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Division 3M Northern shrimp (*Pandalus borealis*) – Interim Monitoring Update

By

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Abstract

This document updates some of the indices for northern shrimp (*Pandalus borealis*) harvested within NAFO Divisions 3M. The assessment for this resource was completed, within Scientific Council during autumn 2010. Scientific Council recommended that the fishing mortality for 2011 and 2012 be set as close to zero as possible. Now, the low indices of biomass estimated in the 2011 EU summer survey, where the stock size was well below B_{lim} proxy, confirm the depletion of the stock after several years of downward trend, even though the levels of exploitation have been low since 2005 and close to zero in 2011, due to the moratoria initiated in the present year. The catch table (1993-2010) and biomass estimates (EU survey summer 1988-2011) are updated within this report. Data indicate that 1766 t of shrimp was taken in 2010 when the effort was reduced by 50% well below comparing to 5374 t taken in 2009 without reduction on the effort. In the 2011 EU survey the 3M total and female biomass index were 1644 t and 1231 t respectively. These indexes were around 66% lower than last year and the lowest values in the EU survey series. As previous years, the sharp decline of shrimp biomass in Flemish Cap was associated with a strong increase of the cod stock. This unfavorable situation confirms the recommendation carried out within Scientific Council during autumn 2010.

UE Bottom Trawl Research Survey Trends

Summer multi-species research surveys have been conducted onboard the Spanish vessels R/V Cornide de Saavedra since 1988 and R/V Vizconde de Eza since 2003. From 1988 to 2002 the indexes estimated by the R/V Cornide de Saavedra were calibrated and transformed to the R/V Vizconde de Eza following the Warren's method. Fishing sets of 30 minute duration, with a tow speed of 3 knots, were randomly allocated to strata covering the Flemish Cap Bank to a depth of 1462 m since 2004, with the number of sets in a stratum proportional to its size (Figure 1). Both vessels used the same gear (Lofoten) with a codend mesh size of 35 mm. In order to obtain information about the juvenile fraction of the stock, since 2001 a bag with 6 mm mesh size was attached to the cod-end of the Lofoten gear. SIMRAD ITI and SCANMAR sensors were employed to monitor net geometry. Details of the survey design and fishing protocols are outlined in (Casas, 2008). In 2011 the number of tows planned was lower than previous years due to technical problems. Anyway all strata were sampled properly and general trend of shrimp stock can be described.

The increasing of biomass from 1988 to 1992, coincided with a period of time where there was not a directed fishery to shrimp and the cod stock began to decline. With the beginning of the shrimp fishery in 1993 the biomass declined up to 1997. After that from 1998 to 2008 the stock recovered reasonably well although with high annual variability (historical maximums in 2002 and 2005 were followed by years with lower biomass but at a relative high level). In 2009 the biomass decreased to values between the lowest of the historical series. In 2010 despite of the biomass increase about 77% compared to 2009 this was still among the lowest in the total of the historical series. The total biomass estimated in 2011, around 1644 t. was the lowest value showing the depletion state of the shrimp stock (Table 1). This low values in the size of the shrimp stock are likely associated to the increase of the cod stock experimented in the last years (Figure 2) and they are now well below B_{lim} proxy (Figure 3).

Biomass estimated by depth strata from 1988 to 2009 is shown in Table 2. The presence of shrimp in shallowest strata, with depths less than 140 fathoms (257 m), was scarce in the first years (1988-1995). However, since 1996, a noticeable amount of shrimp occurred in these strata and the estimated biomass increased up to 2002 and 2003 years where the 36 % and 40% respectively of the total biomass were estimated in depths lesser than 140 fathoms. After these years the biomass estimated in

these depths declined each year and practically disappears in 2011 (0.1% of total biomass). The figure 4 shows this evolution between the years 2006-2011.

As in previous years the youngest specimens (age 1) didn't appear in the catches and the abundance at age 2 were weakly presents suggesting the absence of any strong year classes since 2003. (Figure 5)

Considering the abundance at age 2 as indicator of recruitment, the number of shrimp of two years old in the survey and from juvenile bag (Figure 6) were estimated and the index average-weighted. Since 2005, both indices showed low values indicating the sequence in recent years of weak year classes. Although in 2011 the index corresponding to juvenile bag increases slightly, a further drop in the value obtained from the main gear seems to indicate the weakness of the last recruitments.

Fishery and Management

Catch trends

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 3 and Figure 7) of approximately 26000 t to 48000 t in the years 1993 through 1996. After 1996 the catches were lower and rising slowly from 26000 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 (64000t), declining in the following years to about 1766 in 2010. In 2011 following the NAFO SC recommendation no effort was directed to shrimp fishery in Flemish Cap and removals to September 2011 have not been recorded.

Exploitation rate

Considering the Exploitation rate estimated as nominal catches divided by the EU survey biomass index of the same year (Figure 8 and Table 4), 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. This trend has continued in the recent years despite the low values of the exploitation rate in 2010 and the moratorium established on 3M shrimp stock in 2011.

Effort and TAC regulation

During 2010 meeting, Scientific Council (NAFO 2010) noted the stock remained near the lowest recorded in the time series and near B_{lim} , All year classes since 2002 had been weak and recruitment prospects remained poor. Therefore, Scientific Council reiterated its September 2010 recommendation for 2011 that the fishing mortality be set as close to zero as possible. Scientific Council recommended that fishing mortality in 2011 and 2012 be set as close to zero as possible.

In the light of new information from EU Survey summer in 2011, the stock is at lowest level in the time series and it is again in the collapse zone. Also the recovery of the cod stock in recent years (the second highest in the time series in 2011), coinciding with the decline of shrimp stock and the low values of the exploitation level in 2010 and 2011 suggest that this drastic decline of the shrimp biomass is caused by the increasing of the natural mortality linked to predation by cod rather than fishing mortality.

Conclusions

The low values of the Total and Female biomass indexes in 2009 continued in 2010 and well below the B_{lim} proxy in 2011, confirming the strong decrease of this stock caused by the weak recruitments in the last seven years and the increase of cod stock, one of their most important predators.

Based on the information available in October 2010 Scientific Council reiterated its September 2010 recommendation for 2010 and 2011 that the fishing mortality was set as close to zero as possible. The new and unfavourable information from EU Survey summer in 2011, confirms the recommendation carried out within Scientific Council during autumn 2010 according to which the fishing mortality for 2011 and 2012 should be as close to zero as possible.

References

Casas, J. M. 2008. Northern Shrimp (*Pandalus borealis*) on Flemish Cap Surveys 2007. NAFO SCR Doc.08/ 68, Serial No.N5600

NAFO. 2010. Scientific Council Meeting, 20-27 October, 2010.

Table 1. Total and Female Biomass (tons) of shrimp estimated by swept area method in the years 1988-2011 on EU Flemish Cap surveys.

Year	Total Biomass (tons)	Female Biomass (tons)	Valid Sets Number*
1988	5615	4525	115
1989	2252	1359	116
1990	3405	1363	113
1991	11352	6365	117
1992	24508	15472	117
1993	11673	6923	101
1994 ¹	3879	2945	116
1995	7276	4857	121
1996	10461	5132	117
1997	7449	4885	117
1998 ²	39367	11444	119
1999	24692	13669	117
2000	19003	10172	120
2001	27204	13336	120
2002	36510	17091	120
2003	21087	11589	177
2004	20182	12081	177
2005	30675	14381	176
2006	16235	11477	179
2007	17046	12843	176
2008	11092	8630	166
2009	2797	1764	178
2010	4894	3819	153
2011	1643	1231	126

*Since 2003 the area surveyed and strata number increased up to depths from 740 to 1450 m. increasing proportionally the number of sets.

Table 2. Total shrimp biomass estimated by strata (tons) in the years 1988-2011 from EU Flemish Cap surveys. Between 1988 and 2002 data were transformed by Warren's method. (cells with 0 values corresponding to strata with biomass lower than 0.5 t; empty cells corresponding to strata with biomass = 0 t.)

Stratum	(Fathoms)	1988	1989	1990	1991	1992	1993	1994 ¹	1995	1996	1997	1998 ²	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	70-80																3	0			0				
2	81-100											175			69	112	690	217	164	8	50	0	0	1	0
3	101-140				10					148	39	639	450	1486	2169	5527	1817	2107	1023	477	20	11	36	21	1
4	101-140											239	596	306	1099	1942	637	785	2395	1195	11	1	3	15	0
5	101-140					8				26	110	1107	1948	2135	2782	2445	3780	867	695	664	558	11	28	21	1
6	101-140				32	2	5		20	422	161	2915	1142	657	2112	2951	1667	1250	883	299	462	23	1	43	0
7	141-200		30	400	1265	3763	2704	117	506	1336	988	4056	3072	2213	3006	4632	1521	3108	2607	1370	1642	468	32	495	8
8	141-200			88	248	1662	826	4	248	676	393	2402	2507	1140	2900	4257	1110	2043	4585	3084	709	1938	308	326	6
9	141-200	133	69	35			135		613	459	412	3981	1139	1110	1483	1754	819	673	583	1435	1277	1159	48	235	31
10	141-200	275	75	321	2103	3235	1778	752	1315	1148	1099	7186	4052	2771	3760	3748	4685	2489	2447	614	3248	671	154	467	58
11	141-200	263		148	1144	4096	1335	447	650	1235	1018	6049	3017	3005	4091	3460	3003	2350	2284	1086	2878	368	174	712	16
12	201-300	2170	505	512	2361	4654	2115	636	1201	1295	1195	2042	2127	1082	845	1468	378	1222	1510	1524	1965	1585	569	1060	169
13	201-300		66	64	89	38	136		28	687	554	1580	1465	43	620	217	23	230	689	691	373	1080	149	80	56
14	201-300	618	375	623	995	2543		679	792	1076	426	3034	1717	689	843	2014	303	726	2155	923	1481	1593	215	305	460
15	201-300	963	451	855	2004	3605	2292	1078	1370	1278	478	2575	1156	1753	837	1108	483	993	1039	1539	1597	1944	649	824	407
16	301-400	777	253	355	179	420	139	49	57	237	168	515	172	464	375	506	92	696	1099	840	526	136	145	188	208
17	301-400						35										3		5	196	56	33	2		
18	301-400						175			43	9			6		44		42	42	115	8	10	3	20	
19	301-400	134	359		792	388		118	467	397	404	887	109	121	229	311	61	366	402	173	187	61	278	77	172
20	401-500																	6	250	29	20	7	1	0	39
28	401-500																	52	130	175	54	71	26	6	11
33	401-500																		5		0	0	7		
21	501-600																		0			0	0		0
34	501-600																	13		0	1	0			0
29	501-600																								1
32	501-600																								0
22	601-700																						0		
30	601-700																								0
<140		0.0%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	0.3%	5.7%	4.2%	12.9%	16.8%	24.2%	30.2%	35.6%	40.8%	25.9%	21.0%	16.3%	6.5%	0.4%	2.4%	2.1%	0.1%

¹codend mesh-size 40 mm

²codend mesh-size 25 mm liner

Table 3. 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 ²	295 ¹	16				10 ¹				
Cuba							119	46 ¹	1037 ¹	1537 ¹	1462 ¹	969 ¹	964 ¹	1126 ¹	446 ¹	11		
EU/Estonia		1081	2092	1900	3240	5694	10835 ¹	13256 ²	9851 ¹	14215 ²	12851 ¹	13444 ¹	12009 ¹	8466 ²	10607 ²	10255 ²	2078 ¹	254 ¹
EU/Denmark	800	400	200			437	235		93 ¹	359 ¹								
EU/Latvia		300	350	1940	997 ¹	1191 ¹	3080 ¹	3105 ¹	2961 ¹	1892 ¹	3533 ¹	3059 ¹	2212 ¹	1330 ¹	1939 ¹	1285 ¹	1194 ¹	610 ¹
EU/Lithuania		1225	675	2900	1785 ¹	3107 ¹	3370 ¹	3529 ¹	2701 ¹	3321 ¹	3744 ¹	4802 ¹	3652 ¹	1245 ¹	1992 ¹	485 ¹		102 ¹
EU/Poland					824	148 ¹	894 ¹	1692 ¹	209 ¹			1158 ¹	458 ¹	224 ¹				
EU/Portugal	300		150		170 ¹	203 ¹	227 ¹	289 ¹	420 ¹	16 ¹		50 ¹					3	
EU/Spain	240	300	158	50	423 ¹	912 ¹	1020 ¹	1347 ¹	855 ¹	674 ¹	857 ¹	1049 ²	725 ²	997 ²	768 ¹	406 ²	537 ¹	298 ²
EU/United Kingdom											547 ¹							
Faroe Is.	7333	6791	5993	8688	7410	9368	9199	7719 ²	10228 ²	8516 ²	12676 ²	4952 ¹	2457 ¹	1102 ¹	2303 ¹	1201	1349 ¹	495 ¹
France (SPM)					150			138 ¹	337 ¹	161 ¹			487		741 ¹		193 ¹	
Greenland	3788 ¹	2275 ¹	2400 ¹	1107 ¹	104 ¹	866 ¹	576 ¹	1734 ¹		644 ¹	1990 ²		12 ¹	778 ²				
Iceland	2243	2355 ¹	7623	20680 ¹	7197 ¹	6572 ¹	9277 ²	8912 ²	5265 ²	5754 ¹	4715 ¹	3567 ¹	4014 ¹	2099 ¹				
Japan								114 ¹	130	100 ¹	117 ¹							
Norway	7183	8461	9533	5683	1831 ¹	1339 ¹	2975 ¹	2669 ²	12972 ¹	11833 ¹	21238 ¹	11738 ¹	223 ¹	890 ²	1914 ¹	321 ²		
Russia		350	3327	4445	1090		1142	7070 ¹	5687 ¹	1176 ¹	3 ¹	654 ¹	266 ¹	46 ¹	73 ¹	21 ¹	20 ¹	7 ¹
Ukraine									348 ¹		237 ¹	315 ¹		282 ¹				
USA								629 ¹										
Total	25611	24579	33471	48299	26028	30321	43439	52867	53389	50214	63970	45757	27479	18595	20741	13985	5374	1766

¹ NAFO Statland 21 A² From the fisheries biologist of respective countries

Table 4.- Exploitation Rate of Shrimp (Div. 3M) as Nominal Catches (tons) divided by UE Survey Index (tons).

Year	Nominal Catches	UE Survey Female 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	18595	11359	1.6
2007	20741	12843	1.6
2008	12889	8630	1.5
2009	5286	1764	3.0
2010	1766	3818	0.5
2011*	0	1231	0

*moratorium on fishing shrimp in 3M

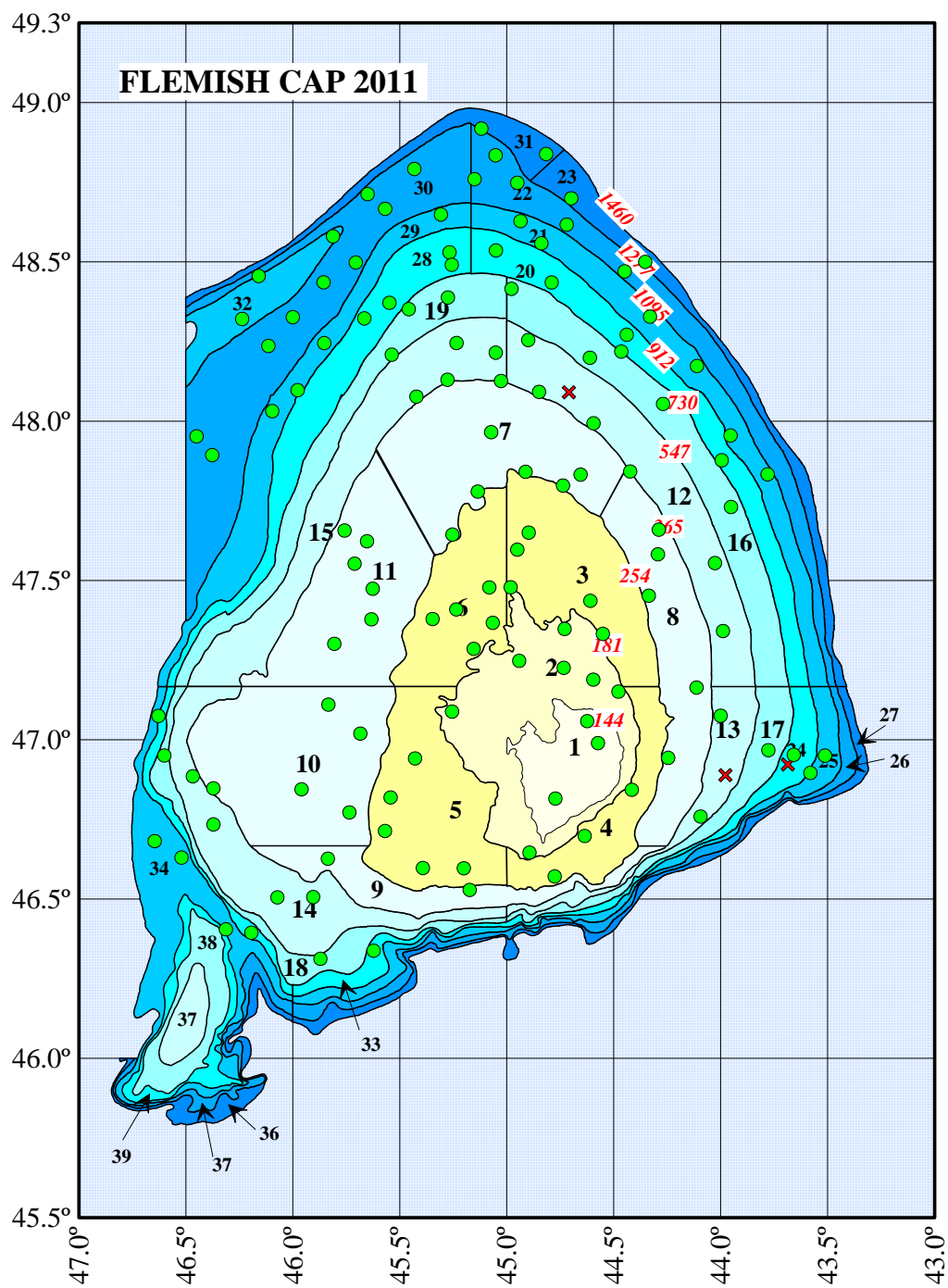


Figure 1. The NAFO 3M stratification scheme used in EU research bottom trawl survey showing the sets carried out in 2011.

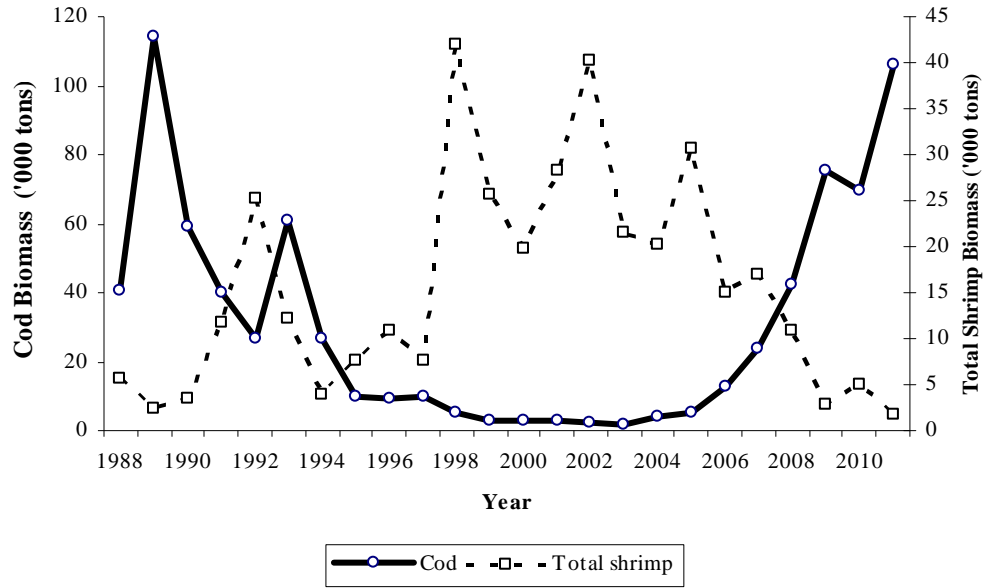


Figure 2. EU survey cod biomass (gross solid line) and total shrimp biomass (dashed line) in the years 1988-2011 on Flemish Cap.

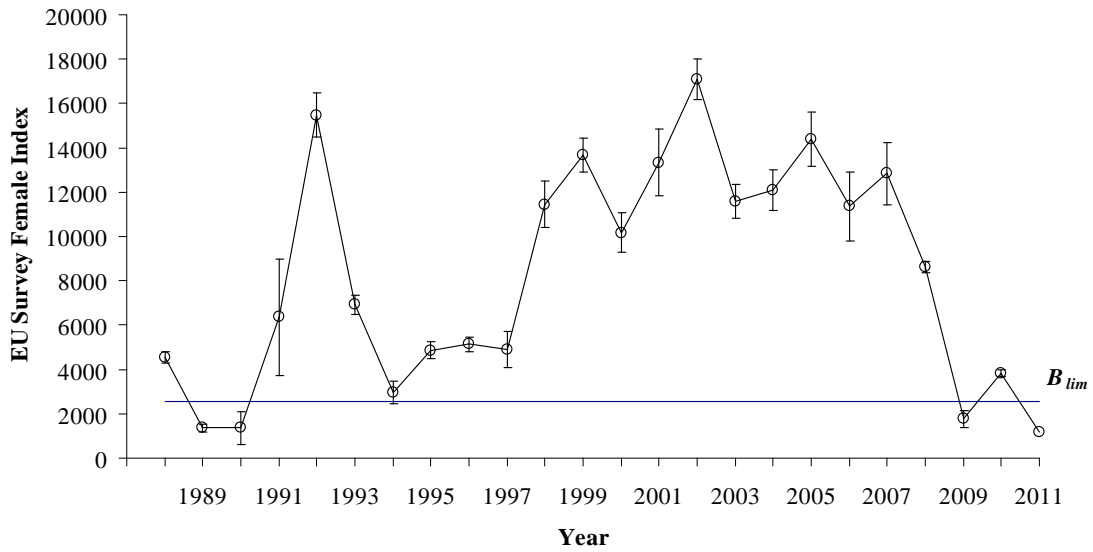


Figure 3. EU survey female shrimp biomass in the years 1988-2011 on Flemish Cap and B_{lim} proxy of 3M shrimp stock.

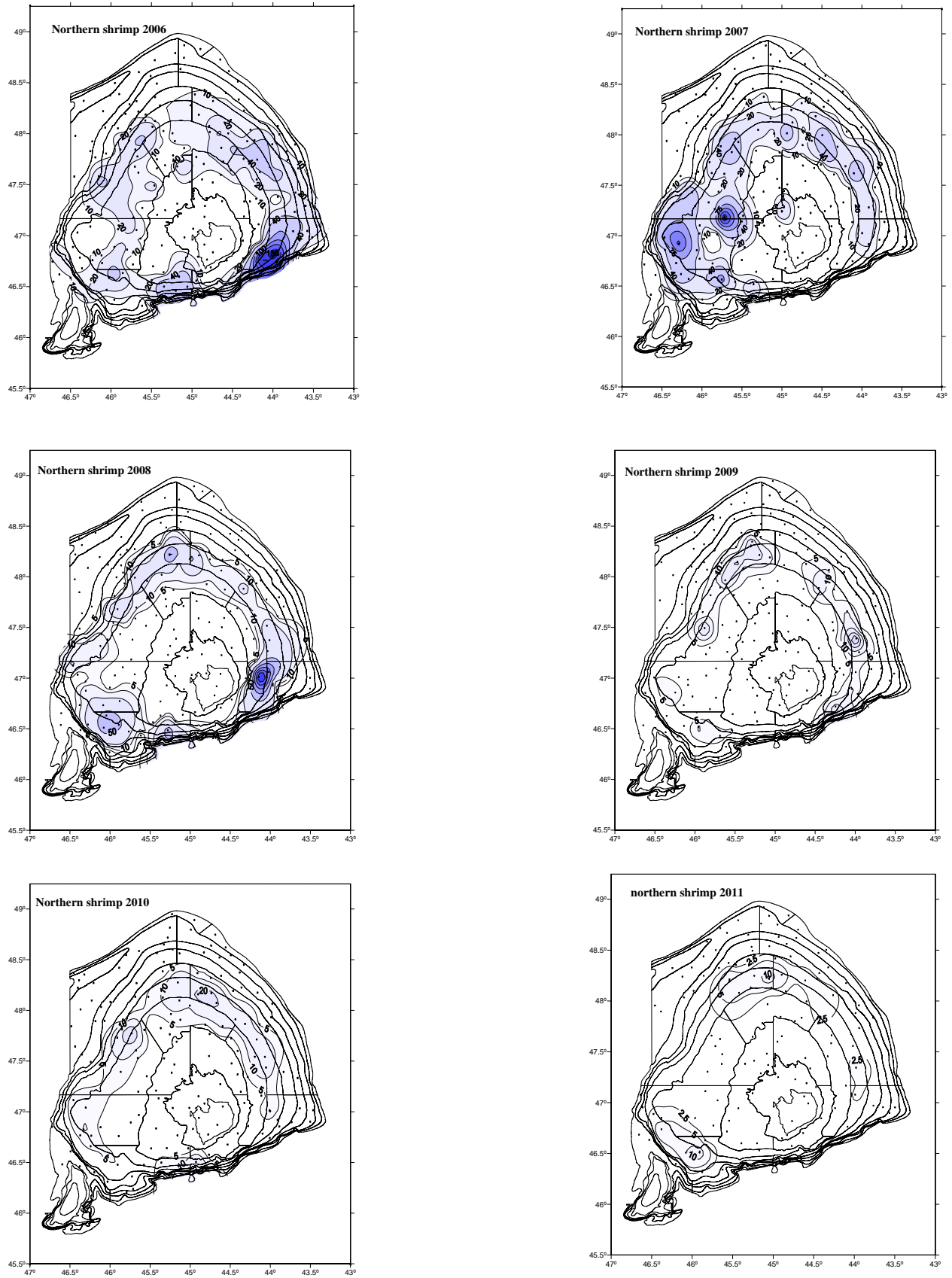


Figure 4.- Distribution of NAFO Div. 3M Northern shrimp (*Pandalus borealis*) catches kg/tow as obtained from EU research bottom trawl surveys conducted over the period 2006-2011.

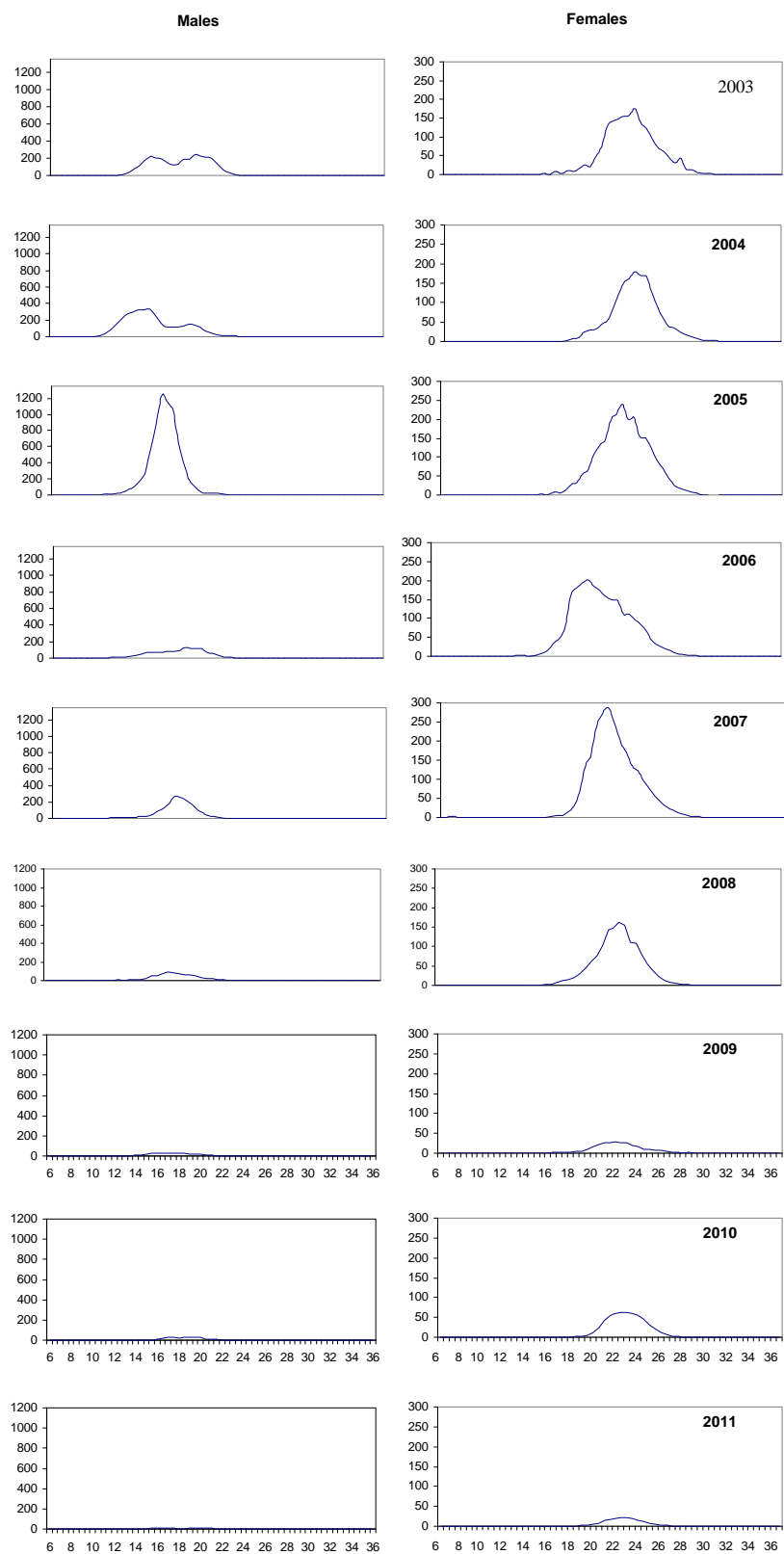


Figure 5. Shrimp size distribution from Flemish Cap 2003-2011 surveys.
Y-Axis=Frequency (10^6), X-Axis=Carapace Length (mm).

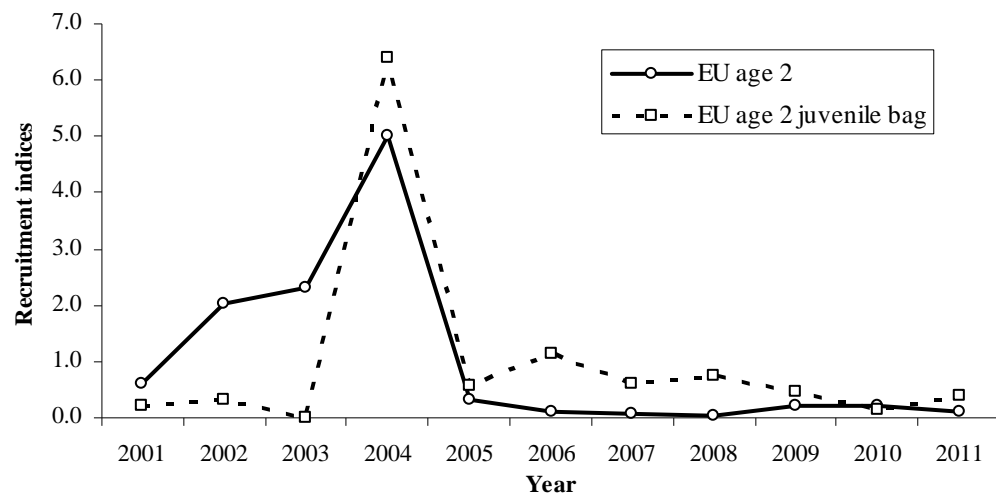


Figure 6. Abundance indexes at age 2 obtained in EU Flemish Cap surveys from Lofoten gear (black line) and Juvenile bag (dotted line).

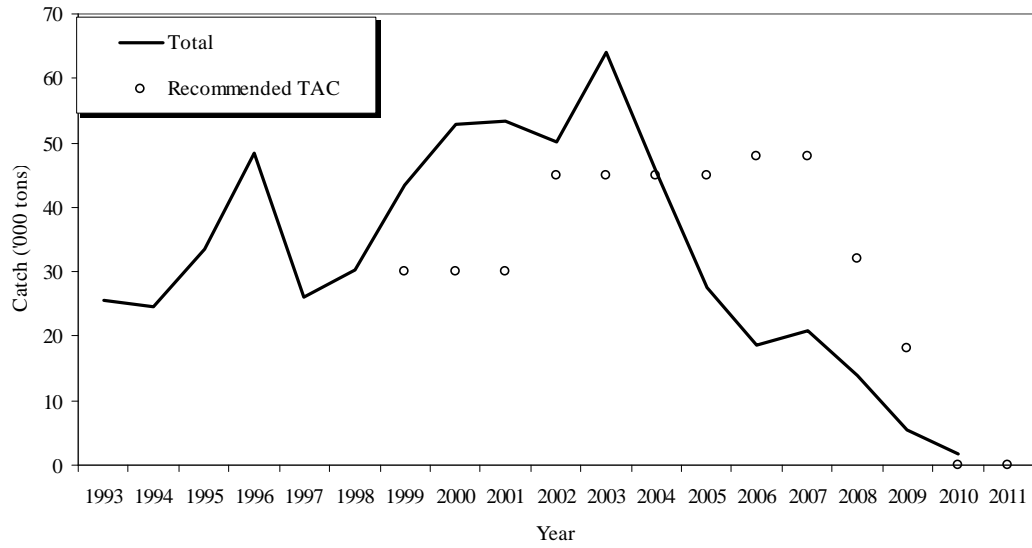


Figure 7. Trends in NAFO Div. 3M northern shrimp (*Pandalus borealis*) catch (t) and TAC over the period 1993-2011.

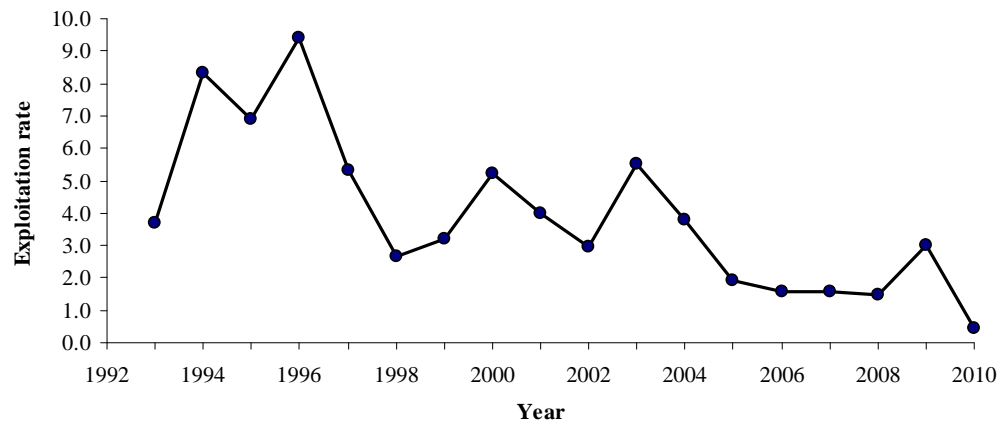


Figure 8. Exploitation rates as nominal catch divided by the EU survey biomass index of the same year.