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Research and Commercial Fishing for Shrimp (Pandalus borealis) in Division 0A, 1986

by

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INTRODUCTION

Quota reports, preliminary to December 31, 1986, show that about 50% (2995 t) of the 6120 t shrimp quota in Division 0A were taken by vessels fishing for Canada. This is similar to the catch in 1985 (3078 t). Eight vessels participated in the fishery but not concurrently; over half the catch (approx. 1800 t, 60%) was taken by two vessels. The fishery began in the first week of June and continued into late November, similar to the pattern of the previous year.

Fishing logs from both foreign and domestic vessels were not available in time for this meeting. Therefore, data on fleet performance are limited to those obtained from observers. Observer coverage for foreign-owned vessels was maintained at a high level in 1986, providing data for each month of the fishery. Although no samples were available from the commercial vessels for separation by sex and maturity stages, samples were obtained during a groundfish survey by the research vessel GADUS ATLANTICA. Following are descriptions of the distribution of catch and effort in 1986 and 1985 (updated), length distribution of shrimp taken in the 1986 commercial catches, observations on by-catches and discards and analysis of the research samples for sex, maturity and age interpretation.

MATERIALS AND METHODS

Monthly catch and effort data were compiled from observers' reports (1979-86) and vessel logs (1979-85 (updated)). Fishing effort and CPUE for each month were plotted by Danish statistical square for 1985 (vessel logs updated) and 1986 (observer reports only). Length frequencies obtained by observers from the catches were summarized by month and by 100 m depth intervals. Data on by-catch were compiled as percentages of the total observed catch in each month. Estimates of the proportions of discarded shrimp also were derived from the data sources.

Two samples of shrimp were obtained on September 7, 1986 during a groundfish cruise of the research vessel GADUS ATLANTICA. The gear used was an unlined Sputnik 1600 shrimp trawl (codend mesh size about 40 mm), towed for 30 minutes at 3.0 knots. The samples were taken at 68°07.7'N, 58°47.3'W and 67°59.4'N, 58°45.0'W in 271 and 256 m, respectively. Bottom temperatures at both stations were 2.5°C. Carapace lengths (CL) were measured to the nearest 0.1 mm and recombined to 0.5 mm intervals. Sex was determined by observation of the first pleopod and maturity by condition of the gonads. The size of the ovary in females was observed to determine the spawning potential in 1986. Condition of sternal spines (McCrary 1971) was determined for non-ovigerous females to distinguish primiparous and multiparous females. Age composition of the pooled samples was interpreted from the separation of sexual stages and modal analysis (Macdonald and Pitcher 1979) of the length distributions. Pooling was considered appropriate because there were no major differences in the proportions and size distributions of the various sexual components.

RESULTS

Effort and CPUE

The monthly catch rate (kg/hr) data for 1986 from observers' reports showed the characteristic decline in catch rates over the season (Fig. 1, Table 1). As in 1985, there was a recovery in catch rates late in the season with levels in November only being exceeded by those observed in June. In years prior to 1985, there was more of a leveling off in catch rates late in the season, rather than a distinct recovery.

The weighted catch rates for the July to September period based on observers' reports were 315, 344, 409, 330, 338, 320, and 354 kg per hour from 1980 to 1986, respectively. The increase between the 1985 and 1986 levels was 10.6%. It should be noted that the June 1986 catch rate (682 kg/hr) was the highest observed in any month of any previous year and the July-September rate was the second highest in the series.

The distribution of fishing effort in 1985 as determined from vessel logs (updated from Parsons and Veitch 1986) showed that the fishery was concentrated between 58°N and 59°W, similar to previous years (Fig. 2). Some fishing occurred north of 68°N in all months, but mostly in October. Effort was concentrated near the median line in June but spread to the north and west as the season progressed. This movement likely reflects the increase in available fishing grounds with receding ice rather than changes in shrimp distribution. Data from individual squares show good catch rates throughout the area. In November, catch rates and effort were highest in the southeast, probably in response to advancing ice and/or by-catch problems (eg. Greenland shark).

Observer records for 1986 (Fig. 3) show that the fishery occurred in the same general area as in previous years (i.e. between 67° and 68°N, 58° and 59°W) but less effort was expended in the northwestern areas, especially during the period from August to October. The data for August and to a lesser extent, September, suggest that catch rates were higher in the southeast. In October and November, however, shrimp appeared to be more highly concentrated in the northwest but, by this time, other factors (eg. ice, by-catch) might have been limiting factors.

Length distributions

Length frequencies for the observed monthly catches by depth intervals (Fig. 4) show two modal groups of shrimp at approximately 22 mm (males) and 25 mm (females) occurring in all months. In June, however, only the female mode was present in the deeper water. Otherwise, similar size distributions were observed in both the deep and shallow water for all months. Shrimp densities (number per hour) were greater in shallow water in June and August and in deeper water later in the season (October and November). Densities in July and September appeared to be similar in both depth intervals.

In 1985, the larger female size group dominated in June but decreased in abundance through to September (Parsons and Veitch 1986). In October and November, the catches were comprised mainly of ovigerous females. In 1986, the male component (mode at 22 mm) contributed substantially to the catches in all months and there was a lesser dependence on ovigerous females late in the season.

Few females were ovigerous in August and most egg-laying occurred in September, as in previous years. Prior to 1985, a smaller mode of males around 18-20 mm CL was evident in the commercial sampling data. This size (age) group has not been apparent in the data for 1985 and 1986 and there remains a virtual absence of shrimp less than 18 mm.

Shrimp discards

Estimates of shrimp discards obtained by observers in 1986 (Table 2) suggest that discarding was less of a problem than in previous years. Only the November rate (2.4%) was higher than in 1985 and most monthly values for 1986 are lower than corresponding months in earlier years when a substantial catch was observed. No length frequencies of discarded shrimp were obtained in 1986.

By-catches

Observer data on by-catches for each month of the 1986 fishery are given in Table 3. Percent by-catch by weight increased from 14.5% of the total catch in June to about 30% in August and September, which can be explained by the declining catch rates of shrimp over the period, coupled with increasing catch rates of redfish (Sebastes spp.) from June to August. Characteristically, incidence of Greenland shark increased in October and November.

Redfish remains the most abundant commercial finfish species in the catches, ranging from 8 to 20% of the total weight of all species. Greenland halibut accounted for less than 2.5% of the total catch in all months.

Catch rates from 1980 to 1986 show that by-catches of redfish declined during the first four years, increased in 1984 and 1985 and substantially in 1986 to exceed 1980 levels. Catch rates of Greenland halibut remained low over the same period.

	Catch per hour (kg)						
	1980	1981	1982	1983	1984	1985	1986
Redfish	63	32	20	9	16	20	90
Greenland halibut	2	3	4	5	6	4	8

Biological data

A length distribution for the pooled September 1986 samples and a breakdown by male, primiparous, multiparous, and ovigerous female groups are shown in Figure 5. Males dominated (65% of total), ranging in size from 16 to 25.5 mm CL. Most females (77%) were not ovigerous and most of those (84%) appeared to be multiparous. Average lengths of primiparous, multiparous, and ovigerous females were 24.8, 25.6, and 25.5 mm, respectively.

A breakdown of the sample by maturity stages showed that all males were mature with large vasa deferentia (Table 4). Fifty-nine shrimp were identified as transitional based on characteristics of the first pleopod and all possessed large ovaries (primiparous). All but 4 of 332 non-ovigerous females lacked sternal spines or maintained only remnants (multiparous). Fifty-one of the 328 non-ovigerous multiparous females possessed small ovaries and most likely would not have spawned in 1986. This suggests the possibility of a spawning failure of 10% of all potential spawners.

The interpretation of the age composition of the pooled samples was difficult, mainly because the samples were obtained during the spawning period. Over 20% of females had already spawned and most others were close to spawning. This is not an appropriate time to distinguish females by condition of sternal spines since these spines are lost at the first moult into breeding dress (McCrary 1971). However, ageing was attempted and the shortcomings of the analysis are detailed under 'Discussion'.

Only one modal group of males was evident from the sampling data with average length of 21.6 mm CL (Fig. 5). These were assumed to be primarily the 1981 year-class or 5-year-old shrimp (Parsons et al. 1985). The mean length of this group was in good agreement with the length-at-age estimated in previous studies (21.0 and 22.5 mm) (Parsons and Tucker 1984, Parsons et al. 1985). The previously identified age group with mean size of roughly 19 mm was notably absent from the 1986 data.

Primiparous, non-ovigerous shrimp were unimodal with average length of 24.8 mm (Fig. 5) and non-ovigerous, multiparous females were bimodal at approximately 25 and 27.5 mm. Modes were not clearly defined in the pooled samples for ovigerous females but a separation by sample showed three modes at 23.5, 25, and 27.5 mm in 271 m (Fig. 6). Results of the Macdonald and Pitcher (1979) analysis are given in Table 5. Almost 90% of multiparious females were estimated in the group with mean length of 25.0 mm. The average length of the second component was estimated at 27.6 mm. The fitting procedure worked well with no constraints necessary on any of the parameters (χ^2 = 8.03, P = 0.53). Ovigerous females were more problematical. In order to estimate representative parameters for three components, it was necessary to hold standard deviations fixed in the final run. The expected length distribution was very similar to the observed, under these assumptions (χ^2 = 5.09, P = 0.75).

The combined analysis (Table 6) provided estimates of proportions and average lengths for three year-classes, presumably 1981, 1980 and 1979. Another component with average length of 27.7 mm was identified but the age of this group is uncertain. Age 5 males comprised over 65% of the total sample, primiparous females only 6% and age 7 multiparous females about 24%. Average lengths were estimated at 21.6, 24.3, and 25.0 mm, respectively. The latter is smaller than estimated in previous studies but, for the first time, a larger component has been identified whereas in other years it would have been included in a 7+ group.

DISCUSSION AND CONCLUSIONS

Fishery data

The catch rate series for the Canadian fishery in Division 0A has shown an increase from 1980 to 1982 followed by a period of relative stability from 1983 to 1985. This trend is consistent with other CPUE indices for the stock over the same period. The 1986 July to September catch rate was over 10% greater than the 1985 value which could be interpreted as an increase in stock abundance. However, at least two other factors must be considered which might have affected the 1986 catch rate. Firstly, the improvements in trawl design, noted in

this fishery since 1980 (NAFO 1986), likely accounts for some of the increase. Vessels fishing northern shrimp for Canada in both the Davis Strait and Labrador Sea are using larger, more efficient trawls which are capable of producing economical catch rates in areas where previously shrimp densities were too low to be commercially viable. One unofficial report specifies a net with a 56 m horizontal opening and a 21 m vertical opening! Secondly, markets changed in 1986, accepting more smaller grade shrimp than in previous years. Thus, it is possible that in 1986 catch rates were maximized, regardless of size whereas in earlier years some optimization was likely necessary to avoid the smaller sizes.

Under these conditions, the CPUE index can only be used as a very approximate indicator of stock size. More information is needed on the improvements in gear design and, if indeed, fleet performance is affected by changing market conditions, then these factors must be taken into account as well. For years, STACFIS has recommended that trawl surveys be conducted in this area to monitor changes in distribution and abundance but, since 1979, none have been carried out. Contracting parties must realize that with so many changes taking place in the fishery, an independent estimate of stock abundance is necessary, if we are to interpret fleet performance correctly.

The recovery of catch rates late in the season in 1985 was attributed to a concentration of berried females rather than new recruitment (Parsons and Veitch 1986). Increased concentration in the late months of 1986 also is apparent, not only for females but males as well. The same two size groups which supported good catch rates in June also comprised most of the catch in November, after a period of decreased availability.

The differences in size composition of the shrimp catches observed in 1986 might have been due to changes in the distribution of fishing effort compared to the previous year (i.e. reduced effort in the northwestern areas) but are more likely a reflection of the increased acceptability of smaller shrimp in the market place. The continued absence of a smaller mode of male shrimp in the 1986 commercial data may not be a major concern for future recruitment. The (presumed) 1981 year-class was poorly represented in the 1985 data (Parsons and Veitch 1986) but formed a substantial proportion of the 1986 catch. Carlsson (1986) suggested that the lack of smaller shrimp might not indicate poor recruitment but rather non-availability to the gear. Kanneworff (1986) observed that only large shrimp seem to inhabit the same areas with roughly the same degree of preference from year to year.

In 1985, discards of shrimp were lower than levels observed in 1984 and this was thought to be a reflection of a reduction in the proportion of smaller shrimp in the catch (Parsons and Veitch 1986). The 1986 discard estimates were again lower, despite an increase in the relative importance of males in the catch. Reduced discards in 1986 likely reflect the improved markets for small shrimp.

Except for the damage to gear and catch caused by Greenland sharks, by-catches of finfish are not a major problem in this fishery. However, the abundance of redfish appears to be increasing and their occurrence in the catches should be closely monitored over the next few years.

Biological data

Although the sizes of shrimp in the samples obtained from Division 0A in 1986 were similar to those observed in the commercial catch, the data cannot be considered representative of either catch or stock. Consequently, the data have no practical use for making assumptions on catch or stock composition and year-class strength. The results can, however, be reviewed in relation to age interpretation and the associated problems.

The present analysis assumes only one component of male shrimp representing the 1981 year-class. The range of lengths extends from 16.0 to 25.5 mm suggesting large variation in length within a single year-class. It is likely that some of the smaller males belong to the 1982 year-class (age 4 in 1986) but are not represented strongly enough to be identified as a separate component. Similarly, the right side of the distribution suggests the possibility of overlapping modes but the evidence for making this assumption is also insufficient. It should be noted, however, that irregularities on the right side of the male length distributions have occurred in the previous two attempts at age interpretation. In order to interpret growth accurately, it is necessary to follow the development of a cohort over time and especially through the period of transition.

Primiparous females were poorly represented in the 1986 samples. This could be due to a weak year-class or, more likely, to the problem of interpreting sternal spines at this time of year, as mentioned previously. In studying age compositions of samples from other areas, we have found that modal analysis of a composite group of females can give much different results compared to the separation of primiparous and multiparous groups by sternal spines.

A sample obtained in late September 1984 (Parsons et al. 1985) showed that most

non-ovigerous females were without spines (multiparous) and that ovigerous females formed two modal groups, the larger (but less numerous) of which was similar in size to the non-ovigerous, multiparous females. Thus, it was interpreted that primiparous females laid their eggs earlier than older females. This is not so apparent in the 1986 samples since a wide range of sizes is well-represented in the ovigerous group. Nevertheless, the analysis indicates that about 30% of primiparous females were ovigerous compared to just over 20% for multiparous females. These results are not consistent with laboratory observations by Nunes (1984) which showed a tendency for primiparous females to extrude their eggs later than multiparous females.

Samples analyzed in recent years have indicated that the potential for spawning failure has increased over previous years.

	1978	1979	1980	1981	1984	1986
Transitionals and females	256	243	333	144	324	510
Non-spawners	9	7	5	2	29	51
% non-spawners	3.5	2.9	1.5	1.4	9.0	10.0

The proportion of non-spawners declined from 3.5 to 1.4 % in samples analyzed from 1978 to 1981. There was a substantial increase to 9% in 1984 and 10% in 1986. The relatively high level observed in 1984 samples was supported by the occurrence of substantial numbers of non-ovigerous females in the commercial catch taken in Division 0A in October and November of that year (Parsons et al. 1985). No data were available from Subarea 1 to substantiate an increase but Carlsson (1985) noted that samples from the Hare Island area (Statistical Unit LS 014) in 1983 and 1984 showed a high proportion of females without roe. The data from the 1986 fishery indicate that the proportion of non-spawning females occurring in the catches in October and November could have been higher than 10% (12-16%).

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Table 1. CPUE (tons per hour fished) by month for Division 0A, 1980-86 from A) observer reports (including discards) and B) vessel logs.

	1980		1981		1982		1983		1984		1985		1986	
Month	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE
A. OBSERVER REPORTS														
May	1	0.496												
June	26	0.481	364	0.487			17	0.518			332	0.555	287	0.682
July	13	0.410	862	0.413	588	0.561	547	0.391	430	0.451	698	0.458	558	0.433
August	177	0.328	795	0.322	653	0.384	503	0.330	203	0.314	459	0.267	318	0.336
September	48	0.261	728	0.306	398	0.317	397	0.272	399	0.275	340	0.236	169	0.236
October			784	0.256	471	0.287	452	0.274	419	0.257	452	0.328	388	0.372
November	22	0.671	798	0.248	421	0.318	181	0.261	117	0.277	262	0.380	637	0.523
December	74	0.343	75	0.161										
TOTAL	360	0.340	4406	0.305	2531	0.363	2097	0.310	1568	0.307	2537	0.347	2357	0.418
B. VESSEL LOGS														
June			347	0.465			9	0.405			290	0.487		
July	54	0.445	756	0.419	373	0.603	752	0.389	379	0.448	924	0.369	NOT	
August			665	0.307	650	0.354	1241	0.303	354	0.260	604	0.251		
September			585	0.297	458	0.305	798	0.253	398	0.243	414	0.232	AVAILABLE	
October			833	0.258	335	0.268	992	0.248	324	0.237	582	0.323		
November			743	0.249	249	0.261	257	0.239	40	0.311	255	0.308		
December	62	0.306	72	0.149										
TOTAL	116	0.358	4001	0.299	2064	0.335	4057	0.284	1495	0.300	2721	0.306		

Table 2. Shrimp discards in Division 0A, 1980-86, estimated by observers.

	1980		1981		1982		1983		1984		1985		1986	
Month	Observed catch (tons)	% discards	Observed catch (tons)	% discards	Observed catch (tons)	% discards	Observed catch (tons)	% discards	Observed catch (tons)	% discards	Observed catch (tons)	% discards	Observed catch (tons)	% discards
May	1.4	18.0												
June	25.6	15.5	363.9	2.7			16.8	0.6			332.3	4.0	286.5	2.2
July	12.6	15.7	862.4	2.6	587.8	2.4	547.0	1.6	430.4	6.5	698.4	2.9	557.8	2.3
August	176.5	6.0	795.1	4.4	653.3	3.3	502.6	3.0	203.2	4.9	459.4	3.4	317.9	2.7
September	48.5	2.5	727.9	5.6	398.3	3.4	396.5	3.3	398.8	5.8	338.9	2.9	168.9	2.5
October			784.4	5.7	471.0	3.4	452.3	4.6	419.3	2.8	448.5	3.8	388.1	1.9
November	21.6	0.0	797.7	3.3	420.7	2.9	181.2	5.3	117.3	6.0	165.1	2.2	636.7	2.4
December	74.2	1.3	74.8	4.2	-	-	-	-	-	-	-	-	-	-
TOTAL	360.4	5.26	4406.2	4.13	2531.1	3.06	2096.4	3.22	1569.0	5.09	2442.6	3.26	2355.9	2.32

Table 3. Observed by-catch in Division 0A, 1986.

	June		July		August		September		October		November	
	Wt. (t)	%	Wt. (t)	%	Wt. (t)	%	Wt. (t)	%	Wt. (t)	%	Wt. (t)	%
Shrimp (P. borealis)	232.324	85.47	483.563	76.84	295.119	69.09	150.428	70.87	319.083	81.18	523.062	73.27
American plaice	0.732	0.27	1.311	0.21	1.304	0.31	1.462	0.69	1.841	0.47	2.943	0.41
Cod	0.079	0.03	0.631	0.10	0.206	0.05	0.331	0.16	0.065	0.02	0.146	0.02
Arctic cod	0.382	0.14	0.874	0.14	0.548	0.13	1.140	0.54	1.725	0.44	3.365	0.47
Halibut	0.005	0.00	0.180	0.03					0.013	0.00	0.145	0.02
Redfish spp.	21.400	7.87	130.303	20.71	119.989	28.09	48.539	22.87	32.619	8.30	79.584	11.15
Greenland halibut	1.286	0.47	4.059	0.65	4.005	0.94	4.828	2.27	4.719	1.20	17.524	2.45
Witch											0.076	0.01
Eelpouts/blennies	0.611	0.22	0.937	0.15	0.298	0.07	0.332	0.16	0.655	0.17	0.659	0.09
Skate (thorny)	0.366	0.13	1.300	0.21	0.375	0.09	0.453	0.21	1.566	0.40	0.490	0.07
(unspecified)			0.695	0.11	1.271	0.30	1.405	0.66	0.092	0.02	1.260	0.18
Wolffish (striped)	0.221	0.08	0.068	0.01	0.037	0.01	0.451	0.21	0.363	0.09	0.107	0.01
(spotted)	0.062	0.02	0.183	0.03	0.138	0.03	0.143	0.07	0.087	0.02	0.031	0.00
(broadhead)									0.002	0.00		
Greenland shark			0.350	0.06	2.350	0.55	1.250	0.59	27.699	7.05	78.439	10.99
Other	14.364	5.28	4.836	0.77	1.508	0.35	1.507	0.71	2.614	0.67	6.055	0.85
By-catch totals	39.506	14.53	145.721	23.15	132.028	30.91	61.839	29.13	73.964	18.81	190.831	26.73
Grand totals	271.831	100.00	629.281	100.00	427.139	100.00	212.268	100.00	393.041	100.00	713.890	100.00

Table 4. Sex and maturity of shrimp taken in Division 0A, September 7, 1986.

Sex	Maturity	No.	% of total
Juvenile	Immature	0	0.00
Male	Immature	0	0.00
Male	Maturing (small VD)	0	0.00
Male	Mature (large VD)	955	65.19
Transitional	Small ovary	0	0.00
Transitional	Large ovary	59	4.03
Female (non-ovigerous)	Primiparous, small ovary	0	0.00
Female (non-ovigerous)	Primiparous, large ovary	4	0.27
Female (non-ovigerous)	Multiparous, small ovary	51	3.48
Female (non-ovigerous)	Multiparous, large ovary	277	18.91
Female	Ovigerous	119	8.12
TOTAL		1465	100.00

Table 5. Results of the Macdonald and Pitcher (1979) analysis of males and ovigerous females in samples from Division 0A, September 7, 1986.

Sex	Group	%	No.	Average length	S.D.	x^2	D.F.	P
Multiparous females	1	89.0	289	25.0	1.06	8.03	9	0.53
	2	11.0	36	27.6	0.59			
Ovigerous females	1	22.2	26	23.3	0.60	5.09	8	0.75
	2	50.5	59	25.0	0.89			
	3	27.3	32	27.4	0.93			

Table 6. Age structure of pooled samples from Division 0A, September 7, 1986 interpreted from stages of sexual development and the Macdonald and Pitcher method of modal separation.

	Males		Primiparous females		Multiparous females		Ovigerous females				
Age	No.	Average length	No.	Average length	No.	Average length	No.	Average length	Total	%	Average length
5	955	21.6							955	65.2	21.6
6			63	24.8			27	23.2	90	6.1	24.3
7					289	25.0	59	25.0	348	23.8	25.0
?					39	27.8	33	27.5	72	4.9	27.7
TOTAL	955		63		328		119		1465	100.0	

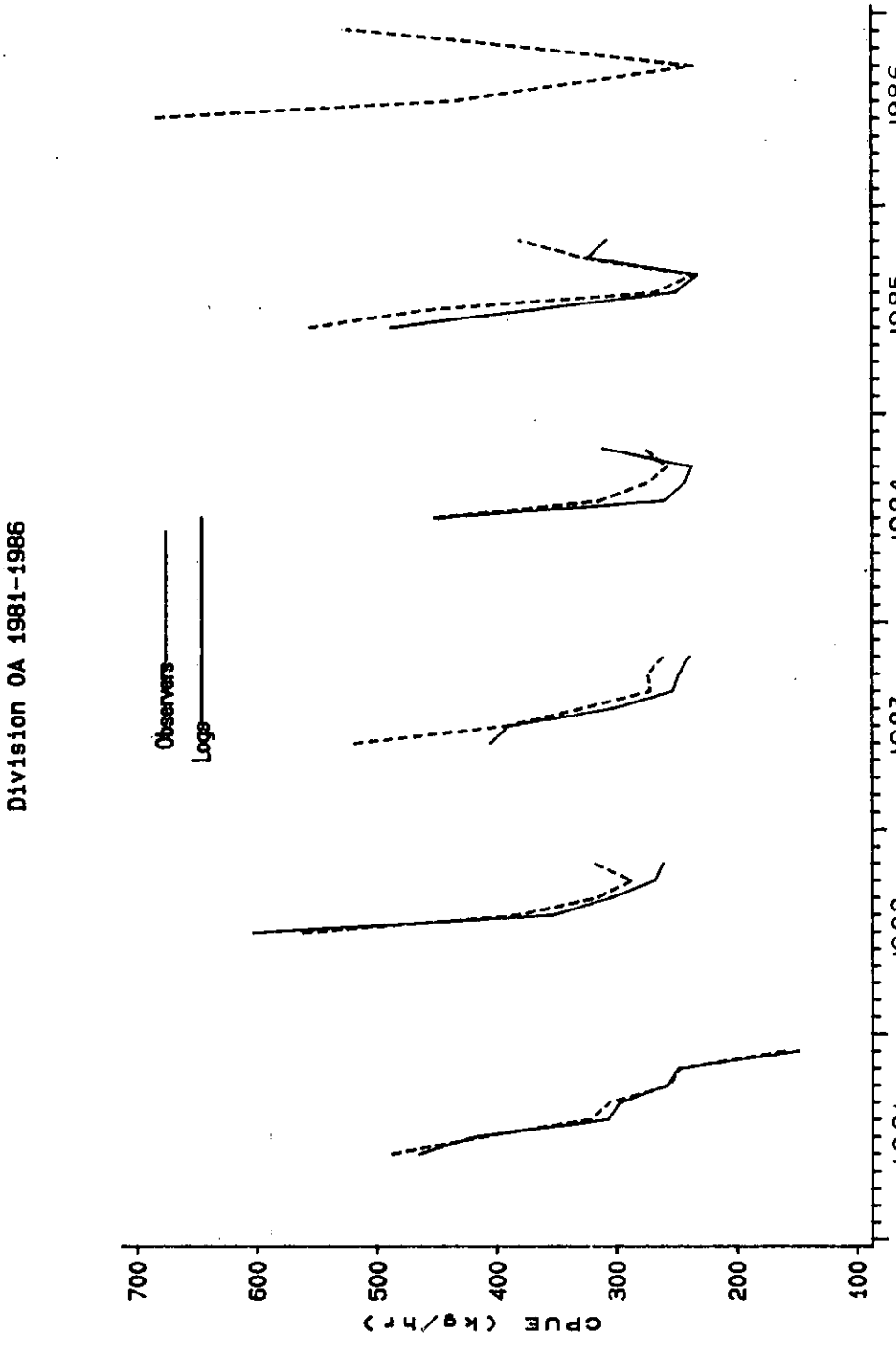

Fig.1. Monthly CPUE (kg/hr) for vessels of tonnage classes 4,5 and 6 in Division 0A,1981-1986.

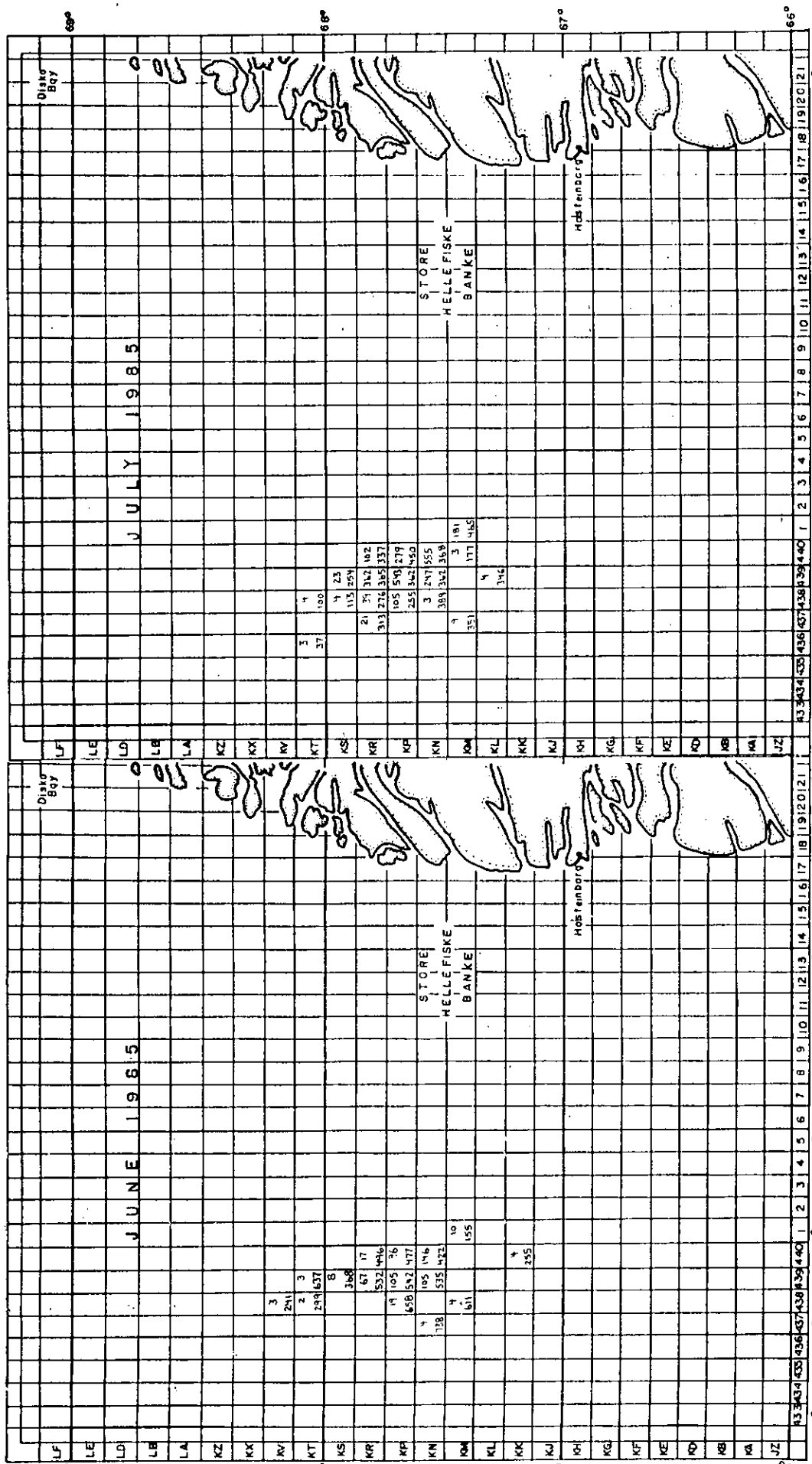

Fig.2. Hours fished (upper) and kg/hr.(lower) by statistical square, updated from 1985 vessel logs.

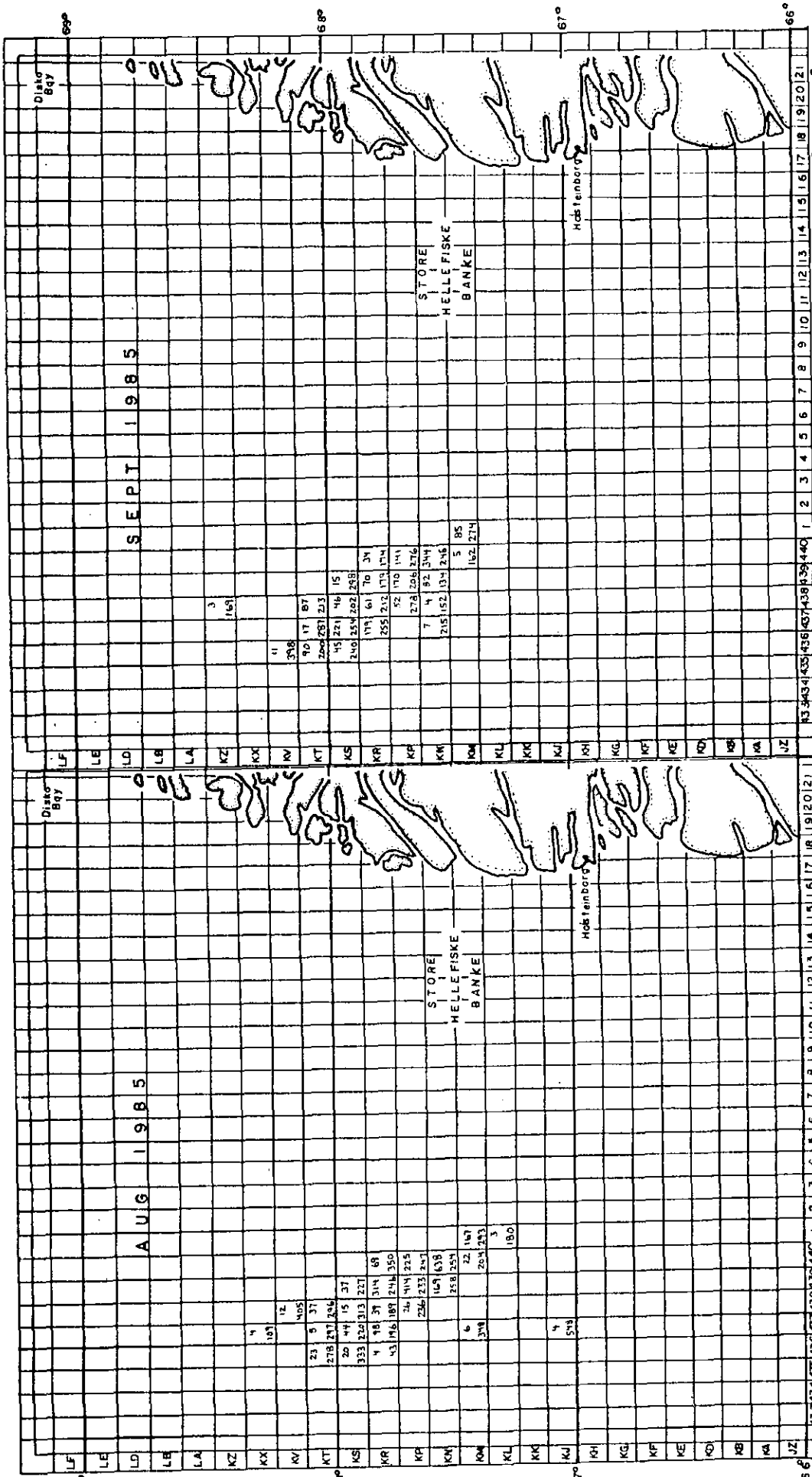

Fig.2. Continued.

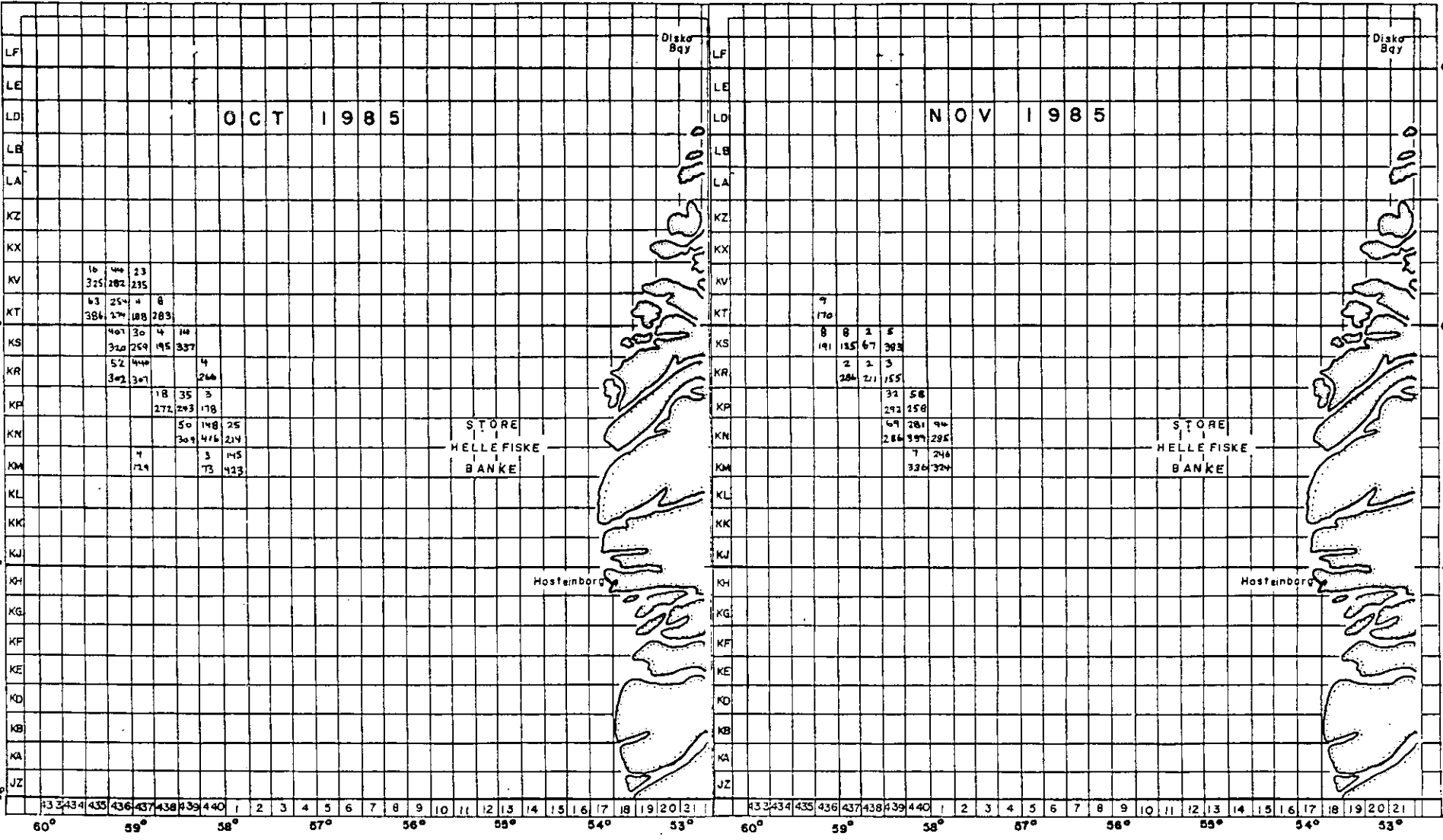

Fig.2. Continued.

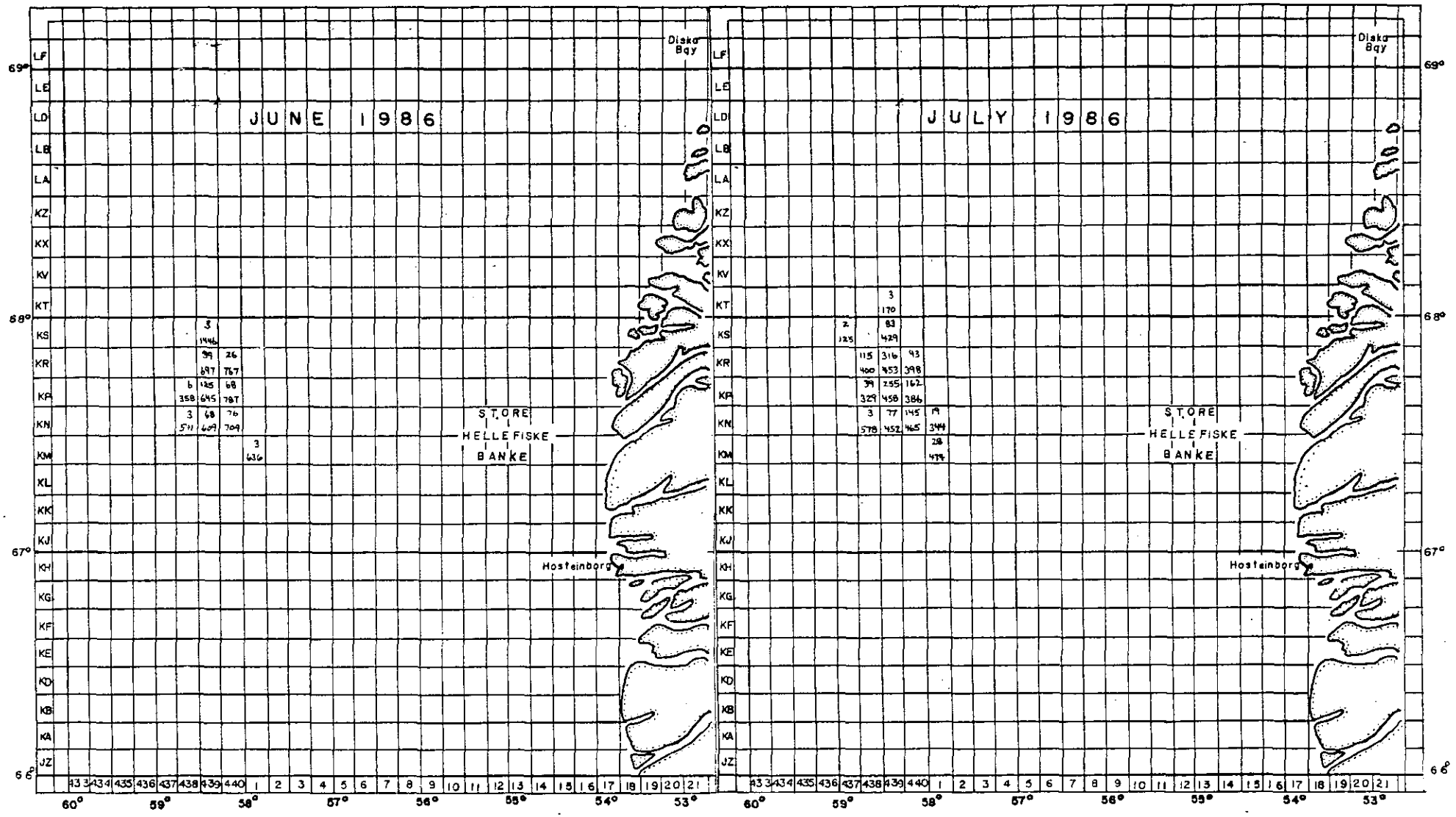

Fig.3. Hours fished (upper) and kg/hr (lower) by statistical square from 1986 observer reports.

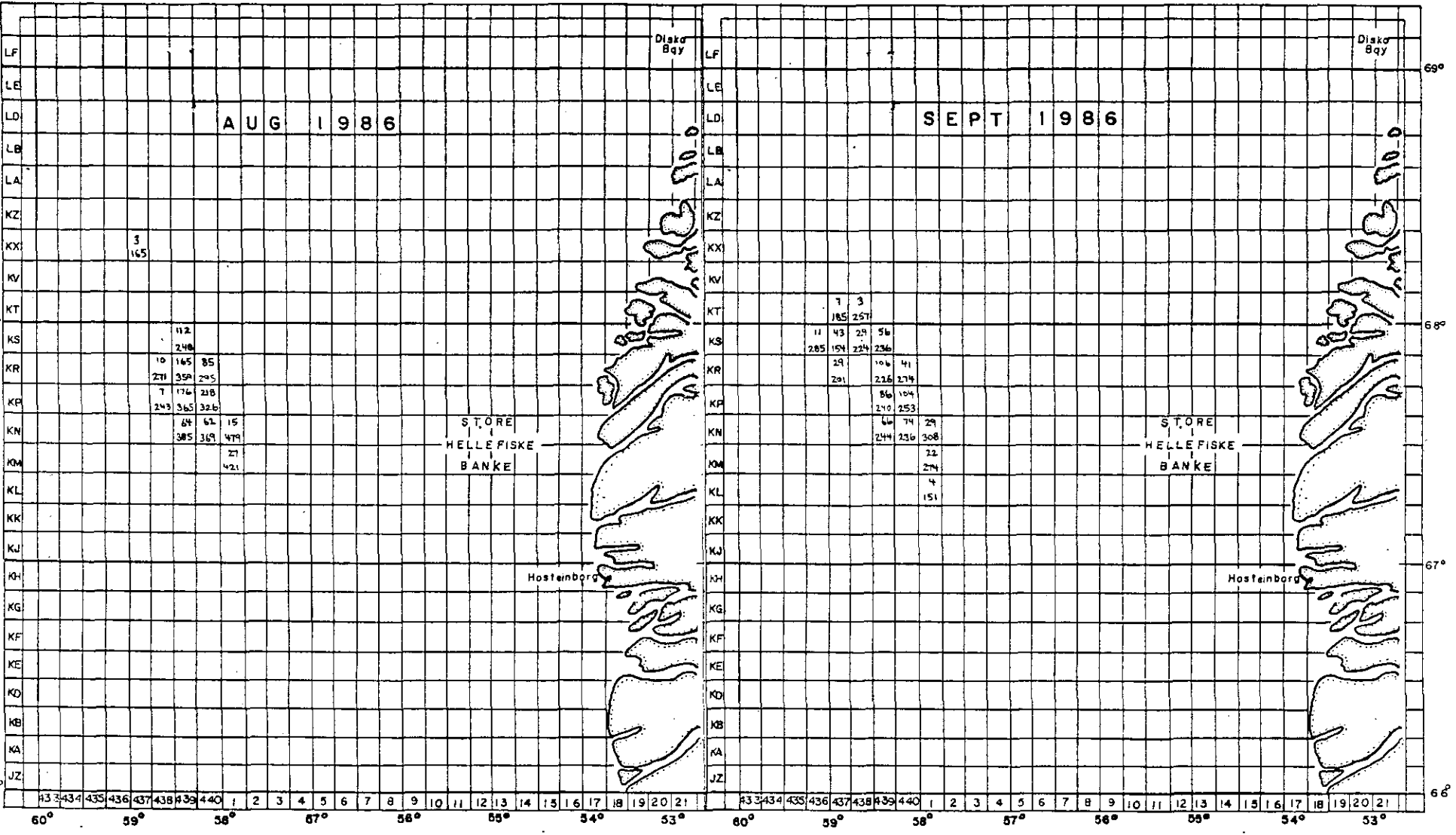

Fig.3. Continued.

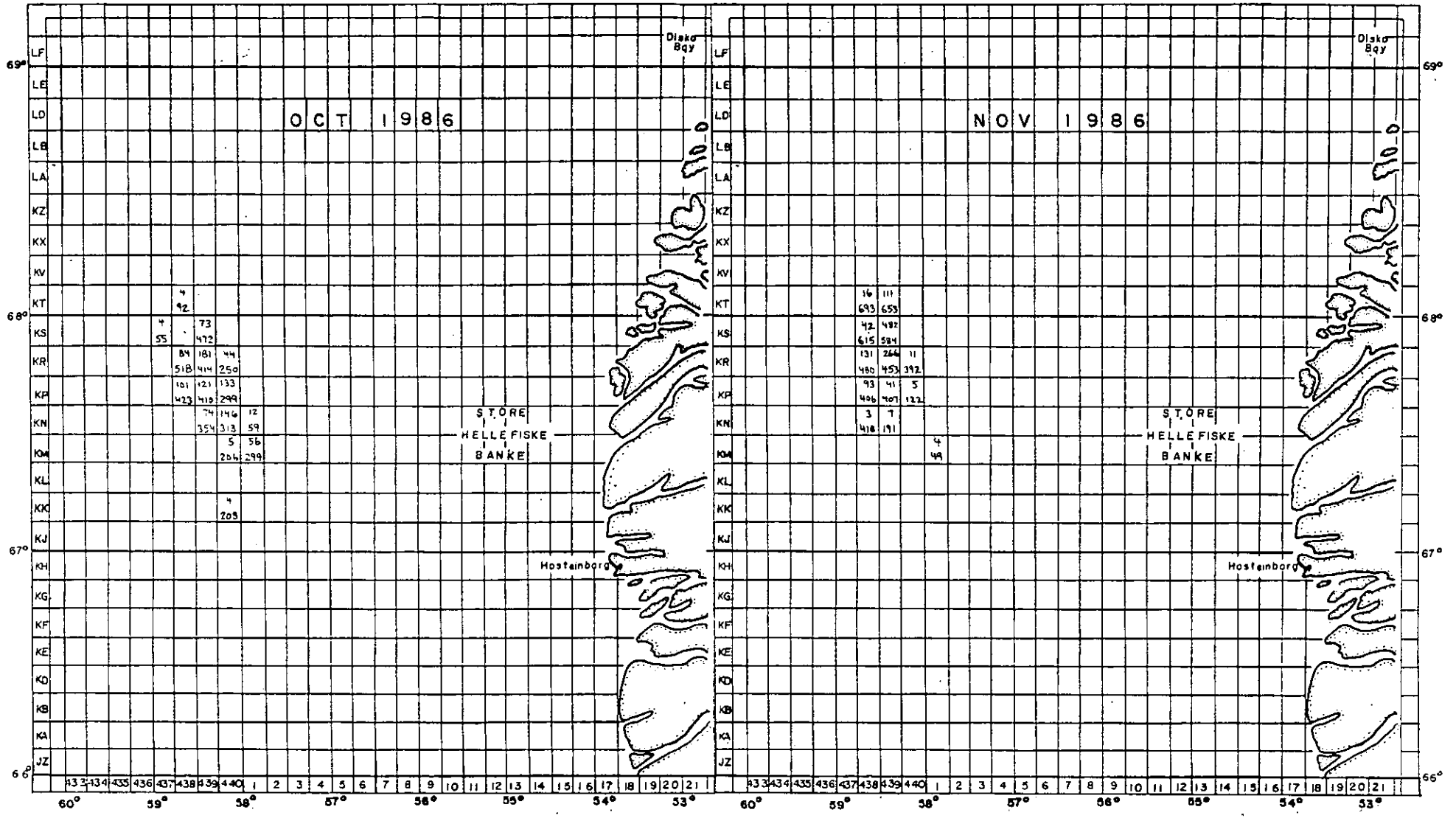

Fig.3. Continued.

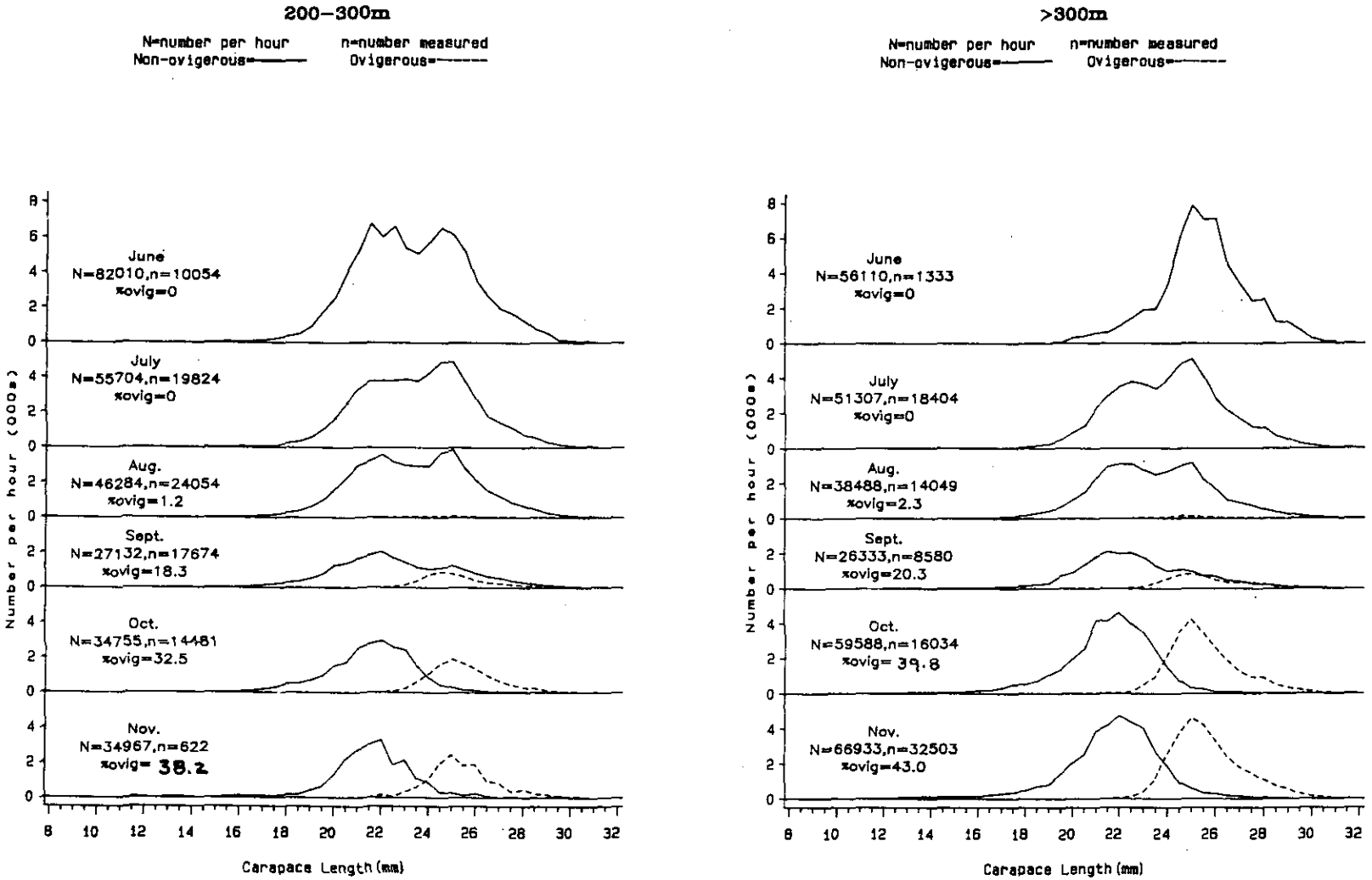

Fig.4. Commercial length frequencies by month and depth interval, Division OA, 1986.

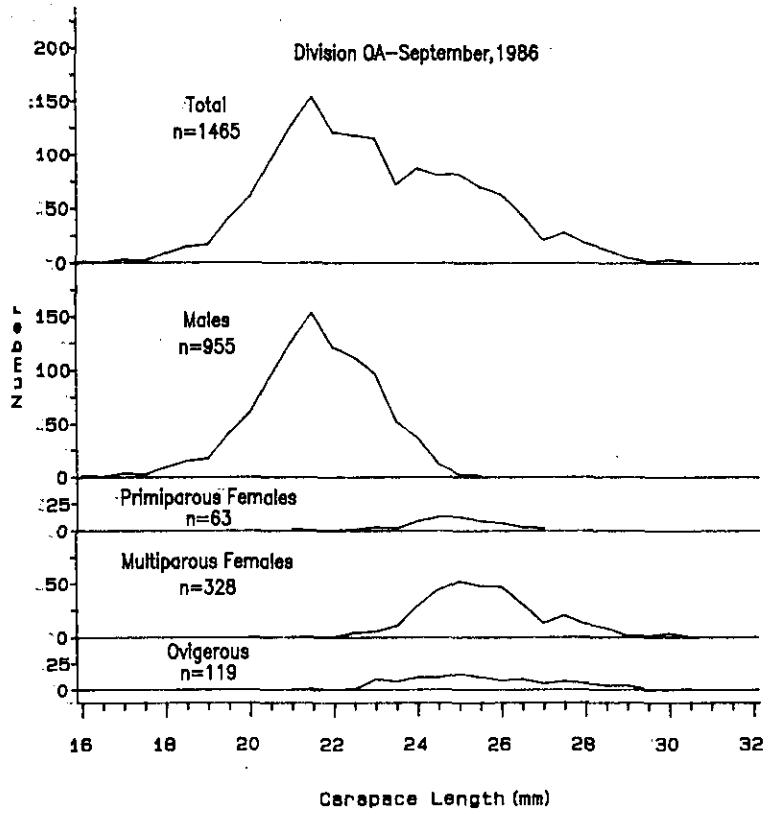

Fig.5. Length distributions of shrimp by stages of sexual development from samples taken in Division OA, September 1986.

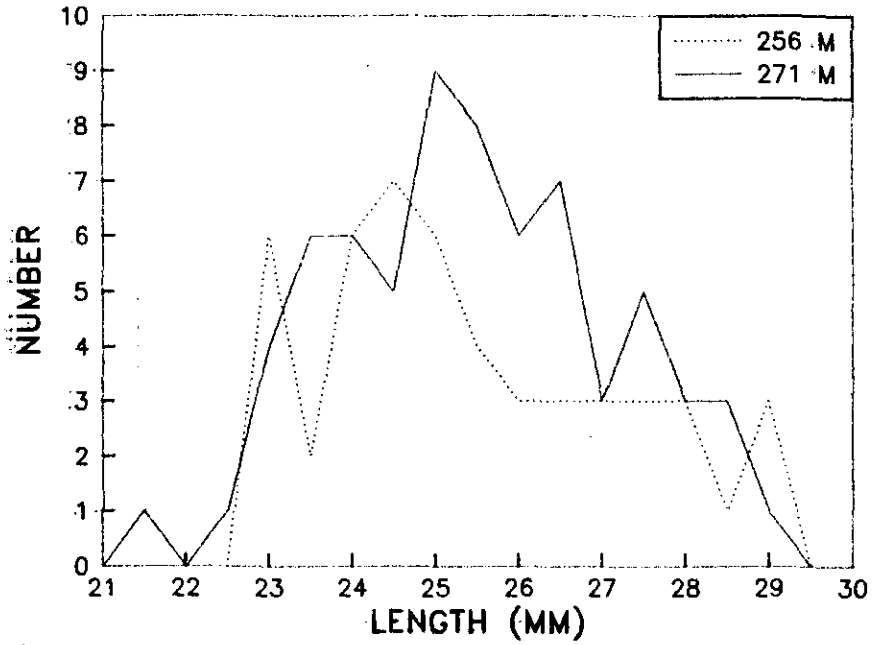

Fig. 6. Length distributions of ovigerous female shrimp taken in different depths, September 7, 1986.