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An Exploratory Extended Survivors Formulation (XSA) for Northern Shrimp (*Pandalus borealis*) in Flemish Cap (Division 3M)

by

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Abstract

A Virtual Population Analysis calibrated with two tuning series is presented for the shrimp stock in Div. 3M. The results indicate that the high landings in 1996 created a peak in the fishing mortality and a minimum in SSB. Thereafter, as the catches decreased, the fishing mortality decreased and SSB recovered also as a result of the good recruitment. There is however a negative trend in recruitment indicated for the most recent period. The shortness of the time series available does not allow to analyse the retrospective pattern of the fishing mortality, recruitment and SSB and causes general concern about the results.

Introduction

The shrimp stock in Flemish Cap is assessed by the NAFO Scientific Council based on age aggregated survey results and CPUE series derived from the commercial fleets. The data and analysis presented here are considered as a first step towards the formulation of an age structured production model for the stock in order to provide improved information on projections of stock biomass and catches under different management option scenarios.

Material and Data

The input data for the VPA are given in Appendix 1. Catch in numbers have been derived from Canadian length frequency samples for the period 1993-1995. Thereafter, sampling results were made available mainly from Iceland but also from Canada and Greenland. The modes of the length composition of the catches were split into ages 2 to 7 applying the MIX software (MacDonald and Pitcher, 1979). Mean weights at age in the catches were calculated by means of a length weight regression and were used also as input for mean weights at age in the stock. Natural mortality was set at M=0.2 for all ages. This value seems reasonable since total mortality is indicated to amount to a level of Z=0.55 for ages 3 to 6 as derived from both series of abundance indices available. The maturity ogive over ages was kept constant between years and resulted from experience of the experts for the stock.

There are two tuning fleets available for calibration of the terminal fishing mortality (Appendix 2). One is derived from the commercial Icelandic CPUE (Skúladóttir, 2000) and the second from the Faeroese shrimp survey (Nicolajsen, 2000).

The applied software for the age structured assessment of historical stock and spawning stock size in numbers and weight as well as exploitation rates is the Lowestoft VPA Version 3.1 with the Extended Survivors Analysis (XSA). Settings of the XSA and the results are given in Appendix 3. Age 6 was not determined as a plus group since the estimates of older shrimp were extremely low indicating that the shrimp cohorts die out during their seventh year of life. Catchability was set to be dependent on stock size for age 2 (recruitment) and independent of age for ages >=4. Single runs for both tuning series revealed no trends in log-transformed catchability residuals (Fig. 1 and 2) and resulting estimates of Fbar 3-5 and SSB in 1999 are not significantly different (Fig. 3).

Results

The results of the final VPA are given in Appendix 4 and the summary table is illustrated in Fig. 4 and 5 for trends in fishing mortality, SSB and recruits, respectively. They indicate that the high landings in 1996 created a peak in the fishing mortality and a minimum in SSB. Thereafter, as the catches decreased, the fishing mortality decreased and SSB recovered as a result of the recruitment of the strong 1993 year-class. There is however a negative trend in recruitment at age 2 since 1995 and the 1997 year-class is estimated to be only 50 % of the average size.

The shortness of the time series available does not allow to analyse the retrospective pattern of the fishing mortality, recruitment and SSB and causes general concern about the results. The present formulation of the XSA calibration requires more exploration.

References

Skúladóttir, U. 2000. The Icelandic Shrimp Fishery (*Pandalus borealis* Kr.) at Flemish Cap in 1993-2000. *NAFO SCR Doc*., No. 74, Serial No. N4331, 33 p.

MacDonald and T. Pitcher 1979. The MIX software. Age separation of length distributions. *J. Fish. Res. Board Can*., **36**: 987-1001

Nicolajsen, Á. 2000. Biomass estimate, growth, length and age distribution of the northern shrimp (Pandalus borealis) stock on Flemish Cap (NAFO Div. 3M) in June. *NAFO SCR Doc*., No. 83, Serial No. N4340, 17 p.

Appendix 1 VPA input tables

```
Landings in tonnes

Year   Landing
1993   26876
1994   24549
1995   32982
1996   48299
1997   24675
1998   30308
1999   42005

1

    Run title : Shrimp 3M 10/11/2000

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       Table  1    Catch numbers at age                              Numbers*10**-3
       YEAR,       1993,    1994,    1995,    1996,    1997,    1998,    1999,

       AGE
         2,       369209,  646823, 3048376,  500354,  281106,  370219,  315960,
         3,       690175, 1291865, 1831996, 4779827, 1616036, 1641601, 1879164,
         4,       371781,  304010,  342234, 1621994, 1674075, 2277693, 1517988,
         5,       842297,  692033,  649366,  494678,  318792,  677275, 2194478,
         6,       929453,  625108,  878197,  223362,   59754,   32960,  674342,
0    TOTALNUM,   3202915, 3559839, 6750169, 7620215, 3949763, 4999748, 6581932,
     TONSLAND,     26876,   24549,   32982,   48299,   24675,   30308,   42005,
     SOPCOF %,         0,       0,       0,       0,       0,       0,       0,
1


    Run title : Shrimp 3M 10/11/2000

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       Table  2    Catch weights at age (g)
       YEAR,       1993,    1994,    1995,    1996,    1997,    1998,    1999,

       AGE
         2,       2.7720,  2.5760,  1.9650,  2.1600,  3.2010,  2.0660,  2.0240,
         3,       5.2250,  4.9980,  4.9240,  4.8530,  4.1300,  3.9410,  3.3780,
         4,       8.1880,  7.1010,  6.4620,  9.2340,  7.9660,  6.7470,  5.6310,
         5,      10.4410, 10.0800,  9.6110, 11.5590, 10.6310, 11.0470,  8.3070,
         6,      11.1890, 11.8840, 10.8400, 14.7010, 14.3500, 14.4530, 11.0730,
0    SOPCOFAC,     .0010,   .0010,   .0010,   .0010,   .0010,   .0010,   .0010,
1

    Run title : Shrimp 3M 10/11/2000

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       Table  3    Stock weights at age (g)
       YEAR,       1993,    1994,    1995,    1996,    1997,    1998,    1999,

       AGE
         2,       2.7720,  2.5760,  1.9650,  2.1600,  3.2010,  2.0660,  2.0240,
         3,       5.2250,  4.9980,  4.9240,  4.8530,  4.1300,  3.9410,  3.3780,
         4,       8.1880,  7.1010,  6.4620,  9.2340,  7.9660,  6.7470,  5.6310,
         5,      10.4410, 10.0800,  9.6110, 11.5590, 10.6310, 11.0470,  8.3070,
         6,      11.1890, 11.8840, 10.8400, 14.7010, 14.3500, 14.4530, 11.0730,
1
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Run title : Shrimp 3M 10/11/2000

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Table 4 Natural Mortality (M) at age

YEAR,	1993,	1994,	1995,	1996,	1997,	1998,	1999,
AGE							
2,	.2000,	.2000,	.2000,	.2000,	.2000,	.2000,	.2000,
3,	.2000,	.2000,	.2000,	.2000,	.2000,	.2000,	.2000,
4,	.2000,	.2000,	.2000,	.2000,	.2000,	.2000,	.2000,
5,	.2000,	.2000,	.2000,	.2000,	.2000,	.2000,	.2000,
6,	.2000,	.2000,	.2000,	.2000,	.2000,	.2000,	.2000,

1

Run title : Shrimp 3M 10/11/2000

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Table 5 Proportion mature at age

YEAR,	1993,	1994,	1995,	1996,	1997,	1998,	1999,
AGE							
2,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
3,	.1000,	.1000,	.1000,	.1000,	.1000,	.1000,	.1000,
4,	.3000,	.3000,	.3000,	.3000,	.3000,	.3000,	.3000,
5,	.7000,	.7000,	.7000,	.7000,	.7000,	.7000,	.7000,
6,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,

1

Run title : Shrimp 3M 10/11/2000

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Table 6 Proportion of M before Spawning

YEAR,	1993,	1994,	1995,	1996,	1997,	1998,	1999,
AGE							
2,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
3,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
4,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
5,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
6,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,

1

Run title : Shrimp 3M 10/11/2000

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Table 7 Proportion of F before Spawning

YEAR,	1993,	1994,	1995,	1996,	1997,	1998,	1999,
AGE							
2,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
3,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
4,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
5,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
6,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,

1

Appendix 2 Tuning series used.

```
Shrimp 3M, Tuning data
102
ICEFLSTA
1993   1999
1      1      0      1
2      6
100    4.987  9.322  5.021  11.376 12.554
100    6.324  12.63  2.972  6.766  6.111
100    26.156 15.719 2.937  5.572  7.535
100    2.248  21.475 7.288  2.223  1.004
100    2.187  12.574 13.027 2.481  0.465
100    3.591  15.924 22.095 6.66   0.32
100    1.896  12.274 9.106  13.165 4.046
FAESUR
1997   1999
1      1      0.5    0.6
2      4
100    901    1653   470
100    226    1366   1006
100    214    1288   835
```

Appendix 3 XSA output

```
Lowestoft VPA Version 3.1

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 Extended Survivors Analysis

 Shrimp 3M 10/11/2000

 CPUE data from file SHI3MT1.DAT

 Catch data for   7 years. 1993 to 1999. Ages  2 to   6.

      Fleet,            First, Last, First, Last, Alpha,  Beta
                  ,    year, year,  age ,  age
 ICEFLSTA       ,        1993, 1999,   2,     6,   .000,  1.000
 FAESUR         ,        1997, 1999,   2,     4,   .500,   .600


 Time series weights :

      Tapered time weighting applied
      Power =    3 over  20 years


 Catchability analysis :

      Catchability dependent on stock size for ages <    3

         Regression type = C
         Minimum of   5 points used for regression
         Survivor estimates shrunk to the population mean for ages <  3

      Catchability independent of age for ages >=    4

 Terminal population estimation :

      Survivor estimates shrunk towards the mean F
      of the final   5 years or the   4 oldest ages.

      S.E. of the mean to which the estimates  are shrunk =    .500

      Minimum standard error for population
      estimates derived from each fleet =    .300

      Prior weighting not applied
```

```
 Tuning converged after   31 iterations

1

 Regression weights
       ,  .921,  .954,  .976,  .990,  .997, 1.000, 1.000

 Fishing mortalities
    Age,  1993,  1994,  1995,  1996,  1997,  1998,  1999

      2,  .102,  .110,  .200,  .038,  .031,  .050,  .068
      3,  .273,  .611,  .512,  .552,  .166,  .255,  .381
      4,  .075,  .185,  .318, 1.285,  .379,  .372,  .397
      5,  .229,  .195,  .752, 1.082,  .988,  .258,  .755
      6,  .184,  .265,  .406,  .638,  .339,  .239,  .444

1
 XSA population numbers (Thousands)

                               AGE
 YEAR ,           2,            3,            4,            5,            6,

 1993 ,    4.22E+06, 3.20E+06, 5.69E+06, 4.56E+06, 6.12E+06,
 1994 ,    6.88E+06, 3.12E+06, 1.99E+06, 4.32E+06, 2.97E+06,
 1995 ,    1.86E+07, 5.05E+06, 1.39E+06, 1.36E+06, 2.91E+06,
 1996 ,    1.48E+07, 1.24E+07, 2.48E+06, 8.27E+05, 5.24E+05,
 1997 ,    1.02E+07, 1.17E+07, 5.87E+06, 5.61E+05, 2.30E+05,
 1998 ,    8.42E+06, 8.07E+06, 8.10E+06, 3.29E+06, 1.71E+05,
 1999 ,    5.29E+06, 6.56E+06, 5.12E+06, 4.57E+06, 2.08E+06,

 Estimated population abundance at 1st Jan 2000

    ,     0.00E+00, 4.01E+06, 3.66E+06, 2.78E+06, 1.73E+06,

 Taper weighted geometric mean of the VPA populations:

    ,     8.70E+06, 6.36E+06, 3.71E+06, 2.09E+06, 1.09E+06,

 Standard error of the weighted Log(VPA populations) :

    ,        .5316,    .5618,    .6627,    .8912,   1.3994,
1

 Log catchability residuals.

 Fleet : ICEFLSTA

  Age  ,  1993,  1994,  1995,  1996,  1997,  1998,  1999
     2 ,   .89,   .64,  1.11, -1.20,  -.85,  -.16,  -.32
     3 ,   .23,   .71,   .41,  -.16,  -.81,  -.16,  -.16
     4 ,  -.93,  -.36,   .05,   .79,   .13,   .33,  -.08
     5 ,   .18,  -.31,   .91,   .62,  1.08,  -.02,   .55
     6 ,  -.04,   .00,   .29,   .10,   .02,  -.11,   .03

 Mean log catchability and standard error of ages with catchability
 independent of year class strength and constant w.r.t. time

    Age ,         3,         4,         5,         6
 Mean Log q,  -17.3583,  -17.4762,  -17.4762,  -17.4762,
 S.E(Log q),     .4955,     .5358,     .6876,     .1358,

 Regression statistics :

 Ages with q dependent on year class strength

 Age, Slope , t-value , Intercept, RSquare, No Pts, Reg s.e, Mean Log q

  2,    1.45,    -.415,     20.34,     .15,      7,    1.38,  -18.99,

 Ages with q independent of year class strength and constant w.r.t. time.

 Age, Slope , t-value , Intercept, RSquare, No Pts, Reg s.e,  Mean Q

  3,    3.89,   -3.439,     22.25,     .23,      7,    1.14,  -17.36,
  4,    1.10,    -.245,     17.71,     .56,      7,     .64,  -17.48,
  5,    1.77,   -2.695,     18.96,     .72,      7,     .62,  -17.04,
  6,     .97,     .745,     17.33,     .99,      7,     .13,  -17.43,
1
```

```
 Fleet : FAESUR

  Age  ,  1993,  1994,  1995,  1996,  1997,  1998,  1999
     2 , 99.99, 99.99, 99.99, 99.99,   .65,  -.53,  -.11
     3 , 99.99, 99.99, 99.99, 99.99,  -.23,   .00,   .22
     4 , 99.99, 99.99, 99.99, 99.99,  -.39,   .05,   .34
     5 , No data for this fleet at this age
     6 , No data for this fleet at this age

 Mean log catchability and standard error of ages with catchability
 independent of year class strength and constant w.r.t. time

    Age ,         3,         4
 Mean Log q,  -13.0422,  -13.3336,
 S.E(Log q),     .2233,     .3630,

 Regression statistics :

 Ages with q dependent on year class strength

 Age, Slope , t-value , Intercept, RSquare, No Pts, Reg s.e, Mean Log q

  2,     .56,     .480,     15.07,     .55,      3,     .43,  -14.46,

 Ages with q independent of year class strength and constant w.r.t. time.

 Age, Slope , t-value , Intercept, RSquare, No Pts, Reg s.e,  Mean Q

  3,    4.07,   -6.709,      4.08,     .83,      3,     .19,  -13.04,
  4,    1.37,    -.178,     12.48,     .19,      3,     .69,  -13.33,
1

 Terminal year survivor and F summaries :

 Age  2   Catchability dependent on age and year class strength

 Year class = 1997

 Fleet,                Estimated,    Int,       Ext,    Var,    N, Scaled,  Estimated
      ,                Survivors,    s.e,       s.e,   Ratio,    , Weights,    F
 ICEFLSTA       ,   2932308.,   .948,       .000,    .00,   1,  .102,     .093
 FAESUR           ,   3607980.,   .693,       .000,    .00,   1,  .191,     .076

   P shrinkage mean  ,   6362681.,    .56,,,,                        .312,     .044

   F shrinkage mean  ,   3183996.,    .50,,,,                        .394,     .086

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
   4013869.,       .31,      .21,    4,    .674,   .068


 Age  3   Catchability constant w.r.t. time and dependent on age

 Year class = 1996

 Fleet,                Estimated,    Int,       Ext,    Var,    N, Scaled,  Estimated
      ,                Survivors,    s.e,       s.e,   Ratio,    , Weights,    F
 ICEFLSTA       ,   3130748.,   .463,       .001,    .00,   2,  .196,     .434
 FAESUR           ,   4081719.,   .275,       .271,    .98,   2,  .556,     .348

   F shrinkage mean  ,   3237544.,    .50,,,,                        .249,     .422

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
   3658337.,       .22,      .12,    5,    .553,   .381

1
 Age  4   Catchability constant w.r.t. time and dependent on age

 Year class = 1995

 Fleet,                Estimated,    Int,       Ext,    Var,    N, Scaled,  Estimated
      ,                Survivors,    s.e,       s.e,   Ratio,    , Weights,    F
 ICEFLSTA       ,   2275451.,   .363,       .173,    .47,   3,  .233,     .472
 FAESUR           ,   3394197.,   .232,       .154,    .66,   3,  .558,     .340
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  F shrinkage mean  ,   2056002.,    .50,,,,                        .209,     .512

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
   2784272.,       .19,      .13,    7,    .682,   .397

 Age  5   Catchability constant w.r.t. time and age (fixed at the value for age)  4

 Year class = 1994

 Fleet,                Estimated,    Int,       Ext,    Var,    N, Scaled,  Estimated
     ,                 Survivors,    s.e,       s.e,   Ratio,    , Weights,    F
 ICEFLSTA       ,   1581270.,   .332,       .386,   1.16,   4,  .260,     .813
 FAESUR           ,   1557514.,   .245,       .133,    .54,   2,  .407,     .822

  F shrinkage mean  ,   2119937.,    .50,,,,                        .333,     .661

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
   1732955.,       .21,      .16,    7,    .753,   .755

1
 Age  6   Catchability constant w.r.t. time and age (fixed at the value for age)  4

 Year class = 1993

 Fleet,                Estimated,    Int,       Ext,    Var,    N, Scaled,  Estimated
     ,                 Survivors,    s.e,       s.e,   Ratio,    , Weights,    F
 ICEFLSTA       ,   1134885.,   .237,       .078,    .33,   5,  .626,     .430
 FAESUR           ,    743080.,   .420,       .000,    .00,   1,  .121,     .599

  F shrinkage mean  ,   1228712.,    .50,,,,                        .252,     .403

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
   1099838.,       .20,      .08,    7,    .400,   .444

1
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Appendix 4 VPA results

```
1

    Run title : Shrimp 3M 10/11/2000

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       Table  8    Fishing mortality (F) at age
       YEAR,       1993,    1994,    1995,    1996,    1997,    1998,    1999,       FBAR 97-99

       AGE
         2,        .1016,   .1096,   .2001,   .0380,   .0310,   .0498,   .0683,       .0497,
         3,        .2725,   .6108,   .5121,   .5523,   .1659,   .2548,   .3809,       .2672,
         4,        .0750,   .1846,   .3180,  1.2849,   .3789,   .3719,   .3971,       .3826,
         5,        .2286,   .1948,   .7525,  1.0815,   .9876,   .2583,   .7555,       .6671,
         6,        .1838,   .2650,   .4056,   .6377,   .3391,   .2392,   .4437,       .3407,
0  FBAR  3- 5,     .1920,   .3301,   .5275,   .9729,   .5108,   .2950,   .5111,
1

    Run title : Shrimp 3M 10/11/2000

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       Table  9    Relative F at age
       YEAR,       1993,    1994,    1995,    1996,    1997,    1998,    1999,       MEAN 97-99

       AGE
         2,        .5292,   .3321,   .3794,   .0391,   .0608,   .1689,   .1337,       .1211,
         3,       1.4192,  1.8505,   .9708,   .5677,   .3248,   .8636,   .7452,       .6445,
         4,        .3905,   .5592,   .6028,  1.3207,   .7417,  1.2609,   .7768,       .9265,
         5,       1.1903,   .5903,  1.4264,  1.1117,  1.9336,   .8755,  1.4780,      1.4290,
         6,        .9574,   .8028,   .7688,   .6555,   .6639,   .8110,   .8681,       .7810,
0     REFMEAN,     .1920,   .3301,   .5275,   .9729,   .5108,   .2950,   .5111,
1

    Run title : Shrimp 3M 10/11/2000

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    Table 10 Stock number at age (start of year)      Numbers*10**-4
    YEAR,    1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000,   GMST 93-97 AMST 93-97

    AGE
   2,    422333,  688498, 1857340, 1482437, 1016363,  841745,  528575,    0,   959609,  1093394,
   3,    319774,  312370,  505168, 1244833, 1168443,  806692,  655664,  401387,   593107,   710118,
   4,    568779,  199359,  138854,  247830,  586687,  810415,  511925,  365834,   296442,   348302,
   5,    455586,  432037,  135713,   82717,   56142,  328862,  457418,  278427,   165470,   232439,
   6,    611678,  296788,  291104,   52356,   22963,   17120,  207967,  173296,   144744,   254978,
TOTAL,   2378150, 1929052, 2928180, 3110174, 2850598, 2804834, 2361548, 1218943,
1

    Run title : Shrimp 3M 10/11/2000

    At 11/11/2000  16:52


       Table 11    Spawning stock number at age (spawning time)      Numbers*10**-3
       YEAR,       1993,    1994,    1995,    1996,    1997,    1998,    1999,

       AGE
         2,           0,       0,       0,       0,       0,       0,       0,
         3,       319774,  312370,  505168, 1244833, 1168443,  806692,  655664,
         4,      1706338,  598077,  416562,  743491, 1760060, 2431246, 1535776,
         5,      3189100, 3024259,  949994,  579022,  392996, 2302033, 3201924,
         6,      6116779, 2967879, 2911042,  523557,  229630,  171199, 2079669,
1
```

Run title : Shrimp 3M 10/11/2000

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Table 12 Stock biomass at age (start of year) Tonnes*10**-2

YEAR,	1993,	1994,	1995,	1996,	1997,	1998,	1999,
AGE							
2,	117071,	177357,	364967,	320207,	325338,	173904,	106984,
3,	167082,	156122,	248745,	604118,	482567,	317917,	221483,
4,	465716,	141565,	89727,	228847,	467355,	546787,	288265,
5,	475677,	435493,	130434,	95613,	59685,	363294,	379977,
6,	684406,	352703,	315557,	76968,	32952,	24743,	230282,
0 TOTALBIO,	1909953,	1263241,	1149431,	1325752,	1367896,	1426646,	1226991,
1							

Run title : Shrimp 3M 10/11/2000

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Table 13 Spawning stock biomass at age (spawning time) Tonnes*10**-2

YEAR,	1993,	1994,	1995,	1996,	1997,	1998,	1999,
AGE							
2,	0,	0,	0,	0,	0,	0,	0,
3,	16708,	15612,	24874,	60412,	48257,	31792,	22148,
4,	139715,	42469,	26918,	68654,	140206,	164036,	86480,
5,	332974,	304845,	91304,	66929,	41779,	254306,	265984,
6,	684406,	352703,	315557,	76968,	32952,	24743,	230282,
0 TOTSPBIO,	1173804,	715630,	458654,	272963,	263194,	474877,	604893,
1							

Run title : Shrimp 3M 10/11/2000

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Table 14 Stock biomass at age with SOP (start of year) Tonnes

YEAR,	1993,	1994,	1995,	1996,	1997,	1998,	1999,
AGE							
2,	11711,	17637,	36496,	32049,	31911,	17247,	10899,
3,	16713,	15525,	24874,	60465,	47333,	31529,	22564,
4,	46586,	14078,	8972,	22905,	45841,	54227,	29367,
5,	47582,	43307,	13043,	9570,	5854,	36029,	38710,
6,	68461,	35074,	31555,	7704,	3232,	2454,	23460,
0 TOTALBIO,	191053,	125622,	114939,	132692,	134173,	141487,	125000,
1							

Run title : Shrimp 3M 10/11/2000

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Table 15 Spawning stock biomass with SOP (spawning time) Tonnes

YEAR,	1993,	1994,	1995,	1996,	1997,	1998,	1999,
AGE							
2,	0,	0,	0,	0,	0,	0,	0,
3,	1671,	1553,	2487,	6047,	4733,	3153,	2256,
4,	13976,	4223,	2692,	6871,	13752,	16268,	8810,
5,	33308,	30315,	9130,	6699,	4098,	25221,	27097,
6,	68461,	35074,	31555,	7704,	3232,	2454,	23460,
0 TOTSPBIO,	117416,	71165,	45864,	27320,	25816,	47096,	61624,
1							

```
    Run title : Shrimp 3M 10/11/2000                                                ,

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        Table 16    Summary     (without SOP correction)

,            RECRUITS,    TOTALBIO,    TOTSPBIO,    LANDINGS,   YIELD/SSB,  FBAR  3- 5,
 ,             Age 2
    1993,      4223333,   190995264,   117380352,       26876,       .0002,       .1920,
    1994,      6884981,   126324048,    71562976,       24549,       .0003,       .3301,
    1995,     18573404,   114943056,    45865360,       32982,       .0007,       .5275,
    1996,     14824374,   132575184,    27296306,       48299,       .0018,       .9729,
    1997,     10163627,   136789600,    26319432,       24675,       .0009,       .5108,
    1998,      8417447,   142664592,    47487684,       30308,       .0006,       .2950,
    1999,      5285750,   122699048,    60489336,       42005,       .0007,       .5111,

 Arith.
   Mean   ,    9767559,   138141541,    56628777,       32813,       .0008,       .4771,
0 Units,   (Thousands),    (Tonnes),    (Tonnes),    (Tonnes),
1

    Run title : Shrimp 3M 10/11/2000                                                ,

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        Table 17    Summary     (with SOP correction)

,            RECRUITS,    TOTALBIO,    TOTSPBIO,    LANDINGS,   YIELD/SSB,    SOPCOFAC,  FBAR  3- 5,
 ,             Age 2
    1993,      4223333,      191053,      117416,       26876,       .2289,       .0010,       .1920,
    1994,      6884981,      125622,       71165,       24549,       .3450,       .0010,       .3301,
    1995,     18573404,      114939,       45864,       32982,       .7191,       .0010,       .5275,
    1996,     14824374,      132692,       27320,       48299,      1.7679,       .0010,       .9729,
    1997,     10163627,      134173,       25816,       24675,       .9558,       .0010,       .5108,
    1998,      8417447,      141487,       47096,       30308,       .6435,       .0010,       .2950,
    1999,      5285750,      125000,       61624,       42005,       .6816,       .0010,       .5111,

 Arith.
   Mean   ,    9767559,      137852,       56614,       32813,       .7631                     .4771,
0 Units,   (Thousands),    (Tonnes),    (Tonnes),    (Tonnes),
1
```

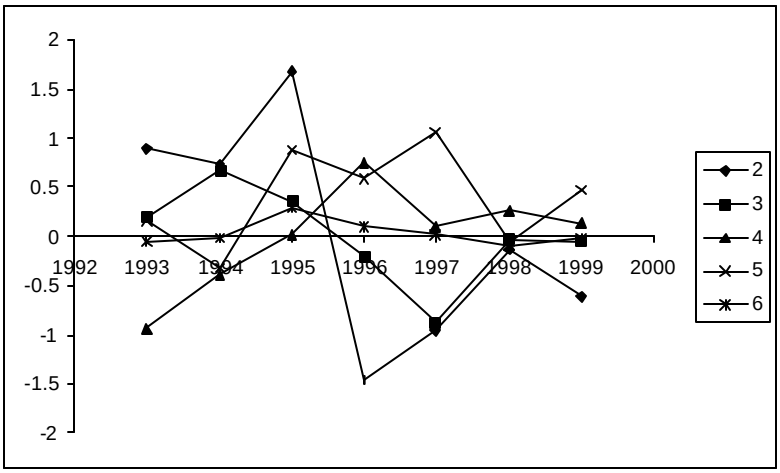

Fig. 1 Log-transformed catchability residuals derived from the Island trawl fleet tuning series for ages 2 to 6. Catchability set dependent on stock size for ages < 3 and independent of age for ages >= 4.

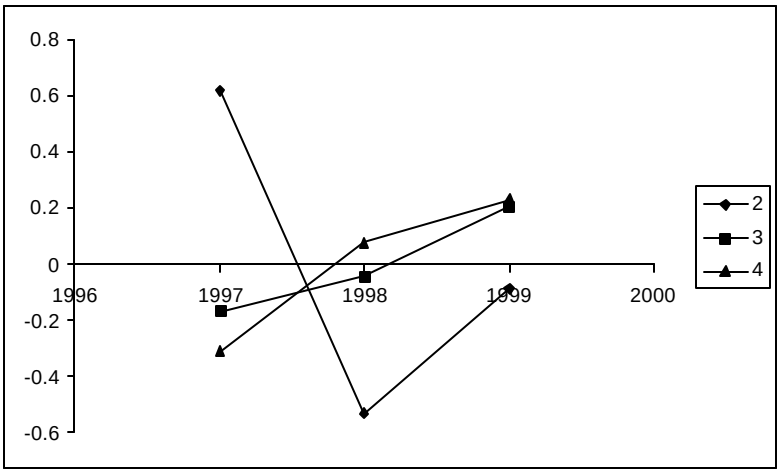

Fig. 2 Log-transformed catchability residuals derived from the Faeroes survey tuning series for ages 2 to 4. Catchability set dependent on stock size for ages < 3 and independent of age for ages >= 4.

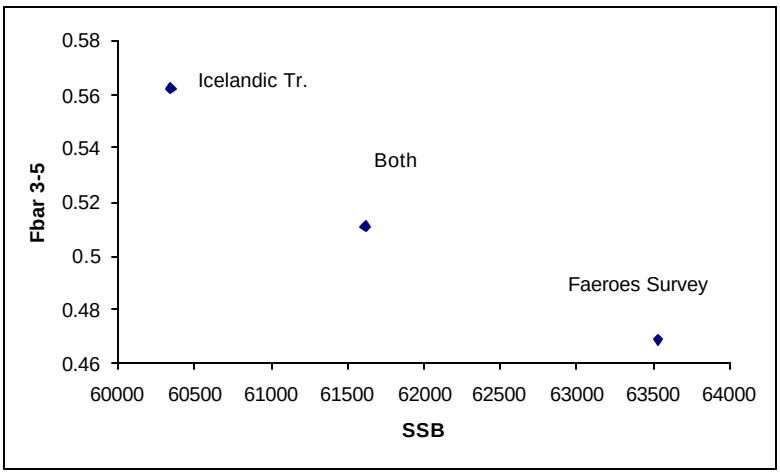

Fig. 3 Estimates of Fbar (3-5) and SSB in 1999 as derived from single fleet (Icelandic Trawlers or Faeroe survey) and combined tuning. Catchability set dependent on stock size for ages < 3 and independent of age for ages >= 4.

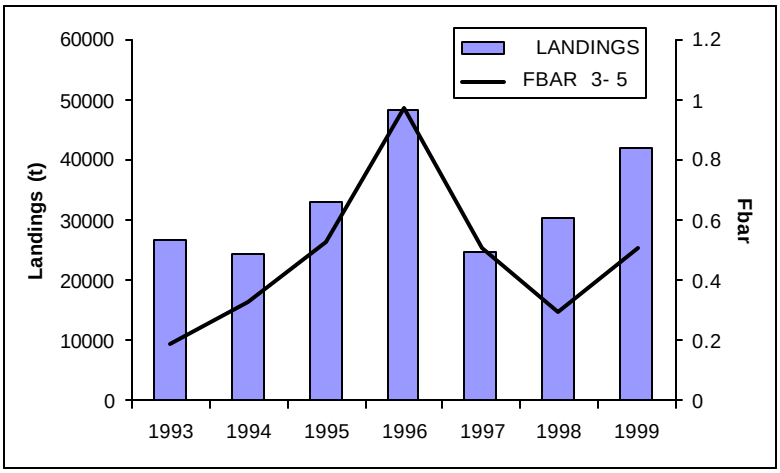

Fig. 4 Trends in landings and fishing mortality, 1993-1999

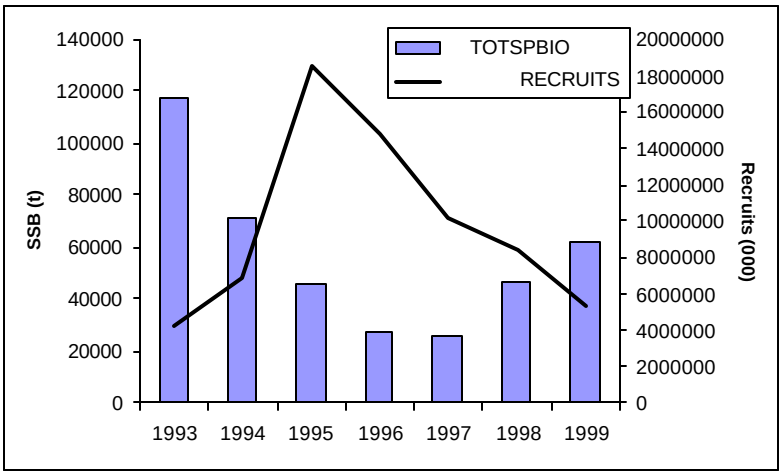

Fig. 5 Trends in SSB and recruitment at age 2.