Northwest Atlantic Fisheries Organization

Serial No. N4246 **NAFO SCR Doc. 00/17**

SCIENTIFIC COUNCIL MEETING – JUNE 2000

Evaluation of Greenland Halibut Dynamics in 2J3KLMNO Using Separable Models in Bayes and Maximum-Likelihood Approaches

by

K.R. Patterson[1] and E. de Cárdenas[2]

[1] European Commission, DG FISH, Rue de la Loi 200, B-1040 Brussels, Belgium; email Kenneth.Patterson@cec.eu.int
[2] Instituto Español de Oceanografía, Av. de Brasil 31, Madrid, Spain, email e.decardenas@md.ieo.es

1. Abstract

We address the problem of estimating stock dynamics parameters with partial information on catches at age. We use models assuming separability of fishing mortality by year and by age, and apply these in either maximum-likelihood or Bayes statistical frameworks incorporating a random walk in fishing mortality. We use three approaches to estimating selection parameters, either assuming these are fixed parameters estimable from selectivity experiments, or estimating them from either Canadian or total international catches at age for the years in which these data are available. Results are generally similar, indicating that fishing mortality increased about threefold during the early 1990s but has returned to approximately its previous level since 1994. Biomass declined from 1978 until about 1994 and increased afterwards, concomitant with an increase in recruitment snce 1994. Corresponding forecasts of F-status quo catches in 2001 range from 30 000t to 55 000t.

2. Introduction

The assessment of Greenland halibut (Brodie et al. 1998) is presently beset by a number of problems of missing data and complicated structure. This results in an essentially subjective decision being made about the state of the stock and about any suitable catch option.

It could be helpful to bring together beliefs about the stock, and the available data, in a modelling framework that allows joint inference to be made about interest parameters such as trends in biomass and in fishing mortality. This approach is conceptually similar to the 'stock synthesis' approach, where a case-specific model and likelihood function are written to describe the available data.

We explore a number of models in which uncertainty is admitted and in which prior beliefs about various parameters are stated explicitly. A Bayes MCMC approach is used to evaluate the precision of the various estimates. We begin with a simple model based on the approach of de Cárdenas et al. 1999, and from this base we further develop model complexity and also inculde additional sources of information. We also report on some trials made using a similar model in a maximul-likelihood approach, where we incorporate the latest information.

3. Model Development

We begin by formulating a model similar to that of de Cárdenas et al. 1999, but in a Bayes time-series framework and with a slightly different parameterisation. Due to the large computational overhead of the method, we also investigate a maximum-likelihood approach with a similar structural model.

To fit our models, we take observations of survey abundaces at age and weights at age from Table 22 of Brodie et al. 1999, for ages 1 to 16 only and for years 1978 to 1998. Zero observations were treated as missing values. Records of catches are taken from table 1a form the same source. Canadian catches at age were taken from Table 6 of Brodie et al. 1998. Total international catches at age are taken from Table 4 of Bowering et al. (1996). Standardised survey data for 1999 were kindly provided by R. Bowering (pers comm.).

We have conventionally assumed a natural mortality of 0.2 for all ages and for both sexes and all areas.

For the Bayes models, we computed posterior distributions by MCMC numerical integration using the "WinBUGS" software package (Spiegelhalter et al. 1995). For the simpler model, a single chain was run for 12000 iterations and the first 6000 iterations were discarded as a "burn-in period". This choice was made by visual inspection of the chain only. Further diagnostics of the application of the methods are relegated to a technical appendix.

3.1 Bayes TS approach, Structural model for Survey and Landings Data, Selection assumed known

Denote the annual fishing mortality as F_y , the selection at age (=partial recruitment) as S_a and mean weights at age in the catch as $W_{a,y}$. Abundance at age is represented by $N_{a,y}$,natural mortality as $M_{a,y}$, catches at age by $C_{a,y}$ and total yield in weight by Y. The survey catchability is represented by q_a. Population dynamics are then modelled according to the conventional model assuming constant selection in the commercial fishery (Fournier and Archibald, 1982):

$$N_{a+1,y+1} = N_{a,y} \exp\left(-F_{a,y} - M_{a,y}\right)$$

$$F_{a,y} = F_y S_a$$

$$\hat{C}_{a,y} = \frac{N_{a,y} F_{a,y}\left(1 - \exp\left(-F_{a,y} - M_{a,y}\right)\right)}{F_{a,y} + M_{a,y}}$$

$$\hat{Y}_y = \sum_{a,y} \hat{C}_{a,y} W_{a,y}$$

Expected values from an age-structured survey U are calculated as

$$\hat{U}_{a,y} = q_a N_{a,y}$$

This approximation only holds where fishing mortality changes little between years, and is made to reduce the computational burden in the Bayes calculation. In the years 1992 to 1995 the assumption may introduce some bias. We add the structural assumption that F by year varies according to a random walk having lognormal distribution with variance τ^2:

$$F_y = F_{y-1} \exp\left(\psi_{y-1}\right) \qquad \psi \sim N\left(0, \tau^2\right)$$

where **N**(mean,variance) represents the normal distribution. Note that the plus-group is not included in the above formulation. The approach is generally similar to that of Cook (1997), although rather than fixing an arbitrary smoothing parameter here we estimate probability distributions conditional on the assumption that the 'smoothing parameter' has unknown value but describes a random walk process with lognormal errors.

3.1.1 Observation Model

De Cárdenas (1999) used data on two sources : landings and age-structured surveys. In the simplest case, we assume landings are measured precisely but we admit uncertainty in the survey observations and in the variance of these observations. As is conventional, a lognormal error-distribution model is assumed. The logarithm of the likelihood of the data given the structural model is modelled as:

$$L_1 \alpha \prod_a \prod_y \frac{1}{\sigma_s} \exp\left(\frac{1}{2\,\sigma_s^2} \ln\left(\frac{U_{a,y}}{\hat{U}_{a,y}} \right)^2 \right)$$

3.1.2 Constraints

In the formulation of de Cárdenas et al. (1999) survey catchability are not estimated, but selection at age by the commercial fishery are not estimated. Here however, in the first step of the analysis we assume that selection at age is known from the characteristics of the commercial fishing gear in operation. This assumption is introduced early for simplifying purposes, the intention being to relax this assumption later. Values for selection are initially taken from Table 1 of de Cárdenas et al. (1999).

We further constrain S(16) = 1.

3.1.3 Priors for the analysis

We have chosen uniform priors on a logarithmic scale for the parameters qa, $N_{a,1978}$ and $N_{1,y}$, with the intention of representing prior ignorance about these values. We assign a prior for the logarithm of fishing mortality in F in 1978 as as having mean -1.2 and variance 1, being also very weakly informative.

Unrestrictive, reciprocal priors were chosen for both variance terms τ^2 and σ_s^2.

3.2 Bayes TS approach,Structural model for Survey and Partial Catch-At-Age Data, Selection Estimated

Selectivity as measured in a trawling experiment may not adequately reflect the effective selectivity of the fishing fleet due to diversity of gear types, targeting practices, and size-selective migration of the fish. We attempt to relax the assumption that selectivity is known precisely by introducing a structural model of selectivity and associated observations, and to estimate the selection parameters. To do so, we introduce observations of catches at age from the Canadian fleet from 1988 to 1994 (from Table 2 of Bowering et al. 1996). The structural model of selection is a simple separable model, with a weighted-normal approximation to a multinomial distribution (Haist et al. 1993; Patterson, 1998). The contribution to the likelihood function is :

$$L_2 \alpha \prod_a \prod_y \frac{1}{\sqrt{\xi_{a,y}}} \exp\left(\frac{\left(P_{a,y} - \hat{P}_{a,y}\right)^2}{\xi_{a,y}} \right)$$

in which the weighting term ξ is given as

$$\xi_{a,y} = \sigma_c^2 \left(\hat{P}_{a,y} \left(1 - \hat{P}_{a,y}\right) + 0.01 \right)$$

where $P_{a,y}$ represents the proportion by number of fish in the commercial catches at age, from 1988 to 1994 and from ages 5 to 16.

In addition a small change was made to the fishing mortality model, in that instead of assuming a simple random walk in F (with zero expectation in the error term) an underlying linear trend in the F process was assumed:

$$F_y = F_{1978} + \gamma\,(y-1978)\exp(\psi)$$

where γ is an additional estimated parameter and ψ is assumed distributed with mean zero and variance τ^2.

However, as landings are taken as fixed in both models, the cosntraining effects of the landings would tend to overwhelm the relatively weak structural assumptions about F that are made here.

In this formulation we introduce new parameters: a term representing the variability of the catch-at-age observations σ_c^2, (with unrestrictive prior α 1/ σ_c^2 [but see appendix 1]) and a selection vector S (with unrestrictive uniform priors).

3.3 Maximum-Likelihood Approach, Structural model for Survey and International Catch-At-Age Data, Selection Estimated

Shortly before the meeting, survey data for 1999 became available. Due to computational time constraints it was impractical to repeat the Bayes analyses as above. Instead, a similar model was written and fitted in a maximum-likelihood framework. With the same structural model, a nonlinear least-squares approximation to maximum likelihood was used. The term minimised was :

$$\sum_{y=1978}^{y=1999}\sum_{a=1}^{a=16} \lambda_{a,y} \ln\left(U_{a,y}/\hat{U}_{a,y}\right)^2 + \sum_{y=1978}^{y=1988}\sum_{a=5}^{a=16} \ln\left(C_{a,y}/\hat{C}_{a,y}\right)^2 + \sum_{y=1989}^{y=1998} 10\ln(A_y/\hat{A}_y)^2$$

An adaptation of the 'ICA' programme (Patterson and Melvin, 1996) was used. Standard outputs and residual plots are given in Appendix 2. The factor 10 is used to constrain modelled landings to reported landings for the period in which catch-at-age data are not available. Two variants were used, one, as described above fitted to the total international catches at age from 1978 to 1988, to the survey information from 1978 to 1999 and to landings from 1978 to 1998. In the second, the model was fitted to Canadian catches at age (raised to the level of reported international landings) from 1988 to 1997, the remaining information being used in the same way. $\lambda_{a,y}$ are weighting factors subjectively chosen as =0.1 for age 1, O.5 for age 2, to represent a belief that time-trends in recruitment indices may be less reliable than for other ages, on account of possible uncertainty in the standardisation of research vessel indices after a change in fishing gear.

4. Results

4.1. Results Using Only Catch and Survey Data (Bayes TS model)

A summary of the principal stock dynamic parameters estimated using the simple model is given in Figure 1. This indicates generally similar trends in biomass and fishing mortality to those estimated by de Cárdenas et al., albeit with considerably narrower confience intervals than were calculated using the Monte-Carlo simulation used therein.

The percentiles of the distributions of the estimated process (τ^2) and observation-error (σ^2) parameters were:

	5%	25%	Median	75%	95%
Process error (τ^2)	31.75	0.26	0.18	0.15	0.12
Observation error (σ^2)	0.92	0.81	0.76	0.72	0.62

This indicates that the log. variance of the survey is estimated to be of the order of about 0.6 to 0.9, which is an unexceptional range for an age-structured assessment. The log-scale process error estimate has 50th percentile range 0.26 to 0.15, suggesting an interannual variability in F of the order of 15 to 25%. This value also seems unexceptionable.

4.2. Results Using Catch, Survey Data, and Catch-at-age Data (Bayes TS Model)

Results obtained by relaxing the assumption of known selectivity are given in Figure 2. These results are generally similar to those obtained with the simple model, but the computational overhead was significantly greater.

The posterior distribution of catches in 1999 corresponding to F-status quo fishing mortality based on this model are given in Figure 3; some percentiles of this distribution are also given in the text table below:

	Expected	5%	25%	Median	75%	95%
F-status-quo catch	19 300	18 500	19 200	19 800	20 400	21 300

This model returns apparently reasonable results in that :

- Recruitment estimates are somewhat higher in 1994-1996 at age 1.
- F-status quo catches are estimated to be slightly higher than recent catches, as these recruitments enter the fishery.
- The pattern of fishing mortality generally follows the pattern of catches
- Biomass shows a declining trend over the period of the data, which is reversed when quota controls were imposed and recruitment improved.

These trends concord with previous belief about the dynamics of this stock.

4.2. Results Using Catch, Survey Data, and International Catch-at-age Data (ML Model)

Summary results are provided in Figure 4. Compared with the foregoing models, this model fit shows some similarities and some differences. As in the foregoing models, fishing mortality is stable in the period 1978 to 1985, then increases rapidly, followed by a decline after 1994 to the levels observed previously. Trends in recruitment and biomass are similar, but more extreme: the decline in biomass is much more pronounced, and the strength of the 1994 to 1997 year-classes is relatively greater. This greater variability in the results compared with the foregoing may be due to the lack of integration over the observation-error and process-error terms, which will tend to 'smooth' the results - introducing a process error is somewhat akin to 'shrinkage'.

Summary results are shown in Figure 4 and in detail in Appendix 2. Estimates of F-status quo catches from this model are 31 000t in 1999, 41 000t in 2000 and 55 000t in 2001.

4.3. Results Using Catch, Survey Data, and Canadian Catch-at-age Data (ML Model)

The above analysis was repeated using the Canadian catch-at-age data for the period 1988 to 1997. Detailed results are given in Appendix 3 and summary results are given in Figure 5. Trends in results are similar to those obtained with the Bayes-TS model, but are more "noisy". The estimate of F-status-quo catches are 20 600t in 1999; 24 900t in 2000 and 30, 000t in 2001. Scaling of fishing mortality is however very different, suggesting the assessment is very sensitive to assumptions made about selection at the oldest ages.

5. Discussion

This exercise introduces a class of simple Bayes time-series models and maximum-likelihood separable models with missing observations with apparently plausible results. We do not claim this approach has yet been thoroughly tested nor evaluated, but we indicate that this class of modelling approach may prove useful in data-poor situations.

The modelling approach used here is based on the assumption that selection remains constant. In this fishery, selection is likely to depart from a simple flat-topped exploitation pattern and also is liable change markedly over time. This is because different gill-net fisheries operating with various mesh sizes have developed in different regions. Under such circumstances, there is significant risk that perceptions of long-term trends in biomass may be strongly dependent on selection pattern assumptions. It would be highly preferable to develop this approach by fitting separate selection models to separate fleets which are known to have operated homogeneously for particular periods of time.

We have investigated the implications of using each of two data sources that provide information on selection - the historic international catches at age from 1978 to 1988 and the Canadian catches at age from 1988 to 1997. The implications of assuming that either of these represent the selection by the fishery both historically and in 1999 and 2000 are rather different. Both the Bayes-TS and ML models using the Canadian catches at age indicate an F-status quo catch of about 20 000t in 1999, and plausibly also some 25 000t in 2000 and 30 000 in 2001. In contrast, the model representing fishery selection using the historic international catches at age indicates F-status quo catches of 31 000t in 1999, 41 000t in 2000 and 55 000t in 2001. Both models indicate that increasing recruitment will lead to increasing catches at constant fishing mortality, but the rate and extent of the increase depends strongly on the selection pattern which is estimated.

Results obtained here are conditioned on the assumption that selection pattern in the fishery during unsampled periods can be represented using information from the sampled periods, be it using information from the Canadian fishery 1988 to 1997 or using information from the international fishery from 1975 to 1988. This assumption is likely to be false to a greater or lesser extent, as selection is likely to have changed due to a change in the dominant gear used in the fishery, being a change from gillnetters to offshore demersal trawlers in the early 1990s. Such change in selection may have resulted in a failure adequately to represent the increase in abundance seen in the trawl surveys. Marked residual trends appear in ages up to 5 (Figures A3.1 to A.3.5). For example, the offshore trawl fleet also catches 4 year old fish (e.g. p. 104 of Anon. 1996; Fig. 6 of de Cárdenas, 1999) , and such catches are not represented in the data sources used here

We consider our preliminary results to be indicative of historic trends in stock dynamics parameters and in estimating "status quo" catches. This fishery exploits a stock in which older fish (and especially males, de Cárdenas, 1997) appear to be lost from the fishing area. As such, parameters of selection, emigration, catchability at age and natural mortality are extremely difficult to estimate independently. For this reason, we consider these results should not be used as measures of absolute biomass, fishing mortality or catchability. Additionally, we have here used a conventional value for natural mortality = 0.2 rather than the value of 0.15 which has previously been used for this stock.

Reference points

The estimate of the absolute value of fishing mortality is strongly dependent on the assumed selection pattern and reliable estimates cannot be provided. Estimates of absolute biomass, strongly correlated with these parameters, are similarly unreliable. However, historic trends in biomass and fishng mortality are thought to be more reliable.

For the reason stated above we do not advocate the use of model-specific reference points as absolute values. Changes in selection assumptions are likely to result in large changes in perceptions of absolute values of biomass. However, we note that there was not any apparent decline in recruitment when stock size reached its lowest level in 1994, and that the biomass in 1994 could therefore serve as a reference for a biomass to be avoided.

Stock sizes appear to have declined when fishing mortality was stable in the period 1978 to 1989, but stock size also appears to have recovered when fishing was reduced to a silimar level after 1995. It may be appropriate to use this level as a reference value which should not be exceeded.

Calculation of other reference points is not attempted because of the uncertainties relating to the appropriate way to estimate selection.

References

Anonymous, 1996. NAFO Scientific Council Reports, 1996. 226pp.

Bowering, W.R., W.B. Brodie, M.J. Morgan, D. Power and D. Orr. 1996. The status of Greenlmand Halibut Resource in the Management Area of NAFO Subarea 2 and Divisions 3KLMNO. NAFO SCR Doc. 96/73.

Brodie, W.B., W.R. Bowering, D. Power and D. Orr. 1998. An assessment of Greenland Halibut in NAFO subarea 2 and Divisions 3KLMNO. NAFO SCR Doc. 98/47.

Brodie, W.B., W.R. Bowering, D. Power, M.J. Morgan and G. Boland. 1999. An assessment of Greenland Halibut in NAFO Subarea 2 and Divisions 3KLMNO. NAFO SCR Doc. 99/38.

Cook, R.M. 1997. Stock trends in six North Sea stocks as revealed by an analysis of research vessel surveys. ICES Journal of Marine Science, 54:924-933.

De Cárdenas, E. 1996. The female ratio as an indicator of sexual differences in mortality of Greenland halibut (*Reinhartius hippoglossoides*) at age 8+. NAFO SCR Doc. 96/35.

De Cárdenas, E., L. Motos, and S. Junquera (1999). A simple method to project catches, in the absence of VPA. NAFO SCR Doc. 99/2.

Fournier, D. and C.P. Archibald. 1982. A general theory for analyzing catch at age data. Canadian Journal of Fisheries and Aquatic Sciences 39: 1195-1207.

Haist, V. Fournier, D.A. and J.F. Schweigert. 1993. Estimation of density-dependeny natural mortality in British Columbia herring stocks through SSPA and its impact on sustainable harvest strategies. *In* Risk evaluation and Biological Reference Points for Fisheries management, pp. 269-282, Eds. by S.J. Smith, J.J. Hunt and D. Rivard. Canadian Special publications in Fisheries and Aquatic Science, 120.

Patterson, K.R. and G.D. Melvin. 1996. Integrated catch-at-age analysis, version 1.2. Scottish Fisheries Research Report, 58: 60pp.

Patterson, K.R. 1998. Assessing fish stocks when catches are misreported: model, simulation tests and application to cod, haddock and whiting in the ICES area. ICES Journal of Marine Sciences, 55: 878-891.

Spiegelhalter, D., A. Thomas, N. Best and W. Gilks (1996). BUGS 0.5: Bayesian inference using Gibbs Sampling Manual (version ii). MRC Biostatistics Unit, Institute of Public Health, Robinson Way, Cambridge CB2 2SR, United Kingdom.

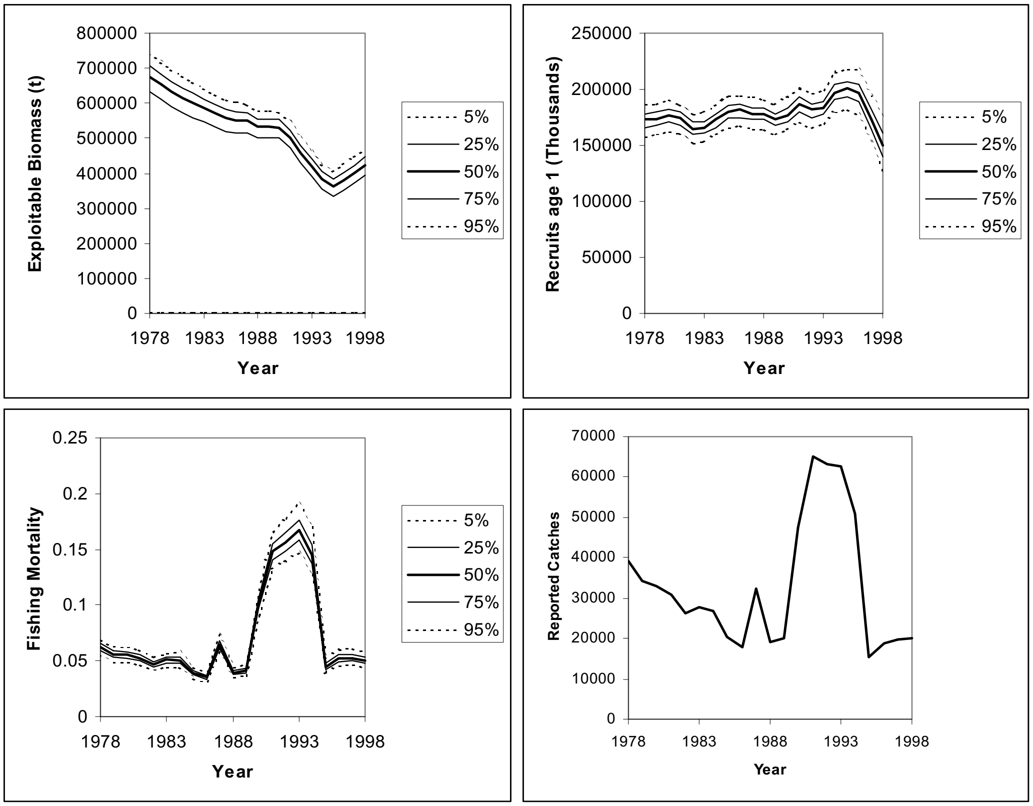


Figure 1. Greenland Halibut. Summary results of fitting the simple model, which is conditioned on knowing the selection pattern precisely.

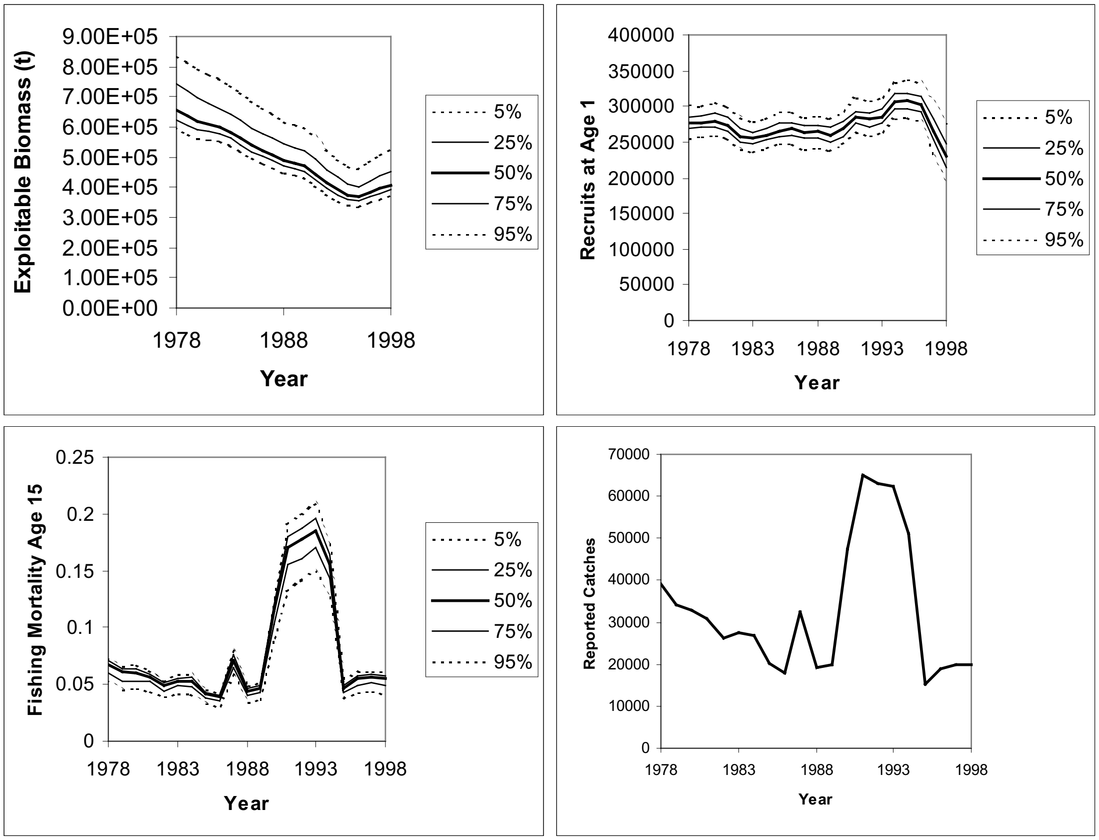


Figure 2. Greenland Halibut. Summary results of fitting the Bayes Time Series model in which selection is estimated and Canadian catches at age from 1988 to 1994 are used.

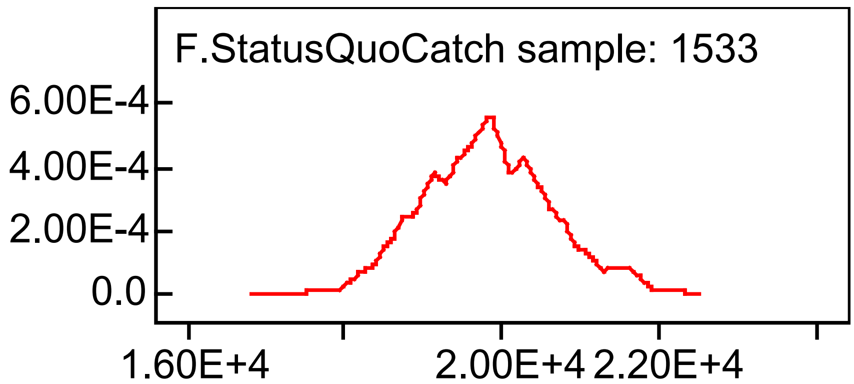


Figure 3. Estimated posterior probability distribution for the catch of Greenland halibut in 1999, for "status quo" fishing mortality, ie F_{1999}=F_{1998}

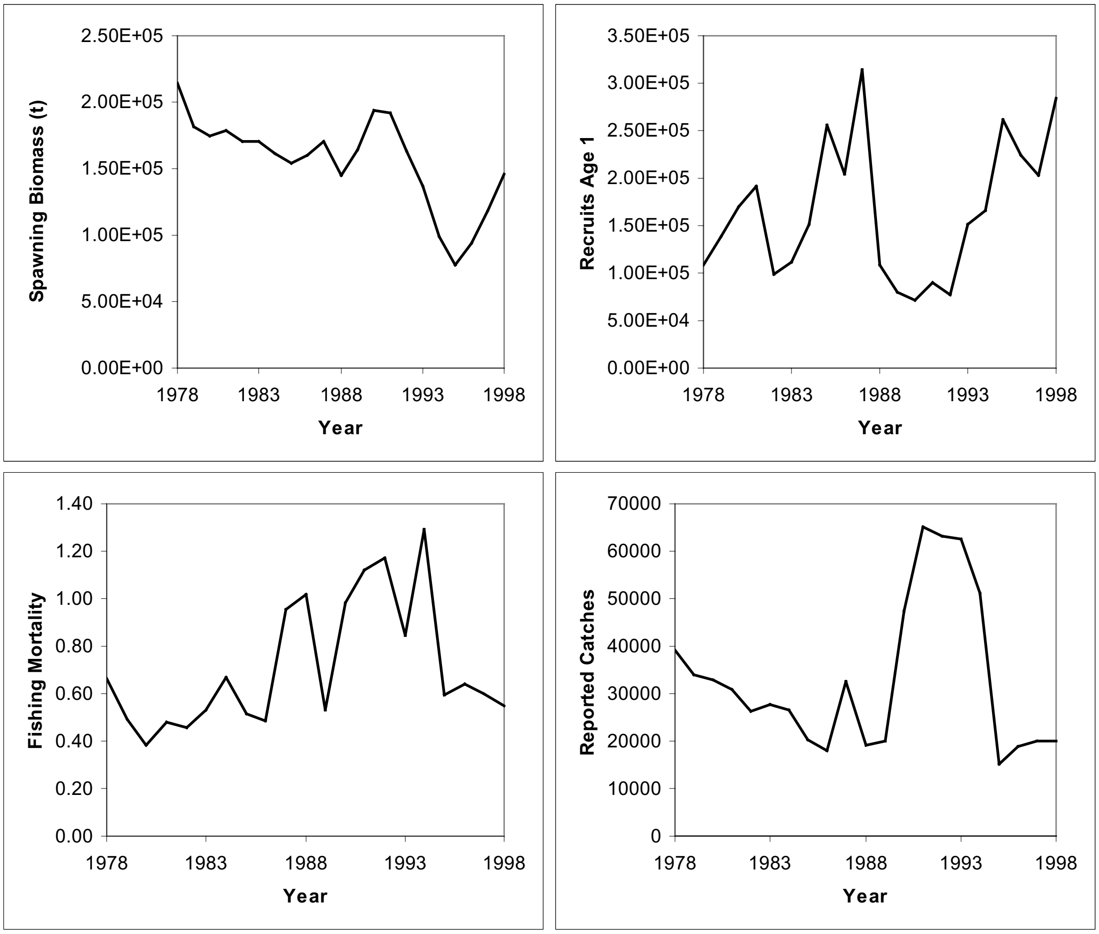


Figure 4. Greenland Halibut. Summary results of fitting a maximum-likelihood model in which selection is estimated from international catches at age from 1978 to 1988.

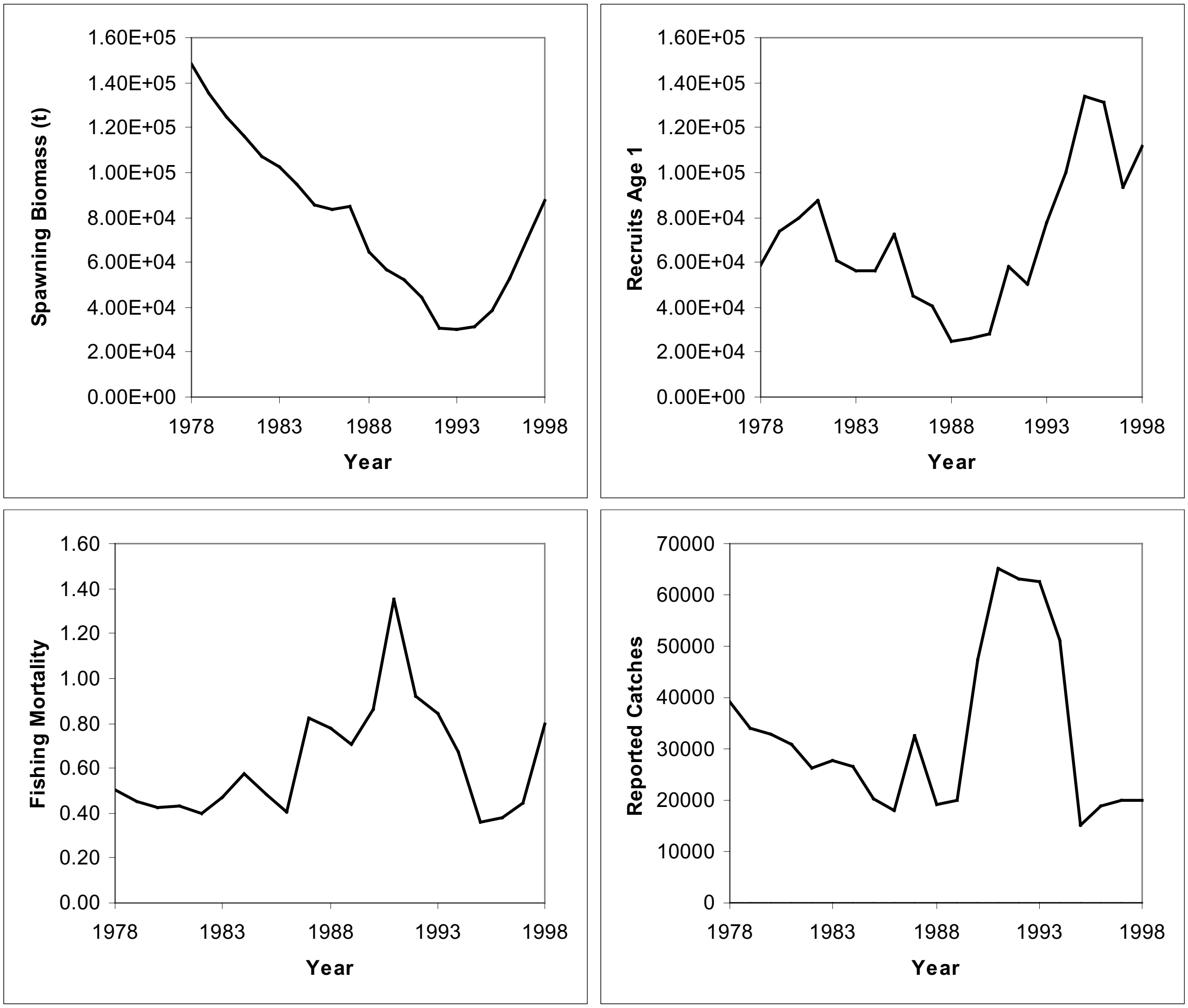


Figure 5. Greenland Halibut. Summary results of fitting a maximum-likelihood model in which selection is estimated from Canadian catches at age from 1988 to 1997.

Appendix 1. Technical Details of Bayes-Time Series model implementation.

1. Model Definition and Specification of Priors

```
model
 {

# Set up the Canadian N-at-age from reported catch at age

 Nmulti<-1

for (year in 11:maxyear-1) {
   CanadaSum[year]<-sum(CanadaCN[year, ])
    for (age in 1:maxage) {
    CanadaMN[year,age]<-CanadaCN[year,age]/CanadaSum[year]*Nmulti }}

# the F as random walk with unknown mean, variance, around long term trend

ReferenceF[1]<-exp(StartF)

for (year in 1:maxyear-1) {
   Error[year] ~dnorm(logFslope,ProcessErrorTau)

  ReferenceF[year+1] <- ReferenceF[year] * exp(Error[year] )}

# define the F matrix
    for (age in 1:maxage-2) {
      for (year in 1:maxyear) {
       F[year,age]<-ReferenceF[year] *(S[age])       }   }

    for (age in maxage-1:maxage) {
      for (year in 1:maxyear) {F[year,age]<- ReferenceF[year]} }

# define matrix of  Z

  for (age in 1:maxage) {
      for (year in 1:maxyear) {
        Z[year,age] <- F[year,age]+M     }  }

# define the starting populations to use for each cohort

   for (year in 1:maxyear) {N[year,1]<-exp(Recruits[year])}
   for (age in 1:maxage-1)   {N[1,age+1]<-exp(BeginN[age])}

   for (year in 1:maxyear-1) {
     for (age in 1:maxage-1) {
       N[year+1,age+1]<-N[year,age] *exp(-Z[year,age])        }}

# define the landings predictions

for (age in 1:maxage) {
   for (year in 1:maxyear) {
            CN[year,age] <- F[year,age]*N[year,age]*(1-exp(-Z[year,age]))/ (Z[year,age])
            CNCW[year,age]<-CN[year,age] * CW[age]    } }

# define the F-status quo catch forecast, assumes average recruitment

RecruitmentForecast<-mean(Recruits[])
CNForecast[1]<-F[maxyear,1]*RecruitmentForecast*(1-exp(-Z[maxyear,1]))/ (Z[maxyear,1])

for (age in 1:maxage-1) {
  CNForecast[age+1]<- F[maxyear,age]*N[maxyear,age]*(1-exp(-Z[maxyear,age]))/ (Z[maxyear,age]) }

for (age in 1:maxage) {
  ForecastCatchInWeight[age]<-CNForecast[age]*CW[age] }

F.StatusQuoCatch<-sum(ForecastCatchInWeight[] )


for (year in 1:maxyear){
  LAPred[year] <- log(sum(CNCW[year, ]) )
```

```
  LA[year]~dlnorm(LAPred[year], tau.c) }

# define the expected proportions in the total international catch at age

for (year in 11:maxyear-1) {
  CNTotal[year] <-sum(CN[year, ])
    for (age in 5:maxage) {
    CNProportion[year,age] <-CN[year,age]   /CNTotal[year]       }}

for (year in 11:maxyear-1) {
  for (age in 5:maxage) {
  ApproxTau[year,age]<-(1/(CNProportion[year,age]*(1-CNProportion[year,age])+0.01))*CNTauScaling
  CanadaMN[year,age ] ~dlnorm(CNProportion[year,age ], ApproxTau[year,age]) }}

# define the survey predictions
for (age in 1:maxage) {
  for (year in 1:maxyear) {
    Upred[year,age]<-exp(Q[age])*N[year,age]
    U[year,age]~dlnorm(Upred[year,age], tau.u)   } }

# define the exploitable biomass
  for (year in 1:maxyear) {
    BiomassAtAge[year,maxage] <- N[year,maxage]*CW[maxage]
    BiomassAtAge[year,maxage-1] <- N[year,maxage-1]*CW[maxage-1]

    for (age in 1:maxage-2) {
        BiomassAtAge[year,age] <- N[year,age]*CW[age]*S[age] }}

for (year in 1:maxyear) {
   ExploitableBiomass[year]<- sum(BiomassAtAge[year, ])}

# priors for the parameters

 StartF ~dnorm(-1.2,1)

logFslope~dunif(-0.29, 0.22)

 for (age in 1:maxage) { Q[age] ~dnorm(-9.72, 0.0625) }

 BeginN[1] ~dnorm(12.4,0.001)
 BeginN[2] ~dnorm(12.4,0.001)
 BeginN[3] ~dnorm(12.4,0.001)
 BeginN[4] ~dnorm(11.9,0.001)
 BeginN[5] ~dnorm(11.7,0.001)
 BeginN[6] ~dnorm(11.5,0.001)
 BeginN[7] ~dnorm(11.3,0.0012)
 BeginN[8] ~dnorm(11.2,0.0012)
 BeginN[9] ~dnorm(11.0,0.0013)
 BeginN[10] ~dnorm(10.8,0.0013)
 BeginN[11] ~dnorm(10.7,0.0013)
 BeginN[12] ~dnorm(10.3,0.0013)
 BeginN[13] ~dnorm(10.2,0.0013)
 BeginN[14] ~dnorm(10.0,0.0013)
 BeginN[15] ~dnorm(9.8,0.0017)


for (year in 1:maxyear) {
   Recruits[year] ~dnorm(12.61,0.001)  }

tau.c ~dunif(1000,1001)
ProcessErrorTau~dunif(0.1,50)
CNTauScaling~dunif(0.01,50)
tau.u~dunif(0.1, 50)

S[1]<-0.001
S[2]<-0.001
S[3]<-0.001
S[4]<-0.001

for (age in 5:14) {
  S[age]~dunif(0.01,3)}

 }
```

For reasons of space, data definitions are not printed here but are available from the author.

2. MCMC Convergence diagnostics

Figure A1.a. Time series of F status quo catch in 1999

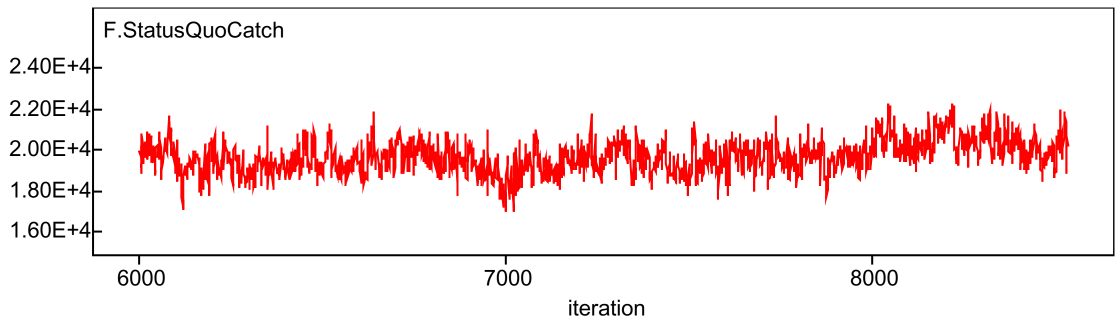


Figure A1.b. Time series of deviance

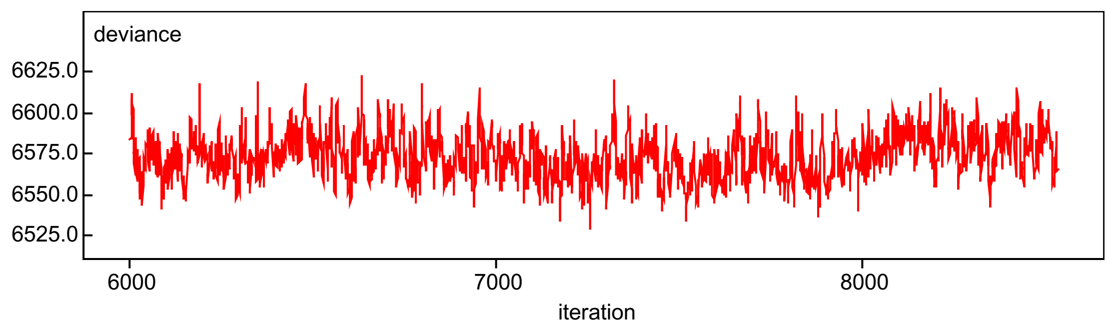


Figure A1. c. Time series of the estimate of the reciprocal of the process error variance

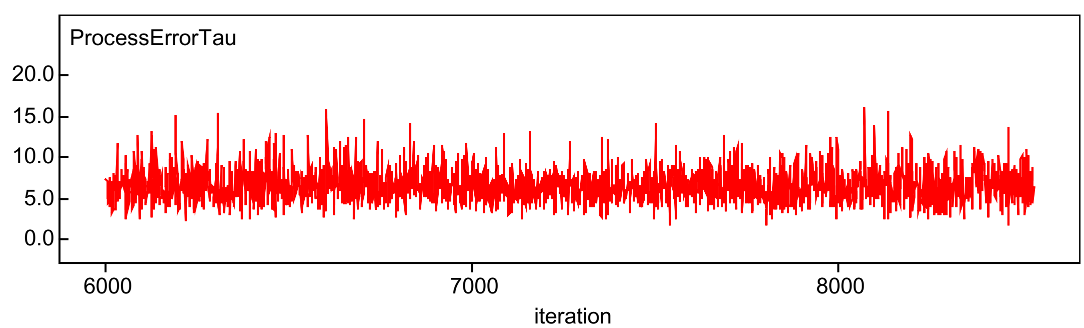


Figure A1. d. Time series of the estimate of the reciprocal of the survey observation error variance

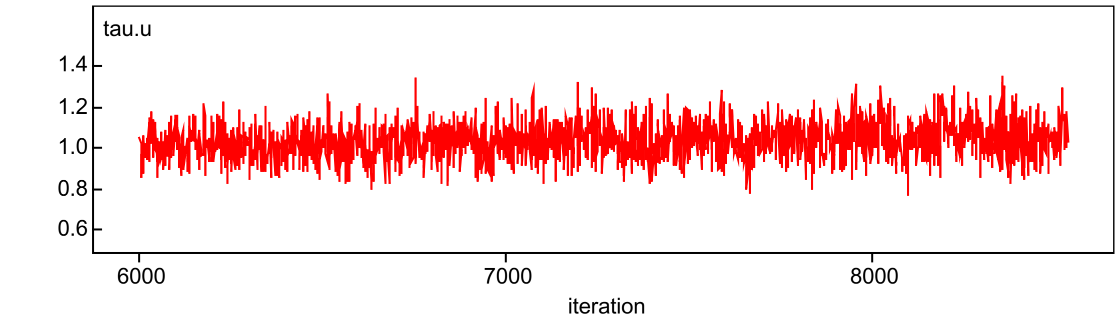


Figure A1.e. Time series of the estimate of the scaling factor for the normal approximation to multinomial errors in the catches at age.

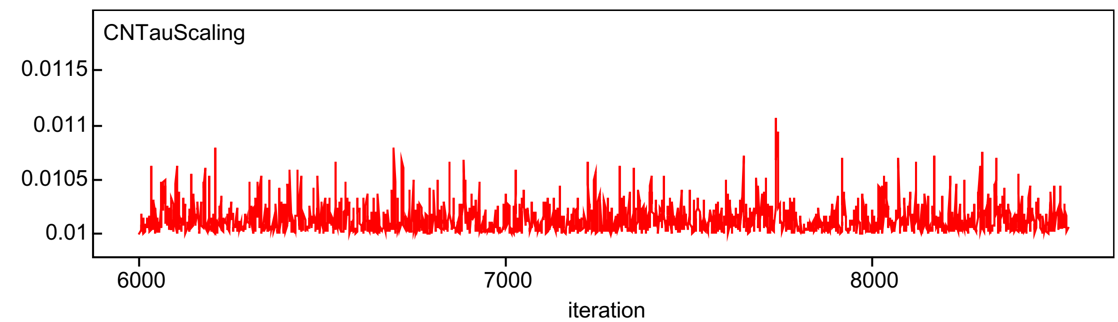


Figure A1.f. Time series of the estimate of exploitable biomass in 1998.

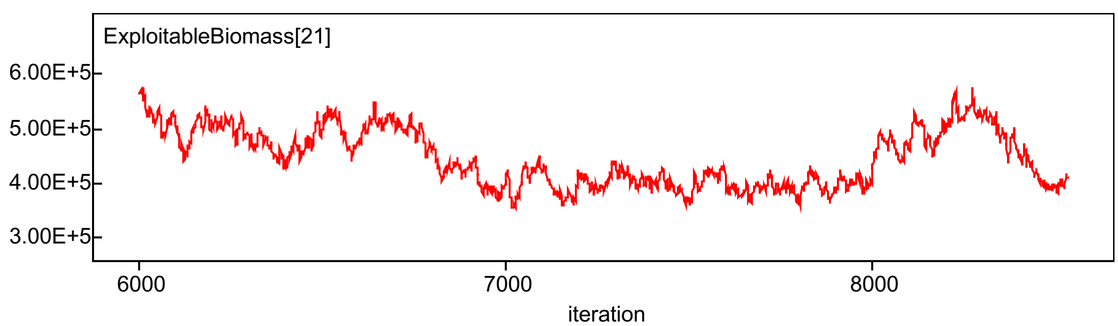


Figure A1.g. Time series of the estimate of fishing mortality at age 15 in 1998.

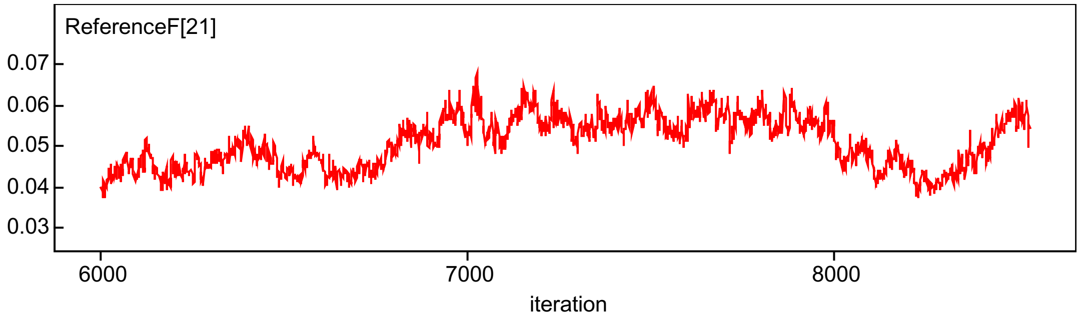


Figure A2. a. Matrix of correlations between Fishing mortality in 1978-1998 (Y-Axis) and Exploitable Biomass in 1978 - 1998 (X-Axis)

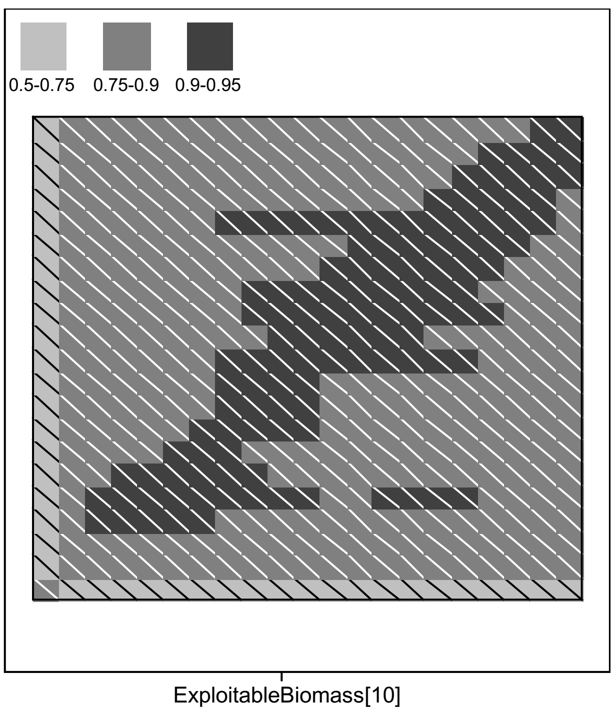
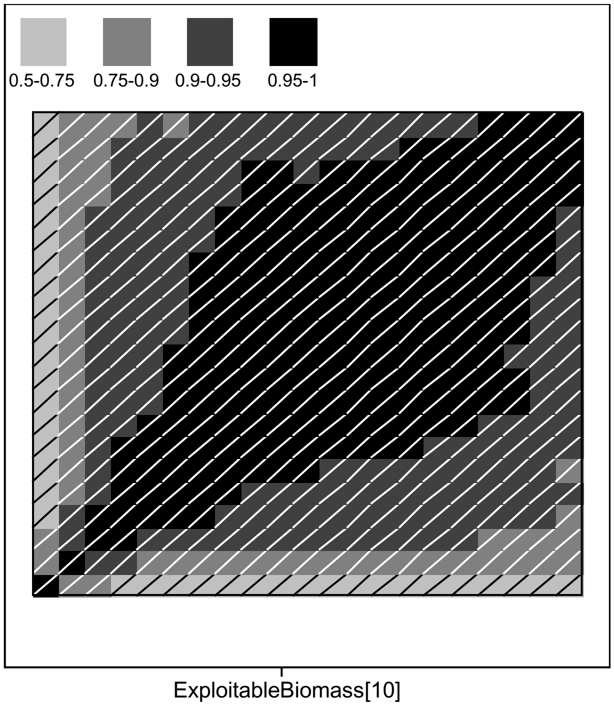


Figure A2. a. Matrix of correlations between Fishing mortality in 1978-1998 (Y-Axis) and Exploitable Biomass in 1978 - 1998 (X-Axis)



As with many MCMC processes, it is difficult to ascertain with certitude that the process has properly converged. In this case, the remaining apparent serial correlations in exploitable biomass and fishing mortality (Figure A1f and A1g) suggest that it would have been preferable to extend the analysis for a greater number of simulations in order to estimate the percentiles of the distributions more accurately. This regrettably was not possible due to time constraints. However, we note that:

- The lack of trend in deviance suggests the process is stable around a likelihood maximum;
- close positive correlations between the biomass estmates in various years (Figure A2.a) suggest that reasonably robust statements can be made about trends in biomass, if not in the actual distributions of biomasses;
- Stationarity in the F-status quo catch estimates (Figure A1.a) suggests that reasonable reliance can be placed on the estimated distribution of this parameter, subject of course to structural uncertainties.

It may also have been appropriate to specify a wider prior range for the CNTauScaling parameter (Figure A1.e).

Appendix 2. Summary Results of Maximum likelihood model fit using total international catches at age from 1975 to 1988.

Greenland Halibut in 2+3KLMNO

Catch in Number

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	3.02	2.18	0.20	0.81	0.24	0.77	0.86	1.66	0.24	0.13	0.27	0.00	0.00	0.00	0.00
6	8.51	7.98	2.03	4.24	2.02	3.89	2.21	4.45	1.96	1.78	2.90	0.00	0.00	0.00	0.00
7	9.07	11.73	8.91	9.21	5.55	10.71	5.56	4.96	5.60	10.29	7.41	0.00	0.00	0.00	0.00
8	7.66	5.61	9.43	10.75	5.06	8.21	7.31	2.93	4.45	8.36	3.99	0.00	0.00	0.00	0.00
9	2.90	1.07	5.26	4.04	3.11	2.51	3.89	1.16	1.28	2.65	1.17	0.00	0.00	0.00	0.00
10	1.45	0.44	3.73	0.84	1.48	0.76	1.20	0.43	0.41	0.80	0.42	0.00	0.00	0.00	0.00
11	0.73	0.26	0.99	0.24	0.52	0.23	0.39	0.13	0.21	0.36	0.18	0.00	0.00	0.00	0.00
12	0.37	0.14	0.13	0.13	0.23	0.08	0.14	0.08	0.12	0.26	0.10	0.00	0.00	0.00	0.00
13	0.23	0.13	0.05	0.04	0.14	0.12	0.10	0.07	0.06	0.21	0.10	0.00	0.00	0.00	0.00
14	0.11	0.08	0.01	0.03	0.07	0.09	0.06	0.04	0.05	0.16	0.06	0.00	0.00	0.00	0.00
15	0.06	0.08	0.01	0.02	0.06	0.07	0.07	0.02	0.03	0.10	0.05	0.00	0.00	0.00	0.00
16	0.05	0.06	0.00	0.01	0.03	0.01	0.03	0.01	0.02	0.05	0.01	0.00	0.00	0.00	0.00

x 10 ^ 6

Catch in Number

AGE	1993	1994	1995	1996	1997	1998
1	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00

x 10 ^ 6

Predicted Catch in Number

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	746.	570.	399.	498.	351.	519.	802.	697.	342.	748.	1089.	957.	1414.	2476.	889.
6	4549.	3464.	2839.	3143.	2974.	2562.	4038.	3865.	4168.	4080.	4817.	3536.	10801.	9648.	15489.
7	30211.	19549.	17083.	21132.	17892.	19911.	16942.	17784.	21608.	36819.	18334.	13834.	29068.	49080.	38944.
8	19630.	10370.	9009.	12506.	11096.	11043.	11127.	5901.	8884.	15765.	9400.	3132.	9062.	7230.	9634.
9	5115.	2574.	1936.	2874.	2719.	2922.	2616.	1485.	1212.	2960.	1456.	511.	922.	814.	478.
10	1591.	1165.	762.	942.	993.	1133.	1147.	609.	493.	669.	575.	166.	255.	178.	125.
11	511.	335.	305.	328.	291.	374.	415.	248.	183.	264.	137.	65.	81.	53.	30.
12	262.	210.	164.	239.	190.	203.	257.	176.	140.	181.	113.	33.	59.	35.	20.
13	165.	98.	94.	118.	126.	121.	127.	99.	90.	126.	69.	25.	28.	23.	12.
14	118.	57.	40.	62.	57.	74.	70.	45.	47.	76.	45.	14.	19.	10.	7.
15	51.	48.	27.	31.	35.	39.	50.	29.	25.	45.	32.	11.	12.	8.	4.

x 10 ^ 3

Appendix 2 (contd.) . Summary Results of Maximum likelihood model fit using total international catches at age from 1975 to 1988.

Predicted Catch in Number

AGE	1993	1994	1995	1996	1997	1998
1	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.
5	474.	647.	376.	345.	642.	648.
6	3924.	4293.	1848.	2515.	2027.	3675.
7	51003.	22166.	10305.	10609.	12887.	10425.
8	6287.	17220.	2485.	4800.	4301.	5459.
9	483.	845.	532.	473.	772.	728.
10	56.	131.	64.	172.	132.	221.
11	16.	16.	10.	20.	45.	35.
12	8.	9.	3.	6.	10.	23.
13	5.	4.	2.	2.	3.	5.
14	3.	2.	1.	1.	1.	1.
15	2.	2.	0.	0.	0.	0.

x 10 ^ 3

Weights at age in the catches (Kg)

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260
4	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220
5	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830
6	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810
7	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090
8	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640
9	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500
10	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270
11	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040
12	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960
13	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410
14	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430
15	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580
16	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000

Weights at age in the catches (Kg)

AGE	1993	1994	1995	1996	1997	1998
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260
4	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220
5	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830
6	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810
7	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090
8	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640
9	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500
10	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270
11	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040
12	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960
13	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410
14	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430
15	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580
16	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000

Appendix 2 (contd.) . Summary Results of Maximum likelihood model fit using total international catches at age from 1975 to 1988.

Weights at age in the stock (Kg)

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260
4	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220
5	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830
6	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810
7	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090
8	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640
9	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500
10	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270
11	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040
12	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960
13	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410
14	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430
15	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580
16	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000

Weights at age in the stock (Kg)

AGE	1993	1994	1995	1996	1997	1998
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260
4	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220
5	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830
6	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810
7	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090
8	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640
9	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500
10	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270
11	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040
12	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960
13	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410
14	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430
15	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580
16	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000

Natural Mortality (per year)

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
2	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
3	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
4	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
5	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
6	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
7	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
8	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
9	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
10	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
11	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
12	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
13	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
14	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
15	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
16	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000

Natural Mortality (per year)

AGE	1993	1994	1995	1996	1997	1998
1	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
2	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
3	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
4	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
5	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
6	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
7	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
8	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
9	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
10	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
11	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
12	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
13	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
14	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
15	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
16	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000

Appendix 2 (contd.) . Summary Results of Maximum likelihood model fit using total international catches at age from 1975 to 1988.

Proportion of fish spawning

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
4	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200
5	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300
6	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500
7	0.0800	0.0800	0.0800	0.0800	0.0800	0.0800	0.0800	0.0800	0.0800	0.0800	0.0800	0.0800	0.0800	0.0800	0.0800
8	0.1800	0.1800	0.1800	0.1800	0.1800	0.1800	0.1800	0.1800	0.1800	0.1800	0.1800	0.1800	0.1800	0.1800	0.1800
9	0.3200	0.3200	0.3200	0.3200	0.3200	0.3200	0.3200	0.3200	0.3200	0.3200	0.3200	0.3200	0.3200	0.3200	0.3200
10	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800
11	0.6200	0.6200	0.6200	0.6200	0.6200	0.6200	0.6200	0.6200	0.6200	0.6200	0.6200	0.6200	0.6200	0.6200	0.6200
12	0.7400	0.7400	0.7400	0.7400	0.7400	0.7400	0.7400	0.7400	0.7400	0.7400	0.7400	0.7400	0.7400	0.7400	0.7400
13	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200
14	0.8900	0.8900	0.8900	0.8900	0.8900	0.8900	0.8900	0.8900	0.8900	0.8900	0.8900	0.8900	0.8900	0.8900	0.8900
15	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200
16	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Proportion of fish spawning

AGE	1993	1994	1995	1996	1997	1998
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
4	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200
5	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300
6	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500
7	0.0800	0.0800	0.0800	0.0800	0.0800	0.0800
8	0.1800	0.1800	0.1800	0.1800	0.1800	0.1800
9	0.3200	0.3200	0.3200	0.3200	0.3200	0.3200
10	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800
11	0.6200	0.6200	0.6200	0.6200	0.6200	0.6200
12	0.7400	0.7400	0.7400	0.7400	0.7400	0.7400
13	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200
14	0.8900	0.8900	0.8900	0.8900	0.8900	0.8900
15	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200
16	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

AGE-STRUCTURED INDICES

Canada RV,,,,,,,,,,,,,,,

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	67.13	76.28	47.94	141.17	33.75	12.13	31.85	192.90	125.26	36.23	74.06	52.95	9.86	84.58	52.91
2	315.36	128.77	46.19	158.15	39.59	34.73	50.92	113.56	106.16	81.05	71.55	95.76	39.74	59.21	188.12
3	243.38	95.88	43.77	109.46	88.92	71.28	70.14	65.43	112.55	212.68	109.25	174.20	70.54	44.64	148.38
4	146.86	50.86	39.30	41.43	75.65	75.71	74.84	54.23	104.61	99.11	114.84	174.69	177.41	103.16	95.26
5	90.82	53.10	49.74	47.20	57.10	71.10	103.17	66.32	72.30	75.27	119.82	108.47	115.86	65.70	38.55
6	68.60	50.98	52.63	49.99	41.10	51.58	61.33	69.54	81.84	53.19	59.22	87.21	70.70	40.33	22.09
7	40.91	24.41	32.28	35.48	43.10	50.70	42.30	42.81	71.75	47.14	41.43	38.56	36.65	12.49	10.47
8	19.17	9.98	11.10	15.61	41.24	39.42	27.03	17.03	22.14	25.79	12.23	9.60	6.20	2.38	1.07
9	9.94	4.78	4.96	7.02	16.57	15.22	13.06	7.98	6.55	9.43	3.13	2.85	1.50	0.64	0.14
10	7.37	4.57	3.89	4.21	6.76	4.41	6.31	5.30	2.38	2.83	1.10	0.75	0.75	0.31	0.09
11	6.47	3.00	4.46	3.35	4.13	3.18	2.60	2.26	1.86	1.48	0.78	0.57	0.64	0.18	0.01
12	4.12	2.64	2.88	1.56	2.71	2.29	1.81	2.00	1.67	1.45	0.46	0.15	0.39	0.10	*******
13	2.68	2.19	1.87	0.86	1.93	1.66	1.48	0.87	0.88	0.75	0.36	0.03	0.22	0.02	*******
14	0.99	1.08	1.07	0.45	1.98	1.11	1.29	1.00	0.54	0.58	0.33	0.08	0.16	0.01	0.01
15	0.56	0.70	0.41	0.27	1.26	0.49	0.68	0.61	0.56	0.39	0.24	0.10	0.09	*******	*******
16	0.36	0.62	0.23	0.04	0.59	0.13	0.46	0.30	0.32	0.20	0.15	0.03	0.02	0.00	*******

x 10 ^ 3

Appendix 2 (contd.) . Summary Results of Maximum likelihood model fit using total international catches at age from 1975 to 1988.

Canada RV,,,,,,,,,,,,,,,,

AGE	1993	1994	1995	1996	1997	1998	1999
1	62.24	359.98	342.06	793.45	222.01	199.61	93.49
2	281.18	189.87	397.12	452.54	486.57	216.98	289.04
3	497.52	171.49	122.86	267.48	398.36	265.73	217.04
4	182.33	112.86	39.61	96.57	192.05	188.60	227.68
5	42.96	51.87	50.37	55.61	89.81	92.11	162.88
6	13.68	9.90	15.86	22.31	40.11	38.35	90.15
7	5.90	4.48	3.51	7.42	17.32	17.25	29.59
8	1.97	1.35	0.92	1.92	5.66	4.77	5.05
9	0.23	0.17	0.27	1.14	1.55	1.10	1.10
10	0.03	0.07	0.10	0.38	0.49	0.58	0.41
11	0.02	0.01	0.05	0.18	0.28	0.24	0.14
12	0.09	0.02	*******	0.12	0.15	0.15	0.09
13	0.04	0.01	*******	0.12	0.10	0.14	0.17
14	0.02	*******	*******	0.04	0.05	0.02	0.01
15	*******	*******	*******	0.01	*******	*******	*******
16	*******	*******	*******	*******	*******	0.02	*******

x 10 ^ 3

Fishing Mortality (per year)

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0115	0.0085	0.0067	0.0084	0.0080	0.0093	0.0116	0.0089	0.0085	0.0167	0.0178	0.0093	0.0172	0.0195	0.0204
6	0.0919	0.0680	0.0535	0.0669	0.0634	0.0740	0.0926	0.0713	0.0679	0.1329	0.1417	0.0737	0.1368	0.1554	0.1627
7	0.9370	0.6933	0.5455	0.6821	0.6470	0.7542	0.9446	0.7271	0.6921	1.3557	1.4446	0.7517	1.3948	1.5851	1.6593
8	1.4174	1.0489	0.8252	1.0318	0.9787	1.1409	1.4290	1.0999	1.0470	2.0510	2.1854	1.1372	2.1100	2.3980	2.5102
9	0.9542	0.7061	0.5555	0.6946	0.6589	0.7680	0.9620	0.7405	0.7048	1.3806	1.4712	0.7655	1.4204	1.6142	1.6898
10	0.7999	0.5919	0.4657	0.5823	0.5523	0.6438	0.8064	0.6207	0.5908	1.1574	1.2332	0.6417	1.1907	1.3532	1.4165
11	0.5152	0.3812	0.2999	0.3750	0.3557	0.4146	0.5194	0.3998	0.3805	0.7454	0.7943	0.4133	0.7669	0.8715	0.9123
12	0.5600	0.4144	0.3260	0.4077	0.3867	0.4507	0.5646	0.4346	0.4137	0.8103	0.8634	0.4493	0.8336	0.9474	0.9917
13	0.5674	0.4199	0.3303	0.4130	0.3918	0.4567	0.5720	0.4403	0.4191	0.8210	0.8748	0.4552	0.8446	0.9599	1.0048
14	0.5218	0.3861	0.3038	0.3798	0.3603	0.4200	0.5260	0.4049	0.3854	0.7550	0.8045	0.4186	0.7767	0.8827	0.9240
15	0.5600	0.4144	0.3260	0.4077	0.3867	0.4507	0.5646	0.4346	0.4137	0.8103	0.8634	0.4493	0.8336	0.9474	0.9917
16	0.5600	0.4144	0.3260	0.4077	0.3867	0.4507	0.5646	0.4346	0.4137	0.8103	0.8634	0.4493	0.8336	0.9474	0.9917

Fishing Mortality (per year)

AGE	1993	1994	1995	1996	1997	1998
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0148	0.0225	0.0104	0.0111	0.0105	0.0096
6	0.1177	0.1792	0.0826	0.0888	0.0836	0.0765
7	1.2002	1.8274	0.8422	0.9051	0.8528	0.7805
8	1.8157	2.7644	1.2740	1.3693	1.2901	1.1808
9	1.2223	1.8609	0.8576	0.9218	0.8685	0.7949
10	1.0246	1.5600	0.7190	0.7727	0.7280	0.6663
11	0.6599	1.0047	0.4630	0.4976	0.4689	0.4291
12	0.7173	1.0922	0.5034	0.5410	0.5097	0.4665
13	0.7268	1.1066	0.5100	0.5481	0.5164	0.4727
14	0.6684	1.0176	0.4690	0.5041	0.4749	0.4347
15	0.7173	1.0922	0.5034	0.5410	0.5097	0.4665
16	0.7173	1.0922	0.5034	0.5410	0.5097	0.4665

Population Abundance (1 January)

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	108.53	137.95	170.23	191.99	98.93	110.97	151.71	255.18	203.95	314.61	107.96	79.41	71.42	89.59	76.50
2	119.66	88.85	112.94	139.37	157.19	81.00	90.85	124.21	208.92	166.98	257.58	88.39	65.02	58.48	73.35
3	98.21	97.97	72.75	92.47	114.11	128.70	66.31	74.38	101.69	171.05	136.71	210.89	72.37	53.23	47.88
4	90.40	80.41	80.21	59.56	75.71	93.42	105.37	54.29	60.90	83.26	140.04	111.93	172.66	59.25	43.58
5	71.76	74.01	65.83	65.67	48.76	61.98	76.49	86.27	44.45	49.86	68.17	114.66	91.64	141.36	48.51
6	57.09	58.08	60.08	53.54	53.32	39.61	50.28	61.90	70.00	36.09	40.15	54.83	93.01	73.75	113.50
7	53.97	42.64	44.43	46.63	41.00	40.97	30.12	37.52	47.19	53.55	25.87	28.53	41.70	66.42	51.69
8	27.94	17.31	17.45	21.08	19.30	17.58	15.78	9.59	14.85	19.34	11.30	4.99	11.01	8.46	11.14
9	9.04	5.54	4.97	6.26	6.15	5.94	4.60	3.09	2.61	4.27	2.04	1.04	1.31	1.09	0.63
10	3.15	2.85	2.24	2.33	2.56	2.61	2.26	1.44	1.21	1.06	0.88	0.38	0.40	0.26	0.18
11	1.39	1.16	1.29	1.15	1.07	1.21	1.12	0.82	0.63	0.55	0.27	0.21	0.17	0.10	0.05
12	0.67	0.68	0.65	0.78	0.65	0.61	0.65	0.55	0.45	0.35	0.21	0.10	0.11	0.06	0.03
13	0.42	0.31	0.37	0.38	0.43	0.36	0.32	0.30	0.29	0.25	0.13	0.07	0.05	0.04	0.02
14	0.32	0.19	0.17	0.22	0.21	0.24	0.19	0.15	0.16	0.16	0.09	0.04	0.04	0.02	0.01
15	0.13	0.15	0.11	0.10	0.12	0.12	0.13	0.09	0.08	0.09	0.06	0.03	0.02	0.01	0.01
16	0.14	0.18	0.01	0.04	0.10	0.03	0.07	0.04	0.06	0.10	0.02	0.03	0.03	0.02	0.01

x 10 ^ 6

Appendix 2 (contd.) . Summary Results of Maximum likelihood model fit using total international catches at age from 1975 to 1988.

Population Abundance (1 January)

AGE	1993	1994	1995	1996	1997	1998	1999
1	150.96	166.33	261.76	224.46	203.20	283.87	169.10
2	62.63	123.60	136.18	214.31	183.77	166.37	232.41
3	60.05	51.28	101.19	111.49	175.46	150.46	136.21
4	39.20	49.17	41.99	82.85	91.28	143.66	123.19
5	35.68	32.09	40.25	34.37	67.83	74.73	117.62
6	38.91	28.78	25.69	32.62	27.83	54.95	60.60
7	78.97	28.32	19.70	19.37	24.44	20.96	41.68
8	8.05	19.47	3.73	6.95	6.41	8.53	7.86
9	0.74	1.07	1.00	0.85	1.45	1.45	2.14
10	0.10	0.18	0.14	0.35	0.28	0.50	0.53
11	0.04	0.03	0.03	0.05	0.13	0.11	0.21
12	0.02	0.01	0.01	0.02	0.03	0.07	0.06
13	0.01	0.01	0.00	0.00	0.01	0.01	0.03
14	0.01	0.00	0.00	0.00	0.00	0.00	0.01
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.01	0.00	0.00	0.00	0.00	0.00	0.00

x 10 ^ 6

Weighting factors for the catches in number

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
13	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
14	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
15	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Weighting factors for the catches in number

AGE	1993	1994	1995	1996	1997	1998
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
13	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
14	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
15	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Predicted Age-Structured Index Values

Canada RV,,,,,,,,,,,,,,, Predicted

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	60.03	76.31	94.16	106.20	54.72	61.38	83.92	141.15	112.82	174.03	59.72	43.93	39.51	49.56	42.32
2	123.96	92.05	117.00	144.37	162.84	83.91	94.12	128.67	216.43	172.98	266.83	91.56	67.35	60.58	75.98
3	133.45	133.12	98.85	125.65	155.04	174.87	90.11	101.07	138.18	232.42	185.76	286.55	98.33	72.33	65.05
4	112.69	100.24	99.99	74.25	94.38	116.46	131.35	67.68	75.92	103.79	174.58	139.53	215.23	73.86	54.33
5	80.39	83.04	73.93	73.69	54.73	69.52	85.68	96.77	49.87	55.72	76.13	128.60	102.37	157.74	54.10
6	48.88	50.33	52.44	46.42	46.31	34.22	43.03	53.55	60.66	30.27	33.53	47.37	77.87	61.17	93.80
7	33.78	30.14	33.82	33.15	29.66	28.10	18.78	26.08	33.38	27.18	12.56	19.59	20.76	30.06	22.54
8	18.88	14.07	15.85	17.27	16.24	13.64	10.60	7.59	12.07	9.52	5.20	3.88	5.26	3.50	4.36
9	9.47	6.58	6.35	7.47	7.47	6.83	4.80	3.61	3.10	3.61	1.65	1.20	1.09	0.82	0.46
10	4.49	4.51	3.78	3.71	4.13	4.02	3.21	2.24	1.91	1.26	1.01	0.59	0.46	0.28	0.19
11	2.80	2.50	2.91	2.50	2.34	2.56	2.26	1.77	1.37	0.99	0.48	0.45	0.29	0.17	0.09
12	2.10	2.30	2.29	2.66	2.23	2.04	2.05	1.83	1.53	0.99	0.58	0.34	0.31	0.16	*******
13	1.60	1.29	1.59	1.59	1.79	1.47	1.23	1.24	1.20	0.83	0.43	0.30	0.18	0.13	*******
14	1.30	0.85	0.77	0.95	0.92	1.02	0.77	0.64	0.70	0.57	0.31	0.19	0.14	0.06	0.04
15	0.63	0.80	0.58	0.53	0.63	0.60	0.61	0.46	0.42	0.38	0.25	0.16	0.10	*******	*******
16	0.46	0.65	0.03	0.15	0.36	0.11	0.24	0.13	0.23	0.31	0.06	0.10	0.09	0.05	*******

x 10 ^ 3

Appendix 2 (contd.) . Summary Results of Maximum likelihood model fit using total international catches at age from 1975 to 1988.

Canada RV,,,,,,,,,,,,,,, Predicted

AGE	1993	1994	1995	1996	1997	1998	1999
1	83.51	92.01	144.80	124.16	112.40	157.03	93.54
2	64.88	128.03	141.07	222.01	190.37	172.34	240.76
3	81.60	69.68	137.50	151.49	238.42	204.44	185.08
4	48.86	61.29	52.34	103.28	113.79	179.08	153.56
5	39.91	35.76	45.12	38.52	76.03	83.81	131.89
6	32.89	23.59	22.10	27.97	23.93	47.42	52.29
7	43.33	11.36	12.93	12.32	15.95	14.18	28.21
8	4.46	6.71	2.71	4.81	4.62	6.49	5.98
9	0.68	0.71	1.10	0.91	1.58	1.64	2.43
10	0.12	0.17	0.20	0.50	0.41	0.76	0.81
11	0.07	0.04	0.06	0.11	0.27	0.23	0.44
12	0.05	0.04	*******	0.05	0.09	0.22	0.19
13	0.04	0.02	*******	0.02	0.03	0.05	0.14
14	0.02	*******	*******	0.01	0.01	0.02	0.03
15	*******	*******	*******	0.00	*******	*******	*******
16	*******	*******	*******	*******	*******	0.00	*******

x 10 ^ 3

Fitted Selection Pattern

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0206	0.0206	0.0206	0.0206	0.0206	0.0206	0.0206	0.0206	0.0206	0.0206	0.0206	0.0206	0.0206	0.0206	0.0206
6	0.1641	0.1641	0.1641	0.1641	0.1641	0.1641	0.1641	0.1641	0.1641	0.1641	0.1641	0.1641	0.1641	0.1641	0.1641
7	1.6731	1.6731	1.6731	1.6731	1.6731	1.6731	1.6731	1.6731	1.6731	1.6731	1.6731	1.6731	1.6731	1.6731	1.6731
8	2.5311	2.5311	2.5311	2.5311	2.5311	2.5311	2.5311	2.5311	2.5311	2.5311	2.5311	2.5311	2.5311	2.5311	2.5311
9	1.7039	1.7039	1.7039	1.7039	1.7039	1.7039	1.7039	1.7039	1.7039	1.7039	1.7039	1.7039	1.7039	1.7039	1.7039
10	1.4283	1.4283	1.4283	1.4283	1.4283	1.4283	1.4283	1.4283	1.4283	1.4283	1.4283	1.4283	1.4283	1.4283	1.4283
11	0.9199	0.9199	0.9199	0.9199	0.9199	0.9199	0.9199	0.9199	0.9199	0.9199	0.9199	0.9199	0.9199	0.9199	0.9199
12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
13	1.0132	1.0132	1.0132	1.0132	1.0132	1.0132	1.0132	1.0132	1.0132	1.0132	1.0132	1.0132	1.0132	1.0132	1.0132
14	0.9317	0.9317	0.9317	0.9317	0.9317	0.9317	0.9317	0.9317	0.9317	0.9317	0.9317	0.9317	0.9317	0.9317	0.9317
15	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
16	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Fitted Selection Pattern

AGE	1993	1994	1995	1996	1997	1998
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0206	0.0206	0.0206	0.0206	0.0206	0.0206
6	0.1641	0.1641	0.1641	0.1641	0.1641	0.1641
7	1.6731	1.6731	1.6731	1.6731	1.6731	1.6731
8	2.5311	2.5311	2.5311	2.5311	2.5311	2.5311
9	1.7039	1.7039	1.7039	1.7039	1.7039	1.7039
10	1.4283	1.4283	1.4283	1.4283	1.4283	1.4283
11	0.9199	0.9199	0.9199	0.9199	0.9199	0.9199
12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
13	1.0132	1.0132	1.0132	1.0132	1.0132	1.0132
14	0.9317	0.9317	0.9317	0.9317	0.9317	0.9317
15	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
16	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Appendix 2 (contd.) . Summary Results of Maximum likelihood model fit using total international catches at age from 1975 to 1988.

STOCK SUMMARY

Year	Recruits Age 1 thousands	Total Biomass tonnes	Spawning Biomass tonnes	Landings tonnes	Yield /SSB ratio	Mean F Ages 5-12	SoP (%)
1978	108520	214676	32151	39070	1.2152	0.6609	99
1979	137950	181457	25443	34104	1.3404	0.4890	114
1980	170220	174416	23251	32867	1.4136	0.3848	74
1981	191990	178336	25508	30754	1.2056	0.4811	85
1982	98920	170918	24882	26278	1.0561	0.4563	99
1983	110960	170920	23803	27681	1.1629	0.5319	86
1984	151710	161735	21714	26711	1.2301	0.6663	91
1985	255170	153915	17618	20347	1.1549	0.5128	125
1986	203950	160662	18277	17976	0.9835	0.4882	103
1987	314600	170302	19490	32442	1.6645	0.9563	98
1988	107960	144872	12100	19215	1.5880	1.0189	101
1989	79400	164390	9582	20034	2.0907	0.5302	***
1990	71420	193639	12830	47454	3.6985	0.9838	***
1991	89580	191679	12670	65008	5.1308	1.1180	***
1992	76500	163499	11453	63193	5.5175	1.1704	***
1993	150960	136443	10172	62455	6.1396	0.8465	***
1994	166320	99416	9012	51029	5.6623	1.2889	***
1995	261760	77407	4688	15272	3.2572	0.5940	***
1996	224460	93651	5948	18840	3.1674	0.6384	***
1997	203190	118775	7021	19858	2.8282	0.6015	***
1998	283870	145827	8681	20000	2.3036	0.5505	***

No of years for separable analysis : 21
Age range in the analysis : 1 . . . 16
Year range in the analysis : 1978 . . . 1998
Number of indices of SSB : 0
Number of age-structured indices : 1

Parameters to estimate : 86
Number of observations : 546

Conventional single selection vector model to be fitted.

PARAMETER ESTIMATES

Parm. No.		Maximum Likelh. Estimate	CV (%)	Lower 95% CL	Upper 95% CL	-s.e.	+s.e.	Mean of Param. Distrib.
Separable model : F by year								
1	1978	0.5600	21	0.3654	0.8582	0.4504	0.6963	0.5735
2	1979	0.4144	21	0.2700	0.6361	0.3330	0.5157	0.4244
3	1980	0.3260	22	0.2109	0.5041	0.2610	0.4072	0.3342
4	1981	0.4077	21	0.2675	0.6213	0.3288	0.5054	0.4172
5	1982	0.3867	21	0.2534	0.5900	0.3117	0.4797	0.3958
6	1983	0.4507	20	0.3000	0.6772	0.3662	0.5548	0.4606
7	1984	0.5646	20	0.3812	0.8361	0.4621	0.6898	0.5760
8	1985	0.4346	21	0.2875	0.6568	0.3520	0.5365	0.4443
9	1986	0.4137	21	0.2708	0.6320	0.3332	0.5135	0.4235
10	1987	0.8103	19	0.5564	1.1802	0.6689	0.9817	0.8254
11	1988	0.8634	19	0.5948	1.2534	0.7139	1.0443	0.8792
12	1989	0.4493	14	0.3357	0.6014	0.3872	0.5214	0.4543
13	1990	0.8336	16	0.6081	1.1428	0.7097	0.9792	0.8445
14	1991	0.9474	17	0.6720	1.3356	0.7951	1.1288	0.9621
15	1992	0.9917	17	0.7017	1.4017	0.8313	1.1832	1.0073
16	1993	0.7173	17	0.5070	1.0150	0.6009	0.8563	0.7287
17	1994	1.0922	17	0.7826	1.5243	0.9214	1.2947	1.1081
18	1995	0.5034	17	0.3557	0.7122	0.4217	0.6009	0.5113
19	1996	0.5410	17	0.3805	0.7692	0.4521	0.6474	0.5498
20	1997	0.5097	19	0.3512	0.7398	0.4215	0.6164	0.5190
21	1998	0.4665	20	0.3091	0.7040	0.3781	0.5755	0.4769
Separable Model: Selection (S) by age								
22	1	0.0000	48	0.0000	0.0000	0.0000	0.0000	0.0000
23	2	0.0000	39	0.0000	0.0000	0.0000	0.0000	0.0000
24	3	0.0000	33	0.0000	0.0000	0.0000	0.0000	0.0000
25	4	0.0000	30	0.0000	0.0000	0.0000	0.0000	0.0000
26	5	0.0206	27	0.0120	0.0353	0.0156	0.0271	0.0214
27	6	0.1641	27	0.0958	0.2811	0.1247	0.2159	0.1704
28	7	1.6731	19	1.1451	2.4446	1.3788	2.0302	1.7047
29	8	2.5311	18	1.7444	3.6725	2.0933	3.0604	2.5771
30	9	1.7039	21	1.1182	2.5962	1.3744	2.1123	1.7436
31	10	1.4283	22	0.9107	2.2402	1.1353	1.7970	1.4665
32	11	0.9199	24	0.5739	1.4744	0.7231	1.1702	0.9469
	12	1.0000		Fixed : Reference Age				
33	13	1.0132	24	0.6307	1.6275	0.7955	1.2904	1.0432
34	14	0.9317	24	0.5813	1.4934	0.7324	1.1853	0.9591
	15	1.0000		Fixed : Last true age				

Appendix 2 (contd.) . Summary Results of Maximum likelihood model fit using total international catches at age from 1975 to 1988.

Separable model: Populations in year 1998

35	1	283870	57	91301	882595	159137	506370	335625
36	2	166364	38	77819	355658	112903	245140	179346
37	3	150460	31	81748	276926	110216	205397	157927
38	4	143657	26	85003	242782	109914	187757	148898
39	5	74733	24	45816	121902	58224	95925	77099
40	6	54953	23	34827	86710	43545	69351	56461
41	7	20957	19	14404	30491	17308	25375	21344
42	8	8526	23	5377	13518	6739	10786	8765
43	9	1444	29	806	2584	1073	1943	1509
44	10	495	29	276	890	367	668	518
45	11	108	28	61	192	81	145	113
46	12	66	28	38	116	50	88	69
47	13	12	27	7	21	9	16	12
48	14	2	34	1	5	1	3	2
49	15	0	0	0	0	0	0	0

Separable model: Populations at age

50	1978	130	52	46	362	77	219	149
51	1979	152	38	71	327	103	225	164
52	1980	106	33	55	204	76	148	112
53	1981	100	29	56	179	74	135	105
54	1982	119	26	70	203	91	157	124
55	1983	117	25	71	191	91	150	121
56	1984	125	23	78	201	99	160	129
57	1985	89	23	55	142	70	113	91
58	1986	79	23	50	125	63	100	81
59	1987	88	22	56	136	70	110	90
60	1988	58	23	36	94	46	74	60
61	1989	31	27	18	53	23	41	32
62	1990	22	26	13	38	17	29	23
63	1991	13	27	7	23	10	17	13
64	1992	5	31	2	9	3	7	5
65	1993	3	38	1	6	2	4	3
66	1994	1	48	0	3	0	2	1
67	1995	0	193	0	8	0	1	1
68	1996	.2395E-04	***	.0000E+00	.1000+309	.0000E+00	.1000+309	.1000+309
69	1997	0	0	0	0	0	0	0

Recruitment in year 1999

70	1998	169095	226	2003	14274146	17590	1625544	2189327

Age-structured index catchabilities

Canada RV,,,,,,,,,,,,,,,

Linear model fitted. Slopes at age :

71	1	Q	.6113	48	.3833	2.580	.6113	1.617	1.119
72	2	Q	1.145	21	.9272	2.193	1.145	1.776	1.461
73	3	Q	1.502	15	1.290	2.401	1.502	2.062	1.782
74	4	Q	1.378	15	1.185	2.195	1.378	1.887	1.632
75	5	Q	1.245	15	1.071	1.980	1.245	1.703	1.474
76	6	Q	.9908	15	.8520	1.578	.9908	1.357	1.174
77	7	Q	1.105	16	.9418	1.809	1.105	1.541	1.323
78	8	Q	1.517	18	1.268	2.635	1.517	2.203	1.860
79	9	Q	1.866	19	1.552	3.292	1.866	2.739	2.302
80	10	Q	2.351	18	1.965	4.090	2.351	3.417	2.885
81	11	Q	2.890	18	2.420	4.998	2.890	4.185	3.538
82	12	Q	4.607	18	3.844	8.052	4.607	6.718	5.663
83	13	Q	5.647	18	4.705	9.908	5.647	8.256	6.952
84	14	Q	5.892	19	4.871	10.59	5.892	8.756	7.325
85	15	Q	7.033	26	5.477	15.21	7.033	11.84	9.441
86	16	Q	4.877	26	3.782	10.68	4.877	8.284	6.583

RESIDUALS ABOUT THE MODEL FIT

Separable Model Residuals

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	-0.030	0.725	0.061	0.410	0.433	0.858	-0.373	0.062	-0.358	-0.770	-0.457	1.196	-0.009	0.329	-0.252
2	0.367	0.273	0.966	-0.161	0.465	0.281	0.634	-0.110	0.113	-1.029	-0.833	0.197	0.579	-0.136	0.285
3	-0.377	0.620	0.464	0.694	-0.157	0.263	0.007	0.847	-0.109	-0.608	-1.141	-0.228	-0.470	0.403	-0.230
4	0.217	-0.058	0.878	0.259	0.765	-0.292	0.056	0.287	0.915	-0.763	-0.654	-0.469	-0.828	-0.579	0.375
5	1.397	1.342	-0.672	0.487	-0.396	0.389	0.068	0.869	-0.333	-1.766	-1.399	*******	*******	*******	*******
6	0.626	0.835	-0.334	0.300	-0.387	0.417	-0.602	0.141	-0.755	-0.830	-0.508	*******	*******	*******	*******
7	-1.203	-0.511	-0.651	-0.831	-1.170	-0.620	-1.114	-1.278	-1.350	-1.275	-0.907	*******	*******	*******	*******
8	-0.941	-0.614	0.046	-0.151	-0.784	-0.296	-0.420	-0.699	-0.691	-0.635	-0.858	*******	*******	*******	*******
9	-0.568	-0.879	0.999	0.342	0.135	-0.152	0.396	-0.251	0.058	-0.110	-0.217	*******	*******	*******	*******
10	-0.090	-0.974	1.588	-0.120	0.399	-0.405	0.044	-0.351	-0.180	0.176	-0.308	*******	*******	*******	*******
11	0.359	-0.245	1.175	-0.314	0.588	-0.489	-0.070	-0.623	0.153	0.307	0.290	*******	*******	*******	*******
12	0.348	-0.435	-0.273	-0.587	0.172	-0.893	-0.638	-0.749	-0.137	0.375	-0.165	*******	*******	*******	*******
13	0.309	0.293	-0.593	-1.083	0.126	-0.039	-0.231	-0.302	-0.394	0.510	0.338	*******	*******	*******	*******
14	-0.067	0.396	-1.053	-0.835	0.202	0.231	-0.240	-0.114	0.048	0.729	0.223	*******	*******	*******	*******
15	0.119	0.467	-1.110	-0.439	0.441	0.635	0.376	-0.480	0.250	0.778	0.410	*******	*******	*******	*******

Appendix 2 (contd.) . Summary Results of Maximum likelihood model fit using total international catches at age from 1975 to 1988.

Separable Model Residuals

Age	1993	1994	1995	1996	1997	1998
1	0.086	-1.125	-0.110	-0.722	0.130	-0.115
2	0.074	-0.333	-0.349	-0.181	-0.661	-0.473
3	0.560	-0.395	0.393	-0.469	-0.170	0.072
4	0.112	0.158	0.398	0.339	-0.392	-0.757
5	*******	*******	*******	*******	*******	*******
6	*******	*******	*******	*******	*******	*******
7	*******	*******	*******	*******	*******	*******
8	*******	*******	*******	*******	*******	*******
9	*******	*******	*******	*******	*******	*******
10	*******	*******	*******	*******	*******	*******
11	*******	*******	*******	*******	*******	*******
12	*******	*******	*******	*******	*******	*******
13	*******	*******	*******	*******	*******	*******
14	*******	*******	*******	*******	*******	*******
15	*******	*******	*******	*******	*******	*******

AGE-STRUCTURED INDEX RESIDUALS

Canada RV,,,,,,,,,,,,,,,,

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.112	0.000	-0.675	0.285	-0.483	-1.621	-0.969	0.312	0.105	-1.569	0.215	0.187	-1.388	0.535	0.223
2	0.934	0.336	-0.929	0.091	-1.414	-0.882	-0.614	-0.125	-0.712	-0.758	-1.316	0.045	-0.527	-0.023	0.907
3	0.601	-0.328	-0.815	-0.138	-0.556	-0.897	-0.250	-0.435	-0.205	-0.089	-0.531	-0.498	-0.332	-0.482	0.825
4	0.265	-0.678	-0.934	-0.583	-0.221	-0.431	-0.563	-0.221	0.321	-0.046	-0.419	0.225	-0.193	0.334	0.562
5	0.122	-0.447	-0.396	-0.445	0.043	0.022	0.186	-0.378	0.371	0.301	0.454	-0.170	0.124	-0.876	-0.339
6	0.339	0.013	0.004	0.074	-0.119	0.410	0.354	0.261	0.299	0.564	0.569	0.610	-0.097	-0.417	-1.446
7	0.191	-0.211	-0.046	0.068	0.374	0.590	0.812	0.495	0.765	0.550	1.194	0.677	0.568	-0.879	-0.767
8	0.015	-0.343	-0.356	-0.101	0.932	1.061	0.936	0.808	0.606	0.997	0.855	0.906	0.164	-0.385	-1.407
9	0.049	-0.320	-0.247	-0.062	0.797	0.802	1.001	0.794	0.747	0.960	0.643	0.866	0.321	-0.260	-1.183
10	0.495	0.014	0.030	0.127	0.493	0.094	0.676	0.859	0.218	0.810	0.091	0.234	0.474	0.100	-0.741
11	0.836	0.181	0.429	0.294	0.570	0.216	0.141	0.246	0.304	0.406	0.490	0.243	0.778	0.082	-2.025
12	0.671	0.137	0.229	-0.535	0.198	0.118	-0.124	0.087	0.084	0.389	-0.219	-0.797	0.221	-0.449	*******
13	0.515	0.528	0.164	-0.618	0.074	0.127	0.189	-0.354	-0.310	-0.097	-0.165	-2.145	0.236	-1.758	*******
14	-0.270	0.238	0.329	-0.758	0.761	0.084	0.518	0.445	-0.261	0.024	0.038	-0.855	0.116	-2.071	-1.041
15	-0.119	-0.130	-0.348	-0.677	0.684	-0.195	0.106	0.269	0.286	0.018	-0.049	-0.467	-0.100	*******	*******
16	-0.229	-0.039	2.056	-1.270	0.491	0.209	0.669	0.824	0.315	-0.405	0.921	-1.152	-1.471	-2.601	*******

Canada RV,,,,,,,,,,,,,,,,

Age	1993	1994	1995	1996	1997	1998	1999
1	-0.294	1.364	0.860	1.855	0.681	0.240	0.000
2	1.466	0.394	1.035	0.712	0.938	0.230	0.183
3	1.808	0.901	-0.113	0.569	0.513	0.262	0.159
4	1.317	0.611	-0.279	-0.067	0.523	0.052	0.394
5	0.074	0.372	0.110	0.367	0.167	0.094	0.211
6	-0.877	-0.869	-0.332	-0.226	0.517	-0.212	0.545
7	-1.993	-0.931	-1.303	-0.506	0.082	0.196	0.048
8	-0.818	-1.605	-1.079	-0.918	0.203	-0.307	-0.169
9	-1.074	-1.424	-1.424	0.227	-0.022	-0.399	-0.793
10	-1.332	-0.927	-0.668	-0.291	0.181	-0.267	-0.675
11	-1.106	-1.225	-0.264	0.471	0.026	0.034	-1.126
12	0.581	-0.754	*******	0.825	0.544	-0.397	-0.811
13	0.118	-0.856	*******	1.991	1.210	0.956	0.195
14	0.052	*******	*******	1.612	1.878	0.234	-1.072
15	*******	*******	*******	0.722	*******	*******	*******
16	*******	*******	*******	*******	*******	1.683	*******

PARAMETERS OF THE DISTRIBUTION OF ln(CATCHES AT AGE)

Separable model fitted from 1978 to 1998	
Variance	0.5378
Skewness test stat.	-2.7187
Kurtosis test statistic	-0.4068
Partial chi-square	21.5564
Significance in fit	0.0000
Degrees of freedom	**

Appendix 2 (contd.) . Summary Results of Maximum likelihood model fit using total international catches at age from 1975 to 1988.

PARAMETERS OF THE DISTRIBUTION OF THE AGE-STRUCTURED INDICES

DISTRIBUTION STATISTICS FOR Canada RV,,,,,,,,,,,,,,,

Linear catchability relationship assumed

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Variance	0.0758	0.3285	0.4235	0.2742	0.1182	0.2938	0.6084	0.6794	0.6352	0.3326	0.5243	0.2460	0.8496	0.8096	0.1564	1.5361
Skewness test stat.	-0.2882	-0.1137	1.9486	0.8356	-1.6308	-1.9932	-1.6645	-0.6223	-0.8308	-1.1493	-2.7631	-0.3815	-0.6793	-0.1071	0.5414	-0.5641
Kurtosis test statisti	-0.0436	-0.9422	0.7383	0.0753	-0.0064	0.5354	0.2040	-0.9379	-0.9703	-0.2946	1.1847	-0.8937	0.7844	0.4562	-0.2828	-0.2648
Partial chi-square	0.1395	0.5864	0.7713	0.5123	0.2188	0.5734	1.2728	1.6301	1.8397	1.1832	2.2475	0.9399	3.9684	5.0050	0.5780	6.7254
Significance in fit	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0006	0.0000	0.0552
Number of observations	22	22	22	22	22	22	22	22	22	22	22	20	20	20	14	15
Degrees of freedom	21	21	21	21	21	21	21	21	21	21	21	19	19	19	13	14
Weight in the analysis	0.1000	0.5000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

ANALYSIS OF VARIANCE

Unweighted Statistics

Variance

	SSQ	Data	Parameters	d.f.	Variance
Total for model	244.2697	546	86	460	0.5310
Catches at age	73.1395	205	69	136	0.5378
Aged Indices					
Canada RV,,,,,,,,,,,,,,,	171.1302	331	16	315	0.5433

Weighted Statistics

Variance

	SSQ	Data	Parameters	d.f.	Variance
Total for model	218.1685	546	86	460	0.4743
Catches at age	73.1395	205	69	136	0.5378
Aged Indices					
Canada RV,,,,,,,,,,,,,,,	145.0289	331	16	315	0.4604

Appendix 2 (contd.) . Summary Results of Maximum likelihood model fit using total international catches at age from 1975 to 1988.

Results of F-status quo deterministic projection

Populations in the Projection

AGE	1998	1999	2000	2001	2002	2003
1	147.19	147.19	147.19	147.19	147.19	147.19
2	166.37	120.50	120.50	120.50	120.50	120.50
3	150.46	136.21	98.66	98.66	98.66	98.66
4	143.66	123.19	111.52	80.78	80.78	80.78
5	74.73	117.62	100.86	91.30	66.13	66.13
6	54.95	60.60	95.38	81.78	74.04	53.63
7	20.96	41.68	45.96	72.33	62.03	56.15
8	8.53	7.86	15.63	17.24	27.13	23.27
9	1.45	2.14	1.98	3.93	4.33	6.82
10	0.50	0.53	0.79	0.73	1.45	1.60
11	0.11	0.21	0.22	0.33	0.31	0.61
12	0.07	0.06	0.11	0.12	0.18	0.16
13	0.01	0.03	0.03	0.06	0.06	0.09
14	0.00	0.01	0.02	0.02	0.03	0.03
15	0.00	0.00	0.00	0.01	0.01	0.02
16	0.00	0.00	0.00	0.00	0.01	0.01

x 10 ^ 3

Fishing Mortality in the Projection

AGE	1998	1999	2000	2001	2002	2003
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0096	0.0096	0.0096	0.0096	0.0096	0.0096
6	0.0765	0.0765	0.0765	0.0765	0.0765	0.0765
7	0.7805	0.7805	0.7805	0.7805	0.7805	0.7805
8	1.1808	1.1808	1.1808	1.1808	1.1808	1.1808
9	0.7949	0.7949	0.7949	0.7949	0.7949	0.7949
10	0.6663	0.6663	0.6663	0.6663	0.6663	0.6663
11	0.4291	0.4291	0.4291	0.4291	0.4291	0.4291
12	0.4665	0.4665	0.4665	0.4665	0.4665	0.4665
13	0.4727	0.4727	0.4727	0.4727	0.4727	0.4727
14	0.4347	0.4347	0.4347	0.4347	0.4347	0.4347
15	0.4665	0.4665	0.4665	0.4665	0.4665	0.4665
16	0.4665	0.4665	0.4665	0.4665	0.4665	0.4665

Natural Mortality, Maturity Ogive and Stock Weights

1	0.20000000E+00	0.00000000E+00	0.10000000E-07
2	0.20000000E+00	0.00000000E+00	0.10000000E-07
3	0.20000000E+00	0.10000000E-01	0.12600000E+00
4	0.20000000E+00	0.20000000E-01	0.22200000E+00
5	0.20000000E+00	0.30000000E-01	0.38300000E+00
6	0.20000000E+00	0.50000000E-01	0.58100000E+00
7	0.20000000E+00	0.80000000E-01	0.90900000E+00
8	0.20000000E+00	0.18000000E+00	0.12640000E+01
9	0.20000000E+00	0.32000000E+00	0.18500000E+01
10	0.20000000E+00	0.48000000E+00	0.24270000E+01
11	0.20000000E+00	0.62000000E+00	0.31040000E+01
12	0.20000000E+00	0.74000000E+00	0.39960000E+01
13	0.20000000E+00	0.82000000E+00	0.51410000E+01
14	0.20000000E+00	0.89000000E+00	0.59430000E+01
15	0.20000000E+00	0.92000000E+00	0.66580000E+01
16	0.20000000E+00	0.10000000E+01	0.70000000E+01

s.d. of Maturity Ogive and Stock Weights
for root-arcsine and log transforms

1	0.00000000E+00	0.54977006E-06
2	0.00000000E+00	0.54977006E-06
3	0.24691303E-08	0.37747872E-07
4	0.35675171E-08	0.48518241E-07
5	0.53518138E-08	0.92290261E-08
6	0.69225527E-08	0.12167044E-07
7	0.85067664E-08	0.23507537E-08
8	0.89013198E-08	0.70305602E-08
9	0.98792651E-08	0.37658152E-08
10	0.13996201E-07	0.28396940E-07
11	0.98913297E-08	0.42881312E-08
12	0.26143470E-07	0.49705062E-07
13	0.71049598E-08	0.36784294E-07
14	0.55879354E-08	0.46737178E-07
15	0.28279100E-07	0.46499025E-07
16	0.43547672E-07	0.28669007E-07

Appendix 2 (contd.) . Summary Results of Maximum likelihood model fit using total international catches at age from 1975 to 1988.

```
 Stock Size Trajectory
1998       0.868191818818E+04
1999       0.113187664895E+05
2000       0.145571090265E+05
2001       0.176627699225E+05
2002       0.199601007012E+05
2003       0.204402362765E+05
 Fleet Catches by Weight
Catch Estimates by Fleet
1998     0.000000000000E+00
1999     0.308942618871E+05
2000     0.406440978188E+05
2001     0.552400622681E+05
2002     0.594504621125E+05
2003     0.557081075375E+05
Fleet Catches by Number
```

Catch Estimates by Fleet 1

AGE	1998	1999	2000	2001	2002	2003
1	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.
5	0.	1019.	874.	791.	573.	573.
6	0.	4052.	6377.	5469.	4951.	3586.
7	0.	20732.	22862.	35980.	30853.	27931.
8	0.	5033.	10009.	11037.	17370.	14895.
9	0.	1079.	995.	1979.	2182.	3435.
10	0.	238.	353.	326.	648.	714.
11	0.	67.	72.	106.	98.	195.
12	0.	20.	38.	41.	60.	56.
13	0.	12.	10.	20.	21.	31.
14	0.	2.	6.	5.	9.	10.
15	0.	1.	1.	3.	3.	5.
16	0.	0.	1.	1.	2.	3.

Total Catches by Number

AGE	1998	1999	2000	2001	2002	2003
1	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.
5	648.	1019.	874.	791.	573.	573.
6	3675.	4052.	6377.	5469.	4951.	3586.
7	10425.	20732.	22862.	35980.	30853.	27931.
8	5459.	5033.	10009.	11037.	17370.	14895.
9	728.	1079.	995.	1979.	2182.	3435.
10	221.	238.	353.	326.	648.	714.
11	35.	67.	72.	106.	98.	195.
12	23.	20.	38.	41.	60.	56.
13	5.	12.	10.	20.	21.	31.
14	1.	2.	6.	5.	9.	10.
15	0.	1.	1.	3.	3.	5.
16	0.	0.	1.	1.	2.	3.

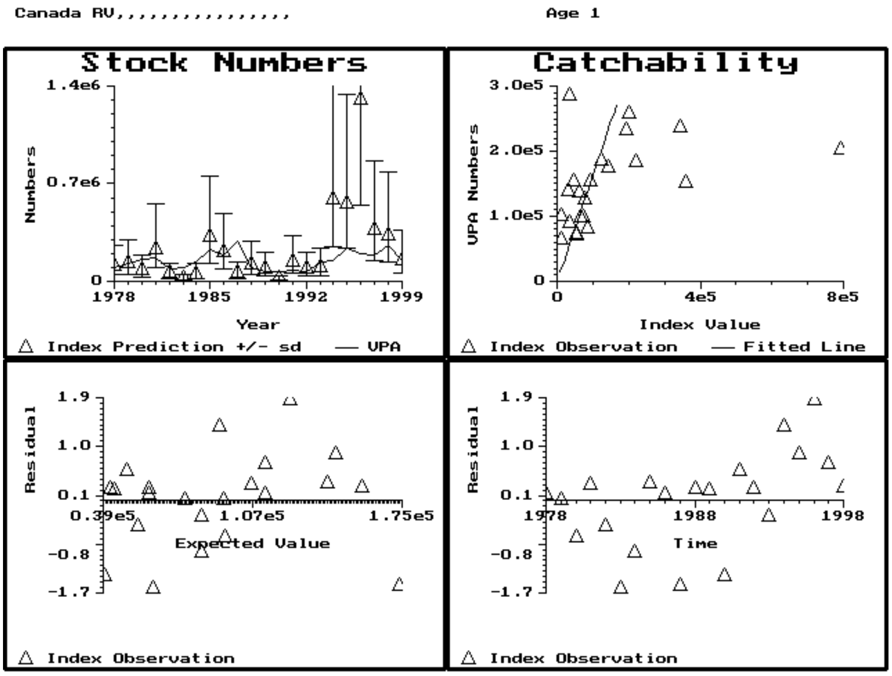


Figure A2.1. Residual plots and observed and fitted values for the Canada standardised RV series, at age 1.

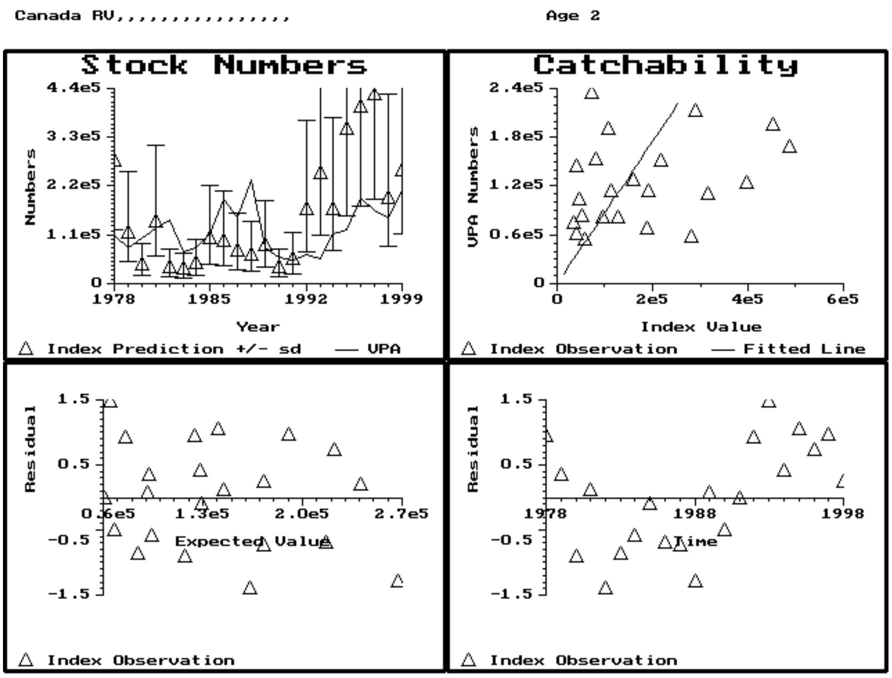


Figure A2.2. Residual plots and observed and fitted values for the Canada standardised RV series, at age 2.

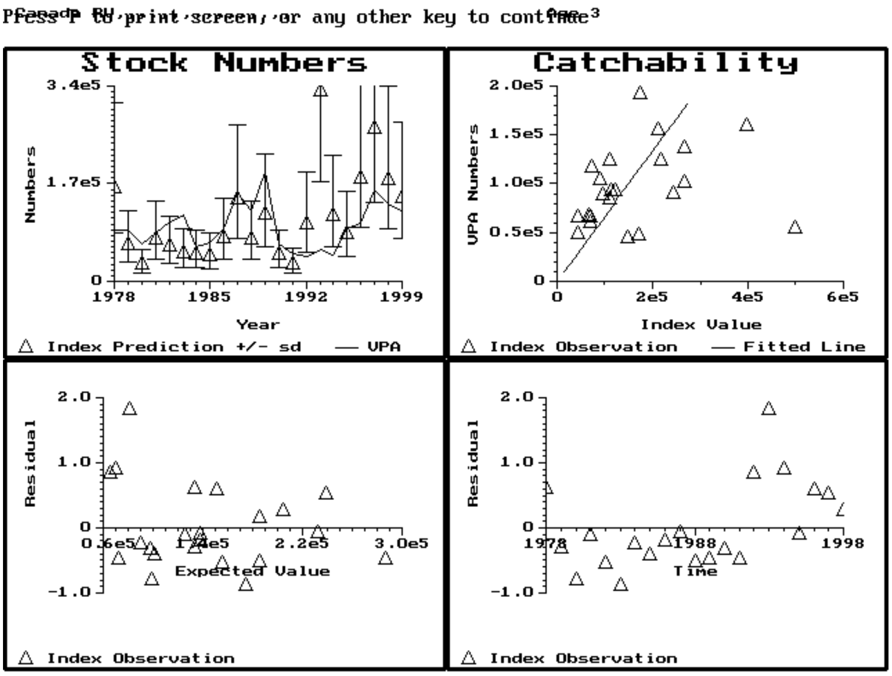


Figure A2.3. Residual plots and observed and fitted values for the Canada standardised RV series, at age 3

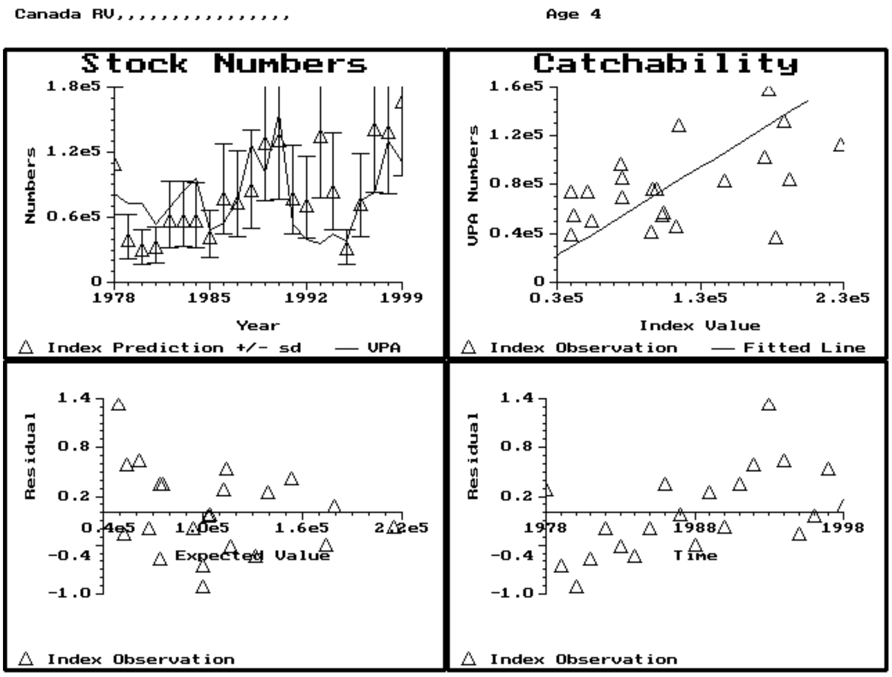


Figure A2.4. Residual plots and observed and fitted values for the Canada standardised RV series, at age 4

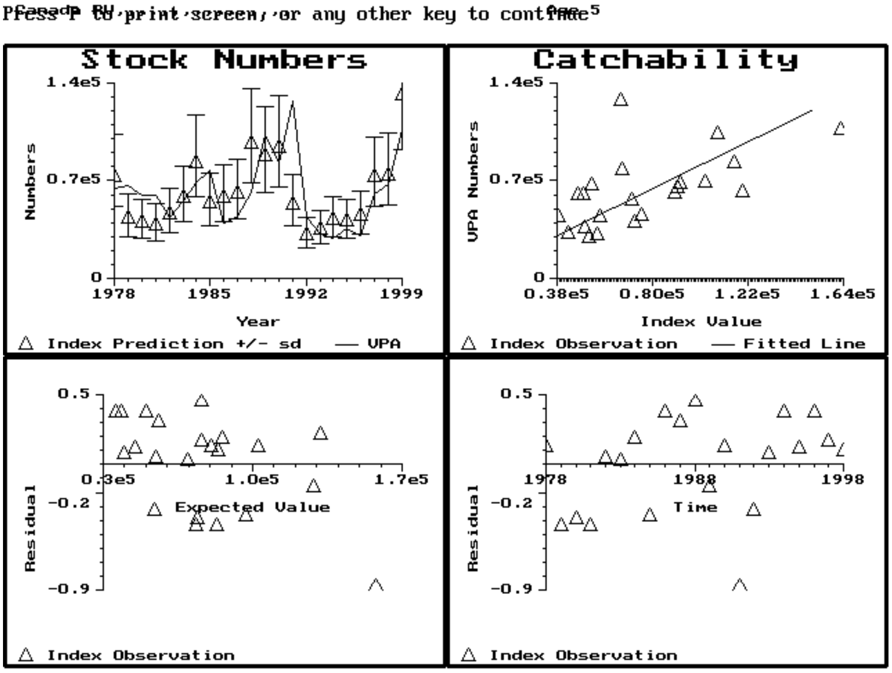


Figure A2.5. Residual plots and observed and fitted values for the Canada standardised RV series, at age 5

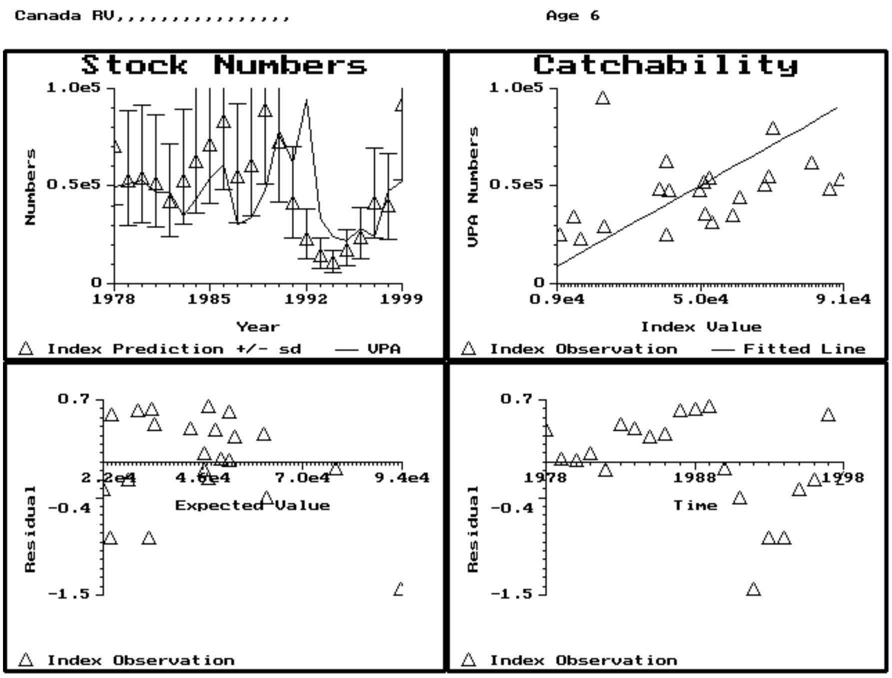


Figure A2.6. Residual plots and observed and fitted values for the Canada standardised RV series, at age 6

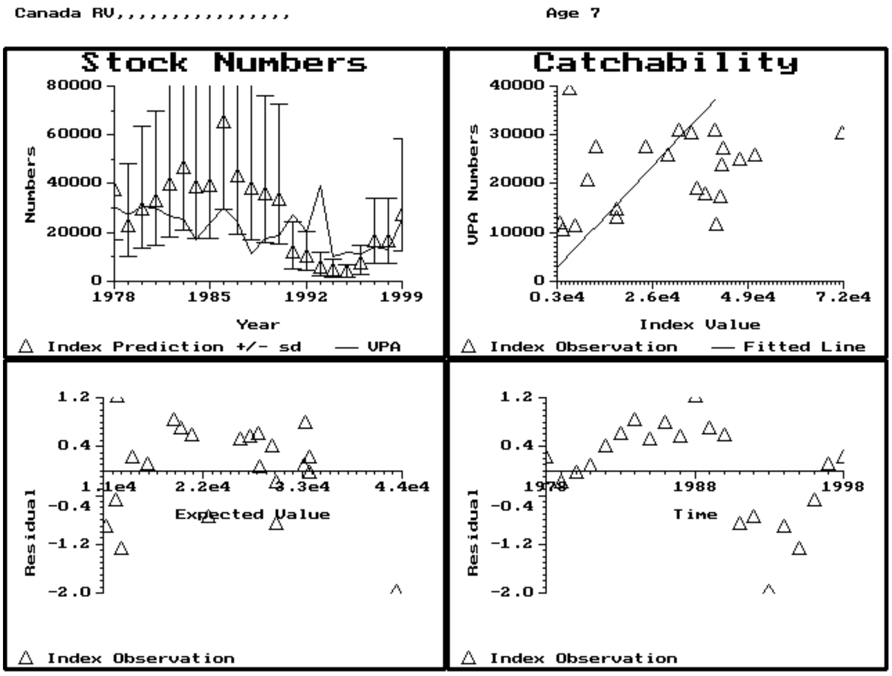


Figure A2.7. Residual plots and observed and fitted values for the Canada standardised RV series, at age 7.

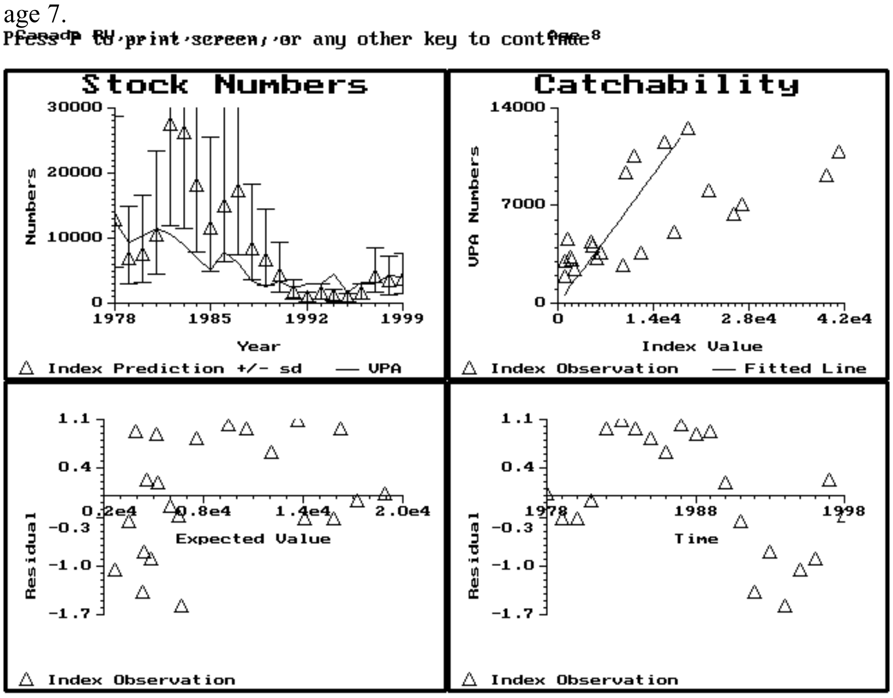


Figure A2.8. Residual plots and observed and fitted values for the Canada standardised RV series, at age 7

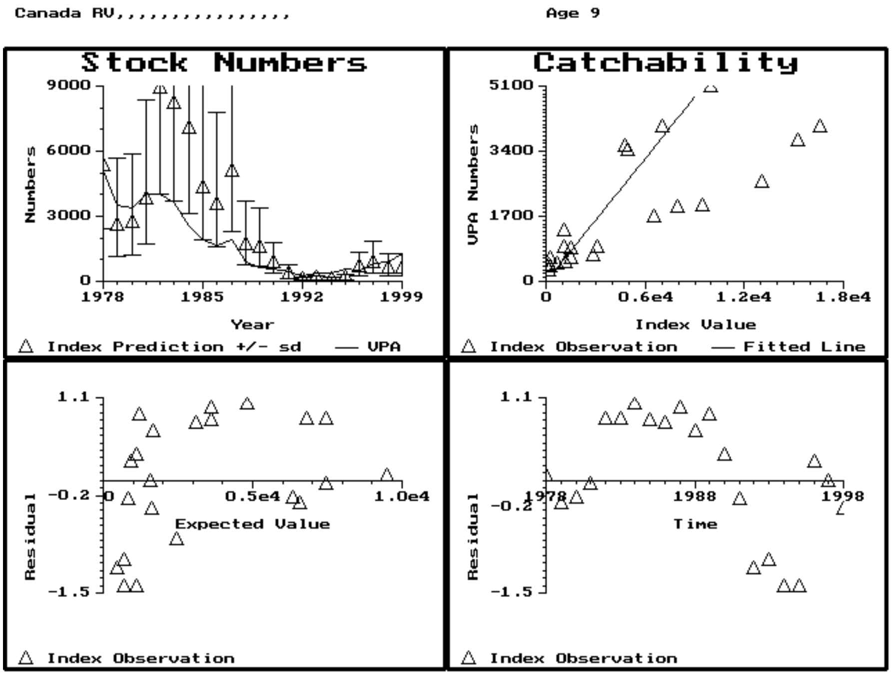


Figure A2.9. Residual plots and observed and fitted values for the Canada standardised RV series, at age 7

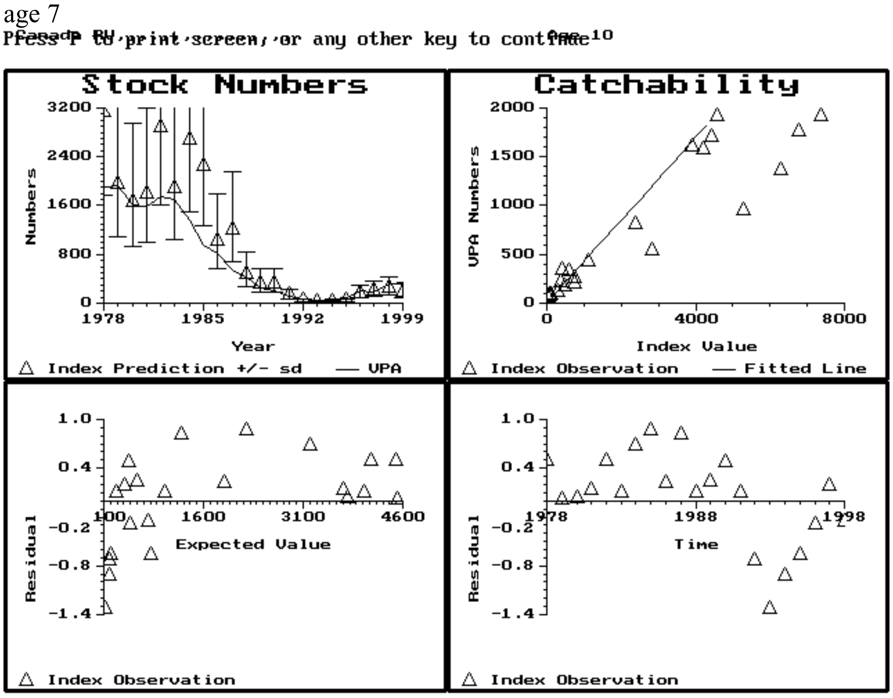


Figure A2.10. Residual plots and observed and fitted values for the Canada standardised RV series, at age 10

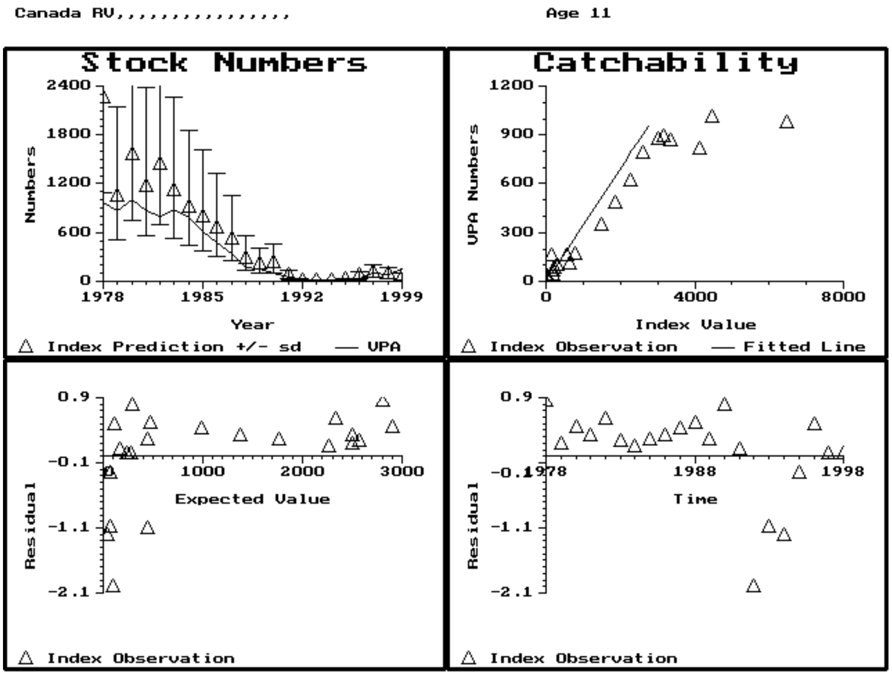


Figure A2.11. Residual plots and observed and fitted values for the Canada standardised RV series, at age 11

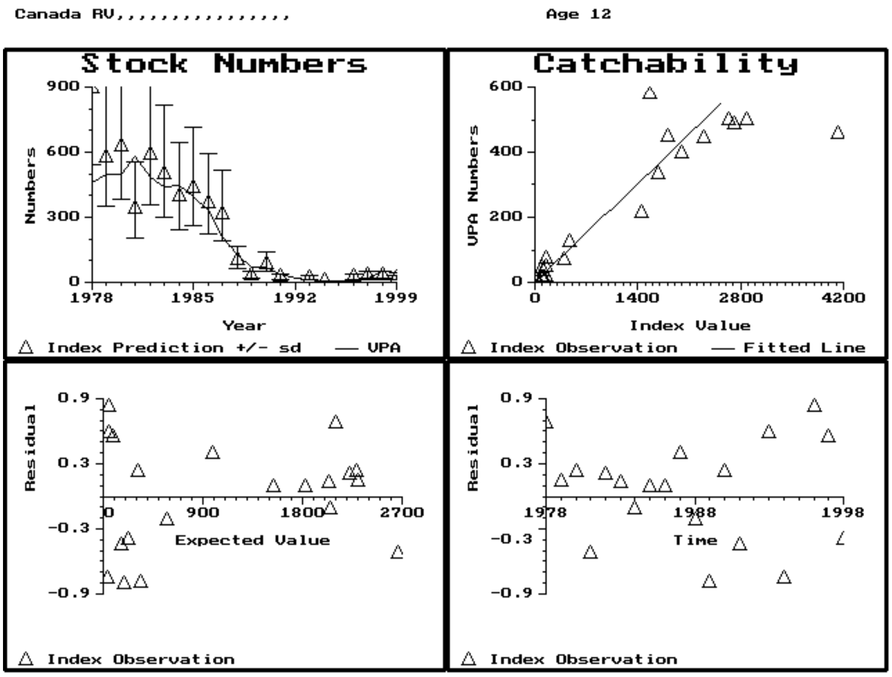


Figure A2.12. Residual plots and observed and fitted values for the Canada standardised RV series, at age 12

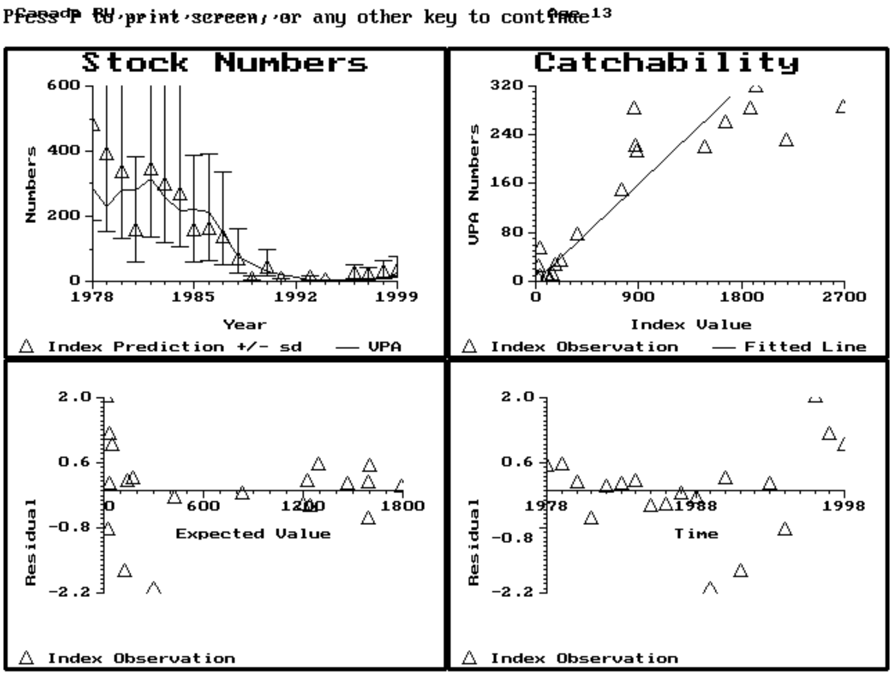


Figure A2.13. Residual plots and observed and fitted values for the Canada standardised RV series, at age 13

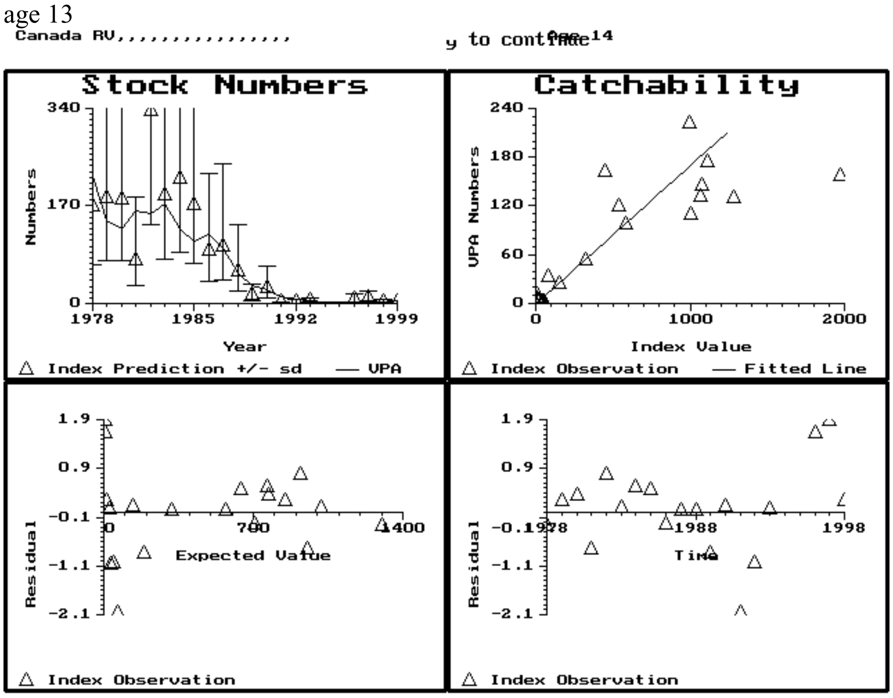


Figure A2.14. Residual plots and observed and fitted values for the Canada standardised RV series, at age 14

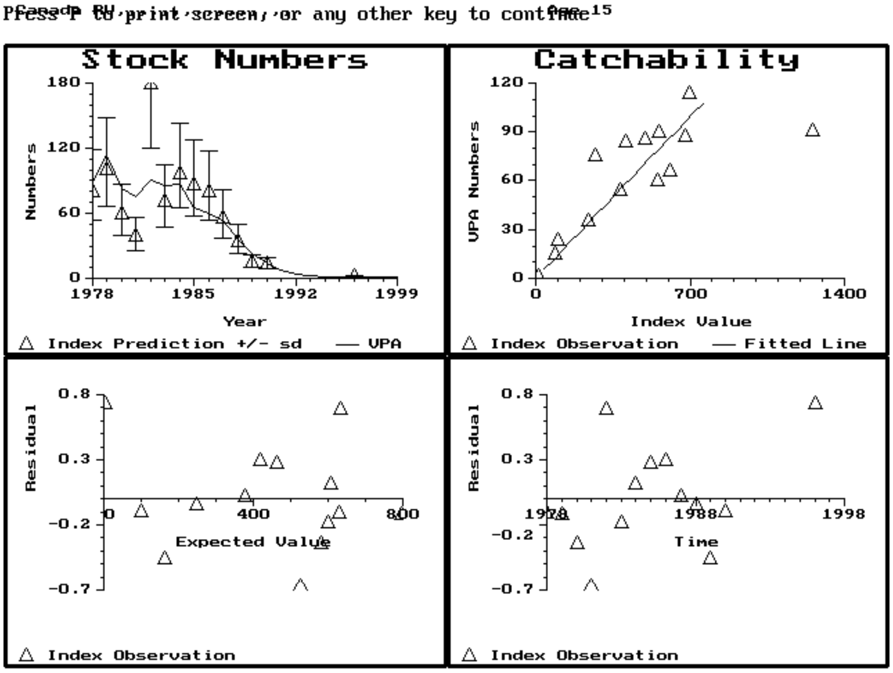


Figure A2.15. Residual plots and observed and fitted values for the Canada standardised RV series, at age 15

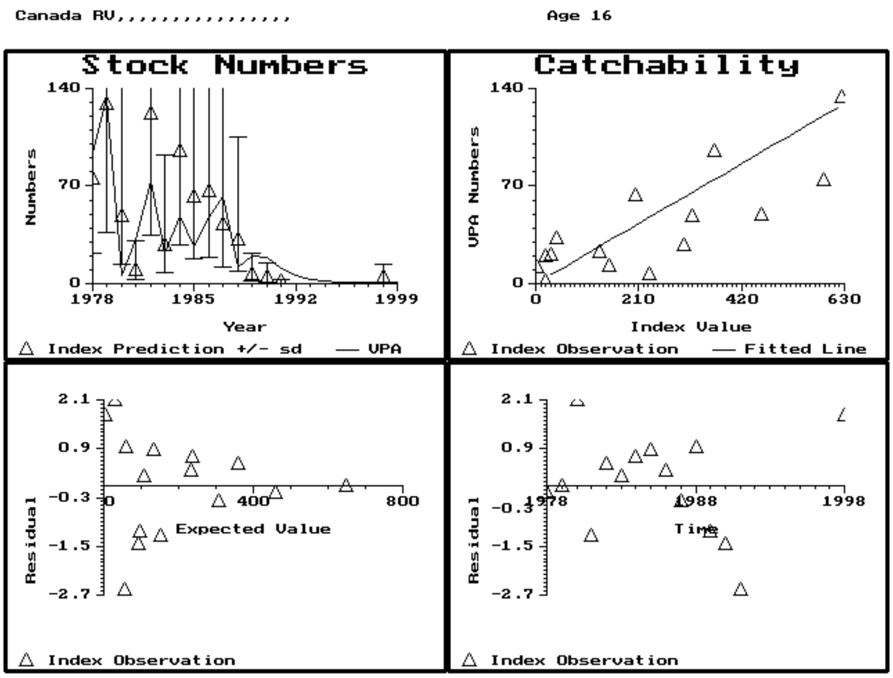


Figure A2.16. Residual plots and observed and fitted values for the Canada standardised RV series, at age 16

Appendix 3. Summary results of ML fit using Canadian catch-at-age data from 1988 to 1997 to estimate selection pattern.

Greenland Halibut in 2+3KLMNO

Catch in Number

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	3.02	2.18	0.20	0.81	0.24	0.77	0.86	1.66	0.24	0.13	0.27	0.00	0.00	0.00	0.00
6	8.51	7.98	2.03	4.24	2.02	3.89	2.21	4.45	1.96	1.78	2.90	0.00	0.00	0.00	0.00
7	9.07	11.73	8.91	9.21	5.55	10.71	5.56	4.96	5.60	10.29	7.41	0.00	0.00	0.00	0.00
8	7.66	5.61	9.43	10.75	5.06	8.21	7.31	2.93	4.45	8.36	3.99	0.00	0.00	0.00	0.00
9	2.90	1.07	5.26	4.04	3.11	2.51	3.89	1.16	1.28	2.65	1.17	0.00	0.00	0.00	0.00
10	1.45	0.44	3.73	0.84	1.48	0.76	1.20	0.43	0.41	0.80	0.42	0.00	0.00	0.00	0.00
11	0.73	0.26	0.99	0.24	0.52	0.23	0.39	0.13	0.21	0.36	0.18	0.00	0.00	0.00	0.00
12	0.37	0.14	0.13	0.13	0.23	0.08	0.14	0.08	0.12	0.26	0.10	0.00	0.00	0.00	0.00
13	0.23	0.13	0.05	0.04	0.14	0.12	0.10	0.07	0.06	0.21	0.10	0.00	0.00	0.00	0.00
14	0.11	0.08	0.01	0.03	0.07	0.09	0.06	0.04	0.05	0.16	0.06	0.00	0.00	0.00	0.00
15	0.06	0.08	0.01	0.02	0.06	0.07	0.07	0.02	0.03	0.10	0.05	0.00	0.00	0.00	0.00
16	0.05	0.06	0.00	0.01	0.03	0.01	0.03	0.01	0.02	0.05	0.01	0.00	0.00	0.00	0.00

x 10 ^ 6

Catch in Number

AGE	1993	1994	1995	1996	1997	1998
1	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00

x 10 ^ 6

Predicted Catch in Number

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	937.	707.	560.	533.	363.	535.	701.	646.	375.	709.	671.	785.	592.	834.	349.
6	5614.	4877.	3897.	3325.	2913.	2501.	3725.	3404.	3164.	4263.	3702.	3418.	5251.	4758.	3042.
7	13440.	12580.	11775.	10152.	8067.	8679.	7163.	7613.	7341.	13595.	8076.	7066.	8169.	12532.	5560.
8	8513.	6716.	7008.	7174.	5772.	5654.	5526.	3122.	3737.	7035.	4546.	2824.	3156.	3155.	1827.
9	3495.	2456.	2187.	2516.	2392.	2409.	2120.	1366.	886.	2194.	1269.	865.	710.	672.	210.
10	1116.	1070.	839.	820.	874.	1045.	968.	565.	408.	566.	460.	277.	250.	186.	59.
11	500.	420.	444.	380.	344.	461.	517.	322.	206.	321.	159.	132.	105.	91.	25.
12	268.	271.	250.	288.	229.	258.	324.	249.	169.	224.	130.	66.	71.	53.	18.
13	138.	102.	114.	115.	123.	122.	128.	108.	92.	133.	62.	37.	25.	25.	7.
14	107.	63.	51.	62.	58.	77.	72.	51.	47.	85.	45.	21.	17.	10.	4.
15	46.	48.	31.	28.	31.	36.	45.	29.	22.	43.	28.	15.	9.	7.	2.

x 10 ^ 3

Predicted Catch in Number

AGE	1993	1994	1995	1996	1997	1998
1	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.
5	339.	291.	322.	293.	534.	1222.
6	1754.	1520.	914.	2005.	2006.	5341.
7	5349.	2958.	2087.	2574.	6017.	7607.
8	1618.	1599.	837.	1435.	1845.	4988.
9	280.	257.	246.	343.	614.	925.
10	38.	51.	43.	104.	153.	336.
11	15.	9.	11.	21.	55.	104.
12	9.	5.	3.	8.	16.	52.
13	4.	2.	1.	1.	4.	11.
14	2.	1.	1.	1.	1.	3.
15	1.	1.	0.	0.	0.	1.

x 10 ^ 3

Appendix 3 (contd.). Summary results of ML fit using Canadian catch-at-age data from 1988 to 1997 to estimate selection pattern.

Weights at age in the catches (Kg)

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260
4	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220
5	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830
6	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810
7	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090
8	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640
9	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500
10	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270
11	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040
12	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960
13	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410
14	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430
15	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580
16	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000

Weights at age in the catches (Kg)

AGE	1993	1994	1995	1996	1997	1998
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260
4	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220
5	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830
6	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810
7	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090
8	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640
9	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500
10	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270
11	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040
12	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960
13	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410
14	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430
15	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580
16	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000

Weights at age in the stock (Kg)

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260
4	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220
5	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830
6	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810
7	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090
8	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640
9	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500
10	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270
11	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040
12	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960
13	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410
14	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430
15	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580
16	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000

Weights at age in the stock (Kg)

AGE	1993	1994	1995	1996	1997	1998
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.1260	0.1260	0.1260	0.1260	0.1260	0.1260
4	0.2220	0.2220	0.2220	0.2220	0.2220	0.2220
5	0.3830	0.3830	0.3830	0.3830	0.3830	0.3830
6	0.5810	0.5810	0.5810	0.5810	0.5810	0.5810
7	0.9090	0.9090	0.9090	0.9090	0.9090	0.9090
8	1.2640	1.2640	1.2640	1.2640	1.2640	1.2640
9	1.8500	1.8500	1.8500	1.8500	1.8500	1.8500
10	2.4270	2.4270	2.4270	2.4270	2.4270	2.4270
11	3.1040	3.1040	3.1040	3.1040	3.1040	3.1040
12	3.9960	3.9960	3.9960	3.9960	3.9960	3.9960
13	5.1410	5.1410	5.1410	5.1410	5.1410	5.1410
14	5.9430	5.9430	5.9430	5.9430	5.9430	5.9430
15	6.6580	6.6580	6.6580	6.6580	6.6580	6.6580
16	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000

Appendix 3 (contd.). Summary results of ML fit using Canadian catch-at-age data from 1988 to 1997 to estimate selection pattern.

Natural Mortality (per year)

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
2	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
3	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
4	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
5	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
6	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
7	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
8	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
9	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
10	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
11	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
12	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
13	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
14	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
15	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
16	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000

Natural Mortality (per year)

AGE	1993	1994	1995	1996	1997	1998
1	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
2	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
3	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
4	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
5	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
6	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
7	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
8	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
9	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
10	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
11	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
12	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
13	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
14	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
15	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
16	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000

Proportion of fish spawning

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
4	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200
5	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300
6	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500
7	0.0800	0.0800	0.0800	0.0800	0.0800	0.0800	0.0800	0.0800	0.0800	0.0800	0.0800	0.0800	0.0800	0.0800	0.0800
8	0.1800	0.1800	0.1800	0.1800	0.1800	0.1800	0.1800	0.1800	0.1800	0.1800	0.1800	0.1800	0.1800	0.1800	0.1800
9	0.3200	0.3200	0.3200	0.3200	0.3200	0.3200	0.3200	0.3200	0.3200	0.3200	0.3200	0.3200	0.3200	0.3200	0.3200
10	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800
11	0.6200	0.6200	0.6200	0.6200	0.6200	0.6200	0.6200	0.6200	0.6200	0.6200	0.6200	0.6200	0.6200	0.6200	0.6200
12	0.7400	0.7400	0.7400	0.7400	0.7400	0.7400	0.7400	0.7400	0.7400	0.7400	0.7400	0.7400	0.7400	0.7400	0.7400
13	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200
14	0.8900	0.8900	0.8900	0.8900	0.8900	0.8900	0.8900	0.8900	0.8900	0.8900	0.8900	0.8900	0.8900	0.8900	0.8900
15	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200
16	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Proportion of fish spawning

AGE	1993	1994	1995	1996	1997	1998
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
4	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200
5	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300
6	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500
7	0.0800	0.0800	0.0800	0.0800	0.0800	0.0800
8	0.1800	0.1800	0.1800	0.1800	0.1800	0.1800
9	0.3200	0.3200	0.3200	0.3200	0.3200	0.3200
10	0.4800	0.4800	0.4800	0.4800	0.4800	0.4800
11	0.6200	0.6200	0.6200	0.6200	0.6200	0.6200
12	0.7400	0.7400	0.7400	0.7400	0.7400	0.7400
13	0.8200	0.8200	0.8200	0.8200	0.8200	0.8200
14	0.8900	0.8900	0.8900	0.8900	0.8900	0.8900
15	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200
16	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Appendix 3 (contd.). Summary results of ML fit using Canadian catch-at-age data from 1988 to 1997 to estimate selection pattern.

AGE-STRUCTURED INDICES

Canada RV,,,,,,,,,,,,,,,,

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	67.13	76.28	47.94	141.17	33.75	12.13	31.85	192.90	125.26	36.23	74.06	52.95	9.86	84.58	52.91
2	315.36	128.77	46.19	158.15	39.59	34.73	50.92	113.56	106.16	81.05	71.55	95.76	39.74	59.21	188.12
3	243.38	95.88	43.77	109.46	88.92	71.28	70.14	65.43	112.55	212.68	109.25	174.20	70.54	44.64	148.38
4	146.86	50.86	39.30	41.43	75.65	75.71	74.84	54.23	104.61	99.11	114.84	174.69	177.41	103.16	95.26
5	90.82	53.10	49.74	47.20	57.10	71.10	103.17	66.32	72.30	75.27	119.82	108.47	115.86	65.70	38.55
6	68.60	50.98	52.63	49.99	41.10	51.58	61.33	69.54	81.84	53.19	59.22	87.21	70.70	40.33	22.09
7	40.91	24.41	32.28	35.48	43.10	50.70	42.30	42.81	71.75	47.14	41.43	38.56	36.65	12.49	10.47
8	19.17	9.98	11.10	15.61	41.24	39.42	27.03	17.03	22.14	25.79	12.23	9.60	6.20	2.38	1.07
9	9.94	4.78	4.96	7.02	16.57	15.22	13.06	7.98	6.55	9.43	3.13	2.85	1.50	0.64	0.14
10	7.37	4.57	3.89	4.21	6.76	4.41	6.31	5.30	2.38	2.83	1.10	0.75	0.75	0.31	0.09
11	6.47	3.00	4.46	3.35	4.13	3.18	2.60	2.26	1.86	1.48	0.78	0.57	0.64	0.18	0.01
12	4.12	2.64	2.88	1.56	2.71	2.29	1.81	2.00	1.67	1.45	0.46	0.15	0.39	0.10	*******
13	2.68	2.19	1.87	0.86	1.93	1.66	1.48	0.87	0.88	0.75	0.36	0.03	0.22	0.02	*******
14	0.99	1.08	1.07	0.45	1.98	1.11	1.29	1.00	0.54	0.58	0.33	0.08	0.16	0.01	0.01
15	0.56	0.70	0.41	0.27	1.26	0.49	0.68	0.61	0.56	0.39	0.24	0.10	0.09	*******	*******
16	0.36	0.62	0.23	0.04	0.59	0.13	0.46	0.30	0.32	0.20	0.15	0.03	0.02	0.00	*******

x 10 ^ 3

Canada RV,,,,,,,,,,,,,,,,

AGE	1993	1994	1995	1996	1997	1998	1999
1	62.24	359.98	342.06	793.45	222.01	199.61	93.49
2	281.18	189.87	397.12	452.54	486.57	216.98	289.04
3	497.52	171.49	122.86	267.48	398.36	265.73	217.04
4	182.33	112.86	39.61	96.57	192.05	188.60	227.68
5	42.96	51.87	50.37	55.61	89.81	92.11	162.88
6	13.68	9.90	15.86	22.31	40.11	38.35	90.15
7	5.90	4.48	3.51	7.42	17.32	17.25	29.59
8	1.97	1.35	0.92	1.92	5.66	4.77	5.05
9	0.23	0.17	0.27	1.14	1.55	1.10	1.10
10	0.03	0.07	0.10	0.38	0.49	0.58	0.41
11	0.02	0.01	0.05	0.18	0.28	0.24	0.14
12	0.09	0.02	*******	0.12	0.15	0.15	0.09
13	0.04	0.01	*******	0.12	0.10	0.14	0.17
14	0.02	*******	*******	0.04	0.05	0.02	0.01
15	*******	*******	*******	0.01	*******	*******	*******
16	*******	*******	*******	*******	*******	0.02	*******

x 10 ^ 3

Fishing Mortality (per year)

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0192	0.0171	0.0161	0.0164	0.0152	0.0180	0.0219	0.0183	0.0153	0.0314	0.0296	0.0270	0.0329	0.0516	0.0350
6	0.1468	0.1312	0.1234	0.1252	0.1165	0.1378	0.1675	0.1404	0.1172	0.2404	0.2267	0.2064	0.2517	0.3947	0.2677
7	0.6290	0.5619	0.5287	0.5363	0.4989	0.5905	0.7175	0.6015	0.5021	1.0298	0.9713	0.8841	1.0781	1.6906	1.1467
8	0.8531	0.7621	0.7171	0.7273	0.6766	0.8009	0.9732	0.8157	0.6809	1.3967	1.3174	1.1991	1.4622	2.2930	1.5553
9	0.7237	0.6466	0.6083	0.6170	0.5740	0.6794	0.8256	0.6920	0.5777	1.1849	1.1176	1.0173	1.2405	1.9452	1.3194
10	0.5690	0.5084	0.4783	0.4851	0.4513	0.5342	0.6491	0.5441	0.4542	0.9316	0.8787	0.7998	0.9753	1.5294	1.0374
11	0.4874	0.4354	0.4097	0.4155	0.3866	0.4575	0.5560	0.4660	0.3890	0.7980	0.7526	0.6851	0.8354	1.3100	0.8885
12	0.6001	0.5362	0.5045	0.5117	0.4760	0.5634	0.6846	0.5739	0.4790	0.9826	0.9268	0.8436	1.0287	1.6131	1.0941
13	0.5396	0.4821	0.4536	0.4601	0.4280	0.5066	0.6156	0.5160	0.4307	0.8835	0.8333	0.7585	0.9249	1.4504	0.9838
14	0.5625	0.5025	0.4728	0.4796	0.4461	0.5281	0.6417	0.5379	0.4490	0.9209	0.8686	0.7907	0.9642	1.5119	1.0255
15	0.6001	0.5362	0.5045	0.5117	0.4760	0.5634	0.6846	0.5739	0.4790	0.9826	0.9268	0.8436	1.0287	1.6131	1.0941
16	0.6001	0.5362	0.5045	0.5117	0.4760	0.5634	0.6846	0.5739	0.4790	0.9826	0.9268	0.8436	1.0287	1.6131	1.0941

Fishing Mortality (per year)

AGE	1993	1994	1995	1996	1997	1998
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0321	0.0256	0.0137	0.0145	0.0169	0.0305
6	0.2457	0.1960	0.1048	0.1107	0.1296	0.2331
7	1.0525	0.8396	0.4489	0.4743	0.5550	0.9988
8	1.4275	1.1387	0.6089	0.6433	0.7528	1.3546
9	1.2110	0.9660	0.5165	0.5457	0.6386	1.1492
10	0.9522	0.7595	0.4061	0.4291	0.5021	0.9035
11	0.8155	0.6505	0.3478	0.3675	0.4301	0.7739
12	1.0042	0.8010	0.4283	0.4525	0.5296	0.9530
13	0.9029	0.7203	0.3851	0.4069	0.4762	0.8568
14	0.9412	0.7508	0.4015	0.4242	0.4964	0.8932
15	1.0042	0.8010	0.4283	0.4525	0.5296	0.9530
16	1.0042	0.8010	0.4283	0.4525	0.5296	0.9530

Appendix 3 (contd.). Summary results of ML fit using Canadian catch-at-age data from 1988 to 1997 to estimate selection pattern.

Population Abundance (1 January)

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	59.02	73.55	79.47	87.23	60.51	56.27	56.43	72.42	44.93	40.72	24.91	26.36	28.23	58.07	50.13
2	66.01	48.32	60.21	65.07	71.41	49.54	46.07	46.20	59.29	36.78	33.34	20.40	21.58	23.11	47.54
3	57.61	54.05	39.56	49.30	53.27	58.47	40.56	37.72	37.83	48.54	30.12	27.30	16.70	17.67	18.92
4	56.09	47.17	44.25	32.39	40.36	43.62	47.87	33.21	30.88	30.97	39.74	24.66	22.35	13.67	14.47
5	54.38	45.92	38.62	36.23	26.52	33.05	35.71	39.19	27.19	25.28	25.36	32.54	20.19	18.30	11.19
6	45.25	43.67	36.96	31.11	29.18	21.38	26.57	28.60	31.50	21.92	20.06	20.15	25.93	15.99	14.23
7	31.43	31.99	31.36	26.75	22.47	21.26	15.25	18.40	20.35	22.94	14.11	13.09	13.42	16.51	8.82
8	16.14	13.72	14.93	15.13	12.81	11.17	9.65	6.09	8.26	10.09	6.71	4.37	4.43	3.74	2.49
9	7.40	5.63	5.24	5.97	5.99	5.33	4.11	2.98	2.21	3.42	2.04	1.47	1.08	0.84	0.31
10	2.81	2.94	2.41	2.34	2.64	2.76	2.21	1.47	1.22	1.01	0.86	0.55	0.44	0.26	0.10
11	1.42	1.30	1.45	1.23	1.18	1.37	1.32	0.95	0.70	0.64	0.33	0.29	0.20	0.13	0.05
12	0.65	0.71	0.69	0.79	0.66	0.65	0.71	0.62	0.49	0.39	0.23	0.13	0.12	0.07	0.03
13	0.36	0.29	0.34	0.34	0.39	0.34	0.31	0.29	0.29	0.25	0.12	0.08	0.04	0.04	0.01
14	0.27	0.17	0.15	0.18	0.18	0.21	0.17	0.14	0.14	0.15	0.08	0.04	0.03	0.01	0.01
15	0.11	0.13	0.09	0.08	0.09	0.09	0.10	0.07	0.06	0.08	0.05	0.03	0.02	0.01	0.00
16	0.13	0.15	0.01	0.04	0.08	0.03	0.06	0.03	0.06	0.09	0.02	0.02	0.02	0.01	0.00

x 10 ^ 6

Population Abundance (1 January)

AGE	1993	1994	1995	1996	1997	1998	1999
1	78.03	99.94	133.67	131.14	93.28	111.97	71.12
2	41.04	63.89	81.82	109.44	107.37	76.37	91.67
3	38.92	33.60	52.31	66.99	89.60	87.90	62.53
4	15.49	31.87	27.51	42.82	54.85	73.36	71.97
5	11.84	12.68	26.09	22.52	35.06	44.90	60.06
6	8.85	9.39	10.12	21.07	18.18	28.22	35.66
7	8.91	5.67	6.32	7.46	15.44	13.07	18.30
8	2.30	2.55	2.00	3.30	3.80	7.26	3.94
9	0.43	0.45	0.67	0.89	1.42	1.47	1.53
10	0.07	0.11	0.14	0.33	0.42	0.61	0.38
11	0.03	0.02	0.04	0.08	0.17	0.21	0.20
12	0.02	0.01	0.01	0.02	0.04	0.09	0.08
13	0.01	0.00	0.00	0.00	0.01	0.02	0.03
14	0.00	0.00	0.00	0.00	0.00	0.01	0.01
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00

x 10 ^ 6

Weighting factors for the catches in number

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
13	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
14	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
15	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Weighting factors for the catches in number

AGE	1993	1994	1995	1996	1997	1998
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
13	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
14	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
15	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Appendix 3 (contd.). Summary results of ML fit using Canadian catch-at-age data from 1988 to 1997 to estimate selection pattern.

Predicted Age-Structured Index Values

Canada RV,,,,,,,,,,,,,,,, Predicted

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	77.59	96.68	104.48	114.67	79.55	73.97	74.19	95.20	59.07	53.53	32.75	34.66	37.11	76.34	65.90
2	160.51	117.49	146.41	158.21	173.64	120.47	112.01	112.35	144.16	89.44	81.06	49.59	52.48	56.19	115.59
3	180.45	169.28	123.92	154.41	166.86	183.13	127.05	118.13	118.49	152.04	94.33	85.49	52.30	55.35	59.26
4	158.97	133.69	125.41	91.80	114.40	123.62	135.68	94.13	87.52	87.78	112.64	69.89	63.34	38.75	41.00
5	137.15	115.94	97.55	91.50	67.02	83.40	89.94	98.89	68.71	63.38	63.62	81.75	50.57	45.41	28.01
6	87.59	85.21	72.38	60.88	57.35	41.58	50.91	55.55	61.89	40.50	37.31	37.87	47.63	27.35	25.92
7	49.76	52.36	52.19	44.34	37.97	34.31	23.10	29.53	34.32	29.72	18.83	18.24	16.97	15.37	10.78
8	22.10	19.66	21.88	22.06	19.15	15.70	12.44	8.50	12.32	10.52	7.28	5.04	4.47	2.49	2.40
9	9.77	7.73	7.33	8.31	8.52	7.20	5.15	4.00	3.13	3.59	2.21	1.68	1.10	0.60	0.30
10	4.34	4.67	3.90	3.76	4.31	4.33	3.28	2.30	2.00	1.31	1.13	0.75	0.55	0.24	0.12
11	2.62	2.47	2.78	2.35	2.29	2.58	2.36	1.77	1.36	1.01	0.53	0.49	0.31	0.16	0.07
12	1.97	2.24	2.20	2.50	2.14	2.03	2.07	1.92	1.57	0.97	0.60	0.34	0.29	0.13	*******
13	1.53	1.27	1.51	1.50	1.73	1.45	1.24	1.26	1.28	0.88	0.43	0.29	0.15	0.09	*******
14	1.33	0.87	0.75	0.90	0.91	1.02	0.78	0.67	0.74	0.62	0.35	0.18	0.12	0.04	0.03
15	0.69	0.82	0.56	0.49	0.60	0.58	0.59	0.45	0.43	0.39	0.26	0.16	0.08	*******	*******
16	0.59	0.68	0.03	0.17	0.40	0.12	0.26	0.14	0.27	0.34	0.08	0.09	0.07	0.03	*******

x 10 ^ 3

Canada RV,,,,,,,,,,,,,,,, Predicted

AGE	1993	1994	1995	1996	1997	1998	1999
1	102.58	131.38	175.72	172.40	122.63	147.20	93.49
2	99.79	155.34	198.95	266.10	261.06	185.70	222.90
3	121.91	105.24	163.83	209.82	280.64	275.33	195.85
4	43.90	90.32	77.97	121.38	155.45	207.92	203.98
5	29.68	31.88	65.99	56.94	88.53	112.62	150.63
6	16.30	17.74	20.01	41.53	35.49	52.33	66.11
7	11.42	8.07	10.95	12.76	25.37	17.20	24.08
8	2.36	3.02	3.10	5.02	5.47	7.73	4.20
9	0.45	0.53	0.98	1.29	1.96	1.56	1.64
10	0.09	0.15	0.24	0.54	0.68	0.80	0.50
11	0.04	0.04	0.08	0.15	0.33	0.34	0.33
12	0.04	0.03	*******	0.08	0.14	0.24	0.20
13	0.03	0.02	*******	0.02	0.05	0.08	0.11
14	0.01	*******	*******	0.01	0.01	0.03	0.03
15	*******	*******	*******	0.01	*******	*******	*******
16	*******	*******	*******	*******	*******	0.00	*******

x 10 ^ 3

Fitted Selection Pattern

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320
6	0.2447	0.2447	0.2447	0.2447	0.2447	0.2447	0.2447	0.2447	0.2447	0.2447	0.2447	0.2447	0.2447	0.2447	0.2447
7	1.0481	1.0481	1.0481	1.0481	1.0481	1.0481	1.0481	1.0481	1.0481	1.0481	1.0481	1.0481	1.0481	1.0481	1.0481
8	1.4215	1.4215	1.4215	1.4215	1.4215	1.4215	1.4215	1.4215	1.4215	1.4215	1.4215	1.4215	1.4215	1.4215	1.4215
9	1.2059	1.2059	1.2059	1.2059	1.2059	1.2059	1.2059	1.2059	1.2059	1.2059	1.2059	1.2059	1.2059	1.2059	1.2059
10	0.9482	0.9482	0.9482	0.9482	0.9482	0.9482	0.9482	0.9482	0.9482	0.9482	0.9482	0.9482	0.9482	0.9482	0.9482
11	0.8121	0.8121	0.8121	0.8121	0.8121	0.8121	0.8121	0.8121	0.8121	0.8121	0.8121	0.8121	0.8121	0.8121	0.8121
12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
13	0.8991	0.8991	0.8991	0.8991	0.8991	0.8991	0.8991	0.8991	0.8991	0.8991	0.8991	0.8991	0.8991	0.8991	0.8991
14	0.9373	0.9373	0.9373	0.9373	0.9373	0.9373	0.9373	0.9373	0.9373	0.9373	0.9373	0.9373	0.9373	0.9373	0.9373
15	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
16	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Fitted Selection Pattern

AGE	1993	1994	1995	1996	1997	1998
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320
6	0.2447	0.2447	0.2447	0.2447	0.2447	0.2447
7	1.0481	1.0481	1.0481	1.0481	1.0481	1.0481
8	1.4215	1.4215	1.4215	1.4215	1.4215	1.4215
9	1.2059	1.2059	1.2059	1.2059	1.2059	1.2059
10	0.9482	0.9482	0.9482	0.9482	0.9482	0.9482
11	0.8121	0.8121	0.8121	0.8121	0.8121	0.8121
12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
13	0.8991	0.8991	0.8991	0.8991	0.8991	0.8991
14	0.9373	0.9373	0.9373	0.9373	0.9373	0.9373
15	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
16	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Appendix 3 (contd.). Summary results of ML fit using Canadian catch-at-age data from 1988 to 1997 to estimate selection pattern.

STOCK SUMMARY

Year	Recruits Age 1 thousands	Total Biomass tonnes	Spawning Biomass tonnes	Landings tonnes	Yield /SSB ratio	Mean F Ages 5-12	SoP (%)
1978	59020	148448	25090	39070	1.5571	0.5035	99
1979	73540	135512	22850	34104	1.4925	0.4499	114
1980	79470	124501	20966	32867	1.5676	0.4233	74
1981	87220	116008	20938	30754	1.4687	0.4293	85
1982	60510	107395	20484	26278	1.2828	0.3994	99
1983	56260	102776	19563	27681	1.4149	0.4727	86
1984	56430	94486	17619	26711	1.5160	0.5744	91
1985	72410	85702	13946	20347	1.4589	0.4815	125
1986	44920	83601	13053	17976	1.3771	0.4019	103
1987	40720	84648	13618	32442	2.3823	0.8244	98
1988	24910	64677	8556	19215	2.2456	0.7776	101
1989	26360	56961	6369	20034	3.1453	0.7078	***
1990	28220	52453	5542	47454	8.5626	0.8631	***
1991	58060	44566	4423	65008	******	1.3534	***
1992	50120	30529	2433	63193	******	0.9180	***
1993	78030	30221	2191	62455	******	0.8426	***
1994	99930	31243	2102	51029	******	0.6721	***
1995	133660	38629	2398	15272	6.3671	0.3594	***
1996	131130	52598	3608	18840	5.2203	0.3797	***
1997	93280	70760	5152	19858	3.8541	0.4443	***
1998	111960	87400	6772	20000	2.9533	0.7996	***

No of years for separable analysis : 21
Age range in the analysis : 1 . . . 16
Year range in the analysis : 1978 . . . 1998
Number of indices of SSB : 0
Number of age-structured indices : 1

Parameters to estimate : 86
Number of observations : 547

Conventional single selection vector model to be fitted.

PARAMETER ESTIMATES

Parm. No.		Maximum Likelh. Estimate	CV (%)	Lower 95% CL	Upper 95% CL	-s.e.	+s.e.	Mean of Param. Distrib.
Separable model : F by year								
1	1978	0.6001	15	0.4426	0.8136	0.5138	0.7009	0.6074
2	1979	0.5362	15	0.3968	0.7244	0.4598	0.6251	0.5425
3	1980	0.5045	15	0.3741	0.6803	0.4331	0.5876	0.5104
4	1981	0.5117	15	0.3800	0.6890	0.4396	0.5956	0.5176
5	1982	0.4760	15	0.3543	0.6395	0.4094	0.5534	0.4814
6	1983	0.5634	14	0.4201	0.7556	0.4851	0.6544	0.5698
7	1984	0.6846	14	0.5111	0.9171	0.5898	0.7947	0.6923
8	1985	0.5739	15	0.4270	0.7712	0.4935	0.6673	0.5804
9	1986	0.4790	15	0.3554	0.6457	0.4113	0.5578	0.4846
10	1987	0.9826	16	0.7177	1.3452	0.8371	1.1534	0.9953
11	1988	0.9268	19	0.6335	1.3558	0.7633	1.1253	0.9444
12	1989	0.8436	25	0.5077	1.4017	0.6510	1.0931	0.8724
13	1990	1.0287	25	0.6190	1.7095	0.7939	1.3330	1.0638
14	1991	1.6131	22	1.0472	2.4846	1.2940	2.0108	1.6527
15	1992	1.0941	26	0.6448	1.8566	0.8354	1.4330	1.1347
16	1993	1.0042	25	0.6098	1.6539	0.7785	1.2953	1.0373
17	1994	0.8010	26	0.4774	1.3442	0.6151	1.0432	0.8295
18	1995	0.4283	30	0.2348	0.7813	0.3152	0.5821	0.4490
19	1996	0.4525	31	0.2442	0.8385	0.3304	0.6199	0.4755
20	1997	0.5296	27	0.3076	0.9117	0.4014	0.6987	0.5503
21	1998	0.9530	17	0.6765	1.3424	0.8001	1.1350	0.9676
Separable Model: Selection (S) by age								
22	1	0.0000	28	0.0000	0.0000	0.0000	0.0000	0.0000
23	2	0.0000	26	0.0000	0.0000	0.0000	0.0000	0.0000
24	3	0.0000	25	0.0000	0.0000	0.0000	0.0000	0.0000
25	4	0.0000	24	0.0000	0.0000	0.0000	0.0000	0.0000
26	5	0.0320	23	0.0200	0.0511	0.0252	0.0406	0.0329
27	6	0.2447	23	0.1533	0.3904	0.1928	0.3105	0.2517
28	7	1.0481	20	0.7056	1.5567	0.8565	1.2825	1.0696
29	8	1.4215	18	0.9864	2.0485	1.1797	1.7128	1.4464
30	9	1.2059	20	0.8144	1.7856	0.9871	1.4733	1.2303
31	10	0.9482	21	0.6199	1.4502	0.7633	1.1777	0.9707
32	11	0.8121	23	0.5153	1.2799	0.6439	1.0242	0.8343
	12	1.0000	Fixed : Reference Age					
33	13	0.8991	22	0.5817	1.3899	0.7200	1.1229	0.9216
34	14	0.9373	21	0.6108	1.4382	0.7533	1.1661	0.9599
	15	1.0000	Fixed : Last true age					
Separable model: Populations in year 1998								
35	1	111968	38	52259	239901	75901	165174	120758
36	2	76371	30	42094	138563	56355	103497	79982
37	3	87903	25	53047	145661	67935	113740	90870
38	4	73356	22	46881	114783	58376	92181	75295
39	5	44902	21	29515	68311	36249	55621	45943
40	6	28223	19	19083	41740	23114	34460	28791
41	7	13071	17	9316	18340	10997	15536	13267
42	8	7257	19	4999	10533	6000	8776	7389
43	9	1465	23	921	2329	1156	1856	1506
44	10	613	23	383	981	482	779	631
45	11	208	23	131	332	164	264	214
46	12	91	23	57	145	72	115	94
47	13	19	24	12	32	15	25	20
48	14	5	28	2	9	3	6	5
49	15	0	107	0	2	0	0	0

Appendix 3 (contd.). Summary results of ML fit using Canadian catch-at-age data from 1988 to 1997 to estimate selection pattern.

Separable model: Populations at age

50	1978	110	47	43	281	68	178	123
51	1979	126	35	62	254	88	180	134
52	1980	84	30	46	153	62	114	88
53	1981	74	27	43	127	56	97	77
54	1982	89	25	54	145	69	114	91
55	1983	91	23	57	144	72	115	93
56	1984	98	22	63	153	78	123	100
57	1985	70	22	45	110	56	88	72
58	1986	63	22	41	98	50	79	65
59	1987	74	21	49	111	60	91	75
60	1988	48	24	30	79	38	62	50
61	1989	27	28	15	47	20	36	28
62	1990	14	27	8	25	11	19	15
63	1991	8	32	4	15	5	11	8
64	1992	1	56	0	4	0	2	1
65	1993	0	68	0	3	0	1	1
66	1994	0	262	0	23	0	1	4
67	1995	0	644	0	13354	0	27	44847183
68	1996	0	0	0	0	0	0	0
69	1997	0	206	0	7	0	1	1

Recruitment in year 1999

70	1998	71116	65	19562	258537	36810	137394	88336

Age-structured index catchabilities

Canada RV,,,,,,,,,,,,,,,,

Linear model fitted. Slopes at age :

71	1	Q	1.453	15	1.250	2.313	1.453	1.989	1.721
72	2	Q	2.687	15	2.320	4.227	2.687	3.650	3.169
73	3	Q	3.462	15	2.996	5.407	3.462	4.679	4.070
74	4	Q	3.132	14	2.715	4.869	3.132	4.220	3.676
75	5	Q	2.814	14	2.442	4.359	2.814	3.782	3.298
76	6	Q	2.302	14	1.998	3.563	2.302	3.092	2.697
77	7	Q	2.396	15	2.068	3.769	2.396	3.254	2.825
78	8	Q	2.318	16	1.976	3.790	2.318	3.231	2.775
79	9	Q	2.095	17	1.779	3.471	2.095	2.947	2.521
80	10	Q	2.266	17	1.922	3.766	2.266	3.194	2.730
81	11	Q	2.605	17	2.212	4.313	2.605	3.662	3.134
82	12	Q	4.533	17	3.838	7.574	4.533	6.413	5.473
83	13	Q	6.121	17	5.176	10.26	6.121	8.680	7.401
84	14	Q	7.139	19	5.929	12.66	7.139	10.51	8.827
85	15	Q	9.270	24	7.346	18.99	9.270	15.05	12.16
86	16	Q	6.680	24	5.268	13.89	6.680	10.96	8.821

RESIDUALS ABOUT THE MODEL FIT

Separable Model Residuals

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	-0.155	0.431	-0.279	0.307	0.052	0.649	-0.242	0.379	0.343	0.416	0.273	1.004	0.044	-0.434	-0.592
2	0.244	-0.025	0.509	-0.276	0.397	-0.099	0.472	-0.048	0.577	-0.358	0.492	0.385	0.823	-0.389	-0.029
3	-0.550	0.320	-0.001	0.458	-0.240	0.191	-0.331	0.611	0.096	-0.179	-0.336	0.549	0.149	0.336	-0.037
4	-0.009	-0.416	0.402	0.006	0.552	-0.388	0.018	-0.133	0.813	-0.601	-0.099	-0.221	0.372	-0.279	0.745
5	1.169	1.126	-1.010	0.419	-0.431	0.359	0.202	0.945	-0.424	-1.712	-0.914	*******	*******	*******	*******
6	0.416	0.492	-0.651	0.244	-0.366	0.441	-0.522	0.268	-0.480	-0.874	-0.244	*******	*******	*******	*******
7	-0.393	-0.070	-0.278	-0.097	-0.374	0.211	-0.253	-0.429	-0.270	-0.278	-0.087	*******	*******	*******	*******
8	-0.105	-0.180	0.297	0.405	-0.131	0.374	0.280	-0.062	0.175	0.172	-0.131	*******	*******	*******	*******
9	-0.187	-0.832	0.877	0.475	0.263	0.041	0.606	-0.167	0.371	0.189	-0.079	*******	*******	*******	*******
10	0.264	-0.889	1.492	0.019	0.526	-0.324	0.213	-0.276	0.011	0.344	-0.085	*******	*******	*******	*******
11	0.380	-0.472	0.799	-0.460	0.420	-0.699	-0.289	-0.884	0.035	0.112	0.142	*******	*******	*******	*******
12	0.325	-0.688	-0.693	-0.772	-0.018	-1.134	-0.867	-1.097	-0.326	0.162	-0.306	*******	*******	*******	*******
13	0.486	0.252	-0.782	-1.056	0.153	-0.053	-0.241	-0.395	-0.407	0.457	0.451	*******	*******	*******	*******
14	0.025	0.295	-1.287	-0.828	0.189	0.185	-0.270	-0.250	0.032	0.619	0.229	*******	*******	*******	*******
15	0.231	0.454	-1.239	-0.319	0.569	0.709	0.480	-0.463	0.354	0.828	0.551	*******	*******	*******	*******

Separable Model Residuals

Age	1993	1994	1995	1996	1997	1998
1	-0.256	-0.970	0.058	-0.671	0.206	-0.564
2	-0.489	-0.012	-0.327	0.021	-0.811	-1.058
3	0.020	-0.300	0.577	-0.419	-0.174	-0.742
4	0.070	0.267	0.347	0.543	-0.555	-1.433
5	*******	*******	*******	*******	*******	*******
6	*******	*******	*******	*******	*******	*******
7	*******	*******	*******	*******	*******	*******
8	*******	*******	*******	*******	*******	*******
9	*******	*******	*******	*******	*******	*******
10	*******	*******	*******	*******	*******	*******
11	*******	*******	*******	*******	*******	*******
12	*******	*******	*******	*******	*******	*******
13	*******	*******	*******	*******	*******	*******
14	*******	*******	*******	*******	*******	*******
15	*******	*******	*******	*******	*******	*******

Appendix 3 (contd.). Summary results of ML fit using Canadian catch-at-age data from 1988 to 1997 to estimate selection pattern.

AGE-STRUCTURED INDEX RESIDUALS

Canada RV,,,,,,,,,,,,,,,,

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	-0.145	-0.237	-0.779	0.208	-0.857	-1.808	-0.846	0.706	0.752	-0.390	0.816	0.424	-1.325	0.103	-0.220
2	0.675	0.092	-1.154	0.000	-1.478	-1.244	-0.788	0.011	-0.306	-0.099	-0.125	0.658	-0.278	0.052	0.487
3	0.299	-0.568	-1.041	-0.344	-0.629	-0.944	-0.594	-0.591	-0.051	0.336	0.147	0.712	0.299	-0.215	0.918
4	-0.079	-0.966	-1.160	-0.796	-0.414	-0.490	-0.595	-0.551	0.178	0.121	0.019	0.916	1.030	0.979	0.843
5	-0.412	-0.781	-0.674	-0.662	-0.160	-0.160	0.137	-0.400	0.051	0.172	0.633	0.283	0.829	0.369	0.319
6	-0.244	-0.514	-0.319	-0.197	-0.333	0.216	0.186	0.225	0.279	0.273	0.462	0.834	0.395	0.388	-0.160
7	-0.196	-0.763	-0.480	-0.223	0.127	0.390	0.605	0.371	0.737	0.461	0.789	0.749	0.770	-0.208	-0.029
8	-0.142	-0.678	-0.678	-0.346	0.767	0.920	0.776	0.695	0.586	0.897	0.519	0.645	0.327	-0.045	-0.811
9	0.017	-0.481	-0.391	-0.169	0.665	0.749	0.930	0.690	0.736	0.967	0.347	0.530	0.309	0.053	-0.772
10	0.529	-0.022	-0.002	0.114	0.450	0.018	0.654	0.834	0.175	0.775	-0.024	-0.007	0.308	0.239	-0.299
11	0.904	0.194	0.474	0.356	0.591	0.210	0.096	0.245	0.313	0.387	0.390	0.153	0.717	0.095	-1.743
12	0.737	0.165	0.270	-0.471	0.237	0.123	-0.135	0.042	0.061	0.400	-0.267	-0.810	0.277	-0.230	*******
13	0.559	0.548	0.218	-0.561	0.111	0.139	0.175	-0.364	-0.377	-0.152	-0.185	-2.107	0.364	-1.456	*******
14	-0.293	0.215	0.354	-0.705	0.773	0.082	0.501	0.408	-0.313	-0.065	-0.065	-0.822	0.288	-1.699	-0.555
15	-0.212	-0.155	-0.308	-0.600	0.748	-0.167	0.134	0.296	0.264	-0.001	-0.107	-0.426	0.132	*******	*******
16	-0.472	-0.089	2.186	-1.352	0.389	0.124	0.556	0.796	0.150	-0.511	0.683	-1.059	-1.132	-1.897	*******

Canada RV,,,,,,,,,,,,,,,,

Age	1993	1994	1995	1996	1997	1998	1999
1	-0.500	1.008	0.666	1.527	0.594	0.305	0.000
2	1.036	0.201	0.691	0.531	0.623	0.156	0.260
3	1.406	0.488	-0.288	0.243	0.350	-0.035	0.103
4	1.424	0.223	-0.677	-0.229	0.211	-0.098	0.110
5	0.370	0.487	-0.270	-0.024	0.014	-0.201	0.078
6	-0.176	-0.583	-0.232	-0.622	0.123	-0.311	0.310
7	-0.659	-0.589	-1.137	-0.542	-0.381	0.003	0.206
8	-0.181	-0.808	-1.215	-0.962	0.033	-0.483	0.184
9	-0.653	-1.120	-1.302	-0.121	-0.236	-0.353	-0.397
10	-0.991	-0.759	-0.816	-0.359	-0.315	-0.324	-0.179
11	-0.709	-1.029	-0.487	0.169	-0.166	-0.336	-0.825
12	0.908	-0.513	*******	0.413	0.099	-0.453	-0.853
13	0.357	-0.676	*******	1.679	0.637	0.616	0.477
14	0.511	*******	*******	1.335	1.395	-0.242	-1.101
15	*******	*******	*******	0.402	*******	*******	*******
16	*******	*******	*******	*******	*******	1.629	*******

PARAMETERS OF THE DISTRIBUTION OF ln(CATCHES AT AGE)

Separable model fitted from 1978 to 1998	
Variance	0.4051
Skewness test stat.	-2.7229
Kurtosis test statistic	0.9236
Partial chi-square	17.9484
Significance in fit	0.0000
Degrees of freedom	**

Appendix 3 (contd.). Summary results of ML fit using Canadian catch-at-age data from 1988 to 1997 to estimate selection pattern.

PARAMETERS OF THE DISTRIBUTION OF THE AGE-STRUCTURED INDICES

DISTRIBUTION STATISTICS FOR Canada RV,

Linear catchability relationship assumed

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Variance	0.6575	0.4463	0.3675	0.4885	0.1826	0.1486	0.3193	0.4541	0.4314	0.2419	0.3952	0.2198	0.6567	0.5841	0.1275	1.2395
Skewness test stat.	-0.6365	-1.4597	0.5420	0.6713	-0.1660	0.2982	-0.2841	-0.3432	-0.4205	-0.3784	-2.1791	-0.1649	-1.3438	-0.3146	0.5107	0.3098
Kurtosis test statisti	-0.3182	-0.1353	-0.2266	-0.6764	-0.6125	-0.7513	-0.9720	-1.2350	-0.8543	-0.4698	0.8926	-0.4652	1.1421	-0.0504	-0.2422	-0.4052
Partial chi-square	1.2216	0.7923	0.6601	0.9191	0.3437	0.2943	0.6811	1.0793	1.2343	0.8480	1.7147	0.8179	2.8146	3.2488	0.3310	5.8240
Significance in fit	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0293
Number of observations	22	22	22	22	22	22	22	22	22	22	22	20	20	20	14	15
Degrees of freedom	21	21	21	21	21	21	21	21	21	21	21	19	19	19	13	14
Weight in the analysis	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

ANALYSIS OF VARIANCE

Unweighted Statistics

Variance

	SSQ	Data	Parameters	d.f.	Variance
Total for model	188.6496	547	86	461	0.4092
Catches at age	55.0963	205	69	136	0.4051
Aged Indices					
Canada RV,,,,,,,,,,,,,,,,	133.5533	331	16	315	0.4240

Weighted Statistics

Variance

	SSQ	Data	Parameters	d.f.	Variance
Total for model	188.6496	547	86	461	0.4092
Catches at age	55.0963	205	69	136	0.4051
Aged Indices					
Canada RV,,,,,,,,,,,,,,,,	133.5533	331	16	315	0.4240

Appendix 3 (contd.). Summary results of ML fit using Canadian catch-at-age data from 1988 to 1997 to estimate selection pattern.

Results of F-status quo deterministic projection

Populations in the Projection

AGE	1998	1999	2000	2001	2002	2003
1	61219.	61219.	61219.	61219.	61219.	61219.
2	76373.	50122.	50122.	50122.	50122.	50122.
3	87904.	62529.	41036.	41036.	41036.	41036.
4	73358.	71969.	51194.	33597.	33597.	33597.
5	44904.	60060.	58923.	41914.	27507.	27507.
6	28224.	35661.	47698.	46795.	33287.	21845.
7	13072.	18302.	23125.	30930.	30345.	21585.
8	7258.	3942.	5519.	6974.	9328.	9151.
9	1466.	1533.	833.	1166.	1473.	1971.
10	614.	380.	398.	216.	303.	382.
11	210.	204.	126.	132.	72.	100.
12	93.	79.	77.	48.	50.	27.
13	21.	29.	25.	24.	15.	16.
14	6.	7.	10.	9.	8.	5.
15	1.	2.	2.	3.	3.	3.
16	1.	1.	1.	1.	1.	1.

Fishing Mortality in the Projection

AGE	1998	1999	2000	2001	2002	2003
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0305	0.0305	0.0305	0.0305	0.0305	0.0305
6	0.2331	0.2331	0.2331	0.2331	0.2331	0.2331
7	0.9988	0.9988	0.9988	0.9988	0.9988	0.9988
8	1.3546	1.3546	1.3546	1.3546	1.3546	1.3546
9	1.1492	1.1492	1.1492	1.1492	1.1492	1.1492
10	0.9035	0.9035	0.9035	0.9035	0.9035	0.9035
11	0.7739	0.7739	0.7739	0.7739	0.7739	0.7739
12	0.9530	0.9530	0.9530	0.9530	0.9530	0.9530
13	0.8568	0.8568	0.8568	0.8568	0.8568	0.8568
14	0.8932	0.8932	0.8932	0.8932	0.8932	0.8932
15	0.9530	0.9530	0.9530	0.9530	0.9530	0.9530
16	0.9530	0.9530	0.9530	0.9530	0.9530	0.9530

Natural Mortality, Maturity Ogive and Stock Weights

1	0.20000000E+00	0.00000000E+00	0.10000000E-07
2	0.20000000E+00	0.00000000E+00	0.10000000E-07
3	0.20000000E+00	0.10000000E-01	0.12600000E+00
4	0.20000000E+00	0.20000000E-01	0.22200000E+00
5	0.20000000E+00	0.30000000E-01	0.38300000E+00
6	0.20000000E+00	0.50000000E-01	0.58100000E+00
7	0.20000000E+00	0.80000000E-01	0.90900000E+00
8	0.20000000E+00	0.18000000E+00	0.12640000E+01
9	0.20000000E+00	0.32000000E+00	0.18500000E+01
10	0.20000000E+00	0.48000000E+00	0.24270000E+01
11	0.20000000E+00	0.62000000E+00	0.31040000E+01
12	0.20000000E+00	0.74000000E+00	0.39960000E+01
13	0.20000000E+00	0.82000000E+00	0.51410000E+01
14	0.20000000E+00	0.89000000E+00	0.59430000E+01
15	0.20000000E+00	0.92000000E+00	0.66580000E+01
16	0.20000000E+00	0.10000000E+01	0.70000000E+01

s.d. of Maturity Ogive and Stock Weights
for root-arcsine and log transforms

1	0.00000000E+00	0.54977006E-06
2	0.00000000E+00	0.54977006E-06
3	0.24691303E-08	0.37747872E-07
4	0.35675171E-08	0.48518241E-07
5	0.53518138E-08	0.92290261E-08
6	0.69225527E-08	0.12167044E-07
7	0.85067664E-08	0.23507537E-08
8	0.89013198E-08	0.70305602E-08
9	0.98792651E-08	0.37658152E-08
10	0.13996201E-07	0.28396940E-07
11	0.98913297E-08	0.42881312E-08
12	0.26143470E-07	0.49705062E-07
13	0.71049598E-08	0.36784294E-07
14	0.55879354E-08	0.46737178E-07
15	0.28279100E-07	0.46499025E-07
16	0.43547672E-07	0.28669007E-07

Appendix 3 (contd.). Summary results of ML fit using Canadian catch-at-age data from 1988 to 1997 to estimate selection pattern.

```
  Stock Size Trajectory
 1998       0.676996689623E+04
 1999       0.650935523748E+04
 2000       0.688638174779E+04
 2001       0.739132634933E+04
 2002       0.745853849512E+04
 2003       0.680920986207E+04
  Fleet Catches by Weight
 Catch Estimates by Fleet
 1998     0.000000000000E+00
 1999     0.205523047653E+05
 2000     0.248659189653E+05
 2001     0.300691447429E+05
 2002     0.305283814367E+05
 2003     0.251534198874E+05
 Fleet Catches by Number
```

Catch Estimates by Fleet 1

AGE	1998	1999	2000	2001	2002	2003
1	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.
5	0.	1634.	1603.	1140.	748.	748.
6	0.	6748.	9025.	8854.	6298.	4133.
7	0.	10650.	13457.	17999.	17658.	12561.
8	0.	2709.	3793.	4793.	6410.	6289.
9	0.	967.	525.	736.	929.	1243.
10	0.	208.	218.	118.	166.	209.
11	0.	101.	62.	65.	35.	50.
12	0.	45.	44.	27.	28.	15.
13	0.	15.	13.	13.	8.	8.
14	0.	4.	6.	5.	5.	3.
15	0.	1.	1.	2.	2.	2.
16	0.	0.	1.	1.	1.	1.

Total Catches by Number

AGE	1998	1999	2000	2001	2002	2003
1	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.
5	1222.	1634.	1603.	1140.	748.	748.
6	5341.	6748.	9025.	8854.	6298.	4133.
7	7607.	10650.	13457.	17999.	17658.	12561.
8	4988.	2709.	3793.	4793.	6410.	6289.
9	925.	967.	525.	736.	929.	1243.
10	336.	208.	218.	118.	166.	209.
11	104.	101.	62.	65.	35.	50.
12	52.	45.	44.	27.	28.	15.
13	11.	15.	13.	13.	8.	8.
14	3.	4.	6.	5.	5.	3.
15	1.	1.	1.	2.	2.	2.
16	0.	0.	1.	1.	1.	1.

Press P to print screen, or any other key to continue

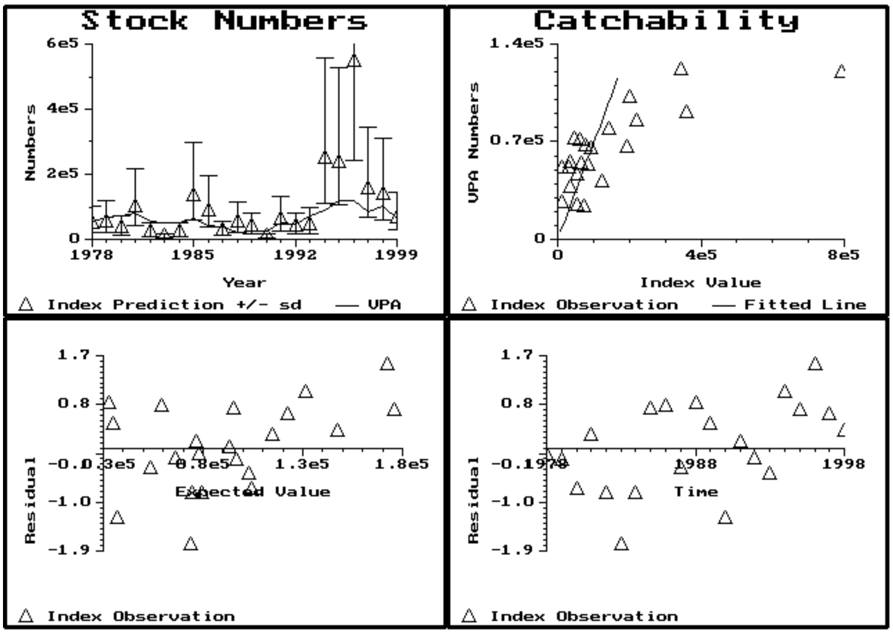


Figure A3.1. Residual plots and observed and fitted values for the Canada standardised RV series, at age 1

Canada RV,,,,,,,,,,,,,,, Age 2

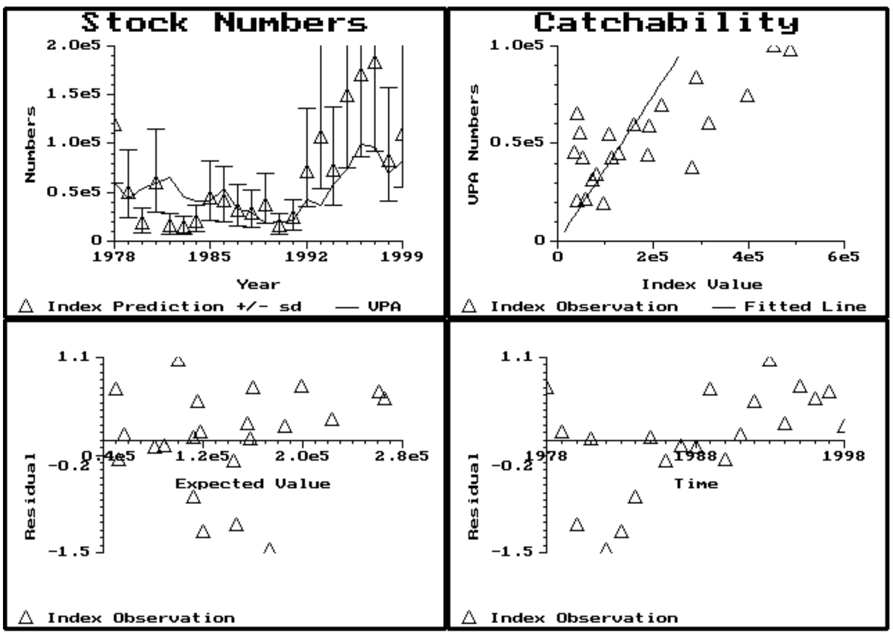


Figure A3.2. Residual plots and observed and fitted values for the Canada standardised RV series, at age 2

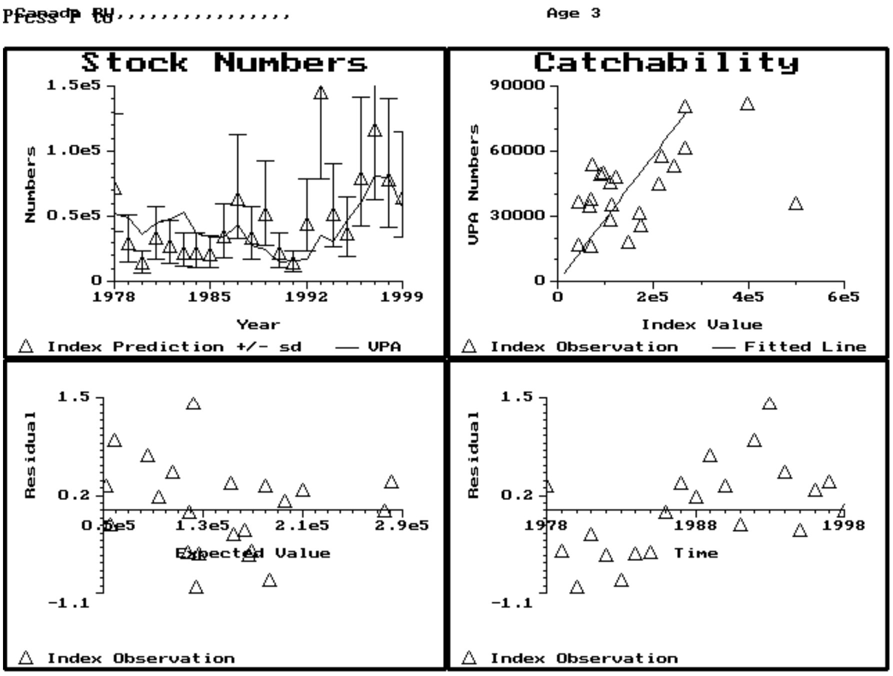


Figure A3.3. Residual plots and observed and fitted values for the Canada standardised RV series, at age 3

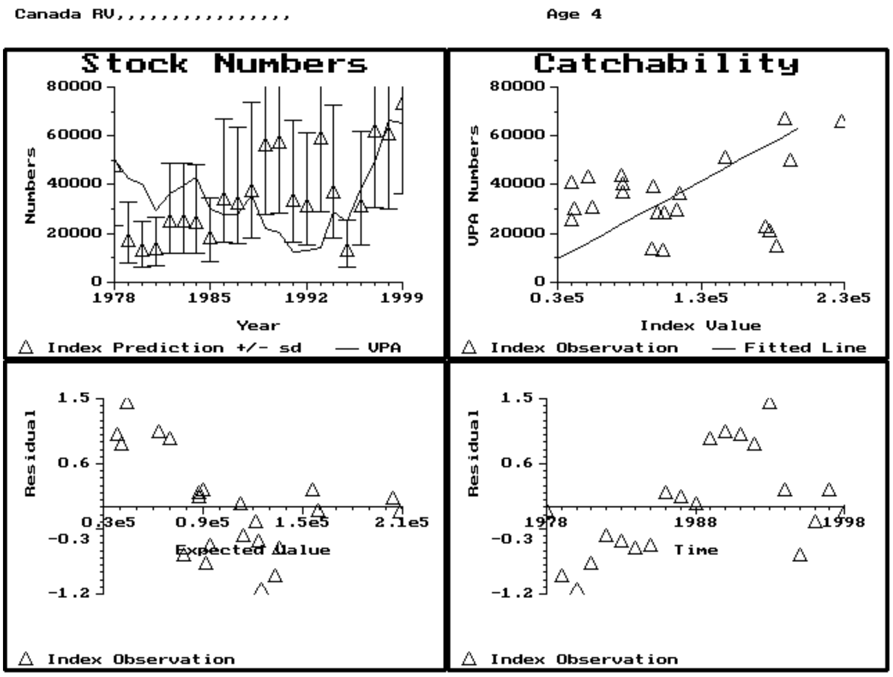


Figure A3.4. Residual plots and observed and fitted values for the Canada standardised RV series, at age 4

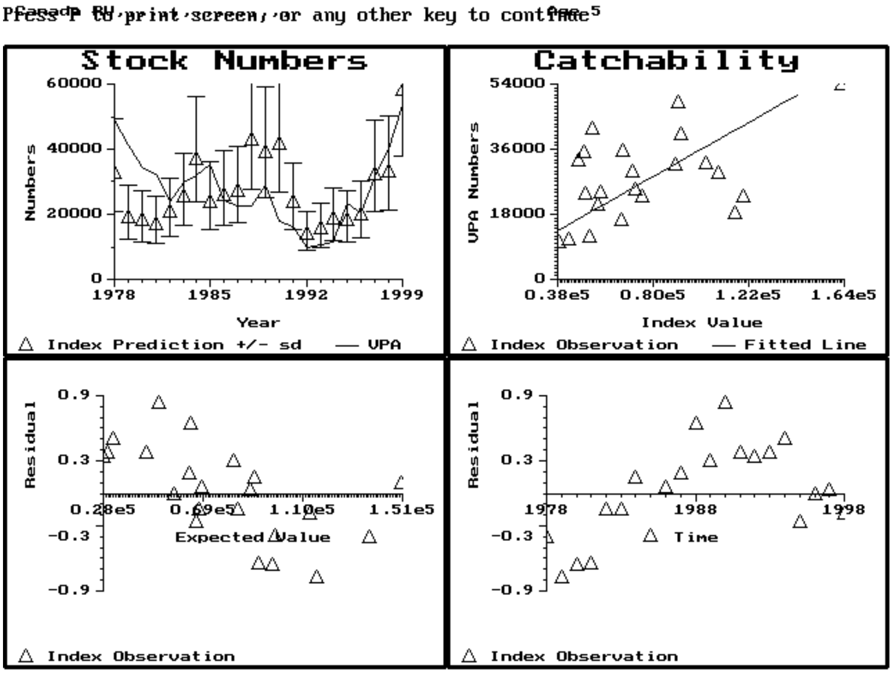


Figure A3.5 Residual plots and observed and fitted values for the Canada standardised RV series, at age 5

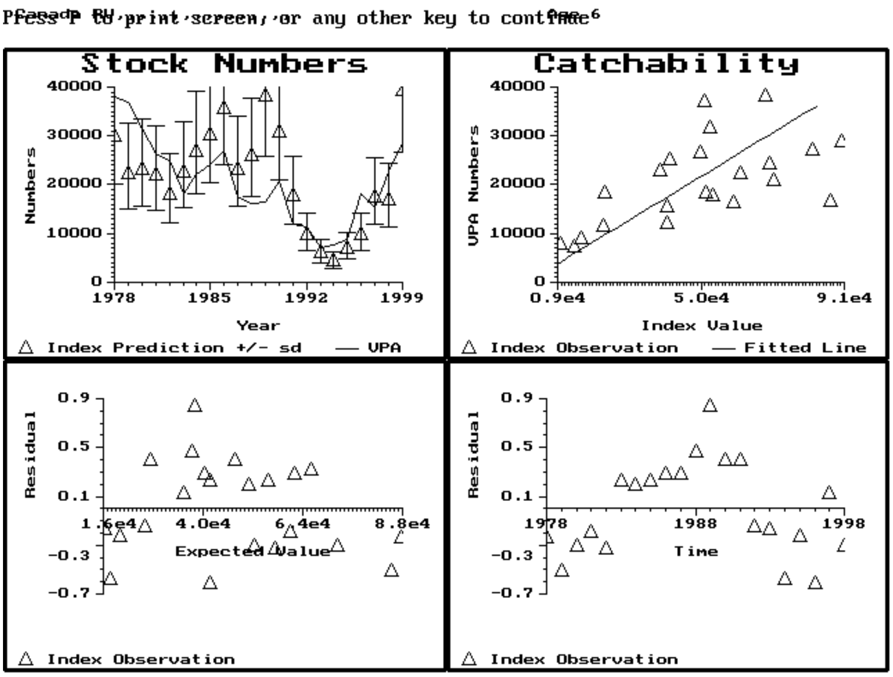


Figure A3.6 Residual plots and observed and fitted values for the Canada standardised RV series, at age 6

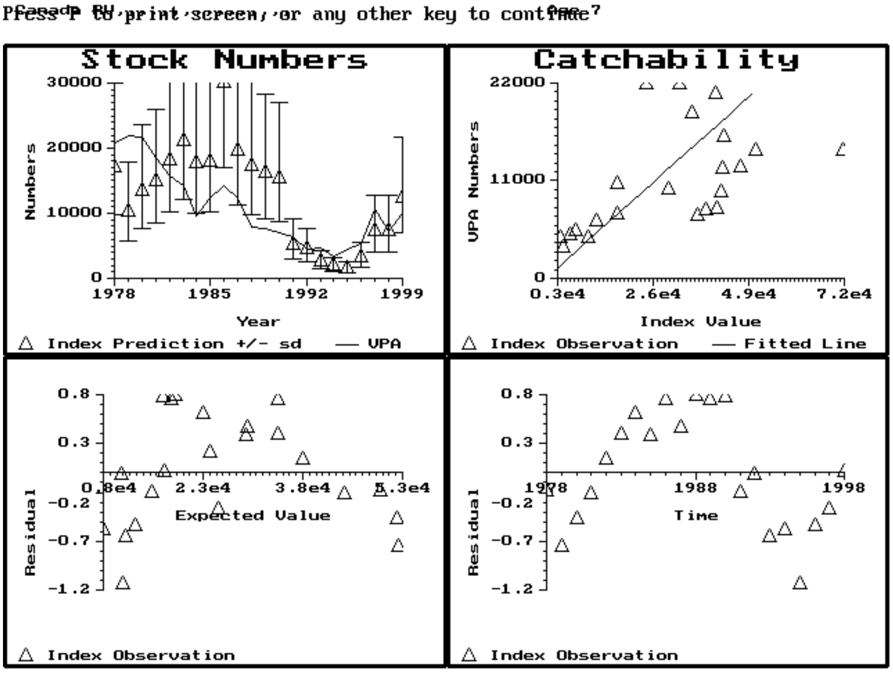


Figure A3.7 Residual plots and observed and fitted values for the Canada standardised RV series, at age 7

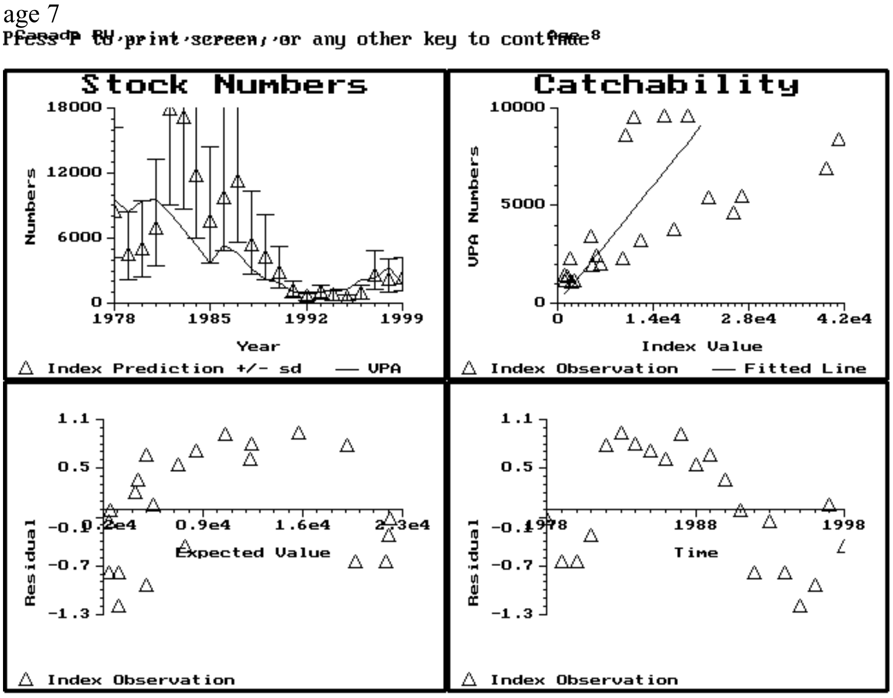


Figure A3.8 Residual plots and observed and fitted values for the Canada standardised RV series, at age 8

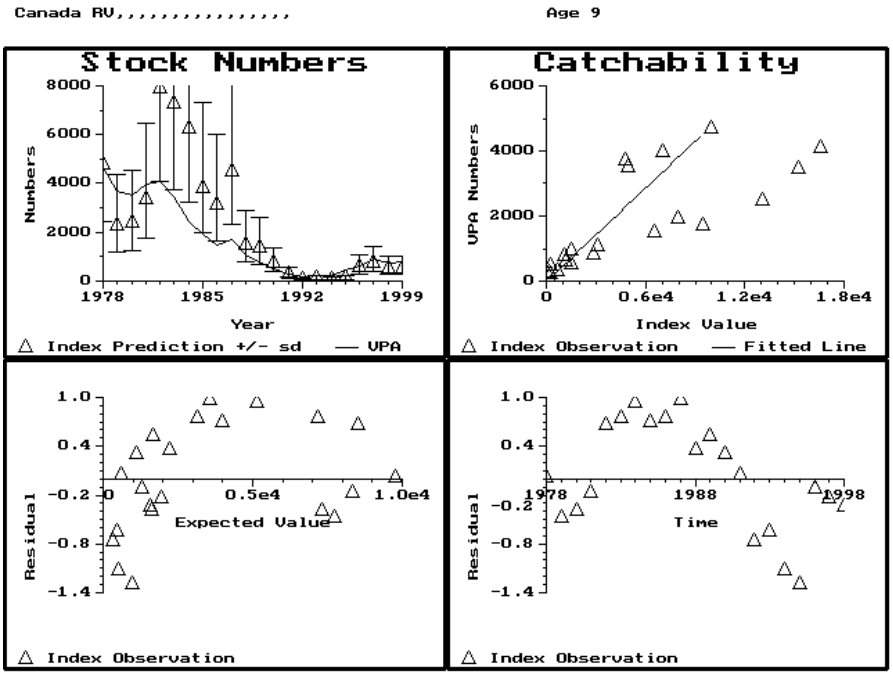


Figure A3.9 Residual plots and observed and fitted values for the Canada standardised RV series, at age 9.

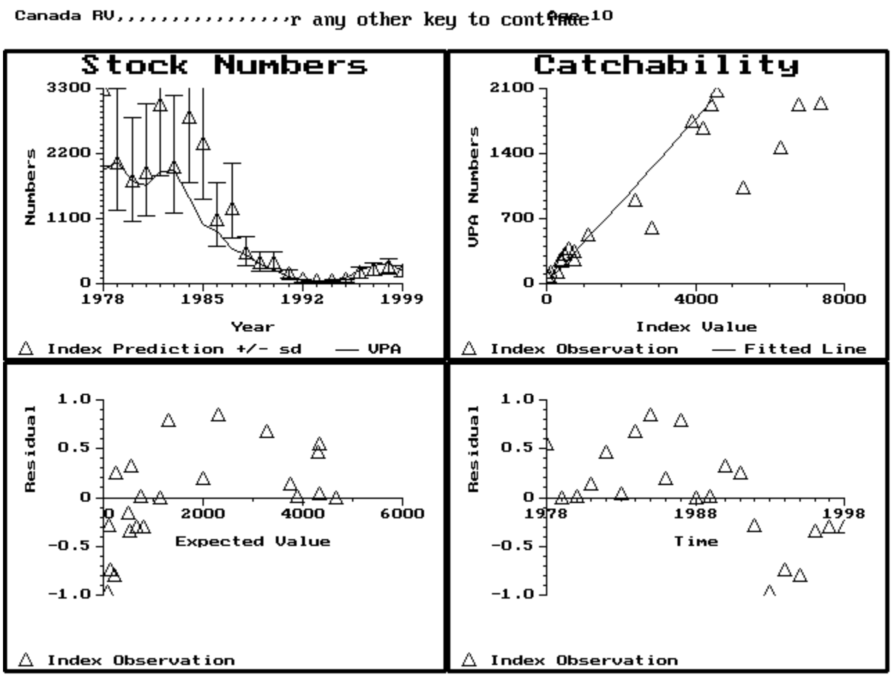


Figure A3.10 Residual plots and observed and fitted values for the Canada standardised RV series, at age 10.

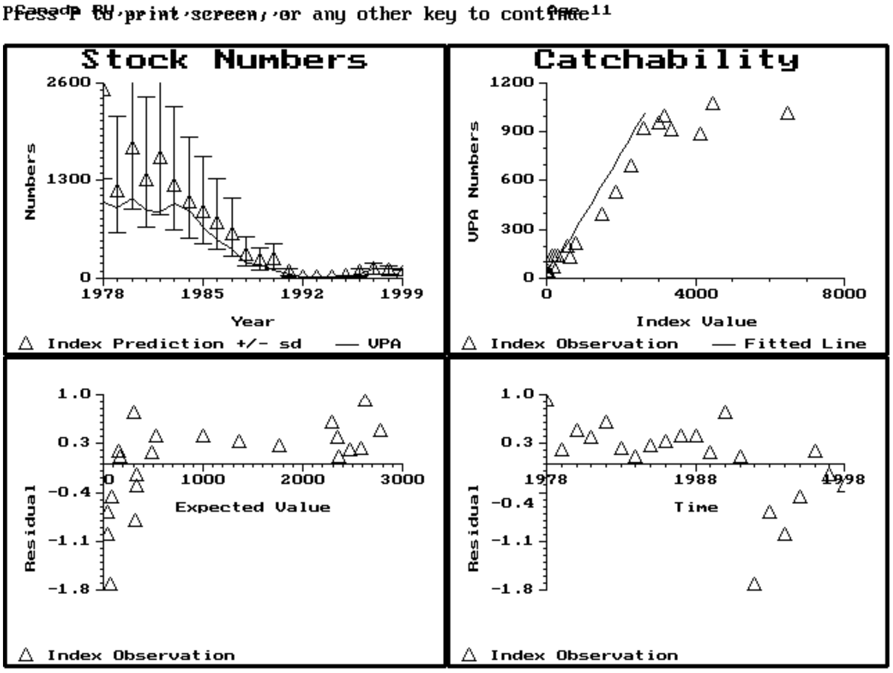


Figure A3.11 Residual plots and observed and fitted values for the Canada standardised RV series, at age 11.

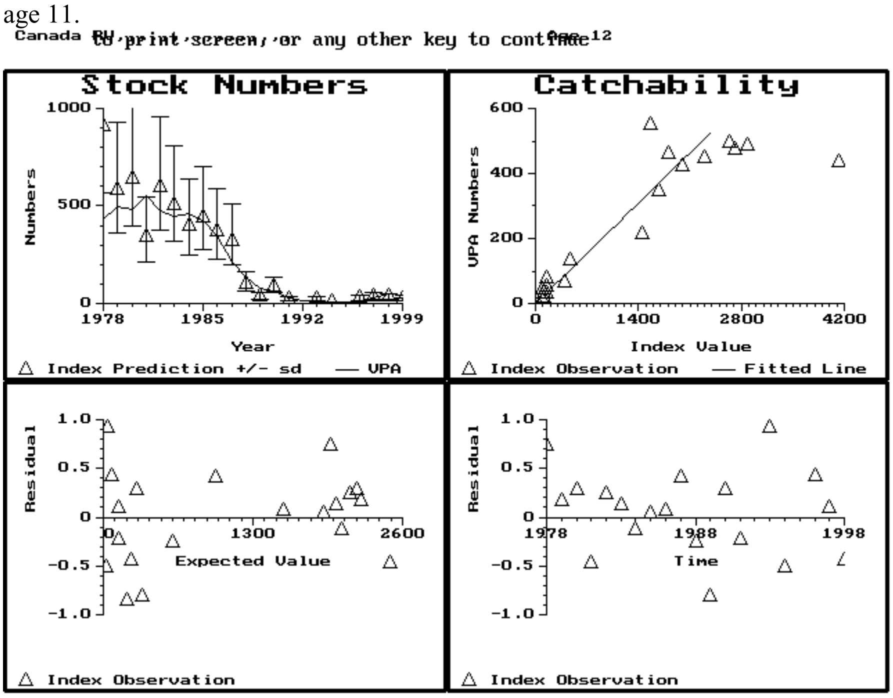


Figure A3.12 Residual plots and observed and fitted values for the Canada standardised RV series, at age 12.

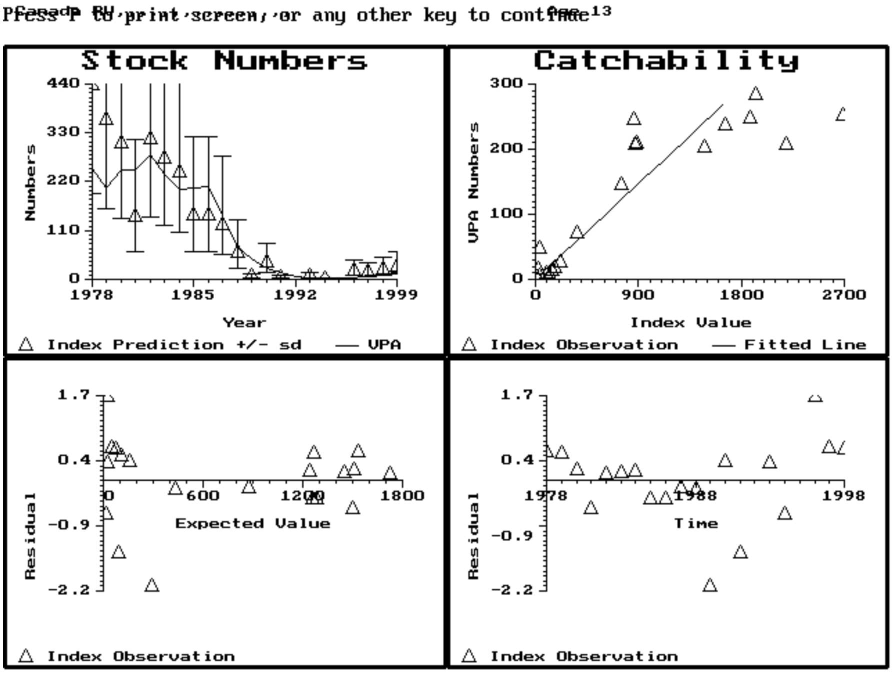


Figure A3.13 Residual plots and observed and fitted values for the Canada standardised RV series, at age 13.

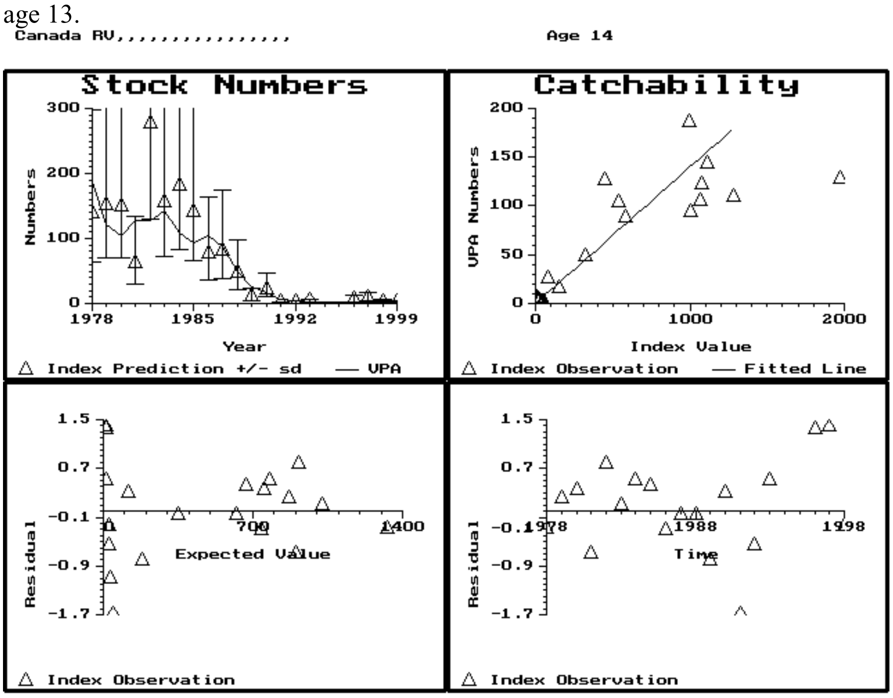


Figure A3.14 Residual plots and observed and fitted values for the Canada standardised RV series, at age 14.

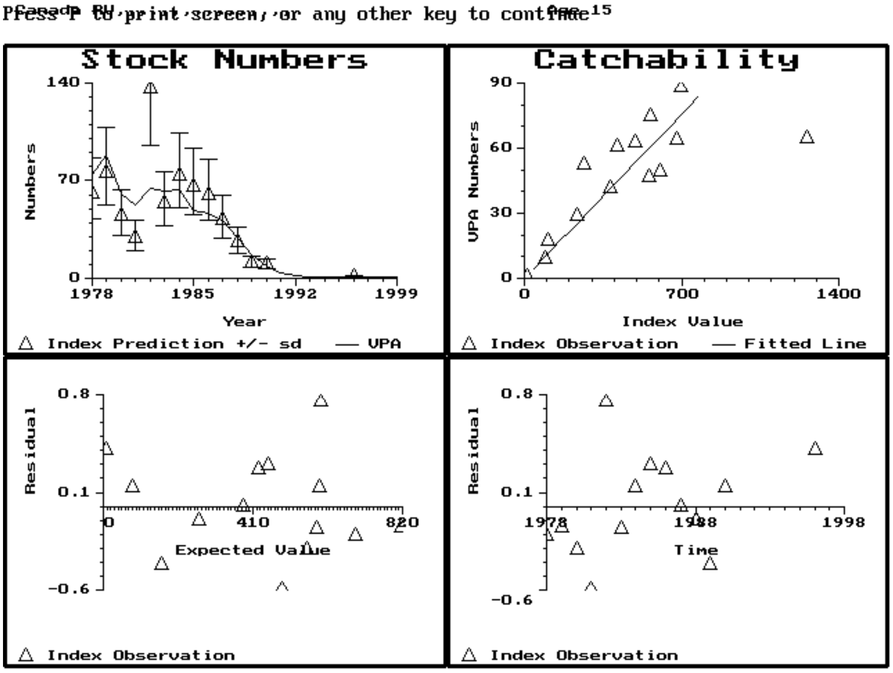


Figure A3.15 Residual plots and observed and fitted values for the Canada standardised RV series, at age 15.

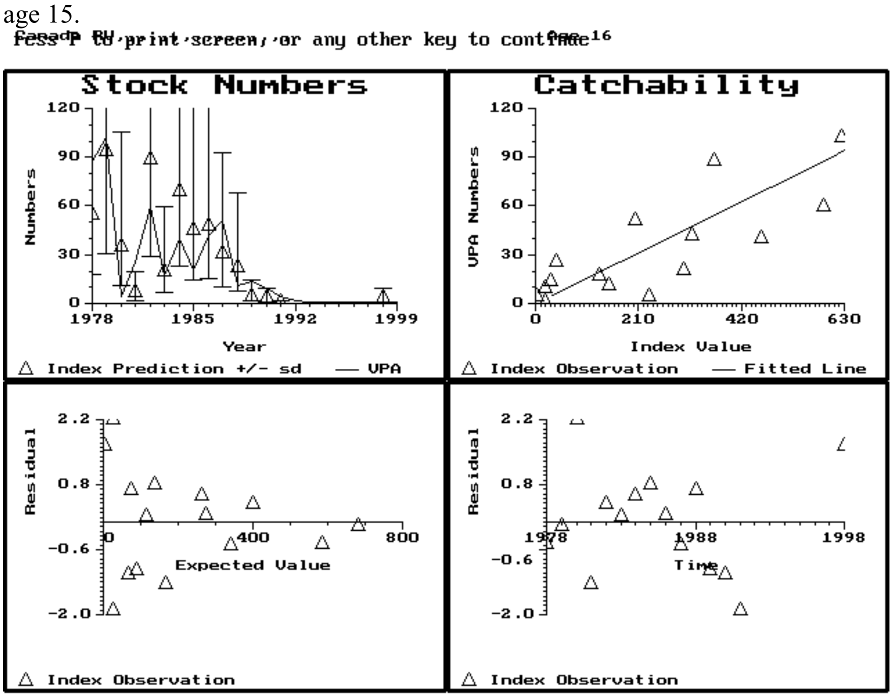


Figure A3.16 Residual plots and observed and fitted values for the Canada standardised RV series, at age 16.