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Assessment of the International Fishery for Shrimp (*Pandalus borealis*) in Division 3M (Flemish Cap), 1993-2007

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 even the stock is in high levels in 2006 and 2007 the lack of good recruitments in the last years and the progressive disappearance of the strong year classes 2001 and 2002 in the next years could lead to the stock decline. The effort in the last years was low due to high cost of oil and low marketing prize of shrimp. Vessels were around 17 in 2005 against 50 in 2004. In 2006 and 2007 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 2007 is only 5 700 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 five year olds per hour in 2007 proving the 2002 year-class to be very strong. While the female biomass EU survey stay stable from 1998, the female standardized CPUE is growing since then. However for CPUE there are scanty data in 2007. 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 and 2005 year-class being also very small.

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 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 increased much to 2003, namely to the highest ever of 63,000 tons declining to about 32,000 and 16,500 tons in 2005 and 2006 respectively. Removals to September 2007 of about 6,500 tons are even much lower than usually reported for the same period. Since 1993 the number of vessels ranged from 40-110, and in 2006 there were approximately 20 vessels fishing shrimp in Div. 3M compared to 50 in 2004. No information is available on the number of vessels taking part in the shrimp fishery in 2007.

The development of the international shrimp (*Pandalus borealis*) fishery in NAFO Division 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 is 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).

2. MATERIAL AND METHODS

Standardization of CPUE

A standardized dataset, consisting of data from Canada, Faroe Islands, Greenland, Iceland, Norway, Russia, Estonia and Spain from 1993 to 2007 exists but due to suspicion of misreporting in 2005-2007 between 3M and 3L the international CPUE database was reviewed. To correct the database all trips for 2005 and 2007 where the catches were mixed up between 3M and 3L were eliminated. This way we can get the true CPUE per month for 3M. In 2007 only data from Estonia were available. 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. Since 2006 the modal analysis was only conducted on length distributions estimated in the EU survey carried out in summer on Flemish Cap. 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 total catch per year is listed by nations in Table 1. The catch is mostly as it is reported to NAFO either provisionally in monthly reports and annually some StatlantA reports. But in some cases information are got from the shrimp specialists of the individual countries. As the flag nations of EU do not report provisionally on shrimp catch on Flemish Cap in 2007, the small catch of 5,861tons to 1 September is underestimated compared to the years prior to 2005. The total catch per year is shown in figure 1.

4. CPUE MODEL

A summary table was made from the data, shown in Table 2. Table 3 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 (Figure 2). Since the coefficients of variance were constant (Table 4) 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. Some results from the model fit and the analysis of the deviance are shown in Table 5 and 6. Standard Splus diagnostic plots for the fit are shown in Figure 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. From the analysis of deviance shown in table 6, it can be observed that most of the variation is explained by year and vessel factors. The resulting index is shown in Table 7 and Figure 4. The index declined from 1993 to 1994 and was at low levels until 1997. From 1998 it gradually increased to 2006. In 2007 the standardized CPUE declined, however data for this 2007 were very scanty as there was only 1 country that turned in CPUE reports for the year.

5. EXPLOTATION RATE

Exploitation rate is shown in Figure 5. This was high in the years 1994-1997 when biomass was generally lower. In the years 1998-2006 the catch rate has been rather stable at a lower level. However the provisional catch rate estimated in 2007 was the lowest in the historical series showing a probable decreasing trend initiated in 2003.

6. RECRUITMENT

The Faroese survey provided two recruitment indices in the years 1996-2003. Since 1997, a juvenile shrimp bag has been attached to the gear in the Faroese survey (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.

Since 2001 in the EU survey the juvenile shrimp bag was introduced. A series of 2 year olds in the EU survey is presented (Table 9, Figure 6), (Casas, 2007). 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 winches 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 surveys were regressed against 3+ biomass (Table 9). 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 have been plotted against the standardized CPUE of 3 + years (Table 8) by lagging 1, 2 or 3 years respectively. The best fit was between no. of age 2 and te CPUE 3+ two years later where $R^2 = 0.81$ (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, 2004 and 2005 seem very poor (Fig. 6).

7. 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 2007 (Table 10, fig. 9), (Casas, 2007).

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 10. This index was standardized to the mean of the series and plotted (fig. 10). The SSB from EU surveys appears to be stable with fluctuations since 1998. The standardized SSB CPUE showed an increasing trend reaching in 2007 a historical maximum. However as it said before the CPUE in 2007 is based on scanty data so the biomass can be overestimated as seen in the wide confidence limits in this year (Fig. 4).

8. AGE ASSESSMENTS

Age analysis was carried out on biological samples obtained from a few nations in the past years. Table 11 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.

In table 12 the calculated mean lengths are listed. The weights at age (Table 13) 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 14 is listed number of shrimp caught. Again the mean weights 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. In 2007, due to the lack of length distributions from the commercial fisheries, the mean lengths as well as the length weight relationship and proportions estimated from EU survey were applied to provisional catch.

Table 15 lists the number per hour caught in the commercial fishery. This is also calculated from Table 11 by first calculating proportions of standardized kg/hour for each age and sex class. The female part of the standardized CPUE is that of transitional, primiparous and multiparous females combined. The female CPUE is presented in figure 10. The prominent 1993 value was due to the strong 1987 year-class, but later the year-class appears to have decreased in strength. 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-classses, especially the latter appear to be above average in the 2005, 2006 and 2007 fishery. In fact the 2002 year-class appears to be the strongest ever in the Flemish stock population as shown be no. per hour in 2006 and 2007 with four and five years old respectively (Table 15).

Finally there is a Table 16 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. 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 63% seem to have changed sex by the age 4 and the rest change sex as five year olds, whereas only 18% and 28% of the four year olds have changed sex in 2006 and 2007 respectively while the rest change sex as five year olds.

9. SUMMARY

Catches of shrimp on the Flemish Cap have been maintained at a high level averaging for the last 8 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 2006. 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 2007 but the last year is uncertain due to few data. The 2001 year-class appears above average and the 2002 year-class appears to be extremly strong, three times the average for the years 1996-2006. These year-classes maintain the stock in 2007 and probably in some degree will do it in 2008 given that the 2003-2005 year-classes appears to be weak.

10 ACKNOWLEDGEMENT

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Table 1. 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	2007*
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 8466	2 5861
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	2 997	
EU/United Kingdom											1 547				
Faroe Is.	7333	6791	5993	8688	7410	9368	9199	2 7719	10228	8516	12676	1 4952	4 2341	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	2 5741	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	1 1330	
Lithuania		1225	675	2900	1785	3106	3370	1 3529	1 2701	1 3321	1 3744	1 4802	1 3652	1 1245	
Norway	7183	8461	9533	5683	1831	1339	2975	2 2669	213291	111833	122765	1 10819	4 184	1 461	
Poland					2 824	148	894	2 1692	1 209			1 1158	2 444	1 224	
Russia		350	3327	4445	1090		1142	2 7078	1 5687	1 1176	1 3	1 654	4 268	1 46	
Fr. St. Pierre and Michelong		75			150				1 337	1 161			4 487		
Ukraina									1 348		1 237	1 315		1 282	
USA								1 629							
Total	**26876**	**24599**	**33471**	**48300**	**25211**	**30308**	**43438**	**52664**	**52671**	**48704**	**63226**	**45543**	**31862**	**16510**	**5861**

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 2. Analysis about the CPUE data

year	No. of obs	Mean CPUE	Std. dev	Min	Max	CV
1993	245	357	149	44	895	0.417
1994	236	235	104	10	709	0.443
1995	473	269	129	47	1182	0.479
1996	928	227	114	45	848	0.503
1997	379	285	98	44	602	0.346
1998	325	374	144	78	1316	0.384
1999	359	380	146	58	837	0.384
2000	377	419	165	48	1153	0.394
2001	275	411	140	59	966	0.342
2002	194	502	163	25	932	0.325
2003	240	600	233	129	1371	0.389
2004	163	567	209	227	1425	0.368
2005	127	569	177	65	1145	0.311
2006	52	587	213	56	1011	0.363
2007	15	629	289	229	1277	0.460

Table 3. Number of data records which are used in the final model fit by year and country.

year	ICE	CAN	FRO	GRL	NOR	RUS	EST	SP
1993	41	55		75	74			
1994	50	38		44	104			
1995	172	54	86	37	111	13		
1996	466	27	236	32	65	102		
1997	153	19	176	7	13	11		
1998	130	16	155	15	9			
1999	178	10	119	8	18	26		
2000	167	8	121	27	19	35		
2001	127	8			75	65		
2002	90			15	64	25		
2003	61			13	77		89	
2004	32				51		80	
2005	20				2		83	22
2006	6				2		26	18
2007							15	

Table 4. Results of fitting standard error versus mean CPUE.

Call: lm(formula = std.error ~ meancpue, data = SDF1, na.action = na.exclude)
Residuals:

Min	1Q	Median	3Q	Max
-35.86	-12.28	-2.768	8.815	55.81

Coefficients:

	Value	Std. Error	t value	Pr(>|t|)
(Intercept)	20.0126	19.4575	1.0285	0.3225
meancpue	0.3389	0.0434	7.8079	0.0000

Residual standard error: 22.72 on 13 degrees of freedom
Multiple R-Squared: 0.8242
F-statistic: 60.96 on 1 and 13 degrees of freedom, the p-value is 2.915e-006

Table 5. Results from the multiplicative model. The ship factors are not shown.

Call: glm(formula = cpue ~ year + vessel + month + gear, family = Gamma(link = log), data = standcpue07rew, weights = effort, contrasts = list(year = contr.treatment, vessel = contr.treatment, month = contr.treatment, gear = contr.treatment))

Deviance Residuals:

Min	1Q	Median	3Q	Max
-21.3222	-1.945497	-0.3481368	1.305868	19.07495

Coefficients:

	Value	Std. Error	t value
(Intercept)	5.98137260	0.08035650	74.4354568
year1994	-0.35760804	0.02230006	-16.0361921
year1995	-0.19980950	0.02261880	-8.8337780
year1996	-0.32828913	0.02387430	-13.7507358
year1997	-0.31904619	0.02598544	-12.2778823
year1998	-0.06096016	0.02723828	-2.2380329
year1999	-0.02832847	0.02693798	-1.0516182
year2000	0.07966063	0.02761357	2.8848358
year2001	0.05449278	0.03183147	1.7119151
year2002	0.08034164	0.03388665	2.3708937
year2003	0.23672756	0.03484707	6.7933280
year2004	0.16011430	0.03650466	4.3861336
year2005	0.27718812	0.03929507	7.0540183
year2006	0.43022090	0.04798049	8.9665803
year2007	0.30763147	0.06104158	5.0397033
month2	0.02836559	0.03512378	0.8075892
month3	0.05628907	0.03163602	1.7792712
month4	0.02037180	0.03021139	0.6743087
month5	0.05163003	0.02962906	1.7425472
month6	0.11053572	0.02921746	3.7832077
month7	0.03431515	0.02921805	1.1744504
month8	-0.07199177	0.02965562	-2.4275927
month9	-0.14107409	0.03000635	-4.7014750
month10	-0.12400391	0.03030225	-4.0922342
month11	-0.13283036	0.03149899	-4.2169717
month12	-0.11004083	0.03494339	-3.1491167
gear2	0.17385188	0.01879286	9.2509524
gear3	0.17181726	0.06920615	2.4826878

(Dispersion Parameter for Gamma family taken to be 9.698348)

Null Deviance: 215183.8 on 4387 degrees of freedom

Residual Deviance: 40851.43 on 4158 degrees of freedom

Number of Fisher Scoring Iterations: 4

Table 6.- Analysis of deviance table for generalized linear models fitted to shrimp catch rate data from 1993 to 2007 in Flemish Cap.

Source of variation	df	Deviance	Resid.Df	Resid.Dev	F Value	Pr(F)	% explained
NULL			4387	215183.8		<0.001	
year	14	103519	4373	111664.8	762.4198	<0.001	48.1%
vessel	202	65033.9	4171	46630.9	33.1964	<0.001	30.2%
month	11	4981	4160	41649.9	46.6906	<0.001	2.3%
gear	2	798.5	4158	40851.4	41.1657	<0.001	0.4%

Table 7. 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	0.6993	0.7306	0.6694
1995	0.8189	0.8632	0.7834
1996	0.7202	0.7669	0.6872
1997	0.7268	0.7778	0.6907
1998	0.9409	0.9942	0.8919
1999	0.9721	1.0249	0.9221
2000	1.0829	1.1370	1.0259
2001	1.0560	1.1184	0.9921
2002	1.0837	1.1501	1.0140
2003	1.2671	1.3354	1.1834
2004	1.1736	1.2452	1.0926
2005	1.3194	1.3964	1.2216
2006	1.5376	1.6316	1.3996
2007	1.3602	1.3602	1.2068

Table 8.- 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	2602	257.03
1997	2133	259.37
1998	3342	335.79
1999	2664	346.95
2000	1107	386.50
2001	6905	376.77
2002	4602	386.81
2003	8626	452.10
2004	12716	419.11
2005	5563	471.01
2006	0	549.38
2007	847	495.08

Table 9.- Shrimp in Div. 3M. Recruitment abundance of age 2 in the UE survey and biomass of 3 years and older.

Year	Main trawl ('000)	Juvenile bag	Biomasa 3+
1996	3424		9853
1997	629		7311
1998	54968*		30266
1999	4735		23861
2000	1069		18813
2001	3321	1361	26633
2002	11004	2125	34216
2003	12572	0	18540
2004	27415	41818	15589
2005	1792	3741	30489
2006	582	7498	16242
2007	301	3824	17007

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

Table 10.- Shrimp in Div. 3M. Indices of female biomass in the EU survey, and in the commercial fishery standardized CPUE.

Year	EU survey Biomass	Standarized CPUE Kg/hour
1988	4525	
1989	1359	
1990	1363	
1991	6365	
1992	15472	
1993	6923	254.7
1994	2945	145.0
1995	4857	159.2
1996	5132	131.5
1997	4885	127.0
1998	11444	180.7
1999	13669	221.3
2000	10172	231.4
2001	13336	189.7
2002	17091	214.7
2003	11589	253.8
2004	12081	232.7
2005	14381	297.5
2006	11359	261.2
2007	12843	373.6

Table 11. 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 356.6	No./hour	Number (´000´000)
Males	1	10.4	0.0041	0.646	0.00265	9	0.1	175	13.2
Males	2	16.8	0.1148	2.772	0.31823	1023	13.6	4899	369.2
Males	3	20.7	0.2146	5.225	1.12129	3606	47.9	9158	690.2
Males	4	24.0	0.1156	8.188	0.94653	3044	40.4	4933	371.8
Primip.	5	26.0	0.2619	10.441	2.73450	8794	116.7	11177	842.3
Multip.	6+	26.5	0.2890	11.189	3.23362	10400	138.0	12333	929.4
Total			1.0000		8.35681	26876	356.6	42675	3216.1

1994

Sex	Age	Mean CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 24599 tons	kg/hr 249.5	No./hour	Number (´000´000)
Males	1								
Males	2	16.4	0.1817	2.576	0.46806	1670	16.9	6573	648.1
Males	3	20.4	0.3629	4.998	1.81377	6470	65.6	13129	1294.5
Males	4	22.9	0.0854	7.101	0.60643	2163	21.9	3090	304.6
Primip.	5	25.7	0.1944	10.08	1.95955	6990	70.9	7033	693.5
Multip.	6+	26.9	0.1756	11.664	2.04820	7306	74.1	6353	626.4
Total			1		6.89601	24599	249.5	36177	3567.1

1995

Sex	Age	Mean CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 33471 tons	kg/hr 292.2	No./hour	Number (´000´000)
Males	1								
Males	2	15	0.4516	1.965	0.88739	6079	53.1	27008	3093.5
Males	3	20.3	0.2714	4.924	1.33637	9154	79.9	16231	1859.1
Primip.	4	22.2	0.0507	6.462	0.32762	2244	19.6	3032	347.3
Primip.	5	25.3	0.0962	9.611	0.92458	6333	55.3	5753	659.0
Multip.	6+	26.2	0.1301	10.84	1.41028	9660	84.3	7781	891.2
Total			1		4.88625	33471	292.2	59805	6850.0

1996

Sex	Age		Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 48300 tons	kg/hr 257.0	No./hour	Number (´000´000)
Males	1								0.0
Males	2	15.25	0.0622	2.066	0.12860	1011	5.4	2604	489.4
Males	3	20.03	0.6076	4.728	2.87283	22585	120.2	25421	4776.9
Primip.	3	21.41	0.0379	5.788	0.21921	1723	9.2	1584	297.7
Primip.	4	24.79	0.1511	9.034	1.36509	10732	57.1	6322	1187.9
Multip.	3	22.15	0.0063	6.799	0.04274	336	1.8	263	49.4
Multip.	4	24.79	0.0474	9.296	0.44108	3468	18.5	1985	373.0
Multip.	5	26.60	0.0574	11.306	0.64930	5105	27.2	2403	451.5
Multip.	6	28.85	0.0300	14.167	0.42486	3340	17.8	1255	235.8
Total			1		6.14372	48300	257.0	41836	7861.7

Table 11. Continued

1997

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 25211	kg/hr 259.4	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	2134	207.5
Males	3	19.0	0.4092	4.117	1.68462	6694	68.9	16727	1625.9
Males	4	22.3	0.2089	6.633	1.38567	5506	56.6	8540	830.1
Primip.	3	20.6	0.0029	5.237	0.01498	60	0.6	117	11.4
Primip.	4	24.3	0.1724	8.390	1.44630	5747	59.1	7047	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	19.1	1996	194.1
Multip.	5	25.6	0.0845	10.631	0.89822	3569	36.7	3454	335.7
Multip.	6	28.3	0.0171	14.350	0.24558	976	10.0	700	68.0
Multip.	7	29.3	0.0015	15.070	0.02232	89	0.9	61	5.9
Total			1		6.34481	25211	259.4	40877	3974.1

1998

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 30308	Kg/hr 335.79	No./hour	Number (´000´000)
Males	2	14.90	0.0596	1.923	0.11460	581	6.4	3345	301.9
Males	3	18.75	0.3462	3.868	1.33904	6783	75.2	19430	1753.7
Males	4	21.23	0.2321	5.642	1.30929	6633	73.5	13025	1175.6
Primip.	4	23.17	0.1399	7.355	1.02911	5213	57.8	7853	708.8
Primip.	5	25.87	0.0218	10.287	0.22439	1137	12.6	1224	110.5
Multip.	3	18.56	0.0025	4.160	0.01020	52	0.6	138	12.4
Multip.	4	23.51	0.0359	8.02	0.28781	1458	16.2	2014	181.8
Multip.	5	25.17	0.1083	9.7	1.05035	5321	59.0	6078	548.6
Multip.	6	26.47	0.0484	11.15	0.53946	2733	30.3	2716	245.1
Multip.	7	29.07	0.0054	14.47	0.07848	398	4.4	304	27.5
Total			1.0000		5.98273	30308	335.8	56127	5065.9

1999

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 43438	kg/hr 346.95	No./hour	Number (´000´000)
Males	1	6.0	0.0001	0.122	0.00001	0	0.0	6	0.7
Males	2	14.5	0.0467	1.769	0.08268	591	4.7	2666	333.8
Males	3	17.6	0.2773	3.176	0.88073	6291	50.2	15820	1980.7
Males	4	21.0	0.2253	5.490	1.23680	8834	70.6	12852	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	27.5	4324	541.4
Primip.	5	24.22	0.1327	8.418	1.11680	7977	63.7	7569	947.6
Multip.	3	18.25	0.0009	3.970	0.00361	26	0.2	52	6.5
Multip.	4	22.00	0.0207	6.672	0.13820	987	7.9	1182	147.9
Multip.	5	24.18	0.1259	8.674	1.09238	7802	62.3	7185	899.5
Multip.	6	26.42	0.0932	11.06	1.03086	7363	58.8	5317	665.7
Multip.	7	29.57	0.0011	15.171	0.01638	117	0.9	62	7.7
Total									

Table 11 continued

2000

Sex	Age	CL mm	Prop. by no.	Weight g	Prop. by weight	Nominal catch 52664	kg/hr 386.5	No./hour	Number (´000´000)
Males	2	13.16	0.0157	1.326	0.02078	200	1.5	1108	151.0
Males	3	17.31	0.3258	3.035	0.98868	9527	69.9	23037	3139.0
Males	4	19.99	0.2457	4.692	1.15299	11110	81.5	17378	2367.9
Males	5	21.90	0.0049	6.200	0.03026	292	2.1	345	47.0
Primip.	4	21.01	0.0776	5.458	0.42336	4079	29.9	5485	747.4
Primip.	5	24.16	0.0935	8.514	0.79646	7675	56.3	6615	901.4
Multip.	3	18.35	0.0021	4.012	0.00854	82	0.6	151	20.5
Multip.	4	21.89	0.0580	6.613	0.38387	3699	27.1	4105	559.3
Multip.	5	24.33	0.1271	8.825	1.12131	10805	79.3	8985	1224.3
Multip.	6	26.32	0.0473	10.703	0.50630	4879	35.8	3345	455.8
Multip.	7	27.64	0.0023	14.320	0.03289	317	2.3	162	22.1
Total			1.0000		5.46543	52664	386.5	70717	9635.8

2001

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 52671	kg/hr 376.8	No./hour	Number (´000´000)
Males	2	15.23	0.1040	2.058	0.21403	1988	14.2	6908	965.8
Males	3	17.78	0.1393	3.292	0.45858	4258	30.5	9253	1293.6
Males	4	20.82	0.3925	5.315	2.08614	19372	138.6	26073	3644.9
Males	5	21.76	0.0095	6.081	0.05777	536	3.8	631	88.2
Primip.	4	21.48	0.0293	5.848	0.17135	1591	11.4	1946	272.1
Primip.	5	24.02	0.1147	8.204	0.94100	8738	62.5	7619	1065.1
Multip.	4	20.50	0.0240	5.484	0.13179	1224	8.8	1596	223.2
Multip.	5	23.24	0.1111	7.769	0.86314	8015	57.3	7380	1031.7
Multip.	6	25.13	0.0666	9.652	0.64282	5969	42.7	4424	618.5
Multip.	7	26.93	0.0090	11.701	0.10531	978	7.0	598	83.6
Total			1.0000		5.67192	52671	376.8	66429	9286.6

2002

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 48704	kg/hr 386.8	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	4606	579.9
Males	3	18.14	0.5095	3.497	1.78172	17079	135.6	38789	4884.0
Males	4	20.57	0.0681	5.124	0.34894	3345	26.6	5185	652.8
Primip.	4	20.32	0.0458	4.94	0.22625	2169	17.2	3487	439.0
Primip.	5	23.04	0.0675	7.231	0.48809	4679	37.2	5139	647.0
Multip.	3	19.42	0.0009	4.718	0.00425	41	0.3	69	8.6
Multip.	4	22.17	0.0598	6.818	0.40772	3908	31.0	4553	573.2
Multip.	5	24.11	0.1430	8.6	1.22980	11789	93.6	10887	1370.8
Multip.	6	25.69	0.0430	10.266	0.44144	4232	33.6	3274	412.2
Multip.	7	28.25	0.0017	13.359	0.02271	218	1.7	129	16.3
Total			1.000		5.08082	48704	386.8	76139	9586.8

Table 11 continued

2003

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 63226	kg/hr 452.1	No./hour	Number (´000´000)
Males	1	12.09	0.0086	1.02	0.00875	95	0.7	666	93.2
Males	2	15.81	0.1111	2.303	0.25586	2780	19.9	8630	1206.9
Males	3	18.41	0.1222	3.658	0.44702	4856	34.7	9493	1327.6
Males	4	20.49	0.3638	5.062	1.84139	20004	143.0	28258	3951.8
Primip.	4	21.73	0.0855	6.052	0.51737	5621	40.2	6641	928.7
Primip.	5	24.15	0.0554	8.347	0.46263	5026	35.9	4305	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	21.1	3176	444.1
Multip.	5	24.34	0.1358	8.833	1.19913	13027	93.1	10546	1474.8
Multip.	6	26.01	0.0753	10.622	0.79948	8685	62.1	5847	817.7
Multip.	7	27.88	0.0011	12.885	0.01437	156	1.1	87	12.1
Total			1.0000		5.81996	63226	452.1	77681	10863.6

2004

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 45543	kg/hr 419.1	No./hour	Number (´000´000)
Males	1								
Males	2	14.36	0.1583	1.720	0.27228	2380	21.9	12732	1383.6
Males	3	18.36	0.3719	3.631	1.35037	11802	108.6	29912	3250.5
Males	4	21.09	0.1082	5.529	0.59824	5229	48.1	8703	945.7
Males	5	21.51	0.0164	5.867	0.09622	841	7.7	1319	143.3
Primip.	4	20.83	0.0091	5.327	0.04848	424	3.9	732	79.5
Primip.	5	23.44	0.1657	7.618	1.26230	11033	101.5	13327	1448.2
Multip.	4	21.55	0.0158	6.296	0.09948	869	8.0	1271	138.1
Multip.	5	24.26	0.0993	8.756	0.86947	7599	69.9	7987	867.9
Multip.	6	26.45	0.0548	11.126	0.60970	5329	49.0	4408	479.0
Multip.	7	28.87	0.0003	14.199	0.00426	37	0.3	24	2.6
Total			0.9998		5.2108	45543	419.1	80415	8738.4

2005

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 31862	kg/hr 471.0	No./hour	Number (´000´000)
Males	1								
Males	2	15.70	0.0607	2.229	0.13530	840	12.4	5568	376.7
Males	3	17.49	0.3794	3.038	1.15262	7153	105.7	34804	2354.4
Males	4	19.95	0.1287	4.689	0.60347	3745	55.4	11806	798.6
Primip.	3	19.92	0.0153	4.689	0.07174	445	6.6	1404	94.9
Primip.	4	21.90	0.1893	6.206	1.17480	7290	107.8	17365	1174.7
Primip.	5	23.54	0.0550	7.405	0.40728	2527	37.4	5045	341.3
Multip.	4	22.37	0.0264	6.830	0.18031	1119	16.5	2422	163.8
Multip.	5	24.33	0.1090	8.952	0.97577	6055	89.5	9999	676.4
Multip.	6	26.24	0.0322	11.552	0.37197	2308	34.1	2954	199.8
Multip.	7	26.90	0.0053	11.552	0.06123	380	5.6	486	32.9
Total			1.0013		5.1345	31862	471.0	91854	6213.5

Table 11 continued

2006

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 16510	kg/hr 549.4	No./hour	Number (´000´000)
Males	1								
Males	2								
Males	3	16.92	0.0832	3.038	0.25276	724	24.1	7933	238.4
Males	4	18.54	0.5907	4.689	2.76979	7936	264.1	56320	1692.5
Primip.	4	20.49	0.1041	6.206	0.64604	1851	61.6	9925	298.3
Primip.	5	22.03	0.0090	7.405	0.06665	191	6.4	858	25.8
Multip.	4	20.97	0.0227	6.830	0.15504	444	14.8	2164	65.0
Multip.	5	22.71	0.1256	8.952	1.12437	3222	107.2	11975	359.9
Multip.	6	24.74	0.0603	11.552	0.69659	1996	66.4	5749	172.8
Multip.	7	26.16	0.0044	11.552	0.05083	146	4.8	420	12.6
Total			1.0000		5.76207	16510	549.4	95344	2865.3

2007

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 5481	kg/hr 495.1	No./hour	Number (´000´000)
Males	1								
Males	2	12.52	0.008	1.278	0.01054	12	1.1	864	9.6
Males	3	15.25	0.103	2.176	0.22320	259	23.4	10751	119.0
Males	4	18.85	0.240	3.854	0.92556	1074	97.0	25171	278.7
Primip.	3	16.57	0.003	2.659	0.00876	10	0.9	345	3.8
Primip.	4	19.13	0.095	3.962	0.37763	438	39.6	9990	110.6
Primip.	5	20.83	0.173	5.018	0.86690	1006	90.9	18108	200.5
Primip.	6	23.13	0.046	6.710	0.30680	356	32.2	4792	53.1
Multip.	5	20.48	0.180	4.891	0.87941	1020	92.2	18845	208.6
Multip.	6	23.05	0.117	6.917	0.80673	936	84.6	12224	135.3
Multip.	7	25.19	0.035	8.973	0.31822	369	33.4	3717	41.1
Total			1.0000		4.72375	5481	495.1	104806	1160.3

Table 12. Shrimp. Mean length (oblique carapace length mm) at age

Agegr.	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006*	2007
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		12.52
3	20.54	19.01	18.75	17.58	17.32	17.78	18.14	18.41	18.36	17.58	16.92	15.29
4	24.7	23.32	22.09	21.34	20.46	20.84	21.06	20.83	21.13	21.21	18.90	18.93
5	24.8	25.56	25.29	24.2	24.27	23.56	23.76	24.28	23.62	24.06	22.66	20.65
6	26.6	28.33	26.47	26.42	26.08	25.13	25.69	26.01	26.45	26.24	24.74	23.07
7	28.8	29.28	29.07	29.57	29.32	26.93	28.25	27.88	28.87	26.90	26.16	25.19

* Only the months January-March

Table 13. 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*	2007
1		0.91					1.01	1.02				
2	2.07	2.27	1.92	1.64	1.33	2.06	2.14	2.30	1.72	2.26		1.28
3	4.79	4.13	3.82	3.07	3.04	3.29	3.50	3.66	3.63	3.19	2.83	2.19
4	8.95	7.67	6.44	6.35	5.12	5.36	5.66	5.37	5.61	4.84	4.00	3.88
5	9.30	10.63	9.80	8.50	8.64	7.91	8.16	8.69	7.92	8.45	7.22	4.95
6	11.31	14.35	11.15	11.06	10.70	9.65	10.27	10.62	11.13	10.89	9.24	6.86
7	14.17	15.07	14.47	15.10	14.32	11.70	13.36	12.89	14.20	11.66	10.79	8.97

* Only the months January- March

Table 14. 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	2007*
1		1		1			3	93				
2	489	208	302	334	151	966	580	1207	1384	377		10
3	5124	1647	1766	1987	3160	1294	4893	1332	3251	2449	238	123
4	1561	1709	2066	2299	3675	4140	1665	5325	1163	2137	2056	389
5	452	336	659	1849	2173	2185	2018	2077	2460	1018	386	409
6	236	68	245	666	456	619	412	818	479	200	173	188
7		6	28	8	22	84	16	12	3	33	13	41
	7862	3974	5066	7143	9636	9287	9587	10864	8739	6214	2865	1160

* provisional, assuming a catch of 5481 tons.

Table 15. 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	2007*	Mean
1	0	0	0	6	0	0	23	666	0	0	0		63
2	2604	2134	3345	2666	1108	14999	4606	8630	12732	5568	0	864	4938
3	27268	16945	19568	15872	23187	4424	38858	9526	29912	36208	7933	11096	20066
4	8307	17583	22892	18358	26968	598	13224	38074	10705	31593	68409	35161	24323
5	2403	3454	7302	14770	15946	14999	16026	14851	22633	15044	12833	36953	14768
6	1255	700	2716	5317	3345	4424	3274	5847	4408	2954	5749	17016	4750
7	0	61	304	62	162	598	129	87	24	486	420	3717	504
	41836	40877	56127	57052	70717	65798	76139	77681	80415	91854	95344	104806	71554

* provisional, assuming a catch of 5481 tons.

Table 16. 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	2007	Mean
1	0	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	0.000
3	0	0	0	0.068	0.013	0	0	0.006	0	0.002	0.003	0	0.039	0	0.031	0.011
4	0	0	1	1	0.514	0.431	0.300	0.356	0.12	0.608	0.258	0.187	0.626	0.177	0.284	0.391
5	1	1	1	1	1	1	0.999	1	0.960	1	1	0.942	1	1	1	0.993
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7				1	1	1	1	1	1	1	1	1	1	1	1	1

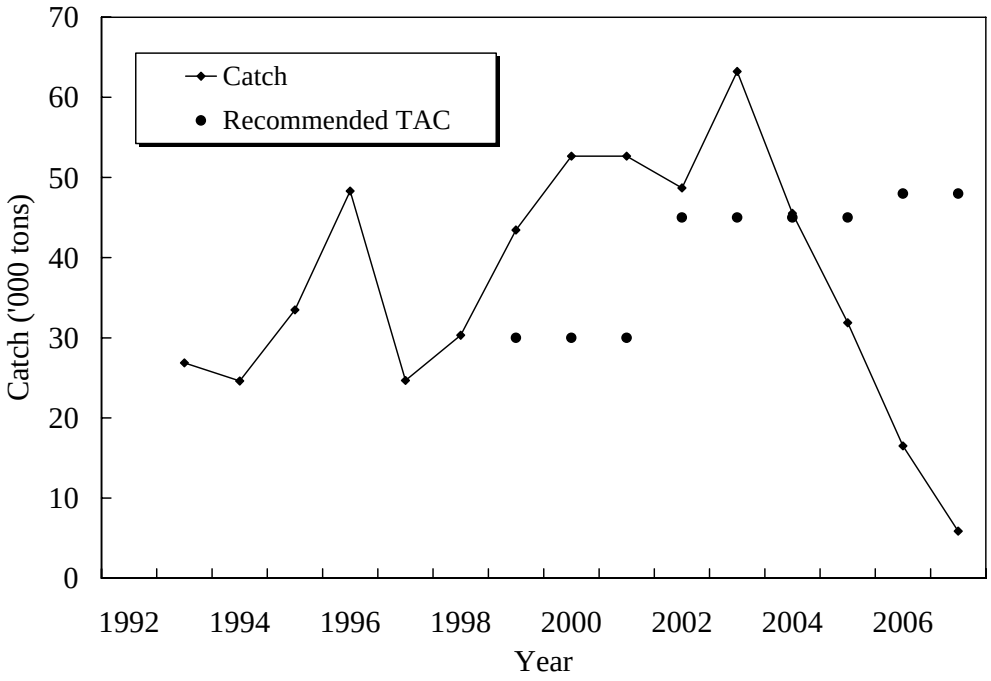

Fig.1. Shrimp in Div. 3M: catch.

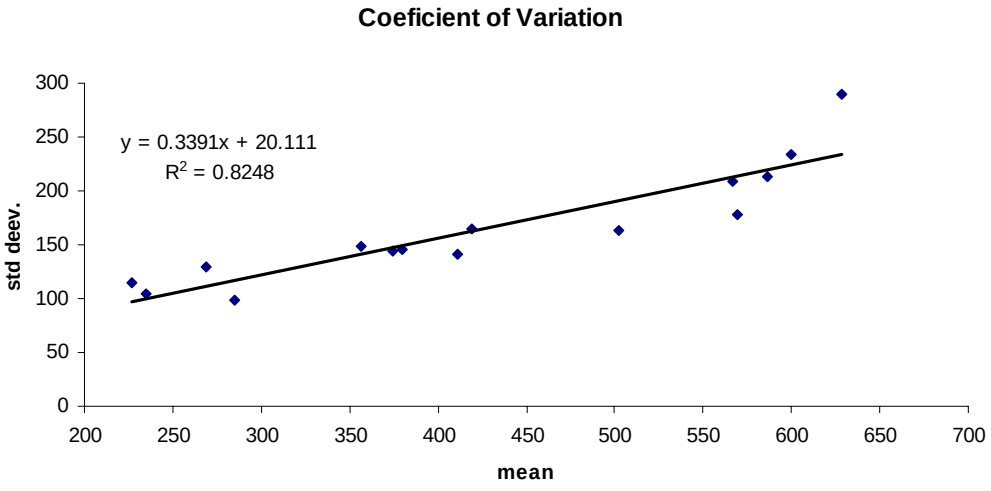

Fig. 2. Coefficient of variation around the annual mean CPUE.

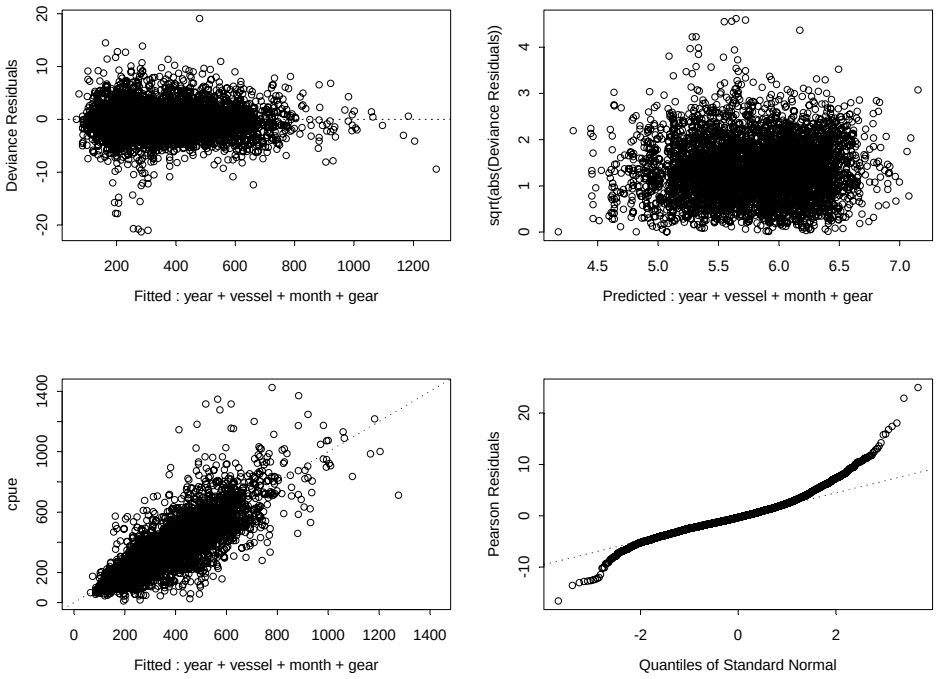

Fig.3. Plots of the generalized linear model of CPUE predicted by year, vessel, month and gear.

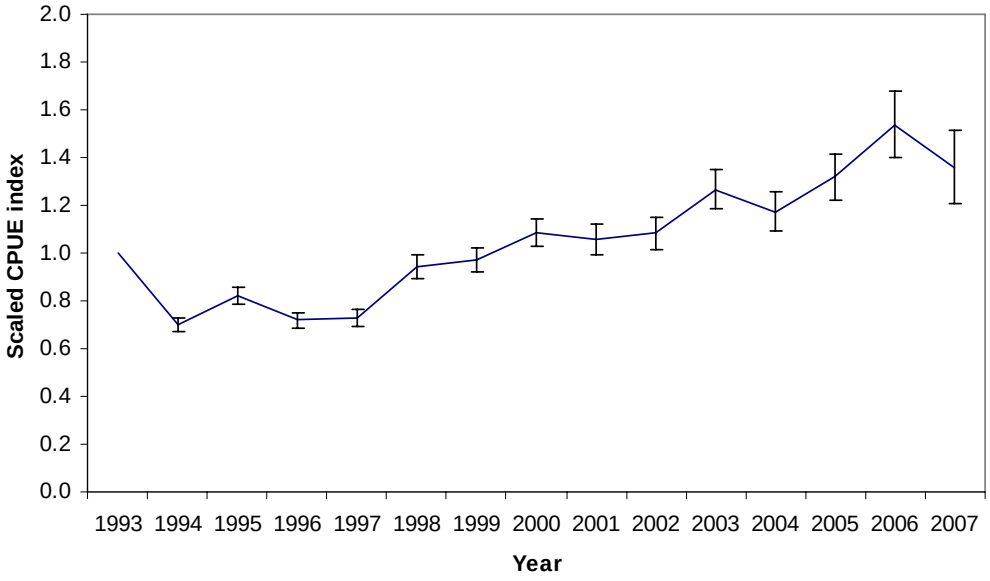

Fig. 4. Standarized CPUE series for shrimp in 3M Division, scaled to CPUE in 1993 with approximate 95% confidence limits.

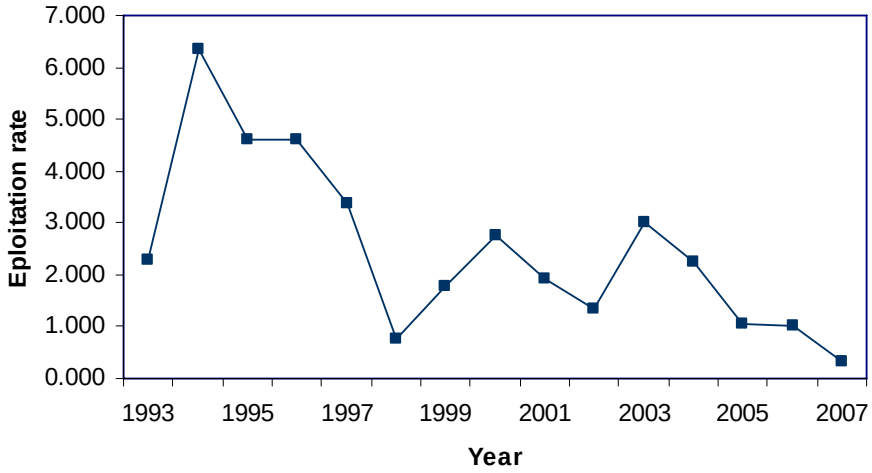

Fig. 5. Shrimp in Div. 3M: exploitation rates as derived by catch divided by the EU survey biomass index of the same year .

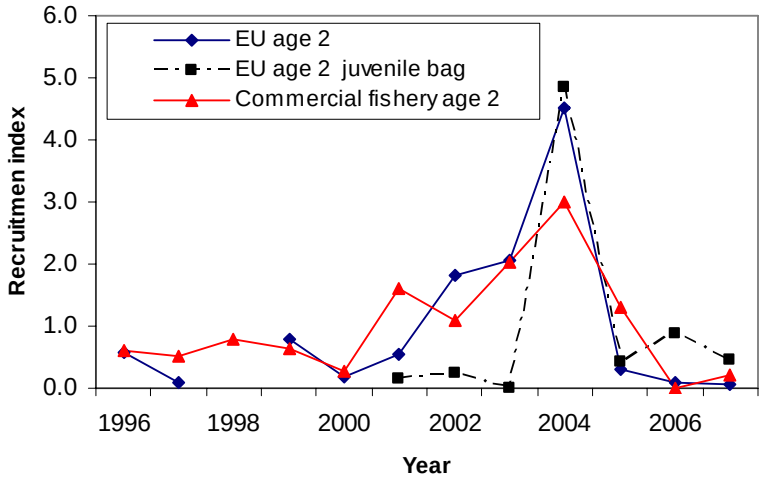

Fig. 6. Shrimp in Div. 3M: the index of the number of age 2 in the commercial fishery is shown along with the abundance indices at age 2 from the EU survey and from the juvenile bag. Each series was standardized to its mean.

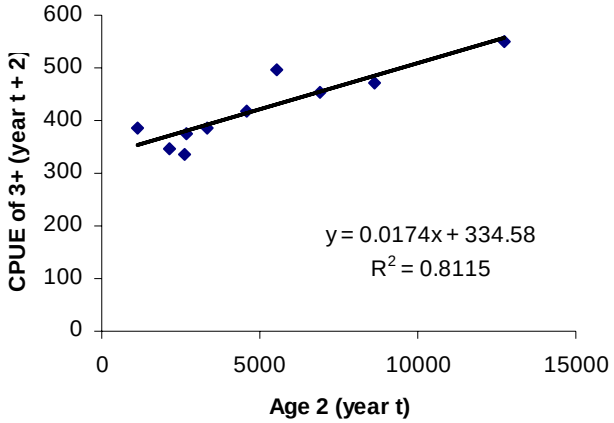

Fig. 7. Shrimp in Div. 3M: no./hour of 2 year olds in the commercial fishery and standardized kg/hour of 3 years and older lagged by 2 years.

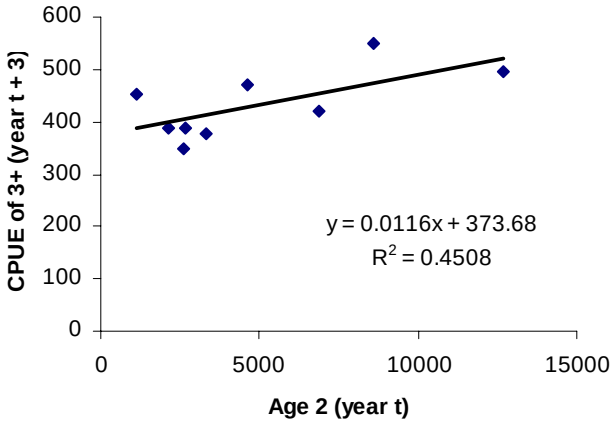

Fig. 8. Shrimp in Div. 3M: no./hour of 2 year olds in the commercial fishery and standardized kg/hour of 3 years and older lagged by 3 years.

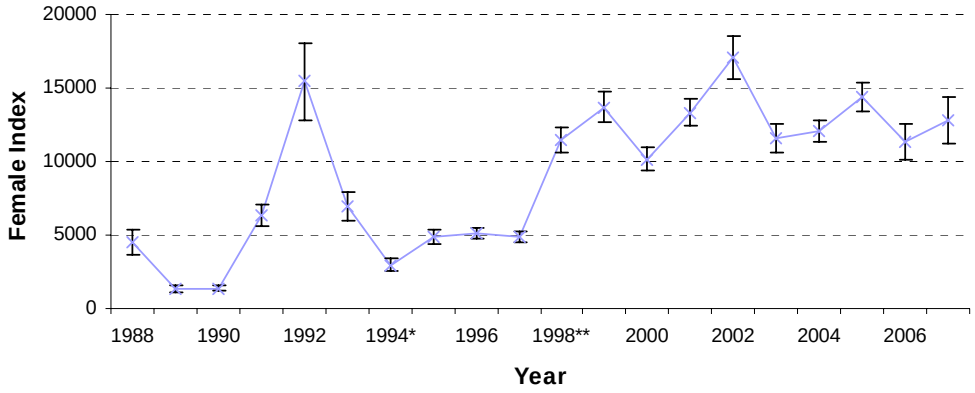

Fig. 9. Shrimp in Div. 3M: female biomass index from EU surveys, 1988-2007.

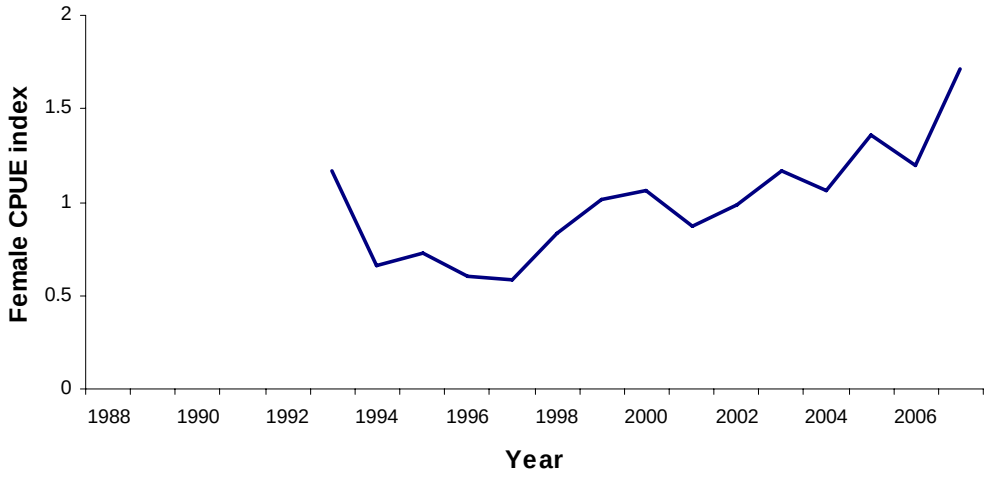

Fig. 10. Shrimp in Div. 3M: standardized female CPUE, 1993-2006. The series was standardized to the mean of the series.