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Assessment of the International Fishery for Shrimp (*Pandalus borealis*) in Division 3M (Flemish Cap), 1993-2005

by

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Abstract

The development of the international shrimp (*Pandalus borealis*) fishery in NAFO Division 3M is described. Various indices show that the stock is in a better state in 2005 as compared to 2004. In spite of all indices being promishing the effort was low due to high cost of oil and low marketing prize of shrimp. Vessels were only 26 in 2005 against 50 in 2004. Nominal catch was 45 500 tons in 2004 as compared to 63 000 tons in 2003. The catch in 2005 is only 9 000 tons to 1 September and is expected to reach about 15 000 tons in the whole year of 2005. The results from the ageing which is based on biological sampling shows a great number of three year olds per hour in 2004 proving the 2001 year-class to be rather strong. The 2002 year-class appears strong as judged by the three year olds in 2005. The 1999 year-class, now 6 year old appeared to be still present in the 2005 commercial fishery although small in numbers. Female biomass is either stable (EU survey) or increasing, depending on which index one looks at. The standardized female CPUE being significantly higher in 2005 as compared to 2004. There are however scanty data to substantiate the last year's standardized data. New recruitment indices were looked for. The number of 2 year-old shrimp in the EU survey were plotted against 3+ years of biomass. These did not have any relationship either with a 2 or 3 years lag. Indices of recruitment from the commercial fishery are plotted against 3+ CPUE and found to show a good relationship between age 2 in numbers and CPUE of 3+ two years later. From the recruitment indices of both commercial fishery and EU survey show a very strong 2002 year-class and a very weak 2003 year-class.

1. INTRODUCTION

The fishery for northern shrimp at Flemish Cap began in the spring of 1993 and has since continued with estimated annual catches (as estimated by STACFIS) of approximately 27 000 to 48 000 tons in the years 1993 through 1996. After 1996 catches were lower or rising slowly from 25 000 tons in 1997 to 52 000 tons in 2000 and further to 54 000 tons in 2001. There was 49 000 tons taken in 2002. The catch was higher than ever before in 2003, namely 63 000 tons declining to about 45 500 tons in 2004. Removals to September 2005 of about 9 000 tons are much lower than reported for the same period in 2004. Vessels from as many as 19 nations have participated in this fishery since its beginning.

The development of the international shrimp (*Pandalus borealis*) fishery in NAFO Div. 3M is described. Various indices are listed with the purpose of tracking the status of the Flemish Cap shrimp stock. Among these, the standardized CPUE and an international database of observer samples are used on which ageing was carried out. The results from the ageing are presented as well as numbers/hour per age based on the standardised CPUE. The indices of female stock are mainly from the EU survey. Also there is calculated a standardized CPUE series of female index. Moreover there is recruitment index from the EU survey and the commercial fishery.

Background on the assessment and management of this resource since 1993 can be found in Parsons (1998), Skúladóttir and Orr (2002), Gudmundsdóttir (2003), Gudmundsdóttir and Nicolajsen (2003) Skúladóttir and Gudmundsdóttir (2003) and NAFO Scientific Council Reports (2004).

2. MATERIAL AND METHODS

Standardization of CPUE

A standardized dataset, consisting of data from Canada, Faroe Islands, Greenland, Iceland, Norway and Russia from 1993 to 2005 exists. Data were selected from the standardized datafile where catch >0 kg and/or effort >10 hours. Like in 2003 and 2004 the Norwegian data before 1999 were not used as it was not possible to split the logbook data into single, double or triple trawls before 1999. As area is not defined in the Norwegian data and it has been noticed that area is not important to the regression (Gudmundsdottir, 2003) area is not used in the regression. CPUE is modelled against year, vessel, month and gear, by using the generalized Linear Model function glm in Splus (version 6) where the modelled CPUE is log-linked. Effort is used as the weighting factor. The model is standardized to data from 1993, June, single trawl and Icelandic data.

Samples

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 using sliding callipers and grouped 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 using each nation's catch, for weighting. 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 was calculated for the whole period, weighted by number caught each month and by nation. The 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:	$\ln y = 3.037 * \ln x - 7.549$
For multiparous females in April-June:	$\ln y = 2.778 * \ln x - 6.689$

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

For multiparous females July:	$\ln y = 2.921 * \ln x - 7.144$
For multiparous females August:	$\ln y = 3.111 * \ln x - 7.689$
For multiparous females Sept-March:	$\ln y = 2.929 * \ln x - 7.085$

3. CATCH

The catch is shown by months in Tables 1 to 3 as reported to NAFO as preliminary figures. The total catch per year is listed by nations in Table 4. The catch is mostly as it is reported to NAFO. But in some cases information are got from the shrimp specialists of the individual countries. The total catch per year is shown in Fig. 1. Although the year is not complete the projected catch to the end of the year is anticipated to be about 15 000 tons at the end of year 2005.

4. CPUE MODEL

A summary table was made from the data, shown in Table 5. Table 6 shows the no. of data records used in the model by year and country. Whether the data had constant variance was tested by plotting standard errors versus mean CPUE (Smith and Showell, 1996) and fitting a line through the points (Fig. 2). Since the coefficients of

variance were constant (Table 7) a gamma distribution can be used, so the family parameter in glm was set as Gamma. The model was run and the diagnostic plots inspected. Outliers were observed so it was decided to exclude data with the deviance >=10 and the model was fitted again. Some results from the model fit are shown in Table 8. Standard Splus diagnostic plots for the fit are shown in Fig. 3. From the deviance residuals plots it can be seen that the right link function as well as the assumed variance function has been chosen. In spite of the right tail being broad the model is considered appropriate. The resulting index is shown in Table 9 and Fig. 4. The index declined from 1993 to 1994 and were at low levels until 1997. From 1998 it gradually increased to 2005. Index values of all years were significantly different (P <0.05) from zero. Data for year 2005 were very scanty as there were only 2 countries left fishing and effort was extremely low.

Standardized nominal effort is shown in Fig. 5. The effort was highest in 1996 when fishing was quite intense. After that there was little effort in the years 1997 and 1998. The effort increased in 1999 and remained at a stable rather high level since then to decrease drastically in year 2005.

5. **RECRUITMENT**

The Faroese survey provides two recruitment indices in the years 1996-2003. Since 1997, a juvenile shrimp bag has been attached to the gear in the Faroese survey. The results are shown in Fig. 6. (Nicolajsen and Brynjólfsson, 2003). The abundance of two year olds obtained in the main trawl in the Faroese survey was observed for 7 years and is also shown in Fig. 6 (Nicolajsen , 2003). The two indices do not agree in all years. The Faroese survey has not been carried out since 2003, but the indices can be compared to new indices for recruitment. During 2001, two-year-olds were abundant in both the main trawl and the juvenile bag in the Faroese survey. This 1999 year-class has turned out to be quite strong. The 2000 year-class appeared to be small in both the main trawl and the juvenile bag and has turned out to be rather low in numbers in both 2003 and 2004. The 2001 year-class appears above average in the Faroese survey and is also quite conspicuous as seen in deviations as 3 year olds in 2004 and as 4 year olds in 2005 (Skúladóttir, 2005).

A series of 2 year olds (numbers/hour) in the commercial fishery are listed in Table 10. These have been plotted against the standardized CPUE of 3 + years (Table 10). By lagging 1, 2 or 3 years respectively the best fit was between no. of age 2 and 3+ two years later where $R^2 = 0.74$ (Fig. 7).

a series of 2 year olds in the EU survey is presented (Table 11, Fig. 8)(Casas *et al*., 2005). The series is shown since 1996 for the main gear and since 2001 for the juvenile bag. The first years showed very small numbers of age 2 but by 2002 there were more age 2 appearing. Since 2003 when automatic winces were introduced in the EU bottom trawl survey the gear was considered to catch much more young shrimp than before. The number of age 2 of the EU survey (Table 11) were regressed against 3+ biomass (Table 11). There was never any fit whether it was lagged by 1, 2 or 3 years.

6. **FEMALE BIOMASS**

The biomass indices have been corrected in the years 1988 to 2002 for adjusting for the more efficient research vessel taken into use in 2003 (Casas *et al*., 2004).

The spawning stock (female biomass) as determined from the EU survey biomass index increased rapidly during the years prior to the fishery, from 1989 and 1990 to 1992. This may have been due to a gradual increase in stock size after the cod biomass declined 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 then an increase during 1998. The SSB of EU survey has fluctuated since 1998 to 2005 (Casas *et al*., 2005).

The female biomass from the Faroese survey indices have shown much the same trend as the EU although not fluctuating as much.

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. The data are provided in Table 12. Once again, each index was standardized to the mean of the series and shown in Fig. 9 and 10.

7. **AGE ASSESSMENTS**

Age analysis was carried out on biological samples obtained from a few nations in the past years. Table 13 provides results of the age analyses (length and weight at age and sex are listed). This analysis allows the calculation of the number per hour caught and number caught per year (based on nominal catch and the CPUE model) by age group. It should be noted that there are difficulties in the aging, once shrimp reach carapace lengths of 26 mm. For this reason, it is likely that 6 and 7 year olds are badly defined. As the modal analysis is quite flexible in fixing age groups the deviation method was used as a guide (Skúladóttir, 2005) and sometimes the number of male age classes were found to be four instead of three if that was used as a basis or *vice versa*.

In Table 14 the calculated mean lengths are listed. The weights at age (Table 15) are calculated from the length weight relationship for each month. A new overall weight at age and sex for the months January to September was calculated by weighting by total catch of each nation in each month. In Table 16 is listed number of shrimp caught. Again the mean weight-at-age and sex group are calculated for the period January through September and the proportions are applied to the nominal catch every year to get the total number of shrimp caught every year.

Table 17 lists the number per hour caught in the commercial fishery. This is also calculated from Table 13 by first calculating proportions of standardized kg/hour for each age and sex-class. The female part of the standardized CPUE is that of transitionals, primiparous and multiparous females combined. The female CPUE is presented in Fig. 10.

Finally there is a Table 18 of age groups to show when shrimp change sex from male to female. Shrimp appear to be changing sex about half of them as 4 year olds in most years and the rest of an age-class then changed sex as 5 year olds. Exceptions from this are found in 1993 and 1994 when all shrimp seemed to change sex at age 5. In 1995 and 1996 shrimp seem to be changing sex a year earlier. In 2001 and 2004 very few shrimp change sex until they are 5 year olds.

In 1993, the 1987 year-class appeared as a very strong age-class (6+ cohort) as approximately 13 000 animals/ hr. The next prominent year-class was the 1993 year-class, two years old in 1995. 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 than might be expected. The 1996 year-class was considered mediocre during 1998, but appeared stronger during 1999-2001. It is important to note that the 1998 year-class is by far the weakest in the series in the commercial fishery. The 1999 year-class appears e.g. to be very strong in the commercial samples in years 2003 and 2004, but in 2005 the numbers are less than expected and could be underestimated at the same time as the 2000 year-class may be overestimated due to the combination with the 1999 year-class. The 2001 and 2002 year-classes appear to be above average in the 2005 fishery.

8. **SUMMARY**

Catches of shrimp on the Flemish Cap have been maintained at a high level averaging for the last 6 years. The CPUE model indicated that there was a general decline between 1993 and 1996. Then beginning in 1997, catch rates began to increase and increased to 2005. The spawning stock biomass also decreased between 1993 and 1994. The SSB of the EU survey increased from 1997 to 1998 and stayed stable thereafter. The female CPUE index increased to 2005 but the last year is uncertain due to few data. The 2001 year-class appears above average and 2002 year-class appears to be strong. These are supposed to maintain the stock in 2006 and 2007. The 2003 year-class appears to be one of the weakest in years 1996-2005.

9. **ACKNOWLEDGEMENT**

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Table 1. Catch (tons) by nations and months as reported provisionally to NAFO in year 2003.

Nation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**	**Year to date**
Canada													**0**	
Cuba													**0**	**81**
Estonia	602	392	1279	1318		1217	1506	1371	1169	883			**9737**	**12732**
EU/Denmark													**0**	
EU/Portugal													**0**	
EU/Spain				6	15	6	21		19	33	26	11	**137**	**161**
Faroe Is.	125	294	1087	1022	1239	1705	1380	1453	1253	952	851	501	**11862**	**12622**
France													**0**	
Greenland						15	760						**775**	**873**
Honduras													**0**	
Iceland		382	240	440	721	591	595	431	194	376	312	306	**4588**	**4588**
Japan										73	29	15	**117**	**116**
Latvia		254	530	480	425	319	363	247	245	159	192		**3214**	**3453**
Lithuania		87	289	453	382	365	450	338	292	402	333	353	**3744**	**3744**
Norway	165	306	1257	2305	2402	2995	2435		3074		1234	680	**16853**	**22874**
Poland													**0**	
Portugal													**0**	
Russia				3									**3**	**3**
Ukraina							73	141	24				**238**	**238**
USA								162	215	245		6	**628**	**628**
Total	**892**	**1715**	**4682**	**6027**	**5184**	**7213**	**7583**	**4143**	**6485**	**3123**	**2977**	**1872**	**51896**	**62113**

Table 2. Catch (tons) by nations and months as reported provisionally to NAFO in year 2004.

Nation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**	**Year to date**
Canada													**0**	
Cuba	95	2	178	218	241								**734**	**969**
Estonia	50	829	510	971			1214	1063	1318	1684	1571	1436	**10646**	**13455**
EU/Denmark													**0**	
EU/Portugal													**0**	
EU/Spain				22	528	570		222	233	249	265	47	**2136**	**2724**
Faroe Is.	26		60	227	434	564	455	491	324	369	654	449	**4053**	**4932**
France									72	188	135	28	**423**	**423**
Greenland													**0**	
Honduras													**0**	
Iceland		272	290	360		356	476	456	284	296	403	326	**3519**	**3519**
Japan													**0**	
Latvia			305	240	267	154	73	444	398				**1881**	**2332**
Lithuania	203	529	410	443	576	790	604	462	538	247			**4599**	**4802**
Norway		579			369	447		2319	1591	1553	1493	522	**8873**	**10743**
Poland		93	242	62						173	204	352	**1126**	**1124**
Portugal													**0**	
Russia										288	252	114	**654**	**654**
Ukraina						147	132	35					**314**	**314**
USA			153	180			287	32					**652**	**952**
Total	**374**	**2304**	**2148**	**2723**	**2415**	**3028**	**3241**	**5524**	**4758**	**5047**	**4977**	**3274**	**39610**	**46943**

Table 3. Catch (tons) by nations and months as reported provisionally to NAFO in year 2005.

Nation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**	**Year to date**
Canada													**0**	
Cuba	150	174	186	321									**831**	**1043**
Estonia													**0**	
EU		126	124	130	136	9	282	169					**976**	**1295**
EU/Denmark													**0**	
EU/Portugal													**0**	
EU/Spain													**0**	
Faroe Is.	242	147	173	347	302	343	143	178					**1875**	**2153**
France							126	174					**300**	**300**
Greenland													**0**	**10**
Honduras													**0**	
Iceland			311	394	456	468	443	469					**2541**	**2541**
Japan													**0**	
Latvia													**0**	
Lithuania													**0**	
Norway													**0**	**184**
Poland													**0**	
Portugal													**0**	
Russia			2	41	212	13							**268**	**268**
Ukraina													**0**	
USA		57	353	297									**707**	**1188**
Total	**392**	**504**	**1149**	**1530**	**1106**	**833**	**994**	**990**	**0**	**0**	**0**	**0**	**7498**	**8982**

Table 4. Catch (tons) by nations as estimated by STACFIS.

Nation	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003***	**2004***	**2005***
Canada	3724	1041	970	906	807	484	490	618	1 295	4 16			
Cuba							119	46	1 797	4 153	81	4 969	4 1043
Estonia		1081	2092	1900	3240	5694	10835	13256	3 9850	2 14215	4 12732	4 13455	
EU													4 1295
EU/Denmark	800	400	200			437	235		4 92	4 359			
EU/Portugal	300		150		170	203	227	289	4 420	4 15			
EU/Spain	240	300	158	50	421	913	1019	1388	4 799	671	4 161	4 2724	
Faroe Is.	7333	6791	5993	8688	7410	9368	9199	7719	3 10228	2 8516	2 12676	4 4932	4 2153
Greenland	3788	2275	2400	1107	105	853	576	1636		2 684	4 873		10
Honduras	1265												
Iceland	2243	2300	7623	20681	6381	6572	9277	8912	2 5265	2 5741	2 4695	2 3587	4 2541
Japan									1 130		116		
Latvia		300	350	1940	997	1191	3080	3105	4 2990	4 1885	4 3453	4 2332	
Lithuania		1225	675	2900	1785	3106	3370	3595	1 2702	4 3321	4 3744	4 4802	
Norway	7183	8461	9533	5683	1831	1339	2975	2669	1 13291	4 11624	4 22765	4 10743	4 184
Poland					2 824	148	894	2 1692	1 209			4 1124	4
Russia		350	3327	4445	1090		1142	7078	1 5687	2 1148	2 3		4 268
Fr. St. Pierre and Michelong		75			150				1 408	4 161		4 423	4 300
Ukraina									1 348		4 238	4 314	4
USA									1 411	4 96	4 628	4 952	4 1188
Total	**26876**	**24599**	**33471**	**48300**	**25211**	**30308**	**43438**	**52003**	**53922**	**48605**	**62165**	**46337**	**8982**

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

* Provisional to 1 October

Table 5. Analysis about the CPUE data.

year	Number of obs.	Mean cpue	Std.dev.	Minimum	Maximum
1993	170	386.2746	147.7421	92.8182	894.5
1994	130	246.4198	126.2234	10.375	720.8765
1995	362	276.7768	141.3902	38.1435	1181.9231
1996	863	229.4332	116.9914	45.236	847.5866
1997	365	284.8268	99.6234	44.3088	602.2971
1998	316	377.0577	147.2426	34.3878	1315.7314
1999	346	383.074	149.0381	35.2576	851.3818
2000	316	447.8508	162.1424	47.9591	1185.8592
2001	274	413.7121	141.1518	59.2308	976.8994
2002	172	503.3756	165.2182	123.8806	944.8406
2003	146	696.2644	223.7653	251.4034	1370.6957
2004	74	712.6376	230.5029	298.5625	1424.7738
2005	10	657.6244	286.2399	65.0602	1018.3964

Table 6. Number of data records which are used in the final model fit by year and country.

year	ICE	CAN	FRO	GRL	NOR	RUS
1993	41	54	0	75	0	0
1994	47	38	0	44	0	0
1995	171	51	84	37	0	13
1996	469	27	235	30	0	101
1997	152	17	169	7	0	9
1998	131	16	153	14	0	0
1999	164	10	113	8	18	26
2000	107	4	121	25	16	35
2001	126	8	0	0	75	65
2002	69	0	0	15	63	25
2003	56	0	0	13	76	0
2004	23	0	0	0	50	0
2005	8	0	0	0	2	0

Table 7. Results of fitting standard error *versus* mean CPUE.

```
Call: lm(formula = cpue.std ~ cpue.mean, data = tab)
Residuals:
   Min     1Q Median    3Q   Max
 -23.18 -15.39 -3.747 9.855 58.02

Coefficients:
             Value Std. Error t value Pr(>|t|)
(Intercept) 42.2553 18.3407     2.3039  0.0417
  cpue.mean  0.2828  0.0398     7.1037  0.0000

Residual standard error: 23 on 11 degrees of freedom
Multiple R-Squared: 0.821
F-statistic: 50.46 on 1 and 11 degrees of freedom, the p-value is 1.984e-05

Correlation of Coefficients:
          (Intercept)
cpue.mean -0.9375
```

Table 8. Results from the multiplicative model. The ship factors are not shown.

Call: glm(formula = cpue ~ factor(year) + factor(ship.nr) + factor(month.nr) + factor(
gear), family = Gamma(link = log), data = new.reg.data, weights = effort)
Deviance Residuals:

Min	1Q	Median	3Q	Max
-11.49087	-1.856368	-0.3515377	1.157158	10.42743

Coefficients:

	Value	Std. Error	t value
(Intercept)	6.3585	0.03899	163.0836
factor(year)1994	-0.5179	0.03346	-15.4767
factor(year)1995	-0.3352	0.03387	-9.896
factor(year)1996	-0.4388	0.03383	-12.9711
factor(year)1997	-0.4029	0.03502	-11.5049
factor(year)1998	-0.1861	0.03571	-5.2112
factor(year)1999	-0.1479	0.03581	-4.131
factor(year)2000	-0.0354	0.03587	-0.9877
factor(year)2001	-0.0231	0.03801	-0.6081
factor(year)2002	-0.0005	0.03997	-0.0123
factor(year)2003	0.1486	0.04069	3.6508
factor(year)2004	0.0855	0.04375	1.9547
factor(year)2005	0.1841	0.06177	2.9806
factor(month.nr)2-jan	-0.0918	0.03749	-2.448
factor(month.nr)3-feb	-0.0649	0.03023	-2.1459
factor(month.nr)4-mar	-0.0321	0.01867	-1.7182
factor(month.nr)5-apr	-0.0723	0.01581	-4.5722
factor(month.nr)6-may	-0.0590	0.01413	-4.1722
factor(month.nr)7-jul	-0.0814	0.01314	-6.1964
factor(month.nr)8-aug	-0.1670	0.01512	-11.0447
factor(month.nr)9-sep	-0.2305	0.01567	-14.7067
factor(month.nr)10-oct	-0.2445	0.01671	-14.6302
factor(month.nr)11-nov	-0.2580	0.01916	-13.471
factor(month.nr)12-dec	-0.1657	0.02705	-6.1268
factor(gear)2	0.1706	0.0168	10.1561
factor(gear)3	0.1664	0.0601	2.7694

(Dispersion Parameter for Gamma family taken to be 7.219541)
Null Deviance: 144283.4 on 3505 degrees of freedom
Residual Deviance: 24262.83 on 3331 degrees of freedom
Number of Fisher Scoring Iterations: 5

Table 9. CPUE index by year and the approximate 95% confidence intervall.

		Confidence limits	
year	index	upper 95%	lower 95%
1993	1	1	1
1994	0.5957881	0.636172	0.5579677
1995	0.7152047	0.7642963	0.6692663
1996	0.6448114	0.6890144	0.6034441
1997	0.6683963	0.7158825	0.62406
1998	0.830193	0.8903826	0.7740723
1999	0.8625024	0.9252078	0.8040468
2000	0.9651939	1.0354874	0.8996723
2001	0.9771513	1.0527252	0.9070028
2002	0.9995081	1.0809598	0.9241939
2003	1.1601543	1.2564713	1.0712206
2004	1.0892756	1.1867944	0.99977
2005	1.2021497	1.3568684	1.0650731

Table 10. Shrimp in Div. 3M. Recruitment indices of 2 year olds (numbers) in the Faroese survey.

Year	Main trawl	juvenile bag
1997	855	
1998	210	2532
1999	214	5683
2000	108	456
2001	1242	4377
2002	416	913
2003	1119	1337

Table 11. Shrimp in Div. 3M. Recruitment indices of 2 year olds (numbers) in the EU survey.

Year	Main trawl	juvenile bag
1999	4735	
2000	1069	
2001	3321	1487
2002	11004	2218
2003	12572	0
2004	27415	44812
2005	1271	9162

Table 12. Shrimp in Div. 3M. Indices of female biomass in the EU survey, Faroese survey and the commercial fishery standardized CPUE. The indices in the EU survey were converted by the Warren method in 2003 and 2004 after the introduction of a new vessel.

Year	EU survey biomass	Faroese Survey biomass	Standardized CPUE Kg/hour
1988	4525		
1989	1359		
1990	1363		
1991	6365		
1992	15472		
1993	6923		275.9
1994	2945		134.0
1995	4857		150.6
1996	5132		127.4
1997	4885	6731	126.4
1998	11444	12559	172.4
1999	13669	8863	212.5
2000	10172	10154	223.2
2001	13336	9374	190.0
2002	17091	11761	214.3
2003	11589	12402	251.6
2004	12081		233.7
2005	11642		327.2

Table 13. Mean weights at age and sex for the period January-September. Nominal catch for the whole year used for calculating proportion of weight and number caught at age and sex. Standardized CPUE for the whole year of single, double and triple 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 386.3	No./hour	Number ('000'000)
Males	1	10.4	0.0041	0.646	0.00265	9	0.1	190	13.2
Males	2	16.8	0.1148	2.772	0.31823	1023	14.7	5306	369.2
Males	3	20.7	0.2146	5.225	1.12129	3606	51.8	9919	690.2
Males	4	24.0	0.1156	8.188	0.94653	3044	43.8	5343	371.8
Primip.	5	26.0	0.2619	10.441	2.73450	8794	126.4	12106	842.3
Multip.	6+	26.5	0.2890	11.189	3.23362	10400	149.5	13358	929.4
Total			1.0000		8.35681	26876	386.3	46222	3216.1

1994

Sex	Age		Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 24599 tons	kg/hr 230.5	No./hour	Number ('000'000)
Males	1								
Males	2	16.4	0.1817	2.576	0.46806	1670	15.6	6073	648.1
Males	3	20.4	0.3629	4.998	1.81377	6470	60.6	12130	1294.5
Males	4	22.9	0.0854	7.101	0.60643	2163	20.3	2855	304.6
Primip.	5	25.7	0.1944	10.08	1.95955	6990	65.5	6498	693.5
Multip.	6+	26.9	0.1756	11.664	2.04820	7306	68.5	5869	626.4
Total			1		6.89601	24599	230.5	33425	3567.1

1995

Sex	Age		Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 33471 tons	kg/hr 276.3	No./hour	Number ('000'000)
Males	1								
Males	2	15	0.4516	1.965	0.88739	6079	50.2	25536	3093.5
Males	3	20.3	0.2714	4.924	1.33637	9154	75.6	15347	1859.1
Primip.	4	22.2	0.0507	6.462	0.32762	2244	18.5	2867	347.3
Primip.	5	25.3	0.0962	9.611	0.92458	6333	52.3	5440	659.0
Multip.	6+	26.2	0.1301	10.84	1.41028	9660	79.7	7357	891.2
Total			1		4.88625	33471	276.3	56546	6850.0

1996

Sex	Age		Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 48300 tons	kg/hr 249.1	No./hour	Number ('000'000)
Males	1								0.0
Males	2	15.3	0.0622	2.066	0.12860	1011	5.2	2524	489.4
Males	3	20.0	0.6076	4.728	2.87283	22585	116.5	24636	4776.9
Primip.	3	21.4	0.0379	5.788	0.21921	1723	8.9	1536	297.7
Primip.	4	24.8	0.1511	9.034	1.36509	10732	55.3	6127	1187.9
Multip.	3	22.2	0.0063	6.799	0.04274	336	1.7	255	49.4
Multip.	4	24.8	0.0474	9.296	0.44108	3468	17.9	1924	373.0
Multip.	5	26.6	0.0574	11.306	0.64930	5105	26.3	2329	451.5
Multip.	6	28.8	0.0300	14.167	0.42486	3340	17.2	1216	235.8
Total			1		6.14372	48300	249.1	40545	7861.7

Table 13. Continued

1997

Sex	Age		Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 25211	kg/hr 258.2	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	664	6.8	2125	207.5
Males	3	19.0	0.4092	4.117	1.68462	6694	68.6	16652	1625.9
Males	4	22.3	0.2089	6.633	1.38567	5506	56.4	8501	830.1
Primip.	3	20.6	0.0029	5.237	0.01498	60	0.6	116	11.4
Primip.	4	24.3	0.1724	8.390	1.44630	5747	58.9	7015	685.0
Multip.	3	19.1	0.0025	5.018	0.01240	49	0.5	101	9.8
Multip.	4	24.2	0.0488	9.570	0.46737	1857	19.0	1987	194.1
Multip.	5	25.6	0.0845	10.631	0.89822	3569	36.6	3438	335.7
Multip.	6	28.3	0.0171	14.350	0.24558	976	10.0	696	68.0
Multip.	7	29.3	0.0015	15.070	0.02232	89	0.9	60	5.9
Total			1		6.34481	25211	258.2	40692	3974.1

1998

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 30308	Kg/hr 320.7	No./hour	Number ('000'000)
Males	2	14.90	0.0596	1.923	0.11460	581	6.1	3194	301.9
Males	3	18.75	0.3462	3.868	1.33904	6783	71.8	18557	1753.7
Males	4	21.23	0.2321	5.642	1.30929	6633	70.2	12439	1175.6
Primip.	4	23.17	0.1399	7.355	1.02911	5213	55.2	7500	708.8
Primip.	5	25.87	0.0218	10.287	0.22439	1137	12.0	1169	110.5
Multip.	3	18.56	0.0025	4.160	0.01020	52	0.5	131	12.4
Multip.	4	23.51	0.0359	8.02	0.28781	1458	15.4	1924	181.8
Multip.	5	25.17	0.1083	9.7	1.05035	5321	56.3	5804	548.6
Multip.	6	26.47	0.0484	11.15	0.53946	2733	28.9	2593	245.1
Multip.	7	29.07	0.0054	14.47	0.07848	398	4.0	279	27.5
Total			1.0000		5.98273	30308	320.5	53593	5065.9

1999

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 43438	kg/hr 333.2	No./hour	Number ('000'000)
Males	1	6.0	0.0001	0.122	0.00001	0	0.0	5	0.7
Males	2	14.5	0.0467	1.769	0.08268	591	4.5	2561	333.8
Males	3	17.6	0.2773	3.176	0.88073	6291	48.3	15193	1980.7
Males	4	21.0	0.2253	5.490	1.23680	8834	67.8	12343	1609.1
Males	5	22.3	0.0003	6.560	0.00187	13	0.1	16	2.0
Primip.	4	22.07	0.0758	6.348	0.48118	3437	26.4	4153	541.4
Primip.	5	24.22	0.1327	8.418	1.11680	7977	61.2	7269	947.6
Multip.	3	18.25	0.0009	3.970	0.00361	26	0.2	50	6.5
Multip.	4	22.00	0.0207	6.672	0.13820	987	7.6	1135	147.9
Multip.	5	24.18	0.1259	8.674	1.09238	7802	59.9	6900	899.5
Multip.	6	26.42	0.0932	11.06	1.03086	7363	56.5	5107	665.7
Multip.	7	29.57	0.0011	15.171	0.01638	117	0.9	59	7.7
Total			1.0000		6.08151	43438	333.2	54791	7142.8

Table 13 continued

2000

Sex	Age	CL mm	Prop. by no.	Weight g	Prop. by weight	Nominal catch 52003	kg/hr 372.8	No./hour	Number ('000'000)
Males	2	13.16	0.0157	1.326	0.02078	198	1.4	1069	149.1
Males	3	17.31	0.3258	3.035	0.98868	9407	67.4	22220	3099.6
Males	4	19.99	0.2457	4.692	1.15299	10971	78.6	16762	2338.1
Males	5	21.90	0.0049	6.200	0.03026	288	2.1	333	46.4
Primip.	4	21.01	0.0776	5.458	0.42336	4028	28.9	5291	738.0
Primip.	5	24.16	0.0935	8.514	0.79646	7578	54.3	6381	890.1
Multip.	3	18.35	0.0021	4.012	0.00854	81	0.6	145	20.3
Multip.	4	21.89	0.0580	6.613	0.38387	3652	26.2	3959	552.3
Multip.	5	24.33	0.1271	8.825	1.12131	10669	76.5	8667	1209.0
Multip.	6	26.32	0.0473	10.703	0.50630	4817	34.5	3227	450.1
Multip.	7	27.64	0.0023	14.320	0.03289	313	2.2	157	21.9
Total			1.0000		5.46543	52003	372.8	68211	9514.9

2001

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 53922	kg/hr 377.5	No./hour	Number ('000'000)
Males	2	15.23	0.1040	2.058	0.21403	2035	14.2	6922	988.7
Males	3	17.78	0.1393	3.292	0.45858	4360	30.5	9271	1324.3
Males	4	20.82	0.3925	5.315	2.08614	19833	138.8	26123	3731.4
Males	5	21.76	0.0095	6.081	0.05777	549	3.8	632	90.3
Primip.	4	21.48	0.0293	5.848	0.17135	1629	11.4	1950	278.6
Primip.	5	24.02	0.1147	8.204	0.94100	8946	62.6	7634	1090.4
Multip.	4	20.50	0.0240	5.484	0.13179	1253	8.8	1599	228.5
Multip.	5	23.24	0.1111	7.769	0.86314	8206	57.4	7394	1056.2
Multip.	6	25.13	0.0666	9.652	0.64282	6111	42.8	4433	633.2
Multip.	7	26.93	0.0090	11.701	0.10531	1001	7.0	599	85.6
Total			1.0000		5.67192	53922	377.5	66558	9507.1

2002

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 48605	kg/hr 386.1	No./hour	Number ('000'000)
Males	1	12.05	0.0003	1.011	0.00030	3	0.0	23	2.9
Males	2	15.43	0.0605	2.142	0.12959	1240	9.8	4597	578.8
Males	3	18.14	0.5095	3.497	1.78172	17045	135.4	38718	4874.1
Males	4	20.57	0.0681	5.124	0.34894	3338	26.5	5175	651.5
Primip.	4	20.32	0.0458	4.94	0.22625	2164	17.2	3480	438.1
Primip.	5	23.04	0.0675	7.231	0.48809	4669	37.1	5129	645.7
Multip.	3	19.42	0.0009	4.718	0.00425	41	0.3	68	8.6
Multip.	4	22.17	0.0598	6.818	0.40772	3900	31.0	4544	572.1
Multip.	5	24.11	0.1430	8.6	1.22980	11765	93.5	10867	1368.0
Multip.	6	25.69	0.0430	10.266	0.44144	4223	33.5	3268	411.4
Multip.	7	28.25	0.0017	13.359	0.02271	217	1.7	129	16.3
Total			1.0001		5.08082	48605	386.1	75999	9567.3

Table 13 continued

2003

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 62165	kg/hr 448.2	No./hour	Number ('000'000)
Males	1	12.09	0.0086	1.02	0.00875	93	0.7	660	91.6
Males	2	15.81	0.1111	2.303	0.25586	2733	19.7	8556	1186.7
Males	3	18.41	0.1222	3.658	0.44702	4775	34.4	9411	1305.3
Males	4	20.49	0.3638	5.062	1.84139	19668	141.8	28014	3885.5
Primip.	4	21.73	0.0855	6.052	0.51737	5526	39.8	6583	913.1
Primip.	5	24.15	0.0554	8.347	0.46263	4941	35.6	4268	592.0
Multip.	3	19.96	0.0004	4.678	0.00198	21	0.2	33	4.5
Multip.	4	21.98	0.0409	6.653	0.27199	2905	20.9	3148	436.7
Multip.	5	24.34	0.1358	8.833	1.19913	12808	92.3	10455	1450.1
Multip.	6	26.01	0.0753	10.622	0.79948	8540	61.6	5796	803.9
Multip.	7	27.88	0.0011	12.885	0.01437	153	1.1	86	11.9
Total			1.0000		5.81996	62165	448.2	77011	10681.3

2004

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 46337	kg/hr 420.8	No./hour	Number ('000'000)
Males	1								
Males	2	14.36	0.1583	1.720	0.27228	2421	22.0	12784	1407.7
Males	3	18.36	0.3719	3.631	1.35037	12008	109.0	30033	3307.1
Males	4	21.09	0.1082	5.529	0.59824	5320	48.3	8738	962.2
Males	5	21.51	0.0164	5.867	0.09622	856	7.8	1324	145.8
Primip.	4	20.83	0.0091	5.327	0.04848	431	3.9	735	80.9
Primip.	5	23.44	0.1657	7.618	1.26230	11225	101.9	13381	1473.5
Multip.	4	21.55	0.0158	6.296	0.09948	885	8.0	1276	140.5
Multip.	5	24.26	0.0993	8.756	0.86947	7732	70.2	8019	883.0
Multip.	6	26.45	0.0548	11.126	0.60970	5422	49.2	4425	487.3
Multip.	7	28.87	0.0003	14.199	0.00426	38	0.3	24	2.7
Total			0.9998		5.21079	46337	420.8	80739	8890.7

2005

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 15000	kg/hr 464.3	No./hour	Number ('000'000)
Males	1								
Males	2	15.64	0.0205	2.229	0.04569	124	3.8	1717	55.7
Males	3	17.31	0.3174	3.038	0.96426	2618	80.8	26591	861.6
Males	4	19.98	0.1301	4.689	0.61004	1656	51.1	10900	353.2
Males	5					0			
Primip.	4	21.91	0.3062	6.206	1.90028	5159	159.2	25653	831.2
Primip.	5	23.22	0.0505	7.405	0.37395	1015	31.3	4231	137.1
Multip.	4	22.19	0.0113	6.830	0.07718	210	6.5	947	30.7
Multip.	5	24.46	0.1309	8.952	1.17182	3181	98.2	10967	355.3
Multip.	6	26.81	0.0331	11.552	0.38237	1038	32.0	2773	89.9
Total			1.0000		5.52559	15000	462.9	83779	2714.6

Table 14. Shrimp. Mean length (oblique carapace length mm) at age

Age gr.	1993	1994	1995	Agegr.	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Mean
1	10.4			1		10.44					12.05	12.09			11.53
2	16.8	16.4	15	2	15.25	15.73	14.9	14.49	13.18	15.23	15.43	15.81	14.36	15.64	15.00
3	20.7	20.4	20.3	3	20.54	19.01	18.75	17.58	17.32	17.78	18.14	18.41	18.36	17.31	18.32
4	24	22.9	22.2	4	24.7	23.32	22.09	21.34	20.46	20.84	21.06	20.83	21.13	21.35	21.71
5	26	25.7	25.3	5	24.8	25.56	25.29	24.2	24.27	23.56	23.76	24.28	23.62	24.11	24.35
6+	26.5	26.9	26.2	6	26.6	28.33	26.47	26.42	26.08	25.13	25.69	26.01	26.45	26.81	26.40
				7	28.8	29.28	29.07	29.57	29.32	26.93	28.25	27.88	28.87		28.66

Table 15. 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	2003	2004	2005	Mean
1	0.646			1		0.910					1.011	1.02			0.980
2	2.772	2.576	1.965	2	2.066	2.270	1.923	1.639	1.326	2.058	2.142	2.303	1.720	2.229	1.968
3	5.225	4.998	4.924	3	4.79	4.130	3.815	3.069	3.044	3.292	3.499	3.661	3.631	3.038	3.597
4	8.188	7.101	6.462	4	8.945	7.671	6.439	6.347	5.122	5.359	5.659	5.367	5.606	5.781	6.230
5	10.441	10.080	9.611	5	9.296	10.631	9.800	8.502	8.641	7.913	8.161	8.692	7.918	8.521	8.808
6+	11.189	11.664	10.840	6	11.306	14.350	11.150	11.060	10.703	9.652	10.266	10.622	11.126	11.552	11.179
				7	14.167	15.070	14.470	15.100	14.32	11.701	13.359	12.885	14.199		13.919

Table 16. 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	2003	2004	2005	Mean
1	13.2			1		0.9		0.7			2.9	91.6			24.0
2	369.2	648.1	3047.8	2	489.4	203.1	301.9	333.8	121.2	988.7	578.8	1186.7	1407.0	55.7	566.6
3	690.2	1294.5	1831.7	3	5124.1	1612.1	1766.2	1987.2	3026.5	1324.3	4882.7	1309.8	3307.1	861.6	2520.2
4	371.8	304.6	342.2	4	1561.0	1672.8	2066.2	2298.5	3415.9	4238.4	1661.7	5235.3	1183.6	1215.1	2454.9
5	842.3	693.5	649.2	5	451.5	328.6	659.1	1849.2	2038.7	2237.0	2013.7	2042.1	2502.4	492.4	1461.5
6+	929.4	626.4	878.0	6	235.8	66.6	245.1	665.7	510.4	633.2	411.4	803.9	487.3	89.9	414.9
				7		5.8	27.5	7.7	25.2	85.6	16.3	11.9	2.7	0.0	20.3
Total	3216.1	3567.1	6748.9		7861.8	3889.9	5066.0	7142.8	9137.9	9507.2	9567.5	10681.3	8890.1	2714.7	7445.9

Table 17. 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	2003	2004	2005*	Mean
1	189			1	0	0	0	5	0	0	23	660	0	0	69
2	5306	6073	25536	2	2524	2125	3195	2561	1069	6922	4598	8556	12784	1717	4605
3	9919	12130	15347	3	26427	16869	18689	15243	22366	9271	38786	9444	30033	26591	21372
4	5343	2855	2867	4	8051	17504	21863	17631	26012	29673	13200	34446	10749	37500	21663
5	12106	6498	5440	5	2329	3438	6974	14184	15381	15028	15996	14723	22725	15198	12598
6+	13358	5870	7357	6	1216	696	2594	5107	3227	4433	3268	5796	4425	2773	3354
				7	0	60	279	59	157	599	129	86	24	0	139
Total	46221	33426	56547		40547	40692	53594	54790	68212	65926	76000	73711	80740	83779	63799

* 5 and 6 yr olds are merged together so the no of 6 yr olds is probably underestimated.

Table 18. Shrimp. Maturity of females (transitionals , primiparous and multiparous) at age based on the period January to September.

Age gr.	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Mean
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000
3	0	0	0	0.06	0.013	0	0	0.012	0	0	0	0	0	0.007
4	0	0	1	1	0.514	0.431	0.3	0.356	0.12	0.608	0.258	0.187	0.709	0.422
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1.000
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1.000
7					1	1	1	1	1	1	1	1		1.000

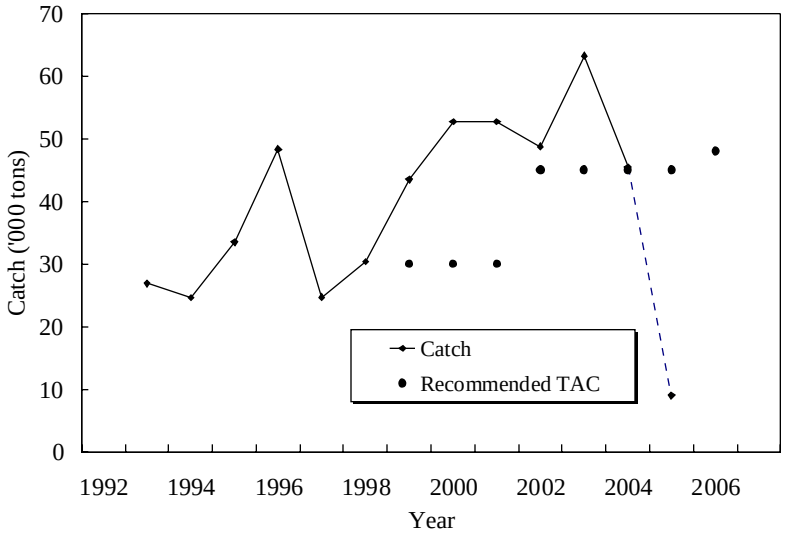

Fig. 1. Shrimp in Div. 3M: catch.

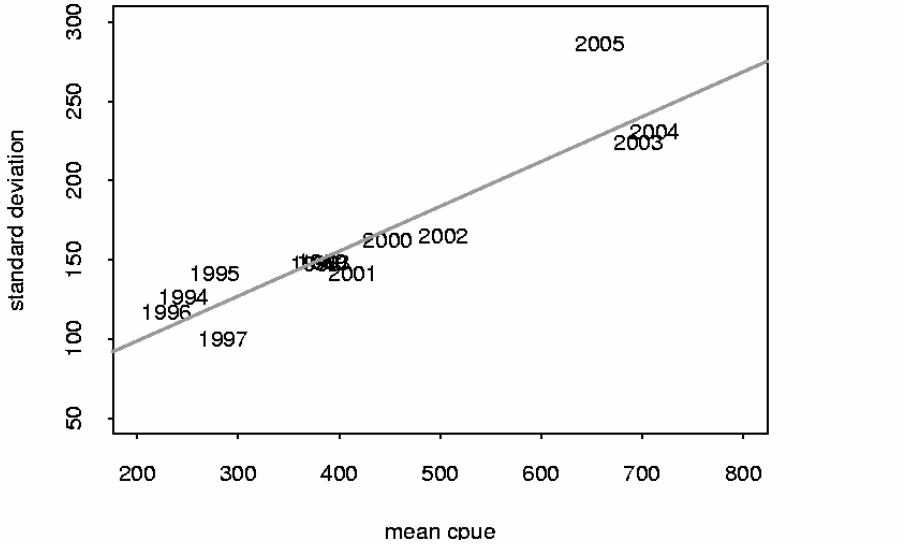

Fig. 2. Coefficient of variation around the annual mean CPUE. The numbers indicate the years.

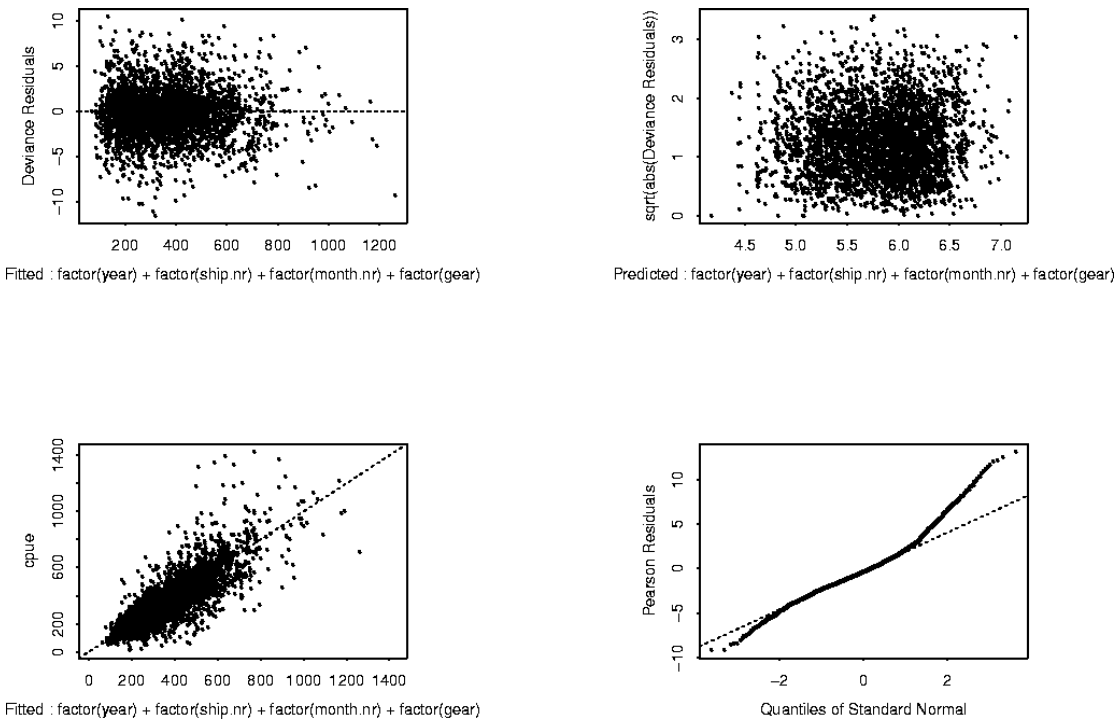

Fig. 3. Plots of the generalized linear model of CPUE predicted by year, vessel, month and gear.

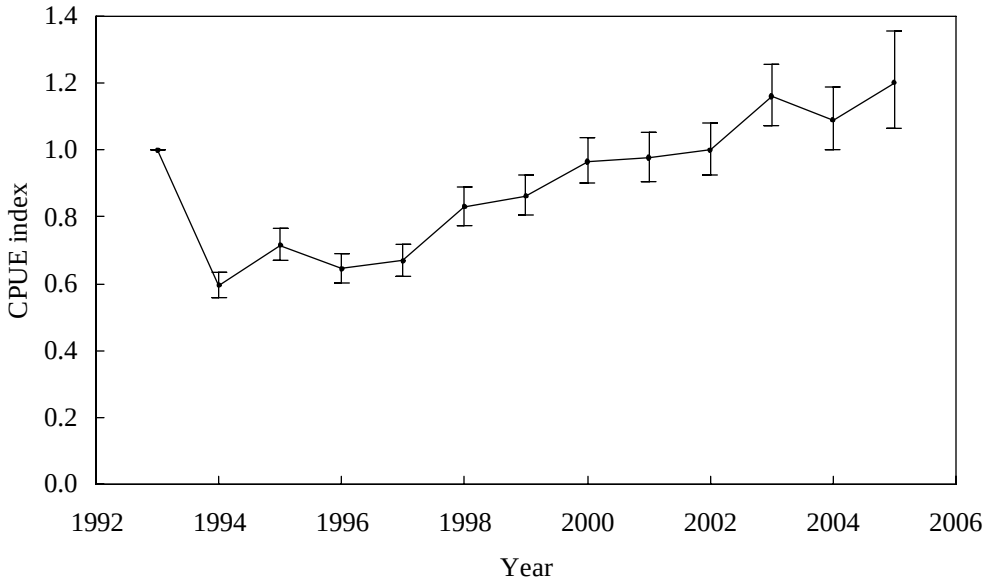

Fig. 4. The modelled CPUE index with approximate 95% confidence limits.

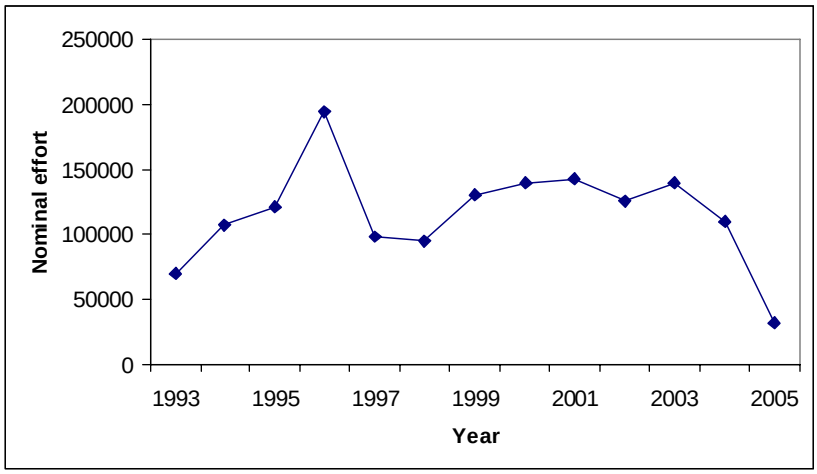

Fig. 5. Shrimp in Div. 3M: standardized nominal effort in the commercial fishery. 2005 effort is projected to the end of the year.

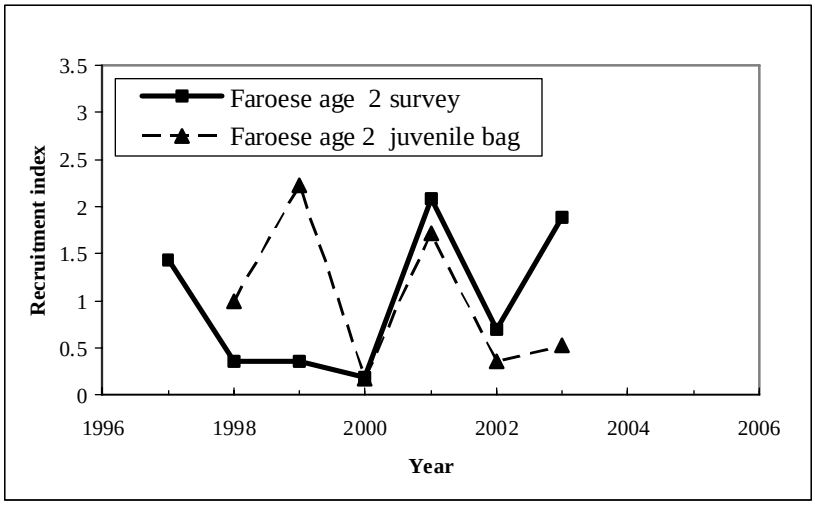

Fig. 6. Shrimp in Div. 3M: abundance indices at age 2 from the Faroese survey and from the juvenile bag. Each series was standardized to its mean.

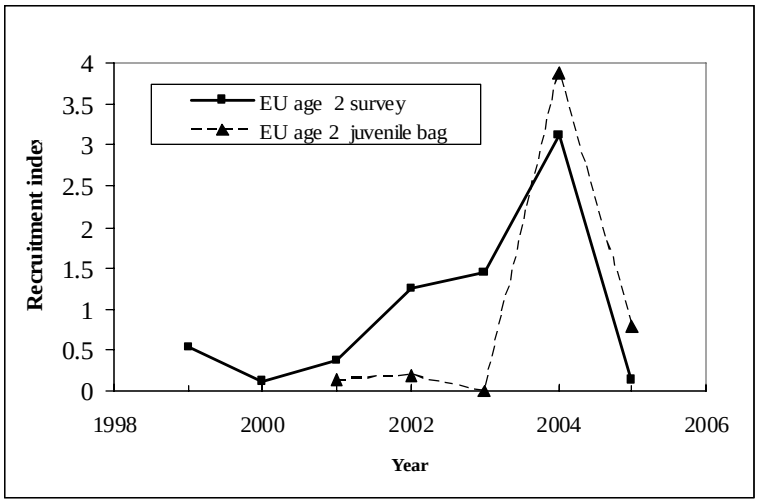

Fig.7. Shrimp in Div. 3M: abundance indices at age 2 from the EU survey and from the juvenile bag. Each series was standardized to its mean.

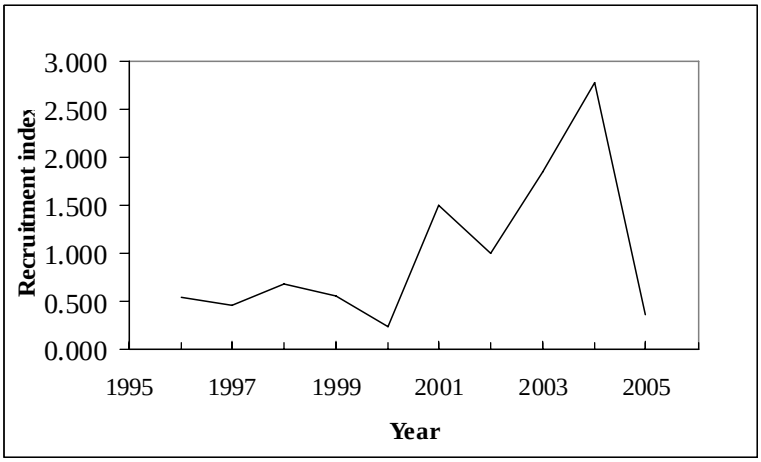

Fig. 8. Shrimp Div. 3M: abundance indices at age 2 from the commercial fishery. Each series was standardized to its mean.

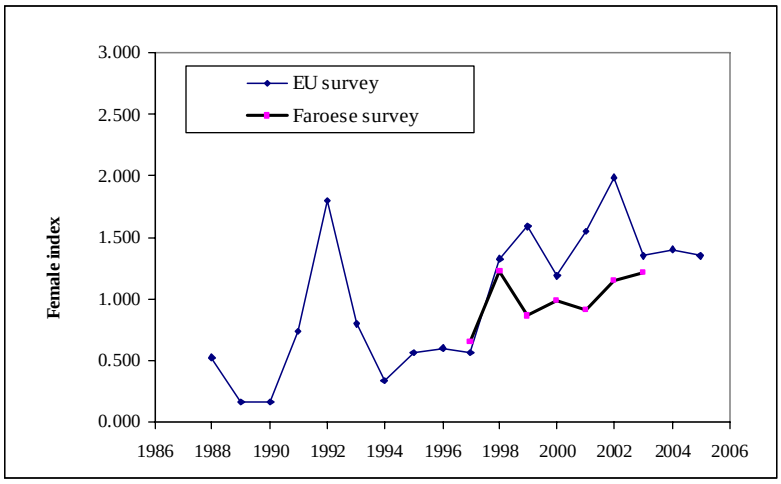

Fig. 9. Shrimp in Div. 3M: female biomass index from EU trawl surveys, 1988-2005, Faroese survey, 1997-2003 Each series was standardized to the mean of that series.

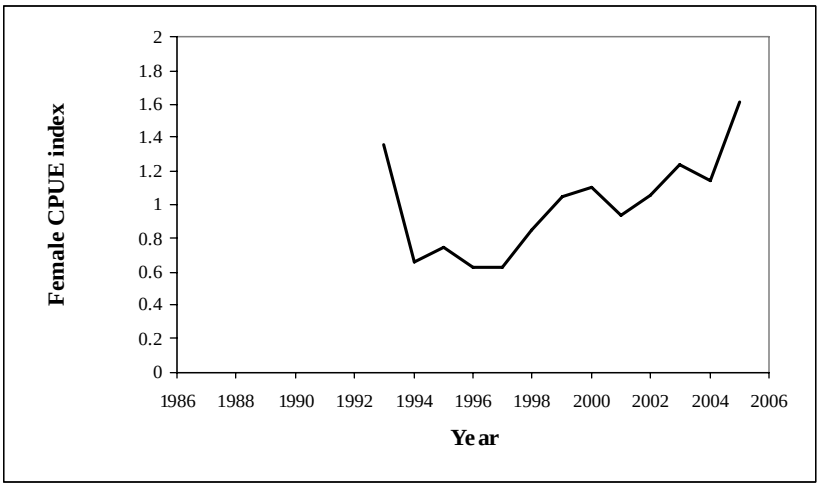

Fig.. 10. Shrimp in Div. 3M: standardized female CPUE, 1993-2005. The series was, standardized to the mean of the series.