**15 March 2001**

# SeaFIC assessment of
# Chatham Rise ling (LIN 3 & 4)

**Arni Magnusson**

**Ray Hilborn**

# Estimated parameters

**$R_0$**     Expected recruitment at virgin state

**$R_{init}$**     Recruitment in first year of assessment, as a fraction of $R_0$

**$q_{SURV}$**     Survey catchability coefficient

**$q_{CPUE}$**     Longline CPUE catchability coefficient

**Trawl selectivity (M&F)**     Four shape parameters

**Longline selectivity (M&F)**     <u>Three shape parameters</u> (fixed right hand)

**Survey selectivity (M&F)**     Four shape parameters

**Recruitment residuals**     One parameter for each year

# Fixed parameters

**Von Bertalanffy L@A parameters (M&F)**

**$\alpha$ and $\beta$ W@L parameters (M&F)**

**Natural mortality rate**

**Maturity ogive**

**Steepness of recruitment function**

# Model specifications

| | |
|---|---|
| **Age of plus group** | 30 years |
| **StDev$_{Rec}$** | 0.6 |
| **Age error matrix** | ±15% |
| **Length bins (cm)** | 0-30, 35, 40, ..., 165, 170+ |
| **Max harvest rate** | 0.6 |

# Data

**FISHERY**   Landings (trawl and longline): 1973-2000

C@L (trawl observer data): 1989-2000

C@L (longline logbook data): 1995-2000

CPUE biomass index (longline): 1990-1999

**SURVEYS**   Survey C@A: 1990, 1992-2000

Survey biomass index: 1992-2000
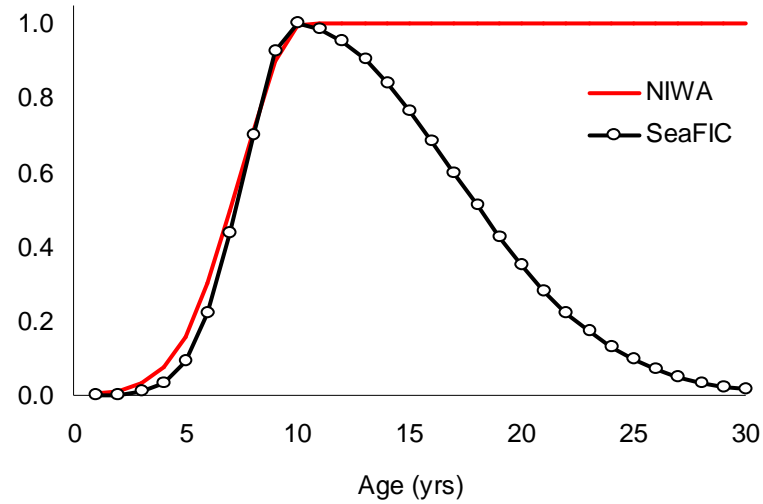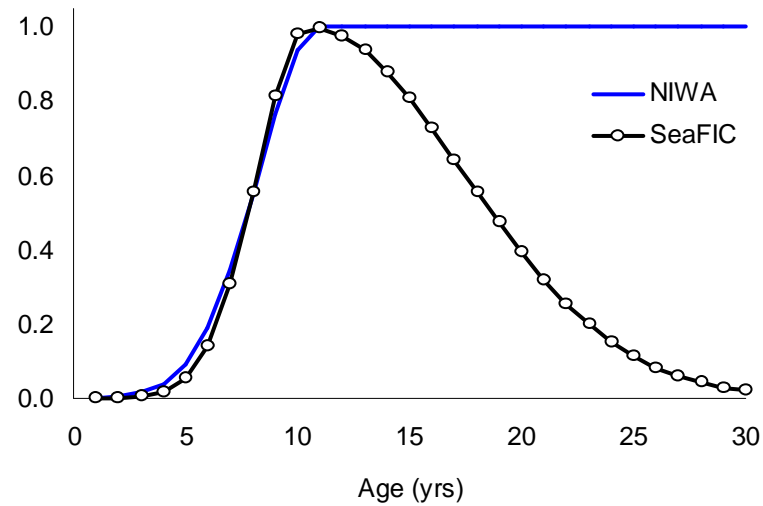
# Landings

Landings (t)
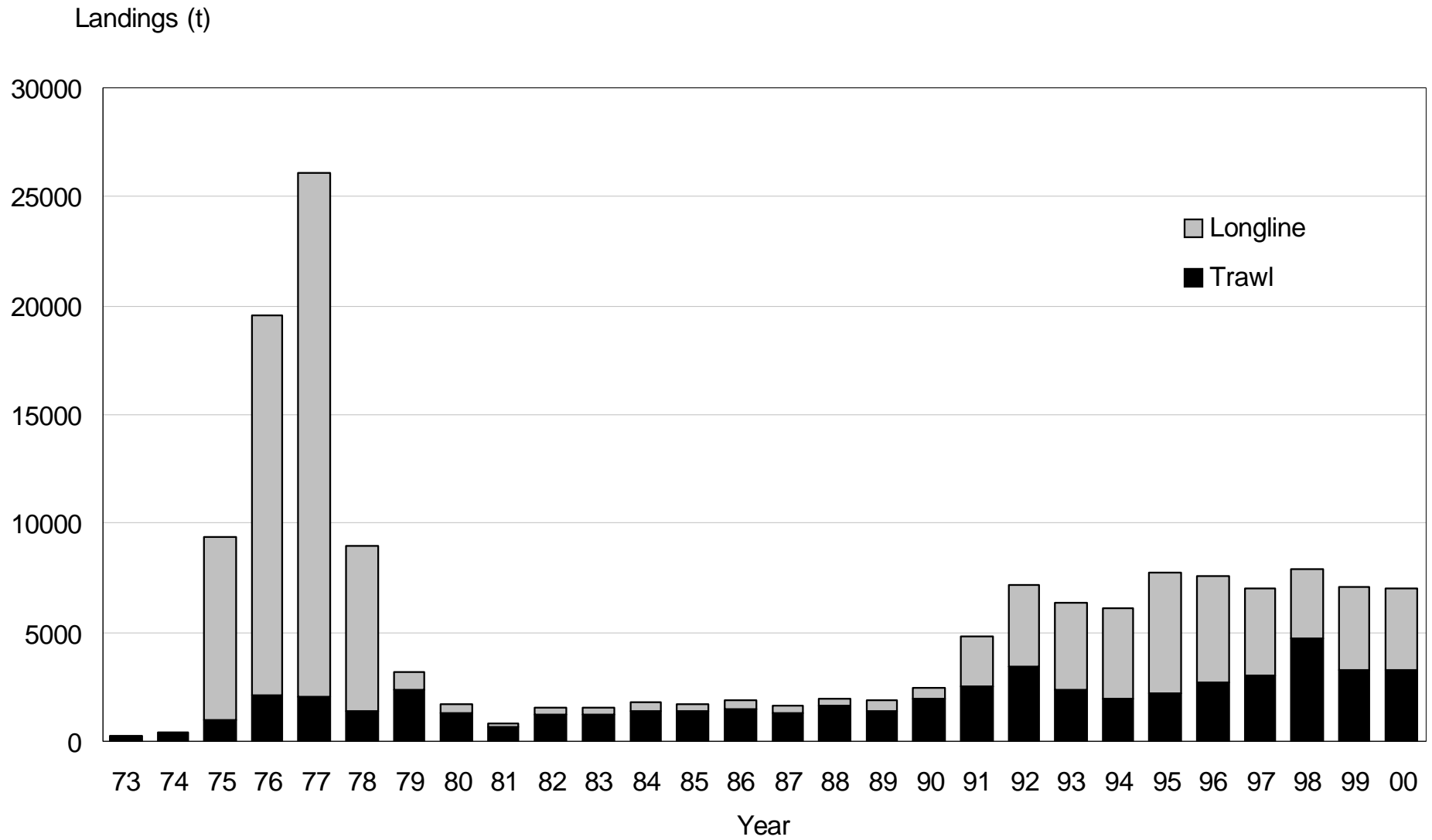
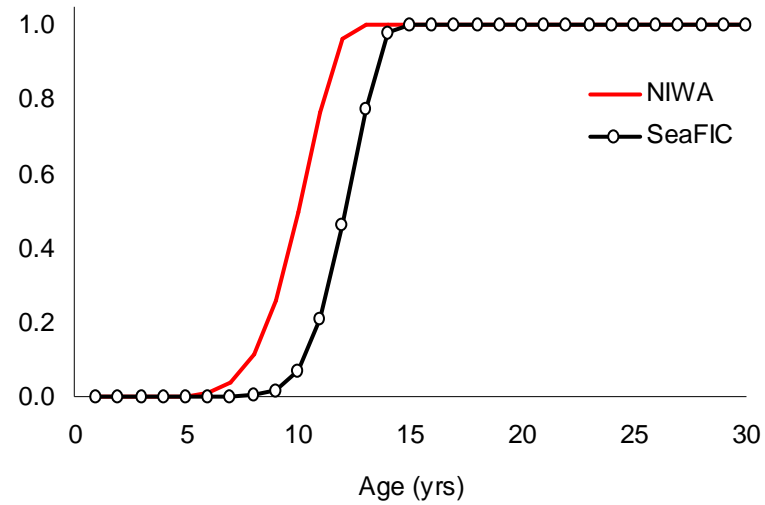# Comparison of average C@L
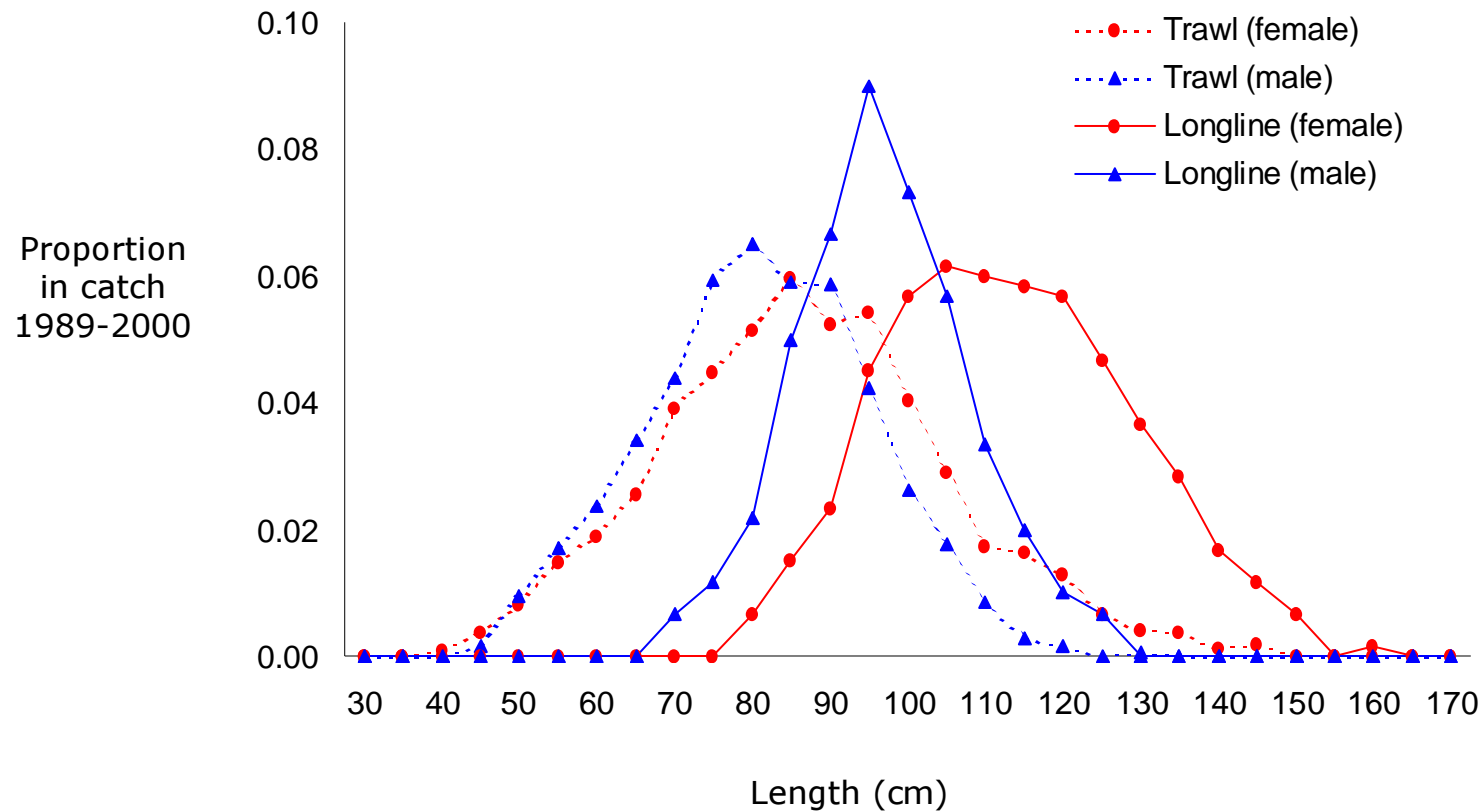
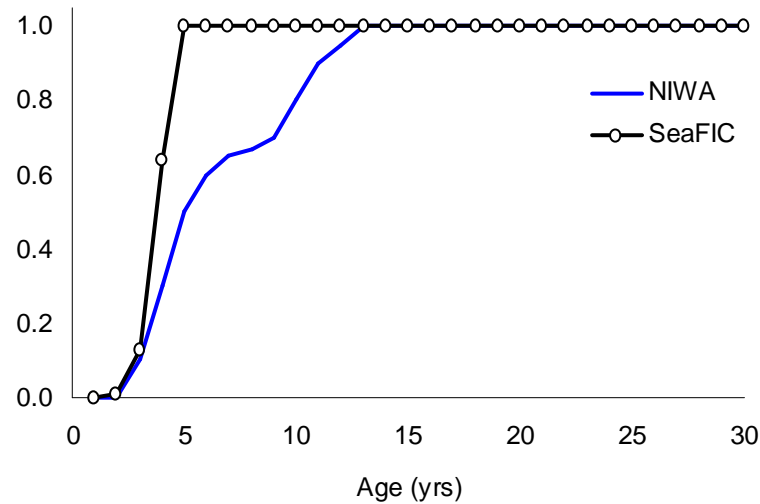# NIWA vs SeaFIC trawl selectivity

**Female**



**Male**

# NIWA vs SeaFIC longline selectivity
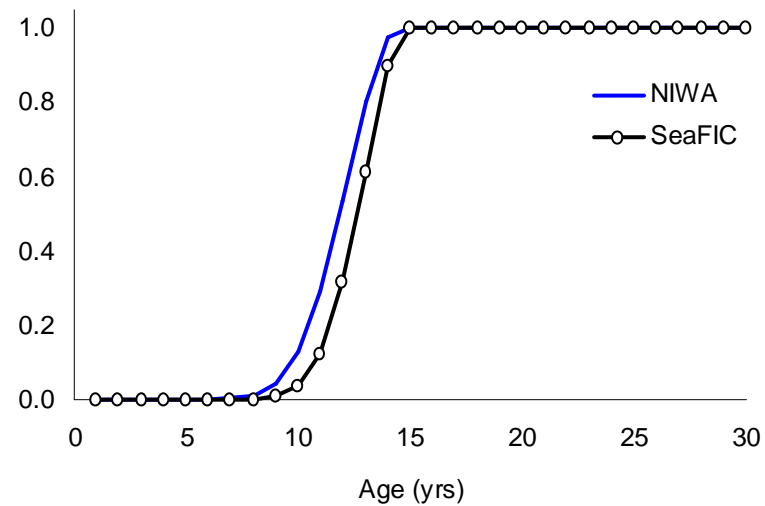
# NIWA vs SeaFIC survey selectivity

# Trawl C@L fit

Proportion in catch 1989

Proportion in catch 1995

1990

1996

1991

1997

1992

1998

1993

1999

1994

2000

Female length (cm)  Male length (cm)  Female length (cm)  Male length (cm)
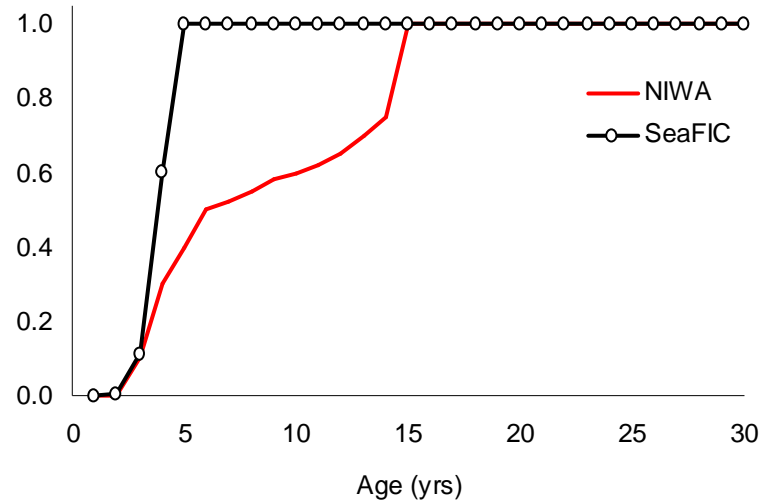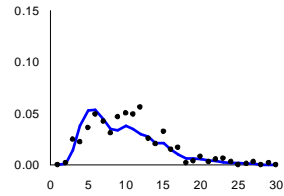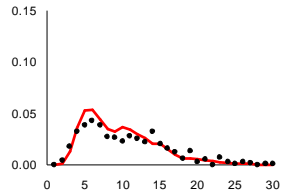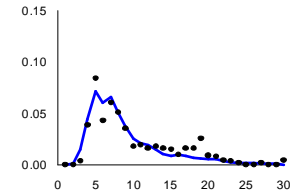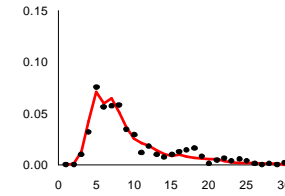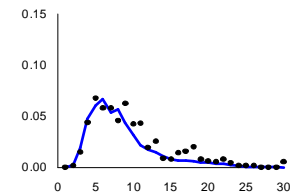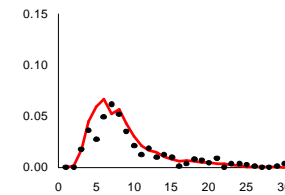
# Longline C@L fit
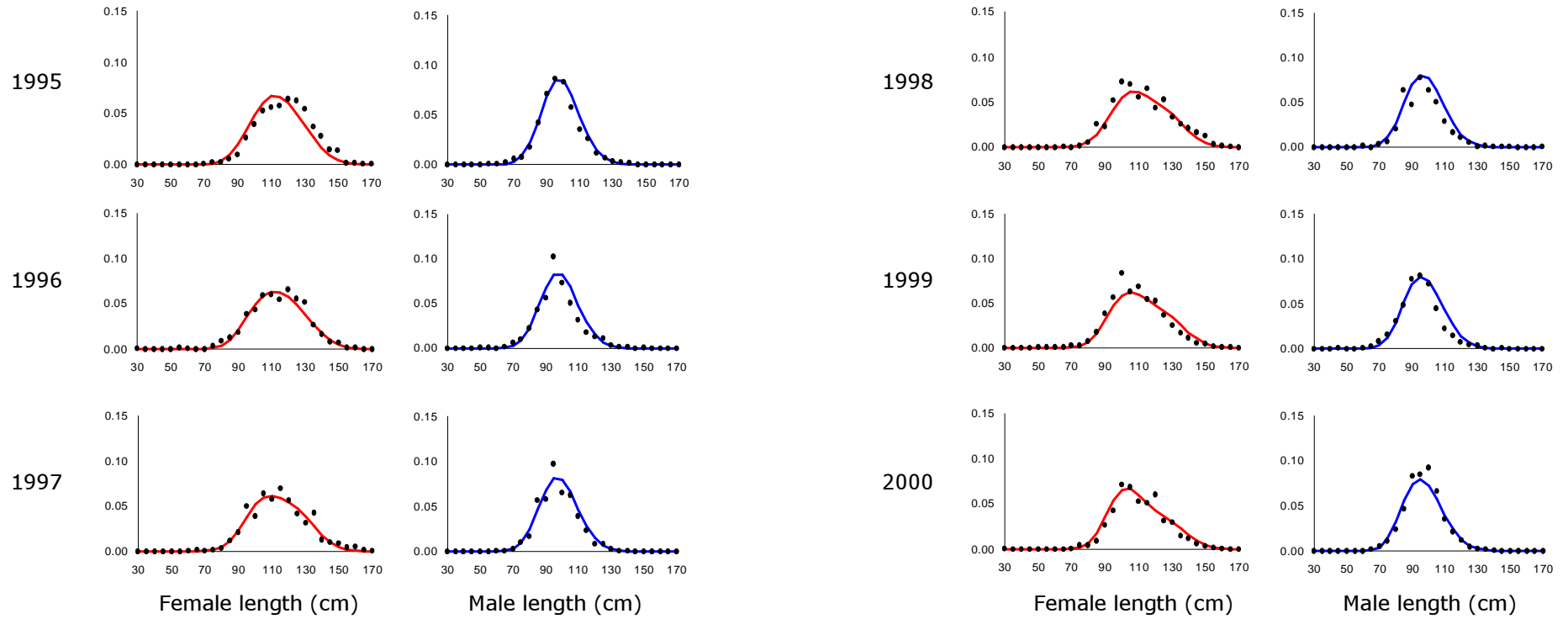
# Survey C@A fit



Proportion in catch 1990

1992

1993

1994

1995

Proportion in catch 1995
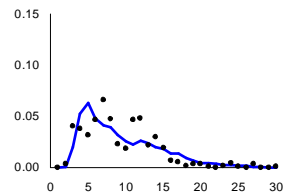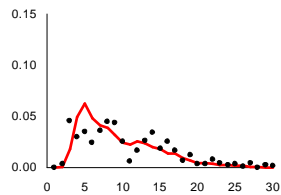
1996
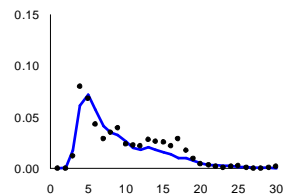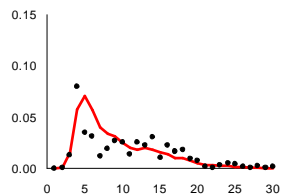
1997
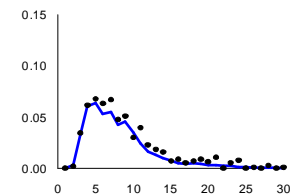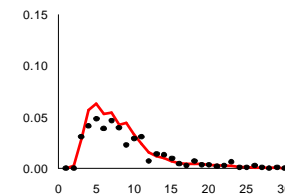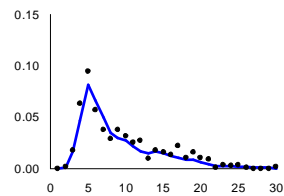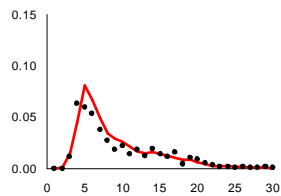
1998
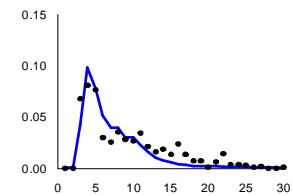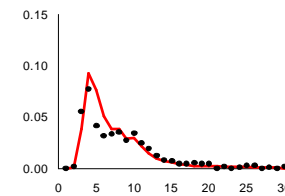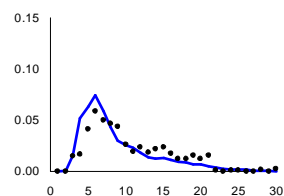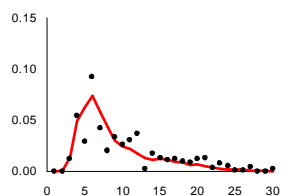
1999
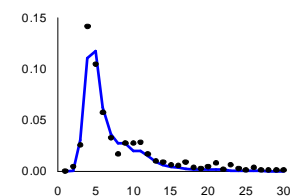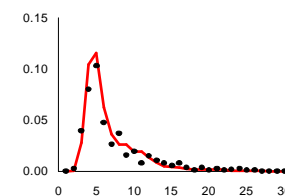
Female age (yrs)　　Male age (yrs)　　　Female age (yrs)　　Male age (yrs)

# Survey C@A standardized residuals
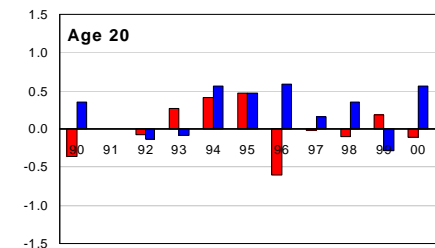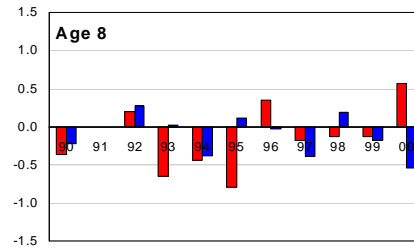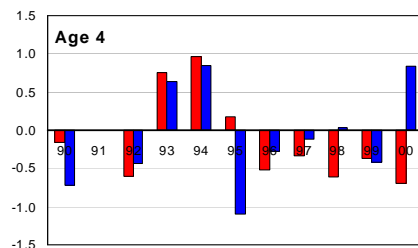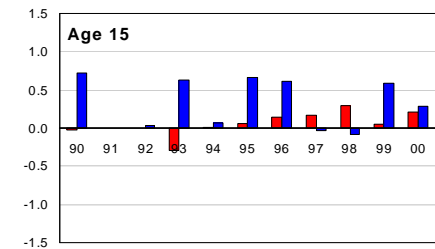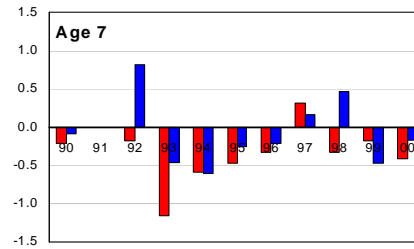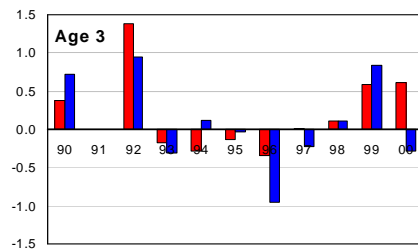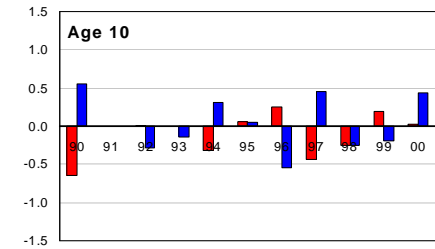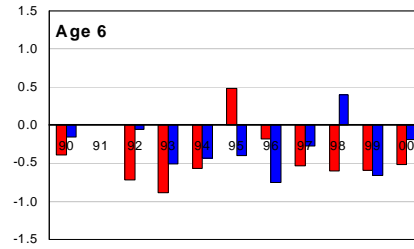
# Biomass index fits

### Tangaroa trawl survey
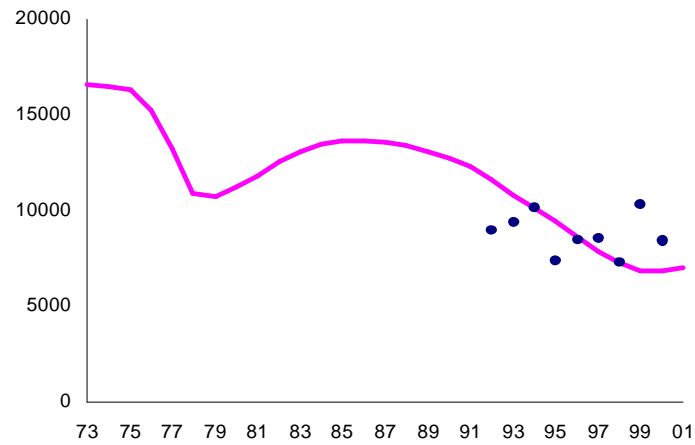


### Longline CPUE
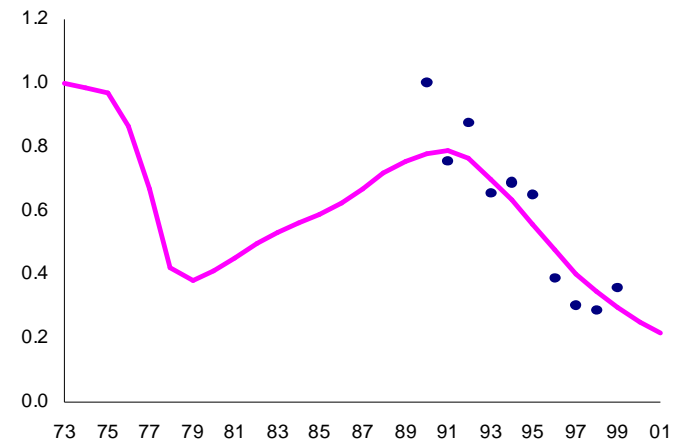
# Sensitivity analysis (1-7)

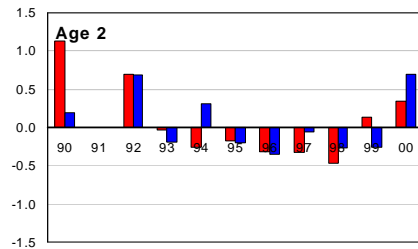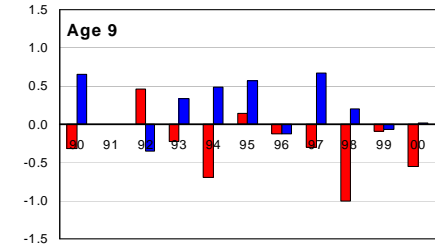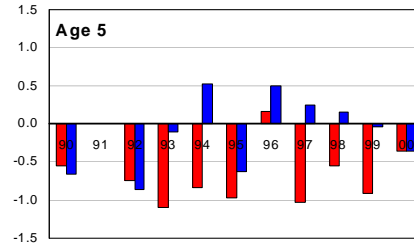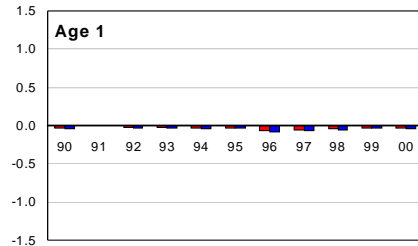| | Case 1 Base | Case 2 RSD=1 | Case 3 Rinit=1 | Case 4 FreeM | Case 5 M-0.04 | Case 6 M+0.04 | Case 7 NoCPUE |
|---|---|---|---|---|---|---|---|
| *Model specifications* | | | | | | | |
| CPUE used | **Yes** | Yes | Yes | Yes | Yes | Yes | **No** |
| C@L used | **Yes** | Yes | Yes | Yes | Yes | Yes | Yes |
| Natural mortality rate | **0.18** | 0.18 | 0.18 | **0.07** | **0.14** | **0.22** | 0.18 |
| Rinit | **1.04** | 0.72 | **1.00** | 0.37 | 0.77 | 1.50 | 0.99 |
| Recruitment SD | **0.6** | **1.0** | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| Sample sizes | **72-59-153** | 72-59-153 | 72-59-153 | 72-59-153 | 72-59-153 | 72-59-153 | 72-59-153 |
| Trawl selectivity | **Estimated** | Estimated | Estimated | Estimated | Estimated | Estimated | Estimated |
| Longline selectivity | **Full Right** | Full Right | Full Right | Full Right | Full Right | Full Right | Full Right |
| Survey selectivity | **Estimated** | Estimated | Estimated | Estimated | Estimated | Estimated | Estimated |
| | | | | | | | |
| *Likelihoods* | | | | | | | |
| CPUE | 1.3 | 1.2 | 1.3 | 1.8 | 1.4 | 1.2 | - |
| Trawl catch @ length | -1638.6 | -1638.8 | -1638.6 | -1639.7 | -1639.1 | -1638.3 | -1638.3 |
| Longline catch @ length | -834.9 | -834.4 | -834.8 | -836.7 | -835.2 | -834.2 | -834.6 |
| Survey catch @ age | -1346.9 | -1348.2 | -1346.9 | -1349.5 | -1348.5 | -1344.0 | -1347.2 |
| Survey index | 2.9 | 3.1 | 2.8 | 2.0 | 2.5 | 2.7 | 2.6 |
| Penalties | 4.8 | 2.1 | 4.9 | 3.8 | 3.6 | 6.9 | 4.8 |
| Total likelihood | **-3811.4** | -3814.9 | -3811.4 | -3818.4 | -3815.3 | -3805.7 | -3812.7 |
| | | | | | | | |
| *Catchabliity* | | | | | | | |
| Survey q | 0.11 | 0.12 | 0.11 | 0.19 | 0.14 | 0.07 | 0.11 |
| CPUE q ($\times 10^6$) | 12.6 | 12.7 | 12.5 | 22.2 | 16.0 | 7.7 | 12.4 |
| | | | | | | | |
| *Stock indicators* | | | | | | | |
| $R_0$ (millions) | 15 | 21 | 15 | 4 | 8 | 34 | 16 |
| $R_{avg[1973-1989]}$ (millions) | 13 | 13 | 13 | 3 | 7 | 31 | 14 |
| $R_{1997}$ (millions) | 25 | 27 | 25 | 8 | 15 | 56 | 26 |
| | | | | | | | |
| $SB_0$ (t) | 72,000 | 100,000 | 73,000 | 166,000 | 80,000 | 89,000 | 76,000 |
| $SB_{1973}$ (t) | 75,000 | 72,000 | 73,000 | 62,000 | 62,000 | 134,000 | 76,000 |
| $SB_{1990}$ (t) | 60,000 | 60,000 | 60,000 | 29,000 | 44,000 | 102,000 | 62,000 |
| $SB_{2001}$ (t) | 21,000 | 20,000 | 21,000 | 13,000 | 17,000 | 36,000 | 23,000 |
| $SB_{2001}/SB_{1990}$ | 35% | 33% | 35% | 45% | 39% | 35% | 37% |
| | | | | | | | |
| Longline $VB_{1973}$ (t) | 79,000 | 77,000 | 78,000 | 80,000 | 72,000 | 129,000 | 80,000 |
| Longline $VB_{1990}$ (t) | 62,000 | 62,000 | 62,000 | 31,000 | 46,000 | 106,000 | 65,000 |
| Longline $VB_{2001}$ (t) | 17,000 | 16,000 | 17,000 | 9,000 | 13,000 | 31,000 | 20,000 |
| Longline $VB_{2001}/VB_{1990}$ | 27% | 26% | 27% | 29% | 28% | 29% | 31% |

# Sensitivity analysis (8-13)

| | Case 1 Base | Case 8 NIWAsel | Case 9 NIWAselNoC@L | Case 10 BaseFixComNoC@L | Case 11 TrawlRightFull | Case 12 Double SS | Case 13 Triple SS |
|---|---|---|---|---|---|---|---|
| *Model specifications* | | | | | | | |
| CPUE used | **Yes** | Yes | Yes | Yes | Yes | Yes | Yes |
| C@L used | **Yes** | Yes | **No** | **No** | Yes | Yes | Yes |
| Natural mortality rate | **0.18** | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 |
| Rinit | **1.04** | 1.45 | 0.93 | 0.89 | 1.09 | 1.04 | 1.06 |
| Recruitment SD | **0.6** | 0.6 | 0.6 | 0.6 | 0.6 | 1.6 | 2.6 |
| Sample sizes | **72-59-153** | 72-59-153 | 72-59-153 | 72-59-153 | 72-59-153 | **144-117-307** | **216-176-460** |
| Trawl selectivity | **Estimated** | **NIWA** | **NIWA** | **From Base** | **Full Right** | Estimated | Estimated |
| Longline selectivity | **Full Right** | NIWA | NIWA | From Base | Full Right | Full Right | Full Right |
| Survey selectivity | **Estimated** | Full Right | Full Right | Estimated | Estimated | Estimated | Estimated |
| | | | | | | | |
| *Likelihoods* | | | | | | | |
| CPUE | 1.3 | 2.5 | 3.1 | 2.7 | 1.2 | 1.2 | 1.2 |
| Trawl catch @ length | -1638.6 | -1550.7 | - | - | -1632.9 | -1580.1 | -1529.3 |
| Longline catch @ length | -834.9 | -648.5 | - | - | -836.1 | -808.9 | -783.9 |
| Survey catch @ age | -1346.9 | -1343.5 | -1351.0 | -1351.7 | -1341.9 | -1302.5 | -1259.3 |
| Survey index | 2.9 | 3.1 | 1.5 | 1.7 | 2.8 | 3.8 | 4.2 |
| Penalties | 4.8 | 6.7 | 5.2 | 5.4 | 4.0 | 6.0 | 6.6 |
| Total likelihood | **-3811.4** | -3530.5 | -1341.2 | -1342.0 | -3802.9 | -3680.4 | -3560.4 |
| | | | | | | | |
| *Catchabliity* | | | | | | | |
| Survey q | 0.11 | 0.06 | 0.05 | 0.06 | 0.13 | 0.13 | 0.13 |
| CPUE q ($\times 10^6$) | 12.6 | 4.5 | 4.2 | 6.0 | 18.2 | 13.6 | 14.3 |
| | | | | | | | |
| *Stock indicators* | | | | | | | |
| $R_0$ (millions) | 15 | 20 | 27 | 24 | 13 | 14 | 13 |
| $R_{avg[1973-1989]}$ (millions) | 13 | 18 | 23 | 21 | 12 | 12 | 12 |
| $R_{1997}$ (millions) | 25 | 17 | 44 | 39 | 24 | 22 | 21 |
| | | | | | | | |
| $SB_0$ (t) | 72,000 | 95,000 | 127,000 | 116,000 | 65,000 | 66,000 | 63,000 |
| $SB_{1973}$ (t) | 75,000 | 137,000 | 119,000 | 103,000 | 70,000 | 69,000 | 67,000 |
| $SB_{1990}$ (t) | 60,000 | 110,000 | 114,000 | 103,000 | 50,000 | 57,000 | 55,000 |
| $SB_{2001}$ (t) | 21,000 | 49,000 | 63,000 | 53,000 | 17,000 | 17,000 | 15,000 |
| $SB_{2001}/SB_{1990}$ | 35% | 45% | 55% | 51% | 34% | 30% | 27% |
| | | | | | | | |
| Longline $VB_{1973}$ (t) | 79,000 | 196,000 | 170,000 | 115,000 | 67,000 | 73,000 | 71,000 |
| Longline $VB_{1990}$ (t) | 62,000 | 157,000 | 163,000 | 110,000 | 45,000 | 58,000 | 56,000 |
| Longline $VB_{2001}$ (t) | 17,000 | 69,000 | 88,000 | 55,000 | 9,000 | 14,000 | 12,000 |
| Longline $VB_{2001}/VB_{1990}$ | 27% | 44% | 54% | 50% | 20% | 24% | 21% |

# Selectivity parameters

| | Trawl | | | Longline | | | Survey | | |
|---|---|---|---|---|---|---|---|---|---|
| | Age | Left | Right | Age | Left | Right | Age | Left | Right |
| Case 1: Base | 9.9 | 2.3 | 4.6 | 14.4 | 2.0 | F | 4.9 | 0.5 | F |
| Case 2: RSD=1 | 9.9 | 2.3 | 4.6 | 14.3 | 1.9 | F | 4.9 | 0.5 | F |
| Case 3: Rinit=1 | 9.9 | 2.3 | 4.6 | 14.4 | 2.0 | F | 4.9 | 0.5 | F |
| Case 4: FreeM | 9.6 | 2.3 | 4.8 | 15.0 | 2.2 | F | 4.5 | 0.3 | F |
| Case 5: M-0.04 | 9.8 | 2.3 | 4.7 | 14.6 | 2.0 | F | 4.8 | 0.5 | F |
| Case 6: M+0.04 | 10.0 | 2.3 | 4.4 | 14.0 | 1.8 | F | 5.4 | 0.9 | F |
| Case 7: NoCPUE | 9.9 | 2.3 | 4.5 | 14.3 | 1.9 | F | 4.9 | 0.5 | F |
| Case 8: NIWAsel | 10.3 | 2.7 | F | 12.6 | 2.3 | F | 4.3 | 0.1 | F |
| Case 9: NIWAselNoC@L | 10.3 | 2.7 | F | 12.6 | 2.3 | F | 4.8 | 0.5 | F |
| Case 10: BaseFixComNoC@L | 9.9 | 2.3 | 4.6 | 14.4 | 2.0 | F | 4.8 | 0.5 | F |
| Case 11: TrawlRightFull | 9.3 | 2.1 | F | 16.0 | 2.5 | F | 5.0 | 0.6 | F |
| Case 12: Double SS | 9.9 | 2.3 | 4.6 | 14.3 | 2.0 | F | 4.9 | 0.5 | F |
| Case 13: Triple SS | 9.9 | 2.3 | 4.6 | 14.4 | 2.0 | F | 4.9 | 0.5 | F |

*Age* is the age at which fish are fully selected by that gear.

*Left* and *Right* describe the selectivity slopes on each side of *Age* (low number → steep slope). F means the selectivity stays flat (>15).
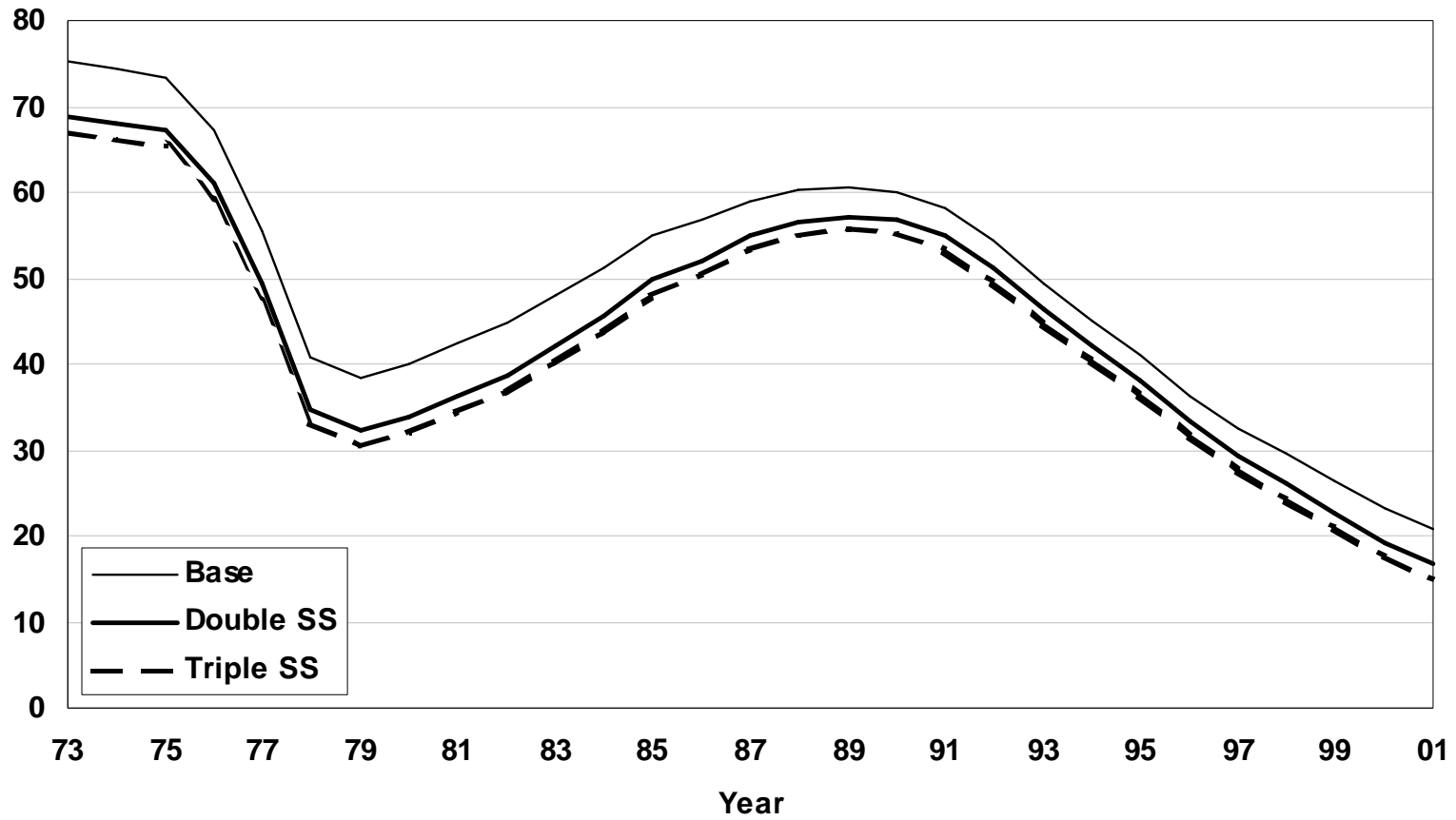
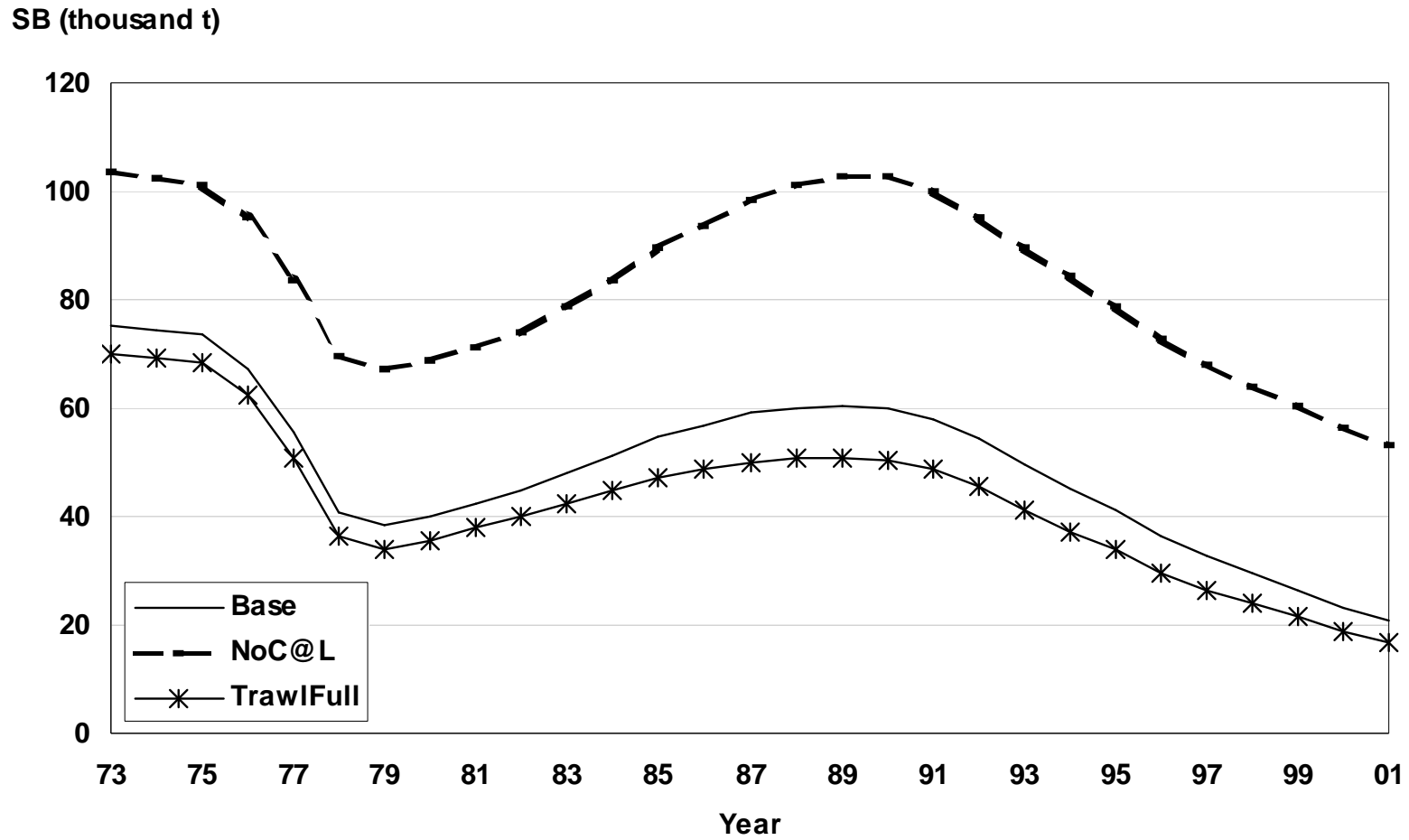Shaded parameters were not estimated

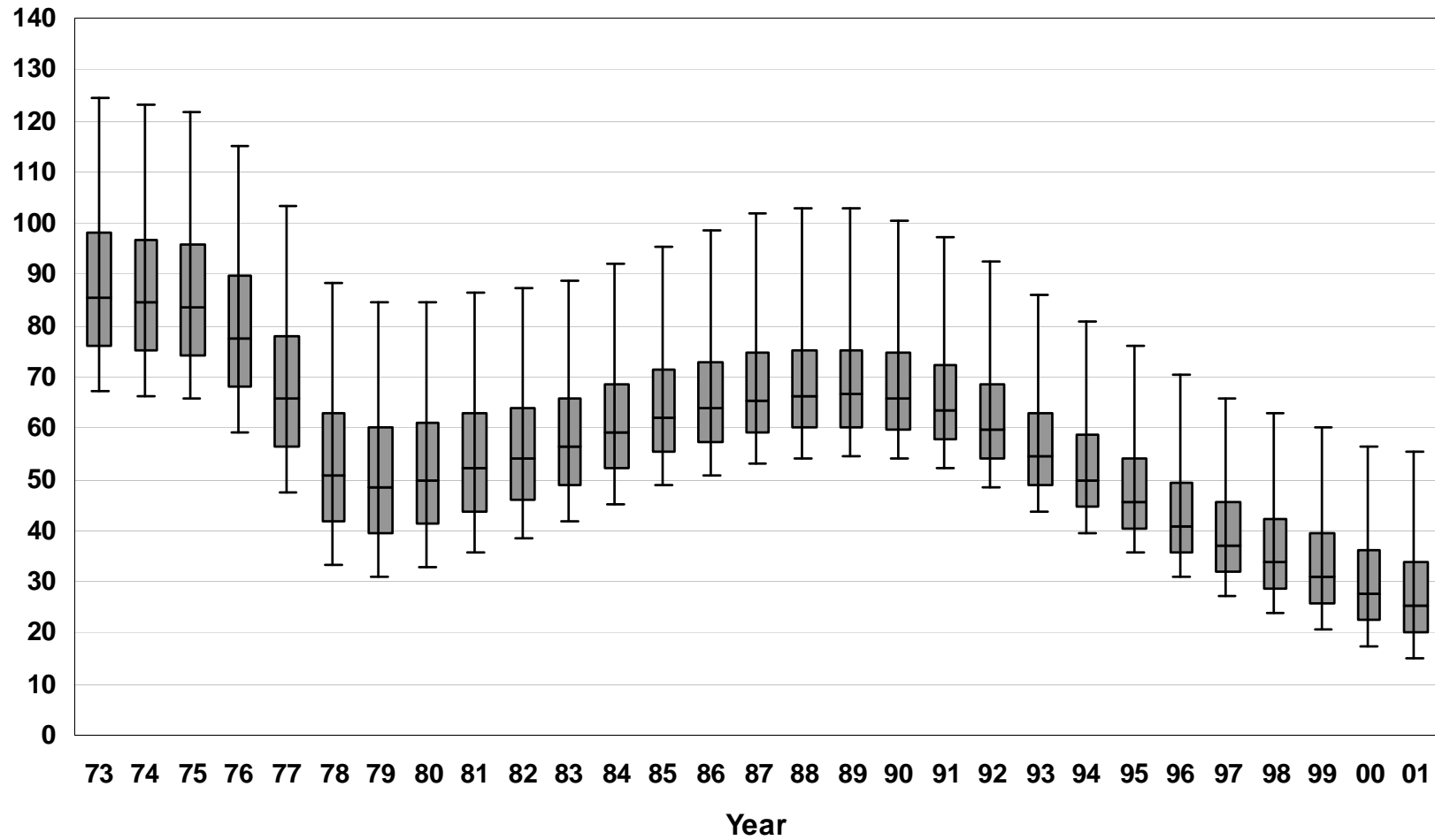# Biomass proportions in each scenario
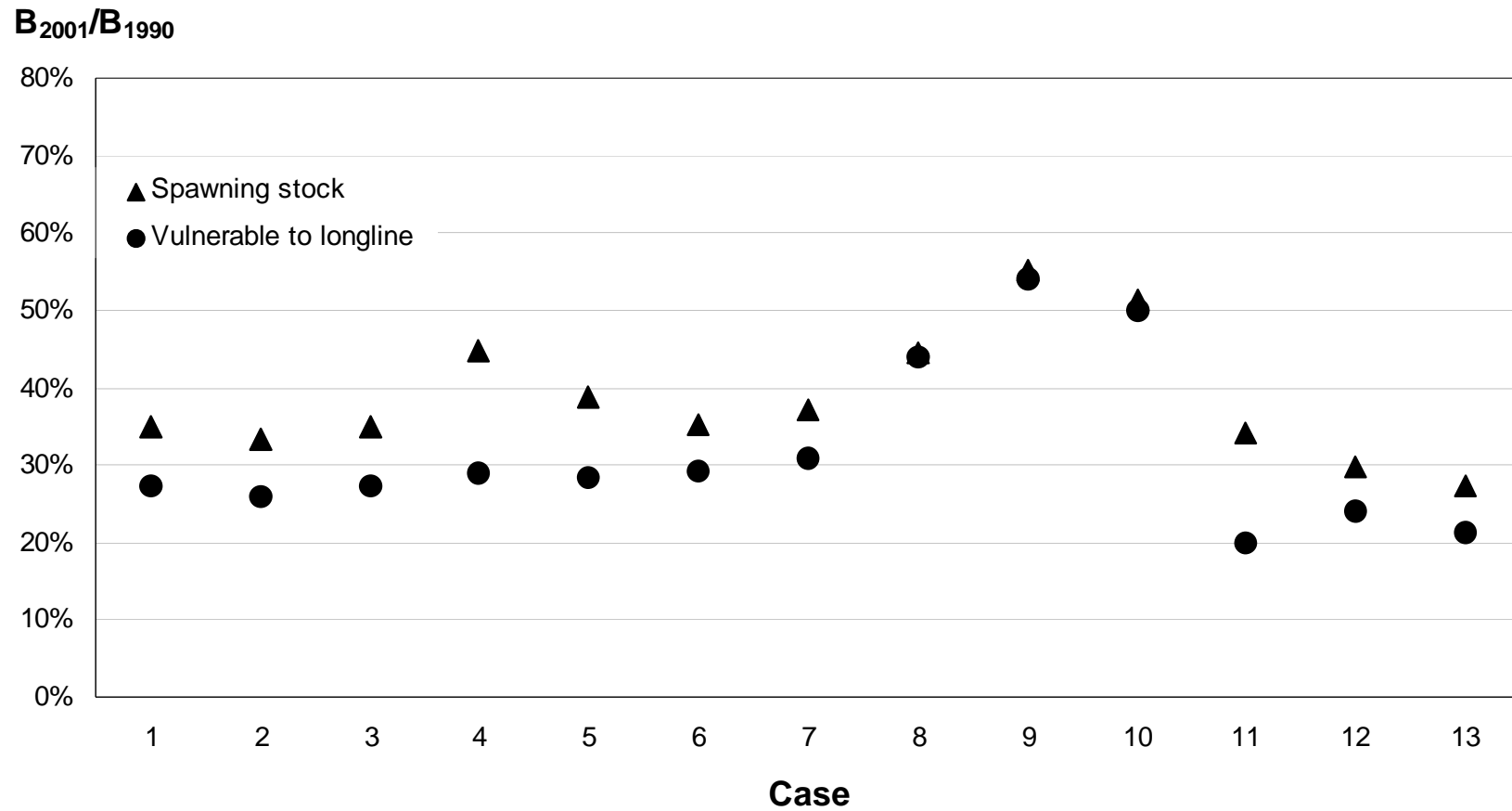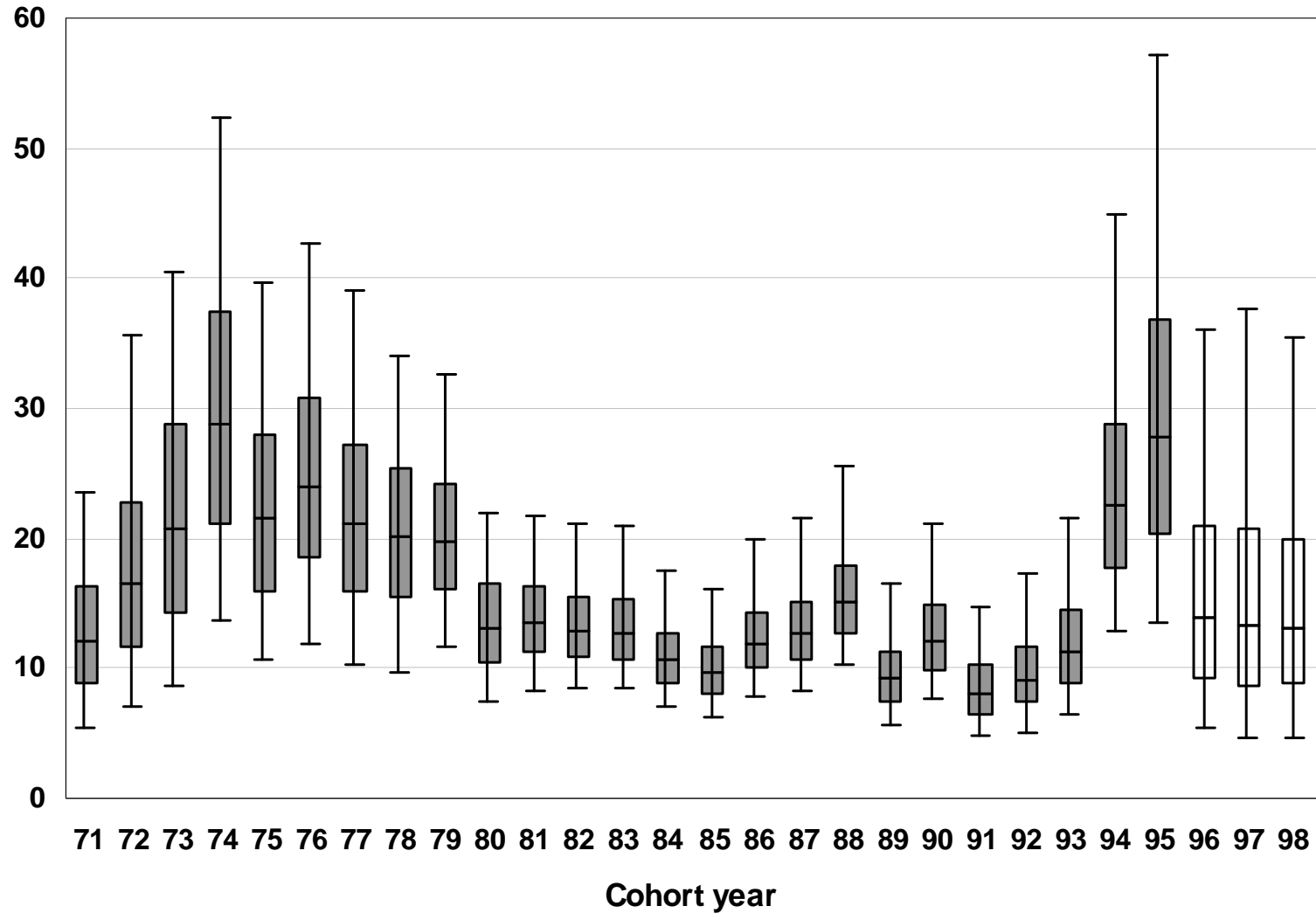
# Effect of sample size on SB

# Effect of C@L data on SB
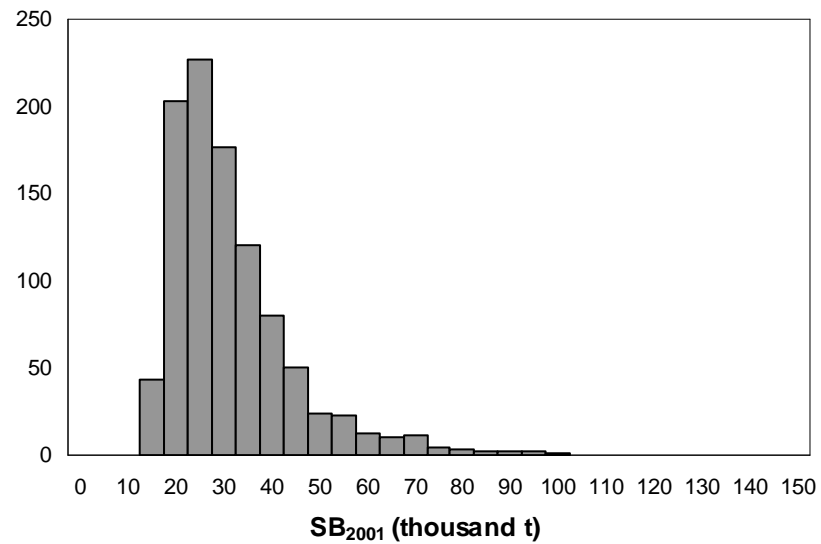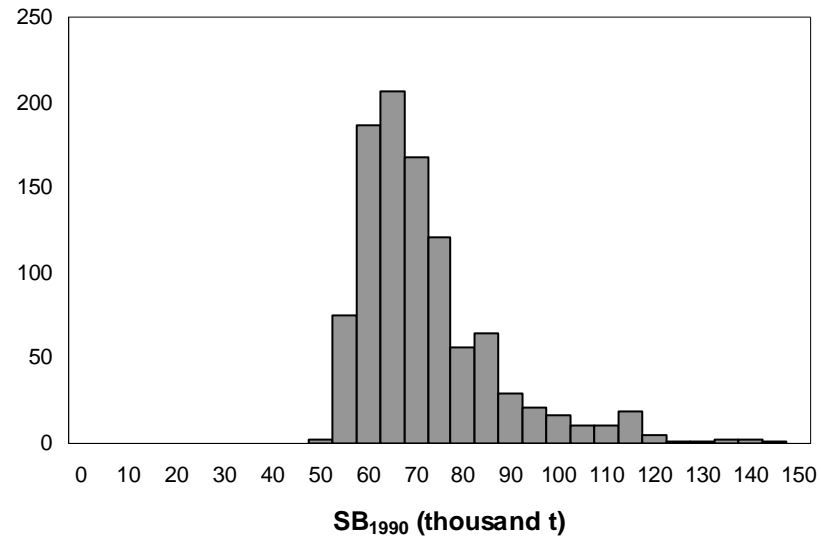
# MCMC spawning biomass

# MCMC recruitment

Recruits at age 1 (millions)



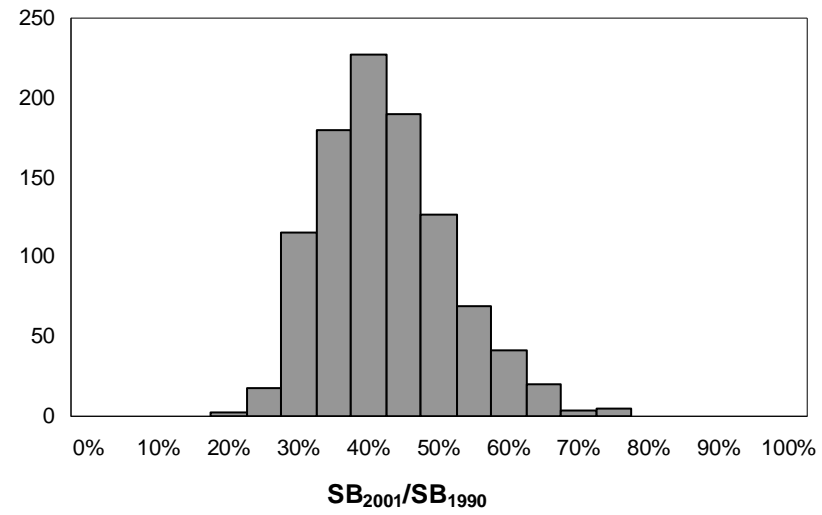Cohort year

# Biomass posterior distribution

# SB$_{1990}$ and SB$_{2001}$

**SB$_{2001}$ (thousand t)**
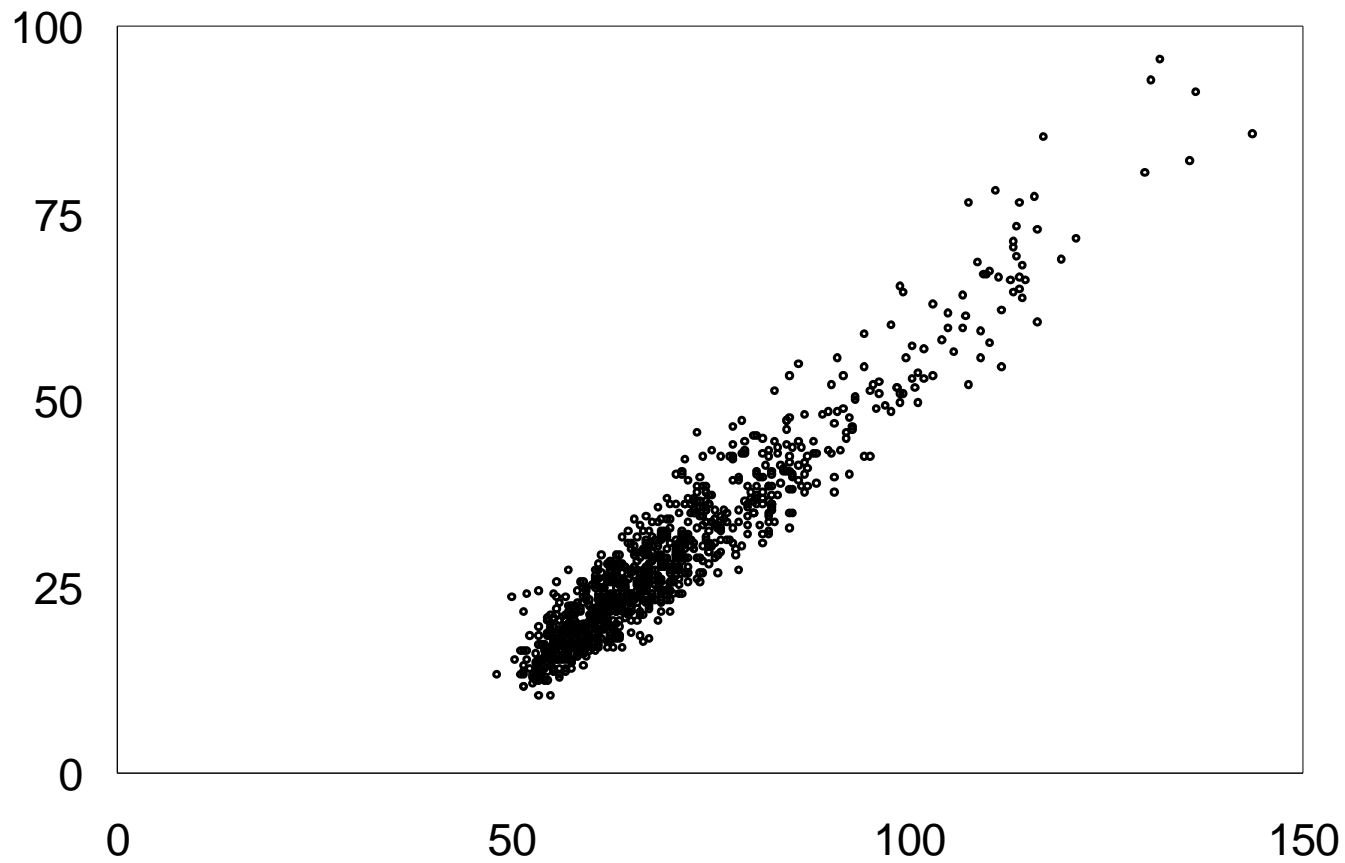


**SB$_{1990}$ (thousand t)**

# Biomass ratio
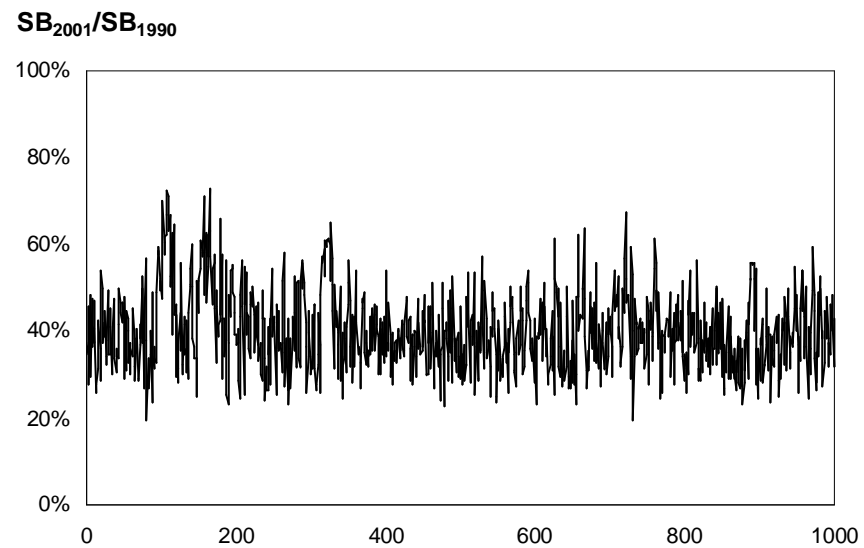
# Spawning biomass projections
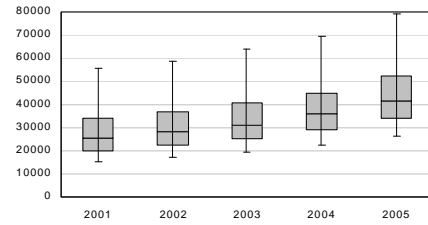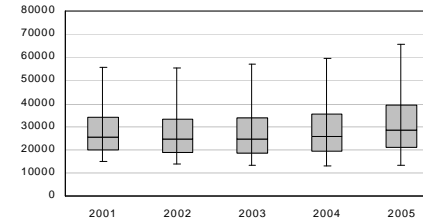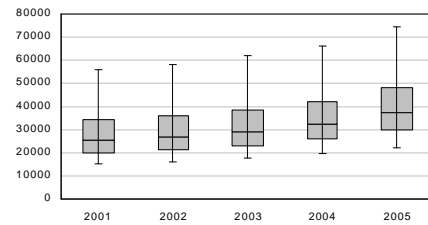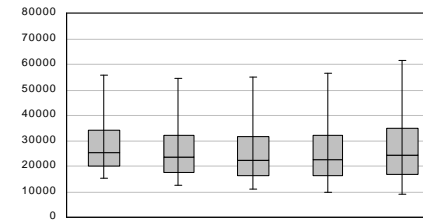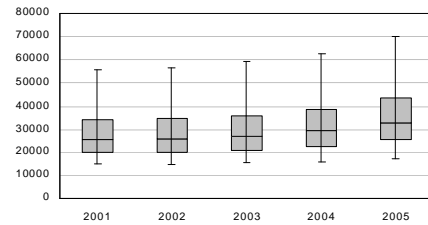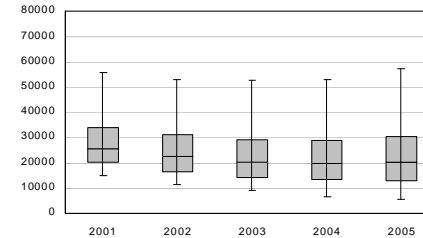
# Probability of spawning biomass going below current level

| Annual catch | $Pr(SB_{2002} < SB_{2001})$ | $Pr(SB_{2003} < SB_{2001})$ | $Pr(SB_{2004} < SB_{2001})$ | $Pr(SB_{2005} < SB_{2001})$ |
|---|---|---|---|---|
| 0 t | 0% | 0% | 0% | 0% |
| 1000 t | 0% | 0% | 0% | 0% |
| 2000 t | 0% | 0% | 0% | 0% |
| 3000 t | 10% | 2% | 1% | 0% |
| 4000 t | 39% | 17% | 6% | 2% |
| 5000 t | 72% | 47% | 25% | 9% |
| 6000 t | 88% | 71% | 50% | 27% |
| 7000 t | 95% | 87% | 70% | 46% |
| 8000 t | 98% | 94% | 83% | 64% |
| 9000 t | 99% | 97% | 90% | 77% |
| 10000 t | 99% | 99% | 95% | 85% |

# Expected spawning biomass level as a proportion of $SB_{1990}$

| Annual catch | Median($SB_{2002}$/$SB_{1990}$) | Median($SB_{2003}$/$SB_{1990}$) | Median($SB_{2004}$/$SB_{1990}$) | Median($SB_{2005}$/$SB_{1990}$) |
|---|---|---|---|---|
| 0 t | 0.42 | 0.47 | 0.53 | 0.62 |
| 1000 t | 0.42 | 0.46 | 0.51 | 0.59 |
| 2000 t | 0.41 | 0.44 | 0.49 | 0.56 |
| 3000 t | 0.40 | 0.43 | 0.46 | 0.52 |
| 4000 t | 0.39 | 0.41 | 0.44 | 0.49 |
| 5000 t | 0.38 | 0.39 | 0.41 | 0.46 |
| 6000 t | 0.38 | 0.38 | 0.39 | 0.43 |
| 7000 t | 0.37 | 0.36 | 0.37 | 0.40 |
| 8000 t | 0.36 | 0.34 | 0.34 | 0.36 |
| 9000 t | 0.35 | 0.33 | 0.32 | 0.33 |
| 10000 t | 0.34 | 0.31 | 0.30 | 0.30 |