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The Icelandic Shrimp Fishery (*Pandalus borealis* Kr.) at the Flemish Cap in 1993 - 1996.

by

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Abstract

Some 25-43 vessels Icelandic vessels have been fishing in the waters at the Flemish Cap in 1996. In this paper there are logbook information on the Icelandic fishery for the years 1993-1996. The samples were analyzed both spatially and depth wise with regard to proportions of sex groups. Several indices, and age divided catch rates are discussed.

Introduction

The Spanish investigators have been measuring the biomass index of northern shrimp at the Flemish Cap since 1988 in their annual bottom trawl survey at the Flemish Cap. In 1993 the fishery was initiated by Canada followed closely by Faroe Islands and Iceland. The fishery was some 23-26 thousand tons in the year s 1993-1995.

In this paper there are related the main results of the fishery, CPUE, effort and Catch. From the logbook information there are also information on the catch by time of day or night.

More over the many shrimp samples of 1996 are analyzed in many ways.

Material and Methods

For most of the catch data there are logbook data which include catch and effort. Not all skippers send in the logbooks, but information on landings can be obtained elsewhere. Thus the equivalent of the nominal catch can be calculated for the effort. This was done by first calculating the effort and CPUE from the logbooks. After this, the effort was raised to that of the nominal catch by dividing the nominal catch by CPUE.

Standardization of the CPUE was done by fitting a regression to CPUE of every haul in the period January to July against the size of trawl. Then the CPUE at 2900 meshes (circumference of the belly) was used.

When calculating the CPUE at different times of the day the length of the haul was divided by 2 and then added to the time at the beginning of the haul. Thus the time on a diagram is the mid-time of the haul.

The measuring of shrimp was carried out using sliding callipers and measuring the carapace from the eye socket to the hind end of the carapace mid-dorsally to the nearest half mm. After this every specimen in a length class is grouped by sexual character as done by Rasmussen (1953) as well as detecting the presence or absence of sternal spines (McCrary, 1971). The sex groups detected are 9. Later the 9 sex groups are combined and grouped together in the three main groups males, primiparous females (with sternal spines) and multiparous females (without sternal spines). Included in the group primiparous females are also transitionals.

When assessing the by-catch the observers were told to take a sample of the catch, one or two baskets of unsorted catch, sort the catch and weigh each species as well as the shrimp from that basket(s). In order to be able to raise this to the whole catch of the haul the catch of shrimp was noted. Another way of assessing the by-catch was often used and this was to sort the whole catch. in that case the crew would help.

Catch and effort data

In 1996 the fishery was carried out in the period January through August. But most of the catch was taken in May - August The total catch was some 16 thous. tons in 1996 as compared to 7622 tons in 1995 see below.

	Nominal Catch Tons
1993	2 243
1994	2 300
1995	7 622
1996	16 016

Figure 2 and table 3 shows the proportion of the total catch taken every year by areas. In 1993 the shrimp appears to have been caught in the same proportions in all areas except the South East (SE). both in 1994 and 1996 most of the shrimp was caught in the north west area (NW). In general fishing takes place in a much larger area in 1996 as compared to previous years (Fig. 3). There has also been increased effort in shallower waters as compared to previous years.

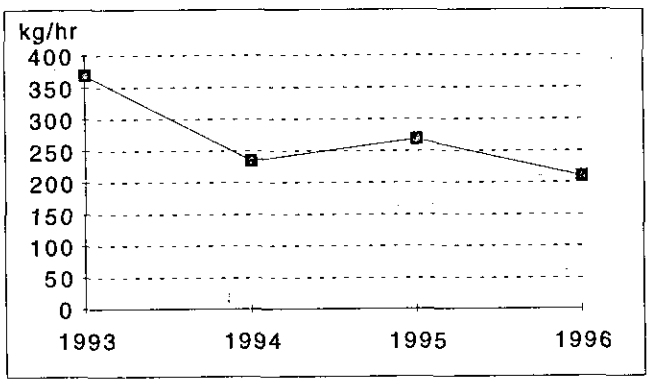
The mean CPUE for the year 1996 was the lowest ever for Iceland, namely 199 kg per trawling hour for the period January through July (table 1). In 1995 the mean CPUE for the same period was 235 kg/hr. The average size of gear was 2843 meshes circumference in 1996. There has been no increasing trend in the size of gear of the Icelandic vessels. Moreover the percentage of vessels operating with twin trawls was almost the same in 1996 as in 1994 and 1995.

	No. of meshes	Twin trawls %
1993	3 087	23.0
1994	2 975	28.1
1995	2 688	28.8
1996	2 843	30.0
Average	2 898	27.4

In calculating the CPUE for the twin trawls the effort has been doubled. When comparing the CPUE of twin trawl as compared to single trawl there appears to be a difference in catchability of twin trawls as compared to that of single trawls. Thus the twin trawls in 1995 had the CPUE 220.2 kg/hr each as compared to 289.1 kg/hr for a single trawl, a difference of 24%. In 1996 standardized CPUE (2900 meshes) of twin trawls was found to be 197.8 kg/hr as compared to 215.2 kg/hr in a single trawl, a difference of 8%. The comparison was irrespective of area and month but all within the period January through July. As there is no change in the proportion of twin trawls in the time series the CPUE for all trawls should be comparable.

The standardized CPUE for the Icelandic fleet using the period January through July in all years and the size of trawl 2900 meshes is shown below.

Year	CPUE
1993	370
1994	235
1995	269
1996	210



Standardized CPUE (January-July) of the Icelandic fleet.

The commercial samples

The great majority of the samples were measured and sexed by observers at sea. But some samples were measured at the Marine Research Institute of Iceland (MRI). Altogether some 680 thousand shrimps were measured. These were sexed and compiled by months.

The main length distributions of males primiparous and multiparous females are shown in Fig. 5. Most notable is the large peak of males of 19.1 mm in January. This is considered to be the 1993 year-class. The 1993 year-class is a strong year-class. The bimodality of the male distribution only seen in January is curious. As the primiparous group becomes bimodal in February and onwards it is possible that the fastest growing component of the 3 year old males is changing sex yet another year earlier than usual. In 1995 there was also bimodality in the primiparous group and the males changed sex at the age of 4 and 5 instead of only at age 5 before (Parsons, 1995). For the age analysis see Skúladóttir (1996). The drop in age at sex change could be caused by lack of multiparous females. Charnow and Andersen (1989) noted a change of size at sex in northern shrimp (P. borealis) in Pavlov bay. They used the size at sex change where 50% of the individuals where females (L50), against the mean carapace length of the breeding population. The L50 could be anywhere from 15 mm CL to 19 mm, small when the mean carapace length of the breeding population was small. The northern shrimp in Pavlov Bay has been found to change sex between the third and sixth year.

The occurrence of different sex and/or age groups

The proportions of sex groups, males, primiparous and multiparous females, are calculated first by area and month see Table 2. An average can be taken for each area. Males are most numerous in NE area, namely 69%. In the same area multiparous females are only 12 % on the average. In the NW area where most of the Icelandic fishery took place the multiparous females were a bit more numerous or 16%. In the SW area males were only 55% but primiparous and multiparous females were 22 and 23% respectively. In the SE area there is hardly any fishery as seen in Fig. 2.

The overall proportion of sex groups for the whole year 1996 was calculated from the different

areas and months by weighting with catch for the same. For comparison there are proportions from other years and other countries see table below (Skúladóttir 1994, Nicolajsen 1994, Parsons and Veitch 1995 and Siegstad and Hvingel 1995).

Year Nation	males %	pimip. females %	multip. females %
1993			
Canada	37.0	31.0	32.0
Iceland	42.2	25.1	32.7
Faroe Islands	41.3	5.2	53.5
1994			
Canada	58.0	13.5	28.5
Iceland	69.4	9.3	21.3
Greenland	40.0		
1995			
Canada	78.4	9.6	12.0
Greenland	85.0		
1996			
Iceland	63.8	21.5	14.7

From the table it appears that the proportion of primiparous females is increasing again after the decrease since 1993. The proportions of multiparous females is still low. However the proportions may be very misleading as if there increased recruitment namely a great increase in the numbers of males then the proportion of females may decrease even if their number in the stock are unchanged.

In order to see the actual numbers in a stock the total number per age group were calculated by using the results from the modal analysis of the data of 1994 and 1996 (Skúladóttir 1994, Skúladóttir 1996) and the total catch. The numbers caught by Iceland were 307 million in year 1994 and 2,333 million in 1996. For further break down into age groups see the table below. Number per hour should be proportional to the number in stock if the coverage of samples is sufficient. The coverage of Icelandic samples in 1994 was not very good and covered only the months June-August where some 2 thousand shrimps were measured. In 1996 there were however 680 thousand shrimp measured with a good coverage both spatially and temporally. The No./hr. in 1996 was quite high for the 3 year olds, 1993 year-class, which appears to be twice the number of 3 year olds in 1994.

Icelandic data calculated from Nominal catch and effort as well as results from age assessments (Skúladóttir 1996).

1994	N (000 000)	81,63	96,05	21,06	34,68	73,49
1996	N (000 000)	107.22	1620.95	574,94	147.95	78.14
1994	No./hr.	8494	9994	2191	3608	7647
1995	No./hr.	1108	19953	7206	1949	110

In 1994 the numbers per age group are those of the whole year, but No./hr in 1994 and 1996 are only of the period January-July for the sake of comparison.

There were no samples available to the Marine Research Institute in 1995. but according to Kristjánsson who collected samples in November and December 1995 the No./hr. for one vessel the number was very high or 44508 of 1993 year-class (Kristjansson 1996) as compared to 30562 of the 1993 year-class in 1995 according to the studies of Parsons (1995) for the months March-June (Parsons personal communication). There may be an overestimation in the 1993 year-class by Kristjánsson as most of his samples were from the NE area, where at least in 1996 according to our findings the proportion of males was the highest of all areas. The No./hr of 4 year olds was much higher in 1996 than in 1994 or three times as high. Looking at the findings of Parsons the No./hr. of 4 year olds was twice as high as his numbers for the years 1993-1995. On the other hand the No./hr. of either 5 or 6 year olds are very low. It may be noted that about one third of the 4 year olds are primiparous females and the rest is multiparous females.

There is yet another way to look at the occurrence of age groups namely as weight. The number per age group is then turned into weight using the length-weight relationship for males primiparous females and multiparous females respectively (Skúladóttir, 1996) see table below.

Indices of various age groups as kg/hr. As Icelandic data are missing in 1993 and 1995 the indices in the years 1993-1995 are built on Canadian samples, Parsons (1995). In all cases the nominal catch and effort for the months January through July of Iceland is used.

Canada	1993	9.3	36.6	32.9	152.3
Canada	1994	14.0	53.9	19.3	111.4
Iceland	1994	26.3	57.8	17.2	97.0
Canada	1995	60.5	63.5	15.4	73.5
Iceland	1996	2.1	87.9	56.*	50.6

* A primiparous group containing mainly 4 year olds but also a small proportion of 3 year olds.

From this table it appears that the 2 group in 1996 is weakest seen in this series. The 3 group in 1996 is not so strong by weight as it seemed to be in numbers. The reason is that the growth of the strong year-class is slightly slower than that of the 1991 year-class. Thus the CL is about 1 mm less than that of the 1991 year-class in the same months (Skúladóttir 1994). Comparison to the CL, 20.3 mm CL of the 1992 year-class as 3 year olds in 1995 from Parsons (1995) is difficult as Parsons does not present CL by months. The 4 group in 1996 appears to be twice as strong as the ones of 1994 and 1995. But it is evident that there has been a continuous drop in the weight of the multiparous females. These are now only one third of what they were in 1993.

The difference between day and night

It has long been known that northern shrimp has diurnal behaviour. During the day the shrimp stays close to the bottom. At night the shrimp lifts from the bottom and spreads through the water even up to the surface layer of the sea. Not all the shrimp leaves the bottom at night see figs. 4A and 4B. During the summer the CPUE goes down to one third of what it was during midday. But during the winter when there is less difference in light between day and night there is generally less difference, namely reduction by one half or less see the months September-December, February and March.

From january to mid April all shrimp samples have come from the day hauls. Since April samples have been taken mainly from the day hauls but every 6th haul sampled was to be taken from a night haul. This was meant to reflect the stock composition based on the knowledge of CPUE by different times of the year. Some preliminary examinations of the difference between day, afternoon and night hauls showed the following results. In May there was no difference in sex composition between night and day. In June and July however the day and afternoon hauls were quite the same but the night hauls were vastly different. Thus the male proportion had diminished to half of what it was during the day. night. Thus the females both primiparous and multiparous would seem to be twice as prevalent. the conclusion is that males are more apt to migrate at night than females.

By-catches

Here are some preliminary results showing the occurrence of by-catch. It may be noted that the by-catch is not necessarily all assessed from the same hauls. the main emphasis was on calculating the occurrence of redfish. The by-catch was found to be mainly redfish, wolf-fish and greenland halibut. The observers were told to look for cod as well. Cod was hardly ever seen. In table 5 the main results are listed. The occurrence of redfish was 2% in the SW area, but only 1.4 as a mean for all areas. Wolf-fish was just as numerous as redfish or 1,3% on the average. Greenland halibut was rarer than the other two, namely 0,3% on the average. Although the observers had strict instructions to keep to a scheme when deciding on measuring the by-catch there were however some who had this tendency only to measure the by-catch when it occurred in greater quantities than usually. Thus there is more danger of an overestimate of by-catch than an underestimate. There is also some danger when the crew is helping out that some of the smallest specimens of redfish (6-7 cm) are missed.

Acknowledgements

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References

Charnov, E. L. and P. J. Andersson 1989. Sex change and population fluctuations in pandalid shrimp. Amer. Natur, 134, 824-827.

McCrary, J. A. 1971. Sternal spines as characteristic for differentiating between females of some Pandalidae. J. Fish. Res. Board Can., 36: 987-1001.

Kristjánsson, J. 1996. On the biology and exploitation of shrimp (Pandalus borealis at the Flemish Cap in November and December 1995. NAFO SCR Doc. 5 p.

Nicolajsen, Á. 1994 Age structure of northern shrimp in division 3M in September-November 1993 and in division 3L in March 1994. NAFO SCR Doc. 94/76, Serial No. N2455, 9 p.

Parsons, D. G. and P.J. Veitch 1995. The Canadian fishery for northern shrimp (*Pandalus borealis*) on Flemish Cap (NAFO Division 3M), 1993 to 1995. NAFO SCR Doc. 95/103, Serial No. N2626, 10 p.

Rasmussen, B. 1953. On the geographical variation in growth and sexual development of the deep sea prawn (*Pandalus borealis* Kr.). FiskDir. Skr. Ser. Havunders. 10 (3): 160 p.

Siegstad, H. andg C. Hvingel 1995. The Greenland fishery for northern shrimp (*Pandalus borealis*) on Flemish Cap, NAFO Division 3M, in 1994 and 1995. NAFO SCR Doc. 95/101, Serial No. N2624, 9 p.

Skúladóttir, U. 1994. The Icelandic shrimp (*Pandalus borealis*) fishery at the Flemish Cap in 1994. NAFO SCR Doc. 94/85, Serial No. N2465, 9 p.

Table 1. Catch effort and CPUE of Icelandic vessels at the Flaemish Cap.

	January - July				August - December		
Year	Month	CPUE	Effort	Catch	Month	CPUE	Effort	Catch
1993	Jan							
	Feb				Aug	311	1363	424
	Mar				Sep	342	1064	364
	Apr				Oct	215	372	80
	May				Nov	297	606	180
	June	374	1848	691	Dec	221	579	128
	Jul	324	1160	376				
	Total	355	3008	1067	Total	295	3985	1176
1994	Jan	216	194	42				
	Feb	325	880	286	Aug	203	2025	411
	Mar	281	719	202	Sep	159	748	119
	Apr				Oct	125	632	79
	May				Nov	113	230	26
	June	252	1698	428	Dec	75	13	1
	Jul	204	3461	706				
	Total	239	6953	1664	Total	174	3648.5	636
1995	Jan							
	Feb	278.7	94	26.2	Aug	174.6	9283	1620.5
	Mar	246.8	1003	247.5	Sep	130.9	5605	733.7
	Apr	146.0	2155	314.7	Oct	162.4	3997	649.0
	May	257.8	3068	790.8	Nov	143.4	2022	289.9
	June	244.1	3993	974.6	Dec	175.9	1372	241.3
	Jul	245.8	7053	1733.7				
	Total	235.4	17366	4087.5	Total	158.6	22279	3534.4
1996	Jan	203.3	1783	362.7				
	Feb	243.7	1370	333.7	Aug	153.7	12700	1952.4
	Mar	255.8	4711	1205.1	Sep			
	Apr	206.2	10570	2179.5	Oct			
	May	185.5	12603	2338.0	Nov			
	June	198.8	19826	3941.5	Dec			
	Jul	184.6	20061	3703.7				
	Total	198.3	70924	14064.1	Total	153.7	12700	1952.4

Table 2. Percentage of sex groups by areas and months

NW area 1996			
Month	Males	Primip. females	Multip. females
Jan	63.61%	17.05%	19.34%
Feb	63.34%	18.23%	18.44%
Mars	70.97%	10.09%	18.94%
April	64.16%	23.65%	12.19%
May	57.53%	30.64%	11.83%
June	57.44%	28.66%	13.90%
July	72.58%	13.07%	14.36%
Aug	78.08%	2.01%	19.91%
Mean	65.96%	17.93%	16.11%
Mean weighted by catch	65.09%	18.12%	14.70%

NE area 1996			
Month	Males	Primip. females	Multip. females
Jan	54.37%	22.12%	23.50%
Feb	53.51%	28.10%	18.39%
Mars	82.52%	11.73%	5.74%
April	80.97%	15.47%	3.57%
May	63.21%	28.72%	8.07%
June	69.40%	22.79%	7.82%
July	71.19%	18.45%	10.37%
Aug	77.44%	2.74%	19.82%
Mean	69.08%	18.77%	12.16%
Mean weighted by catch	70.57%	18.87%	10.57%

SW area 1996			
Month	Males	Primip. females	Multip. females
Jan	42.04%	30.09%	27.88%
Feb	46.93%	19.58%	33.49%
Mars	54.47%	15.63%	29.90%
April	61.22%	18.00%	20.77%
May	44.94%	39.60%	15.46%
June	56.14%	32.03%	11.83%
July	66.29%	17.75%	15.97%
August	65.33%	4.32%	30.35%
Mean	54.67%	22.13%	23.21%
Mean weighted by catch	58.50%	22.25%	19.25%

SE area 1996			
Month	Males	Primip. females	Multip. females
Jan			
Feb			
Mars			
April	60.76%	38.40%	0.84%
May	32.78%	54.44%	12.78%
June	57.35%	32.08%	10.57%
July	70.84%	17.25%	11.89%
August	74.72%	1.71%	23.57%
Mean	59.29%	28.78%	11.93%
Mean weighted by catch	71.06%	13.29%	15.64%

Table 3. Nominal catch by areas

Catch (tons)by areas1996				
Month	NW	NE	SW	SE
Jan	224.8	133.9	4.0	0.0
Feb	40.8	25.5	266.0	1.4
Mars	926.0	53.3	225.3	0.6
April	1425.7	199.6	551.4	2.8
May	1630.5	223.0	482.6	1.9
June	2136.1	924.9	838.7	41.9
July	1556.1	709.9	1068.3	369.3
August	1023.2	317.7	404.4	207.1
Total	8963.2	2587.8	3840.5	625.0

Table 4. Percentage of sex groups by depth stratum and month in 1996.

Stratum 0-182 m			
Month	Males	Primip. females	Multip. females
Jan			
Feb			
Mars			
April	82.94%	9.48%	7.58%
May	72.13%	14.96%	12.91%
June	83.52%	8.79%	7.69%
July			
Aug			
Mean	79.53%	11.08%	9.39%

Stratum 183-255 m			
Month	Males	Primip. females	Multip. females
Jan	89.26%	3.03%	7.71%
Feb	55.96%	15.03%	29.02%
Mars	72.25%	9.94%	17.81%
April	65.21%	13.87%	21.01%
May	71.45%	18.97%	9.58%
June	70.82%	24.35%	4.83%
July	65.92%	23.01%	11.07%
August			
Mean	70.12%	15.46%	14.43%

Stratum 256-365 m			
Month	Males	Primip. females	Multip. females
Jan	69.64%	10.70%	19.66%
Feb	48.67%	17.73%	33.61%
Mars	69.18%	11.12%	19.70%
April	71.84%	14.92%	13.25%
May	75.77%	17.56%	6.66%
June	77.13%	16.18%	6.69%
July	69.54%	16.88%	13.58%
Aug	80.37%	3.68%	15.95%
Mean	70.27%	13.60%	16.14%

Stratum 366-548 m			
Month	Males	Primip. females	Multip. females
Jan	35.72%	37.84%	26.45%
Feb	47.04%	30.69%	22.27%
Mars	62.87%	14.13%	23.01%
April	60.13%	30.56%	9.31%
May	39.41%	43.91%	16.68%
June	51.87%	33.23%	14.91%
July	69.39%	15.95%	14.66%
Aug	71.66%	2.19%	26.16%
Mean	54.76%	26.06%	19.18%

Stratum 549-1000 m			
Month	Males	Primip. females	Multip. females
Jan			
Feb	47.83%	34.47%	17.70%
Mars	37.73%	52.34%	9.92%
April	37.73%	52.34%	9.92%
May	35.19%	50.55%	14.25%
June	33.13%	50.04%	16.83%
July	59.78%	13.12%	27.10%
August			
Mean	41.90%	42.14%	15.95%

Table 5. the percentage of the 3 main species of fish as bycatch in the shrimp fishery of Iceland at the Flemish Cap in 1996.

A		Redfish		Shrimp	Redfish	
	Hauls Number	Weight kg	Number	Weight kg	Weight %	Number per 1000 kg shrimp
NW	1044	29564	727511	2238800	1.3	325
NE	124	1835	94883	242729	0.8	391
SW	390	14914	270616	727223	2.0	372
SE	13	194	2127	18008	1.1	118
	1571	**46507**	**1095137**	**3226760**	**1.4**	**339**

B		Greenland halibut		Shrimp	Greenland halibut	
	Hauls Number	Weight kg	Number	Weight kg	Weight %	Number per 1000 kg shrimp
NW	418	2950	43740	805230	0.4	54
NE	120	780	10030	220997	0.4	45
SW	369	1684	24424	667739	0.3	37
SE	31	49	825	46413	0.1	18
	938	**5463**	**79019**	**1740379**	**0.3**	**45**

C		Wolf-fish		Shrimp	Wolf-fish	
	Hauls Number	Weight kg	Number	Weight kg	Weight %	Number per 1000 kg shrimp
NW	225	6534	180480	526781	1.2	343
NE	27	408	8668	51651	0.8	168
SW	134	4307	116943	304514	1.4	384
SE						
	386	**11249**	**306091**	**882946**	**1.3**	**347**

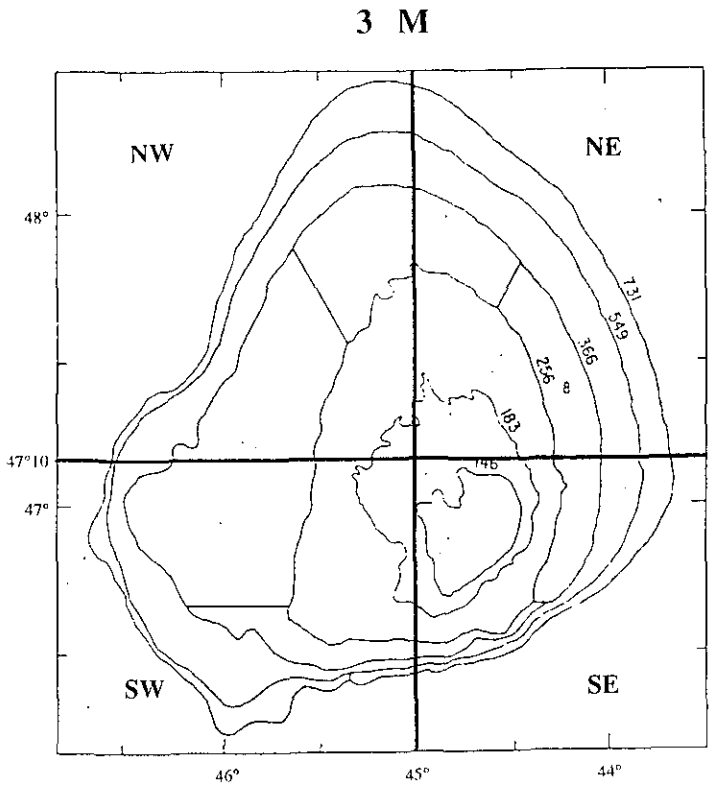

Fig. 1. The four areas at the Flemish Cap divided by 45° West and 47°10' North.

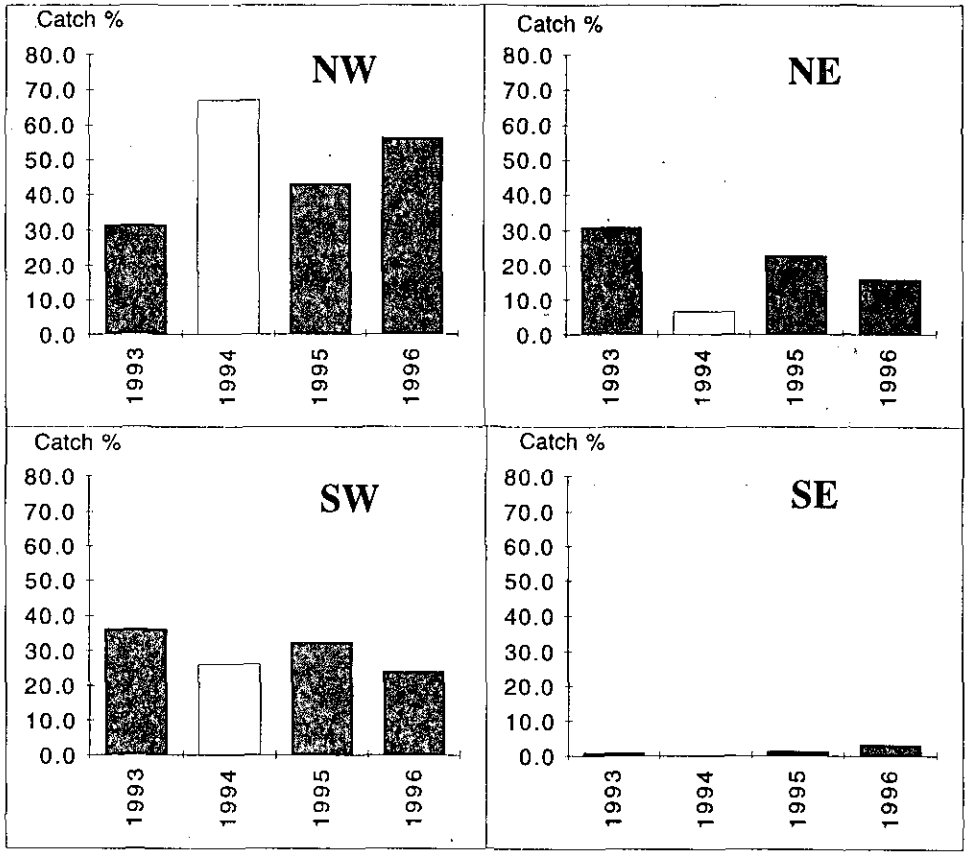

Fig. 2. The proportions of nominal catch by areas and years.

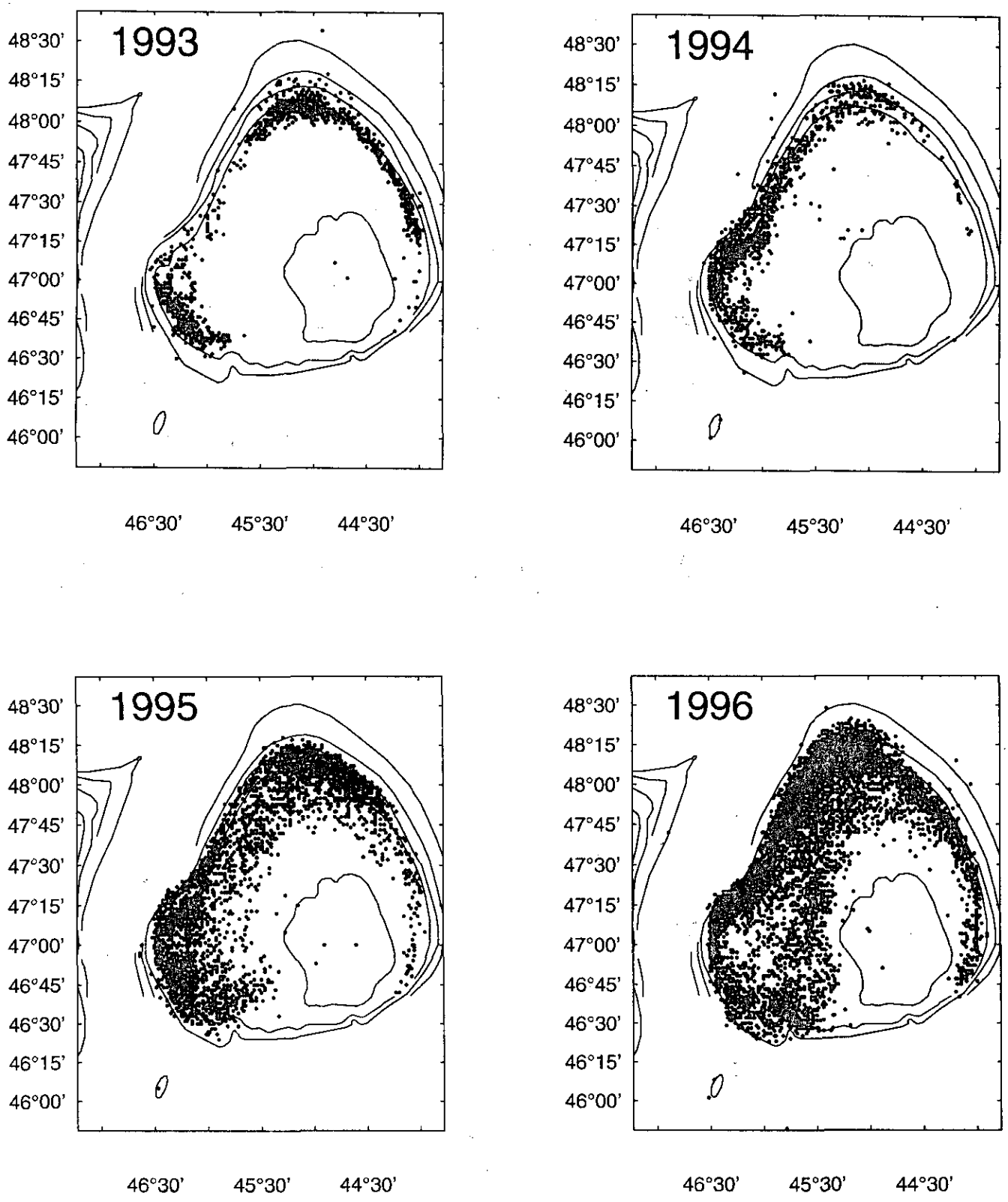

Fig. 3. Fishing positions of the Icelandic fleet on the Flemish Cap by year.

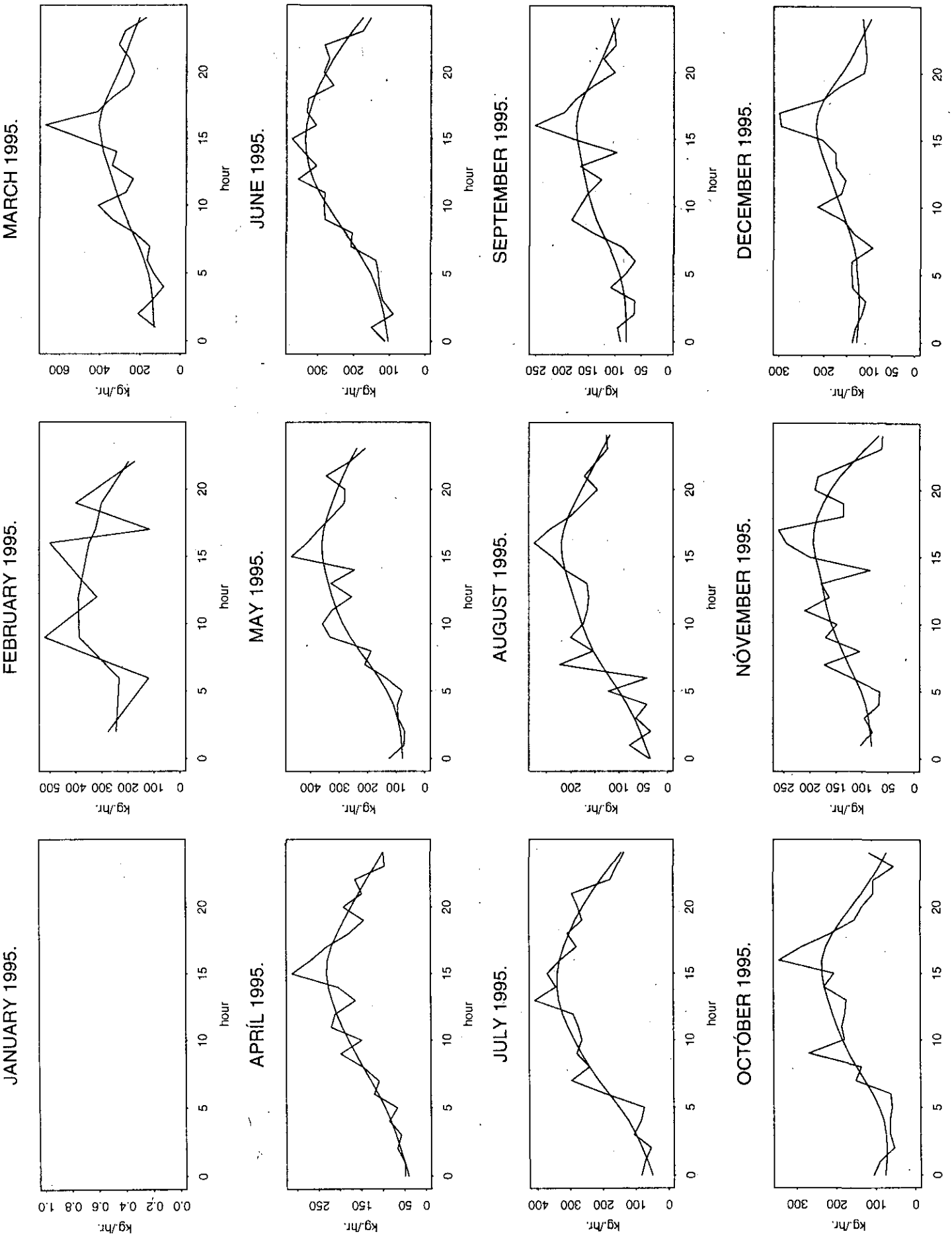

Fig. 4A. The CPUE (Icelandic fleet) at the Flemish Cap in 1995 by time of day, Greenwich time.

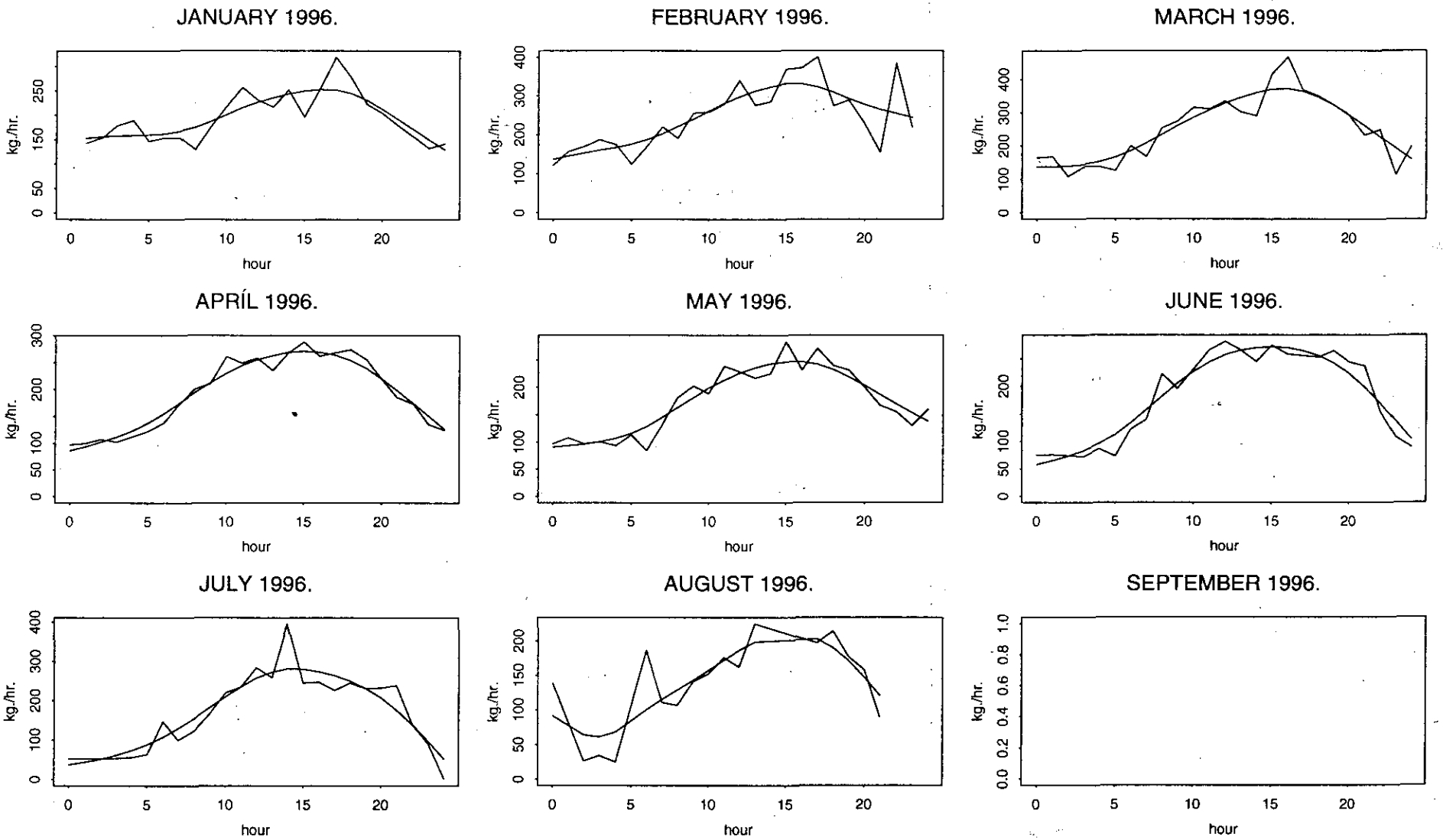

Fig. 4B. The CPUE (Icelandic fleet) at the Flemish Cap in 1996 by time of day, Greenwich time.

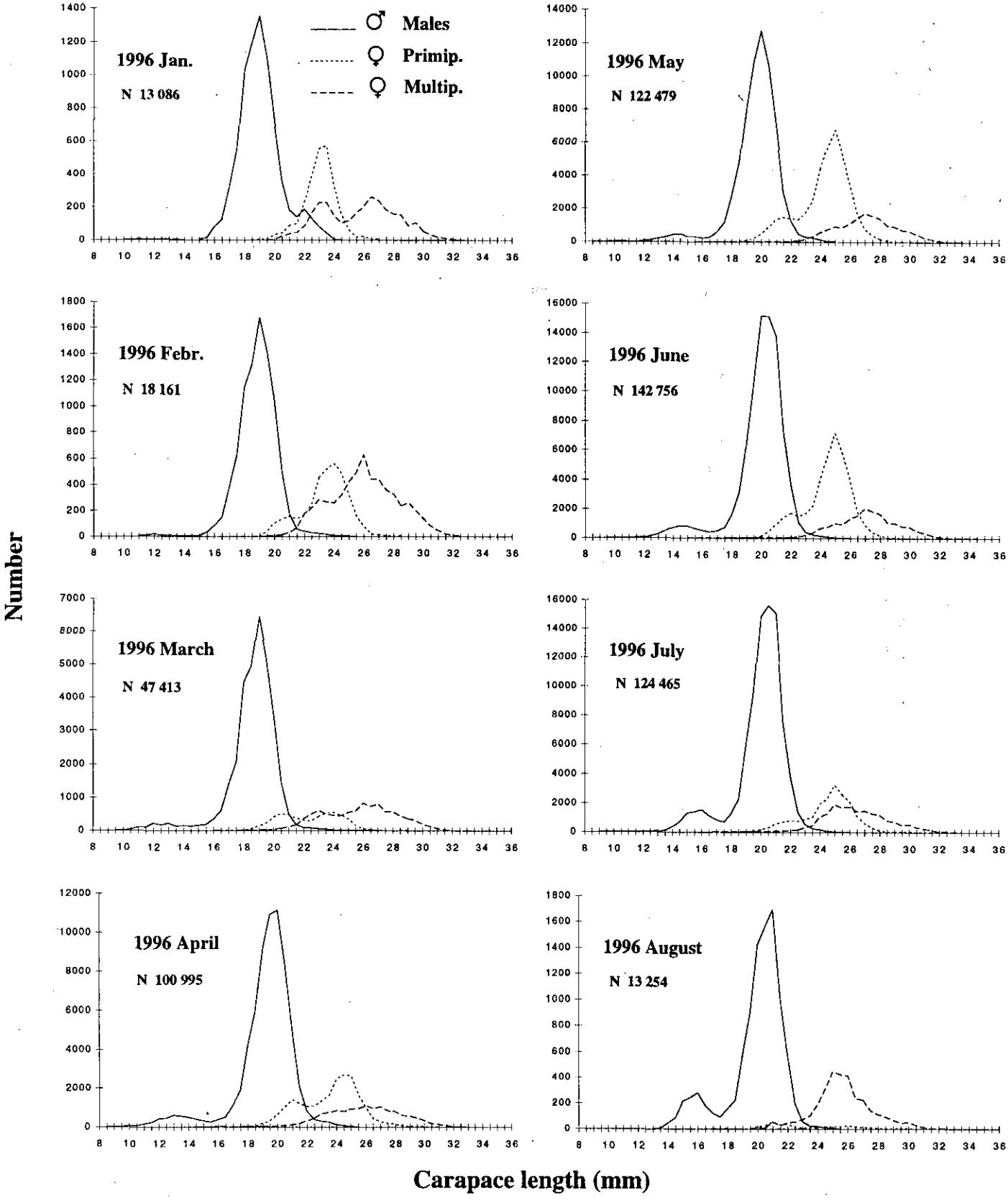

Fig. 5. The length frequency distributions of northern shrimp at the Flemish cap by months in 1996.