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An Integrated Catch-at-Age Analysis of the American Plaice in NAFO Division 3M

By

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Abstract

An assessment of the American Plaice in Div. 3m was carried out using Integrated Catch at Age (ICA). The results indicate that the stock has been in a continual decline since 1988. The rate of exploitation has been relatively constant in recent years at levels close to the assumed value of natural mortality.

Methods

The Integrated catch at Age (ICA, Patterson and Melvin, 1996) stock assessment model was fitted to the stock assessment data set for the American Plaice in NAFO Div. 3M. The separable model fitted to the last four years of catch at age data. The reference age was set at age 7 and after an iterative selection process, model selection at the oldest age was set to 1.5. The catch at age data for the youngest partially selected ages produced large residuals within the fitted model structure. The youngest ages were therefore down-weighted by setting the relative weighting to 0.01 for age 3, 0.1 at age 4 and 0.5 at age 5 all other ages were assigned a weight of 1.0. The model was fitted to the cpue data from the EU Div. 3m survey for the years 1994-2001. Data for the years 1988-1993 were excluded as they were derived using an average age length key and showed strong positive residuals within the results from exploratory model fits.

Results

The assessment data, fitted model diagnostics and population abundance and exploitation rates are presented. Figure 1 illustrates the sum of squares surface and Fig. 2 the stock trends.

The residuals of the model fit to the catch at age data show that there is extensive noise in the fit, especially at the youngest ages, which were down weighted during fitting. There are year effects within the residual pattern that indicate changes in selection have taken place during the last four years.

The residual patterns of the model fit to the survey CPUE data also indicate departures from the assumption of constant catchability at age. There is a strong cohort effect at the oldest ages in the early part of the time series and substantial year effect in the final year.

The noise levels in the fit of the ICA model to the American plaice in Div. 3M data indicate that the assessment results should be used to estimate the overall level and recent trends of the population levels and exploitation rates, rather than for the estimation of absolute values.

Figure 2 illustrates the population and exploitation summary series. Fishing mortality has is estimated to be at a similar level as natural mortality and has remained constant during 1996-2001. The stock is estimated to have been

in a continual state of decline since the start of the time series. Recruitment to the stock declined strongly in the mid-1990s and has remained at a low level.

References

Patterson, K. R. and Melvin, G. D. (1996). Integrated Catch At Age Analysis Version 1:2, *ScottishFisheries Research Report*. FRS: Aberdeen.

Output Generated by ICA Version 1.4

AMERICAN PLAICE NAFO DIVISION 3M INDEX O

Catch in Number

AGE	1988	1989	1990	1991	1992	1993	1994	1995
3	311.00	209.00	49.00	19.00	17.00	47.00	6.00	24.00
4	731.00	573.00	183.00	133.00	76.00	42.00	219.00	167.00
5	549.00	527.00	112.00	185.00	75.00	26.00	98.00	458.00
6	440.00	482.00	87.00	168.00	76.00	11.00	77.00	235.00
7	720.00	886.00	158.00	342.00	136.00	112.00	75.00	231.00
8	532.00	715.00	147.00	331.00	124.00	13.00	254.00	155.00
9	386.00	520.00	110.00	243.00	100.00	24.00	24.00	250.00
10	265.00	356.00	78.00	174.00	77.00	12.00	48.00	31.00
11	173.00	230.00	55.00	124.00	60.00	9.00	16.00	35.00
12	118.00	148.00	39.00	84.00	46.00	11.00	17.00	30.00
13	65.00	80.00	24.00	50.00	31.00	15.00	20.00	30.00
14	102.00	118.00	33.00	68.00	45.00	49.00	40.00	58.00
15	43.00	39.00	13.00	23.00	23.00	2.00	43.00	45.00
16	25.00	19.00	7.00	12.00	14.00	2.00	1.00	7.00

x 10 ^ 3

Catch in Number

AGE	1996	1997	1998	1999	2000	2001
3	13.00	0.10	0.30	0.10	0.10	5.00
4	60.00	0.10	1.00	4.00	19.00	6.00
5	101.00	4.00	2.00	6.00	25.00	16.00
6	173.00	17.00	7.00	8.00	25.00	8.00
7	63.00	61.00	28.00	27.00	12.00	10.00
8	41.00	12.00	57.00	59.00	13.00	21.00
9	23.00	28.00	36.00	60.00	33.00	30.00
10	34.00	23.00	31.00	35.00	35.00	41.00
11	6.00	35.00	32.00	40.00	17.00	35.00
12	3.00	13.00	33.00	21.00	13.00	29.00
13	3.00	3.00	8.00	9.00	6.00	10.00
14	3.00	9.00	14.00	5.00	3.00	6.00
15	2.00	4.00	7.00	3.00	3.00	3.00
16	0.40	10.00	10.00	5.00	4.00	3.00

x 10 ^ 3

Predicted Catch in Number

AGE	1998	1999	2000	2001
3	326.	409.	137.	760.
4	5100.	5083.	4821.	2597.
5	7720.	8488.	6401.	9740.
6	15938.	9044.	7519.	9088.
7	36576.	16892.	7247.	9645.
8	62384.	50686.	17749.	12088.
9	41744.	57119.	35094.	19531.
10	33419.	33055.	34152.	33405.
11	24748.	30531.	22845.	37407.
12	19895.	23347.	21817.	25728.
13	6779.	8659.	7616.	11455.
14	6222.	5719.	5518.	7739.
15	4684.	4685.	3250.	5011.

Weights at age in the catches (Kg)

AGE	1988	1989	1990	1991	1992	1993	1994	1995
3	0.2000	0.1650	0.1910	0.1890	0.2100	0.1620	0.1550	0.1900
4	0.3120	0.3420	0.3200	0.3670	0.3270	0.2960	0.3140	0.3350
5	0.4490	0.4790	0.4240	0.4800	0.4870	0.3940	0.4870	0.4940
6	0.5720	0.6170	0.5580	0.5980	0.6060	0.5800	0.5620	0.6260
7	0.6840	0.7500	0.7380	0.7630	0.7230	0.7560	0.6530	0.6840
8	0.7620	0.8420	0.8890	0.8910	0.8550	0.8130	0.8240	0.8160
9	0.7900	0.8600	0.9240	0.9290	0.9190	0.8650	0.9690	0.9250
10	0.8230	0.8820	0.9630	0.9620	0.9660	0.9790	0.9540	1.2440
11	0.8860	0.9280	1.0310	1.0350	1.0740	1.0390	1.0680	1.3200
12	0.9810	0.9850	1.0950	1.0870	1.1690	1.0590	1.0650	1.4740
13	1.2150	1.1360	1.2230	1.1880	1.3730	1.1790	1.3180	1.5320
14	1.2710	1.1850	1.2620	1.2060	1.3810	1.3390	1.2890	1.5470
15	1.5900	1.4840	1.4810	1.3610	1.5740	1.8190	1.5610	1.5710
16	1.7360	1.7170	1.6180	1.4770	1.6660	1.6270	1.8950	2.1080

Weights at age in the catches (Kg)

AGE	1996	1997	1998	1999	2000	2001
3	0.2250	0.1870	0.1850	0.1870	0.1150	0.2630
4	0.3310	0.3200	0.2690	0.3650	0.2680	0.2830
5	0.4250	0.4450	0.3960	0.4950	0.3590	0.3400
6	0.5350	0.6390	0.5540	0.5360	0.4440	0.4010
7	0.6710	0.7260	0.7760	0.5810	0.5660	0.4710
8	0.7330	0.6820	0.8890	0.7860	0.6370	0.5950
9	0.8520	0.9490	0.9500	0.8720	0.7060	0.6150
10	0.8250	1.0590	1.1400	0.9430	0.6920	0.6910
11	1.0020	1.0970	1.3370	1.1090	0.7820	0.7030
12	1.3020	1.2700	1.3800	1.1940	0.8910	0.8050
13	1.2020	1.2610	1.4610	1.3370	1.2250	0.9750
14	1.3850	1.5090	1.5090	1.4450	1.1400	1.1500
15	1.5390	1.5080	1.5890	1.4390	1.2900	1.2980
16	1.3330	1.5130	1.6130	1.3890	1.3890	1.5300

Weights at age in the stock (Kg)

AGE	1988	1989	1990	1991	1992	1993	1994	1995
3	0.1520	0.1510	0.1890	0.1570	0.1580	0.1600	0.1630	0.1910
4	0.3360	0.2920	0.3110	0.3390	0.3120	0.2950	0.3140	0.3260
5	0.4850	0.5140	0.4160	0.4690	0.5060	0.3990	0.4780	0.4800
6	0.6100	0.6230	0.5500	0.5530	0.6090	0.5720	0.5570	0.6200
7	0.7150	0.7200	0.7010	0.6520	0.6810	0.7260	0.6450	0.6690
8	0.7840	0.8160	0.8300	0.7680	0.7600	0.7600	0.8120	0.7970
9	0.7990	0.8410	0.8590	0.7980	0.8120	0.8010	0.9610	0.9010
10	0.8250	0.8640	0.9010	0.8350	0.8420	0.8850	0.9350	1.2390
11	0.8880	0.9240	0.9690	0.8970	0.9260	0.9270	1.0510	1.3020
12	0.9740	1.0070	1.0440	0.9660	1.0190	0.9520	1.0490	1.4820
13	1.2310	1.2010	1.1970	1.1590	1.1990	1.0980	1.3030	1.5310
14	1.2470	1.2160	1.2260	1.1850	1.2170	1.2490	1.2620	1.5280
15	1.5730	1.4880	1.4360	1.4420	1.4260	1.8650	1.5650	1.5710
16	1.7640	1.6630	1.5950	1.6440	1.7870	1.6290	1.8950	2.1080

Weights at age in the stock (Kg)

AGE	1996	1997	1998	1999	2000	2001
3	0.1900	0.1710	0.1740	0.1660	0.1150	0.2110
4	0.3290	0.2360	0.2590	0.3150	0.2450	0.2450
5	0.4610	0.4210	0.3780	0.4310	0.4030	0.3660
6	0.5840	0.5500	0.5060	0.5410	0.5110	0.4260
7	0.7100	0.6680	0.6470	0.5600	0.6100	0.5200
8	0.8280	0.6370	0.7810	0.7780	0.6740	0.5980
9	0.9470	0.8700	0.8300	0.8550	0.7600	0.6210
10	0.8770	1.0170	1.0430	1.0130	0.7540	0.7090
11	1.1040	1.0310	1.2560	1.1960	0.8560	0.7110
12	1.4000	1.2330	1.3420	1.2930	0.9600	0.8660
13	1.3190	1.2770	1.5440	1.4700	1.2360	1.1000
14	1.5400	1.4500	1.5190	1.7290	1.2000	1.3420
15	1.6630	1.6220	1.6190	1.5710	1.3160	1.4510
16	1.8250	1.5260	1.6650	1.5990	1.3920	1.4900

Natural Mortality (per year)

AGE	1988	1989	1990	1991	1992	1993	1994	1995
3	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
4	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
5	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
6	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
7	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
8	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
9	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
10	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
11	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
12	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
13	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
14	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
15	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
16	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000

Natural Mortality (per year)

AGE	1996	1997	1998	1999	2000	2001
3	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
4	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
5	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
6	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
7	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
8	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
9	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
10	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
11	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
12	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
13	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
14	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
15	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000
16	0.20000	0.20000	0.20000	0.20000	0.20000	0.20000

Proportion of fish spawning

AGE	1988	1989	1990	1991	1992	1993	1994	1995
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
13	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
14	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
15	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
16	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Proportion of fish spawning

AGE	1996	1997	1998	1999	2000	2001
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
13	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
14	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
15	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
16	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

AGE-STRUCTURED INDICES

EU BOTTOM TRAWL SURVEY

AGE	1994	1995	1996	1997	1998	1999	2000	2001
3	3.60	9.38	9.76	9.10	2.56	1.89	0.57	4.26
4	169.49	59.78	21.51	2.08	3.79	5.40	6.92	4.74
5	73.80	153.20	44.62	9.28	5.68	5.78	8.24	7.77
6	61.30	93.70	118.24	29.75	19.23	5.50	11.18	4.26
7	66.89	93.42	62.81	85.55	43.49	17.15	8.24	7.67
8	234.11	62.91	39.32	19.04	62.25	32.78	10.61	18.19
9	22.83	107.06	29.37	29.75	36.85	35.91	27.38	29.46
10	45.10	11.94	45.19	21.22	25.49	18.19	29.75	39.51
11	15.73	13.55	10.80	35.43	22.45	25.01	16.39	33.16
12	15.44	11.27	6.16	9.76	21.89	15.63	13.26	29.46
13	18.38	11.37	6.44	1.89	7.01	9.47	5.59	13.64
14	37.71	22.93	9.00	7.30	8.91	9.76	4.17	12.32
15	37.61	17.34	5.87	3.79	4.55	4.74	3.60	8.72

x 10 ^ -3

Fishing Mortality (per year)

AGE	1988	1989	1990	1991	1992	1993	1994	1995
3	0.1300	0.0614	0.0270	0.0098	0.0096	0.0170	0.0042	0.0440
4	0.2617	0.3727	0.0701	0.0950	0.0492	0.0295	0.1026	0.1535
5	0.2205	0.3055	0.1146	0.0939	0.0711	0.0213	0.0891	0.3216
6	0.1662	0.3067	0.0751	0.2510	0.0507	0.0133	0.0809	0.3175
7	0.3256	0.5826	0.1556	0.4650	0.3309	0.0982	0.1180	0.3674
8	0.2725	0.6245	0.1759	0.5583	0.3050	0.0471	0.3351	0.3782
9	0.2082	0.4664	0.1793	0.4883	0.3243	0.0884	0.1150	0.6466
10	0.3626	0.3016	0.1160	0.4743	0.2804	0.0580	0.2550	0.2131
11	0.2674	0.6187	0.0690	0.2720	0.2962	0.0475	0.1023	0.2992
12	0.3514	0.3853	0.1968	0.1429	0.1531	0.0806	0.1189	0.2823
13	0.2192	0.4281	0.0982	0.4144	0.0718	0.0683	0.2059	0.3164
14	0.6864	0.7736	0.3143	0.4388	0.8227	0.1550	0.2605	1.5728
15	0.4034	0.6185	0.1727	0.3769	0.2590	0.0727	0.1979	0.5228
16	0.4034	0.6185	0.1727	0.3769	0.2590	0.0727	0.1979	0.5228

Fishing Mortality (per year)

AGE	1996	1997	1998	1999	2000	2001
3	0.0530	0.0004	0.0016	0.0018	0.0015	0.0021
4	0.1473	0.0005	0.0266	0.0304	0.0262	0.0364
5	0.1307	0.0130	0.0494	0.0564	0.0486	0.0676
6	0.1929	0.0292	0.0660	0.0752	0.0648	0.0902
7	0.1309	0.0962	0.0810	0.0923	0.0796	0.1107
8	0.1017	0.0331	0.1348	0.1538	0.1325	0.1844
9	0.0874	0.0935	0.1542	0.1759	0.1515	0.2109
10	0.1651	0.1182	0.1541	0.1757	0.1514	0.2107
11	0.0579	0.2554	0.1801	0.2054	0.1770	0.2463
12	0.0374	0.1715	0.2257	0.2575	0.2219	0.3088
13	0.0408	0.0476	0.1269	0.1448	0.1248	0.1737
14	0.0467	0.1653	0.1316	0.1501	0.1293	0.1800
15	0.1797	0.0811	0.1214	0.1385	0.1193	0.1661
16	0.1797	0.0811	0.1214	0.1385	0.1193	0.1661

Population Abundance (1 January)

AGE	1988	1989	1990	1991	1992	1993	1994	1995
3	2809.1	3868.4	2029.3	2154.2	1964.2	3072.8	1584.5	615.2
4	3487.5	2019.6	2978.6	1617.2	1746.6	1592.8	2473.3	1291.9
5	3050.3	2197.9	1139.1	2273.6	1204.1	1361.4	1266.2	1827.5
6	3162.2	2003.3	1325.8	831.6	1694.6	918.2	1091.1	948.2
7	2843.3	2192.6	1207.0	1007.0	529.7	1318.8	741.8	823.9
8	2449.8	1681.0	1002.5	845.8	517.9	311.5	978.7	539.7
9	2257.8	1527.3	737.0	688.3	396.2	312.6	243.3	573.2
10	955.7	1501.0	784.3	504.4	345.8	234.6	234.3	177.6
11	809.8	544.5	908.9	571.8	257.0	213.9	181.2	148.6
12	436.8	507.4	240.1	694.6	356.7	156.5	167.0	133.9
13	363.0	251.7	282.6	161.5	493.0	250.6	118.2	121.4
14	224.1	238.7	134.3	209.7	87.4	375.6	191.6	78.8
15	142.0	92.3	90.1	80.3	110.7	31.4	263.4	120.9
16	82.5	45.0	48.5	41.9	67.4	31.4	6.1	18.8

x 10 ^ 3

Population Abundance (1 January)

AGE	1996	1997	1998	1999	2000	2001	2002
3	277.7	261.6	229.2	251.9	97.9	390.5	1383.8
4	482.0	215.6	214.1	187.4	205.8	80.1	319.0
5	907.2	340.6	176.5	170.6	148.8	164.2	63.2
6	1084.7	651.8	275.2	137.5	132.1	116.1	125.6
7	565.2	732.3	518.3	210.9	104.4	101.3	86.8
8	467.1	406.0	544.5	391.3	157.5	79.0	74.3
9	302.7	345.5	321.5	389.6	274.7	112.9	53.8
10	245.8	227.1	257.6	225.6	267.5	193.3	74.9
11	117.5	170.6	165.2	180.8	155.0	188.3	128.2
12	90.2	90.8	108.2	113.0	120.5	106.3	120.5
13	82.7	71.2	62.6	70.7	71.5	79.1	63.9
14	72.4	65.0	55.5	45.1	50.1	51.7	54.4
15	13.4	56.6	45.1	39.9	31.8	36.0	35.3
16	2.7	141.5	96.3	42.5	39.2	21.6	39.9

x 10 ^ 3

Weighting factors for the catches in number

AGE	1998	1999	2000	2001
3	0.0100	0.0100	0.0100	0.0100
4	0.1000	0.1000	0.1000	0.1000
5	0.5000	0.5000	0.5000	0.5000
6	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000
10	1.0000	1.0000	1.0000	1.0000
11	1.0000	1.0000	1.0000	1.0000
12	1.0000	1.0000	1.0000	1.0000
13	1.0000	1.0000	1.0000	1.0000
14	1.0000	1.0000	1.0000	1.0000
15	1.0000	1.0000	1.0000	1.0000

Predicted Age-Structured Index Values

EU BOTTOM TRAWL SURVEY Predicted

AGE	1994	1995	1996	1997	1998	1999	2000	2001
3	17610.	6689.	3005.	2913.	2551.	2803.	1090.	4344.
4	79760.	40513.	15166.	7355.	7197.	6287.	6923.	2678.
5	57957.	73611.	40589.	16255.	8255.	7953.	6966.	7605.
6	69672.	53163.	65127.	42818.	17719.	8807.	8507.	7373.
7	69271.	67075.	52406.	69210.	49394.	19979.	9959.	9501.
8	95593.	51480.	51875.	46813.	59380.	42228.	17194.	8378.
9	30390.	53437.	38388.	43661.	39301.	47058.	33628.	13380.
10	26738.	20742.	29481.	27949.	31082.	26902.	32328.	22607.
11	23401.	17222.	15546.	20255.	20441.	22060.	19206.	22461.
12	21299.	15613.	12033.	11247.	13013.	13350.	14526.	12212.
13	10753.	10396.	8239.	7064.	5950.	6653.	6802.	7322.
14	32809.	6552.	13952.	11726.	10211.	8215.	9216.	9248.
15	38058.	14610.	1952.	8722.	6797.	5952.	4800.	5297.

x 10 ^ -6

Fitted Selection Pattern

AGE	1988	1989	1990	1991	1992	1993	1994	1995
3	0.3992	0.1054	0.1735	0.0210	0.0290	0.1732	0.0355	0.1197
4	0.8038	0.6396	0.4507	0.2042	0.1486	0.3005	0.8694	0.4177
5	0.6771	0.5243	0.7367	0.2020	0.2149	0.2168	0.7551	0.8754
6	0.5104	0.5264	0.4825	0.5398	0.1532	0.1355	0.6858	0.8640
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	0.8370	1.0719	1.1309	1.2007	0.9216	0.4795	2.8391	1.0293
9	0.6396	0.8006	1.1529	1.0503	0.9801	0.8999	0.9741	1.7598
10	1.1136	0.5177	0.7456	1.0200	0.8474	0.5910	2.1608	0.5800
11	0.8215	1.0619	0.4437	0.5851	0.8951	0.4836	0.8668	0.8142
12	1.0793	0.6614	1.2649	0.3072	0.4626	0.8209	1.0072	0.7684
13	0.6734	0.7347	0.6314	0.8913	0.2171	0.6949	1.7444	0.8610
14	2.1084	1.3277	2.0204	0.9436	2.4864	1.5778	2.2070	4.2807
15	1.2389	1.0616	1.1105	0.8107	0.7829	0.7406	1.6765	1.4229
16	1.2389	1.0616	1.1105	0.8107	0.7829	0.7406	1.6765	1.4229

Fitted Selection Pattern

AGE	1996	1997	1998	1999	2000	2001
3	0.4047	0.0044	0.0194	0.0194	0.0194	0.0194
4	1.1254	0.0053	0.3289	0.3289	0.3289	0.3289
5	0.9986	0.1355	0.6106	0.6106	0.6106	0.6106
6	1.4731	0.3033	0.8147	0.8147	0.8147	0.8147
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	0.7766	0.3443	1.6653	1.6653	1.6653	1.6653
9	0.6677	0.9717	1.9045	1.9045	1.9045	1.9045
10	1.2610	1.2285	1.9030	1.9030	1.9030	1.9030
11	0.4425	2.6532	2.2242	2.2242	2.2242	2.2242
12	0.2853	1.7814	2.7886	2.7886	2.7886	2.7886
13	0.3118	0.4945	1.5681	1.5681	1.5681	1.5681
14	0.3569	1.7177	1.6257	1.6257	1.6257	1.6257
15	1.3724	0.8422	1.5000	1.5000	1.5000	1.5000
16	1.3724	0.8422	1.5000	1.5000	1.5000	1.5000

STOCK SUMMARY

Year	Recruits Age 3 thousands	Total Biomass tonnes	Spawning Biomass tonnes	Landings tonnes	Yield /SSB ratio	Mean F Ages 6-10	SoP (%)
1988	2800	13792	9491	2800	0.2950	0.2670	100
1989	3860	10902	7017	3500	0.4987	0.4564	100
1990	2020	7372	5095	790	0.1550	0.1404	100
1991	2150	6493	4074	1600	0.3927	0.4474	99
1992	1960	5440	3664	765	0.2088	0.2582	100
1993	3070	4883	3270	275	0.0841	0.0610	99
1994	1580	5159	3280	669	0.2039	0.1808	99
1995	610	4649	2873	1300	0.4524	0.3845	100
1996	270	3057	2316	300	0.1295	0.1356	100
1997	260	2657	2215	208	0.0939	0.0741	99
1998	220	2364	1956	294	0.1503	0.1180	99
1999	250	1908	1530	255	0.1666	0.1346	99
2000	90	1262	1021	133	0.1302	0.1160	100
2001	390	985	728	149	0.2046	0.1614	100

No of years for separable analysis : 4
Age range in the analysis : 3 . . . 16
Year range in the analysis : 1988 . . . 2001
Number of indices of SSB : 0
Number of age-structured indices : 1
Parameters to estimate : 44
Number of observations : 156

Conventional single selection vector model to be fitted.

PARAMETER ESTIMATES

Parm. No.		Maximum Likelh. Estimate	CV (%)	Lower 95% CL	Upper 95% CL	-s.e.	+s.e.	Mean of Param. Distrib.
Separable model : F by year								
1	1998	0.0810	29	0.0451	0.1454	0.0600	0.1092	0.0847
2	1999	0.0923	29	0.0519	0.1642	0.0688	0.1239	0.0964
3	2000	0.0796	29	0.0447	0.1415	0.0593	0.1067	0.0831
4	2001	0.1107	29	0.0615	0.1994	0.0820	0.1495	0.1158
Separable Model: Selection (S) by age								
5	3	0.0194	288	0.0001	5.5001	0.0011	0.3461	1.2314
6	4	0.3289	94	0.0514	2.1062	0.1275	0.8482	0.5152
7	5	0.6106	48	0.2359	1.5805	0.3759	0.9920	0.6869
8	6	0.8147	38	0.3851	1.7233	0.5559	1.1940	0.8764
	7	1.0000		Fixed : Reference Age				
9	8	1.6653	37	0.7909	3.5063	1.1389	2.4348	1.7899
10	9	1.9045	38	0.8984	4.0372	1.2981	2.7942	2.0497
11	10	1.9030	38	0.8909	4.0648	1.2920	2.8028	2.0511
12	11	2.2242	38	1.0385	4.7639	1.5081	3.2806	2.3987
13	12	2.7886	37	1.3252	5.8681	1.9078	4.0761	2.9969
14	13	1.5681	37	0.7472	3.2911	1.0743	2.2890	1.6844
15	14	1.6257	37	0.7832	3.3745	1.1200	2.3597	1.7426
	15	1.5000		Fixed : Last true age				
Separable model: Populations in year 2001								
16	3	389	61	115	1310	209	723	471
17	4	79	43	33	186	51	122	86
18	5	163	34	83	318	115	229	173
19	6	115	28	65	201	86	153	119
20	7	100	26	59	169	76	131	103
21	8	77	25	47	127	60	100	80
22	9	111	24	68	182	87	143	115
23	10	192	25	116	316	149	247	198
24	11	187	25	112	311	144	242	193
25	12	105	26	63	175	81	136	108
26	13	78	27	45	133	59	102	80
27	14	50	27	29	86	38	66	52
28	15	35	27	20	59	26	46	36
Separable model: Populations at age								
29	1998	44	45	17	108	27	69	49
30	1999	38	34	19	76	27	55	41
31	2000	30	30	16	55	22	41	32

Age-structured index catchabilities

EU BOTTOM TRAWL SURVEY

Linear model fitted. Slopes at age :

32	3	Q	.1243E-04	23	.9895E-05	.2515E-04	.1243E-04	.2002E-04	.1623E-04
33	4	Q	.3809E-04	22	.3068E-04	.7421E-04	.3809E-04	.5977E-04	.4894E-04
34	5	Q	.5366E-04	22	.4344E-04	.1030E-03	.5366E-04	.8337E-04	.6853E-04
35	6	Q	.7452E-04	21	.6046E-04	.1420E-03	.7452E-04	.1152E-03	.9488E-04
36	7	Q	.1112E-03	21	.9040E-04	.2108E-03	.1112E-03	.1714E-03	.1413E-03
37	8	Q	.1311E-03	21	.1066E-03	.2483E-03	.1311E-03	.2018E-03	.1665E-03
38	9	Q	.1485E-03	21	.1207E-03	.2818E-03	.1485E-03	.2289E-03	.1888E-03
39	10	Q	.1466E-03	21	.1190E-03	.2786E-03	.1466E-03	.2262E-03	.1864E-03
40	11	Q	.1525E-03	21	.1238E-03	.2901E-03	.1525E-03	.2355E-03	.1940E-03
41	12	Q	.1520E-03	21	.1232E-03	.2902E-03	.1520E-03	.2353E-03	.1937E-03
42	13	Q	.1138E-03	22	.9203E-04	.2186E-03	.1138E-03	.1769E-03	.1453E-03
43	14	Q	.2206E-03	22	.1778E-03	.4291E-03	.2206E-03	.3458E-03	.2833E-03
44	15	Q	.1798E-03	23	.1439E-03	.3579E-03	.1798E-03	.2863E-03	.2331E-03

RESIDUALS ABOUT THE MODEL FIT

Separable Model Residuals

Age	1998	1999	2000	2001
3	-0.084	-1.408	-0.314	1.884
4	-1.629	-0.240	1.372	0.837
5	-1.351	-0.347	1.362	0.496
6	-0.823	-0.123	1.201	-0.128
7	-0.267	0.469	0.504	0.036
8	-0.090	0.152	-0.311	0.552
9	-0.148	0.049	-0.062	0.429
10	-0.075	0.057	0.025	0.205
11	0.257	0.270	-0.296	-0.067
12	0.506	-0.106	-0.518	0.120
13	0.166	0.039	-0.238	-0.136
14	0.811	-0.134	-0.609	-0.254
15	0.402	-0.446	-0.080	-0.513

AGE-STRUCTURED INDEX RESIDUALS

EU BOTTOM TRAWL SURVEY

Age	1994	1995	1996	1997	1998	1999	2000	2001
3	-1.588	0.338	1.178	1.139	0.003	-0.392	-0.651	-0.019
4	0.754	0.389	0.349	-1.261	-0.641	-0.152	-0.001	0.570
5	0.242	0.733	0.095	-0.560	-0.373	-0.319	0.168	0.021
6	-0.128	0.567	0.596	-0.364	0.082	-0.472	0.273	-0.548
7	-0.035	0.331	0.181	0.212	-0.127	-0.153	-0.189	-0.214
8	0.896	0.200	-0.277	-0.899	0.047	-0.253	-0.483	0.775
9	-0.286	0.695	-0.268	-0.384	-0.064	-0.270	-0.206	0.789
10	0.523	-0.552	0.427	-0.275	-0.199	-0.391	-0.083	0.558
11	-0.397	-0.240	-0.364	0.559	0.094	0.126	-0.159	0.390
12	-0.322	-0.326	-0.670	-0.142	0.520	0.158	-0.091	0.881
13	0.536	0.089	-0.246	-1.316	0.164	0.354	-0.196	0.622
14	0.139	1.253	-0.438	-0.475	-0.137	0.172	-0.793	0.287
15	-0.012	0.171	1.102	-0.834	-0.402	-0.228	-0.288	0.498

PARAMETERS OF THE DISTRIBUTION OF ln(CATCHES AT AGE)

Separable model fitted from 1998 to 2001

Variance	0.4110
Skewness test stat.	1.4635
Kurtosis test statistic	1.2279
Partial chi-square	4.3124
Significance in fit	0.0000
Degrees of freedom	21

PARAMETERS OF THE DISTRIBUTION OF THE AGE-STRUCTURED INDICES

DISTRIBUTION STATISTICS FOR EU BOTTOM TRAWL SURVEY

Linear catchability relationship assumed

Age	3	4	5	6	7	8
Variance	0.8423	0.4560	0.1697	0.2043	0.0442	0.3755
Skewness test stat.	-0.2709	-0.8918	0.3866	0.1820	0.5616	0.2415
Kurtosis test statisti	-0.3803	-0.2971	-0.3547	-0.8449	-0.8022	-0.5788
Partial chi-square	1.1960	0.7676	0.3613	0.4134	0.0979	0.8496
Significance in fit	0.0090	0.0022	0.0002	0.0003	0.0000	0.0031
Number of observations	8	8	8	8	8	8
Degrees of freedom	7	7	7	7	7	7
Weight in the analysis	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

9	10	11	12	13	14	15
0.2180	0.1925	0.1232	0.2511	0.3807	0.3951	0.3545
1.2121	0.2858	0.4403	0.6389	-1.3934	0.9254	0.6559
-0.4190	-0.8955	-0.6909	-0.3872	0.3826	0.0515	-0.1927
0.4394	0.3651	0.2210	0.4044	0.5440	0.5754	0.4533
0.0004	0.0002	0.0000	0.0003	0.0007	0.0009	0.0004
8	8	8	8	8	8	8
7	7	7	7	7	7	7
1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

ANALYSIS OF VARIANCE

Unweighted Statistics

Variance

	SSQ	Data	Parameters	d.f.	Variance
Total for model	49.0522	156	44	112	0.4380
Catches at age	21.0017	52	31	21	1.0001
Aged Indices					
EU BOTTOM TRAWL SURVEY	28.0505	104	13	91	0.3082

Weighted Statistics

Variance

	SSQ	Data	Parameters	d.f.	Variance
Total for model	36.6820	156	44	112	0.3275
Catches at age	8.6315	52	31	21	0.4110
Aged Indices					
EU BOTTOM TRAWL SURVEY	28.0505	104	13	91	0.3082

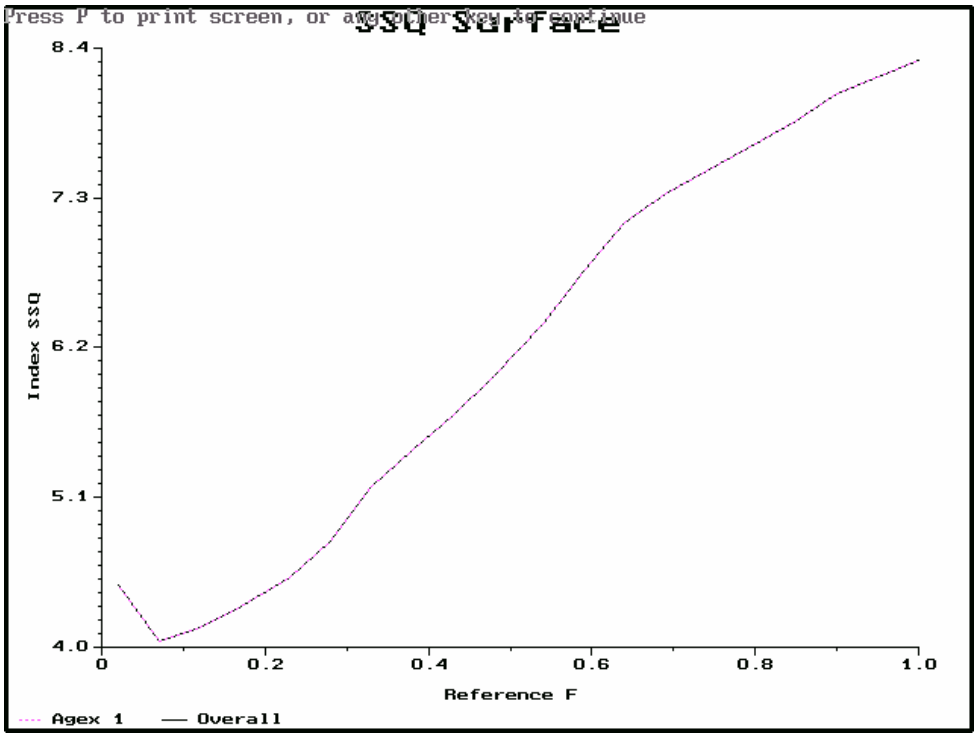

Fig. 1. The sum of squares surface for the American Plaice in NAFO Div. 3M

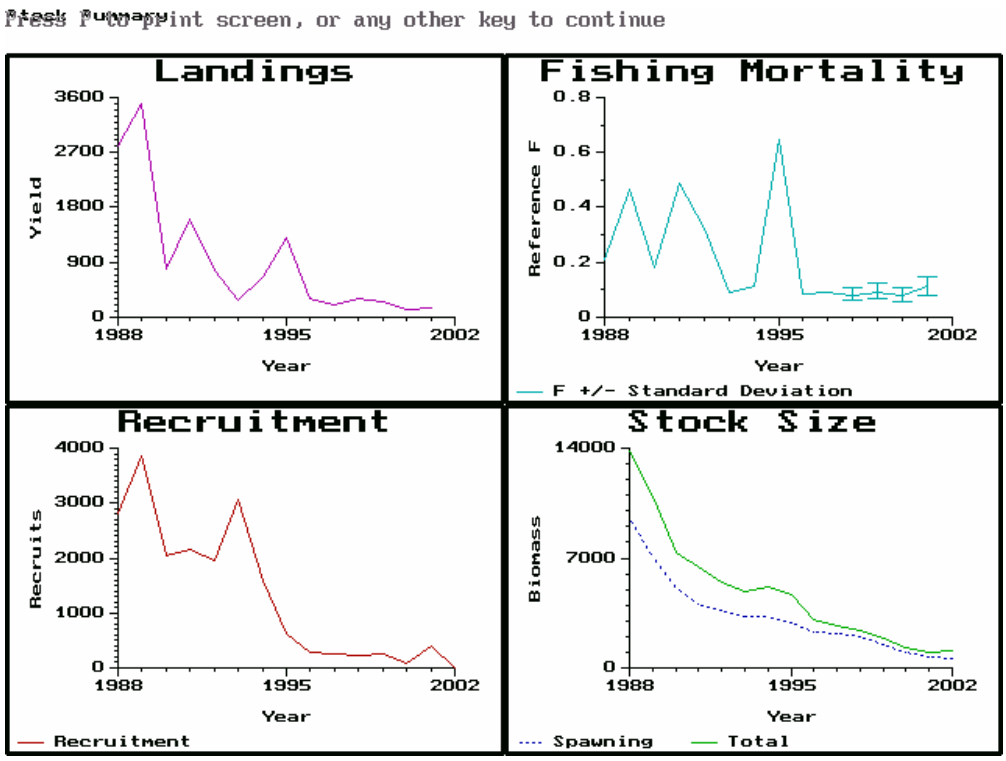

Fig. 2. The stock summary figures for the American Plaice in NAFO Div. 3M