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Assessment of the International Fishery for Shrimp (*Pandalus borealis*) in Division 3M (Flemish Cap), 1993-2006

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 stable in the last couple of years. 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 17 in 2005 against 50 in 2004. In 2006 there were even fewer vessels fishing for shrimp due to economic reasons. Nominal catch was 32 000 tons in 2005 as compared to 45 500 tons in 2004. The catch in 2005 is only 11 000 tons to 1 September. Noting the lack of reports on catch this figure might increase considerably. The results from the ageing which is based on biological sampling shows a great number of four year olds per hour in 2006 proving the 2002 year-class to be very strong. Female biomass EU survey is stable but the standardized CPUE has increased. Due to misreporting of CPUE between Div. 3L and 3M the indices which are built on those are doubtful. The female biomass being slightly lower than that of 2005 as survey biomass. Indices of recruitment from the commercial fishery are plotted against 3+ CPUE are found to show a good relationship between age 2 in numbers and CPUE of 3+ two years later. The recruitment indices of both commercial fishery and EU survey show a very strong 2002 year-class and a much weaker 2003 year-class. The 2004 year-class being also very small.

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 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 were 49 000 tons taken in 2002. The catch increased much to 2003, namely to the highest ever of 63 000 tons declining to about 32 000 tons in 2005. Removals to September 2006 of about 11 000 tons are much lower than usually reported for the same period. 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 is 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), Gudmundsdóttir (2003), Gudmundsdóttir and Nicolajsen (2003) Skúladóttir and Pétursson (2005) and NAFO Scientific Council Reports (2005).

Materials and Methods

Standardization of CPUE

A standardized dataset, consisting of data from Canada, Faroe Islands, Greenland, Iceland, Norway, Russia and Estonia from 1993 to 2006 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 calipers 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, 2003). 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

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 either annually as STATLANT A reports or provisionally in monthly reports where STALANT A was missing. But in some cases information is obtained from the fishery biologists of the individual countries (see footnotes under Table 4). As the flag nations of EU do not report provisionally on shrimp catch on Flemish Cap in 2006, the small catch of 11 000 tons to 1 September is underestimated compared to the years prior to 2005. The total catch was now found to be almost 32 000 tons in 2005 as compared to the 9 000 tons reported to 1 September in 2005. The total catch of shrimp has decreased steadily since 2003 due to economic reasons. The total catch per year is shown in Fig. 1.

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 was 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 2006 were very scanty as there was only 1 country that turned in CPUE reports for the year. Recent news about misreporting of shrimp catch between Div. 3L and 3M as indicated by Canadian surveillance render the CPUE results useless for the last couple of years.

Catch Rates

Catch rate is shown in Fig. 5. The catch rate was high in the years 1994-1997 when biomass was generally lower. In the years 1998-2005 catch rate has been rather stable at a lower niveau.

Recruitment

The Faroese survey provided two recruitment indices in the years 1996-2003 (Nicolajsen and Brynjólfsson, 2003). The abundance of two year olds obtained in the main trawl in the Faroese survey was observed for 7 years (Nicolajsen, 2003). The Faroese survey has not been carried out since 2003. The juvenile shrimp bag was introduced in the EU survey in 2001. A series of 2 year olds in the EU survey is presented (Table 11, Fig. 6) (Casas *et. al.*, 2006). 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 in the main gear. 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 were regressed against 3+ biomass (Table 11). There was never any fit whether it was lagged by 1, 2 or 3 years. 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 = 0.89 (Fig. 7). There is also some fit when lagged by 3 years (Fig. 8) but not so good. The 2000 year-class appeared to be small in 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 EU survey main gear and also in the commercial fishery, but hardly seen in the juvenile bag. The 2002 year-class, 2 year old in 2004 is the biggest seen in all gears and was also very conspicuous as seen in deviations and length frequencies as 3 year olds in 2005 and as 4 year olds in 2006 (Skúladóttir, 2006). The following year-classes 2003 and 2004 seem very poor (Fig. 6).

Female Biomass

The biomass indices have been corrected in the years 1988 to 2002 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 2006 (Table 12, Fig. 9) (Casas *et. al.*, 2006).

The female biomass from the Faroese survey indices have shown much the same trend as the EU although not fluctuating as much (Nicolajsen, 2003).

A spawning stock biomass (SSB) index was calculated as kg/hr of primiparous (including transitionals) plus multiparous females from the international observer data base and the standardized CPUE model. The data are provided in Table 12 and Fig. 10. Once again, each index was standardized to the mean of the series. The SSB from EU surveys appears to be stable with fluctuations since 1998. The standardized SSB CPUE appears to be higher in 2005 and 2006 than ever before. As said before the CPUE in 2006 is based on scanty data so the biomass can be

overestimated as seen in the wide confidence limits in this year (Fig. 4). On top of that there is the misreporting between 3L and 3M that makes the CPUE from commercial fishery useless as an indicator.

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 >24 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 three instead of four if that was used as a basis or *vice versa*. The columns of Table 13 containing kg/hr and no/hour were not found to be reliable in the last couple of years.

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 are listed numbers 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. The prominent 1993 year-class was the 1993 year-class, 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, especially the latter appear to be above average in the 2005 and 2006 fishery. In fact the 2002 year-class appears to be the strongest ever in the Flemish stock population as shown by no. per hour in 2006 (Table 17).

The samples were scrutinized and compared to the samples of 3L sent by Iceland. These were found to be completely different. So the Flemish Cap samples were considered taken in Flemish Cap area. However table 17 was not relyable for the last couple of years on account of the wrong CPUE due to misreporting.

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 40% of them as 4 year olds in most years and the rest of an age-class then changes 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 till they are 5 year olds. In 2005 65% seem to have changed sex by the age 4 and the rest change sex as five year olds, whereas only 18% of the four year olds have changed sex in 2006. The rest will probably all change sex as five year olds. As there are no samples after March in 2006 and many shrimp change sex after that month in a given year, the results of only 18% of four year olds changing sex are considered an underestimate.

Summary

Catches of shrimp on the Flemish Cap have been maintained at a high level averaging for the last 7 years. The CPUE model indicated that there was a general decline between 1993 and 1996. Then beginning in 1997, catch rates began to increase. 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 that is uncertain due to misreporting of catch per hour. The 2001 year-class appears above average and the 2002 year-class appears to be extremely strong. These are supposed to maintain the stock in 2007 and also to some degree in 2008. The 2003 year-class appears to be weak. The same appears to be the case with the 2004 year-class.

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Table 1. 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 St. Pierre an Michelong									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**				**39610**	**46943**

Table 2. 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										188	188		**376**	**188**
Cuba	150	174	186	321									**831**	**1043**
EU		126	124	130	136	9	282	169				65	**1041**	**1724**
EU/Estonia													**0**	
EU/Latvia													**0**	
EU/Lithuania													**0**	
EU/Poland													**0**	
EU/Portugal													**0**	
EU/Spain													**0**	
Faroe Is.	242	147	173	347	302	343	143	178	22		6	160	**2063**	**2341**
France St. Pierre an Michelong							126	174	154			32	**486**	**487**
Greenland													**0**	
Honduras													**0**	
Iceland			311	394	456	468	443	469	422	295	381	434	**4073**	**4073**
Japan													**0**	
Norway													**0**	**184**
Russia			2	41	212	13							**268**	**268**
Ukraina													**0**	
USA		57	363	297									**717**	**1188**
Total	**392**	**504**	**1159**	**1530**	**1106**	**833**	**994**	**990**	**598**	**483**	**575**	**691**	**9855**	**11496**

Table 3. Catch (tons) by nations and months as reported provisionally to NAFO in year 2006 by countries other than EU which does not report on catch.

Nation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**	**Year to date**
Canada													**0**	
Cuba													**0**	
EU													**0**	
EU/Estonia													**0**	
EU/Latvia													**0**	
EU/Lithuania													**0**	
EU/Poland													**0**	
EU/Portugal													**0**	
EU/Spain													**0**	
Faroe Is.	45	184	110	37		120	110						**606**	**606**
France St. Pierre an Michelong													**0**	
Greenland						596	97						**693**	**754**
Honduras													**0**	
Iceland		389	360	545	388	417							**2099**	**2099**
Japan													**0**	
Norway													**0**	
Russia					46								**46**	**46**
Ukraina					32	2	175	68					**277**	**277**
USA													**0**	
Total	**45**	**573**	**470**	**582**	**466**	**1135**	**382**	**68**	**0**	**0**	**0**	**0**	**3721**	**3782**

Table 4. Shrimp in 3M. Catch (tons) by nations as estimated by STACFIS.

Nation	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006*
Canada	3724	1041	970	906	807	484	490	2 618	1 295	2 16				
Cuba							119	1 46						
Estonia		1081	2092	1900	3240	5694	10835	213256	1 9851	2 14215	112851	1 13443	217525	2 6801
EU/Denmark	800	400	200			437	235		1 93	1 359				
EU/Portugal	300		150		170	203	227	1 289	1 420	1 16		1 50		
EU/Spain	240	300	158	50	421	913	1019	2 1388	1 855	1 674	1 857	2 2724	2 725	
EU/United Kingdom											1 547			
Faroe Is.	7333	6791	5993	8688	7410	9368	9199	2 7719	10228	8516	12676	1 4952	42341	4 606
Greenland	3788	2275	2400	1107	105	853	576	11734		2 684	11181		4 10	4 754
Honduras	1265													
Iceland	2243	2300	7623	20681	6381	6572	9277	2 8912	2 5265	25741	2 4715	2 3567	1 4014	4 2099
Japan									1 130	1 100	1 117			
Latvia		300	350	1940	997	1191	3080	1 3105	1 2961	1 1892	1 3533	1 3059	1 2212	
Lithuania		1225	675	2900	1785	3106	3370	1 3529	1 2701	1 3321	1 3744	1 4802	1 3652	
Norway	7183	8461	9533	5683	1831	1339	2975	2 2669	2 13291	1 11833	122765	1 10819	4 184	
Poland					2 824	148	894	2 1692	1 209			1 1158	2 444	
Russia		350	3327	4445	1090		1142	2 7078	1 5687	11176	1 3	1 654	4 268	4 46
Fr. St. Pierre and Michelong		75			150				1 337	1 161			4 487	
Ukraina									1 348		1 237	1 315		2 279
USA								1 629						
Total	**26876**	**24599**	**33471**	**48300**	**25211**	**30308**	**43438**	**52664**	**52671**	**48704**	**63226**	**45543**	**31862**	**10585**

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 September

Table 5. Analysis about the CPUE data

	year	no. of obs.	Mean cpue	Std. dev.	Minimu	Maximum
1	1993	170	386.2746	147.7421	92.81818	894.5000
2	1994	130	246.4198	126.2234	10.37500	720.8765
3	1995	362	276.7768	141.3902	38.14345	1181.9231
4	1996	863	229.4332	116.9914	45.23596	847.5866
5	1997	365	284.8268	99.6234	44.30877	602.2971
6	1998	316	377.0577	147.2426	34.38776	1315.7314
7	1999	346	383.0740	149.0381	35.25763	851.3818
8	2000	316	447.8508	162.1424	47.95910	1185.8592
9	2001	274	413.7121	141.1518	59.23077	976.8994
10	2002	172	503.3756	165.2182	123.88060	944.8406
11	2003	235	605.7619	235.1533	128.81818	1370.6957
12	2004	166	577.1031	221.6816	226.93333	1424.7738
13	2005	107	605.0041	206.8540	65.06024	1675.0165
14	2006	14	1143.8720	417.1038	552.74983	1705.4350

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

	ICE	CAN	FRO	GRL	NOR	RUS	EST
1993	41	54	0	75	0	0	0
1994	47	38	0	44	0	0	0
1995	171	51	84	37	0	13	0
1996	469	27	235	30	0	101	0
1997	152	17	169	7	0	9	0
1998	131	16	153	14	0	0	0
1999	164	10	113	8	18	26	0
2000	107	4	121	25	16	35	0
2001	126	8	0	0	75	65	0
2002	69	0	0	15	63	25	0
2003	56	0	0	13	76	0	89
2004	35	0	0	0	50	0	80
2005	21	0	0	0	2	0	82
2006	14	0	0	0	0	0	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
 -25.17 -15.39 -1.361 13.44 26.14

Coefficients:
             Value Std. Error t value Pr(>|t|)
(Intercept) 23.4695 10.5286     2.2291  0.0457
  cpue.mean  0.3316  0.0205    16.2107  0.0000

Residual standard error: 17.22 on 12 degrees of freedom
Multiple R-Squared: 0.9563
F-statistic: 262.8 on 1 and 12 degrees of freedom, the p-value is 1.595e-09

Correlation of Coefficients:
          (Intercept)
cpue.mean -0.8994
```

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
 -11.2532 -1.911436 -0.3626767 1.19967 10.28888

Coefficients:
                         Value Std.    Error        t value
      (Intercept)           6.3477   0.03988       159.1865
 factor(year)1994          -0.5146   0.03446       -14.9348
 factor(year)1995          -0.3378   0.03487        -9.6895
 factor(year)1996          -0.4379   0.03479       -12.5875
 factor(year)1997          -0.4053   0.03603       -11.2486
 factor(year)1998          -0.1883   0.03674        -5.1248
 factor(year)1999          -0.1507   0.03683        -4.0911
 factor(year)2000          -0.0382   0.03689        -1.0366
 factor(year)2001          -0.0212   0.03908        -0.5424
 factor(year)2002           0.0011   0.04104         0.0263
 factor(year)2003           0.1635   0.04107         3.9814
 factor(year)2004           0.0767   0.04224         1.8160
 factor(year)2005           0.2032   0.04426         4.5919
 factor(year)2006           0.5130   0.07907         6.4880

 factor(month.nr)2-jan     -0.1040   0.02898        -3.5892
 factor(month.nr)3-feb     -0.1235   0.02554        -4.8374
 factor(month.nr)4-mar     -0.0353   0.01772        -1.9918
 factor(month.nr)5-apr     -0.0782   0.01519        -5.1463
 factor(month.nr)6-may     -0.0685   0.01377        -4.9730
 factor(month.nr)7-jul     -0.0750   0.01294        -5.7957
 factor(month.nr)8-aug     -0.1529   0.01465       -10.4411
 factor(month.nr)9-sep     -0.2162   0.01509       -14.3266
factor(month.nr)10-oct     -0.2052   0.01592       -12.8867
factor(month.nr)11-nov     -0.2389   0.01791       -13.3378
factor(month.nr)12-dec     -0.1877   0.02328        -8.0625

     factor(gear)2          0.1875   0.01686        11.1194
     factor(gear)3          0.1723   0.06163         2.7961

(Dispersion Parameter for Gamma family taken to be 7.661995)
    Null Deviance: 158497.2 on 3795 degrees of freedom
Residual Deviance: 27787.2 on 3610 degrees of freedom
Number of Fisher Scoring Iterations: 5
```

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

		Confidence limits	
Year	Index	upper 95%	Lower 95%
1993	1.0000	1.0000	1.0000
1994	0.5977	0.6395	0.5587
1995	0.7133	0.7638	0.6662
1996	0.6454	0.6909	0.6029
1997	0.6668	0.7156	0.6213
1998	0.8284	0.8902	0.7708
1999	0.8601	0.9245	0.8002
2000	0.9625	1.0346	0.8954
2001	0.9790	1.0570	0.9068
2002	1.0010	1.0849	0.9237
2003	1.1777	1.2764	1.0866
2004	1.0797	1.1729	0.9939
2005	1.2253	1.3364	1.1235
2006	1.6703	1.9503	1.4305

Table 10. Shrimp in Div. 3M. Recruitment indices of age 2 (numbers/hour) in the commercial fishery and CPUE of 3 year olds and older

Year	Numbers/hr ('000)	CPUE 3+
1996	2526	244.1
1997	2120	250.8
1998	3187	313.9
1999	2553	327.7
2000	1066	370.4
2001	6935	360.1
2002	4605	376.8
2003	8684	434.2
2004	12671	395.3
2005	5595	460.8
2006	0	645.2

Table 11. Shrimp in Div. 3M. Recruitment, abundance of age 2 in the EU survey and biomass of 3years and older.

Year	Main trawl ('000)	juvenile bag	Biomass 3+
1996	3424		9852
1997	629		7310
1998	54968*		30266
1999	4735		23863
2000	1069		18813
2001	3321	1487	26632
2002	11004	2218	34216
2003	12572	0	18540
2004	27415	44812	15588
2005	1792	9162	30489
2006	1085	7498	16149

* 1998 mesh size 25 was used instead of 35 mm in EU survey, main gear.

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

Year	EU survey biomass	Standardized CPUE Kg/hour
1988	4525	
1989	1359	
1990	1363	
1991	6365	
1992	15472	
1993	6923	275.9
1994	2945	134.2
1995	4857	150.3
1996	5132	127.5
1997	4885	126.4
1998	11444	172.2
1999	13669	211.9
2000	10172	222.6
2001	13336	190.4
2002	17091	214.6
2003	11589	255.4
2004	12081	231.6
2005	14381	298.9
2006	11359	306.8

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 230.9	No./hour	Number (´000´000)
Males	1								
Males	2	16.4	0.1817	2.576	0.46806	1670	15.7	6084	648.1
Males	3	20.4	0.3629	4.998	1.81377	6470	60.7	12151	1294.5
Males	4	22.9	0.0854	7.101	0.60643	2163	20.3	2859	304.6
Primip.	5	25.7	0.1944	10.08	1.95955	6990	65.6	6509	693.5
Multip.	6+	26.9	0.1756	11.664	2.04820	7306	68.6	5880	626.4
Total			1		6.89601	24599	230.9	33483	3567.1

1995

Sex	Age		Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 33471 tons	kg/hr 275.5	No./hour	Number (´000´000)
Males	1								
Males	2	15	0.4516	1.965	0.88739	6079	50.0	25462	3093.5
Males	3	20.3	0.2714	4.924	1.33637	9154	75.3	15302	1859.1
Primip.	4	22.2	0.0507	6.462	0.32762	2244	18.5	2859	347.3
Primip.	5	25.3	0.0962	9.611	0.92458	6333	52.1	5424	659.0
Multip.	6+	26.2	0.1301	10.84	1.41028	9660	79.7	7357	891.2
Total			1		4.88625	33471	275.7	56404	6850.0

1996

Sex	Age		Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 48300 tons	kg/hr 249.3	No./hour	Number (´000´000)
Males	1								0.0
Males	2	15.3	0.0622	2.066	0.12860	1011	5.2	2526	489.4
Males	3	20.0	0.6076	4.728	2.87283	22585	116.6	24656	4776.9
Primip.	3	21.4	0.0379	5.788	0.21921	1723	8.9	1537	297.7
Primip.	4	24.8	0.1511	9.034	1.36509	10732	55.4	6132	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	1925	373.0
Multip.	5	26.6	0.0574	11.306	0.64930	5105	26.3	2330	451.5
Multip.	6	28.8	0.0300	14.167	0.42486	3340	17.2	1217	235.8
Total			1		6.14372	48300	249.3	40578	7861.7

Table 13. Continued

1997

Sex	Age		Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 25211	kg/hr 257.6	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	2120	207.5
Males	3	19.0	0.4092	4.117	1.68462	6694	68.4	16613	1625.9
Males	4	22.3	0.2089	6.633	1.38567	5506	56.3	8482	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	58.7	6999	685.0
Multip.	3	19.1	0.0025	5.018	0.01240	49	0.5	100	9.8
Multip.	4	24.2	0.0488	9.570	0.46737	1857	19.0	1983	194.1
Multip.	5	25.6	0.0845	10.631	0.89822	3569	36.5	3430	335.7
Multip.	6	28.3	0.0171	14.350	0.24558	976	10.0	695	68.0
Multip.	7	29.3	0.0015	15.070	0.02232	89	0.9	60	5.9
Total			1		6.34481	25211	257.6	40598	3974.1

1998

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 30308	Kg/hr 320	No./hour	Number (´000´000)
Males	2	14.90	0.0596	1.923	0.11460	581	6.1	3187	301.9
Males	3	18.75	0.3462	3.868	1.33904	6783	71.6	18517	1753.7
Males	4	21.23	0.2321	5.642	1.30929	6633	70.0	12412	1175.6
Primip.	4	23.17	0.1399	7.355	1.02911	5213	55.0	7484	708.8
Primip.	5	25.87	0.0218	10.287	0.22439	1137	12.0	1167	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	1919	181.8
Multip.	5	25.17	0.1083	9.7	1.05035	5321	56.2	5792	548.6
Multip.	6	26.47	0.0484	11.15	0.53946	2733	28.9	2588	245.1
Multip.	7	29.07	0.0054	14.47	0.07848	398	4.2	290	27.5
Total			1.0000		5.98273	30308	320.0	53487	5065.9

1999

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 43438	kg/hr 332.2	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	2553	333.8
Males	3	17.6	0.2773	3.176	0.88073	6291	48.1	15148	1980.7
Males	4	21.0	0.2253	5.490	1.23680	8834	67.6	12306	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	26.3	4141	541.4
Primip.	5	24.22	0.1327	8.418	1.11680	7977	61.0	7247	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	7.5	1131	147.9
Multip.	5	24.18	0.1259	8.674	1.09238	7802	59.7	6879	899.5
Multip.	6	26.42	0.0932	11.06	1.03086	7363	56.3	5091	665.7
Multip.	7	29.57	0.0011	15.171	0.01638	117	0.9	59	7.7
Total			1.0000		6.08151	43438	332.2	54626	7142.8

Table 13 continued

2000

Sex	Age	CL mm	Prop. by no.	Weight g	Prop. by weight	Nominal catch 52664	kg/hr 371.8	No./hour	Number (´000´000)
Males	2	13.16	0.0157	1.326	0.02078	200	1.4	1066	151.0
Males	3	17.31	0.3258	3.035	0.98868	9527	67.3	22161	3139.0
Males	4	19.99	0.2457	4.692	1.15299	11110	78.4	16717	2367.9
Males	5	21.90	0.0049	6.200	0.03026	292	2.1	332	47.0
Primip.	4	21.01	0.0776	5.458	0.42336	4079	28.8	5277	747.4
Primip.	5	24.16	0.0935	8.514	0.79646	7675	54.2	6364	901.4
Multip.	3	18.35	0.0021	4.012	0.00854	82	0.6	145	20.5
Multip.	4	21.89	0.0580	6.613	0.38387	3699	26.1	3949	559.3
Multip.	5	24.33	0.1271	8.825	1.12131	10805	76.3	8644	1224.3
Multip.	6	26.32	0.0473	10.703	0.50630	4879	34.4	3218	455.8
Multip.	7	27.64	0.0023	14.320	0.03289	317	2.2	156	22.1
Total			1.0000		5.46543	52664	371.8	68028	9635.8

2001

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 52671	kg/hr 378.2	No./hour	Number (´000´000)
Males	2	15.23	0.1040	2.058	0.21403	1988	14.3	6935	965.8
Males	3	17.78	0.1393	3.292	0.45858	4258	30.6	9288	1293.6
Males	4	20.82	0.3925	5.315	2.08614	19372	139.1	26172	3644.9
Males	5	21.76	0.0095	6.081	0.05777	536	3.9	633	88.2
Primip.	4	21.48	0.0293	5.848	0.17135	1591	11.4	1954	272.1
Primip.	5	24.02	0.1147	8.204	0.94100	8738	62.7	7648	1065.1
Multip.	4	20.50	0.0240	5.484	0.13179	1224	8.8	1602	223.2
Multip.	5	23.24	0.1111	7.769	0.86314	8015	57.6	7408	1031.7
Multip.	6	25.13	0.0666	9.652	0.64282	5969	42.9	4441	618.5
Multip.	7	26.93	0.0090	11.701	0.10531	978	7.0	600	83.6
Total			1.0000		5.67192	52671	378.2	66681	9286.6

2002

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 48704	kg/hr 386.7	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	1242	9.9	4605	579.9
Males	3	18.14	0.5095	3.497	1.78172	17079	135.6	38778	4884.0
Males	4	20.57	0.0681	5.124	0.34894	3345	26.6	5183	652.8
Primip.	4	20.32	0.0458	4.94	0.22625	2169	17.2	3486	439.0
Primip.	5	23.04	0.0675	7.231	0.48809	4679	37.1	5137	647.0
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	3908	31.0	4551	573.2
Multip.	5	24.11	0.1430	8.6	1.22980	11789	93.6	10884	1370.8
Multip.	6	25.69	0.0430	10.266	0.44144	4232	33.6	3273	412.2
Multip.	7	28.25	0.0017	13.359	0.02271	218	1.7	129	16.3
Total			1.0001		5.08082	48704	386.7	76117	9586.8

Table 13 continued

2003

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 63226	kg/hr 454.9	No./hour	Number (´000´000)
Males	1	12.09	0.0086	1.02	0.00875	95	0.7	670	93.2
Males	2	15.81	0.1111	2.303	0.25586	2780	20.0	8684	1206.9
Males	3	18.41	0.1222	3.658	0.44702	4856	34.9	9552	1327.6
Males	4	20.49	0.3638	5.062	1.84139	20004	143.9	28433	3951.8
Primip.	4	21.73	0.0855	6.052	0.51737	5621	40.4	6682	928.7
Primip.	5	24.15	0.0554	8.347	0.46263	5026	36.2	4332	602.1
Multip.	3	19.96	0.0004	4.678	0.00198	21	0.2	33	4.6
Multip.	4	21.98	0.0409	6.653	0.27199	2955	21.3	3195	444.1
Multip.	5	24.34	0.1358	8.833	1.19913	13027	93.7	10611	1474.8
Multip.	6	26.01	0.0753	10.622	0.79948	8685	62.5	5883	817.7
Multip.	7	27.88	0.0011	12.885	0.01437	156	1.1	87	12.1
Total			1.0000		5.81996	63226	454.9	78162	10863.6

2004

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 45543	kg/hr 417.1	No./hour	Number (´000´000)
Males	1								
Males	2	14.36	0.1583	1.720	0.27228	2380	21.8	12671	1383.6
Males	3	18.36	0.3719	3.631	1.35037	11802	108.1	29769	3250.5
Males	4	21.09	0.1082	5.529	0.59824	5229	47.9	8661	945.7
Males	5	21.51	0.0164	5.867	0.09622	841	7.7	1313	143.3
Primip.	4	20.83	0.0091	5.327	0.04848	424	3.9	728	79.5
Primip.	5	23.44	0.1657	7.618	1.26230	11033	101.0	13264	1448.2
Multip.	4	21.55	0.0158	6.296	0.09948	869	8.0	1265	138.1
Multip.	5	24.26	0.0993	8.756	0.86947	7599	69.6	7948	867.9
Multip.	6	26.45	0.0548	11.126	0.60970	5329	48.8	4386	479.0
Multip.	7	28.87	0.0003	14.199	0.00426	37	0.3	24	2.6
Total			0.9998		5.2108	45543	417.1	80029	8738.4

2005

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 31862	kg/hr 473.3	No./hour	Number (´000´000)
Males	1								
Males	2	15.70	0.0607	2.229	0.13530	840	12.5	5595	376.7
Males	3	17.49	0.3794	3.038	1.15262	7153	106.2	34973	2354.4
Males	4	19.95	0.1287	4.689	0.60347	3745	55.6	11864	798.6
Primip.	3	19.92	0.0153	4.689	0.07174	445	6.6	1410	94.9
Primip.	4	21.90	0.1893	6.206	1.17480	7290	108.3	17450	1174.7
Primip.	5	23.54	0.0550	7.405	0.40728	2527	37.5	5070	341.3
Multip.	4	22.37	0.0264	6.830	0.18031	1119	16.6	2434	163.8
Multip.	5	24.33	0.1090	8.952	0.97577	6055	89.9	10048	676.4
Multip.	6	26.24	0.0322	11.552	0.37197	2308	34.3	2968	199.8
Multip.	7	26.90	0.0053	11.552	0.06123	380	5.6	489	32.9
Total			1.0013		5.1345	31862	473.3	92300	6213.5

2006

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 15000	kg/hr 645.2	No./hour	Number (´000´000)
Males	1								
Males	2								
Males	3	16.92	0.0832	3.038	0.25276	658	28.3	9316	216.6
Males	4	18.54	0.5907	4.689	2.76979	7210	310.1	66143	1537.7
Primip.	4	20.49	0.1041	6.206	0.64604	1682	72.3	11656	271.0
Primip.	5	22.03	0.0090	7.405	0.06665	173	7.5	1008	23.4
Multip.	4	20.97	0.0227	6.830	0.15504	404	17.4	2542	59.1
Multip.	5	22.71	0.1256	8.952	1.12437	2927	125.9	14064	327.0
Multip.	6	24.74	0.0603	11.552	0.69659	1813	78.0	6752	157.0
Multip.	7	26.16	0.0044	11.552	0.05083	132	5.7	493	11.5
Total			1.0000		5.76207	15000	645.2	111974	2603.2

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

Agegr.	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006*
1		10.44					12.05	12.09			
2	15.25	15.73	14.9	14.49	13.18	15.23	15.43	15.81	14.36	15.70	
3	20.54	19.01	18.75	17.58	17.32	17.78	18.14	18.41	18.36	17.58	16.92
4	24.7	23.32	22.09	21.34	20.46	20.84	21.06	20.83	21.13	21.21	18.9
5	24.8	25.56	25.29	24.2	24.27	23.56	23.76	24.28	23.62	24.06	22.67
6	26.6	28.33	26.47	26.42	26.08	25.13	25.69	26.01	26.45	26.24	24.74
7	28.8	29.28	29.07	29.57	29.32	26.93	28.25	27.88	28.87	26.90	26.16

* Only the months January-March

Table 15. Shrimp. Mean weight at age for the period January to September based on international data base.

Agegr.	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006*
1		0.910					1.011	1.02			
2	2.066	2.270	1.923	1.639	1.326	2.058	2.142	2.303	1.720	2.256	
3	4.79	4.130	3.815	3.069	3.044	3.292	3.499	3.661	3.631	3.192	2.834
4	8.945	7.671	6.439	6.347	5.122	5.359	5.659	5.367	5.606	4.837	3.998
5	9.296	10.631	9.800	8.502	8.641	7.913	8.161	8.692	7.918	8.453	7.224
6	11.306	14.350	11.150	11.060	10.703	9.652	10.266	10.622	11.126	10.891	9.241
7	14.167	15.070	14.470	15.100	14.32	11.701	13.359	12.885	14.199	11.664	10.789

* Only the months January- March

Table 16. Shrimp. Number (000.000) of shrimp caught annually, based on the ageing of international samples in the period January to September.

Agegr.	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006*
1		0.9		0.7			2.9	93.2			
2	489.4	207.5	301.9	333.8	151.0	965.8	579.9	1206.9	1383.6	376.7	
3	5124.1	1647.1	1766.2	1987.2	3159.5	1293.6	4892.6	1332.2	3250.5	2449.3	216.6
4	1561.0	1709.1	2066.2	2298.5	3674.6	4140.1	1665.1	5324.7	1163.3	2137.2	1867.8
5	451.5	335.7	659.1	1849.2	2172.8	2185.1	2017.8	2076.9	2459.5	1017.7	350.4
6	235.8	68.0	245.1	665.7	455.8	618.5	412.2	817.7	479.0	199.8	157.0
7		5.9	27.5	7.7	22.1	83.6	16.3	12.1	2.6	32.9	11.5
	7861.8	3974.2	5066.0	7142.8	9635.8	9286.7	9586.8	10863.7	8738.5	6213.6	2603.3

* provisional, assuming a catch of 15 000 tons.

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.

Agegr.	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006*	Mean
1	0	0	0	5	0	0	23	670	0	0	0	70
2	2526	2120	3188	2553	1066	6935	4605	8684	12671	5595	0	4742
3	26448	16830	18648	15198	22306	9288	38846	9585	29769	36384	9316	20617
4	8057	17463	21816	17578	25942	29728	13220	38310	10654	31747	80341	28680
5	2330	3430	6959	14142	15339	15056	16021	14943	22525	15118	15072	13861
6	1217	695	2588	5091	3218	4441	3273	5883	4387	2968	6752	3930
7	0	60	290	59	156	600	129	87	24	489	493	239
	40578	40598	53489	54626	68027	66048	76117	78162	80030	92301	111974	72137

* provisional, assuming a catch of 15 000 tons.

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	2006	Mean
1	0	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	0.000
3	0	0	0	0.06	0.013	0	0	0.012	0	0	0	0	0.039	0	0.009
4	0	0	1	1	0.514	0.431	0.3	0.356	0.12	0.608	0.258	0.187	0.626	0.177	0.398
5	1	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	1	1	1.000

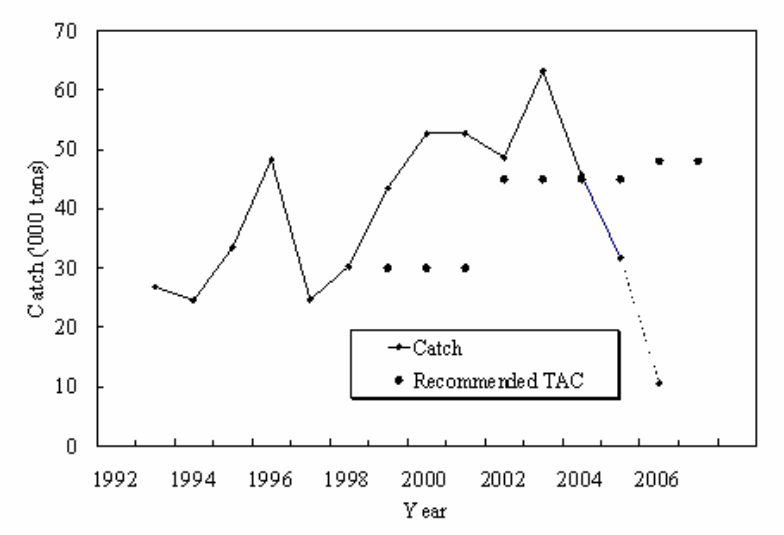

Fig.1. Shrimp in Div. 3M: catch.

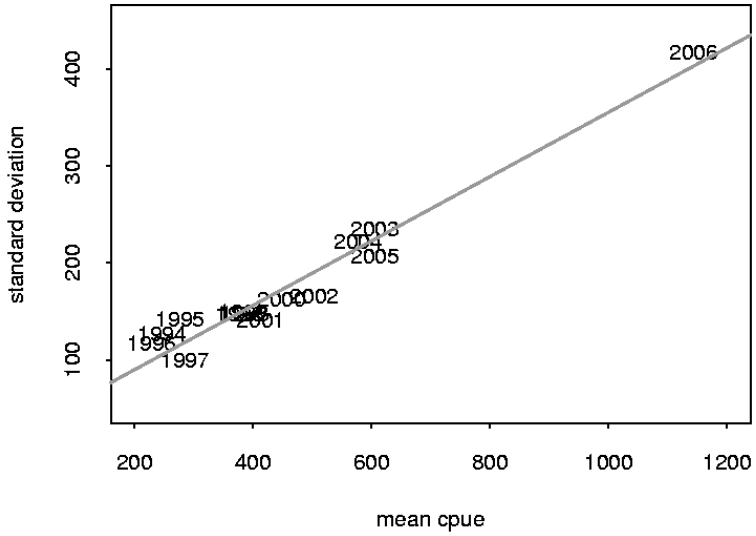

Fig.2. Coefficient of variation around the annual mean CPUE. The numbers indicate the years.

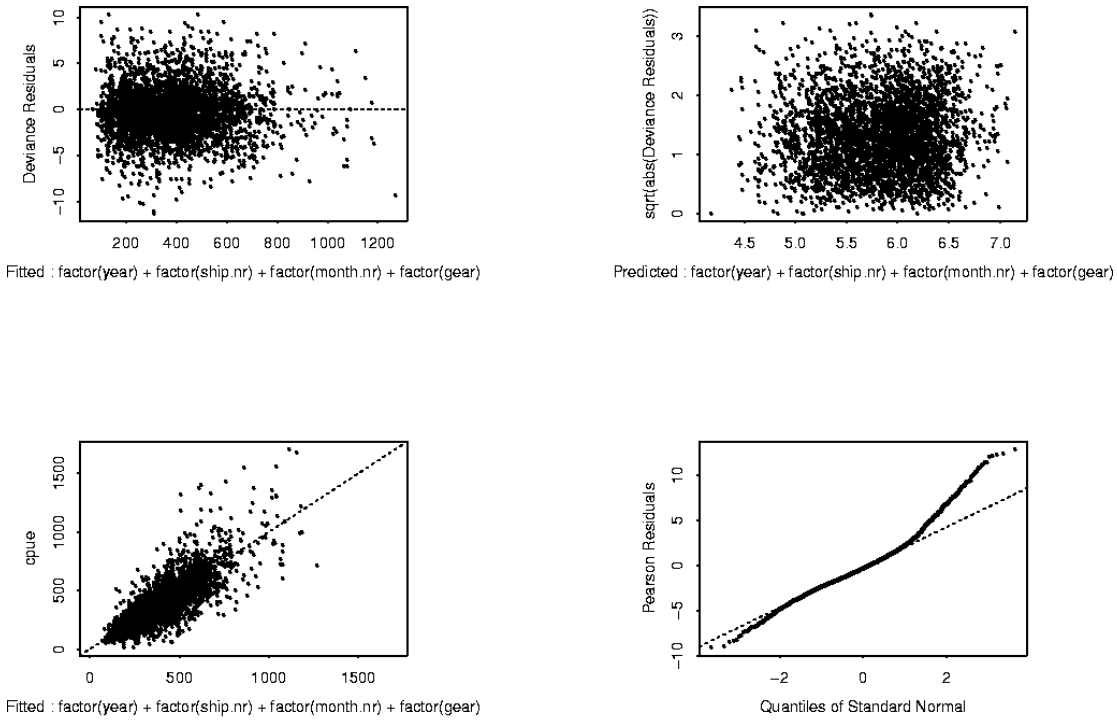

Fig.3. Plots of the generalized linear model of CPUE predicted by year, vessel, month and gear.

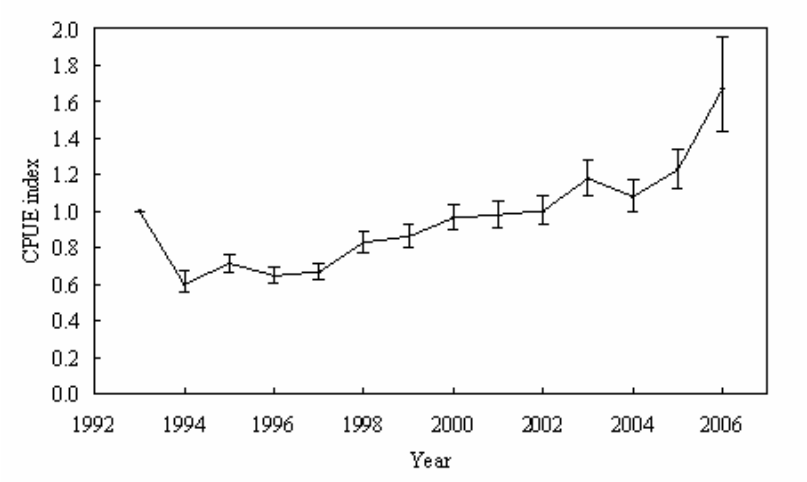

Fig. 4. The modelled CPUE index with approximate 95% confidence limits.

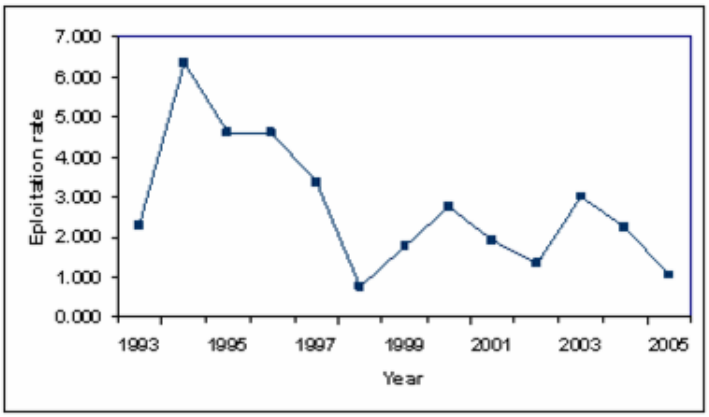

Fig. 5. Shrimp in Div. 3M: exploitation rates as derived by catch divided by the EU survey biomass index of the same year.

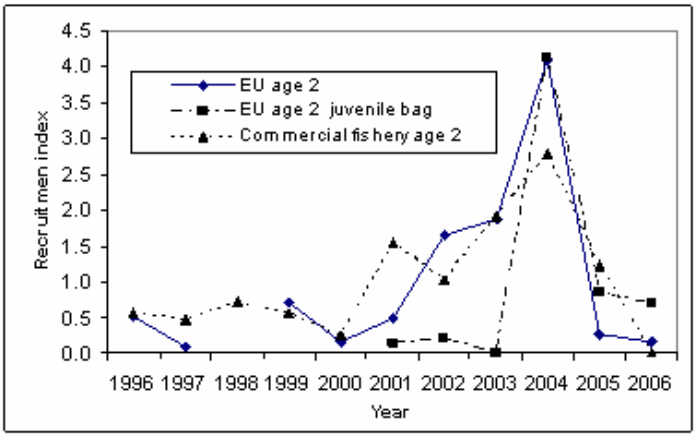

Fig. 6. Shrimp in Div. 3M: the index of the number of age 2 in the commercial fishery is shown along with the abundance indices at age 2 from the EU survey and from the juvenile bag. Each series was standardized to its mean.

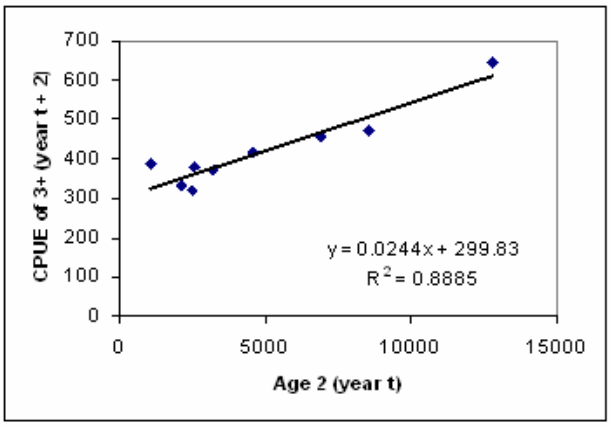

Fig. 7. Shrimp in Div. 3M: no./hour of 2 year olds in the commercial fishery and standardized kg/hour of 3 years and older lagged by 2 years.

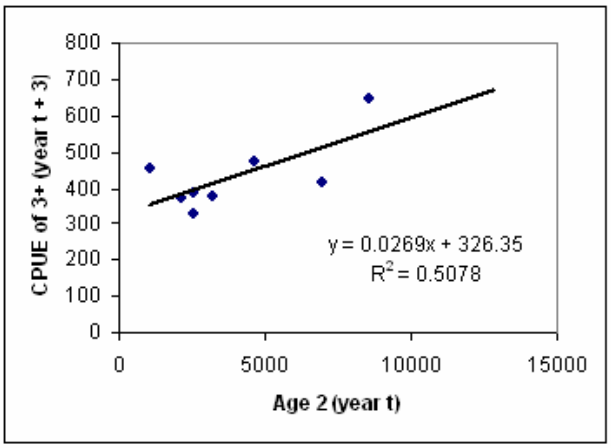

Fig. 8. Shrimp in Div. 3M: no./hour of 2 year olds in the commercial fishery and standardized kg/hour of 3 years and older lagged by 3 years.

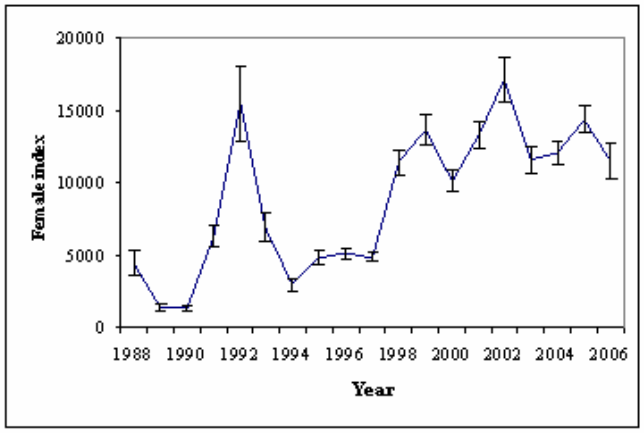

Fig. 9. Shrimp in Div. 3M: female biomass index from EU surveys, 1988-2006. The series was standardized to the mean of the series.

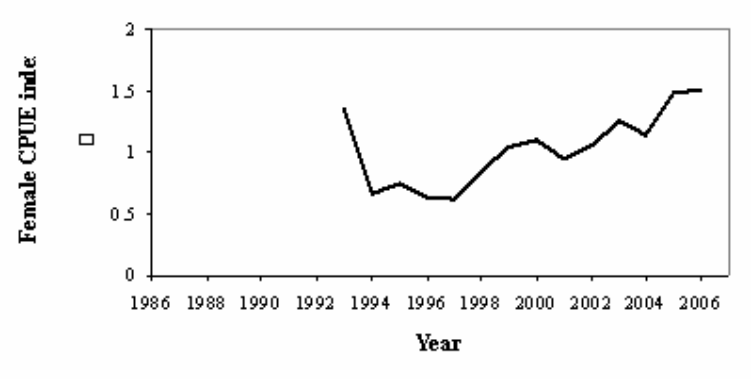

Fig. 10. Shrimp in Div. 3M: standardized female CPUE, 1993-2006. The series was standardized to the mean of the series.