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The Assessment of the International Fishery for Shrimp (*Pandalus borealis*) in Division 3M (Flemish Cap), 1993-2002

by

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Abstract

The development of the international shrimp (*Pandalus borealis*) fishery in NAFO Division 3M is described. A standard six nation data set is used to create a series of standardized catch per unit effort (CPUE) indices with the purpose of tracking the status of the Flemish Cap shrimp stock. Also an international observer database of length frequencies was created for the purpose of ageing.observer samples is used on which ageing was carried out. Shrimp ages are presented as well as number/kg/age based on both nominal catch and standardised CPUE. Indices of recruitment and female stock are calculated from this using the standardized CPUE series. Recruitment indices were determined from the Faroese survey trawl and the juvenile net attached to the trawl. While Spawning Stock Biomass index (SSB) was obtained from the EU survey and the Faroese surveys.

Introduction

The fishery for northern shrimp on the Flemish Cap began during the spring of 1993 and has since continued with catches (estimated by STACFIS) of approximately 27 000 to 48 000 in the years 1993 through 1996. During 1997 catches decreased to 25 000 tons then increased to 50 000 tons in 2000 and finally 54 000 tons in 2001, the highest in the series. Removals to October 2002 of about 39 000 tons are lower than those reported for the same period in 2001 (41 000 tons) and projections to the end of year 2002 are expected to reach 51 000 tons. Vessels from as many as 19 nations have participated in this fishery since its beginning.

The following is an overview of the international fishery for shrimp on Flemish Cap. Trends in catch and effort from data provided by fleets from several nations are described. A standardized catch per unit effort (CPUE) model was developed to serve as an indicator of stock change over time. The model accounts for changes in catch rate due to nation, fishing power of individual vessels, seasonality of the fishery, and gear type (single, double or triple).

The spawning stock and recruitment indices are presented from the EU and Faroese surveys. Shrimp catch-at-age is also provided.

Background on the assessment and management of this resource since 1993 can be found in Parsons (1998), Skuladottir and Orr (2001) and NAFO Scientific Council Reports (2001).

Material and Methods

Commercial Samples and Aging

Shrimp were separated into 3 categories namely, males, primiparous females (including transitionals) and multiparous females according to the sternal spine criterion (McCrary, 1971), oblique carapace lengths were measured to 0.1 mm length-classes using sliding calipers and then combined into 0.5 mm length-classes. These data form the International shrimp aging database as recommended Appendix II of the 1999 NAFO Scientific Council meeting on shrimp (NAFO, 1999). Modal analysis (MacDonald and Pitcher, 1979) was conducted on an individual month by month basis weighted by each nation's catch. This analysis provided the mean lengths and proportions at age and sex per month. The mean lengths were converted to mean weights using length weight relationships for the appropriate months to calculate the number caught (Skuladottir, 1997). An average length-at-age, weighted by number caught each month and nation, was calculated for the whole period. Mean lengths were then converted to weights using the length weight relationship for April-June. This was said to be the average weight for that particular year at age and sex.

Since the Canadian data (Parsons and Veitch, 1996) were only available as annual results for the years 1993-1995, the following two equations were used for this period:

For males and primiparous females for April and all year around : $ln\ y = 3.037 \times ln\ x - 7.549$

For multiparous females in April-June: $ln\ y = 2.778 \times ln\ x - 6.689$

Analyses for 1996-2001 also made use of the following:

For multiparous females July: $ln\ y = 2.921 \times ln\ x - 7.144$

For multiparous females August: $ln\ y = 3.111 \times ln\ x - 7.689$

For multiparous females Sept-March: $ln\ y = 2.929 \times ln\ x - 7.085$

Catch-Per-Unit-Effort (CPUE) Model

The General Linear Modeling Procedure (Proc GENMOD), within the SAS program, was used to model CPUE against year, month, vessel and area. A standardized data set, consisting of data from Canada, the Faroe Islands, Greenland, Iceland, Norway and Russia, was used as model input. Data were deleted if CATCH <= 0 kg and/or EFFORT <10 hours. Prior to modeling, we tested whether the data had a constant variance. This is one of the assumptions necessary for linear regression modeling,.. This assumption was tested by plotting standard error versus mean cpue (Smith and Showell, 1996).

Since the coefficient of variance was constant (Fig. 1), it was felt that the data would fit a gamma distribution rather than a normal distribution. Effort (hrs.) was used as a weighting factor. No attempt was made to determine interaction effects. The model was standardized to 1993, June, single trawl and Icelandic data. Results were then scaled to the average CPUE during 1993. Modelled CPUE was log-linked within the Proc Genmod procedure (McCallagh and Nelder, 1989). Standardized deviance residuals were plotted against scaled model CPUE The appropriate scaling factor is 2×log (model CPUE) for gamma distributions (McCallagh and Nelder, 1989).

Results

Catch and Effort

Preliminary catch per month as reported to NAFO for the years 2001 and 2002 is shown in Tables 1 and 2. Much of the 2001 catch was taken during the period March to July. The lowest amount of catch was taken in January during both 2001 and 2002. Catch (tons) by nations as estimated by STACFIS is presented in Table 3. The highest catch

54 000 tons was taken in 2001. Catches were somewhat lower in 2002 or 39 000 tons from January to October as compared to the 41 000 ton preliminary catch for the same period during 2001 (Skuladottir and Orr, 2001). Projected total catch to the end of the year 2002 is 51 000 tons. Much of the nominal catch data were obtained from STATLANT 21A, however, some were obtained directly from assessment biologists working within nations that fish for Div. 3M shrimp. If a logbook catch differed from the STATLANT 21A catch, then the higher of the two was used in the analyses. Figure 2 shows the total catch of shrimp in 3M.

Standardized CPUE

Figure 3 illustrates a plot of the standardized residual deviance residuals *versus* 2×(log (predicted value)). There does not appear to be a trend in the residuals over change in model CPUE indicating that the model provides an unbiased representation of the CPUE. In general, the model shows a decline in catch-per-unit-effort from 1993 through to 1996 after which CPUE gradually increased. CPUE in 2002 was similar to that in 1993, while CPUEs for all intervening years were significantly lower ($P<0.05$) (Table 4 and Fig. 4).

Standardized Effort (nomial catch divided by standardized CPUE) is presented in Fig. 5. Effort increased to 1996 declined in 1997 and 1998 to increase again to 2001 although not as high as the effort in 1996. Effort in 2002 decreased to average levels for the 1993-2002 period.

Recruitment

The Faroese survey provides two recruitment indices. Since 1997, a juvenile shrimp bag has been attached to the gear in the Faroese survey. The results are shown in Fig. 6 and the table below (Nicolajsen and Brynjolfsson, 2002). The abundance of two year olds obtained in the main trawl in the Faroese survey was observed for 5 years and is also shown in Fig. 6 and the table below (Nicolajsen, 2002).

Survey/Year	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Faroese survey main trawl	855	210	214	108	1242	416
Faroese survey juvenile bag		2532	5683	456	4377	913

The two indices do not agree in all years. In 1999 the juvenile bag showed a greater abundance of two-year-olds, which was not apparent in the main survey gear. This 1997 year-class was above average in the 2001 commercial catch and is still strong at age 5 in 2002. Both indices showed that the 1998 year-class was weak in 2000 and although the 1998 year-class has improved with time it is still a little under average in 2002. During 2001, two year olds (1999 year-class) were abundant in both the main trawl and the juvenile bag. This indication has been confirmed by the presence of numerous shrimp at age 3 in the 2002 fishery. The 2000 year-class on the other hand appears average both in the juvenile bag and the main trawl (Nicolajsen, 2002; Nicolajsen and Brynjolfsson, 2002) as seen in year 2002 (Fig. 6).

Female Biomass

Similarly a spawning stock biomass (SSB) index was calculated as kg/hr of primiparous (including transitionals) plus multiparous females from the international observer database and the standardized CPUE model. This was compared to the results of the EU survey (Del Rio *et al*., 2002) and Faroese survey biomass indices (Nicolajsen, 2002). The raw data are provided in the table below. Once again, each index was standardized to the mean of the series and shown in Fig. 7.

Survey/Year	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
EU survey biomass	1874	1340	1132	5362	11509	6839	2823	4286	4149	3807	8091	9051	6553	8977	11664
Faroese survey biomass										6417	11783	8621	9487	8930	11803
Standardized CPUE						249	138	141	114	65	171	200	205	189	162

The spawning stock (female biomass) as determined from the EU survey biomass index gradually increased during the years prior to the fishery. This coincided with the decline in cod biomass in the area. But this was also a reflection of the very strong 1987 year-class, most of which were female during 1992. The index showed a decrease from 1994 through to 1997 followed by an increase during 1998. The SSB remained high during all years except 2000. The female biomass from the Faroese survey indices have shown much the same trend as the other two indices although showing the highest values during 1998 and 2002.

A standardized female SSB was calculated from the standardized CPUE as kg/hr of primiparous plus multiparous females. The standardized SSB declined from 1993 to 1997 increased in 1998 and stayed stable thereafter (Fig. 7).

Catch-at-age

Age analysis was carried out on biological samples obtained from Canadian, Icelandic and Russian vessels. Table 5 provides results of the age analyses. Table 6 shows the mean length at age while Table 7 shows the mean weight at age based on Table 5.

Table 8 indicates the number per hour standarized harvested in the commercial fishery. In 1993, the 1987 year-class appeared as a very strong age 6+ cohort (approximately 9 800 animals/hr). The 1993 year-class were two years old in 1995 namely some 17 900 the strongest ever seen in the series. It was strong in 1995 and 1996, but later the year-class appears to have decreased in strength resulting in fewer 4 and 5 year olds as might be expected also seen in the Spanish survey (Skuladottir and Diaz, 2001). The 1996 year-class was considered average during 1998, but appeared stronger during 1999-2001. The 1997 cohort was a strong year-class almost as numerous as the 1993 year-class at age 3. It continued to be strong in 2000-2002 being still exceptionally high in numbers at age 5. It is important to note that the 1998 year-class is by far the weakest in the series at age 3 and is still below average at age 4 in 2002. The 1999 year-class appears to be above average at age 3 in 2003 and is very promising for the future. First indications of the 2000 year-class are that it appears average.

Finally Table 9 indicates the catch in number of shrimp based on nominal catch per year from Table 3 and an estimated total catch for year 2002.

Summary

Catches of shrimp on the Flemish Cap have been maintained at a high level averaging about 44 000 tons for the last four years including year 2001 due to a possible increase in biomass. There was a general decline in CPUE between 1993 and 1994, varied without a trend to 1997, and increased to 2000, after which it remained stable. The spawning stock biomass also decreased between 1993 and 1994 increased between 1997 and 1998 and flutuated without a trend thereafter if in standardized CPUE and the Faroese survey.. the EU female biomass index increased in 2002 to the highest level since the fishery started.

The 1997 year-class was above average judging by its occurrence in the fishery in 2001 and 2002 as well as in the biomass estimates of the surveys. The 1998 year-class on the other hand is considered to be below average, confirming the results obtained during 2001. The 1999 year-class appears as promising as the 1997 year-class. The 2000 year-class appears to be average.

Although the standardization of CPUE has been improved by including double trawl effort and even triple trawls, results are still difficult to interpret as an index of stock size due to the major changes in fishing pattern between years.

In general the stock is in a stable conditions and recruitment although variable it is rather good and prospects for the years 2003 and 2004 are considered good provided total catch is reduced from the level of year 2001.

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Table 1. Catch (tons) by nations and months as reported provisionally to NAFO in year 2001.

Nation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total by months**	**Total by year**
Canada													**294**	**294**
Cuba										246	226	325	**797**	**797**
Estonia	217	311	1129	1345	1029	1041	1327		1133	774	891	241	**9438**	**9638**
EU/Denmark													**0**	**0**
EU/Spain			31		168			304		423			**926**	**756**
Faroe Is.		440	1443	1548	1548	2187		1238	508		624	570	**10106**	**12280**
France										157	126	125	**408**	**408**
Greenland													**0**	**0**
Honduras													**0**	**0**
Iceland		361	801	170		564	949	780	203	530	573	360	**5291**	**5301**
Japan									10	60	54	6	**130**	**130**
Latvia		102	418	327	346	545	284	314	189	172	80	213	**2990**	**2984**
Lithuania	4	116	212	221	213	399	473	284	241	235	215	89	**2702**	**2702**
Norway		565	566	986	1135	1972	2101		1336			568	**9229**	**13255**
Poland												196	**196**	**196**
Portugal													**0**	**0**
Russia	375	563	872	865	895	424	344	130	276	349	377	430	**5900**	**5687**
Ukraina												44	**44**	**348**
USA											186	225	**411**	**411**
Total	**596**	**2458**	**5472**	**5462**	**5334**	**7132**	**5478**	**3050**	**3896**	**2946**	**3352**	**3392**	**48862**	**55187**

Table 2. Catch (tons) by nations and months as reported provisionally to NAFO in year 2002.

Nation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**	**Tot NAFO**
Canada						8			8				16	**16**
Cuba								106	47				153	**153**
Estonia	316	1027	1286	1666	1325	1356	1692	1418	1041				11127	**11127**
EU/Denmark													0	**0**
EU/Spain				54			358	339					751	**751**
Faroe Is.	523	554	485	725	1501	1043	1043	1346	727				7947	**7346**
France							29						29	**29**
Greenland						347							347	**680**
Honduras													0	**0**
Iceland			524	564	748	818	301	587					3542	**3748**
Japan													0	**0**
Latvia		100	142	365	175	403	206	95	344				1830	**1830**
Lithuania		336	378	404	246	345	370	284	336				2699	**2699**
Norway		83		451	1362	1484	1694		1739				6813	**8314**
Poland													0	**0**
Portugal													0	**0**
Russia	178	189	206			142	114	83	175				1087	**1087**
Ukraina													0	**0**
USA									96				96	**96**
Total	**1017**	**2289**	**3021**	**4229**	**5357**	**5946**	**5807**	**4258**	**4513**				**36437**	**37876**

Table 3. Catch (tons) by nations as estimated by STACFIS.

Nation	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002*
Canada	3724	1041	970	906	807	484	490	618	1 295	4 16
Cuba							119	46	1 797	4 153
Estonia		1081	2092	1900	3240	5694	10835	13256	3 9850	4 11127
EU/Denmark	800	400	200			437	235		1 92	
EU/Spain	240	300	158	50	421	913	1019	1388	2 1095	1 751
Faroe Is.	7333	6791	5993	8688	7410	9368	9199	7719	3 10228	2 7712
Greenland	3788	2275	2400	1107	105	853	576	1636		4 680
Honduras	1265									
Iceland	2243	2300	7623	20681	6381	6572	9277	8912	2 5265	2 4340
Japan									1 130	
Latvia		300	350	1940	997	1191	3080	3105	1 2961	4 1830
Lithuania		1225	675	2900	1785	3106	3370	3595	1 2702	4 2699
Norway	7183	8461	9533	5683	1831	1339	2975	2669	1 13291	8314
Poland					288	148	894		1 209	
Portugal	300		150		170	203	227	289	1 420	
Russia		350	3327	4445	1090		1142	7078	1 5687	2 1087
St. Vincent's		75			150				1 408	4 29
Ukraina									1 348	
USA									1 411	4 96
Total	**26876**	**24599**	**33471**	**48300**	**24675**	**30308**	**43438**	**50311**	**54189**	**38834**

1 NAFO Statlant 21 A
2 From the fisheries biologist of respective countries
3 Assessed by Stacfis
4 Reported to NAFO provisionally

* Provisional to October

Table 4. Multiplicative, year, month, vessel and area model for CPUE in Div. 3M, 1993-2002, weighted by effort.

Proc Genmod multiplicative model 1993 - 2002

The GENMOD Procedure

Model Information

Data Set	WORK.D1
Distribution	Gamma
Link Function	Log
Dependent Variable	CPUE
Scale Weight Variable	effort
Observations Used	3387
Missing Values	386

Class Level Information

Class	Levels	Values
year	10	1994 1995 1996 1997 1998 1999 2000 2001 2002 2003
vessel	139	
month	12	1 2 3 4 5 7 8 9 10 11 12 13
area	4	1 2 3 4
gear	3	2 3 4

Criteria For Assessing Goodness Of Fit

Criterion	DF	Value	Value/DF
Deviance	3223	57078.7763	17.7098
Scaled Deviance	3223	3551.6627	1.1020
Pearson Chi-Square	3223	54150.7040	16.8013
Scaled Pearson X2	3223	3369.4667	1.0454
Log Likelihood		-21187.5000	

Algorithm converged.

Analysis Of Parameter Estimates

Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept		1	6.5079	0.0601	6.3902	6.6257	11737.1	<.0001
year	1994	1	-0.5341	0.0502	-0.6325	-0.4358	113.26	<.0001
year	1995	1	-0.4029	0.0504	-0.5016	-0.3042	64.01	<.0001
year	1996	1	-0.5242	0.0505	-0.6231	-0.4253	107.95	<.0001
year	1997	1	-0.5427	0.0521	-0.6449	-0.4405	108.32	<.0001
year	1998	1	-0.2904	0.0533	-0.3949	-0.1860	29.72	<.0001
year	1999	1	-0.2726	0.0532	-0.3768	-0.1684	26.28	<.0001
year	2000	1	-0.1221	0.0535	-0.2269	-0.0173	5.21	0.0224
year	2001	1	-0.2180	0.0569	-0.3296	-0.1064	14.67	0.0001
year	2002	1	-0.1283	0.0672	-0.2600	0.0033	3.65	0.0561
year	2003	0	0.0000	0.0000	0.0000	0.0000	.	.

Criteria For Assessing Goodness Of Fit

Criterion	DF	Value	Value/DF
Deviance	3223	57078.7763	17.7098
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Table 4. (Continued)

Analysis Of Parameter Estimates

Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept		1	6.5079	0.0601	6.3902	6.6257	11737.1	<.0001
year	1994	1	-0.5341	0.0502	-0.6325	-0.4358	113.26	<.0001
year	1995	1	-0.4029	0.0504	-0.5016	-0.3042	64.01	<.0001
year	1996	1	-0.5242	0.0505	-0.6231	-0.4253	107.95	<.0001
year	1997	1	-0.5427	0.0521	-0.6449	-0.4405	108.32	<.0001
year	1998	1	-0.2904	0.0533	-0.3949	-0.1860	29.72	<.0001
year	1999	1	-0.2726	0.0532	-0.3768	-0.1684	26.28	<.0001
year	2000	1	-0.1221	0.0535	-0.2269	-0.0173	5.21	0.0224
year	2001	1	-0.2180	0.0569	-0.3296	-0.1064	14.67	0.0001
year	2002	1	-0.1283	0.0672	-0.2600	0.0033	3.65	0.0561
year	2003	0	0.0000	0.0000	0.0000	0.0000	.	.

Least Squares Means

Effect	year	Estimate	Standard Error	DF	Chi-Square	Pr > ChiSq	Alpha	Confidence Limits	
year	1996	5.1439	0.0533	1	9306.6	<.0001	0.05	5.0394	5.2484
year	1997	5.1254	0.0552	1	8628.8	<.0001	0.05	5.0173	5.2336
year	1998	5.3777	0.0558	1	9298.4	<.0001	0.05	5.2684	5.4870
year	1999	5.3955	0.0554	1	9476.7	<.0001	0.05	5.2869	5.5042
year	2000	5.5460	0.0549	1	10223	<.0001	0.05	5.4385	5.6536
year	2001	5.4502	0.0573	1	9040.9	<.0001	0.05	5.3378	5.5625
year	2002	5.5398	0.0693	1	6387.9	<.0001	0.05	5.4039	5.6756
year	2003	5.6681	0.0665	1	7267.3	<.0001	0.05	5.5378	5.7985

Table 5. Mean weights at age and sex for the period January-September. Nominal catch for the whole year used for calculating weight at age and sex. Standardized CPUE for the whole year of double and single trawl is used to calculate CPUE and abundance in numbers at age and sex group.

1993

Sex	Age	Mean CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 26876 tons	kg/hr 289.5	No./hour	Number (´000´000)
Males	1	10.4	0.0041	0.646	0.00265	9	0.1	142	13.2
Males	2	16.8	0.1148	2.772	0.31823	1023	11.0	3977	369.2
Males	3	20.7	0.2146	5.225	1.12129	3606	38.8	7434	690.2
Males	4	24.0	0.1156	8.188	0.94653	3044	32.8	4005	371.8
Primip.	5	26.0	0.2619	10.441	2.73450	8794	94.7	9073	842.3
Multip.	6+	26.5	0.2890	11.189	3.23362	10400	112.0	10012	929.4
Total			1.0000		8.35681	26876	289.5	34642	3216.1

1994

Sex	Age		Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 24599 tons	kg/hr 169.7	No./hour	Number
Males	1								
Males	2	16.4	0.1817	2.576	0.46806	1670	11.5	4471	648.1
Males	3	20.4	0.3629	4.998	1.81377	6470	44.6	8930	1294.5
Males	4	22.9	0.0854	7.101	0.60643	2163	14.9	2102	304.6
Primip.	5	25.7	0.1944	10.08	1.95955	6990	48.2	4784	693.5
Multip.	6+	26.9	0.1756	11.664	2.04820	7306	50.4	4321	626.4
Total			1		6.89601	24599	169.7	24608	3567.1

1995

Sex	Age		Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 33471 tons	kg/hr 193.5	No./hour	Number
Males	1								
Males	2	15	0.4516	1.965	0.88739	5989	35.1	17884	3047.8
Males	3	20.3	0.2714	4.924	1.33637	9019	52.9	10748	1831.7
Primip.	4	22.2	0.0507	6.462	0.32762	2211	13.0	2008	342.2
Primip.	5	25.3	0.0962	9.611	0.92458	6240	36.6	3810	649.2
Multip.	6+	26.2	0.1301	10.84	1.41028	9518	55.8	5152	878.0
Total			1		4.88625	32977	193.5	39601	6748.9

1996

Sex	Age		Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 48300 tons	kg/hr 171.4	No./hour	Number
Males	1								0.0
Males	2	15.3	0.0622	2.066	0.12860	1011	3.6	1737	489.4
Males	3	20.0	0.6076	4.728	2.87283	22585	80.1	16952	4776.9
Primip.	3	21.4	0.0379	5.788	0.21921	1723	6.1	1057	297.7
Primip.	4	24.8	0.1511	9.034	1.36509	10732	38.1	4216	1187.9
Multip.	3	22.2	0.0063	6.799	0.04274	336	1.2	175	49.4
Multip.	4	24.8	0.0474	9.296	0.44108	3468	12.3	1324	373.0
Multip.	5	26.6	0.0574	11.306	0.64930	5105	18.1	1602	451.5
Multip.	6	28.8	0.0300	14.167	0.42486	3340	11.9	837	235.8
Total			1		6.14372	48300	171.4	27898	7861.7

Table 5. Continued

1997

Sex	Age		Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 24675	kg/hr 168.2	No./hour	Number (000 000)
Males	1	10.4	5.5E-05	0.910	0.0002	1			0.9
Males	2	15.7	0.0522	3.201	0.16714	650	4.4	1384	203.1
Males	3	19.0	0.4092	4.117	1.68462	6552	44.7	10847	1591.3
Males	4	22.3	0.2089	6.633	1.38567	5389	36.7	5538	812.4
Primip.	3	20.6	0.0029	5.237	0.01498	58	0.4	76	11.1
Primip.	4	24.3	0.1724	8.390	1.44630	5625	38.3	4570	670.4
Multip.	3	19.1	0.0025	5.018	0.01240	48	0.3	65	9.6
Multip.	4	24.2	0.0488	9.570	0.46737	1818	12.4	1295	189.9
Multip.	5	25.6	0.0845	10.631	0.89822	3493	23.8	2240	328.6
Multip.	6	28.3	0.0171	14.350	0.24558	955	6.5	454	66.6
Multip.	7	29.3	0.0015	15.070	0.02232	87	0.6	39	5.8
Total			1		6.34481	24675	168.2	26508	3889.6

1998

Sex	Age		Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 30308	kg/hr 216.5	No./hour	Number
Males	2	14.90	0.0598	1.925	0.11503	587	4.2	2177	304.7
Males	3	18.75	0.3471	3.869	1.34301	6849	48.9	12645	1770.2
Males	4	21.23	0.2327	5.642	1.31282	6695	47.8	8476	1186.6
Primip.	4	23.17	0.1403	7.358	1.03230	5264	37.6	5111	715.5
Primip.	5	25.87	0.0219	10.284	0.22493	1147	8.2	797	111.5
Multip.	3	18.56	0.0025	4.160	0.01023	52	0.4	90	12.5
Multip.	4	23.86	0.0644	8.359	0.53842	2746	19.6	2346	328.5
Multip.	5	25.67	0.1103	10.076	1.11150	5668	40.5	4018	562.5
Multip.	6	27.15	0.0204	11.968	0.24438	1246	8.9	744	104.1
Multip.	7	30.02	0.0007	15.821	0.01057	54	0.4	24	3.4
Total			1.0000		5.94319	30308	216.5	36428	5099.6

1999

Sex	Age		Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 43438	kg/hr 220.4	No./hour	Number
Males	1	6.0	0.0001	0.122	0.00001	0	0.0	4	0.7
Males	2	14.5	0.0467	1.769	0.08268	591	3.0	1691	333.8
Males	3	17.6	0.2773	3.176	0.88073	6291	31.9	10032	1980.7
Males	4	21.0	0.2253	5.490	1.23680	8834	44.7	8150	1609.1
Males	5	22.3	0.0003	6.560	0.00187	13	0.1	10	2.0
Primip.	4	22.07	0.0758	6.348	0.48118	3437	17.4	2742	541.4
Primip.	5	24.22	0.1327	8.418	1.11680	7977	40.4	4799	947.6
Multip.	3	18.25	0.0009	3.970	0.00361	26	0.1	33	6.5
Multip.	4	22.00	0.0207	6.672	0.13820	987	5.0	749	147.9
Multip.	5	24.18	0.1259	8.674	1.09238	7802	39.5	4556	899.5
Multip.	6	26.42	0.0932	11.06	1.03086	7363	37.3	3372	665.7
Multip.	7	29.57	0.0011	15.171	0.01638	117	0.6	39	7.7
Total			1.0000		6.08151	43438	220.0	36176	7142.8

Table 5. Continued

2000

Sex	Age		Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 50311	kg/hr 256.2	No./hour	Number
Males	2	12.95	0.0217	1.257	0.02732	257	1.3	1043	204.8
Males	3	17.25	0.3461	3.003	1.03943	9793	49.9	16606	3261.0
Males	4	20.00	0.2314	4.707	1.08916	10261	52.3	11101	2180.0
Males	5	21.90	0.0039	6.200	0.02410	227	1.2	186	36.6
Primip.	4	21.00	0.0906	5.458	0.49460	4660	23.7	4348	853.8
Primip.	5	24.51	0.0985	8.728	0.85947	8097	41.2	4724	927.7
Primip.	6	25.83	0.0017	10.235	0.01744	164	0.8	82	16.1
Multip.	3	18.30	0.0023	4.000	0.00930	88	0.4	112	21.9
Multip.	4	21.96	0.0491	6.638	0.32616	3073	15.6	2357	462.9
Multip.	5	24.32	0.1124	8.815	0.99064	9333	47.5	5392	1058.8
Multip.	6	26.23	0.0404	10.875	0.43905	4137	21.1	1937	380.4
Multip.	7	27.73	0.0018	12.691	0.02341	221	1.1	88	17.4
Total			1		5.34007	50311	256.2	47977	9421.4

2001

Sex	Age		Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 54189	kg/hr 232.8	No./hour	Number
Males	2	15.23	0.1040	2.058	0.21403	2046	8.8	4270	994.0
Males	3	17.77	0.1391	3.287	0.45722	4370	18.8	5712	1329.5
Males	4	20.81	0.3881	5.31	2.06081	19697	84.6	15936	3709.4
Males	5	21.72	0.0141	6.047	0.08526	815	3.5	579	134.8
Primip.	4	20.89	0.0114	5.372	0.06124	585	2.5	468	109.0
Primip.	5	23.72	0.1326	7.901	1.04767	10014	43.0	5445	1267.4
Multip.	4	20.50	0.0240	5.483	0.13176	1259	5.4	987	229.7
Multip.	5	23.24	0.1111	7.77	0.86325	8251	35.4	4562	1061.9
Multip.	6	25.13	0.0666	9.654	0.64296	6145	26.4	2735	636.6
Multip.	7	26.93	0.0090	11.7	0.10530	1006	4.3	370	86.0
Total			1.0000		5.66951	54189	232.8	41063	9558.3

2002

Sex	Age		Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 51000	kg/hr 254.6	No./hour	Number
Males	2	15.18	0.0543	2.037	0.11061	982	4.9	2406	482.0
Males	3	17.88	0.2828	3.349	0.94710	8408	42.0	12533	2510.5
Males	4	20.16	0.2099	4.822	1.01214	8985	44.9	9302	1863.3
Males	5	21.74	0.0020	6.064	0.01213	108	0.5	89	17.8
Primip.	4	20.53	0.0629	5.096	0.32054	2845	14.2	2788	558.4
Primip.	5	23.71	0.1624	7.891	1.28150	11376	56.8	7197	1441.7
Multip.	4	20.22	0.0043	5.278	0.02270	201	1.0	191	38.2
Multip.	5	24.46	0.1670	8.956	1.49565	13277	66.3	7401	1482.5
Multip.	6	25.15	0.0486	9.676	0.47025	4175	20.8	2154	431.4
Multip.	7	27.57	0.0058	12.489	0.07244	643	3.2	257	51.5
Total			1.0000		5.74505	51000	254.6	44316	8877.2

Table 6. Shrimp. Mean length (oblique carapace length mm) at age

Age gr.	1993	1994	1995	Agegr.	1996	1997	1998	1999	2000	2001	2002
1	10.4			1		10.44					
2	16.8	16.4	15	2	15.25	15.73	14.9	14.49	12.95	15.23	15.18
3	20.7	20.4	20.3	3	20.54	19.01	18.75	17.58	17.26	17.77	17.88
4	24	22.9	22.2	4	24.7	23.32	22.24	21.34	20.5	20.79	20.24
5	26	25.7	25.3	5	24.8	25.56	25.71	24.2	24.36	23.41	24.08
6+	26.5	26.9	26.2	6	26.6	28.33	27.15	26.42	26.21	25.13	25.15
				7	28.8	29.28	30.02	29.57	27.73	26.93	27.57

Table 7. Shrimp. Mean weight at age for the period January to September based on international data base.

Age gr.	1993	1994	1995	Agegr.	1996	1997	1998	1999	2000	2001	2002
1	0.646			1		0.910					
2	2.772	2.576	1.965	2	2.066	2.270	1.925	1.639	1.214	2.058	2.037
3	5.225	4.998	4.924	3	4.79	4.130	3.815	3.069	2.974	3.287	3.349
4	8.188	7.101	6.462	4	8.945	7.671	6.586	6.347	5.095	5.321	4.892
5	10.441	10.080	9.611	5	9.296	10.631	10.116	8.502	8.629	7.743	8.417
6+	11.189	11.664	10.840	6	11.306	14.350	11.413	11.060	10.805	9.654	9.676
				7	14.167	15.070	15.821	15.100	12.691	11.700	12.489

Table 8. Shrimp. Number of shrimp caught per hour (Standardized CPUE) annually, based on the ageing of international samples in the period January to September.

Age gr.	1993	1994	1995	Agegr.	1996	1997	1998	1999	2000	2001	2002
1	144			1							
2	4025	4471	17884	2	1735	1394	2194	1654	1052	4271	2407
3	7525	8930	10748	3	18010	11076	12828	9854	16888	5712	12534
4	4054	2102	2008	4	4392	11490	16050	11399	17983	17391	12277
5	9184	4784	3810	5	1323	2257	4851	9174	10404	10586	14688
6+	9818	4321	5152	6	1602	457	749	3301	2040	2735	2154
				7	837	40	26	39	87	370	257
Total	34749	24608	39601		27899	26714	36697	35421	48455	41065	44315

Table 9. Shrimp. Number (000.000) of shrimp caught annually, based on the ageing of international samples in the period January to September.

Age gr.	1993	1994	1995	Agegr.	1996	1997	1998	1999	2000	2001	2002
1	13.9			1							
2	390.6	648.1	3093.5	2	489.0	204.6	307.2	325.7	206.5	994.1	482.1
3	730.1	1294.5	1859.1	3	5075.2	1624.8	1795.8	1940.4	3316.4	1329.6	2510.7
4	393.3	304.6	347.3	4	1237.6	1685.5	2246.8	2244.5	3531.5	4048.1	2459.2
5	891.0	693.5	659.0	5	372.7	331.2	679.1	1806.5	2043.1	2464.2	2942.1
6+	952.6	626.4	891.2	6	451.3	67.0	104.8	650.1	400.6	636.6	431.5
				7	235.9	5.9	3.6	7.7	17.1	86.0	51.5
Total	3371.5	3567.1	6850.0		7861.7	3919.0	5137.2	6974.8	9515.2	9558.7	8877.0

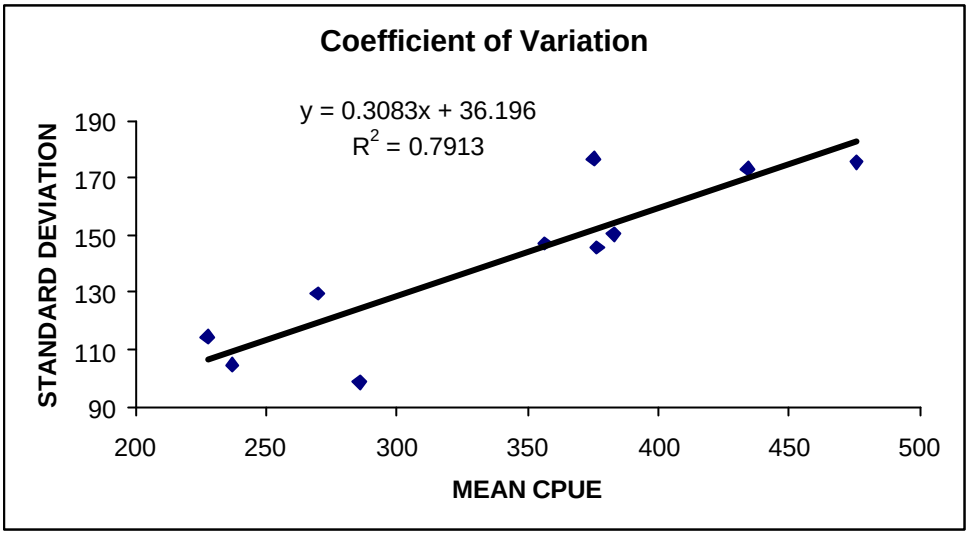

Fig. 1. Coefficient of variation around the annual raw CPUE for the international fishing fæleets fishing 3M shrimp .

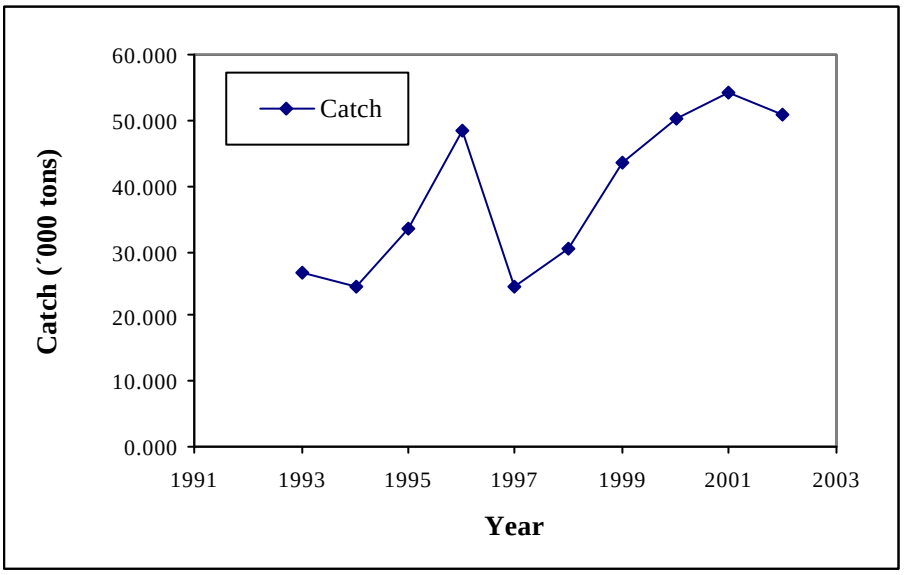

Fig. 2. Shrimp in Div. 3M: catches (2002 projected to the end of the year).

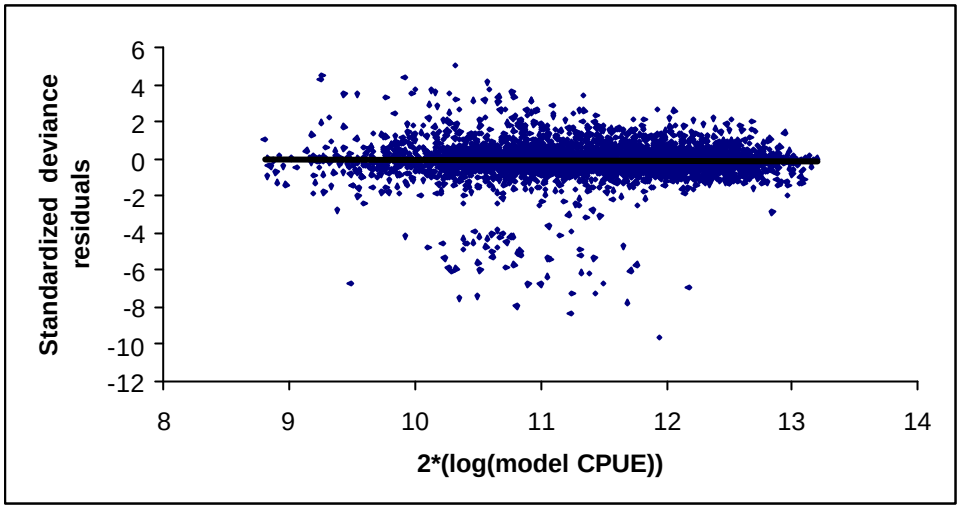

Fig. 3. A plot of the standardized deviance residuals versus 2*(log(model CPUE) which is the appropriate scaling for a gamma distribution (McCullagh and Nelder, 1989

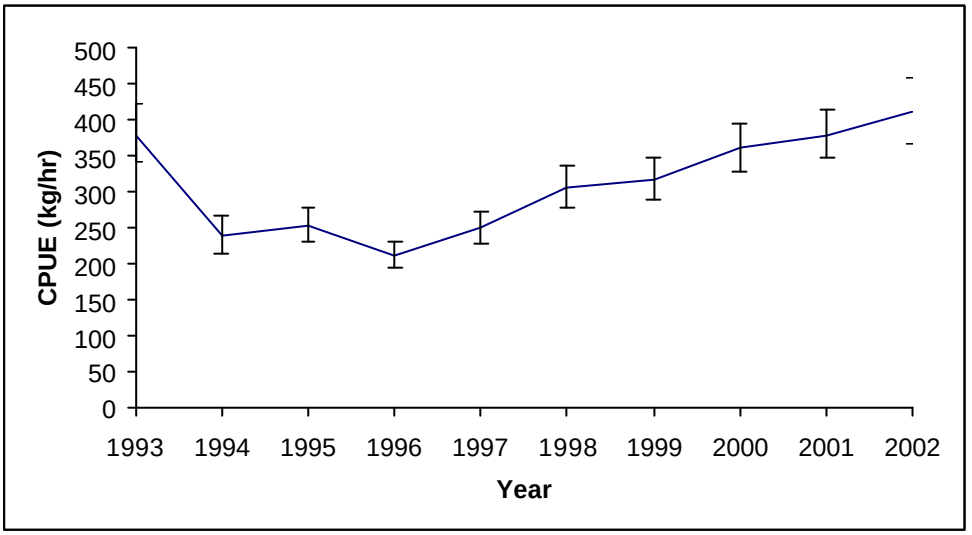

Fig. 4. The model for vessels fishing shrimp on the Flemish Cap between 1993-2002. (The model was standardized to 1993, June, single trawl and Icelandic catch- per-unit data.

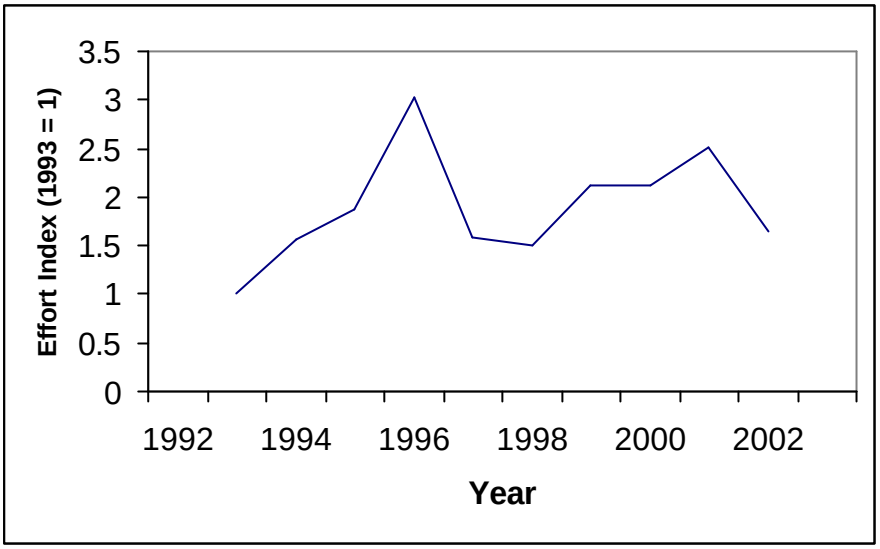

Fig. 5. Shrimp in Div. 3M: annual standardized effort indices (1993 = 1)

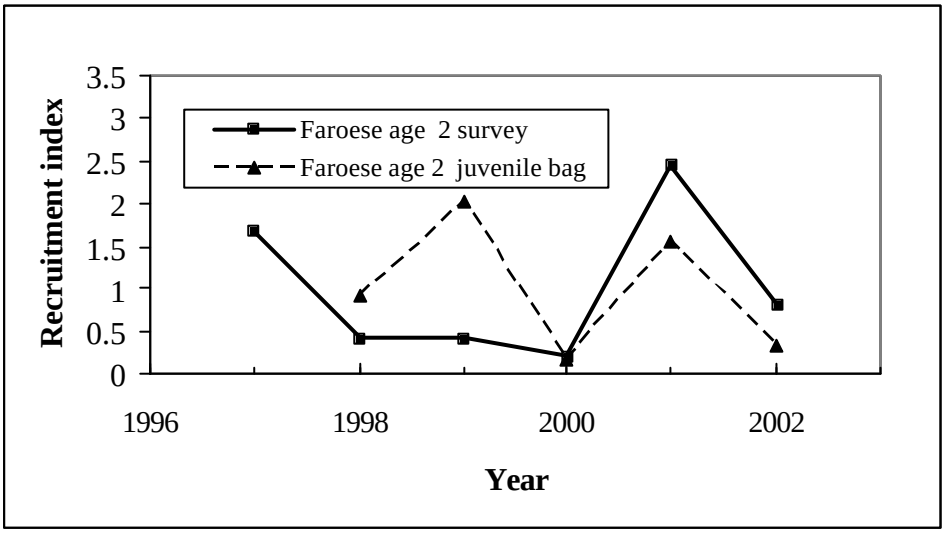

Fig.. 6. Shrimp in Div. 3M: abundance indices at age 2 from the Faroese survey and from the juvenile bag. Each series was standardized to its mean.

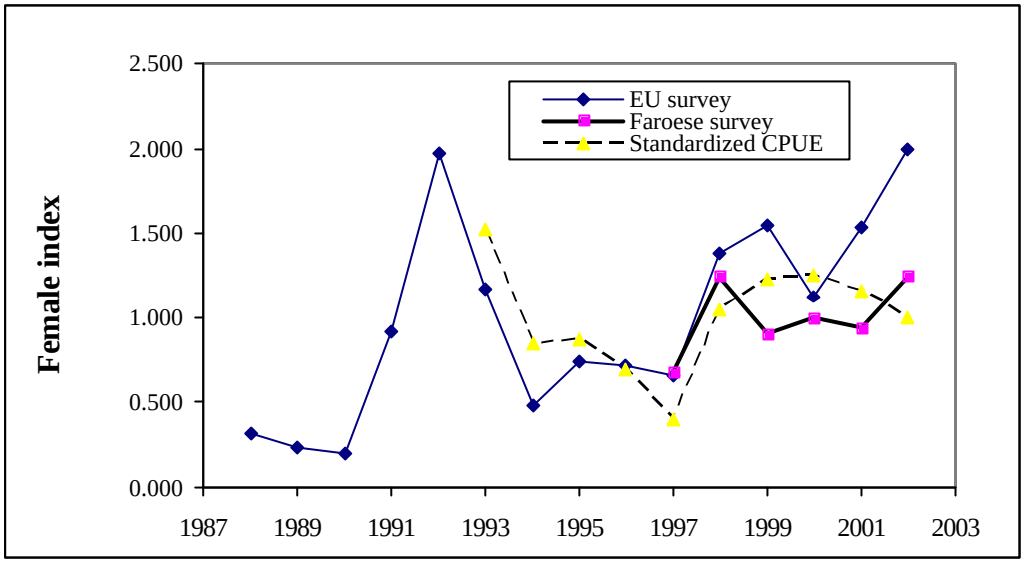

Fig. 7. Shrimp in Div. 3M: female biomass index from EU trawl surveys, 1988-2002, Faroese survey 1997-2002 and standardized female CPUE 1993-2002. Each series was standardized to the mean of that series.