Population Analysis of Horse Mussels of the Inner Bay of Fundy Based on Estimated Age, Valve Allometry and Biomass

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by

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ABSTRACT

Wildish, D., H. Akagi, B. Hatt, N. Hamilton, V. Brock, M. Dalum, C. Gjerulff, B. Henriksen, K. Hesselberg, M. Iversholt, B. Jensen, P. Johannesen, L. Kristensen, B. Mackenhauer, T. Madsen, L. Michelsen, K. Nielsen, H. Norgaard, D. Olesen, L. Pedersen, T. Rosenkrands, B. Søndergård and L. Stottrup. 1998. Population analysis of horse mussels of the inner Bay of Fundy based on estimated age, valve allometry and biomass. Can. Tech. Rep. Fish. Aquat. Sci. 2257: iv + 43 p.

From a preliminary list of 14 geological provinces interpreted by G.B.J. Fader in the inner Bay of Fundy (pers. commun.), we show by 69 videograb and conventional grab samples that the horse mussel, *Modiolus modiolus*, is common in only five of these provinces. They are: sand with bioherms, gravel cobble, gravel/scallop bed, mottled gravel and glacio-marine mud. In all other geological provinces cursorily examined (2-6 grabs per province), horse mussels were occasional and of low density, or absent. These include: rippled sand, sand with comet marks, sand ribbons, mottled sand, gravel with comet marks and gravel ripples. Three provinces, continuous sand, mixed sand/gravel and starved megaripples, were not examined during this study, but are considered unlikely to have horse mussel populations because they lack a suitable substrate for byssus attachment. In all, 673 horse mussels were collected within the inner Bay of Fundy - 425 in 1997 and 248 in 1998. Where possible the sex, age, wet/dry weight of soft tissue, left/right valve weight and allometry of the left valve (height, length, width) were determined. The above nine estimates made on each horse mussel are recorded in two appendices and the valves archived for further study. A population analysis of these data, based on individual grab (=station) samples with >6 up to 80 horse mussels, is also presented. Principal components analysis suggests that the nine biometric variables divide the mussels sampled into three major groups, which correspond to geological provinces: Group 1 - sand with bioherms; Group 2 - gravel/scallop bed; Group 3 - gravel cobble and mottled gravel. The differences are underlain by growth rate differences between each of the groups (1 - fast, 2 - intermediate, 3 - slow), recognized by regression analysis of age determined by reading valve growth lines on dry weight of soft tissue, or linear increments of valve length for the first 4 yr of growth.

RÉSUMÉ

Wildish, D., H. Akagi, B. Hatt, N. Hamilton, V. Brock, M. Dalum, C. Gjerulff, B. Henriksen, K. Hesselberg, M. Iversholt, B. Jensen, P. Johannesen, L. Kristensen, B. Mackenhauer, T. Madsen, L. Michelsen, K. Nielsen, H. Norgaard, D. Olesen, L. Pedersen, T. Rosenkrands, B. Søndergård and L. Stottrup. 1998. Population analysis of horse mussels of the inner Bay of Fundy based on estimated age, valve allometry and biomass. Can. Tech. Rep. Fish. Aquat. Sci. 2257: iv + 43 p.

À partir d'une liste préalablement établie de 14 provinces géologiques interprétées par G.B.J. Fader (comm. pers.) à l'intérieur de la baie de Fundy, nous démontrons à l'aide de 69 échantillons de bennes vidéo et de bennes preneuses conventionnelles que le modiole, *Modiolus modiolus*, est commun dans seulement cinq de ces provinces. Elles sont: sable avec biomonticules, gravier/caillou, gravier/lit de pétoncles, gravier diapré et vase glacio-marine. Dans toutes les autres provinces superficiellement observées (2-6 échantillons par province), les modioles étaient rares et de faible densité ou absents. Celles-ci incluent: sable ridé, sable avec marque de comète, ruban de sable, sable diapré, gravier avec marque de comète et gravier ridé. Trois provinces, sable continu, mélange sable/gravier et ride de sable famélique, n'ont pas été observées au cours de cette étude, mais sont considérées comme des régions où la probabilité d'y trouver une population de modioles est très faible, car il n'y a pas de substrat adéquat pour l'attachement de leur byssus. En tout, 673 modioles ont été recueillis dans la région de l'intérieur de la baie de Fundy - 425 en 1997, et 248 en 1998. Dans la mesure du possible, le sexe, l'âge, les poids secs/humides des tissus mous, les poids des valves droite et gauche et les mesures allométriques de la valve gauche (hauteur, largeur, longueur) ont été déterminés. Ces neuf estimations faites sur chaque modiole ont été enregistrées dans deux annexes, et les données sur les valves archivées en vue de futures recherches. Une analyse des données de population, fondée sur les échantillons de stations individuelles comptant de 6 à 80 modioles, est aussi présentée. Une analyse des composants principaux suggère que les neuf variables biométriques divisent les modioles échantillonnés en trois groupes majeurs, qui correspondent aux provinces suivantes: Groupe 1 - sable avec biomon-ticules; Groupe 2 - gravier/lit de pétoncles; Groupe 3 - gravier/caillou et gravier diapré. La différence

est mise en lumière par un taux de croissance variant d'un groupe à l'autre (1 - rapide, 2 - intermédiaire, 3 - lent), ce que vient confirmer l'analyse de régression de l'âge, qui est déterminé en fonction des lignes de croissances de la valve par rapport au poids sec des tissus mous, ou par l'augmentation linéaire de la longueur de la valve pour les quatre premières années de croissance.

INTRODUCTION

The Bay of Fundy is a large macrotidal estuary draining the Saint John River, as well as a number of lesser rivers in New Brunswick and Nova Scotia. The subtidal area occupied by the whole of the Bay, to an arbitrary line where it joins the Gulf of Maine, is 11,149 km^2. A macro-scale map of secondary macrobenthic production was prepared on the basis of 266 independent grab samples by Wildish et al. (1986). The limitations of the conventional benthic sampling method for mapping are due to:

- logistical constraints on the number of benthic samples which can practically be analyzed taxonomically and for density/biomass. This means that it is possible to conventionally analyze only a very small proportion of the area available.

- the fact that many benthic macrofaunal populations are contagiously distributed (Elliot 1977) at micro-, meso-, and macro-scales. Because of this, the spatial limits of the population distribution of each taxon cannot be determined by conventional benthic methods. Thus, even at macro-scale and with a large and expensive sampling program, very crude benthic maps will result.

- the knowledge that because most of the available historical grab sampling data is not referenced to a precise position, it cannot be used to construct accurate benthic biomass or productivity charts. We point out that current technology does now allow precise positioning of a grab at the point of sampling, involving acoustic short baseline navigation devices on the grab with receivers on the ship (McKeown and Gordon 1997).

In the early 1980s, benthic grab sampling was the only quantitative method available with no recognized alternatives. Other authors such as Caddy (1970) and Fuller et al. (1998) have provided taxonomic lists of the larger macrofauna associated with commercially dredged scallop grounds. These non-quantitative data also suffer the limitations listed above, but add a different slant on sampling bias, making it difficult to reconcile with single-point, non-spatially referenced grab sampling data.

During an interdisciplinary workshop held at Wolfville, N.S. in 1996 to discuss environmental problems, primarily of the northern part of the Bay of Fundy, new acoustic methods being used by surficial geologists were discussed (e.g. Dodds and Fader 1986; Wright et al. 1987; Fader 1988, 1991; Magorrian et al. 1995). It seemed possible that side-scan sonar and high-resolution seismic reflection systems might provide a better mapping tool for benthic macrofaunal communities at all scales of spatial distribution for keystone macrofauna through correlation between the type of geological province and the associated macrofauna. An early success was achieved for this objective when bioherms, recognized on side-scan sonograms and by seismic reflection profiles in the upper Bay of Fundy, were confirmed by video photography carried on a submersible ROV to be horse mussel reefs (Wildish et al. 1998). Previously Fader (1991) had recognized, by acoustic means, benthic sampling and video photography, the following biogenic features from the eastern Canadian continental shelf including:

- white filamentous bacterial mats on sandy sediments associated with shallow, subsurface gas pockets of methane indicated by high-resolution, seismic reflection systems termed "acoustic masking." These features are sometimes associated with dense benthic communities presumed to be trophically dependent on the gas seep community bacteria.

- pockmarks are readily identified on side-scan sonograms as circular areas of less reflectivity, sometimes being 'eyed', that is with a central focus of high reflectivity due either to dense populations of benthic animals (?bivalves) or an artifact due to acoustic focussing. They are interpreted to be caused by gas venting (active or relict) and may be associated with earthquakes and fault lines as in Passamaquoddy Bay (Fader 1988). Examination of two eyed pockmarks in this area from an ROV in 1990 (D. Wildish and D. Peer, pers. commun.) suggested that no epifaunal concentration of benthic animals was present, although these pockmarks may have been relict with no active gas seepage.

- shell beds or specks (but not raised seabed features or bioherms, as referred to in Fader (1991), because they occur in slight depressions or with little increase in the sediment surface roughness) on sand, are recognized as irregular to circular patches of high acoustic backscatter on side-scan sonar imagery. Contrary to a true

bioherm, which shows elevation above the bottom as recognized by high resolution seismic profiler, no elevated seabed structures are present. Underwater photography showed that dense populations of sea cucumbers were present with shell gravel, and possibly live bivalves (see Fig. 5, Fader 1991). Which target species provided the high intensity backscatter on side-scan sonograms of the eastern Grand Banks, Newfoundland, is unknown. Stanic et al. (1989) recorded high frequency acoustic backscattering from a seabed covered with coarse shell gravel and made clear that the backscattering occurs whether the bivalves were live or dead. Soft-bodied epifauna such as sea cucumbers may not yield acoustic backscattering returns.

- to complete this list, sand with bioherms as mentioned above (Wildish et al. 1998) can be acoustically recognized for shell beds but, in addition, high-resolution seismic reflection systems confirm the presence of a bioherm. Such structures are mentioned in Belderson et al. (1972) where the biogenic identity was not known. In the inner Bay of Fundy, the bioherms are horse mussel reefs (Wildish et al. 1998), and bioherms on a muddy substrate in Chesapeake Bay were oyster reefs (Wright et al. 1987) confirmed by SCUBA diving observations.

The two specific objectives of the work presented here were:

- from a preliminary list of geological provinces interpreted by G.B.J. Fader of the Geological Survey of Canada (unpublished) from side-scan sonograms of the inner Bay of Fundy, to sample each province for the presence/absence of horse mussels, *Modiolus modiolus*;

- to determine whether any phenotypic differences exist between horse mussel populations within the inner Bay of Fundy.

This work forms part of a collaborative effort with surficial geologists to adapt modern geological techniques to assess benthic macrofaunal biomass, and thus secondary benthic production, at relevant spatial scales for coastal zone management purposes.

METHODS

FIELD WORK

All field work presented here was completed on two missions as follows:

17-22 June 1997 - [part of] 97-020 CGSS HUDSON
11-15 May 1998 - 98-011 CGSS J.L. HART

The HUDSON mission involved collaboration with G.B.J. Fader who conducted acoustic surveys during the night-time hours. Two side-scan sonar systems were employed - a BIO-designed 70 kHz system and a Simrad dual-frequency system operated at 100 and 330 kHz. Sleevegun and Huntec seismic reflection systems provided information on surface and subsurface stratigraphy and, in particular, the presence/absence of bioherms. The side-scan sonograms obtained still await a full lab analysis involving digitization, but the list shown in Table 1 is a preliminary interpretation of the geological provinces from this and one previous mission in the upper Bay. The day-time work involved a $0.5\text{-}m^2$ video grab described in Schwinghamer et al. (1996). It is supported on a large metal frame and the grab jaws can be closed hydraulically from the mother ship by remote control. A video camera was focussed through the grab jaws and was used to select a suitable site for sampling and to determine whether the jaws closed properly as stones or rocks could become caught and hinder closing. A still camera was also mounted on the frame about 1.5 m above the sediment and could take single exposures by remote control from the ship. A shutter speed of 1/250 s and F stop of 11.5 was preset. All grab sample contents were sieved on a 5 x 5 mm mesh screen and all mussels retained. Two 12-h anchor stations for sampling bottom seawater parameters - inclusive of particle flocs - were also completed and the results will be reported elsewhere (T. Milligan, pers. commun.).

The J.L. HART mission deployed a different $0.5\text{-}m^2$ Van Veen grab which, when full, contained 70-80 L of sediment slurry. Most of the first two days was lost because of wind/wave conditions rendering sampling dangerous and difficult because the grab hit the sediment sideways and often failed to take a sample. As for the HUDSON mission, mussels were sieved from sediments on a 5x5 mesh screen and retained.

In all, 31 grab deployments were made with the video grab from the HUDSON and 78 deployments with the Van Veen from the J.L.

HART. A classification of the fullness of each grab sample follows:

	HUDSON	J.L. HART
0 - empty	11	29
1 - small amount of epifauna	} 20	38
2 - half full		11
3 - full	0	0

These results reflect the hard and difficult-to-sample nature of the inner Bay of Fundy seabed where rocks frequently lodged in the jaws causing variable sample loss. Such grab samples were recorded as empty.

HORSE MUSSEL IDENTIFICATION

In all, 673 specimens of *Modiolus modiolus* were collected during the two missions (Table 1). By multiplying by 2, the density, as number per m^2, could be determined for each grab station, since only 0.5-m^2 grabs were used. As far as possible, individual mussels were shucked at sea, although for about half of the J.L. HART collection, whole mussels were frozen and the following completed on thawing in the laboratory.

After opening the valves with a knife, the sex was determined by the color of the gonad (Rowell 1967) as follows: bright orange - female, creamy yellow - male, color not clear - immature or undecided. The adductor muscles were then cut with a scalpel as close to the valves as possible and the whole of the soft tissue placed in a double-pocketed plastic bag which could be resealed (originally for transport of medical lab specimens). Each mussel was given an individual identification number, such as 00L000H, where the first two digits indicate the grab (=station) sample number, the letter indicates a live or dead bivalve. The following three digits are assigned to individual mussels so that each has a unique number. The final letter refers to the bivalve species, e.g. H - horse mussel, M - blue mussel, C - bar clam, S - scallop. For each mussel a tag was prepared with its individual number and placed in the other pocket of the plastic bag with both right and left valves. All bags were stored at -20°C before further analyses.

LABORATORY ANALYSIS OF HORSE MUSSELS

The following biometric characteristics were recorded on all of the mussels:

- soft tissue wet/dry weight
- dry valve weight of each valve
- left valve length
- maximum valve height
- maximum valve width
- sex
- age

Following thawing, each mussel meat was dried of excess liquid with tissue paper, placed in a numbered, pre-weighed aluminum dish and weighed wet to 0.01 mg. The dish was then placed in a convection drying oven set at ~85°C and left for 48 h. After cooling, the dry weight was determined. Recordings of all weighings were made on forms specially designed for this purpose. A physiological index of condition was determined for each mussel as in Brock and Wolowicz (1994), with the soft tissue dry weight divided by total valve weight multiplied by 100.

Both valves were scrubbed with a scouring pad under running tap water to remove the epifauna and then allowed to dry. Each valve was labelled with a water-resistant marking pen on the inside of the valve and each weighed to 0.001 g on a top-loading balance. For valve allometry, the left valve was measured by electronic calipers to 0.1 mm for three dimensions, length, and height, as shown in Fig. 1. If the left valve was absent or broken, the intact right valve was used instead. The maximum width could only be measured if both valves were intact as in Fig. 1. All data were recorded with the individual mussel identification number on a specially designed master form.

Both valves from the above were stored dry in suitable boxes until they were assessed for their putative age. This was done for each mussel by back-ageing based on valve growth lines (Wiborg 1946; Rowell 1967). Valves were arranged in numbered sequence on a lab bench and each viewed in turn with the aid of backlighting. The age was determined as shown in Fig. 2 where the winter rings were thin white lines and the summer ones the diffuse, often purple space between them. In many cases, it was impossible to follow the rings and, in some, the periostracum of the left valve (only) was removed by immersing for a few hours in 30% Javex solution. Where possible, putative age was recorded for each mussel to the nearest year or left blank to indicate inability to read the valve growth lines on the master sheet. The first four or five growth lines were particularly clear on some mussels, and on a

subsample (chosen on the basis of growth ring clarity), we have measured linear distances between each growth line. This method was also used by Rowell (1967) to determine the mean valve increment at each age.

We also used an acetate peel method as described by Bourget and Brock (1991) to provide an independent method of assessing age.

POPULATION ANALYSIS OF HORSE MUSSEL POPULATIONS

Data from completed master forms were entered in a PC Microsoft Excel spreadsheet. Copying errors were checked manually and electronically corrected.

A series of four experimental tests were performed to determine whether repeated estimates by back-ageing on the same subset of valves were different between independent observers. If the variances between two sample age means are similar, the "t" test for difference can be used (Kelley et al. 1992) to determine whether mean ages are significantly different. We also used regression analysis comparing valve length (fixed) versus age determined independently to see if slope or position differences were present.

Principal components analysis (PCA) was performed on all measured variables, inclusive of wet/dry soft tissue weight, three valve dimensions, weight of each valve and age using public domain software as in Zitko (1994).

Analysis of variance of population ages was employed to determine whether mortality rates were different between populations and binomial statistics of the sex ratio to determine population differences.

RESULTS

We have considered grab contents fullness indices of 1 and 2 (see p. 3) as quantitative samples. Thus, 20 of 31 in the 1997 HUDSON mission and 49 of 78 in the 1998 J.L. HART mission are considered to be good samples (Table 1). These collections resulted in a total of 673 live horse mussels (Table 2, 3), 8 live blue mussels and other live bivalves, inclusive of scallops, bar and razor clams which were not counted or kept. All available right and left valves from both 1997 and 1998 horse mussel

samples are archived in the Atlantic Reference Centre (contact The Curator of Invertebrates, Atlantic Reference Centre, Huntsman Marine Science Centre, Brandy Cove Road, St. Andrews, NB, E0G 2X0; Tel: (506) 529-1203).

We have corrected an earlier report on the CGSS HUDSON results (Wildish and Fader 1998) and the results shown in Tables 1, 2 and 3 and Appendices 1 and 2 are definitive.

The sex of individuals was not recorded for the first few populations sampled in 1997 (see Appendix 1).

HORSE MUSSEL DISTRIBUTION IN GEOLOGICAL PROVINCES

Of the 14 geological provinces recognized (Table 1), three were not sampled at all during 1997-98: continuous sand (H), mixed sand/gravel (L) and starved megaripples (M). Of the remaining 12, each had ≥2 samples taken at various places within the inner Bay. Among these 12, present evidence based on 2-19 quantitative grab replicates suggests that horse mussels may be absent, or rare, in five geological provinces: rippled sand, sand with comet marks, mottled sand, gravel ripples, and mixed sand/gravel. They are common in five geological provinces: sand with bioherms, gravel/cobble, gravel/scallop bed, mottled gravel, and glacio-marine mud, although the video grab (rather than the Van Veen) is required to reliably sample horse mussels in the sand with bioherms province (Table 2, 3). The sand ribbon and gravel with comet mark provinces have a low density of horse mussels.

Because of the low sampling effort in most geological provinces, we realize that our conclusions about horse mussel presence/absence in particular provinces is preliminary.

HORSE MUSSEL POPULATION ANALYSIS

The raw data on which the following analyses are based is shown in Appendices 1 and 2.

For the purposes of population analysis, grab (=station) samples with >6 horse mussels per 0.5-m^2 grab were analyzed.

Wet/dry weight determinations

Our data shown in Appendices 1 and 2 for wet (x) versus dry (y) weights gave a highly significant r^2 value:

$$y = 0.2083x + 0.0633 \quad r^2 = 0.96, N=386 \quad (1)$$

We provided one frozen, soft-tissue population sample (1997, #06 with N=30) to Dr. Chou for analysis of possible chemical contaminants (reported elsewhere). Wet/dry weights were determined by Dr. Chou with a different drying technique involving homogenizing the sample before heating, thus achieving a much more complete drying. The regression equation is:

$$y = 0.1508x - 0.003 \quad r^2 = 0.81, N=30 \quad (2)$$

As shown in Fig. 3, the two methods give significantly different results. Because of this, we have recalculated dry weights based on wet weight and equation (1). Both values are shown in Appendix 1 for #06.

Quality control check for the back-ageing method 1

Horse mussels from a fast growing (1997, #03) and a slower growing (1997, #16) population were selected. Two independent observers determined age on the right (observer 1) and left (observer 2) valves of 20 animals (Table 4). Scatter diagrams (not shown) and fitted regression lines of age in y^{-1} (x) on valve height in cm (y) suggest that the growth lines (=ages) were not particularly reproducible. Thus for observer 1,

$$y = 0.533x + 3.5412 \quad r^2 = 0.68 \quad (3)$$

For observer 2,

$$y = 0.588x + 2.873 \quad r^2 = 0.70 \quad (4)$$

Consequently, we undertook a further statistical test to determine how reproducible the back-ageing by growth lines method was when determined by groups of independent observers. Two 1998 populations, #18 and #22, were examined with both right and left valves used - two groups determined ages in the first and three groups in the latter. Group decisions were made in determining age from growth lines. The data are recorded in Appendix 3. One thing to note from Appendix 3 is that independent observers had differing opinions on which horse mussel growth lines were readable, as shown by unequal pairs of numbers for #22 (single observations excluded). We computed the putative mean age between pairs of observers and tested the difference by "t" test (Table 5). From this we reject the hypothesis that age estimates by back-ageing based on valve growth lines are reproducible for three of the four tested.

The other question of concern was whether the growth lines we determined actually represented annual growth marks. Although we present no additional data on this point, the earlier work of Rowell (1967) based on field observations of marked horse mussels over a 2-yr period at Sandy Point, St. Croix estuary, clearly showed that these growth lines do represent annual growth.

Growth measurement by method 2

Because of difficulties in reproducibility of the method of back ageing for all growth lines, we also attempted two other methods. The acetate peel technique (method 3) for reading growth lines within the cut valve proved to be homogenous and unreadable. The other method involved determining the linear distance between the first four growth lines (method 2). Subsamples from five different populations where L1, L2, L3 and L4 were clearly visible were measured and the results recorded in Appendix 4. These direct growth measure results fall within the range discussed by Rowell (1967). This independent method supports the view that growth rings represent age as found by Rowell (1967) although, because of difficulties in reading later growth rings by method 1, the definition of an annular growth ring becomes problematic at ages >4 yr.

Principal components analysis

The multivariate data of Appendices 1 and 2 have nine variables and different sample numbers in each population (grab = station) that was sampled. The data for both 1997 and 1998 were combined and used untransformed. The results (Table 6) show that the first two principal components account for nearly 92% of the variance in the data set. Consequently, the data can be examined graphically as in Fig. 4. This figure shows how individual populations were visually resolved into three major groups by highlighting each population in turn in a series of similar graphs. By this method, each population could be assigned to the following:

Group 1 - #'s 97-003, 006, 008, 009
Group 2 - #'s 97-014, 015, 016

Group 3 - #'s97-018, 020, 021, 022, 023,
024; #'s 98-022, 023, 024, 025,
026, 070, 076, 077, 078.

Growth

If growth lines observed on horse mussel valves represent annual growth marks as shown by Rowell (1967), then we may use them to indicate age and hence growth from length or biomass on age graphs. Thus L-1 in the data of Appendix 4 represents the valve length growth made in the first summer after settlement and during one winter, L-2 the growth made in the second summer and winter after settlement, and so on for L3 and L4. We have calculated the mean valve lengths for each growth line group (Table 7) which also represents the mean growth at age as shown in Fig. 5. From Fig. 5, all mean valve lengths for L-1 are similar (except #023), suggesting that growth rates are similar in the first year. However, in the second and subsequent years, #03 grows much faster (at a rate similar to that of the first year) than the other four populations tested.

For comparison, we present the valve lengths for the first 4 yr of three different horse mussel populations back-aged by Rowell (1967) in Table 8. Growth in the first year at Georges Bank is remarkable in comparison with the other two populations and the inner Bay of Fundy populations (Table 7). In subsequent years all populations except #03 in Table 8 show a decrease in absolute growth. By contrast, #03 population grows at the same rate and by L4 = 46.8 mm, versus L4 = 46.2 mm for the Georges Bank population.

We have also analyzed growth by method 1 for all the data presented in Appendices 1 and 2 by back-ageing of all growth lines, assuming that each line represents one year's growth. Using soft tissue dry weight as a function of age, we found that growth rates formed three major groups (Fig. 6). These groups corresponded to geological provinces as follows:

Group 1 - sand with bioherms
Group 2 - gravel/scallop bed
Group 3 - gravel/cobble, mottled gravel,
glacio-marine mud,

with Group 1 having fast, Group 2 intermediate and Group 3 having slow growth. These growth results corroborate the PCA graphs, and we suggest that growth rate differences may underlie the PCA results.

Valve length at age results shown in Table 7 and Fig. 5 also support the interpretation of Fig. 6 since #03 belongs to the sand with bioherm province and all other populations shown belong to gravel/cobble or mottled gravel geological provinces.

Condition and density

We calculated condition indices for populations where $N \geq 6$ (not shown) and present the mean for each population in Table 9. Also shown are the densities derived from the grab sampling data (Table 2, 3). We point out that because of the limitations of grab sampling, we know nothing of the way that animals are distributed in the area sampled (i.e. contagious/random/antagonistic distribution). Plotting condition indices (y) as a function of density (x), the straight line relationship is slightly inverse but with a low r^2 value (y = 10.63 - 0.008x, r^2 = 0.037, N=21). We conclude that horse mussel population density is not a major factor influencing individual horse mussel condition index.

We noticed in Table 9 that in one geological province, B, for which both 1997 and 1998 data are available, that the mean condition index is greater in 1997 than in 1998 ($\overline{X}_{1997}$ = 12.85, N=2; $\overline{X}_{1998}$ = 7.95, N=6). A "t" test shows that it is significantly different, t = 4.68, p<0.001. A possible cause of this difference is that the 1998 sampling was completed in May, 5-6 wk earlier in the season than in 1997. For this reason the 1998 horse mussels had less time to benefit from the spring phytoplankton bloom which does not start until May here (Hargrave et al. 1983).

Valve allometry

We analyzed valve allometry on the basis of geological provinces using data from both Appendices 1 and 2. The following were investigated:

- valve width on valve length;
- valve height on valve length;
- soft tissue dry weight on valve length; and
- total valve weight on valve length.

Allometric variants were sought in scatter diagrams of the type shown in Fig. 7 and 8. Further examination of the sand with bioherm data showed that the two distinctly different groups within this province belong to individuals from populations #03

and 08. We believe that some of the "aberrant" points distant from the trend lines may be due to growth anomalies as discussed by Rowell (1967) such as "stunting," "notching" and "denting."

Age distribution

The age distribution for each population was of interest because it might show whether or not differential mortality occurred at a particular location. We calculated the mean and standard deviation of age in years at each station as shown in Table 10. The results do not support the idea that there are great differences in mortality rates between a range of populations from every geological province where horse mussels were present.

Sex ratio

A test of the null hypothesis that the $♀\% = 50\%$ is shown in Table 11. The results show that in 8 out of 10 populations H_0 is accepted and thus the male:female ratio is equal. Of the two other populations, both have significantly fewer females than males.

DISCUSSION

HORSE MUSSELS IN GEOLOGICAL PROVINCES

The observational data presented here suggest that keystone species, such as the horse mussel, may be limited to specific surficial geological sediments. Even within particular surficial geological provinces, however, the mussels are not uniformly distributed on the seabed. Unfortunately, we have not been able to use techniques which locate individual mussels and their distance from each other. The bioherms which occur in megarippled sand in parts of the inner Bay cannot be sampled adequately by grab operated blindly from a vessel. We learned that the video grab, operated in the substantial tidal flows of the inner Bay and which move it rapidly over the seabed, can be used to position the grab to take a sample which includes live mussels. This technique requires that a live horse mussel reef can be recognized from video viewing in real time and that the closing mechanism for the grab can be operated from the vessel. With the video grab we saw that a mussel reef can be recognized by the presence of epibiota (*Flustra* sp., sponges, etc.) and absence of sand bed forms and shell gravel. Other methods which can recognize horse mussel reefs include video photography from an ROV (Wildish et al. 1998).

The side-scan sonograms which formed part of this work suggest that the horse mussel reefs formed long and narrow flow parallel features up to 30 m wide and some kilometers long. Because it is known (see Introduction) that both live and dead bivalves cause acoustic backscatter, the assumption that the reef contains live mussels may not necessarily be correct. The sonograms suggest that some of the mussel reefs appear degraded and broken, suggesting that the state of the reef can be remotely assessed. For other geological provinces, such as gravel/cobble and mottled gravel, the acoustic backscatter is from pebble, cobbles and boulders, as well as bivalves, so that whether the latter are distributed contagiously at the meso- and macro-scale cannot be determined by this technique. Comparing sand with bioherm and gravel/cobble sampling results (Table 2, 3) suggests that the latter has a more uniform distribution because mussels were obtained more frequently (and at higher densities) by grab sampling.

HORSE MUSSEL PHENOTYPES

Principal components analysis suggests that there are three distinct groups with respect to the biometry of the nine basic variables of horse mussels studied here (Appendices 1 and 2). We found that these differences are underlain by growth differences in each group which are also linked to geological provinces, such that:

- the fastest growing horse mussels occur in the sand with bioherm province only;
- intermediate growth rate horse mussels occur in the gravel/scallop bed province only; and
- slow growing horse mussels include all other populations sampled (gravel/cobble, mottled gravel and glacio-marine mud provinces).

Both methods of determining growth rate that we used depended on back-ageing using annular growth rings. That the growth lines represent 1 yr growth was established by Rowell (1967) in field growth experiments with tagged horse mussels from the St. Croix estuary. The problem with back-ageing of all growth lines is that in some mussels it is difficult or impossible to determine them, particularly after the first 4-5 yr of growth. Consequently, if independent and relatively inexperienced observers age the same batch of valves, the results are not reproducible. Because of these difficulties we selected valves where the first four growth lines were clearly readable and measured linear distances between them. These

growth results fall within similar data obtained by Rowell (1967) for three additional populations. The sand with bioherm population studied (1997, #03) is unique in that growth rate is maintained from L1 to L4 and these mussels exceed the growth of the fast growing Georges Bank population studied by Rowell (1967) by L4.

Despite these differences in growth rate of the inner Bay of Fundy horse mussel populations, the condition factor is similar in all of them, with one exception. Thus, we have interpreted the inter-annual difference in mean condition factor for the gravel/cobble populations as a seasonal effect. However, this effect is absent in the glacio-marine mud mussels also collected in May 1998 and which have high condition factors similar to other 1997 populations. Assuming similar food concentrations and because there is no inverse relationship between condition factor on density of mussels, we can discount the possibility that a seston depletion effect is causing differential growth among the populations.

We discovered two valve allometric differences among populations of horse mussels as follows: valve width on length and valve height on length: 1997 #03 and 08 are different than all other populations. The aberrant mussels are fatter and shorter with respect to valve length than all other populations. We do not know whether environmental influences or internal genetic factors control these phenotypic differences.

An examination of the population age structure of those horse mussels with a sufficiently large sample number showed that they did not differ markedly in age structure. Consequently, it follows that the mortality rates of each population did not differ markedly (assuming genetic homogeneity among populations). There was also little evidence of biased sex ratios within populations and most had a male:female equal ratio.

FUTURE WORK

The purpose here is to outline some speculative thoughts (=hypotheses) with respect to the question: "Why are horse mussel populations distributed as they are in the inner Bay of Fundy?"

Some possible limiting factors which influence the development of horse mussel popualtions are:

a) the presence of a solid, non-moving substrate, e.g. cobble or mussel byssus, for larval attachment;

b) the presence near the mussel of a suitable flux of sestonic food not too "diluted" with saltating sand which reduces its food value (Muschenheim 1987; Cranford and Hargrave 1994; Cranford 1995);

c) the absence of excessive hydrodynamic forces which cause inhibition of initial feeding (Wildish and Miyares 1990);

d) different roughness elements on the seabed which cause changes in benthic boundary layer flows: skimming versus non-skimming flow (see Green et al. 1998) which in turn affects seston flux; and

e) the presence of predators.

These limiting factors would operate at larval, settlement, as well as post-settlement stages of the horse mussel life history.

The surficial geological view of how bioherms form (G.B.J. Fader, pers. commun.) is that sand in active transport encroaches in long fingers as sand ribbons across a lag gravel. This may remove mussels in its path by mechanisms linked to b), c) and d) listed above. Saltating sand or "sand blasting" inhibits settlement and recruitment is curtailed. Post-settlement mussels only survive on islands between megarippled sand if they can stay above the saltating sand and avoid the sand dilution effect. Formation of horse mussel reefs (=bioherms) results from optimal hydrodynamic/surficial sediment conditions and the binding effect of horse mussel byssus threads.

How then does the horse mussel population data presented here conform to hypotheses mentioned above?

Horse mussels which live on gravel/cobble or mottled gravel are often present at higher densities because of the ready availability of substrates. The growth rate of these mussels is slow, yet our results suggest that it cannot be caused by seston depletion, linked to density, or is it likely to be due to a sand dilution of ration effect because sand is absent. The slow growth of lag gravel horse mussel populations is hypothesized to be due either to direct flow inhibition as reported in blue mussels (Wildish and Miyares 1990) or to the high roughness coefficient of this substrate which causes a skimming flow inimical to vertical mixing of seston into this type of benthic boundary layer. By being raised

above surrounding megarippled sand, horse mussel reefs grow rapidly because they escape sand dilution and experience very favorable hydrodynamic/ substrate interactions which result in enhanced fluxes of sestonic food and hence growth. The lower densities present on reefs may result from the limited solid surfaces available on them for settlement.

ACKNOWLEDGMENTS

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Table 1. Summary of geological provinces interpreted from side-scan sonograms by G.B.J. Fader and corresponding horse mussel samples, 1997-98.

Geological province	Number of quantitative samples			Numbers of mussels		
	1997	1998	Total	1997	1998	Total
A Sand with bioherms	5	5	10	91	0	91
B Gravel/cobble	4	15	19	81	229	310
B1 Gravel/scallop bed	5	-	5	69	-	69
C Mottled gravel	3	-	3	184	-	184
D Rippled sand	2	-	2	0	-	0
E Sand with comet marks	1	5	6	0	0	0
F Sand ribbons	-	3	3	-	1	1
G Mottled sand	-	4	4	-	0	0
H Continuous sand	-	-	-	-	-	-
I Gravel with comet	-	3	3	-	2	2
marks	-	7	7	-	0	0
J Gravel ripples	-	5	5	-	16	16
K Glacio-marine mud	-	2	2	-	0	0
L Mixed sand/gravel	-	-	-	-	-	-
M Starved megaripples	-	-	-	-	-	-
Totals	20	49	69	425	248	673

Table 2. Summary of quantitative 0.5-m^2 grab samples taken in each geological province during CGSS HUDSON mission of 18-19 June, 1997.

Grab #	Geological province	Coordinates		Depth (m)	Grab fullness index	N	Density number•m^{-2}
		N	W				
01	Sand with bioherms	45°06"07.49'	65°15"57.04'	84	1	2	4
03	"	45 05 62	65 17 06	88	1	39	78
06	"	45 05 62	65 17 07	83	1	32	64
08	"	45 06 13.02	65 15 50.23	84	1	9	18
09	"	45 06 20.30	65 15 43.71	87	1	9	18
12	Gravel/scallop bed	45 01 01.92	65 31 01.09	81	1-2	1	2
13	"	45 00 85.48	65 30 66.41	86	1-2	2	4
14	"	45 00 80.66	65 30 62.51	86	1-2	25	50
15	"	45 00 74.86	65 30 67.85	81	1-2	15	30
16	"	45 00 72.44	65 30 74.53	79	1-2	26	52
17	Rippled sand	45 00 67.95	65 31 05.20	77	1-2	0	0
18	Mottled gravel	44 54 66.59	65 36 87.69	79	1-2	55	110
20	"	44 56 13.05	65 33 76.22	84	1-2	80	160
21	"	44 56 05.73	65 33 89.59	74	1-2	49	98
22	Gravel/cobble	44 54 29.12	65 38 48.92	68	1-2	47	94
23	"	44 54 36.57	65 38 44.25	70	1-2	34	68
24	"	44 57 29.71	65 30 59.20	72	2	0	0
26	Sand with comet marks	45 09 69.51	65 31 48.71	75	1-2	0	0
29	Gravel/cobble	45 02 87.64	65 32 64.11	85	1	0	0
31	Rippled sand	44 59 53.18	65 30 29.79	80	1-2	0	0

Table 3. Summary of quantitative 0.5-m^2 grab samples taken in each geological province on J.L. HART 98-011 of May 1998.

Grab #	Geological province	Coordinates		Depth (m)	Grab fullness index	N	Density number•m^{-2}
		N	W				
11	Gravel/cobble	45°06"20'	65°47"64'	74	1	0	0
12	"	45 08 21	65 47 64	75	1	0	0
13	"	45 08 22	65 47 62	76	1	0	0
14	"	45 08 47	65 38 12	60	1	0	0
15	"	45 08 54	65 38 00	62	1	0	0
16	Gravel ripples	45 08 57	65 37 93	66	1	0	0
17	"	45 08 60	65 37 87	66	1	0	0
18	"	?	?	?	1	0	0
19	"	?	?	?	1	0	0
20	"	?	?	?	1	0	0
22	Gravel/cobble	44 57 24	65 44 85	80	1	34	68
23	"	44 57 27	65 44 87	79	1	43	86
24	"	44 57 32	65 44 68	80	1	60	120
25	"	44 57 36	65 44 66	80	1	11	22
26	"	44 57 41	65 44 63	80	1	65	130
27	Mottled sand	45 58 93	65 39 60	85	1	0	0
29	"	44 58 92	65 39 39	85	1	0	0
30	"	44 58 64	65 39 62	86	1	0	0
31	"	44 58 85	65 39 27	86	1	0	0
32	Gravel/cobble	45 02 68	65 31 96	72	1	0	0
37	Sand with bioherm	45 01 04	95 30 55	78	2	0	0
38	"	45 00 93	65 30 77	75	1	0	0
39	"	45 01 02	65 30 57	80	2	0	0
40	"	45 00 94	65 30 79	77	2	0	0
42	"	45 01 24	65 30 63	80	2	0	0
44	Sand ribbons	44 58 88	65 28 99	75	1	1	2
46	"	44 58 86	65 28 95	75	1	0	0
47	"	44 58 84	65 28 95	75	2	0	0
48	Gravel with comet marks	45 07 04	65 36 27	64	1	0	0
49	"	45 07 15	65 36 96	63	1	2	4
52	"	45 07 18	65 36 00	65	1	0	0
54	Gravel ripples	45 08 70	65 36 94	65	1	0	0
56	"	45 08 57	65 37 17	64	1	0	0
58	Sand with comet marks	45 11 38	65 32 59	71	1	0	0
59	"	45 11 41	65 32 32	70	1	0	0
60	"	45 11 29	65 32 68	72	1	0	0
61	"	45 11 31	65 32 45	71	1	0	0
62	"	45 11 31	65 32 18	71	1	0	0
63	Mixed sand/gravel	45 15 69	65 38 89	48	1	0	0
67	"	45 15 65	65 38 15	48	1	0	0
68	Gravel/cobble	45 08 84	65 46 74	77	2	0	0
70	"	45 08 24	65 47 49	79	1	6	12
71	"	45 08 18	65 47 65	79	2	0	0
72	"	45 08 12	65 48 60	79	1	0	0
73	Glacio-marine mud	45 03 61	66 00 29	88	1	1	2
74	"	45 03 52	66 00 50	90	2	0	0
76	"	45 03 48	66 00 57	85	2	3	6
77	"	45 02 92	66 00 86	91	2	6	12
78	"	45 02 77	66 01 25	88	2	6	12

Table 4. Estimates of age to the nearest year based on right valves (observer 1) and left valves (observer 2) and back ageing from valve growth lines from 1997 collections (see Appendix 1).

Mussel ID #	Valve length (cm)	Observer 1	Observer 2	Mussel ID #	Valve length (cm)	Observer 1	Observer 2
03L011H	9.4	$\geq$15	13	16L022H	6.0	5	5
03L023H	10.5	$\geq$11	14	16L018H	3.2	1	3
03L033H	10.0	$\geq$12	12	16L025H	4.4	2	4
03L015H	12.4	11	10	16L021H	7.1	9	8
03L029H	10.6	13	12	16L015H	7.2	9	9
03L035H	11.4	10	-	16L013H	7.8	6	7
03L037H	9.1	-	11	16L004H	8.4	9	9
03L001H	9.2	10	9	16L005H	9.7	(9-)12	12
03L032H	6.7	8	7	16L010H	8.6	8	11
03L034H	7.9	9	7	16L012H	8.4	12	12
03L022H	8.4	9	8				

- indicates valve absent or broken.

Table 5. "t" tests for differences between means of 1998 ages (y^{-1}) of horse mussels determined by independent groups of observers.

Grab #	Observers X_1	X_2	Difference	df	t	Significance at p>0.05
018	8.85	11.15	2.30	64	4.11	**
022	12.50	11.90	0.60	58	1.39	N.D.
022	12.00	13.72	1.72	36	2.65	**
022	11.80	14.00	2.20	28	3.86	**

Table 6. Principal components (PC) analysis of all complete data entries in Appendices 1 and 2.

Component	Eigen value	Cumulative percentage
PC1	6.3085	78.86
PC2	0.9916	91.25
PC3	0.3151	95.19
PC4	0.1909	97.57
PC5	0.1554	99.52
PC6	0.0283	99.87
PC7	0.0066	99.95
PC8	0.0037	100.00

Table 7. Mean valve length (mm, ±1 standard deviation) between growth lines in early ontogeny of populations of horse mussels in the inner Bay of Fundy.

Growth lines	Population sample number and years				
	03-1997 (n=16)	20-1997 (n=10)	23-1997 (n-15)	22-1998 (n=10)	26-1998 (n=12)
L-1	11.4±1.7	14.6±1.8	7.7±2.8	12.6±1.6	12.9±1.9
L-2	10.8±2.3	5.0±1.9	6.0±1.2	6.2±2.0	4.9±1.2
L-3	11.3±2.0	4.7±1.1	6.1±1.5	5.7±2.2	4.8±1.1
L-4	12.2±1.7	4.4±1.9	5.6±1.2	5.3±0.9	4.3±0.8

Table 8. Mean valve lengths (mm) at age for three populations determined by Rowell (1967).

Age	Georges Bank (n=6)	Letang (n=50)	Sandy Point (n=20)
L-1	19.8	13.4	9.9
L-2	9.3	8.6	4.9
L-3	9.3	9.8	6.9
L-4	7.8	9.8	7.4

Table 9. Population densities of 1997 and 1998 grab samples expressed as per m^{-2} and mean condition indices estimated as described on p. 3.

Year/grab #	Density ($\#/m^{-2}$)	Mean condition index ± standard deviation	Geological province
97-03	78	10.82±2.174	A
97-06	64	10.94±2.605	A
97-08	18	9.22±0.662	A
97-09	18	9.84±1.038	A
97-14	50	10.31±2.175	B1
97-15	30	9.97±1.853	B1
97-16	52	11.46±3.540	B1
97-18	110	9.70±2.505	C
97-20	160	10.83±2.494	C
97-21	98	10.77±2.218	C
97-22	94	13.05±2.858	B
98-22	68	8.40±2.034	B
97-23	68	12.66±2.261	B
98-23	86	7.51±1.542	B
98-24	120	7.09±2.154	B
98-25	22	6.86±1.481	B
98-26	130	7.48±1.571	B
98-70	14	9.13±2.271	B
98-76	6	10.88±4.051	K
98-77	12	12.70±6.450	K
98-78	12	*12.10± -	K

*n=1, due to missing data.

Table 10. Mean age, in years, $\overline{X}$, for each population in Appendices 1 and 2 with N>15. SD = standard deviation. N = sample number.

Year/grab #	Geological province	N	$\overline{X}$	SD	Max, y^{-1}
97-03	A	39	10.3	2.256	14
97-06	A	32	8.6	1.514	12
97-14	B1	23	8.7	3.040	17
97-16	B1	25	8.4	3.700	18
97-18	C	53	9.9	1.176	12
97-20	C	80	9.2	2.113	13
97-21	C	49	11.4	2.426	17
97-22	B	47	9.2	2.321	13
97-23	B	34	10.8	2.320	15
98-22	B	34	12.4	2.000	18
98-23	B	43	12.2	1.862	15
98-24	B	58	9.0	2.305	15
98-25	B	11	11.8	2.819	16
98-26	B	65	10.9	3.057	18
98-76+77+78	K	15	9.8	0.982	12

Table 11. Observed percentage of adult females (♀%) in populations of horse mussels and binomial test of $H_0 = 50$♀% at p=0.05.

Population	N	♀%	Z	H_0
1997: #18	49	34.69	2.19	Reject
20	71	47.89	0.04	Accept
21	45	57.78	0.07	"
22	39	41.02	1.12	"
23	32	46.88	0.35	"
1998: #22	34	41.20	0.98	"
23	42	42.90	0.89	"
24	56	41.90	1.16	"
26	62	50.00	0.00	"
76+77+78	14	14.30	17.85	Reject

Side View
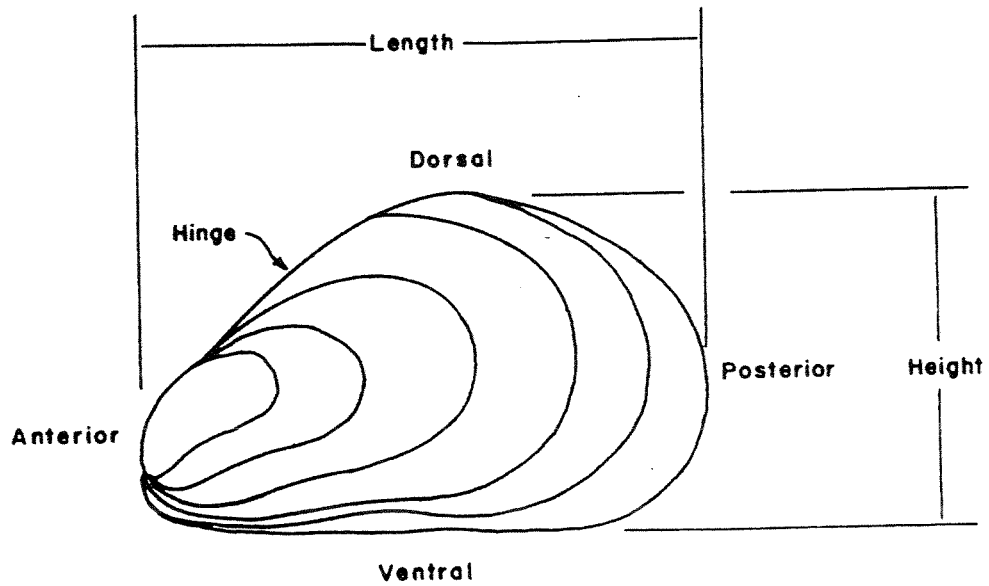
Posterior View
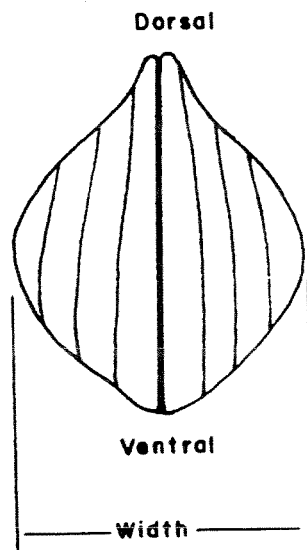
Fig. 1. Measurement criteria in horse mussel valves based on a drawing by Rowell (1967).
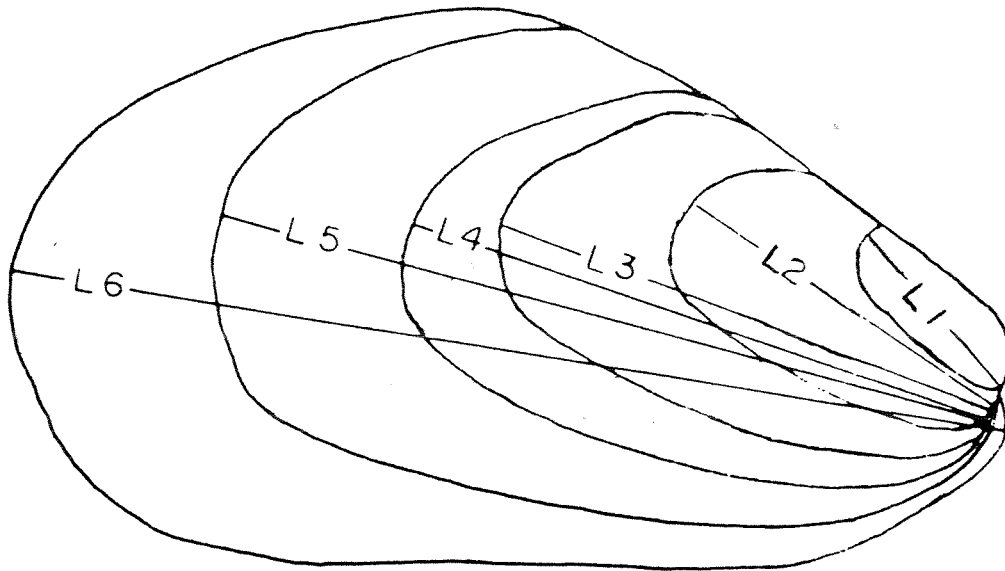
Fig. 2. Growth rings in horse mussel left valve based on a drawing by Rowell (1967).
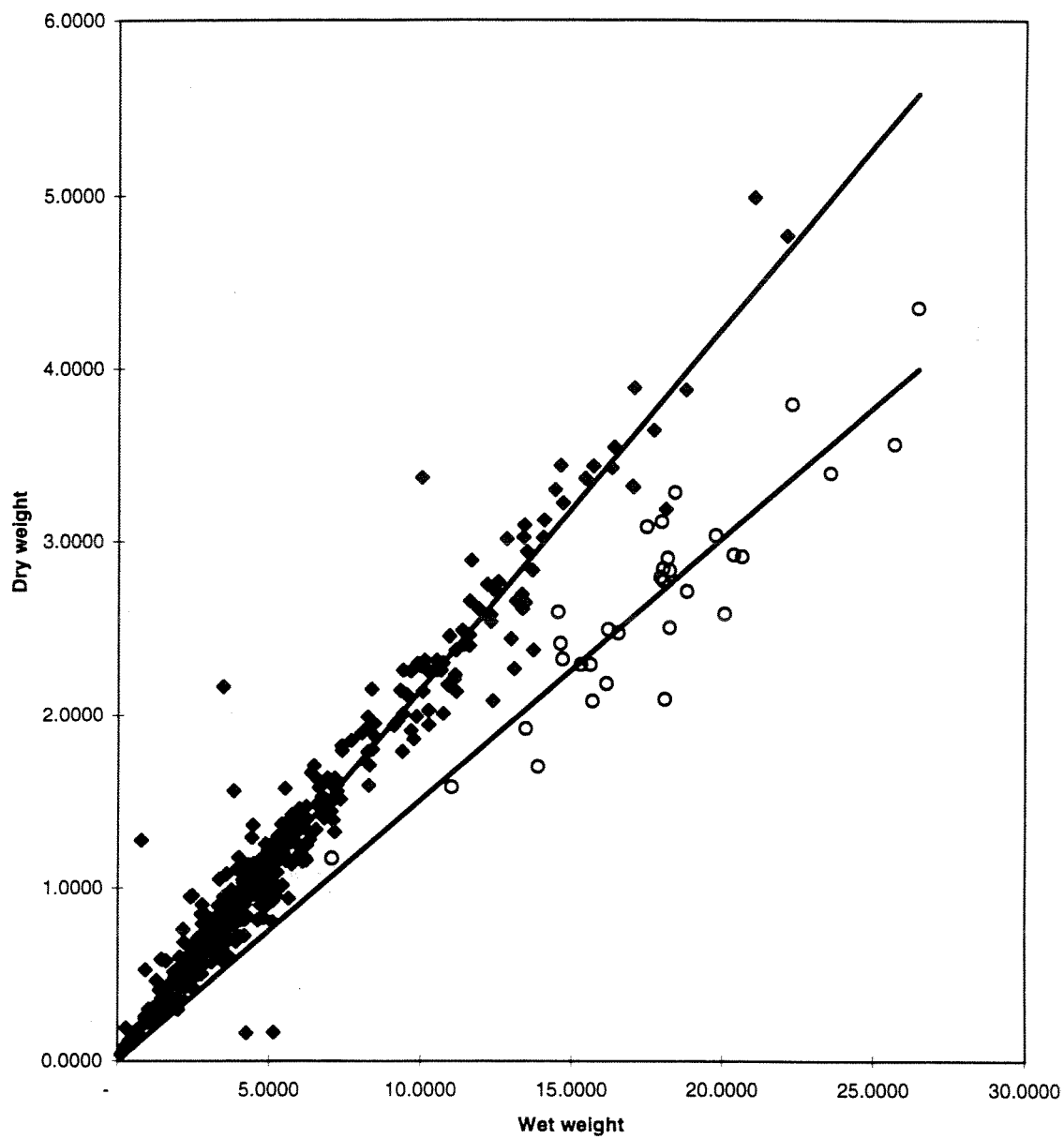
Fig. 3. Scatter diagram and fitted regressions for wet on dry weight of all data (♦) and #06 data (o) for 1997.
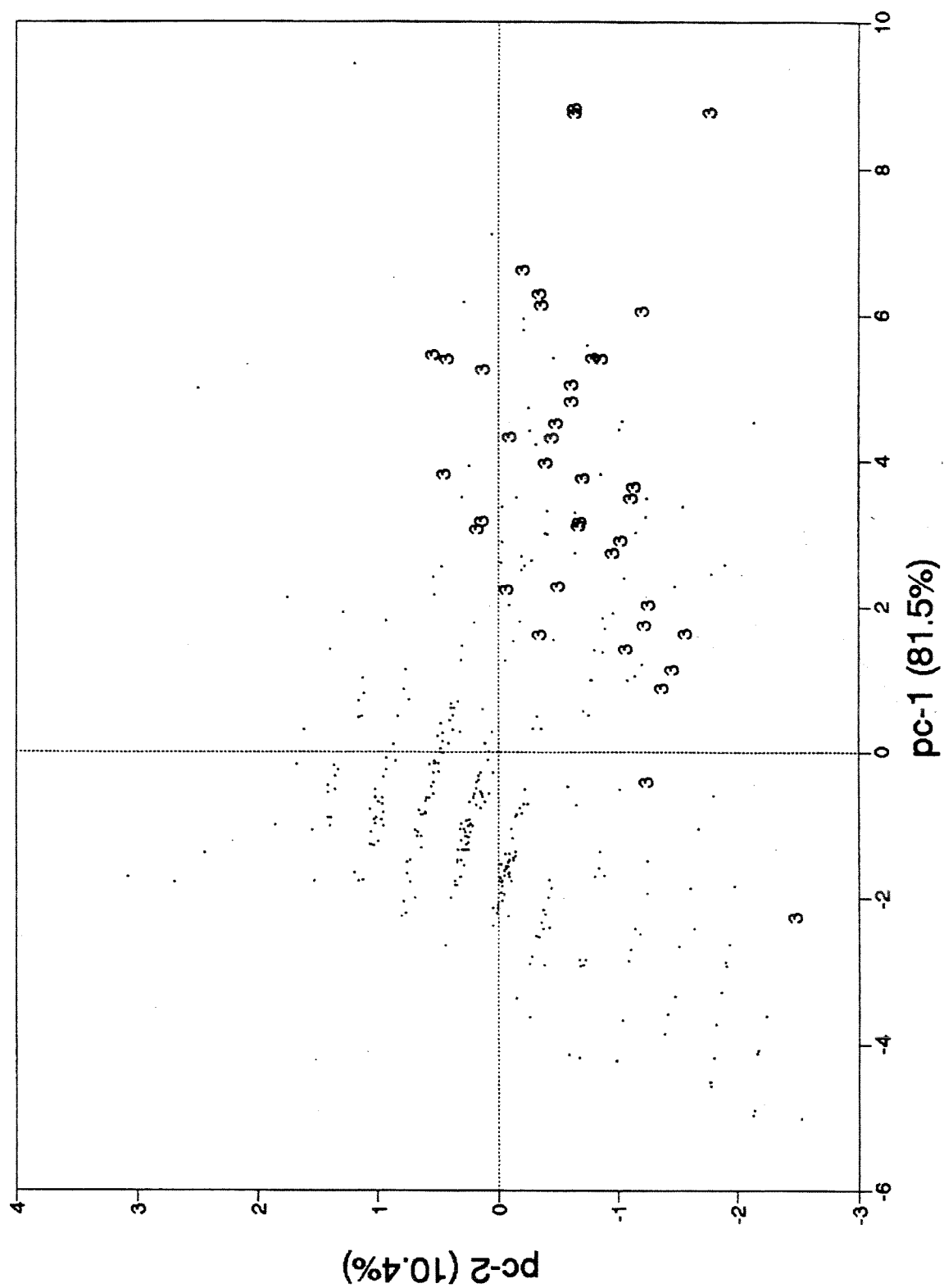
Fig. 4. Horse mussel biometric variables as recorded in Appendix 1: 1997 data only. Scores for the first two principal components are shown. Numbers are from #03, small dots - rest of data.
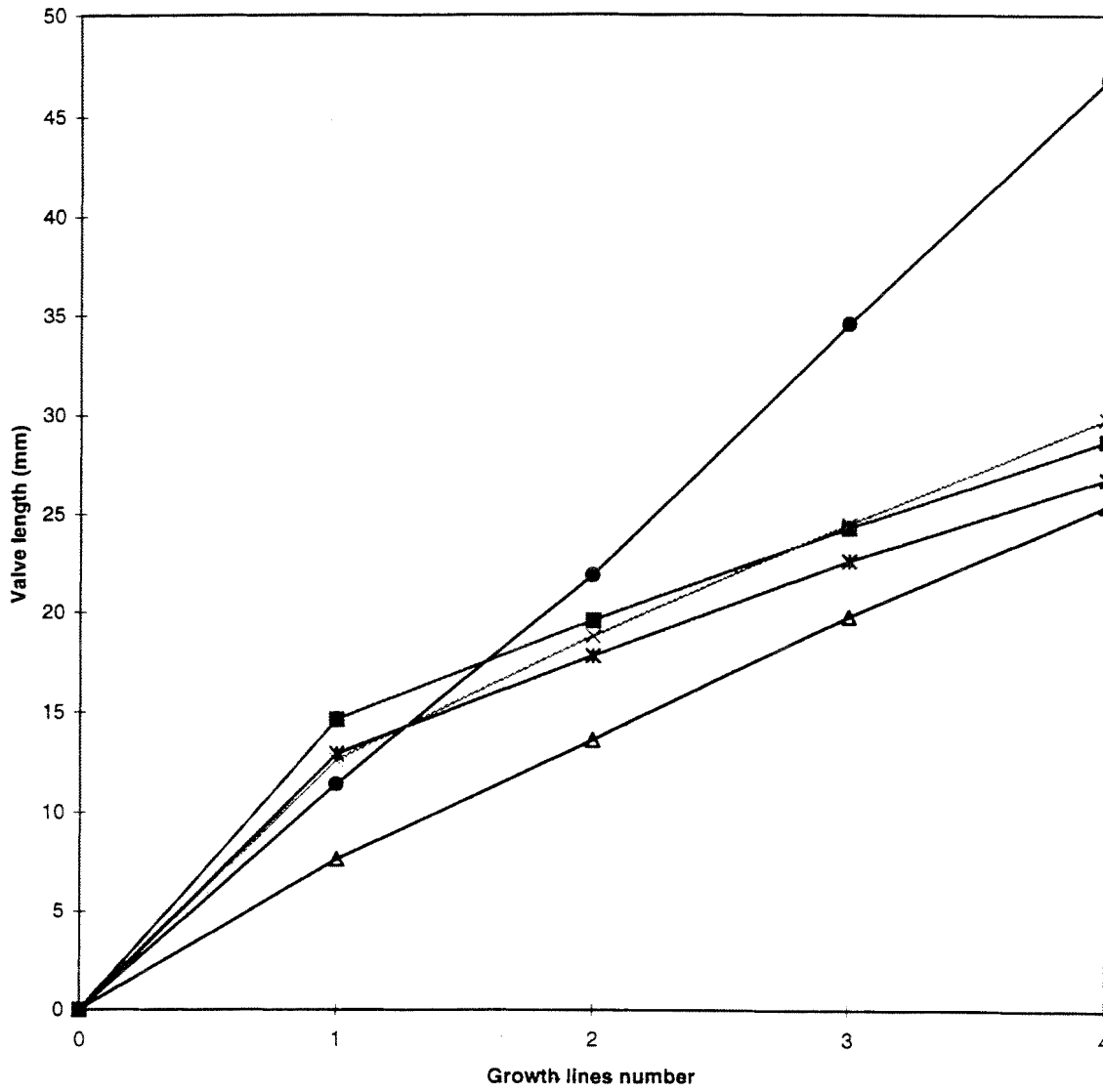
Fig. 5. Mean valve length of horse mussels plotted as a function of growth line number (=age in y⁻¹) for five populations. 1997 #03 ●, 1997 #020 ■, 1997 #023 Δ, 1998 #022 X, 1998 #026 *.
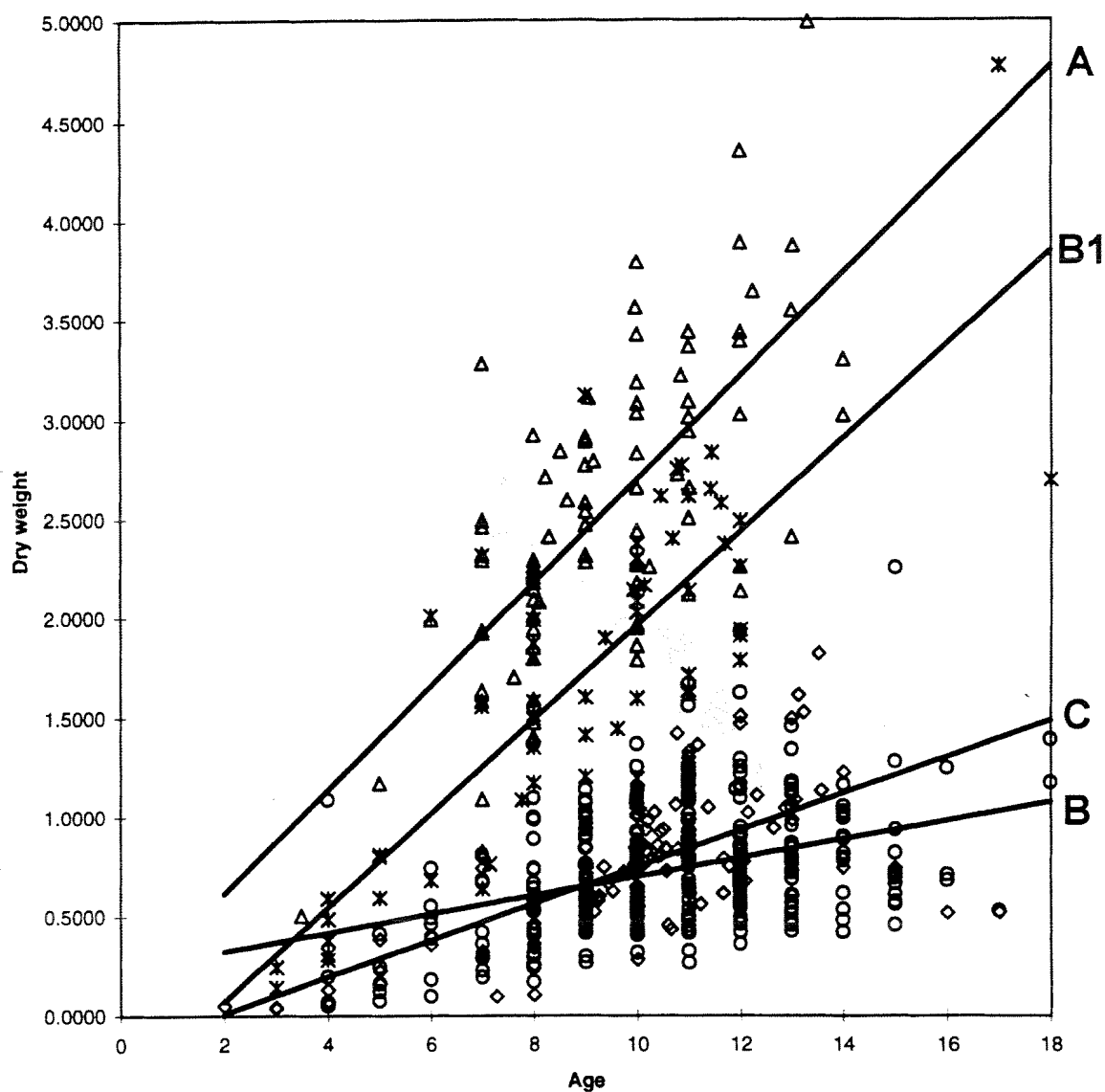
Fig. 6. Fitted regressions of dry weight in g on age in y^{-1}. Based on all available data in appendices 1 and 2 and grouped as geological province: A - sand with bioherm, B1 - gravel/scallop bed, B - gravel/cobble, C - mottled gravel. Symbols as in Fig. 7 and 8. Regression equations: A, $y=0.2604x + 0.0908$, N=86, $r^2=0.48$; B1, $y=0.0238x + 0.4011$, N=61, $r^2=0.69$; C, $y=0.0923x - 0.1748$, N=180, $r^2 0.42$; B, $y=0.0472x + 0.2276$, N=245, $r^2=0.15$.
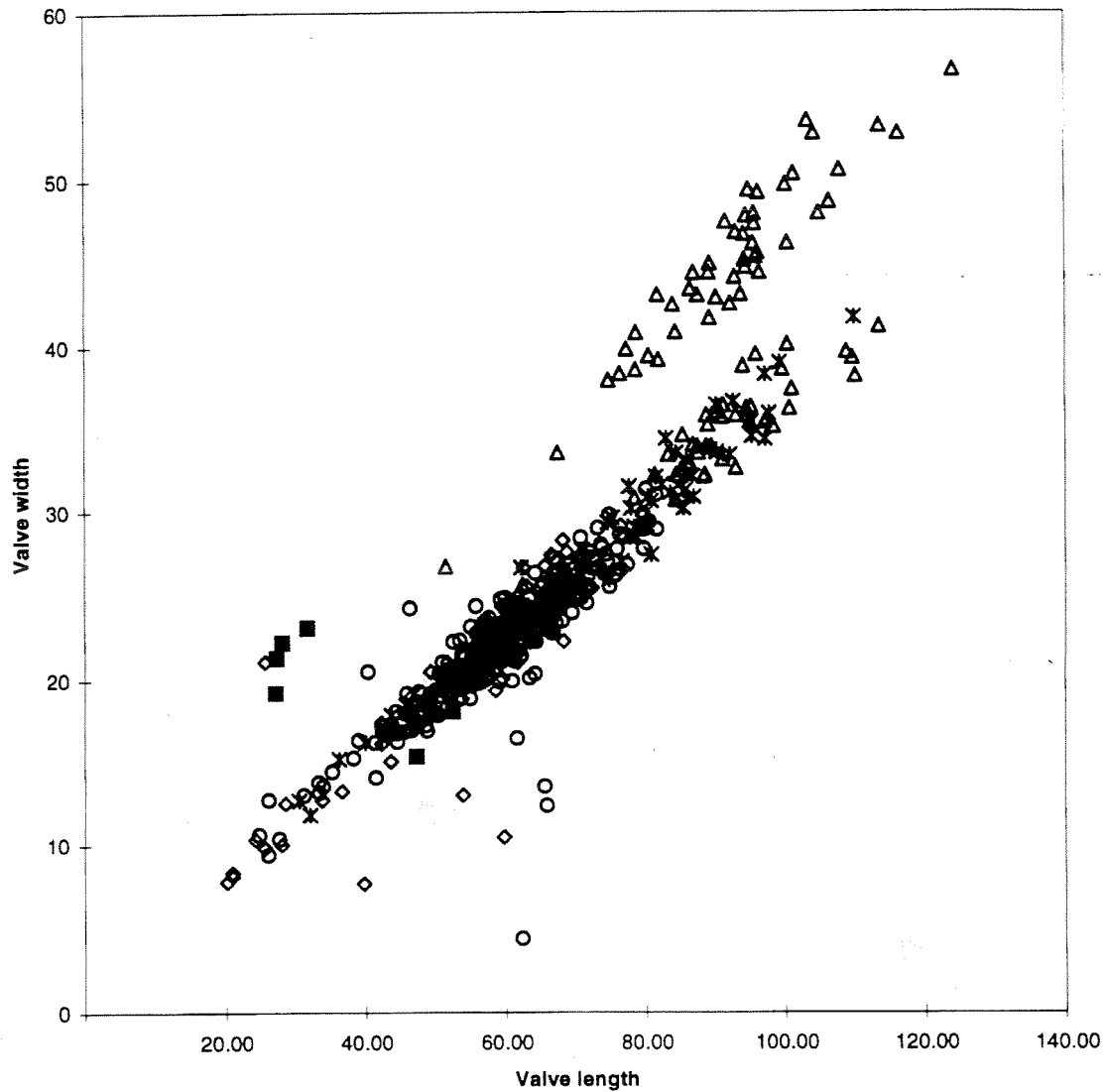
Fig. 7. Scatter diagram of horse mussel valve width (mm) on valve length (mm) grouped by geological province. Based on data in appendices 1 and 2. Δ - sand with bioherms, * - gravel/scallop bed, ◊- mottled gravel, O - gravel/cobble, ■ - glacio-marine mud.
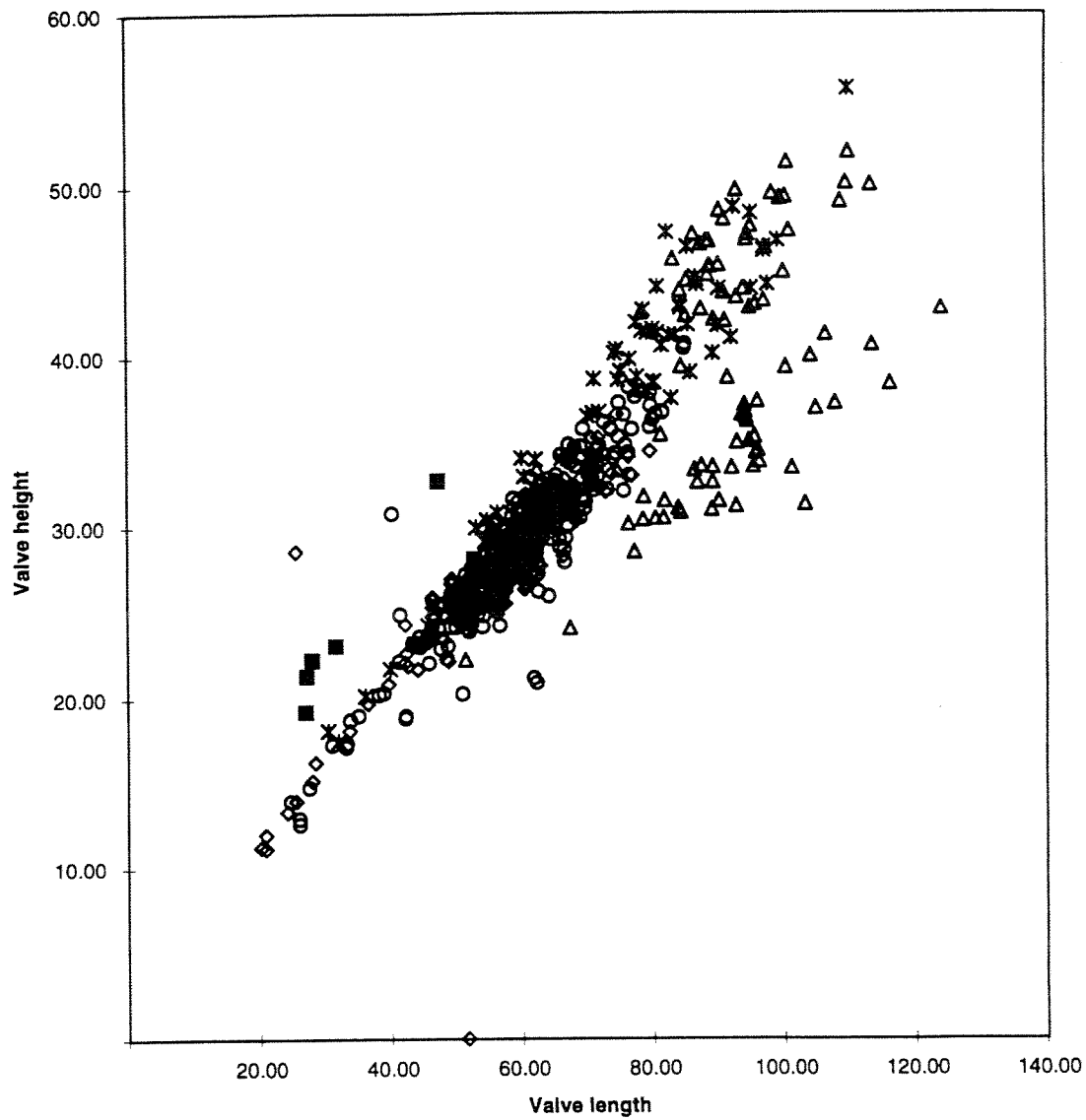
Fig. 8. Scatter diagram of horse mussel valve height (mm) on valve length (mm) grouped by geological province. The geological province symbols are as in Fig. 7 and original data shown in appendices 1 and 2.

Appendix 1. Sex, weight, valve dimensions and estimated age (by method 1) of horse mussels sampled in 1997.

Identification	Sex	Meat weight		Valve dimensions (mm)			Age Yr-1	Valve dry wt (g)	
		Wet (g)	Dry (g)	Length	Height	Width		Left	Right
03L001		11.653	2.889	92.10	33.46	42.55	9	9.95	12.82
2		12.832	3.011	94.40	36.21	47.83	11	9.97	10.20
3		13.149	2.654	96.08	37.38	45.65	11	17.62	17.26
4		9.526	2.116	81.87	31.52	39.18	11	8.72	8.76
5		15.439	3.362	103.32	31.33	53.54	11	15.18	15.52
6		10.214	2.257	90.14	31.53	42.92	10	11.71	11.86
7		13.389	3.021	95.58	35.28	47.97	12	11.25	12.03
8		9.996	2.282	89.19	32.64	41.69	9	10.16	10.00
9		14.043	3.018	101.32	33.45	50.34	14	16.30	15.93
10		14.689	3.219	94.80	35.05	49.38	11	17.10	17.36
11		16.393	3.544	94.08	37.17	46.73	13	13.66	13.70
12		11.414	2.406	95.83	34.38	45.39	13	11.64	11.59
13		21.062	4.989	116.27	38.40	52.78	13	24.16	23.98
14		11.163	2.133	87.46	33.58	43.08	12	10.26	10.08
15		18.105	3.183	124.14	42.80	56.55	10	28.97	29.06
16		17.058	3.887	108.85	49.12	39.67	12	17.60	17.51
17		12.307	2.536	96.34	33.85	44.45	9	11.68	11.80
18		13.413	3.090	95.62	35.31	47.38	11	14.90	15.11
19		10.671	2.257	89.22	33.52	44.97	12	10.28	10.08
20		7.400	1.793	74.68	33.29	37.94	8	7.82	7.74
21		7.706	1.850	81.71	30.52	43.10	8	8.11	8.23
22		4.813	0.825	84.32	30.82	40.85	7	7.59	7.90
23		14.433	3.296	104.92	36.97	47.99	14	14.87	14.12
24		16.320	3.423	100.41	39.35	46.20	10	18.97	19.02
25		11.608	2.654	94.20	36.78	45.19	10	11.46	11.29
26		10.521	2.314	86.42	33.34	43.46	9	10.57	10.45
27		8.370	2.147	83.94	31.09	42.51	8	8.19	8.52
28		12.394	2.722	94.31	36.43	44.75	11	13.90	13.93
29		17.709	3.642	106.45	41.29	48.69	12	15.27	15.29
30		8.277	1.934	78.67	31.77	40.82	7	7.91	7.77
31		10.540	2.277	92.78	31.21	44.15	10	11.33	11.47
32		5.256	1.089	67.38	24.11	33.53	7	4.74	4.77
33		15.707	3.434	100.14	44.97	49.69	12	17.37	17.45
34		6.926	1.632	78.58	30.43	38.56	7	7.27	7.28
35		18.787	3.874	113.57	40.66	53.23	13	28.48	28.39
36		8.459	1.948	80.48	30.47	39.42	10	6.63	6.90
37		14.617	3.437	91.49	38.77	47.47	11	10.46	11.41
38		2.225	0.501	51.42	22.22	26.71	3	2.75	2.73
39		9.763	1.858	89.07	31.02	44.42	10	7.97	7.89

Appendix 1 (cont'd)

Identification	Sex	Meat weight		Valve dimensions (mm)			Age Yr-1	Valve dry wt (g)		Cor. wt.* dry (mg)
		Wet (g)	Dry (g)	Length	Height	Width		Left	Right	
06L001		18.18	2.90	94.4	46.9	36.2	9	14	14	3.850
2		18.25	2.50	95.8	43.1	39.5	11	17	18	3.865
3		17.98	3.11	93.9	44.0	38.8	9	23	23	3.809
4		13.89	1.70	84.4	39.4	32.2	8	12	12	2.957
5		14.69	2.32	83.2	45.7	33.4	7	10	10	3.123
6		26.50	4.35	110.1	52.0	38.2	12	17	18	5.583
7		18.04	2.77	94.9	42.9	35.4	9	15	15	3.821
8		16.54	2.47	92.9	43.5	35.8	9	15	15	3.509
9		18.25	2.83	98.4	49.6	35.1	10	16	16	3.865
10		15.31	2.29	91.0	48.1	33.1	8	10	10	3.252
11		15.62	2.29	86.8	44.5	34.0	7	9	9	3.317
12		20.65	2.91	95.1	47.7	36.3	9	12	12	4.365
13		13.49	1.92	81.3	35.4	32.2	7	10	10	2.873
14		17.94	2.79	94.6	47.2	35.8	9	11	11	3.800
15		14.62	2.41	88.7	45.3	33.9	8	13	14	3.109
16		18.42	3.28	87.4	46.6	33.9	7	9	9	3.900
17		19.78	3.03	97.4	46.4	35.6	10	15	15	4.183
18		20.08	2.58	97.1	43.3	35.4	9	12	12	4.246
19		25.71	3.56	100.4	49.4	40.1	10	18	18	5.419
20		23.58	3.39	99.6	49.3	38.6	12	15	14	4.975
21		18.83	2.71	88.3	46.8	32.1	8	9	9	3.986
22		20.37	2.92	92.9	49.8	32.6	8	11	11	4.306
23		18.09	2.09	90.3	48.6	36.3	8	12	12	3.831
24		16.16	2.18	89.4	42.2	33.9	8	10	10	3.429
25		14.54	2.59	91.1	42.1	36.4	9	13	14	3.092
26		11.03	1.58	78.4	42.6	30.8	7	9	9	2.361
27		18.03	2.84	90.2	45.4	36.0	9	12	11	3.819
28		17.48	3.08	100.7	51.4	36.2	10	14	14	3.704
29		15.69	2.08	87.5	42.8	33.5	8	12	12	3.332
30		22.31	3.79	101.0	47.4	37.4	10	16	16	4.710
31		7.08	1.17	62.4	33.4	25.6	5	4	4	1.538
32		16.21	2.49	86.3	47.2	32.9	7	8	8	3.440

*Corrected - originally done by Dr. Chou in Halifax using a different drying method. To simulate our method we interpolated from wet weights and equation (1).

Appendix 1 (cont'd)

Identification	Sex	Meat weight		Valve dimensions (mm)			Age Yr-1	Valve dry wt (g)	
		Wet (g)	Dry (g)	Length	Height	Width		Left	Right
08L001		10.886	2.174	93.63	36.59	43.13	10	10.80	10.87
2		9.236	1.964	86.86	32.59	44.41	10	10.60	10.78
3		13.501	2.938	104.2	40.02	52.78	11	16.14	16.37
4		6.608	1.473	77.25	28.55	39.82	8	7.48	7.48
5		10.503	2.259	92.91	34.95	46.84	8	11.88	11.83
6		12.983	2.436	96.18	34.53	49.23	10	14.90	14.77
7		11.593	2.459	107.89	37.25	50.56	7	14.82	14.93
8		6.815	1.401	76.32	30.16	38.34	8	7.21	7.04
9		13.091	2.265	95.44	33.53	46.18	10	12.50	12.46
09L001	M	11.117	2.229	88.7	46.8	35.8	8	12.07	11.99
2	F	17.026	3.310	109.7	50.2	39.3	[13]	15.66	15.58
3	F	11.091	2.205	90.9	43.8	35.7	8	11.08	11.27
4	F	10.264	1.942	88.9	45.3	35.2	8	10.97	11.06
5	M	10.735	2.008	85.1	42.4	32.5	8	8.52	8.66
6	F	9.394	1.786	88.5	44.8	32.2	10	8.61	8.77
7	F	16.997	3.317	113.5	50.1	41.2	[13]	20.43	20.43
8	F	8.284	1.588	84.3	43.9	30.7	8	7.83	7.83
9	F	9.854	1.990	85.3	44.5	34.6	6	10.16	10.20
14L001	M	6.216	1.169	70.93	36.66	27.67	8	6.50	6.52
2	M	8.043	1.894	77.69	38.78		9	6.73	broken
3	F	7.232	1.593	75.19	39.10	29.59	10	6.82	6.60
4	F	7.052	1.599	79.24	41.37	28.92	9	8.04	7.99
5	M	6.152	1.348	76.57	39.81	26.98	8	7.57	7.52
6	M	8.243	1.989	80.12	41.58	29.08	8	7.61	7.53
7	F	10.929	2.452		40.57	32.01		broken	broken
8	F	10.725	2.299	86.87	44.23	30.84	10	7.54	7.62
9	M	9.672	1.907	92.04	41.07	33.36	12	14.02	13.70
10	I	5.085	1.097	74.81	38.61	25.90	10	6.33	6.22
11	I	2.814	0.680	56.34	30.83	21.81	6	3.28	3.33
12	F	7.347	1.511	78.68	42.72	28.44	8	7.38	7.41
13	I	0.980	0.244	36.13	20.12	15.19	3	1.11	1.11
14	M	22.130	4.770	109.93	55.65	41.73	17	24.67	25.13
15	M	2.686	0.589	54.71	30.40	20.83	4	2.93	2.94
16	F	6.642	1.491	74.55	40.38	29.29	8	6.31	6.38
17	F	13.451	2.646	95.15	48.43	35.39	11	14.64	14.77
18	M	13.353	2.610	99.25	46.82	38.97	11	18.34	18.08
19	M	5.743	1.421						
20	F	9.883	2.294	85.42	46.41	30.14	10	8.62	8.72
21	M	9.411	2.256	81.46	40.60	32.04	12	8.98	8.96
22	I	4.327	1.083	66.15	33.99		8	broken	4.23
23	I	2.685	0.638	53.04	29.97	20.40	7	2.72	2.76
24	I	3.391	0.763	62.15	33.94	26.62	7	5.49	5.56
25	I	1.323	0.308	45.72	24.25	18.43	4	1.65	1.63

Appendix 1 (cont'd)

Identification	Sex	Meat weight		Valve dimensions (mm)			Age Yr-1	Valve dry wt (g)	
		Wet (g)	Dry (g)	Length	Height	Width		Left	Right
15L001	F	10.02	3.368						
2	M	8.398	1.798	74.29	40.14	26.37	8	7.76	7.85
3	F	8.504	1.869	80.79	41.39	30.59	8	8.57	8.59
4	F	7.165	1.632	77.49	37.99	28.49	11	7.64	7.77
5	F	8.243	1.782	80.35	38.47	30.86	12	9.60	9.53
6	M	12.312	2.575	97.10	46.41	38.27	12	20.07	24.53
7	F	7.242	1.555	78.40	41.47	29.02	7	6.82	6.94
8	F	7.142	1.616	77.87	38.00	30.15	11	9.33	9.48
9	F	7.046	1.441	79.49	37.93	29.00	10	8.93	8.92
10	F	14.071	3.121	92.54	48.79	36.63	9	12.95	12.61
11	F	5.447	1.202	70.10	36.49	25.94	9	5.70	5.76
12	M	12.182	2.750	89.23	40.14	33.66	11	11.49	10.98
13	F	12.555	2.766	90.07	41.79	36.42	11	14.16	14.12
14	F	10.25	2.026	86.68	44.65	32.09	10	12.86	12.88
15	F	11.599	2.398	88.46	43.60	32.25	11	11.09	10.95
16L001	M	12.379	2.082	84.36	42.86	33.49	10	10.07	9.97
2	F	11.898	2.610	85.49	41.85	31.19	10	9.62	9.67
3	M	13.687	2.831	95.18	44.00	34.50	11	13.71	13.57
4	M	11.152	2.373	84.30	43.04	30.73	10	8.38	8.32
5	F	13.334	2.692	97.13	46.21	34.32	18	13.93	13.65
6	F	8.303	1.707	82.92	37.53	34.37	11	12.01	12.01
7	F	9.412	2.006	82.30	47.30	31.58	6	9.92	9.77
8	M	9.320	2.140	80.83	44.09	27.39	10	7.16	7.26
9	M	5.988	1.193	80.12	38.45	29.22	10	11.91	11.08
10	F	10.062	2.135	85.82	39.02	33.03	11	11.19	11.14
11	F	11.357	2.485	90.17	43.97	33.52	12	13.43	13.33
12	F	9.099	1.936	83.51	41.24	31.10	12	8.94	9.04
13	M	10.121	2.313	77.62	41.98	31.48	7	9.27	9.13
14		3.467	2.161	82.61	41.21		10		9.46
15	M	6.182	1.408	71.89	36.73	26.61	9	5.39	5.48
16	F	13.725	2.372	97.70	44.23	35.88	12	23.89	20.66
17	I	0.521	0.149						
18	I	0.500	0.141	32.00	17.46	11.83	3	0.55	0.57
19	I	0.566	0.141	30.42	18.06	12.68	3	0.57	0.58
20	I	1.095	0.280	39.94	21.71	16.18	4	1.38	1.38
21	F	6.647	1.577	71.14	38.66	26.64	8	5.14	5.09
22	I	3.729	0.810	60.40	32.93	23.96	5	4.08	4.06
23	I	1.891	0.484	46.85	25.54	19.12	4	1.69	1.69
24	I	3.412	0.797	60.02	34.03	23.16	5	4.13	4.07
25	I	1.629	0.378	43.61	23.19	17.82	4	1.60	1.59
26		2.456	0.592	54.39	29.15	21.93	5	2.63	2.62

Appendix 1 (cont'd)

Identification	Sex	Mean weight		Valve dimensions (mm)			Age Yr-1	Valve dry wt (g)	
		Wet (g)	Dry (g)	Length	Height	Width		Left	Right
18L001	M	4.847	1.047	73.79	33.07	26.47	11	8.03	7.50
2	F	5.267	1.150	65.77	32.58	25.26	10	5.55	5.46
3	F	3.453	0.768	63.24	29.37	24.10	10	4.63	4.64
4	M	4.705	1.061	68.14	34.48	28.24	11	7.87	7.66
5	M	4.293	0.937	63.23	29.50		10	4.77	4.63
6	F	3.353	0.720	59.84	30.21	21.12	10	3.69	3.74
7	F	4.401	0.980	63.54	31.40	22.33	10	3.58	3.54
8	M	3.937	0.922	61.83	27.41	23.53	10	4.52	4.57
9	M	1.592	0.576	56.16	26.73	20.40	9	3.23	3.29
10	F	5.841	1.269	70.84	32.46	26.47	11	7.84	7.53
11	F	3.847	0.728	66.57	32.80		11	5.53	5.56
12	M	3.796	0.858	62.87	27.74	23.33	10	5.57	5.51
13	M	2.459	0.598	55.30	27.75	19.75	9	2.44	2.50
14	M	3.887	0.884	59.51	30.90	20.04	10	3.02	2.95
15	F	3.430	0.770	57.43	28.01	19.99	12	3.60	3.61
16	F	3.054	0.667	57.52	25.56	21.96	9	3.30	3.38
17	F	3.518	0.743	63.09	30.38	22.41	11	5.01	4.89
18	M	3.158	0.701	56.77	28.98	19.86	9	3.24	3.24
19	F	3.042	0.624	58.27	29.25		10	3.49	3.79
20	F	2.836	0.634	55.38	29.47	19.72	9	2.83	2.84
21									
22									
23	F	2.526	0.547	59.18	27.48	21.70	9	3.59	3.69
24	M	4.068	0.941	59.25	31.47	22.73	9	3.50	3.46
25	M	3.849	0.798	65.23	32.41	25.63	10	5.55	5.55
26	M	3.927	0.824	63.22	31.88	24.37	10	5.52	5.54
27	M	2.230	0.475	49.25	26.73	18.13	9	1.91	1.90
28	F	4.240	0.837	68.47	32.15	25.71	11	6.24	6.56
29	I	5.278	1.297	74.52	36.57	26.21	11	9.98	9.77
30	F	5.114	0.925	65.57	30.74	26.72	10	Broken	6.88
31	M	2.577	0.598	56.29	24.91	19.75	9	3.45	3.41
32	M	4.249	0.936	66.11	31.08	23.46	11	5.14	5.49
33	M	3.112	0.758	61.43	31.23	21.49	10	3.52	3.55
34	M	5.629	0.938	70.33	33.55		11	5.45	5.29
35	M	4.450	1.360	71.94	32.25		11	Broken	8.05
36	I	2.523	0.583	54.40	26.41		9	3.30	Absent
37	M	3.820	0.845	63.28	30.22	24.31	9	4.39	4.51
38	M	4.400	1.039	62.27	30.02	24.09	10	4.52	4.38
39	M	2.301	0.541	53.32	25.47	18.76	9	2.64	2.67
40	M	3.693	0.806	65.79	31.95	25.22	10	5.72	5.71
41	M	3.440	0.843	61.63	27.22	24.90	10	5.20	5.37
42	M	4.097	0.884	70.21	32.20	27.13	11	6.42	6.44
43	M	5.983	1.416	68.39	30.33	24.99	11	6.13	6.16
44	M	2.468	0.589	49.77	25.98	17.85	8	1.89	1.93
45	I	0.978	0.224	36.54	19.67	13.25	5	0.94	0.94
46	M	2.376	0.521	55.58	25.18		9	4.16	Broken
47	F	3.623	0.807	61.67	29.64	21.54	11	3.88	3.93
48	M	3.880	0.967	59.73	30.29	21.10	9	3.08	3.11

Appendix 1 (cont'd)

Identification	Sex	Meat weight		Valve dimensions (mm)			Age Yr-1	Valve dry wt (g)	
		Wet (g)	Dry (g)	Length	Height	Width		Left	Right
49	M	3.370	0.747	56.95	26.81	20.94	9	2.85	2.91
50	M	3.976	0.857	65.13	30.55	23.58	10	4.36	4.27
51	M	3.921	0.841	66.46	34.02	27.39	11	8.30	8.30
52	I	1.210	0.285	42.23	24.32	16.11	7	1.53	1.54
53	F	3.787	0.807	63.26	29.29	22.51	12	3.96	4.05
54	M	4.427	1.023	64.62	30.92	23.57	10	4.27	4.24
55	F	3.995	0.717	67.97	30.65	24.49	9	5.16	5.18
20L001	M	4.815	1.116	70.75	35.18	25.60	11	6.33	6.22
2	M	2.587	0.632	57.06	27.61	20.68	10	3.70	3.83
3	M	4.252	0.986	66.05	32.33	24.49	11	5.39	5.24
4	M	4.828	1.080	72.32	33.77	25.42	11	8.26	8.46
5	I	1.501	0.355	46.19	24.05	17.64	6	1.64	1.67
6	M	2.612	0.645	60.36	27.34	22.13	10	5.04	5.07
7	F	2.733	0.553	58.53	27.26	21.89	10	3.52	3.66
8	M	4.883	1.137	65.60	31.88	23.47	10	4.33	4.39
9	M	3.043	0.744	54.02	27.58	20.28	9	2.81	2.81
10	F	3.580	0.799	64.12	30.00	23.56	11	5.42	5.30
11	F	3.921	0.879	61.79	30.83	22.19	11	3.27	3.32
12	M	3.822	0.863	63.44	30.62	22.20	10	4.81	4.69
13	M	2.766	0.642	52.92	25.63	20.87	10	2.46	2.51
14	M	6.220	1.467	70.48	34.19	25.39	12	5.04	5.00
15	M	2.676	0.652	58.06	28.67	22.31	10	4.01	4.02
16	M	3.082	0.767	54.57	25.99		11	3.81	3.76
17	M	3.389	0.856	56.51	29.05	20.95	11	3.04	3.03
18	F	3.626	0.845	58.27	29.77	22.78	11	4.01	4.11
19	M	3.966	0.935	60.87	29.46	21.71	11	3.37	3.37
20	F	6.885	1.504	70.87	32.83	25.83	12	6.30	6.28
21	F	3.400	0.775	55.53	29.85	21.05	10	2.45	2.45
22	M	3.764	0.782	64.10	30.29	23.95	11	5.52	5.54
23	M	2.490	0.655	53.90	27.65	20.28	9	2.95	2.95
24	M	1.886	0.433	46.30	25.91	18.89	9	2.67	2.57
25	M	4.198	0.928	67.60	30.84	25.82	11	5.60	5.43
26	F	2.952	0.616	56.57	28.33	19.82	10	2.86	2.87
27	M	4.048	0.851	71.68	34.10	25.32	11	6.67	6.54
28	F	2.810	0.643	55.61	28.39	19.67	11	2.36	2.32
29	M	3.306	0.791	59.87	28.64	21.79	12	3.76	3.66
30	M	2.884	0.651	56.28	28.29	22.01	10	3.12	3.12
31	F	4.078	0.926	61.65	28.85	20.99	10	3.75	3.74
32	F	1.433	0.338	46.33	25.32	16.90	8	1.90	1.93
33	I	1.206	0.303	42.41	22.61	16.20	7	1.45	1.42
34	M	5.487	1.230	67.63	33.69	24.85	11	5.91	5.76
35	I	0.114	0.037	20.20	11.22	7.77	3	0.15	0.13
36	I	0.586	0.159	33.71	18.07	12.72	5	0.62	0.64
37	I	0.224	0.058	24.18	13.27	10.35	4	0.34	0.33
38	I	0.144	0.042	20.90	11.93	8.33	3	0.20	0.20
39	F	4.369	1.002	62.51	28.93	26.63	10	5.73	5.84
40	I	0.282	0.071	25.54	13.93	9.84	4	0.37	0.34

Appendix 1 (cont'd)

Identification	Sex	Meat weight		Valve dimensions (mm)			Age Yr-1	Valve dry wt (g)	
		Wet (g)	Dry (g)	Length	Height	Width		Left	Right
41	F	1.891	0.462	48.13	23.43	17.97	8	1.94	1.93
42	F	2.667	0.643	50.72	24.88	19.33	9	2.25	2.26
43	M	3.380	0.764	55.26	26.75	19.60	9	2.61	2.62
44	F	3.497	0.946	56.46	26.55	21.43	9	2.99	2.98
45	M	1.760	0.381	46.29	24.77	18.06	5	1.85	1.80
46	M	4.128	1.045	63.71	32.07	23.97	10	4.63	4.48
47	M	2.789	0.582	55.04	27.82	20.84	8	2.33	2.36
48	M	3.490	0.749	55.60	25.96	21.09	9	3.54	3.50
49	M	2.368	0.544	56.28	25.12	20.80	10	3.65	3.66
50	M	4.451	1.013	60.67	31.87	23.66	10	4.11	4.05
51	M	4.755	1.092	69.07	32.81	25.66	11	7.95	8.15
52	F	2.333	0.536	47.98	24.84	18.46	8	2.11	2.10
53	M	5.216	1.212	65.68	30.93	24.14	11	5.52	5.65
54	M	7.046	1.493	79.62	34.40	29.70	13	9.86	10.1
55	F	0.545	0.104	44.39	23.17	16.94	8	1.43	1.46
56	F	3.476	0.825	56.26	30.45	22.50	10	3.66	3.63
57	F	3.232	0.773	57.05	29.98	21.01	10	3.12	3.11
58	F	3.230	0.762	55.13	27.33	20.56	9	2.84	2.84
59	F	3.601	0.792	57.81	28.92	22.39	10	4.12	4.12
60	F	2.314	0.505	51.76	24.32	20.09	9	3.89	3.91
61	F	3.230	0.727	56.41	25.52		10	2.97	3.44
62	F	2.736	0.610	53.72	26.40	18.80	9	2.79	2.83
63	F	2.871	0.656	54.59	26.71	20.23	9	3.22	3.24
64	F	5.656	1.324	66.40	28.31	26.05	11	6.99	7.12
65	F	3.142	0.741	54.78	29.45	20.70	7	2.71	2.87
66	M	3.152	0.752	58.60	27.18	20.60	10	3.15	3.11
67	F	4.745	1.051	60.20	26.95	24.22	10	5.14	5.19
68	F	2.620	0.597	49.26	26.98	20.47	8	2.73	2.83
69	M	1.943	0.474	52.30	25.14	19.55	9	2.04	2.07
70	I	1.654	0.396	49.10	25.59	19.01	6	2.09	2.12
71	F	3.901	0.906	66.94	31.97		11		4.37
72	F	3.313	0.755	57.03	28.03	21.89	10	4.30	4.17
73	F	2.621	0.620	52.36	26.08	19.43	9	2.47	2.51
74	F	1.926	0.461	45.89	23.85	16.90	8	1.55	1.57
75	I	0.492	0.128	28.46	16.21	12.52	4	0.49	0.5
76	M	1.351	0.323	42.66	21.87	16.69	7	1.46	1.49
77	M	2.214	0.501	55.62	25.84	21.51	9	3.34	3.47
78	F	1.456	0.360	43.56	23.34	15.05	8	1.43	1.45
79	M	1.317	0.320	44.12	21.67	17.05	7	1.74	1.67
80	F	1.777	0.455	49.89	24.65		9	1.84	1.86

Appendix 1 (cont'd)

Identification	Sex	Meat weight		Valve dimensions (mm)			Age Yr-1	Valve dry wt (g)	
		Wet (g)	Dry (g)	Length	Height	Width		Left	Right
21L001	F	2.889	0.686	25.57	28.58	21.05	11	2.68	2.70
2	F	2.226	0.501	51.64	25.87	21.02	10	2.54	2.56
3	F	2.680	0.614	56.63	25.28	22.91	12	3.82	3.77
4	F	3.796	0.877	58.30	28.59	21.33	10	3.03	3.06
5	M	5.100	1.131	76.87	32.99	28.39	14	10.11	10.29
6	F	2.499	0.605	58.56	31.10	19.31	13	3.27	3.28
7	M	2.372	0.578	52.56	26.04	20.10	10	2.26	2.31
8	M	4.586	1.106	62.96	30.12	25.48	12	5.42	5.22
9	F	3.628	0.833	59.13	29.44	23.24	11	3.88	3.76
10	F	3.522	0.789	56.66	25.82	23.45	12	3.87	3.95
11	M	2.848	0.687	56.33	26.65	21.09	12	3.29	3.27
12	M	3.577	0.943	66.30	30.62	23.25	13	5.09	5.06
13	M	4.803	1.042	68.72	31.02	27.55	13	7.43	7.03
14	M	7.392	1.818	76.39	34.11	29.11	14	9.87	9.90
15	F	2.030	0.479	53.04	25.07	19.44	12	2.72	2.72
16	F	3.006	0.660	59.75	28.32	22.79	12	3.65	3.83
17	F	7.037	1.610	71.72	35.19	26.75	13	6.24	6.22
18	F	2.748	0.639	53.52	27.03	19.55	9	2.35	2.31
19	F	2.621	0.616	50.94	25.46	19.75	11	2.15	2.34
20	M	2.082	0.517	48.81	22.14	18.97	16	1.95	2.01
21	F	4.454	0.982	68.27	31.91	22.25	13	4.47	4.40
22	M	3.574	0.792	59.05	30.43	20.97	7	2.93	2.95
23	F	4.391	1.020	61.11	30.84	21.09	12	3.57	3.61
24	M	3.047	0.678	60.65	26.69	23.14	12	5.02	4.95
25	M	3.457	0.751	57.69	28.86	22.05	12	4.07	4.07
26	F	2.612	0.590	51.49	26.93	19.61	10	2.48	2.50
27	F	2.564	0.596	53.55	25.51	20.84	10	2.60	2.67
28	I	0.377	0.095	27.98	15.12	10.05	7	0.45	0.45
29	I	0.162	0.050	20.90	11.12	8.12	2	0.21	0.20
30	M	2.263	0.519	48.49	22.24	18.71	17	1.93	1.94
31	F	3.293	0.744	56.93	28.78	20.96	14	2.99	3.06
32	I	0.918	0.252	39.69	20.81	7.66	8	1.38	1.42
33	F	3.701	0.734	62.56	31.68	22.91	13	4.00	3.90
34	F	6.745	1.524	72.85	32.02	26.62	13	5.98	6.17
35	F	5.047	1.082	70.81	33.43	26.67	13	7.69	7.29
36	M	3.287	0.788	53.85	27.66	13.00	10	2.95	Missing
37	M	5.027	1.221	66.30	31.57	24.70	14	5.83	5.79
38	M	2.984	0.744	59.74	27.78	10.47	15	2.88	2.81
39	M	3.755	0.906	59.40	29.21	24.37	12	3.75	3.79
40	F	1.940	0.449	46.78	24.78	17.36	9	1.70	1.67
41	M	1.880	0.454	47.69	23.49	17.27	11	1.83	1.84
42	F	1.941	0.434	48.12	24.88	18.02	11	2.37	2.41
43	M	2.257	0.525	50.19	24.50	17.99	9	1.87	1.85
44	F	3.379	0.767	57.54	27.21	21.57	11	3.55	3.50
45	I	1.210	0.279	42.18	22.07	17.39	10	1.82	1.80
46	F	2.806	0.611	56.41	26.30	22.71	11	3.54	3.48
47	F	3.541	0.806	60.03	29.84	23.99	12	4.41	4.43
48	F	2.386	0.559	52.78	27.34	19.34	11	2.54	2.53
49	M	3.281	0.774	60.46	26.39	22.47	12	4.12	4.20

Appendix 1 (cont'd)

Identification	Sex	Meat weight		Valve dimensions (mm)			Age Yr-1	Valve dry wt (g)	
		Wet (g)	Dry (g)	Length	Height	Width		Left	Right
22L001	M	4.040	0.981	40.33	30.79	20.46	10	3.87	3.90
2	M	3.293	0.839	55.41	27.91	20.52	11	2.76	2.77
3	F	4.511	1.077	62.40	28.81	22.38	11	3.01	2.99
4	F	4.030	0.937	59.74	28.83	22.92	9	3.66	3.85
5	F	3.594	0.828	55.13	27.92	20.16	10	3.02	3.00
6	F	3.516	0.841	62.90	32.37	23.37	13	5.32	5.06
7	F	5.229	1.188	61.69	30.62	24.07	11	4.27	4.32
8	M	4.560	1.136	60.04	31.10	24.37	9	4.22	4.17
9	F	2.076	0.496	47.71	22.87	18.05	11	2.28	2.19
10	M	2.914	0.734	55.76	27.23	21.06	8	2.65	2.71
11	M	8.257	1.928	76.37	34.33	28.58	12	7.17	7.13
12	M	3.073	0.763	56.72	24.24	21.11	9	3.13	3.11
13	F	2.469	0.582	50.97	20.22	20.12	9	2.54	2.49
14	F	4.797	1.095	63.04	29.49	23.11	10	3.74	3.74
15	M	5.398	1.365	68.11	31.94	23.46	8	5.34	5.33
16	M	6.609	1.622	74.92	37.25	25.48	12	6.95	6.79
17	M	4.935	1.202	68.33	30.49	26.48	11	5.79	5.85
18	F	5.362	1.252	67.38	31.06	24.71	10	4.88	4.78
19	M	4.168	1.070	60.17	29.00	21.96	9	4.08	4.08
20	I	3.026	0.754	57.15	25.72	21.68	9	3.28	3.17
21	F	3.196	0.713	66.46	32.03	23.63	12	4.26	4.29
22	M	4.252	1.069	61.63	30.39	16.44	10		5.83
23	M	2.447	0.571	51.89	25.27	19.21	8	2.48	2.67
24	I	0.759	0.194	35.17	18.93	14.43	4	0.81	0.80
25	M	2.093	0.551	45.63	23.55	17.93	6	2.24	2.32
26	M	2.862	0.742	52.52	26.33	20.73	6	2.41	2.48
27	F	4.201	0.980	59.95	29.69	24.82	11	4.32	4.32
28	F	3.703	0.761	55.85	28.60	22.72	10	3.25	3.17
29	F	3.345	0.809	54.32	26.40	20.17	7	2.85	3.01
30	F	2.984	0.754	57.79	29.78	21.62	10	3.88	3.82
31	M	3.932	1.107	61.91	29.24	24.36	10	4.57	4.54
32	I	1.667	0.412	46.37	24.18	24.22	5	2.07	2.09
33	M	4.146	1.026	63.48	30.29	22.98	9	3.73	3.74
34	M	2.208	0.567	49.28	26.12	18.88	10	2.06	2.05
35	M	4.263	1.100	61.30	29.43	22.88	11	3.87	3.84
36	M	3.683	0.926	58.00	26.90	21.31	10	2.79	2.83
37	M	3.676	0.924	57.29	28.69	20.70	11	3.12	3.17
38	M	1.551	0.391	44.55	22.98	16.23	6	1.52	1.51
39	I	0.920	0.244	39.00	20.28	16.32	5	1.17	1.19
40	F	4.738	1.115	62.70	31.36	22.24	13	3.97	4.09
41	F	4.768	1.093	62.35	20.87	4.38	12	3.67	3.74
42	I	0.155	0.050	26.08	12.88	9.41	4		0.20
43	I	0.284	0.191	26.12	12.54	12.73	7	0.35	0.36
44	I	0.675	0.169	33.23	17.10	13.78	8	0.65	0.66
45	I	0.670	0.181	33.88	18.68	13.55	6	0.79	0.78
46	M	2.323	0.590	50.35	26.37	17.82	12	2.45	2.42
47	M	1.447	0.585	49.19	24.14	17.82	8	2.01	2.02

Appendix 1 (cont'd)

Identification	Sex	Meat weight Wet (g)	Meat weight Dry (g)	Valve dimensions (mm) Length	Height	Width	Age Yr-1	Valve dry wt (g) Left	Right
23L001	F	5.486	1.289	66.59	32.05	22.74	12	4.175	4.092
2	F	2.400	0.545	52.08	23.91	18.87	9	2.445	2.470
3	F	4.754	1.092	67.29	34.80	25.49	10	5.633	5.854
4	M	5.487	1.366	67.21	34.01	25.77	10	5.612	5.790
5	M	5.031	1.083	71.73	32.94	26.03	9	6.906	7.355
6	M	4.064	0.946	63.42	30.25	20.06	12	3.214	3.202
7	I	0.275	0.068	24.76	13.90	10.63	4	0.277	0.276
8	M	4.796	1.117	65.57	30.62	13.52	11		4.268
9	F	1.732	0.407	42.31	18.78	17.18	8	1.384	1.404
10	M	4.608	1.094	62.08	28.17	23.16	8	4.734	4.734
11	F	3.324	0.792	56.07	26.53	21.76	10	3.167	3.130
12	F	4.396	0.994	61.62	28.62	23.75	9	4.605	4.562
13	I	0.414	0.097	27.64	14.71	10.39	6	0.460	0.460
14	M	2.274	0.556	45.89	22.03	19.13	8	1.980	1.975
15	F	3.616	0.827	55.76	27.22	20.26	12	2.653	2.690
16	M	4.869	1.251	65.14	32.67	24.53	11	4.435	4.377
17	F	9.664	2.251	77.42	37.60	26.80	15	7.560	7.469
18	F	3.555	0.843	52.49	27.11	22.23	9	2.947	2.969
19	F	5.085	1.164	63.55	29.98	23.75	11	4.784	4.832
20	M	3.322	0.799	58.34	26.92	21.64	10	3.389	3.354
21	F	4.924	1.153	66.08	34.19	24.86	11	3.650	3.748
22	M	3.406	0.823	55.49	27.03	20.78	10	3.139	3.257
23	M	3.532	0.868	56.79	27.10	21.94	13	3.127	3.184
24	M	3.314	0.810	58.72	27.66	22.26	13	3.590	3.680
25	M	4.960	1.217	64.35	30.74	22.24	12	4.502	4.474
26	M	4.303	1.132	61.81	29.75	23.26	13	3.286	3.381
27	M	4.692	1.160	62.53	31.51	22.99	12	3.983	3.986
28	M	4.468	1.137	67.39	31.86	24.33	12	5.915	5.968
29	F	4.847	1.160	62.45	29.65	24.12	14	4.364	4.390
30	M	2.261	0.567	49.09	25.55	18.70	13	2.382	2.276
31	F	3.081	0.710	55.49	26.04	21.81	12	3.164	3.190
32	F	3.676	0.859	60.18	28.00	21.78	13	3.187	3.144
33	F	3.041	0.654	63.41	31.34	23.40	12	4.518	4.560
34	M	5.987	1.454	66.88	31.55	25.87	13	5.760	5.840

Appendix 2. Sex, weights, valve dimensions and estimated age (by method 1) of horse mussels sampled in 1998.

Identification	Sex	Meat weight		Valve dimensions (mm)			Age Yr-1	Valve dry wt (g)	
		Wet (g)	Dry (g)	Lenght	Height	Width		Left	Right
22L001	F	3.3118	0.8950	60.74	27.47	23.84	9	4.356	4.356
2	M	1.6800	0.4040	52.42	27.59	20.68	10	2.890	2.788
3	M	3.7000	0.8024	63.33	30.8	24.79	11	4.663	4.673
4	F	3.4164	0.7815	62.33	32.12	23.98	14	4.761	4.802
5	M	4.8958	1.0485	71.63	33.52	25.55	13	5.723	5.699
6	M	3.0225	0.6522	67.21	30.01	23.35	12	4.897	4.996
7	F	1.8116	0.4235	51.70	24.08	18.37	11	1.965	1.967
8	M	1.9232	0.4791	51.83	25.22	19.14	13	2.489	2.534
9	M	2.1993	0.5153	53.44	24.93	22.31	9	3.642	3.655
10	M	3.2756	0.6881	63.96	30.11	22.41	13	4.105	4.081
11	M	3.9633	0.8962	67.33	34.18	24.69	14	4.715	4.665
12	M	5.5272	1.1574	73.81	35.68	27.83	14	6.897	6.978
13	M	7.1161	1.3901	81.55	36.66	30.97	18	8.234	8.343
14	F	2.1326	0.4770	51.71	26.66	19.77	11	2.546	2.538
15	F	2.0992	0.4290	50.50	24.99	20.35	11	2.334	2.373
16	F	3.5829	0.7049	61.13	31.39	21.13	15	3.680	3.557
17	F	6.3847	1.6624	72.68	36.12	27.08	11	6.559	3.480
18	M	3.4322	0.5808	66.71	31.18	25.31	11	6.240	6.098
19	F	6.2382	1.1590	76.96	35.69	28.46	13	7.748	7.631
20	F	5.1901	0.9565	72.47	34.24	27.20	13	7.049	7.139
21	M	5.1927	1.0125	75.72	32.08	26.20	14	6.541	6.660
22	M	3.4908	0.7488	60.68	29.76	23.44	11	3.940	4.005
23	F	3.0926	0.6832	61.38	32.88	21.70	11	4.889	4.981
24	F	5.0927	0.9954	66.95	32.10	27.18	14	5.473	5.522
25	M	3.0979	0.5694	64.19	30.55	23.59	12	4.363	4.239
26	M	4.1897	0.9008	67.35	32.06	26.92	14	5.982	6.100
27	M	5.7388	1.1374	74.38	34.27	27.41	12	7.422	7.912
28	M	2.4117	0.4807	50.94	25.26	21.01	14	2.725	2.779
29	M	3.3703	0.7645	60.77	31.78	22.00	13		
30	F	3.7483	0.8475	59.95	30.08	23.06	11	4.041	4.052
31	M	4.1261	0.8586	67.81	32.26	25.79	13	5.625	5.375
32	F	3.5215	0.7194	63.01	32.61		13		
33	M	4.8590	0.8869	70.88	33.02	27.26	8	5.989	6.080
34	F	3.2406	0.6120	61.85	30.75	23.00	15	5.155	5.278

Appendix 2 (cont'd)

Identification	Sex	Meat weight		Valve dimensions (mm)			Age Yr-1	Valve dry wt (g)	
		Wet (g)	Dry (g)	Lenght	Height	Width		Left	Right
23-L001	M	4.746	0.899	69.05	34.7	25.91	12	6.194	6.120
2	F	4.090	0.887	69.77	31.07	26.52	14	6.301	6.273
3	M	3.261	0.809	66.18	30.83	24.19		4.754	4.756
4	F	5.436	1.014	74.87	35.25	29.76	11	8.490	8.418
5	I	1.890	0.414	57.42	27.53	21.74	11	3.952	4.134
6	M	2.314	0.535	56.20	29.35	21.43	14	2.739	2.732
7	M	2.331	0.541	60.94	28.96	21.75	10	4.315	4.315
8	F	2.132	0.508	51.66	26.24	20.56	9	2.386	2.445
9	F	3.992	0.938	65.95	31.5	24.04	9	4.936	5.030
10	M	2.877	0.643	61.06	29.91	23.40	11	4.345	4.271
11	F	1.993	0.297	53.50	26.29	20.62	8	3.145	3.065
12	M	6.483	1.704						
13	M	2.778	0.582	60.05	27.43	23.12	11	3.531	3.570
14	F	2.318	0.451	55.44	27.95	19.90	10	3.163	3.138
15	F	5.085	1.250				12		
16	F	3.101	0.585	60.95	31.77	22.78		3.894	3.941
17	M	1.413	0.264	50.71	26.16	18.98	11	2.366	2.344
18	M	2.637	0.545	56.49	28.96	20.44	12	3.557	3.744
19	F	3.898	0.689	70.24	33.53	24.88	9	5.325	5.225
20	F	4.711	0.937	65.82	32.30	22.99	15	4.278	4.169
21	F	1.921	0.423	55.15	25.56	19.68	14	2.868	2.860
22	M	3.825	0.789	64.16	32.79	24.19	13	5.007	5.070
23	M	3.826	0.792	70.54	33.44	24.80	12	6.053	6.173
24	M	1.607	0.324	46.45	23.67	20.68	11	2.685	2.717
25	F	3.993	0.821	68.21	34.65	24.49	15	5.286	5.128
26	M	3.970	0.858	70.31	33.04	25.12	12	6.473	6.156
27	M	2.841	0.667	57.76	29.84	22.04	15	3.958	3.950
28	F	3.656	0.741	67.30	34.80	25.78	12	6.160	6.280
29	M	5.862	1.339	73.65	35.74	27.97	13	8.260	8.340
30	M	3.765	0.815	67.49	33.76	26.91	14	6.053	6.081
31	M	2.932	0.836						
32	M	2.685	0.618	57.31	28.34	21.20	14	3.635	3.558
33	F	2.826	0.728	58.63	30.65	22.06	13	3.680	3.655
34	F	3.655	0.754	63.08	31.91	23.10	12	4.032	4.268
35	F	6.343	1.279	81.63	36.72	28.89	15	9.007	9.173
36	M	3.818	0.791	64.25	31.84	26.30	14	5.827	5.927
37	M	3.942	0.696	71.95	34.74	27.53	15	7.518	7.552
38	M	3.492	0.667	62.48	27.91	23.82	12	4.919	4.878
39	M	3.750	0.985	66.85	31.78	24.03	11	4.654	4.654
40	M	2.558	0.541	55.45	27.45	21.67	13	3.192	3.258
41	F	1.781	0.420	46.53	25.73	16.90	12	1.922	1.922
42	M	2.152	0.756	52.55	25.85	20.20	11	3.308	3.308
43	F	2.433	0.602	62.13	30.80	22.42	13	4.350	4.350

Appendix 2 (cont'd)

Identification	Sex	Meat weight		Valve dimensions (mm)			Age	Valve dry wt (g)	
		Wet (g)	Dry (g)	Lenght	Height	Width	Yr-1	Left	Right
24L001	M	3.718	0.741	66.13	30.88	24.80	8	5.559	5.571
2	M	3.815	1.558	64.62	28.69	23.58	11		4.379
3	M	4.190	0.813	69.86	31.47	25.52	10	5.710	3.565
4	F	2.422	0.624	55.56	27.21	20.65		2.947	2.903
5	M	3.843	0.899	65.86	31.81	12.37		6.426	6.085
6	M	2.581	0.663						
7	I	0.924	0.256	44.33	23.23	18.04	8	1.634	1.654
8	M	6.096	1.153	84.92	40.45	32.03		9.993	10.110
9	F	5.509	1.572						
10	F	3.409	0.621	66.33	31.35	22.98		4.412	4.580
11	M	2.600	0.570	58.02	29.21	22.19	13	3.778	3.748
12	M	3.584	1.078	66.87	29.34	22.76		4.880	
13	F	2.871	0.576	63.71	30.93	23.69	9	4.550	4.408
14	M	1.917	0.423	56.52	29.2	20.03	10	2.887	2.916
15	M	2.508	0.523	56.82	26.6	21.01	8	3.523	3.575
16	M	1.760	0.353	56.45	27.87	21.51		3.579	3.761
17	M	3.078	0.709	61.05	31.52	22.88	12	4.377	4.274
18	M	1.972	0.433	57.05	26.27	22.68	8	3.883	3.965
19	M	1.158	0.267	49.22	25.86	19.14	9	2.570	2.654
20	F	2.604	0.561	62.48	31.00	23.08	15	3.743	3.734
21	M	2.498	0.416	62.84	30.52	24.10	9	5.160	5.005
22	M	4.044	0.811	69.06	30.52	26.77	7	6.357	6.377
23	M	3.483	0.682	71.07	32.12	27.37	7	6.245	6.206
24	M	2.712	0.566	58.96	29.86	23.27	12	4.338	4.630
25	M	2.110	0.362	56.27	29.07	22.71	7	2.969	3.142
26	M	4.243		75.74	36.55	26.16		7.798	7.971
27	F	2.652	0.497	65.85	29.30	24.19		5.793	5.622
28	M	2.160	0.421	59.16	30.15	19.84	7	3.080	3.284
29	M	1.241	0.290	43.39	23.20	16.85		1.873	1.937
30	F	6.546	1.337	80.55	36.59	29.34		7.994	8.109
31	F	3.329	0.669	62.65	26.24	23.47	7	4.325	4.375
32	F	2.843	0.681	61.90	21.14	23.71	7	4.565	4.601
33	F	4.696	1.085	69.51	34.02	23.95	4	5.010	4.969
34	I	1.282	0.462	44.43	23.58	16.73	6	1.670	1.675
35	M	1.682	0.379	54.41	28.33	20.19		2.980	2.993
36	F	2.521	0.531	62.35	28.48	23.88	8	4.900	4.949
37	F	2.778	0.899	57.15	29.25	20.88	9	3.301	3.359
38	M	7.162	1.323	85.06	40.70	30.56		10.621	10.650
39	M	2.121	0.535	55.18	27.00	21.35	10	3.204	3.231
40	M	3.215	0.708	66.69	27.95	24.34		4.676	4.651
41	M	3.199	0.800	61.75	29.85	23.60		4.084	3.978
42	F	2.233	0.533	57.58	28.71	20.31	8	3.159	3.183
43	F	2.470	0.492	65.95	28.80	23.24	6	4.568	4.605
44	F	3.032	0.622	60.90	29.12	21.58	12	3.499	3.510
45	F	5.132	0.997	79.68	35.82	28.89	8	8.765	9.116
46	F	2.639	0.573	58.14	29.45	21.87	9	4.225	4.235
47	M	2.300	0.456	54.40	29.74	19.67	13	2.897	2.853

Appendix 2 (cont'd)

Identification	Sex	Meat weight		Valve dimensions (mm)			Age Yr-1	Valve dry wt (g)	
		Wet (g)	Dry (g)	Lenght	Height	Width		Left	Right
48	F	3.891	0.909	69.49	35.73	25.30	9	6.597	6.322
49	M	1.858	0.377	51.45	27.22	20.50		2.829	2.830
50	F	2.769	0.501	63.21	30.30	23.63	11	4.256	4.233
51	F	3.410	0.856	64.75	31.71	24.30		3.628	
52	F	2.328	0.495	55.04	25.87	23.12		4.063	4.113
53	M	2.497	0.422	52.95	27.88	20.18	10	2.611	2.625
54	F	4.624	0.811	74.59	34.28	26.98	7	7.883	8.113
55	M	1.849	0.512	65.83	29.32	23.48	10	4.480	4.235
56	F	4.416	1.290	70.89	33.47	24.84		5.409	
57	M	2.666	0.675		27.95	23.48			
25L001	M	2.244	0.431	55.97	26.83	19.84	10	3.16	3.13
2	M	3.577	0.710	71.60	34.51	24.54	16	6.12	5.98
3	F	5.148		76.55	33.00		12		8.67
4	M	1.028	0.298	42.38	18.92	16.89	9	1.64	1.65
5	F	2.900	0.583	59.63	27.21	21.23		3.63	3.37
6	F	2.740	0.659	62.24	27.15	21.39	11	4.62	
7	M	2.104	0.420	54.22	24.82	21.43	14	3.03	2.95
8	M	4.824	0.898	74.09	34.02	26.29		7.17	7.25
9	M	3.354	1.049	69.30	31.65		14		5.88
10	M	2.417	0.428	65.22	31.90	23.67	13	4.57	4.56
11	I	0.778		41.48	24.90	14.07	7	1.50	1.54
26L001	F	2.971	0.642	60.70	28.52	22.76		4.297	4.263
2	M	2.427	0.564	56.83	28.81	20.72		3.181	3.185
3	F	3.374	0.747	60.79	29.20	22.80		5.090	5.130
4	M	3.313	0.681	62.02	28.79	23.62	16	3.717	3.822
5	M	2.082	0.492	54.92	26.88	18.83	10	2.808	2.920
6	M	2.707	0.534	60.16	28.26	21.86	11	4.287	4.353
7	M	2.225	0.425	54.09	24.18	20.52	10	3.567	3.582
8	F	2.040	0.457	57.53	27.92	23.28	15	3.626	3.672
9	F	4.708	0.987	76.48	38.18	26.49	8	5.653	5.616
10	M	2.093	0.470	55.68	26.24	20.22	13	2.913	2.906
11	F	2.048	0.597	56.30	26.78	19.90	9	3.383	3.379
12	M	1.891	0.464	64.20	25.96	20.31	12	2.541	2.573
13	F	6.239	1.246	79.71	37.85	29.82	16	7.690	7.420
14	F	2.225	0.478	57.11	26.91	20.91		3.375	3.470
15	M	2.331	0.461	58.82	31.64	22.88	12	4.272	4.245
16	F	3.515	0.769	65.33	30.69	24.24		5.135	5.320
17	M	1.579	0.314	48.80	23.04	16.88	8	2.009	2.040
18	M	1.960	0.450	59.12	28.29	21.44	11	4.098	4.216
19	M	2.323	0.463	55.75	30.17	24.34	9	3.972	3.918
20	M	2.947	0.660	62.59	27.29	23.54		4.704	4.490
21	M	2.306	0.566	55.58	28.33	19.71		3.277	3.130
22	M	1.091	0.287	45.44	23.26	16.80	7	1.791	1.800
23	F	2.053	0.424	51.04	24.37	20.03	12	2.705	2.690
24	M	2.210	0.517	56.57	26.85	23.22	13	3.635	3.566

Appendix 2 (cont'd)

Identification	Sex	Meat weight		Valve dimensions (mm)			Age Yr-1	Valve dry wt (g)	
		Wet (g)	Dry (g)	Lenght	Height	Width		Left	Right
25	F	2.314	0.491	58.07	27.82	21.38		3.908	3.860
26	I	2.753	0.844	62.05	31.00	21.33		4.138	4.062
27	F	1.894	0.404	51.54	25.82	19.20	8	2.264	2.298
28	M	2.635	0.705	58.76	27.89	22.84	12	4.018	4.067
29	F	3.985	1.173	63.96	31.69	24.01	13	5.539	5.542
30	M	5.536	1.174	80.08	36.27	31.32	18	11.201	11.414
31	M	1.846	0.394	47.61	25.36	19.25	6	2.450	2.480
32	F	2.915	0.568	60.50	28.45	23.85	10	4.357	4.121
33	M	5.109	0.799	75.94	34.77	27.73	11	6.313	6.510
34	F	3.265	0.680	65.25	30.25	23.75	12	4.879	4.850
35	I	0.281	0.075	31.12	17.24	13.00	5	0.617	0.625
36	M	2.261	0.493	53.70	27.92	21.43	12	3.118	4.097
37	F	3.211	0.694	66.53	31.94	25.56	12	5.133	5.103
38	F	3.731	0.818	65.36	33.02	24.58		6.055	6.025
39	F	2.687	0.641	57.66	29.00	20.85	8	3.416	3.374
40	M	2.938	0.667	57.14	28.15	23.47	8	4.217	4.289
41	M	2.828	0.561	60.22	29.71	23.59		5.018	5.074
42	M	3.646	0.607	65.08	30.49	25.44	13	5.279	5.164
43	F	3.386	0.789	62.09	29.00	24.47	11	4.942	5.000
44	F	4.156	0.922	66.43	32.27	25.27	12	4.959	4.836
45	F	2.819	0.585	57.65	26.39	23.63	8	3.408	3.509
46	F	1.528	0.317	47.43	24.05	18.61	10	1.705	1.657
47	M	1.066	0.228	48.59	22.30	17.21	7	2.125	2.096
48	M	2.324	0.452	59.33	27.56	24.74		4.355	4.442
49	F	4.712	0.898	73.17	32.15	28.97	11	7.767	7.500
50	F	4.182	1.025		33.80	24.93	14	3.339	4.264
51	F	2.691	0.528	61.17	30.80	24.55	17	5.355	5.425
52	M	5.945	1.244	79.80	37.07	27.74	11	8.350	8.367
53	F	4.987	0.938	70.76	32.53	28.40		8.104	7.633
54	F	2.436	0.557	57.37	26.76	22.72	12	3.400	3.372
55	M	2.046	0.419	55.57	28.57	20.62	11	3.668	3.508
56	F	3.420	0.850	64.59	29.29	23.18	12	4.437	4.516
57	I	0.415	0.121	33.35	17.33	13.17	5	0.718	0.704
58	M	2.107	0.437	56.75	28.94	21.63	8	3.760	3.828
59	M	3.484	0.619	67.18	30.10	26.33		5.185	5.256
60	M	1.057	0.242	41.36	22.13	16.18	8	1.463	1.469
61	F	4.174	0.722	68.33	33.53	25.18	15	4.982	5.031
62	F	2.681	0.575	60.79	29.79	22.58	15	4.309	4.241
63	I	0.621	0.160	38.25	20.19	15.25	5	1.002	0.997
64	F	1.570	0.360	49.97	24.15	19.33	12	2.372	2.372
65	F	3.154	0.685	61.79	28.10	22.83	11	4.266	4.274

Appendix 2 (cont'd)

Identification	Sex	Meat weight		Valve dimensions (mm)			Age Yr-1	Valve dry wt (g)	
		Wet (g)	Dry (g)	Lenght	Height	Width		Left	Right
70L001	M	1.621	0.327	52.36	37.31	20.33	12	2.396	2.483
2	M	1.963	0.511	52.59	27.33	21.00	13	2.331	2.211
3	I	2.787	0.789	63.38	32.11	23.16	10	3.932	
4	F	2.547	0.554	56.43	28.79	21.54	11		2.971
5	F	1.464	0.330	47.83	25.32	18.75	10	2.122	2.163
6	M	3.505	0.784	60.23	30.76	25.15	9	3.595	3.614
7	M	2.465	0.954	56.00	26.45	21.16			
76L001	M	2.189	0.684	52.82	28.11	20.75	9	2.210	2.229
2	F	2.496	0.654	61.38	31.20	22.98	10	3.580	3.190
3	M	1.882	0.419	54.82	27.06	19.93	10	2.752	2.770
77L001	M	2.394	0.947	52.60	27.20	21.29	9	2.341	2.401
2	M	2.780	0.591	63.09	31.64	23.08	12	3.842	3.875
3	M	2.048	0.532	56.89	28.02	22.22	9	2.500	2.569
4	M	2.614	0.666	-	-	-		-	-
5	M	1.958	0.461	52.76	27.05	19.18	10		2.027
78L001	M	2.367	0.511	58.45	28.48	21.46	9	2.614	-
2	M	1.529	0.296	52.34	24.61	18.04	9	1.627	-
3	M	1.642	0.426	-	25.46	18.72	11	-	-
4	M	1.250	0.301	47.20	23.81	15.34	10	-	1.641
4	F								
5	I	1.390	0.409	-	-	-	-	-	-
6	M	1.193	0.306	-	-	-	-	-	-

Appendix 3. Back-ageing estimates by independent observers on two 1998 horse mussel populations: #018 and #022.

Identification	Age 1	Age 2
18L 001	8	11
18L 002	11	11
18L 003	10	10
18L 007	8	7
18L 011	13	15
18L 013	9	12
18L 014	10	10
18L 015	8	10
18L 017	12	16
18L 018	8	8
18L 019	9	12
18L 021	9	14
18L 022	7	11
18L 023	7	12
18L 024	12	12
18L 025	7	12
18L 028	7	8
18L 030	8	15
18L 033	4	12
18L 034	6	6
18L 036	8	10
18L 037	9	12
18L 039	10	11
18L 042	3	11
18L 044	12	10
18L 045	8	11
18L 046	9	12
18L 047	13	13
18L 048	9	10
18L 050	11	11
18L 053	10	10
18L 054	7	14
18L 055	10	9

Appendix 3 (cont'd)

Identification	Age 1	Age 2		Identification	Age 1	Age 3		Identification	Age 2	Age 3
22L 001	13	11		22L 005	14	14		22L 005	13	14
22L 002	13	11		22L 006	11	14		22L 007	12	14
22L 003	13	11		22L 007	11	14		22L 012	12	12
22L 004	11	10		22L 012	15	12		22L 013	12	12
22L 005	14	13		22L 013	11	12		22L 014	12	13
22L 007	11	12		22L 014	14	13		22L 020	13	16
22L 009	12	13		22L 018	13	12		22L 021	13	19
22L 010	14	11		22L 019	8	11		22L 022	10	14
22L 011	12	16		22L 020	15	16		22L 024	10	15
22L 012	15	12		22L 021	11	19		22L 025	11	14
22L 013	11	12		22L 022	11	14		22L 026	11	13
22L 014	14	12		22L 024	13	15		22L 027	13	13
22L 015	11	14		22L 025	9	14		22L 029	12	16
22L 016	11	12		22L 026	13	13		22L 032	11	13
22L 017	13	12		22L 027	12	13		22L 033	12	12
22L 020	15	13		22L 029	14	16				
22L 021	11	13		22L 032	11	13				
22L 022	11	10		22L 033	10	12				
22L 023	13	13								
22L 024	13	10								
22L 025	9	11								
22L 026	13	11								
22L 027	12	13								
22L 028	14	12								
22L 029	14	12								
22L 030	18	12								
22L 031	14	11								
22L 032	11	11								
22L 033	10	12								
22L 034	9	11								

Appendix 4. Valve lengths (by method 2 in mm) between growth lines L1 to L4.

Individual	Growth lines			
	L1	L2	L3	L4
1997 03L 002	13	10	13	10
03L 005	14	9	8	14
03L 007	12	11	13	14
03L 008	10	10	12	12
03L 009	11	8	10	10
03L 010	10	10	11	11
03L 012	13	8	10	10
03L 013	14	11	12	10
03L 014	10	12	13	13
03L 018	10	15	12	13
03L 021	13	7	15	15
03L 025	9	10	13	13
03L 030	9	16	13	14
03L 036	12	10	9	12
03L 039	-	-	11	14
1997 20L 011	14	5	4	5
20L 013	13	4	4	9
20L 023	15	3	4	3
20L 025	13	6	6	3
20L 030	16	4	4	4
20L 043	14	4	5	5
20L 046	15	10	5	2
20L 055	14	5	3	4
20L 068	13	4	6	4
20L 076	19	5	6	5
1998 22L 003	12	7	4	5
22L 005	14	6	4	5
22L 007	13	4	3	4
22L 008	11	10	8	6
22L 025	10	6	5	4
22L 026	13	5	9	5
22L 028	14	5	5	6
22L 029	11	6	6	6
22L 033	15	4	4	5
22L 034	13	9	9	7
1997 23L 002	7	6	7	5
23L 003	14	7	8	6
23L 006	9	5	5	4
23L 009	6	7	6	6
23L 011	7	6	8	5
23L 011	10	7	5	6
23L 013	9	7	7	3
23L 014	6	6	4	6
23L 015	10	3	6	7
23L 017	9	7	4	6
23L 021	5	5	5	6
23L 023	6	5	6	5

Appendix 4 (cont'd.)

Individual	Growth lines			
	L1	L2	L3	L4
23L 024	6	5	8	8
23L 032	2	8	8	6
1998 26L 004	10	4	7	4
26L008	13	5	3	5
26L 019	12	7	6	5
26L 022	10	7	4	3
26L 032	15	5	5	5
26L 037	15	6	6	5
26L 042	12	5	4	5
26L 046	14	4	4	4
26L 061	15	4	4	4
26L 062	12	4	5	4
26L 064	15	3	4	3
26L 065	12	4	5	4