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Icelandic Shrimp Fishery (*Pandalus borealis* Kr.) at Flemish Cap in 1993-2006

by

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Abstract

One Icelandic vessel went fishing for shrimp in the waters at Flemish Cap in 2004 through 2006 as compared to three in 2003. In this paper there is logbook information on the Icelandic fishery for the years 1993 through 2006. The catch rate of Icelandic vessels in January-September which was very high in the years 2001-2003 decreased or from about 290 kg/hour to 250 kg/hr in 2004, to increase to 387 kg/hour in 2006. Due to misreporting the value for 2006 is considered an over estimate. The fishery is now taking place mainly in the northern part of the Flemish Cap area. The biological samples show that the 2001 year-class is above average in all months of both 2004 and 2005. The samples also show that the 2002 year-class which appeared late in 2003 is very apparent as 2 year olds in 2004, three year olds in 2005 and in 2006 it turns out to be very strong as four year olds. In 2005 the presence of a 2 year old (2003 year-class) is hinted in a few months of the year. There does not seem to be any 2 year olds in 2006 pointing to the 2004 year-class being very poor.

Introduction

The Spanish investigators (EU) have been measuring the biomass index of northern shrimp at the Flemish Cap since 1988 in their annual bottom trawl survey at Flemish cap. In 1993 the fishery was initiated by Canada, followed closely by Faroe Islands and Iceland.

The fishery was some 24-33 thousand tons in the years 1993-1995 to increase in 1996 to 48 thousand tons. Since then the fishery decreased to some 25 thousand tons in 1997. The total catch of all countries has since increased to about 63 thousand tons in 2003 and have decreased there after to 32 000 tons in 2005. Iceland has been catching a fair deal of the catch in some previous years. In later years however the catch has decreased substantially due to low prizes in shrimp and high prize of oil. In June 2006 the last Icelandic vessel fishing on Flemish Cap was sold.

In this paper all the information from the Icelandic side is gathered. From the logbooks come effort, catch and size of trawl. From this CPUE is calculated. From the biological samples taken by Icelandic observers come various information on length and sex distribution of shrimp as well as deviations from a long time average length frequency distribution.

Materials and Methods

The logbook data include catch and effort. Sometimes information on landings as obtained from the Fisheries Directorate in Iceland exceeds the logbook information. The effort is then raised by dividing the nominal catch of each month/half year with the calculated CPUE from the logbooks. The overall CPUE of the January-July was then obtained by summing nominal catch of all months and corresponding effort. Nominal catch for the whole period was then divided by "nominal effort" to get the CPUE for the period January-July. When twin trawls were used the

effort was always multiplied by 1.9 for those but the catch was kept the same. The same method was applied to the period January-September.

For calculation of CPUE to the standard size of trawl of 3 000 meshes, the catch and effort of a period like January to July was calculated in the manner described above. At the same time the average size of trawl (no. of standard meshes (40 mm) in circumference of the belly), be it single or double was calculated. The CPUE for trawl size 3 000 meshes was then considered to be proportional to the mean size of trawl in the same period.

Icelandic observers have sampled shrimp onboard Icelandic vessels since 1996 at Flemish Cap. The shrimp was measured fresh to the nearest 0.5 mm using Vernier calipers. Observers then sorted each length class into males and females using the method of Rasmussen (1953) and the females further into primiparous and multiparous using the sternal spine criterion of McCrary (1971). The multiparous females were sorted further into classes were females were without any special distinction, green in head, ovigerous without eyes, ovigerous with eyes. There was also a look for ovigerous with eyes and green in head at the same time. In this paper the three main sex categories presented are: males, primiparous females (including transitionals) and multiparous females.

The deviatons from an overall mean length frequency distribution (lfd) are calculated using data from Canada, Faroe Islands and Iceland for the years 1993-1995. From 1996-2006 there are only Icelandic data. The basic unit is a promille length frequency distribution for each month where all the samples of that month are compiled. Then a mean overall promille lfd for say April months for all the years 1993-2005 is calculated. From this the overall mean lfd of April is subtracted from the lfd of April in 1993 and so on, every year (Fig. 9). What is unusual about each year appears as a deviation high or low. The positive modes are representative of stronger than usual year-classes. As each year-class is supposed to grow from one year to another, the positive mode one year moves to the right in the following year and so on.

Catch and Effort Data

In 2005 and 206 the fishery was carried out since January (Table 1). The catch in 2006 was 2 070 tons (Table 2). Iceland increased the total allowable catch (TAC) for Icelandic vessels from 6 800 tons in 1999, to about 10 000 tons for years 2000 to 2002 and to 13 500 for year 2003. In spite of this high TAC the total catch was only 5 300 tons in year 2001, 5 700 tons in 2002 and 4 700 in 2003. Iceland decreased the TAC in 2004 to 5 000 tons. Since 2004 there was only one vessel fishing for shrimp. The catch has decreased from 4000 tons in 2005 to 2 000 tons in 2006.

The distribution of effort around the Cap is shown by years in Fig. 1-5 for the years 1993 through 2006. There appears to be a lack of tows in the south east of Flemish Cap area in the last three years but in other years the distribution of tows is traditional. In 2006 the effort was mainly in the northern area and the skipper was set on catching the largest shrimp possible as usual (Fig. 4).

The mean CPUE for the year 1997 was the lowest ever for Iceland or 203 kg per trawling hour for the period January through September (Table 2). In 1998 the mean CPUE for the same period was much higher or 266 kg and decreased slightly in 1999 and 2000 to increase in 2001 and 2002 to 294 kg/hour. In 2003 the CPUE peaked in 291 kg/hour, decreased to 236 kg/hour in 2004 or to the level of the years 1998 to 2000. In 2005 the CPUE increased somewhat or to 284 kg/hour. In 2006 the CPUE of 387 kg/hr is considered an overestimate due to misreporting.

The average size of gear used was about 3 000 meshes in most years, but increased to about 3 500 meshes in the years 1999 to 2001 and to 4 460 meshes in 2004-2006. The trawl size being by far the largest in the series. So the unstandardized CPUE (no correction for size of trawl) of 2004 gives an impression of the shrimp stock being quite large and the raw CPUE of 2006 is 565 kg/hour or much higher than the highest catch per hour in the series. Therefore it makes more sense to look at CPUE at a standard trawl size. At the same time the use of twin trawls has increased from little less than 60% in 1995-1997 to about 99% in the years 2004-2006.

Length Frequencies and Age Groups

The length frequency distributions of Icelandic samples from 2005 through 2006 are shown by months in Fig. 5 and 6. The one year olds of the 2002 year-class were seen in September in year 2003 at about 12 mm CL (Skuladottir, 2005). This 2002 year-class is also very prominent in years 2005-2006 (Fig. 5 and 6).

The deviation method (Sund, 1939; Skuladottir, 1981) is very useful in detecting year-classes and can be of great aid in assessing age when it comes to applying the modal analysis. The major drawback of the modal analysis is the fact that it does not tell you how many components there should be in a lfd. and sometimes there is e.g. no difference in fitting 3 components when there should indeed be 4. From the Fig. 7 to 17 it is possible to study the deviations as positive peaks and occasionally as a peak that is just below the mean line like in Fig. 16 the 2 year olds of November 2001.

The aforementioned 1999 year-class is first seen as a positive peak in August 2001 as a 2 year old (Fig. 13). In year 2003 the most prominent peak is that of the 1999 year-class as four year olds in all months from March and onwards (no samples in January and February). In 2004 one can still see the positive deviation of the 1999 year-class, 5 years old, at around 22 mm in February (Fig. 7). In June the 5 year-old can be guessed at the length of 24 mm. A drawback of the method as in all length based age assessments is when growth slows down there is a fusion with the adjacent year-classes which then form a single peak that may be broader than it should be. The 2000 year-class is weaker than the 1999 year-class and appears to fuse together with it in 2003. This is also shown by the deviation method. The very strong 2002 year-class can be detected in the years 2004-2006.

From the deviations in Fig. 7-17 it has been attempted to follow the various year-classes and the mean length of each is assessed by eye from the deviations. So e.g. the 1993 year-class which was quite strong can be seen first as 2 year old in March 1995 at the CL 14 mm. In the last two years one year olds are detected for the first time as deviations. These are the 2001 and 2002 year-classes at 12.5 to 13.8 mm in the months September through December (Fig. 14 to 17). By assuming 2-3 mm growth per year positive deviations are seen to move to the right with years. The mean lengths of the modes can be used as inputs when assessing age be modal analysis.

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Table 1. Catch (tons) effort (trawling hours *1.9 when double trawl) and unstandardized CPUE (kg/hr) of Icelandic vessels at Flemish Cap.

	January - July				August - December			
Year	Month	CPUE	Effort	Catch	Month	CPUE	Effort	Catch
1993					Aug	320.4	1334	427.4
					Sep	349.8	1034	361.7
					Oct	231.7	334	77.4
	Jun	380.2	1767	671.8	Nov	306.8	588	180.4
	Jul	342.4	1097	375.6	Dec	236.5	537	127.0
	Subtotal	365.7	2864	1047.4	Subtotal	306.7	3827	1173.9
	Total	365.7	2918	1067.0	Total	306.7	3834	1176.0
1994	Jan	228.5	144	32.9	Aug	175.3	1657	290.4
	Feb	371.8	510	189.6	Sep	126.9	476	60.4
	Mar	295.5	531	156.9	Oct	125.4	492	61.7
	Jun	256.4	1297	332.5	Nov	115.5	181	20.9
	Jul	212.9	2653	564.8	Dec	75.0	8	0.6
	Subtotal	248.6	5135	1276.7	Subtotal	154.2	2814	434
	Total	248.6	6693	1664.0	Total	154.2	4123.742	636
1995	Feb	280.0	65	18.2	Aug	178.0	4869	866.9
	Mar	246.8	711	175.5	Sep	134.1	2928	392.5
	Apr	149.9	1487	222.9	Oct	166.3	2088	347.2
	May	260.1	2617	680.7	Nov	144.4	1074	155.1
	June	248.9	3733	929.2	Dec	174.5	740	129.1
	Jul	249.5	6625	1653.0				
	Subtotal	241.5	15238	3679.5	Subtotal	161.6	11699	1890.8
	Total	241.5	16932	4088.5	Total	161.6	21868.49	3534.4
1996	Jan	207.2	1755	363.7	Aug	165.4	8156	1349.4
	Feb	251.7	1326	333.7	Sep	167.1	8089	1351.7
	Mar	261.8	4604	1205.1	Oct	129.7	5482	711.2
	Apr	211.2	10754	2271.2	Nov	137.9	1456	200.8
	May	189.1	12749	2410.2	Dec	158.1	253	40.0
	Jun	202.5	13933	2821.5				
	Jul	235.9	11963	2821.5				
	Subtotal	214.2	57084	12226.9	Subtotal	155.9	23436	3653.1
	Total	214.2	64760	13871.0	Total	155.9	43688.69	6810.0
1997	Jan	175.8	413	72.6	Aug	206.7	4252	879.0
	Feb	214.7	621	133.3	Sep	202.4	3476	703.6
	Apr	135.0	514	69.4	Oct	222.0	2519	559.1
	May	141.4	3736	528.2	Nov	192.5	1039	200.0
	Jun	167.7	5386	903.2	Dec	176.9	429	75.9
	Jul	209.2	5802	1213.7				
	Subtotal	177.3	16472	2920.4	Subtotal	206.4	11715	2417.6
	Total	177.3	19478	3453.3	Total	206.4	14681	3029.6
1998 *	Feb	217.2	297	64.5	Aug	256.4	3184	816.3
	Mar	206.8	812	167.9	Sep	184.5	5028	927.5
	Apr	229.5	880	202.0	Oct	196.3	3612	708.9
	May	261.4	2820	737.2	Nov	204.6	1761	360.3
	Jun	330.7	3537	1169.7	Dec	222.5	644	143.3
	Jul	285.3	4117	1174.7				
	Subtotal	282.1	12463	3516.0	Subtotal	207.8	14229	2956.3
	Total	282.1	12657	3570.8	Total	207.8	14446.55	3001.5
1999 *	Feb	350.5	382	133.9	Aug	250.8	3642	913.4
	Mar	289.4	1851	535.7	Sep	235.5	1371	322.9
	Apr	253.0	3483	881.2	Oct	255.6	2150	549.6
	May	249.5	5941	1482.3	Nov	256.2	2173	556.8
	Jun	285.8	5993	1712.7	Dec	230.6	989	228.1
	Jul	280.4	5224	1464.6				
	Subtotal	271.5	22874	6210.4	Subtotal	249.0	10325	2570.8
	Total	271.5	24009	6518.6	Total	249.0	10837	2698.4
2000 *	Jan	263.8	1050	277.0	Aug	244.9	2357	577.1
	Feb	280.5	2206	618.8	Sep	239.0	2134	510.2
	Mar	306.3	3297	1009.8	Oct	274.8	1787	491.1
	Apr	280.7	4378	1229.0	Nov	256.1	2984	764.3
	May	231.9	4943	1146.6	Dec	267.5	798	213.5
	Jun	304.3	3679	1119.6				
	Jul	250.1	3064	766.4				
	Subtotal	272.7	22618	6167.2	Subtotal	254.1	10060	2556.2
	Total	272.7	22618	6167.2	Total	254.1	11051	2807.8

	January - July				August - December			
Year	Month	CPUE	Effort	Catch	Month	CPUE	Effort	Catch
2001 *	Jan	285.9	538	153.7	Aug	292.6	2094	612.9
	Feb	299.9	1593	477.6	Sep	277.3	1160	321.6
	Mar	303.6	2174	660.0	Oct	267.5	1563	418.1
	Apr	239.6	45	10.8	Nov	253.4	1210	306.6
	May	271.1	917	248.7	Dec	500.8	404	202.5
	Jun	282.9	2777	785.6				
	Jul	296.5	2992	887.2				
	Subtotal	292.1	11036	3223.6	Subtotal	289.5	6431	1861.7
	Total	292.1	11036	3223.6	Total	289.5	7178	2077.8
2002 *	Jan	292.6	372	108.9	Aug	311.7	1739	542.0
	Feb	343.4	705	242.0	Sep	313.2	1054	330.0
	Mar	264.6	1786	472.4	Oct	234.7	923	216.7
	Apr	305.7	2056	628.4	Nov	312.9	559	174.9
	May	330.8	2439	806.6	Dec	359.9	437	157.1
	Jun	346.0	2113	731.1				
	Jul	444.6	1241	551.7				
	Subtotal	330.6	10710	3541.1	Subtotal	301.6	4711	1420.7
	Total	330.6	10711	3541.1	Total	301.6	7296	2200.3
2003 *	Jan	384.3	162	62.1	Aug	395.9	956	378.6
	Feb	422.0	715	301.8	Sep	291.6	818	238.5
	Mar	565.1	1303	736.3	Oct	352.4	941	331.6
	Apr	430.9	967	416.5	Nov	333.4	727	242.4
	May				Dec	606.8	354	214.8
	Jun	329.7	925	305.1				
	Jul	287.6	85	24.5				
	Subtotal	444.2	4157	1846.3	Subtotal	370.3	3796	1405.9
	Total	444.2	6041	2683.3	Total	370.3	5791	2144.7
2004 *	Jan	251.5	403	101.2	Aug	417.2	763	318.2
	Feb	293.3	892	261.5	Sep	291.5	818	238.5
	Mar	267.9	974	261.0	Oct	328.4	936	307.4
	Apr	280.2	1044	292.6	Nov	371.3	928	344.6
	May	315.1	1089	343.0	Dec	606.1	354	214.8
	Jun	403.5	1015	409.5				
	Jul	386.9	967	374.3				
	Subtotal	320.1	6383	2043.0	Subtotal	374.7	3799	1423.5
	Total	320.1	6383	2043.0	Total	374.7	4067	1524.0
2005*	Jan	157.9	4	0.6	Aug	511.0	954	487.5
	Feb	284.4	988	281.0	Sep	523.3	626	327.7
	Mar	344.2	933	321.1	Oct	378.7	840	318.3
	Apr	339.9	969	329.4	Nov	450.0	892	401.6
	May	442.9	860	380.9	Dec	856.2	254	217.3
	Jun	431.7	943	407.1				
	Jul	449.5	994	446.8				
	Subtotal	380.8	5691	2166.9	Subtotal	491.3	3567	1752.4
	Total	380.8	5848	2226.9	Total	491.3	3637	1787.1
2006*	Jan	734.3	441	324.0				
	Feb	706.9	478	337.6				
	Mar	879.6	363	319.0				
	Apr	392.1	776	304.2				
	May	384.3	929	357.0				
	Jun	870.4	147	127.6				
	Subtotal	564.8	3133	1769.3				
	Total	564.8	3467	1958.0				

Table 2. Nominal catch for the whole year and some averages calculated from the Icelandic logbooks to show trends in CPUEs and size of circumference of trawl. In calculations of CPUE the effort of twin trawls is multiplied by 1.9. The adjusted CPUE of January-July and January-September to that of 3 000 meshes trawl are high lighted.

Year	Nominal Catch Tons	Twin trawls % of catch	Mean trawl size No. of meshes January -July	Unstandardized CPUE January-July	**CPUE at size 3000 trawl January-July**	Mean trawl size No. of meshes January-Sept	Unstandardized CPUE January-Sept	**CPUE at size 3000 trawl January-Sept.**
1993	2 243	43.4	3063	373	**363**	3102	356	**344**
1994	2 300	54.4	2994	238	**240**	2951	216	**219**
1995	7623	38.2	2779	254	**283**	2733	228	**251**
1996	20681	42.9	2803	206	**218**	2813	198	**211**
1997	6483	53.4	2780	188	**192**	2921	198	**203**
1998	6572	74.8	3016	288	**294**	2974	264	**266**
1999	9217	70.6	3441	280	**252**	3402	276	**243**
2000	8978	81.4	3528	287	**245**	3528	282	**240**
2001	5301	63.0	3571	328	**290**	3518	325	**289**
2002	5741	73.6	3713	370	**305**	3713	363	**294**
2003	4695	92.6	3949	367	**302**	4004	358	**291**
2004	3567	98.9	4460	320	**227**	4460	332	**236**
2005	4014	99.0	4460	381	**260**	4460	423	**284**
2006	2072	99.0	4460	565	**387**			
Mean 93-2006	7079	70	3501	318	**276**	3429	294	**259**

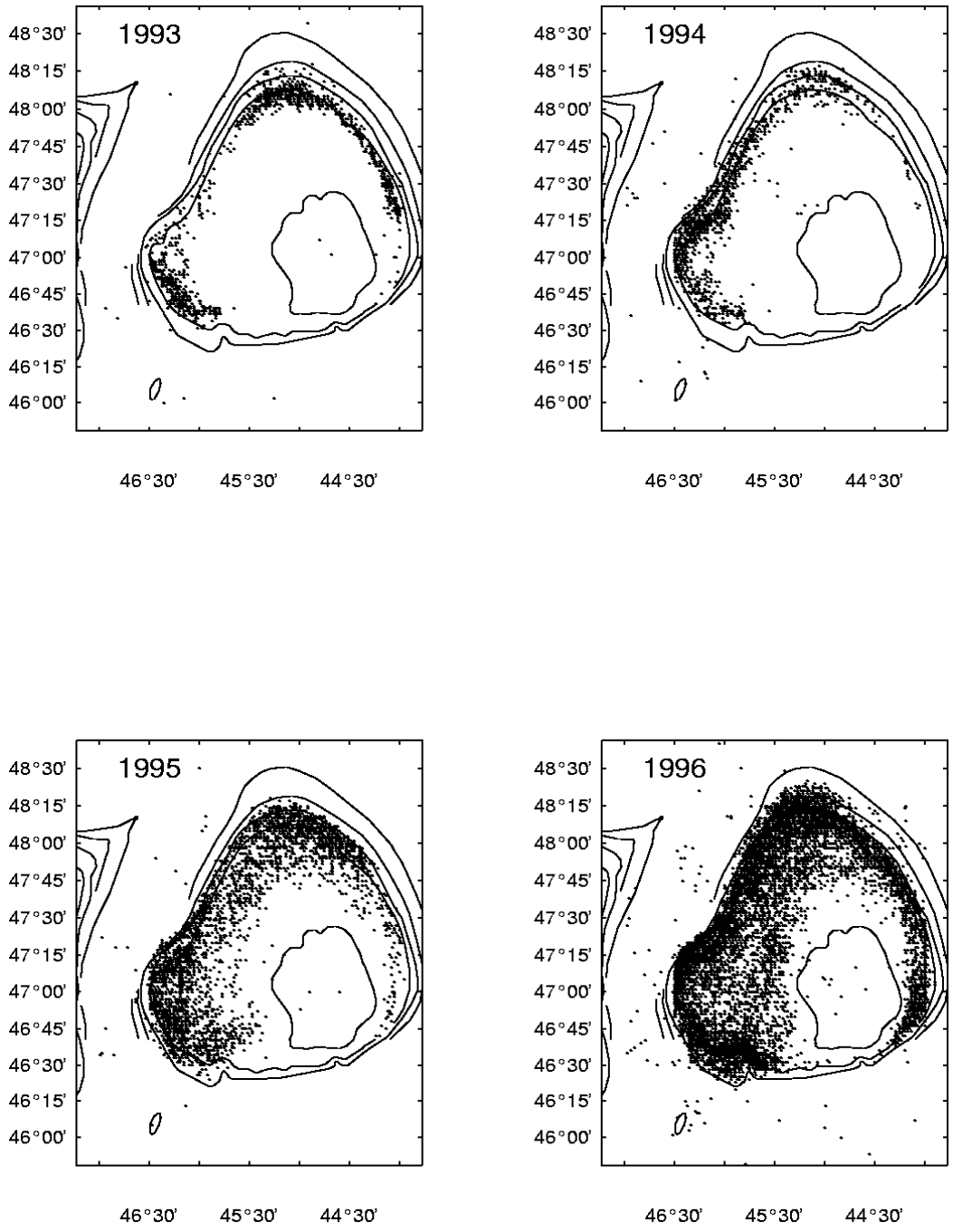


Fig. 1. Towing positions of the Icelandic fleet on Flemish Cap by years.

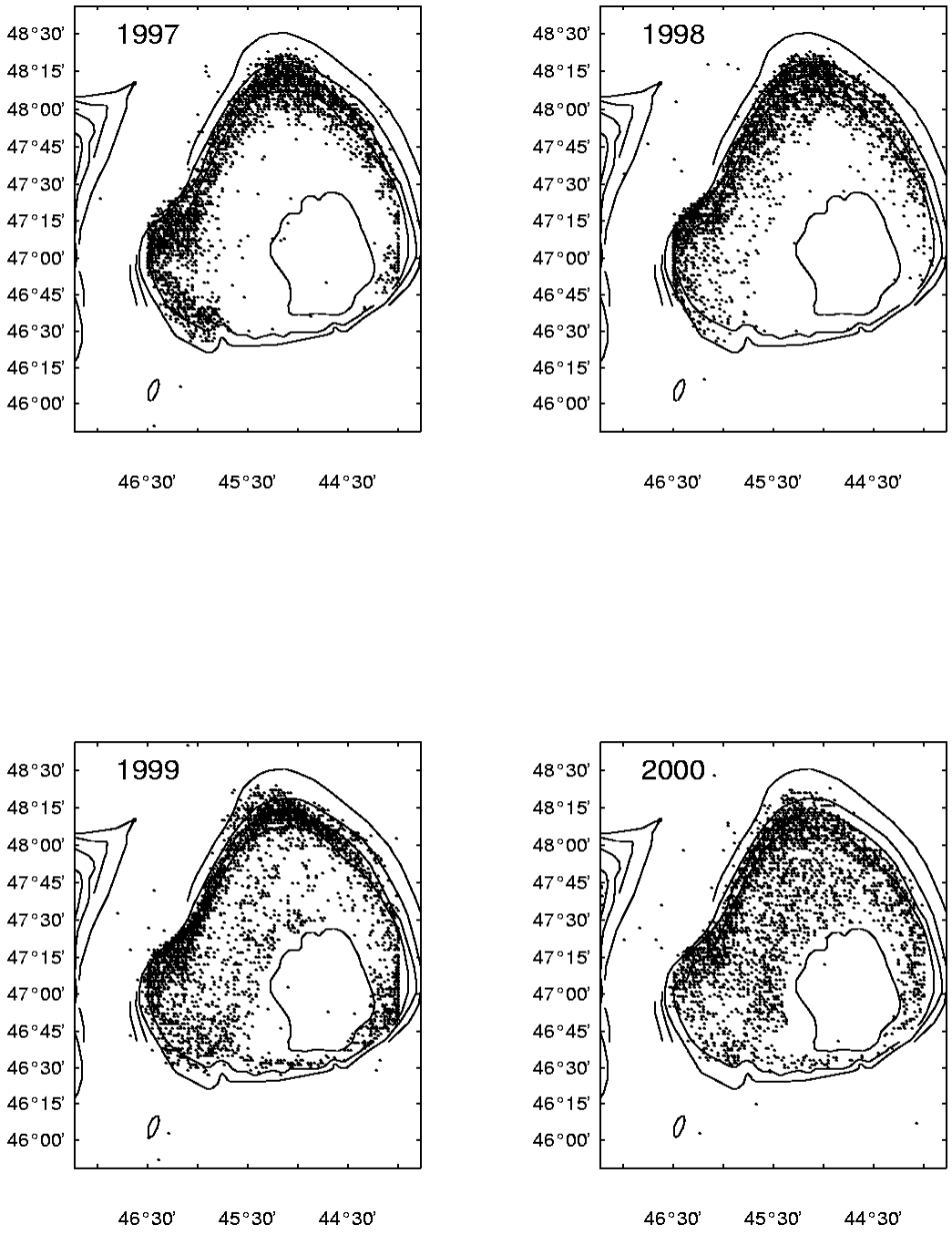


Fig. 2. Towing positions of the Icelandic fleet on Flemish Cap by years.

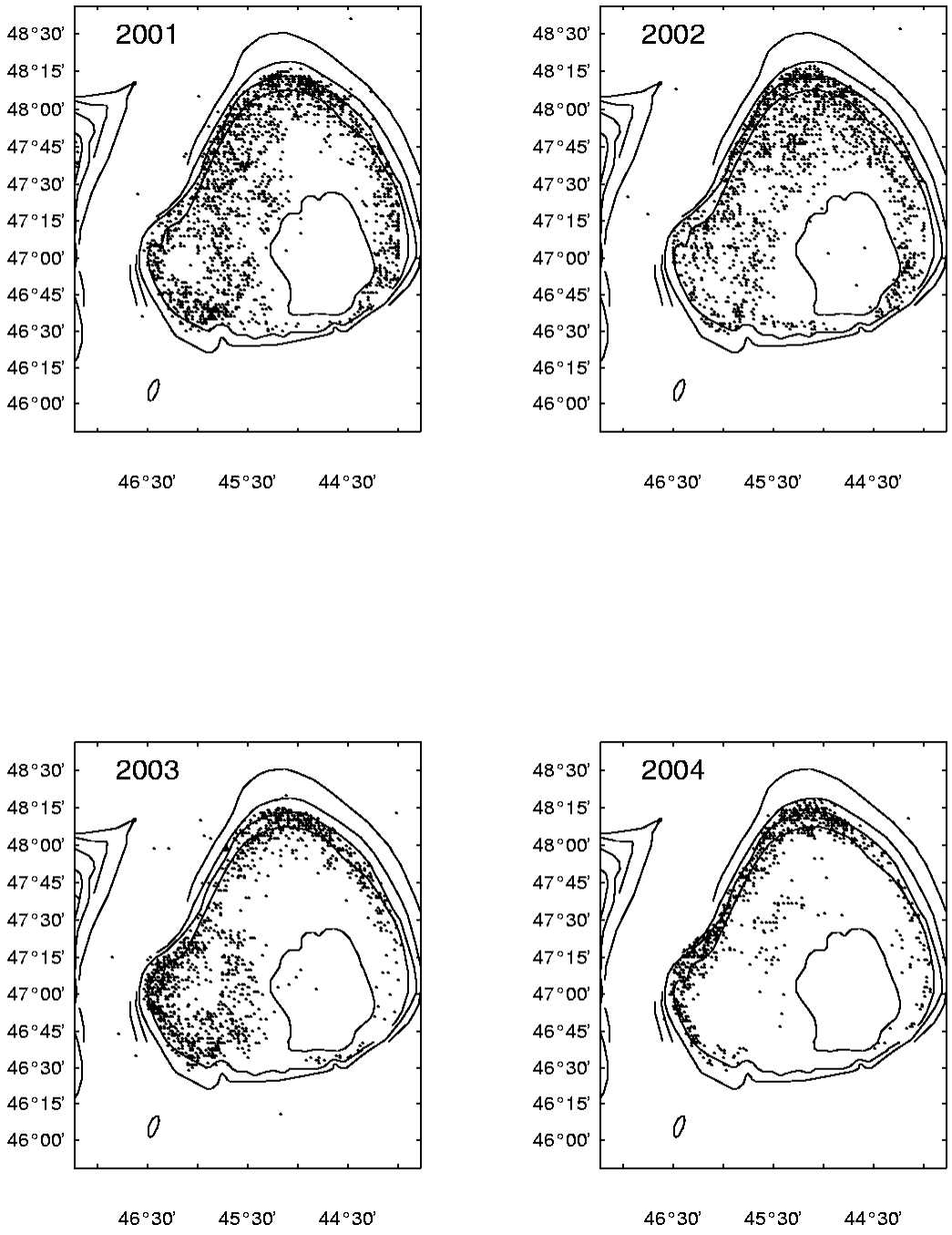


Fig. 3. Towing positions of the Icelandic fleet on Flemish Cap by years.

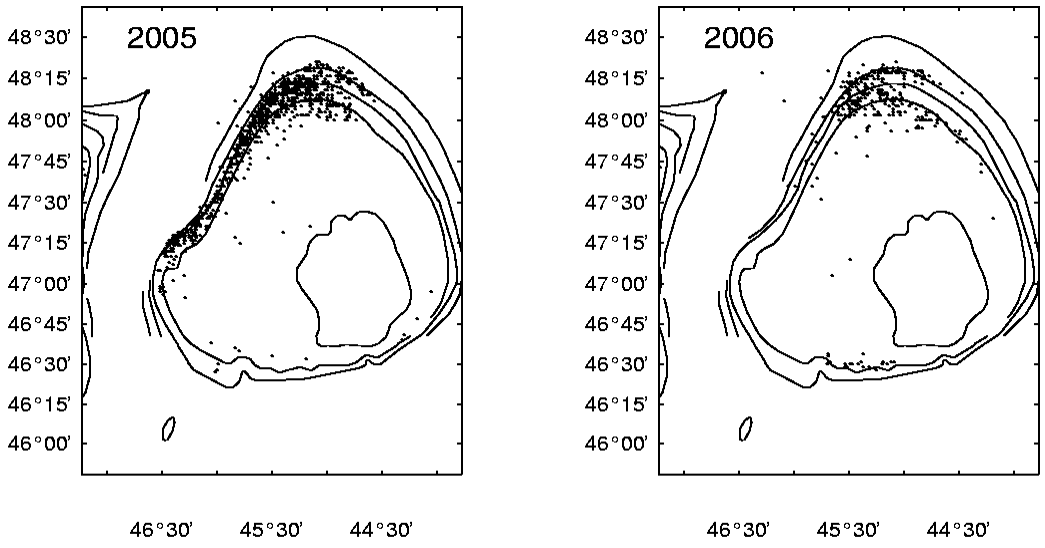


Fig. 4. Towing positions of the Icelandic fleet on Flemish Cap by years.

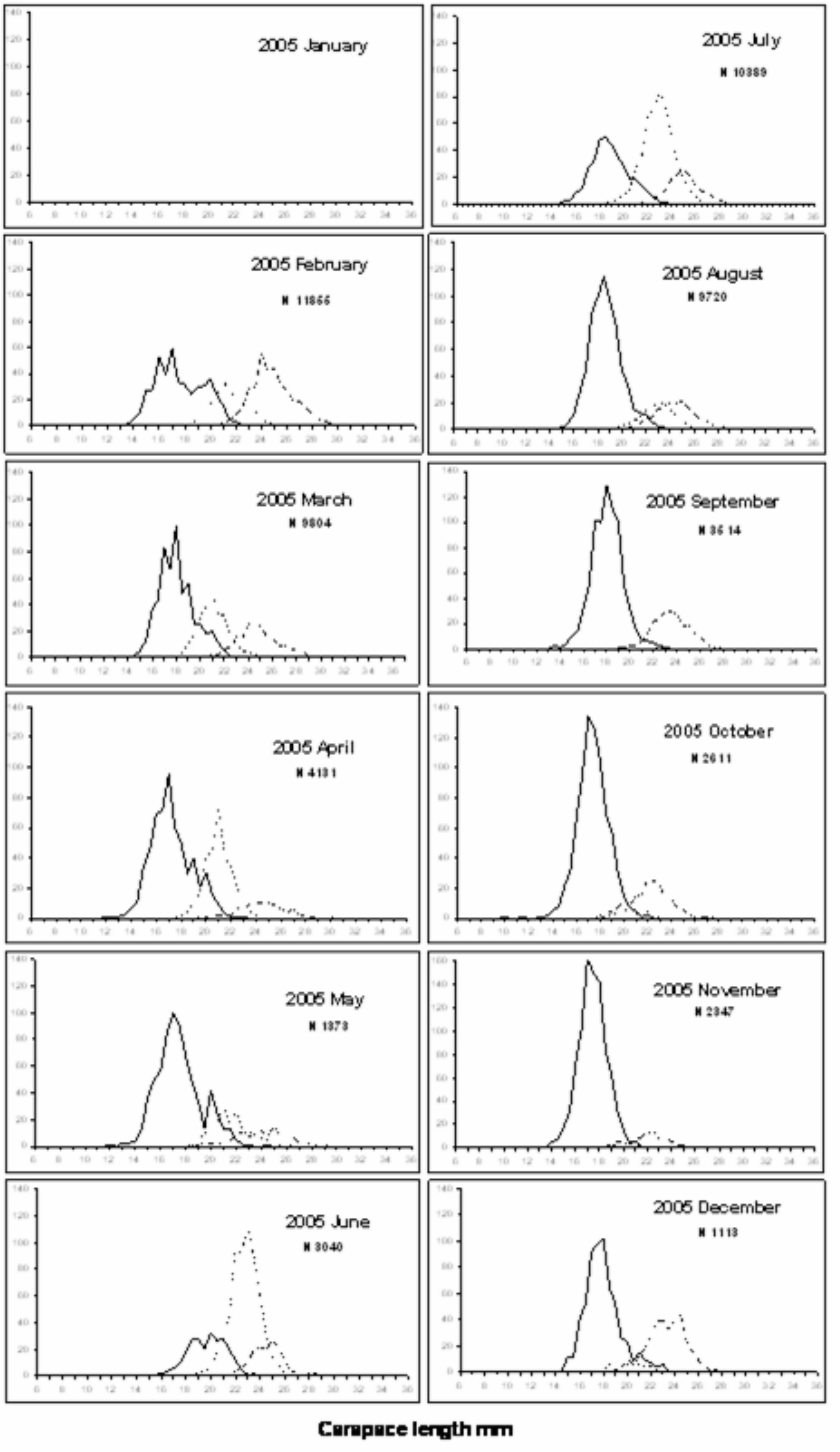


Fig. 5. Length frequency distribution of northern shrimp at Flemish Cap by months in 2005.

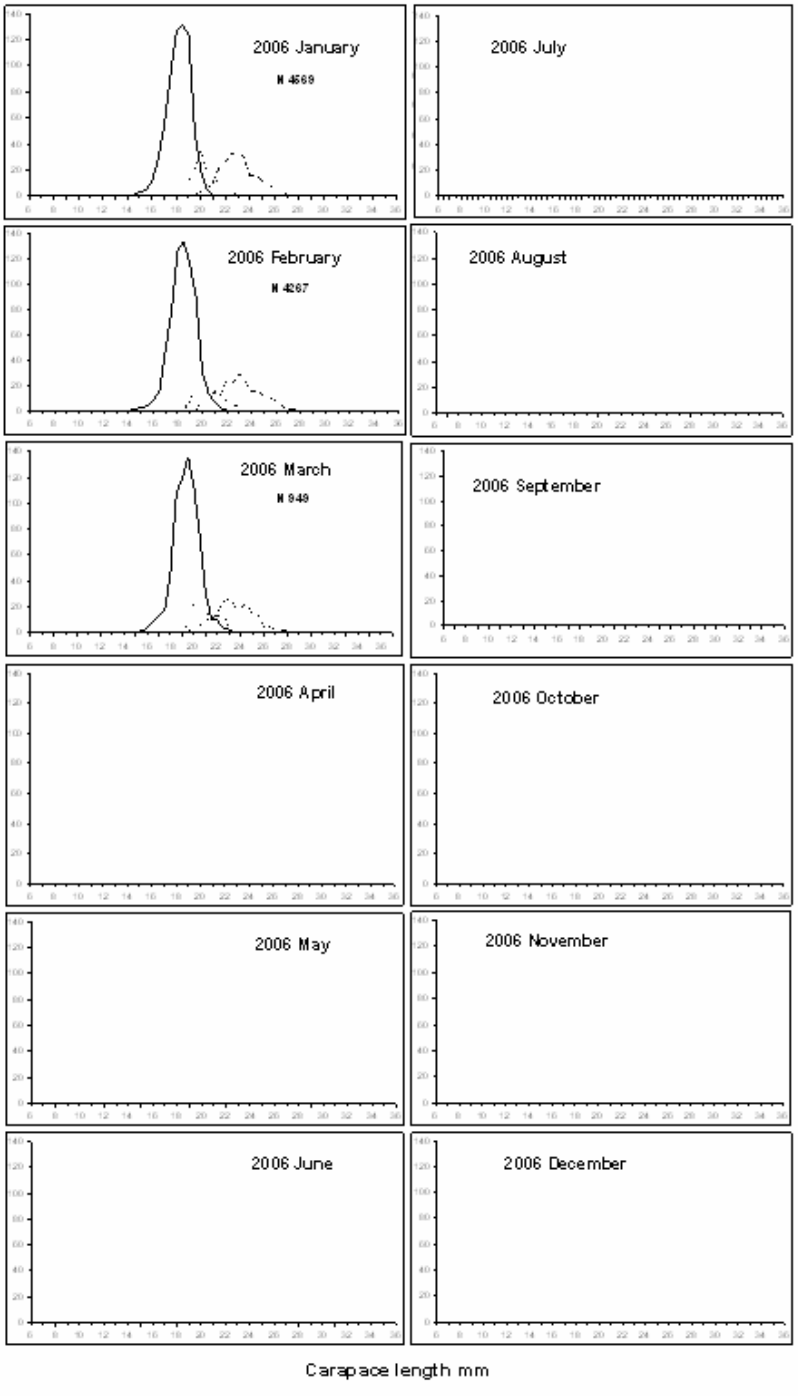


Fig. 6. Length frequency distribution of northern shrimp at Flemish Cap by months in 2005.

February

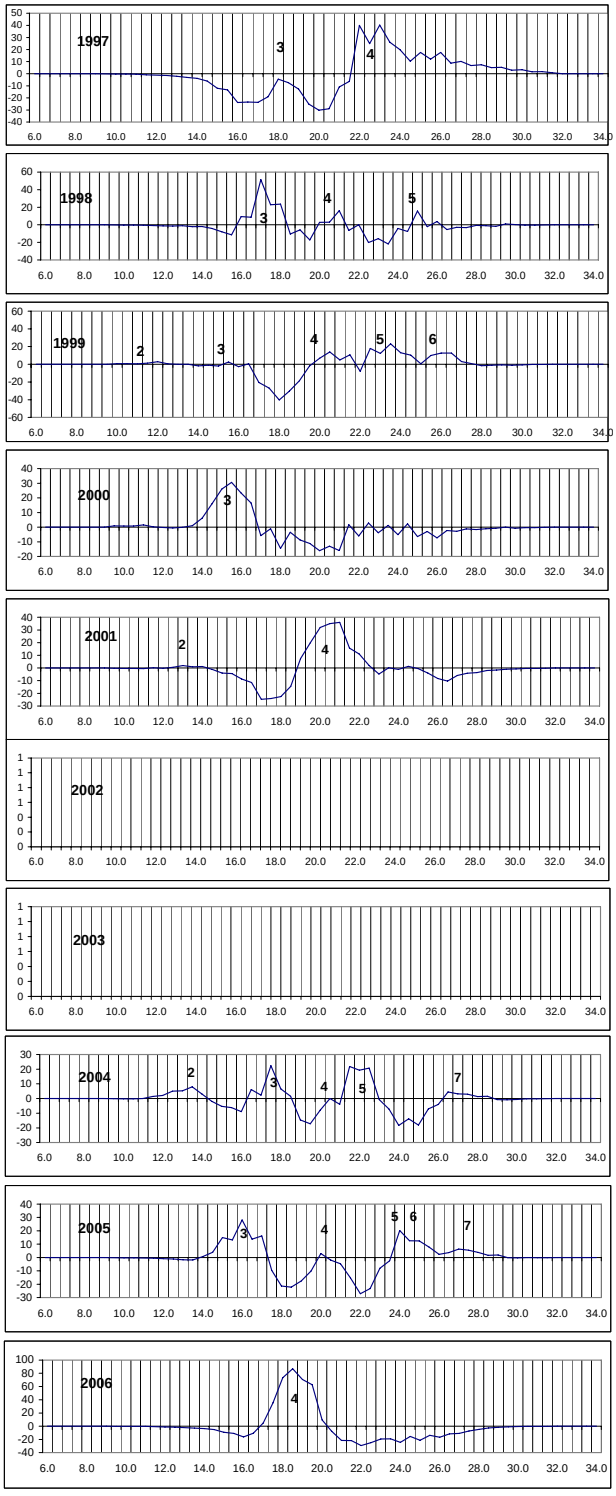


Fig 7. The deviations of length frequencies of northern shrimp by years in February on Flemish Cap from the mean length frequency of the years 1997-2006 in the same month.

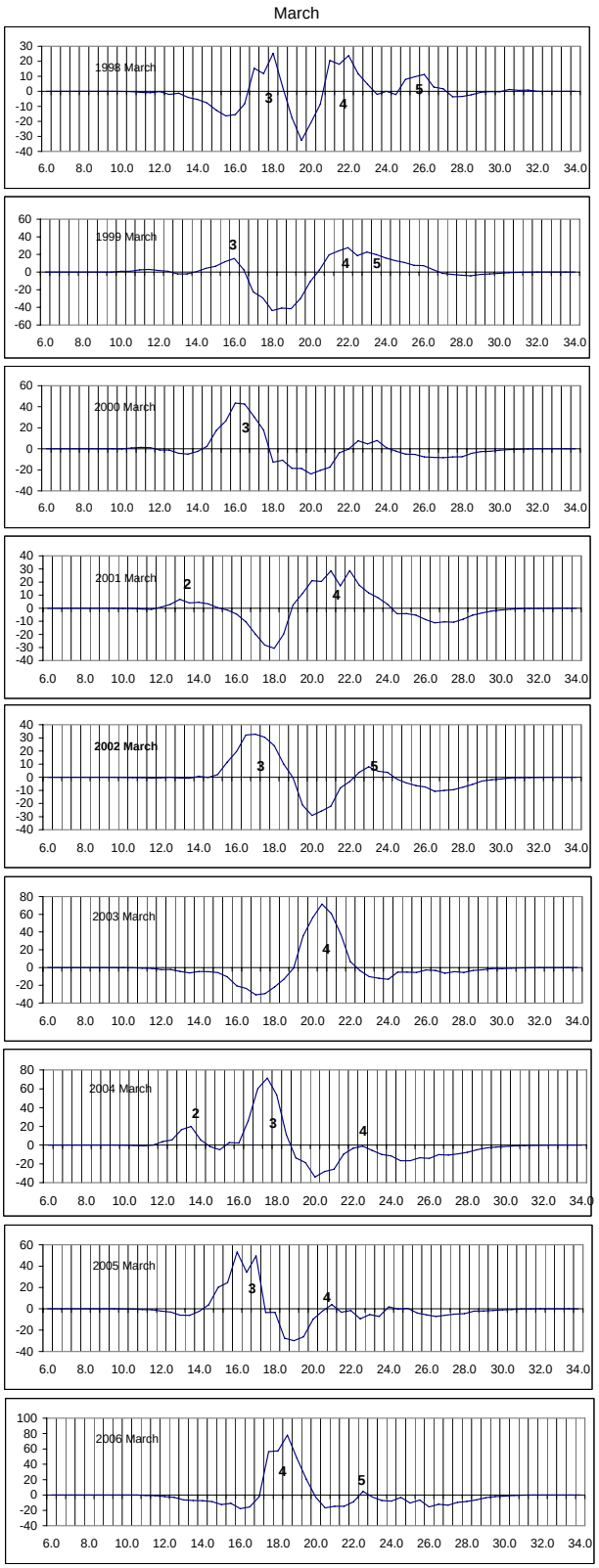


Fig. 8 The deviations of length frequencies of northern shrimp by years in March on Flemish Cap from the mean length frequency distribution of the years 1996-2006 in the same month. 1994 and 1995 are data of Canada and other countries. Since 1996 data are solely from Iceland.

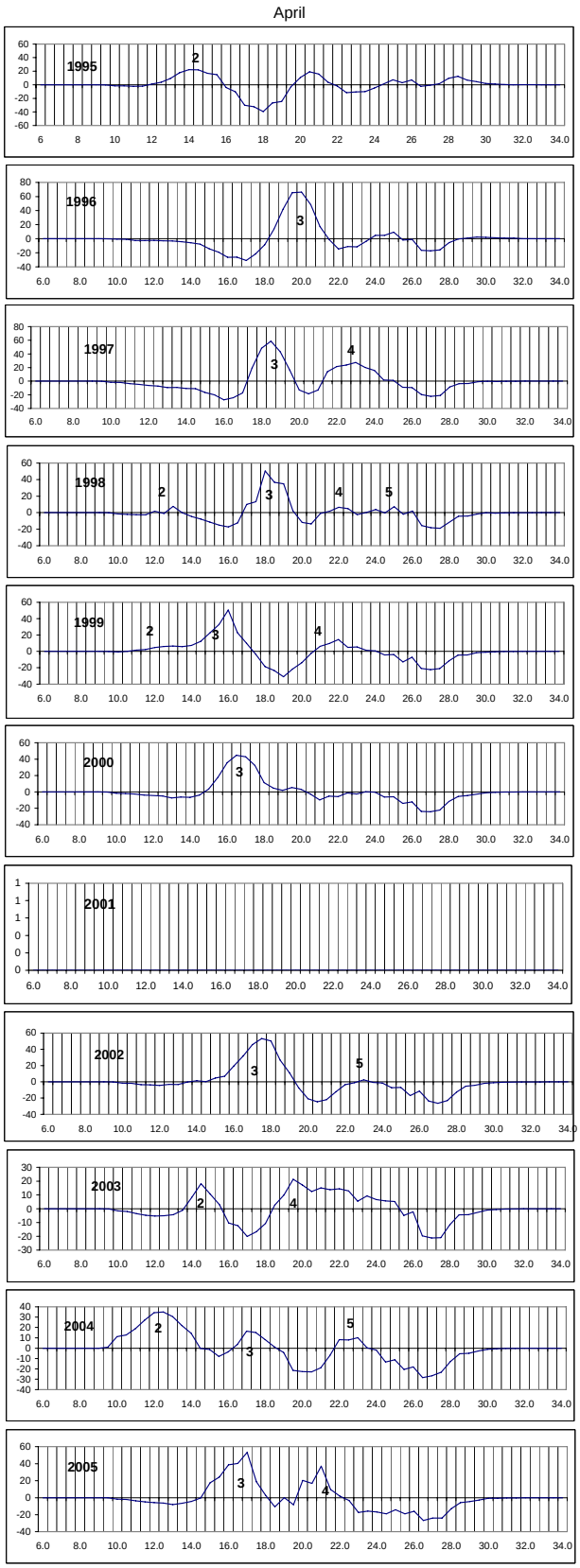


Fig 9. The deviations of length frequencies of northern shrimp by years in April on the Flemish Cap from the mean length frequency of the years 1995-2005 in the same month, 1993 through 1995 a

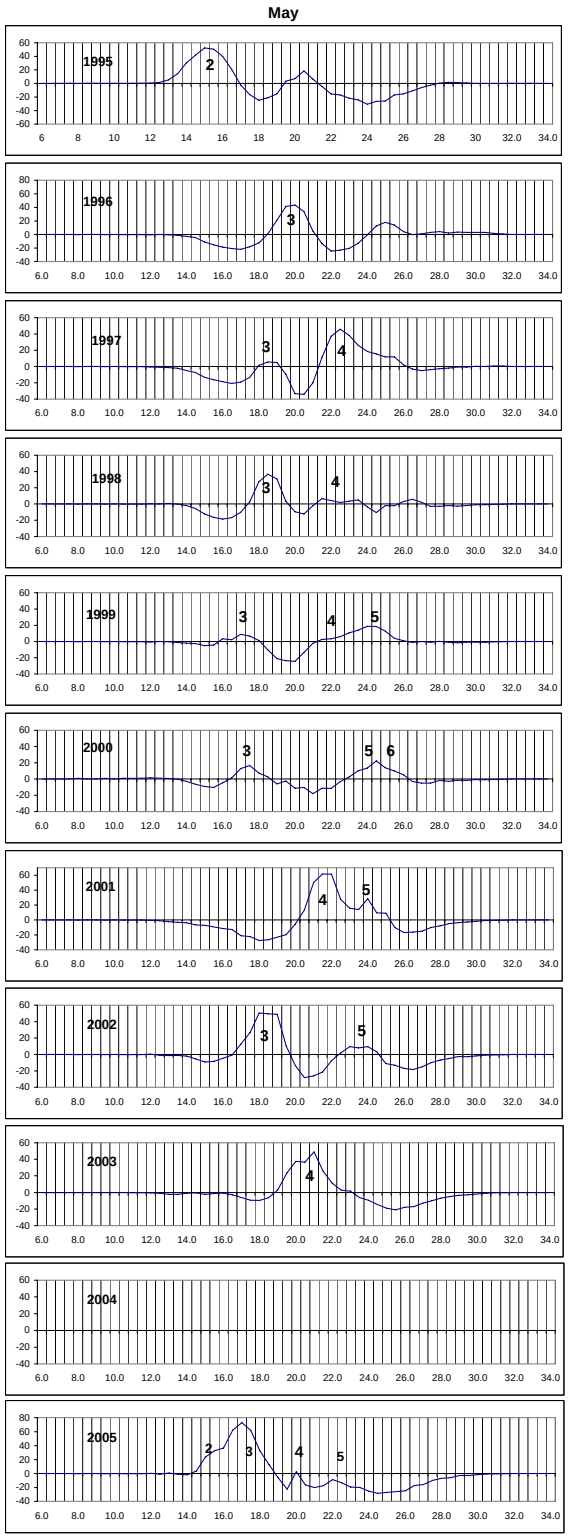
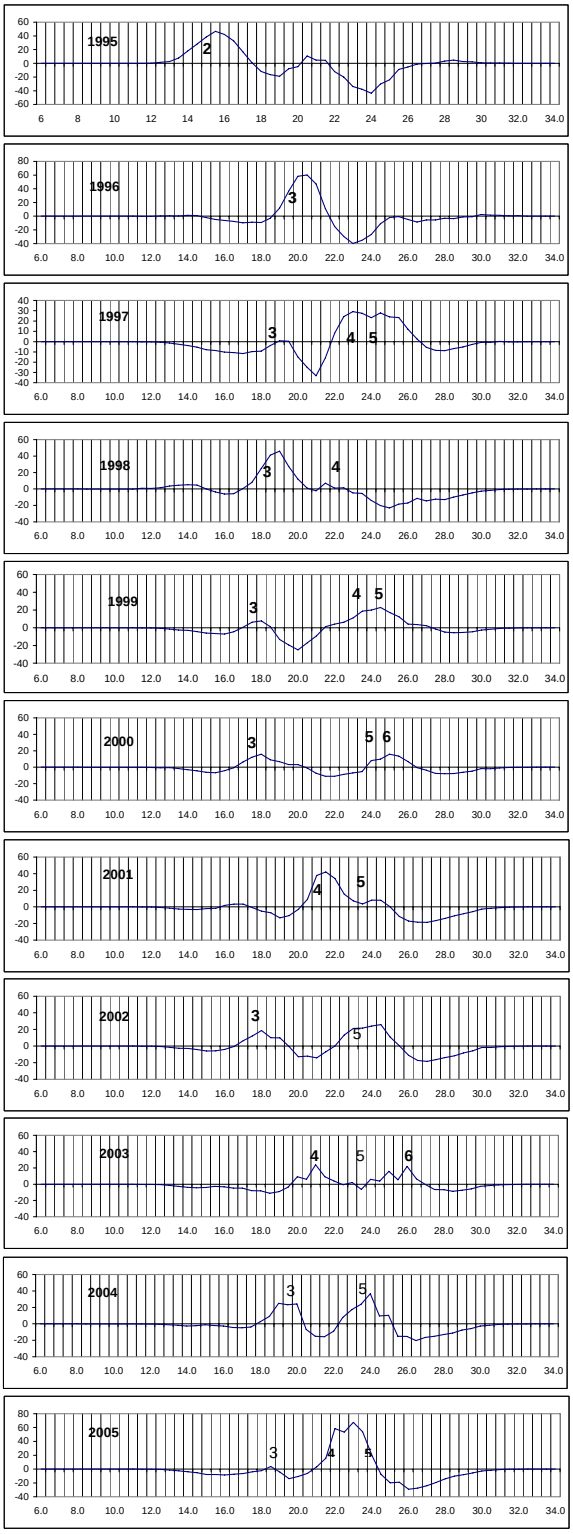


Fig 10. The deviations of length frequencies of northern shrimp by years in May on the Flemish Cap from the mean length frequency of the years 1995-2005 in the same month. 1993 through 1995 are data of Canada and other countries. Since 1996, data are solely from Iceland.

June



Carapace length mm

Fig 11. The deviations of length frequencies of northern shrimp by years in June on the Flemish Cap from the mean length frequency of the years 1993-2005 in the same month. 1993 through 1995 are data of Canada and other countries. Since 1996, data are solely from Iceland.

July

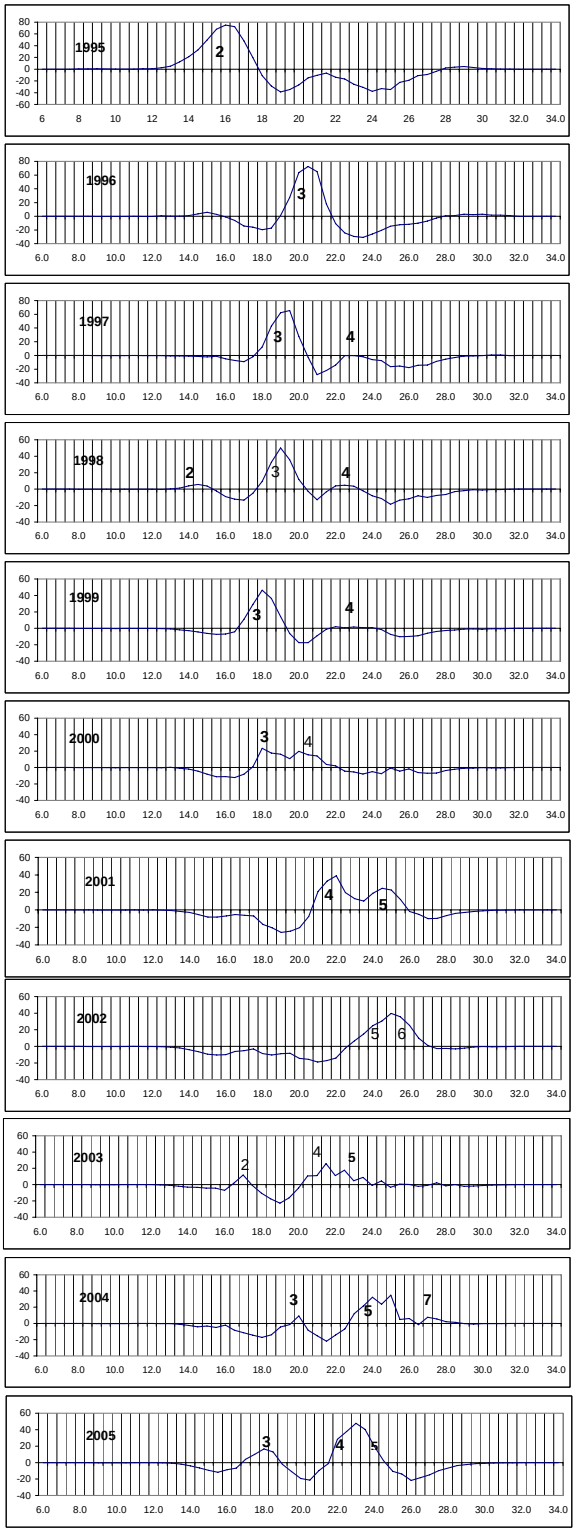


Fig 12. The deviations of length frequencies of northern shrimp by years in July on the Flemish Cap from the mean length frequency of the years 1993-2004 in the same month. 1993 through 1995 are data of Canada and other countries. Since 1996, data are solely from Iceland.

August

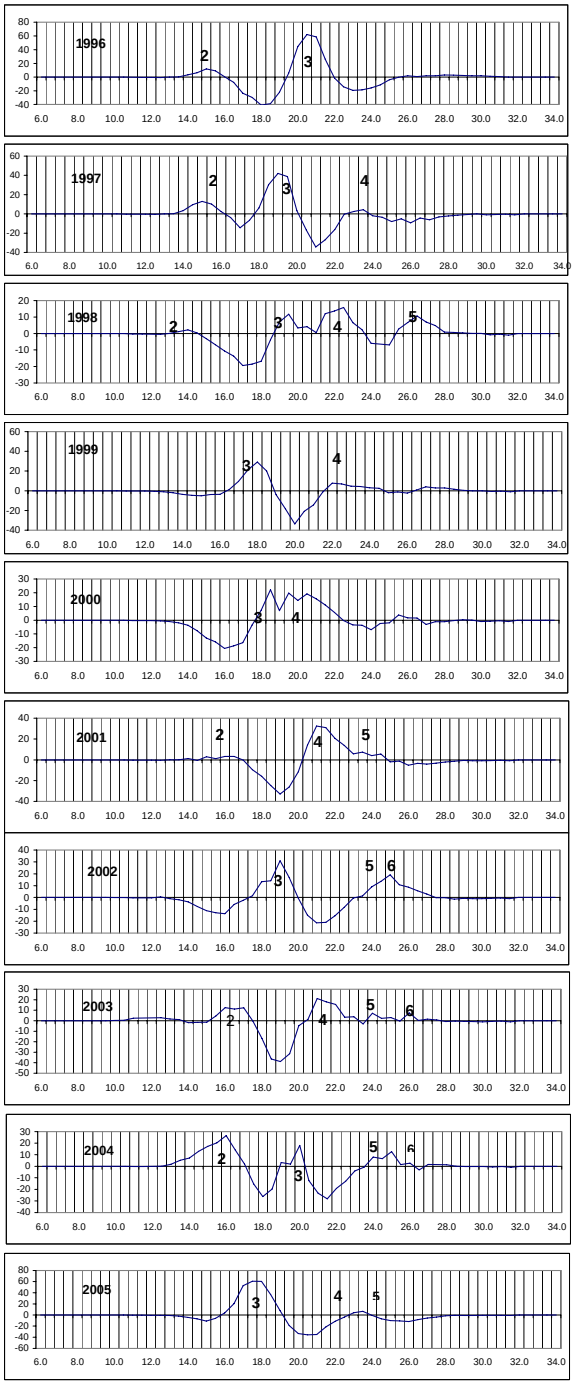


Fig 13. The deviations of length frequencies of northern shrimp by years in August on the Flemish Cap from the mean length frequency of the years 1996-2005 in the same month.

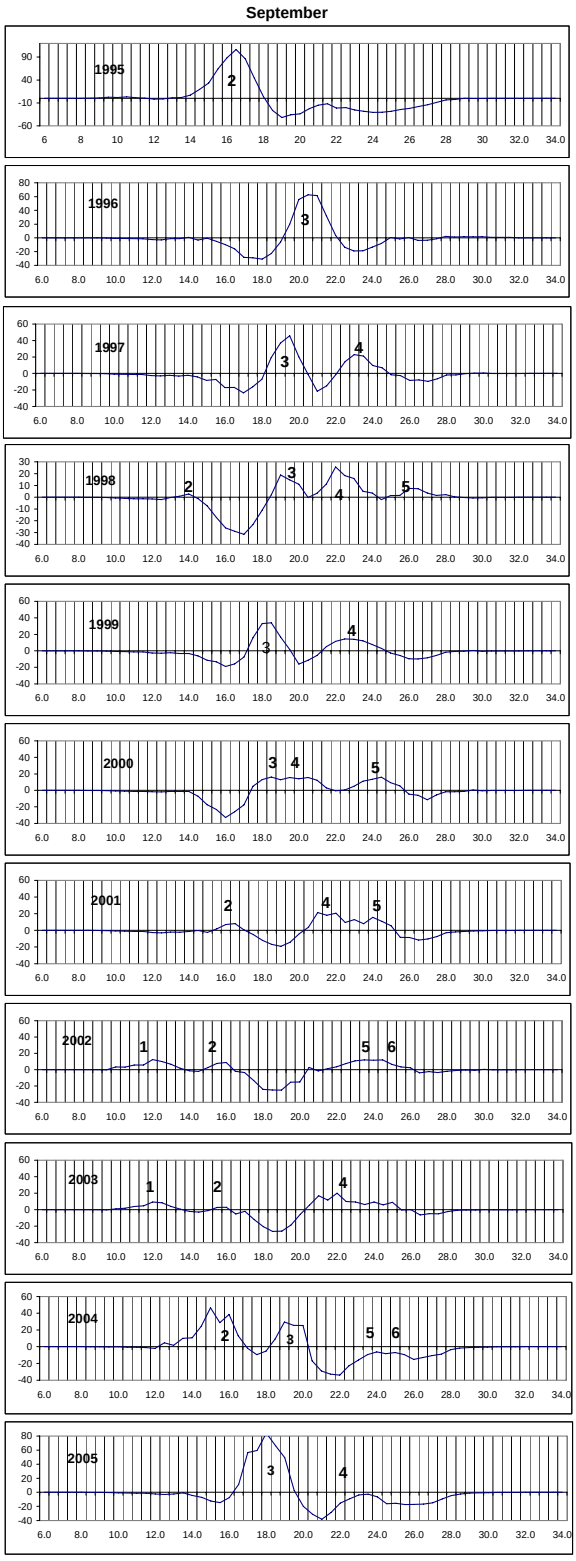


Fig 14. The deviations of length frequencies of northern shrimp by years in September on the Flemish Cap from the mean length frequency of the years 1995-2005 in the same month. 1993 through 1995 are data of Canada and other countries. Since 1996, data are solely from Iceland.

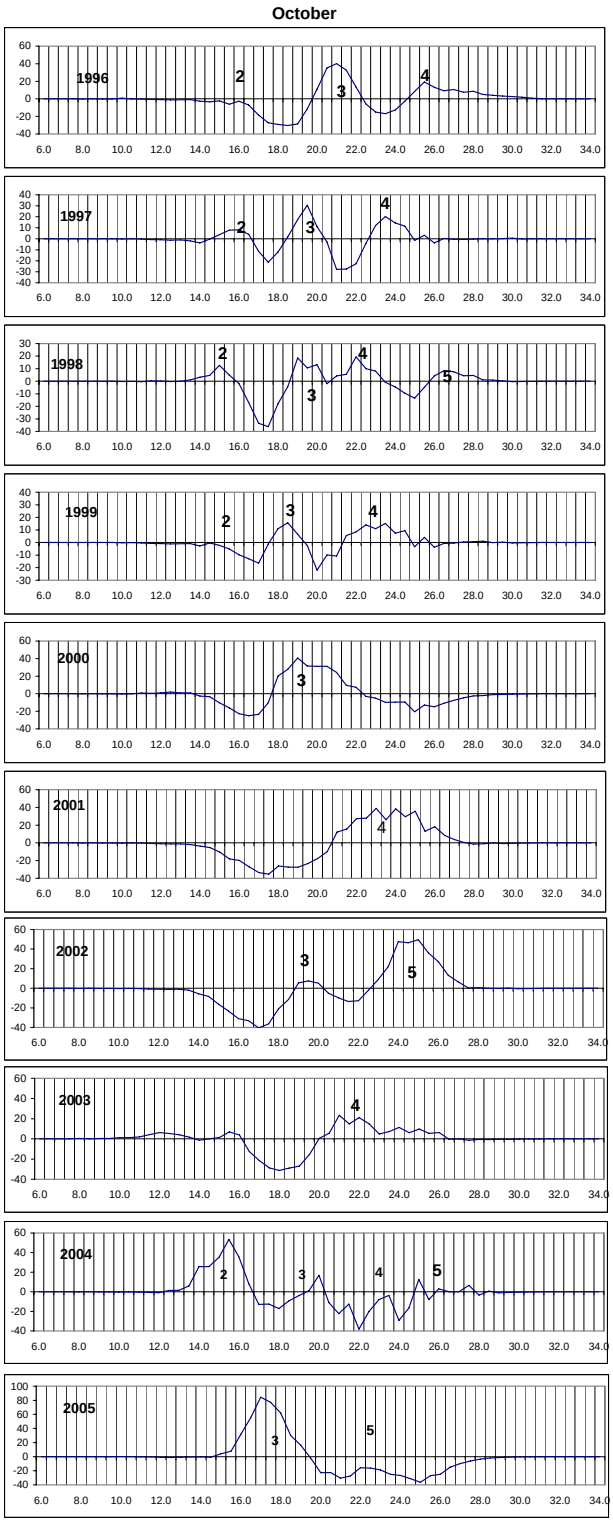


Fig 15. The deviations of length frequencies of northern shrimp by years in Oktober on the Flemish Cap from the mean length frequency of the years 1996-2005 in the same month.

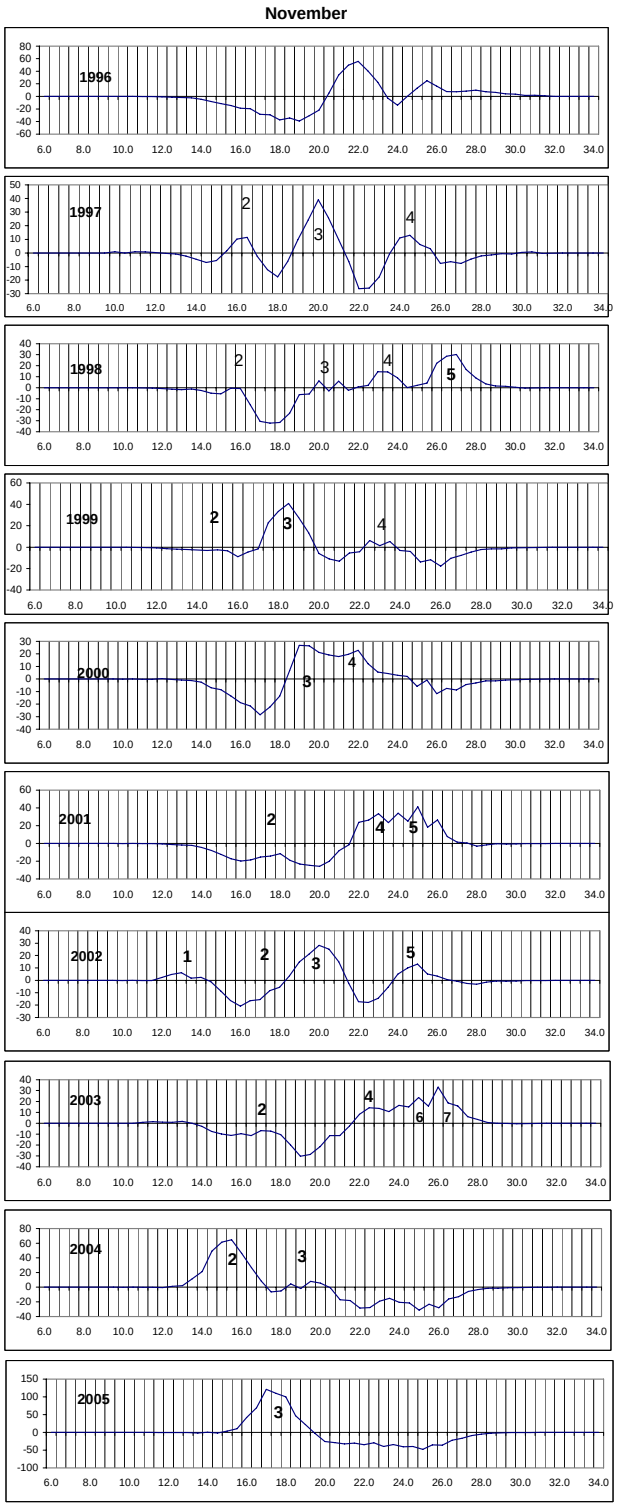


Fig 16. The deviations of length frequencies of northern shrimp on Flemish Cap by years from the mean length frequency of the years 1996-2005 in the same month.

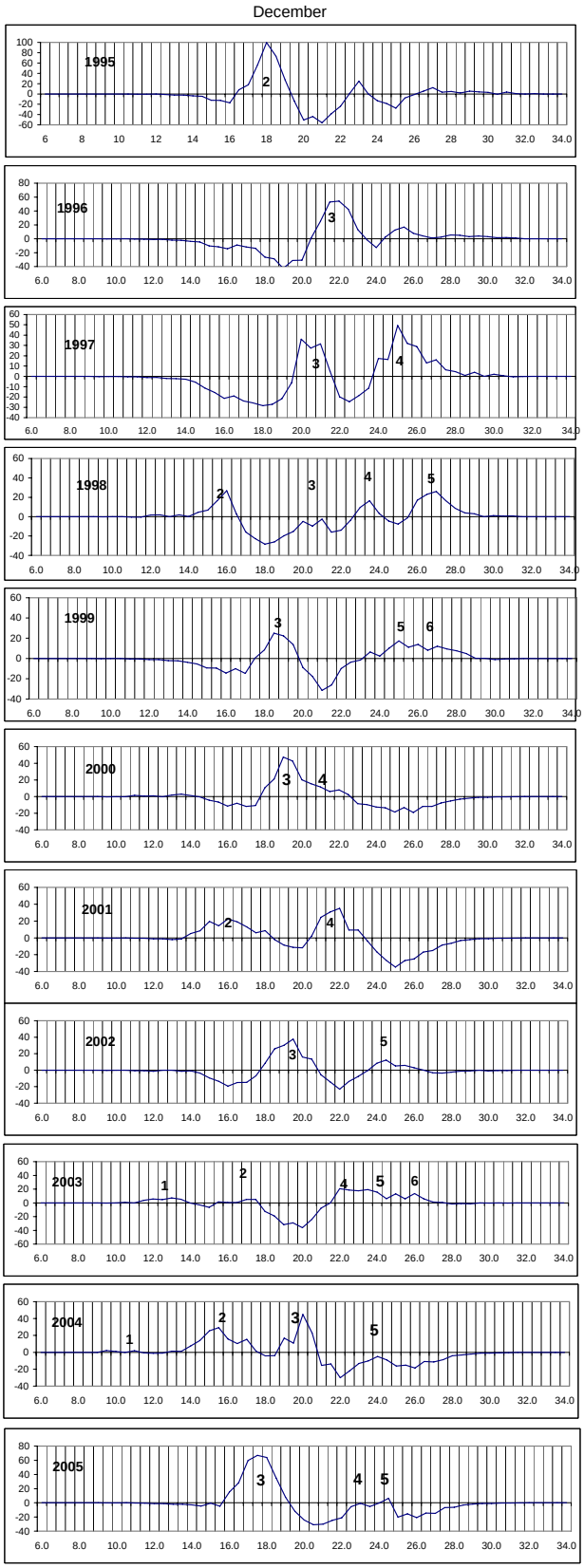


Fig 17. The deviations of length frequencies of northern shrimp on Flemish Cap by years from the mean length frequency of the years 1996-2004 in the same month.