Some Biometric Observations on *Nephrops norvegicus* (L.)

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Current size legislation on Norway lobsters is based on overall length, while for scientific purposes the more accurate carapace length is used. The relationships between these measurements, derived from samples of males and females taken in the Moray Firth and the Minch, are obtained. No sex difference is detected, but the overall length (L) at a given carapace length (C) is found to be slightly higher in the Minch than in the Moray Firth. The best fitting relationships for the two areas are found to be

$$\text{Moray Firth: } L = 3{\cdot}004C + 9{\cdot}2$$
$$\text{Minch: } L = 3{\cdot}004C + 10{\cdot}1$$

These relationships are compared with ones available for English, Irish, Portuguese and Faeroese stocks and, with the exception of the latter, they are found to be very similar everywhere.

Other relationships obtained from the Scottish data are derived. These include the relationship between carapace length and tail width, body weight and tail weight and total weight and carapace length. Sex and area differences in these relationships are studied.

Introduction

Because of the greater facility and accuracy of measurement, carapace length as opposed to overall length has been advocated by the Shellfish Committee of the International Council for the Exploration of the Sea as the basis for legislation as well as for scientific work on Crustacea. Particularly is this applicable in the case of the Norway lobster, *Nephrops norvegicus* (L.), on account of the prehensile nature of the rostrum which shows a considerable degree of variability and which is frequently damaged so that only a stump remains. Present minimum size legislation, where it exists, is based on overall length. It is natural for fishermen and administrators to think in these terms. An equation for converting carapace length to overall length was given for a limited size range of Norway lobsters by THOMAS (1954). In order to interpret earlier work based on total length observations, and to relate present legislation

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Table 1

Ranges of measurements in samples of *Nephrops norvegicus* (L.) taken from the Moray Firth and the Minch

Measurements		Moray Firth Males	Moray Firth Females	Minch Males	Minch Females
Overall length	mm	74–171	72–134	64–234	66–158
Carapace length	mm	23– 53	21– 42	20– 75	20– 51
Tail width	mm	11– 26	11– 23	9– 37	10– 29
Total weight	g	6–120	5– 45	6–304	5– 83
Tail weight	g	2– 32	2– 22	2– 80	2– 52

and non-scientific practice to current research, the relationship between these two measures over the complete size range of the animal must be established.

Whilst future legislation may be based on total length or carapace length, Norway lobsters are frequently "tailed" at sea and only the abdomen ("tail") is marketed. It therefore is necessary to have some measure of the abdomen which can be used to relate the marketed parts to the whole animal and the discarded portion.

Scientific work is, in general, based on stock compositions by length. Fishermen and processors are interested in weights, the larger individuals commanding a better price than the smaller. In order to interpret commercial statistics in the light of length data, the relationship between length and weight must be known. A length/weight relationship for Norway lobsters from the Kattegat and Skagerak is given by POULSEN (1946) who treats males, berried and non-berried females together. It seemed desirable to extend the observations of the length/weight relationship so as to treat the sexes separately and to cover additional areas as there may well be regional differences. Moreover, it is necessary to establish the relationship between total weight and tail weight, the latter representing the commercially important component.

In order to study these problems observations were carried out on board the research ships of the Department of Agriculture and Fisheries for Scotland in the Moray Firth during June 1960 and in the Minch during July 1960.

Measurements were made on 266 male and 163 non-berried female Norway lobsters from the Moray Firth and on 483 males and 191 non-berried females from the Minch. The measurements were of overall length (L), carapace length (C), tail width (W), total weight (B) and tail weight (X) over the ranges given in Table 1. Each of these five measurements was recorded for all but a small number of specimens in the samples from both areas. All measurements were made by one observer.

In this paper the relationships between (1) overall length and carapace length, (2) carapace length and tail width, (3) total weight and tail weight and (4) total weight and carapace length are dealt with. The method of analysis was to determine the appropriate regression equation separately for each sex within each area. For every pair of variates there exist two regression equations and in each case attention has been confined to the more important. The regression equations for males and females were then compared within areas and finally the areas themselves were contrasted. Because of the large number of observations available on each variate the data were subdivided into groups and weighted regressions computed from the means of each group. This procedure results in a negligible loss of efficiency in the analysis.

Biometric Relationships

(1) *Carapace length and overall length*

Total length to the nearest millimetre was taken from the tip of the rostrum to the end of the centre plate of the telson with the tail extended, but not stretched, excluding the setae. Only perfect specimens were recorded. Carapace length to the nearest millimetre was measured by caliper as the minimum distance between the inner eye socket and the posterior end of the carapace.

As already pointed out carapace length is the measure preferred for scientific work whereas legislators and fishermen use overall length. It is therefore desirable to determine the relationship giving overall length from carapace length. That is, the regression of overall length (L) on carapace length (C) is required. In neither area was any significant difference between sexes detected. This is in contrast to the relationship between L and C for the lobster *Homarus vulgaris* Edw. which was found by POPE (1955) to differ significantly between the sexes.

The regression equations for males and females combined are:

$$\text{Moray Firth} \quad L = 3{\cdot}063\ C + 7{\cdot}2 \qquad (1a)$$
$$\text{Minch} \quad L = 2{\cdot}993\ C + 10{\cdot}6 \qquad (1b)$$

both L and C being in millimetres. The coefficients of C in these equations do not differ significantly and their pooled value, 3·0043, may be used in both equations. If this is done the constant in the first equation becomes 9·2 while that in the second becomes 10·1; their difference, 0·9, indicates the amount in millimetres by which the overall lengths of Norway lobsters from the Minch exceed the overall lengths of those from the Moray Firth at corresponding carapace lengths from 20 to 75 mm. Whilst it could be that separate races of Norway lobsters have some variation in body proportions this small difference is probably of no biological significance and the regression relationship between overall length and carapace length may be regarded in this case as being independent of the area from which the data were collected. It is preferable, however, for exact work to use the separate adjusted equations (2a) and (2b) for these areas.

$$\text{Moray Firth} \quad L = 3{\cdot}004\ C + 9{\cdot}2 \qquad (2a)$$
$$\text{Minch} \quad L = 3{\cdot}004\ C + 10{\cdot}1 \qquad (2b)$$

These relationships agree very well with that given for data from the Firth of Forth by THOMAS (1954).

For the purpose of estimating carapace length from observations on overall length the following equations should be employed.

$$\text{Moray Firth} \quad C = 0{\cdot}3326\ L - 3{\cdot}05 \qquad (3a)$$
$$\text{Minch} \quad C = 0{\cdot}3326\ L - 3{\cdot}33 \qquad (3b)$$

(2) *Carapace length and tail width*

Various measurements of the exoskeleton of the abdomen were tried out. The most suitable was found to be the maximum width of the second tergum measured by caliper gauge. The exoskeleton of the first abdominal segment is often torn in the process of "tailing" and is too narrow for easy measuring.

The third and posterior terga are pointed at their extremities and directed outwards so that measurement is again difficult. The second abdominal tergum permits easy measurement by caliper gauge. Measurements were recorded to the nearest millimetre.

The regression of carapace length (C) on tail width (W) was chosen for study as this provides a formula for estimating the scientifically required carapace length from a measure of the width of the commercially landed tail. As was to be expected the regressions for males and females differed significantly in both areas, the males having larger average carapace lengths than the females at corresponding tail widths. The difference, as in *Homarus*, is attributable to the broadening of the abdomen associated with carrying of the eggs on the pleopods.

Area comparisons of the regressions were made separately for males and females. No significant difference was found in the case of males. The equations for the two areas calculated using a common coefficient for W are identical. The equation is:

$$\text{Moray Firth and Minch} \qquad \text{Males } C = 2{\cdot}055\ W - 0{\cdot}8 \qquad (4a)$$

Analysis of the regressions for females revealed a statistically significant difference between areas, Norway lobsters in the Minch having slightly larger carapace lengths than those from the Moray Firth, the difference being the same at all tail widths. As the difference amounts to only 0·4 mm it is of little practical significance but it is preferable that separate equations for the two areas be used for precise work. These equations are:

$$\text{Moray Firth} \qquad \text{Females } C = 1{\cdot}707\ W + 2{\cdot}3 \qquad (5a)$$
$$\text{Minch} \qquad \text{Females } C = 1{\cdot}707\ W + 2{\cdot}7 \qquad (5b)$$

(3) *Body weight and tail weight*

Body weight and tail weight were recorded to the nearest gramme by means of a spring balance. No berried females were sampled. The more important regression here is that giving body weight from tail weight. A sex difference in this regression was expected and confirmed, the total weight of the male Norway lobster being greater for a given tail weight than that of the female. That is the tail weight represents a higher proportion of total weight in the female than in the male.

No significant area difference between the male regression equations was found. Indeed the equations for the two areas were identical, being:

$$\text{Moray Firth and Minch} \qquad \text{Males } B = 3{\cdot}231\ X - 0{\cdot}9 \qquad (6)$$

The equations for females on the other hand did differ significantly. For a tail weight of 5 g the total weights were the same in both areas but the Minch specimens became increasingly heavier than those from the Moray Firth with increasing tail weight, the difference amounting to 5 g for a tail weight of 25 g. The two regression equations are:

$$\text{Moray Firth} \qquad \text{Females } B = 2{\cdot}727\ X + 1{\cdot}6 \qquad (7a)$$
$$\text{Minch} \qquad \text{Females } B = 2{\cdot}990\ X + 0{\cdot}2 \qquad (7b)$$

Table 2

Regression equations calculated from combined data on *Nephrops norvegicus* (L.)

Measurements	Males	Females
Overall length/carapace length	$L = 3{\cdot}004\ C + 9{\cdot}8$	$L = 3{\cdot}004\ C + 9{\cdot}8$
Carapace length/overall length	$C = 0{\cdot}3326\ L - 3{\cdot}22$	$C = 0{\cdot}3326\ L - 3{\cdot}22$
Body weight/tail weight	$B = 3{\cdot}231\ X - 0{\cdot}9$	$B = 2{\cdot}915\ X + 0{\cdot}6$
Body weight/carapace length	$B = 0{\cdot}0003221\ C^{3{\cdot}207}$	$B = 0{\cdot}0006840\ C^{2{\cdot}963}$

(4) *Total weight and carapace length*

The relationship between total weight and carapace length is not a linear one, the weight rising more rapidly than the length. Regression equations of the form $B = aC^b$ were fitted to the data using logarithms. There were significant differences between sexes in both areas, the males being heavier than the females at corresponding lengths. This was as noted by POULSEN (1946).

There was also a significant difference between the relationships for males in the two areas but not for females. At a carapace length of 20 mm the total weights of the Minch and Moray Firth male Norway lobsters were equivalent but at a carapace length of 50 mm the males from the Moray Firth weighed 6 g more than those from the Minch.

The equations for males are, in terms of logarithms to the base 10

Moray Firth	Males $\log B = 3{\cdot}321\ \log C - 3{\cdot}660$	(8a)
Minch	Males $\log B = 3{\cdot}204\ \log C - 3{\cdot}492$	(8b)

In terms of the original measurements these are:

Moray Firth	Males $B = 0{\cdot}0002188\ C^{3{\cdot}321}$	(8c)
Minch	Males $B = 0{\cdot}0003221\ C^{3{\cdot}204}$	(8d)

The equations for the females are almost identical and one equation will serve for both areas. It is:

Moray Firth and Minch	Females $\log B = 2{\cdot}963\ \log C - 3{\cdot}165$	(9a)

or, in terms of the original measurements:

Moray Firth and Minch	Females $B = 0{\cdot}0006840\ C^{2{\cdot}963}$	(9b)

(5) *Combined results for Moray Firth and Minch*

Norway lobster grounds as widely separate as the Moray Firth and Minch may well support discrete racial stocks. It would not be surprising to find small differences in body proportions between these areas. In fact, however, even where significant differences exist they are small and for most practical purposes an equation based on the combined data from these two areas would appear to be acceptable for Scottish stocks in general. Such formulae are given in Table 2.

Apart from area differences the length/weight data must be treated with some reserve since the observations were all taken in June and July and it could well be that there exists a seasonal variation in this relationship.

Table 3

Regressions of overall length on carapace length for *Nephrops norvegicus* (L.) from different areas

Area	Source	Regression equation
England	GROVE & COLE (1960)	$L = 3{\cdot}0\ C + 5{\cdot}5$*
Faeroes	ANDERSEN (1962)	$L = 2{\cdot}2\ C + 0{\cdot}7$
Ireland	O'RIORDAN (1964)	$L = 3{\cdot}2\ C - 1{\cdot}0$
Portugal	FIGUEIREDO & BARRACA (1963)	$L = 3{\cdot}1\ C + 11{\cdot}1$
Scotland	This paper	$L = 3{\cdot}0\ C + 9{\cdot}8$

*Eye-fitted line (see text).

Comparison with Other Results

With a geographical range as wide as that of the Norway lobster, and having regard in particular to the discontinuity of its distribution, area differences in biometric relationships could well exist. Relationships between carapace length and overall length have been studied for specimens taken in Portuguese, Irish, English and Faeroese waters and it is of interest to compare results for these areas with those quoted here for Scottish waters.

FIGUEIREDO and BARRACA (1963) and O'RIORDAN (1964) quote explicit equations for Portuguese and Irish waters respectively. These equations, which are for both sexes combined, are given in Table 3.

ANDERSEN (1962), who deals with *Nephrops* from Faeroese waters, does not give equations relating carapace and overall length but does give data from which such equations may be calculated. The regression of overall length on carapace length for both sexes combined, adjusted to allow for the fact that his measurements are to the unit below, is also given in Table 3.

GROVE and COLE (1960) give a figure showing the relationship between carapace and overall length from measurements made at English markets. The present authors have fitted a line by eye to their points and its equation is shown in Table 3.

Accurate comparison of the equations in Table 3 is not, of course, possible but, although they appear to differ, in fact these lines lie very close to each other with the exception of the regression line for Faeroes. There seems little doubt therefore that the relationship between overall and carapace length is similar in all these areas with the likely exception of that for Faeroes where, according to ANDERSEN's data, overall length is several centimetres smaller than in other areas at corresponding carapace lengths.

For all areas, except the Faeroes, conversion from carapace length to overall length may be made quickly and with reasonable accuracy using the relationship $L = 3{\cdot}1\ C + 6{\cdot}5$.

Summary

1. Measurements of overall length (L), carapace length (C), tail width (W), total weight (B) and tail weight (X) were made on 266 male and 163 non-berried female Norway lobsters from the Moray Firth and on 483 males and 191 non-berried females from the Minch.

2. Relationships between certain pairs of these measurements were estimated and the significance of area and sex differences studied.

3. No sex difference was found in the relationship between C and L, but there was a small area difference. A sufficiently accurate relationship for estimating L from C for both areas was obtained, viz. $L = 3{\cdot}004\ C + 9{\cdot}8$.

4. Sex differences were found in the relationships between C and W, B and X and B and C and in some cases there were also area differences.

5. The relationship between C and L for these data was compared with ones available for English, Irish, Portuguese and Faeroese stocks. The relationship was found to be very similar in all areas except the Faroes.

References

ANDERSEN, F. S., 1962. "The Norway lobster in Faeroe waters". Meddr Danm. Fisk.- og Havunders., N.S., **3**: 265–326.

FIGUEIREDO, M. and BARRACA, I. F., 1963. "Contribuição para o conhecimento da pesca e da biologia do lagosrim, *Nephrops norvegicus* (L.), na losta portuguesa". Notas Estud. Inst. Biol. mar., Lisb., (28) 48 pp.

GROVE, D. J. and COLE, H. A., 1960. "The market measurements of *Nephrops norvegicus* landed as 'tails only' ". ICES CM 1960. Shellfish Committee, Doc. No. 227 (mimeo.), 3 pp.

O'RIORDAN, C., 1964. "*Nephrops norvegicus*, The Dublin Bay prawn, in Irish waters". Scient. Proc. R. Dubl. Soc., Ser. B, **1**: 131–57.

POPE, J. A., 1955. "Body-form and weight-length relationships in the lobster (*Homarus vulgaris* Edw.)." ICES CM 1955. Shellfish Committee, Doc. No. 70 (mimeo.), 4 pp.

POULSEN, E. M., 1946. "Investigations on the Danish fishery for and the biology of the Norway lobster and the deep-sea prawn". Rep. Dan. biol. Stn, **48**: 27–49.

THOMAS, H. J., 1954. "Some observations on the distribution, biology and exploitation of the Norway lobster, *Nephrops norvegicus* (L.) in Scottish waters". Mar. Res., (1) 12 pp.