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# Surplus Production Analysis of Shrimp in the Denmark Strait, 1977-1998

by

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## Abstract

A revised nonequilibrium surplus production model (ASPIC) of landings, effort, and survey indices of shrimp in the northern area of the Denmark Strait suggests that a maximum sustainable yield (MSY) of 8,000 tons can be produced by a stock biomass of 23,000 tons ($B_{MSY}$) at a fishing mortality of 0.35 ($F_{MSY}$). The model indicates that biomass was near the stock's carrying capacity at the beginning of the fishery (1978), decreased to less than $B_{MSY}$ as landings exceeded sustainable levels in the late-1980s and early-1990s, then increased to above $B_{MSY}$ in the late-1990s when landings were relatively low. Precautionary management targets can be derived from conditional probability distributions of MSY and $F_{MSY}$ (e.g. a long-term target catch of 7,200 tons would have a 90% chance of being less than MSY), and risk of management decisions can be assessed with stochastic projection, which incorporates uncertainty in production model parameters and current biomass (e.g. a target catch for 1999 of 5,000 tons has a very low probability of exceeding $F_{MSY}$ or decreasing the stock to below $B_{MSY}$).

## Introduction

A fishery for shrimp (*Pandalus borealis*) in the Denmark Strait began in 1978 and developed to an international fishery yielding up to 12,500 tons annually (Skúladóttir, 1998). The fishery traditionally operated north of 65°N, but began exploiting more southerly areas in 1993. Coastal states request fishery management advice for the Denmark Strait shrimp stock from NAFO (NAFO, 1997). NAFO has endorsed a 'precautionary approach' to fishery management which is based on maintaining $B_{MSY}$ (the level of stock biomass which will produce maximum sustainable yield, MSY), while limiting fishing mortality to below the level which produces MSY ($F_{MSY}$) (Serchuk et al., 1997).

Surplus production models can provide guidance on MSY, $B_{MSY}$, and $F_{MSY}$ where information on age structure is unavailable or unreliable, and provide a valuable perspective for stock assessment. Skúladóttir (1985, 1990) modeled the exponential relationship of yield and catch-per-unit-effort (CPUE; Fox, 1970) from 1980 to 1989 and reported that fishing effort on the Denmark Strait shrimp stock was exceeding sustainable levels and annual catches should be reduced to less than 10,000 tons. A preliminary nonequilibrium production analysis was developed at the November 1997 meeting of the NAFO Scientific Council (Cadrin, 1997) and was reviewed at the March 1998 Scientific Council Meeting (Cadrin and Skúladóttir, 1998). The present investigation was performed to update the previous analysis, revise estimates of MSY, $B_{MSY}$, and $F_{MSY}$, and derive precautionary management targets.

## Methods

A surplus production model incorporating covariates (ASPIC; Prager, 1994, 1995) was applied to the shrimp fishery in the northern area of the Denmark Strait (north of 65°N) using landings, historical unstandardized effort (1978-1987; Skúladóttir, 1998a), standardized commercial catch rates (CPUE; 1987-1997; Skúladóttir, 1998b), and the Greenland survey index of stock abundance (Carlsson, 1996). The model assumes logistic population growth, in which the change in stock biomass over time ($dB_t/dt$) is a quadratic function of biomass (B):

$$dB_t/dt = rB_t - (r/K)B_t^2 \quad (1)$$

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

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

MSY, $B_{MSY}$, and $F_{MSY}$ can be calculated from the production model parameters:

$$MSY = Kr/4 \quad (3)$$
$$B_{MSY} = K/2 \quad (4)$$
$$F_{MSY} = r/2 \quad (5)$$

Initial biomass (expressed as a ratio to $B_{MSY}$: *B1R*), $r$, MSY, historic commercial catchability ($q_1$), catchability of standardized CPUE ($q_2$), and survey catchability ($q_3$) were estimated using nonlinear least squares of lognormally distributed observation errors in historic effort, standardized CPUE, and survey indices. The Norway survey, 1985-1989 (NAFO, 1990), was negatively correlated with unstandardized CPUE and could not be used as a tuning index. Total model error included a penalty function for estimates of *B1R* greater than 2 (initial biomass exceeding the carrying capacity, Prager, 1994). Historic effort, standardized CPUE, and survey indices were iteratively reweighted based on initial mean square errors (MSE). Observation errors were randomly resampled for 1,000 bootstrap simulations to assess model precision. The 1998 TAC (5,000 tons) was assumed for 1999 to project the model one year using all 1,000 bootstrap solutions and provide a conditional probability distribution of biomass in the year 2000. Several alternative analyses were conducted to assess the sensitivity of results to the penalty function, iterative reweighting, and including catch and effort from the southern area (south of 65°N).

## Results

Annual landings of shrimp in the Denmark Strait increased from an annual average of 6,200 tons in the early-1980s to a peak of 12,600 tons in 1988, and gradually decreased to an annual average of 3,600 in the last three years. Survey indices and CPUE generally declined in the 1980s and increased in the 1990s, but correlation between CPUE and the survey series was weak ($r = 0.1$). The model fit the CPUE data well: most of the variance in CPUE was explained by the production model ($R^2 = 0.62$, and 0.73), and there were no apparent patterns in model residuals (Appendix A). The model did not fit the survey data well ($r^2 = 0.22$), and there was a strong pattern in the residuals, in which the survey indicated a greater increase in biomass in the 1990s than predicted by the model.

The production model indicated that an MSY of 8,000 tons can be produced by the Denmark Strait shrimp stock when biomass is approximately 23,000 tons. $F_{MSY}$ was estimated to be 0.35. The model suggests that biomass was near the stock's carrying capacity (46,000 tons) in the late-1970s, decreased to 13,000 in the early-1990s, then grew to 29,000 tons in 1999, which is 124% of $B_{MSY}$. Annual estimates of F averaged 0.15 in the early-1980s, increased to 0.60 by 1990-1991, then decreased to 0.15 in 1998, which is 42% of $F_{MSY}$. Sensitivity analysis showed that results were very similar with no penalty function for *B1R*>2, and equal weighting of tuning indices. Including catch and effort from the southern area (south of 65°N) substantially increased estimates of MSY and $F_{MSY}$, and decreased the estimate of $B_{MSY}$, but decreased goodness of fit (Cadrin and Skúladóttir, 1998).

Bootstrap estimates suggest that MSY was precisely estimated (relative interquartile range, IQR, of bootstrap estimates was 9%), and other parameters were estimated with moderate precision (IQRs were 8% to 35%). Stochastic projection of 5,000 tons catch in 1999, which was the 1998 TAC recommended by the NAFO Scientific Council, suggests that biomass will slightly increase to 32,000 tons with an 80% bootstrap confidence limit of 27,000 to 39,000 tons, which

is well above $B_{MSY}$ (23,000 tons). The projection also indicates that a 5,000 tons catch will slightly increase F to 0.16 in 1999 with an 80% confidence limit of 0.13 to 0.19, which is well below $F_{MSY}$ (0.35).

## Discussion

This analysis provides guidance on stock status and management advice for the shrimp stock in the northern area of the Denmark Strait. Limit reference points can be defined directly from model results: according to the precautionary approach, the fishery should be managed to limit catch to less than 8,000 tons, maintain a stock biomass of at least 23,000 tons, and limit F to less than 0.35. Precautionary targets can be derived from conditional bootstrap distributions of MSY and $F_{MSY}$: a long-term target catch of 7,200 tons would have a 90% probability of being less than MSY, and a long-term target F of 0.23 would have a 90% chance of being less than $F_{MSY}$. These limits and targets apply to a healthy stock, which has a biomass greater than $B_{MSY}$. If the stock should decrease to less than $B_{MSY}$, more restrictive catch and F targets should be advised to rebuild the stock to at least $B_{MSY}$.

These results apply to the northern area of the Denmark Strait stock. Recent landings from south of 65°N are apparently from a previously unexploited resource which is not accurately represented by CPUE or survey catches in the northern area. Including catch and effort from the southern area in these analyses produces unrealistically high values of $r$ (Cadrin and Skúladóttir, 1998).

Estimates of MSY and effort at MSY ($f_{MSY}$) were less than those reported by Skúladóttir (1990) and $CPUE_{MSY}$ was greater. The lower MSY estimate from ASPIC, as compared to previous estimates by Skúladóttir (1990) may result from several aspects of this revised analysis: more years of data providing more contrast in production observations, assuming logistic growth rather than Gompertz growth (Fox, 1970), allowing for non-equilibrium conditions, or tuning biomass estimates with the survey and standardized CPUE indices.

The increase in biomass estimates since 1992 suggests that the stock can sustain the recent levels of catch. However, the increase in CPUE may result from qualitative changes in effort in the northern area or technological improvements in fishing power, and stock biomass may not have increased as substantially as the survey abundance index suggests. If relative changes in CPUE and survey indices do not reflect changes in stock biomass, model results may be misleading. Modifications to this analysis should be explored to improve input data (e.g. an extended series of standardized effort and development of survey biomass indices).

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**Appendix A.**

Denmark Strait Shrimp, Northern Area (biomass and yield in kt units)


04 Nov 1998 at 10:12
IRF Mode

ASPIC -- A Surplus-Production Model Including Covariates (Ver. 3.64)

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CONTROL PARAMETERS USED (FROM INPUT FILE)

| | | | |
|---|---|---|---|
| Number of years analyzed: | 22 | Number of bootstrap trials: | 0 |
| Number of data series: | 3 | Lower bound on MSY: | 1.000E+00 |
| Objective function computed: | in EFFORT | Upper bound on MSY: | 5.000E+01 |
| Relative conv. criterion (simplex): | 1.000E-06 | 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 |

ITERATIVE REWEIGHTING PHASE

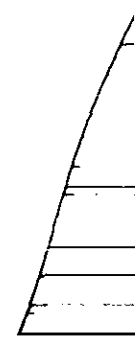
| Iter | Angle | Loss | Revised weights... | | |
|---|---|---|---|---|---|
| User | -- | -- | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| Start | -- | -- | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| 1 | 36.28 | 1.171E+00 | 1.92E+00 | 5.46E-01 | 3.69E-01 |
| 2 | 3.43 | 7.591E-01 | 1.91E+00 | 6.07E-01 | 2.65E-01 |
| 3 | 1.80 | 7.319E-01 | 1.89E+00 | 6.48E-01 | 2.19E-01 |
| 4 | 0.68 | 7.207E-01 | 1.88E+00 | 6.63E-01 | 2.02E-01 |

PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS) code 0

Normal convergence.

CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)

| | | | |
|---|---|---|---|
| 1 effort (thousand hr) | 1.000 | | |
| | 10 | | |
| 2 Standardized CPUE | 0.000 | 1.000 | |
| | 1 | 12 | |
| 3 Greenland Survey | 0.000 | 0.064 | 1.000 |
| | 0 | 6 | 6 |
| | 1 | 2 | 3 |



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 | 2.519E-03 | 1 | N/A | 1.000E+00 | N/A | |
| Loss( 1) | effort (thousand hr) | 2.609E-01 | 10 | 3.262E-02 | 1.892E+00 | 1.883E+00 | 0.625 |
| Loss( 2) | Standardized CPUE | 3.169E-01 | 12 | 3.169E-02 | 6.475E-01 | 6.633E-01 | 0.726 |
| Loss( 3) | Greenland Survey | 1.403E-01 | 6 | 3.509E-02 | 2.189E-01 | 2.025E-01 | 0.218 |

TOTAL OBJECTIVE FUNCTION: 7.20704346E-01

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

Number of restarts required for convergence: 8
Est. B-ratio coverage index (0 worst, 2 best): 1.4483
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 1977 | 2.103E+00 | 2.000E+00 | 1 | 1 |
| MSY | Maximum sustainable yield | 8.025E+00 | 1.000E+01 | 1 | 1 |
| r | Intrinsic rate of increase | 6.928E-01 | 9.000E-01 | 1 | 1 |
| ..... | Catchability coefficients by fishery: | | | | |
| q( 1) | effort (thousand hr) | 5.458E-03 | 1.000E-02 | 1 | 1 |
| q( 2) | Standardized CPUE | 6.820E-02 | 5.000E-02 | 1 | 1 |
| q( 3) | Greenland Survey | 2.137E+01 | 1.700E+01 | 1 | 1 |

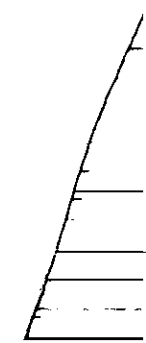
MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

| Parameter | | Estimate | Formula | | |
|---|---|---|---|---|---|
| MSY | Maximum sustainable yield | 8.025E+00 | Kr/4 | | |
| K | Maximum stock biomass | 4.633E+01 | | | |
| Bmsy | Stock biomass at MSY | 2.317E+01 | K/2 | | |
| Fmsy | Fishing mortality at MSY | 3.464E-01 | r/2 | | |
| F(0.1) | Management benchmark | 3.118E-01 | 0.9*Fmsy | | |
| Y(0.1) | Equilibrium yield at F(0.1) | 7.945E+00 | 0.99*MSY | | |
| B-ratio | Ratio of B(1999) to Bmsy | 1.243E+00 | | | |
| F-ratio | Ratio of F(1998) to Fmsy | 4.185E-01 | | | |
| Y-ratio | Proportion of MSY avail in 1999 | 9.412E-01 | 2*Br-Br^2 | Ye(1999) = | 7.553E+00 |
| ..... | Fishing effort at MSY in units of each fishery: | | | | |
| fmsy( 1) | effort (thousand hr) | 6.346E+01 | r/2q( 1) | f(0.1) = | 5.712E+01 |

Denmark Strait Shrimp, Northern Area (biomass and yield in kt units)

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 | 1977 | 0.000 | 4.873E+01 | 4.804E+01 | 0.000E+00 | 0.000E+00 | -1.222E+00 | 0.000E+00 | 2.103E+00 |
| 2 | 1978 | 0.008 | 4.751E+01 | 4.785E+01 | 3.634E-01 | 3.634E-01 | -4.805E-01 | 2.193E-02 | 2.051E+00 |
| 3 | 1979 | 0.028 | 4.666E+01 | 4.605E+01 | 1.285E+00 | 1.285E+00 | 1.972E-01 | 8.055E-02 | 2.014E+00 |
| 4 | 1980 | 0.199 | 4.557E+01 | 4.226E+01 | 8.405E+00 | 8.405E+00 | 2.534E+00 | 5.741E-01 | 1.967E+00 |
| 5 | 1981 | 0.122 | 3.970E+01 | 3.933E+01 | 4.792E+00 | 4.792E+00 | 4.120E+00 | 3.517E-01 | 1.714E+00 |
| 6 | 1982 | 0.126 | 3.903E+01 | 3.875E+01 | 4.902E+00 | 4.902E+00 | 4.396E+00 | 3.652E-01 | 1.685E+00 |
| 7 | 1983 | 0.108 | 3.852E+01 | 3.867E+01 | 4.175E+00 | 4.175E+00 | 4.436E+00 | 3.117E-01 | 1.663E+00 |
| 8 | 1984 | 0.178 | 3.879E+01 | 3.775E+01 | 6.731E+00 | 6.731E+00 | 4.845E+00 | 5.148E-01 | 1.674E+00 |
| 9 | 1985 | 0.228 | 3.690E+01 | 3.558E+01 | 8.110E+00 | 8.110E+00 | 5.715E+00 | 6.580E-01 | 1.593E+00 |
| 10 | 1986 | 0.340 | 3.450E+01 | 3.220E+01 | 1.096E+01 | 1.096E+01 | 6.784E+00 | 9.829E-01 | 1.489E+00 |
| 11 | 1987 | 0.437 | 3.032E+01 | 2.786E+01 | 1.218E+01 | 1.218E+01 | 7.672E+00 | 1.262E+00 | 1.309E+00 |
| 12 | 1988 | 0.538 | 2.582E+01 | 2.333E+01 | 1.256E+01 | 1.256E+01 | 7.999E+00 | 1.553E+00 | 1.114E+00 |
| 13 | 1989 | 0.545 | 2.126E+01 | 1.970E+01 | 1.074E+01 | 1.074E+01 | 7.834E+00 | 1.574E+00 | 9.177E-01 |
| 14 | 1990 | 0.611 | 1.835E+01 | 1.682E+01 | 1.028E+01 | 1.028E+01 | 7.411E+00 | 1.764E+00 | 7.922E-01 |
| 15 | 1991 | 0.594 | 1.549E+01 | 1.457E+01 | 8.657E+00 | 8.657E+00 | 6.915E+00 | 1.715E+00 | 6.686E-01 |
| 16 | 1992 | 0.567 | 1.375E+01 | 1.324E+01 | 7.514E+00 | 7.514E+00 | 6.550E+00 | 1.638E+00 | 5.934E-01 |
| 17 | 1993 | 0.471 | 1.278E+01 | 1.297E+01 | 6.110E+00 | 6.110E+00 | 6.468E+00 | 1.360E+00 | 5.517E-01 |
| 18 | 1994 | 0.345 | 1.314E+01 | 1.411E+01 | 4.873E+00 | 4.873E+00 | 6.793E+00 | 9.969E-01 | 5.672E-01 |
| 19 | 1995 | 0.381 | 1.506E+01 | 1.568E+01 | 5.974E+00 | 5.974E+00 | 7.184E+00 | 1.100E+00 | 6.500E-01 |
| 20 | 1996 | 0.156 | 1.627E+01 | 1.867E+01 | 2.916E+00 | 2.916E+00 | 7.693E+00 | 4.510E-01 | 7.023E-01 |
| 21 | 1997 | 0.181 | 2.105E+01 | 2.303E+01 | 4.157E+00 | 4.157E+00 | 8.006E+00 | 5.212E-01 | 9.084E-01 |
| 22 | 1998 | 0.145 | 2.489E+01 | 2.692E+01 | 3.903E+00 | 3.903E+00 | 7.795E+00 | 4.185E-01 | 1.075E+00 |
| 23 | 1999 | | 2.879E+01 | | | | | | 1.243E+00 |



RESULTS FOR DATA SERIES # 1 (NON-BOOTSTRAPPED) effort (thousand hr)

Data type CE: Effort-catch series Series weight: 1.892

| Obs | Year | Observed effort | Estimated effort | Estim F | Observed yield | Model yield | Resid in log effort | Resid in yield |
|---|---|---|---|---|---|---|---|---|
| 1 | 1977 | * | 0.000E+00 | 0.0000 | 0.000E+00 | 0.000E+00 | 0.00000 | 0.000E+00 |
| 2 | 1978 | 1.250E+00 | 1.392E+00 | 0.0076 | 3.634E-01 | 3.634E-01 | -0.10736 | 0.000E+00 |
| 3 | 1979 | 5.688E+00 | 5.113E+00 | 0.0279 | 1.285E+00 | 1.285E+00 | 0.10665 | 0.000E+00 |
| 4 | 1980 | 3.459E+01 | 3.644E+01 | 0.1989 | 8.405E+00 | 8.405E+00 | -0.05204 | 0.000E+00 |
| 5 | 1981 | 1.959E+01 | 2.232E+01 | 0.1218 | 4.792E+00 | 4.792E+00 | -0.13069 | 0.000E+00 |
| 6 | 1982 | 2.308E+01 | 2.318E+01 | 0.1265 | 4.902E+00 | 4.902E+00 | -0.00419 | 0.000E+00 |
| 7 | 1983 | 2.367E+01 | 1.979E+01 | 0.1080 | 4.175E+00 | 4.175E+00 | 0.17922 | 0.000E+00 |
| 8 | 1984 | 3.197E+01 | 3.267E+01 | 0.1783 | 6.731E+00 | 6.731E+00 | -0.02165 | 0.000E+00 |
| 9 | 1985 | 5.174E+01 | 4.176E+01 | 0.2279 | 8.110E+00 | 8.110E+00 | 0.21419 | 0.000E+00 |
| 10 | 1986 | 5.681E+01 | 6.238E+01 | 0.3405 | 1.096E+01 | 1.096E+01 | -0.09364 | 0.000E+00 |
| 11 | 1987 | 7.326E+01 | 8.011E+01 | 0.4372 | 1.218E+01 | 1.218E+01 | -0.08943 | 0.000E+00 |
| 12 | 1988 | * | 9.860E+01 | 0.5381 | 1.256E+01 | 1.256E+01 | 0.00000 | 0.000E+00 |
| 13 | 1989 | * | 9.992E+01 | 0.5453 | 1.074E+01 | 1.074E+01 | 0.00000 | 0.000E+00 |
| 14 | 1990 | * | 1.119E+02 | 0.6109 | 1.028E+01 | 1.028E+01 | 0.00000 | 0.000E+00 |
| 15 | 1991 | * | 1.089E+02 | 0.5942 | 8.657E+00 | 8.657E+00 | 0.00000 | 0.000E+00 |
| 16 | 1992 | * | 1.040E+02 | 0.5675 | 7.514E+00 | 7.514E+00 | 0.00000 | 0.000E+00 |
| 17 | 1993 | * | 8.635E+01 | 0.4712 | 6.110E+00 | 6.110E+00 | 0.00000 | 0.000E+00 |
| 18 | 1994 | * | 6.328E+01 | 0.3453 | 4.873E+00 | 4.873E+00 | 0.00000 | 0.000E+00 |
| 19 | 1995 | * | 6.981E+01 | 0.3810 | 5.974E+00 | 5.974E+00 | 0.00000 | 0.000E+00 |
| 20 | 1996 | * | 2.862E+01 | 0.1562 | 2.916E+00 | 2.916E+00 | 0.00000 | 0.000E+00 |
| 21 | 1997 | * | 3.308E+01 | 0.1805 | 4.157E+00 | 4.157E+00 | 0.00000 | 0.000E+00 |
| 22 | 1998 | * | 2.656E+01 | 0.1450 | 3.903E+00 | 3.903E+00 | 0.00000 | 0.000E+00 |

* Asterisk indicates missing value(s).

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 1

| Year | Residual | -1 -0.75 -0.5 -0.25 0 0.25 0.5 0.75 1 |
|---|---|---|
| 1977 | 0.0000 | \| |
| 1978 | -0.1074 | ====\| |
| 1979 | 0.1067 | \|==== |
| 1980 | -0.0520 | ==\| |
| 1981 | -0.1307 | =====\| |
| 1982 | -0.0042 | \| |
| 1983 | 0.1792 | \|======= |
| 1984 | -0.0217 | =\| |
| 1985 | 0.2142 | \|========= |
| 1986 | -0.0936 | ====\| |
| 1987 | -0.0894 | ====\| |
| 1988 | 0.0000 | \| |
| 1989 | 0.0000 | \| |
| 1990 | 0.0000 | \| |
| 1991 | 0.0000 | \| |
| 1992 | 0.0000 | \| |
| 1993 | 0.0000 | \| |
| 1994 | 0.0000 | \| |
| 1995 | 0.0000 | \| |
| 1996 | 0.0000 | \| |
| 1997 | 0.0000 | \| |
| 1998 | 0.0000 | \| |

RESULTS FOR DATA SERIES # 2 (NON-BOOTSTRAPPED) Standardized CPUE

Data type I1: Year-average biomass index Series weight: 0.648

| Obs | Year | Observed effort | Estimated effort | Estim F | Observed index | Model index | Resid in log index | Resid in index |
|---|---|---|---|---|---|---|---|---|
| 1 | 1977 | 0.000E+00 | 0.000E+00 | 0.0 | * | 3.276E+00 | 0.00000 | 0.0 |
| 2 | 1978 | 0.000E+00 | 0.000E+00 | 0.0 | * | 3.263E+00 | 0.00000 | 0.0 |
| 3 | 1979 | 0.000E+00 | 0.000E+00 | 0.0 | * | 3.141E+00 | 0.00000 | 0.0 |
| 4 | 1980 | 0.000E+00 | 0.000E+00 | 0.0 | * | 2.882E+00 | 0.00000 | 0.0 |
| 5 | 1981 | 0.000E+00 | 0.000E+00 | 0.0 | * | 2.683E+00 | 0.00000 | 0.0 |
| 6 | 1982 | 0.000E+00 | 0.000E+00 | 0.0 | * | 2.643E+00 | 0.00000 | 0.0 |
| 7 | 1983 | 0.000E+00 | 0.000E+00 | 0.0 | * | 2.637E+00 | 0.00000 | 0.0 |
| 8 | 1984 | 0.000E+00 | 0.000E+00 | 0.0 | * | 2.574E+00 | 0.00000 | 0.0 |
| 9 | 1985 | 0.000E+00 | 0.000E+00 | 0.0 | * | 2.427E+00 | 0.00000 | 0.0 |
| 10 | 1986 | 0.000E+00 | 0.000E+00 | 0.0 | * | 2.196E+00 | 0.00000 | 0.0 |
| 11 | 1987 | 1.000E+00 | 1.000E+00 | 0.0 | 2.280E+00 | 1.900E+00 | 0.18247 | 3.803E-01 |
| 12 | 1988 | 1.000E+00 | 1.000E+00 | 0.0 | 1.960E+00 | 1.591E+00 | 0.20834 | 3.686E-01 |
| 13 | 1989 | 1.000E+00 | 1.000E+00 | 0.0 | 1.330E+00 | 1.344E+00 | -0.01011 | -1.351E-02 |
| 14 | 1990 | 1.000E+00 | 1.000E+00 | 0.0 | 1.280E+00 | 1.147E+00 | 0.10962 | 1.329E-01 |
| 15 | 1991 | 1.000E+00 | 1.000E+00 | 0.0 | 9.500E-01 | 9.936E-01 | -0.04486 | -4.359E-02 |
| 16 | 1992 | 1.000E+00 | 1.000E+00 | 0.0 | 7.300E-01 | 9.031E-01 | -0.21279 | -1.731E-01 |
| 17 | 1993 | 1.000E+00 | 1.000E+00 | 0.0 | 6.200E-01 | 8.843E-01 | -0.35502 | -2.643E-01 |
| 18 | 1994 | 1.000E+00 | 1.000E+00 | 0.0 | 1.330E+00 | 9.624E-01 | 0.32354 | 3.676E-01 |
| 19 | 1995 | 1.000E+00 | 1.000E+00 | 0.0 | 1.320E+00 | 1.069E+00 | 0.21056 | 2.506E-01 |
| 20 | 1996 | 1.000E+00 | 1.000E+00 | 0.0 | 1.000E+00 | 1.273E+00 | -0.24139 | -2.730E-01 |
| 21 | 1997 | 1.000E+00 | 1.000E+00 | 0.0 | 1.370E+00 | 1.570E+00 | -0.13651 | -2.004E-01 |
| 22 | 1998 | 1.000E+00 | 1.000E+00 | 0.0 | 1.770E+00 | 1.836E+00 | -0.03670 | -6.617E-02 |

* Asterisk indicates missing value(s).

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 2

| Year | Residual | -1 -0.75 -0.5 -0.25 0 0.25 0.5 0.75 1 |
|---|---|---|
| 1977 | 0.0000 | \| |
| 1978 | 0.0000 | \| |
| 1979 | 0.0000 | \| |
| 1980 | 0.0000 | \| |
| 1981 | 0.0000 | \| |
| 1982 | 0.0000 | \| |
| 1983 | 0.0000 | \| |
| 1984 | 0.0000 | \| |
| 1985 | 0.0000 | \| |
| 1986 | 0.0000 | \| |
| 1987 | 0.1825 | \|======= |
| 1988 | 0.2083 | \|======== |
| 1989 | -0.0101 | \| |
| 1990 | 0.1096 | \|==== |
| 1991 | -0.0449 | ==\| |
| 1992 | -0.2128 | =========\| |
| 1993 | -0.3550 | ==============\| |
| 1994 | 0.3235 | \|============= |
| 1995 | 0.2106 | \|======== |
| 1996 | -0.2414 | ==========\| |
| 1997 | -0.1365 | =====\| |
| 1998 | -0.0367 | =\| |

RESULTS FOR DATA SERIES # 3 (NON-BOOTSTRAPPED) Greenland Survey

Data type I1: Year-average biomass index Series weight: 0.219

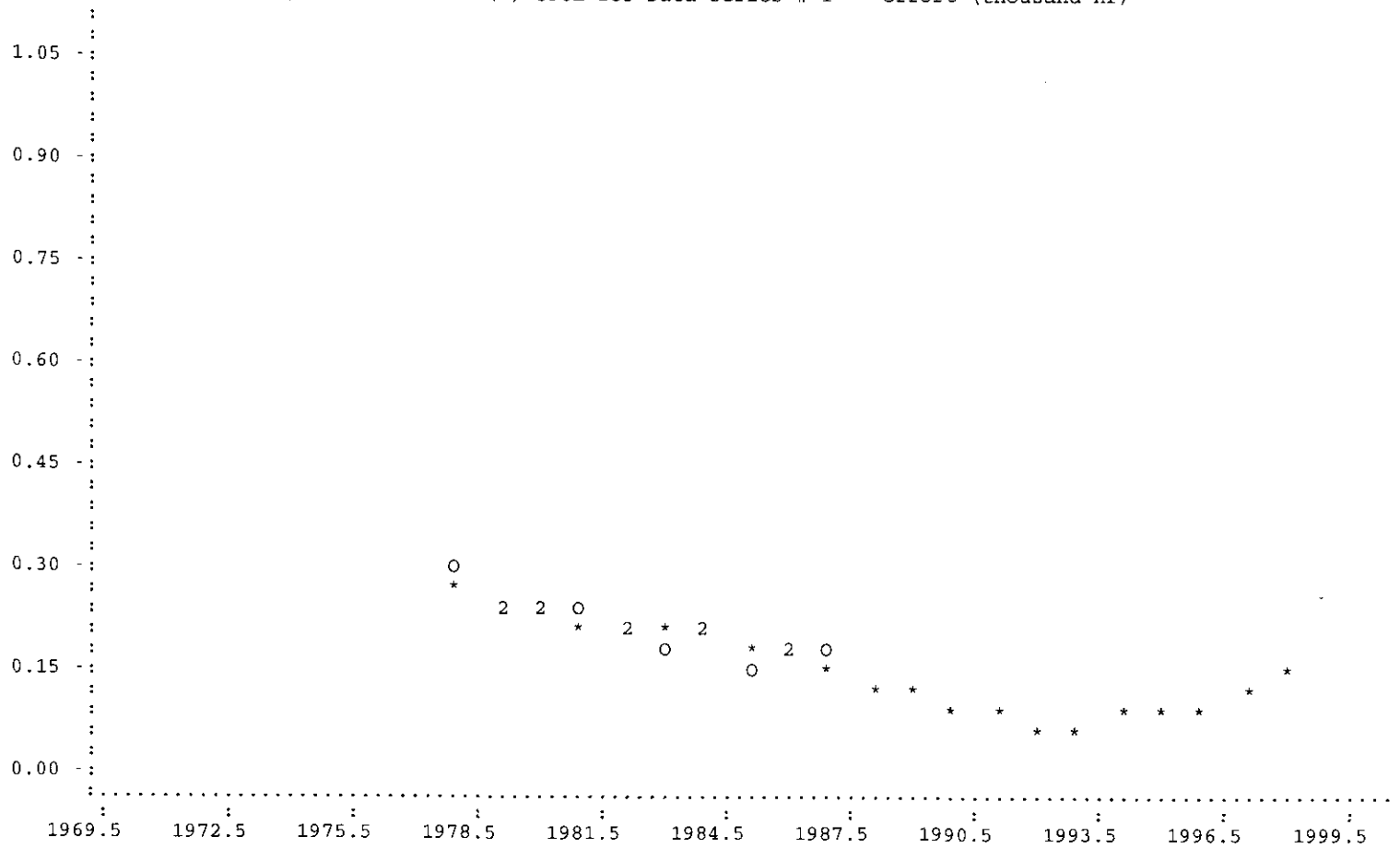
| Obs | Year | Observed effort | Estimated effort | Estim F | Observed index | Model index | Resid in log index | Resid in index |
|---|---|---|---|---|---|---|---|---|
| 1 | 1977 | 0.000E+00 | 0.000E+00 | 0.0 | * | 1.026E+03 | 0.00000 | 0.0 |
| 2 | 1978 | 0.000E+00 | 0.000E+00 | 0.0 | * | 1.022E+03 | 0.00000 | 0.0 |
| 3 | 1979 | 0.000E+00 | 0.000E+00 | 0.0 | * | 9.834E+02 | 0.00000 | 0.0 |
| 4 | 1980 | 0.000E+00 | 0.000E+00 | 0.0 | * | 9.025E+02 | 0.00000 | 0.0 |
| 5 | 1981 | 0.000E+00 | 0.000E+00 | 0.0 | * | 8.399E+02 | 0.00000 | 0.0 |
| 6 | 1982 | 0.000E+00 | 0.000E+00 | 0.0 | * | 8.275E+02 | 0.00000 | 0.0 |
| 7 | 1983 | 0.000E+00 | 0.000E+00 | 0.0 | * | 8.257E+02 | 0.00000 | 0.0 |
| 8 | 1984 | 0.000E+00 | 0.000E+00 | 0.0 | * | 8.060E+02 | 0.00000 | 0.0 |
| 9 | 1985 | 0.000E+00 | 0.000E+00 | 0.0 | * | 7.598E+02 | 0.00000 | 0.0 |
| 10 | 1986 | 0.000E+00 | 0.000E+00 | 0.0 | * | 6.876E+02 | 0.00000 | 0.0 |
| 11 | 1987 | 0.000E+00 | 0.000E+00 | 0.0 | * | 5.948E+02 | 0.00000 | 0.0 |
| 12 | 1988 | 0.000E+00 | 0.000E+00 | 0.0 | * | 4.983E+02 | 0.00000 | 0.0 |
| 13 | 1989 | 1.000E+00 | 1.000E+00 | 0.0 | 3.663E+02 | 4.206E+02 | -0.13834 | -5.434E+01 |
| 14 | 1990 | 1.000E+00 | 1.000E+00 | 0.0 | 2.283E+02 | 3.592E+02 | -0.45308 | -1.309E+02 |
| 15 | 1991 | 0.000E+00 | 0.000E+00 | 0.0 | * | 3.111E+02 | 0.00000 | 0.0 |
| 16 | 1992 | 1.000E+00 | 1.000E+00 | 0.0 | 2.090E+02 | 2.828E+02 | -0.30225 | -7.376E+01 |
| 17 | 1993 | 0.000E+00 | 0.000E+00 | 0.0 | * | 2.769E+02 | 0.00000 | 0.0 |
| 18 | 1994 | 1.000E+00 | 1.000E+00 | 0.0 | 3.548E+02 | 3.013E+02 | 0.16341 | 5.349E+01 |
| 19 | 1995 | 1.000E+00 | 1.000E+00 | 0.0 | 4.256E+02 | 3.348E+02 | 0.23993 | 9.079E+01 |
| 20 | 1996 | 1.000E+00 | 1.000E+00 | 0.0 | 6.513E+02 | 3.986E+02 | 0.49108 | 2.527E+02 |
| 21 | 1997 | 0.000E+00 | 0.000E+00 | 0.0 | * | 4.917E+02 | 0.00000 | 0.0 |
| 22 | 1998 | 0.000E+00 | 0.000E+00 | 0.0 | * | 5.749E+02 | 0.00000 | 0.0 |

* Asterisk indicates missing value(s).

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 3

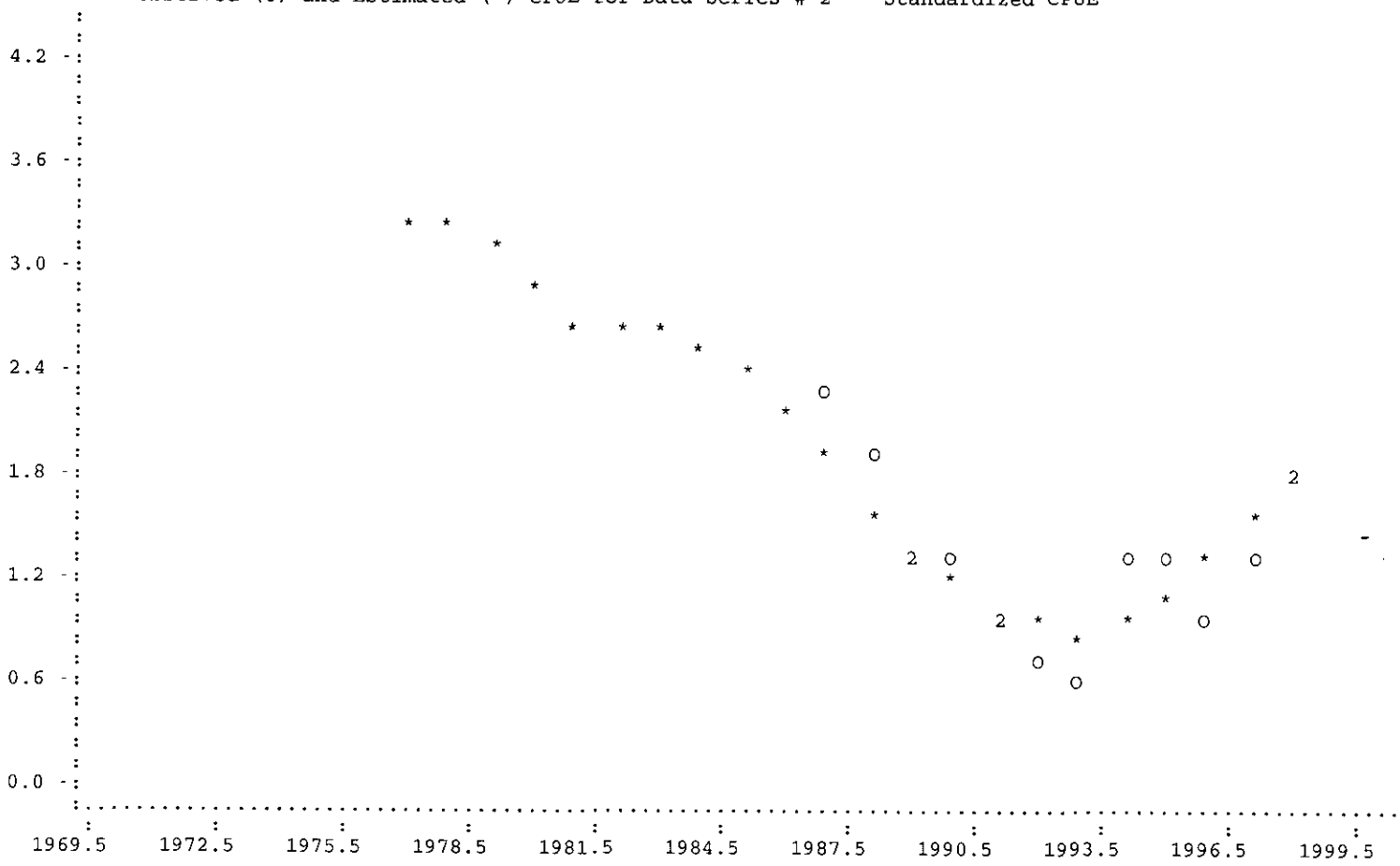
| Year | Residual | -1 -0.75 -0.5 -0.25 0 0.25 0.5 0.75 1 |
|---|---|---|
| 1977 | 0.0000 | |
| 1978 | 0.0000 | |
| 1979 | 0.0000 | |
| 1980 | 0.0000 | |
| 1981 | 0.0000 | |
| 1982 | 0.0000 | |
| 1983 | 0.0000 | |
| 1984 | 0.0000 | |
| 1985 | 0.0000 | |
| 1986 | 0.0000 | |
| 1987 | 0.0000 | |
| 1988 | 0.0000 | |
| 1989 | -0.1383 | ======\| |
| 1990 | -0.4531 | ==========\| |
| 1991 | 0.0000 | \| |
| 1992 | -0.3023 | =======\| |
| 1993 | 0.0000 | \| |
| 1994 | 0.1634 | \|======= |
| 1995 | 0.2399 | \|========== |
| 1996 | 0.4911 | \|========== |
| 1997 | 0.0000 | \| |
| 1998 | 0.0000 | \| |

Denmark Strait Shrimp, Northern Area (biomass and yield in kt units)

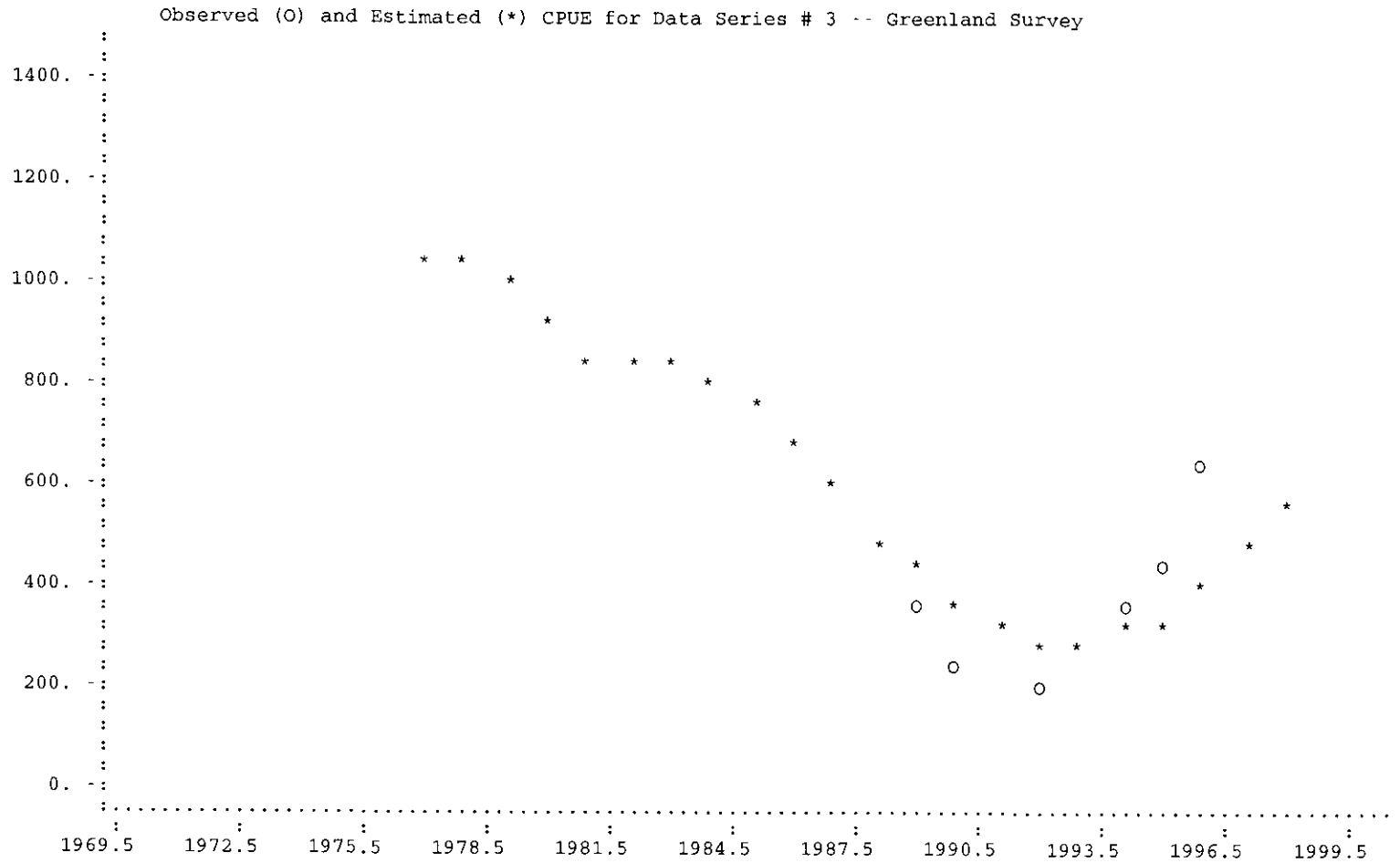


Denmark Strait Shrimp, Northern Area (biomass and yield in kt units)

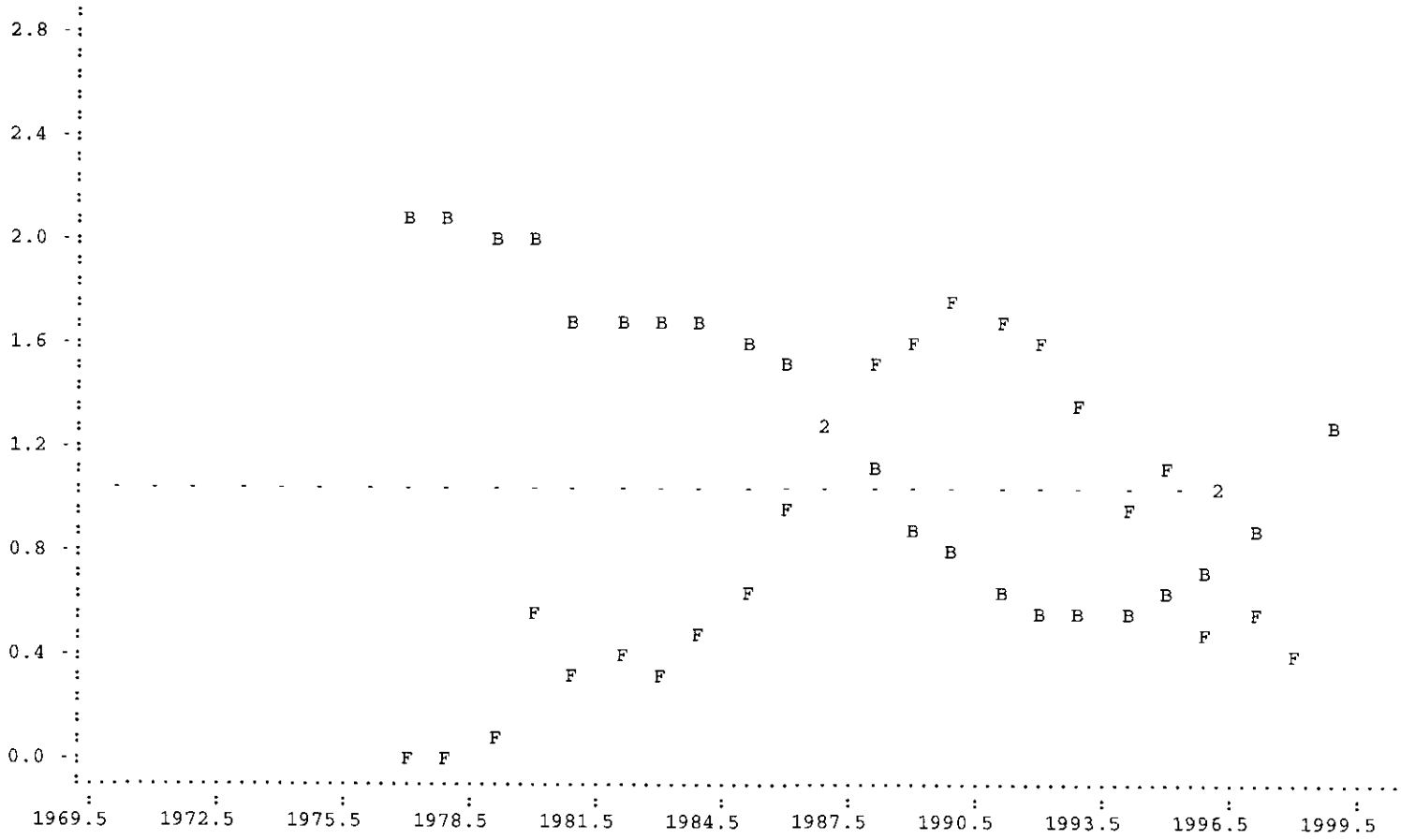
Observed (O) and Estimated (*) CPUE for Data Series # 2 -- Standardized CPUE



Denmark Strait Shrimp, Northern Area (biomass and yield in kt units)



Time Plot of Estimated F-Ratio and B-Ratio



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 | 2.181E+00 | 2.103E+00 | -3.57% | 2.017E+00 | 2.326E+00 | 2.095E+00 | 2.258E+00 | 1.628E-01 | 0.075 |
| K | 4.745E+01 | 4.636E+01 | -2.30% | 3.793E+01 | 6.159E+01 | 4.194E+01 | 5.463E+01 | 1.269E+01 | 0.268 |
| r | 6.643E-01 | 6.924E-01 | 4.22% | 4.607E-01 | 9.004E-1 | 5.456E-01 | 7.788E-01 | 2.332E-01 | 0.351 |
| q(1) | 5.232E-03 | 5.456E-03 | 4.28% | 3.902E-03 | 6.616E-03 | 4.457E-03 | 5.976E-03 | 1.518E-03 | 0.290 |
| q(2) | 6.738E-02 | 6.816E-02 | 1.16% | 4.748E-02 | 9.404E-02 | 5.691E-02 | 8.130E-02 | 2.439E-02 | 0.362 |
| q(3) | 2.111E+01 | 2.134E+01 | 1.13% | 1.411E+01 | 3.238E+01 | 1.697E+01 | 2.584E+01 | 8.867E+00 | 0.420 |
| MSY | 7.914E+00 | 8.024E+00 | 1.39% | 7.175E+00 | 8.562E+00 | 7.536E+00 | 8.259E+00 | 7.229E-01 | 0.091 |
| Ye(1999) | 7.744E+00 | 7.552E+00 | -2.48% | 7.144E+00 | 8.305E+00 | 7.436E+00 | 8.064E+00 | 6.280E-01 | 0.081 |
| Bmsy | 2.372E+01 | 2.318E+01 | -2.30% | 1.896E+01 | 3.079E+01 | 2.097E+01 | 2.732E+01 | 6.347E+00 | 0.268 |
| Fmsy | 3.322E-01 | 3.462E-01 | 4.22% | 2.303E-01 | 4.502E-01 | 2.728E-01 | 3.894E-01 | 1.166E-01 | 0.351 |
| fmsy(1) | 6.328E+01 | 6.345E+01 | 0.26% | 5.725E+01 | 6.905E+01 | 6.006E+01 | 6.612E+01 | 6.060E+00 | 0.096 |
| fmsy(2) | 5.017E+00 | 5.079E+00 | 1.24% | 4.351E+00 | 5.829E+00 | 4.627E+00 | 5.404E+00 | 7.776E-01 | 0.155 |
| fmsy(3) | 1.586E-02 | 1.622E-02 | 2.27% | 1.231E-02 | 2.012E-02 | 1.392E-02 | 1.791E-02 | 3.997E-03 | 0.252 |
| F(0.1) | 2.989E-01 | 3.116E-01 | 3.80% | 2.073E-01 | 4.052E-01 | 2.455E-01 | 3.505E-01 | 1.050E-01 | 0.351 |
| Y(0.1) | 7.835E+00 | 7.944E+00 | 1.38% | 7.104E+00 | 8.476E+00 | 7.461E+00 | 8.176E+00 | 7.156E-01 | 0.091 |
| B-ratio | 1.210E+00 | 1.242E+00 | 2.71% | 9.938E-01 | 1.414E+00 | 1.098E+00 | 1.320E+00 | 2.220E-01 | 0.183 |
| F-ratio | 4.354E-01 | 4.186E-01 | -3.87% | 3.456E-01 | 5.629E-01 | 3.819E-01 | 4.968E-01 | 1.149E-01 | 0.264 |
| Y-ratio | 9.582E-01 | 9.412E-01 | -1.77% | 8.286E-01 | 9.989E-01 | 8.974E-01 | 9.889E-01 | 9.149E-02 | 0.095 |
| f0.1(1) | 5.695E+01 | 5.710E+01 | 0.23% | 5.153E+01 | 6.214E+01 | 5.406E+01 | 5.951E+01 | 5.454E+00 | 0.096 |
| f0.1(2) | 4.515E+00 | 4.571E+00 | 1.11% | 3.916E+00 | 5.246E+00 | 4.164E+00 | 4.864E+00 | 6.998E-01 | 0.155 |
| f0.1(3) | 1.427E-02 | 1.460E-02 | 2.05% | 1.108E-02 | 1.811E-02 | 1.252E-02 | 1.612E-02 | 3.597E-03 | 0.252 |
| q2/q1 | 1.266E+01 | 1.249E+01 | -1.35% | 1.072E+01 | 1.478E+01 | 1.157E+01 | 1.366E+01 | 2.092E+00 | 0.165 |
| q3/q1 | 3.996E+03 | 3.912E+03 | -2.11% | 3.164E+03 | 5.400E+03 | 3.568E+03 | 4.656E+03 | 1.088E+03 | 0.272 |

NOTES ON BOOTSTRAPPED ESTIMATES:

- The bootstrapped results shown were computed from 1000 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: 0
Trials replaced for MSY out-of-bounds: 0
Trials replaced for r out-of-bounds: 0
Residual-adjustment factor: 1.1282

USER CONTROL INFORMATION (FROM INPUT FILE)

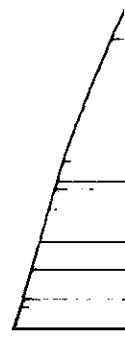
| | |
|---|---|
| Name of biomass (BIO) file | dsshrstd.bio |
| Name of output file (this file) | dsshrstd.prj |
| Number of years of projections | 1 |

| Year | Input data | User data type |
|---|---|---|
| 1999 | 5.000E+00 | TAC |

TRAJECTORY OF ABSOLUTE BIOMASS (BOOTSTRAPPED)

| Year | 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 |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 5.432E+01 | 4.872E+01 | -10.31% | 3.965E+01 | 7.882E+01 | 4.677E+01 | 6.543E+01 | 1.866E+01 | 0.344 |
| 1978 | 5.182E+01 | 4.751E+01 | -8.31% | 3.891E+01 | 7.279E+01 | 4.496E+01 | 6.154E+01 | 1.658E+01 | 0.320 |
| 1979 | 4.981E+01 | 4.667E+01 | -6.31% | 3.881E+01 | 6.831E+01 | 4.374E+01 | 5.870E+01 | 1.496E+01 | 0.300 |
| 1980 | 4.782E+01 | 4.558E+01 | -4.67% | 3.798E+01 | 6.438E+01 | 4.256E+01 | 5.601E+01 | 1.345E+01 | 0.281 |
| 1981 | 4.136E+01 | 3.971E+01 | -3.99% | 3.234E+01 | 5.567E+01 | 3.652E+01 | 4.891E+01 | 1.238E+01 | 0.299 |
| 1982 | 4.040E+01 | 3.904E+01 | -3.36% | 3.200E+01 | 5.403E+01 | 3.585E+01 | 4.739E+01 | 1.153E+01 | 0.286 |
| 1983 | 3.968E+01 | 3.853E+01 | -2.89% | 3.184E+01 | 5.269E+01 | 3.548E+01 | 4.625E+01 | 1.077E+01 | 0.272 |
| 1984 | 3.979E+01 | 3.879E+01 | -2.51% | 3.216E+01 | 5.197E+01 | 3.560E+01 | 4.589E+01 | 1.029E+01 | 0.259 |
| 1985 | 3.782E+01 | 3.691E+01 | -2.42% | 3.036E+01 | 4.910E+01 | 3.350E+01 | 4.358E+01 | 1.008E+01 | 0.267 |
| 1986 | 3.536E+01 | 3.451E+01 | -2.41% | 2.831E+01 | 4.613E+01 | 3.124E+01 | 4.087E+01 | 9.635E+00 | 0.272 |
| 1987 | 3.110E+01 | 3.033E+01 | -2.48% | 2.465E+01 | 4.126E+01 | 2.738E+01 | 3.637E+01 | 8.988E+00 | 0.289 |
| 1988 | 2.653E+01 | 2.583E+01 | -2.66% | 2.073E+01 | 3.591E+01 | 2.318E+01 | 3.133E+01 | 8.155E+00 | 0.307 |
| 1989 | 2.185E+01 | 2.127E+01 | -2.65% | 1.669E+01 | 3.039E+01 | 1.895E+01 | 2.636E+01 | 7.408E+00 | 0.339 |
| 1990 | 1.890E+01 | 1.836E+01 | -2.85% | 1.421E+01 | 2.707E+01 | 1.634E+01 | 2.307E+01 | 6.729E+00 | 0.356 |
| 1991 | 1.601E+01 | 1.550E+01 | -3.19% | 1.160E+01 | 2.377E+01 | 1.356E+01 | 1.977E+01 | 6.202E+00 | 0.387 |
| 1992 | 1.421E+01 | 1.375E+01 | -3.23% | 9.843E+00 | 2.152E+01 | 1.168E+01 | 1.782E+01 | 6.143E+00 | 0.432 |
| 1993 | 1.323E+01 | 1.279E+01 | -3.30% | 8.730E+00 | 2.069E+01 | 1.059E+01 | 1.682E+01 | 6.236E+00 | 0.471 |
| 1994 | 1.351E+01 | 1.315E+01 | -2.64% | 8.686E+00 | 2.110E+01 | 1.062E+01 | 1.706E+01 | 6.439E+00 | 0.477 |
| 1995 | 1.531E+01 | 1.507E+01 | -1.55% | 1.006E+01 | 2.283E+01 | 1.224E+01 | 1.888E+01 | 6.640E+00 | 0.434 |
| 1996 | 1.636E+01 | 1.628E+01 | -0.49% | 1.087E+01 | 2.387E+01 | 1.316E+01 | 1.996E+01 | 6.795E+00 | 0.415 |
| 1997 | 2.105E+01 | 2.106E+01 | 0.02% | 1.554E+01 | 2.832E+01 | 1.774E+01 | 2.457E+01 | 6.832E+00 | 0.324 |
| 1998 | 2.502E+01 | 2.491E+01 | -0.46% | 1.987E+01 | 3.212E+01 | 2.208E+01 | 2.844E+01 | 6.355E+00 | 0.254 |
| 1999 | 2.918E+01 | 2.880E+01 | -1.32% | 2.436E+01 | 3.613E+01 | 2.637E+01 | 3.237E+01 | 5.995E+00 | 0.205 |
| 2000 | 3.173E+01 | 3.111E+01 | -1.95% | 2.724E+01 | 3.892E+01 | 2.915E+01 | 3.504E+01 | 5.887E+00 | 0.185 |

NOTE: Printed BC confidence intervals are always approximate.
At least 500 trials are recommended when estimating confidence intervals.



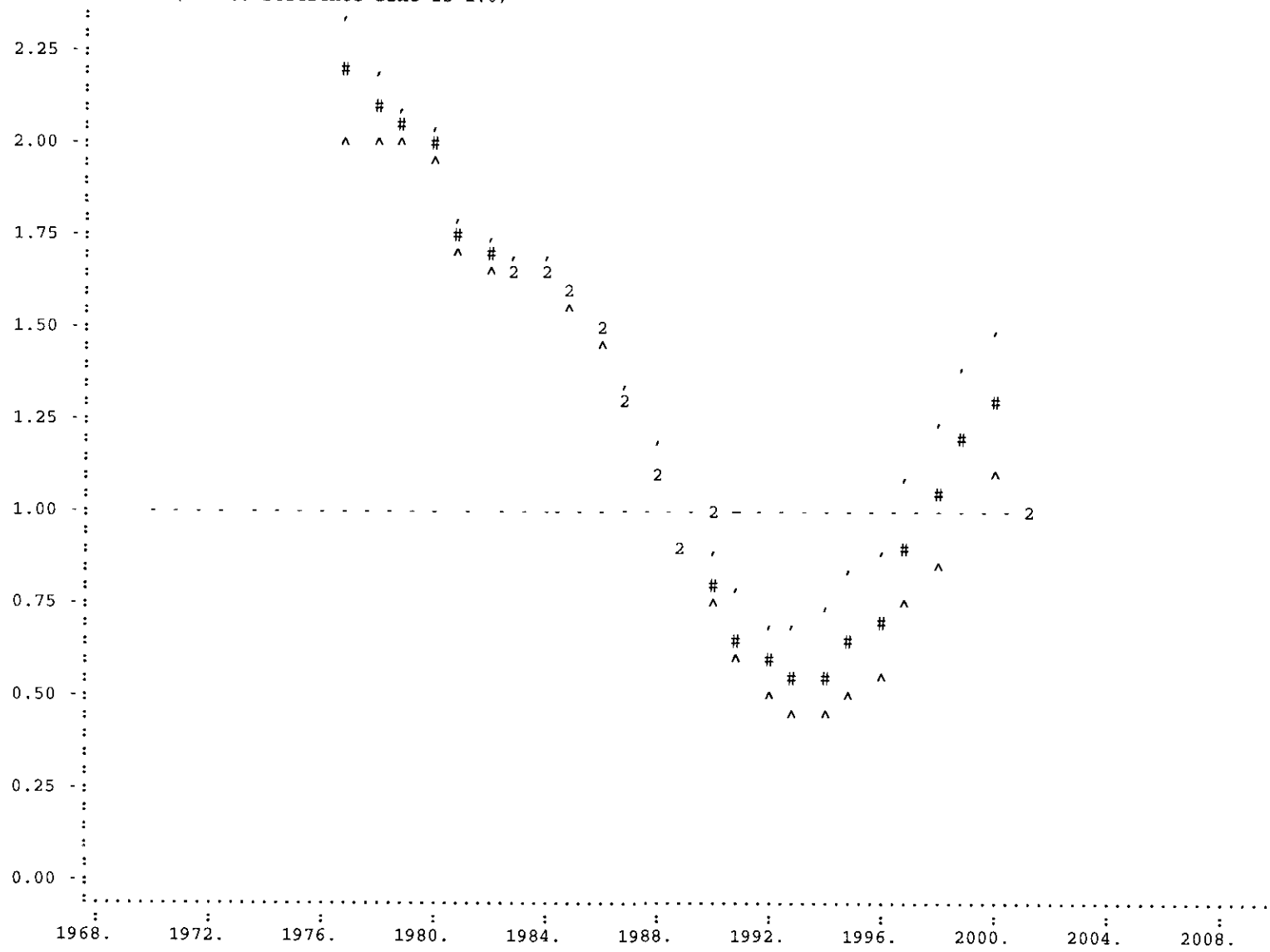
TRAJECTORY OF ABSOLUTE FISHING MORTALITY RATE (BOOTSTRAPPED)

| Year | 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 |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 0.000E+00 | 0.000E+00 | 0.00% | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000 |
| 1978 | 6.991E-03 | 7.594E-03 | 8.62% | 5.035E-03 | 9.151E-03 | 5.932E-03 | 8.047E-03 | 2.115E-03 | 0.303 |
| 1979 | 2.623E-02 | 2.790E-02 | 6.37% | 1.953E-02 | 3.347E-02 | 2.251E-02 | 2.986E-02 | 7.346E-03 | 0.280 |
| 1980 | 1.895E-01 | 1.988E-01 | 4.89% | 1.404E-01 | 2.419E-01 | 1.616E-01 | 2.150E-01 | 5.337E-02 | 0.282 |
| 1981 | 1.171E-01 | 1.218E-01 | 4.01% | 8.752E-02 | 1.492E-01 | 9.977E-02 | 1.326E-01 | 3.283E-02 | 0.280 |
| 1982 | 1.223E-01 | 1.265E-01 | 3.38% | 9.194E-02 | 1.537E-01 | 1.053E-01 | 1.376E-01 | 3.232E-02 | 0.264 |
| 1983 | 1.050E-01 | 1.080E-01 | 2.83% | 8.015E-02 | 1.308E-01 | 9.122E-02 | 1.179E-01 | 2.672E-02 | 0.254 |
| 1984 | 1.737E-01 | 1.783E-01 | 2.62% | 1.336E-01 | 2.158E-01 | 1.508E-01 | 1.952E-01 | 4.434E-02 | 0.255 |
| 1985 | 2.221E-01 | 2.279E-01 | 2.59% | 1.707E-01 | 2.776E-01 | 1.926E-01 | 2.517E-01 | 5.909E-02 | 0.266 |
| 1986 | 3.315E-01 | 3.404E-01 | 2.67% | 2.515E-01 | 4.175E-01 | 2.851E-01 | 3.771E-01 | 9.203E-02 | 0.278 |
| 1987 | 4.252E-01 | 4.371E-01 | 2.78% | 3.168E-01 | 5.425E-01 | 3.623E-01 | 4.864E-01 | 1.240E-01 | 0.292 |
| 1988 | 5.225E-01 | 5.379E-01 | 2.96% | 3.817E-01 | 6.805E-01 | 4.405E-01 | 6.024E-01 | 1.619E-01 | 0.310 |
| 1989 | 5.290E-01 | 5.451E-01 | 3.04% | 3.755E-01 | 7.016E-01 | 4.372E-01 | 6.127E-01 | 1.755E-01 | 0.332 |
| 1990 | 5.905E-01 | 6.106E-01 | 3.42% | 4.071E-01 | 8.030E-01 | 4.844E-01 | 6.930E-01 | 2.086E-01 | 0.353 |
| 1991 | 5.736E-01 | 5.939E-01 | 3.55% | 3.827E-01 | 8.119E-01 | 4.605E-01 | 6.880E-01 | 2.275E-01 | 0.397 |
| 1992 | 5.461E01 | 5.671E-01 | 3.84% | 3.547E-01 | 8.127E-01 | 4.359E-01 | 6.785E-01 | 2.425E-01 | 0.444 |
| 1993 | 4.563E-01 | 4.709E-01 | 3.21% | 2.905E-01 | 7.007E-01 | 3.608E-01 | 5.745E-01 | 2.136E-01 | 0.468 |
| 1994 | 3.380E-01 | 3.451E-01 | 2.11% | 2.209E-01 | 5.164E-01 | 2.702E-01 | 4.235E-01 | 1.533E-01 | 0.454 |
| 1995 | 3.780E-01 | 3.807E-01 | 0.71% | 2.543E-01 | 5.678E-01 | 3.077E-01 | 4.701E-01 | 1.624E-01 | 0.430 |
| 1996 | 1.556E-01 | 1.561E-01 | 0.36% | 1.117E-01 | 2.221E-01 | 1.314E-01 | 1.893E-01 | 5.788E-02 | 0.372 |
| 1997 | 1.800E-01 | 1.804E-01 | 0.22% | 1.367E-01 | 2.338E-01 | 1.556E-01 | 2.074E-01 | 5.185E-02 | 0.288 |
| 1998 | 1.437E-01 | 1.449E-01 | 0.86% | 1.143E-01 | 1.752E-01 | 1.281E-01 | 1.603E-01 | 3.220E-02 | 0.224 |
| 1999 | 1.638E-01 | 1.665E-01 | 1.66% | 1.333E-01 | 1.927E-01 | 1.478E-01 | 1.793E-01 | 3.143E-02 | 0.192 |

NOTES: Printed BC confidence intervals are always approximate.
At least 500 trials are recommended when estimating confidence intervals.

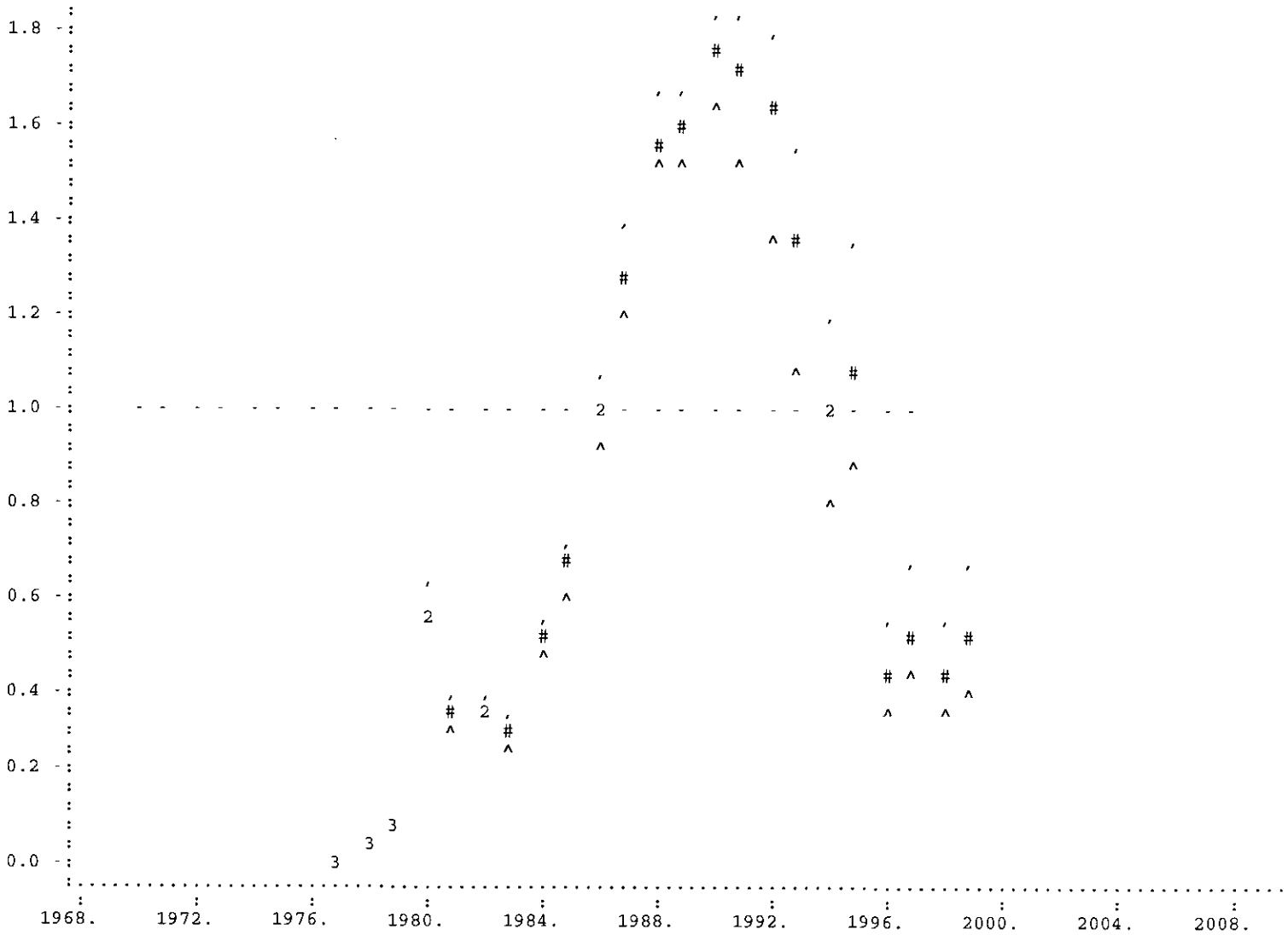
Estimates beginning in 2000 depend on the user projection data listed on page A15.

Bias-Corrected Time Plot of B-Ratio (#) with Approximate 80% Confidence Interval (^,)
(Dashed reference line is 1.0)




NOTE: Estimates beginning in 2000 depend on the user projection data listed on page A15.

Bias-Corrected Time Plot of F-Ratio (#) with Approximate 80% Confidence Interval (^,)
(Dashed reference line is 1.0)




NOTE: Estimates beginning in 1999 depend on the user projection data listed on page A15.