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The Efficiency of Meat Recovery from Sea and Iceland Scallops in the Canadian Offshore Fishery

by

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Abstract

The process of removing adductor muscles (meat) through manual shucking of Iceland and sea scallops results in significant weight losses to industry. In the Iceland scallop the lost yield, compared to total available, is negatively correlated to shell size and decreased from an estimated 30% at 60 mm to 11% at 90 mm with an average loss of 23%. While meat recovery for comparable sizes was relatively more efficient in the sea scallop, the loss in yield paradoxically increased with size. The average loss for commercial-sized sea scallops ($\geq$ 100 mm) was estimated at 11%.

In addition to imponderables such as experience, speed, and shucking habits, relative efficiency of meat recovery in the two species appears to be related to shell size, tenacity of shell closure and shell morphology (curvature).

Résumé

Le prélèvement des muscles adducteurs (chair) par écaillage manuel des pétoncles d'Islande et des pétoncles géants cause à l'industrie des pertes importantes en poids de chair. Dans le cas du pétoncle d'Islande, on constate une corrélation négative entre la perte, comparativement à la chair totale disponible, et la taille de la coquille; de 30 % pour une coquille de 60 mm, la perte diminue à 11 % dans le cas d'une coquille de 90 mm, la perte moyenne étant de 23 %. Bien que pour des tailles comparables la récupération de la chair était relativement plus efficace dans le cas du pétoncle géant, on constate paradoxalement que la perte augmente avec la taille. La perte moyenne dans le cas du pétoncle géant de taille marchande ($\geq$ 100 mm) a été estimée à 11 %.

Si l'on tient compte de certains impondérables telles l'expérience, la rapidité et les habitudes d'écaillage, l'efficacité relative de la récupération de la chair chez les deux espèces semble être liée à la taille de la coquille, à la force de fermeture de la coquille et à la morphologie de la coquille (courbure).

Introduction

North American consumers have a decided preference for shucked scallop meats to scallops in the shell. Scallops cannot maintain tight shell closure for prolonged periods and die soon after they are taken from the water. Because of their perishability they are usually shucked aboard the fishing vessel and the meats iced. Only the adductor muscle is retained, the rest of the visceral mass, including the gonad and shells, are discarded. The process of shucking is quite rapid usually resulting in incomplete recovery of the adductor muscle. Efficient and full recovery of individual meats is seldom a preoccupation. This study was carried out to determine the loss in yield of the adductor muscle tissue from rapid manual shucking at sea. Two commercially exploited species from the Northwest Atlantic are examined, viz. the sea (or giant) scallop, *Placopecten magellanicus* and the smaller Iceland scallop, *Chlamys islandica*.

Materials and Methods

Approximately equal numbers of crew-shucked and biologically dissected meats were assembled from commercially harvested scallops of known sizes. Each of two species was sampled separately but over the same space and time. Sea scallops were sampled from the northern edge of Georges Bank during December 1984; Iceland scallops were drawn from St. Pierre Bank during November 1984. Logistical problems permitted sampling scallop meats from one crew member only (one experienced shucker for each of the species). In each case the individual shucking scallops had not been forewarned about the purpose of the exercise. Shucked meats were simply retained along with the shell which was immediately measured to the nearest millimeter. The observer would then select a scallop of approximately the same size and dissect out the adductor muscle ensuring complete removal of the muscle tissue. Meats from each category were kept individually in numbered 6 oz. whirl-pak bags and ice-chilled until weight determinations could be completed in the laboratory. Meats were weighed to the nearest tenth of a gram. Detailed weight determinations were made on intact muscles of both species and separately on the catch ("bit") and quick components of sea scallops (Fig. 1).

Separate shell height-meat weight regressions were fitted to the data. Least squares regressions of the logarithmic transformations were used to estimate theoretical meat yield at given shell height and the loss between anatomical and commercial yield estimated.

Results

Sampled shell-height distributions of each of two scallop species used (Fig. 2 and 3) were similar (Table 1) with no significant differences ($P > 0.05$) in the mean shell heights of the two categories used in the comparisons for each species.

The following shell height-meat weight regressions were computed for the two species (Fig. 4 and 5).

I.	Iceland scallops	$\log W = 2.752 \log x - 4.277$ (Biological, $r^2 = 0.872$)
		$\log W = 3.382 \log x - 5.558$ (Commercial, $r^2 = 0.824$)
II.	Sea scallops	$\log W = 3.148 \log x - 5.123$ (Biological, $r^2 = 0.913$)
		$\log W = 3.095 \log x - 5.067$ (Commercial, $r^2 = 0.901$)

I. Iceland Scallops

The difference between the slopes in the regressions of commercial and biological meat yield on shell size (Fig. 4) was significant ($P < 0.05$). As expected volume (weight) of meat lost during manual shucking decreased with size in the Iceland scallop. In the size range most commonly retained for shucking the meat recovery increased from 70% (at 60 mm) to 95% among scallops at 100 mm. In terms of number of meats to the pound this translates into a loss in yield equivalent to that from 49 scallops at 60 mm or 5 scallops at 90 mm (Table 2). In fact many more scallops would have to be shucked at these shell heights to compensate for the loss in yield.

II. Sea Scallops

Comparisons of the logarithmic regressions between shell size and meat yields from each category of sea scallops (Fig. 5) pointed to common slopes ($P > 0.05$) but elevations were significantly different ($P < 0.05$). Paradoxically percent recovery of muscle tissue decreased with shell size and ranged from less than 10% in scallops under 80 mm to just over 11% in scallops larger than 120 mm (Table 3). Detailed examination of the two contributing fractions (Table 4) showed that incomplete recovery of the larger quick fraction accounted for most of the loss in yield. Differences in adjusted means between anatomical and commercially extracted adductor muscle weights were highly significant for the two fractions combined and for the larger quick component ($P < 0.01$). The difference in the loss in yield was smaller for the catch component but nevertheless significant ($P < 0.05$). Approximately three times as much muscle tissue (by weight) was lost from the larger quick component which on the average makes up about 92% of the total weight of the adductor muscle than from the catch muscle (Table 5). Less than 4% of the latter was lost during commercial shucking.

Discussion

In scallops the posterior adductor muscle is centrally located between the valves. It usually makes up about 10% of the total weight of the scallop. The adductor muscle is divided into two components, one made up of striated fibres (larger, quick fraction) and the other made of smooth fibres (smaller, catch fraction) commonly referred to by industry as the "bit". The quick muscle is responsible for rapid adductions usually associated with swimming. Prolonged and sustained contraction (tonus) is effected by the smaller catch muscle. At the present time there is no attempt by shuckers to leave the "bit" attached to the shell as was practised in the Strait of Belle Isle Iceland scallop fishery (Naidu et al. 1982). Frequently, however, the "bits" become separated during the "wash" (Naidu 1984).

The following description of the shucking process for sea scallops is taken verbatum from MacPhail (1954). The process is similar for Iceland scallops.

The procedure has three stages:

a. The scallop is held in the left hand with the hinge in the palm and the flat left shell towards the shucker (Fig. 6A). The shucking knife, held in the right hand, is inserted forward and upward along the inner face of the flat shell, being entered just above the right-hand corner of the hinge. The blade is then forced backward and downward and towards the operator in a semi-circular motion so as to sever the attachments of meat (muscle) and rim (viscera) from the flat valve.

b. In the next step (Fig. 6B) the point of the knife is hooked downward and away from the operator under the thick muscular mantle edge. The thumb is then pressed against the shell thus clamping the mantle edge between it and the knife. By lifting upward and toward the operator, the shell and the whole of the rim come away leaving only the meat attached to the cupped valve in the left hand.

c. The meat is then scraped off into the shucking pail (Fig. 6C).

While not providing essential data (Haynes 1966) estimated that fishermen shucking sea scallops leave between 2 and 10% of meat attached to the shell. He attempted to "duplicate" commercial practice to provide a second approximation of 3%. That there should be a fractional loss in yield between available (anatomical) and realized yield is not surprising. Differences in the efficiency of meat extraction arise from many causes, some accidental, some systematic and possibly from a combination of the two. The accidental type is by and large a form of "personal error" attributable to a variety of imponderables such as experience, shucking habits, etc. Rapid communal shucking, for example, frequently elicits a competitive response among participants which tends to sacrifice individual meat yield to total volume shucked. Such differences are disordered in magnitude and difficult to estimate. They were minimized in this investigation by retaining only one individual to shuck all scallops of a given species. Systematic differences between actual and realized yields are more readily determined. These are reported upon in this study.

In terms of relative importance the Iceland scallop has always been considered secondary to the sea scallop. Until recently offshore stocks of the smaller Iceland scallop were underutilized (Naidu et al. 1983). One of the reasons was attitudinal. Not only are they more difficult to shuck but greater numbers must be caught and handled to produce comparable weight of meat. In addition to their smaller size requiring greater dexterity in handling the mollusc, tight shell closure along most of the opposing margins of the valves renders blade (knife) entry relatively more difficult than in the sea scallop. This frequently results in severing the meat several millimeters away from the muscle base. The greater shell curvature of both valves of the Iceland scallop (Fig. 7) coupled with furrows running dorso-ventrally make clean and complete severance of the whole adductor muscle relatively more difficult than in the sea scallop where the inner surface is smooth. Sometimes the upper valve (relative to the shucker) is pried open as the blade is still passing through the meat. This results in some tearing of the adductor muscle tissue. The same shucking knife is employed for both species. The length of the blade customarily employed for shucking sea scallops may not fully accommodate shell morphology in the Iceland scallop resulting in disproportionate loss in yield in the latter. It is not uncommon to see muscle remnants several millimeters thick still attached on discarded valves. Additional losses are incurred in the final stage of the shucking procedure for the same reason. In the sea scallop one of the valves (right) is nearly flat and smooth thus facilitating more efficient recovery of the meat.

Changes in shell curvature with size (if any) may affect efficiency of recovery in each of the two species but these were not investigated in this study. Neither was the relative propensity to tearing of adductor muscle tissue with size (age) examined. This is particularly evident in older scallops whose meats are grayish brown, flaccid and stringy in texture. Such scallops are awkward to shuck with some or all of the muscle coming away with the discarded mantle tissue and is lost. In any case these would not affect the conclusions presented in this study as the two categories of scallops used were drawn from the same population and identical in their size frequency distributions.

In both species, it is apparent that meat yields could be improved with marginally more effort in terms of better shucking practices. In addition, these results indicate a potential for considerable bias in estimating the age composition of commercial landings from sampling meat weights in the commercial landings because shell-height (age)/meat-weight regressions are invariably based on biological dissections in which full meat recovery is attempted from all specimens sampled.

Acknowledgements

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Table 1. Summary of sampled distributions of Iceland and sea scallops.

	Biological			Commercial		
	N	Range (mm)	Mean shell height (mm ± SD)	N	Range (mm)	Mean shell height (mm ± SD)
Iceland scallop	150	46-95	73.77 ± 9.53	149	58-94	71.98 ± 7.60
Sea scallop	300	73-146	103.88 ± 14.25	300	75-144	103.04 ± 15.53

Table 2. Biological and commercial yields (grams meat and meat count/lb) in the Iceland scallop.

	Yield				
Shell size (mm)	Biological (g)	Meat count/lb	Commercial (g)	Meat count/lb	Percent loss
10	0.03		0.01		67
20	0.20		0.07		65
30	0.61		0.27		56
40	1.35		0.72		47
50	2.48		1.53		38
60	4.10	111	2.83	160	31
70	6.26	72	4.77	95	24
80	9.05	50	7.49	60	17
90	12.50	36	11.15	41	11
100	16.71	27	15.92	28	5

Table 3. Biological and commercial yields from the adductor muscle of the sea scallop.

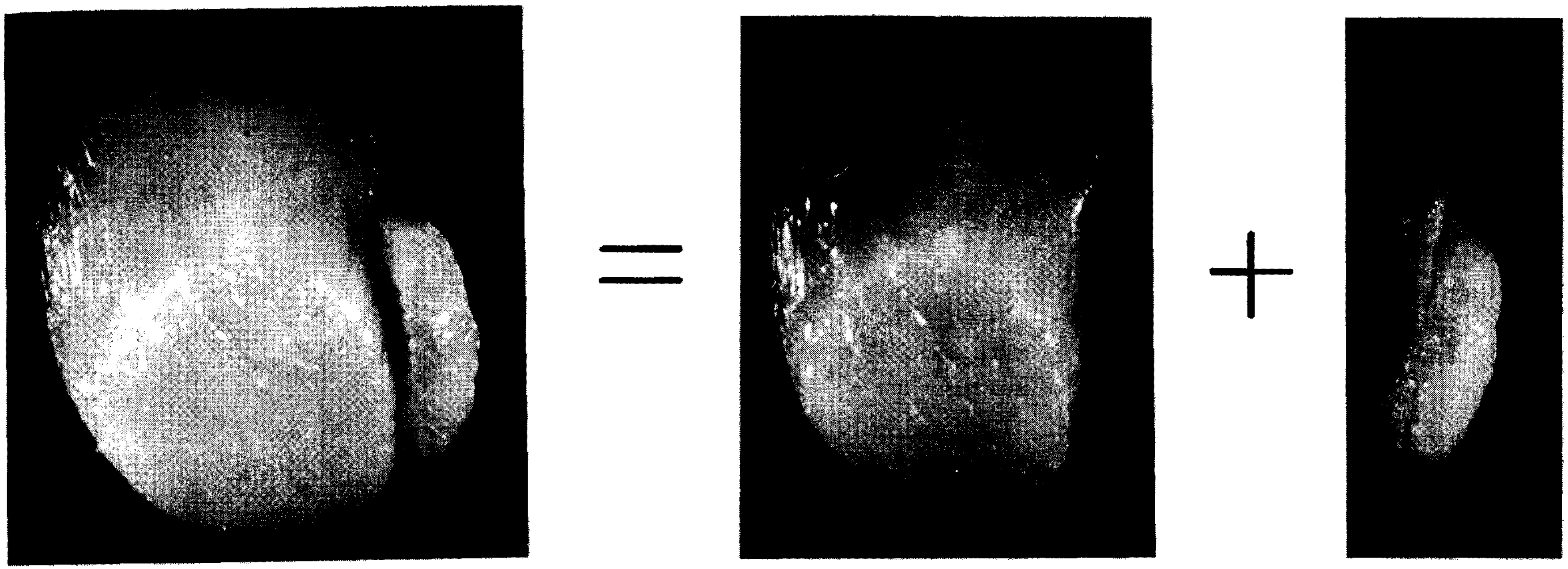
Shell size (mm)	Yield: Biological (g)	Meat count/lb	Commercial (g)	Meat count/lb	Percent loss
60	2.97		2.73		8.0
70	4.83	94	4.40	103	8.9
80	7.36	61	6.66	68	9.5
90	10.66	42	9.58	47	10.1
100	14.86	30	13.28	34	10.6
110	20.05	23	17.84	25	11.0
120	26.37	17	23.35	19	11.4
130	33.93	13	29.92	15	11.8
140	42.84	11	37.64	12	12.1
150	53.22	9	46.59	10	12.5

Table 4. Biological and commercial yields from quick and catch fractions of the adductor muscle of the sea scallop.

Shell height	Quick muscle: Biological (g)	Quick muscle: Commercial (g)	Quick muscle: Percent loss	Catch muscle: Biological (g)	Catch muscle: Commercial (g)	Catch muscle: Percent loss
60	2.70	2.46	8.8	0.276	0.276	0.0
70	4.41	3.98	9.7	0.422	0.417	1.2
80	6.74	6.05	10.2	0.609	0.596	2.1
90	9.81	8.75	10.8	0.841	0.817	2.8
100	13.71	12.17	11.2	1.123	1.084	3.5
110	18.57	16.41	11.6	1.458	1.399	4.0
120	24.50	21.55	12.0	1.851	1.767	4.5
130	31.60	27.69	12.4	2.305	2.189	5.0
140	40.01	34.92	12.7	2.825	2.670	5.5
150	49.83	43.34	13.0	3.413	3.212	5.9

Table 5. Comparison of adjusted means of adductor muscle weights in sea and Iceland scallops.

		Biological (g)	Commercial (g)	Loss	% recovery
Iceland scallop	Total	6.916	5.349	1.567	77.3
Sea scallop	Quick	14.794	13.118	1.676	88.7
	Catch	1.198	1.155	0.043	96.4
	Total	16.010	14.298	1.712	89.3



Posterior adductor muscle
(muscle-on)

quick muscle
(striated)
(muscle-off)

slow muscle
(smooth)

Fig. 1. The posterior adductor muscle of the sea scallop and its components.

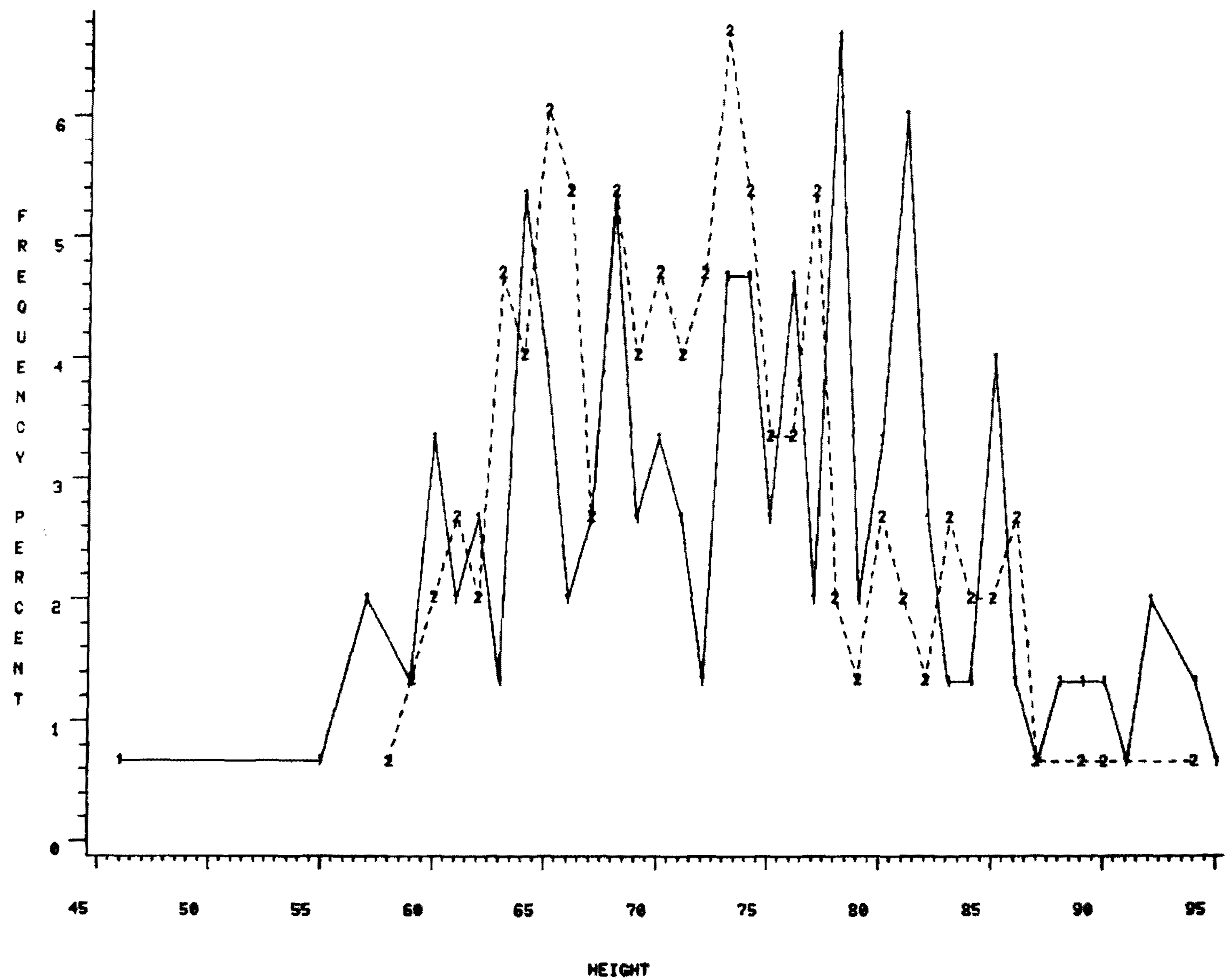


Fig. 2. Iceland scallop shell-height (mm) frequency distributions for biological (1) and commercial (2) samples.

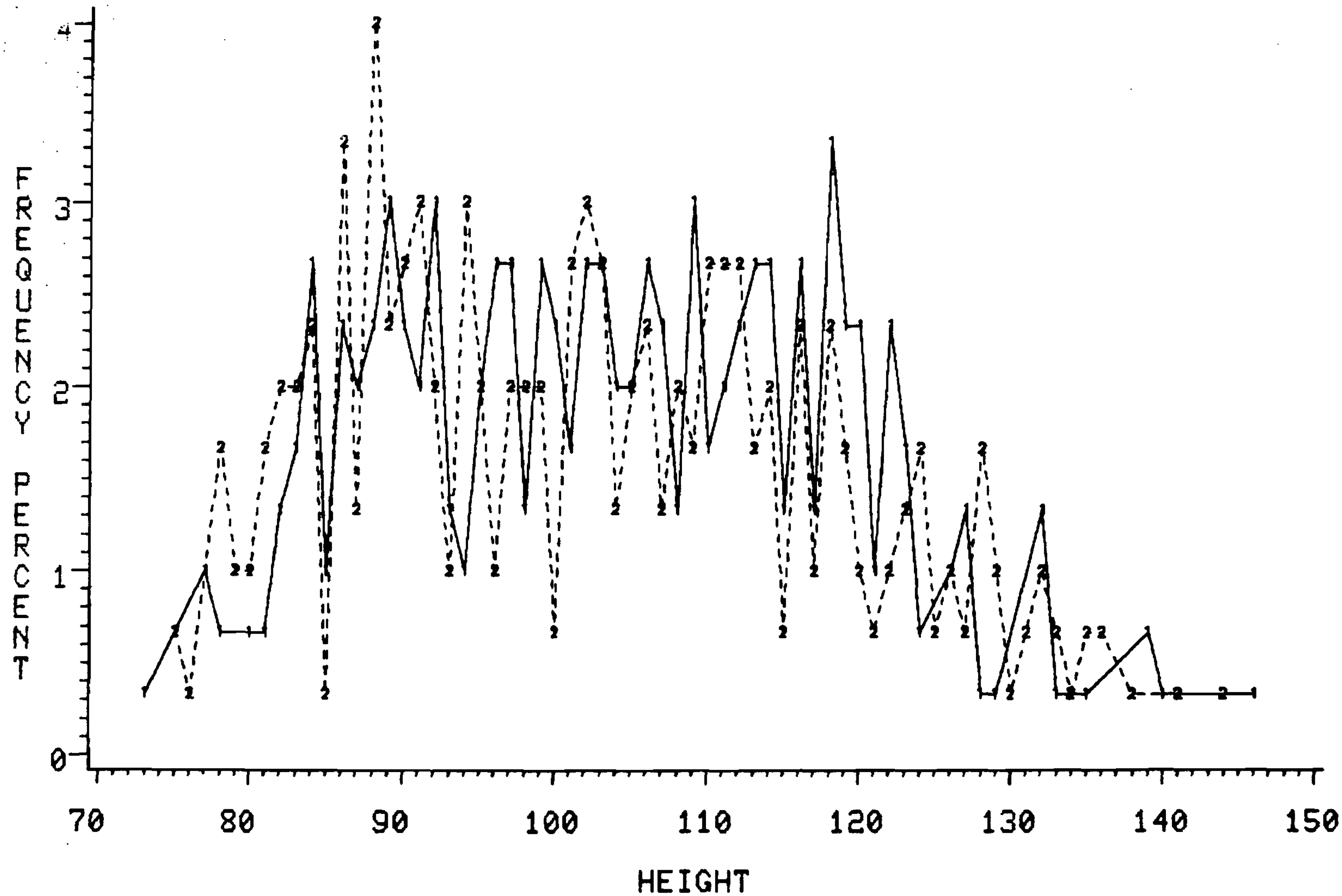


Fig. 3. Sea scallop shell-height (mm) frequency distributions for biological (1) and commercial (2) samples.

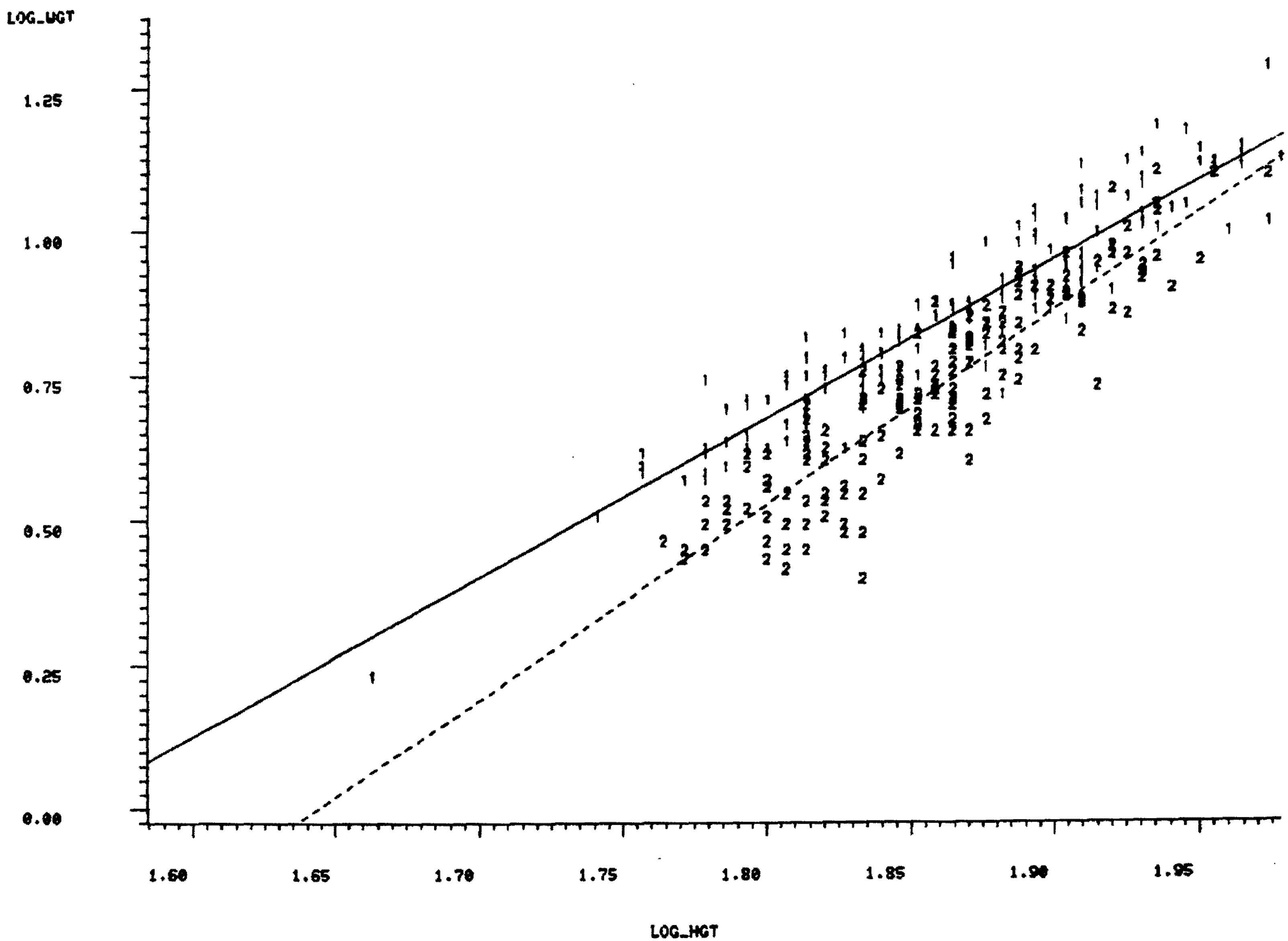


Fig. 4. Regressions of biological (1) and commercial (2) meat yields (g) on shell-height (mm) for Iceland scallops.

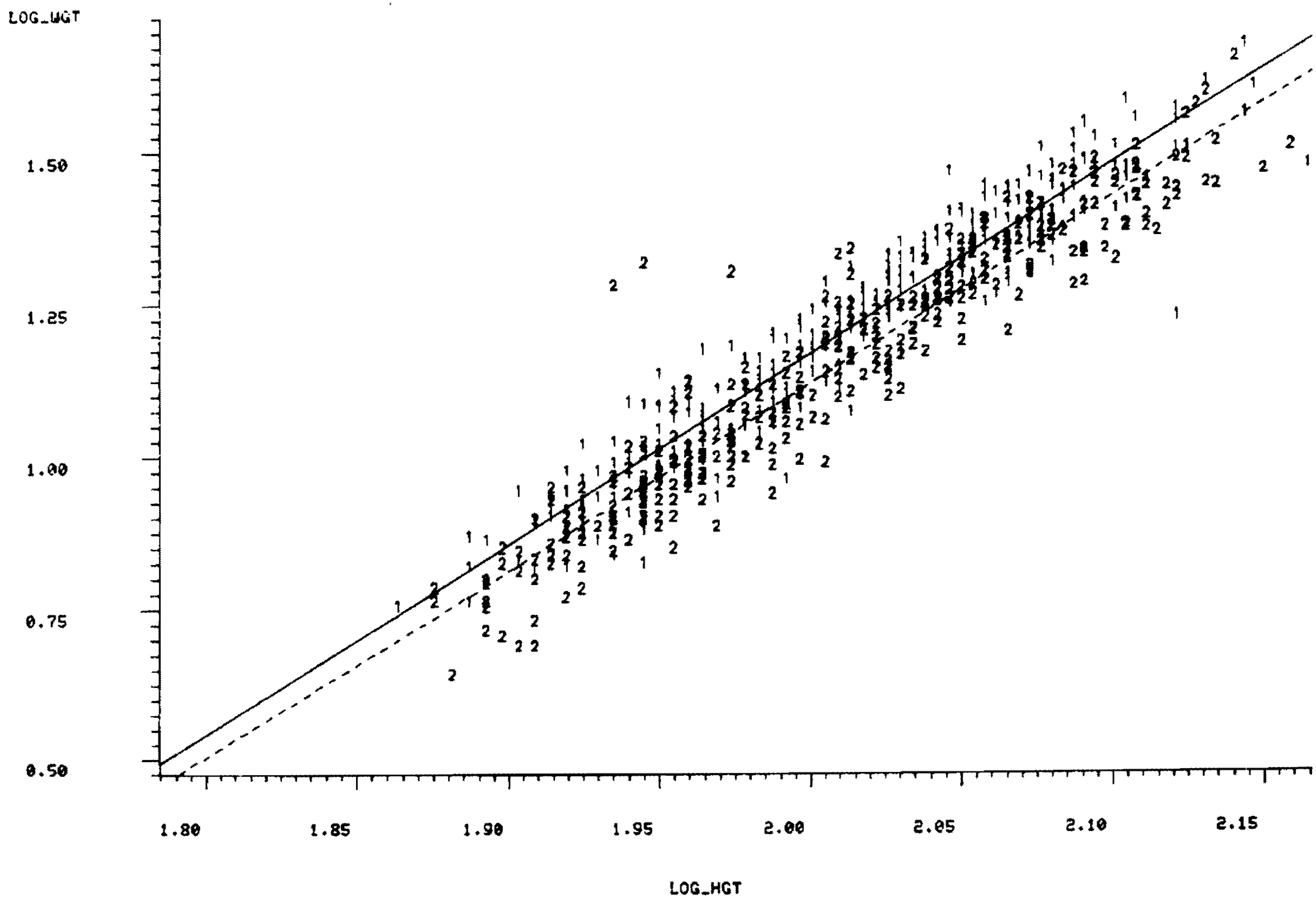


Fig. 5. Regressions of biological (1) and commercial (2) meat yields (g) on shell-height (mm) for sea scallops.

A

B

C

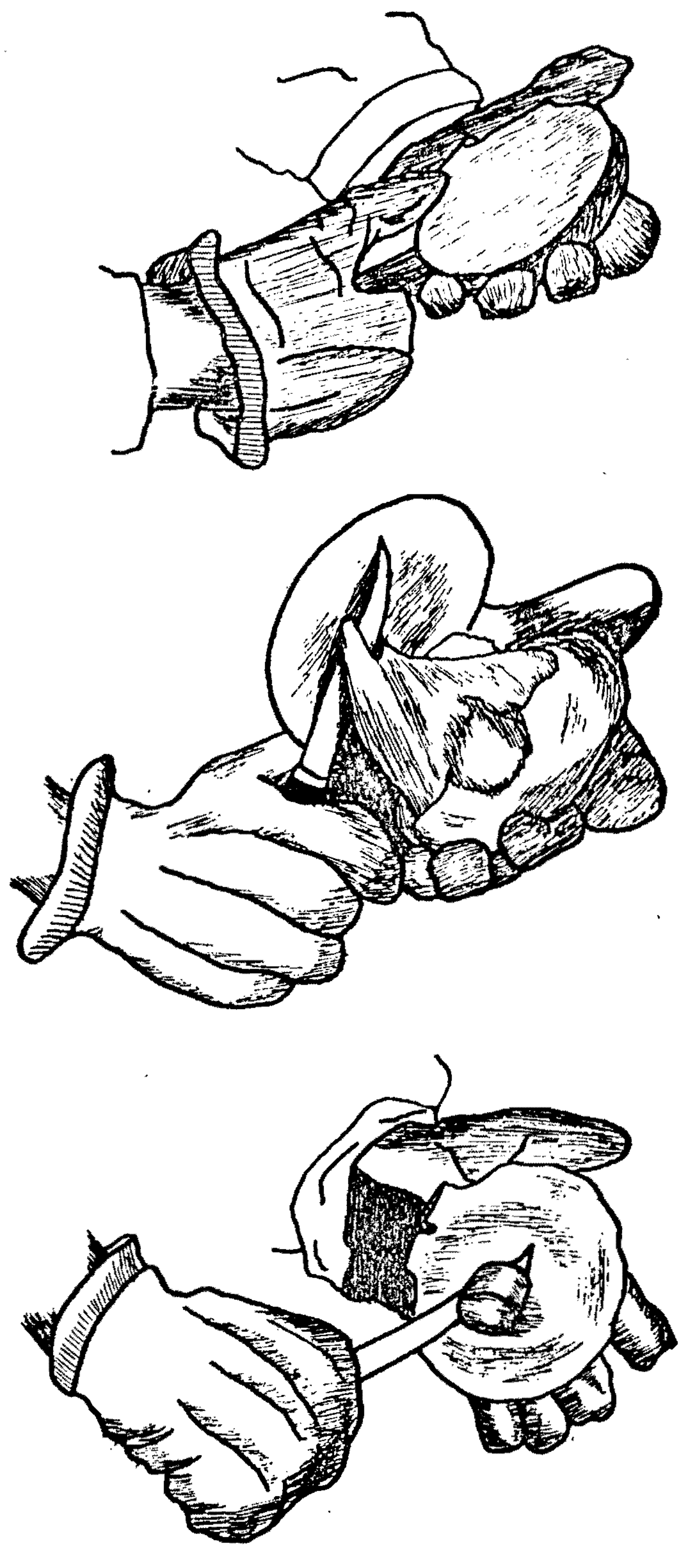


Fig. 6. Shucking procedure (copied from J. S. MacPhail, 1954).

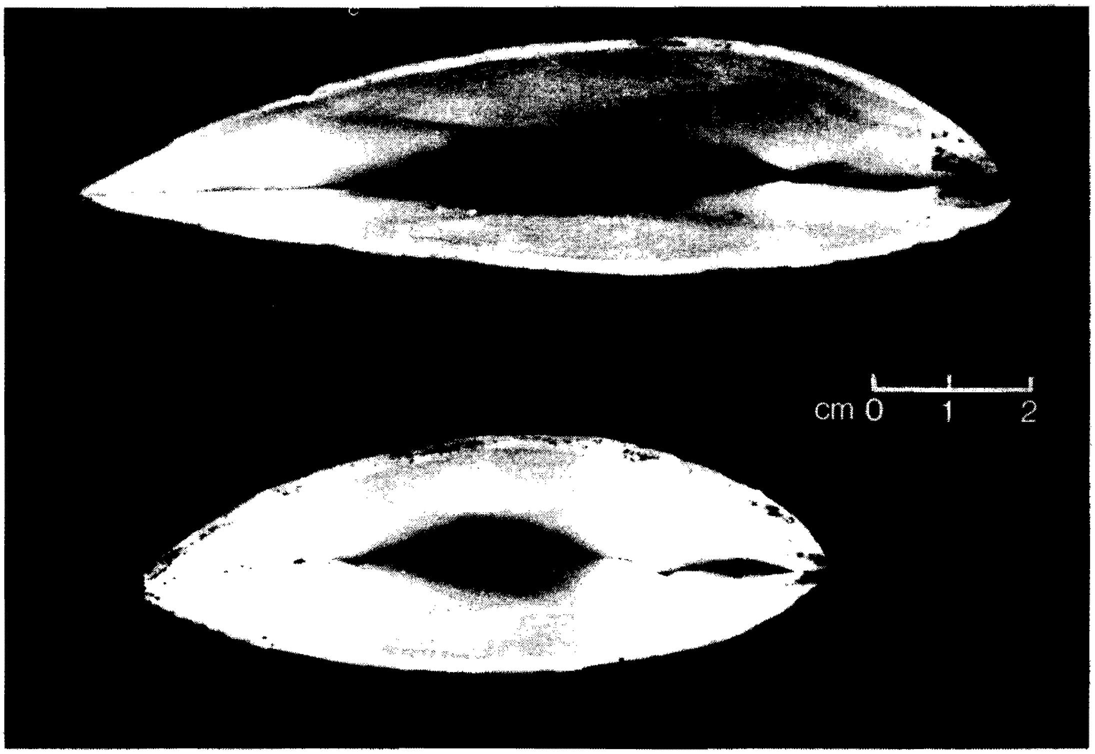


Fig. 7. Vertical section (anterior-posterior axis) through the shell of a sea (top) and Iceland scallop (bottom) showing shell curvature. Right valve is to the bottom in each.