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An Estimate of Shrimp Discard from Shrimp Factory Trawlers

in Davis Strait and Denmark Strait

by

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## ABSTRACT

Size distributions of the catch of shrimp and of the productions on board shrimp factory trawlers were estimated by sampling. Shrimp factory trawlers discards of low value shrimp were estimated by comparing size distributions of catches with size distributions of all size categories kept according to logbooks.

Shrimp factory trawlers landed 26,665 tons of shrimp from NAFO Subarea 1 in 1990 and 6,357 tons of shrimp in ICES Div. XIVB of total landings of 42,913 and 9,897 tons respectively from the total offshore shrimp fishery. The factory trawler discard of shrimp in Subarea 1 was estimated to 10,812 tons and in Div. XIVB to 1,034 tons.

## INTRODUCTION

Price difference between small and big size shrimp on the international fish market is about 1:10 per weight unit. The introduction of effective shrimp grading machines ('shrimp graders') has made it possible at sea to sort shrimp in up to six different size groups.

The offshore shrimp quota in the Greenland economic zone is shared between the trawler companies, on a quota license basis. Because the catching capacity of the trawlers under the present stock conditions is well above the quotas there is a strong economic incentive to discard small low price shrimp. According to Greenland regulations, it is not allowed to discard shrimp below 2 grams.

In 1990 the Greenland Fisheries Research Institute and Greenland Fishery License Control cooperated in an observer program to estimate the magnitude of unreported shrimp discard. The fishermen were guaranteed that data collected in the observer program in 1990 would not be used to proceed against them. Six observers were engaged to take samples and collect information on board shrimp factory trawlers. Sampling was planned to cover all division and quarters with a substantial shrimp fishery. The observer program was continued by Greenland Fisheries Research Institute in 1991 with two observers.

Greenland Fishery License Control continued the inspection visits on board trawlers in 1991 with ten inspectors.

Shrimp factory trawlers which do not land fresh shrimp and which have cooking devices on board ('Sea cookers') were selected for analyses of their discard practice since this group of trawlers is the component of the fleet with the greatest incentive to discard low value shrimp.

## DATA AND MATERIAL

### Sampling Size Distributions of Catch and Products

After prior arrangement with the trawler companies, working teams of 2 observers joined fishing trips onboard trawlers. The observers made 6 hours

shifts (joining the work schedule of the crew) to sample data from the catches on the factory deck.

A sample was taken from each haul from the unsorted catch. Further, one or more samples were taken from the different size groups of shrimp after sorting by a grader. The sample size of an unsorted sample was approximately 600 specimens while the sample size of an sorted sample was approximately 200 specimens. The shrimp samples were weighted either with an electronic gravity compensated balance or when this was not available with a bismer balance. The carapace length of the shrimp was measured with a computer connected calliper to the nearest 0.1 mm and grouped into 1/2 mm below.

The text Table below shows the coverage of the samplings. The sampling fleet is included in the commercial fleet.

| Period (quarters) | Area (division) | COMMERCIAL FLEET | | SAMPLING FLEET | |
|---|---|---|---|---|---|
| | | Number of vessels operating | Number of hauls rep. in logb. | Number of vessels visited | Number of hauls sampled |
| 1. | 1B | 5 | 185 | 0 | 0 |
| 2. | 1B | 29 | 3116 | 3 | 44 |
| 3. | 1B | 30 | 2860 | 4 | 46 |
| 4. | 1B | 27 | 2196 | 3 | 134 |
| 1. | 1A,1C,1D | 10 | 2044 | 0 | 0 |
| 2. | 1A,1C,1D | 33 | 4909 | 0 | 0 |
| 3. | 1A,1C,1D | 32 | 5627 | 3 | 89 |
| 4. | 1A,1C,1D | 27 | 3767 | 1 | 5 |
| 1+2 | XIVB | 27 | 7353 | 6 | 105 |
| 3+4 | XIVB | 19 | 3075 | 2 | 64 |

Discard of shrimp occurs either because of low quality (quality discard) or because of small size (size discard). Quality discard consists of low quality shrimp with little or no market value' (shrimp with soft shell, 'black head' shrimp, broken and wrecked shrimp). Size discard is a fraction of the smaller shrimp from the shrimp grader. Not all small shrimp are discarded but will occasionally be landed for later processing.

The quality discard of shrimp was collected in baskets and weighted on nine trawlers, Table 1. A few times the size discard was measured as well, but often the shrimp grader was connected to an outlet in closed pipes which made sampling impossible. Furthermore the presence of the observers influenced the discarding procedures, and for that reason it was decided not to use the observed discard as an estimate of the general discard practice on all the shrimp factory trawlers. Observer interference with discard behaviour can be seen in Table 1, e.g. trawler 4. was first visited in first quarter of 1990 and no quality discard was observed, while on the second visit in the first quarter of 1991, a 15 % quality discard was measured. At that time it was demonstrated that the observations did not constitute a risk of being proceed against.

Logbook Information

Logbook information from the fishery in Greenland economic zone for all fishing vessel above 50 GRT is reported to Greenland Fisheries Research Institute. The logbook includes information on location of the fishery and quantities of shrimp by size groups for the shrimp trawlers equipped with grading machines. By this information it is possible to obtain an estimate of the total landing by size group. The amount of these products reflects the size composition of the total landing.

The bulk of the shrimp landings in Subarea 1 is from Div. 1B, and to simplify the calculation the remainder divisions are grouped together into an 1xB 'division'. The shrimp fishery in Denmark Strait is divided in a spring and an autumn fishery called A and B 'quarters' respectively. In July, August and September the shrimp fishery ceases due to ice cover and low catch rates in Denmark Strait.

ESTIMATION OF DISCARD

The size discard was estimated by subtracting the summed length frequency of the recorded commercial production categories landed for a given period and area from the length frequency of an average catch distribution for the same period and area.

$$\text{Discard} = \sum_{L=10}^{L=22} [\text{Catch dist.} - \text{Dist. of landings}]$$

L carapace length. The upper limit for L is 22 mm CL on the west coast and 27 mm CL on the east coast.

### Catch distribution.

The catch distributions were obtained by sampling on board commercial shrimp trawlers from the trawl before any sorting or discard had taken place. An average distribution for each area and quarter was calculated. As these distributions were in numbers, they were converted to weight using season and area specific length-weight relations (APP. I).

### Logbook distribution.

Each size group is the result of one of normally 4-5 size sorted outputs of the shrimp grading machine. Normally each sorted output results in several production categories depending on catch length distribution and market demands. Each production size category shows a fairly well normally shaped sorting distribution which only depends on the sorting machine (Lehmann and Degel 1991). Therefore, it is possible to reconstruct the approximate length frequency of each category by weighing this sorting function by the frequency of the average catch of the area and season. The sorting function was chosen as the normal distribution and the mean and standard deviation for each production category have been estimated based on the pooled data for the whole year and all divisions. The length distribution by production category depends on the size distribution of the catches and this length distribution has been estimated by quarters and division. In cases when no samples had been taken of the production category, the mean and standard deviation were based on the count interval and the experience gained from known categories. These "guessed" values apply in all cases to less important categories. A few production categories were non-sorted shrimp. These categories were assumed to have a length distribution equal to the length distribution in the catch. Categories which constitute an open group (categories which have either no upper or no lower limits) did by sampling show an approximate normal distribution and were for simplifying reasons assumed as such weighted by the catch length distribution.

The average length distribution of the landed catch for one period and one area was calculated as the sum of the length frequencies of each landed category. This distribution now represented the average distribution of the landed catch and was scaled by the total landed catch as given in the logbooks per quarter and area. The area under the curve represented the total landed catch for the trawlers as reported to GFLK for the quarter and area.

Based on the scaled distribution of the landings, the distribution of the average catch was scaled. The scaling was obtained by raising the catch distribution to match the best estimated point at the landings curve defined as the peak of the most dominating and best investigated production categories.

The discard in weight was then calculated as the difference between the two curves.

Because of the nature of the calculations the two curves never exactly matched each other except at the point used for scaling. Consequently it was necessary to set an upper limit for the carapace length of the discard for preventing over estimation. On the west coast this limit was set to 22 mm CL and on the east coast to 27 mm CL. On the east coast it was necessary to increase the calculated mean of the 150+ category compared to the west coast, because the weight of landings of this group otherwise would exceed the weight in the catch (The calculated values were based solely on west coast observations). Accordingly the mean length for the 150+ category on the east coast was increased by 4 mm to 23.5 CL mm.

## RESULTS

In the Table below calculated discards are summarized. Discards figures for quarters not covered by observers (in brackets) have been estimated based on an average discard for the same area and on the recorded landings.

| 1B | Log catch (t) | Calc. catch (t) | weight disc. (t) | number disc. * 10E+6 | disc. + log catch (t) | disc. % of calc. catch | disc.% of log catch +disc. |
|---|---|---|---|---|---|---|---|
| I | 171 | (350) | (105) | - | (276) | (30 %) | (38 %) |
| II | 3634 | 8465 | 3024 | 708.3 | 6658 | 36 % | 45 % |
| III | 2838 | 5630 | 1585 | 366.0 | 4422 | 28 % | 36 % |
| IV | 2955 | 5511 | 1382 | 287.8 | 4338 | 25 % | 32 % |
| 1C+ 1D+ 1A | | | | | | | |
| I | 2878 | (5073) | (812) | - | (3690) | (16 %) | (22 %) |
| II | 5339 | (9411) | (1505) | - | (6845) | (16 %) | (22 %) |
| III | 4866 | 7894 | 703 | 132.4 | 5570 | 9 % | 13 % |
| IV | 3984 | 7310 | 1696 | 303.5 | 5680 | 23 % | 30 % |
| ICE S XIV b | | | | | | | |
| A | 5385 | 9958 | 919 | 127.9 | 6304 | 9 % | 15 % |
| B | 972 | 1478 | 115 | 15.9 | 1087 | 8 % | 11 % |

## DISCUSSION

The first sampling visit began in March 1990 in ICES Subdiv. XIVb and the next visits followed in NAFO Div. 1B in the second quarter. It was not possible to get samples from the second quarter in 1A+1C+1D area.

### Discard of low quality shrimp (Quality discard).

Quality discards varied between 0 and 19 percent (Table 1). Variations between trawler, quarter and area of the quality discard were observed. Trawler number 4 was visited twice in nearly the same period of the year. No quality discard was observed during first visit but 15 percent at the second visit. The difference in discard practice can be explained as observer bias at the first visit. The observers general impression was that the level of quality discard was 6 to 7 percent in all areas and quarters.

As the length frequency of the quality discard is regarded as equal to the frequency of the sum of the production categories, the quality discard should be included in the landing curve before scaled as the catch curve. To avoid 'observer bias' and to avoid overestimation of the discard of small shrimp the quality discard was not included when calculating the 'size discard'.

### Discard of small size shrimp (Size discard).

The observers reported op to 50 percent size discard in some hauls, but again to avoid observer bias only the catch distributions from the trawlers observed were used in calculation of the size discard.

The number of hauls sampled by area and quarter (text Table, page 2) varies between five and 134. The observer program does not influence where and when fishing takes place. The coverage of areas 1A+1C+1D is very low (5 hauls). Consequently the observed catch distribution is badly estimated for these areas.

Size discard varied between nine to 36 percent in Davis Strait and was 8 and 9% in first and second half of the year in Denmark Strait. The estimated discard was approximately 100 times bigger than reported in logbooks, which confirms the general impression that the magnitude of the discard is much larger than reported.

Length distributions in samples of shrimp show big variations from station to station in the same area. This has been observed previously (Smidt, 1976), and some variation may be explained as different diel migrations with size.

To obtain mean size distributions that reflect the shrimp population fished, catch samples were when possible taken and measured from every haul 24 hours around the clock during sampling period of 3 weeks. This procedure should average out the variations between hauls.

The catch length distributions (Fig. 1) for NAFO Div. 1B are quite uniform in all quarters observed. This suggests that the catch length distributions comes from the same shrimp population.

Sampling and measuring length distribution of the two-smaller productions size groups were given priority to get samples to fix the length distribution for the size groups which might be discarded and to get length distribution of the size groups which make up the bulk of the landings. The length distribution of the more seldom landed size groups (often of the larger size), were estimated with less accuracy. This means that the left side and the maximum of the landing curve is more accurate than the right hand side of the curve. The catch curves were scaled to match the maximum of the landing curves. The right hand side of landing and catch curves should match closely. This is not the case (Fig. 1-3) and could be due to the less precise estimation of the length distribution of the size categories with larger individuals.

The directly observed size discard always had a count of 120 or more per kg corresponding to carapace length of approximately 23 mm or less in the Davis Strait. To avoid overestimation of the size discard only shrimp smaller than 23 mm carapace length could end up in size discard. In the Denmark Strait a larger maximum length of possible discard size were chosen because the landing curve began to raise at that point.

There was some problems with unspecified size categories of shrimp in the logbook. (6,694 tons on the west coast and 234 tons on the east coast). These categories were given the length distribution of the catch as no other information was available. If the unspecified groups is a remanent of the bigger size shrimp then a bias is introduced and the discard could be overestimated. This would be correct when shrimp are damaged by sharks in the codend which make shrimp useless for product categories.

The discard estimation method given here is simple and it is believed that the calculated discard figures represent a minimum estimate.

## CONCLUSIONS

Discard of low value shrimp in Greenland waters is considerable. Unfortunately it has not been possible to calculate the total yearly discard because of incomplete coverage of all areas and seasons but if an average discard percentage of the seasons covered for the actual areas is applied to seasons not covered, the yearly discard in Div. 1B would be around 6,000 tons, in Div. 1A+1C+1D around 5,000 tons and on the east coast of Greenland approximately 1,000 tons. The total discard of small shrimp (size discard) in Greenland waters made by national trawlers is estimated to approximately 12,000 tons. Adding an average 6% quality discard (by weight) gives an additional discard of 2,300 tons of shrimp. The total discard of shrimp in Greenland waters made by national trawlers is estimated to 14,160 tons or 36.7 or 23.2% depending on whether the figure is calculated based on catch calculated as the sum of discard plus landings or it is based on the observed catch distribution. These figures can be considered as a minimum estimate, as all precautions has been taken to avoid overestimation of the discard.

## ACKNOWLEDGEMENTS

## REFERENCES

Smidt, E. 1976. Diurnal Variation in Shrimp Catches on the offshore grounds in ICNAF Div. 1B and 1C. ICNAF Sel. Pap., 4, p. 45-46.

Table 1.  Observed 'quality discard' of shrimp by quarter, year and division by
          shrimp factory trawlers in Greenland economic zone.   'Catch report
          logbooks' refers to the catch of shrimp for which quality discard were
          observed, 'trawler number' is an internal identification number of the
          visited trawler, and 'number of hauls' are the number of hauls
          observed of the specific trawler and visit.

| YEAR | ICES/NAFO Division | Quarter | Catch report Log-books kg | Quality Discard kg | Quality discard % | Trawler number | Number of Hauls |
|---|---|---|---|---|---|---|---|
| 90 | XIVB | 1 | 826 | 76 | 9 | 1 | 6 |
| 90 | XIVB | 2 | 1567 | 74 | 5 | 2 | 7 |
| 90 | XIVB | 2 | 816 | 62 | 8 | 3 | 5 |
| 90 | XIVB | 2 | 156733 | 0 | 0 | 4 | 51 |
| 90 | XIVB | 3 | 10312 | 135 | 1.3 | 5 | 17 |
| 90 | 1 B | 2 | 23109 | 1270 | 6 | 6 | 15 |
| 90 | 1 B | 2-3 | 42390 | 2256 | 5 | 7 | 61 |
| 90 | 1B-1A | 3 | 73521 | 5286 | 7 | 8 | 68 |
| 90 | 1 B | 4 | 194109 | 3095 | 1.6 | 9 | 62 |
| 91 | XIVB | 1 | 33169 | 4526 | 15 | 4 | 56 |
| 91 | XIVB | 1 | 982 | 190 | 19 | 9 | 3 |

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Fig. 1.    Size distributions of catch, landings and discard of shrimp in NAFO
           Div. 1B, 1990.



II QUARTER



III QUARTER



IV QUARTER
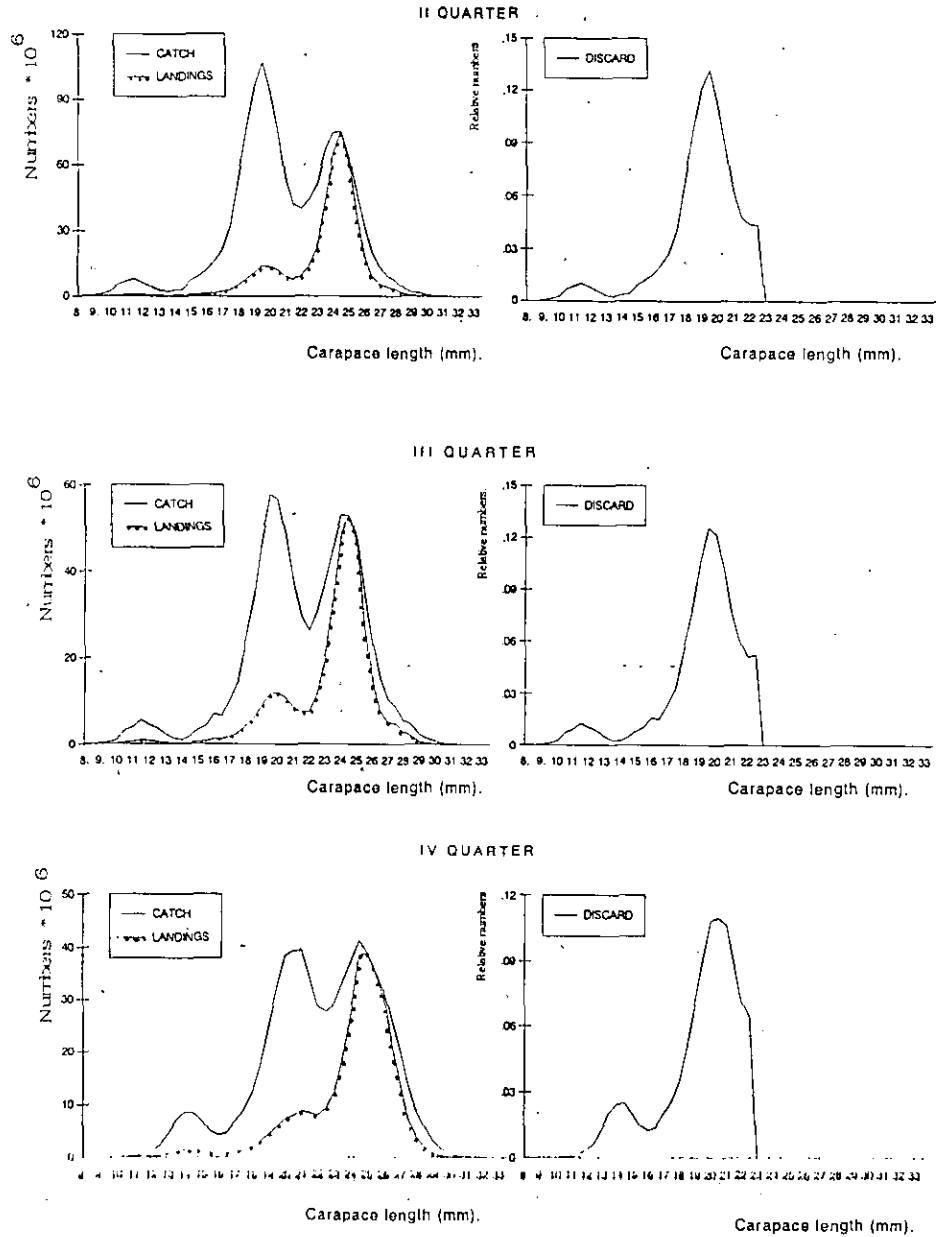
Fig. 2.  Size distributions of catch, landings and discard of shrimp in NAFO Div. 1C and 1E (and 1A), 1990.

### III QUARTER



Carapace length (mm).

Carapace length (mm).

### IV QUARTER



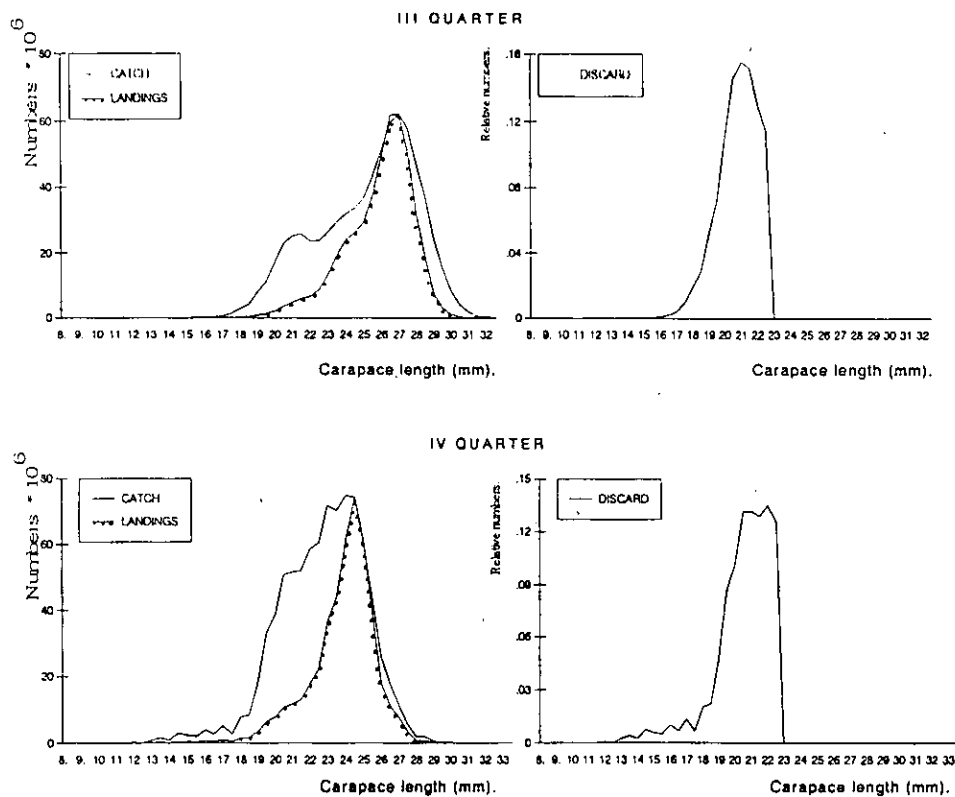Carapace length (mm).

Carapace length (mm).

Fig. 3.  Size distributions of catch, landings and discard of shrimp in ICES Subarea 14B.

### FIRST HALF OF 1990



Carapace length (mm).

Carapace length (mm).

### SECOND HALF OF 1990



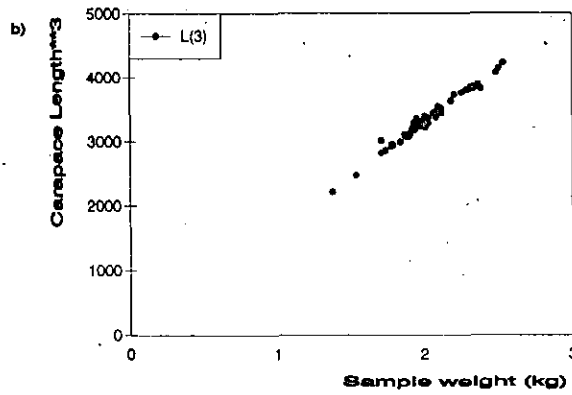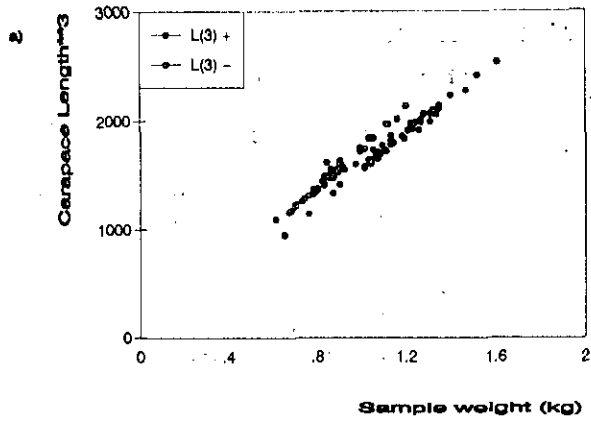Carapace length (mm).
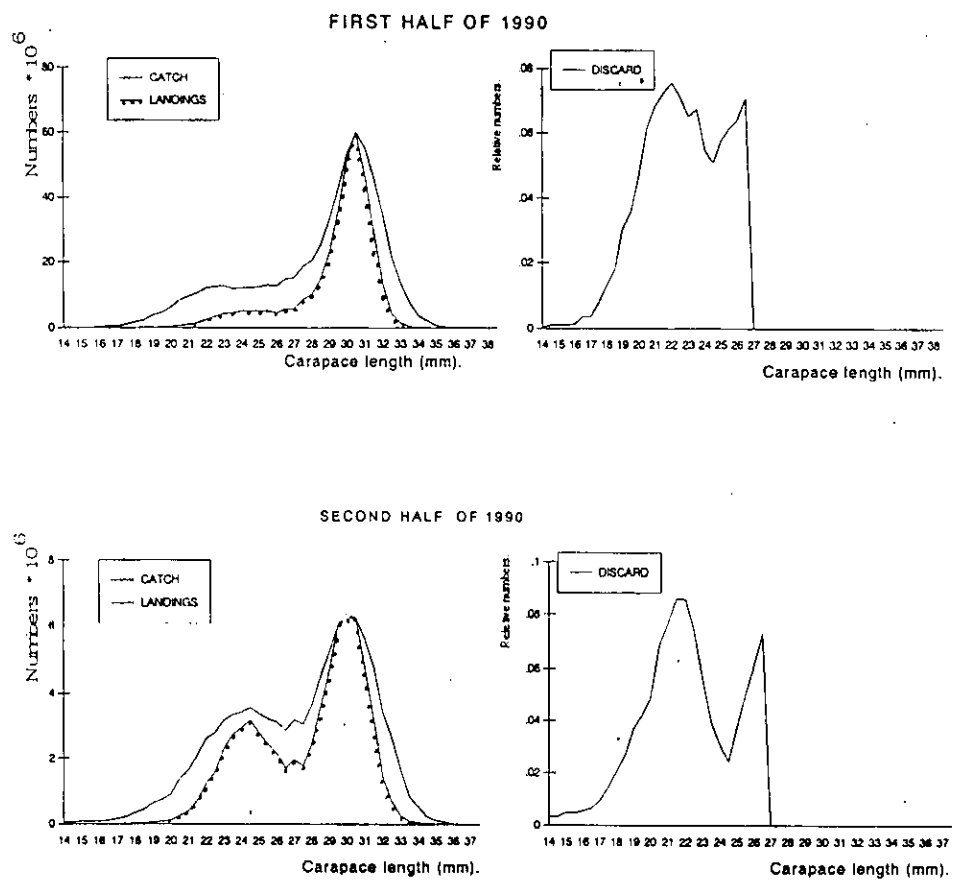
Carapace length (mm).

Fig. 4. Relationship between sample weight and length. Length**3 is sum of cubic carapace length.

Fig. 4a shows samples split in berried females(+) and non-berried females (-).

Fig. 4b shows the same sample not split in berried and non-berried females.

Calculation of selection factor

It had been shown that *Pandalus borealis* has nearly isometric growth and that only minor errors are introduced if exactly isometric growth are assumed. There were significant difference in condition factor for juvenile+ male, female and berried female (Carlsson et al., 1991).

When no length-weight measurements of individuals are available, condition factor can be estimated from length measured samples of same sex with known total weight.

$$1) \qquad sw = a * \Sigma \; l^3$$

sw : sample weight.
a  : condition factor.
l  : length of individual i.

When plotting a number of sample weights against the sum of the cubic length of the same sample the slope of the line are the condition factor. Different slopes can be observed for  non berried females and berried females. (Fig. 4a.).

If the samples are not sorted in non berried females/berried females but this proportion by length are the same in all sample in the samples for a given period and area, a common condition factor for the specific samples can bee estimated by the same method (Fig. 4b).

This condition factor can only be used on samples with the specific non berried females/berried female proportion it was calculated from. However this is a simple method to calculate the weight distribution for a length distribution without sorting the shrimp by sex.

By rearranging 1) the condition factor can be calculated as the mean of sample *weight* divided by the sum of cubic length for all samples for a given period and time.

The results are given in the following Table.

| Division | Quarter | Number of samples | Mean Condition factor | Std. Dev. Condition factor |
|----------|---------|-------------------|-----------------------|----------------------------|
| 1A | III | 85 | 0.000609 | 0.000020 |
| 1B | II | 40 | 0.000594 | 0.000018 |
| 1B | III | 45 | 0.000586 | 0.000016 |
| 1B | IV | 90 | 0.000633 | 0.000030 |
| 1C | IV | 4 | 0.000655 | 0.000011 |
| XVIb | II(90) | 59 | 0.000654 | 0.000023 |
| XVIb | IV(90) | 58 | 0.000643 | 0.000019 |
| XVIb | I(91) | 21 | 0.000623 | 0.000034 |

| Production category | Mean | St.err | Status |
|---|---|---|---|
| Count | mm. | | |
| 40-50 | 32.0 | 1.0000 | estimated |
| 40-60 | 31.0 | 1.2000 | estimated |
| 50-60 | 30.5 | 1.8000 | estimated |
| 50-70 | 30.5 | 2.0000 | estimated |
| 55-60 | 30.0 | 1.0000 | estimated |
| 60-70 | 29.0 | 1.8000 | estimated |
| 60-80 | 29.0 | 1.9700 | estimated |
| 65-70 | 28.5 | 0.8000 | estimated |
| 70-80 | 29.0 | 1.8000 | estimated |
| 70-90 | 28.2 | 1.9769 | calculated |
| 70-100 | 27.0 | 2.0000 | estimated |
| 75-80 | 27.5 | 1.2000 | estimated |
| 80-90 | 26.5 | 1.8000 | estimated |
| 80-100 | 28.1 | 0.6929 | calculated |
| 80-105 | 28.1 | 0.8000 | estimated |
| 80-110 | 23.8 | 1.4255 | calculated |
| 90+ | 25.2 | 2.6160 | calculated |
| 90-100 | 24.5 | 1.9170 | calculated |
| 90-105 | 25.0 | 1.5000 | estimated |
| 90-110 | 25.6 | 1.2603 | calculated |
| 90-115 | 26.5 | 0.7058 | calculated |
| 90-120 | 25.2 | 2.1609 | calculated |
| 90-170 | 24.2 | 2.0000 | estimated |
| 110+ | 23.0 | 2.0000 | estimated |
| 110-160 | 23.0 | 2.0000 | estimated |
| 115-120 | 23.5 | 0.7000 | estimated |
| 120+ | 20.8 | 3.2867 | calculated |
| 120-150 | 23.5 | 1.1365 | calculated |
| 120-160 | 23.5 | 1.1000 | estimated |
| 120-170 | 23.0 | 1.2000 | estimated |
| 120-180 | 23.0 | 1.2000 | estimated |
| 150+ [1] | 19.5 | 1.8171 | calculated |
| 150+ [2] | 23.5 | 3.0000 | estimated |
| 150-180 | 21.5 | 1.0000 | estimated |
| 150-200 | 21.0 | 1.5000 | estimated |
| 170+ | 18.5 | 3.0000 | estimated |
| 170- | 23.0 | 2.0000 | estimated |
| 180+ | 18.5 | 3.0000 | estimated |
| Japan | 34.0 | 1.9100 | calculated |
| Italy | 24.0 | 1.0000 | estimated |

APP. 2.    The values used for reconstructing the length frequency of the landed productions categories. 1) West.   2) East.