Fisheries and Oceans Canada / Pêches et Océans Canada

Canadian Stock Assessment Secretariat
Research Document 99/146

Secrétariat canadien pour lïévaluation des stocks
Document de recherche 99/146

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Surplus Production Analysis of St. Pierre Bank American Plaice (NAFO Div. 3Ps)

by

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ISSN 1480-4883
Ottawa, 1999

Canada

Abstract

A non-equilibrium surplus production model (ASPIC) was applied to catch and survey biomass indices of St. Pierre Bank American plaice (NAFO Div. 3Ps). Various configurations of the data were tested with the model.

Résumé

Un modèle de non-équilibre de la production excédentaire (ASPIC) a été appliqué aux indicateurs de la biomasse des captures et des relevés de la plie canadienne du banc St-Pierre (sous-division de l'OPANO 3Ps). Diverses configurations des données ont été éprouvées avec le modèle.

Introduction

Surplus production models can be useful in situations where information on age structure is unavailable or unreliable, and provide an alternative perspective for stock assessment. Additionally, surplus production analysis may extend back to historical times when catch at age is not available for long-term perspectives of biomass and F. This investigation was performed to derive MSY reference points and their associated uncertainty.

Methods

<u>Surplus Production Model</u>

A nonequilibrium surplus production model incorporating covariates (ASPIC; Prager 1994, 1995) was applied to nominal catch and biomass indices. The production model assumes logistic population growth, in which the change in stock biomass over time (dB_t/dt) is a quadratic function of biomass (B):

$$dB_t/dt = rB_t - (r/K)B^2_t \qquad (1)$$

where r is the intrinsic rate of population growth, and K is carrying capacity. For a fished stock, the rate of change is also a function of catch biomass (C):

$$dB_t/dt = rB_t - (r/K)B_t^2 - C_t \qquad (2)$$

Biological reference points can be calculated from the production model parameters:

$$MSY = K\,r / 4 \qquad (3)$$
$$B_{msy} = K / 2 \qquad (4)$$
$$F_{msy} = r / 2 \qquad (5)$$

Initial biomass (expressed as a ratio to B_{msy}: *B1R*), *r*, MSY, and catchability coefficients for each biomass index (q_i) were estimated using nonlinear least squares of survey residuals. Model output residuals were randomly resampled 500 times to derive bias-corrected probability distributions for parameter estimates and calculated variables.

<u>Input Data</u>

Potential input data for surplus production modeling are listed in Table 1. Estimated landings are used as nominal catch, but do not include discards or unreported landings. Landings increased from 1968 to 1973 to a high of 15 000 tons followed by a decrease to 2 000 tons in 1983. From 1985 to 1992 the catch fluctuated around an average level of 4 000 tons before declining below 1 000 tons during the moratorium which started in 1993 (Figure 1).

Five time series of biomass indices are plotted in Figure 2A and B (CPUE is also plotted in Fig. 3). Standardized Canadian CPUE generally increased from 1974 to a peak in 1985 before declining to the lowest levels in the last 2 years of the fishery.

The Canadian winter-spring surveys used a 'Yankee' otter trawl from 1971 to 1982, an 'Engel' trawl from 1984 to 1995, and a 'Campelen' trawl in 1996 and 1997). Comparative tows of the Yankee and Engel trawls were used to derive a conversion factor of 1.4 for the Yankee Comparative tows of the Engel and Campelen trawls were used to derive a size based conversion function. Methods to link the 1972-1982 Yankee series to the 1984-1999 Campelen series have not been developed Therefore the following alternative configurations were used: 1)1972-1982 (Engel trawl equivalents) and 1983-1999 (Campelen trawl equivalents) series were considered to be separate biomass indices. The advantage of using the two separate series over using the 1972-1995 Engel series for production modeling is to have a survey observation for the current year to determine current stock status; and 2) the Engel 1972-95 biomass index and the Campelen 1983 to 1999 index were used independently (without the other) in the model (Fig 2A).

From 1985 to 1997, the biomass from the annual Canadian surveys has been steadily decreasing and during the 1998-1999 period it increased to a stable level of approximately 15 000 tons (Table 1; Fig 2B). Mean number per tow data were available from annual surveys by France during the period of 1978-1992. Although catch rates were general high from 1978 to 1985, they decreased steadily from 1986-1992. Results from SPA have not been used for annual catch projections since 1991 because of strong year effects in the residuals and unexplained catchability pattern (Morgan et al 1999). However, SPA estimates of biomass may be useful as an index of relative stock biomass, as measured with error. SPA biomass for the period 1973-1986 showed moderate fluctuations around an average value of 31 000 tons (Table 1 Fig. 2A).

Correlations among biomass indices varied widely (Table 2). The survey biomass series were: Canadian Engel 1972-82 series, The Canadian Campelen 1983-99 series, the French index and SPA series. Three alternative configurations of biomass indices were examined as sensitivity analyses: 1) removing the Engel index, 2) removing the French index, and 5) removing the SPA index. The goodness of fit test showed that the production model did not fit the data well (r^2 for each parameter in the model was <0.1). All biomass indices were dropped one at a time due to poor fits until only CPUE was left in the model. Although there was a small improvement in the fit ($r^2 = 0.3$) (Table 2) there was also a strong residual pattern in the calculations which suggests increasing catchability over time (Fig 3) and further runs with this model were discontinued.

A second model chosen was using another variant of CPUE . The new model used the Campelen time series from 1983-99 together with total landings. The Campelen series was chosen because it, as well as the catch, had observations for the current year to determine current stock status. Five alternative configurations of biomass indices were examined as sensitivity analyses: 1) using the Canadian Engel 1972-82 series, the French index and SPA series, 2) also including Canadian CPUE, 3) removing the Engel index, 4) removing the French index, and 5) removing the SPA index. All biomass indices were dropped one at a time due to poor fits ($r^2 < .2$) until only Campelen CPUE was left in the model and a good fit was obtained ($r^2 = .79$; Table 2). A similar approach was adapted for the 1972-95 Engel time series however the model fit were poor ($r^2 < .06$; Table 2)

Results

Scenario #1-Table 3

The Campelen CPUE model fit the data relatively well ($r^2 = .79$). Residuals appeared to be randomly distributed for this index. The model suggests that a maximum sustainable yield (MSY) of 3 000 t can be produced by a total stock biomass of 46 000 t (B_{msy}) at a fishing mortality rate on total biomass of 0.07 (F_{msy}; Appendix A1, Page 11).

Biomass estimates were near the estimated carrying capacity in the 1960s when F was less than F_{msy}. Biomass declined from 1969 onward to approximately 50% of B_{msy} in the late 1970s and early 1980s, as F exceeded F_{msy}. Fishing mortality increased from 1984 to 1992, and biomass decreased to 1% of B_{msy} in the early 1990s. After the moratorium was declared in 1993, fishing mortality was much less than F_{msy} from 1994- 1996, however, the biomass decreased further to an average value of 5% of B_{msy} . Both the biomass and fishing mortality has shown an increase since 1997. Biomass for 2000 is estimated to be 4 000 tons.

Alternative analyses show that estimates of MSY, B_{msy}, F_{msy}, 1998 biomass, and 1997 F are relatively robust to removing a penalty term for *B1R>K* (Table 2). Conditional bootstrap results indicate that model parameters and derived estimates , in particular r and K were not well estimated (Appendix A1, Page 16). This was due to the fact that the model had difficulty estimating r, the rate of intrinsic rate of increase, as evident with 295 out 500 bootstrap trials were replaced because r was out of bounds. It was felt that this was unacceptable.

Scenario #2-Table 3

Brodie (1988) estimated that $F_{0.1}$ was around 0.20 and ASPIC estimated both $F_{0.1}$ and F_{msy} to be extremely low. The estimation of the latter parameter is derived from the formula 'r/2' in the model. Here r was estimated to be 0.14, a value which when compared to some of the other (poorer) model fits was low. The model was re-runned constraining r = 0.35 based upon several other runs above and below values. Table 2 shows a comparison of the output between a normal run and a constrained r version. The constrained model run may give some guidance on relative biomass levels and F, but the MSY reference points are directly affected by the chosen value of r.

The model suggests that a maximum sustainable yield (MSY) of 5 000 t can be produced by a total stock biomass of 31 000 t (B_{msy}) at a fishing mortality rate on total biomass of 0.18 (F_{msy}; Appendix B1, Page 17).

Biomass estimates were approaching 79% of the estimated carrying capacity in the mid-1960s when F was less than F_{msy}. Biomass declined from 1968 onward to approximately 27% of B_{msy} in the late 1980s, as F exceeded F_{msy}. Fishing mortality increased sharply from 1991 to 1992, and biomass decreased to 1% of B_{msy} . After the moratorium was declared in 1993, fishing mortality was much below F_{msy} from 1994 onward, however, the biomass decreased slightly from 1994-95 before beginning a slight upward trend. Biomass for 2000 is estimated to be 4 000 tons.

Conditional bootstrap results indicate that model parameters and derived estimates were relatively well estimated (Appendix B1, Page 21). Eighty percent confidence limits were 5 000 to 6 000 tons for MSY and 29 000 to 36 000 t for B_{msy}. Because r was constrained and F_{msy} =r/2 then there are no confidence intervals for fishing mortalities.

Scenario #3- Table 4

Alternate configurations were again attempted to see how sensitive the Campelen CPUE model was to missing observations of biomass indices early in the time series (1960-82). Two alternate truncated configurations were tried: 1) 1970-99 beginning with Canadian CPUE fishery and progressing down to Campelen CPUE in a manner described for Table 2 above; and 2) 1983-1999 with Campelen CPUE model only. The 1970-99 configuration using Canadian CPUE data fitted the model poorly. Table 3 shows the out come from the two truncated Campelen time series Again the problem with the low r re-occurs but the other parameters and estimates were substantially different from Table 2 Campelen CPUE series. Unfortunately the dynamic range is more limited when a shorter the time series is used.

Conclusions

Imprecise estimates of r, intrinsic rate of population increase, affect the quality of the parameter estimation. The constrained runs have a more stable solution, but relies on an extrinsic estimate of r (and Fmsy). It can provide some guidance on relative biomass levels and F but the MSY reference points are directly affected by the chosen value of r. However, MSY in the unconstrained model (ranged from 1 000 to 3 000 tons) together with relative estimates of stock biomass should be more precisely estimated (Prager 1994). Regardless of which Campelen CPUE model run is used, the estimates of biomass for 2000 are consistently within the range of 4 000 to 5 000 tons.

References

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

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Table 1 Nominal catch, CPUE, survey biomass indices and provisional SPA biomass estimates of St. Pierre Bank American plaice.

Year	Landings (000t)	Canadian CPUE	Engel Biomass (000 tons)	Campelen (000 tons)	France(mean No. /tow)	SPA Biomass (000t)
1960	0.887	-	-	-	-	-
1961	1.455	-	-	-	-	-
1962	1.024	-	-	-	-	-
1963	0.754	-	-	-	-	-
1964	1.542	-	-	-	-	-
1965	2.022	-	-	-	-	-
1966	3.406	-	-	-	-	-
1967	4.494	-	-	-	-	-
1968	14.280	-	-	-	-	-
1969	6.491	-	-	-	-	-
1970	12.328	-	-	-	-	-
1971	7.182	-	-	-	-	-
1972	6.538	-	33.80	-	-	-
1973	14.769	-	13.70	-	-	35.415
1974	6.598	0.458	13.00	-	-	29.899
1975	4.211	0.473	1.90	-	-	29.696
1976	5.458	0.385	37.80	-	-	25.727
1977	4.605	0.422	9.10	-	-	23.177
1978	3.658	0.417	3.80	-	132.00	25.963
1979	3.666	0.478	7.20	-	266.80	36.596
1980	2.935	0.411	35.80	-	496.20	29.133
1981	3.217	0.514	26.00	-	293.50	32.306
1982	2.186	0.628	39.10	-	200.50	33.875
1983	1.726	0.554	45.20	119.58	281.00	35.905
1984	2.963	0.793	22.50	55.48	196.40	29.081
1985	4.220	1.110	64.50	125.39	465.20	35.024
1986	5.130	0.703	30.40	73.02	175.40	34.985
1987	5.331	0.554	33.90	77.93	80.50	26.575
1988	4.406	0.561	27.30	62.47	68.30	-
1989	2.957	0.510	17.00	38.54	94.90	-
1990	4.130	0.580	5.80	13.18	80.80	-
1991	4.395	0.286	12.10	32.95	29.30	-
1992	2.331	0.229	6.80	16.04	27.10	-
1993	0.751	-	4.60	5.88	-	-
1994	0.122	-	4.20	11.30	-	-
1995	0.085	-	3.90	10.57	-	-
1996	0.114	-	-	12.55	-	-
1997	0.220	-	-	8.60	-	-
1998	0.407	-	-	14.50	-	-
1999	0.5*	-	-	14.60	-	-
Average	3.84	0.53	20.81	40.74	192.53	30.89

* landings in 1999 are a guessestimate based on catchhes reported up to October 1999.

Table 2 Correlation coefficients among biomass indices of St. Pierre Bank American plaice

	CPUE	Engel	Campelen	France	SPA
CPUE	1				
Engel	0.38	1			
Campelen	0.67	0.0	1		
France	0.45	0.44	0.84	1	
SPA	0.48	0.23	0.66	0.34	1

Table 3 Results from production model configurations (MSY, K, B Bmsy, and B2000 in thousand tons units) 1960-1999

Model run	B1R	MSY	r	K	Bmsy	Fmsy	B2000	F99	MSE	r^2	Comment
1	1.20	16.6	0.45	148.4	74.22	0.22	148.70	0.000	0.121	< .01	including CPUE
5	0.75	6.04	0.48	50.2	25.1	0.24	32.50	0.017	0.068	0.3	CPUE only
6	3.50	4.53	0.10	181.2	90.6	0.05	154.20	0.003	1.055	<.02	Campelen as proxy for CPUE
10	2.02	3.23	0.14	91.27	45.63	0.07	3.50	0.142	0.143	0.79	Campelen only*
11	0.18	5.48	0.35	62.58	31.29	0.18	3.56	0.154	0.194	0.76	Campelen only, r constrained to 0.35**
15	1.88	5.44	0.40	55.08	27.54	0.20	15.10	0.038	0.759	0.01	Engel only

* Output in Appendix A
** Output in Appendix B

Table 4 Results from production model configurations (MSY, K, B Bmsy, and B2000 in thousand tons units) using truncated data

Model run	B1R	MSY	r	K	Bmsy	Fmsy	B2000	F99	MSE	r^2	Comment
21	2.05	2.59	0.15	70.94	35.47	0.07	3.57	0.14	0.142	0.80	Campelen CPUE 1970-99
23	2.10	3.76	0.30	50.08	25.04	0.15	3.69	0.145	0.169	0.79	Campelen CPUE 1970-99 r fixed at .30
28	2.00	1.25	0.16	32.17	16.08	0.08	4.10	0.123	0.140	0.81	Campelen CPUE 1983-1999
30	1.62	2.30	0.35	26.48	13.24	0.18	4.58	0.119	0.180	0.81	Campelen CPUE 1983-1999 r fixed at .35

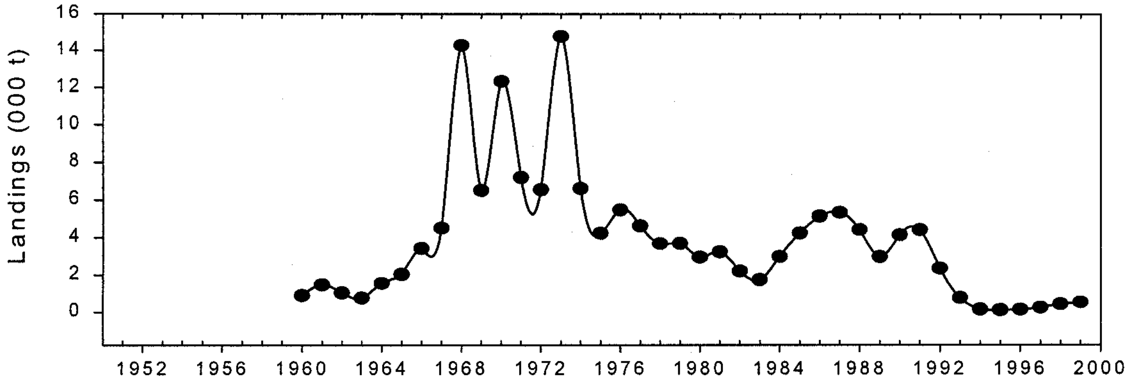


Fig. 1 Landings of St. Pierre Bank American plaice

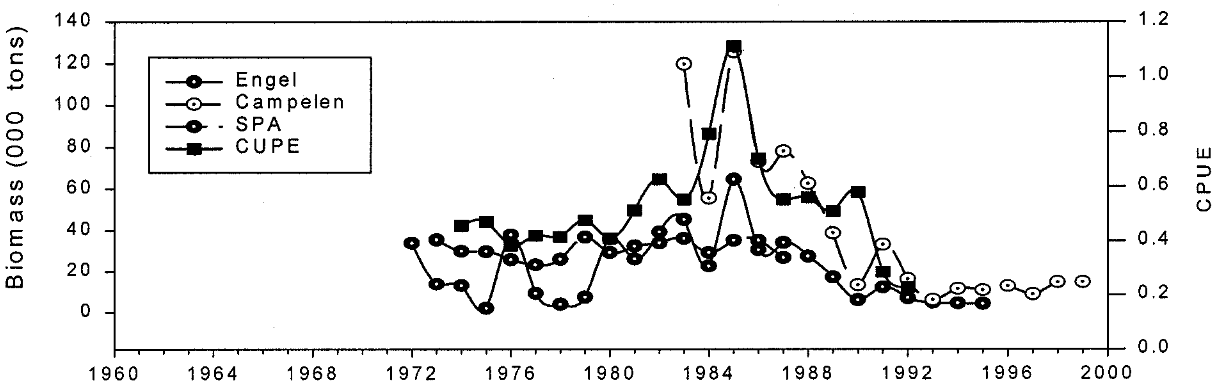


Fig. 2A Indices of St. Pierre Bank American plaice biomass and CPUE

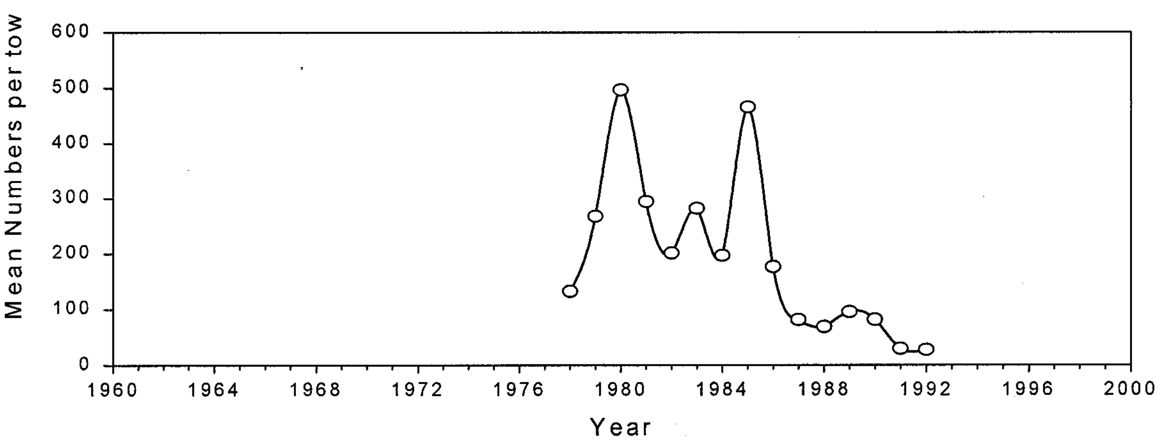
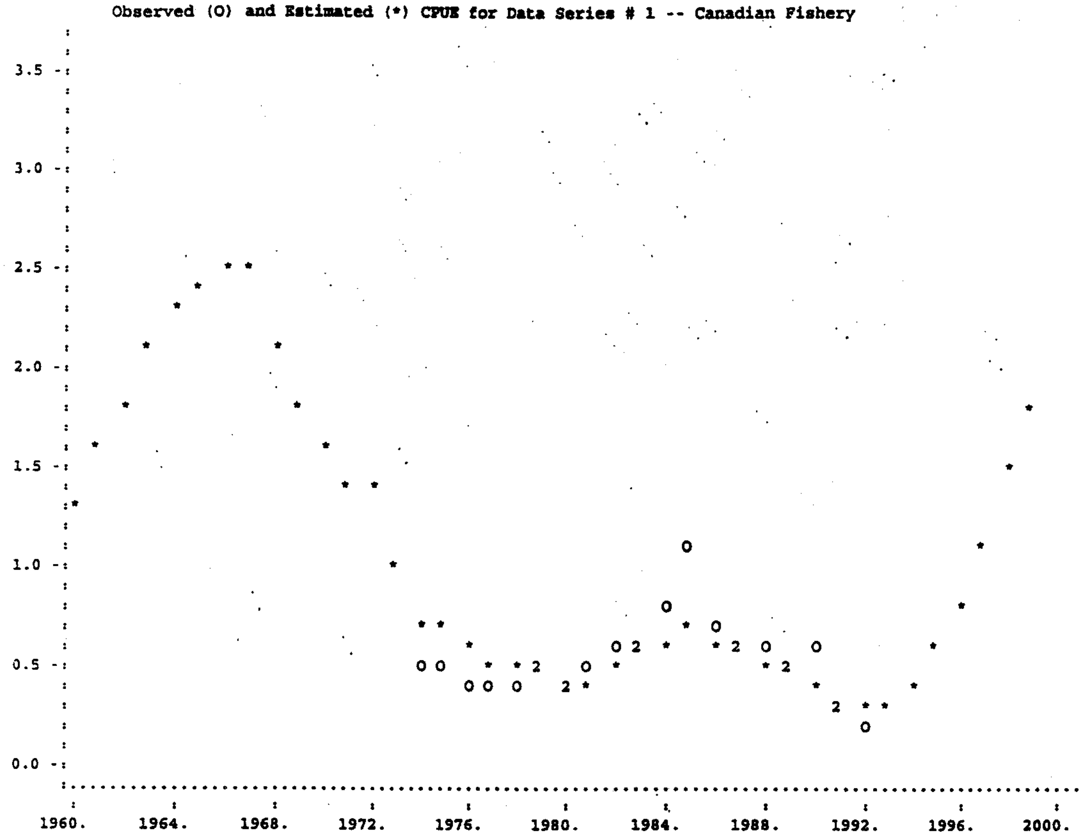


Fig. 2B Index of abundance from French research vessel surveys

Fig. 3 Output from ASPIC model with Canadian CPUE fishery data and Nominal Catch in the model

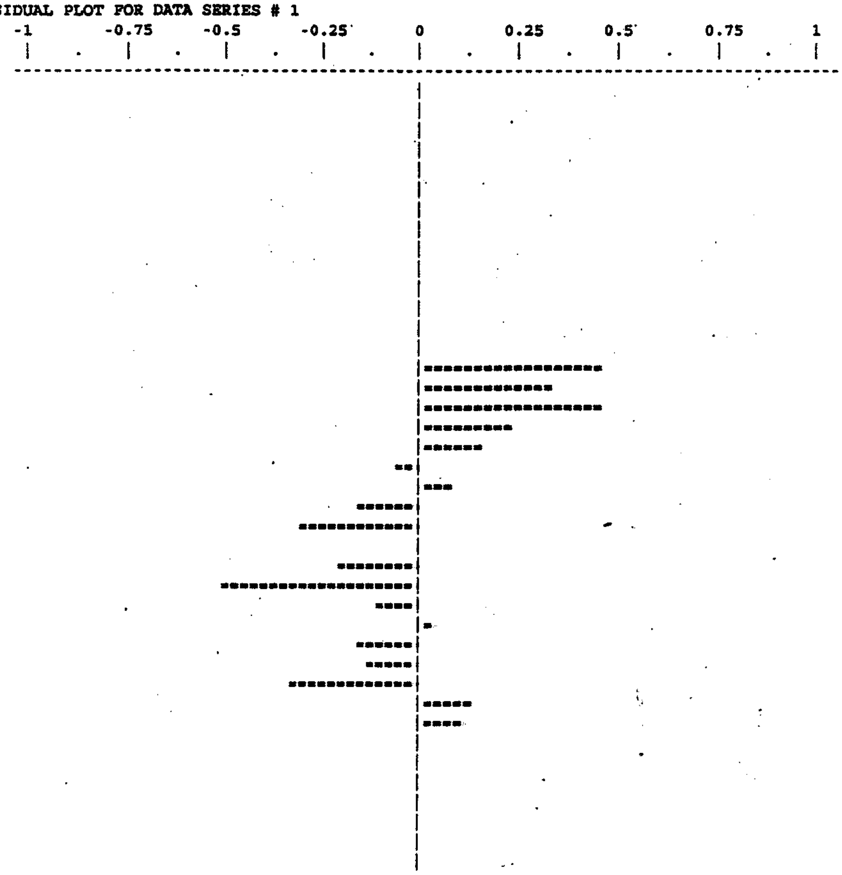
3Ps American plaice -- ASPIC 3.65

Observed (O) and Estimated (*) CPUE for Data Series # 1 -- Canadian Fishery



3Ps American plaice -- ASPIC 3.65

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 1



Year	Residual
1960	0.0000
1961	0.0000
1962	0.0000
1963	0.0000
1964	0.0000
1965	0.0000
1966	0.0000
1967	0.0000
1968	0.0000
1969	0.0000
1970	0.0000
1971	0.0000
1972	0.0000
1973	0.0000
1974	0.4497
1975	0.3242
1976	0.4498
1977	0.2193
1978	0.1457
1979	-0.0499
1980	0.0739
1981	-0.1536
1982	-0.3004
1983	-0.0062
1984	-0.2117
1985	-0.4968
1986	-0.0879
1987	0.0167
1988	-0.1517
1989	-0.1152
1990	-0.3168
1991	0.1199
1992	0.0919
1993	0.0000
1994	0.0000
1995	0.0000
1996	0.0000
1997	0.0000
1998	0.0000
1999	0.0000

APPENDIX A 3Ps American plaice -- ASPIC 3.65

15 Oct 1999 at 15:54

ASPIC -- A Surplus-Production Model Including Covariates (Ver. 3.65)

FIT Mode

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CONTROL PARAMETERS USED (FROM INPUT FILE)

Number of years analyzed:	40	Number of bootstrap trials:	0
Number of data series:	1	Lower bound on MSY:	6.667E-01
Objective function computed:	in EFFORT	Upper bound on MSY:	4.000E+01
Relative conv. criterion (simplex):	1.000E-08	Lower bound on r:	1.000E-01
Relative conv. criterion (restart):	3.000E-08	Upper bound on r:	1.000E+01
Relative conv. criterion (effort):	1.000E-04	Random number seed:	1964286
Maximum F allowed in fitting:	5.000	Monte Carlo search trials:	50000

PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS) code 0

Normal convergence.

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

Loss component number and title	Weighted SSE	N	Weighted MSE	Current weight	Suggested weight	R-squared in CPUE
Loss(-1) SSE in yield	0.000E+00					
Loss(0) Penalty for B1R > 2	6.329E-05	1	N/A	1.000E+00	N/A	
Loss(1) Canadian Fishery	2.148E+00	17	1.432E-01	1.000E+00	1.000E+00	0.793

TOTAL OBJECTIVE FUNCTION: 2.14783767E+00

NOTE: B1-ratio constraint term contributing to loss. Sensitivity analysis advised.

Number of restarts required for convergence:	14
Est. B-ratio coverage index (0 worst, 2 best):	1.9474
Est. B-ratio nearness index (0 worst, 1 best):	1.0000

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Starting guess	Estimated	User guess
B1R	Starting biomass ratio, year 1960	2.016E+00	1.500E+00	1	1
MSY	Maximum sustainable yield	3.231E+00	2.000E+01	1	1
r	Intrinsic rate of increase	1.416E-01	5.000E-01	1	1
....	Catchability coefficients by fishery:				
q(1)	Canadian Fishery	3.651E+00	2.000E+00	1	1

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Formula	
MSY	Maximum sustainable yield	3.231E+00	Kr/4	
K	Maximum stock biomass	9.127E+01		
Bmsy	Stock biomass at MSY	4.563E+01	K/2	
Fmsy	Fishing mortality at MSY	7.081E-02	r/2	
F(0.1)	Management benchmark	6.373E-02	0.9*Fmsy	
Y(0.1)	Equilibrium yield at F(0.1)	3.199E+00	0.99*MSY	
B-ratio	Ratio of B(2000) to Bmsy	7.685E-02		
F-ratio	Ratio of F(1999) to Fmsy	2.007E+00		
Y-ratio	Proportion of MSY avail in 2000	1.478E-01	2*Br-Br^2	Ye(2000) = 4.776E-01
....	Fishing effort at MSY in units of each fishery:			
fmsy(1)	Canadian Fishery	1.939E-02	r/2q(1)	f(0.1) = 1.746E-02

3Ps American plaice -- ASPIC 3.65

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1960	0.010	9.200E+01	9.152E+01	8.870E-01	8.870E-01	-3.641E-02	1.369E-01	2.016E+00
2	1961	0.016	9.107E+01	9.039E+01	1.455E+00	1.455E+00	1.229E-01	2.273E-01	1.996E+00
3	1962	0.011	8.974E+01	8.935E+01	1.024E+00	1.024E+00	2.655E-01	1.618E-01	1.967E+00
4	1963	0.008	8.898E+01	8.877E+01	7.540E-01	7.540E-01	3.437E-01	1.199E-01	1.950E+00
5	1964	0.018	8.857E+01	8.801E+01	1.542E+00	1.542E+00	4.447E-01	2.474E-01	1.941E+00
6	1965	0.023	8.747E+01	8.675E+01	2.022E+00	2.022E+00	6.079E-01	3.292E-01	1.917E+00
7	1966	0.040	8.606E+01	8.475E+01	3.406E+00	3.406E+00	8.561E-01	5.675E-01	1.886E+00
8	1967	0.055	8.351E+01	8.182E+01	4.494E+00	4.494E+00	1.198E+00	7.757E-01	1.830E+00
9	1968	0.194	8.021E+01	7.378E+01	1.428E+01	1.428E+01	1.983E+00	2.733E+00	1.758E+00
10	1969	0.098	6.792E+01	6.591E+01	6.491E+00	6.491E+00	2.591E+00	1.391E+00	1.488E+00
11	1970	0.209	6.402E+01	5.913E+01	1.233E+01	1.233E+01	2.938E+00	2.944E+00	1.403E+00
12	1971	0.137	5.463E+01	5.256E+01	7.182E+00	7.182E+00	3.155E+00	1.930E+00	1.197E+00
13	1972	0.134	5.060E+01	4.890E+01	6.538E+00	6.538E+00	3.213E+00	1.888E+00	1.109E+00
14	1973	0.359	4.728E+01	4.115E+01	1.477E+01	1.477E+01	3.183E+00	5.068E+00	1.036E+00
15	1974	0.195	3.569E+01	3.385E+01	6.598E+00	6.598E+00	3.014E+00	2.753E+00	7.821E-01
16	1975	0.134	3.211E+01	3.145E+01	4.211E+00	4.211E+00	2.919E+00	1.891E+00	7.036E-01
17	1976	0.185	3.081E+01	2.947E+01	5.458E+00	5.458E+00	2.825E+00	2.616E+00	6.752E-01
18	1977	0.169	2.818E+01	2.721E+01	4.605E+00	4.605E+00	2.704E+00	2.390E+00	6.176E-01
19	1978	0.142	2.628E+01	2.575E+01	3.658E+00	3.658E+00	2.618E+00	2.006E+00	5.759E-01
20	1979	0.149	2.524E+01	2.467E+01	3.666E+00	3.666E+00	2.550E+00	2.098E+00	5.531E-01
21	1980	0.123	2.412E+01	2.390E+01	2.935E+00	2.935E+00	2.499E+00	1.734E+00	5.286E-01
22	1981	0.138	2.369E+01	2.330E+01	3.217E+00	3.217E+00	2.458E+00	1.949E+00	5.191E-01
23	1982	0.095	2.293E+01	2.306E+01	2.186E+00	2.186E+00	2.440E+00	1.339E+00	5.024E-01
24	1983	0.073	2.318E+01	2.356E+01	1.726E+00	1.726E+00	2.475E+00	1.035E+00	5.080E-01
25	1984	0.125	2.393E+01	2.369E+01	2.963E+00	2.963E+00	2.484E+00	1.766E+00	5.244E-01
26	1985	0.187	2.345E+01	2.253E+01	4.220E+00	4.220E+00	2.402E+00	2.645E+00	5.139E-01
27	1986	0.255	2.163E+01	2.014E+01	5.130E+00	5.130E+00	2.222E+00	3.597E+00	4.741E-01
28	1987	0.314	1.873E+01	1.698E+01	5.331E+00	5.331E+00	1.956E+00	4.435E+00	4.104E-01
29	1988	0.316	1.535E+01	1.393E+01	4.406E+00	4.406E+00	1.671E+00	4.465E+00	3.364E-01
30	1989	0.250	1.262E+01	1.185E+01	2.957E+00	2.957E+00	1.460E+00	3.524E+00	2.765E-01
31	1990	0.431	1.112E+01	9.584E+00	4.130E+00	4.130E+00	1.214E+00	6.085E+00	2.437E-01
32	1991	0.704	8.203E+00	6.245E+00	4.395E+00	4.395E+00	8.223E-01	9.938E+00	1.798E-01
33	1992	0.641	4.631E+00	3.634E+00	2.331E+00	2.331E+00	4.938E-01	9.058E+00	1.015E-01
34	1993	0.290	2.793E+00	2.591E+00	7.510E-01	7.510E-01	3.565E-01	4.093E+00	6.121E-02
35	1994	0.049	2.399E+00	2.509E+00	1.220E-01	1.220E-01	3.456E-01	6.866E-01	5.257E-02
36	1995	0.031	2.622E+00	2.767E+00	8.500E-02	8.500E-02	3.800E-01	4.337E-01	5.747E-02
37	1996	0.037	2.917E+00	3.068E+00	1.140E-01	1.140E-01	4.199E-01	5.247E-01	6.393E-02
38	1997	0.066	3.223E+00	3.340E+00	2.200E-01	2.200E-01	4.557E-01	9.302E-01	7.064E-02
39	1998	0.117	3.459E+00	3.493E+00	4.070E-01	4.070E-01	4.758E-01	1.645E+00	7.580E-02
40	1999	0.142	3.528E+00	3.517E+00	5.000E-01	5.000E-01	4.789E-01	2.007E+00	7.731E-02
41	2000		3.507E+00						7.685E-02

3Ps American plaice -- ASPIC 3.65

RESULTS FOR DATA SERIES # 1 (NON-BOOTSTRAPPED) Canadian Fishery

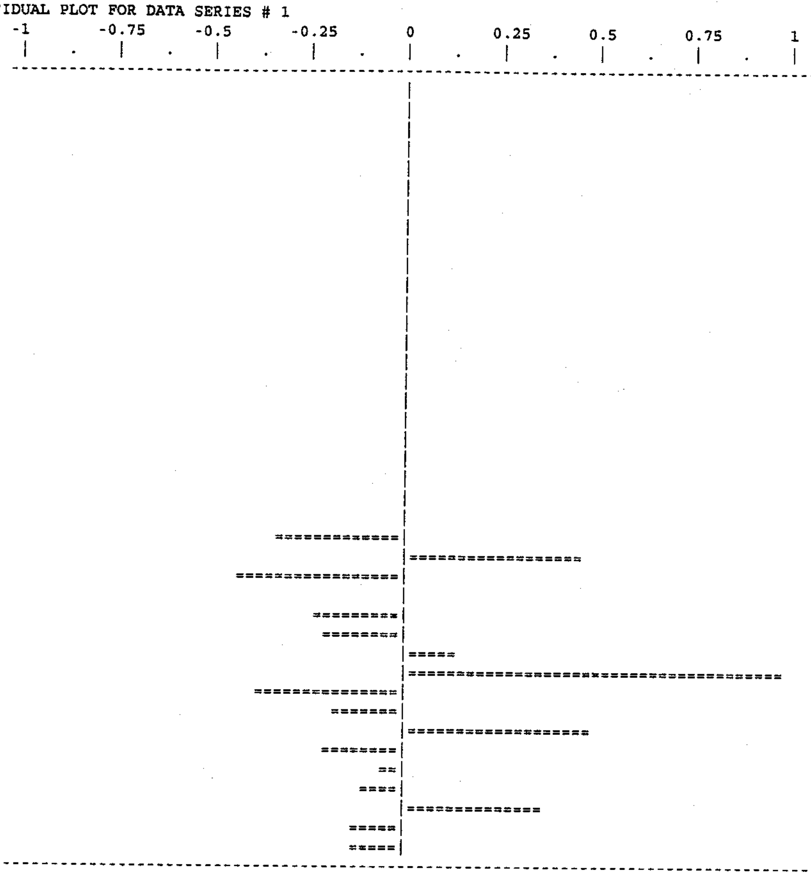
Data type CC: CPUE-catch series Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed yield	Model yield	Resid in log effort	Resid in yield
1	1960	*	2.654E-03	0.0097	8.870E-01	8.870E-01	0.00000	0.000E+00
2	1961	*	4.409E-03	0.0161	1.455E+00	1.455E+00	0.00000	0.000E+00
3	1962	*	3.139E-03	0.0115	1.024E+00	1.024E+00	0.00000	0.000E+00
4	1963	*	2.326E-03	0.0085	7.540E-01	7.540E-01	0.00000	0.000E+00
5	1964	*	4.799E-03	0.0175	1.542E+00	1.542E+00	0.00000	0.000E+00
6	1965	*	6.384E-03	0.0233	2.022E+00	2.022E+00	0.00000	0.000E+00
7	1966	*	1.101E-02	0.0402	3.406E+00	3.406E+00	0.00000	0.000E+00
8	1967	*	1.504E-02	0.0549	4.494E+00	4.494E+00	0.00000	0.000E+00
9	1968	*	5.301E-02	0.1936	1.428E+01	1.428E+01	0.00000	0.000E+00
10	1969	*	2.697E-02	0.0985	6.491E+00	6.491E+00	0.00000	0.000E+00
11	1970	*	5.711E-02	0.2085	1.233E+01	1.233E+01	0.00000	0.000E+00
12	1971	*	3.742E-02	0.1366	7.182E+00	7.182E+00	0.00000	0.000E+00
13	1972	*	3.662E-02	0.1337	6.538E+00	6.538E+00	0.00000	0.000E+00
14	1973	*	9.830E-02	0.3589	1.477E+01	1.477E+01	0.00000	0.000E+00
15	1974	*	5.339E-02	0.1949	6.598E+00	6.598E+00	0.00000	0.000E+00
16	1975	*	3.667E-02	0.1339	4.211E+00	4.211E+00	0.00000	0.000E+00
17	1976	*	5.073E-02	0.1852	5.458E+00	5.458E+00	0.00000	0.000E+00
18	1977	*	4.635E-02	0.1692	4.605E+00	4.605E+00	0.00000	0.000E+00
19	1978	*	3.890E-02	0.1420	3.658E+00	3.658E+00	0.00000	0.000E+00
20	1979	*	4.069E-02	0.1486	3.666E+00	3.666E+00	0.00000	0.000E+00
21	1980	*	3.363E-02	0.1228	2.935E+00	2.935E+00	0.00000	0.000E+00
22	1981	*	3.781E-02	0.1380	3.217E+00	3.217E+00	0.00000	0.000E+00
23	1982	*	2.597E-02	0.0948	2.186E+00	2.186E+00	0.00000	0.000E+00
24	1983	1.443E-02	2.007E-02	0.0733	1.726E+00	1.726E+00	-0.32968	0.000E+00
25	1984	5.339E-02	3.426E-02	0.1251	2.963E+00	2.963E+00	0.44370	0.000E+00
26	1985	3.365E-02	5.131E-02	0.1873	4.220E+00	4.220E+00	-0.42178	0.000E+00
27	1986	7.027E-02	6.977E-02	0.2547	5.130E+00	5.130E+00	0.00719	0.000E+00
28	1987	6.843E-02	8.601E-02	0.3140	5.331E+00	5.331E+00	-0.22859	0.000E+00
29	1988	7.050E-02	8.660E-02	0.3162	4.406E+00	4.406E+00	-0.20576	0.000E+00
30	1989	7.681E-02	6.834E-02	0.2495	2.957E+00	2.957E+00	0.11671	0.000E+00
31	1990	3.129E-01	1.180E-01	0.4309	4.130E+00	4.130E+00	0.97491	0.000E+00
32	1991	1.336E-01	1.928E-01	0.7038	4.395E+00	4.395E+00	-0.36668	0.000E+00
33	1992	1.457E-01	1.757E-01	0.6414	2.331E+00	2.331E+00	-0.18718	0.000E+00
34	1993	1.273E-01	7.939E-02	0.2899	7.510E-01	7.510E-01	0.47212	0.000E+00
35	1994	1.080E-02	1.332E-02	0.0486	1.220E-01	1.220E-01	-0.20985	0.000E+00
36	1995	8.019E-03	8.412E-03	0.0307	8.500E-02	8.500E-02	-0.04789	0.000E+00
37	1996	9.120E-03	1.018E-02	0.0372	1.140E-01	1.140E-01	-0.10966	0.000E+00
38	1997	2.558E-02	1.804E-02	0.0659	2.200E-01	2.200E-01	0.34923	0.000E+00
39	1998	2.807E-02	3.191E-02	0.1165	4.070E-01	4.070E-01	-0.12823	0.000E+00
40	1999	3.425E-02	3.893E-02	0.1422	5.000E-01	5.000E-01	-0.12827	0.000E+00

* Asterisk indicates missing value(s).

3Ps American plaice -- ASPIC 3.65

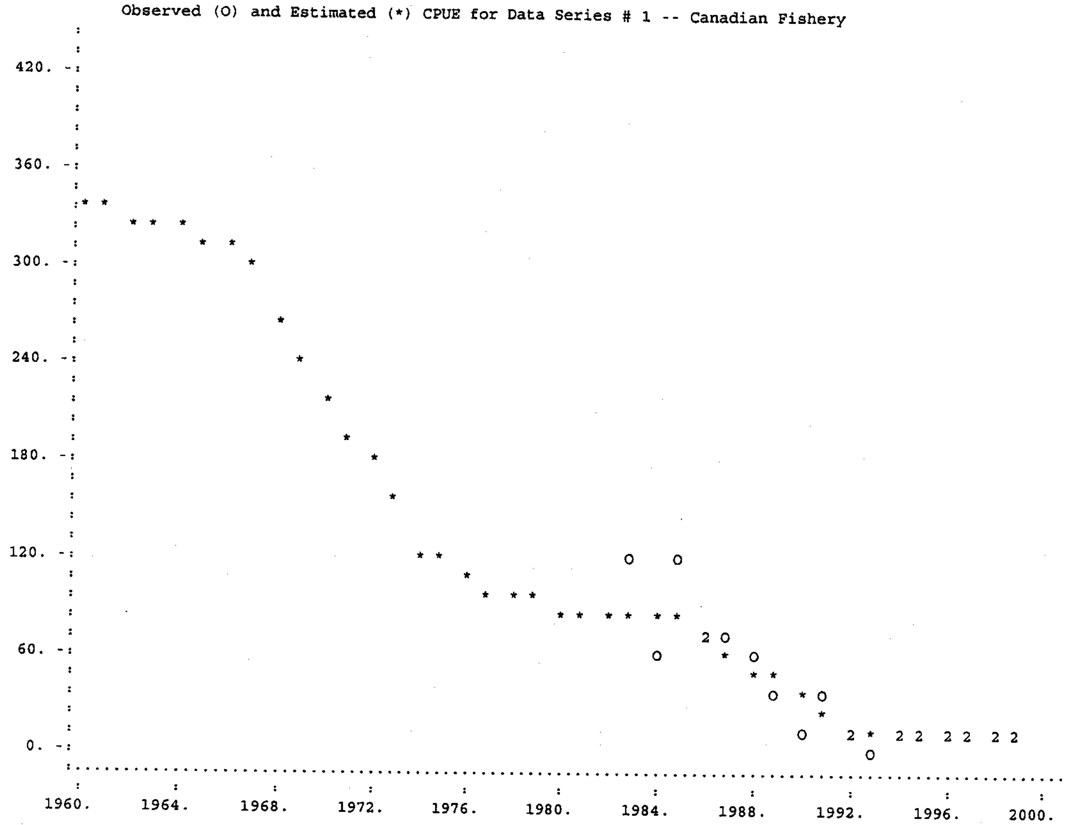
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 1



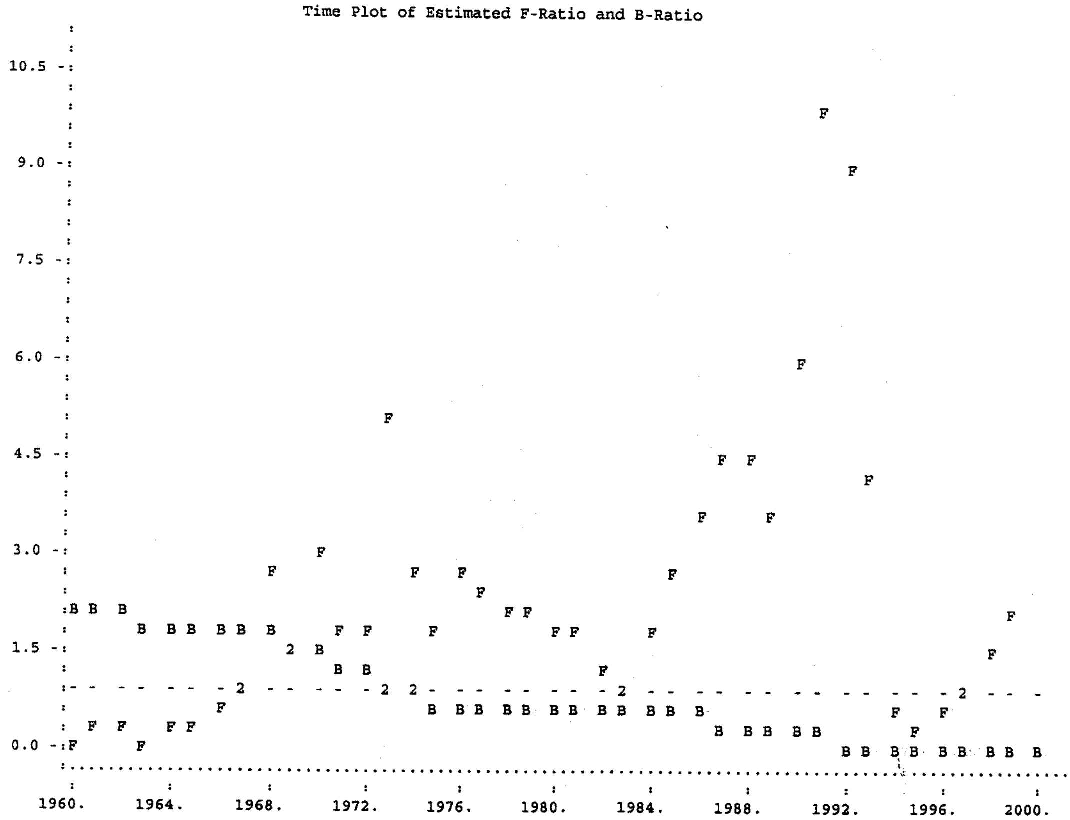
Year	Residual
1960	0.0000
1961	0.0000
1962	0.0000
1963	0.0000
1964	0.0000
1965	0.0000
1966	0.0000
1967	0.0000
1968	0.0000
1969	0.0000
1970	0.0000
1971	0.0000
1972	0.0000
1973	0.0000
1974	0.0000
1975	0.0000
1976	0.0000
1977	0.0000
1978	0.0000
1979	0.0000
1980	0.0000
1981	0.0000
1982	0.0000
1983	-0.3297
1984	0.4437
1985	-0.4218
1986	0.0072
1987	-0.2286
1988	-0.2058
1989	0.1167
1990	0.9749
1991	-0.3667
1992	-0.1872
1993	0.4721
1994	-0.2099
1995	-0.0479
1996	-0.1097
1997	0.3492
1998	-0.1282
1999	-0.1283

3Ps American plaice -- ASPIC 3.65

Observed (O) and Estimated (*) CPUE for Data Series # 1 -- Canadian Fishery



Time Plot of Estimated F-Ratio and B-Ratio



Appendix A1

Boot strapping

3Ps American plaice -- ASPIC 3.65

RESULTS OF BOOTSTRAPPED ANALYSIS

Param name	Bias-corrected estimate	Ordinary estimate	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
B1ratio	2.027E+00	2.016E+00	-0.54%	2.005E+00	2.046E+00	2.016E+00	2.039E+00	2.316E-02	0.011
K	9.498E+01	9.127E+01	-3.91%	7.367E+01	3.414E+02	8.426E+01	1.811E+02	9.681E+01	1.019
r	1.075E-01	1.416E-01	31.76%	1.008E-01	1.828E-01	1.067E-01	1.484E-01	4.164E-02	0.387
q(1)	3.210E+00	3.651E+00	13.73%	2.454E+00	4.294E+00	2.863E+00	3.753E+00	8.898E-01	0.277
MSY	2.374E+00	3.231E+00	36.09%	2.593E+00	3.424E+00	2.608E+00	3.061E+00	4.533E-01	0.191
Ye(2000)	3.392E-01	4.776E-01	40.81%	2.258E-01	5.957E-01	2.926E-01	4.804E-01	1.878E-01	0.554
Bmsy	4.749E+01	4.563E+01	-3.91%	3.683E+01	1.707E+02	4.213E+01	9.053E+01	4.840E+01	1.019
Fmsy	5.374E-02	7.081E-02	31.76%	5.041E-02	9.138E-02	5.336E-02	7.418E-02	2.082E-02	0.387
fmsy(1)	1.719E-02	1.939E-02	12.82%	1.385E-02	2.287E-02	1.485E-02	1.998E-02	5.126E-03	0.298
F(0.1)	4.837E-02	6.373E-02	28.58%	4.537E-02	8.224E-02	4.802E-02	6.676E-02	1.874E-02	0.387
Y(0.1)	2.351E+00	3.199E+00	35.73%	2.567E+00	3.389E+00	2.582E+00	3.031E+00	4.487E-01	0.191
B-ratio	7.377E-02	7.685E-02	4.17%	2.907E-02	1.121E-01	5.104E-02	9.319E-02	4.215E-02	0.571
F-ratio	2.438E+00	2.007E+00	-17.65%	1.612E+00	3.642E+00	2.000E+00	3.173E+00	1.173E+00	0.481
Y-ratio	1.421E-01	1.478E-01	3.99%	5.730E-02	2.116E-01	9.947E-02	1.777E-01	7.823E-02	0.550
f0.1(1)	1.547E-02	1.746E-02	11.54%	1.247E-02	2.059E-02	1.336E-02	1.798E-02	4.614E-03	0.298

NOTES ON BOOTSTRAPPED ESTIMATES:

- The bootstrapped results shown were computed from 500 trials.
- These results are conditional on the constraints placed upon MSY and r in the input file (ASPIC.INP).
- All bootstrapped intervals are approximate. The statistical literature recommends using at least 1000 trials for accurate 95% intervals. The 80% intervals used by ASPIC should require fewer trials for equivalent accuracy. Using at least 500 trials is recommended.
- The bias corrections used here are based on medians. This is an accepted statistical procedure, but may estimate nonzero bias for unbiased, skewed estimators.

Trials replaced for lack of convergence:	111
Trials replaced for MSY out-of-bounds:	0
Trials replaced for r out-of-bounds:	296
Residual-adjustment factor:	1.1435

Appendix B 3Ps American plaice -- ASPIC 3.65 constrined at r=.35

19 Oct 1999 at 08:43

ASPIC -- A Surplus-Production Model Including Covariates (Ver. 3.65)

FIT Mode

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Tiburon, California 94920 USA

CONTROL PARAMETERS USED (FROM INPUT FILE)

Number of years analyzed:	40	Number of bootstrap trials:	0
Number of data series:	1	Lower bound on MSY:	6.667E-01
Objective function computed:	in EFFORT	Upper bound on MSY:	4.000E+01
Relative conv. criterion (simplex):	1.000E-08	Lower bound on r:	1.000E-01
Relative conv. criterion (restart):	3.000E-08	Upper bound on r:	1.000E+01
Relative conv. criterion (effort):	1.000E-04	Random number seed:	1964286
Maximum F allowed in fitting:	5.000	Monte Carlo search trials:	50000

PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS) code 0

Normal convergence.

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

Loss component number and title	Weighted SSE	N	Weighted MSE	Current weight	Suggested weight	R-squared in CPUE
Loss(-1) SSE in yield	0.000E+00					
Loss(0) Penalty for B1R > 2	0.000E+00	1	N/A	1.000E+00	N/A	
Loss(1) Canadian Fishery	2.913E+00	17	1.942E-01	1.000E+00	1.000E+00	0.763

TOTAL OBJECTIVE FUNCTION: 2.91253713E+00

Number of restarts required for convergence:	21
Est. B-ratio coverage index (0 worst, 2 best):	1.5097
Est. B-ratio nearness index (0 worst, 1 best):	1.0000

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Starting guess	Estimated	User guess
B1R	Starting biomass ratio, year 1960	8.102E-01	1.500E+00	1	1
MSY	Maximum sustainable yield	5.476E+00	2.000E+01	1	1
r	Intrinsic rate of increase	3.500E-01	3.500E-01	0	1
....	Catchability coefficients by fishery:				
q(1)	Canadian Fishery	6.023E+00	2.000E+00	1	1

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Formula	
MSY	Maximum sustainable yield	5.476E+00	Kr/4	
K	Maximum stock biomass	6.258E+01		
Bmsy	Stock biomass at MSY	3.129E+01	K/2	
Fmsy	Fishing mortality at MSY	1.750E-01	r/2	
F(0.1)	Management benchmark	1.575E-01	0.9*Fmsy	
Y(0.1)	Equilibrium yield at F(0.1)	5.421E+00	0.99*MSY	
B-ratio	Ratio of B(2000) to Bmsy	1.136E-01		
F-ratio	Ratio of F(1999) to Fmsy	8.773E-01		
Y-ratio	Proportion of MSY avail in 2000	2.143E-01	2*Br-Br^2	Ye(2000) = 1.174E+00
....	Fishing effort at MSY in units of each fishery:			
fmsy(1)	Canadian Fishery	2.906E-02	r/2q(1)	f(0.1) = 2.615E-02

3Ps American plaice -- ASPIC 3.65

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1960	0.032	2.535E+01	2.760E+01	8.870E-01	8.870E-01	5.390E+00	1.836E-01	8.102E-01
2	1961	0.046	2.985E+01	3.188E+01	1.455E+00	1.455E+00	5.466E+00	2.608E-01	9.542E-01
3	1962	0.028	3.387E+01	3.605E+01	1.024E+00	1.024E+00	5.340E+00	1.623E-01	1.082E+00
4	1963	0.019	3.818E+01	4.035E+01	7.540E-01	7.540E-01	5.008E+00	1.068E-01	1.220E+00
5	1964	0.035	4.244E+01	4.399E+01	1.542E+00	1.542E+00	4.569E+00	2.003E-01	1.356E+00
6	1965	0.043	4.546E+01	4.657E+01	2.022E+00	2.022E+00	4.167E+00	2.481E-01	1.453E+00
7	1966	0.071	4.761E+01	4.788E+01	3.406E+00	3.406E+00	3.935E+00	4.065E-01	1.522E+00
8	1967	0.094	4.814E+01	4.785E+01	4.494E+00	4.494E+00	3.942E+00	5.367E-01	1.538E+00
9	1968	0.336	4.758E+01	4.245E+01	1.428E+01	1.428E+01	4.737E+00	1.922E+00	1.521E+00
10	1969	0.174	3.804E+01	3.740E+01	6.491E+00	6.491E+00	5.266E+00	9.916E-01	1.216E+00
11	1970	0.372	3.682E+01	3.314E+01	1.233E+01	1.233E+01	5.434E+00	2.125E+00	1.177E+00
12	1971	0.247	2.992E+01	2.902E+01	7.182E+00	7.182E+00	5.445E+00	1.414E+00	9.563E-01
13	1972	0.237	2.819E+01	2.760E+01	6.538E+00	6.538E+00	5.399E+00	1.354E+00	9.008E-01
14	1973	0.682	2.705E+01	2.165E+01	1.477E+01	1.477E+01	4.911E+00	3.898E+00	8.644E-01
15	1974	0.415	1.719E+01	1.592E+01	6.598E+00	6.598E+00	4.151E+00	2.369E+00	5.494E-01
16	1975	0.289	1.474E+01	1.459E+01	4.211E+00	4.211E+00	3.916E+00	1.649E+00	4.712E-01
17	1976	0.403	1.445E+01	1.355E+01	5.458E+00	5.458E+00	3.713E+00	2.302E+00	4.618E-01
18	1977	0.381	1.270E+01	1.209E+01	4.605E+00	4.605E+00	3.414E+00	2.176E+00	4.060E-01
19	1978	0.324	1.151E+01	1.130E+01	3.658E+00	3.658E+00	3.241E+00	1.850E+00	3.679E-01
20	1979	0.339	1.109E+01	1.082E+01	3.666E+00	3.666E+00	3.133E+00	1.936E+00	3.546E-01
21	1980	0.276	1.056E+01	1.064E+01	2.935E+00	2.935E+00	3.091E+00	1.576E+00	3.375E-01
22	1981	0.302	1.072E+01	1.065E+01	3.217E+00	3.217E+00	3.094E+00	1.725E+00	3.425E-01
23	1982	0.197	1.059E+01	1.110E+01	2.186E+00	2.186E+00	3.195E+00	1.126E+00	3.386E-01
24	1983	0.138	1.160E+01	1.248E+01	1.726E+00	1.726E+00	3.495E+00	7.905E-01	3.708E-01
25	1984	0.215	1.337E+01	1.377E+01	2.963E+00	2.963E+00	3.759E+00	1.230E+00	4.274E-01
26	1985	0.302	1.417E+01	1.395E+01	4.220E+00	4.220E+00	3.794E+00	1.729E+00	4.528E-01
27	1986	0.396	1.374E+01	1.295E+01	5.130E+00	5.130E+00	3.593E+00	2.264E+00	4.392E-01
28	1987	0.481	1.220E+01	1.109E+01	5.331E+00	5.331E+00	3.191E+00	2.747E+00	3.901E-01
29	1988	0.479	1.007E+01	9.203E+00	4.406E+00	4.406E+00	2.746E+00	2.736E+00	3.217E-01
30	1989	0.362	8.405E+00	8.165E+00	2.957E+00	2.957E+00	2.485E+00	2.069E+00	2.686E-01
31	1990	0.600	7.933E+00	6.885E+00	4.130E+00	4.130E+00	2.143E+00	3.428E+00	2.535E-01
32	1991	1.032	5.946E+00	4.260E+00	4.395E+00	4.395E+00	1.385E+00	5.896E+00	1.900E-01
33	1992	1.170	2.936E+00	1.993E+00	2.331E+00	2.331E+00	6.741E-01	6.684E+00	9.384E-02
34	1993	0.697	1.279E+00	1.078E+00	7.510E-01	7.510E-01	3.706E-01	3.982E+00	4.088E-02
35	1994	0.121	8.989E-01	1.007E+00	1.220E-01	1.220E-01	3.468E-01	6.922E-01	2.873E-02
36	1995	0.066	1.124E+00	1.295E+00	8.500E-02	8.500E-02	4.438E-01	3.751E-01	3.591E-02
37	1996	0.067	1.483E+00	1.706E+00	1.140E-01	1.140E-01	5.806E-01	3.819E)1	4.738E-02
38	1997	0.100	1.949E+00	2.201E+00	2.200E-01	2.200E-01	7.431E-01	5.712E)1	6.229E-02
39	1998	0.150	2.472E+00	2.716E+00	4.070E-01	4.070E-01	9.093E-01	8.562E-01	7.901E-02
40	1999	0.154	2.974E+00	3.257E+00	5.000E-01	5.000E-01	1.080E+00	8.773E-01	9.506E-02
41	2000		3.555E+00						1.136E-01

3Ps American plaice -- ASPIC 3.65

RESULTS FOR DATA SERIES # 1 (NON-BOOTSTRAPPED) Canadian Fishery

Data type CC: CPUE-catch series Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed yield	Model yield	Resid in log effort	Resid in yield
1	1960	*	5.336E-03	0.0321	8.870E-01	8.870E-01	0.00000	0.000E+00
2	1961	*	7.579E-03	0.0456	1.455E+00	1.455E+00	0.00000	0.000E+00
3	1962	*	4.716E-03	0.0284	1.024E+00	1.024E+00	0.00000	0.000E+00
4	1963	*	3.103E-03	0.0187	7.540E-01	7.540E-01	0.00000	0.000E+00
5	1964	*	5.820E-03	0.0351	1.542E+00	1.542E+00	0.00000	0.000E+00
6	1965	*	7.209E-03	0.0434	2.022E+00	2.022E+00	0.00000	0.000E+00
7	1966	*	1.181E-02	0.0711	3.406E+00	3.406E+00	0.00000	0.000E+00
8	1967	*	1.560E-02	0.0939	4.494E+00	4.494E+00	0.00000	0.000E+00
9	1968	*	5.586E-02	0.3364	1.428E+01	1.428E+01	0.00000	0.000E+00
10	1969	*	2.881E-02	0.1735	6.491E+00	6.491E+00	0.00000	0.000E+00
11	1970	*	6.176E-02	0.3719	1.233E+01	1.233E+01	0.00000	0.000E+00
12	1971	*	4.109E-02	0.2475	7.182E+00	7.182E+00	0.00000	0.000E+00
13	1972	*	3.934E-02	0.2369	6.538E+00	6.538E+00	0.00000	0.000E+00
14	1973	*	1.133E-01	0.6822	1.477E+01	1.477E+01	0.00000	0.000E+00
15	1974	*	6.883E-02	0.4145	6.598E+00	6.598E+00	0.00000	0.000E+00
16	1975	*	4.791E-02	0.2886	4.211E+00	4.211E+00	0.00000	0.000E+00
17	1976	*	6.690E-02	0.4029	5.458E+00	5.458E+00	0.00000	0.000E+00
18	1977	*	6.324E-02	0.3809	4.605E+00	4.605E+00	0.00000	0.000E+00
19	1978	*	5.375E-02	0.3237	3.658E+00	3.658E+00	0.00000	0.000E+00
20	1979	*	5.624E-02	0.3387	3.666E+00	3.666E+00	0.00000	0.000E+00
21	1980	*	4.580E-02	0.2759	2.935E+00	2.935E+00	0.00000	0.000E+00
22	1981	*	5.013E-02	0.3019	3.217E+00	3.217E+00	0.00000	0.000E+00
23	1982	*	3.271E-02	0.1970	2.186E+00	2.186E+00	0.00000	0.000E+00
24	1983	1.443E-02	2.297E-02	0.1383	1.726E+00	1.726E+00	-0.46478	0.000E+00
25	1984	5.339E-02	3.573E-02	0.2152	2.963E+00	2.963E+00	0.40167	0.000E+00
26	1985	3.365E-02	5.023E-02	0.3025	4.220E+00	4.220E+00	-0.40047	0.000E+00
27	1986	7.027E-02	6.578E-02	0.3962	5.130E+00	5.130E+00	0.06603	0.000E+00
28	1987	6.843E-02	7.982E-02	0.4807	5.331E+00	5.331E+00	-0.15390	0.000E+00
29	1988	7.050E-02	7.949E-02	0.4787	4.406E+00	4.406E+00	-0.12009	0.000E+00
30	1989	7.681E-02	6.013E-02	0.3622	2.957E+00	2.957E+00	0.24471	0.000E+00
31	1990	3.129E-01	9.960E-02	0.5998	4.130E+00	4.130E+00	1.14467	0.000E+00
32	1991	1.336E-01	1.713E-01	1.0318	4.395E+00	4.395E+00	-0.24875	0.000E+00
33	1992	1.457E-01	1.942E-01	1.1697	2.331E+00	2.331E+00	-0.28751	0.000E+00
34	1993	1.273E-01	1.157E-01	0.6969	7.510E-01	7.510E-01	0.09537	0.000E+00
35	1994	1.080E-02	2.011E-02	0.1211	1.220E-01	1.220E-01	-0.62211	0.000E+00
36	1995	8.019E-03	1.090E-02	0.0656	8.500E-02	8.500E-02	-0.30679	0.000E+00
37	1996	9.120E-03	1.110E-02	0.0668	1.140E-01	1.140E-01	-0.19633	0.000E+00
38	1997	2.558E-02	1.660E-02	0.1000	2.200E-01	2.200E-01	0.43257	0.000E+00
39	1998	2.807E-02	2.488E-02	0.1498	4.070E-01	4.070E-01	0.12059	0.000E+00
40	1999	3.425E-02	2.549E-02	0.1535	5.000E-01	5.000E-01	0.29527	0.000E+00

* Asterisk indicates missing value(s).

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3Ps American plaice -- ASPIC 3.65

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 1
                  -2        -1.5       -1       -0.5        0        0.5        1        1.5        2
                   |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual   ---------------------------------------------------------------------------------
1960    0.0000                                             |
1961    0.0000                                             |
1962    0.0000                                             |
1963    0.0000                                             |
1964    0.0000                                             |
1965    0.0000                                             |
1966    0.0000                                             |
1967    0.0000                                             |
1968    0.0000                                             |
1969    0.0000                                             |
1970    0.0000                                             |
1971    0.0000                                             |
1972    0.0000                                             |
1973    0.0000                                             |
1974    0.0000                                             |
1975    0.0000                                             |
1976    0.0000                                             |
1977    0.0000                                             |
1978    0.0000                                             |
1979    0.0000                                             |
1980    0.0000                                             |
1981    0.0000                                             |
1982    0.0000                                             |
1983   -0.4648                                    =========|
1984    0.4017                                             |========
1985   -0.4005                                     ========|
1986    0.0660                                             |=
1987   -0.1539                                          ===|
1988   -0.1201                                           ==|
1989    0.2447                                             |=====
1990    1.1447                                             |=======================
1991   -0.2487                                        =====|
1992   -0.2875                                       ======|
1993    0.0954                                             |==
1994   -0.6221                                 ============|
1995   -0.3068                                       ======|
1996   -0.1963                                         ====|
1997    0.4326                                             |=========
1998    0.1206                                             |==
1999    0.2953                                             |======
                  ---------------------------------------------------------------------------------
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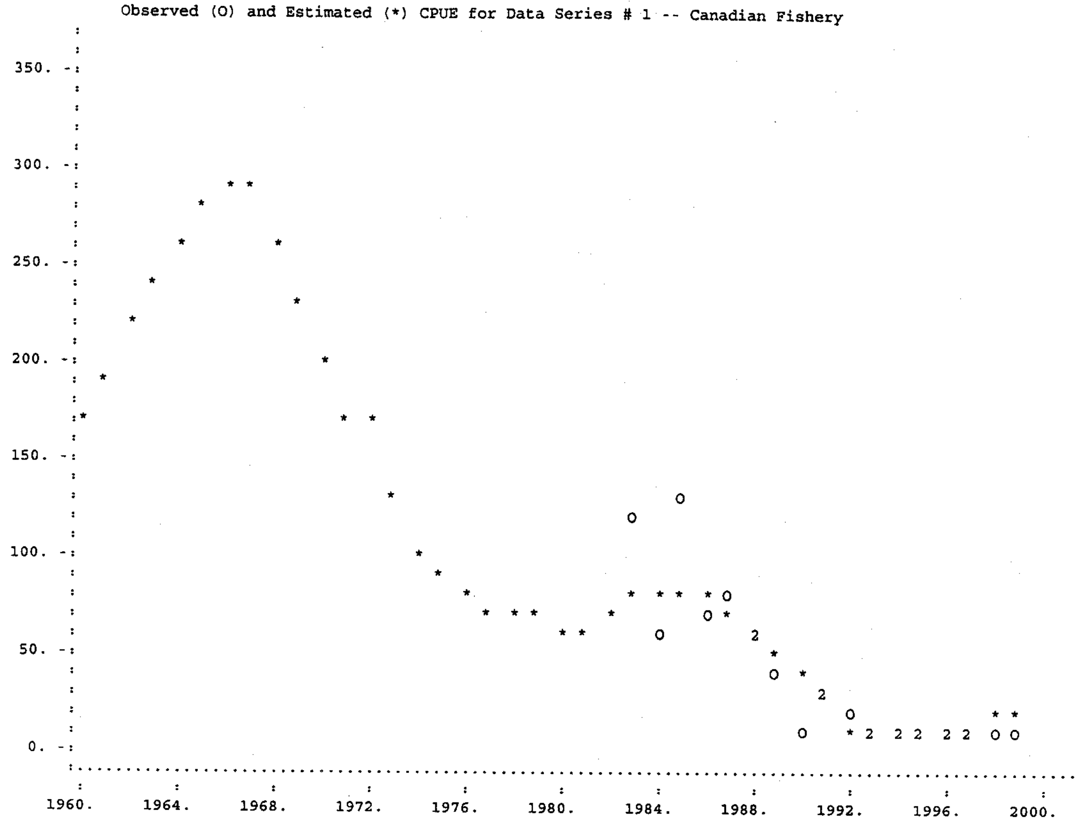
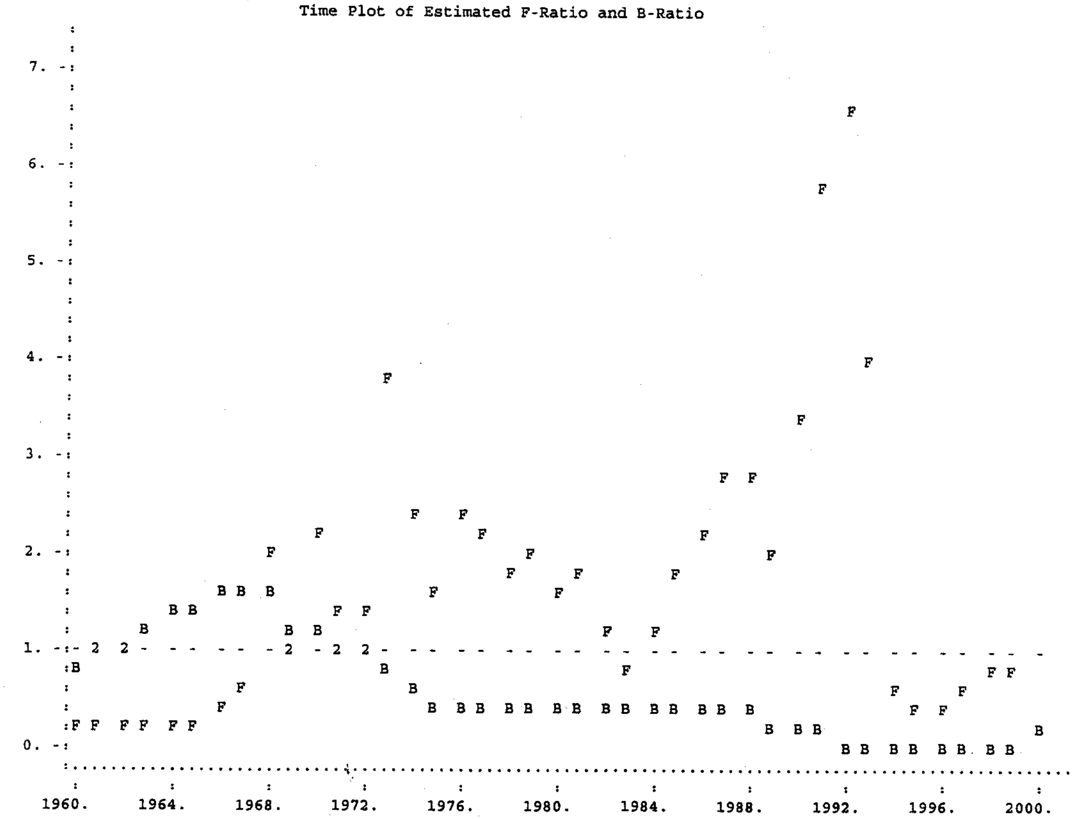
3Ps American plaice -- ASPIC 3.65

Observed (O) and Estimated (*) CPUE for Data Series # 1 -- Canadian Fishery



Time Plot of Estimated F-Ratio and B-Ratio



APPENDIX B1

BOOTSTRAPPING RESULTS

3Ps American plaice -- ASPIC 3.65

RESULTS OF BOOTSTRAPPED ANALYSIS

Param name	Bias-corrected estimate	Ordinary estimate	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
B1ratio	7.956E-01	8.739E-01	9.84%	3.830E-01	4.631E+00	6.556E-01	1.150E+00	4.947E-01	0.622
K	6.259E+01	6.209E+01	-0.80%	5.761E+01	7.122E+01	6.065E+01	6.427E+01	3.622E+00	0.058
r	3.500E-01	3.500E-01	0.00%	3.500E-01	3.500E-01	3.500E-01	3.500E-01	0.000E+00	0.000
q(1)	6.002E+00	6.017E+00	0.25%	4.917E+00	7.080E+00	5.365E+00	6.598E+00	1.233E+00	0.205
MSY	5.477E+00	5.433E+00	-0.80%	5.041E+00	6.232E+00	5.307E+00	5.623E+00	3.169E-01	0.058
Ye(2000)	1.132E+00	1.174E+00	3.74%	6.807E-01	1.583E+00	9.213E-01	1.380E+00	4.591E-01	0.406
Bmsy	3.130E+01	3.104E+01	-0.80%	2.880E+01	3.561E+01	3.032E+01	3.213E+01	1.811E+00	0.058
Fmsy	1.750E-01	1.750E-01	0.00%	1.750E-01	1.750E-01	1.750E-01	1.750E-01	0.000E+00	0.000
fmsy(1)	2.916E-02	2.909E-02	-0.25%	2.470E-02	3.559E-02	2.653E-02	3.262E-02	6.093E-03	0.209
F(0.1)	1.575E-01	1.575E-01	0.00%	1.575E-01	1.575E-01	1.575E-01	1.575E-01	0.000E+00	0.000
Y(0.1)	5.422E+00	5.378E+00	-0.80%	4.990E+00	6.170E+00	5.254E+00	5.567E+00	3.137E-01	0.058
B-ratio	1.110E-01	1.146E-01	3.31%	6.517E-02	1.617E-01	8.900E-02	1.371E-01	4.811E-02	0.433
F-ratio	9.080E-01	8.762E-01	-3.50%	6.513E-01	1.520E+00	7.459E-01	1.117E+00	3.710E-01	0.409
Y-ratio	2.097E-01	2.161E-01	3.10%	1.261E-01	2.973E-01	1.701E-01	2.554E-01	8.533E-02	0.407
f0.1(1)	2.624E-02	2.618E-02	-0.22%	2.223E-02	3.203E-02	2.387E-02	2.936E-02	5.484E-03	0.209

NOTES ON BOOTSTRAPPED ESTIMATES:

- The bootstrapped results shown were computed from 500 trials.
- These results are conditional on the constraints placed upon MSY and r in the input file (ASPIC.INP).
- All bootstrapped intervals are approximate. The statistical literature recommends using at least 1000 trials for accurate 95% intervals. The 80% intervals used by ASPIC should require fewer trials for equivalent accuracy. Using at least 500 trials is recommended.
- The bias corrections used here are based on medians. This is an accepted statistical procedure, but may estimate nonzero bias for unbiased, skewed estimators.

Trials replaced for lack of convergence:	3
Trials replaced for MSY out-of-bounds:	0
Trials replaced for r out-of-bounds:	0
Residual-adjustment factor:	1.1019