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Catch, Effort, CPUE and Biological Data from the Canadian Fishery for Shrimp (*Pandalus borealis*) in Division 0A, 1984

by

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Introduction

Canadian licenced vessels fishing for shrimp in Division 0A in 1984 caught a total of 2012 t (preliminary to December 31) or 40% of the 5000 t quota. This was the lowest catch since 1979 and only half that taken in 1983. Eight vessels participated in the fishery but not on a sustained basis. Fishing began in mid July and continued into November. Ice was a limiting factor in July and August and a combination of low catch rates, large by-catches of Greenland sharks and determination of charter arrangements ended fishing in November.

Observer coverage for part of the shrimp fleet was maintained in 1984 and data were collected in all months during which fishing took place. Vessel logs from most foreign-owned vessels were not available for this meeting but some from domestic vessels were. Data from both sources (observers and vessel logs) are presented, providing representation from both the domestic and foreign components of the fleet. Included in the analysis are distribution of catch and effort, size composition of the catch by month and depth interval, observations on by-catches and discarding and detailed biological data from samples obtained by surveillance officers in September. Data obtained in 1983 have been updated from the previous report (Parsons et al. 1984) where necessary.

Materials and Methods

Catch and effort data were compiled by month from observers' records and vessel logs for 1979 to 1984. Distribution of the 1983 and 1984 effort and the associated CPUE for each month throughout Division 0A were plotted by Danish statistical square. Carapace length frequencies (0.5 mm) from the catch and discarded shrimp obtained by observers were summarized by month and by 100 m depth intervals. Data on by-catch were summarized as a percentage of the total observed catch in each month. Estimates of the proportions of discarded shrimp also were obtained from observers' reports and vessel logs.

Two shrimp samples were obtained by surveillance officers on September 29, 1984 in Division 0A. One was taken at 67°36'N, 58°07'W in 275 m and the other at 67°45'N, 58°33'W in 340 m. The samples were pooled for analysis. Carapace lengths were measured to the nearest 0.1 mm and subsequently recombined in 0.5 mm intervals. Sex was determined by observation of the first pleopod and maturity by observation of the gonads. The size of the ovary in females and transitionals also was noted to determine whether or not they would have spawned in 1984. Condition of sternal spines (McCrary 1971) was recorded for females. Age structure of the pooled samples was interpreted through a breakdown of sexual stages and by the separation of modes within the male and ovigerous female groups. The Macdonald and Pitcher (1979) method of modal separation was used in both cases.

Results

Effort and CPUE

Catch (kg) per hour fished in each month for the years 1979 to 1984 shows the characteristic decrease in catch rates over the season (Fig. 1, Table 1). Weighted catch

rates for the July to September period from observers' records were 315, 344, 409, 330 and 338 kg per hour from 1980 to 1984, respectively. Rates for the same months from vessel logs were 338, 374, 304 and 267 kg from 1981 to 1984, respectively. From the observers' reports, there was a slight increase in catch rates between 1983 and 1984 (2.4%) whereas from vessel logs there was a decrease of 12.2%.

The distribution of fishing effort in 1983 based on vessel logs (Fig. 2) was extensively updated from the previous report (Parsons et al. 1984). As in previous years, most fishing in Div. 0A in 1983 occurred between 58° and 59°W. In June, July and November, most effort was concentrated between 67°22.5'N and 68°N whereas in the intervening months, fishing activity extended beyond the 68° parallel as far as 68°22.5'N. Highest catch rates generally occurred near the 68°N parallel in those months.

Observer reports showed a similar distribution of effort in 1984 (Fig. 3). Fishing occurred north of 68°N from August to October but catch rates appeared to be higher south of this latitude. Effort was restricted to more southern areas in July and November, presumably due to ice. Distribution of effort based on available vessel logs (Fig. 4) was similar to observer reports. In September however, catch rates from the former were similar throughout the area fished whereas observers reported higher catch rates south of 68°N.

Length Distribution

Length frequencies for each month at 100 m depth intervals (Fig. 5) showed a higher proportion of smaller shrimp in shallower water in most months. Abundance (number per hour) in July appeared to be comparable in both depth intervals (200-300 m and 300-400 m) whereas in August and September catch rates were higher in deeper water. After eggs were layed, increased abundance in shallower water is indicated in October and November. Females began laying eggs in September but frequencies for October and November suggest a relatively high proportion of non-spawning females.

Two obvious modes were evident in all months at 21-22 mm (males) and 25-26 mm (females). Another mode of smaller males around 19 mm is evident in most months but there is no clear separation from the larger male size (age) group. No smaller size groups were evident in the commercial data as there was a virtual absence of shrimp less than 18 mm.

Shrimp Discards

Estimates of the discards of shrimp from both observer reports and vessel logs are given in Table 2. In 1984, observed discarding was high (>5%) in most months compared to the previous three years. Vessel logs, on the other hand, indicated extremely low discards compared to previous years and compared to observer data. For purposes of comparison and determining levels of discarding, the observer data are considered to be more reliable.

Length frequencies of discarded shrimp (Fig. 6) show the two smaller size groups which were evident in the catch data, 19 mm and 21-22 mm. No change in size of discards was noted between months or at different depths. The size range of discards (18-24 mm) was similar to the size range of males in detailed sampling (see following section).

By-catches

Catch composition by species was provided by observers for each month from July to November (Table 3). By-catches increased from around 6% in July to 36% in November. Most of this increase in the latter two months is attributed to increased incidence of Greenland sharks. Redfish was the most important commercial fish species present in the catch, in most months comprising less than 5% of the total catch of all species (6.39% in August). Greenland halibut comprised 2.3% of the observed catch in August and less in other months. Other species occurred only incidentally in the catches and in most cases represented less than 1% of the total catch weight.

Catch rates from 1980 to 1984 indicate that redfish, as a by-catch, declined during the first four years and then increased slightly in 1984. By-catches of Greenland halibut increased slightly over the same period but remain at very low levels.

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

Biological Data

A length distribution for the pooled September samples (n = 867) and a breakdown of sexual components into males, ovigerous females, and non-ovigerous females are given in Fig. 7. Males occurred most frequently (62% of total sample) and most ranged in size between 18 and 24 mm. Most females were ovigerous with an obvious mode at 24 mm. Non-ovigerous females were larger with a dominant mode around 26 mm.

A detailed separation of maturity stages (Table 4) showed that all males were either mature or maturing. There were no juveniles or immature males. Six shrimp were identified as transitional based on pleopod characteristics and all had large ovaries. All 91 non-ovigerous females lacked sternal spines or possessed only remnants, indicating that they had spawned in the previous year. Therefore, it can be assumed that all first-year spawners are included in the ovigerous group (except for the six transitionals) and are represented by the mode at 24 mm. The less prominent mode of ovigerous females at 26.5 mm likely represents the multiple spawning group.

The observations on maturity showed that 29 of the 91 non-ovigerous females possessed small ovaries and would not have spawned in 1984. This implies a spawning failure of 9% of all potential spawners (assuming the sample is representative of the stock) which only occurred in the group of females which had spawned in the previous year.

The separation of female age groups by sternal spines was not possible because most were carrying eggs in late September. Separation of ovigerous and non-ovigerous females did not distinguish ages because some multiple spawners were included in the ovigerous group (eg. mode at 26.5 mm). Males covered a wide range of sizes but modes were not clearly defined. Ageing the sample was attempted, nevertheless, by modal separation within the male and ovigerous female groups and through interpretation of sexual stages. For males, two modal groups were identified at approximately 19 mm and 21 mm (Table 5), which was in close agreement with a previous study on the age structure of shrimp in this area (Parsons and Tucker 1984). The ovigerous females were separated into two groups based on modes at 24 mm (first-year females) and 26.5 mm (females which had spawned before). The chi-square values generated by the Macdonald and Pitcher method (Table 5) showed that the expected distribution for females agreed well with the observed data ($P > 0.50$), but the fit for male age-groups was not as good ($0.05 < P < 0.10$).

The combined analysis resulted in a breakdown of the sample into four age-groups (Table 6), two of males, one composed of first-time spawners (i.e. transitionals plus ovigerous females in the 24 mm mode) and one which included all non-ovigerous females (spawned in the previous year) and ovigerous females in the 26.5 mm mode. Average lengths were derived for each age-group: 18.7 and 21.0 mm for males and 23.8 and 25.9 mm for females. The analysis indicated that the older males accounted for over 40% of the sample, whereas the oldest females accounted for only 13%. Younger males and first-year females comprised 21% and 24% of the sample, respectively.

Discussion

The 1984 catch per unit effort figures are inconclusive for a number of reasons. Vessel logs are incomplete and those available cover only the domestic vessels. Observer coverage is for foreign-owned vessels and these, because of charter arrangements, can vary from year to year and within years. Observer reports show a slight increase in CPUE from 1983 to 1984 while vessel logs indicate a decrease. The Canadian catch represents only around 5% of the total offshore catch and to make conclusions on such a small, unstandardized effort base would not be prudent. Therefore, it is necessary to examine data from the more extensive components of the fleet before determing whether or not shrimp abundance has changed between 1983 and 1984.

Distribution of fishing effort in 1984 was similar to that reported in 1982 and 1983. Most fishing in these years occurred between 58° and 59°W and 67° and 68°N. Effort north of 68°N in 1983 and 1984 occurred from August to October but catch rates do not suggest displacement of the stock, rather an accessibility to a greater area after ice receded. Thus, the distribution of the stock in Div. 0A appears to have been similar during the past three years. In 1981, more effort and higher catch rates were reported north of 68°N in September and October (Parsons et al. 1983). The effort pattern for the Canadian fishery has been similar to that observed by Greenland trawlers in the adjacent Subarea 1. In 1980 and 1981, a considerable amount of effort took place north of 69°N whereas in 1982 and 1983, very little fishing occurred in this area (Carlsson 1984).

Length distributions obtained from the catch in July and August 1984 were similar to those obtained from Div. 0A in 1983 (Parsons et al. 1984). However, in later months, there appears to have been a greater dependency on male age groups than in the previous year. As in 1983, there was a scarcity of shrimp less than 18 mm in the catch and in samples of

discarded shrimp, as well. At the 1984 meeting, STACFIS expressed concern over the likelihood of reduced recruitment and a reduction in the spawning stock in 1984 (NAFO 1984). The apparent reduction in the proportion of females in the catch in October-November 1984, suggest that, at least, the latter concern was justified.

The relatively high discard rates in 1984 likely reflect the greater dependency on smaller shrimp. Based on the sizes of the rejected shrimp, it is assumed that most discarding was due to physical damage and not small size. Damage to the catch can be expected to increase with increased by-catches of Greenland sharks, but this is not evident from the observer records. By-catches of other fish species were similair to previous years and at such low levels, do not appear to be a problem either in the processing and quality of shrimp or concerning impact on the fish stocks.

Detailed observations of shrimp taken in September enabled a breakdown of the sample into age groups. Average lengths-at-age differed only slightly from those presented by Parsons and Tucker (1984) for shrimp taken in the Davis Strait from 1978 to 1981. Two separate age groups of males were interpreted, rather than bimodality within a single age group. The smaller of the two male age group (≈19 mm) is interpreted to be age 4. Recent studies on the growth of shrimp larvae (LGL Limited, unpublished) showed that in cold environments larval growth is slow and that the age group at 8.0 mm carapace length (Parsons and Tucker 1984) is likely age 1, not the young of the year. If so, then it takes more than four years before a year-class is fully recruited to the fishery.

Other observations on female shrimp showed that first year spawners layed eggs earlier in the season than older females and that in 1984, there was a potential spawning failure of 9%. The latter is supported by the occurrence of substantial numbers of non-ovigerous females in the commercial catch in October and November. This level of spawning failure is considerably higher than reported by Parsons and Tucker (1984) between 1978 and 1981 during which time the percent of non-spawners in samples declined from 3.5 to 1.4%. Carlsson (1984) stated that that, except for two of the northermost sampling stations, almost all transitional and female shrimp sampled in Subarea 1 in 1983 were ovigerous.

Conclusions

The Canadian research and commercial data for 1984 indicate that the shrimp resource in Division 0A may be showing signs of instability. Recruitment prospects based on interpretation of length frequencies from the shrimp catch and discarded animals, appear to be poor, similar to the situation of the previous year. A decrease in the proportion of females in the catch also was apparent in October and November and this, coupled with reduced spawning potential, could result in further recruitment failure in future years.

Catch rates, as an index of abundance, were inconclusive. Analysis and interpretation of the more extensive effort based are necessary before this assessment is attempted. Indeed, the Canadian data base represents only a small component of the fishery in Subareas 0 and 1 and all the observations above will need corroboration from other sources.

Observed discard rates are not high, but increases in 1984 could reflect an increased dependency on smaller shrimp. By-catches of fish species are not problematic, except when large catches of Greenland sharks occur late in the season.

The age composition of samples examined here and in previous reports needs to be verified before more detailed age-structured models can be considered. Once confidence has been attained in the ageing techniques, work can begin on constructing a catch-at-age matrix for the time series from Subareas 0 and 1. This should provide more definitive estimates of population size, mortality rates and recruitment levels than are presently available.

References

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Table 1. Catch and CPUE (MT per hour fished) by month for Division 0A, 1979-84.

Month	1979		1980		1981		1982		1983		1984	
	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		
July			13	0.410	862	0.413	588	0.561	547	0.391	430	0.451
Aug.	48	0.346	177	0.328	795	0.322	653	0.384	503	0.330	203	0.314
Sept.	-	-	48	0.261	728	0.306	398	0.317	397	0.272	399	0.275
Oct.	5	0.121	-	-	784	0.256	471	0.287	452	0.274	419	0.257
Nov.			22	0.671	798	0.248	421	0.318	181	0.261	117	0.277
Dec.			74	0.343	75	0.161						
	53	0.296	360	0.340	4,406	0.305	2,531	0.363	2,097	0.310	1,568	0.307
B. Vessel Logs												
June					347	0.465			9	0.405		
July			54	0.445	756	0.419	373	0.603	752	0.389	142	0.392
Aug.					665	0.307	650	0.354	1,241	0.303	203	0.232
Sept.	42	0.512			585	0.297	458	0.305	798	0.253	120	0.238
Oct.	64	0.220			833	0.258	335	0.268	992	0.248	91	0.194
Nov.	248	0.231			743	0.249	249	0.261	257	0.239		
Dec.	16	0.140	62	0.306	72	0.149						
	370	0.237	116	0.358	4,001	0.299	2,064	0.335	4,057	0.284	556	0.252

Table 2. Shrimp discards in Division 0A, 1980-84.

Month	1980 Observed catch (tons)	1980 % Discards	1981 Observed catch (tons)	1981 % Discards	1982 Observed catch (tons)	1982 % Discards	1983 Observed catch (tons)	1983 % Discards	1984 Observed catch (tons)	1984 % Discards
A. Observer Reports										
May	1.4	18.0								
June	25.6	15.5	363.9	2.7			16.8	0.6		
July	12.6	15.7	862.4	2.6	587.8	2.4	547.0	1.6	430.4	6.5
Aug.	176.5	6.0	795.1	4.4	653.3	3.3	502.6	3.0	203.2	4.9
Sept.	48.5	2.5	727.9	5.6	398.3	3.4	396.5	3.3	398.8	5.8
Oct.			784.4	5.7	471.0	3.4	452.3	4.6	419.3	2.8
Nov.	21.6	0.0	797.7	3.3	420.7	2.9	181.2	5.3	117.3	6.0
Dec.	74.2	1.3	74.8	4.2						
B. Vessel Logs										
June			347.4	2.3			16.8	0.3		
July	53.9	0.2	755.8	1.5	372.6	0.4	752.2	1.0	141.6	0.3
Aug.			664.9	1.4	650.3	0.5	1,240.9	1.0	202.7	0.3
Sept.			585.2	3.0	457.7	1.7	798.3	1.1	120.3	0.0
Oct.			833.0	5.1	334.6	2.3	992.1	1.5	90.9	0.0
Nov.			742.8	3.7	248.7	1.0	256.6	2.2		
Dec.	62.0	0.0	71.9	4.1						

Table 3. Observed by-catch Division 0A, 1984.

Species Name	July Weight (MT)	July %	August Weight (MT)	August %	September Weight (MT)	September %	October Weight (MT)	October %	November Weight (MT)	November %
Shrimp (Pandalus)	370.289	94.15	162.876	88.65	354.914	91.32	343.526	80.74	94.163	63.73
American plaice	0.200	0.05	0.209	0.11	0.226	0.06	0.778	0.18	0.389	0.26
Cod	0.038	0.01	0.024	0.01	0.047	0.01	0.145	0.03	0.031	0.02
Arctic cod	0.385	0.10	0.422	0.23	0.629	0.16	1.127	0.26	0.151	0.10
Halibut	0.031	0.01	0.037	0.02	0.176	0.05	0.133	0.03	0.013	0.01
Redfish (unspecified)	11.370	2.89	11.740	6.39	16.292	4.19	17.310	4.07	6.920	4.68
Greenland halibut	4.480	1.14	4.277	2.33	8.777	2.26	5.394	1.27	2.560	1.73
Eelpouts/blennies	0.389	0.10	0.248	0.13	0.300	0.08	0.170	0.04	0.007	0.00
Skate (unspecified)	1.428	0.36	0.668	0.36	1.532	0.39	1.226	0.29	0.143	0.10
Skate (Thorny)					0.110	0.03	2.207	0.52	1.225	0.83
Wolffish (Broadhead)			0.043	0.02	0.045	0.01	0.010	0.00	0.005	0.00
Wolffish (Striped)	0.537	0.14	0.144	0.08	0.067	0.02	0.588	0.14	0.451	0.31
Wolffish (Spotted)	0.276	0.07	0.108	0.06	0.035	0.01	0.260	0.06	0.087	0.06
Greenland shark	1.450	0.37	2.260	1.23	3.710	0.96	41.925	9.86	22.300	15.10
Other	2.433	0.62	0.709	0.39	1.786	0.46	10.662	2.51	19.311	13.07
By-catch totals	23.017	5.85	20.889	11.36	33.732	8.69	81.935	19.26	53.593	36.27
Grand totals	393.306	100.00	183.765	100.00	388.646	100.00	425.461	100.00	147.756	100.0

Table 4. Sex and maturity of shrimp taken in Division 0A, September 29, 1984.

Sex	Maturity	No.	% of total
Juvenile	Immature	0	0.00
Male	Immature	0	0.00
Male	Maturing (small vas deferens)	9	1.04
Male	Mature (large vas deferens)	534	61.60
Transitional	Small ovary	0	0.00
Transitional	Large ovary	6	0.69
Female (non-ovigerous)	Sternal spines, small ovary	0	0.00
Female (non-ovigerous)	Sternal spines, large ovary	0	0.00
Female (non-ovigerous)	No spines, small ovary	29	3.34
Female (non-ovigerous)	No spines, large ovary	62	7.15
Female	Ovigerous	227	26.18
TOTALS		867	100.00

Table 5. Results of Macdonald and Pitcher analysis of males and ovigerous females in the sample from Division 0A, September 29, 1984.

Sex	Group	%	No.	Ave. length	S.D.	X^2	D.F.	P
Male	1	33.9	184	18.7	1.06	24.9	16	.05 < P < .1
	2	66.1	359	21.0	1.28			
Ovigerous female	1	90.3	205	23.8	1.03	12.2	14	.5 < P < .75
	2	9.7	22	26.6	0.73			

Table 6. Age structure of the sample from Division 0A, Sept. 29, 1984 determined by stages of sexual development and the MacDonald and Pitcher method of modal separation.

	Modal analysis		Sexual stages: Transitionals		Sexual stages: Females without spines				
Age[a]	No.	Ave. length	No.	Ave. length	No.	Ave. length	Total	%	Aver. length
4	184	18.7					184	21.2	18.7
5	359	21.0					359	41.4	21.0
6	205	23.8	6	24.3			211	24.4	23.8
7+	22	26.6			91	25.7	113	13.0	25.9
Total	770		6		91		867	100.0	

[a]Based on revised interpretation of ages by Parsons (unpublished).

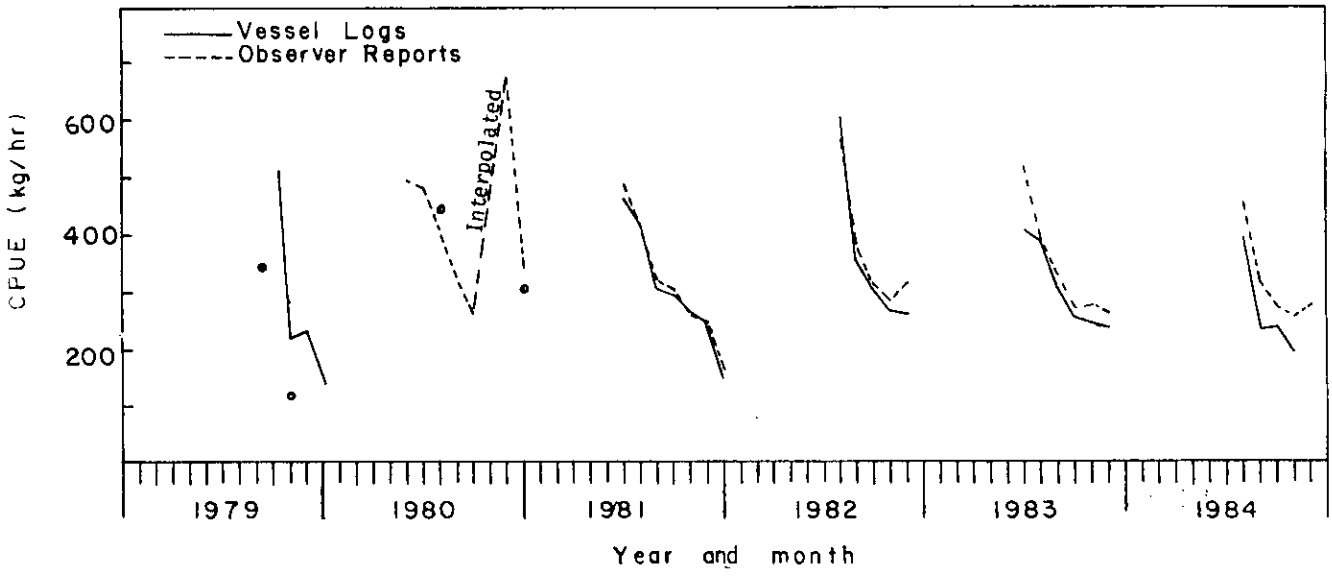


Fig. 1. Monthly catch (kg) per hour fished for vessels of tonnage classes 4,5,and 6 in Division 0A, 1979-1984.

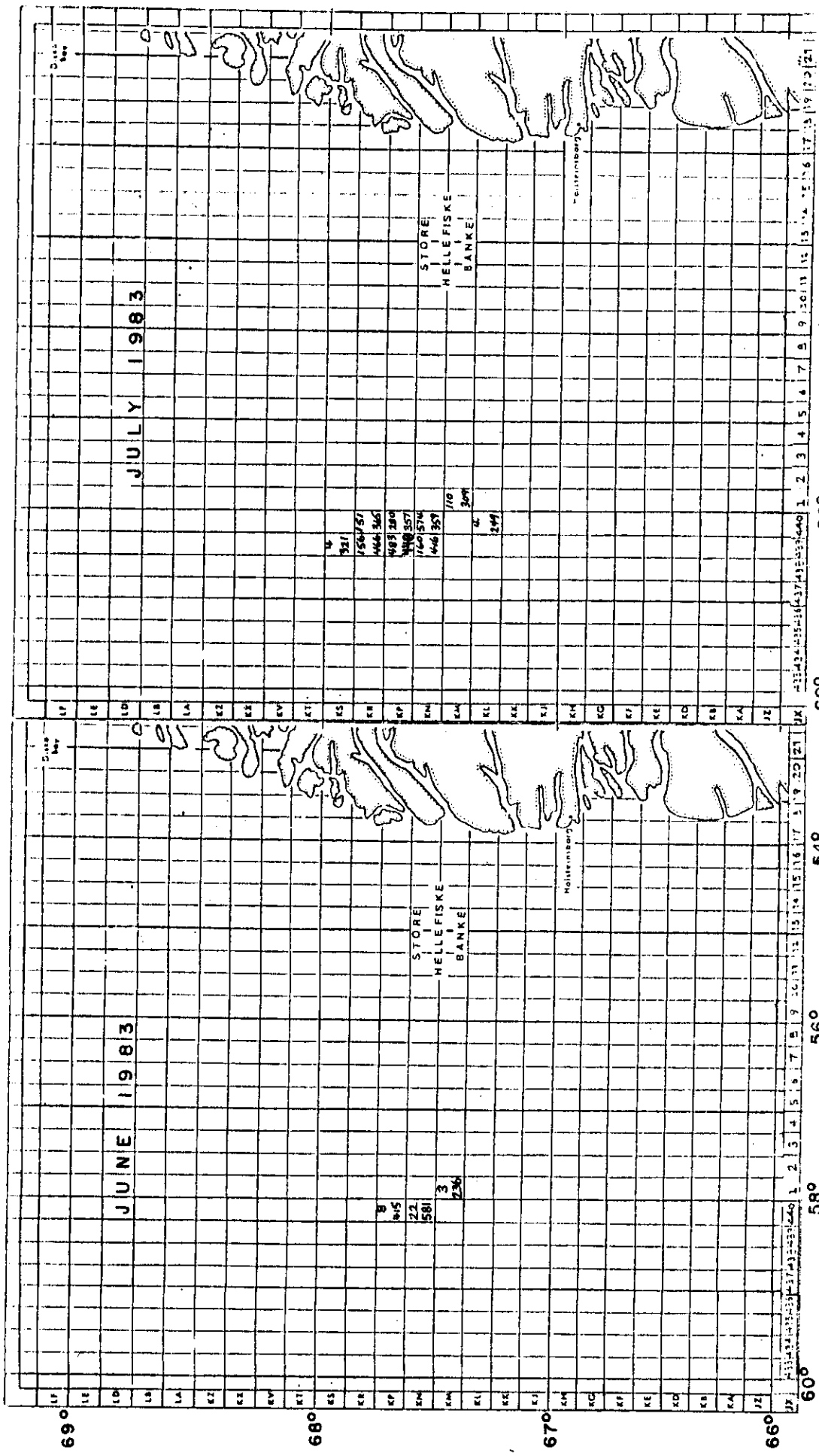
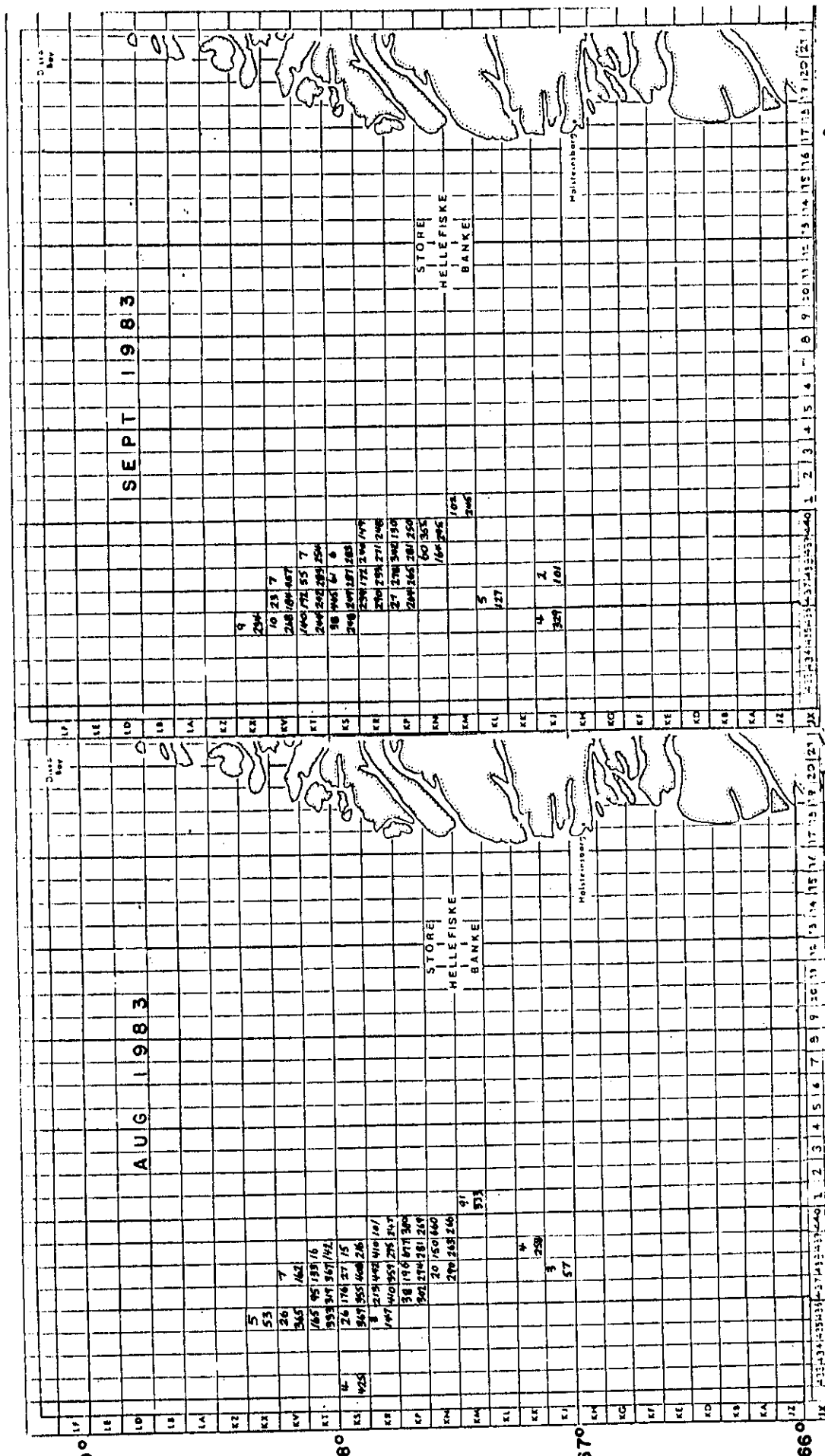


Fig.2. Hours fished (upper) and kg/hr (lower) by statistical square, 1983, from vessel logs.



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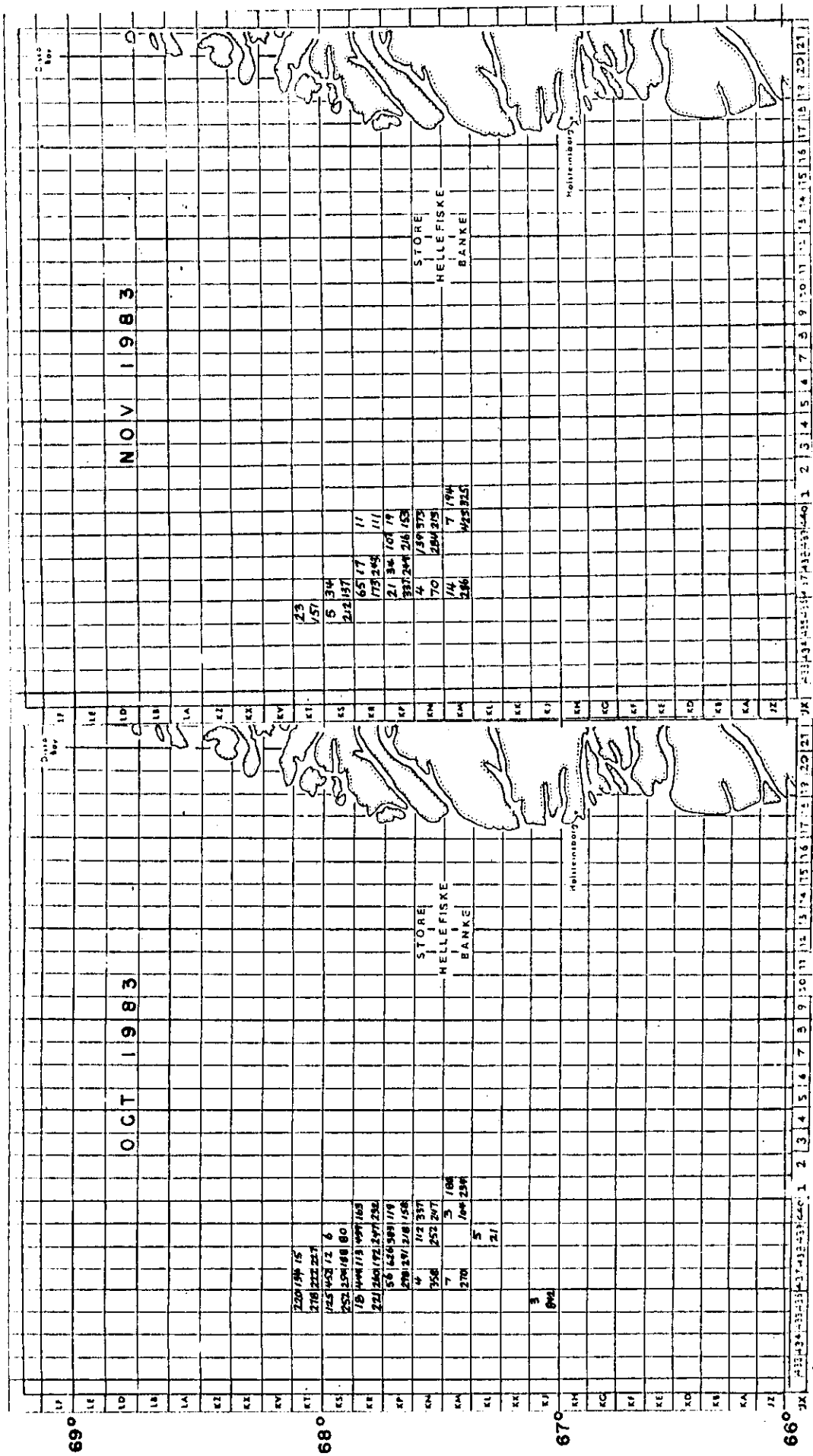

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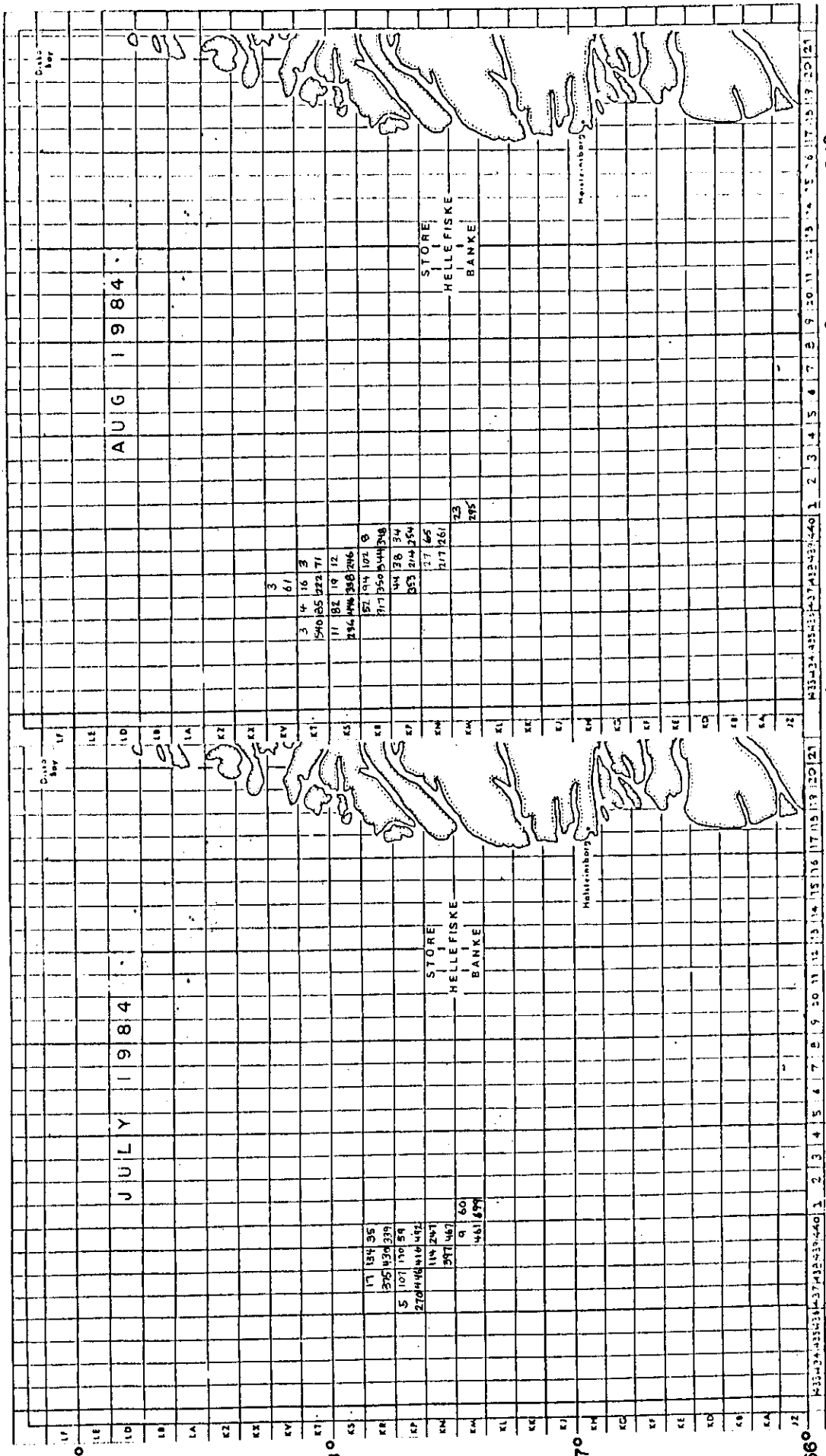
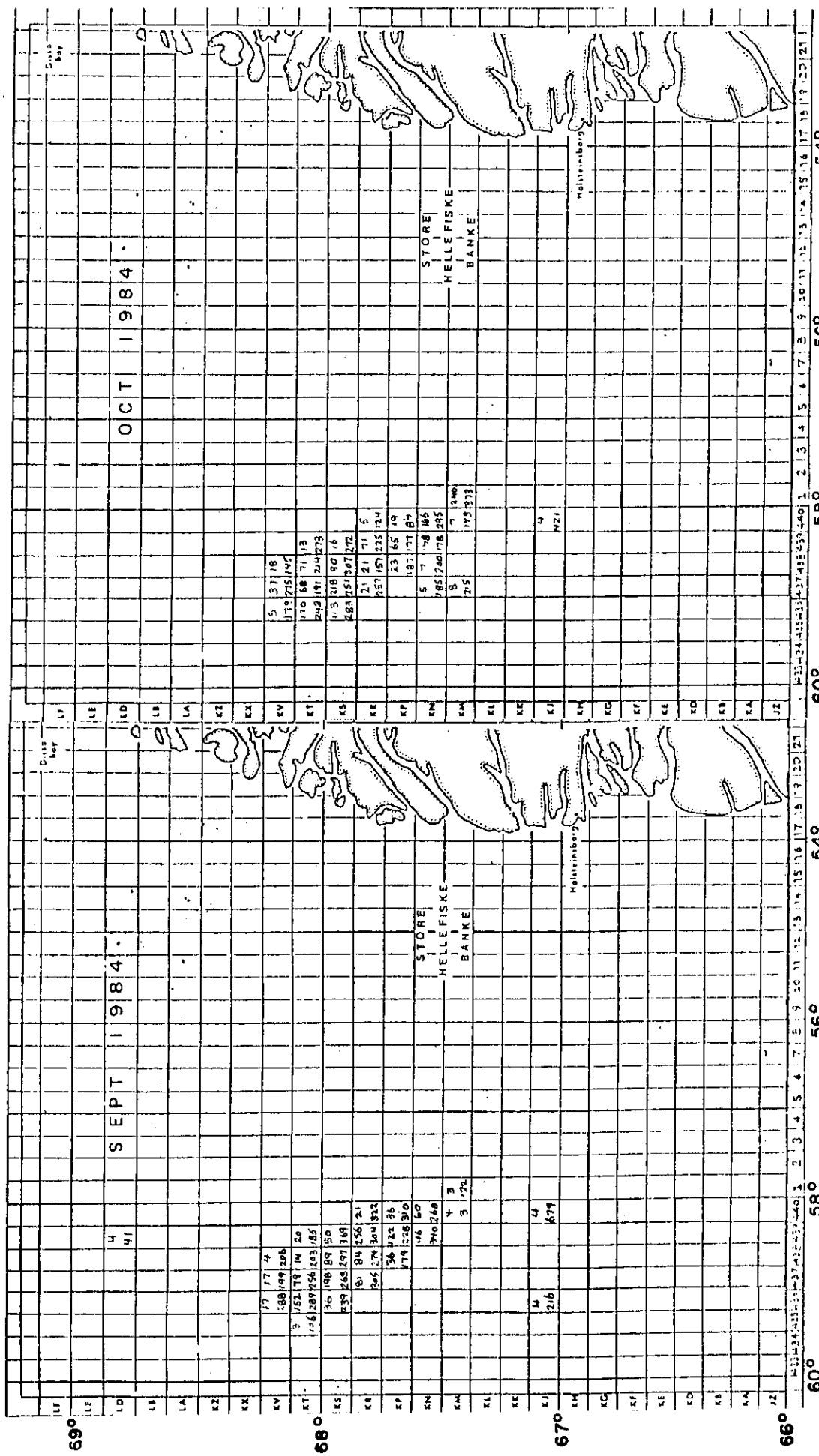


Fig. 3. Hours fished (upper) and kg/hr (lower) by statistical square, 1984, from observer reports.



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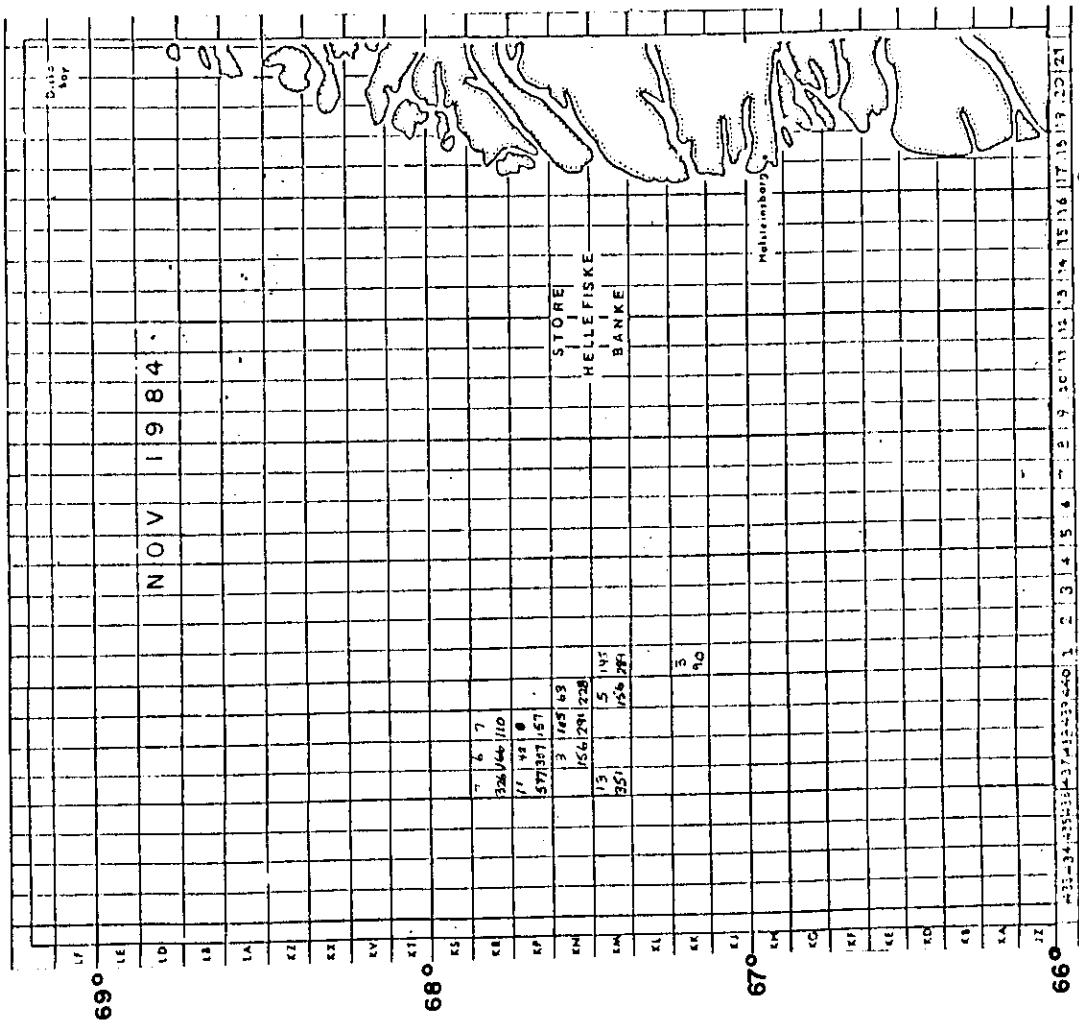

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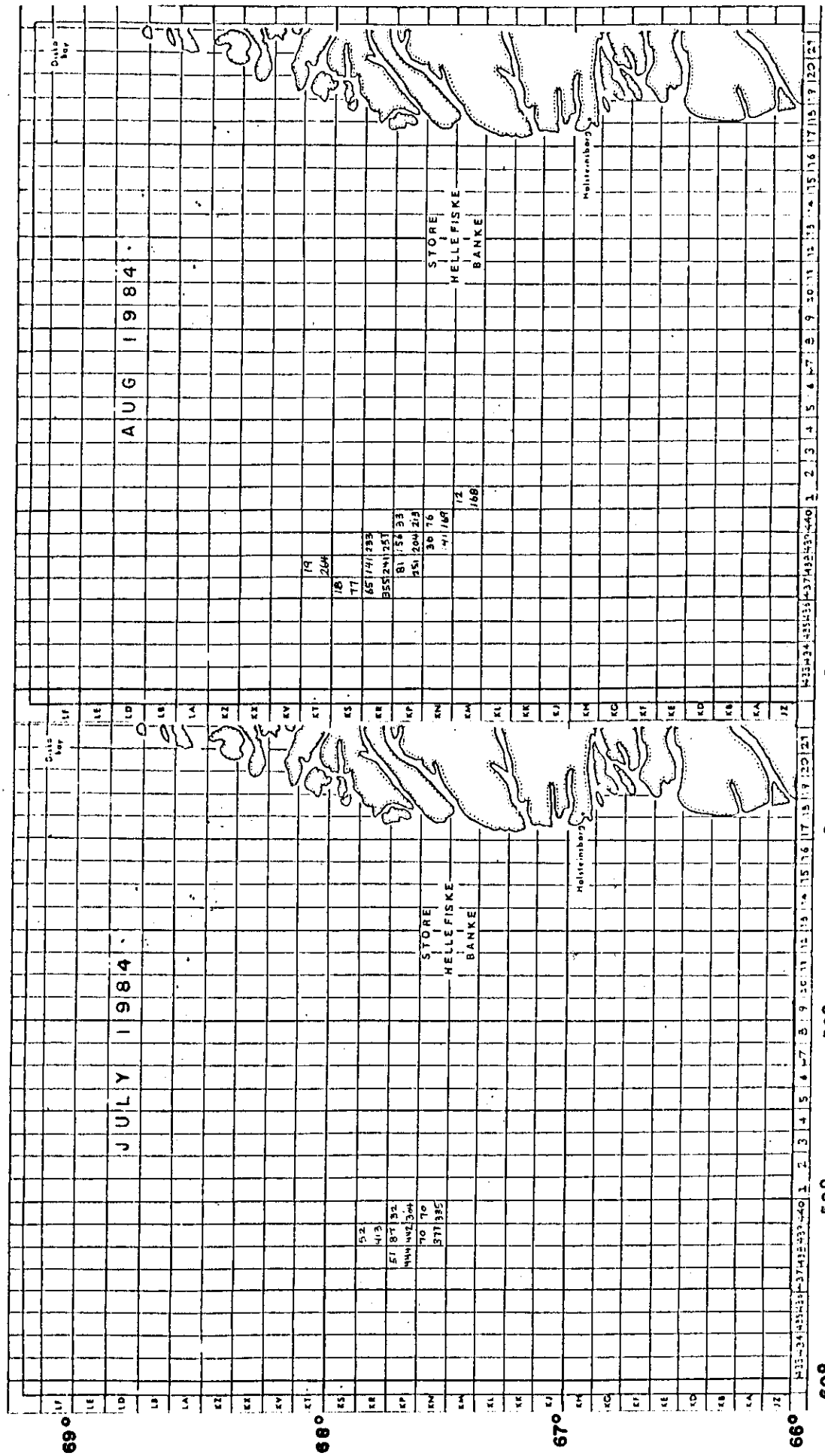


Fig.4. Hours fished (upper) and kg/hr (lower) by statistical square 1984, from vessel logs.

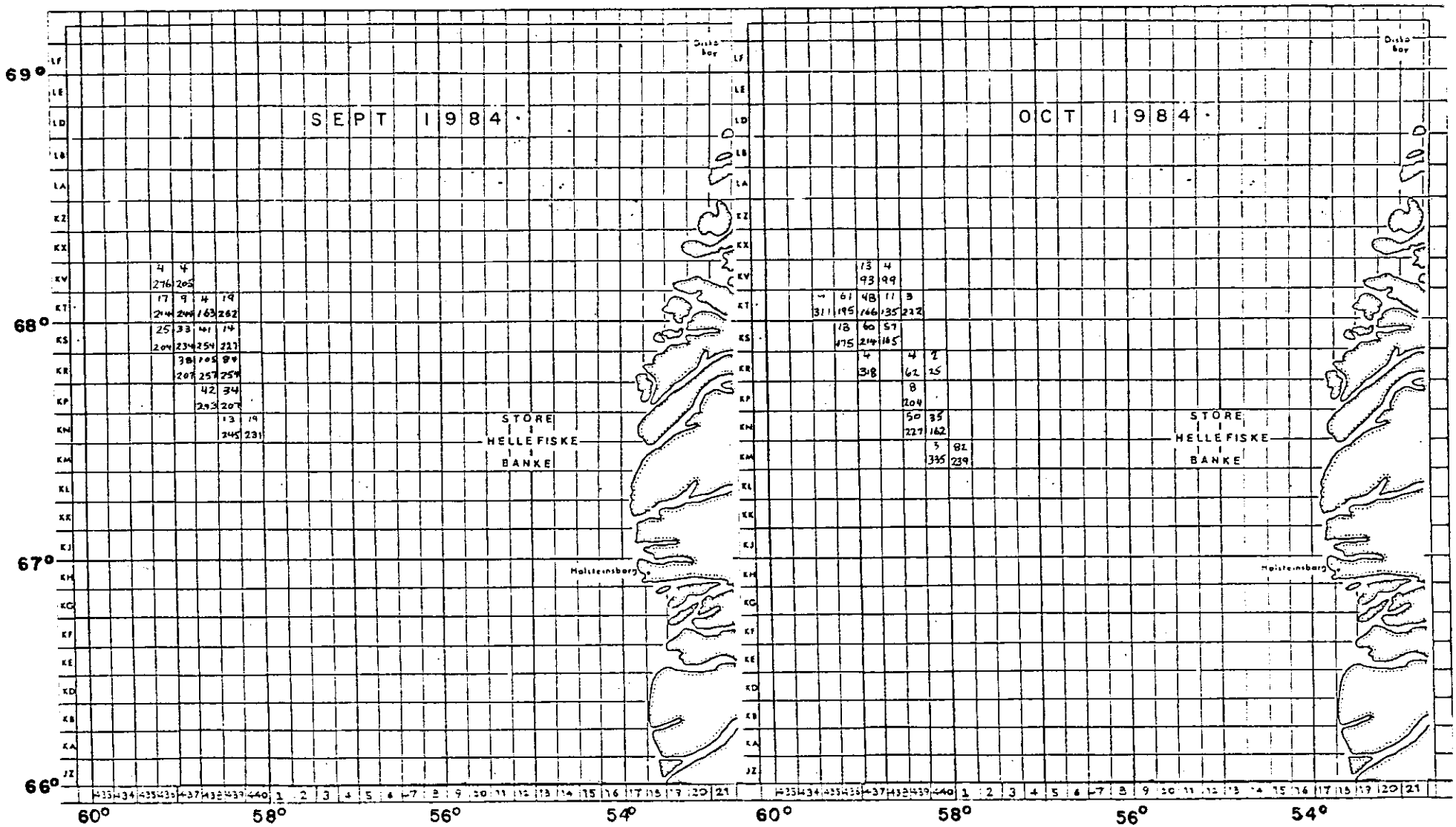
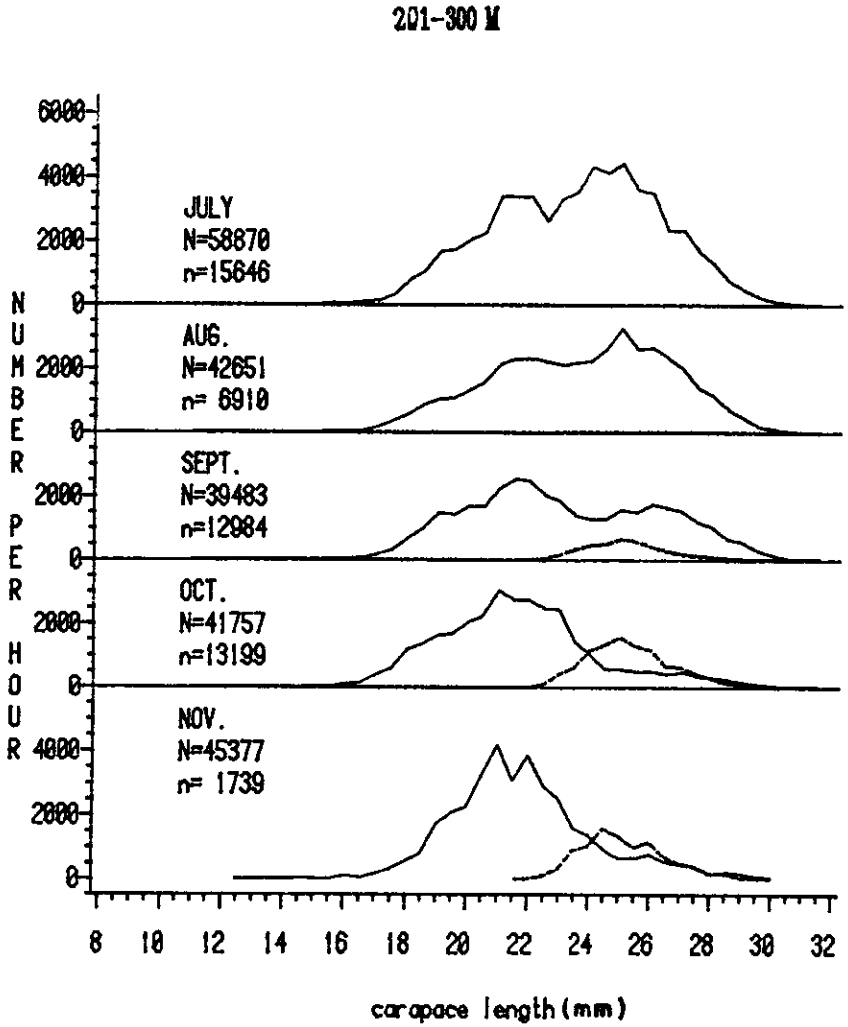


Fig.4. Continued.



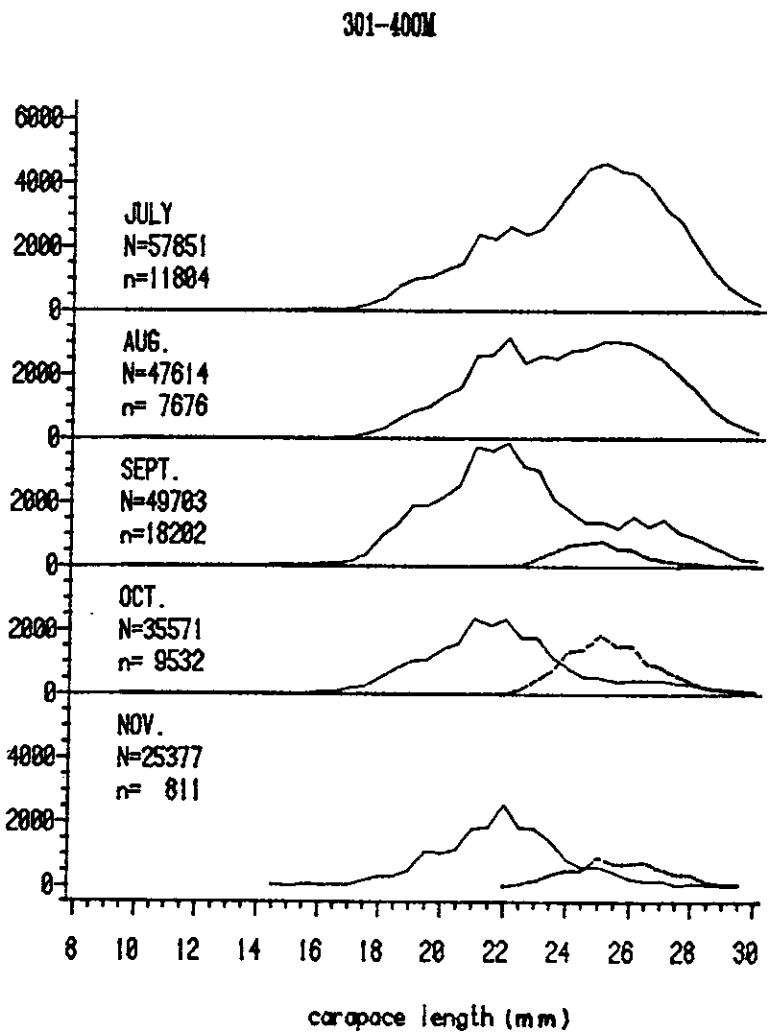


Fig.5. Commerical length frequencies,Division CA,1984. (Ovigerous represented by broken line.)

N = Number per hour

n = Number measured.

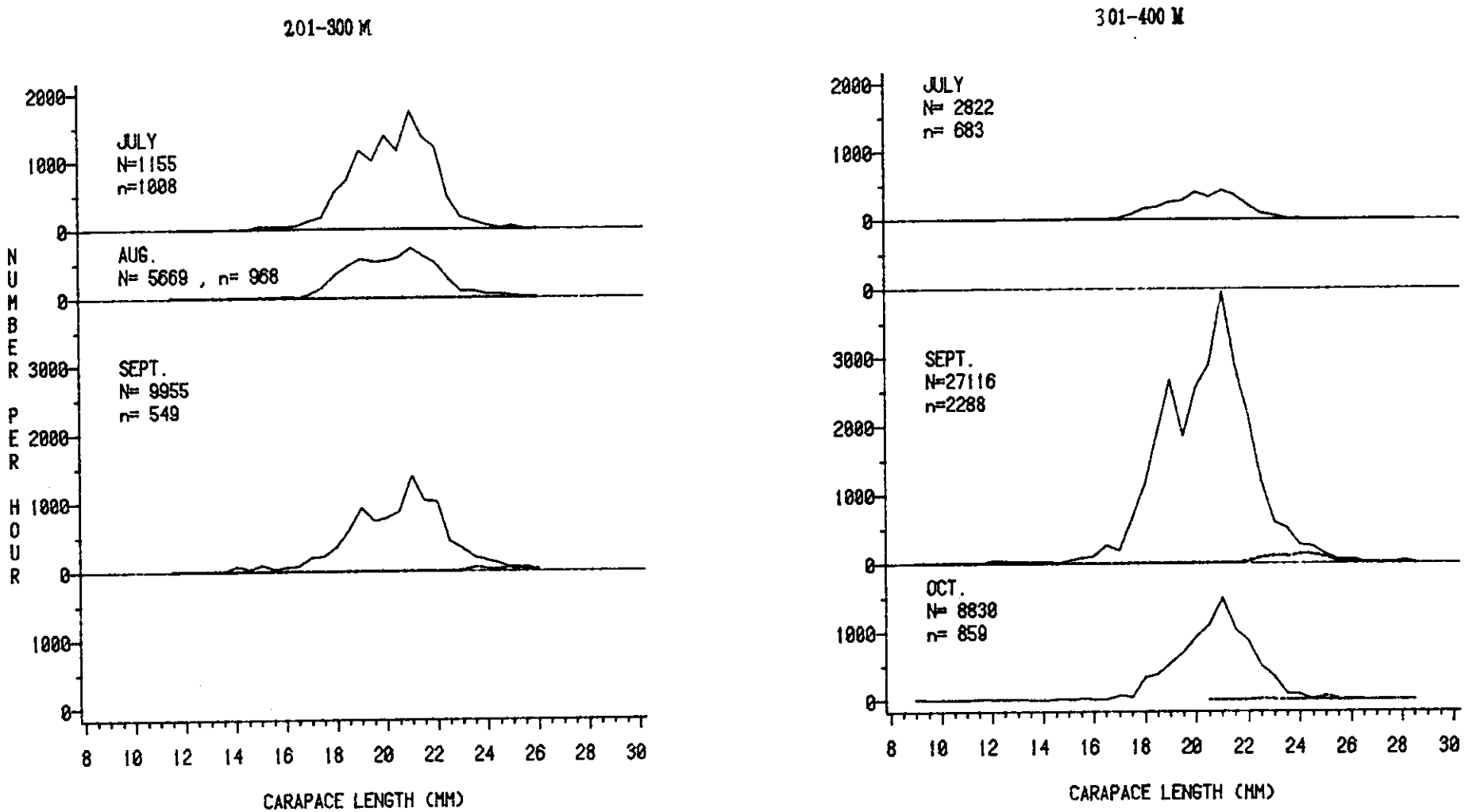


Fig. 6. Length frequencies for discarded shrimp, Division 0A , 1984.

N = Number per hour.

n = Number measured.

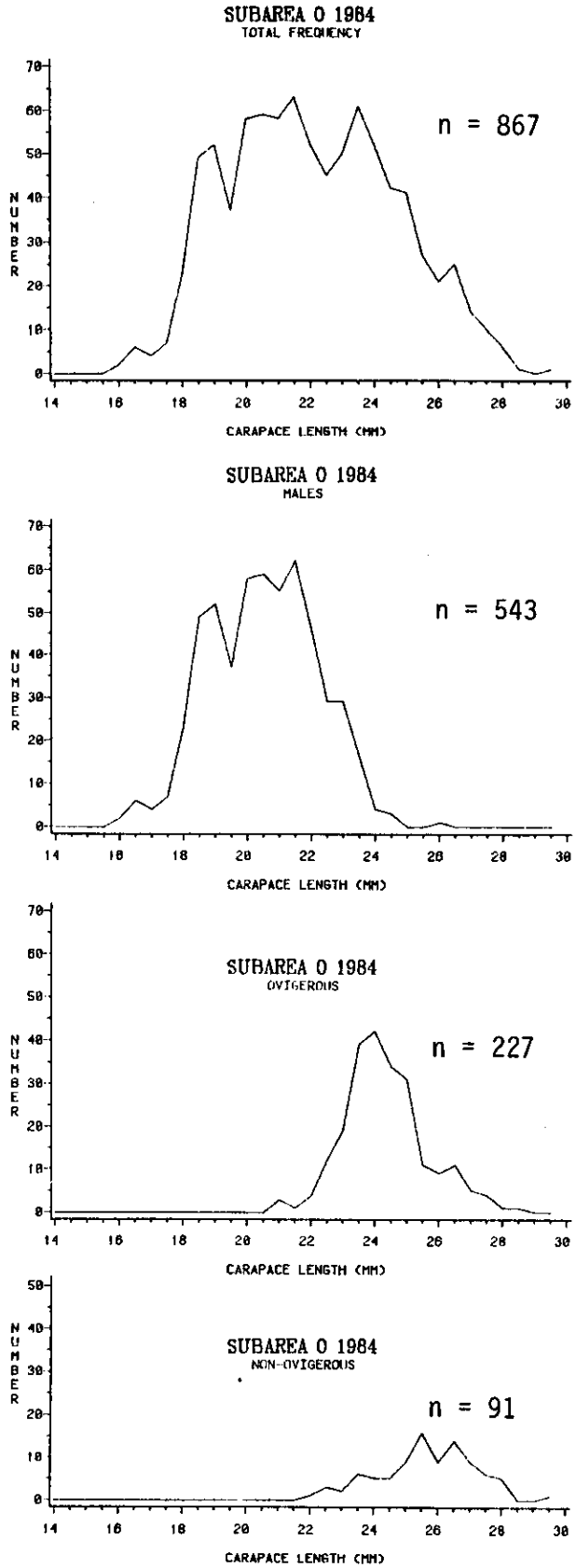


Fig.7. Breakdown of length distribution by stages of sexual development for a sample of P.borealis from Div. 0A, September 1984.