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Assessment of Northern Shrimp, *Pandalus borealis*, in Hopedale Channel Using a Revised Stratification Scheme

by

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Abstract

Landings in the Hopedale Channel in 1985 based on preliminary data were approximately 1400 t, twice that of 1984. Effort increased in 1985 due to less ice in July in this area and low catch rates in Div. 0A.

The 1985 survey was conducted using a new stratification scheme. All successful sets from trips in 1979 to 1984 were reanalyzed using this revised stratification and new biomass estimates obtained. The 1985 biomass estimate was the highest since 1980 .

There was a high incidence of small male shrimp as indicated by both commercial and research data. This increase in abundance of smaller animals led to apparent increase in shrimp discards in 1985, and is likely to continue for 1986. Cold bottom temperatures in 1985 possibly contributed to this discard problem by retarding growth. TAC advice was provided based on recent biomass estimates.

Résumé

D'après les données préliminaires, les débarquements dans le Hopedale Channel en 1985 s'élèvent à environ 1 400 tonnes, soit le double des prises de 1984. L'effort de pêche a augmenté en 1985 à cause du peu de glace dans ce secteur en juillet et des faibles taux de prise dans la division 0A.

L'étude de 1985 a été effectuée suivant une nouvelle stratification. On a procédé à une nouvelle analyse de chacun des traits de chalut réussis lors de voyages effectués entre 1979 et 1984 et ainsi obtenu de nouvelles estimations sur la biomasse. Les estimations de biomasse de 1985 sont les plus élevées depuis 1980.

On a constaté une forte présence de petites crevettes mâles, à la fois à partir des données sur les prises commerciales et des résultats des croisières de recherche. Cette abondance d'animaux plus petits a donné lieu à une augmentation marquée des rejets de crevettes en 1985 et se poursuivra probablement en 1986. Les températures froides des eaux de fond en 1985 ont possiblement contribué au problème de rejet en retardant la croissance. Le TPA recommandé se fonde sur les dernières estimations de la biomasse.

Introduction

The fishery for northern shrimp in 1985 was conducted in two areas, Div. 0A in the Davis Strait and Hopedale Channel off the coast of Labrador. The Canadian Atlantic quota report (preliminary to December 31, 1985) indicates that approximately 50% of the TAC was taken in each area, 3103 t in Div. 0A (TAC = 6120) and 1409 t in Hopedale Channel (TAC = 2800). Ten vessels (three domestic and seven foreign) participated in the fishery in the former area while five (all domestic) fished off Labrador. Except for one ton of shrimp taken from the Hawke Channel, there were no catches reported for either Cartwright Channel, Div. 2G or Div. 3K.

Observer coverage for vessels fishing in Hopedale Channel in 1985 was limited to two trips, providing catch sampling data from August 2 to September 20 and from October 13 to November 9. Only one vessel's catch was sampled during each trip, thus limiting the value of the catch data as a means of monitoring changes in the stock. This situation has existed for the Labrador fishery for three consecutive years.

The research cruise in 1985 was conducted from July 31 to August 21, approximately three weeks later than in previous years. This delay was arranged to avoid problems with ice which, in 1984, necessitated a change from a stratified random survey design in the Hopedale Channel to a line survey. Icebergs were numerous in 1985 but there was no pack ice and, consequently, the stratified random survey design was carried out with no difficulty.

Also, in 1985, new hydrographic charts became available for areas off Labrador, including the Hopedale Channel. These provided more detailed and accurate information on the topography of the area surveyed, so much in fact, that the officers onboard the research vessel GADUS ATLANTICA preferred to use these hydrographic charts for depth and direction rather than the existing navigation charts. Therefore, much of this paper is devoted to the reanalysis of previous survey data, taking into account the new stratification scheme.

In assessing the Labrador shrimp stocks in March, 1985, it was agreed to use the current year biomass estimate to revise the advice in mid-season, provided that the inclusion of the current estimate results in an increased TAC or maintains staus quo. In this way, the problem of year to year variability in abundance observed in these areas could be addressed. Preliminary TAC's were advised in March, mainly based on biomass estimates from past surveys, effectively projecting one year ahead. In early September, the results of the 1985 survey were reviewed by the chairmen of the I&MP Subcommittee and CAFSAC, resulting in a revision of advice for Hopedale and Cartwright Channels. TAC advice was revised upwards from 2800 to 2975 t for Hopedale Channel and from 770 to 1000 t for Cartwright Channel, using the biomass estimates for 1984 and 1985 and the 35% exploitation rate. Although the 1985 survey in the Hopedale Channel was carried out using the revised stratification scheme, the biomass estimate used to update the TAC was based on the old stratification, for consistency with previous years and given that the new scheme had not been reviewed by CAFSAC. In assessing the status of the shrimp stock in the Hopedale Channel, the current analysis takes into account the improved information on bottom topography and the recent decision to incorporate current year biomass estimates for mid-season revision. As well, the most recent data from the 1985 fishery are reviewed along with other biological and ecological data obtained during the 1985 research survey.

Catch and CPUE

The 1985 catch of approximately 1400 t was substantially higher than that obtained in 1984 (712 t). The fishing grounds in the Hopedale Channel were not restricted due to ice in July, unlike the previous year. Also, declining catch rates early in the season in the Davis Strait encouraged Canadian vessels to devote more effort to the Hopedale Channel. As in the previous three years, partial and non-utilization of licences also occurred in 1985. Four licences did not operate off Labrador because of charter arrangements (restricted to Davis Strait) and the two licences for Newfoundland remained unutilized.

The catch per unit effort by month from 1977 to 1985 is summarized in Table 1. For the years 1977-84, catch rates for tonnage class 4 vessels were adjusted upward by a factor of 1.26 (Parsons et al. 1982) as a means of standardization. No differences in fishing power were detected between tonnage classes 5 and 6. In 1985, only one tonnage class 4 vessel fished in the Hopedale Channel. A review of daily catch rates for this vessel and tonnage class 5 vessels showed that the use of the 1.26 conversion factor was inappropriate for 1985. Therefore, the 1985 values are for tonnage classes 5 and 6 only.

The July catch rate (202 kg/hr) is not reliable because it is based on so little catch. The August and September rates (351 and 208 kg/hr) are higher and similar to, respectively, those of the previous year and both are similar to 1982 values for those months. October and November catch rates, however, are the lowest recorded over the time series. Catch rates in December improved but, again, are based on a relatively small catch.

The value of CPUE data as an index of stock abundance has decreased over the years, especially due to low effort levels in 1983 and 1984. Effort increased in 1985 but catch rates may be biased downwards due to extensive discarding (see Discards section). Thus, the catch rate series has little value in assessing stock status, except to show that current fishable stock abundance is lower than in the early years of the fishery.

Shrimp Biomass

A detailed comparison of the old and new stratification schemes applied to the 1985 survey results is given in Figure 1 and Table 2. The new divisions stratification, like the old, divides the Channel into three zones. These divisions are based on the distribution of shrimp (catch per tow) observed in surveys conducted from 1979 to 1984. All data were plotted and the lines drawn where there were obvious differences in abundance.

Zone 1 (northwest) is essentially the same as the old Zone 1, the areas being very similar. Shrimp density and biomass are high in this zone and, in most years, has accounted for 50-70% of the overall biomass estimate (Parsons and Veitch 1985).

The new Zone 2 includes the Saddle and the deepest part of the Channel and has an estimated area of 2537 sq n mi, almost 1000 sq n mi greater than the old Zone 2. This difference is due to three reasons: the new zone includes all depths greater than 550 m, parts of which were previously included in Zone 3; the new zone includes depths from 150 to 275 m, not previously considered; and, most importantly, the area within the depth range of about 300-450 m was significantly underestimated using the old system. Shrimp are usually less concentrated in this zone, but because of the large area, estimates of biomass were high, usually around 30-40% of the overall estimate when using the old scheme.

Zone 3 of the new stratification is much smaller than used previously, primarily due to the inclusion of the deeper strata (> 550 m) in Zone 2. Also, the line separating the two zones is oriented in a NW-SE direction rather than WSW-ENE under the old system. This zone is characterized by low shrimp density and biomass and, even using the larger area of the old scheme, has never accounted for more than 10% of the overall estimate.

All the fishing stations occupied successfully in previous surveys were reassigned new stratum numbers based on the revised stratification. Groupings of sets by stratum differed from the previous combinations for two reasons: the depth interval changed from approximately 36 m to 50 m resulting in between stratum differences and the lines separating zones changed, as described above, resulting in changes in combinations of sets between zones. After the changes were completed for each survey, the biomass was reestimated using the STRAP system of Smith and Somerton (1981). No changes were incorporated in the calculation of mean biomass and confidence intervals to reflect the post-stratification of survey data obtained prior to 1985.

Biomass estimates obtained from 1979 to 1985 using both the old and new stratification schemes are summarized in Tables 3 and 4. Restratification resulted in increases in the estimated mean biomass for all years, most of which can be attributed to the revised areas surveyed each year.

	Year						
Increase	1979	1980	1981	1982	1983	1984	1985
Biomass	1.5	1.2	1.2	1.2	1.2	1.1	1.4
Area	1.2	1.1	1.1	1.2	1.1	1.1	1.4

The remaining 'unexplained' differences result from the recombination of sets within and between strata as discussed above.

In past assessments, a decrease in the proportion of biomass in the northernmost zone since 1979 has been observed (Parsons and Veitch 1985). The 1985 data, using the old stratification, indicates a continuation of this trend.

Percent biomass by Zone (old)

	1979	1980	1981	1982	1983	1984	1985
Zone 1	70	62	68	41	50	49	43
Zone 2	27	30	25	57	41	43	55
Zone 3	3	8	7	2	9	8	2

The trend is more clearly demonstrated using the revised stratification but the percentage of biomass in Zone 2 is higher in most years after 1980 due to the changes as described above.

Percent biomass by Zone (new)

	1979	1980	1981	1982	1983	1984	1985
Zone 1	72	65	60	41	46	40	30
Zone 2	26	31	36	58	46	54	69
Zone 3	2	4	4	1	8	6	1

Table 4 also indicates a substantial increase in survey area in 1985 compared to previous years. This increase is due to the inclusion in the 1985 survey of shallower strata (<275 m) in all three zones and the deeper strata (>550 m) of Zone 2. These strata, not surveyed or surveyed only sporadically in past years, accounted for a small amount of biomass in 1985.

Percent of 1985 biomass for strata not surveyed previously

1979	1980	1981	1982	1983	1984
3.6	0.3	0.3	0.3	0.3	1.1

The 1979 survey was the first July survey conducted in this area and sampling intensity was less than adequate, and in 1984, ice prevented access to parts of the fishing grounds. Therefore, the actual area surveyed in a year is not critical, provided that the main area of shrimp concentration has been covered. This, however, limits the usefulness of density estimates (biomass per sq ni mi) as an indicator of changes in abundance between years.

Results of the 1985 survey showed that shrimp were most abundant in depths between 350 and 450 m compared to 275 to 450 m in 1984 (Parsons and Veitch 1985). The estimated biomass of 12,756 t (± 7616) was the highest observed since 1980 but the relative importance of Zones 1 and 2 has been reversed. Accepting the 1981 estimate as being anomalously low, the biomass calculated for 1985 represents an increase of 55% from the lowest level observed in 1983 but still remains lower than the abundance apparent in 1979 and 1980 (Table 4, Fig. 2).

Size Composition

1. Research

Length frequencies from the research cruise in the Hopedale Channel in August 1985 (Fig. 3) show increasing mean size with depth in the northern zone. This trend was not so pronounced over the saddle (Zone 2) and not at all evident in Zone 3. In Zone 1, small (male) shrimp ranging in size from about 16-20 mm dominated in depths less than 300 m. There was a broad range of sizes (13-29 mm) from 300 to 500 m where most biomass occurred (Table 2) and a prominent mode of male shrimp around 20 mm. In depths greater than 500 m females (22-28 mm) predominated but overall abundance in these areas was lower.

In the shallower depths (< 300 m) over the Saddle a smaller mode of males was evident at 17 mm carapace length but biomass estimates in these depths were low. Most biomass occurred between 350 and 450 m (Table 2) and sampling data show a broad range of sizes comprised mostly of male shrimp less than 22 mm. There was a general scarcity of larger female shrimp throughout the zone and females did not dominate in the length samples from the deeper strata (>450 m).

The low densities in Zone 3 were characterized by small, mostly male shrimp, especially in the deeper strata (>400 m). In shallower water females were small and many were ovigerous. These anomalies are likely related to the cold temperatures present especially in this Zone in 1985 (see Temperature section).

Compared to 1984 (Parsons and Veitch 1985), there appears to be a greater proportion of smaller male shrimp in 1985 in depths where most biomass was found, especially in Zone 1. Two age groups of males can be interpreted from the 1985 sampling data at approximately 18 and 20 mm carapace length. These might represent the 1981 and 1980 year-classes, however, as usual, overlapping of the modal groups is severe and there is general inconsistency between depths, making age interpretation difficult and highly subjective. The overall situation is similar to 1984 with high biomass of small shrimp indicating some potential for improved recruitment. The effects on the 1986 fishery will depend on the acceptability of a high proportion of these recruiting size (age) groups in the catches. Also, discarding in 1985 was extremely high and these recruiting shrimp have already experienced some fishing mortality.

2. Commercial

Sampling data from one vessel fishing in August and September show that commercial catches of shrimp in depths of highest abundance consisted of a high proportion of male shrimp, with overlapping modes occurring around the same sizes as in the research sampling data (Fig. 4). Abundance of males decreased in deeper water but so did the catch rates.

Length frequencies from the catch of another vessel in October and November showed a continued dependency on the smaller shrimp at times when, in the previous two years, there has been a dominance of ovigerous females in the catches. The size of the two modes of male shrimp appear to be consistent with the other sampling data. The late season data in 1985 appear more similar to those available for 1982 and especially 1981 (Parsons et al. 1982, 1983).

Biomass of Predators

Revisions of the biomass estimates for Greenland halibut and cod also were made based on the new hydrographic information. The old and revised estimates are compared in Tables 5 and 6 and show relatively little change for Greenland halibut in most years compared to shrimp. This implies that both stratifications provided good representation for the deeper strata where Greenland halibut are more abundant. Cod biomass estimates increased in all years except 1985 but remain very imprecise. These changes reflect the inaccuracy of the old stratification scheme for the shallower depths.

Estimated biomass for Greenland halibut (based on the new stratification) increased from about 9000 t in 1981 to over 24,000 t in 1983, then decreased to 18,600 t in 1984 and 11,700 t in 1985. The latter estimate is similar to abundance levels observed in 1981 and 1982. Survey data from 1982 to 1985 suggest a decrease in the abundance of cod in this area, the 1985 estimate being one of the lowest in the time series. Therefore, the effectiveness of cod as predators of shrimp in 1985 appeared reduced, not only due to the lower cod abundance, but also because shrimp were more heavily concentrated in deeper water than in the previous year (Parsons and Veitch 1985) where fewer cod were found. Predation by Greenland halibut, however, might have increased due to the deeper shrimp distribution.

Changes in the stratification scheme as described resulted in changes in the proportionate breakdown by zone for both species, but in no systematic way. Neither the old or new stratifications showed a decrease in the percentage of Greenland halibut biomass by zone as observed for shrimp. Cod in Zone 1, however, showed decreasing proportions from 1979 to 1983 with some stability since then.

Percent cod biomass by Zone (new)

	1979	1980	1981	1982	1983	1984	1985
Zone 1	52	35	27	33	9	10	15
Zone 2	39	47	35	66	88	62	65
Zone 3	9	18	38	1	3	28	20

By-catch

Observer data from August to November showed that Greenland halibut was the major by-catch species over the season, comprising 12-16% of the observed catch in all months. Catch rates declined from 148 kg/hr in August to 38 kg/hr in November. The lower rates at the end of the season were similar to those in the same months of the previous two years.

Redfish by-catches were high in the observed catch from August and September, comprising 16 and 18%, respectively. The catch rates in these months of 151 and 103 kg/hr were much higher than observed in 1982 and 1981 (Parsons et al. 1983, 1982). Catch rates later in the season were much lower and similar to those observed in 1983 and 1984 ($\leq$10 kg/hr).

By-catches of cod showed a pattern similar to that observed for redfish, i.e. high rates in August and September and much lower in October and November. The highest catch rate was 88 kg/hr in September comprising 15% of the observed catch.

It must be noted, however, that only two vessels were observed over the season, one in August-September and the other in October-November. Therefore, the patterns described above likely reflect different fishing performance between vessels as well as seasonal variation in by-catch composition.

Discards

Estimates of shrimp discards in 1985 from vessel logs were extremely high in all months compared to previous years, and higher than previously recorded in observer reports.

% of Shrimp discards

July	August	September	October	November	December
2.7	15.1	23.0	8.5	6.5	11.9

Comparison of individual vessel logs indicated high rates of discards for two vessels and lesser amounts for the other three. It was apparent that in one case at least shrimp were discarded at two stages during the processing of the catch; an initial cull whereby up to 50% of the catch was discarded and a further discard after the remainder was processed. The latter amount was recorded on the vessel log in the appropriate column but the first and more extensive discard was included in the 'remarks' section of the daily log.

A comparison of daily catch rates from this vessel, with and without the 'remarks' information included, shows large discrepancies, especially in the earlier part of the season (Fig. 5). Vessels fishing shrimp in these northern areas use similar trawls with a 40 mm mesh size. It is surprising, therefore, that one vessel would have extremely high discard rates while others would remain within an acceptable level. Observer data indicate that the high catches reported by this vessel were reasonably accurate.

The discarding practices observed in 1985 cast more doubt on the suitability of the CPUE data as an index of change in stock abundance. If discarding for the fleet was more similar to the levels indicated by the vessel mentioned above, catch rates would have been considerably higher than reported. Based on the above information, it seems reasonable to assume that the catch rate data for 1985 from vessel logs is biased downwards.

The limited data available on the sizes of discarded shrimp suggest no substantial change from previous years (Fig. 6). This is rather surprising, given the large increase in discard rates in 1985. Two explanations might be considered, both related to marketing of the shrimp:

1. acceptability of small grade shrimp might have decreased from 1984 to 1985 and vessels were forced to discard the smaller sizes that in previous years were kept and processed;

2. a certain portion of small grade shrimp is acceptable but when these sizes begin to dominate in the catch, discarding is necessary to maintain that proportion.

Discards consisted mostly of male shrimp between 16 and 22 mm. Sizes of discards from one vessel sampled during August and September were larger than those from the vessel sampled in October and November. These differences could represent between vessel and/or between season differences. The data from November show two modes of male shrimp around 18 and 20 mm, similar to the research and commercial catch data.

Temperature

A detailed review of bottom temperatures in the Hopedale Channel by Parsons and Veitch (1984) showed an increasing trend in most areas and depths in the early 1980's. In 1984, temperatures in Zones 2 and 3 were similar to those of the previous year but a decrease was noted in the northern Zone (Parsons and Veitch 1985). Bottom temperatures in 1985 were much colder throughout the channel but especially in Zone 3 where temperatures were more than 2°C colder at depths between 350-450 m (Table 7). This likely accounts for the presence of small shrimp and high proportion of berried females in this zone.

Temperatures in Zone 1 were the coldest observed since summer surveys were initiated and did not exceed 3°C at any depth. Over the Saddle temperatures generally were 0.5-1°C lower than 1984 at depths where shrimp were abundant. Depths between 450 and 550 m were the warmest areas observed throughout the Channel with temperatures between 3.1 and 3.4°C.

Discussion

Although fishing effort for shrimp increased in the Hopedale Channel in 1985 over the previous two years, the CPUE data are still not reliable for comparison with the years prior to 1983 because of potential bias due to excessive discarding. Estimated mean biomass levelled off at 8200 to 8500 t in 1983 and 1984 and increased to around 12,750 t in 1985. Much of the 1985 biomass consisted of small male shrimp which suggests improved recruitment for 1986. The same was predicted for 1985 but, apparently, the smaller shrimp were unacceptable for processing and much was discarded. This represents a tremendous loss in yield due to almost total mortality of discarded animals. Based on the findings from the 1985 survey, a similar discard problem is likely for 1986 unless regulations concerning discards are enforced or size requirements change.

The cold bottom temperatures observed in 1985 likely resulted in a slower rate of growth, contributing to the discard problem. If the cold temperatures persist in this area, productivity will be reduced due to slower growth and a decrease in reproductive potential. A decrease in temperature is a major concern for shrimp stocks, especially off Labrador where they are at the lower end of the tolerance range. The Cartwright Channel stock has been shown to be very unstable in the colder water environment.

Shrimp mortality due to predation by cod and Greenland halibut is less of a concern because of evidence of declining abundance of both predators over the last three to four years. Also, shrimp distribution in 1985 was concentrated in deeper water, generally outside the range of the more voracious cod. Changes in shrimp distribution between Zones 1 and 2 over the years were reflected in the cod data but not for Greenland halibut. This may reflect a greater dependency on shrimp as a prey species by cod.

The apparent changes in shrimp distribution between zones also affects the catch rate data. Although, proportionately, more biomass has been estimated over the Saddle in recent years, densities are still higher in the northern zone where the fishing effort is concentrated. Therefore, a decline in catch rates primarily from Zone 1 may not represent decreased abundance, merely decreased density as distribution of the shrimp shifts to Zone 2. The Saddle is such a large area that shrimp density may not be sufficient to attract significant fishing effort. In future surveys, it will be necessary to sample the Saddle more intensively to ensure that the change in distribution is real and not an artifact of previous sampling designs.

In 1985, it was stated that in a fishery which has been virtually self-regulating since 1981, a TAC based on historical and highly variable estimates of stock size was inappropriate. Consequently, CAFSAC suggested mid-season updates using current year estimates. This was done in September 1985 and the revised TAC of 2975 t could remain effective until the 1986 survey has been completed. However, the new stratification scheme estimated biomass at 8534 t in 1984 and 12,756 t in 1985. If this stratification scheme and the post-stratified biomass estimates are acceptable, then the TAC advised for 1986 should be 3725 t to reflect our improved knowledge of the fishing grounds and shrimp distribution in this area.

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Table 1. Catch per hour fished, 1977-85, Hopedale Channel (monthly values determined from vessel logs) adjusted to tonnage class 5 for 1977-84 and using tonnage classes 5 and 6 for 1985.

	1977		1978		1979		1980		1981		1982		1983		1984		1985	
	Catch (kg)	CPUE (kg)	Catch (kg)	CPUE (kg)	Catch (kg)	CPUE (kg)	Catch (kg)	CPUE (kg)	Catch (kg)	CPUE (kg)	Catch (kg)	CPUE (kg)	Catch (kg)	CPUE (kg)	Catch (kg)	CPUE (kg)	Catch (kg)	CPUE (kg)
Hopedale Channel																		
May									5,455	253								
June					196,741	957	28,970	872	408,457	539	171,265	467	166,729	390				
July			131,544	773	965,454	706	736,840	645	360,770	356	302,674	397	253,121	336	39,890	571	2,615	202
Aug.	93,695	611	85,570	560	812,378	368	589,206	475	474,218	344	219,227	376	6,625	981	35,190	276	435,745	351
Sept.	206,111	631	68,591	383	81,907	297	599,724	304	555,279	402	62,621	211	2,125	123	49,855	207	171,064	208
Oct.	330,574	361	584,589	580			390,295	423	406,217	404	246,110	389			335,304	336	385,389	246
Nov.	641,516	780	470,170	555			163,316	598	469,023	418	471,095	569	370,427	353	100,031	350	357,632	260
Dec.			-[c]	-					168,375	607	113,325	366	71,302	239	55,946	260	30,492	330
Total[a]	1,271,896	573	1,340,464	569	2,056,480	507	2,508,351	449	2,847,794	409	1,586,317	420	870,329	341	616,216	318	1,382,937	271
Total[b]	1,203,000		2,109,000		2,693,000		3,938,000		3,382,266		1,707,900		1,014,000		712,000[d]		1,409,000[d]	

[a]Based on catches from vessel logs.
[b]Based on statistics from landings.
[c]Months with catches but no vessel logs.
[d]Preliminary.

Table 2. Comparison of the old and new stratification schemes for the Hopedale Channel, 1985 survey.

Hopedale (old)					Hopedale (new)				
Stratum no.	No. sets	Depth (m)	Biomass (t)	Area (sq n mi)	Stratum no.	No. sets	Depth (m)	Biomass (t)	Area (sq n mi)
101	3	166-201	8.71	61	101	2	151-200	4.85	54
102		202-238		49	102	3	201-250	8.99	46
103	5	239-274	21.66	44	103	3	251-300	25.77	40
104	4	275-311	723.29	39	104	4	301-350	375.73	40
105		312-348		39	105	4	351-400	1315.58	54
106	4	349-384	998.86	41	106	4	401-450	975.26	52
107	4	385-421	1444.13	38	107	4	451-500	605.71	66
108		422-457		39	108	3	501-550	363.71	177
109	4	458-494	385.45	42	109	2	551-600	120.36	38
110	3	495-530	226.03	110	110		601-650		3
111	2	531-567	164.70	51					
112		568-604		1					
113		605-641		1					
114		> 641		1					
Totals	**29**		**3972.83**	**556**		**29**		**3795.96**	**570**
204	3	275-311	319.55	290	201	2	151-200	3.85	73
205		312-348		174	202	2	201-250	13.82	84
206	3	349-384	1732.71	135	203	2	251-300	323.00	174
207		385-421		95	204	2	301-350	41.23	398
208	3	422-457	2611.87	148	205	3	351-400	2403.20	319
209	4	458-494	338.82	162	206	3	401-450	5364.91	304
210	2	495-530	49.38	168	207	3	451-500	482.44	173
211		531-567		168	208	2	501-550	53.49	182
212	2	568-604	20.29	163	209	2	551-600	167.99	185
213		605-641		64	210		601-650		305
214		> 641		1	211	2	251-300	9.84	184
					212	2	201-250	1.63	91
					213		151-200		23
					214	2	> 550	2.16	42
Totals	**17**		**5072.62**	**1568**		**27**		**8867.56**	**2537**
304		275-311		47	301	2	151-200	1.02	40
305	4	312-348	11.16	30	302		201-250		33
306		349-384		23	303	2	251-300	0.36	37
307		385-421		19	304	2	301-350	4.00	30
308	2	422-457	60.95	18	305	2	351-400	1.05	20
309		458-494		19	306	2	401-450	84.65	25
310		495-530		24	307	3	451-500	1.65	31
311	4	531-567	64.15	31	308		501-550		65
312		568-604		38					
313		605-641		236					
314		> 641		1					
Totals	**10**		**136.26**	**486**		**13**		**92.73**	**281**
GRAND TOTALS	**56**		**9181.70**	**2610**		**69**		**12,756.19**	**3388**

Table 3. Biomass estimates (t) and 95% confidence intervals for shrimp in Hopedale Channel, 1979-85 (old stratification).

Year	Mean	Upper	Lower	Area (sq n mi)	No. sets
1979	11,608	19,730	3,487	1,878	54
1980	11,840	19,134	4,545	2,499	83
1981	4,213	5,974	2,452	2,434	56
1982	9,498	12,003	6,993	2,308	76
1983	6,882	8,330	5,434	2,605	89
1984	7,738	9,640	5,837	2,175	59
1985	9,182	14,795	3,568	2,478	56

Table 4. Biomass estimates (t) and 95% confidence intervals for shrimp in Hopedale Channel, 1979-85 (new stratification).

Year	Mean	Upper	Lower	Area (sq n mi)	No. sets
1979	17,800	33,642	1,958	2,302	56
1980	14,739	23,220	6,258	2,802	84
1981	4,914	7,015	2,813	2,724	56
1982	11,563	15,370	7,757	2,724	76
1983	8,236	9,688	6,784	2,778	87
1984	8,534	12,238	4,830	2,456	60
1985	12,756	20,372	5,140	3,385	69

Table 5. Biomass estimates (t) and 95% confidence intervals for Greenland halibut and cod in Hopedale Channel, 1979-85 (old stratification).

	Greenland halibut			Cod		
Year	Mean	Upper	Lower	Mean	Upper	Lower
1979	4,140	5,422	2,857	435	899	-30
1980	23,045	25,894	20,197	1,763	2,284	1,242
1981	8,550	12,805	4,295	504	900	107
1982	11,118	15,218	7,018	2,204	3,247	1,162
1983	24,180	34,456	13,904	1,548	3,792	-695
1984	18,184	22,123	14,244	1,246	1,929	563
1985	10,026	13,093	6,959	907	1,779	35

Table 6. Biomass estimates (t) and 95% confidence intervals for Greenland halibut and cod in Hopedale Channel, 1979-85 (new stratification).

	Greenland halibut			Cod		
Year	Mean	Upper	Lower	Mean	Upper	Lower
1979	4,785	6,563	3,007	649	3,341	-2,042
1980	23,621	27,876	19,365	2,043	2,642	1,443
1981	9,105	13,363	4,848	788	2,093	-517
1982	12,239	14,049	10,430	2,655	4,123	1,187
1983	24,018	27,434	20,602	1,622	2,367	878
1984	18,602	21,759	15,445	1,435	2,488	383
1985	11,746	18,354	5,138	897	1,356	437

Table 7. Mean bottom temperatures (°C) for Hopedale Channel, 1979-85. (new stratification)

Stratum	Year 1979	1980	1981	1982	1983	1984	1985
101	-1.2				-1.0	-1.3	-1.4
102	-0.2		0.2	-0.6	-0.6	-1.1	-0.2
103	2.3	2.0	1.5	1.8	1.9	0.7	0.2
104	2.9	2.7	2.7	2.2	3.0	2.2	1.5
105	3.0	2.9	3.3	3.3	3.7	2.7	2.1
106	3.5	3.1	3.2	3.3	3.8	3.5	2.7
107	3.3	3.0	3.3	3.4	3.9	3.7	2.6
108	3.1	3.3	3.6	3.9	3.8	3.7	2.8
109	3.2	3.2	3.2	3.4	4.0	3.6	2.6
110	3.2	3.2					
201							-1.3
202		1.7				1.0	-0.3
203		2.6	3.6	1.6	2.8	3.0	1.3
204	3.5	3.0	3.0	1.6	2.1	2.9	1.1
205	3.2	3.1	3.5	3.5	3.6	3.4	2.9
206	3.4	3.2	3.7	3.3	3.7	3.7	2.8
207	3.3	3.4		3.4	3.9	4.0	3.1
208	3.3	3.5	3.6	3.7	3.8	3.9	3.4
209	3.2	3.3	3.4	3.5	3.8	3.8	2.8
210	3.5	3.5	3.3	3.6	3.9		2.2
211					0.8		1.5
212							-0.7
213							-1.6
214							3.2
301							-1.6
302							-1.7
303		2.2	1.9	0.3	-0.6	0.4	0.1
304	1.4	1.6	2.5	0.8	1.9	0.9	0.4
305	2.1	2.8	2.3	2.6	2.7	2.9	0.6
306	2.4	3.1	2.9	2.4	3.2	3.9	1.4
307	3.3	3.0	3.1	3.0	3.8	3.6	2.2
308	2.9	3.3	3.3	3.2	3.8	3.5	2.3

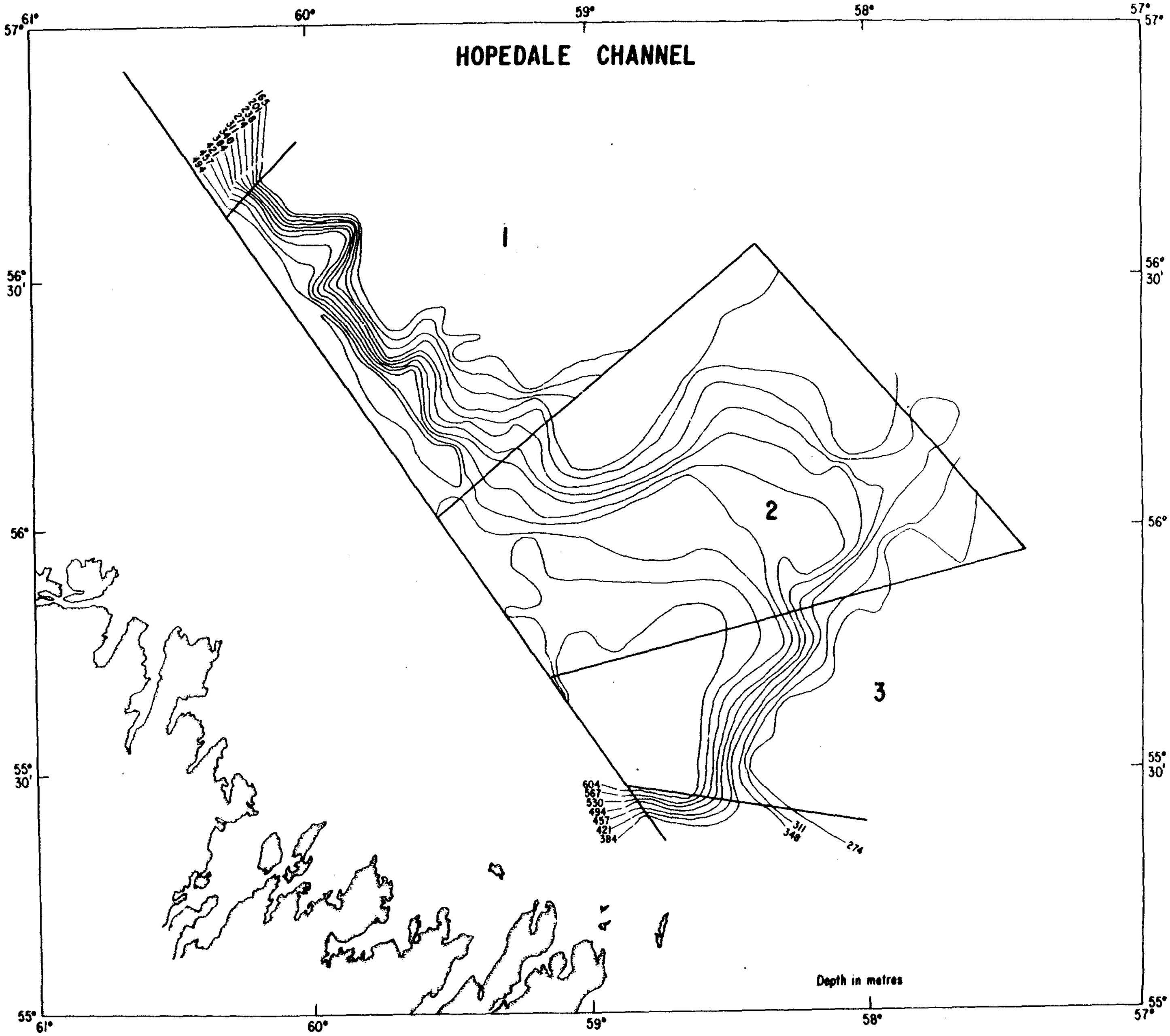

Fig.1(a). Old stratification scheme for the Hopedale Channel.

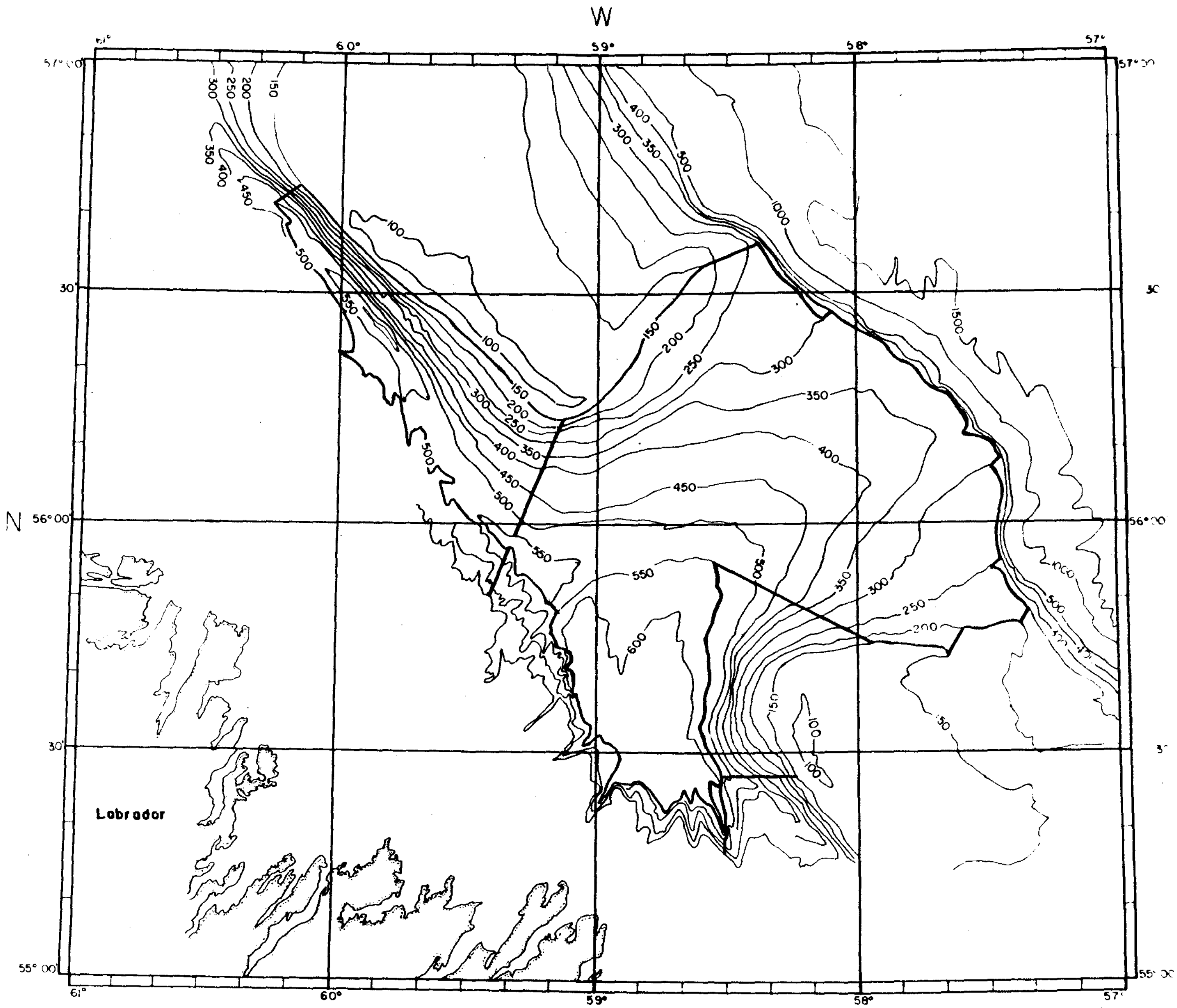

Fig.1(b). New stratification scheme for the Hopedale Channel.

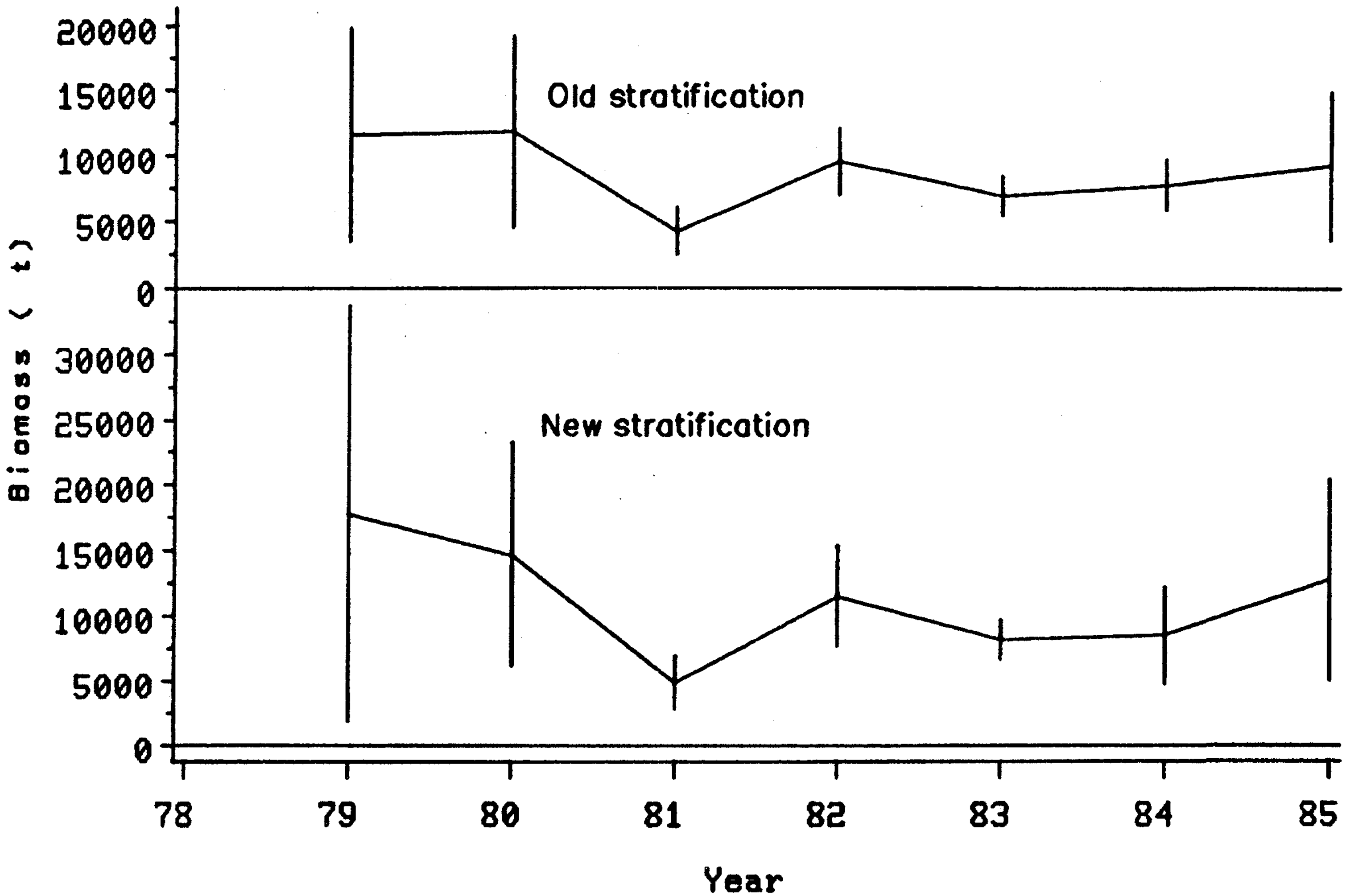

Fig.2. Estimates of mean biomass and 95% confidence intervals for shrimp in Hopedale Channel,1979-1985.

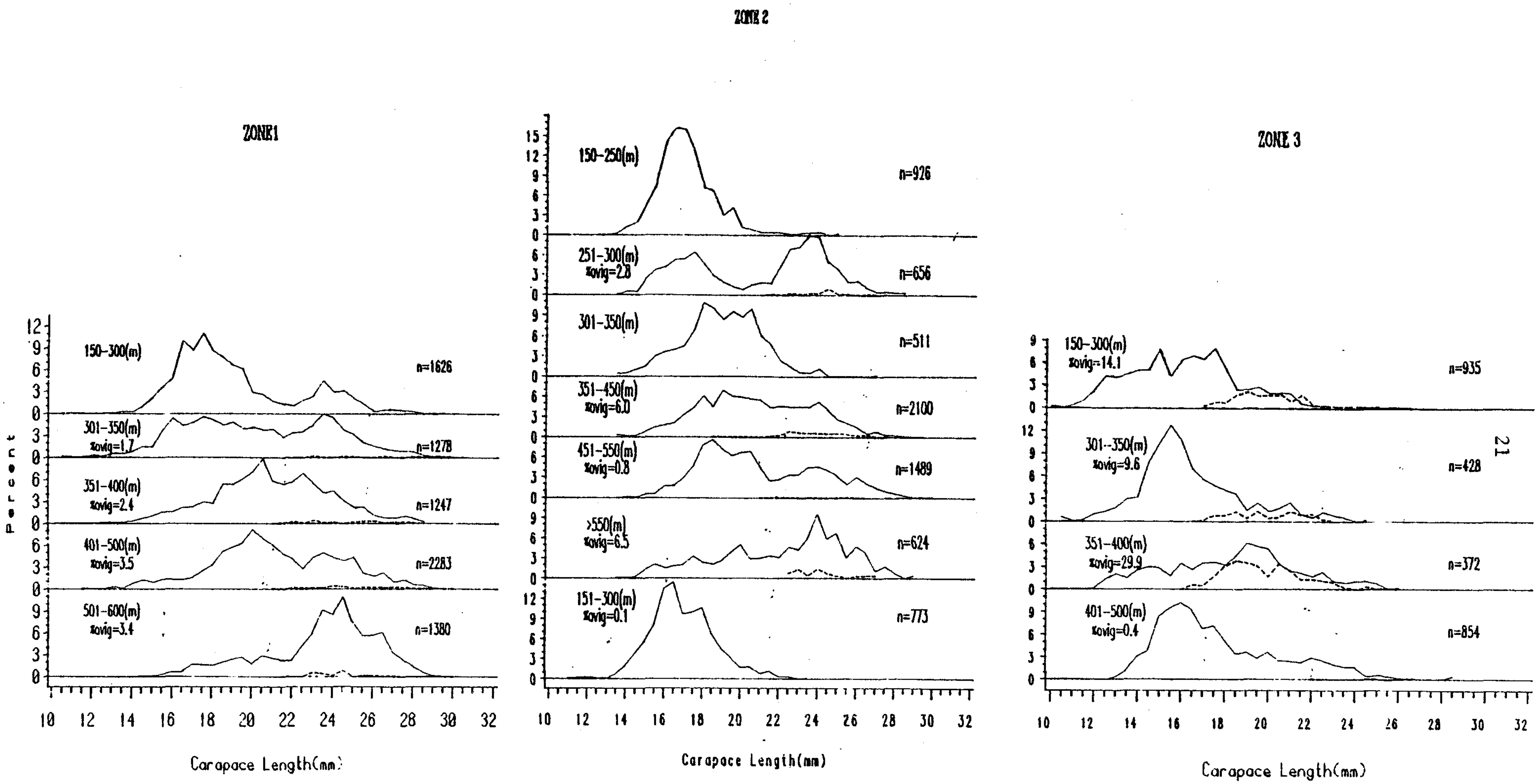

Fig. 3. Size distribution of shrimp in the Hopedale Channel from the August,1985 research survey.(Broken line represents ovigerous females.)

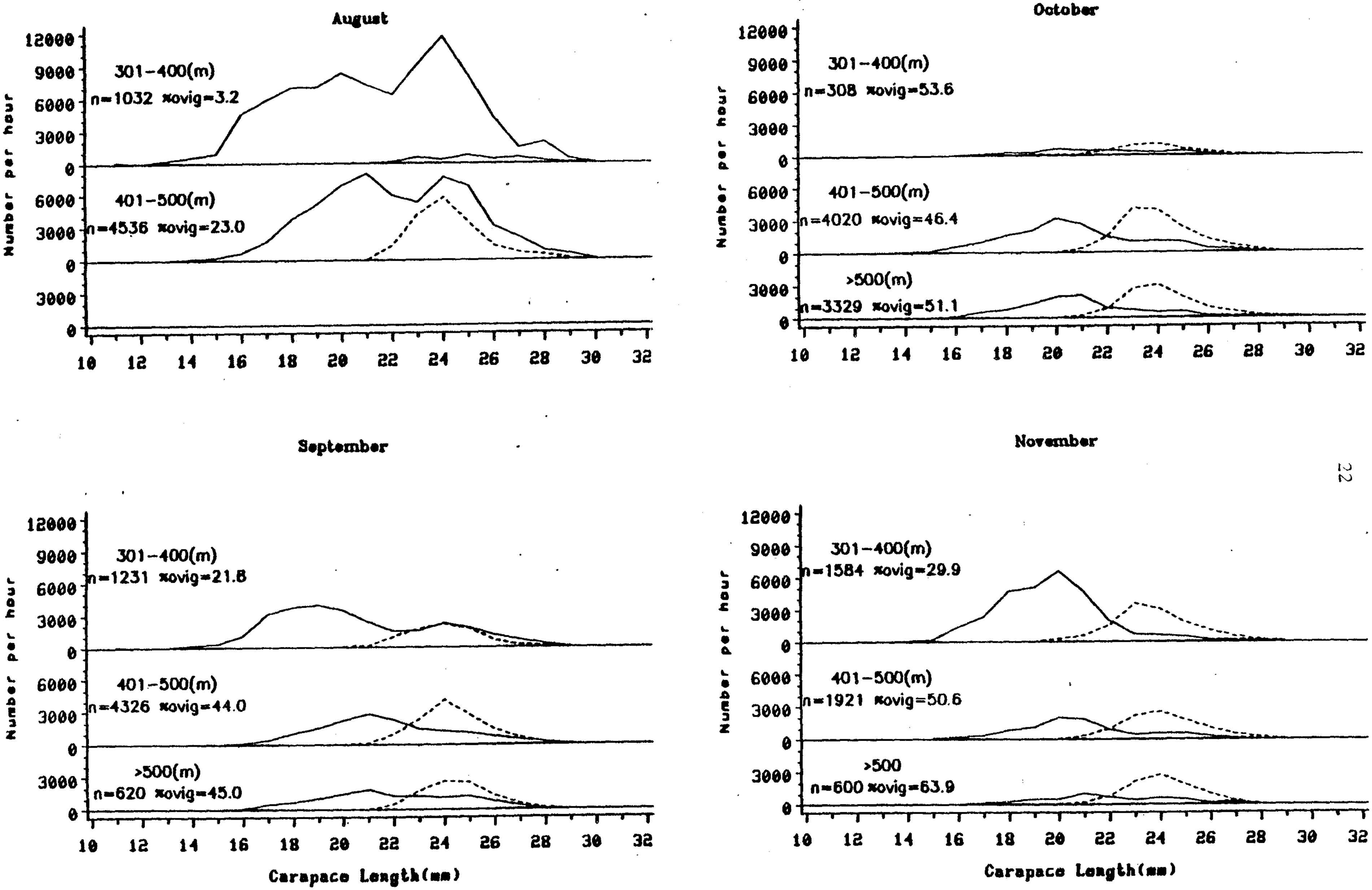

Fig.4. Size distribution of shrimp from commercial sampling in the Hopedale Channel,1985.(Broken line represents ovigerous females.)

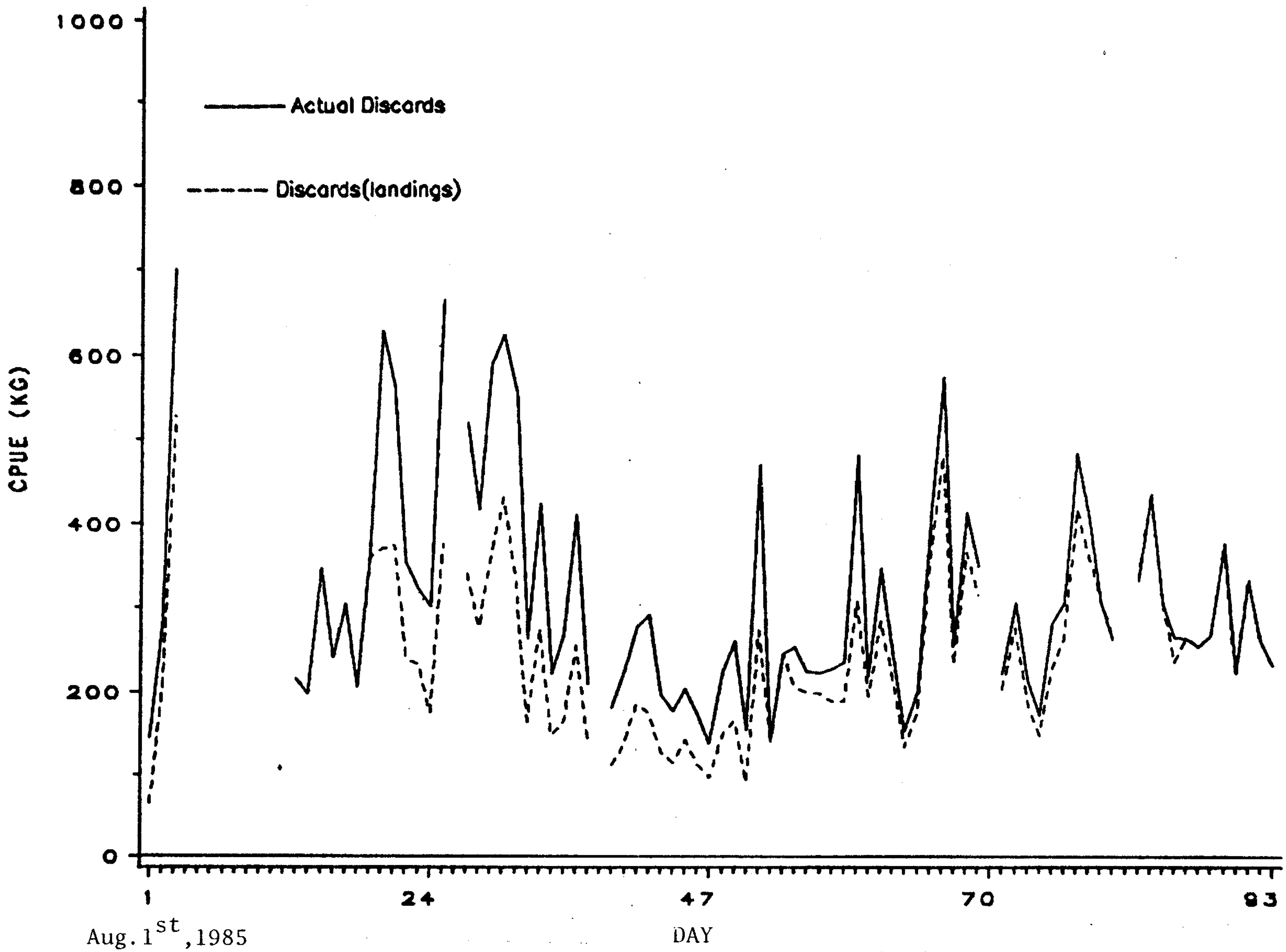

Fig.5. Daily catch rates from one vessel fishing for shrimp in Hopedale Channel,1985,illustrating the discard problem.

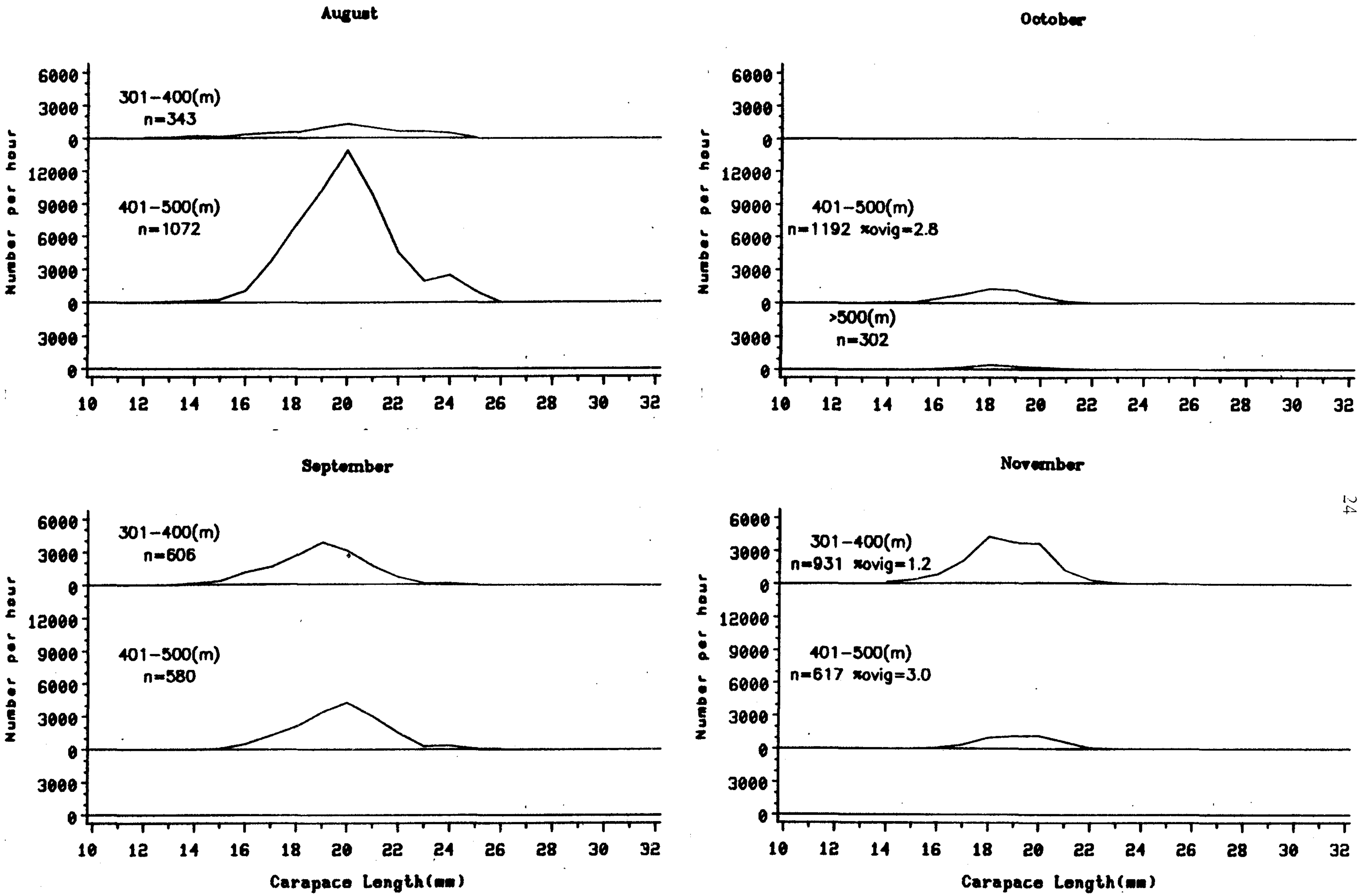

Fig.6. Size distribution of discarded shrimp from commercial sampling in the Hopedale Channel,1985.

Appendix 1. Details of research sampling for shrimp in the central zone of Hopedale Channel,1984 vs 1985.

		Zone 2			
		1984		1985	
Sex	Maturity	No.	% of Total	No.	% of Total
Juvenile	Immature	0	0.00	0	0.00
Male	Immature	0	0.00	5	0.46
Male	Maturing (small vas deferens)	109	11.96	118	10.93
Male	Mature (large vas deferens)	617	67.73	559	51.76
Transitional	Small ovary	1	0.11	2	00.19
Transitional	Large ovary	114	12.51	171	15.83
Female (non-ovigerous)	Sternal spines, small ovary	0	0.00	0	0.00
Female (non-ovigerous)	Sternal spines, large ovary	11	1.21	7	0.65
Female (non-ovigerous)	No spines, small ovary	7	0.77	30	2.78
Female (non-ovigerous)	No spines, large ovary	50	5.49	130	12.04
Female	Ovigerous	2	0.22	58	5.37
Totals		911	100.00	1080	100.0