.86	0.63	10	0.25	-18.79

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
3	0.23	3.643	11.84	0.74	10	0.22	-19.09
4	0.55	0.975	14.98	0.37	10	0.5	-19.82

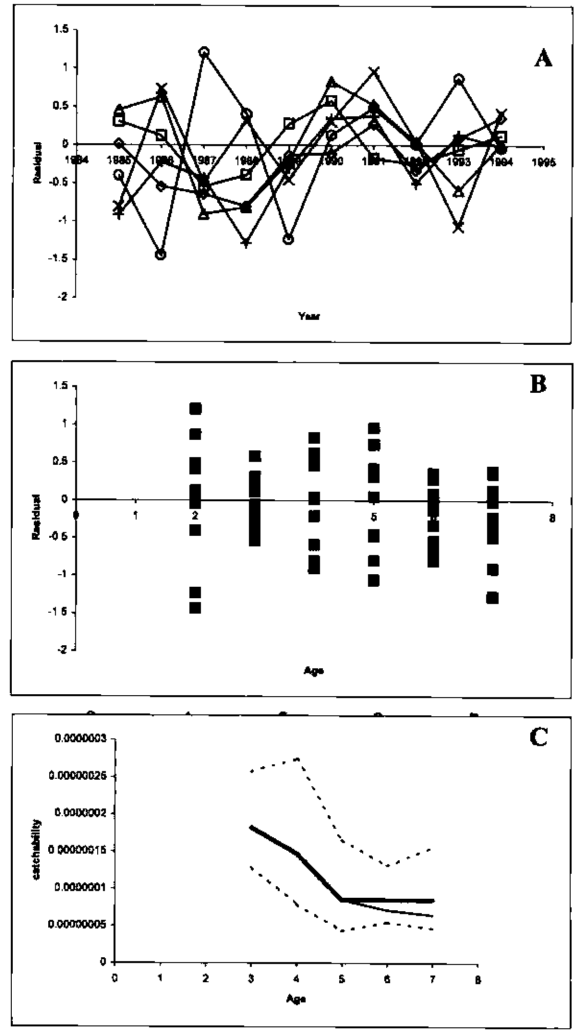

Fig. 4. The Prawn trawl log catchability residuals plotted against (**A**) time and (**B**) age and (**C**) estimated catchability +/- one standard deviation

TABLE 6. The Seine log catchability residuals at age, the estimated log catchability and the power model regression diagnostics.

Fleet : Seine

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
2	0.01	0.55	-0.57	-0.1	0.72	0.59	0.08	-0.15	-0.65	-0.48
3	-0.9	-0.32	-1.59	-0.67	-0.35	-0.29	0.56	0.78	1.11	1.68
4	-0.56	0.67	-1.69	-0.85	-0.58	-0.48	0.22	1.62	0.14	1.52
5	-1.67	1.09	-1.94	0.15	-1.36	-0.19	0.11	1.59	0.45	1.77
6	No data for this fleet at this age									
7	No data for this fleet at this age									

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	3	4	5
Mean Log q	-15.5078	-15.7074	-16.4243
S.E(Log q)	1.0043	1.0477	1.3153

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
2	-0.43	-2.516	7.31	0.28	10	0.52	-15.8

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
3	-1.07	-2.485	3.37	0.15	10	0.86	-15.51
4	-1.75	-1.811	-2.26	0.05	10	1.64	-15.71
5	-3.52	-1.187	-19.71	0.01	10	4.52	-16.42

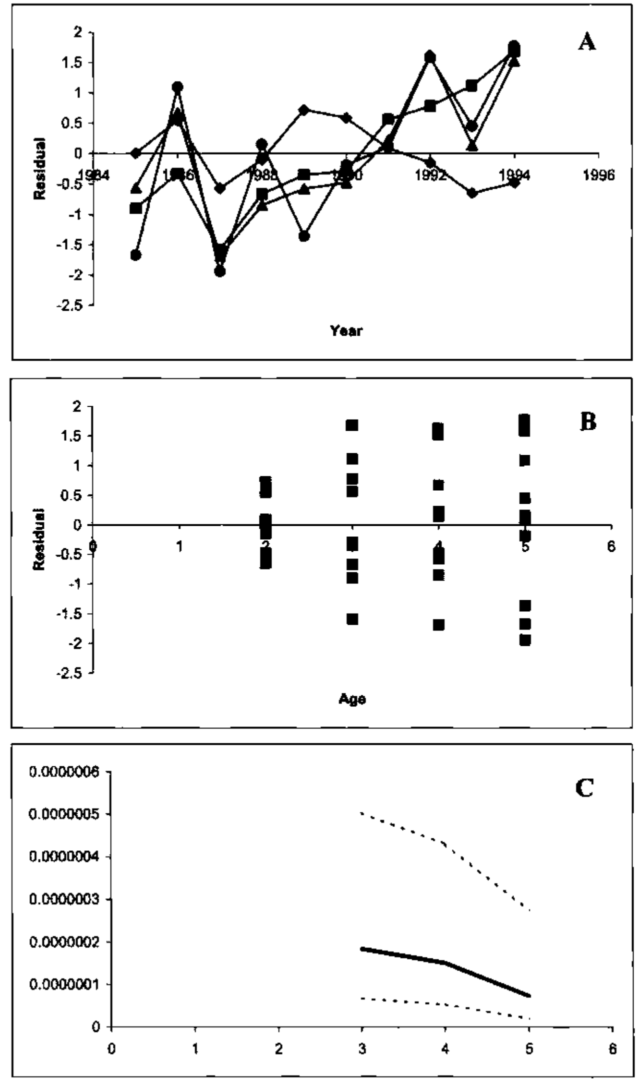

Fig. 5. The Seine log catchability residuals plotted against (A) time and (B) age and (C) estimated catchability +/- one standard deviation

TABLE 7. The XSA estimates of Blackfin terminal population numbers and fishing mortality and their standard errors at ages 1 and 2.

Fleet disaggregated estimates of survivors :

Age 1 Catchability dependent on age and year class strength

Year class = 1993

Otter trawl	
Age	1
Survivors	0
Raw Weights	0
Light trawl	
Age	1
Survivors	0
Raw Weights	0
Prawn trawl	
Age	1
Survivors	0
Raw Weights	0
Seine	
Age	1
Survivors	0
Raw Weights	0

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Otter trawl	1	0	0	0	0	0	0
Light trawl	1	0	0	0	0	0	0
Prawn trawl	1	0	0	0	0	0	0
Seine	1	0	0	0	0	0	0
P shrinkage mean	21733	0.3				0.92	0
F shrinkage mean	657	1				0.08	0.003

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
16412	0.28	9.75	2	34.421	0

Age 2 Catchability dependent on age and year class strength

Year class = 1992

Otter trawl		
Age	2	1
Survivors	8174	0
Raw Weights	0.759	0
Light trawl		
Age	2	1
Survivors	10140	0
Raw Weights	0.936	0
Prawn trawl		
Age	2	1
Survivors	6904	0
Raw Weights	9.203	0
Seine		
Age	2	1
Survivors	6505	0
Raw Weights	2.387	0

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Otter trawl	8174	1.045	0	0	1	0.031	0.236
Light trawl	10140	0.941	0	0	1	0.038	0.195
Prawn trawl	6904	0.3	0	0	1	0.37	0.274
Seine	6505	0.589	0	0	1	0.096	0.289
P shrinkage mean	16215	0.31				0.425	0.126
F shrinkage mean	20703	1				0.04	0.1

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
10518	0.19	0.26	6	1.372	0.188

TABLE 8. The XSA estimates of Blackfin terminal population numbers and fishing mortality and their standard errors at ages 3 and 4.

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 1991

Otter trawl			
Age	3	2	1
Survivors	7940	9770	0
Raw Weights	0.796	0.62	0
Light trawl			
Age	3	2	1
Survivors	8210	17278	0
Raw Weights	6.073	0.712	0
Prawn trawl			
Age	3	2	1
Survivors	3814	6620	0
Raw Weights	0.353	7.365	0
Seine			
Age	3	2	1
Survivors	39081	3781	0
Raw Weights	0.72	1.824	0

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F	
	(27)	**(28)**	**(29)**	**(30)**		**(31)**	**(32)**	
Otter trawl	8695	0.722	0.103	0.14	2	0.073	0.192	
Light trawl	8876	0.34	0.228	0.67	2	0.349	0.188	
Prawn trawl	6455	0.294	0.115	0.39	2	0.397	0.25	
Seine	7321	0.525	1.052	2	2	0.131	0.224	
F shrinkage mean	3599	1				0.051	0.412	**(33)**

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
7272	0.19	0.16	9	0.848	0.225
(34)	**(35)**	**(36)**	**(37)**	**(38)**	**(39)**

Age 4 Catchability constant w.r.t. time and dependent on age

(24) Year class = 1990

	Otter trawl				
	Age	4	3	2	1
(25)	Survivors	5338	3955	4058	0
(26)	Raw Weights	0.411	0.573	0.495	0
	Light trawl				
	Age	4	3	2	1
	Survivors	4045	3743	4027	0
	Raw Weights	1.898	4.374	0.6	0
	Prawn trawl				
	Age	4	3	2	1
	Survivors	1788	1112	4940	0
	Raw Weights	0.87	0.254	5.941	0
	Seine				
	Age	4	3	2	1
	Survivors	18174	12077	3429	0
	Raw Weights	0.665	0.518	1.643	0

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Otter trawl	4336	0.65	0.092	0.14	3	0.077	0.203
Light trawl	3849	0.304	0.026	0.09	3	0.357	0.226
Prawn trawl	4131	0.284	0.296	1.04	3	0.367	0.212
Seine	6396	0.463	0.528	1.14	3	0.147	0.142
F shrinkage mean	966	1				0.052	0.699

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
3997	0.18	0.16	13	0.867	0.219

TABLE 9. The XSA estimates of Blackfin terminal population numbers and fishing mortality and their standard errors at ages 5 and 6.

Age 5 Catchability constant w.r.t. time and dependent on age

Year class = 1989

Otter trawl					
Age	5	4	3	2	1
Survivors	4380	680	2648	6875	0
Raw Weights	0.293	0.234	0.37	0.291	0

Light trawl					
Age	5	4	3	2	1
Survivors	3229	1185	1666	3469	0
Raw Weights	1.672	1.077	2.82	0.38	0

Prawn trawl					
Age	5	4	3	2	1
Survivors	0	1560	607	2422	0
Raw Weights	0	0.494	0.164	3.719	0

Seine					
Age	5	4	3	2	1
Survivors	12545	2453	4636	2300	0
Raw Weights	0.435	0.378	0.334	1.088	0

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Otter trawl	2899	0.643	0.462	0.72	4	0.08	0.143
Light trawl	1977	0.293	0.223	0.76	4	0.403	0.203
Prawn trawl	2189	0.283	0.204	0.72	3	0.297	0.185
Seine	3592	0.452	0.381	0.84	4	0.152	0.117
F shrinkage mean	644	1				0.068	0.525

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2132	0.18	0.15	16	0.851	0.19

Age 6 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1988

Otter trawl						
Age	6	5	4	3	2	1
Survivors	2005	529	1886	2879	368	0
Raw Weights	0.62	0.203	0.172	0.241	0.169	0

Light trawl						
Age	6	5	4	3	2	1
Survivors	2191	528	1585	1287	1739	0
Raw Weights	4.164	1.161	0.795	1.838	0.251	0

Prawn trawl						
Age	6	5	4	3	2	1
Survivors	0	0	1385	671	1753	0
Raw Weights	0	0	0.364	0.107	2.45	0

Seine						
Age	6	5	4	3	2	1
Survivors	0	2398	7703	2669	2755	0
Raw Weights	0	0.302	0.279	0.218	0.666	0

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Otter trawl	1424	0.637	0.357	0.56	5	0.094	0.164
Light trawl	1530	0.273	0.241	0.89	5	0.547	0.153
Prawn trawl	1644	0.284	0.135	0.48	3	0.195	0.144
Seine	3241	0.466	0.244	0.52	4	0.098	0.075
F shrinkage mean	451	1				0.067	0.447

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1529	0.19	0.15	18	0.777	0.154

TABLE 10. The XSA estimates of Blackfin terminal population numbers and fishing mortality and their standard errors at ages 7 and 8.

Age 7 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1987

Otter trawl							
Age	7	6	5	4	3	2	1
Survivors	0	405	1137	1915	2315	213	0
Raw Weights	0	0.487	0.145	0.106	0.117	0.093	0
Light trawl							
Age	7	6	5	4	3	2	1
Survivors	604	671	645	1048	1095	181	0
Raw Weights	2.135	3.27	0.829	0.491	0.894	0.106	0
Prawn trawl							
Age	7	6	5	4	3	2	1
Survivors	0	0	0	663	300	436	0
Raw Weights	0	0	0	0.225	0.052	1.246	0
Seine							
Age	7	6	5	4	3	2	1
Survivors	0	0	3032	767	461	1266	0
Raw Weights	0	0	0.216	0.172	0.106	0.328	0

Fleet	:stimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Otter trawl	658	0.694	0.392	0.57	5	0.079	0.14
Light trawl	694	0.278	0.115	0.41	6	0.643	0.133
Prawn trawl	458	0.288	0.119	0.41	3	0.127	0.195
Seine	1258	0.507	0.358	0.71	4	0.068	0.076
F shrinkage mean	205	1				0.083	0.393

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
617	0.21	0.13	19	0.6	0.149

Age 8 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1986

Otter trawl								
Age	8	7	6	5	4	3	2	1
Survivors	0	0	769	2094	5304	1074	608	0
Raw Weights	0	0	0.412	0.118	0.083	0.088	0.068	0
Light trawl								
Age	8	7	6	5	4	3	2	1
Survivors	0	536	339	1234	1086	625	708	0
Raw Weights	0	1.906	2.767	0.676	0.381	0.67	0.08	0
Prawn trawl								
Age	8	7	6	5	4	3	2	1
Survivors	0	0	0	0	1355	1916	562	0
Raw Weights	0	0	0	0	0.174	0.039	0.828	0
Seine								
Age	8	7	6	5	4	3	2	1
Survivors	0	0	0	524	291	331	428	0
Raw Weights	0	0	0	0.176	0.133	0.079	0.244	0

Fleet	:stimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Otter trawl	1124	0.713	0.327	0.46	5	0.077	0.051
Light trawl	511	0.284	0.196	0.69	6	0.653	0.109
Prawn trawl	682	0.293	0.273	0.93	3	0.105	0.083
Seine	404	0.513	0.126	0.25	4	0.064	0.136
F shrinkage mean	110	1				0.101	0.426

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
473	0.22	0.17	19	0.744	0.117

TABLE 11. The XSA estimates of Blackfin terminal population numbers and fishing mortality and their standard errors at age 9.

Age 9 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 1985

Otter trawl									
Age	9	8	7	6	5	4	3	2	1
Survivors	0	0	0	816	4597	560	400	117	0
Raw Weights	0	0	0	0.295	0.088	0.051	0.066	0.055	0

Light trawl									
Age	9	8	7	6	5	4	3	2	1
Survivors	0	0	189	412	426	253	211	1046	0
Raw Weights	0	0	1.667	1.981	0.505	0.234	0.505	0.055	0

Prawn trawl									
Age	9	8	7	6	5	4	3	2	1
Survivors	0	0	0	0	0	369	75	359	0
Raw Weights	0	0	0	0	0	0.107	0.029	0.683	0

Seine									
Age	9	8	7	6	5	4	3	2	1
Survivors	0	0	0	0	260	175	160	176	0
Raw Weights	0	0	0	0	0.131	0.082	0.06	0.197	0

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Otter trawl	788	0.71	0.479	0.68	5	0.071	0.056
Light trawl	293	0.294	0.176	0.6	6	0.635	0.145
Prawn trawl	340	0.285	0.207	0.73	3	0.105	0.126
Seine	194	0.507	0.106	0.21	4	0.06	0.212
F shrinkage mean	303	1				0.128	0.14

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
313	0.24	0.12	19	0.502	0.136

TABLE 12. The Blackfin catch-per-unit effort data corrected to the beginning of the year using the estimated fishing mortalities and natural mortality.

(40)

Otter trawl

CPUE adjusted to start of year

YEAR	AGE 1	2	3	4	5	6	7	8	9
1985	0	0.02893	0.00354	0.00053	0.00013	0.00041	0	0	0
1986	0	0.02282	0.01939	0.00222	0.00067	0.00061	0	0	0
1987	0	0.00296	0.00238	0.00519	0.00054	0.00086	0	0	0
1988	0	0.01142	0.0188	0.00544	0.00408	0.00078	0	0	0
1989	0	0.00191	0.03114	0.00789	0.00215	0.0024	0	0	0
1990	0	0.00134	0.04116	0.03761	0.01603	0.0091	0	0	0
1991	0	0.01618	0.0204	0.00862	0.00447	0.00143	0	0	0
1992	0	0.00446	0.01001	0.00429	0.00162	0.00079	0	0	0
1993	0	0.00735	0.00789	0.00094	0.00044	0.00029	0	0	0
1994	0	0.00385	0.00934	0.00341	0.00207	0.00091	0	0	0

Prawn trawl

CPUE adjusted to start of year

YEAR	AGE 1	2	3	4	5	6	7	8	9
1985	0	0.00057	0.00067	0.0001	0	0	0	0	0
1986	0	0.00023	0.00187	8.1E-05	0	0	0	0	0
1987	0	0.00044	0.00012	4.1E-05	0	0	0	0	0
1988	0	0.00053	2.3E-05	3.5E-06	0	0	0	0	0
1989	0	4E-05	0.00037	3.1E-05	0	0	0	0	0
1990	0	0.00019	3.6E-05	5.7E-05	0	0	0	0	0
1991	0	7.8E-05	3.2E-05	1.8E-05	0	0	0	0	0
1992	0	8.9E-05	1.5E-05	1.9E-05	0	0	0	0	0
1993	0	6.2E-05	1.5E-05	1.3E-05	0	0	0	0	0
1994	0	2E-05	3E-05	6.7E-06	0	0	0	0	0

Light trawl

CPUE adjusted to start of year

YEAR	AGE 1	2	3	4	5	6	7	8	9
1985	0	0.0021	0.00613	0.00325	0.00026	0.0004	7.4E-05	0	0
1986	0	0.00052	0.0057	0.00434	0.00153	0.00021	0.00018	0	0
1987	0	0.00586	0.00156	0.00097	0.00027	0.00016	0.00013	0	0
1988	0	0.00308	0.00235	0.00066	0.00081	9.4E-05	4.1E-05	0	0
1989	0	0.0006	0.0043	0.00125	0.00027	0.00025	6.6E-05	0	0
1990	0	0.0019	0.00462	0.0027	0.00039	0.00016	0.00017	0	0
1991	0	0.00201	0.00216	0.00166	0.0007	0.00019	0.00012	0	0
1992	0	0.00131	0.00149	0.00127	0.00024	9.2E-05	4.4E-05	0	0
1993	0	0.0031	0.00177	0.00057	0.00012	0.00013	8.8E-05	0	0
1994	0	0.00141	0.00229	0.00091	0.0004	0.00026	7.3E-05	0	0

Seine

CPUE adjusted to start of year

YEAR	AGE 1	2	3	4	5	6	7	8	9
1985	0	0.00061	0.00185	0.00119	9.5E-05	0	0	0	0
1986	0	0.00079	0.00369	0.00457	0.00187	0	0	0	0
1987	0	0.00546	0.00055	0.00045	5.4E-05	0	0	0	0
1988	0	0.00173	0.0018	0.00065	0.0006	0	0	0	0
1989	0	0.00058	0.0023	0.00088	9.5E-05	0	0	0	0
1990	0	0.00073	0.00196	0.00074	0.00021	0	0	0	0
1991	0	0.00459	0.00453	0.00124	0.00026	0	0	0	0
1992	0	0.00855	0.0042	0.00629	0.00099	0	0	0	0
1993	0	0.0178	0.00577	0.00121	0.00046	0	0	0	0
1994	0	0.01349	0.01101	0.00417	0.00136	0	0	0	0

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Appendix 1: Lowestoft Stock Assessment Suite

Tutorial 5

Retrospective Analysis (RETVPA00.EXE)

by

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Abstract

This document is number five in a series of tutorials designed to assist users of the Lowestoft VPA Suite assessment software and prediction programs that use the results. The tutorial takes the user through the options required for running the retrospective program RETVPA00.EXE.

Introduction

Retrospective studies have established that patterns of consistent under- or over-estimation bias in estimates of F and population numbers-at-age can be produced by the application of assessment methodologies to fish stock data (Sinclair *et al*., MS 1990, ICES, MS 1991). Such biases may cause problems in the advice given to managers and therefore need to be examined and if possible removed from the assessment and subsequent predictions.

This tutorial takes the user through the options required for running the program RETVPA00.EXE and carrying out a retrospective analysis of an XSA model structure. The tutorial assumes that the required Blackfin data files have been placed in a directory c:\vpas\data\, and that the index file (Blackfin.ind) contains path names that point to the appropriate files.

Description of the method

For each stock and analysis procedure a series of assessments are performed with the terminal year decreased by one year at each run. This simulates the results of assessments with progressively shorter time series. All input parameters to the analysis are held constant, e.g. number of tuning data years, time series weights, reference ages. The values estimated by the most recent assessment, derived from all available data, are assumed to be the 'truth' and compared with the estimates from the runs which pre-date it. The accuracy of an assessment methodology is determined by its ability to consistently predict the 'truth'. Bias is the degree to which the method consistently under- or over-estimates the 'truth'. The analysis procedure usually involves the creation of retrospective time series plots for particular assessment estimates (e.g. F, population numbers-at-age, SSB) followed by a statistical or subjective analysis of the accuracy and bias of the method.

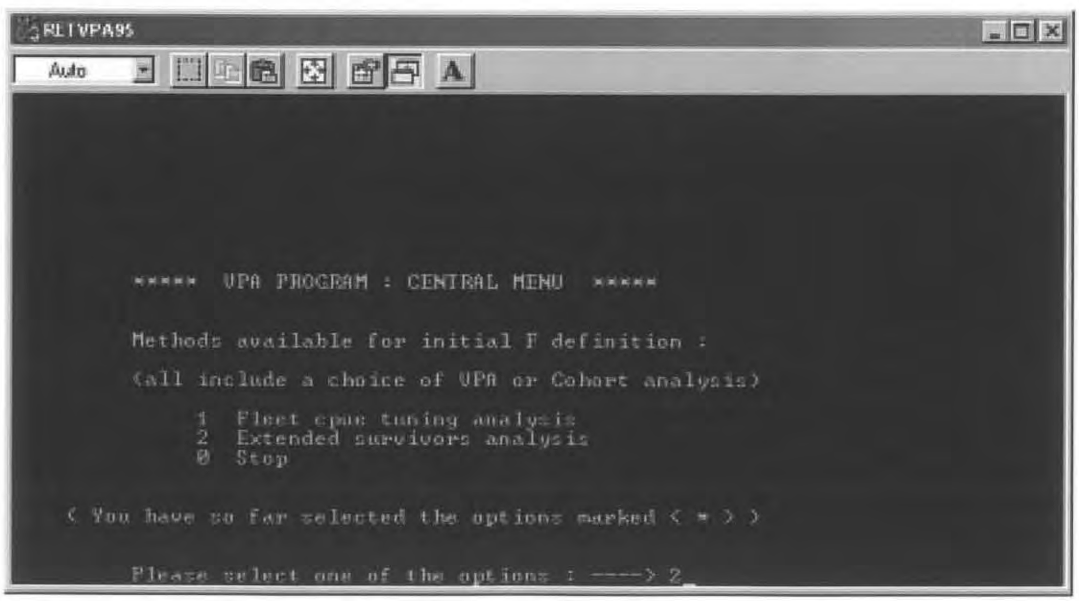
When carrying out retrospective analyses the selection of tuning fleets to be used in the assessments is important. Fleets with short time series should be avoided. As the program steps back through the data range they may drop out when there are insufficient years of fleet data for the specified analysis. In addition, short series with artificially low standard errors may erroneously dominate the assessment. The use of short time series can introduce sudden changes in the retrospective patterns and should be avoided. If required, the short series can be reintroduced for restricted retrospective analyses after the full runs.

Retrospective Extended Survivors Analysis

In the following text **action to be taken by the user** is highlighted in bold. The symbol ↵ is used to represent the Return or Enter key on the keyboard.

Open the VPA suite program and read in the index file C:\VPAS\DATA\BLACKFIN.IND. Take the default year, age and summary mean settings until the main menu is reached.

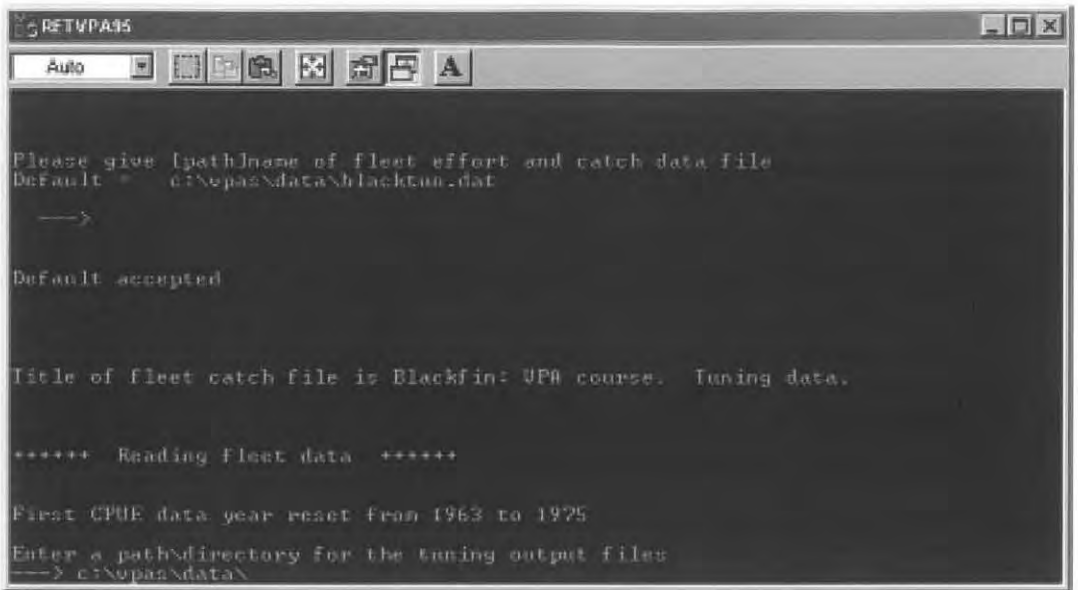
Note that we only have two options for the assessment model that we can run.



Type 2 ↵ to select the XSA model.
Type ↵ to select the default tuning data file, Blacktun.dat

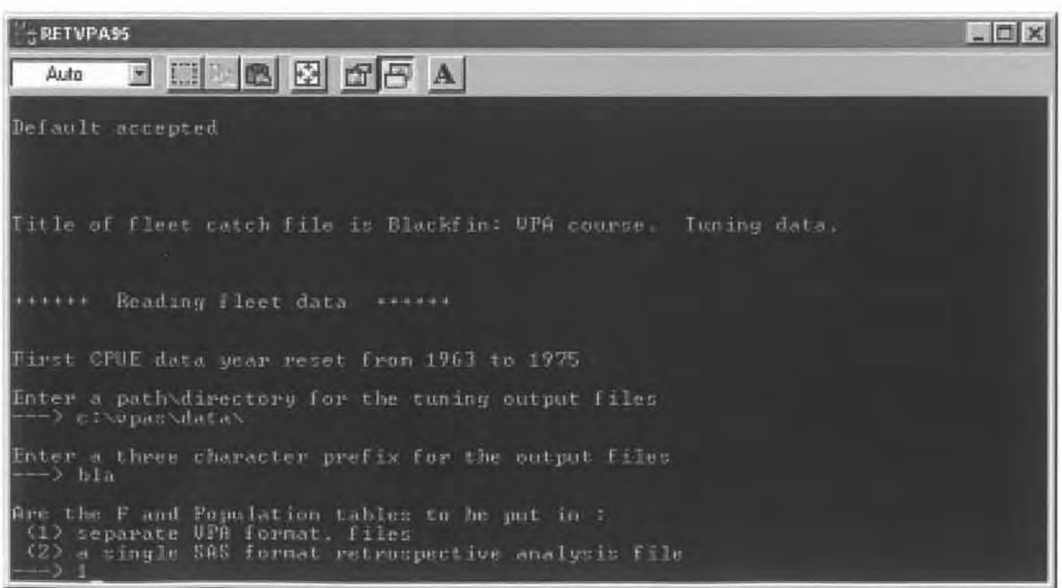
The retrospective program steps back in time fitting assessment models which finish in successively earlier years. It produces tuning diagnostic and population summary files. The user can specify where the files are to be placed.

Enter a directory path for the output files.



The program asks for a three letter code to prefix the output files for later identification. The program will create each tuning file by adding RT<yr>.CSV to the end of the prefix, <yr> represents the terminal year for the assessment being performed.

Enter a three letter code for the data files.



In addition to the tuning diagnostics files, the program generates output tables with one of two user-selected formats. They are:

1) F and population numbers-at-age tables for each assessment in the retrospective series and the stock time series summary (Tables 8, 10 and 16 from the main menu of the output from the main suite). The program will create each output file by adding RO<yr>.CSV to the end of the user-defined prefix.

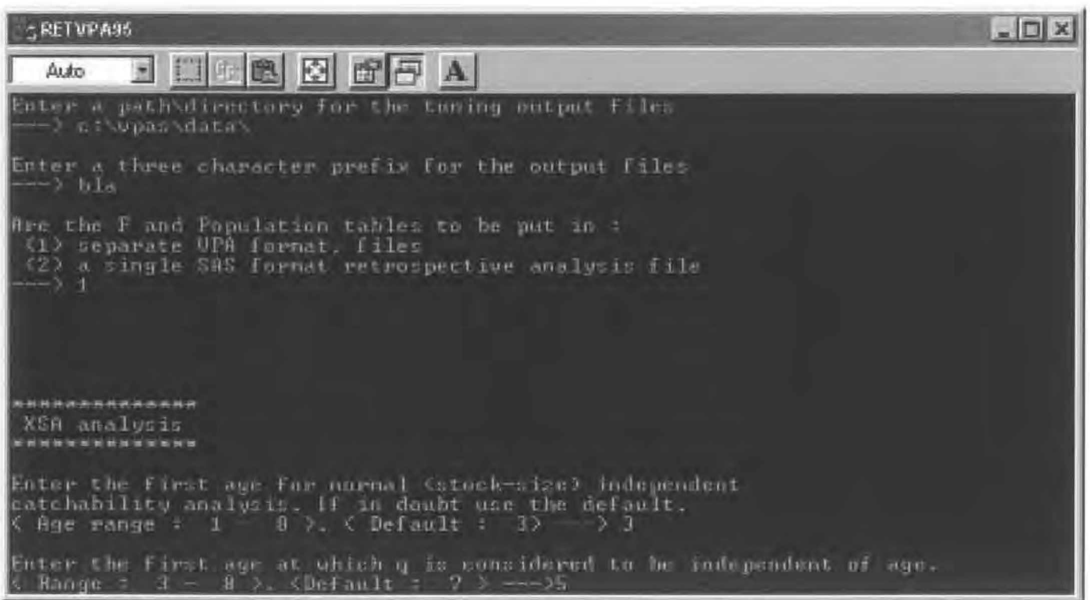
2) A single file containing the F and population numbers tables from each run in the format defined for the SAS program used to generate the figures and summary tables presented in ICES (MS 1991) and ICES (MS 1993).

Type 1 to output separate files.

We now set up the XSA analysis model that we wish to use retrospectively. The options are taken from Tutorial 4 that describes the fitting of the XSA model to the Blackfin data set.

Type 3 ↵ as the first age for the constant catchability model, that is, age 2 has a power model.

Type 5 ↵ so that catchability at ages older than 5 is set at that estimated at age 5.



Type Y ↵ in order to change the default XSA settings.

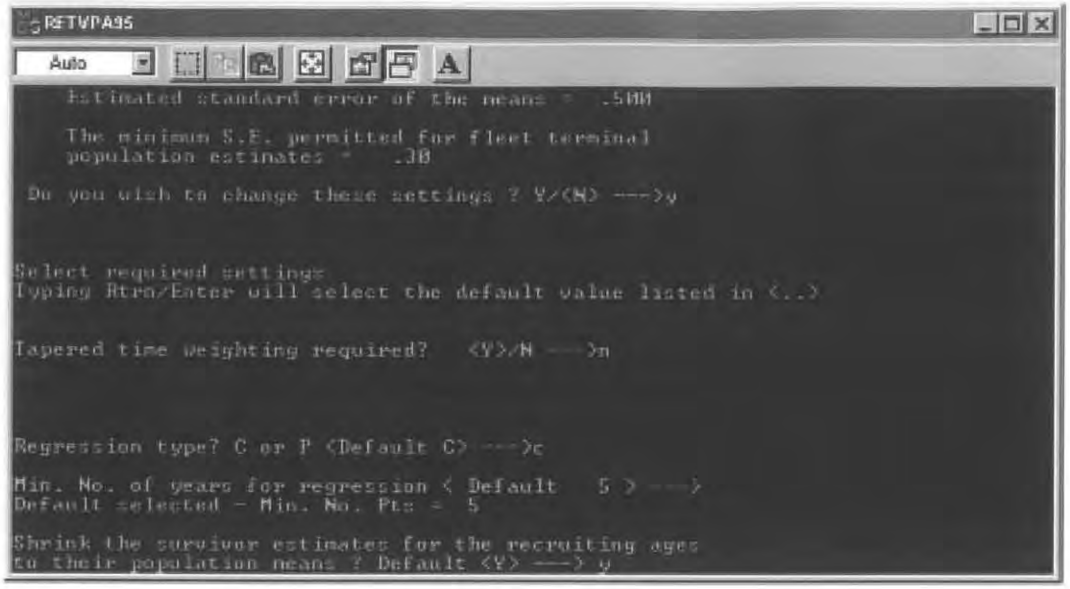
Type N ↵ to use all data in the time series with equal weight.

Type ↵ to apply the default calibration regression model

Type ↵ to take the default of a minimum of 5 data points for the fitting of a regression model.

Type ↵ to use the default option of shrinkage to the population mean with the calibration regression.

Type ↵ to take the default of using shrinkage to the mean fishing mortality.



Type ↵ to use 5 years in the fishing mortality shrinkage mean across years.

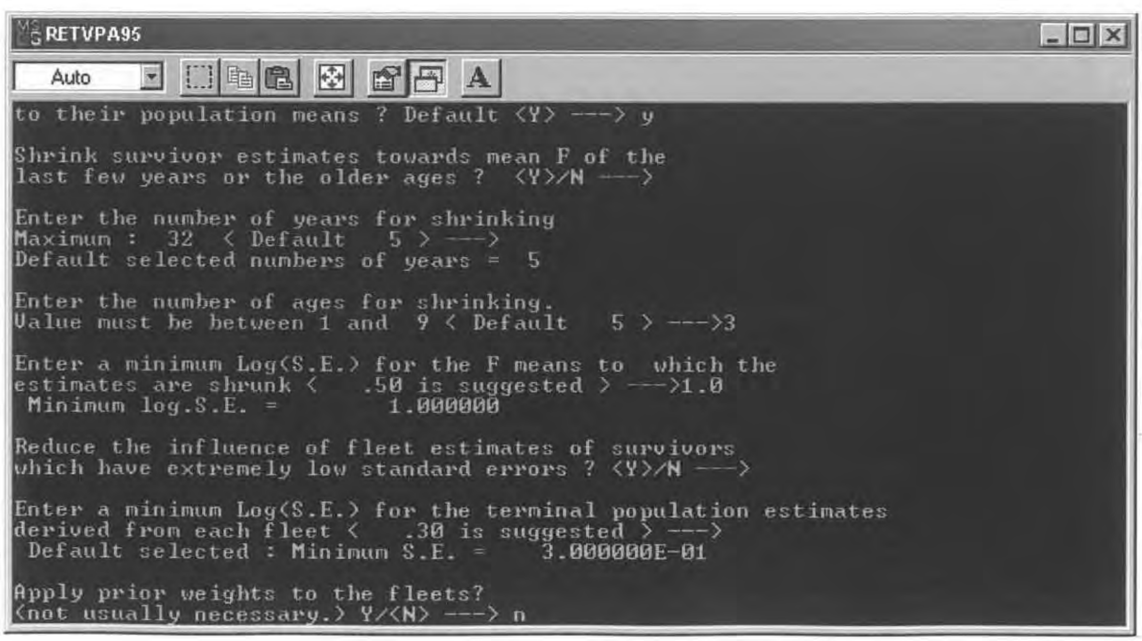
Type 3 ↵ to use 3 ages in the fishing mortality shrinkage mean across ages.

Type 1.0 ↵ for the weight (c.v) to be used for the fishing mortality shrinkage means.

Type ↵ to use a minimum value for the standard error.

Type ↵ to set the minimum to 0.3.

Type ↵ to take the default option of no individual fleet weighting.



After selection of the assessment method and model fitting options, the program asks an additional series of questions in order to define the characteristics of the retrospective run:

The first question refers to the use of the tuning data time series. The user can select between:

(1) a tuning range window, e.g. 10 years of fleet data, which is moved backwards with the terminal year for each new assessment, or
(2) the full data range in the tuning file and the removal of the most recent years data as the program steps back for each new terminal year.

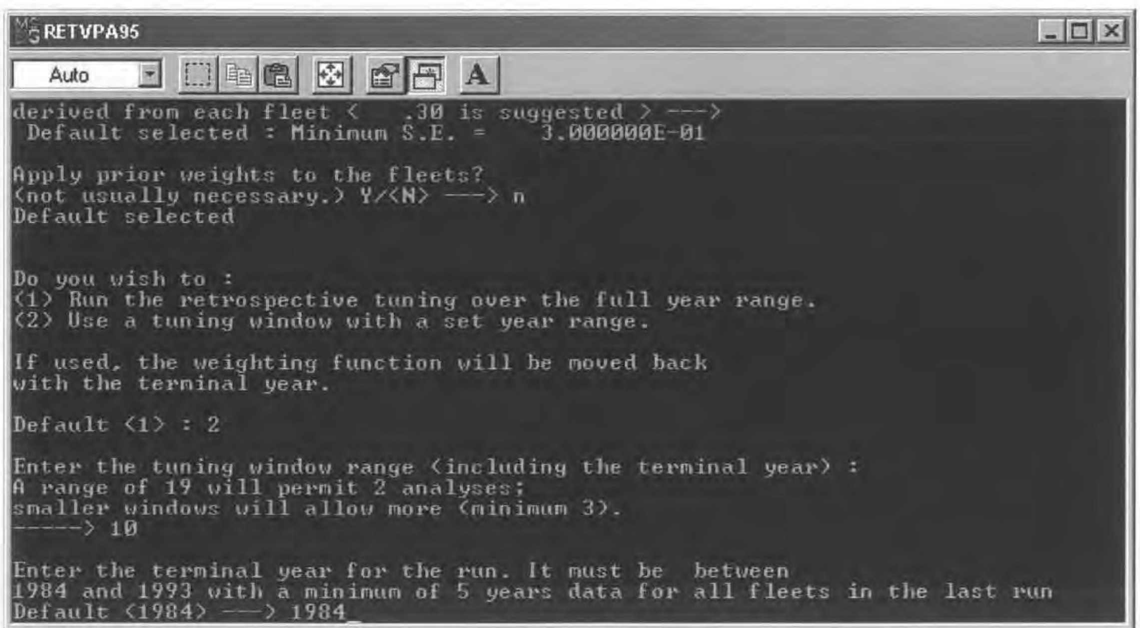
Time series weights, if used, are moved back with the assessment terminal year.

Type 2 to use a tuning window that will be moved back in time for each assessment.

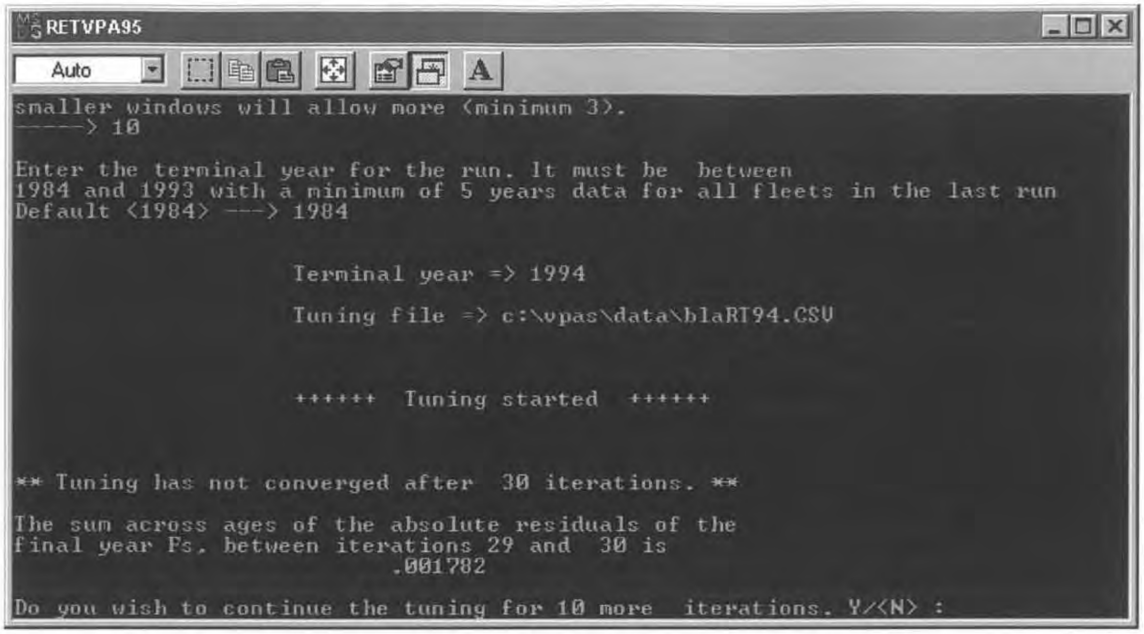
Type 10 for the number of years to use for the tuning range

The next question defines the number of years for which the retrospective analysis is to be run. Enter the finishing year for the run: the earliest terminal year. Acceptable values lie between the penultimate year in the data file and the earliest year in the complete tuning range that allows 5 years of data for each fleet. Short fleet tuning series should be removed if a retrospective series with sufficient comparison years for an acceptable analysis is to be achieved (8 years of tuning data will give 4 assessments in the retrospective series).

Type 1984 **for the final assessment year.**

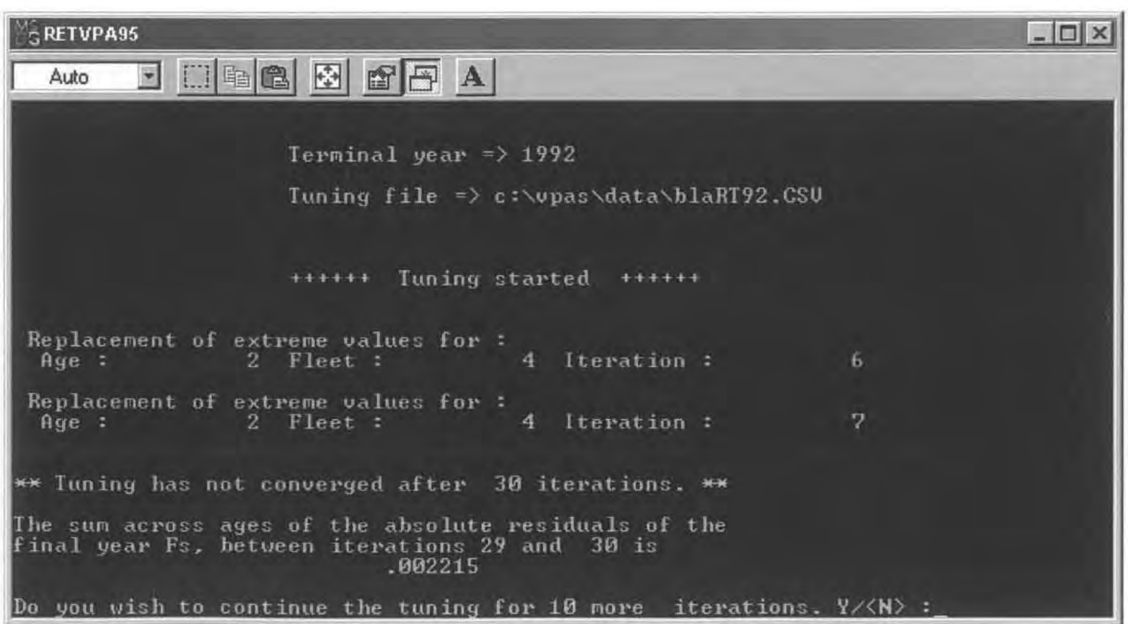


The program then begins the retrospective analysis of the data sets, printing the terminal year for the current assessment to the screen.

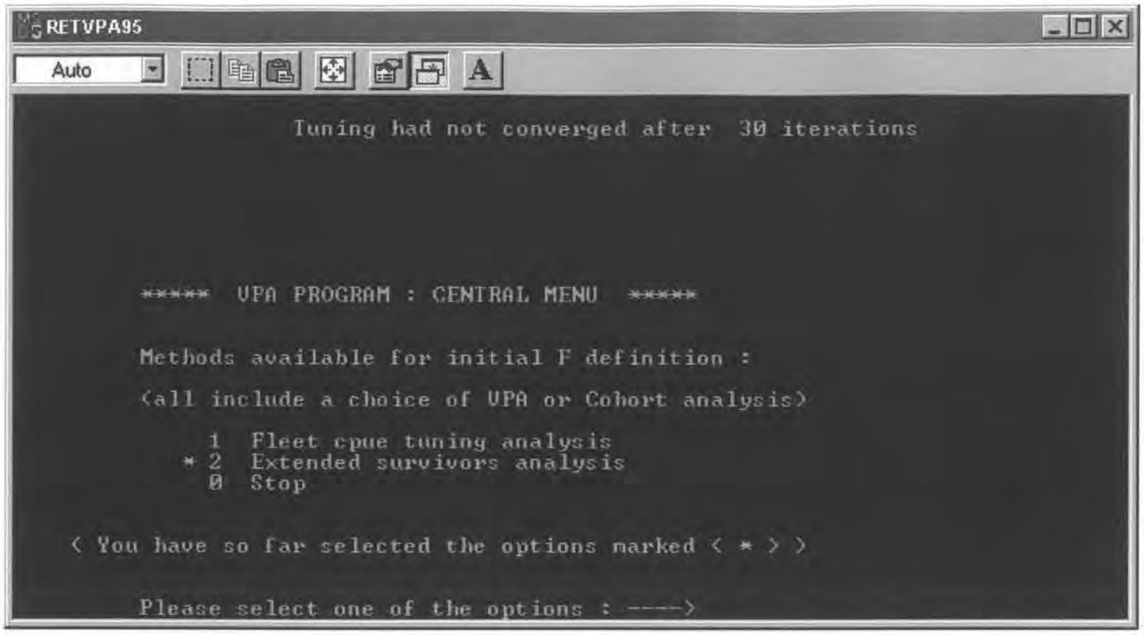


If the assessment has not converged after the required numbers of iterations (described earlier for each of the methods) the program will request clearance for further iterations.

When converged or the current assessment is terminated by the user, the program will write the output data to the file defined earlier. It will then proceed with the next assessment in the series.



After fitting an assessment to each of the user defined year ranges, the program returns to the central menu.



Results

In the directory specified for the retrospective analysis output files the program will write a tuning analysis and output summary file (Table 16) from each model fit. They are identified by the three character prefix followed by _ _ _RT<yr>.CSV, for the tuning file name and _ _ _RO<yr>.CSV for the summary files; <yr> represents the terminal year of the fitted assessment.

The analysis procedure involves the creation of retrospective time series plots for particular assessment estimates. Fig. 1–3 present the retrospective plots for the Blackfin assessment model. Fig. 1 is a plot of the time series of average fishing mortality estimates from each fit of the XSA model, Fig. 2 the estimates of recruitment and Fig. 3, spawning stock biomass.

The objective of the analysis is to compare the variation between the 'truth', the final assessment in the series, and the values estimated in each terminal year by earlier assessments. Note that this assumes that the most recent assessment, which uses all of the available data is the most unbiased.

For the majority of the time series of assessments, XSA estimates of the Blackfin stock fishing mortality are consistent from year to year (Fig. 1). The first two model fits overestimated fishing mortality; and in the most recent assessment runs there is a systematic under-estimation of average F with this XSA model structure. The model has consistently picked up the trends and the change points in fishing mortality.

The XSA estimates of Blackfin recruitment have been relatively consistent from year to year (Fig. 2). Historically there are three years in which the level of recruitment was underestimated and in recent years there is a systematic over-estimation of recruitment when using the specified XSA model structure. When fitting the XSA model we have used the power model at age 2.

The retrospective pattern for spawning stock biomass is of greater concern. Overall the assessments show an increase in the stock size during the 1960s and 1970s with a decline since the early 1980s. However, the rate at which that decline took place and when it began is uncertain (Fig. 3a). The most recent assessments with terminal years from 1990 to 1994 indicate that with the addition of more years of data the estimation of SSB is more consistent from year to year. There is no retrospective pattern that would cause concern (Fig. 3b).

Retrospective series should now be used to investigate the influence of particular assessment parameters (e.g. shrinkage to the mean F) on the accuracy and bias of the terminal year estimates. Changes to the assessment model structure are evaluated not only in terms of their influence on the model diagnostics, but also their ability to remove bias in the retrospective patterns of key model estimates. For SSB the changes to the model structure may not be required. For this stock we would be trying to improve the consistency of the estimates of fishing mortality and recruitment in the most recent years. For example a repeat of the retrospective run with a proportional catchability model at age 2 could be used to test the improvement in the predictions for recruitment.

Retrospective runs should be performed with a range of values for the selected parameter (all other parameter values are held constant), and the model structure producing the 'best' retrospective pattern chosen as the optimum value for the assessment of the particular stock. In order to simplify the analysis, it is assumed that there are no interactions in the effects on the assessment predictions.

Discussion

Sinclair *et al.* (MS 1990) and ICES (MS 1991) have shown that the biases in F and N estimates appear to be stock specific, and data induced. They are not attributable to a particular tuning methodology. Sinclair *et al.*, (MS 1990) concluded that the retrospective patterns found in the estimates for the stocks of the Northwest Atlantic could result from patterns of misreporting, trends in catchability, or mis-specification of natural mortality. Each will affect the data in a particular way and therefore influence the outcome of the tuning procedures.

ICES (MS 1991) established that the degree of bias could usually be reduced by the introduction of shrinkage to the mean F to the assessment packages. Subsequent work by the Methods Working Group has examined the influence of the degree of shrinkage imposed on the assessment (ICES, MS 1993). It recommended that retrospective analyses be used regularly to screen stock assessments.

The retrospective problem has been recognized as widespread and serious. The reasons why this problem appears are not fully known. There is a general understanding that trends in catchability, when used in models that assume constancy can cause this effect. However, it has been clearly demonstrated that the problem is more complex and that for example trends or shifts in natural mortality, discards and misreporting, mis-specification of selection and catchability at age can contribute to the problem, sometimes in a quite complex way (ICES, MS 1997).

Warning

There may be cases where the present estimate of the stock trajectory is biased, whilst those in the past may have been "right" (ICES, MS 1997). This is illustrated by the early retrospective series of the Blackfin retrospective sequence. The retrospective assessments carried out with the terminal years between 1984 and 1988 (Fig. 3c) show that the SSB was apparently consistently under-estimated during those years. In each successive year the level of SSB is increased and the latest assessment in the sequence estimates that there was a high stable stock between 1973–84.

Taking the final assessment estimates, with terminal year 1988, as the "truth", the assessment model structure would usually be altered to make the earlier assessment as consistent as possible with it. However if we examine the most recent assessments with the early series (Fig. 3c) is seen that the retrospective pattern noted in the early years was caused by the assessment estimates having a successively greater bias from the "truth" – the most recent (1994) perception of the stock trends. The estimated SSB series terminating in 1988 was actually the most distant (biased) from the most recent perception of the stock dynamics. This is a warning case where alteration of the assessment model structure to correct the retrospective pattern would have induced bias to the assessment results. Simply changing the assessment model structure to correct a retrospective pattern would have been incorrect in this instance.

References

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ICES. MS 1991 Report of the Working Group on Methods of Fish Stock Assessment. *ICES C.M. Doc.*, No. /Assess: 25, 147 p.

1993 Report of the Working Group on Methods of Fish Stock Assessment. *ICES C.M. Doc.*, No. /Assess:12, 86 p.

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SINCLAIR, A., D. GASCON, R. O'BOYLE, D. RIVARD and S. GAVARIS, MS 1990. Consistency of some Northwest Atlantic groundfish stock assessments. *NAFO SCR Doc.*, No. 96, Serial No. N1831, 26 p.

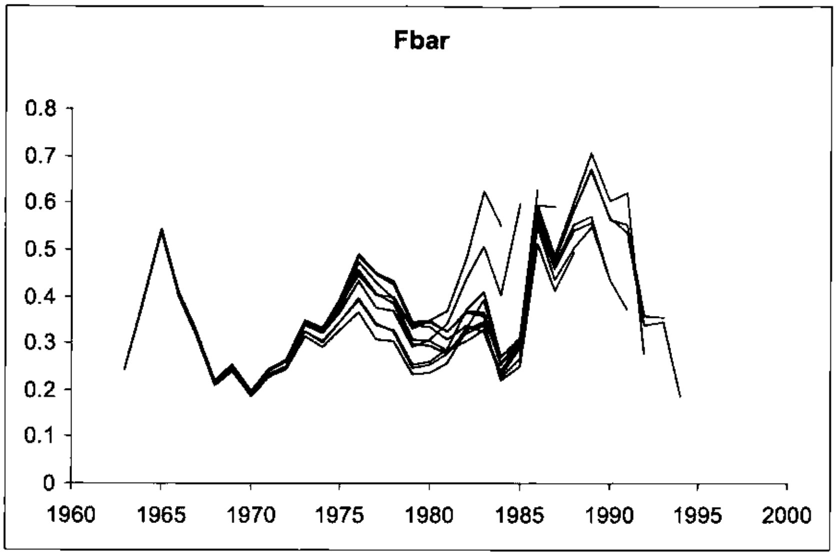

Fig. 1. The retrospective time series of XSA estimates of Blackfin average fishing mortality.

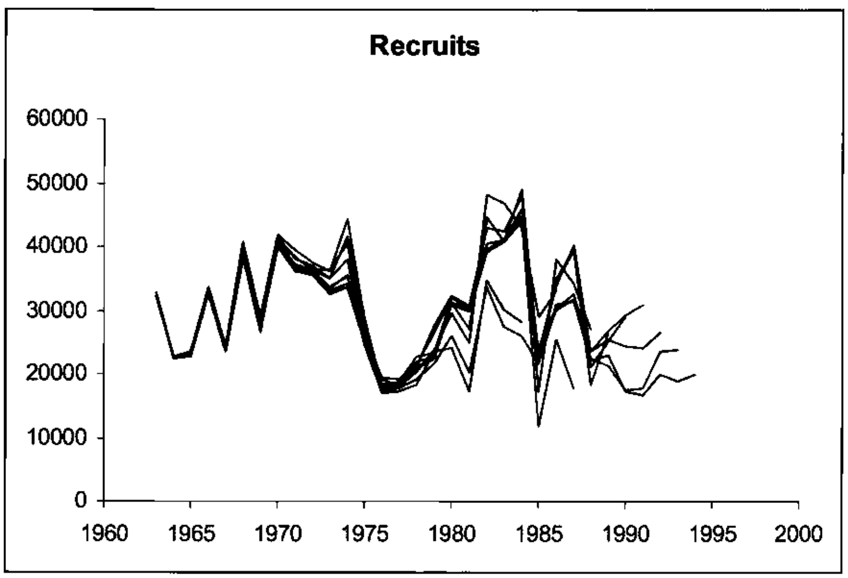

Fig. 2. The retrospective time series of XSA estimates of recruitment-at-age 1 to the Blackfin stock

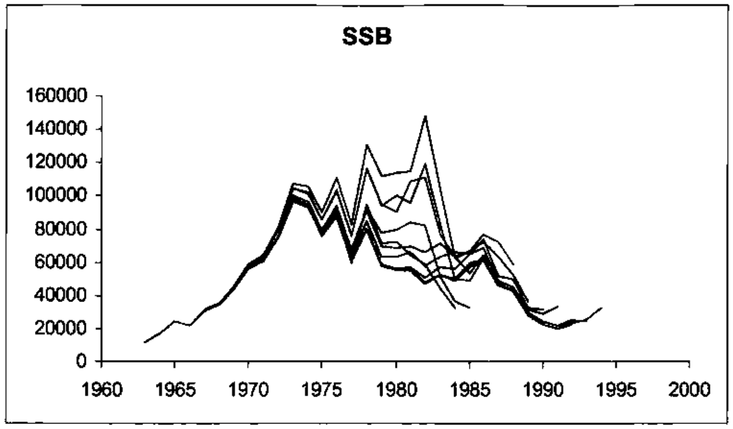

Fig. 3a. The retrospective time series of XSA estimates of spawning stock bioass of the Blackfin stock for the assessments ending in the years 1984–94.

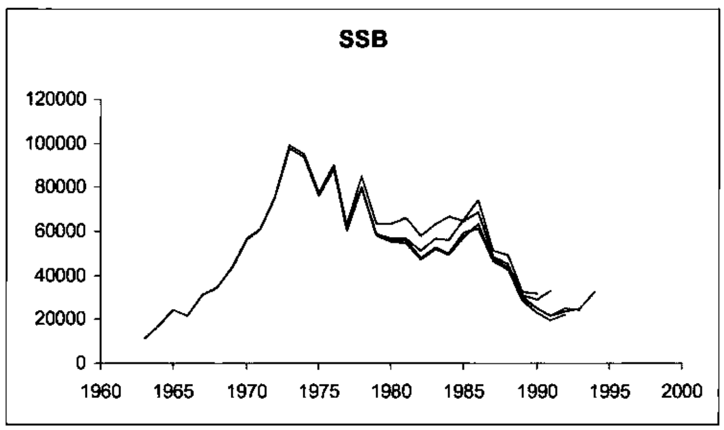

Fig. 3b. The retrospective time series of XSA estimates of spawning stock bioass of the Blackfin stock for the assessments ending in the years 1990–94.

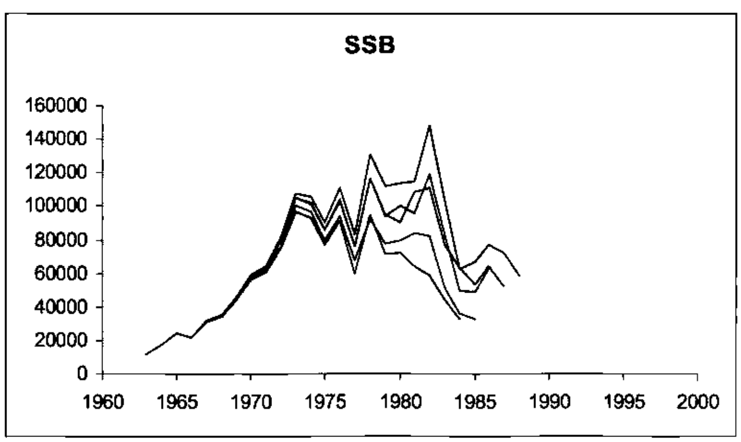

Fig. 3c. The retrospective time series of XSA estimates of spawning stock bioass of the Blackfin stock for the assessments ending in the years 1984 – 1988.

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Appendix 1: Lowestoft Stock Assessment Suite

Tutorial 6

The Multi-Fleet Deterministic Projection Program (MFDP)

by

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Abstract

This document is number six in a series of tutorials designed to assist users of the Lowestoft VPA Suite assessment software and prediction programs which use the results. The tutorial takes the user through the options required for running the multi-fleet deterministic projection program MFDP developed for ICES at CEFAS.

Introduction

This document is part of a series of tutorials that provide an introduction to the Lowestoft VPA Suite assessment software and programs which make use of the results from it. The tutorial takes the user through the options required for running multi-fleet deterministic projection program MFDP1a.exe. The tutorial assumes that the required Blackfin data files have been placed in a directory c:\vpas\data\prediction, and that the prediction index files (Blpred_standard.ind, Blpred_discards.ind) contain path names that point to the appropriate files.

In the following text **action to be taken by the user** is highlighted in bold. The symbol ↵ is used to represent the Return or Enter key on the keyboard.

Installation of the Program

Copy the directory C:\VPAS\PROGRAMS\MFDP\ to a directory on your computer. Using Explorer go to the directory C:\VPAS\PROGRAMS\MFDP\Disk1. Start the program Setup.exe and follow the on screen instructions

Data Files

The program will carry out predictions using historic data sets from age structured assessments. The user selects the targets for fishing mortality or TAC constraints for each fleet from within the user dialogs. In addition the program will allow the user to set up future selection pattern and catch weight files that can be used to examine potential changes in selection etc. Here we only consider runs from historic data.

The program uses an index file that is similar to (but not the same as) the Lowestoft format index file used for inputting data to the Lowestoft VPA Suite stock assessment program (Darby and Flatman 1994). The index file for historic data is given below, the differences in the index files are that the first, ninth, tenth and eleventh files from the VPA suite list have been omitted in MFDP. The missing files are the total landings and the optional fishing mortality on the oldest age, fishing mortality in the final year and fleet tuning files.

Several files have been added to the list required for MFDP, these are:

for single fleet or category disaggregated predictions

1) the fishing mortality at age for each of the historic assessment years;

2) population numbers at age for the historic assessment years **and one extra year** the survivors at the start of the year after the final assessment year;

in addition **for multifleet predictions**

3) a file for each fleet with total and category disaggregated catch numbers at age
4) a file for each fleet with total and category disaggregated catch weights at age

The complete index file list for a run using historic data is given below:

Index file contents	Index file number
Title	
Historic data flag (1 = Historic, 0 = Future)	
Total catch numbers at age numbers file name and path	2
Weight at age in the catch file name and path	3
Weight at age in the stock file name and path	4
Natural mortality file name and path	5
Proportion mature file name and path	6
Proportion of F before spawning file name and path	7
Proportion of M before spawning file name and path	8
Fishing mortality file name and path	12
Population numbers file name and path	13

If the prediction is not fleet or category disaggregated then this is sufficient, however if fleet or category disaggregation is required then the following lines are required.

Index file contents	Index number
Number of fleets	
Fleet 1 catch numbers at age file name and path	2
...	2
Fleet n catch numbers at age file name and path	2
Fleet 1 weight at age in the catch file name and path	3
...	3
Fleet n weight at age in the catch file name and path	3
An optional control file, if specified it must always be the last file.	

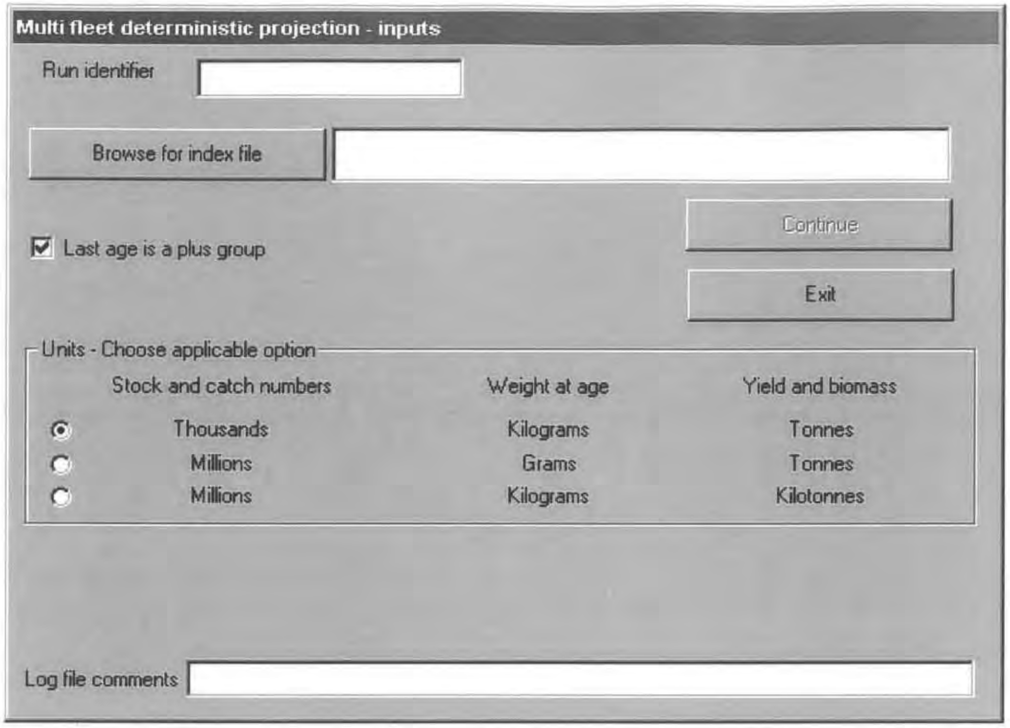
Note: If the population and fishing mortality files from the final assessment have a different age range to that of the initial VPA suite input data files, the program will make the adjusment to the new range for the user.

Running the Program for a Single Fleet Prediction

Open program MFDP1a.EXE from within Windows Explorer or using the Start button

Press the F1 key, this is the undocumented way to see the help file and documentation. The help files are installed in the C:\windows\help directory during setup.

Initially, the program presents the inputs dialog screen. The run identifier should be entered, the plus group specified and the index file located using the browse button. If errors are encountered in the input data then control will return to the inputs dialog and an error message is displayed in red type. The user can makes changes to the files, within a text editor, without closing the program and press browse again to continue. If no errors are encountered a message is displayed detailing the directory in which output files will be saved.



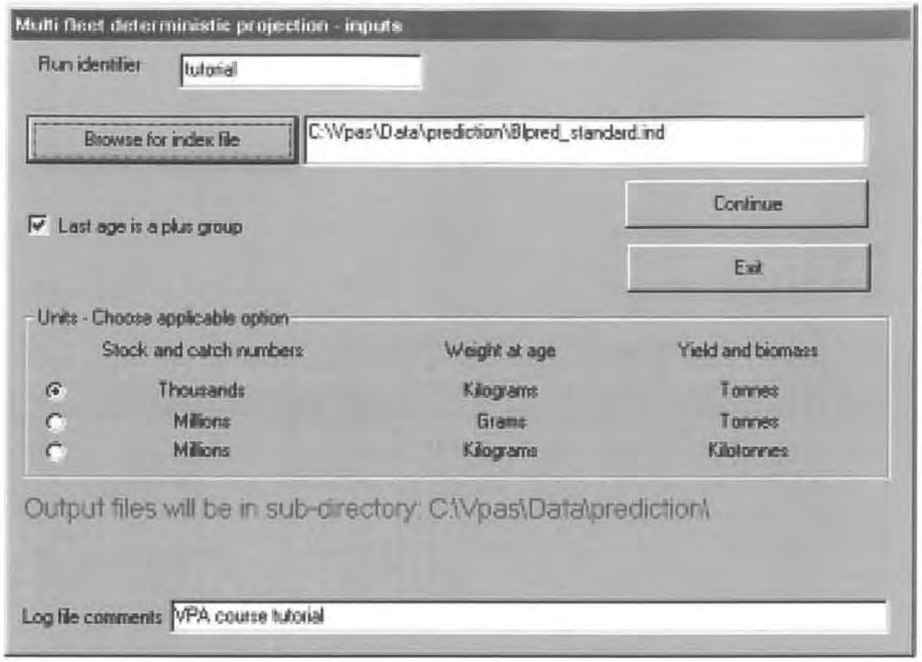
Enter run identifier.

Enter any log file comments required.

Check if the last age is age plus group for this projection run and set the option box.

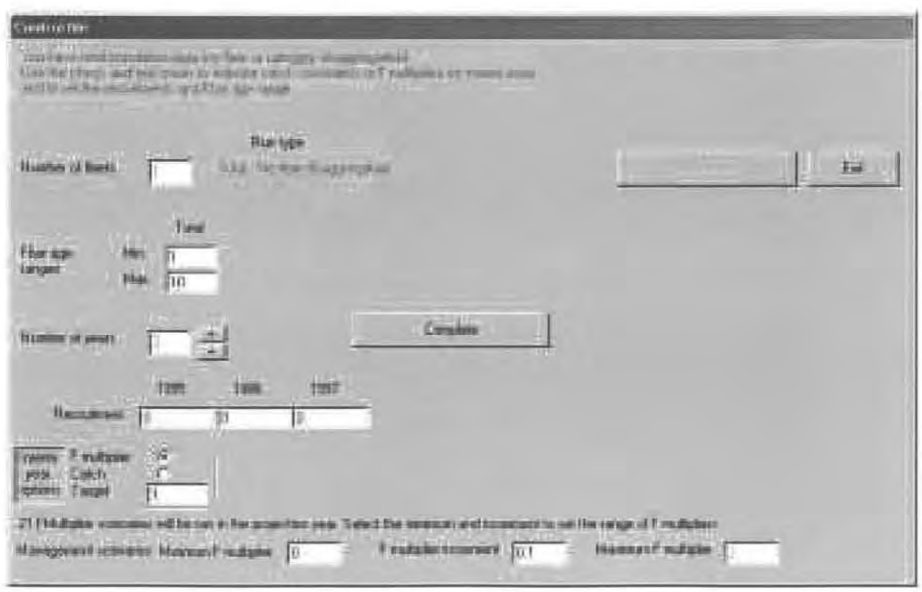
Check the units for the run

Browse for the projection run index file C:\VPAS\DATA\PREDICTION\Blpred_standard.ind.



Note that on return from the browsing the data file, the program has parsed the data files and should report any errors as red text printed above the log file comments box. If there are no errors the program will inform the user that the output files will be put in the same directory as the index file.

Press the continue button.



The text at the top of the control file box should describe the run type that you are trying to achieve. In this example we are running a single fleet projection with no disaggregation into discards or multiple use of the landed catch.

Set the minimum and maximum age for the Fbar age range.

Set the number of projection years to the required time series.

The "normal" catch forecast table has three years: the intermediate year of the assessment, the TAC year and the SSB forecast year. The defaults settings are for this form of forecast table.

Set the recruitment values for the initial age to the values required for the projection years.

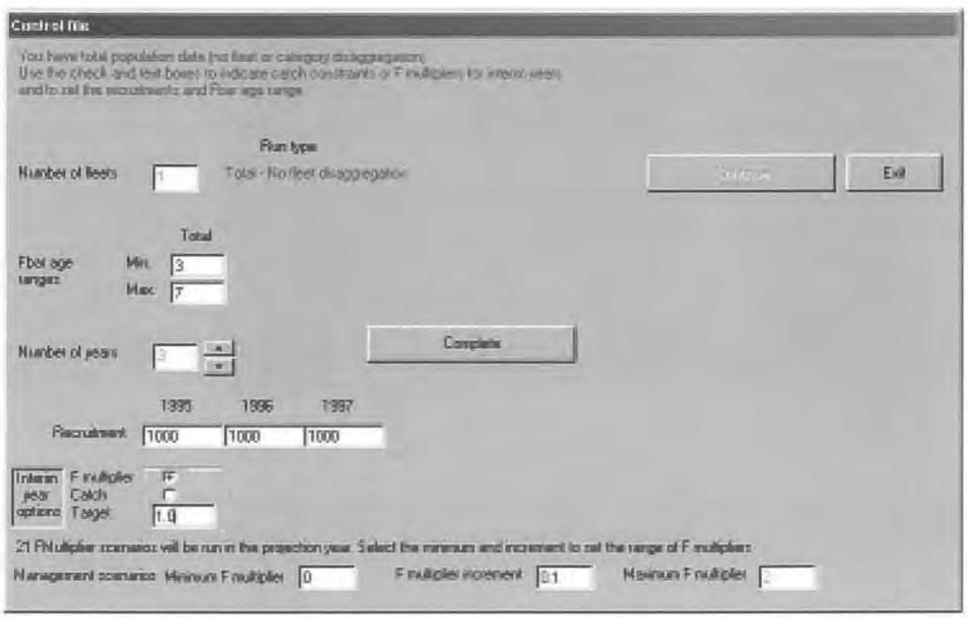
Set the intermediate year forecast option to either an F constraint or a catch constraint.

These options allow the user to specify whether a catch or F multiplier is to be used in each intermediate year. If the number of years is altered then the F multiplier and catch option buttons will be added to, or removed from the dialog. If the run is a multi target type run then these controls are not visible and are presented by fleet on a subsequent dialog.

Enter the F multiplier or catch target for the intermediate year.

In this example we shall use a status quo fishing mortality constraint in the intermediate year; an F multiplier of 1.

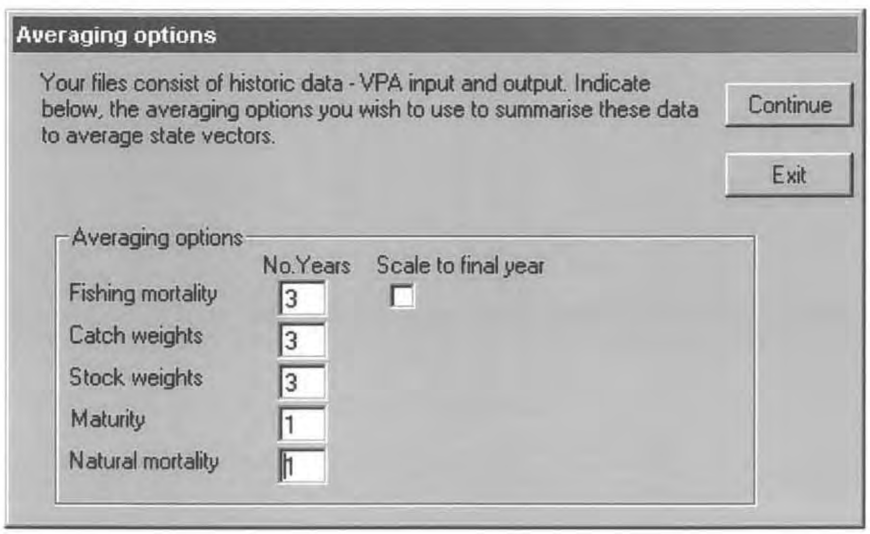
The management option table minimum, maximum and increment can usually be left unchanged. The default setting will give the standard management option table.



Press the complete button.

The button vanishes and the Continue button is enabled if the settings conform to the required input. The red information text changes and the program creates a control file for future usage.

Press the Continue Button. The program now requires us to set up the vectors used for the predictions. Initially this is carried out using the usual averaging process but the individual year vectors can be modified subsequently if required.

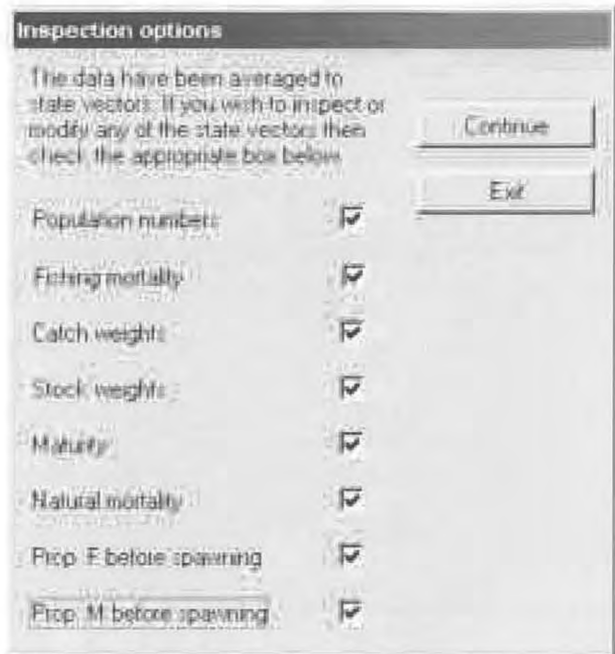


Set the required time periods to be used in calculating the average vectors.

Set the scale to the final year box if required.

Press the continue button.

If we require user input of specific values of population numbers, weights or fishing mortalities etc. we can check any of the required boxes and edit the vectors to be used in the forecast. The vectors should always be reviewed for outliers.



Each of the input data vectors is presented in turn in the format shown below.

After reviewing each input data set the program runs to completion

New Input Data Files

The program creates up to a series of 12 new input data files in the same directory as the index file. The files are prefixed by the run identifier entered by the user and contain the vectors of fishing mortalities, maturity at age etc. for the years over which the projection was made. They allow repeat runs using the same prediction vectors, without having to go through the set up process again. The file names are:

File contents	Filename
Index	RunCode + "ind.txt"
Natural mortality	RunCode + "M.txt"
Total catch weight	RunCode + "CWt.txt"
Stock weight	RunCode + "SWt.txt"
Maturity	RunCode + "Mat.txt"
Proportion of F before spawning	RunCode + "PF.txt"
Proportion of M before spawning	RunCode + "PM.txt"
Population numbers	RunCode + "N.txt"
Total fishing mortality	RunCode + "F.txt"
Control file	RunCode + "Ctrl.txt"

If the data are fleet disaggegated then fleet disaggegated files will be produced giving the fleet selection patterns and catch weights and the total fishing mortality and total catch weight files will not be created.

File contents	Filename
Disaggregated selection pattern	RunCode + "FleetF" + fleet number + ".txt"
Disaggregated catch weights	RunCode + "FleetCWt" + fleet number + ".txt"

Output Files

The following 5 files of output are produced:

Results in a comma delimited file with a format based on that specified by the ICES Workshop on Standard Assessment Tools for Working Groups (MS 1999), but with minor modifications (see Modifications to Workshop on Standard Assessment Tools for Working Groups output format, below). This file is named with a filename of the run index and the file extension .pro. If no run index has been specified then results will be appended to a file named MFDP.pro (Table 1).

Results in a comma delimited file with a structure similar to that of the prediction with management options table currently used by ICES. This file is named with a filename of the run index and the file extension .prm. If no run index has been specified then results will be appended to a file named MFDP.prm (Table 2).

Results in a comma delimited file with a structure similar to the single option prediction: detailed tables currently used by ICES. This file is named with a filename of the run index and the file extension .prs. If no run index has been specified then results will be appended to a file named MFDP.prs (Table 3).

A comma delimited file containing the steady state vectors used for the projection, in a form similar to the prediction with management: input data table used by ICES. This file is named with a filename of the run index and the file extension .prd. If no run index has been specified then results will be appended to a file named MFDP.prd (Table 4).

A log file in comma delimited format containing the files used for the run, the raw data, the options chosen, truncated data when appropriate, the steady state vectors, and a summary of the results. The log file is named with the run code and the file extension .prl. If no run code has been specified then this file is named MFDP.prl (Table 5).

NOTE: **If repeat runs are made with the same run identifier, the results for each run are appended to the existing files along with the run name, program name and version, stock name, time and date.**

Plotting and Tablulating Results

Open the spreadsheet TEMPLATE1.XLS

Open the output file from the MFDP run TUTORIAL.PRM in EXCEL. The file is comma separated.

Copy the sheet from TUTORIAL.PRM and paste it into the prm sheet of TEMPLATE1.XLS.

On the sheet labeled Chart (Fig. 1), the right hand graph is the standard ICES short-term forecast plot which shows the forecast catch at different levels of fishing mortality two years beyond the assessment series and for SSB three years ahead. The data is automatically plotted when the prm sheet is updated.

Running the Program for a Multi fleet or Single fleet with Discards Prediction

Open program MFDP.EXE from within Windows Explorer or using the Start button

Enter run identifier.

Enter any log file comments required.

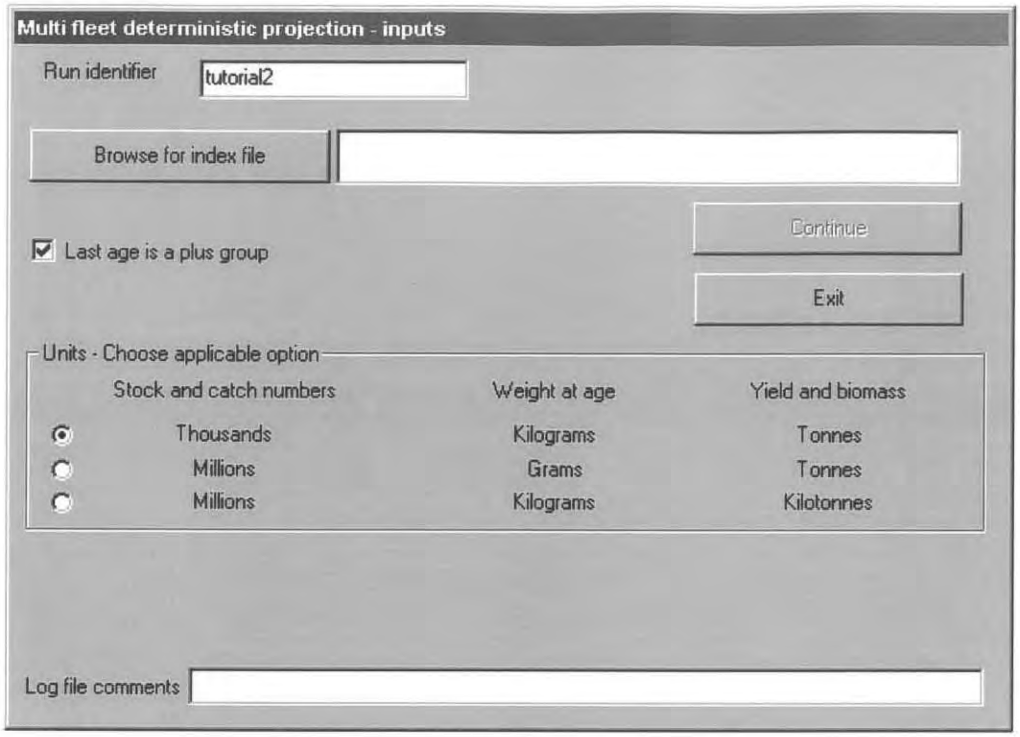
Check if the last age is age plus group for this projection run and set the option box.

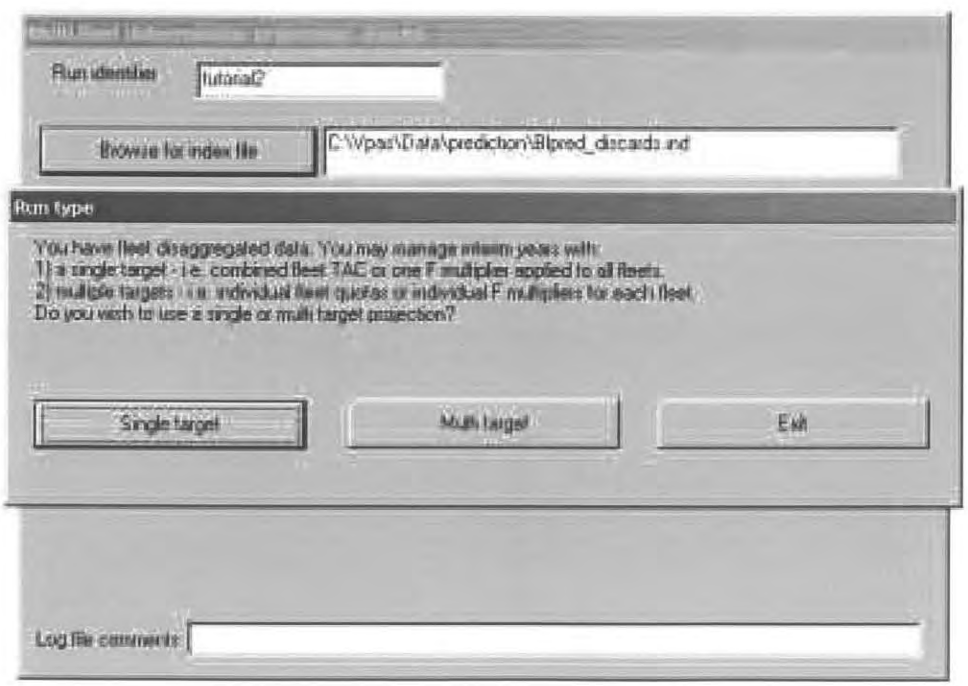
Check the units for the run

Browse for the projection run index file C:\VPAS\DATA\PREDICTION\Blpred_standard.ind.

If errors are encountered in the input data then control will return to the inputs dialog and an error message is displayed in red type. The user can makes changes to the files, within a text editor, without closing the program and press browse again to continue. If no errors are encountered a message is displayed detailing the directory in which output files will be saved.

The index file for a multi fleet (or a single fleet disaggregated by category) contains more information than the single fleet index file. The user must supply catch numbers at age files with total catch at age in each year and also the values for each fleet (see the help F1) and disaggregated catch weight at age files.



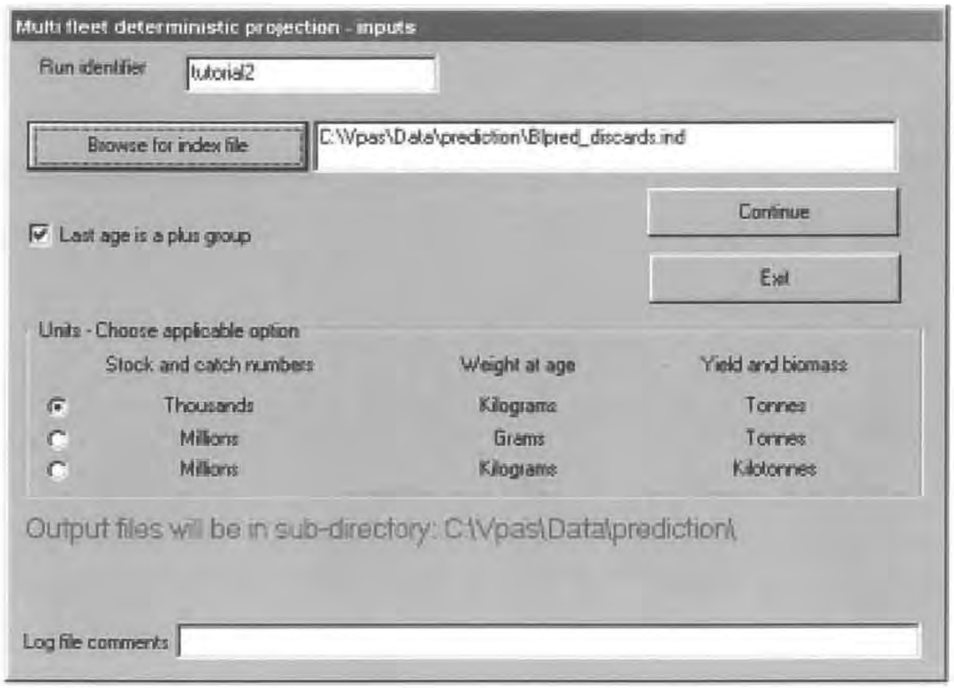


The program reads the information in the index file and notes that this will be a two category (human consumption and discards) prediction.

Select a single target such as a combined fleet TAC or F multiplier or a multi target run.

On return from the browsing the data file, the program has parsed the data files and should report any errors as red text printed above the log file comments box. If there are no errors the program will inform the user that the output files will be put in the same directory as the index file.

Press the continue button.



The multi fleet program has similar input settings to those of the single fleet run.

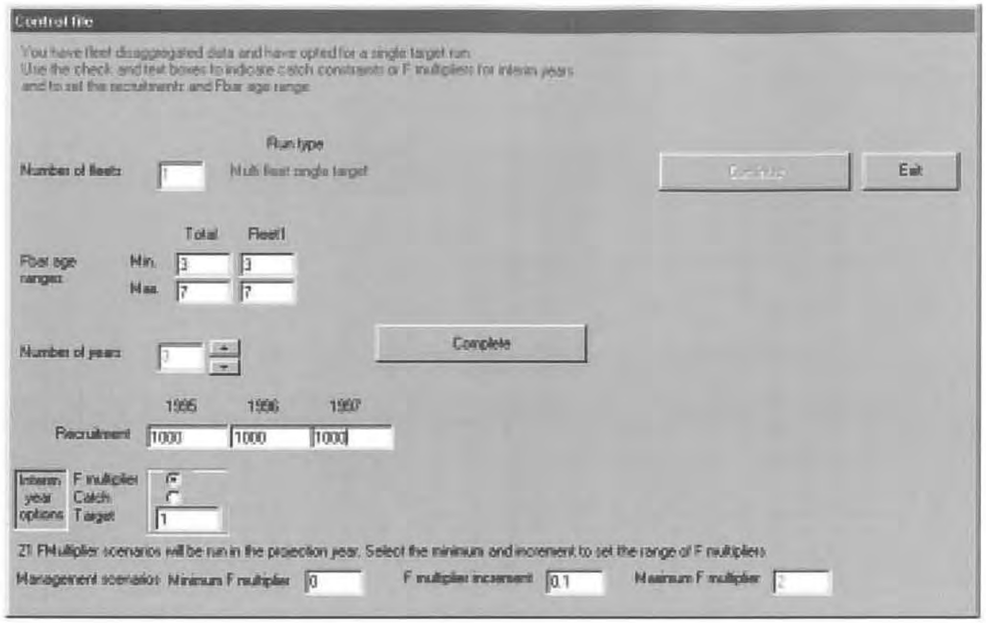
Enter the reference ages for fishing mortality of each fleet.

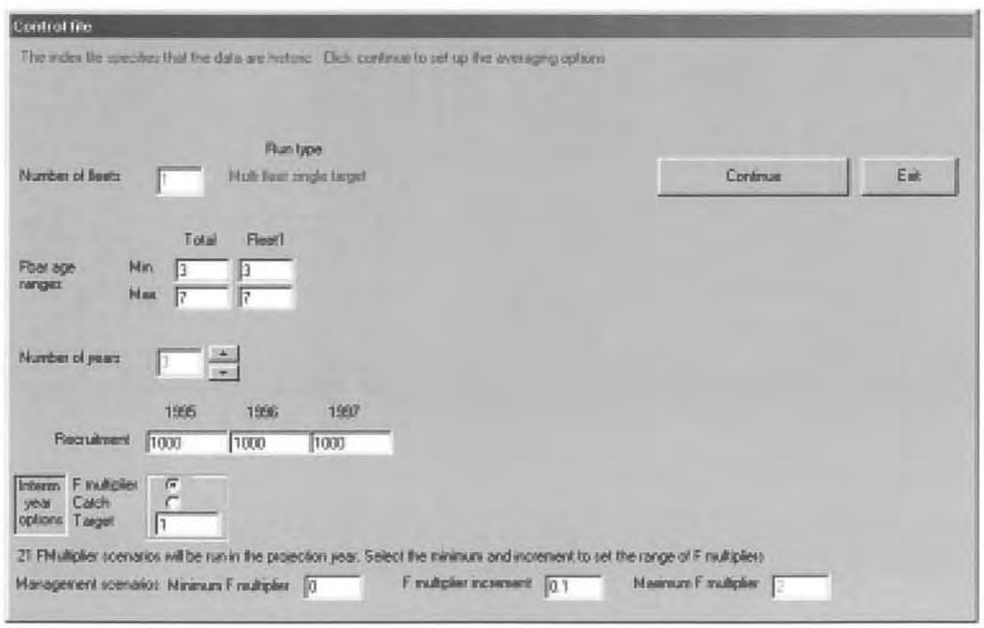
Select the number of years for the forecast and enter the recruitment at the first age for each year.

Enter the fishing mortality multiplier, in this case 1.0 for a status quo projection.

Do not adjust the range of F's or increment it is not usually necessary.

Press complete, to indicate that the inputs are complete. The program notes that the data are historic and sets up a control file. Press continue.

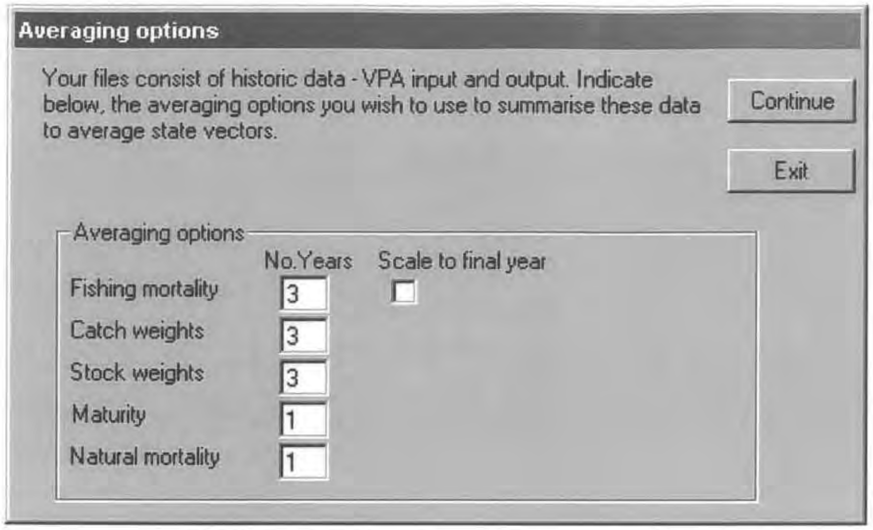




As before the program requires us to set up the vectors used for the predictions. Initially this is carried out using the usual averaging process but the individual year vectors can be modified subsequently if required.

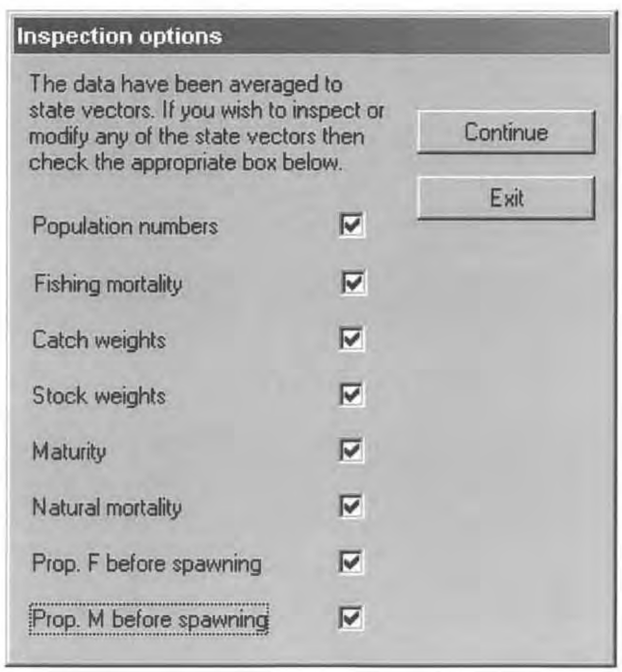
Set the required time periods to be used in calculating the average vectors.

Set the scale to the final year box if required.



Press the continue button.

If we require user input of specific values of population numbers, weights or fishing mortalities etc. we can check any of the required boxes and edit the vectors to be used in the forecast. The vectors should always be reviewed for outliers.



Each of the input data vectors is presented in turn in the format shown below.

After reviewing each input data set the program runs to completion

Output Files

The output files of are the same 5 file types produced for by the single fleet run.

NOTE if repeat runs are made with the same run identifier, the results for each run are appended to the existing files along with the run name, program name and version, stock name, time and date.

Plotting and Tabulating Results

Open the spreadsheet TEMPLATE2.XLS

Open the output file from the MFDP run TUTORIAL2.PRM in EXCEL. The file is comma separated.

Copy the sheet from TUTORIAL2.PRM and paste it into the prm sheet of TEMPLATE2.XLS.

On the sheet labeled Chart, the right hand graph is the short-term forecast plot which shows the forecast catch at different levels of fishing mortality two years beyond the assessment series and for SSB three years ahead. The data is automatically plotted when the prm sheet is updated.

References

DARBY, C. D. and S. FLATMAN. 1994. Virtual Population Analysis: Version 3.1 (Windows/DOS) user guide. *Info. Tech. Ser.*, MAFF Direct. Fish. Res., Lowestoft, **1**: 85 p.

ICES, MS 1999. Report of the Workshop on Standard Assessment Tools for Working Groups, Aberdeen, United Kingdom, 3–5 March 1999. *ICES C.M. Doc.*, No. 1999/ACFM:25.

TABLE 1. The MFDP short-term forecast results in the ICES SGFADS file format (*.pro)

Short term	MFDP vers	Blackfin: A	Run:tutoria		01:55	03/02/02	
1							
3							
21							
1995							
Total							
3	7						
-99	1	0.601933	0	12060.11	0	9363.821	
1996							
Total							
1	0	0	0	0	0	9575.09	
2	0.1	6.02E-02	0	1288.179	0	9575.09	
3	0.2	0.120387	0	2493.309	0	9575.09	
4	0.3	0.18058	0	3621.171	0	9575.09	
5	0.4	0.240773	0	4677.126	0	9575.09	
6	0.5	0.300967	0	5666.144	0	9575.09	
7	0.6	0.36116	0	6592.838	0	9575.09	
8	0.7	0.421353	0	7461.483	0	9575.09	
9	0.8	0.481547	0	8276.05	0	9575.09	
10	0.9	0.54174	0	9040.221	0	9575.09	
11	1	0.601933	0	9757.415	0	9575.09	
12	1.1	0.662127	0	10430.81	0	9575.09	
13	1.2	0.72232	0	11063.34	0	9575.09	
14	1.3	0.782513	0	11657.76	0	9575.09	
15	1.4	0.842707	0	12216.6	0	9575.09	
16	1.5	0.9029	0	12742.23	0	9575.09	
17	1.6	0.963093	0	13236.84	0	9575.09	
18	1.7	1.023287	0	13702.47	0	9575.09	
19	1.8	1.08348	0	14141.03	0	9575.09	
20	1.9	1.143673	0	14554.27	0	9575.09	
21	2	1.203867	0	14943.84	0	9575.09	
1997							
1	20127.82						
2	18739.4						
3	17450.9						
4	16254.92						
5	15144.62						
6	14113.67						
7	13156.23						
8	12266.88						
9	11440.63						
10	10672.85						
11	9959.259						
12	9295.893						
13	8679.091						
14	8105.463						
15	7571.872						
16	7075.415						
17	6613.403						
18	6183.349						
19	5782.951						
20	5410.074						
21	5062.745						

Input units are thousands and kg - output in tonnes

TABLE 2. The Blackfin MFDP single category short-term forecast management options table output (*.prm).

MFDP version 1a
Run: tutorial
Blackfin: Assessment course. Combined sex; plusgroup.
Time and date: 01:55 03/02/02
Fbar age range: 3-7

1995				
Biomass	SSB	FMult	FBar	Landings
34816	9364	1	0.6019	12060

1996					1997	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
23924	9575	0	0	0	27071	20128
.	9575	0.1	0.0602	1288	25476	18739
.	9575	0.2	0.1204	2493	23988	17451
.	9575	0.3	0.1806	3621	22601	16255
.	9575	0.4	0.2408	4677	21306	15145
.	9575	0.5	0.301	5666	20098	14114
.	9575	0.6	0.3612	6593	18970	13156
.	9575	0.7	0.4214	7461	17917	12267
.	9575	0.8	0.4815	8276	16933	11441
.	9575	0.9	0.5417	9040	16014	10673
.	9575	1	0.6019	9757	15154	9959
.	9575	1.1	0.6621	10431	14350	9296
.	9575	1.2	0.7223	11063	13598	8679
.	9575	1.3	0.7825	11658	12894	8105
.	9575	1.4	0.8427	12217	12236	7572
.	9575	1.5	0.9029	12742	11619	7075
.	9575	1.6	0.9631	13237	11041	6613
.	9575	1.7	1.0233	13702	10499	6183
.	9575	1.8	1.0835	14141	9991	5783
.	9575	1.9	1.1437	14554	9515	5410
.	9575	2	1.2039	14944	9068	5063

Input units are thousands and kg - output in tonnes

TABLE 3. Blackfin MFDP single category short-term forecast detailed status quo forecast table output (*.prs).

MFDP version 1a
Run: tutorial
Time and date: 01:55 03/02/02
Fbar age range: 3-7

Year:		1995	F multiplier		1	Fbar:	0.6019			
Age		F	CatchNos	Yield	StockNos	Biomass	SSNos(Jar	SSB(Jan)	SSNos(ST	SSB(ST)
	1	0.001	1	1	1000	590	0	0	0	0
	2	0.178	884	761	5963	5132	0	0	0	0
	3	0.4037	3197	3616	10549	11931	0	0	0	0
	4	0.8263	2756	4029	5334	7798	0	0	0	0
	5	0.7633	651	1374	1328	2805	1328	2805	1328	2805
	6	0.592	239	685	584	1676	584	1676	584	1676
	7	0.4243	111	460	352	1458	352	1458	352	1458
	8	0.3877	46	236	157	804	157	804	157	804
	9	0.4707	31	201	91	585	91	585	91	585
	10	0.4707	77	698	225	2036	225	2036	225	2036
Total			7992	12060	25583	34816	2737	9364	2737	9364

Year:		1996	F multiplier		1	Fbar:	0.6019			
Age		F	CatchNos	Yield	StockNos	Biomass	SSNos(Jar	SSB(Jan)	SSNos(ST	SSB(ST)
	1	0.001	1	1	1000	590	0	0	0	0
	2	0.178	121	104	818	704	0	0	0	0
	3	0.4037	1238	1400	4086	4621	0	0	0	0
	4	0.8263	2980	4357	5768	8433	0	0	0	0
	5	0.7633	937	1978	1911	4037	1911	4037	1911	4037
	6	0.592	207	595	507	1454	507	1454	507	1454
	7	0.4243	83	346	265	1096	265	1096	265	1096
	8	0.3877	55	283	189	965	189	965	189	965
	9	0.4707	30	192	87	561	87	561	87	561
	10	0.4707	55	502	162	1463	162	1463	162	1463
Total			5708	9757	14792	23924	3120	9575	3120	9575

Year:		1997	F multiplier		1	Fbar:	0.6019			
Age		F	CatchNos	Yield	StockNos	Biomass	SSNos(Jar	SSB(Jan)	SSNos(ST	SSB(ST)
	1	0.001	1	1	1000	590	0	0	0	0
	2	0.178	121	104	818	704	0	0	0	0
	3	0.4037	170	192	560	634	0	0	0	0
	4	0.8263	1154	1688	2234	3266	0	0	0	0
	5	0.7633	1013	2139	2067	4365	2067	4365	2067	4365
	6	0.592	298	856	729	2093	729	2093	729	2093
	7	0.4243	72	300	230	951	230	951	230	951
	8	0.3877	42	213	142	725	142	725	142	725
	9	0.4707	36	231	105	673	105	673	105	673
	10	0.4707	44	395	127	1152	127	1152	127	1152
Total			2951	6118	8012	15154	3399	9959	3399	9959

Input units are thousands and kg - output in tonnes

TABLE 4. The Blackfin MFDP single category short-term forecast input data file (*.prd).

MFDP version 1a
Run: tutorial
Time and date: 01:55 03/02/02
Fbar age range: 3-7

1995

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	1000	0.2	0	0	0	0.590	0.001	0.590
2	5963	0.2	0	0	0	0.861	0.178	0.861
3	10549	0.2	0	0	0	1.131	0.404	1.131
4	5334	0.2	0	0	0	1.462	0.826	1.462
5	1328	0.2	1	0	0	2.112	0.763	2.112
6	584	0.2	1	0	0	2.869	0.592	2.869
7	352	0.2	1	0	0	4.143	0.424	4.143
8	157	0.2	1	0	0	5.120	0.388	5.120
9	91	0.2	1	0	0	6.426	0.471	6.426
10	225	0.2	1	0	0	9.051	0.471	9.051

1996

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	1000	0.2	0	0	0	0.590	0.001	0.590
2	.	0.2	0	0	0	0.861	0.178	0.861
3	.	0.2	0	0	0	1.131	0.404	1.131
4	.	0.2	0	0	0	1.462	0.826	1.462
5	.	0.2	1	0	0	2.112	0.763	2.112
6	.	0.2	1	0	0	2.869	0.592	2.869
7	.	0.2	1	0	0	4.143	0.424	4.143
8	.	0.2	1	0	0	5.120	0.388	5.120
9	.	0.2	1	0	0	6.426	0.471	6.426
10	.	0.2	1	0	0	9.051	0.471	9.051

1997

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	1000	0.2	0	0	0	0.590	0.001	0.590
2	.	0.2	0	0	0	0.861	0.178	0.861
3	.	0.2	0	0	0	1.131	0.404	1.131
4	.	0.2	0	0	0	1.462	0.826	1.462
5	.	0.2	1	0	0	2.112	0.763	2.112
6	.	0.2	1	0	0	2.869	0.592	2.869
7	.	0.2	1	0	0	4.143	0.424	4.143
8	.	0.2	1	0	0	5.120	0.388	5.120
9	.	0.2	1	0	0	6.426	0.471	6.426
10	.	0.2	1	0	0	9.051	0.471	9.051

Input units are thousands and kg - output in tonnes

TABLE 5. The first few lines of the Blackfin MFDP single category short-term forecast log file (*.prl).

MFDP version 1a
Run: tutorial
Blackfin: Assessment course. Combined sex; plusgroup.
Time and date: 01:55 03/02/02
IndexFile C:\Vpas\Data\prediction\Blpred_standard.ind

Comments
VPA course tutorial

***** Data files *****
c:\vpas\data\prediction\blackCN.DAT
c:\vpas\data\prediction\blackCW.DAT
c:\vpas\data\prediction\blackSW.DAT
c:\vpas\data\prediction\blackNM.DAT
c:\vpas\data\prediction\blackMO.DAT
c:\vpas\data\prediction\blackPF.DAT
c:\vpas\data\prediction\blackPM.DAT
c:\vpas\data\prediction\f.txt
c:\vpas\data\prediction\n.txt

Input units are thousands and kg - output in tonnes

Last age is a plus group
***** Averaging options *****

Variable	Average Y(	ScaleToFinalYr
Selection	3	0
Natural mortality	1	0
Catch weight	3	0
Stock weight	3	0
Maturity	1	0

***** Projection type *****
Single fleet

Historic data

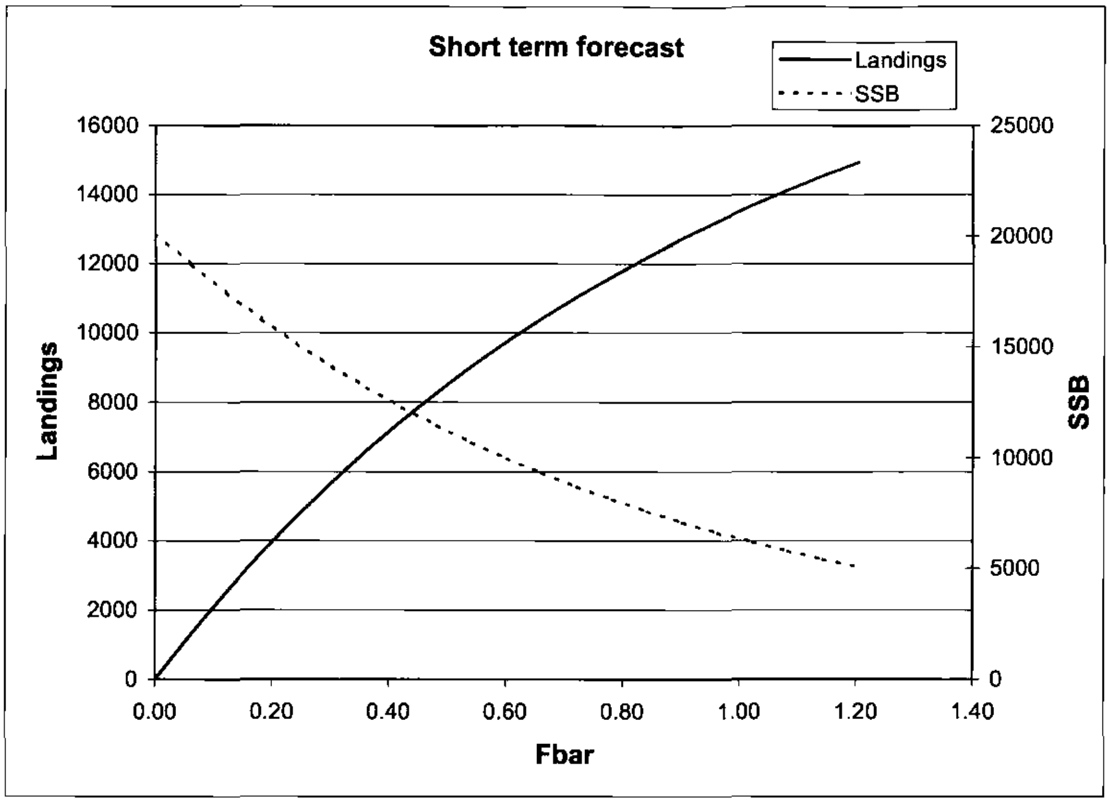
***** Control File *****

Number of years	3		
Number of fleets	1	Fleet disag #FALSE#	
Population Fbar age	3	7	
Future recruitment	1000	1000	1000

Target is catch constraint flag
#FALSE#
Targets
1

***** Raw Data *****

Population numbers	1963	1995	1	10					
32418	13434	12035	3513	1690	804	378	379	172	165
22360	26541	10858	8511	2254	1087	464	244	175	328
22893	18306	21625	6957	4851	1212	583	236	162	315
32785	18743	14779	14694	2928	2382	528	232	110	199
23609	26842	15284	9532	7589	1293	1323	310	155	259
38405	19330	21629	10656	5193	4464	816	672	171	341



MFDP version 1
Run: tutorial
Blackfin: NAFO course 2000. Combined sex; plusgroup.
Time and date: 01:55 03/02/02
Fbar age range: 3-7

Input units are thousands and kg - output in tonnes

Fig. 1. The short-term projection options figure for the Blackfin stock, showing the forecast catch at different levels of fishing mortality two years beyond the assessment series and for SSB three years ahead.

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Appendix 1: Lowestoft Stock Assessment Suite

Tutorial 7

The Multi-Fleet Yield-per-Recruit Program

by

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Abstract

This document is number seven in a series of tutorials designed to assist users of the Lowestoft VPA Suite assessment software and prediction programs that use the results. The tutorial takes the user through the options required for running the multi-fleet deterministic yield per recruit program MFYPR developed for ICES at CEFAS.

Introduction

This tutorial takes the user through the options required for running multi-fleet deterministic projection program MFYPR2a.exe. The tutorial assumes that the required Blackfin data files are placed in a directory c:\vpas\data\prediction, and that the prediction index files (Blpred_standard.ind, Blpred_discards.ind) contain path names that point to the appropriate files.

In the following text action **to be taken by the user** is highlighted in bold. The symbol ↵ is used to represent the Return or Enter key on the keyboard.

Installation of the Program

Copy the MFYPR Disk1 and Disk2 files to a directory on your computer here it is assumed that we are using C:\VPAS\PROGRAMS\MFYPR. Using Explorer go to the directory C:\VPAS\PROGRAMS \MFYPR\Disk1. Start the program Setup.exe and follow the on screen instructions

Data Files

The program will carry out yield per recruit using historic data sets from age structured assessments. The analysis is per recruit, hence no units of numbers are required. The user is prompted on the inputs dialog to indicate the units of weight being used. This unit will be indicated in the output. No checks on the units are carried out and it is the responsibility of the user to ensure they are consistent.

The program uses an index file that is similar to (but not the same as) the Lowestoft format index file used for inputting data to the Lowestoft VPA Suite stock assessment program (Darby and Flatman 1994). The index file for the yield per recruit data is given below, the differences in the index files are that the first, ninth, tenth and eleventh files from the VPA suite list have been omitted in MFYPR. The missing files are the total landings and the optional fishing mortality, fishing mortality in the final year and fleet tuning files.

Several files have been added to the list required for MFYPR, these are, **for single fleet analyses:**

1) the fishing mortality at age for each of the historic assessment years;
2) population numbers at age for the historic assessment years **and one extra year** the survivors at the start of the year after the final assessment year; although the program runs a yield per recruit the stock numbers file is kept here for consistency with the program MFDP.

For multifleet predictions

3) a file with total and fleet disaggregated catch numbers at age
4) a file with total and fleet disaggregated catch weights at age

The complete index file list for a run using historic data is given below:

Index file contents	Index file number
Title	
Historic data flag (1 = Historic, 0 = Future)	
Total catch numbers at age numbers file name and path	2
Weight at age in the catch file name and path	3
Weight at age in the stock file name and path	4
Natural mortality file name and path	5
Proportion mature file name and path	6
Proportion of F before spawning file name and path	7
Proportion of M before spawning file name and path	8
Fishing mortality file name and path	12
Population numbers file name and path	13

The population numbers file is not needed for a yield per recruit run. It can be replaced by four stars (****). However, if it is placed in the index file the index file can be used for both yield per recruit and short term prediction.

If the prediction is not fleet or category disaggregated then this is sufficient, however if fleet or category disaggregation is required then the following lines are required.

Index file contents	Index number
Number of fleets	
Fleet 1 catch numbers at age file name and path	2
...	2
Fleet n catch numbers at age file name and path	2
Fleet 1 weight at age in the catch file name and path	3
...	3
Fleet n weight at age in the catch file name and path	3
An optional control file, if specified it must always be the last file.	

Note: If the population and fishing mortality files from the final assessment have a different age range to that of the initial VPA suite input data files, the program will make the adjusment to the new range for the user.

Running the Program

Open program MFYPR2a.EXE from within Windows Explorer or using the Start button

Press the F1 key, this is the undocumented way to see the help file and documentation. The help files are installed in the C:\windows\help directory during setup.

Initially, the program presents the inputs dialog screen. The run identifier should be entered, the plus group specified and the index file located using the browse button. If errors are encountered in the input data then control will return to the inputs dialog and an error message is displayed in red type. The user can makes changes to the files, within a text editor, without closing the program and press browse again to continue. If no errors are encountered a message is displayed detailing the directory in which output files will be saved.

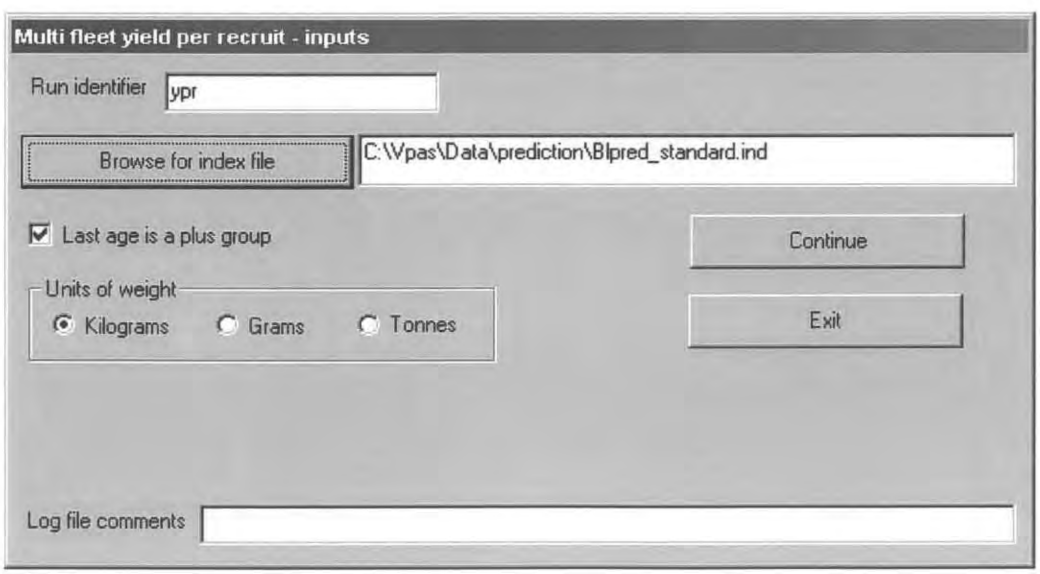
Enter run identifier.

Enter any log file comments required.

Check if the last age is age plus group for this projection run and set the option box.

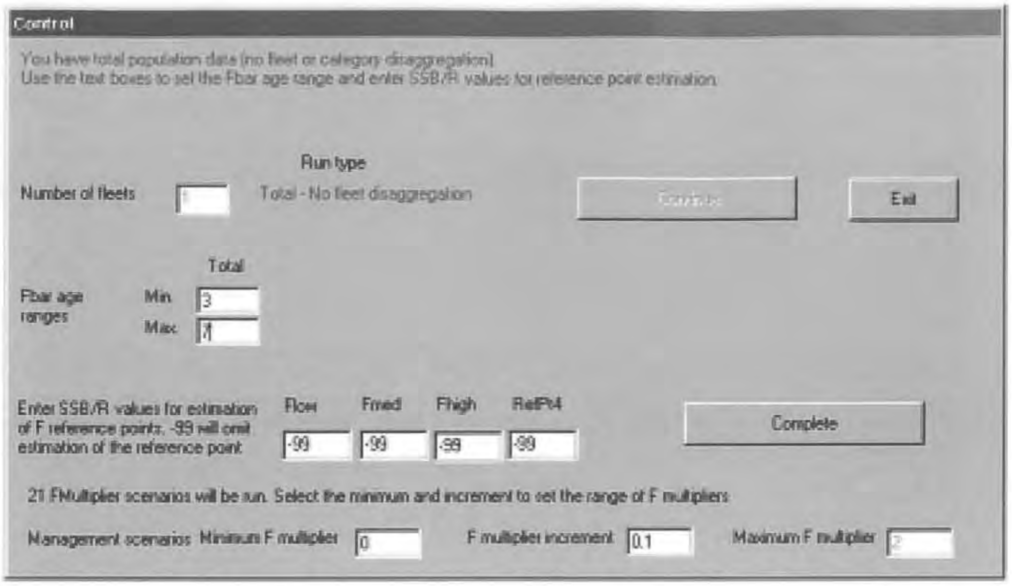
Check the units for the run

Browse for the projection run index file C:\VPAS\DATA\PREDICTION\Blpred_standard.ind.



Note that on return from the browsing the data file, the program has parsed the data files and should report any errors as red text printed above the log file comments box. If there are no errors the program will inform the user that the output files will be put in the same directory as the index file.

Press the continue button.



The text at the top of the control file box should describe the run type that you are trying to achieve. In this example we are running a single fleet yield per recruit with no disaggregation into discards or multiple use of the landed catch.

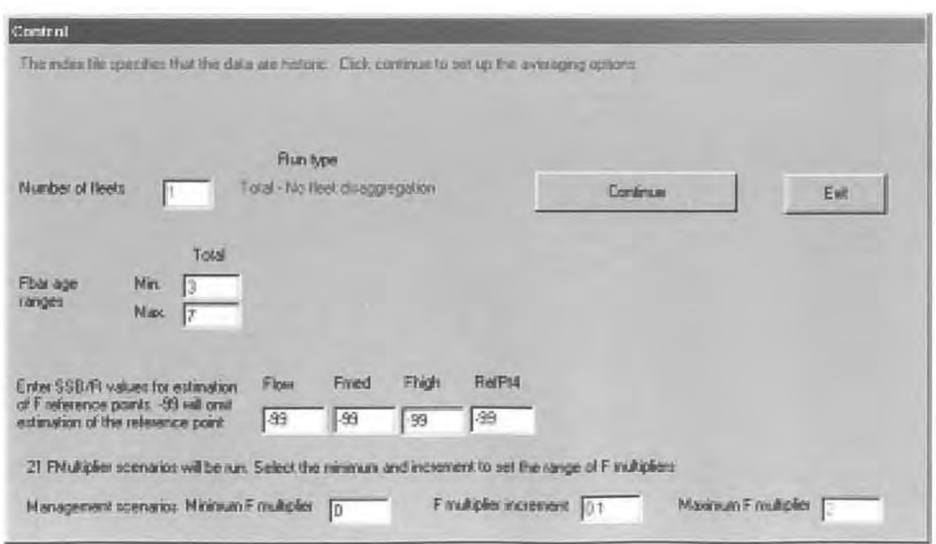
Set the minimum and maximum age for the Fbar age range.

If required set the SSB/B values for the reference points in this example leave them unchanged.

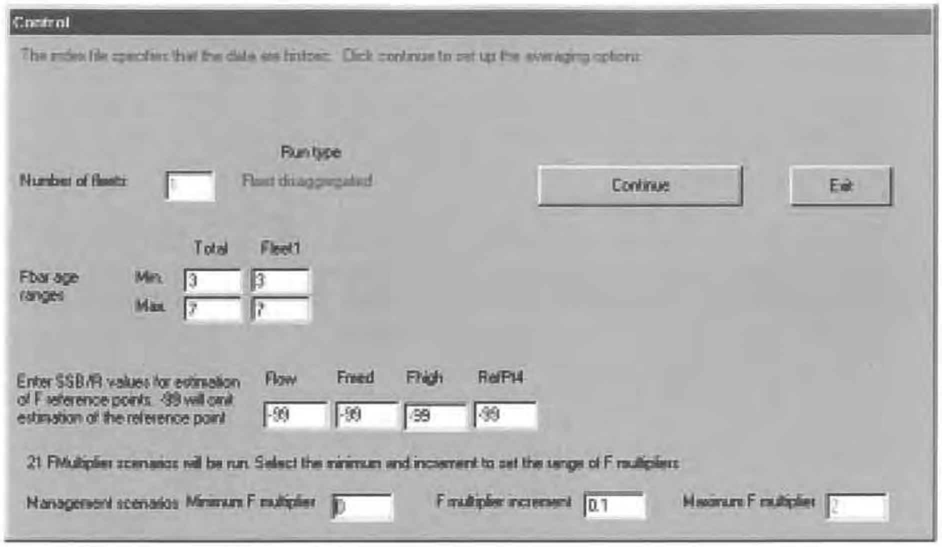
The management option table minimum, maximum and increment can usually be left unchanged. The default setting will give the standard management option table.

Press the complete button.

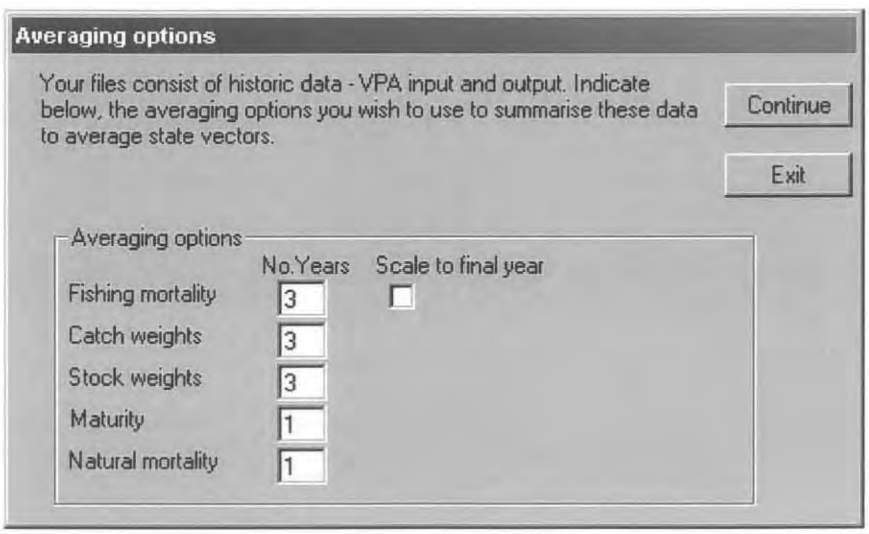
The button vanishes and the Continue button is enabled if the settings conform to the required input. The red information text changes and the program creates a control file for future usage.



If a fleet disaggregated data set has been input to the program the only difference in the option box is that there are two fishing mortality mean ranges to define.



Press the Continue Button. The program now requires us to set up the vectors used for the predictions. Initially this is carried out using the usual averaging process but the individual year vectors can be modified subsequently if required.

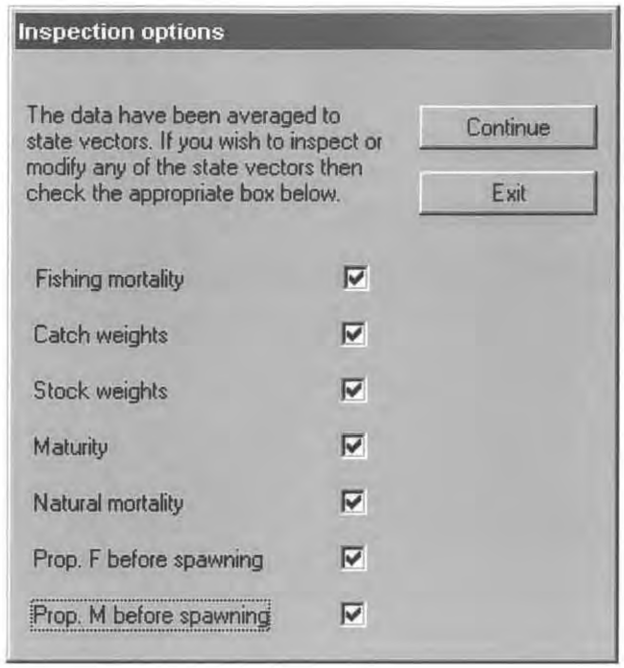


Set the required time periods to be used in calculating the average vectors.

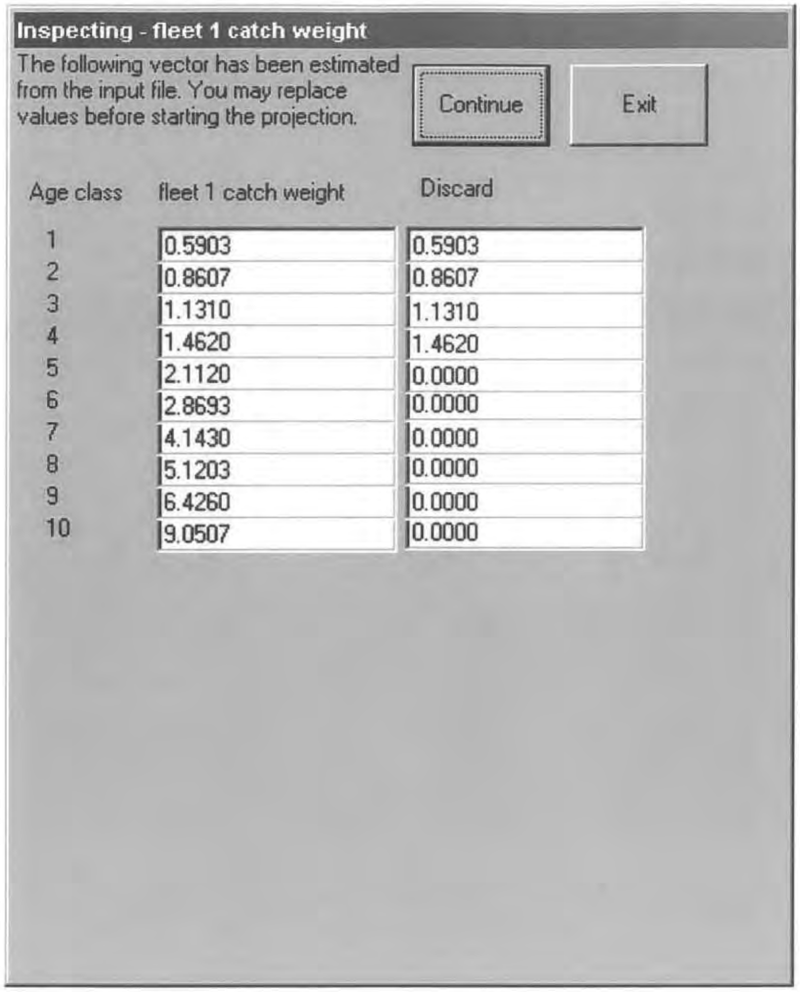
Set the scale to the final year box if required.

Press the continue button.

If we require user input of specific values of population numbers, weights or fishing mortalities etc. we can check any of the required boxes and edit the vectors to be used in the forecast. The vectors should always be reviewed for outliers.



Each of the input data vectors is presented in turn in the format shown below where the two fleet inspection box is illustrated.



After reviewing each input data set the program runs to completion

New Input File Set

The program creates up to a series of 12 new input data files in the same directory as the index file. The files are prefixed by the run identifier entered by the user and contain the vectors of fishing mortalities, maturity at age etc. for the years over which the projection was made. They allow repeat runs using the same prediction vectors, without having to go through the set up process again. The file names are:

File contents	Filename
Index	RunCode + "ind.txt"
Total catch weight	RunCode + "CWt.txt"
Stock weight	RunCode + "SWt.txt"
Maturity	RunCode + "Mat.txt"
Proportion of F before spawning	RunCode + "PF.txt"
Proportion of M before spawning	RunCode + "PM.txt"
Total fishing mortality	RunCode + "F.txt"
Control file	RunCode + "Ctrl.txt"

If the data are fleet disaggregated then no file for total F and catch weight will be produced, but files will be produced for each fleet giving the fleet partial Fs and fleet catch weights.

File contents	Filename
Disaggregated selection pattern	RunCode + "FleetF" + fleet number + ".txt"
Disaggregated catch weights	RunCode + "FleetCWt" + fleet number + ".txt"

Producing the modified file set allows subsequent runs to be undertaken without editing the data on each occasion.

Output Files

The following 4 files of output are produced. They are listed in Tables 1–4.

1) Output (Table 1)

   Results in a comma delimited file with the format specified by the ICES Workshop on Standard Assessment Tools for Working Groups (1999), see the Yield per recruit results section. This file is named with a filename of the run index and the file extension .yro. If no run index has been specified then results will be appended to a file named MFYPR.yro. The results for each run are appended to the file along with the run name, program name and version, stock name, time and date.

2) Summary (Table 2)

   Results in a comma delimited file with a structure similar to that of the yield per recruit summary table currently used by ICES. This file is named with a filename of the run index and the file extension .yrs. If no run index has been specified then results will be appended to a file named MFYPR.yrs. The results for each run are appended to the file along with the run name, program name and version, stock name, time and date.

3) Data (Table 3)

   A comma delimited file containing the steady state vectors used for the yield per recruit analysis. This file is named with a filename of the run index and the file extension .yrd. If no run index has been specified then results will be appended to a file named MFYPR.yrd. The data for each run are appended to the file along with the run name, program name and version, stock name, time and date.

4) Log (Table 4)

A log file in comma delimited format containing the files used for the run, the raw data, the options chosen, truncated data when appropriate, the steady state vectors, and a summary of the results. The log file is named with the run code and the file extension .yrl. If no run code has been specified then this file is named MFYPR.yrl.

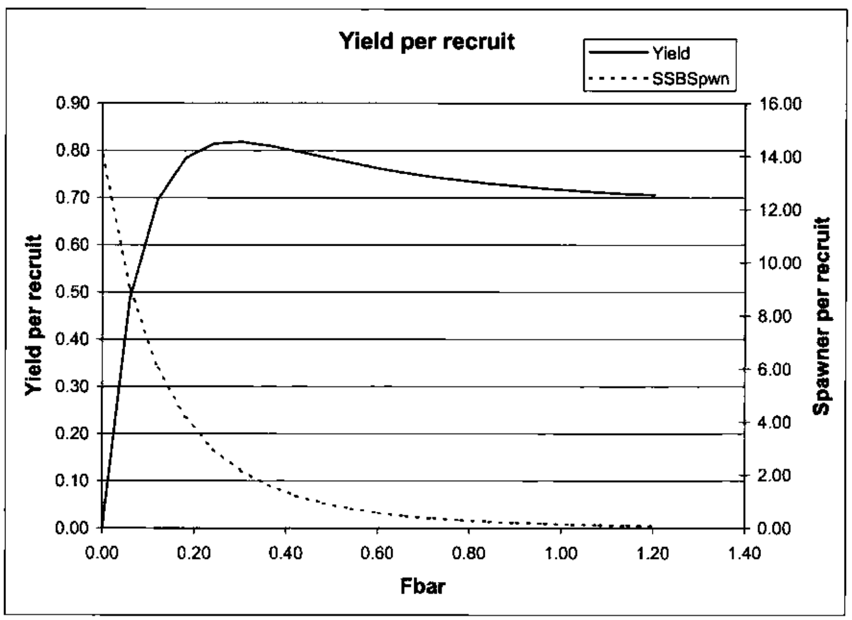
Plotting and Tabulating Results

Open the spreadsheet TEMPLATE1.XLS

Open the output file from the MFYPR run YPR.YRS in EXCEL. The file is comma separated.

Copy the sheet from YPR.YRS and paste it into the .yrs sheet of TEMPLATE1.XLS.

On the sheet labeled Chart, the left hand graph is the standard ICES yield per recruit plot which shows the yield in kilograms at different levels of fishing mortality. The data is automatically plotted when the .yrs sheet is updated.



MFYPR version 2a
Run: blackfin SAC
Time and date: 17:51 04/03/03

Reference point	F multiplier	Absolute F
Fbar(3-7)	1.0000	0.6019
FMax	0.4720	0.2841
F0.1	0.2661	0.1602
F35%SPR	0.2545	0.1532

Weights in kilograms

Fig. 1. The Blackfin single category yield per recruit plot and fishing mortality reference points.

References

DARBY, C. D. and S. FLATMAN. 1994. Virtual Population Analysis: version 3.1 (Windows/DOS) user guide. *Info. Tech. Ser.*, MAFF Direct. Fish. Res., Lowestoft, 1: 85 p.

ICES. MS 1999. Report of the Workshop on Standard Assessment Tools for Working Groups, Aberdeen, United Kingdom, 3–5 March 1999. *ICES C.M. Doc.*, No. 1999/ACFM:25.

TABLE 1. The MFYPR yield per recruit results in the ICES SGFADS format.

Blackfin: as	Yield per re	MFYPR ve	Run:ypr	23:08	06/02/02
1					
1					
21					
Total					
0.601933	0	3	7		
1	0	0	0	14.06572	16.9212
2	0.1	0.487108	0	9.004979	11.80153
3	0.2	0.697293	0	6.03255	8.772971
4	0.3	0.784026	0	4.182221	6.869175
5	0.4	0.813972	0	2.98003	5.616035
6	0.5	0.817871	0	2.172361	4.759802
7	0.6	0.810366	0	1.614692	4.155827
8	0.7	0.798509	0	1.220628	3.717597
9	0.8	0.785654	0	0.936535	3.391363
10	0.9	0.773323	0	0.728067	3.142674
11	1	0.762133	0	0.572655	2.948862
12	1.1	0.752258	0	0.455133	2.794664
13	1.2	0.743665	0	0.365107	2.669597
14	1.3	0.736235	0	0.295328	2.566328
15	1.4	0.729822	0	0.240662	2.47964
16	1.5	0.724278	0	0.197415	2.405766
17	1.6	0.719471	0	0.162896	2.341944
18	1.7	0.715284	0	0.135122	2.286121
19	1.8	0.711619	0	0.11261	2.236752
20	1.9	0.708393	0	0.094242	2.192656
21	2	0.705537	0	7.92E-02	2.152925

Weights in kilograms

TABLE 2. Blackfin MFYPR yield-per-recruit table output.

MFYPR version 2a
Run: ypr
Time and date: 23:08 06/02/02
Yield per results

FMult	Fbar	CatchNos	Yield	StockNos	Biomass	SpwnNosJ.	SSBJan	SpwnNosS	SSBSpwn
0	0	0	0	5.5167	16.9212	2.4788	14.0657	2.4788	14.0657
0.1	0.0602	0.1572	0.4871	4.7338	11.8015	1.739	9.005	1.739	9.005
0.2	0.1204	0.2603	0.6973	4.2221	8.773	1.2683	6.0326	1.2683	6.0326
0.3	0.1806	0.3322	0.784	3.8657	6.8692	0.9512	4.1822	0.9512	4.1822
0.4	0.2408	0.3849	0.814	3.6058	5.616	0.7287	2.98	0.7287	2.98
0.5	0.301	0.4249	0.8179	3.409	4.7598	0.5677	2.1724	0.5677	2.1724
0.6	0.3612	0.4563	0.8104	3.2555	4.1558	0.4483	1.6147	0.4483	1.6147
0.7	0.4214	0.4814	0.7985	3.1327	3.7176	0.3581	1.2206	0.3581	1.2206
0.8	0.4815	0.5021	0.7857	3.0322	3.3914	0.2889	0.9365	0.2889	0.9365
0.9	0.5417	0.5194	0.7733	2.9483	3.1427	0.2349	0.7281	0.2349	0.7281
1	0.6019	0.5342	0.7621	2.8773	2.9489	0.1924	0.5727	0.1924	0.5727
1.1	0.6621	0.5469	0.7523	2.8161	2.7947	0.1586	0.4551	0.1586	0.4551
1.2	0.7223	0.5581	0.7437	2.7627	2.6696	0.1314	0.3651	0.1314	0.3651
1.3	0.7825	0.568	0.7362	2.7156	2.5663	0.1095	0.2953	0.1095	0.2953
1.4	0.8427	0.5768	0.7298	2.6736	2.4796	0.0915	0.2407	0.0915	0.2407
1.5	0.9029	0.5847	0.7243	2.6358	2.4058	0.0768	0.1974	0.0768	0.1974
1.6	0.9631	0.592	0.7195	2.6016	2.3419	0.0647	0.1629	0.0647	0.1629
1.7	1.0233	0.5986	0.7153	2.5703	2.2861	0.0547	0.1351	0.0547	0.1351
1.8	1.0835	0.6047	0.7116	2.5415	2.2368	0.0463	0.1126	0.0463	0.1126
1.9	1.1437	0.6104	0.7084	2.515	2.1927	0.0393	0.0942	0.0393	0.0942
2	1.2039	0.6156	0.7055	2.4903	2.1529	0.0335	0.0792	0.0335	0.0792

Reference	F multiplier	Absolute F
Fbar(3-7)	1	0.6019
FMax	0.472	0.2841
F0.1	0.2661	0.1602
F35%SPR	0.2545	0.1532

Weights in kilograms

TABLE 3. Blackfin MFYPR yield-per-recruit input data table.

MFYPR version 2a
Run: ypr
Blackfin: assessment course. Combined sex; plusgroup.
Time and date: 23:08 06/02/02
Fbar age range: 3-7

Age	M	Mat	PF	PM	SWt	Sel	CWt
1	0.2	0	0	0	0.590333	0.001	0.590333
2	0.2	0	0	0	0.860667	0.178	0.860667
3	0.2	0	0	0	1.131	0.403667	1.131
4	0.2	0	0	0	1.462	0.826333	1.462
5	0.2	1	0	0	2.112	0.763333	2.112
6	0.2	1	0	0	2.869333	0.592	2.869333
7	0.2	1	0	0	4.143	0.424333	4.143
8	0.2	1	0	0	5.120333	0.387667	5.120333
9	0.2	1	0	0	6.426	0.470667	6.426
10	0.2	1	0	0	9.050667	0.470667	9.050667

Weights in kilograms

TABLE 4. The first few lines of the Blackfin MFYPR yield-per-recruit log file describing the analysis settings

MFYPR version 2a
Run: ypr
Time and date: 23:08 06/02/02
Blackfin: assessment course. Combined sex; plusgroup.

Comments

Weights in kilograms

IndexFile C:\Vpas\Data\prediction\Blpred_standard.ind
Data files
c:\vpas\data\prediction\blackCN.DAT
c:\vpas\data\prediction\blackCW.DAT
c:\vpas\data\prediction\blackSW.DAT
c:\vpas\data\prediction\blackNM.DAT
c:\vpas\data\prediction\blackMO.DAT
c:\vpas\data\prediction\blackPF.DAT
c:\vpas\data\prediction\blackPM.DAT
c:\vpas\data\prediction\f.txt
c:\vpas\data\prediction\n.txt

Averaging options

Variable	Average Y€	ScaleToFinalYr
Selection	3	0
Natural mo	1	
Catch weig	3	
Stock weig	3	
Maturity	1	
Fleet details		
Number of	1	Fleet disag #FALSE#
Population	3	7

Reference points - SPR values

-99	-99	-99	-99

Raw Data
Historic data

Fishing mo	1963	1994	1	10					
0	0.013	0.146	0.244	0.241	0.351	0.24	0.571	0.39	0.39
0	0.005	0.245	0.362	0.421	0.423	0.475	0.211	0.372	0.372
0	0.014	0.186	0.666	0.511	0.63	0.722	0.562	0.644	0.644
0	0.004	0.239	0.461	0.617	0.388	0.333	0.204	0.31	0.31
0	0.016	0.161	0.407	0.331	0.261	0.477	0.393	0.379	0.379
0	0.003	0.133	0.271	0.294	0.167	0.224	0.231	0.208	0.208
0	0.012	0.15	0.399	0.286	0.195	0.227	0.247	0.224	0.224
0	0.002	0.133	0.264	0.267	0.176	0.133	0.113	0.141	0.141
0	0.013	0.088	0.314	0.355	0.254	0.202	0.303	0.254	0.254

NAFO Sci. Coun. Studies, 36: 147–161

Appendix 1: Lowestoft Stock Assessment Suite

Tutorial 8

Running the PA Software Excel Add-in (PASoft)

by

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Abstract

This document is number eight in a series of tutorials designed to assist users of the Lowestoft VPA Suite assessment software and the prediction programs that use the results. The tutorial takes the user through the options required for running the PA software EXCEL add-in used to estimate reference points and developed for ICES at CEFAS.

Introduction

This tutorial takes the user through the options required for running the PA software EXCEL add-in. The tutorial assumes that the user has followed the previous XSA tutorials and can run the VPA suite package to produce the required files or has constructed the sen and sum output files resulting from the Aberdeen medium term suite of programs.

In the following text **action to be taken by the user** is highlighted in bold. The symbol ↵ is used to represent the Return or Enter key on the keyboard.

Installing the PA Software

The software is intended to be used with Microsoft Excel Version 7 upwards. The software is an Excel add-in and results are output as Excel workbooks.

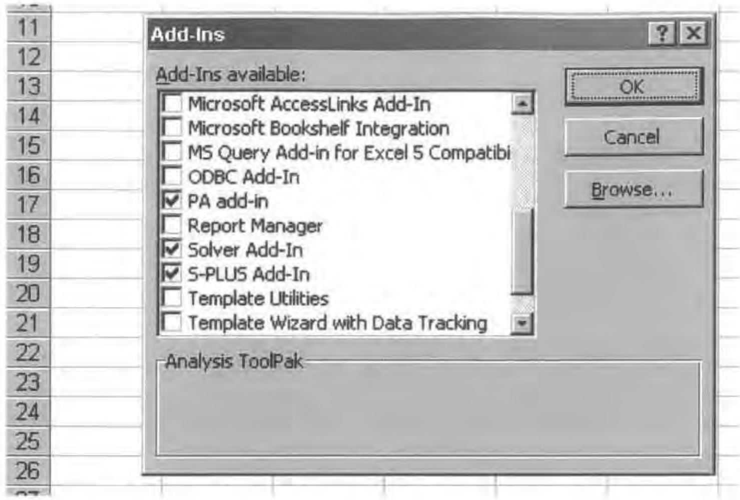
Copy the PA soft directory to your hard drive. Enter the directory disk 1 and run the setup.exe. Follow the instructions to install the pa add in.

Open EXCEL

From the menu bar **Select "Tools", "Add-ins"**

Browse for the file PAXLA.XLA which will have been placed in the installation directory.

Select PAXLA.XLA and press OK



Note that the PA add-in box has been entered and checked.

Select OK

Notice that the PASummary drop down menu has been added to the menu at the top of Excel.

Note: If you do not want to keep loading the PA add-in every time Excel is opened select "Tools", "Add-ins" and uncheck the PA add-in box. The add in box can be re-checked each time the program is required.

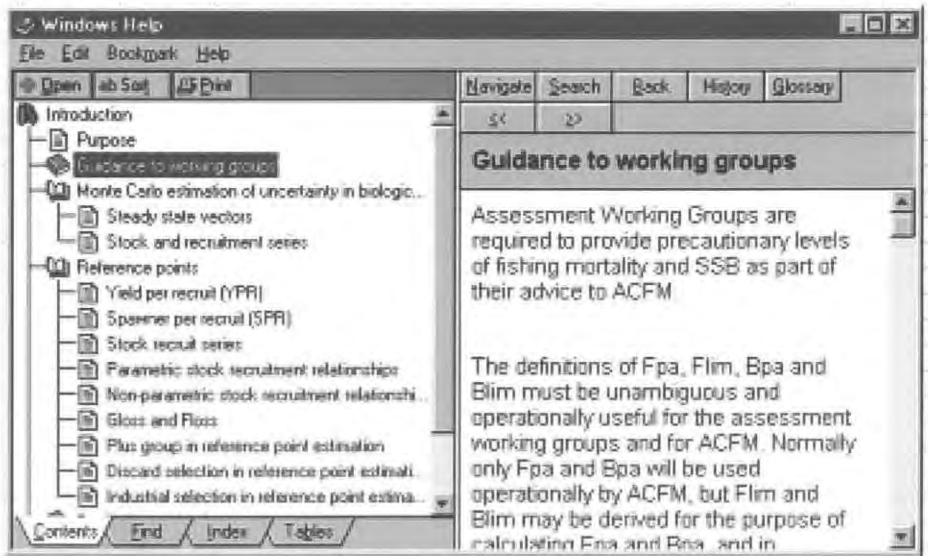
Run the program VPA95.exe for the stock for which you wish to estimate the PA reference points. Select the options for the age range, reference means etc selected in previous tutorials. When the assessment model has been fitted select option 8 from the main menu. This option will print a file that contains all of the VPA suite output in a form that can be read by the PA software.

Return to EXCEL

The PA Software Help File

At the menu bar select the "PASummary" drop down menu.
Select the Help menu option

During installation a help file is added to the Windows\system\ directory for reference when using the program. The methods used in the calculation of the reference points are detailed in the help system.

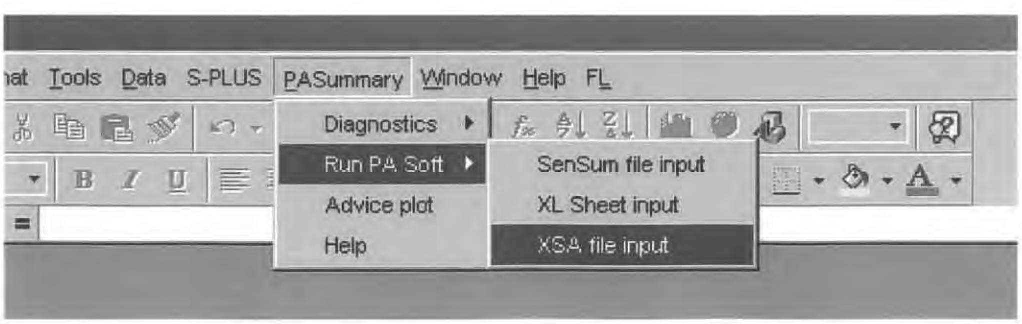


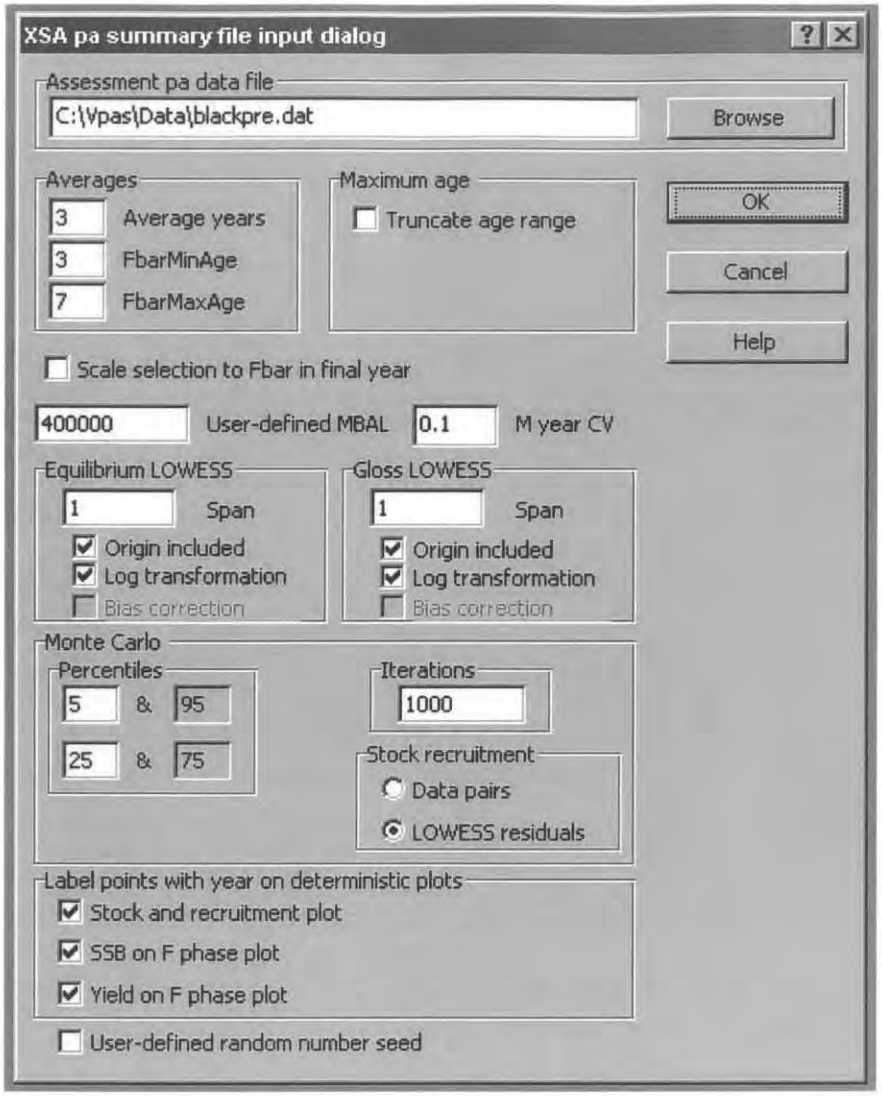
Calculation of the PA Reference Points

In this section we shall run the PA software to calculate fishing mortality and biomass reference points. This will allow us to examine the approach and the results of the methodology. In the following section we shall run a diagnostic routine to examine the selection of settings used for the smoothers used to estimate particular reference points.

At the menu bar select the "PASummary" drop down menu.

Select "Run PA Soft" and "XSA file input" Note that two other input file formats are permitted, spreadsheet entry and the .sen and .sum files created by the Aberdeen suite program INSENS.



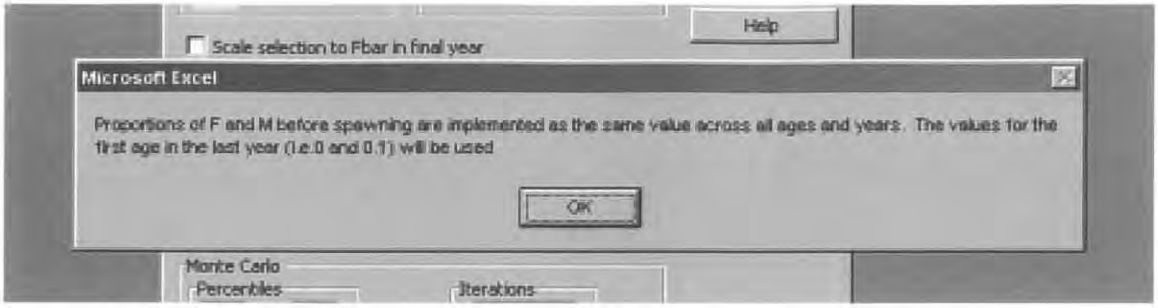


Browse for the PA software XSA input file created during the XSA run.

The range of ages for calculating average fishing mortality should correspond to those used in the XSA assessment. Default options for the setting of two LOWESS models are presented. These should be chosen after reference to the diagnostic output presented below. Other options for the percentile used in the summary plots and the number of iterations to use in the Monte Carlo simulations can be user defined. The user guide for the program details selection criteria.

The default number of iterations for the PA Software is 100 as with this number the output can be obtained fairly quickly. This is however a relatively small number for a Monte Carlo and for a final run a larger number such as 1000 is likely to give more stable estimates of the percentiles.

After completion of the selections press the OK button.



The program informs us that, as the proportions of F and M are equal for all ages and years it will use the values for the final year.

Select the OK button.

The PA soft program runs the Monte Carlo iterations sampling from the distributions of the input data and then creates five EXCEL sheets containing data and results.

Sheet Intro (Table 1)

This sheet provides a brief introduction to the results.

Sheet RefPts (Fig. 1 and Table 2)

This sheet summarizes the estimated reference points. Box and whisker plots showing the 5^{th}, 25^{th}, 50^{th}, 75^{th} and 95^{th} percentiles of the F reference points are plotted. A table showing the deterministic value of the reference point together with the median and 2 user-specified pairs of percentiles is produced for stock and fishing mortality reference points. If the user has specified 5^{th}, 25^{th}, 75^{th} and 95^{th} percentiles then the 75^{th} and 95^{th} percentiles would be displayed for the stock reference points, while the 5^{th} and 25^{th} would be displayed for the F reference points.

The RefPts sheet also provides a record of the run specification, these include:

Spans used by the LOWESS smoothers and data transformations.
Stock name.
Averaging details for Fbar and the steady state vectors (the latter will be zero when these vectors are the input, i.e. Sen_Sum input and XLSheet input).
Number of iterations.
The type of Monte Carlo for the stock recruitment data.
The data source.
Details of the FishLab DLL used for reference point estimations.
The PASoft version.
The date and time of the run.

Sometimes certain combinations of data may cause some reference points (particularly F_{max}, F_{high} and F_{loss}) to give unreliable results, for example F_{max} may tend to infinity. The percentiles are based on the full distribution of the reference points estimations and will include these points. The output sheet "PDist" contains the estimates of all the reference points by iteration number and can be checked for outlying values. "PDist" acts as the input for the box and whisker plots hence if different percentiles are required on these plots the user can alter the percentile function calls at the foot of the data in "PDist".

Sheet Plots (Fig. 3)

This sheet provides graphical output of deterministic results. 4 plots are presented:

Recruitment against SSB
Spawner per recruit and yield per recruit curves against Fbar
Equilibrium SSB against Fbar
Equilibrium yield against Fbar

In plots 1, 3 and 4 the points are linked in chronological order by a dashed line and a colored solid line represents expected values estimated from the LOWESS smoothed stock recruitment relationship. The user also has the option to label each point with the year when the program is run.

In plots 1 and 2 a number of fishing mortality reference points are indicated as labeled points on the right axis of the stock recruit plot and at the top of the SPR and YPR chart.

Plot 1, the stock recruit plot, gives details of the LOWESS span and data transformations used for the smoother in the top left corner. This smoother is used to estimate the expected values (the solid line) in plots 3 and 4. The data used to plot the charts are held on the Plots sheets in columns U to AP.

Sometimes a large value for a reference point may cause the stock recruitment plot to be squashed at the bottom of the chart. This is because Excel has scaled the chart automatically to the largest value of R. By selecting the outlying point (which lies under the label) and deleting it the chart will re-scale more appropriately. This has been carried out for the Floss point in the Blackfin example.

Sheet Pdist (Table 3)

This sheet provides the estimates of each reference point by iteration number. These data form the input for the box and whisker plots on the "RefPts" sheet. The complete distributions of the reference point estimation allow the user to check for erroneous values or to further investigate the empirical distributions.

Sheet SV (Table 4)

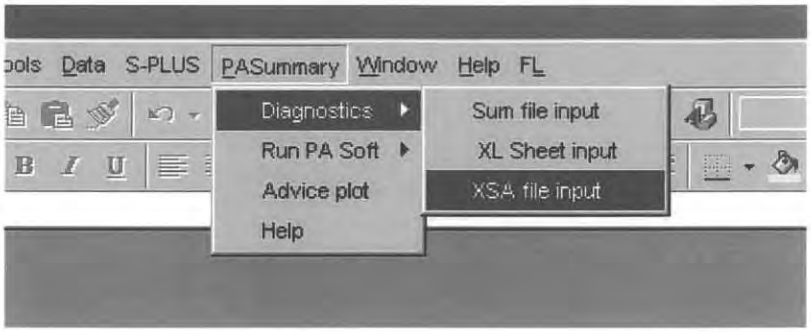
The SV sheet provides the user with the steady state vectors used during the PA run. For Sen_Sum file input or XLSheet input these should be the same as the input data. For the other input formats they will be derived from the data and as such provide a useful record of the steady state vectors.

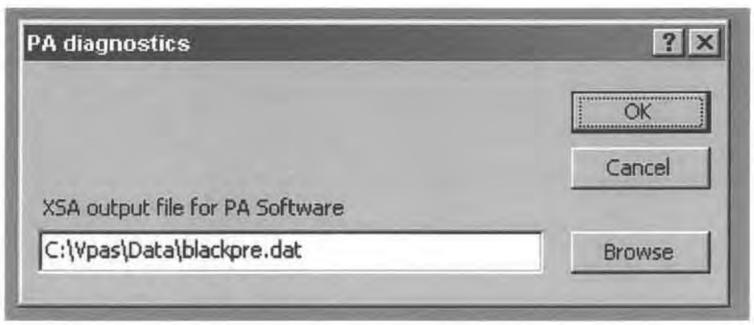
The sheet is presented in a suitable format to be used as input for further PA runs using the XLSheet dialog and can therefore be used as the basis for more investigative work. For example the effects of mortality, weight and maturity at age schedules could be explored, or the effects of different CVs investigated. This may be of particular interest where the variables or CVs are assumptions.

Diagnostic Calculation for the Lowess Smoother

At the menu bar select the "PASummary" drop down menu.

Select "Diagnostics" and "XSA file input" Note that two other input file formats are permitted, spreadsheet entry and the .sen and .sum files created by the "Aberdeen suite program INSENS".





Browse for the PA software XSA input file created during the XSA run.

The program informs us that, as the proportions of F and M are equal for all ages and years it will use the values for the final year.

Select the OK button.

The diagnostics program runs and creates four EXCEL graphs in a new sheet they present diagnostic plots used for determining the settings of the models used for the precautionary approach reference point calculations.

PASoft Diagnostic Output Graphs

Fig. 3 presents the diagnostic plots produced by PASoft within Excel.

The top left-hand chart shows recruitment (Recruits) plotted against spawning stock biomass (SSB); together with the LOWESS fits corresponding to the two spans of 0.5 (Rhat0.5) and 1.0 (Rhat1.0). The relative difference in G_{loss} between the two spans can be judged by the discrepancy in fitted values corresponding to the lowest observed SSB; i.e. the extreme left-hand points of each LOWESS fit. This graph will assist in the qualitative assessment of the effect that span has on expected recruitment.

The top right-hand chart shows the time series of recruitment with recruitment estimates obtained from the LOWESS fits corresponding to spans of 0.5 (Rhat0.5) and 1.0 (Rhat1.0). This graph, in conjunction with the one described in the previous paragraph, will assist in a qualitative assessment of time trends in the level of recruitment.

The bottom left-hand chart shows the log-normal residuals obtained from the two LOWESS fits with spans of 0.5 (LnRes0.5) and 1.0 (LnRes1.0) plotted against SSB. In addition, the residuals obtained from the LOWESS fit with a span of 1.0 are connected through time with a dashed line. This graph will aid in the detection of heteroscedasticity; i.e. non-constant variance, and the detection of patterns and trends with SSB/time that might violate modelling assumptions.

The bottom right-hand chart shows an improved Akaike information criterion (Hurvich *et al.*, 1998) for a range of LOWESS fits obtained with spans in the interval (0.5, 1], generally thought appropriate for stocks within the current ICES areas (O'Brien, 1999). A span is selected to minimise the bias-corrected Akaike information criterion (AIC) but it is important to remember that any smoothing parameter selection should be viewed as only a guideline (or benchmark), and can be adjusted based upon other factors. Such factors might include: prior knowledge about the shape of the stock-recruitment (S–R) relationship; suitability of the S–R relationship for deriving equilibrium plots; and sensitivity of the estimates of G_{loss} to outliers in the S–R data. To give an indication of the stability of the reference point G_{loss}, numerical estimates are shown (denoted by Gloss) at each span calculated. In general, a LOWESS fit with a high span near to 1.0 is appropriate for the S–R relationship if the production of equilibrium plots is required, whereas a low span will *track* the data and give inappropriate equilibrium values. Furthermore, a LOWESS fit with a high span near to 1.0 is likely to produce more robust estimates of G_{loss} and this is especially true if the data are *noisy*.

All the LOWESS fits have been achieved by inclusion of the origin as a pseudo-data point; i.e. zero recruitment from a non-existent SSB, and with the assumption that recruitment variation may be considered to follow a log-normal distribution.

For the Blackfin data set the plots show that the most appropriate span for the smoother, based on the Akaike information criterion is 1.0. However there is no significant trend in Gloss across all values of the smoother range.

The time series plot of the estimated recruitment with the observed values shows time series correlations in the residual patterns which are also obvious in the residual plots against expected value. The diagnostics illustrate that the model is a poor estimator of recruitment in the most recent time period and would not be appropriate for the estimation of recent recruitment and the value of Gloss. The fit of the smoother and therefore the estimate of Gloss appears to be highly dependent on the recruitment at the two lowest SSB values, which are the first years in the assessment time series. A sensitivity analysis exploring the influence of these point on the estimated reference points would therefore be appropriate.

References

O'BRIEN, C. M. 1999. A note on the distribution of G_{loss}. *ICES Journal of Marine Science*, **56**: 180–183.

HURVICH, C. M., J. S. SIMONOFF, and C. L. TSAI. 1998. Smoothing parameter selection in nonparametric regression using an improved Akaike information criterion. *Journal of the Royal Statistical Society*, **B60**: 271–293.

TABLE 1. The Introduction sheet from the Blackfin PaSoft Excel output file.

Introduction to PA Add-in outputs

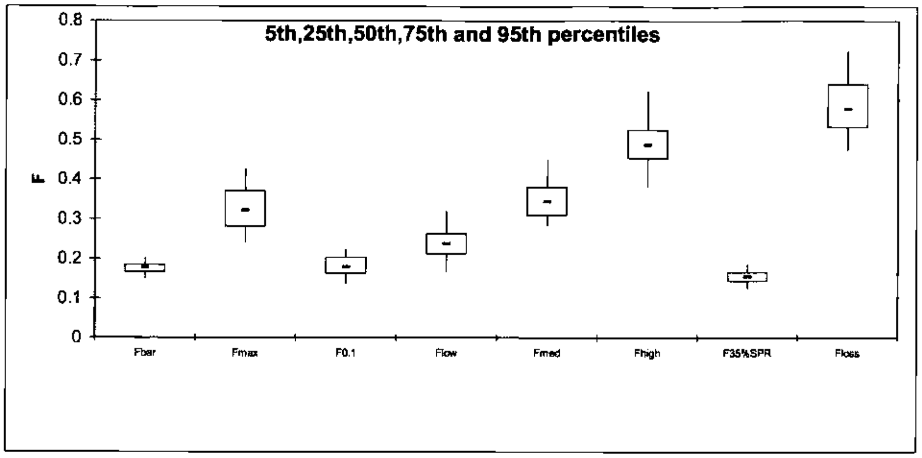
Four sheets of results are included in this workbook:

RefPts - provides stochastic output in the form of a table of reference points and a chart summarising the distributions of some referenc

Plots - provides 4 plots:
A stock recruitment plot with a LOWESS smoother as a possible stock recruitment relationship. Some reference points are also indica
A plot of YPR and SPR curves with some reference points indicated.
A plot of historical SSB against Fbar with an equilibrium curve based on the LOWESS stock recruitment relationship.
A plot of historical yield against Fbar with an equilibrium curve based on the LOWESS stock recruitment relationship.

PD - gives the value of the reference points during each iteration of the simulation and the percentiles plotted on the chart on RefPts.

SV - contains the steady state vectors and stock recruitment series used. These can be used as the basis for further runs.



Reference point	Deterministic	Median	75th percentile	95th percentile	Hist SSB < ref pt %
MedianRecruits	26149	26149	29338	31387	
MBAL	0				0.00
Bloss	11711				
SSB90%R90%Surv	31674	30240	33223	37964	31.25
SPR%ofVirgin	30.31	30.47	33.53	38.20	
VirginSPR	14.07	14.16	15.81	21.70	
SPRloss	0.56	0.50	0.55	0.60	

	Deterministic	Median	25th percentile	5th percentile	Hist F > ref pt %
FBar	0.18	0.18	0.16	0.15	96.88
Fmax	0.31	0.32	0.28	0.24	65.63
F0.1	0.18	0.18	0.16	0.14	96.88
Flow	0.21	0.24	0.21	0.17	96.88
Fmed	0.34	0.34	0.31	0.28	62.50
Fhigh	0.48	0.49	0.45	0.38	21.88
F35%SPR	0.15	0.16	0.14	0.12	100.00
Floss	0.56	0.58	0.53	0.47	18.75

For estimation of Gloss and Floss:
A LOWESS smoother with a span of 1 was used.
Stock recruit data were log-transformed
A point representing the origin was included in the stock recruit data.
For estimation of the stock recruitment relationship used in equilibrium calculations:
A LOWESS smoother with a span of 1 was used.
Stock recruit data were log-transformed
A point representing the origin was included in the stock recruit data.

Blackfin: VPA course. Combined sex; plusgroup.

Steady state selection averaged over 3 years.
FBar averaged from age 4 to 7

Number of iterations = 100
Random number seed = -99
Stock recruitment data Monte Carloed using residuals from the equilibrium LOWESS fit

Data source:
C:\vpas\data\xsapadata.csv

FishLab DLL used
FLVB32.DLL built on Jun 14 1999 at 11:53:37
PASoft 4 October 1999

14/02/03 13:18:25

Fig. 1 and Table 2. The PA Reference Point estimates estimated for the Blackfin stock and listed in the RefPts sheet from the PaSoft Excel output file.

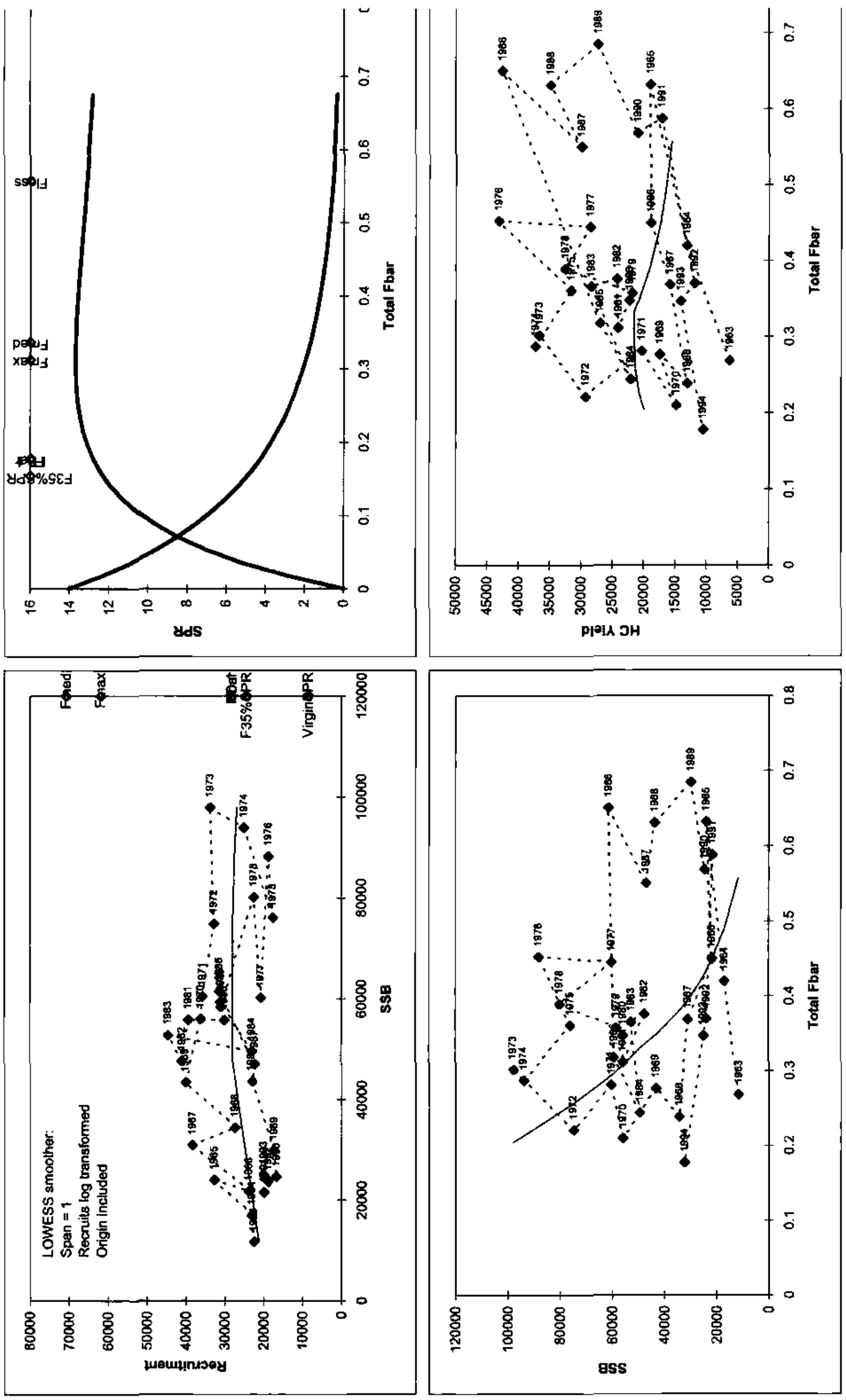


Fig. 2. The PA Reference Point plots for the Blackfin stock, presented in the Plots sheet from the PaSoft Excel output file. Top left – Recruitment against SSB; Top right – Spawner per recruit and yield per recruit curves against Fbar; Bottom left – Equilibrium SSB against Fbar; Bottom right – Equilibrium yield against Fbar.

TABLE 3. The initial 30 bootstrap estimates of the PA Reference Point for the Blackfin stock, presented in the PDist sheet from the PaSoft Excel output file.

MedianRecruits	MBAL	BLOSS	SSB90%R	SPR%ofVi	VirginSPR	SPRloss	Fbar	Fmax	F0.1	Flow	Fmed	Fhigh	F35%
30500.1	0	11710.78	31987.81	32.92425	12.56292	0.492193	0.144098	0.30429	0.158286	0.148992	0.296653	0.398416	0.13
30500.1	0	11710.78	28821.32	28.06901	16.9407	0.476719	0.186422	0.287982	0.165465	0.284807	0.367829	0.542471	0.15
29092.62	0	11710.78	26384.61	31.6019	17.61149	0.391794	0.163926	0.280576	0.170775	0.249986	0.379455	0.523765	0.14
23605.62	0	11710.78	34572.25	30.42786	14.38138	0.508237	0.182946	0.31677	0.175411	0.231237	0.335241	0.505033	0.15
25037.47	0	11710.78	34084.12	34.31776	11.91618	0.476817	0.171758	0.334967	0.185622	0.253005	0.343447	0.504724	0.16
31709.35	0	11710.78	26896.93	35.2088	11.97367	0.362807	0.149738	0.311996	0.169403	0.194907	0.331645	0.499853	0.15
30074.89	0	11710.78	28951.75	28.42961	11.25885	0.518501	0.206695	0.426189	0.219188	0.229276	0.321172	0.483275	0.17
22623.305	0	11710.78	31739.28	23.36975	32.54827	0.566127	0.179196	0.176472	0.106927	0.358247	0.490666	0.6286	0.12
31370.43	0	11710.78	38922.85	36.88409	10.24911	0.619018	0.169865	0.448276	0.22273	0.196868	0.347578	0.440352	0.17
30074.89	0	11710.78	30985.35	30.80486	14.2572	0.537598	0.170803	0.337349	0.202142	0.20084	0.308771	0.445832	0.15
30074.89	0	11710.78	34732.04	28.35328	14.9713	0.505754	0.216613	0.405366	0.241789	0.290092	0.424223	0.524647	0.17
26148.7	0	11710.78	28502.84	32.4721	15.76868	0.500545	0.174331	0.316702	0.177159	0.278479	0.391798	0.588867	0.16
25432.775	0	11710.78	29729.93	24.81739	17.22952	0.463005	0.184098	0.254437	0.152597	0.238555	0.342454	0.472543	0.13
23247.35	0	11710.78	30075.01	29.89	14.12951	0.48707	0.154949	0.256911	0.137724	0.213592	0.299843	0.438707	0.13
26148.7	0	11710.78	35261.05	37.07819	12.88021	0.580616	0.14861	0.350266	0.188054	0.247337	0.338614	0.468119	0.15
27259.93	0	11710.78	29279.96	25.93441	12.51622	0.472268	0.184941	0.293628	0.163261	0.202204	0.286881	0.430571	0.14
23605.62	0	11710.78	30226.5	35.03407	15.23995	0.598271	0.150278	0.312342	0.17861	0.263362	0.327842	0.452285	0.15
24022.39	0	11710.78	23300.66	32.65281	14.29413	0.452	0.190465	0.392838	0.220128	0.249938	0.39822	0.594555	0.17
30925.31	0	11710.78	27819.15	29.81821	12.20651	0.418844	0.179038	0.333256	0.189511	0.210965	0.303154	0.445012	0.15
25037.47	0	11710.78	30253.14	27.79232	12.10182	0.51839	0.19315	0.338441	0.186312	0.258973	0.3325	0.475037	0.15
22948.195	0	11710.78	26555.73	31.11318	15.18016	0.518481	0.150074	0.242278	0.142524	0.224594	0.307531	0.46416	0.13
22889.08	0	11710.78	31653.4	28.91018	18.59249	0.462596	0.169392	0.245365	0.150577	0.274225	0.358615	0.487562	0.14
22981.845	0	11710.78	28658.1	22.99329	18.25419	0.428346	0.202298	0.261919	0.150539	0.276289	0.370082	0.498208	0.13
22922.73	0	11710.78	28646	24.74067	13.50679	0.494508	0.197191	0.322591	0.17394	0.214684	0.283565	0.460055	0.14
25432.775	0	11710.78	24092.28	28.66087	12.11946	0.49517	0.186122	0.358012	0.174597	0.230333	0.300794	0.502544	0.15
31370.43	0	11710.78	29798.36	30.14793	10.05675	0.49633	0.179867	0.358814	0.18154	0.166608	0.29823	0.447809	0.15
26148.7	0	11710.78	37572.37	34.4339	14.18645	0.613901	0.153254	0.32775	0.183061	0.240253	0.342903	0.436936	0.15
30074.89	0	11710.78	23825.86	30.98678	15.91894	0.40612	0.178543	0.30738	0.179479	0.231221	0.358914	0.545596	0.15
26148.7	0	11710.78	34895.76	31.59613	11.31906	0.50573	0.178534	0.362696	0.192132	0.215579	0.332003	0.42874	0.16
30964.5	0	11710.78	28727.33	33.31394	11.76719	0.480599	0.163386	0.312125	0.171665	0.185222	0.308376	0.472055	0.15

TABLE 4. The input data for the estimation of the PA Reference Point for the Blackfin stock, presented in the SV sheet from the PaSoft Excel output filefile.

Age	N	M	CWt	SWt	Mat	F	FPreSpwn	MPreSpwn
1	0	0.2	0.590333	0.590333	0	0.000443	0	0
2	16412.25	0.2	0.860667	0.860667	0	0.106141		
3	10517.84	0.2	1.131	1.131	0	0.165427		
4	7271.93	0.2	1.462	1.462	0	0.260107		
5	3997.49	0.2	2.112	2.112	1	0.211053		
6	2131.86	0.2	2.869333	2.869333	1	0.141556		
7	1528.56	0.2	4.143	4.143	1	0.098364		
8	617	0.2	5.120333	5.120333	1	0.085274		
9	472.54	0.2	6.426	6.426	1	0.103553		
10	992.17	0.2	9.050667	9.050667	1	0.103553		

FbarMinAge	4
FbarMaxAge	7
M year CV	0.1

NCV	MCV	CWtCV	SWtCV	MatCV	FCV
0	0.1	0.098371	0.098371	0.1	0.68172
9.75222	0.1	0.086421	0.086421	0.1	0.72884
0.26225	0.1	0.029814	0.029814	0.1	0.381266
0.19439	0.1	0.09449	0.09449	0.1	0.165987
0.18015	0.1	0.087517	0.087517	0.1	0.116818
0.1817	0.1	0.049484	0.049484	0.1	0.097805
0.18811	0.1	0.059178	0.059178	0.1	0.443046
0.2105	0.1	0.045287	0.045287	0.1	0.359722
0.22298	0.1	0.011354	0.011354	0.1	0.275606
0.22298	0.1	0.068573	0.068573	0.1	0.275606

Year	SSB	Recruitment	Yield	Fbar
1963	11710.78	32415.01	6280.488	0.268748
1964	17014.45	22357.53	13070.21	0.420165
1965	23999.6	22889.08	18876.47	0.632308
1966	21826.96	32779.56	18836.04	0.44973
1967	30964.24	23605.62	15793.87	0.368828
1968	34441.75	38390.83	13060.77	0.238885
1969	43435.16	27259.93	17454.17	0.276788
1970	56042.43	40147.54	14796.16	0.21009
1971	60518.81	36124.96	20298.13	0.281355
1972	74879.81	35679.46	29303.82	0.22157
1973	97936.71	32747.65	36686.26	0.30204
1974	93920.01	33736.42	37281.2	0.28761
1975	76136.96	25037.47	31620.7	0.36094
1976	88272.5	17554.59	43184.3	0.452655
1977	60282.17	18780.98	28509.34	0.445075
1978	80184.72	20692.79	32564.8	0.389535
1979	58436.55	22519.5	21849.07	0.35779
1980	55866.28	30925.31	22303.76	0.347528
1981	55837.82	30074.89	24071.67	0.311733
1982	47672.17	39271.43	24283.43	0.376188
1983	52781.94	40946.7	28404.82	0.365575
1984	49608.76	44469.4	22082.54	0.244073
1985	59340.07	22956.38	27004.21	0.317903
1986	61470.84	31003.69	42551.18	0.65082
1987	47081.24	31370.43	29839.76	0.550345
1988	43667.4	22295.84	34828.51	0.6314
1989	29895.96	23007.31	27311.24	0.68496
1990	24651.49	17353.34	20885.03	0.568433
1991	21559.32	16793.23	17017.17	0.587965
1992	23878.47	20007.37	11868.62	0.370095
1993	25044.56	18950.84	14055.82	0.347048
1994	32347.56	20043.07	10528.84	0.17777

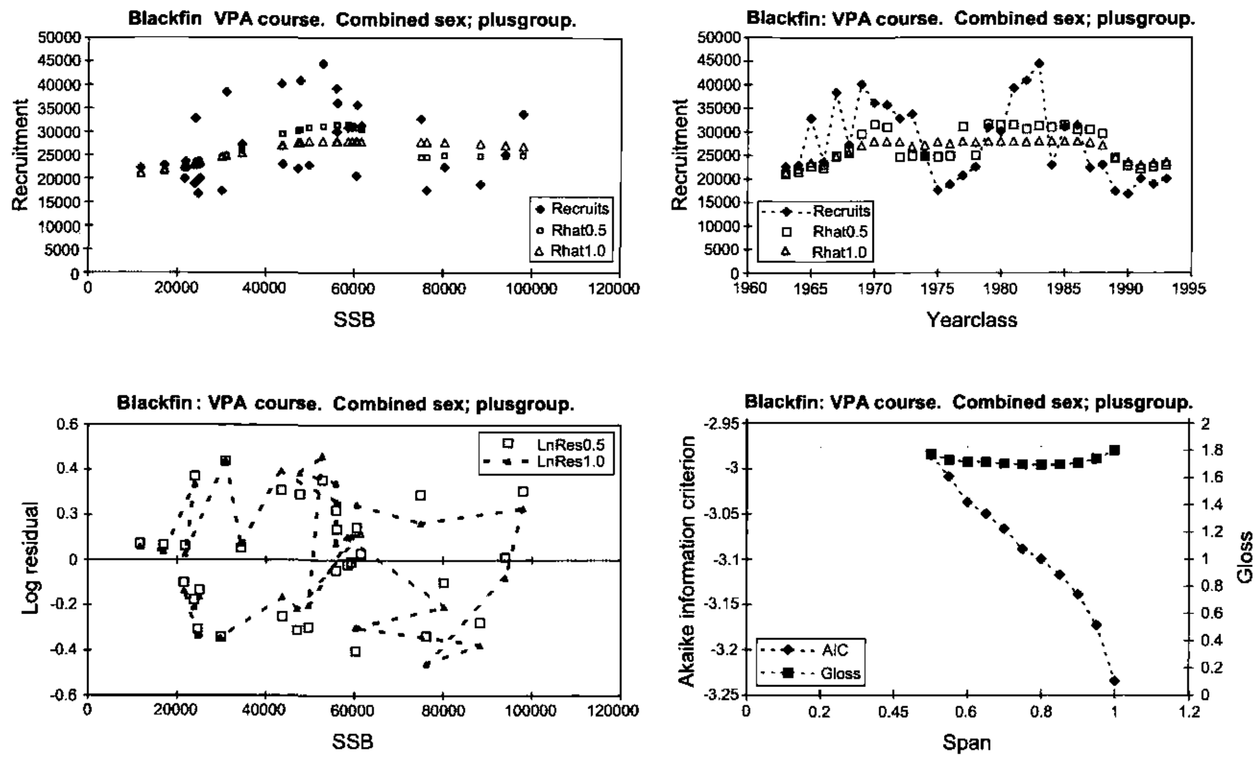


Fig. 3. The PASoft diagnostic plots for the Blackfin stock. Top left – recruitment plotted against SSB; with the LOWESS fits corresponding to the spans of 0.5 and 1.0. Top right – the time series of recruitment with recruitment estimates obtained from the two LOWESS fits. The bottom left – the log-normal residuals obtained from the two LOWESS fits.