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Assessment of the International Fishery for Shrimp (*Pandalus borealis*) in Division 3M (Flemish Cap), 1993-2010

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 was 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 have caused a drastic decline of the stock. Although the effort in the last years was low due to high cost of oil and low marketing prize of shrimp, the increase of cod biomass (the most important predator of northern shrimp in 3M) has probably been the cause of the successive bad recruitments and resulting decline of the stock. The revised Nominal catches declined from 63970 tonnes in 2003 to 5429 tonnes in 2009. The catch in 2010 was only 1233 tonnes to 10 October. Noting the lack of reports on catch this figure might increase although is very unlikely that the catches exceed the 3000 tonnes. 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 and 2009 this year class was barely represented and it was residual in 2010. 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 and in 2009 it was between the lowest estimated in the EU survey series, confirming the decrease initiated in 2002. In 2010 although the female shrimp biomass increased 116% with respect to 2009, remain between the lowest in the historical series. This pessimistic picture confirms the decreasing trend on the female standardized CPUE from 2007. Indices of recruitment from the commercial fishery (age 2 in numbers per hor) are plotted against CPUE of 3+ two 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.

Considering the 15% of the maximum survey female biomass index as a limit reference point for biomass (B_{lim}), the stock is now outside to B_{lim} but close to the collapse zone defined by the NAFO PA framework. Also the recruitment prospects remain uncertain and therefore the fishing mortality would be set as close to zero as possible in 2010.

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 26000 t to 48000 t in the years 1993 through 1996. After 1996 the catches were lower and rising slowly from 26 000 t in 1997 to 53000 t in 2000 and 2001. There was 50000 t taken in 2002. The catch increased in 2003, reaching the highest value in the catches series (64000 t). After 2003 the catches decreased all years to 5400 t in 2009. Removals to October 2010 (about 1200 t) are much lower than reported in 2009 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. There is not a lot of information on the number of vessels taking part in the shrimp fishery since 2007 but probably they do not exceeded 15 units in 2009.

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 2009 was updated. Only Stonian data were available from 2010 and new information about Spanish in 2009 was added. Data were selected from the standardized data file where catch >0 kg and/or effort >10 hours. As area is not defined in some of the reported 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 cause for concern about the correct locations of some catches between 3M and 3L Divisions. Up to 2009 the followed criterion was to analyse those trips where the catches were carried out exclusively in 3M Division. In 2009 and 2010 this rule it could not be applied to the Estonian vessels because all the trips with available information in 2009 and 2010 presented catches in both divisions 3M and 3L. From this reason the CPUE database was only updated adding the data set from Spain in 2009.

As in previous years possible outliers were identified by Cock's distances estimated from a preliminary linear regression carried out with the updated CPUE dataset. The CPUE was modelled against year, vessel, month and gear and all the cases with Cock's distances bigger than 0.00008 were remove and the international data base rebuilt.

With the updated international dataset the CPUE was again modelled against year, vessel, month and gear, but 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. As previous years the model was 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.

The absence of significant differences since 1994 in the growth curves estimated by EU survey and Commercial fishery would allow us to use the EU survey length distribution to estimate the age composition of the catches carried out by international fleet directed to shrimp fishery in 3M Division (Casas, 2009).

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 2010, the small catch of 650 t to 1o September is only one preliminary estimate. The total catch recorded around 1100 t was much lower that the recorded last year for this date (figure 1).

4. CPUE MODEL

Table 2 shows the no. of data records used in the model by year and country. A summary table was made from the data, shown in Table 3. 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 (79%). 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 following years up to 2009.

In spite of the efforts to discriminate the correct allocation of the Estonian catches in 2009 and 2010, there is a severe concern about the reliability of this data and thus they could not be used in the analysis. For 2009 only Spanish catches were used. The wider range of the 95% confidence level in 2009 shows the uncertainty of the glm carried out this year where the number of cases in the International CPUE data base was lower than the others 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 1998-2004 the catch rate has been rather stable at a lower level. From 2005 to 2008 despite the exploitation rate remains stable at relative low values (between 1.9-1.5), the UE survey indexes estimated decreased year after year. In 2009, in spite of the low catches carried out the exploitation rate increased about twice as consequence the low biomass estimated that year. The preliminary exploitation rate to 10 October 2010 was the lowest of the observed in the series, but this is not based on projected catches and it will increase when the total catch for the year is known.

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. Both are presented together with the biomass and abundance index for age 3 and older (Table 9). 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= 0.45).

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 = 0.64 (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 (2001-2003) 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. The preliminary and outstanding values corresponding to age 2 (no./hour) from the commercial fishery in 2009 and 2010 are probably due to the slight increase of the 2007 and 2008 year classes. However these abnormal increases of the CPUE index at age 2 ought to be considered with caution because the length increase for these age groups (15.9 mm. in 2009 and 17.6 mm. in 2010), make them more accessible to commercial fishery than previous years.

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. This change in the source of samples does not affect significantly the estimates of the age composition based on nominal catches (Casas, 2009) and therefore they can be compared along the years in the historical series.

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 provisional estimations in 2010 are carried out assuming the nominal catches to 10 September and the CPUE values corresponding to 2009 year.

The Tables 12 list the number at age of shrimp caught in the commercial fishery from 1996 to 2010 corresponding to the nominal catches annually recorded The Tables 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 stock recovered reasonably well although with high annual variability in the last years (historical maximums in 2002 and 2005 were followed by years with lower biomass but at a relative high level). The female biomass estimated in 2009 about 1764 tons showed a decrease of 74 % with respect to 2008 and it was between the lowest values of biomass recorded in the total of the historical series. The female biomass 3819 t estimated in 2010 show an increase about 77 % compared to 2009. Despite this increase the values of biomass are still among the lowest recorded in the total of the historical series. This drastic decline of shrimp biomass in the two last years is likely associated to the increase of the cod stock experimented in the last years (Figures 10 A and B). These figures show the significant and inverse correlation between cod and female shrimp biomass.

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 11). The prominent 1993 value was due to the strong 1987 year-class, but the next year-class appeared to have decreased in strength. The gradual 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 strong increase carried out between 2004 and 2006 where is reached 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 following years up to 2009.

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 2009 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 before the beginning of the fishery (1989 and 1990), and in 2009. If this method is accepted to define B_{lim} the index in 2010 it is now outside of the collapse zone but close to it (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 until October around 1200 tons the catch level in 2010 will be probably much lower than 2009.

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 following years up to 2009. For 2010 there was not available reliable information to update the standardized CPUE series.

The preliminary exploitation rate to 10 October 2010 was the lowest in the series. From 2005 to 2008 despite the exploitation rate remained stable at relative low values (between 1.9-1.5), the UE survey indexes estimated decreased year after year. In spite of the low catches carried out in 2009, the exploitation rate increased about twice as consequence the low biomass estimated that year. In 2010 although it will increase somewhat when the total annual catch is recorded, it probably will remain well below the level recorded in 2009.

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 strong decline of the female biomass index in 2008, 2009 and 2010 confirm the decreasing trend of this stock caused by the weak recruitment in the last five years.

The drastic stock decline on Div. 3M shrimp is inversely associated to the rebuilding of the cod stock in 3M Division.

10 ACKNOWLEDGEMENT

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REFERENCES

Casas J.M., J. L. Del Rio, J.L., and D. Gonzales Troncoso, 2004. Northern shrimp (*Pandalus borealis*) on Flemish Cap surveys 2003 and 2004. NAFO SCR Doc. 04/77, Serial No. N5047: 24p.

Casas J.M., 2010. Northern shrimp (*Pandalus borealis*) on Flemish Cap surveys 2010. NAFO SCR Doc. 10/ Serial No. N:

Casas, J.M., 2009. Comparison of Northern Shrimp Age composition calculated from Length distributions in the EU Survey and from Commercial Samples in 3M Division. NAFO SCR Doc. 09/057 Serial No. N:5718

Gudmundsdóttir, Á. 2003. A short note on modelling in S-plus the standardized CPUE for northern shrimp (Pandalus borealis) in Division 3M. NAFO SCR Doc. 03/89, Serial No. N4931: 5p.

Gudmundsdóttir, Á., and A. Nicolajsen 2003. Standardized CPUE indices for shrimp (Pandalus borealis) in Division 3M(Flemish Cap) 1993-2003. NAFO SCR Doc. 03/90, Serial No. N4932: 8p.

Kimura, D.K. 1980. Likelihood methods for the von Bertalanffy growth curve. U.S. Fish. Bull. 77(4):765-776.

McCrary, J.A. 1971. Sternal spines as a characteristic for differentiating between females of some Pandalidae. J.Fish. Res. Board Can. 28: 98-100.

MacDonald P. D. M.. and T. J. Pitcher 1979. Age groups from size-frequency data: A versatile and efficient method of analysing distribution mixtures. . J.Fish. Res. Board Can. 36: 987-1011.

NAFO. 2003. Scientific Council Reports, 2003.

NAFO. 2005. Scientific Council Reports, 2005.

Parsons, D.G., 1998. The International Fishery for Shrimp (Pandalus borealis) in Division 3M (Flemish Cap), 1993 - 1998. NAFO SCR Doc. 98/92, Serial No. N3093: 12p.

Skúladóttir, U., 1997. The Icelandic shrimp fishery (Pandalus borealis Kr.) at Flemish Cap in 1993-1997. NAFO SCR Doc. 97/85, Serial No. N2931: 30p.

Skúladóttir, U., 2006. The Icelandic shrimp fishery (Pandalus borealis Kr.) at Flemish Cap in 1993-2006. NAFO SCR Doc. 97/85, Serial No. N2931: 30p.

Skúladóttir, U., and G. Pétursson 2005 . Assessment of the international fishery for shrimp (Pandalus borealis Kr.) in division 3M (Flemish Cap), 1993- 2005. NAFO SCR Doc. 05/89, Serial No. N5194: 21p.

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	2009	2010*
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] 12009	[2] 8466	[2] 10607 [2]	10255 [2]	2133 [2]	
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 [2]	[1] 1892	[1] 3533	[1] 3059	[1] 2212	[1] 1330	[1] 1939	1285	1194 [1]	
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	485		750 [4]
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					3 [1]	
EU/Spain	240	300	158	50	[1] 423	[1] 912	[1] 1020	[1] 1347	[1] 855	[1] 674	[1] 857	[2] 1049	[2] 725	[2] 997	768	406	537 [1]	
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	1201	1349 [1]	483 [4]
France (SPM)					150			[1] 138	[1] 337	[1] 161		[1]	487		[1] 741		193 [1]	
Greenland	[1] 3788	[1] 2275	[1] 2400	[1] 1107	[1] 104	866	[1] 576	[1] 1734		[1] 644	[2] 1990		[1] 12	[2] [1] 778				
Iceland	2243	[1] 2355	7623	[1] 20680	[1] 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	[2] 890	[1] 1872	321		
Russia		350	3327	4445	1090		1142	[1] 7070	[1] 5687	[1] 1176	[1] 3	[1] 654	[1] 266	[1] 46	[1] 73	21	20 [1]	
Ukraine									[1] 348		[1] 237	[1] 315		[1] 282				
USA								[1] 629										
Total	25611	24579	33471	48299	26028	30321	43439	52867	53389	50214	63970	45757	27479	18595	20741	12889	5429	1233

1 NAFO Statlant 21 A
2 From the fisheries biologist of respective countries
* Provisional to 10 September

Table 2. 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		88		13	61	77		
2004		80			32	50		
2005		82			20	2		22
2006		24		9	6	2		18
2007		16				7		18
2008		10				1		12
2009								12

Table 3. 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	472	270	129	48	1182	0.477
1996	928	227	114	45	848	0.503
1997	376	286	97	92	602	0.337
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	239	600	234	129	1371	0.390
2004	162	564	206	227	1425	0.366
2005	126	567	176	65	1145	0.310
2006	59	606	228	56	1021	0.377
2007	41	599	274	183	1353	0.457
2008	23	450	178	57	683	0.395
2009	12	377	173	18	653	0.458

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

Call: lm(formula = std ~ mean, data = table10, na.action = na.exclude)

Residuals:

Min	1Q	Median	3Q	Max
-37.17	-5.71	1.349	9.897	50.11

Coefficients:

	Value	Std. Error	t value	Pr(>|t|)
(Intercept)	24.7172	18.1784	1.3597	0.1940
cpue	0.3322	0.0410	8.0998	0.0000

Residual standard error: 21.31 on 15 degrees of freedom
Multiple R-Squared: 0.8139
F-statistic: 65.61 on 1 and 15 degrees of freedom, the p-value is 7.389e-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 = standcpue10, 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
-21.27485	-1.941668	-0.3601794	1.297377	14.37399

Coefficients:

	Value	Std. Error	t value
Intercept)	5.9877	0.07865	76.134488
year1994	-0.35792076	0.02185	-16.380495
year1995	-0.20012938	0.02217	-9.027235
year1996	-0.32850668	0.02339	-14.042977
year1997	-0.31380490	0.02548	-12.313538
year1998	-0.06425370	0.02669	-2.407128
year1999	-0.02987118	0.02640	-1.131618
year2000	0.08045066	0.02705	2.974686
year2001	0.05514703	0.03115	1.770202
year2002	0.07276186	0.03305	2.20141
year2003	0.23845324	0.03385	7.04482
year2004	0.14753176	0.03541	4.16671
year2005	0.26209230	0.03802	6.89280
year2006	0.41385919	0.04469	9.26040
year2007	0.30885074	0.05077	6.08366
year2008	0.20514238	0.06048	3.39169
year2009	0.15508091	0.12812	1.21040
month2	0.0232	0.03402	0.68204
month3	0.0457463	0.03078	1.4863722
month4	0.01506938	0.02934	0.5136581
month5	0.04130329	0.02877	1.4356371
month6	0.106347	0.02836	3.750407
month7	0.02732115	0.02835	0.9637674
month8	-0.08018915	0.02878	-2.7863279
month9	-0.14740049	0.02913	-5.0605927
month10	-0.12900166	0.02940	-4.3879803
month11	-0.15922209	0.03072	-5.1823936
month12	-0.11895046	0.03383	-3.5157255
gear2	0.17784772	0.01842	9.6529345
gear3	0.19087866	0.06302	3.0288831

Dispersion Parameter for Gamma family taken to be 9.312684

Null Deviance: 216206.9 on 4448 degrees of freedom

Residual Deviance: 39483.08 on 4214 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 2010 in Flemish Cap.

Source of variation	df	Deviance	Resid.Df	Resid.Dev	F Value	Pr(F)	% explained
NULL			4448	216207		<0.001	
year	16	104607.3	4432	111600	702.0484	<0.001	48.4%
vessel	205	66063.8	4227	45536	34.6047	<0.001	30.6%
month	11	5209	4216	40327	50.8495	<0.001	2.4%
gear	2	843.8	4214	39483	45.3026	<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	0.6991	0.7297	0.6698
1995	0.8186	0.8550	0.7838
1996	0.7200	0.7538	0.6877
1997	0.7307	0.7681	0.6951
1998	0.9378	0.9881	0.8900
1999	0.9706	1.0221	0.9216
2000	1.0838	1.1428	1.0278
2001	1.0567	1.1232	0.9941
2002	1.0755	1.1475	1.0080
2003	1.2693	1.3563	1.1878
2004	1.1590	1.2423	1.0813
2005	1.2996	1.4002	1.2063
2006	1.5126	1.6511	1.3858
2007	1.3619	1.5043	1.2329
2008	1.2277	1.3822	1.0905
2009	1.1678	1.5011	0.9084

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	45757	12081	3.8
2005	27479	14381	1.9
2006	18162	11359	1.6
2007	20267	12843	1.6
2008	12889	8630	1.5
2009	5429	1764	3.1
2010[1]	1233	3818	0.3

[1]Provisional to 10 September

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 older	
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
2009	1177	3011	2432	4525
2010	1103	954	4512	7178

*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	2602	120.4
1997	2144	183.4
1998	3331	252.6
1999	2660	291.1
2000	1108	314.5
2001	6910	328.3
2002	4567	238.9
2003	8641	397.2
2004	12557	284.6
2005	5479	340.8
2006	1693	518.4
2007	848	460.8
2008	866	354.3
2009	18697	281.1

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		8.35681	25611	356.6	42675	3064.7

1994

Sex	Age		Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 24579	kg/hr 249.3	No./hour	Number (´000´000)
Males	1								
Males	2	16.4	0.1817	2.576	0.46806	1668	16.9	6570	647.6
Males	3	20.4	0.3629	4.998	1.81377	6465	65.6	13121	1293.5
Males	4	22.9	0.0854	7.101	0.60643	2161	21.9	3088	304.4
Primip.	5	25.7	0.1944	10.080	1.95955	6984	70.8	7029	692.9
Multip.	6+	26.9	0.1756	11.664	2.04820	7300	74.1	6349	625.9
Total			1		6.89601	24579	249.3	36156	3564.2

1995

Sex	Age		Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 33471	kg/hr 291.9	No./hour	Number (´000´000)
Males	1								
Males	2	15.0	0.4516	1.965	0.88739	6079	53.0	26983	3093.5
Males	3	20.3	0.2714	4.924	1.33637	9154	79.8	16216	1859.1
Primip.	4	22.2	0.0507	6.462	0.32762	2244	19.6	3029	347.3
Primip.	5	25.3	0.0962	9.611	0.92458	6333	55.2	5748	659.0
Multip.	6+	26.2	0.1301	10.840	1.41028	9660	84.3	7773	891.2
Total			1		4.88625	33471	291.9	59749	6850.0

1996

Sex	Age		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	15.3	0.0622	2.066	0.12860	1011	5.4	2602	489.4
Males	3	20.0	0.6076	4.728	2.87283	22585	120.1	25395	4776.9
Primip.	3	21.4	0.0379	5.788	0.21921	1723	9.2	1583	297.7
Primip.	4	24.8	0.1511	9.034	1.36509	10732	57.1	6315	1187.9
Multip.	3	22.2	0.0063	6.799	0.04274	336	1.8	263	49.4
Multip.	4	24.8	0.0474	9.296	0.44108	3468	18.4	1983	373.0
Multip.	5	26.6	0.0574	11.306	0.64930	5105	27.1	2400	451.5
Multip.	6	28.8	0.0300	14.167	0.42486	3340	17.8	1253	235.8
Total			1		6.14372	48300	256.8	41795	7861.7

Table 11. Continued

1997

Sex	Age		Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 26028	kg/hr 260.6	No./hour	Number (´000´000)
Males	1	10.4	0.0001	0.910	0.00020	1	0.0	9	0.9
Males	2	15.7	0.0522	3.201	0.16714	686	6.9	2144	214.2
Males	3	19.0	0.4092	4.117	1.68462	6911	69.2	16805	1678.6
Males	4	22.3	0.2089	6.633	1.38567	5684	56.9	8580	857.0
Primip.	3	20.6	0.0029	5.237	0.01498	61	0.6	118	11.7
Primip.	4	24.3	0.1724	8.390	1.44630	5933	59.4	7080	707.2
Multip.	3	19.1	0.0025	5.018	0.01240	51	0.5	101	10.1
Multip.	4	24.2	0.0488	9.570	0.46737	1917	19.2	2006	200.3
Multip.	5	25.6	0.0845	10.631	0.89822	3685	36.9	3470	346.6
Multip.	6	28.3	0.0171	14.350	0.24558	1007	10.1	703	70.2
Multip.	7	29.3	0.0015	15.070	0.02232	92	0.9	61	6.1
Total			1		6.34481	26028	260.6	41076	4102.9

1998

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 30321	Kg/hr 334.4	No./hour	Number (´000´000)
Males	2	14.9	0.0596	1.923	0.11460	581	6.4	3331	302.0
Males	3	18.7	0.3462	3.868	1.33904	6786	74.9	19352	1754.5
Males	4	21.2	0.2321	5.642	1.30929	6636	73.2	12972	1176.1
Primip.	4	23.2	0.1399	7.355	1.02911	5216	57.5	7822	709.1
Primip.	5	25.9	0.0218	10.287	0.22439	1137	12.5	1219	110.6
Multip.	3	18.6	0.0025	4.160	0.01020	52	0.6	137	12.4
Multip.	4	23.5	0.0359	8.020	0.28781	1459	16.1	2006	181.9
Multip.	5	25.2	0.1083	9.700	1.05035	5323	58.7	6053	548.8
Multip.	6	26.5	0.0484	11.150	0.53946	2734	30.2	2705	245.2
Multip.	7	29.1	0.0054	14.470	0.07848	398	4.4	303	27.5
Total			1		5.98273	30321	334.4	55901	5068.1

1999

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 43439	kg/hr 346.1	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	2660	333.8
Males	3	17.6	0.2773	3.176	0.88073	6291	50.1	15783	1980.8
Males	4	21.0	0.2253	5.490	1.23680	8834	70.4	12822	1609.2
Males	5	22.3	0.0003	6.560	0.00187	13	0.1	16	2.0
Primip.	4	22.1	0.0758	6.348	0.48118	3437	27.4	4314	541.4
Primip.	5	24.2	0.1327	8.418	1.11680	7977	63.6	7551	947.6
Multip.	3	18.2	0.0009	3.970	0.00361	26	0.2	52	6.5
Multip.	4	22.0	0.0207	6.672	0.13820	987	7.9	1179	148.0
Multip.	5	24.2	0.1259	8.674	1.09238	7803	62.2	7168	899.5
Multip.	6	26.4	0.0932	11.060	1.03086	7363	58.7	5305	665.8
Multip.	7	29.6	0.0011	15.171	0.01638	117	0.9	61	7.7
Total			1		6.08151	43439	346.1	56918	7143.0

Table 11 continued

2000

Sex	Age	CL mm	Prop. by no.	Weight g	Prop. by weight	Nominal catch 52867	kg/hr 386.5	No./hour	Number (´000´000)
Males	2	13.2	0.0157	1.326	0.02078	201	1.5	1108	151.6
Males	3	17.3	0.3258	3.035	0.98868	9564	69.9	23038	3151.1
Males	4	20.0	0.2457	4.692	1.15299	11153	81.5	17378	2377.0
Males	5	21.9	0.0049	6.200	0.03026	293	2.1	345	47.2
Primip.	4	21.0	0.0776	5.458	0.42336	4095	29.9	5486	750.3
Primip.	5	24.2	0.0935	8.514	0.79646	7704	56.3	6616	904.9
Multip.	3	18.4	0.0021	4.012	0.00854	83	0.6	151	20.6
Multip.	4	21.9	0.0580	6.613	0.38387	3713	27.1	4105	561.5
Multip.	5	24.3	0.1271	8.825	1.12131	10846	79.3	8986	1229.1
Multip.	6	26.3	0.0473	10.703	0.50630	4897	35.8	3345	457.6
Multip.	7	27.6	0.0023	14.320	0.03289	318	2.3	162	22.2
Total			1		5.46543	52867	386.5	70719	9673.0

2001

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 53389	kg/hr 376.9	No./hour	Number (´000´000)
Males	2	15.2	0.1040	2.058	0.21403	2015	14.2	6910	978.9
Males	3	17.8	0.1393	3.292	0.45858	4317	30.5	9255	1311.2
Males	4	20.8	0.3925	5.315	2.08614	19637	138.6	26079	3694.5
Males	5	21.8	0.0095	6.081	0.05777	544	3.8	631	89.4
Primip.	4	21.5	0.0293	5.848	0.17135	1613	11.4	1947	275.8
Primip.	5	24.0	0.1147	8.204	0.94100	8857	62.5	7621	1079.7
Multip.	4	20.5	0.0240	5.484	0.13179	1240	8.8	1597	226.2
Multip.	5	23.2	0.1111	7.769	0.86314	8125	57.3	7382	1045.8
Multip.	6	25.1	0.0666	9.652	0.64282	6051	42.7	4425	626.9
Multip.	7	26.9	0.0090	11.701	0.10531	991	7.0	598	84.7
Total			1		5.67192	53389	376.9	66444	9413.2

2002

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 50214	kg/hr 383.6	No./hour	Number (´000´000)
Males	1	12.1	0.0003	1.011	0.00030	3	0.0	23	3.0
Males	2	15.4	0.0605	2.142	0.12959	1281	9.8	4567	597.9
Males	3	18.1	0.5095	3.497	1.78172	17609	134.5	38462	5035.4
Males	4	20.6	0.0681	5.124	0.34894	3449	26.3	5141	673.0
Primip.	4	20.3	0.0458	4.940	0.22625	2236	17.1	3457	452.6
Primip.	5	23.0	0.0675	7.231	0.48809	4824	36.8	5096	667.1
Multip.	3	19.4	0.0009	4.718	0.00425	42	0.3	68	8.9
Multip.	4	22.2	0.0598	6.818	0.40772	4029	30.8	4514	591.0
Multip.	5	24.1	0.1430	8.600	1.22980	12154	92.8	10795	1413.3
Multip.	6	25.7	0.0430	10.266	0.44144	4363	33.3	3246	425.0
Multip.	7	28.3	0.0017	13.359	0.02271	224	1.7	128	16.8
Total			1		5.08082	50214	383.6	75498	9884.0

Table 11 continued

2003

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 63970	kg/hr 452.7	No./hour	Number (´000´000)
Males	1	12.1	0.0086	1.020	0.00875	96	0.7	667	94.3
Males	2	15.8	0.1111	2.303	0.25586	2812	19.9	8641	1221.1
Males	3	18.4	0.1222	3.658	0.44702	4913	34.8	9505	1343.2
Males	4	20.5	0.3638	5.062	1.84139	20240	143.2	28293	3998.3
Primip.	4	21.7	0.0855	6.052	0.51737	5687	40.2	6649	939.6
Primip.	5	24.2	0.0554	8.347	0.46263	5085	36.0	4311	609.2
Multip.	3	20.0	0.0004	4.678	0.00198	22	0.2	33	4.6
Multip.	4	22.0	0.0409	6.653	0.27199	2990	21.2	3180	449.4
Multip.	5	24.3	0.1358	8.833	1.19913	13180	93.3	10559	1492.2
Multip.	6	26.0	0.0753	10.622	0.79948	8787	62.2	5854	827.3
Multip.	7	27.9	0.0011	12.885	0.01437	158	1.1	87	12.3
Total			1		5.81996	63970	452.7	77779	10991.5

2004

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 45757	kg/hr 413.3	No./hour	Number (´000´000)
Males	1								
Males	2	14.4	0.1583	1.720	0.27228	2391	21.6	12557	1390.1
Males	3	18.4	0.3719	3.631	1.35037	11858	107.1	29500	3265.7
Males	4	21.1	0.1082	5.529	0.59824	5253	47.5	8583	950.1
Males	5	21.5	0.0164	5.867	0.09622	845	7.6	1301	144.0
Primip.	4	20.8	0.0091	5.327	0.04848	426	3.8	722	79.9
Primip.	5	23.4	0.1657	7.618	1.26230	11085	100.1	13144	1455.0
Multip.	4	21.6	0.0158	6.296	0.09948	874	7.9	1253	138.7
Multip.	5	24.3	0.0993	8.756	0.86947	7635	69.0	7877	872.0
Multip.	6	26.5	0.0548	11.126	0.60970	5354	48.4	4347	481.2
Multip.	7	28.9	0.0003	14.199	0.00426	37	0.3	24	2.6
Total			1		5.21079	45757	413.3	79306	8779.4

2005

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 27479	kg/hr 463.5	No./hour	Number (´000´000)
Males	1								
Males	2	15.7	0.0607	2.229	0.13530	724	12.2	5479	324.9
Males	3	17.5	0.3794	3.038	1.15262	6169	104.0	34249	2030.5
Males	4	20.0	0.1287	4.689	0.60347	3230	54.5	11618	688.8
Primip.	3	19.9	0.0153	4.689	0.07174	384	6.5	1381	81.9
Primip.	4	21.9	0.1893	6.206	1.17480	6287	106.1	17088	1013.1
Primip.	5	23.5	0.0550	7.405	0.40728	2180	36.8	4965	294.4
Multip.	4	22.4	0.0264	6.830	0.18031	965	16.3	2383	141.3
Multip.	5	24.3	0.1090	8.952	0.97577	5222	88.1	9840	583.4
Multip.	6	26.2	0.0322	11.552	0.37197	1991	33.6	2907	172.3
Multip.	7	26.9	0.0053	11.552	0.06123	328	5.5	478	28.4
Total			1		5.13448	27479	463.5	90389	5358.8

Table 11. Continued

2006

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 18162	kg/hr 539.5	No./hour	Number (´000´000)
Males	1								
Males	2	12.6	0.0142	1.136	0.01613	65	1.9	1693	57.0
Males	3	15.6	0.0616	2.128	0.13110	527	15.6	7350	247.5
Males	4	17.6	0.2887	3.047	0.87985	3534	105.0	34451	1159.8
Males	5	19.7	0.0629	4.188	0.26343	1058	31.4	7506	252.7
Primip.	3	15.9	0.0089	2.401	0.02129	86	2.5	1058	35.6
Primip.	4	18.6	0.1548	4.082	0.63207	2539	75.4	18474	622.0
Primip.	5	20.5	0.1408	5.639	0.79388	3189	94.7	16797	565.5
Primip.	6	22.9	0.0366	8.276	0.30299	1217	36.2	4369	147.1
Multip.	3	17.5	0.0028	2.900	0.00819	33	1.0	337	11.3
Multip.	4	19.6	0.0318	4.046	0.12853	516	15.3	3790	127.6
Multip.	5	21.9	0.0903	5.651	0.51018	2049	60.9	10772	362.7
Multip.	6	24.0	0.0908	7.454	0.67692	2719	80.8	10835	364.8
Multip.	7	26.3	0.0158	9.904	0.15659	629	18.7	1887	63.5
Total			1		4.52115	18162	539.5	119319	4017.1

2007

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 20267	kg/hr 485.7	No./hour	Number (´000´000)
Males	1								
Males	2	12.5	0.0082	1.278	0.01054	45	1.1	848	35.4
Males	3	15.3	0.1026	2.176	0.22320	958	22.9	10547	440.1
Males	4	18.9	0.2402	3.854	0.92556	3971	95.2	24693	1030.4
Primip.	3	16.6	0.0033	2.659	0.00876	38	0.9	339	14.1
Primip.	4	19.1	0.0953	3.962	0.37763	1620	38.8	9800	409.0
Primip.	5	20.8	0.1728	5.018	0.86690	3719	89.1	17764	741.3
Primip.	6	23.1	0.0457	6.710	0.30680	1316	31.5	4701	196.2
Multip.	5	20.5	0.1798	4.891	0.87941	3773	90.4	18487	771.4
Multip.	6	23.1	0.1166	6.917	0.80673	3461	82.9	11992	500.4
Multip.	7	25.2	0.0355	8.973	0.31822	1365	32.7	3646	152.2
Total			1		4.72375	20267	485.7	102818	4290.4

2008

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 12889	kg/hr 437.8	No./hour	Number (´000´000)
Males	1								
Males	2	13.4	0.0103	1.510	0.01550	39	1.3	866	25.5
Males	3	17.4	0.2362	3.091	0.73025	1815	61.6	19941	587.0
Males	4	19.6	0.0940	4.331	0.40731	1012	34.4	7938	233.7
Primip.	3	18.1	0.0415	3.471	0.14422	358	12.2	3507	103.2
Primip.	4	20.9	0.1328	5.160	0.68522	1703	57.8	11209	330.0
Primip.	5	23.0	0.1435	6.782	0.97332	2419	82.2	12114	356.6
Multip.	3	19.7	0.0228	4.359	0.09933	247	8.4	1923	56.6
Multip.	4	21.8	0.1741	5.791	1.00811	2505	85.1	14693	432.5
Multip.	5	23.9	0.1259	7.476	0.94096	2338	79.4	10625	312.8
Multip.	6	26.2	0.0189	9.675	0.18280	454	15.4	1595	47.0
Multip.	7								
Total			1		5.18702	12889	437.8	84411	2484.9

Table 11. Continued

2009

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 2958	kg/hr 416.5	No./hour	Number (´000´000)
Males	1								
Males	2	15.9	0.1972	2.573	0.50739	574	44.0	17107	223.0
Males	3	18.2	0.2458	3.696	0.90845	1027	78.8	21324	278.0
Males	4	20.1	0.0849	4.864	0.41288	467	35.8	7364	96.0
Primip.	2	15.8	0.0087	2.522	0.02200	25	1.9	757	9.9
Primip.	3	18.7	0.0337	3.991	0.13431	152	11.7	2920	38.1
Primip.	4	21.0	0.1871	5.470	1.02373	1158	88.8	16235	211.6
Primip.	5	23.1	0.0759	7.124	0.54071	612	46.9	6585	85.8
Multip.	3	17.6	0.0020	3.405	0.00686	8	0.6	175	2.3
Multip.	4	20.9	0.0245	5.425	0.13266	150	11.5	2121	27.7
Multip.	5	22.9	0.0833	6.914	0.57611	652	50.0	7229	94.2
Multip.	6	25.1	0.0443	8.869	0.39332	445	34.1	3847	50.2
Multip.	7	27.4	0.0127	11.203	0.14201	161	12.3	1100	14.3
Total			1		4.80041	5429	416.5	86764	1131.1

2010*

Sex	Age	CL mm	Prop. by no.	Mean weight g	Prop. by weight	Nominal catch 1087	kg/hr 416.5	No./hour	Number (´000´000)
Males	1	11.7	0.0092	1.120	0.01035	2	0.7	658	1.9
Males	2	17.6	0.1297	3.365	0.43647	92	31.1	9244	27.4
Males	3	19.7	0.1821	4.529	0.82472	174	58.8	12976	38.4
Males	4	1.0	0.0000	0.001	0.00000	0	0.0	0	0.0
Primip.	2	18.1	0.0035	3.639	0.01255	3	0.9	246	0.7
Primip.	3	21.4	0.2598	5.703	1.48174	313	105.6	18516	54.8
Primip.	4	23.5	0.1947	7.293	1.41967	300	101.2	13874	41.1
Primip.	5	24.7	0.0336	8.348	0.28021	59	20.0	2392	7.1
Multip.	2	17.6	0.0004	3.324	0.00143	0	0.1	31	0.1
Multip.	3	21.4	0.0216	5.687	0.12288	26	8.8	1540	4.6
Multip.	4	23.0	0.0860	6.891	0.59233	125	42.2	6126	18.1
Multip.	5	24.2	0.0611	7.924	0.48450	102	34.5	4358	12.9
Multip.	6	26.0	0.0183	9.651	0.17677	37	12.6	1305	3.9
Total			1		5.84363	1233	416.5	71267	211.0

*provisional, assuming a catch of 1233 tons and $CPUE_{2010} = CPUE_{2009}$

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 (2006-10).

Age.	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010*
1		1		1			3	94							2
2	489	214	302	334	152	979	598	1221	1390	325	57	35	25	233	28
3	5124	1700	1767	1987	3172	1311	5044	1348	3266	2112	294	454	747	318	98
4	1561	1764	2067	2299	3689	4197	1717	5387	1169	1843	1909	1439	996	335	59
5	451	347	659	1849	2181	2215	2080	2101	2471	878	1181	1513	669	180	20
6	236	70	245	666	458	627	425	827	481	172	512	697	47	50	4
7		6	27	8	22	85	17	12	3	28	64	152		14	
	7862	4103	5068	7143	9673	9413	9884	10991	8779	5359	4017	4290	2485	1131	211

*provisional, assuming a catch of 1233 tons.

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	2009	2010
1		10.44		6.00			12.05	12.09							11.75
2	15.25	15.73	14.90	14.49	13.16	15.23	15.43	15.81	14.36	15.70	12.59	12.52	13.43	15.89	17.65
3	20.13	19.05	18.75	17.58	17.32	17.78	18.14	18.42	18.36	17.58	15.71	15.29	17.65	18.23	20.74
4	24.79	23.30	22.09	21.34	20.49	20.85	21.05	20.83	21.13	21.21	18.08	18.93	20.98	20.74	23.31
5	26.60	25.56	25.29	24.22	24.21	23.56	23.77	24.28	23.62	24.07	21.00	20.65	23.43	23.01	24.35
6	28.85	28.33	26.47	26.42	26.32	25.13	25.69	26.01	26.45	26.24	23.65	23.07	26.19	25.10	26.01
7		29.28	29.07	29.57	27.64	26.93	28.25	27.88	28.87	26.90	26.31	25.19		27.36	

* 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	2009	2010
1		0.91		0.12			1.01	1.02							1.12
2	2.07	3.20	1.92	1.77	1.33	2.06	2.14	2.30	1.72	2.23	1.14	1.28	1.51	2.57	3.37
3	4.81	4.13	3.87	3.18	3.04	3.29	3.50	3.66	3.63	3.10	2.19	2.19	3.24	3.73	5.24
4	9.10	7.67	6.44	5.77	5.14	5.36	5.66	5.37	5.61	5.69	3.45	3.88	5.24	5.29	7.17
5	11.31	10.63	9.80	8.54	8.64	7.91	8.16	8.69	7.92	8.43	5.64	4.95	7.11	7.01	8.07
6	14.17	14.35	11.15	11.06	10.70	9.65	10.27	10.62	11.13	11.55	7.69	6.86	9.67	8.87	9.65
7		15.07	14.47	15.17	14.32	11.70	13.36	12.89	14.20	11.55	9.90	8.97		11.20	

* 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 (2006-09).

Age	1996	1997	1998	1999	2000	2001	2002	2003
1		9		6			23	667
2	2602	2144	3331	2660	1108	6910	4567	8641
3	27241	17024	19489	15835	23188	9255	38530	9538
4	8299	17665	22800	18316	26969	29622	13113	38122
5	2400	3470	7272	14735	15946	15634	15891	14870
6	1253	703	2705	5305	3345	4425	3246	5854
7		61	303	61	162	598	128	87
	41795	41076	55901	56918	70719	66444	75498	77779

Age	2004	2005	2006	2007	2008	2009	2010*	Mean 1996-2009
1							658	
2	12557	5479	1693	848	866	17864	9521	5150
3	29500	35630	8745	10885	25371	24419	33033	21128
4	10558	31090	56715	34493	33840	25721	20000	26323
5	22321	14805	35076	36251	22739	13814	6750	16848
6	4347	2907	15204	16693	1595	3847	1305	5115
7	24	478	1887	3646		1100		715.5
	79306	90389	119319	102818	84411	86764	71267	75228

*provisional, assuming a catch of 1233 tons and $CPUE_{2010} = CPUE_{2009}$

Table 16.- Female biomass Indices from the EU survey, and the female 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	144.9
1995	4857	159.1
1996	5132	131.3
1997	4885	127.6
1998	11444	180.0
1999	13669	220.8
2000	10172	231.4
2001	13336	189.7
2002	17091	212.9
2003	11589	254.1
2004	12081	229.5
2005	14381	292.8
2006	11359	385.5
2007	12843	366.5
2008	8630	340.5
2009	1764	257.8
2010	3819	325.8

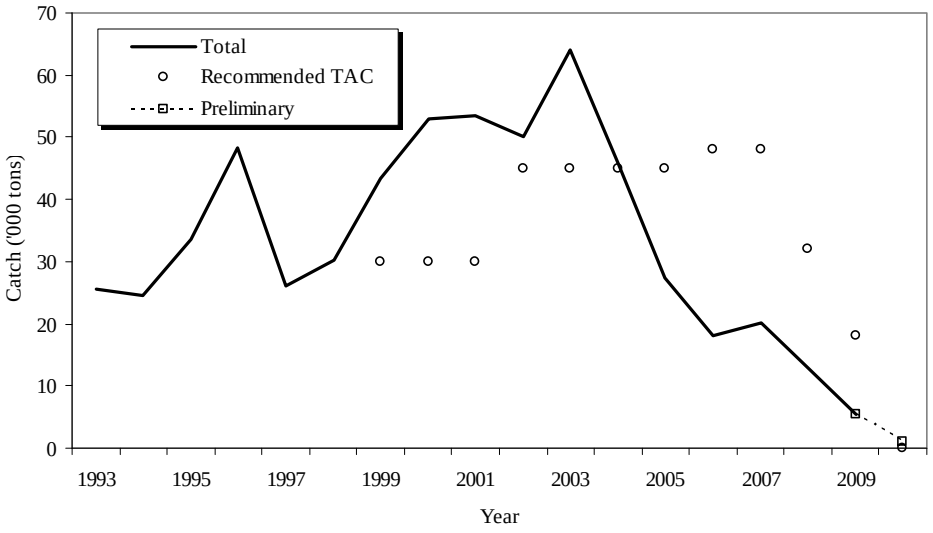

Fig.1. Shrimp in Div. 3M: catch.

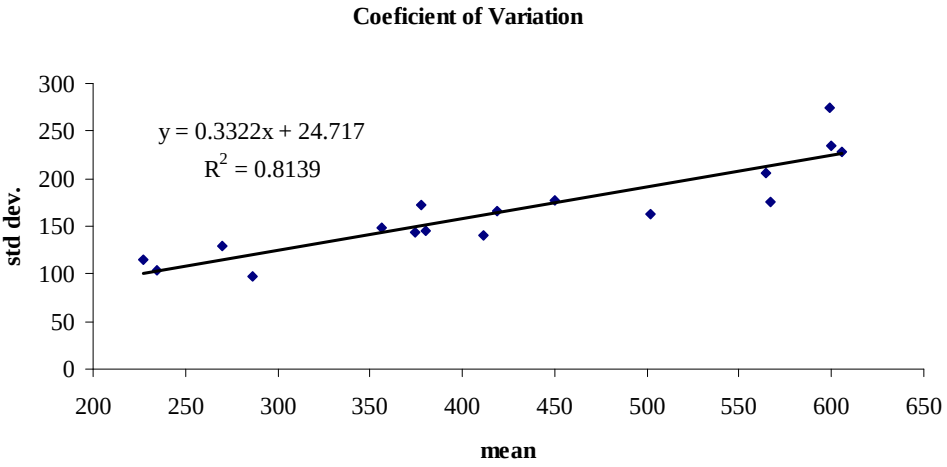

Fig. 2. Coefficient of variation around the annual means CPUE.

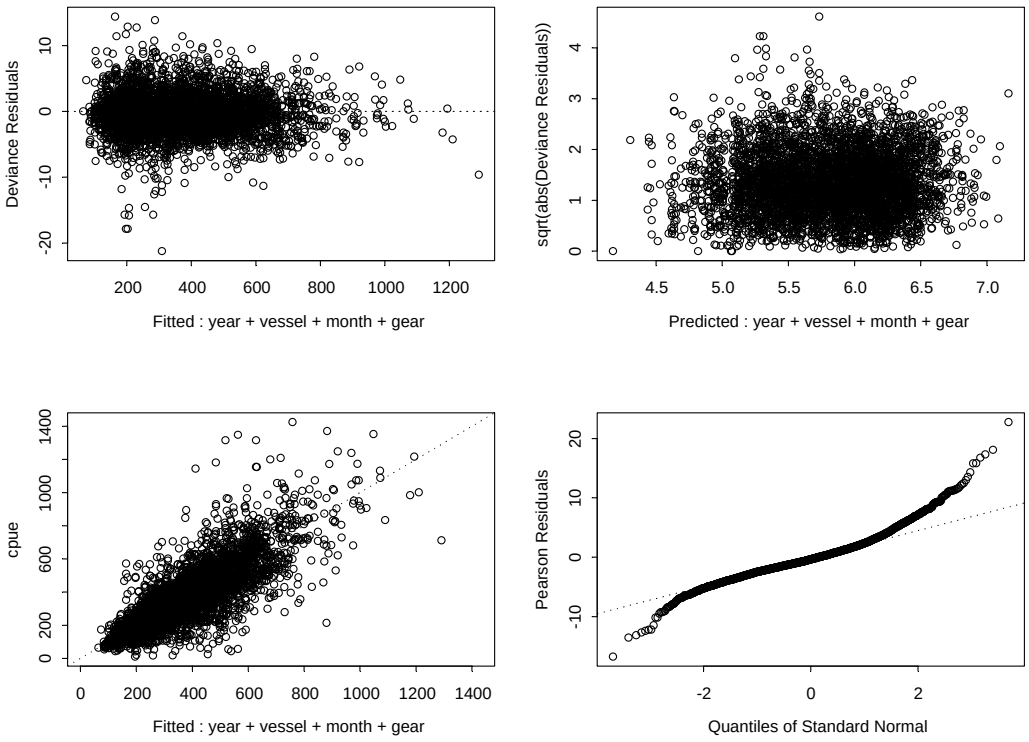

Fig.3. Plots of the generalized linear model of CPUE predicted by year, vessel, month and gear.

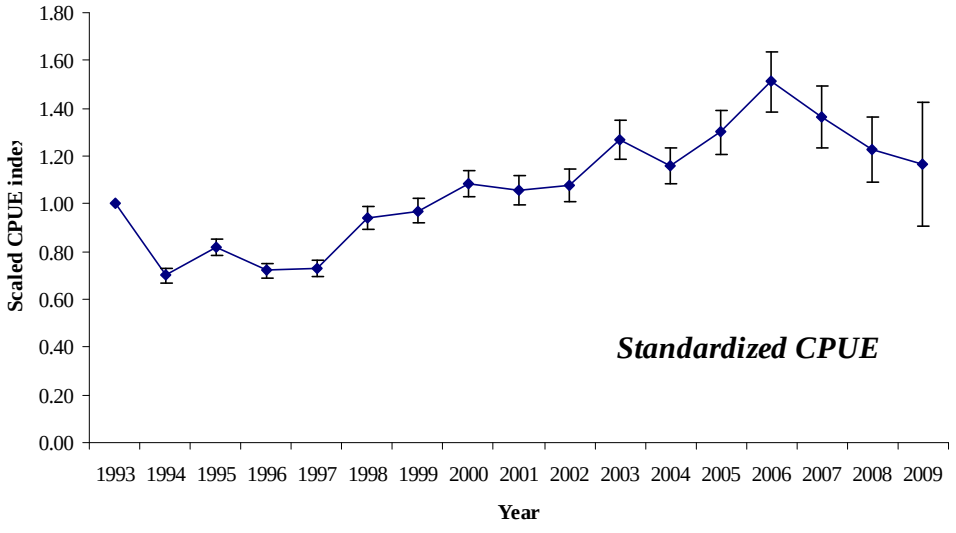

Fig. 4. Standardized CPUE series for shrimp in 3M Division, scaled to CPUE in 1993 with approximate 95% confidence limits.

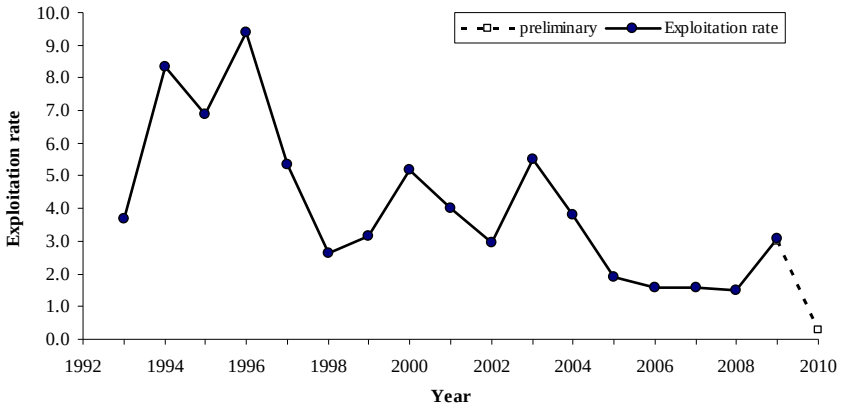

Fig. 5. Exploitation rates as nominal catch divided by the EU survey biomass index of the same year.

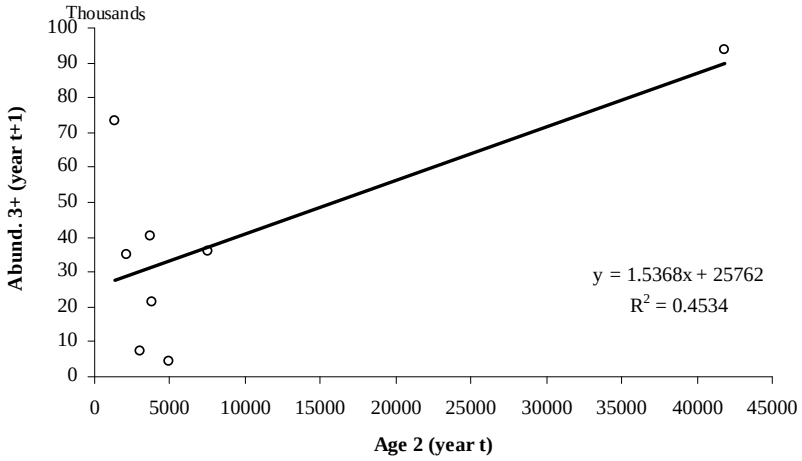

Fig. 6. Relationship from the EU Survey between the number of age 2 estimated and the number of age 3 and older one year later .

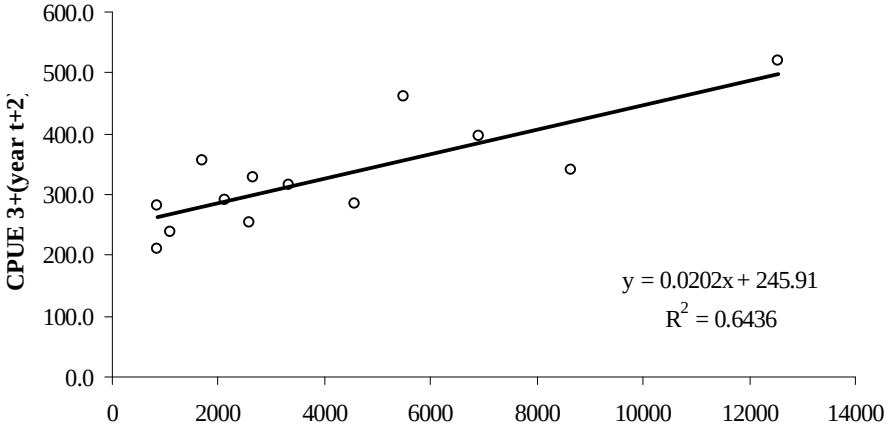

Fig. 7. No./hour of 2 year olds in the commercial fishery and standardized kg/hour (CPUE 3+) lagged by 2 years.

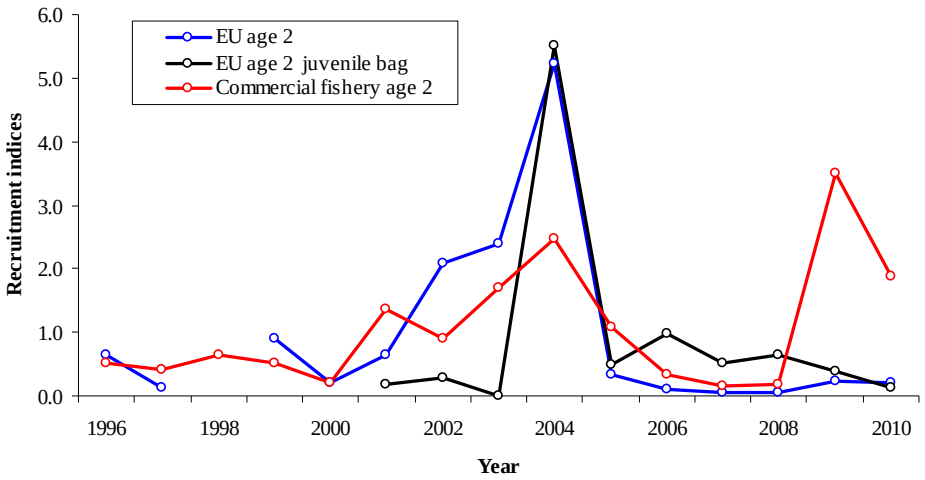

Fig. 8. Recruitment indices (no./hour of 2 years old) from the commercial fishery and abundances of age 2 in EU Survey. Each series was standardized to its mean.

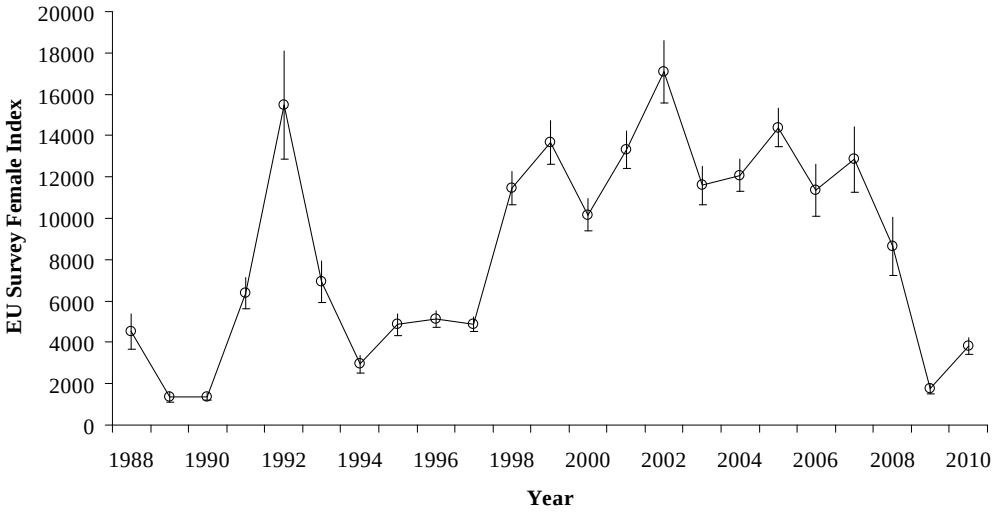

Fig. 9. Shrimp in Div. 3M: female biomass index from EU surveys, 1988-2010.

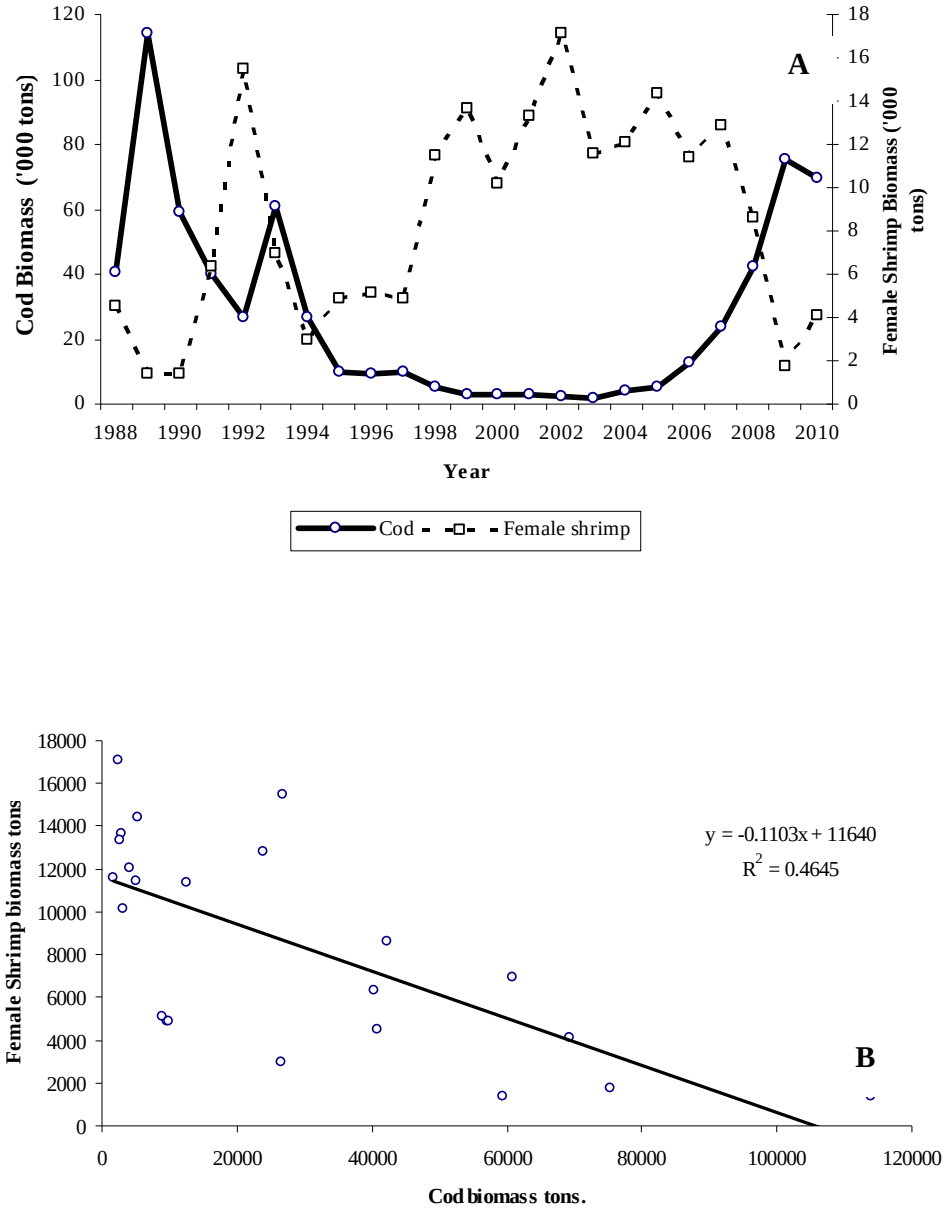

Figure 10. **A**) EU survey cod biomass (black line) and female shrimp biomass (dotted line) in the years 1988-2010 on Flemish Cap. **B**) Relationship from cod biomass and female shrimp biomass from EU Survey indexes estimated in the years 1988-2010 on Flemish Cap.

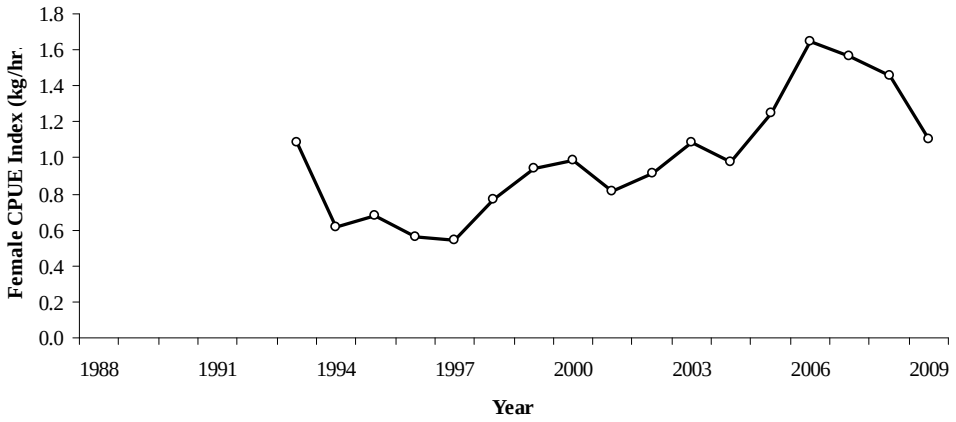

Fig. 11. Shrimp in Div. 3M: standardized female CPUE, 1993-2010. The series was standardized to the mean of the series.

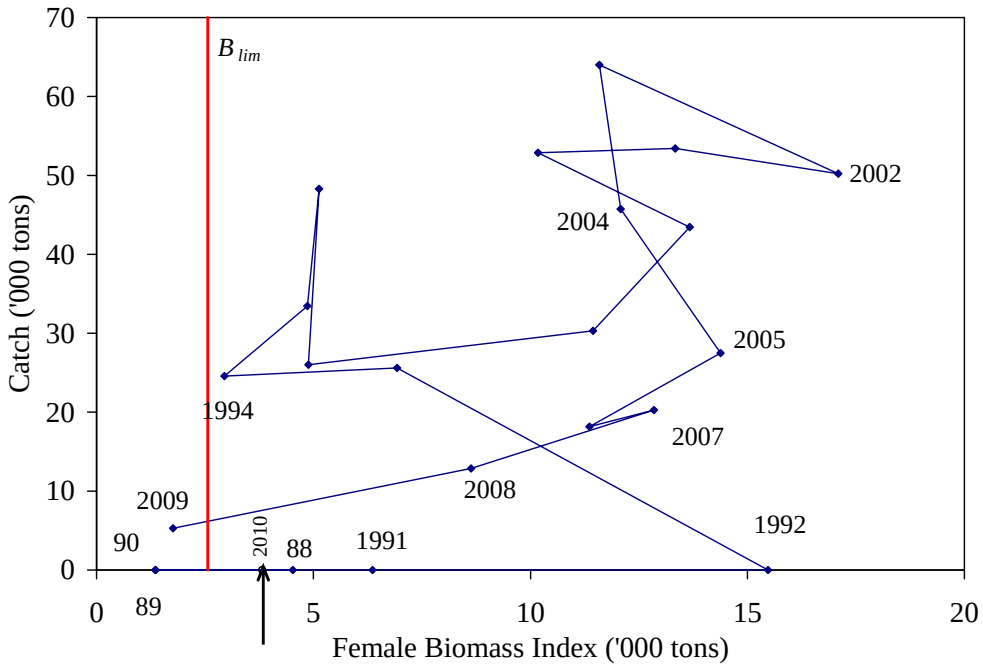

Fig. 12. Catch plotted against female biomass index from EU survey. Line denoting B_{lim} is drawn where biomass is 85% lower than the maximum point in 2002. Not updated for 2010 owing to incomplete catch.