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Assessment of the International Fishery for Shrimp (*Pandalus borealis*) in Division 3M (Flemish Cap), 1993-2008

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 will 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. Nominal catch was 17 600 tons in 2007 as compared to 21 431 tons in 2006. The catch in 2008 was only 7 805 tons to 1 October. Noting the lack of reports on catch this figure might increase considerably. The results from the ageing which is based on biological sampling showed a great number of five year olds per hour in 2007 proving the 2002 year-class to be very strong. However in 2008 this year class was barely represented. The female biomass from EU survey was variable though without trends at a relative high level from 1998 to 2007 but in 2008 the estimated biomass decreased to levels prior to 1998. This pessimistic picture is not agreed with the observed trend in the female standardized CPUE that is growing since 1998. Indices of recruitment from the commercial fishery (age 2 in numbers) are plotted against CPUE of 3+ two and three years later showing a significative relationship between them. The recruitment indices of both commercial fishery and EU survey show a very strong 2002 year-class followed by weak year-class since then.

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, Table 1) of approximately 26 000 t to 48 000 t in the years 1993 through 1996. After 1996 the catches were lower and rising slowly from 26 000 t in 1997 to 53 000 t in 2000 and 2001. There was 50 000 t taken in 2002. The catch increased in 2003, reaching the highest value in the catches series (64 000t). After 2003 the catches decreased all years to 17 600 t in 2007. Removals to September 2008 (about 8 000 t) are similar to the reported in 2007 for the same period but much lower than usually reported in previous years.

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 and 2008.

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 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).

2. MATERIAL AND METHODS

Standardization of CPUE

The standardized dataset, consisting of data from Canada, Faroe Islands, Greenland, Iceland, Norway, Russia, Estonia and Spain from 1993 to 2008 was updated. Only Stonian data were available from 2008 and new information about Spanish and Norwegian fleets in 2007 and Greenland in 2006 were available. Data were selected from the standardized data file 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. As in previous years there was problems with the correct allocation of some catches. The criterion fallowed was the same that previous years and only were analysing those trips where the catches only were carried out in 3M Division.

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 transitional) 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 2006, due to the lack of good information about length distributions from commercial fishery, the modal analysis was only conducted on length distributions estimated in the EU survey carried out in summer on Flemish Cap. In the same way, since 2006 the mean weights used in the calculations were estimated from the lengths-weight relationship obtained in the EU survey each year.

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 2008, the small catch of 7 805 t to 1 October is only one preliminary estimate and similar to the recorded last year for this date. 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. Since 1998 it gradually increased up to 2006 declining in the two last years.

5. EXPLOITATION RATE

Exploitation rate estimated as nominal catches divided by the EU survey biomass index of the same year is shown in Figure 5 and Table 8. 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 exploitation rate estimated in 2007 was the lowest in the historical series showing a probable decreasing trend initiated in 2003.

6. RECRUITMENT

The EU survey provided two recruitment indices. The abundance of two years olds obtained in the main trawl since 1996 and the abundance for this age group in the juvenile shrimp bag attached to the gear since 2001 are presented together with the biomass and abundance index for age 3 and older (Table 9). The series is shown since 1996 for the main gear and since 2001 for juvenile bag. The first years of the series showed very small numbers of age 2 but since 2002 the abundance increased. 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. When the number of age 2 in the EU surveys were regressed against 3+ biomass. There was never any fit whether it was lagged by 1, 2 or 3 years. However when the relationship is carried out with the abundance of age 3+ one year later (Figure 6), we can observe a significative correlation (R^2= 0.57).

Also, a series of 2 year olds (numbers/hour) in the commercial fishery 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 the CPUE 3+ two years later where R^2 = 0.51 (Fig. 7).

The evolution of these recruitment indices shows a general agreement along the years (Figure 8). In the first tree years of the series where the juvenile bag was used, the values estimated were very low if they are compared with the obtained for the commercial fishery and main gear in the EU survey. Probably this was due to the bad behaviour of the small bag attached to the main gear in those years. From the picture, 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 (2003-2006) were weak and well below average.

7. AGE ASSESSMENTS

Age analysis was carried out on biological samples obtained from a few nations in the past years (1993-2005). From 2006 due to the lack of adequate data from commercial fisheries the mean lengths and weights at age and sex group as well as their proportions in the catches were estimated from EU surveys.

Table 11 provides results of the age analyses (length and weight at age and sex are listed). This analysis allows the calculation by sex and age group of the number per hour, kg per hour and number caught (based on nominal catch and the CPUE model). 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.

The Tables 12 list the number at age of shrimp caught in the commercial fishery from 1996 to the present corresponding to the nominal catches annually recorded The Table 13 and 14 show on a yearly basis the average lengths and weights at age weighted by the total number of shrimp caught annually.

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.

7. FEMALE INDICES

The biomass indices From EU surveys 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 (Figure 9 and Table 16) 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. After that the index declined and stayed at low levels from 1994 through to 1997. In 1998 the female biomass increased very much fluctuating without trend up to 2008 where the estimated female biomass (8 630 t.) was about 33% lesser than the estimated in 2007 and the lowest value in the last ten years (Casas, 2008).

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 female CPUE is presented Table 16. This index was standardized to the mean of the series and plotted (Figure 10). The prominent 1993 value was due to the strong 1987 year-class, but the next year-class appeared to have decreased in strength. The gradually increase between 1998 and 2004 was due to the presence in the fishery of the above average year classes 1996, 1997 and 1999. The strong 2001 and 2002 year classes especially the latter were the cause of the gradual increase carried out between 2004 and 2006 and reaching the highest value of the historical series. Since 2003 the incoming year classes were very weak causing the decline of the Female CPUE in the last two years.

8. PRECAUTIONARY APPROACH

In the absence of other suitable methods to indicate a limit reference point for biomass the EU survey biomass female index was used (SCS Doc. 04/12). The point at which a valid index of stock size has declined by 85% from the maximum observed index level provides a proxy for B_{lim}.

The EU survey of Division 3M provides an index of female shrimp biomass from 1988 to 2007 with a maximum value of 17 091t in 2002 and a similar value of 15 500 in 1992. An 85% decline in this value would give a B_{lim} = 2 600 t. The female biomass index was below this value only in 1989 and 1990, before the fishery. In 2007 and 2008 it was about 25% and 51% below the maximum. If this method is accepted to define B_{lim} then it appears unlikely that the stock is below B_{lim} at the present time (Figure 11).

9. SUMMARY

Catches of shrimp on the Flemish Cap have been maintained at a high level averaging between 1995 and 2005. However since 2006 they have been falling gradually and from the provisional catches reported for August a catch level similar to 2007 is predicted with catches around 16 000 tons.

The CPUE model shows a general declined between 1993 and 1996, increasing the catch rate from 1997 up to 2006. After then the CPUE show a decreasing trend in the last two years.

The provisional exploitation rate estimated in 2008 was the lowest in the historical series confirming the decreasing trend in the last years. This trend appears to be mostly due to decreasing catches.

The spawning stock biomass from the EU survey also decreased between 1993 and 1994, increased since 1997 to 1998 and stayed stable to 2007. The low values of the female biomass index in 2008 confirm the decreasing trend of this stock caused by the weak recruitment in the last four years.

The female CPUE index show a similar picture increasing up to 2006 and declining the last two years. The strong year classes 2001 and 2002 maintained the stock in 2007 and in some degree in 2008, but given that the 2003-2006 year-classes appears to be weak the level of stock probably will decrease in 2009.

10 ACKNOWLEDGEMENT

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Table 1. Annual nominal catches (t) by country of northern shrimp (*Pandalus borealis*) caught in NAFO Div. 3M.

Nation	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Canada	3724	1041	970	906	807	484	490	2 618	1 295	2 16				2 10		
Cuba							119	1 46	1 1037	1 1537	1 1462	969	1 964	1 1126	1 446	* 11
EU/Estonia		1081	2092	1900	3240	5694	10835	2 13256	1 9851	2 14215	1 12851	1 13444	2 17525	1 11302	1 7466	
EU/Denmark	800	400	200			437	235		1 93	1 359						
EU/Latvia		300	350	1940	1 997	1 1191	1 3080	1 3105	1 2961	1 1892	1 3533	1 3059	1 2212	1 1330	1 1939	
EU/Lithuania		1225	675	2900	1 1785	1 3107	1 3370	1 3529	1 2701	1 3321	1 3744	1 4802	1 3652	1 1245	1 1992	* 7081
EU/Poland					824	1 148	1 894	1 1692	1 209			1 1158	1 458	1 224		
EU/Portugal	300		150		1 170	1 203	1 227	1 289	1 420	1 16		1 50				
EU/Spain	240	300	158	50	1 423	1 912	1 1020	1 1347	1 855	1 674	1 857	2724	4 725	4 997	768	
EU/United Kingdom											1 547					
Faroe Is.	7333	6791	5993	8688	7410	9368	9199	2 7719	2 10228	2 8516	2 12676	1 4952	1 2457	1 1102	1 2303	* 693
France (SPM)					150			1 138	1 337	1 161			487		1 741	
Greenland	1 3788	1 2275	1 2400	1 1107	1 104	866	1 576	1 1734		1 644	1 1990		1 12	2 778		
Iceland	2243	1 2355	7623	1 20680	7197	1 6572	9277	2 8912	2 5265	1 5754	1 4715	1 3567	1 4014	1 2099		
Japan								1 114	1 130	1 100	1 117					
Norway	7183	8461	9533	5683	1 1831	1 1339	1 2975	2 2669	1 12972	1 11833	1 21238	1 11738	1 223	1 890	1 1872	
Russia		350	3327	4445	1090		1142	1 7070	1 5687	1 1176	1 3	1 654	1 266	1 46	1 73	* 20
Ukraine									1 348		1 237	1 315		1 282		
USA								1 629								
Total	25611	24579	33471	48299	26028	30321	43439	52867	53389	50214	63970	47432	32995	21431	17600	7805

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

Table 2. Analysis about the CPUE data

year	No. of obs	Mean CPUE	Std. dev	Min	Max	CV
1993	245	357	44	895	149	0.417
1994	236	235	10	709	104	0.443
1995	472	270	48	1182	129	0.477
1996	928	227	45	848	114	0.503
1997	376	286	92	602	97	0.337
1998	325	374	78	1316	144	0.384
1999	359	380	58	837	146	0.384
2000	377	419	48	1153	165	0.394
2001	275	411	59	966	140	0.342
2002	194	502	25	932	163	0.325
2003	240	600	129	1371	233	0.389
2004	162	564	227	1425	206	0.366
2005	127	569	65	1145	177	0.311
2006	61	607	56	1021	226	0.373
2007	43	631	183	1353	290	0.460
2008	12	572	217	975	231	0.403

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

Year	CAN	EST	FRO	GRL	ICE	NOR	RUS	SP
1993	55			75	41	74		
1994	38			44	50	104		
1995	53		86	37	172	111	13	
1996	27		236	32	466	65	102	
1997	17		175	7	153	13	11	
1998	16		155	15	130	9		
1999	10		119	8	178	18	26	
2000	8		121	27	167	19	35	
2001	8				127	75	65	
2002				15	90	64	25	
2003		89		13	61	77		
2004		80			32	50		
2005		83			20	2		22
2006		26		9	6	2		18
2007		18				7		18
2008		12						

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

Call: lm(formula = std ~ mean, data = table08, na.action = na.exclude)
Residuals:

Min	1Q	Median	3Q	Max
-38.61	-10.76	-0.4898	9.335	52.67

Coefficients:

	Value	Std. Error	t value	Pr(>|t|)
(Intercept)	16.2536	18.7393	0.8674	0.4004
mean	0.3504	0.0409	8.5747	0.0000

Residual standard error: 22.35 on 14 degrees of freedom
Multiple R-Squared: 0.84
F-statistic: 73.52 on 1 and 14 degrees of freedom, the p-value is 6.052e-007

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 = standcpue08new, weights = effort, na.action = na.exclude, control = list(epsilon = 0.0001, maxit = 50, trace = F), contrasts = list(year = contr.treatment, vessel = contr.treatment, month = contr.treatment, gear = contr.treatment))

Deviance Residuals:

Min	1Q	Median	3Q	Max
-17.85063	-1.941063	-0.3517459	1.310567	14.33837

Coefficients:

	Value	Std. Error	t value
(Intercept)	5.98266002	0.07865054	76.0663579
year1994	-0.35727505	0.02182679	-16.3686465
year1995	-0.20070749	0.02214540	-9.0631675
year1996	-0.32858348	0.02336731	-14.0616718
year1997	-0.30321803	0.02550412	-11.8889803
year1998	-0.06469360	0.02666330	-2.4263163
year1999	-0.03192825	0.02636966	-1.2107949
year2000	0.07814870	0.02701810	2.8924571
year2001	0.05463746	0.03112007	1.7556984
year2002	0.07366306	0.03307265	2.2273101
year2003	0.23479178	0.03384447	6.9373746
year2004	0.14257740	0.03540219	4.0273613
year2005	0.26565416	0.03796271	6.9977656
year2006	0.40603561	0.04471326	9.0808759
year2007	0.33992298	0.05026605	6.7624757
year2008	0.24415204	0.06354088	3.8424403
month2	0.02239749	0.03432044	0.65259929
month3	0.05119128	0.03093999	1.65453447
month4	0.01533516	0.02955414	0.51888381
month5	0.04296971	0.02896221	1.48364738
month6	0.11434013	0.02857909	4.00083192
month7	0.03049811	0.02856965	1.06750042
month8	0.07861061	0.02900236	-2.71049008
month9	0.14665517	0.02934965	-4.99682857
month10	0.12837791	0.02960777	-4.33595279
month11	-0.1507311	0.03084253	-4.887121
month12	-0.1195920	0.03397512	-3.519988
gear2	0.1774711	0.01843617	9.626250
gear3	0.1816665	0.06769429	2.683631

(Dispersion Parameter for Gamma family taken to be 9.292147)

Null Deviance: 216645.1 on 4430 degrees of freedom

Residual Deviance: 39084.7 on 4197 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 2008 in Flemish Cap.

Source of variation	df	Deviance	Resid.Df	Resid.Dev	F Value	Pr(F)	% explained
NULL			4430	216645.1		<0.001	
year	15	105547.3	4415	111097.9	757.2506	<0.001	48.7%
vessel	205	65824.0	4210	45273.8	34.5553	<0.001	30.4%
month	11	5358.3	4199	39915.5	52.4229	<0.001	2.5%
gear	2	830.8	4197	39084.7	44.703	<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	0.6996	0.7302	0.6703
1995	0.8182	0.8544	0.7834
1996	0.7199	0.7537	0.6877
1997	0.7384	0.7763	0.7024
1998	0.9374	0.9876	0.8896
1999	0.9686	1.0200	0.9198
2000	1.0813	1.1401	1.0255
2001	1.0562	1.1226	0.9937
2002	1.0764	1.1485	1.0089
2003	1.2646	1.3514	1.1835
2004	1.1532	1.2361	1.0759
2005	1.3043	1.4050	1.2108
2006	1.5009	1.6383	1.3749
2007	1.4048	1.5503	1.2730
2008	1.2765	1.4458	1.1271

Table 8.- Exploitation Rate of Shrimp (Div. 3M) as Nominal Catches (tons) divided by UE Survey Index (tons).

	Nominal Catches	UE Survey Index	Exploitation Rate
1993	25611	6923	3.7
1994	24579	2945	8.3
1995	33471	4857	6.9
1996	48299	5132	9.4
1997	26028	4885	5.3
1998	30321	11444	2.6
1999	43439	13669	3.2
2000	52867	10172	5.2
2001	53389	13336	4.0
2002	50214	17091	2.9
2003	63970	11589	5.5
2004	47432	12081	3.9
2005	32995	14381	2.3
2006	21431	11359	1.9
2007	17600	12843	1.4
2008	7805	8630	0.9

Table 9.- Estimated recruitment index as number of Age 2 and the Biomass and Abundance Index for age 3 and older in the EU Survey series.

	Age 2		Age 3 and olders	
Year	Main gear (10^5)	Juvenile bag	Biomass (tons)	Abundance (10^5)
1996	3424		9853	13916
1997	629		7311	9832
1998	54968*		30266	61601
1999	4735		23861	47018
2000	1069		18813	37598
2001	3321	1361	26633	54153
2002	11004	2125	34216	73272
2003	12572	0	18540	34812
2004	27415	41818	15589	25395
2005	1792	3741	30489	93749
2006	582	7498	16242	40403
2007	301	3824	17007	36005
2008	221	4969	11059	21189

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

Table 10.- Index of age 2 (numbers/hour) and CPUE 3 + in the commercial fishery .

Year	Age 2 Numbers/hr	CPUE 3+
1996	2601	120.4
1997	2167	185.3
1998	3330	252.5
1999	2655	290.5
2000	1106	313.8
2001	6906	328.2
2002	4571	239.1
2003	8610	395.7
2004	12495	283.2
2005	5459	342.0
2006	1680	514.3
2007	874	475.3
2008	901	368.4

Table 11.- Results of the age analyses and different indices (No/hr, kg/hr and Number) by sex and age group based on nominal catch and the CPUE model.

1993

Sex	Age	Mean CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 25611	kg/hr 356.6	No./hour	Number (´000´000)
Males	1	10.4	0.0041	0.646	0.00265	8	0.1	175	12.6
Males	2	16.8	0.1148	2.772	0.31823	975	13.6	4899	351.8
Males	3	20.7	0.2146	5.225	1.12129	3436	47.9	9158	657.7
Males	4	24.0	0.1156	8.188	0.94653	2901	40.4	4933	354.3
Primip.	5	26.0	0.2619	10.441	2.73450	8380	116.7	11177	802.6
Multip.	6+	26.5	0.2890	11.189	3.23362	9910	138.0	12333	885.7
Total			1.0000		8.35681	25611	356.6	42675	3064.7

1994

Sex	Age	Mean CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 24579	kg/hr 249.5	No./hour	Number (´000´000)
Males	1								
Males	2	16.4	0.1817	2.576	0.46806	1668	16.9	6574	647.6
Males	3	20.4	0.3629	4.998	1.81377	6465	65.6	13129	1293.5
Males	4	22.9	0.0854	7.101	0.60643	2161	21.9	3090	304.4
Primip.	5	25.7	0.1944	10.08	1.95955	6984	70.9	7033	692.9
Multip.	6+	26.9	0.1756	11.664	2.04820	7300	74.1	6353	625.9
Total			1		6.89601	24579	249.5	36179	3564.2

1995

Sex	Age	Mean CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 33471	kg/hr 291.8	No./hour	Number (´000´000)
Males	1								
Males	2	15	0.4516	1.965	0.88739	6079	53.0	26967	3093.5
Males	3	20.3	0.2714	4.924	1.33637	9154	79.8	16207	1859.1
Primip.	4	22.2	0.0507	6.462	0.32762	2244	19.6	3028	347.3
Primip.	5	25.3	0.0962	9.611	0.92458	6333	55.2	5745	659.0
Multip.	6+	26.2	0.1301	10.84	1.41028	9660	84.2	7769	891.2
Total			1		4.88625	33471	291.8	59714	6850.0

1996

Sex	Age	Mean CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 48300	kg/hr 256.8	No./hour	Number (´000´000)
Males	1								0.0
Males	2	15.25	0.0622	2.066	0.12860	1011	5.4	2601	489.4
Males	3	20.03	0.6076	4.728	2.87283	22585	120.1	25394	4776.9
Primip.	3	21.41	0.0379	5.788	0.21921	1723	9.2	1583	297.7
Primip.	4	24.79	0.1511	9.034	1.36509	10732	57.1	6315	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	18.4	1983	373.0
Multip.	5	26.60	0.0574	11.306	0.64930	5105	27.1	2400	451.5
Multip.	6	28.85	0.0300	14.167	0.42486	3340	17.8	1253	235.8
Total			1		6.14372	48300	256.8	41792	7861.7

Table 11. Continued

1997

Sex	Age	Mean CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 26028	kg/hr 263.4	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	686	6.9	2167	214.2
Males	3	19.0	0.4092	4.117	1.68462	6911	69.9	16984	1678.6
Males	4	22.3	0.2089	6.633	1.38567	5684	57.5	8671	857.0
Primip.	3	20.6	0.0029	5.237	0.01498	61	0.6	119	11.7
Primip.	4	24.3	0.1724	8.390	1.44630	5933	60.0	7155	707.2
Multip.	3	19.1	0.0025	5.018	0.01240	51	0.5	103	10.1
Multip.	4	24.2	0.0488	9.570	0.46737	1917	19.4	2027	200.3
Multip.	5	25.6	0.0845	10.631	0.89822	3685	37.3	3507	346.6
Multip.	6	28.3	0.0171	14.350	0.24558	1007	10.2	710	70.2
Multip.	7	29.3	0.0015	15.070	0.02232	92	0.9	61	6.1
Total			1		6.34481	26028	263.3	41504	4102.9

1998

Sex	Age	Mean CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 30321	Kg/hr 334.29	No./hour	Number (´000´000)
Males	2	14.90	0.0596	1.923	0.11460	581	6.4	3330	302.0
Males	3	18.75	0.3462	3.868	1.33904	6786	74.8	19343	1754.5
Males	4	21.23	0.2321	5.642	1.30929	6636	73.2	12967	1176.1
Primip.	4	23.17	0.1399	7.355	1.02911	5216	57.5	7818	709.1
Primip.	5	25.87	0.0218	10.287	0.22439	1137	12.5	1219	110.6
Multip.	3	18.56	0.0025	4.160	0.01020	52	0.6	137	12.4
Multip.	4	23.51	0.0359	8.02	0.28781	1459	16.1	2005	181.9
Multip.	5	25.17	0.1083	9.7	1.05035	5323	58.7	6050	548.8
Multip.	6	26.47	0.0484	11.15	0.53946	2734	30.1	2703	245.2
Multip.	7	29.07	0.0054	14.47	0.07848	398	4.4	303	27.5
Total			1.0000		5.98273	30321	334.3	55876	5068.1

1999

Sex	Age	Mean CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 43439	kg/hr 345.43	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	2655	333.8
Males	3	17.6	0.2773	3.176	0.88073	6291	50.0	15751	1980.8
Males	4	21.0	0.2253	5.490	1.23680	8834	70.3	12796	1609.2
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	27.3	4305	541.4
Primip.	5	24.22	0.1327	8.418	1.11680	7977	63.4	7536	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	7.8	1177	148.0
Multip.	5	24.18	0.1259	8.674	1.09238	7803	62.0	7153	899.5
Multip.	6	26.42	0.0932	11.06	1.03086	7363	58.6	5294	665.8
Multip.	7	29.57	0.0011	15.171	0.01638	117	0.9	61	7.7
Total			1.0000		6.08151	43439	345.4	56802	7143.0

Table 11 continued

2000

Sex	Age	Mean CL mm	Prop. by no.	Weight g	Prop. by weight	Nominal catch 52867	kg/hr 385.6	No./hour	Number (´000´000)
Males	2	13.16	0.0157	1.326	0.02078	201	1.5	1106	151.6
Males	3	17.31	0.3258	3.035	0.98868	9564	69.8	22984	3151.1
Males	4	19.99	0.2457	4.692	1.15299	11153	81.4	17338	2377.0
Males	5	21.90	0.0049	6.200	0.03026	293	2.1	344	47.2
Primip.	4	21.01	0.0776	5.458	0.42336	4095	29.9	5473	750.3
Primip.	5	24.16	0.0935	8.514	0.79646	7704	56.2	6600	904.9
Multip.	3	18.35	0.0021	4.012	0.00854	83	0.6	150	20.6
Multip.	4	21.89	0.0580	6.613	0.38387	3713	27.1	4096	561.5
Multip.	5	24.33	0.1271	8.825	1.12131	10846	79.1	8965	1229.1
Multip.	6	26.32	0.0473	10.703	0.50630	4897	35.7	3338	457.6
Multip.	7	27.64	0.0023	14.320	0.03289	318	2.3	162	22.2
Total			1.0000		5.46543	52867	385.6	70556	9673.0

2001

Sex	Age	Mean CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 53389	kg/hr 376.7	No./hour	Number (´000´000)
Males	2	15.23	0.1040	2.058	0.21403	2015	14.2	6906	978.9
Males	3	17.78	0.1393	3.292	0.45858	4317	30.5	9251	1311.2
Males	4	20.82	0.3925	5.315	2.08614	19637	138.5	26065	3694.5
Males	5	21.76	0.0095	6.081	0.05777	544	3.8	631	89.4
Primip.	4	21.48	0.0293	5.848	0.17135	1613	11.4	1946	275.8
Primip.	5	24.02	0.1147	8.204	0.94100	8857	62.5	7617	1079.7
Multip.	4	20.50	0.0240	5.484	0.13179	1240	8.8	1596	226.2
Multip.	5	23.24	0.1111	7.769	0.86314	8125	57.3	7378	1045.8
Multip.	6	25.13	0.0666	9.652	0.64282	6051	42.7	4423	626.9
Multip.	7	26.93	0.0090	11.701	0.10531	991	7.0	598	84.7
Total			1.0000		5.67192	53389	376.7	66410	9413.2

2002

Sex	Age	Mean CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 50214	kg/hr 383.9	No./hour	Number (´000´000)
Males	1	12.05	0.0003	1.011	0.00030	3	0.0	23	3.0
Males	2	15.43	0.0605	2.142	0.12959	1281	9.8	4571	597.9
Males	3	18.14	0.5095	3.497	1.78172	17609	134.6	38497	5035.4
Males	4	20.57	0.0681	5.124	0.34894	3449	26.4	5146	673.0
Primip.	4	20.32	0.0458	4.94	0.22625	2236	17.1	3461	452.6
Primip.	5	23.04	0.0675	7.231	0.48809	4824	36.9	5100	667.1
Multip.	3	19.42	0.0009	4.718	0.00425	42	0.3	68	8.9
Multip.	4	22.17	0.0598	6.818	0.40772	4029	30.8	4518	591.0
Multip.	5	24.11	0.1430	8.6	1.22980	12154	92.9	10805	1413.3
Multip.	6	25.69	0.0430	10.266	0.44144	4363	33.4	3249	425.0
Multip.	7	28.25	0.0017	13.359	0.02271	224	1.7	128	16.8
Total			1.0001		5.08082	50214	383.9	75566	9884.0

Table 11 continued

2003

Sex	Age	Mean CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 63970	kg/hr 451.02	No./hour	Number (´000´000)
Males	1	12.09	0.0086	1.02	0.00875	96	0.7	665	94.3
Males	2	15.81	0.1111	2.303	0.25586	2812	19.8	8610	1221.1
Males	3	18.41	0.1222	3.658	0.44702	4913	34.6	9470	1343.2
Males	4	20.49	0.3638	5.062	1.84139	20240	142.7	28190	3998.3
Primip.	4	21.73	0.0855	6.052	0.51737	5687	40.1	6625	939.6
Primip.	5	24.15	0.0554	8.347	0.46263	5085	35.9	4295	609.2
Multip.	3	19.96	0.0004	4.678	0.00198	22	0.2	33	4.6
Multip.	4	21.98	0.0409	6.653	0.27199	2990	21.1	3168	449.4
Multip.	5	24.34	0.1358	8.833	1.19913	13180	92.9	10520	1492.2
Multip.	6	26.01	0.0753	10.622	0.79948	8787	62.0	5833	827.3
Multip.	7	27.88	0.0011	12.885	0.01437	158	1.1	86	12.3
Total			1.0000		5.81996	63970	451.0	77495	10991.5

2004

Sex	Age	Mean CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 47432	kg/hr 411.29	No./hour	Number (´000´000)
Males	1								
Males	2	14.36	0.1583	1.720	0.27228	2478	21.5	12495	1440.9
Males	3	18.36	0.3719	3.631	1.35037	12292	106.6	29354	3385.3
Males	4	21.09	0.1082	5.529	0.59824	5446	47.2	8540	984.9
Males	5	21.51	0.0164	5.867	0.09622	876	7.6	1294	149.3
Primip.	4	20.83	0.0091	5.327	0.04848	441	3.8	718	82.8
Primip.	5	23.44	0.1657	7.618	1.26230	11490	99.6	13079	1508.3
Multip.	4	21.55	0.0158	6.296	0.09948	906	7.9	1247	143.8
Multip.	5	24.26	0.0993	8.756	0.86947	7914	68.6	7838	903.9
Multip.	6	26.45	0.0548	11.126	0.60970	5550	48.1	4325	498.8
Multip.	7	28.87	0.0003	14.199	0.00426	39	0.3	24	2.7
Total			0.9998		5.2108	47432	411.3	78915	9100.8

2005

Sex	Age	Mean CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 32995	kg/hr 465.15	No./hour	Number (´000´000)
Males	1								
Males	2	15.70	0.0607	2.229	0.13530	869	12.3	5499	390.1
Males	3	17.49	0.3794	3.038	1.15262	7407	104.4	34371	2438.1
Males	4	19.95	0.1287	4.689	0.60347	3878	54.7	11659	827.0
Primip.	3	19.92	0.0153	4.689	0.07174	461	6.5	1386	98.3
Primip.	4	21.90	0.1893	6.206	1.17480	7549	106.4	17149	1216.5
Primip.	5	23.54	0.0550	7.405	0.40728	2617	36.9	4983	353.4
Multip.	4	22.37	0.0264	6.830	0.18031	1159	16.3	2392	169.7
Multip.	5	24.33	0.1090	8.952	0.97577	6270	88.4	9875	700.4
Multip.	6	26.24	0.0322	11.552	0.37197	2390	33.7	2917	206.9
Multip.	7	26.90	0.0053	11.552	0.06123	393	5.5	480	34.1
Total			1.0013		5.1345	32995	465.2	90711	6434.5

Table 11 continued

2006

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 21431	kg/hr 535.26	No./hour	Number (´000´000)
Males	1								
Males	2	12.59	0.014	1.136	0.01613	76	1.9	1680	67.3
Males	3	15.60	0.062	2.128	0.13110	621	15.5	7293	292.0
Males	4	17.65	0.289	3.047	0.87985	4171	104.2	34182	1368.6
Males	5	19.68	0.063	4.188	0.26343	1249	31.2	7448	298.2
Primip.	3	15.90	0.009	2.401	0.02129	101	2.5	1050	42.0
Primip.	4	18.59	0.155	4.082	0.63207	2996	74.8	18330	733.9
Primip.	5	20.45	0.141	5.639	0.79388	3763	94.0	16667	667.3
Primip.	6	22.90	0.037	8.276	0.30299	1436	35.9	4335	173.5
Multip.	3	17.53	0.003	2.900	0.00819	39	1.0	334	13.4
Multip.	4	19.57	0.032	4.046	0.12853	609	15.2	3761	150.6
Multip.	5	21.86	0.090	5.651	0.51018	2418	60.4	10688	427.9
Multip.	6	23.95	0.091	7.454	0.67692	3209	80.1	10751	430.5
Multip.	7	26.31	0.016	9.904	0.15659	742	18.5	1872	74.9
Total			1.0000		4.52115	21431	535.3	118390	4740.2

2007

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 17600	kg/hr 501.01	No./hour	Number (´000´000)
Males	1								
Males	2	12.52	0.008	1.278	0.01054	39	1.1	874	30.7
Males	3	15.25	0.103	2.176	0.22320	832	23.7	10879	382.2
Males	4	18.85	0.240	3.854	0.92556	3449	98.2	25472	894.8
Primip.	3	16.57	0.003	2.659	0.00876	33	0.9	349	12.3
Primip.	4	19.13	0.095	3.962	0.37763	1407	40.1	10110	355.1
Primip.	5	20.83	0.173	5.018	0.86690	3230	91.9	18325	643.7
Primip.	6	23.13	0.046	6.710	0.30680	1143	32.5	4850	170.4
Multip.	5	20.48	0.180	4.891	0.87941	3277	93.3	19070	669.9
Multip.	6	23.05	0.117	6.917	0.80673	3006	85.6	12370	434.6
Multip.	7	25.19	0.035	8.973	0.31822	1186	33.8	3761	132.1
Total			1.0000		4.72375	17600	501.0	106062	3725.8

2008

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 7805	kg/hr 455.26	No./hour	Number (´000´000)
Males	1								
Males	2	13.4318	0.010	1.510	0.01550	23	1.4	901	15.4
Males	3	17.3757	0.236	3.091	0.73025	1099	64.1	20734	355.5
Males	4	19.6153	0.094	4.331	0.40731	613	35.7	8254	141.5
Primip.	3	18.1151	0.042	3.471	0.14422	217	12.7	3646	62.5
Primip.	4	20.8898	0.133	5.160	0.68522	1031	60.1	11655	199.8
Primip.	5	23.0461	0.144	6.782	0.97332	1465	85.4	12596	216.0
Multip.	3	19.6611	0.023	4.359	0.09933	149	8.7	2000	34.3
Multip.	4	21.7747	0.174	5.791	1.00811	1517	88.5	15278	261.9
Multip.	5	23.8672	0.126	7.476	0.94096	1416	82.6	11047	189.4
Multip.	6	26.1852	0.019	9.675	0.18280	275	16.0	1658	28.4
Multip.	7								
Total			1.0000		5.18702	7805	455.3	87770	1504.7

Table 12. Number (10^6) of shrimp caught annually, based on the ageing of international samples in the period January to September (1996-05) and EU surveys samples (2006-08).

Age.	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008*
1		1		1			3	94					
2	489	214	302	334	152	979	598	1221	1441	390	67	31	16
3	5124	1700	1767	1987	3172	1311	5044	1348	3385	2536	347	394	462
4	1561	1764	2067	2299	3689	4197	1717	5387	1212	2213	2253	1250	617
5	452	347	659	1849	2181	2215	2080	2101	2561	1054	1393	1314	414
6	236	70	245	666	458	627	425	827	499	207	604	605	29
7		6	27	8	22	85	17	12	3	34	75	132	
	7862	4103	5068	7143	9673	9413	9884	10991	9101	6436	4740	3726	1539

*provisional, assuming a catch of 7805tons.

Table 13. Shrimp Mean length (oblique carapace length mm) at age

Agegr.	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006*	2007	2008
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	12.59	12.52	13.43
3	20.54	19.01	18.75	17.58	17.32	17.78	18.14	18.41	18.36	17.58	15.60	15.29	17.67
4	24.7	23.32	22.09	21.34	20.46	20.84	21.06	20.83	21.13	21.21	18.08	18.93	21.00
5	24.8	25.56	25.29	24.2	24.27	23.56	23.76	24.28	23.62	24.06	21.00	20.65	23.44
6	26.6	28.33	26.47	26.42	26.08	25.13	25.69	26.01	26.45	26.24	23.95	23.07	26.19
7	28.8	29.28	29.07	29.57	29.32	26.93	28.25	27.88	28.87	26.90	26.31	25.19	

* Since 2006 the mean length at age is estimated from EU survey

Table 14. 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	2008
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	1.14	1.28	1.51
3	4.79	4.13	3.82	3.07	3.04	3.29	3.50	3.66	3.63	3.19	2.19	2.19	3.15
4	8.95	7.67	6.44	6.35	5.12	5.36	5.66	5.37	5.61	4.84	3.45	3.88	4.82
5	9.30	10.63	9.80	8.50	8.64	7.91	8.16	8.69	7.92	8.45	5.33	4.95	6.24
6	11.31	14.35	11.15	11.06	10.70	9.65	10.27	10.62	11.13	10.89	7.69	6.86	7.00
7	14.17	15.07	14.47	15.10	14.32	11.70	13.36	12.89	14.20	11.66	9.90	8.97	9.67

* Since 2006 the weight at age is estimated from EU survey

Table 15. Number of shrimp caught per hour (Standardized CPUE) annually, based on the ageing of international samples in the period January to September (1996-05) and EU surveys samples (2006-08).

Age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008*	Mean
1		0		6			23	665						53
2	2601	2167	3330	2655	1106	6906	4571	8610	12495	5499	1680	874	901	4107
3	27239	17205	19480	15803	23135	9251	38565	9503	29354	35757	8677	11229	26381	20891
4	8298	17853	22790	18278	26907	29607	13125	37983	10506	31200	56273	35582	35186	26430
5	2400	3507	7269	14705	15910	15626	15905	14816	22211	14857	34802	37395	23644	17157
6	1253	710	2703	5294	3338	4423	3249	5833	4325	2917	15085	17220	1658	5231
7		61	303	61	162	598	128	86	24	480	1872	3761	0	580
	41792	41504	55876	56802	70556	66410	75566	77495	78915	90711	118390	106062	87770	74450

* provisional, assuming a catch of 7805 tons.

Table 16.- Female biomass Indices from the EU survey, and 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	159.0
1996	5132	131.3
1997	4885	129.0
1998	11444	179.9
1999	13669	220.4
2000	10172	230.9
2001	13336	189.6
2002	17091	213.1
2003	11589	253.2
2004	12081	228.4
2005	14381	293.8
2006	11359	382.5
2007	12843	378.1
2008	8630	354.1

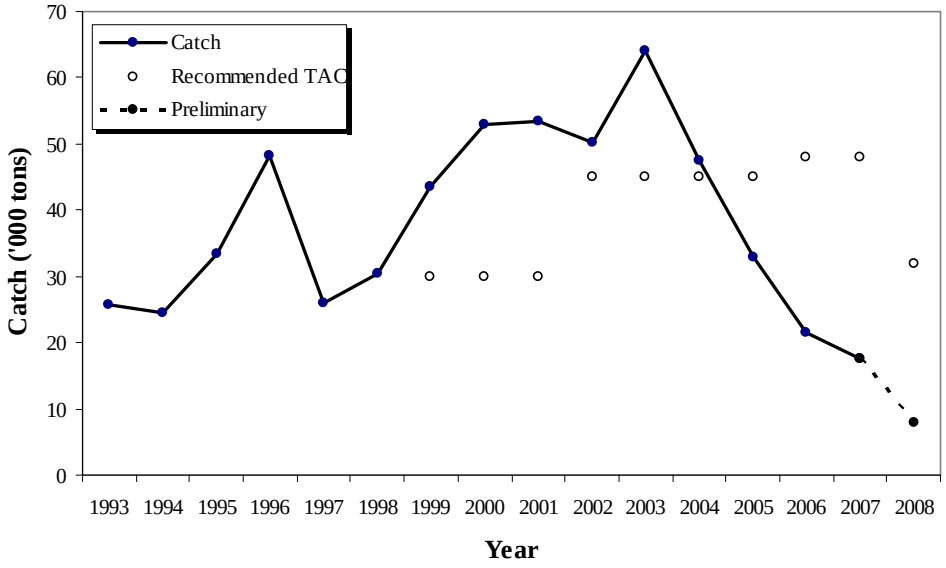

Fig.1. Shrimp in Div. 3M: catch.

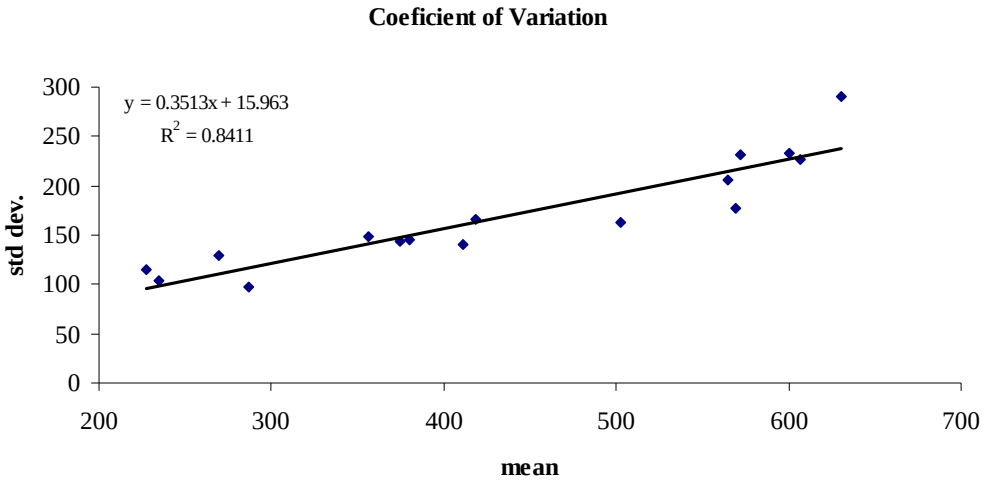

Fig. 2. Coefficient of variation around the annual mean CPUE.

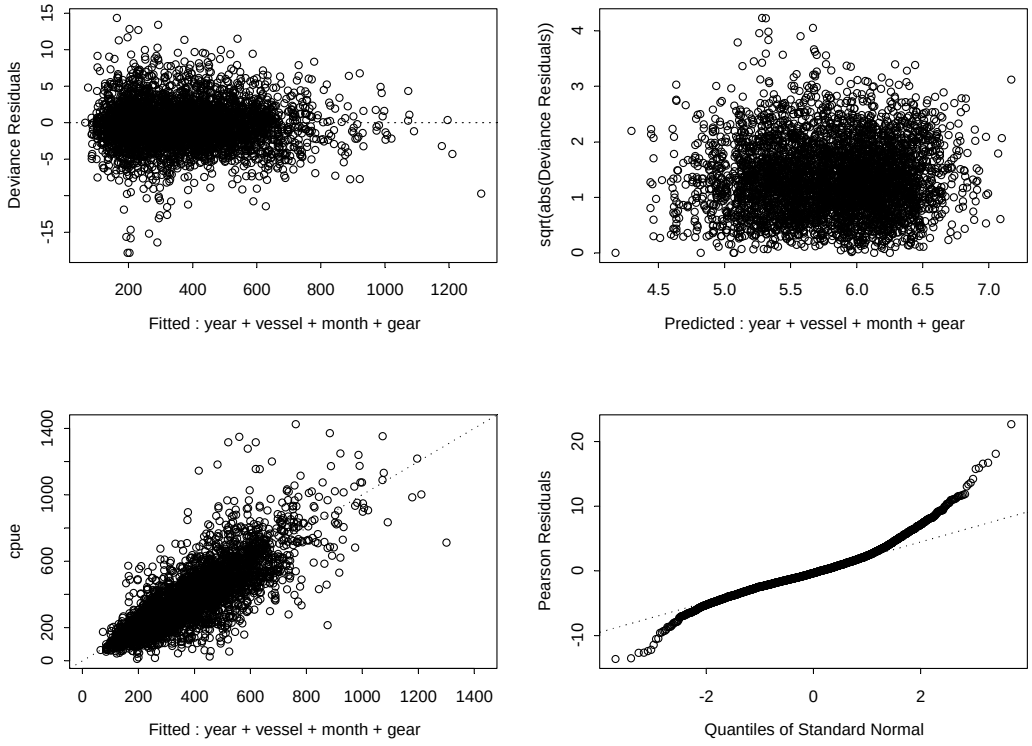

Fig.3. Plots of the generalized linear model of CPUE predicted by year, vessel, month and gear.

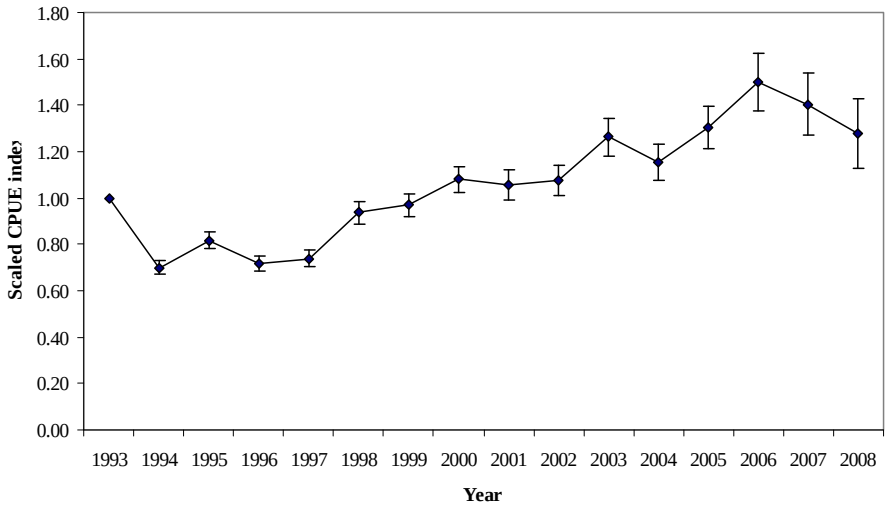

Fig. 4. Standarized CPUE series for shrimp in 3M Division, scaled to CPUE in 1993 with approximate 95% confidence limits.

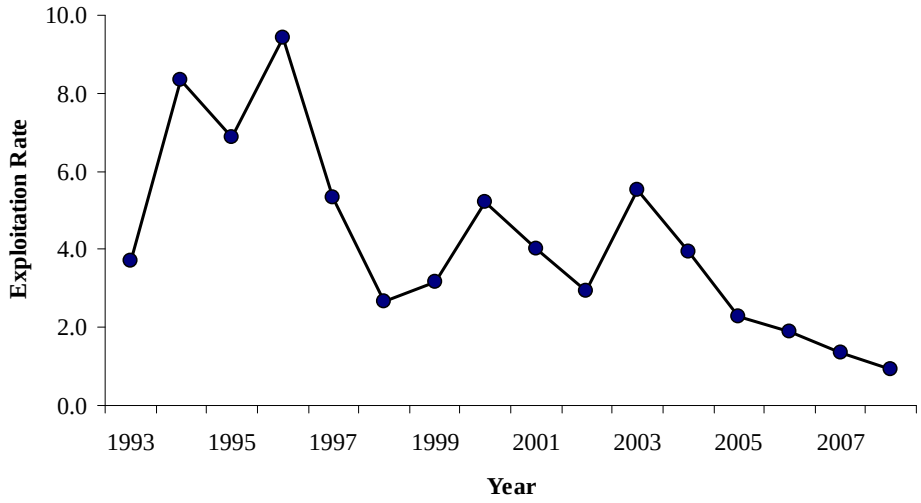

Fig. 5. Exploitation rates as nominal catch divided by the EU survey biomass index of the same year .

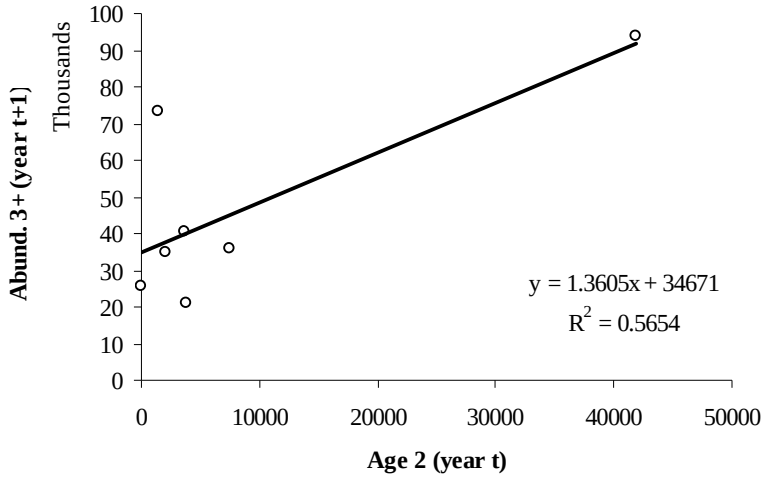

Fig. 6. Relationship from the EU Survey between the number of age 2 estimated and the number of age 3 and older one year later .

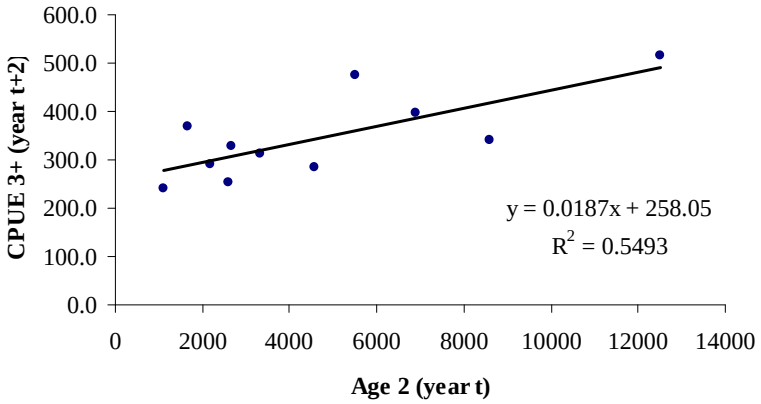

Fig. 7. No./hour of 2 year olds in the commercial fishery and standardized kg/hour (CPUE 3+) lagged by 2 years.

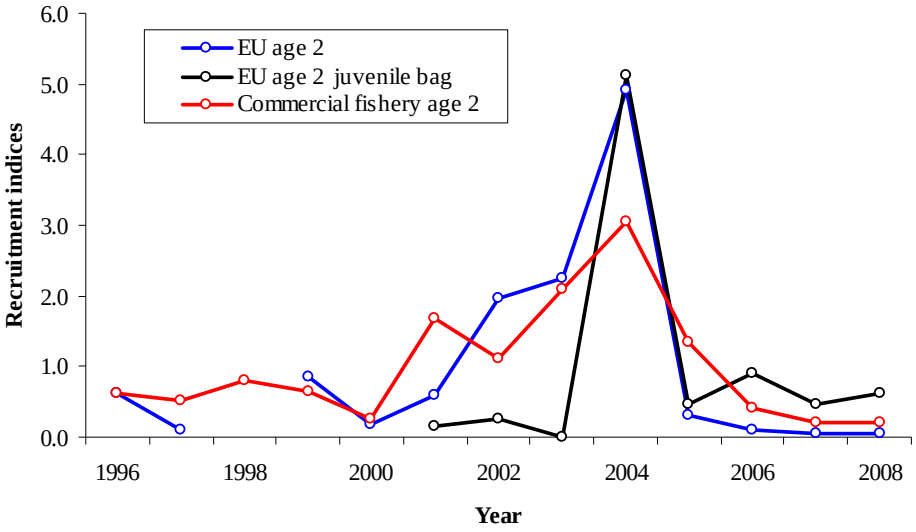

Fig. 8. Recruitment indices (number of 2 years old) from the commercial fishery and EU Survey. Each series was standardized to its mean.

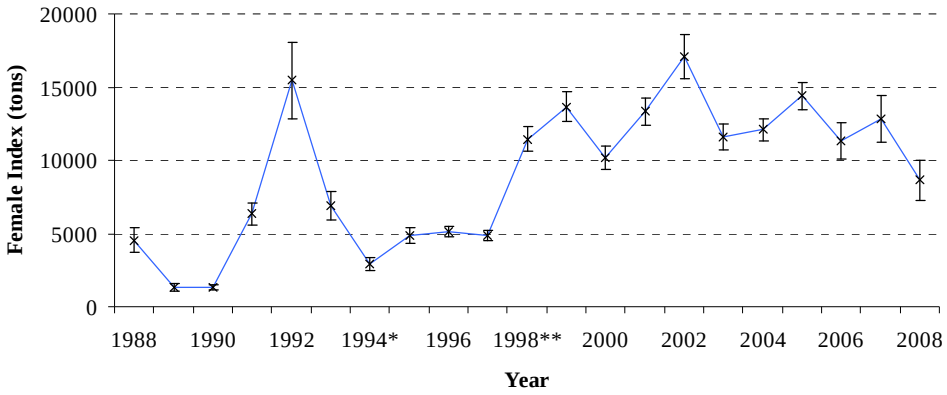

Fig. 9. Shrimp in Div. 3M: female biomass index from EU surveys, 1988-2008.

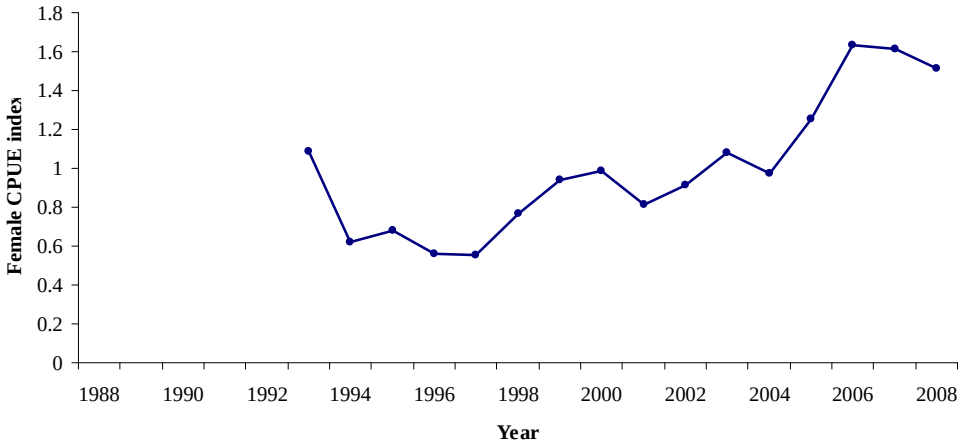

Fig. 10. Shrimp in Div. 3M: standardized female CPUE, 1993-2008. The series was standardized to the mean of the series.

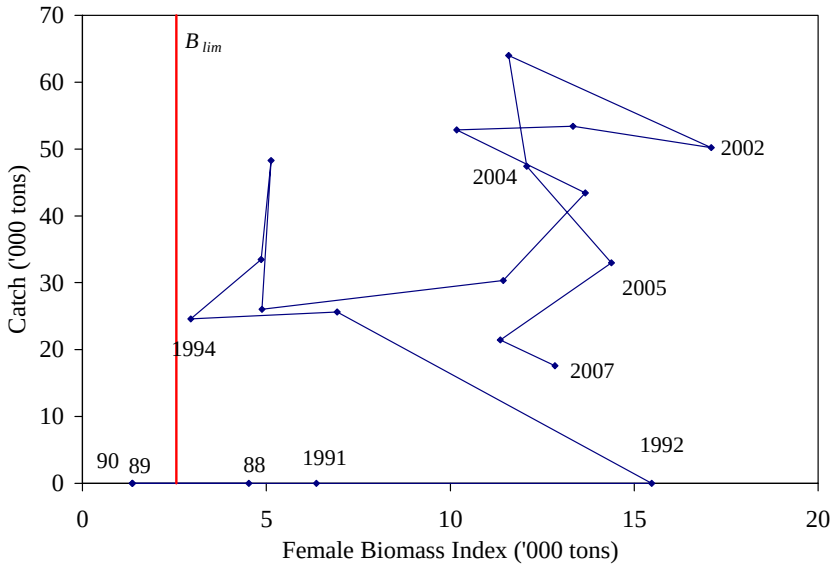

Fig. 11. Catch plotted against female biomass index from EU survey. Line denoting B_{lim} is drawn where biomass is 85% lower than the maximum point in 2002. Not updated for 2008 owing to incomplete catch.