INTERNATIONAL COUNCIL FOR
THE EXPLORATION OF THE SEA

C.M. 1991/D:17
Statistics Committee/Sess. S

BIAS IN VIRTUAL POPULATION ANALYSIS WHEN THE UNIT STOCK ASSESSED CONSISTS OF SUB-STOCKS

by

N. Daan
Netherlands Institute for Fisheries Research
P.O. Box 68, 1970 AB IJmuiden
The Netherlands

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ICES C.M. 1991/D:17
Demersal Fish Committee
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Niels Daan
Netherlands Institute for Fishery Investigations

ABSTRACT
A simulation model is presented which allows an evaluation of possible bias in the results of standard Virtual Population Analysis in combination with Separable VPA and tuning methods when applied to an heterogeneous unit stock. The results indicate that, if a unit stock defined for assessment purposes is composed in reality by two or more sub-stocks which are exploited differentially, the estimated exploitation curve is dome-shaped, even when the exploitation pattern imposed upon both sub-stocks individually is flat-topped. This bias may cause significant underestimates of fishing effort due to an associated change in apparent catchability. In particular, the apparent recent trend in fishing mortality and spawning stock biomass may deviate considerably from the true trend. These features may easily lead to inappropriate management advice. The paper does not offer a solution how this bias may be resolved other than to assess the different components individually, which of course is rarely a practical solution. However, the results suggest that integrated effort and survey indices over the entire area of distribution of the stock assessed result in less bias than when disaggregated data series are used. Further, it is concluded that simulation models provide a valuable tool to investigate problems of interpretation of the results obtained with the existing assessment methodology and that more research should be focused on the evaluation of this kind of problems.

INTRODUCTION
Methods of fish stock assessment for providing management advice have been largely standardised within ICES. The central basis is formed by Virtual Population Analysis in combination with separable VPA and tuning methods based on effort series and survey data. However, even when standard procedures are followed, there may be a variety of reasons why the results of any assessment may be questioned. There are essentially three different possible causes for problems: the input data may be unreliable, inappropriate options may have been selected from the range of possible procedures or the assumptions of the underlying model are violated. This paper deals with the latter aspect.
The primary assumption underlying all assessment work is that the stock under consideration represents an unit stock. In practice, however, stocks are often defined on logistic rather than on biological grounds. For instance, when management areas are uniformly defined to apply equally to all species, and catch data are only available by these areas, there is no other option than to use the same areas for stock assessment, even when there would be biological information available in support of a different spatial structure for distinguishing unit stocks. Thus, there is evidence that various North Sea fish stocks which are presently assessed at a total North Sea scale consist in fact of different sub-stocks (Daan et al., 1990). Because of the complexity of the models used, it is not directly obvious what the effect of a wrong assumption in terms of the unit stock will be on the results of the assessment, but some bias may be expected because the relative contribution of the different sub-stocks in the overall assessment will change as a function of the fishing mortality on these sub-stocks. In this

paper, a simulation model is developed by which the effect of combining data from two independent sub-stocks in a single assessment can be evaluated.

THE MODEL

Two independent populations are set up with a constant natural mortality and recruitment at age 1. For convenience, the values are taken identical. The exploitation pattern is also identical but the trends in F in each sub-stock are different. One is held constant, whereas the other is allowed to change annually by a fixed fraction. Two runs have been made, one for an annual increase in exploitation rate by 5% and one for an annual decrease by 5%.
The calculated catch-at-age arrays for each substock separately have then been added to obtain the input for a VPA on the combined stock. In reality, some mixing will generally occur between sub-stocks. Therefore, the present model represents an extreme case where two truly independent sub-stocks are assessed as one unit.
Assuming identical catchabilities, the fishing effort is directly proportional to the fishing mortalities on each stock. Thus, two unbiased effort data series for tuning the VPA are given by the F-values times a multiplier together with the catch-at-age arrays for the two sub-stocks (disaggregated series). Alternatively, one combined effort series might be applied by adding both the effort and the catch-at-age arrays (total series).
In addition, we assume that surveys have been carried out over the entire area, which yield a true image of the abundance by age group in each areas. Thus again two series of survey indices are given by the stock numbers in each population (disaggregated series) or alternatively by the sum of these two (total series).
Thus the output of this simple model provides a catch at age array and tuning data, which can be used to mimick a standard assessment on the combined stock. The results should be capable of identifying a possible bias due only to the violation of the assumption that the assessment is carried out on a unit stock. Obviously, in practice there will be stochastic variations and uncertainty in the parameter estimates superimposed on the observed values, but that is not our concern here.

PARAMETERIZATION OF THE MODEL

The parameter values used in the simulations are given in Table 1. The populations were followed over a period of 20 years and an 8-digit precision was maintained in all calculations. Age group 13 was treated as a +-group.

ASSESSMENT

On the total catch data from the two runs with an effort increase and decrease, a separable VPA was run and in addition two tuning runs were made, one using the disaggregated effort and survey indices by sub-stock and one using the combined series. Unless otherwise stated, the standard default values were used in order to limit the number of options. The package used is a copy of the ICES package.

Separable VPA.

The weight values of all years and age groups were set to 1, the reference age was set at 4, and the terminal population was used to provide the terminal F's for VPA. Table 2 provides the matrix of residuals for RUN 1. Although there is a clear shift in the occurrence of negative values over time, the values are relatively low due the gradual changes over time and therefore it was decided not to explore a different option.

VPA with Tuning.

Tables 3 and 4 provide the tuning data for RUN 1 for the 'disaggregated' with the four fleets and the 'total' data set with two fleets, respectively. All tuning runs included the full range of years and ages, the regressions were not weighted, and the log-catchability was used. The fleets were weighted by the reciprocal variance and q was fixed to the mean for all fleets. The tuning data for the two sets are given in tables 5 and 6.

RESULTS

Because of the simplicity of the model, the input data can be easily reproduced and they are not included in the paper. The same is true for all the output data from the final VPA's. The tables included for RUN 1 (effort increase) are just given as an example to allow a judgement of the statistical performance of these components of the assessment. It may be noted that the figures used in Table 4 actually represent the input catch arrays (top part) for the combined assessment and the true stock numbers for the two sub-stocks combined (bottom part). The data for RUN 2 showed essentially the same features and have therefore not been included.

Figures 1 and 2 summarise the results in terms of fishing mortalities, spawning stock biomasses and recruitment, in comparison with the 'true' values derived from the original model. Obviously, neither the separable VPA nor the tuning method are capable of reproducing the exploitation pattern imposed on the two sub-stocks, simply because the average fishing mortality for the combined stock is down-weighted for the older age groups in the more heavily exploited sub-stock. This in fact indicates that even though a constant and equal catchability has been imposed on the two sub-stocks, the overall catchability of the combined stock changes if the two sub-stocks are differentially exploited. The reason appears to be that the 'average' fish within the combined stock has not a constant chance of being caught by one unit of effort.

The general exploitation pattern estimated for the two runs is very similar with an apparent high mortality on the younger age groups and a significantly reduced fishing mortality on the older ones, although the curvature depends on the direction of the actual change. The separable VPA appears to yield less of a reduction in the older age groups compared to tuning methods.

The average fishing mortalities appear to be consistently underestimating the total effort employed in the two stocks, but particularly noteworthy are the markedly deviating trends in the most recent years. Again, the separable VPA appears to follow the true trend more closely than the tuning methods. Among the latter two series, it seems that in both runs the total data series yield considerably better results than the disaggregated series.

In terms of spawning stock biomass, the tuning method based on the integrated data set follows the true biomass most closely, whereas the disaggregated data series results in overestimates in recent years and the separable VPA results in underestimates.

Finally, the estimated recruitment appears to be least sensitive to any of the methods, although the results vary depending on the effort change. Excluding the last data year, the variation is within the region of $\pm 5\%$, which seems not worth worrying about given the large variations in recruitment anyway.

DISCUSSION

The assessment is based upon the assumption that the average fishing mortality (F) experienced by an individual in the combined population is equal to the total fishing effort (f) in the two sub-stocks multiplied by a constant catchability (q):

$$\bar{F} = q * (f1 + f2)$$

However, the true average fishing mortality experienced by an individual in the combined population will not be the simple average of the fishing mortalities imposed on the individual sub-stocks, but will depend on the relative numbers (N) surviving in each sub-stock:

$$\bar{F} = \frac{N1 * F1 + N2 * F2}{N1 + N2} = \frac{N1 * q * f1 + N2 * q * f2}{N1 + N2}$$

Thus, although catchability was modelled as a constant in the two sub-stocks, the apparent change in estimated q is caused by the fact that the relative N's in the two populations change over time. The assessment procedures are obviously not developed to cope with this problem, and, even if different options were applied in order to get rid of the trends, the interpretation of assessments of mixed stocks will remain difficult because one can never be sure if a trend in apparent q is an artefact or a true trend. The important point appears to be that for mixed populations there is not a direct relationship between the overall fishing mortality and the total fishing effort, if the latter is differentially employed within the different sub-stocks. In extreme cases, when recruitment of a sub-stock would be affected by overfishing, one component might even be wiped out completely, whereas the assessment would give the impression that fishing mortality were gradually reduced!

Although the present analysis is limited in scope because of the many possible options available in the ICES assessment package, the results suggest that the accepted procedures may easily lead to the wrong interpretation of the situation, when one is not absolutely sure that the basic assumptions are correct. The example of the effect of sub-stocks is relevant, because in many cases there is strong evidence that the unit stock for which management advice is provided is composed of two or more sub-stocks, which are at least partly separated and exploited differentially. This applies for instance to a variety of North Sea species (see Daan et al., 1990, for specific references). Herring has been shown to consist of a number of races, which are mixed during the feeding season but separate during the spawning season, when they attract specific effort. Plaice and sole are other examples, where tagging experiments have indicated that different sub-stocks exist . In the case of cod, there is evidence of a cline of sub-populations, which undoubtedly mix to a large extent between neighbouring groups, but the extremes of which are completely separated. Infestation with specific parasites indicated the existence of at least two fairly well separated whiting stocks to the north and to the south of the Doggerbank.

Figure 3a,b provide examples of the estimated exploitation patterns for North Sea sole and plaice based on Anonymous (1990), but there are many other examples to be found in different assessment working group reports. The similarity between the curvature in these patterns and the ones produced on the basis of the simulation model (fig 1a, 2a) is remarkable. This coincidence is of course no proof that this kind of problem is important in those cases. However, the observation that an apparent reduction in exploitation rate of the older age groups might be caused entirely by an artefact due to the methodological necessity to make a combined assessment for the accepted management units can change our perception of the status of various stocks and the consequences of different management options..

In addition to effects on the exploitation pattern, the available assessment methodology may also easily result in a biased view on the present state of the stocks. Separable VPA and tuning methods appear to result in a general underestimate of the true trends in fishing effort, because the differential exploitation automatically leads to differences in apparent 'catchability' of the combined stock, which are not related to the 'catchability' within a sub-stock. In particular, the tuning methods may not describe the present trend in fishing mortality very well according to figures 1b and 2b. The same applies obviously to the spawning stock biomass which may be over- or underestimated depending on the method used, but also the apparent recent trend may deviate considerably from the true trend.

Recruitment estimates appear to be in general much less affected by the method applied; probably, because the estimate reflects to a very large extent the sum of the observed catches of each year class over its life span.

One particularly noteworthy result is that the simulations suggest that in general an aggregated effort index over the entire range of sub-stocks as well as an aggregated survey index result in less bias than when disaggregated indices are used. The reason is probably that some a priori averaging enhances the coherence between the tuning data and the combined assessment. The apparent reduction in variation would seem to support a different approach by working groups, which probably should try to come up with integrated effort and survey series rather than with all the individual data sets which are known to apply only to particular parts of the unit stock under consideration.

The present investigation suggests that fish stock assessment is still characterised by considerable pitfalls and that simulation studies provide an important tool to investigate these.

REFERENCES

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Table 1. Parameter values used in the simulations.

	Sub-stock I	Sub-stock II
Recruitment at age 1	1000	1000
M	0.2	0.2
Relative F age 1	0.5	0.5
Relative F age 2-13+	1.0	1.0
catchability coefficient q	0.002	0.002
W_∞ (kg)	10	10
k	0.3	0.3
Age at maturity	4	4
RUN 1.		
Effort-first year	200	200
Annual change in effort	0%	+5%
Effort-final year	200	505
RUN 2.		
Effort-first year	505	505
Annual change in effort	0%	-5%
Effort-final year	505	200

Table 2
Results of Separable analysis of the combined catch at age data - RUN 1 : effort INCREASE

From 1970 to 1989 on ages 1 to 12 with Terminal F of 0.710 on age 4 and Terminal S of 1.000
Initial sum of squared residuals was 30.459 and final sum of squared residuals is 0.569 after 33 iterations

Matrix of Residuals

Years	70/71	71/72	72/73	73/74	74/75	75/76	76/77	77/78	78/79	79/80
Ages										
1/ 2	-0.054	-0.063	-0.063	-0.062	-0.060	-0.056	-0.051	-0.044	-0.035	-0.025
2/ 3	-0.086	-0.084	-0.082	-0.079	-0.074	-0.067	-0.058	-0.048	-0.036	-0.022
3/ 4	-0.070	-0.067	-0.065	-0.061	-0.056	-0.050	-0.042	-0.033	-0.022	-0.021
4/ 5	-0.050	-0.047	-0.044	-0.041	-0.036	-0.030	-0.024	-0.016	-0.009	0.000
5/ 6	-0.029	-0.026	-0.023	-0.020	-0.016	-0.011	-0.007	-0.002	0.004	0.008
6/ 7	-0.009	-0.006	-0.003	0.000	0.003	0.005	0.008	0.011	0.013	0.014
7/ 8	0.010	0.013	0.015	0.017	0.019	0.020	0.020	0.020	0.018	0.016
8/ 9	0.028	0.031	0.032	0.033	0.032	0.031	0.029	0.025	0.021	0.015
9/10	0.046	0.047	0.047	0.046	0.044	0.040	0.035	0.028	0.020	0.011
10/11	0.062	0.063	0.061	0.058	0.053	0.047	0.039	0.029	0.018	0.007
11/12	0.151	0.139	0.126	0.109	0.091	0.071	0.050	0.029	0.008	-0.013
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WTS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Years	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89		WTS
Ages											
1/ 2	-0.013	0.000	0.015	0.031	0.049	0.069	0.091	0.116	0.156	0.000	1.000
2/ 3	-0.006	0.010	0.028	0.048	0.068	0.088	0.109	0.130	0.162	0.000	1.000
3/ 4	0.001	0.014	0.027	0.041	0.054	0.066	0.078	0.088	0.107	0.000	1.000
4/ 5	0.008	0.017	0.024	0.031	0.037	0.042	0.044	0.045	0.049	0.000	1.000
5/ 6	0.013	0.016	0.019	0.020	0.019	0.017	0.012	0.006	0.000	0.000	1.000
6/ 7	0.014	0.013	0.010	0.006	0.001	-0.006	-0.014	-0.024	-0.036	0.000	1.000
7/ 8	0.012	0.007	0.000	-0.007	-0.016	-0.025	-0.035	-0.045	-0.060	0.000	1.000
8/ 9	0.008	-0.001	-0.010	-0.020	-0.030	-0.040	-0.050	-0.059	-0.074	0.000	1.000
9/10	0.001	-0.009	-0.020	-0.031	-0.042	-0.051	-0.061	-0.069	-0.084	0.000	1.000
10/11	-0.005	-0.018	-0.029	-0.040	-0.051	-0.060	-0.068	-0.075	-0.091	0.000	1.000
11/12	-0.032	-0.049	-0.065	-0.078	-0.089	-0.099	-0.107	-0.114	-0.130	0.000	1.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.001
WTS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	

Fishing Mortalities (F)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
F-values	0.4531	0.4655	0.4739	0.4816	0.4886	0.4947	0.5001	0.5047	0.5087	0.5122

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
F-values	0.5154	0.5185	0.5220	0.5264	0.5324	0.5416	0.5563	0.5814	0.6271	0.7100

Selection-at-age (S)

	1	2	3	4	5	6	7	8	9	10	11	12
S-values	0.5112	1.032	0.0173	1.0000	0.9840	0.9712	0.9626	0.9593	0.9623	0.9740	0.9993	1.0000

Table 3

Input Disaggregated Tuning Data - RUN 1 : effort INCREASE

```
104                          (100 + number of fleets)
>>Effort Sub-pop I<<     *)
1970,1989                    (first year, last year)
1,1                          (sex code, effort code)
1,13                         (first age group, last age group)
200,164.839977,201.62707,110.655282,60.7289064,33.3287305,18.2911951,10.0384207,5.5092021,3.02351422,1.65933978,0.91066498,0.49978354,0.60778461
200,164.839977,201.62707,110.655282,60.7289064,33.3287305,18.2911951,10.0384207,5.5092021,3.02351422,1.65933978,0.91066498,0.49978354,0.60784629
..
..
(19 times repeated)
..
>>Effort Sub-pop II<<     *)
1970,1989
1,1
1,13
200,164.839977,206.483404,115.932933,65.030689,36.445597,20.408453,11.419170,6.384662,3.567286,1.991825,1.111458,0.499784,0.607785
210,172.276701,217.270105,119.526639,65.693247,36.073920,19.792729,10.851227,5.944733,3.254498,1.780534,0.973523,0.425803,0.632527
220.5,180.008555,223.773549,120.550691,64.880056,34.886685,18.743005,10.061710,5.397313,2.893178,1.549821,0.829684,0.355442,0.592193
231.525,188.043302,230.247881,121.334786,63.877085,33.597149,17.655596,9.270599,4.864068,2.550217,1.336158,0.699614,0.293335,0.519011
243.10125,196.388499,236.669134,121.862321,62.684062,32.213156,16.539558,8.485016,4.349520,2.227973,1.140450,0.583388,0.239193,0.435016
255.256313,205.051451,243.011557,122.117550,61.302641,30.743969,15.404490,7.711980,3.857786,1.928344,0.963217,0.480811,0.192603,0.352615
268.019128,214.039148,249.247639,122.085853,59.736531,29.200200,14.260369,6.958253,3.392481,1.652737,0.804597,0.391435,0.153052,0.278168
281.420085,223.358204,255.348160,121.754025,57.991599,27.593697,13.117367,6.230195,2.956643,1.402039,0.664363,0.314596,0.119946,0.214354
295.491089,233.014790,261.282252,121.110577,56.075943,25.937400,11.985648,5.533614,2.552662,1.176622,0.541953,0.249451,0.092642,0.161696
310.265643,243.014563,267.017510,120.146039,53.999925,24.245153,10.875157,4.873635,2.182241,0.976355,0.436505,0.195015,0.070468,0.119541
325.778925,253.362585,272.520111,118.853266,51.776153,22.531477,9.795408,4.254584,1.846374,0.800634,0.346914,0.150211,0.052748,0.086657
342.067872,264.063242,277.754988,117.227736,49.419415,20.811325,8.755268,3.679903,1.545351,0.648435,0.271880,0.113914,0.038825,0.061600
359.171265,275.120160,282.686020,115.267835,46.946564,19.099791,7.762760,3.152076,1.278786,0.518376,0.209971,0.084989,0.028077,0.042927
377.129828,286.536106,287.276276,112.975119,44.376339,17.411815,6.824880,2.672609,1.045668,0.408785,0.159685,0.062333,0.019931,0.029311
395.98632,298.312898,291.488285,110.354540,41.729127,15.761869,5.947449,2.242024,0.844433,0.317784,0.119499,0.044904,0.013875,0.019598
415.785636,310.451301,295.284351,107.414637,39.026674,14.163643,5.134994,1.859898,0.673057,0.243363,0.087927,0.031745,0.009464,0.012821
436.574918,322.950921,298.626911,104.167671,36.291737,12.629746,4.390668,1.524927,0.529151,0.183464,0.063560,0.022004,0.006319,0.008198
458.403664,335.810103,301.478920,100.629694,33.547692,11.171427,3.716225,1.235028,0.410075,0.136047,0.045101,0.014940,0.004125,0.005119
481.323847,349.025813,303.804285,96.820556,30.818099,9.798325,3.112033,0.987456,0.313043,0.099158,0.031385,0.009927,0.002630,0.003118
505.390039,362.593535,296.520782,88.352742,26.326003,7.844221,2.337301,0.696433,0.207513,0.061831,0.018424,0.005490,0.001636,0.001851
>>Survey Sub-pop I<<     **)
1970,1989
1,1
1,13
1,1000,670.320046,367.879441,201.896518,110.803158,60.8100626,33.37327,18.3156389,10.0518357,5.51656442,3.02755475,1.66155727,2.02061264
1,1000,670.320046,367.879441,201.896518,110.803158,60.8100626,33.37327,18.3156389,10.0518357,5.51656442,3.02755475,1.66155727,2.0208177
..
..
(19 times repeated)
..
>>Survey Sub-pop II<<     **)
1970,1989
1,1
1,13
1,1000,670.320046,367.879441,201.896518,110.803158,60.8100626,33.37327,18.3156389,10.0518357,5.51656442,3.02755475,1.66155727,2.02061264
1,1000,670.320046,360.59494,193.980042,104.350485,56.1347628,30.1973834,16.2445144,8.73864619,4.70090611,2.52882629,1.36036804,2.0208177
1,1000,663.65025,349.587986,184.150854,97.0042972,51.098507,26.9169252,14.1789047,7.46895636,3.93438775,2.07249932,1.09172092,1.81889006
1,1000,656.718379,338.392099,174.36578,89.8467354,46.2959868,23.8552729,12.2920816,6.33383108,3.26367963,1.68170016,0.86654198,1.53320914
1,1000,649.517824,327.022109,164.650538,82.8989817,41.7383462,21.0146072,10.5805275,5.32713079,2.68212738,1.35040936,0.67991008,1.23653738
1,1000,642.042197,315.494549,155.031571,76.1813098,37.4349039,18.395221,9.03926873,4.44182645,2.18267902,1.07255152,0.52704348,0.96490145
1,1000,634.285372,303.827684,145.535851,69.7128176,33.3929881,15.995504,7.66197228,3.67014501,1.75802833,0.8421094,0.40337703,0.73313015
1,1000,626.241545,292.041519,136.19066,63.5111603,29.6177983,13.8119658,6.44107297,3.00373035,1.40075979,0.65323041,0.30462751,0.54439588
1,1000,617.905291,280.1578,127.023339,57.5922875,26.1123004,11.8392976,5.36792877,2.43381492,1.10348988,0.50032149,0.22684539,0.39593362
1,1000,609.271627,268.199982,118.061021,51.9701924,22.8771603,10.0704738,4.43299963,1.95139633,0.85900022,0.37812994,0.16645194,0.28236754
1,1000,600.336082,256.193184,109.330339,46.6566787,19.9107191,8.49689143,3.62604503,1.54741327,0.660358,0.28180751,0.12026124,0.19756931
1,1000,591.094766,244.164117,100.857121,41.6611535,17.2090151,7.1085454,2.93633409,1.21291451,0.50101983,0.20695677,0.08548784,0.13563406
1,1000,581.544449,232.140984,92.6660663,36.9904517,14.765853,5.894235,2.35286145,0.93921552,0.37491617,0.14965908,0.05974093,0.09133905
1,1000,571.682641,220.153352,84.7804268,32.6487001,12.5729211,4.84179601,1.86456181,0.71803743,0.27651416,0.10648481,0.041007,0.06030813
1,1000,561.507679,208.231993,77.2216742,28.6372275,10.6199562,3.93835157,1.46051573,0.54162412,0.20085829,0.07448718,0.02762315,0.03901616
1,1000,551.018817,196.408699,70.0091827,24.9545244,8.89495153,3.17057386,1.13013978,0.40283431,0.14358886,0.05118174,0.01824355,0.02471282
1,1000,540.216315,184.716055,63.1599231,21.5962597,7.38440469,2.52494799,0.86335495,0.29520678,0.10094,0.03451439,0.0118015,0.01531164
1,1000,529.10154,173.18719,56.6881791,18.5553541,6.07359722,1.98802906,0.65072796,0.21299834,0.06971929,0.02282074,0.00746976,0.00927079
1,1000,517.677062,161.855494,50.6052957,15.8221133,4.94689863,1.54668379,0.48358192,0.1511954,0.04727234,0.01478004,0.00462109,0.00547957
1,1000,505.946753,150.754299,44.9194675,13.384418,3.98808482,1.18830871,0.35407411,0.1055016,0.03143576,0.00936675,0.00279096,0.00315804
```

*) the first value in each row represents the true fishing effort in each sub-stock; the other 13 represent the catch at age array for age groups 1 to 13.

**) the first value in each row represents the standardized survey effort in each sub-stock; the other 13 represent the population numbers at the beginning of the year for age groups 1 to 13.

Table 3
Input Aggregated Tuning Data - RUN 1 : effort INCREASE

```
102                      (100 + number of fleets)
>>Effort Sub-pop I<<     *)
1970,1989                (first year, last year)
1,1                      (sex code, effort code)
1,13                     (first age group, last age group)
400,329.679954,408.110474,226.588215,125.759595,69.7743275,38.6996479,21.4575911,11.8938639,6.59080064,3.6511652,2.02212279,0.99956708,1.21556922
410,337.116678,418.897175,230.181921,126.422153,69.4026509,38.0839238,20.8896482,11.453935,6.27801187,3.43987342,1.88418797,0.92558605,1.2403731
420.5,344.848532,425.400619,231.205973,125.608963,68.2154152,37.0342001,20.1001306,10.9065149,5.91669213,3.20916073,1.74034858,0.85522549,1.20007346
431.525,352.883279,431.874951,231.990068,124.605991,66.9258795,35.9467909,19.30902,10.3732703,5.57373124,2.99549814,1.61027873,0.79311898,1.12690944
443.10125,361.228476,438.296204,232.517603,123.412969,65.5418867,34.8307528,18.5234372,9.8587225,5.25148673,2.79979003,1.49405334,0.73897697,1.04292469
455.256313,369.891428,444.638627,232.772832,122.031548,64.0726999,33.6956847,17.7504005,9.3669878,4.9518583,2.6225566,1.39147561,0.69238702,0.96052938
468.019128,378.879125,450.874709,232.741135,120.465437,62.5289304,32.551564,16.9966739,8.90168321,4.67625072,2.46393649,1.30209961,0.65283509,0.88608588
481.420085,388.198181,456.975229,232.409307,118.720505,60.9224277,31.4085619,16.268616,8.46584477,4.42555322,2.32370286,1.22526117,0.61972939,0.82227295
495.491089,397.854767,462.909322,231.765859,116.80485,59.266131,30.2768427,15.5720348,8.06186363,4.20013671,2.20129232,1.16011555,0.59242553,0.76961656
510.265643,407.85454,468.644579,230.801321,114.728832,57.5738831,29.1663523,14.9120553,7.69144261,3.99986904,2.09584493,1.1056796,0.57025156,0.72746199
525.778925,418.202562,474.147181,229.508548,112.505059,55.8602078,28.0866033,14.2930052,7.35557593,3.82414786,2.00625353,1.06087629,0.55253189,0.69457778
542.067872,428.903219,479.382058,227.883018,110.148321,54.1400556,27.0464632,13.7183233,7.05455325,3.67194928,1.93121936,1.02457919,0.5386087,0.66952069
559.171265,439.960137,484.31309,225.923117,107.675471,52.4285218,26.0539546,13.1904969,6.78798815,3.54189004,1.86931117,0.99565442,0.52786005,0.65084793
577.129828,451.376083,488.903346,223.630401,105.105246,50.7405457,25.1160749,12.7110301,6.55486983,3.43229956,1.81902463,0.9729983,0.51971407,0.63723266
595.98632,463.152875,493.115355,221.009822,102.458034,49.0905991,24.2386444,12.2804451,6.35363541,3.34129822,1.77883878,0.95556885,0.51365882,0.62751934
615.785636,475.291278,496.911421,218.069919,99.7555807,47.4923731,23.4261888,11.8983183,6.18225913,3.26687756,1.747267,0.94241022,0.50924796,0.62074186
636.574918,487.790898,500.253981,214.822953,97.0206439,45.9584768,22.681863,11.5633475,6.03835353,3.20697822,1.72290017,0.93266938,0.50610239,0.61611958
658.403664,500.65008,503.10599,211.284976,94.2765987,44.5001577,22.0074202,11.2734486,5.91927741,3.15956168,1.70444041,0.9256054,0.50390843,0.61304075
681.323847,513.86579,505.431355,207.475838,91.5470057,43.1270557,21.4032281,11.0258763,5.8222446,3.12267266,1.69072481,0.92059169,0.50241342,0.61103976
705.390039,527.433512,498.147852,199.008024,87.0549093,41.1729514,20.6284965,10.7348541,5.71671471,3.08534566,1.67776337,0.91615456,0.50141924,0.60977215
>>Survey Tot Pop<<       **)
1970,1989
1,1
1,13
1,2000,1340.64009,735.758882,403.793036,221.606317,121.620125,66.7465399,36.6312778,20.1036715,11.0331288,6.05510949,3.32311455,4.04122529
1,2000,1340.64009,728.474381,395.87656,215.153643,116.944825,63.5706534,34.5601533,18.7904819,10.2174705,5.55638104,3.02192531,4.04163539
1,2000,1333.9703,717.467427,386.047372,207.807456,111.90857,60.2901952,32.4945436,17.5207921,9.45095217,5.10005406,2.7532782,3.83982029
1,2000,1327.03842,706.27154,376.262298,200.649894,107.106049,57.2285429,30.6077204,16.3856668,8.78024405,4.7092549,2.52809926,3.55420114
1,2000,1319.83787,694.90155,366.547056,193.70214,102.548409,54.3878772,28.8961663,15.3789665,8.1986918,4.37796411,2.34146736,3.25756326
1,2000,1312.36224,683.37399,356.928089,186.984468,98.2449665,51.768491,27.3549076,14.4936622,7.69924344,4.10010626,2.18860076,2.98594594
1,2000,1304.60542,671.707125,347.432369,180.515976,94.2030507,49.368774,25.9776112,13.7219808,7.27459276,3.86966415,2.0649343,2.75418485
1,2000,1296.56159,659.920961,338.087178,174.314319,90.4278609,47.1852358,24.7567119,13.0555661,6.91732421,3.68078515,1.96618478,2.56545618
1,2000,1288.22534,648.037241,328.919857,168.395446,86.9223631,45.2125676,23.6835677,12.4856507,6.6200543,3.52787624,1.88840267,2.41699699
1,2000,1279.59167,636.079423,319.957539,162.773351,83.6872229,43.4437438,22.7486385,12.0032321,6.37556464,3.40568468,1.82800921,2.3034326
1,2000,1270.65613,624.072625,311.226857,157.459837,80.7207817,41.8701614,21.9416839,11.599249,6.17692242,3.30936226,1.78181852,2.2186353
1,2000,1261.41481,612.043558,302.753639,152.464312,78.0190777,40.4818154,21.251973,11.2647503,6.01758425,3.23451152,1.74704512,2.15670056
1,2000,1251.86449,600.020425,294.562584,147.79361,75.5759156,39.267505,20.6685003,10.9910513,5.89148059,3.17721383,1.7212982,2.11240583
1,2000,1242.00269,588.032793,286.676945,143.451859,73.3829838,38.215066,20.1802007,10.7698732,5.79307858,3.13403956,1.70256427,2.08137506
1,2000,1231.82773,576.111435,279.118192,139.440386,71.4300188,37.3116215,19.7761546,10.5934599,5.71742271,3.10204192,1.68918043,2.06008318
1,2000,1221.33886,564.28814,271.905701,135.757683,69.7050142,36.5438438,19.4457787,10.4546701,5.66015328,3.07873648,1.67980082,2.04577988
1,2000,1210.53636,552.595496,265.056441,132.399418,68.1944673,35.898218,19.1789938,10.3470425,5.61750442,3.06206914,1.67335877,2.03637873
1,2000,1199.42159,541.066631,258.584697,129.358512,66.8836598,35.361299,18.9663669,10.2648341,5.58628371,3.05037548,1.66902703,2.03033789
1,2000,1187.99711,529.734935,252.501814,126.625272,65.7569613,34.9199537,18.7992208,10.2030311,5.56383676,3.04233479,1.66617836,2.02654668
1,2000,1176.2668,518.63374,246.815986,124.187576,64.7981474,34.5615787,18.669713,10.1573373,5.54800018,3.03692149,1.66434823,2.02422515
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*) the first value in each row represents the true fishing effort in the combined stock; the other 13 represent the catch at age array for age groups 1 to 13.

**) the first value in each row represents the standardized survey effort in the combined stock; the other 13 represent the population numbers at the beginning of the year for age groups 1 to 13.

Table 5

Output tuning module VPA for Disaggregated Tuning Data - RUN 1 : effort INCREASE

DISAGGREGATED Qs /LOG TRANSFORMATION /NO explanatory variate (Mean used)

Fleet 1 ,>>Effort Sub-pop I << , has terminal q estimated as the mean

Fleet 2 ,>>Effort Sub-pop II<< , has terminal q estimated as the mean

Fleet 3 ,>>Survey Sub-pop I << , has terminal q estimated as the mean

Fleet 4 ,>>Survey Sub-pop II<< , has terminal q estimated as the mean

FLEETS COMBINED BY ** VARIANCE ** /Terminal Fs estimated using Laurec/Shepherd method

Regression weights

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Oldest age F = 1.000*average of 5 younger ages. Fleets combined by variance of predictions

Fishing mortalities

Age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.204	0.208	0.213	0.219	0.224	0.230	0.236	0.242	0.249	0.256	0.263	0.270	0.277	0.284	0.290	0.296	0.302	0.309	0.323	0.329
2	0.416	0.429	0.440	0.450	0.461	0.472	0.484	0.495	0.507	0.519	0.531	0.542	0.553	0.563	0.571	0.578	0.582	0.583	0.587	0.597
3	0.425	0.438	0.448	0.458	0.468	0.478	0.488	0.497	0.506	0.514	0.522	0.529	0.535	0.539	0.540	0.539	0.533	0.523	0.510	0.485
4	0.434	0.447	0.457	0.466	0.474	0.482	0.490	0.497	0.502	0.507	0.511	0.513	0.515	0.514	0.510	0.503	0.492	0.475	0.453	0.417
5	0.444	0.456	0.465	0.473	0.480	0.486	0.491	0.495	0.498	0.499	0.499	0.498	0.494	0.491	0.484	0.473	0.459	0.440	0.416	0.379
6	0.454	0.465	0.473	0.479	0.485	0.489	0.491	0.492	0.492	0.491	0.487	0.483	0.477	0.469	0.463	0.451	0.436	0.417	0.393	0.359
7	0.464	0.475	0.481	0.486	0.490	0.491	0.491	0.490	0.487	0.482	0.477	0.470	0.462	0.453	0.442	0.435	0.421	0.403	0.381	0.350
8	0.476	0.486	0.491	0.494	0.495	0.494	0.492	0.488	0.482	0.475	0.468	0.459	0.450	0.441	0.430	0.419	0.412	0.396	0.376	0.348
9	0.490	0.499	0.502	0.503	0.502	0.499	0.494	0.488	0.480	0.471	0.462	0.452	0.442	0.433	0.423	0.412	0.400	0.395	0.376	0.350
10	0.508	0.515	0.517	0.516	0.512	0.507	0.500	0.491	0.481	0.470	0.460	0.449	0.439	0.429	0.420	0.410	0.399	0.385	0.381	0.356
11	0.535	0.540	0.539	0.535	0.529	0.521	0.511	0.500	0.488	0.476	0.464	0.453	0.442	0.431	0.422	0.412	0.401	0.388	0.370	0.366
12	0.494	0.503	0.506	0.507	0.506	0.503	0.498	0.491	0.484	0.475	0.466	0.457	0.447	0.437	0.427	0.417	0.406	0.393	0.377	0.354

Log catchability estimates

Age 1

Fleet	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-7.58	-7.58	-7.58	-7.58	-7.58	-7.58	-7.57	-7.57	-7.57	-7.57	-7.57	-7.57	-7.57	-7.57	-7.57	-7.57	-7.58	-7.58	-7.57	-7.57
2	-7.58	-7.59	-7.59	-7.59	-7.60	-7.60	-7.61	-7.61	-7.61	-7.62	-7.62	-7.63	-7.64	-7.65	-7.66	-7.67	-7.69	-7.70	-7.69	-7.71
3	-0.48	-0.48	-0.48	-0.48	-0.48	-0.47	-0.47	-0.47	-0.47	-0.47	-0.47	-0.46	-0.46	-0.47	-0.47	-0.47	-0.48	-0.48	-0.46	-0.47
4	-0.48	-0.48	-0.48	-0.48	-0.48	-0.47	-0.47	-0.47	-0.47	-0.47	-0.47	-0.46	-0.46	-0.47	-0.47	-0.47	-0.48	-0.48	-0.46	-0.47

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-7.57	0.005	0.1028	0.3288	0.000E+00	0.000E+00	-7.574	0.001
2	-7.63	0.042	0.2445	0.3557	0.000E+00	0.000E+00	-7.634	0.009
3	-0.47	0.007	0.6233	0.3288	0.000E+00	0.000E+00	-0.473	0.001
4	-0.47	0.007	0.6233	0.3288	0.000E+00	0.000E+00	-0.473	0.001

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.329	0.350E-02	0.375E-02	0.375E-02	1.153

Age 2

Fleet	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-6.88	-6.88	-6.87	-6.86	-6.85	-6.84	-6.83	-6.82	-6.81	-6.80	-6.79	-6.78	-6.77	-6.76	-6.75	-6.75	-6.75	-6.75	-6.75	-6.72
2	-6.86	-6.85	-6.86	-6.87	-6.88	-6.90	-6.91	-6.92	-6.94	-6.96	-6.97	-6.99	-7.01	-7.04	-7.07	-7.10	-7.14	-7.18	-7.22	-7.26
3	-0.38	-0.38	-0.37	-0.36	-0.35	-0.34	-0.33	-0.32	-0.31	-0.30	-0.29	-0.28	-0.27	-0.26	-0.25	-0.25	-0.25	-0.25	-0.25	-0.22
4	-0.38	-0.38	-0.38	-0.38	-0.38	-0.38	-0.39	-0.39	-0.39	-0.39	-0.40	-0.40	-0.41	-0.42	-0.43	-0.44	-0.46	-0.49	-0.51	-0.50

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-6.80	0.051	0.2229	0.5507	0.000E+00	0.000E+00	-6.799	0.011
2	-7.00	0.130	0.4624	0.7769	0.000E+00	0.000E+00	-6.997	0.028
3	-0.30	0.051	0.7411	0.5507	0.000E+00	0.000E+00	-0.300	0.011
4	-0.42	0.045	0.6603	0.6501	0.000E+00	0.000E+00	-0.415	0.010

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.596	0.275E-01	0.566E-01	0.566E-01	4.234

Age 3

Fleet	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-6.87	-6.86	-6.84	-6.82	-6.80	-6.78	-6.76	-6.74	-6.72	-6.70	-6.68	-6.66	-6.64	-6.62	-6.61	-6.59	-6.59	-6.59	-6.60	-6.61
2	-6.82	-6.83	-6.85	-6.87	-6.90	-6.93	-6.95	-6.99	-7.02	-7.06	-7.10	-7.14	-7.18	-7.23	-7.29	-7.36	-7.43	-7.52	-7.61	-7.76
3	-0.37	-0.36	-0.34	-0.32	-0.30	-0.28	-0.26	-0.24	-0.22	-0.20	-0.18	-0.16	-0.14	-0.12	-0.11	-0.10	-0.09	-0.09	-0.10	-0.11
4	-0.37	-0.38	-0.39	-0.40	-0.42	-0.43	-0.45	-0.47	-0.49	-0.52	-0.54	-0.57	-0.60	-0.63	-0.68	-0.72	-0.78	-0.85	-0.92	-1.00

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-6.70	0.100	0.2454	0.4413	0.000E+00	0.000E+00	-6.703	0.022
2	-7.14	0.284	0.4000	0.9011	0.000E+00	0.000E+00	-7.141	0.062
3	-0.20	0.100	0.8157	0.4413	0.000E+00	0.000E+00	-0.204	0.022
4	-0.58	0.194	0.5597	0.7388	0.000E+00	0.000E+00	-0.580	0.042

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.485	0.649E-01	0.126	0.126	3.753

Age 4

Fleet	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-6.86	-6.84	-6.81	-6.78	-6.75	-6.73	-6.70	-6.67	-6.64	-6.61	-6.59	-6.56	-6.53	-6.51	-6.49	-6.48	-6.48	-6.48	-6.50	-6.53
2	-6.79	-6.81	-6.84	-6.88	-6.92	-6.96	-7.01	-7.06	-7.11	-7.17	-7.23	-7.30	-7.38	-7.46	-7.55	-7.66	-7.77	-7.91	-8.06	-8.29
3	-0.36	-0.34	-0.31	-0.28	-0.25	-0.23	-0.20	-0.17	-0.14	-0.11	-0.09	-0.06	-0.03	-0.01	0.01	0.02	0.02	0.02	0.00	-0.03

4	-0.36	-0.38	-0.40	-0.43	-0.46	-0.49	-0.52	-0.56	-0.60	-0.65	-0.70	-0.76	-0.81	-0.88	-0.96	-1.04	-1.14	-1.25	-1.38	-1.54

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-6.63	0.133	0.2648	0.3795	0.000E+00	0.000E+00	-6.627	0.029
2	-7.31	0.454	0.3389	1.1207	0.000E+00	0.000E+00	-7.307	0.099
3	-0.13	0.133	0.8802	0.3795	0.000E+00	0.000E+00	-0.128	0.029
4	-0.77	0.361	0.4650	0.9013	0.000E+00	0.000E+00	-0.766	0.079

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.417	0.895E-01	0.166	0.166	3.432

Age 5

Fleet	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-6.85	-6.82	-6.78	-6.74	-6.71	-6.67	-6.64	-6.60	-6.57	-6.54	-6.51	-6.48	-6.46	-6.43	-6.41	-6.40	-6.40	-6.41	-6.43	-6.48
2	-6.76	-6.79	-6.83	-6.88	-6.94	-7.00	-7.06	-7.14	-7.21	-7.30	-7.39	-7.49	-7.60	-7.71	-7.84	-7.99	-8.15	-8.33	-8.54	-8.85
3	-0.35	-0.32	-0.28	-0.25	-0.21	-0.17	-0.14	-0.11	-0.07	-0.04	-0.01	0.02	0.04	0.07	0.09	0.10	0.10	0.09	0.07	0.02
4	-0.35	-0.38	-0.41	-0.45	-0.50	-0.55	-0.60	-0.66	-0.73	-0.80	-0.87	-0.96	-1.05	-1.15	-1.27	-1.39	-1.53	-1.70	-1.88	-2.09

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-6.57	0.154	0.2812	0.3474	0.000E+00	0.000E+00	-6.567	0.034
2	-7.49	0.637	0.2824	1.4820	0.000E+00	0.000E+00	-7.490	0.139
3	-0.07	0.154	0.9349	0.3474	0.000E+00	0.000E+00	-0.067	0.034
4	-0.97	0.540	0.3804	1.1701	0.000E+00	0.000E+00	-0.967	0.118

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.379	0.105	0.188	0.188	3.192

Age 6

Fleet	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-6.84	-6.80	-6.75	-6.71	-6.67	-6.63	-6.59	-6.55	-6.51	-6.48	-6.45	-6.42	-6.39	-6.37	-6.35	-6.34	-6.34	-6.36	-6.39	-6.44
2	-6.73	-6.77	-6.83	-6.89	-6.96	-7.04	-7.13	-7.22	-7.32	-7.44	-7.56	-7.69	-7.84	-7.99	-8.16	-8.34	-8.55	-8.78	-9.04	-9.43
3	-0.34	-0.30	-0.25	-0.21	-0.17	-0.13	-0.09	-0.05	-0.01	0.02	0.05	0.08	0.11	0.13	0.15	0.16	0.16	0.14	0.11	0.06
4	-0.34	-0.38	-0.43	-0.48	-0.54	-0.61	-0.69	-0.77	-0.86	-0.96	-1.06	-1.18	-1.31	-1.45	-1.60	-1.77	-1.95	-2.16	-2.40	-2.67

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-6.52	0.166	0.2952	0.3329	0.000E+00	0.000E+00	-6.518	0.036
2	-7.69	0.828	0.2323	2.0500	0.000E+00	0.000E+00	-7.685	0.181
3	-0.02	0.166	0.9815	0.3329	0.000E+00	0.000E+00	-0.019	0.036
4	-1.18	0.728	0.3075	1.5904	0.000E+00	0.000E+00	-1.179	0.159

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.359	0.115	0.199	0.199	3.007

Age 7

Fleet	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-6.83	-6.78	-6.72	-6.67	-6.63	-6.58	-6.54	-6.49	-6.46	-6.42	-6.39	-6.37	-6.34	-6.33	-6.32	-6.30	-6.31	-6.32	-6.36	-6.42
2	-6.70	-6.75	-6.82	-6.90	-6.99	-7.09	-7.19	-7.31	-7.44	-7.59	-7.74	-7.91	-8.09	-8.28	-8.50	-8.72	-8.97	-9.25	-9.55	-10.01
3	-0.33	-0.28	-0.22	-0.17	-0.13	-0.08	-0.04	0.00	0.04	0.08	0.11	0.13	0.16	0.17	0.18	0.20	0.19	0.18	0.14	0.08
4	-0.33	-0.38	-0.44	-0.51	-0.59	-0.68	-0.77	-0.88	-0.99	-1.12	-1.26	-1.41	-1.58	-1.76	-1.95	-2.15	-2.39	-2.64	-2.93	-3.25

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-6.48	0.172	0.3074	0.3287	0.000E+00	0.000E+00	-6.478	0.038
2	-7.89	1.024	0.1893	2.9185	0.000E+00	0.000E+00	-7.890	0.223
3	0.02	0.172	1.0218	0.3287	0.000E+00	0.000E+00	0.022	0.038
4	-1.40	0.921	0.2465	2.2268	0.000E+00	0.000E+00	-1.400	0.201

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.350	0.120	0.203	0.203	2.863

Age 8

Fleet	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-6.81	-6.75	-6.69	-6.64	-6.58	-6.53	-6.49	-6.45	-6.41	-6.38	-6.35	-6.32	-6.31	-6.29	-6.28	-6.28	-6.28	-6.30	-6.33	-6.39
2	-6.66	-6.72	-6.81	-6.91	-7.02	-7.13	-7.27	-7.41	-7.57	-7.74	-7.93	-8.13	-8.35	-8.59	-8.84	-9.12	-9.40	-9.72	-10.08	-10.60
3	-0.31	-0.25	-0.19	-0.14	-0.08	-0.03	0.01	0.05	0.09	0.12	0.15	0.18	0.19	0.21	0.22	0.22	0.22	0.20	0.17	0.11
4	-0.31	-0.37	-0.45	-0.54	-0.63	-0.74	-0.86	-0.99	-1.14	-1.29	-1.47	-1.65	-1.86	-2.08	-2.31	-2.57	-2.83	-3.13	-3.47	-3.84

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-6.44	0.174	0.3183	0.3303	0.000E+00	0.000E+00	-6.443	0.038
2	-8.10	1.224	0.1534	4.2266	0.000E+00	0.000E+00	-8.100	0.267
3	0.06	0.174	1.0584	0.3303	0.000E+00	0.000E+00	0.057	0.038
4	-1.63	1.118	0.1966	3.1742	0.000E+00	0.000E+00	-1.627	0.244

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.348	0.122	0.202	0.202	2.749

Age 9

Fleet	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-6.79	-6.72	-6.66	-6.60	-6.54	-6.49	-6.44	-6.40	-6.36	-6.33	-6.31	-6.29	-6.27	-6.26	-6.26	-6.26	-6.27	-6.27	-6.31	-6.37
2	-6.63	-6.70	-6.80	-6.91	-7.04	-7.18	-7.34	-7.51	-7.70	-7.90	-8.12	-8.36	-8.62	-8.90	-9.20	-9.51	-9.86	-10.20	-10.60	-11.18
3	-0.29	-0.23	-0.16	-0.10	-0.04	0.01	0.06	0.10	0.14	0.17	0.19	0.21	0.23	0.24	0.24	0.24	0.23	0.23	0.19	0.13
4	-0.29	-0.37	-0.46	-0.56	-0.67	-0.80	-0.95	-1.11	-1.28	-1.47	-1.68	-1.90	-2.14	-2.40	-2.68	-2.98	-3.30	-3.63	-4.01	-4.42

SUMMARY STATISTICS

Fleet	Pred.	SE(q)	Partial	Raised	SLOPE	SE	INTRCPT	SE

	q		F	F		Slope		Intrcpt
1	-6.41	0.172	0.3290	0.3357	0.000E+00	0.000E+00	-6.410	0.038
2	-8.31	1.428	0.1240	6.1856	0.000E+00	0.000E+00	-8.313	0.312
3	0.09	0.172	1.0938	0.3357	0.000E+00	0.000E+00	0.090	0.038
4	-1.85	1.319	0.1565	4.5756	0.000E+00	0.000E+00	-1.855	0.288
Fbar		SIGMA(int.)		SIGMA(ext.)		SIGMA(overall)		Variance ratio
0.350		0.121		0.197		0.197		2.654

Age 10

Fleet	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-6.76	-6.69	-6.62	-6.55	-6.49	-6.44	-6.39	-6.35	-6.31	-6.29	-6.27	-6.25	-6.24	-6.24	-6.24	-6.24	-6.26	-6.28	-6.28	-6.34
2	-6.58	-6.67	-6.78	-6.91	-7.06	-7.22	-7.40	-7.60	-7.82	-8.06	-8.32	-8.60	-8.89	-9.21	-9.55	-9.91	-10.30	-10.72	-11.13	-11.77
3	-0.26	-0.19	-0.12	-0.05	0.01	0.06	0.11	0.15	0.19	0.21	0.23	0.25	0.26	0.26	0.26	0.26	0.24	0.22	0.22	0.16
4	-0.26	-0.35	-0.46	-0.58	-0.71	-0.86	-1.03	-1.22	-1.42	-1.65	-1.89	-2.15	-2.43	-2.73	-3.05	-3.39	-3.76	-4.15	-4.54	-5.01

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-6.38	0.167	0.3405	0.3443	0.000E+00	0.000E+00	-6.376	0.036
2	-8.53	1.635	0.1002	9.1261	0.000E+00	0.000E+00	-8.526	0.357
3	0.12	0.167	1.1319	0.3443	0.000E+00	0.000E+00	0.124	0.036
4	-2.08	1.523	0.1247	6.6543	0.000E+00	0.000E+00	-2.082	0.332
Fbar		SIGMA(int.)		SIGMA(ext.)		SIGMA(overall)		Variance ratio
0.356		0.117		0.188		0.188		2.570

Age 11

Fleet	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-6.72	-6.64	-6.56	-6.49	-6.43	-6.37	-6.33	-6.29	-6.26	-6.23	-6.22	-6.21	-6.20	-6.21	-6.21	-6.22	-6.24	-6.26	-6.30	-6.31
2	-6.52	-6.62	-6.76	-6.90	-7.07	-7.26	-7.46	-7.69	-7.94	-8.21	-8.51	-8.82	-9.16	-9.52	-9.90	-10.31	-10.74	-11.20	-11.70	-12.35
3	-0.22	-0.14	-0.06	0.01	0.07	0.13	0.17	0.21	0.24	0.27	0.28	0.29	0.30	0.29	0.29	0.28	0.26	0.24	0.20	0.19
4	-0.22	-0.32	-0.44	-0.58	-0.74	-0.91	-1.11	-1.32	-1.56	-1.81	-2.09	-2.39	-2.71	-3.05	-3.42	-3.80	-4.21	-4.65	-5.13	-5.59

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-6.34	0.159	0.3545	0.3566	0.000E+00	0.000E+00	-6.335	0.035
2	-8.73	1.848	0.0815	******	0.000E+00	0.000E+00	-8.733	0.403
3	0.16	0.159	1.1785	0.3566	0.000E+00	0.000E+00	0.164	0.035
4	-2.30	1.734	0.1000	9.7764	0.000E+00	0.000E+00	-2.303	0.378
Fbar		SIGMA(int.)		SIGMA(ext.)		SIGMA(overall)		Variance ratio
0.366		0.112		0.177		0.177		2.489

Table 6

Output tuning module VPA for Aggregated Tuning Data - RUN 1 : effort INCREASE

DISAGGREGATED Qs /LOG TRANSFORMATION /NO explanatory variate (Mean used)

Fleet 1 ,>>Effort Tot Pop<< , has terminal q estimated as the mean

Fleet 2 ,>>Survey Tot Pop<< , has terminal q estimated as the mean

FLEETS COMBINED BY ** VARIANCE ** /Terminal Fs estimated using Laurec/Shepherd method

Regression weights

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Oldest age F = 1.000*average of 5 younger ages. Fleets combined by variance of predictions

Fishing mortalities

Age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988.	1989
1	0.204	0.208	0.213	0.219	0.224	0.230	0.236	0.243	0.249	0.256	0.263	0.271	0.279	0.287	0.296	0.305	0.314	0.323	0.335	0.348
2	0.416	0.429	0.440	0.450	0.461	0.472	0.484	0.496	0.508	0.520	0.532	0.545	0.558	0.570	0.583	0.597	0.609	0.621	0.630	0.631
3	0.425	0.438	0.448	0.458	0.468	0.478	0.488	0.497	0.506	0.515	0.524	0.532	0.540	0.547	0.553	0.559	0.564	0.568	0.569	0.549
4	0.434	0.447	0.457	0.466	0.474	0.483	0.490	0.497	0.503	0.509	0.513	0.517	0.520	0.522	0.523	0.523	0.523	0.521	0.519	0.500
5	0.444	0.456	0.465	0.473	0.480	0.486	0.491	0.495	0.499	0.501	0.501	0.501	0.500	0.499	0.496	0.493	0.489	0.486	0.482	0.469
6	0.454	0.466	0.473	0.479	0.485	0.489	0.492	0.493	0.493	0.492	0.490	0.486	0.482	0.477	0.474	0.469	0.464	0.461	0.458	0.450
7	0.464	0.475	0.481	0.486	0.490	0.491	0.492	0.490	0.488	0.484	0.479	0.473	0.467	0.461	0.455	0.453	0.448	0.445	0.443	0.440
8	0.476	0.486	0.491	0.494	0.495	0.495	0.492	0.488	0.483	0.477	0.470	0.463	0.455	0.449	0.443	0.437	0.439	0.436	0.436	0.436
9	0.490	0.499	0.502	0.503	0.502	0.499	0.494	0.488	0.481	0.472	0.464	0.455	0.447	0.440	0.435	0.430	0.427	0.434	0.434	0.436
10	0.508	0.515	0.517	0.516	0.512	0.507	0.500	0.491	0.482	0.472	0.462	0.453	0.444	0.437	0.431	0.427	0.425	0.425	0.438	0.441
11	0.535	0.540	0.539	0.535	0.529	0.521	0.512	0.501	0.489	0.478	0.467	0.456	0.447	0.439	0.433	0.429	0.427	0.427	0.429	0.452
12	0.494	0.503	0.506	0.507	0.506	0.503	0.498	0.492	0.485	0.476	0.468	0.460	0.452	0.445	0.439	0.435	0.433	0.433	0.436	0.441

Log catchability estimates

Age 1

Fleet	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-7.58	-7.58	-7.59	-7.59	-7.59	-7.59	-7.59	-7.59	-7.60	-7.60	-7.60	-7.60	-7.60	-7.61	-7.61	-7.61	-7.61	-7.62	-7.62	-7.61
	0.21	0.21	0.21	0.22	0.22	0.22	0.22	0.22	0.23	0.23	0.23	0.23	0.24	0.24	0.25	0.25	0.25	0.25	0.26	0.28

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-7.60	0.013	0.3532	0.3532	0.000E+00	0.000E+00	7.599	0.003
2	0.23	0.019	1.2632	0.3331	0.000E+00	0.000E+00	0.234	0.004

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.347	0.106E-01	0.269E-01	0.269E-01	6.434

Age 2

Fleet	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-6.87	-6.86	-6.86	-6.87	-6.87	-6.87	-6.87	-6.88	-6.88	-6.89	-6.90	-6.90	-6.91	-6.92	-6.93	-6.94	-6.95	-6.97	-6.99	-7.02
2	0.31	0.32	0.32	0.32	0.33	0.33	0.34	0.34	0.35	0.35	0.36	0.36	0.37	0.37	0.38	0.38	0.39	0.39	0.39	0.40

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-6.91	0.046	0.7059	0.7059	0.000E+00	0.000E+00	-6.907	0.010
2	0.35	0.028	1.4258	0.6038	0.000E+00	0.000E+00	0.355	0.006

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.630	0.242E-01	0.697E-01	0.697E-01	8.270

Age 3

Fleet	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-6.85	-6.84	-6.84	-6.85	-6.85	-6.86	-6.87	-6.88	-6.89	-6.90	-6.91	-6.93	-6.94	-6.96	-6.98	-7.00	-7.03	-7.06	-7.09	-7.16
2	0.32	0.33	0.33	0.33	0.34	0.34	0.34	0.35	0.35	0.35	0.35	0.36	0.36	0.36	0.37	0.37	0.37	0.37	0.37	0.36

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-6.93	0.095	0.6872	0.6872	0.000E+00	0.000E+00	-6.934	0.021
2	0.35	0.017	1.4206	0.5451	0.000E+00	0.000E+00	0.351	0.004

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.549	0.163E-01	0.392E-01	0.392E-01	5.796

Age 4

Fleet	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-6.83	-6.82	-6.82	-6.83	-6.84	-6.85	-6.86	-6.88	-6.89	-6.91	-6.93	-6.96	-6.98	-7.01	-7.04	-7.07	-7.11	-7.14	-7.18	-7.25
2	0.33	0.34	0.34	0.34	0.34	0.34	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.36	0.36	0.36	0.35

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-6.96	0.136	0.6697	0.6697	0.000E+00	0.000E+00	-6.960	0.030
2	0.35	0.007	1.4167	0.4997	0.000E+00	0.000E+00	0.348	0.002

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.500	0.717E-02	0.155E-01	0.155E-01	4.654

Age 5

Fleet	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-6.80	-6.80	-6.81	-6.82	-6.83	-6.84	-6.86	-6.88	-6.90	-6.93	-6.96	-6.99	-7.02	-7.05	-7.09	-7.13	-7.17	-7.21	-7.25	-7.32
2	0.34	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.35	0.35

SUMMARY STATISTICS

Fleet	Pred.	SE(q)	Partial	Raised	SLOPE	SE	INTRCPT	SE

	q		F	F		Slope		Intrcpt
1	-6.98	0.169	0.6544	0.6544	0.000E+00	0.000E+00	-6.983	0.037
2	0.35	0.003	1.4138	0.4687	0.000E+00	0.000E+00	0.346	0.001

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.469	0.266E-02	0.526E-02	0.526E-02	3.901

Age 6

Fleet	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-6.78	-6.78	-6.79	-6.80	-6.82	-6.84	-6.86	-6.88	-6.91	-6.94	-6.98	-7.02	-7.06	-7.10	-7.14	-7.18	-7.22	-7.27	-7.31	-7.36
2	0.35	0.36	0.36	0.36	0.36	0.35	0.35	0.35	0.35	0.34	0.34	0.34	0.34	0.33	0.34	0.33	0.33	0.34	0.34	0.35

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-7.00	0.195	0.6425	0.6425	0.000E+00	0.000E+00	-7.001	0.043
2	0.35	0.009	1.4124	0.4496	0.000E+00	0.000E+00	0.345	0.002

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.450	0.927E-02	0.169E-01	0.169E-01	3.344

Age 7

Fleet	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-6.76	-6.76	-6.77	-6.79	-6.81	-6.83	-6.86	-6.89	-6.92	-6.96	-7.00	-7.04	-7.09	-7.13	-7.18	-7.22	-7.26	-7.30	-7.34	-7.38
2	0.37	0.37	0.37	0.37	0.36	0.36	0.36	0.35	0.35	0.34	0.34	0.33	0.33	0.33	0.32	0.33	0.33	0.33	0.34	0.35

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-7.01	0.215	0.6341	0.6341	0.000E+00	0.000E+00	-7.014	0.047
2	0.35	0.016	1.4136	0.4391	0.000E+00	0.000E+00	0.346	0.003

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.440	0.158E-01	0.270E-01	0.270E-01	2.917

Age 8

Fleet	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-6.73	-6.74	-6.75	-6.77	-6.80	-6.82	-6.86	-6.89	-6.93	-6.98	-7.02	-7.07	-7.11	-7.16	-7.21	-7.25	-7.28	-7.32	-7.35	-7.39
2	0.38	0.38	0.38	0.38	0.37	0.37	0.36	0.36	0.35	0.34	0.34	0.33	0.33	0.32	0.32	0.32	0.33	0.33	0.34	0.35

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-7.02	0.230	0.6293	0.6293	0.000E+00	0.000E+00	-7.022	0.050
2	0.35	0.022	1.4185	0.4343	0.000E+00	0.000E+00	0.350	0.005

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.436	0.222E-01	0.356E-01	0.356E-01	2.576

Age9

Fleet	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-6.71	-6.71	-6.73	-6.75	-6.78	-6.82	-6.85	-6.89	-6.94	-6.98	-7.03	-7.08	-7.13	-7.18	-7.22	-7.27	-7.31	-7.33	-7.36	-7.39
2	0.40	0.40	0.40	0.39	0.39	0.38	0.37	0.36	0.36	0.35	0.34	0.33	0.33	0.32	0.32	0.32	0.32	0.34	0.35	0.36

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-7.02	0.243	0.6285	0.6285	0.000E+00	0.000E+00	-7.023	0.053
2	0.36	0.029	1.4290	0.4341	0.000E+00	0.000E+00	0.357	0.006

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.436	0.288E-01	0.436E-01	0.436E-01	2.293

Age 10

Fleet	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-6.67	-6.68	-6.70	-6.73	-6.76	-6.80	-6.84	-6.89	-6.94	-6.99	-7.04	-7.09	-7.14	-7.19	-7.23	-7.27	-7.31	-7.35	-7.35	-7.38
2	0.43	0.43	0.42	0.41	0.41	0.40	0.39	0.38	0.37	0.36	0.35	0.34	0.34	0.33	0.33	0.33	0.33	0.33	0.37	0.38

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-7.02	0.255	0.6327	0.6327	0.000E+00	0.000E+00	-7.016	0.056
2	0.37	0.037	1.4484	0.4380	0.000E+00	0.000E+00	0.370	0.0082

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.441	0.365E-01	0.520E-01	0.520E-01	2.0330

Age 11

Fleet	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-6.62	-6.63	-6.66	-6.69	-6.73	-6.77	-6.82	-6.87	-6.92	-6.97	-7.03	-7.08	-7.13	-7.18	-7.23	-7.27	-7.31	-7.34	-7.37	-7.35
2	0.47	0.46	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38	0.36	0.36	0.35	0.34	0.34	0.34	0.34	0.35	0.40

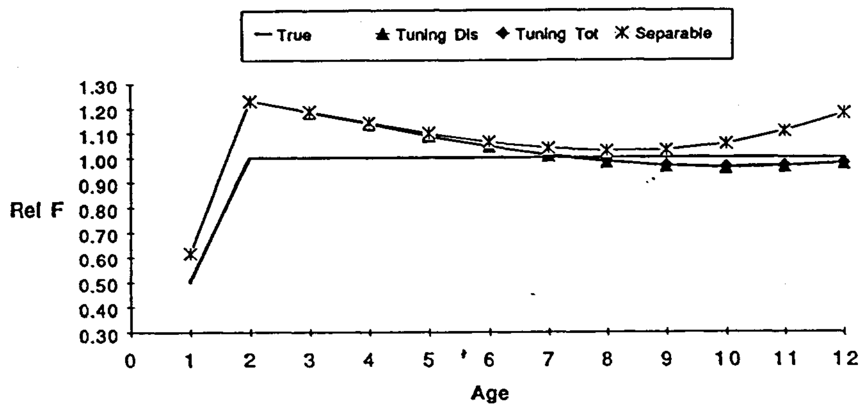
SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-7.00	0.271	0.6442	0.6442	0.000E+00	0.000E+00	-6.998	0.059 q
2	0.39	0.047	1.4826	0.4473	0.000E+00	0.000E+00	0.394	0.0100

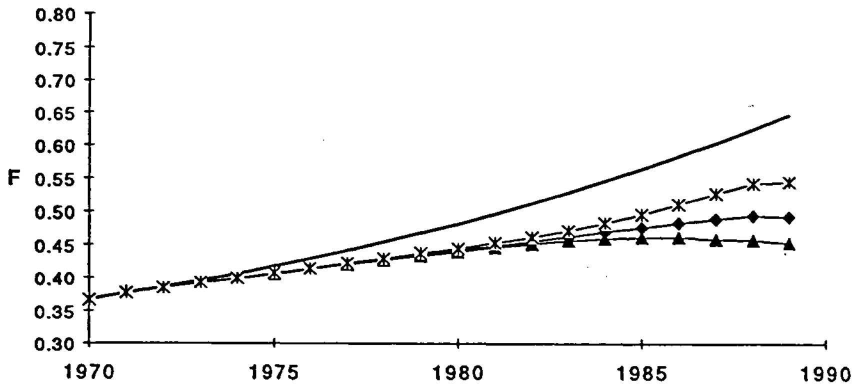
Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.452	0.466E-01	0.620E-01	0.620E-01	1.765

Figure 1. Estimated exploitation pattern (A), fishing mortality (B), spawning stock biomass (C), and recruitment (D) from RUN 1. The true values as well as the values obtained by separable VPA and on the basis of two sets of tuning data (see text) are indicated.

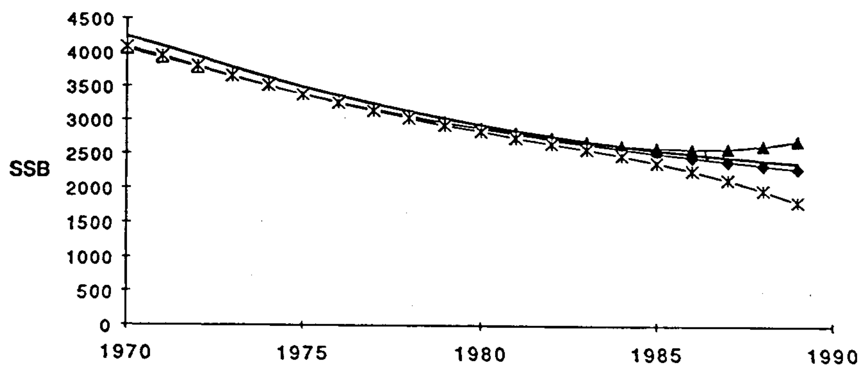
A. Average exploitation pattern (1970-1986)



B. Average fishing mortality (weighted by age class)



C. Spawning stock biomass



D. Recruitment

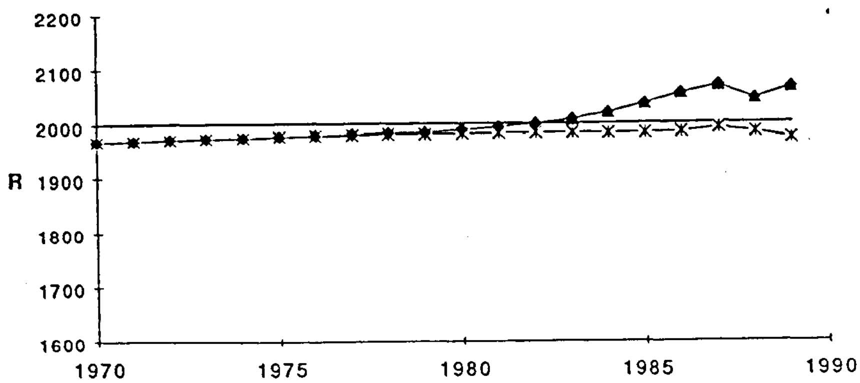


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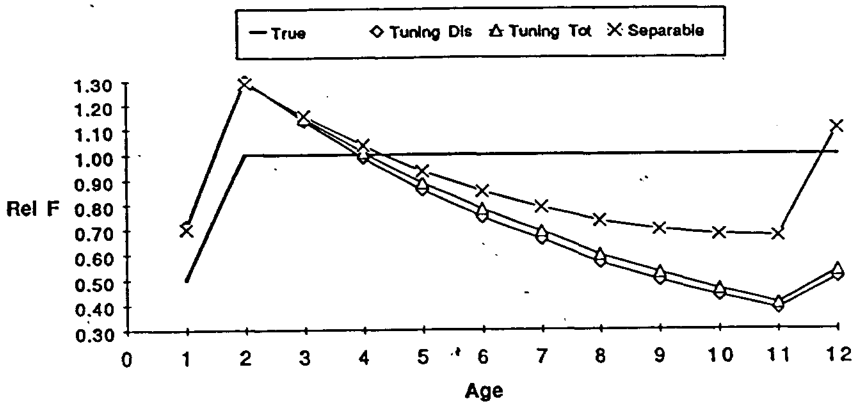
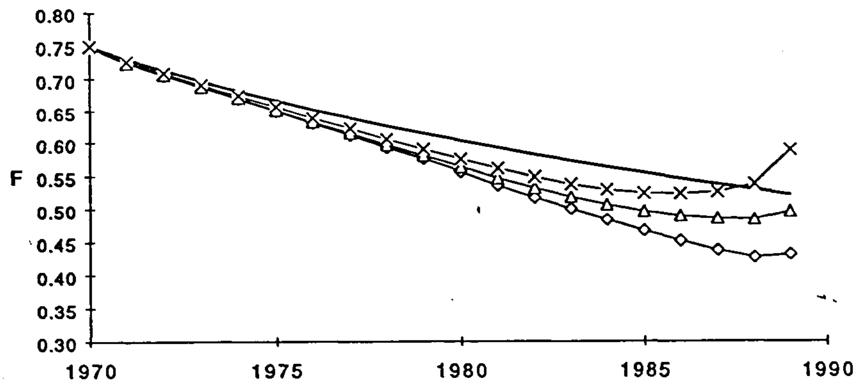
Figure 2. Estimated exploitation pattern (A), fishing mortality (B), spawning stock biomass (C), and recruitment (D) from RUN 2. The true values as well as the values obtained by separable VPA and on the basis of two sets of tuning data (see text) are indicated.

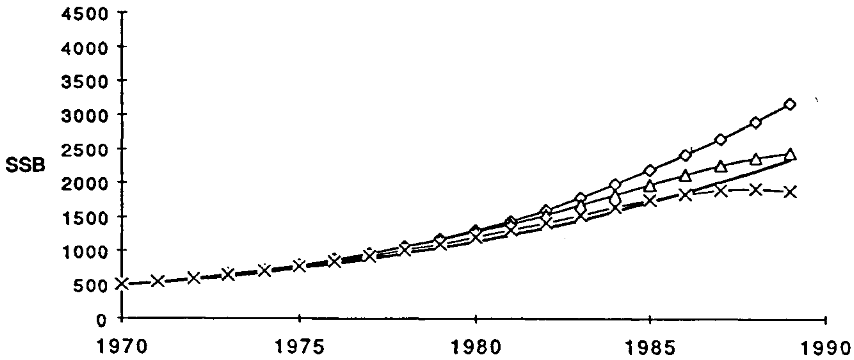
A. Average exploitation pattern (1970-1986)



B. Average fishing mortality (weighted by age class)



C. Spawning stock biomass



D. Recruitment

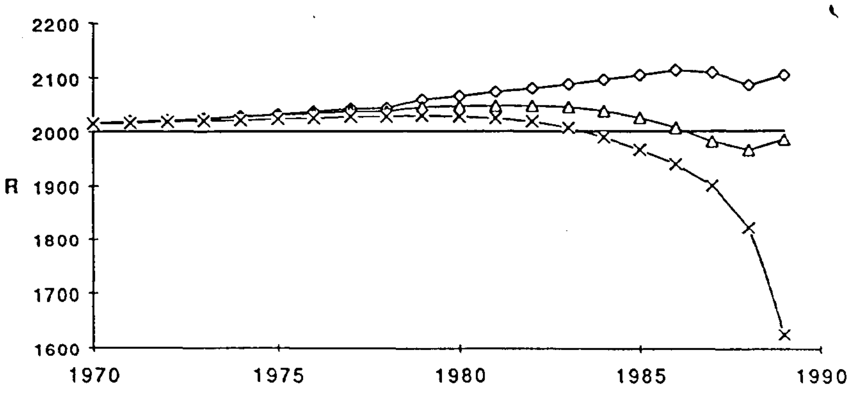


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Figure 3. Estimated exploitation patterns from separable VPA and tuning for North Sea sole (A) and plaice (B). (from Anonymus, 1990).

A. Sole

B. Plaice