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Report of Working Group on Methods Used in North Sea Herring Investigations

Hamburg, 5th and 7th May 1962

Introduction

In accordance with the recommendation of the Herring Committee at its 1961 meeting in Copenhagen (Recommendation No. B1 in Report of Committee), a Working Group, comprising North Sea herring workers, met for two days in Hamburg on 5th and 7th May 1962 to make an appraisal of some of the routine methods used in North Sea herring research with special reference to:-

(a) comparing the criteria, dimensions and methods used by different workers.

(b) where possible, arriving at a greater degree of standardisation in the criteria, dimensions and methods used in routine studies, and in the reporting of data.

Participation

The following representatives, from nine member countries, participated in the meetings of the Working Group:-

B. B. Parrish (Convener)	Scotland
Ch. Gilis	Belgium
K. Popp Madsen	Denmark
K. P. Andersen	Denmark
D. H. Cushing	England
A. C. Burd	England
C. Nédélec	France
K. Schubert	Germany
G. Krefft	Germany
G. Hempel	Germany
Mrs. H. Bohl	Germany
A. Schumacher	Germany
K. Postuma	Netherlands
O. J. Østvedt	Norway
A. Saville	Scotland
H. Höglund	Sweden

In addition, Dr. O. J. Nawratil of the Hydrobiologische Anstalt der Max-Planck Ges., Plon, Germany, and Dr. R. Lasker of the U.S. Fish and Wildlife Service Laboratory, La Jolla, California, attended some of the meetings of the Group.

Objectives

The following routine methods were examined:-

(a) Length measurement

(b) The estimation of maturity stages

(c) Age determination

(d) The calculation of growth from scales and otoliths.

In addition, the Group dealt briefly with the general problem of sampling, with special reference to sampling for length and age, and the reporting of sampling data.

In its treatment of these items the Working Group took note of the recommendations passed by the Atlanto-Scandian "Methods" Working Group at an earlier meeting in Bergen, as given in the "Report on Meeting on Scale and Otolith Typing and other Methods in Atlanto-Scandian Herring Research".

1. Length Measurement

A survey was first made of the length dimensions measured, the grouping of measurements in routine reporting and the source and "state" of the samples in each participating country. These are given in Table 1 (page 6).

The Working Group noted that there are some important differences between countries in their published length data. After detailed consideration of the main uses to which routine length data are put, in international herring work, and of the special need for comparability of routine length composition data it passed the following recommendations:-

(a) The dimension used in routine length sampling should be TOTAL LENGTH, measured from the tip of the snout to the longest caudal fin ray, when the lobes of the tail are held in the mid line.

(b) Published length composition data should be in $\frac{1}{2}$ cm grouping intervals, and should be to the $\frac{1}{2}$ cm BELOW (e.g. fish measuring between 2o.o and 2o.4 cm should be reported as 2o cm; those between 2o.5 and 2o.9 as 2o.5 cm, etc.) The number of observations should always be given along with the length composition data.

(c) All published MEANS of length compositions should, however, be adjusted to the TRUE MEAN (e.g. if derived from routine sample data grouped to the $\frac{1}{2}$ cm below, o.25 cm should be added to the calculated value).

(d) The published means should always be accompanied by the number of observations and the VARIANCE, to 4 places of decimals, but unadjusted by "Shepherd's" correction.

(e) In the light of evidence presented to the Working Group, on the change in length with treatment after capture, all countries should in reporting length composition data specify the source (e.g. market; research vessel) and type of treatment or storage (e.g. fresh; iced; frozen; etc.) of the samples. Countries are also urged to undertake experiments to determine the changes in length caused by the treatments or storage methods used in their fisheries.

2. Maturity Stages

Information presented by the participants showed that the maturity scales used in North Sea herring research differ between countries. Belgium, Netherlands and Scotland use the Hjort (191o) scale (or a modification of it), Denmark and Norway use the Johansen (1919) scale, and England, Germany and Sweden use modifications of the Heinke (1898)scale.

The most important differences between these scales arise in the descriptions and use of stages II, VII-II and VIII.

The Group considered that the scales used in most countries were deficient in not distinguishing between recovering spents and maturing virgin spawners, and it agreed that a standard scale, which distinguished between them in the early stages of maturation should be adopted in routine North Sea herring work. The scale drawn up for the Atlanto-Scandian herring (see "Report on Meeting on Scale and Otolith Typing and Other Methods in Atlanto-Scandian Herring Research") was examined in detail, and the Group concluded that it met the requirements for North Sea herring. It therefore recommends that this scale be adopted by all North Sea herring workers. The scale, with a description of the stages for fresh material is as follows:-

Maturity Scale

Description

Stage	
I	Virgin herring. Gonads very small, threadlike, 2-3 mm broad. Ovaries wine red. Testes whitish or grey brown.
II	Virgin herring with small sexual organs. The height of ovaries and testes about 3-8 mm. Eggs not visible to naked eye but can be seen with magnifying glass. Ovaries a bright red colour; testes a reddish grey colour.
III	Gonads occupying about half of the ventral cavity. Breadth of sexual organs between 1 and 2 cm. Eggs small but can be distinguished with naked eye. Ovaries orange; testes reddish grey or greyish.
IV	Gonads almost as long as body cavity. Eggs larger, varying in size, opaque. Ovaries orange or pale yellow; testes whitish.
V	Gonads fill body cavity. Eggs large, round; some transparent. Ovaries yellowish; testes milkwhite. Eggs and sperm do not flow, but sperm can be extruded by pressure.
VI	Ripe gonads. Eggs transparent; testes white; eggs and sperm flow freely.
VII	Spent herring. Gonads baggy and bloodshot. Ovaries empty or containing only a few residual eggs. Testes may contain remains of sperm.
VIII	Recovering spents. Ovaries and testes firm and larger than virgin herring in Stage II. Eggs not visible to naked eye. Walls of gonads striated; blood vessels prominent. Gonads wine red colour. (This stage passes into Stage III).

This scale, and the description of the stages is based on the Johansen (1919) scale, but differs from it and the other scales used hitherto, in allocating separate stages to early maturing virgin fish (Stage II) and recovering spents (Stage VIII).

A paper on "The duration of maturity stages of spring, autumn and winter spawning herring" by Mr. T. D. Iles of the Lowestoft Laboratory, giving the results of investigations on the rates of maturation and duration of the maturity stages in a number of herring spawning groups in the North Sea and elsewhere was examined by the Working Group. In particular, note was taken of the conclusion in the paper that the principal difference between the maturation cycles of North Sea "Bank" and "Downs" spawners is in the duration of Stage V. This has an important bearing on the use of maturity data in investigating the mixing of spawning groups during the prespawning phase (see report of North Sea Working Group). It was therefore agreed that all countries should examine their maturity data from the point of view of maturation rate and the duration of the maturity stages and, where possible, should present their results to the meeting of the Herring Committee in 1962.

3. Age Determination

The skeletal structures used for age determination and the age reference used in recording and reporting age data in the participating countries are given in Table 2 (page 7).

It is evident that both scales and otoliths are used for routine age determination in North Sea herring investigations; in Belgium, France, Norway and Sweden only scales are used; in Scotland only otoliths[1], while in Denmark, England, Germany and Netherlands both scales and otoliths are used.

As a guide to the comparability of the age readings, made by different countries, from scales and otoliths, the Working Group examined the results of comparative readings made in Denmark, England, Germany, Netherlands and Scotland on samples taken from the north-western North Sea, the Dogger area and East Anglia respectively. The results of a statistical analysis of these data, kindly undertaken for the Group by Mr. K. P. Andersen (Denmark), are given in the Appendix.

These results show that in general the agreement between the age readings made in the five countries from both scales and otoliths was good, thus suggesting a satisfactory level of comparability between their routine age composition data. However, the readings from otoliths tended to be slightly higher, on average, than those from scales, especially amongst the older age groups. This result is in general accordance with those of earlier comparative age reading studies of herring and other species [2], and it was the view of a number of the participants that the otolith gives the more reliable readings for herring older than 5-6 years of age.

It is also evident from Table 2 that the age reference used in reporting routine age composition data differs between countries. In some, it is measured in terms of winter rings, and in others in terms of summer growth zones; further, in publishing their age composition data some countries record the year-classes as well as the age while others do not. The Working Group agreed that in routine reporting of age data it is necessary to adopt an unambiguous age reference, and it therefore recommends that YEAR-CLASSES should always be specified together with the age, measured either in terms of winter rings or summer zones. It also recommends that, whenever data at the top of the age scale (i.e. all readings above a specified age) are grouped together, the symbol + should be used. /E.g. the grouping together of fish older than 8, would be referred to as 8+, and the age table would read 0, 1, 2, 3, 4, 5, 6, 7, 8, 8+/.

A paper describing "A New Method to Determine the Age of some Clupeoids" by O. J. Nawratil, was considered in some detail by the Working Group. This method is based on the relation between scale size (from a particular part of the body), length and age. Investigations of the relationship for Sardinops ocellata, Clupea harengus and Sardina pilchardus had shown that:-

(a) for fish of a given length and age, the variation in scale size between individuals is small.

(b) scale sizes differ significantly between ages.

(c) fish of the same size but different ages have significantly different scale sizes.

It was agreed that the method held great promise for species for which age determination by "normal" methods is difficult (e.g. many tropical species). However, its effectiveness is governed by the availability of well scaled fish; these are often scarce amongst samples taken from the North Sea herring trawl fisheries. As a next step in determining its possible use in North Sea herring investigations, Dr. Nawratil offered to examine the scale size-fish length and age relationships for Buchan, Dogger and Channel spawners.

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1) Up to 1952 age readings were made exclusively from scales; in 1952 otolith readings was introduced and between 1952 and 1955 both scales and otolith readings were taken, but since 1955 routine age reading has almost been exclusively from otoliths.

2) See for example pp. 169-17o in "Some Problems for Biological Fishery Survey and Techniques for their Solution". A Symposium held at Biarritz, March 1-1o, 1956". Special ICNAF publication, No.1, 1958.

4. Growth Calculations from Skeletal Structures

The skeletal structures and method used in making growth calculations in the participating countries, and the length scales used in reporting their l_1 and other growth data are given in Table 3 (page 7).

These data show that the methods used in growth studies in the participating countries are similar. In all countries, except Sweden, the technique is based on Lea's projection method, and in all except Norway, no corrections are applied to the calculated l_1 value.

In order to determine the comparability of l_1 data obtained by workers in different countries the Working Group examined the results of comparative readings made by workers in Denmark, England, Germany, Netherlands and Scotland on the selected scale samples from the north-western North Sea, Dogger and East Anglia. Again, a statistical analysis of these data was made by Mr. K. P. Andersen, the results of which are given in the Appendix.

As with age readings, these results show generally good agreement between the readings obtained by the different countries. However, the analysis showed that there was a systematic difference between the readings taken by some of the countries; the English readings tended to be lower and the Netherlands higher than the average. It was agreed that the workers in these countries should make further comparative studies and examine their techniques with a view to determining the origin of these differences.

Table 3 also shows that, as with length measurements, the reporting of l_1 data differs between countries. In publishing l_1 distributions, some countries report their readings to the $\frac{1}{2}$ cm or cm below, while others report them to the nearest $\frac{1}{2}$ cm or cm. However, in all cases, the means of distributions are given as the "true" means.

The Working Group agreed that uniformity in the reporting of l_1 and other growth data in North Sea herring investigations is necessary, and it recommends that when publishing l_1 (l_2, l_3, etc.) distributions, all workers should use $\frac{1}{2}$ cm grouping intervals, and these should refer to the $\frac{1}{2}$ CM BELOW [e.g. l_1's between 10.0 and 10.4 should be reported as 10.0; those between 10.5 and 10.9 as 10.5 etc.] It also recommends that all means should be given as TRUE MEANS (i.e. adjusted for the grouping interval).

The results of preliminary studies in Denmark, Netherlands and Scotland on the use of the otolith in growth studies were presented to the Group. A striking feature of these results was the systematically higher l_1's determined from otoliths than those obtained from scales from the same fish. It was agreed that those countries undertaking these studies should examine closely the relations between the dimensions of both otoliths and scales and the length of the fish, with a view to determining the origin of this difference and the relative merits of these two structures in growth studies.

5. Sampling Methods

The Working Group considered briefly the general problem of sampling for length, age, maturity and meristic characters in the light of a written contribution "Errors in Sampling" prepared by Mr. A. C. Burd of the Lowestoft Laboratory, which paid special attention to the possible sources of bias and error in sampling. It also emphasized the important distinction between random spot sampling (e.g. by research vessels) in an area, and intensive, systematic sampling of a fishery.

The Working Group recognised the great importance of the problems raised in this contribution, and recommends that the Herring Committee give them detailed consideration at its next meeting. It was agreed that Mr. Burd's paper should be available as a meeting document for this purpose.

6. Units of Weight used in Herring Fisheries

A number of different weight (or volume) measures are used in the herring fisheries in different European countries. These, together with the sizes of the baskets or boxes used in the fisheries or on research vessels, in the participating countries, are given in Table 4 (page 8).

Table 1. Length Measurements

Country	Dimension	Source and State of fish	Recording of Measurements	Reporting of Measurements
Belgium	Total length:- snout to longest caudal fin ray	Sandettié - fresh Other areas - iced	to nearest mm	to cm below
Denmark	Total length:- as Belgium	Market - fresh, unfrozen Research vessel- fresh, after rigor mortis	Routine market: to $\frac{1}{2}$ cm below Detailed examination: to nearest mm	to cm below (plan to change to $\frac{1}{2}$ cm below)
England	Total length:- longest fin ray, but tail in normal position	Fresh or lightly iced	Routine market: to cm below Detailed examination: to nearest mm	to cm below
France	Total length:- as Belgium	Fresh or iced	Routine market: to cm below Detailed examination: to nearest mm	to nearest cm
Germany	Total length:- as England	Market - iced Research vessel - fresh or frozen	Routine market: to cm below Detailed examination: to nearest mm	to cm below
Netherlands	Total length:- as Belgium	Market - iced or salted (corrections applied) Research vessel - fresh	Routine market: to nearest cm Detailed examination: to nearest mm	to nearest cm
Norway	Total length:- snout to line drawn vertically between flukes of tail	Fresh or iced	to nearest $\frac{1}{2}$ cm	to nearest $\frac{1}{2}$ cm
Scotland	Total length:- as Belgium	Fresh, iced or frozen	to nearest mm	to neare[illegible] cm
Sweden	Total length:- snout to tip of ventral lobe of caudal fin	Fresh or iced	Routine market: to nearest $\frac{1}{2}$ cm Detailed examination: to nearest mm	to nearest $\frac{1}{2}$ cm

Table 2. Age Determination

Country	Structure used	Age reference
Belgium	Scales	Summer zones (years)
Denmark	Scales and otoliths (age determined independently from each)	Winter rings (birthday taken as 1st of January)
England	Scales and otoliths	Summer zones (years) and year-class
France	Scales	Summer zones (years)
Germany	Scales and otoliths	Summer zones (years) but changing to winter rings and year-class
Netherlands	Scales and otoliths	Summer zones and year-class
Norway	Scales	Summer zones (birthday: 1st January)
Scotland	Otoliths	Winter rings and year-class (birthday: 1st April)
Sweden	Scales	Winter rings and year-class

Table 3. Growth Calculations

Country	Structure used	Method of Measurement	Corrections applied	Grouping interval used in reporting frequency data
Belgium	Scales	Projector + proportion apparatus (Lea type)	None	-
Denmark	Scales	Projector + proportion apparatus (direct from projection)	None	$\frac{1}{2}$ cm (below) or 1 cm (nearest)
England	Scales	Projector + Lea apparatus	None	1 cm (below)
Germany	Scales	Projector + Lea apparatus	None	1 cm (below)
France				
Netherlands	Scales	Projector (vertical) + reading apparatus (as in Denmark)	None	1 cm (nearest)
Norway	Scales	Projector + Lea apparatus	1 cm, incorporated in reading apparatus	-
Scotland	Scales	Projector (vertical) + Lea apparatus	None	1 cm (nearest)
Sweden	Scales	Microscope with micrometer eyepiece	None	$\frac{1}{2}$ cm (nearest)

Table 4. Unit Measure

Country	Unit measure	Equivalent in kilograms	Size of basket or box
Belgium	Kilogramme	1	basket 5o kg
Denmark	Kilogramme	1	basket 5o kg
England	Cran (3.5 cwts)	178	basket (7 stones) = 45 kg
France	Kilogramme	1	-
Netherlands	Kantje	1oo	a) Market: box = 5o kg b) Research vessel: basket = 3o kg
Germany	a) Kilogramme b) Dopplezentner c) Kantje d) Kisten (Box) (i) Trawlers (ii) Luggers	1 1oo 1oo 5o 35	Research vessel: basket: 5o kg.
Norway	Hectolitre	93	hectolitre = 93 kg
Scotland	Cran (3.5 cwts.)	178	a) box = 44.5 kg b) basket =(variable)
Sweden	a) Kilogramme b) Hectolitre c) Box (= ½ hectolitre)	1 9o 45	Box (½ hectolitre) = 45 kg

Note The Swedish and Norwegian hectolitres differ in weight by 3 kg.

APPENDIX

An Analysis of Comparative Age, L_1, L_2, and Otolith Type Data

by

Knud P. Andersen

The data used in this analysis resulted from an examination of six North Sea herring samples by Danish, German, English, Dutch, and Scottish workers in preparation for the meeting of the ICES' North Sea Herring Methods Working Group.

Since the results of the examinations were circulated to the participants in advance of the meeting, the full details are not presented here; only extracts are given in Tables 1-3.

1. L_1 measurements

In the calculation only fish with all five L_1 determinations are utilised because the high number of missing values would make a statistical treatment of the whole material very time-consuming and complicated. In Table 1 the data used in the analysis are given. A few additional values have been discarded, as it was obvious that different rings had been used for the L_1 determinations in the five countries. The following mathematical model has been used: The L_1 measurements are supposed to have the following form:-

$$L_{1,i,j,k} = \lambda_{1,k} + f_{i,k} + c_{j,k} + \varepsilon_{i,j,k}. \qquad \text{(i)}$$

where 1) λ, f and c are constants, 2) i refers to the individual fish, 3) j refers to the country, 4) k refers to the area (the 6 samples consist of two from each of three areas), 5) the ε's are stochastic components.

This model is a so-called two-way classification. If it is demanded that $\sum f = \sum c = 0$, $\lambda_{1,k}$ will be the mean L_1 for the area k.

It is further supposed that 6) the ε's are all independent and normally distributed $(0, \sigma_k)$.

The sum of squares $\sum L_{1,i,j,k}^2$ for an area can now be split up in the following way:-

$\sum L_{1,i,j,k}^2$ = (contribution from the mean) +
(contribution from the f's) +
(contribution from the c's) +
remainder

or in a specified form

Contribution from the mean	A	$= (\sum L_{1,i,j,k})^2 / r \cdot s$
Contribution from the f's	B	$= \sum^{r} (\sum^{s} L_{1,i,j,k})^2 / s - A$
Contribution from the c's	C	$= \sum_{j=1}^{s} (\sum_{i=1}^{r} L_{1,i,j,k})^2 / r - A$
Remainder	D	$=$ Total $- (A + B + C)$
Total		$\sum L_{1,i,j,k}^2$

(r = number of fish, s = number of countries).

The expectations and degrees of freedom of the sums of squares are:-

	expectation	df (degrees of freedom)
Contribution from the mean	$r \cdot s \cdot \lambda^2_{1,k} + \sigma_k^2$	1
Contribution from the f's	$(r-1)\sigma_k^2 + s(r-1)\sigma_f^2$	r - 1
Contribution from the c's	$(s-1)\sigma_k^2 + r(s-1)\sigma_c^2$	s - 1
Remainder	$(r-1)\ (s-1)\ \sigma_k^2$	(r-1) (s-1)

where $\sigma_f^2 = \sum f^2 / r-1$ and $\sigma_c^2 = \sum c^2 / s-1$

The expectations of the mean squares are:-

Mean	$\sigma_k^2 + r\,s\,\lambda^2_{1,k}$
f	$\sigma_k^2 + s\ \sigma_f^2$
c	$\sigma_k^2 + r\ \sigma_c^2$
Remainder	σ_k^2

The hypothesis $c_1 = c_2 = \ldots\ldots\ldots\ldots = c_s = 0$ can now be tested by means of

$$v^2 = \frac{c \quad \text{mean square}}{\text{Remainder mean square}}$$

which, according to the hypothesis is v^2 distributed with s - 1 and (r-1) (s-1) degrees of freedom, and this test is independent of the values of the f's. The proposed model is not fulfilled for all data in Table 1, as the Danish measurements are to the halfcentimeter below, whereas all other measurements are to the nearest millimeter. The Danish measurements are therefore excluded from the analysis of variance shown here:-

1. Area 1 (Samples 14 E A 61 and 18 E A 61)

Contribution from	df	Sum of squares	Mean square	v^2
Mean	1	2,o42,362.o6		
f's	39	71,751.69		
c's	3	471.52	157.17	15.o3
Remainder	117	1,223.73	1o.459	
Total	16o	2,115,8o9.oo		

2. Area 2 (Samples H 43 ÷ H 44)

Contribution from	df	Sum of squares	Mean square	v^2
Mean	1	1,3o5,224.13		
f's	16	43,487.12		
c's	3	133.22	44.4o7	7.82
Remainder	48	272.53	5.6777	
Total	68	1,349,117.oo		

3. Area 3 (Samples FR 22/7-58 and FR 16/8-58)

Contribution from	df	Sum of squares	Mean square	v^2
Mean	1	3,392,957.61		
f's	44	1o1,9o4.64		
c's	3	296.59	98.863	9.o6
Remainder	132	1,44o.16	1o.91o	
Total	18o	3,496,599.oo		

The three v^2-values are all highly significant, and the hypothesis $c_1 = c_2 = c_3 = c_4$ therefore is strongly rejected.

The next table shows the c-values for the three localities:-

	EA	H	FR
c_1 (Germany)	+o.o7	-o.13	-o.31
c_2 (England)	-2.5o	-2.o1	-1.76
c_3 (Netherlands)	+2.34	+1.93	+1.8o
c_4 (Scotland)	+o.1o	+o.22	+o.35

The c-values are very consistent and for the three variances Bartletts Test gives $\chi^2 \approx 7.01$ with two degrees of freedom, which gives $5\% > p > 2.5\%$. It is in this way reasonable to pool the data. If we do so we get a new analysis of variance:-

Contribution from	df	Sum of squares	Mean square	v^2
Mean	1	6,681,344.41		
f's	1o1	276,342.84		
c's	3	877.o9	292.36	29.92
Remainder	3o3	2,96o.66	9,7712	
Total	4o8	6,961,525.oo		

and the following c-values:-

c_1 (Germany):	-o.17
c_2 (England):	-2.1o
c_3 (Netherlamds):	+2.o3
c_4 (Scotland):	+o.23

The difference between two c's has the variance $2\sigma^2 / 102 \approx 2 \times 0.7712 / 102 = 0.19159 = (0.43771)^2$ and confidence limits can now be calculated for the differences:-

	Δc	95% Confidencelimits
Germany - England	+1.93	[+1.o7, +2.79]
Germany - Netherlands	-2.2o	[-3.o6, -1.34]
Germany - Scotland	-o.4o	[-1.26, +1.46]
England - Netherlands	-4.13	[-4.99, -3.27]
England - Scotland	-2.33	[-3.19, -1.47]
Netherlands - Scotland	+1.8o	[+o.94, +2.66]

If we calculate c_0 (Denmark) and correct for measuring to the half-centimeter below we get:-

c_0	(Denmark)	:	+1.07
c_1	(Germany)	:	-0.44
c_2	(England)	:	-2.37
c_3	(Netherlands)	:	+1.76
c_4	(Scotland)	:	-0.04

Denmark - Germany	+1.51
Denmark - England	+3.44
Denmark - Netherlands	-0.69
Denmark - Scotland	+1.11

2. L_2 measurements

In Table 2 are given the L_2 measurements in the same way as the L_1 measurements in Table 1 and we get the following analysis of variance.

Area 1. (Samples 14 E 61 + 18 E A 61)

Contribution from	df	Sum of squares	Mean square	v^2
Mean	1	5,674,597.30		
f's	36	28,805.20		
c's	3	356.59	118.86	10.76
Remainder	108	1,192.91	11.046	
Total	148	5,699,952.00		

Area 2. (Samples H 43 and H 44)

Contribution from	df	Sum of squares	Mean square	v^2
Mean	1	3,005,455.64		
f's	15	25,947.61		
c's	3	36.92	12,307	1,45
Remainder	45	382.83	8.5073	
Total	64	3,031,823.00		

Area 3. (Samples F R 22/7 and F R 16/8-58)

Contribution from	df	Sum of squares	Mean square	v^2
Mean	1	7,892,327.53		
f's	42	61,157.47		
c's	3	262.47	87.490	18.60
Remainder	126	592.53	4.7026	
Total	172	7,954,340.00		

The v^2 values are highly significant for Area 1 and 3 but not significant for Area 2. A calculation of the c's gives:-

	Area 1	Area 2	Area 3
c_1 (Germany)	-o.78	-o.95	-1.51
c_2 (England)	-1.59	-o.14	-o.88
c_3 (Netherlands)	+2.54	+1.18	+1.49
c_4 (Scotland)	-o.16	-o.o8	+o.91

Even if these figures look less consistent than the corresponding L_1 values, there are nevertheless satisfactory agreement. The variances on the other hand, are not in agreement as Bartletts Test gives $\chi^2 \approx 21.13$ with 2 degrees of freedom and $P \ll$ o.o5%. It is, therefore, not wise to pool the data but we can find mean $(c_i - c_j)$'s by using the weights $r_k : 2\sigma_k^2$, which are the reciprocal of the variance of $c_i - c_j$. This procedure gives, taking the corrected Danish data into account:

		95% confidence interval
Denmark-Germany	+o.62	([-o.13, +1.37])
Denmark - England	+o.32	([-o.43, +1.o7])
Denmark - Netherlands	-2.35	([-3.1o, -1.6o])
Denmark - Scotland	-1.19	([-1.94, -o.44])
Germany - England	-o.3o	[-1.o5, +o.45]
Germany - Netherlands	-2.97	[-3.72, -2.22]
Germany - Scotland	-1.81	[-2.56, -1.o6]
England - Netherlands	-2.67	[-3.42, -1.92]
England - Scotland	-1.51	[-2.26, -o.76]
Netherlands - Scotland	+1.16	[+o.41, +1.91]

The confidence interval is found as $2 \cdot s$, where $1 : s^2 = \sum r_k : 2s_k^2$ This procedure is not quite correct for the Danish figures as mentioned before, but the approximation is reasonably good.

For the c-values we get:-

c_0 (Denmark)	-o.52
c_1 (Germany)	-1.14
c_2 (England)	-o.84
c_3 (Netherlands)	+1.83
c_4 (Scotland)	+o.67

Discussion

From the above analysis of variance it is quite clear that there exist highly significant differences between countries. The differences are consistent for the L_1 and L_2 measurements respectively. For comparing the L_1 and L_2 measurements Figure 1 has been drawn, which gives the $(c_i - c_j)$'s and the confidence limits. As the fish lengths were given one should expect differences between L_1 and L_2 measurements, if L_1 differences between countries exist, but the sort of differences to be expected would be a sort of similarity, the L_2 countries differences values being the smaller ones. The L_2 values are the smaller ones, but the picture is not one of similarity. There are in fact specific L_1 differences and specific L_2 differences. As regards the variances, which are estimates of the measuring error, they are of the order of magnitude of 1o $mm^2 \approx (3mm)^2$ and compare well with the estimates found by Burd (personal communication), but it has to be borne in mind that only the best scales have been used in the calculations, so that the variance found is certainly an underestimate of the true measuring error.

3. Age Determination

For the scale and otoliths readings the following model is being used:-

If $\underline{a}$ is the correct reading of a scale (otolith) there is a probability P_i' for determining the age as a-1, P_i'' for a+1, and $1-P_i' - P_i''$ for $\underline{a}$. Here i refers to countries and it is supposed that P is independent of age.

A reading x_{ijk} can then be written as:

$$x_{ijk} = a_{jk} + \varepsilon_{ijk}$$

where a_{jk} is the correct age of the j'th fish from sample no. K, and ε is a discrete stochastic variable with mean $P_i'' - P_i'$ and variance $P_i' + P_i'' - (P_i'' - P_i')^2$ which approximates to $P_i' + P_i''$, if $P_i'' - P_i'$ is small.

If n_k fish from sample k have been used for age determination, the estimated mean age will be:-

$$\bar{x}_{ik} = \frac{\sum a_{jk}}{n_k} + \frac{\sum \varepsilon_{ijk}}{n_k} = \frac{\sum a_{jk}}{n_k} + P_i'' - P_i' + \frac{\sum \eta_{ijk}}{n_k}$$

where η_{ijk} has mean 0 and variance $P_i' + P_i''$ (app.). If all n_k's are equal, all $(P_i' + P_i'')$ are equal, and $\sum (P_i'' - P_i') = 0$, then the mean ages for sample no. k can be written as:-

$$\bar{x}_{ik} = \bar{a} + S_k + (P_i'' - P_i') + \delta_{ik}$$

where $\bar{a}$ is the mean ages of all fishes, S_k a sample difference with $\sum S_k = 0$, and δ_{ik} is a stochastic variable approximately normally distributed

$$\left(0, \sqrt{\frac{P' + P''}{n_k}}\right) \quad \text{(The central limit theorem).}$$

In the following analysis only fish which have got both a scale and an otolith age reading have been used. The numbers of these fish are not constant for the six samples, but very nearly so. (The numbers are in fact 42, 46, 47, 44, 45 and 49). The proposed model will in this way still be correct if n_k is replaced by the mean number of fish with both scale and otolith readings. In Table 3 the mean ages for the six samples are given, and the above model is exactly analogous to the model used for the L_1 and L_2 measurements. The data give the following analysis of variance:-

Scale readings

Contribution from	df	Sum of squares	Mean square	v^2
Mean	1	282.464631		
S's	5	9.779251		
(P' + P'')'s	4	0.016558	0.0041395	4.08
Remainder	20	0.020304	0.0010152	
Total	30	292.280744		

Otolith readings

Contribution from	df	Sum of squares	Mean square	v^2
Mean	1	285.559942		
S's	5	10.248069		
(P' + P")'s	4	0.003170	0.0007925	1.26
Remainder	20	0.012604	0.0006302	
Total	30	295.823785		

The v^2 value is significant ($2.5\% > P > 1\%$) for the scales but not for the otoliths. This means that differences between countries probably exist for the scale readings but not for the otolith readings. The variances (Remainder mean square) are very nearly the same for otoliths and scales. The assumption $\sum (P"-P') = 0$ is equivalent to the assumption that mean of all countries has the correct age as expectation and from Table 2 we get for scales:-

	P"-P'
Denmark	+0.0033
Germany	+0.0258
England	-0.0388
Netherlands	+0.0210
Scotland	-0.0115

and as $P" + P' = 45.5\ \sigma^2 \approx 45.5 \times 0.0010152 = 0.0462$ we get

	P'	1-P'-P"	P"
Denmark	2.1%	95.4%	2.5%
Germany	1.0%	95.4%	3.6%
England	4.2%	95.4%	0.4%
Netherlands	1.3%	95.4%	3.3%
Scotland	2.9%	95.4%	1.7%

Discussion

It must be kept in mind that the above analysis only gives an approximation to the truth, the most intricate thing being that P most certainly is not independent of age. It is nevertheless reasonable to conclude that for scale readings country differences exist whereas this is not the case for otolith. As to the measuring error, the data do not clearly indicate what sort of reading is to be preferred. The difference in mean ages for otolith and scales is 0.0167 years, with a standard deviation of $\sqrt{2\ \sigma^2 : 30} \approx 0.0074$ and 40 degrees of freedom.

This gives $t = 2.26$ with $5\% > P > 2\%$, which indicate that scale and otolith readings should not be compared indiscriminately, and, for comparative purposes, only one method should be used.

4. Otolith Type Determination

The numbers of W and N types are given in the following table.

Sample	D	G	E	N	S
14EA 61	31W, 9N	28W, 12N	27W, 13N	-	24W, 16N
18EA 61	35W, 3N	3oW, 8N	29W, 9N	-	2oW, 18N
H 43	21W, 19N	-	2W, 38N	-	4W, 36N
H 44	28W, 15N	19W, 24N	8W, 35N	-	11W, 32N
FR 22/7-58	13W, 22N	4W, 31N	4W, 31N	2W, 33N	2W, 33N
FR 16/8-58	1oW, 29N	5W, 34N	6W, 33N	5W, 34N	3W, 36N

For the EA samples no. Dutch data were available, and only fish that had been "typed" by all other countries are used.

For H 43 only the fish typed by D, E, and S are used.

For the FR samples the fish typed by all countries are used.

The table evidently shows that the typing is not done in the same way in the different countries. Consequently, a statistical treatment of the data was not undertaken but the following table illustrates the discrepancies:-

D	G	E	S	14EA 61	18EA 61	H 44
N	N	N	N	8	2	15
N	N	N	W			
N	N	W	N			
N	N	W	W			
N	W	N	N		1	
N	W	N	W			
N	W	W	N			
N	W	W	W	1		
W	N	N	N	3	5	9
W	N	N	W			
W	N	W	N	1	1	
W	N	W	W			
W	W	N	N	1	1	8
W	W	N	W	1		3
W	W	W	N	3	8	
W	W	W	W	22	2o	8

D	E	S	H 43
N	N	N	19
N	N	W	
N	W	N	
N	W	W	
W	N	N	17
W	N	W	2
W	W	N	
W	W	W	2

D	G	E	N	S	FR 22/7-58	FR 16/8-58
N	N	N	N	N	22	29
N	N	N	N	W		
N	N	N	W	N		
N	N	N	W	W		
N	N	W	N	N		
N	N	W	N	W		
N	N	W	W	N		
N	N	W	W	W		
N	W	N	N	N		
N	W	N	N	W		
N	W	N	W	N		
N	W	N	W	W		
N	W	W	N	N		
N	W	W	N	W		
N	W	W	W	N		
N	W	W	W	W		
W	N	N	N	N	8	3
W	N	N	N	W		
W	N	N	W	N		1
W	N	N	W	W		
W	N	W	N	N		1
W	N	W	N	W		
W	N	W	W	N	1	
W	N	W	W	W		
W	W	N	N	N	1	
W	W	N	N	W		
W	W	N	W	N		
W	W	N	W	W		
W	W	W	N	N	1	1
W	W	W	N	W		
W	W	W	W	N		1
W	W	W	W	W	1	3

The figures are the number of otoliths which has been typed as indicated under D, G, E, N, and S, e.g., line 9 means that in sample 14 EA 61 3 otoliths typed as W by D(anmark) has been typed as N by G(ermany),E(ngland) and S(cotland), whereas the figure was 5 and 9 for 18EA 61 and H 44 respectively.

5. Maturity Stages

At the meeting in Hamburg, the maturity stage of 15 herrings was determined by 8 participants. No statistical procedure is used but the results are given in the table below.

Fish no.	Be	De	En	Ge	Ne	No	Sc	Sw
1	V	IV	IV-V	IV	VI	V	V	IV
2	VIII-II	VII	VII	VII-II	VII	VII	VII	VII-II
3	V	V(VI?)	V	V	V-VI	VI	VI	V
4	VIII-II	VII	VII	VII-II	VII	II	I	VII
5	VIII-II	VII	VII	II	VII	II	VII	VII-II
6	VIII-II-III	VII-VIII	VII	II	VII	II	VII	VII-II
7	II	I	I	I	II	I	I	I
8	II-III	I	I	I	II	I	II	I
9	VIII-II	VIII	II	II	VIII-II	II	VII-II	II
1o	VIII-II	VIII	II	II	VIII-II	VIII	II	VII-II
11	V	V	IV	VI	VI-V	V	V	V
12	V	IV	IV	IV	V	V	V	IV
13	V	IV	IV	IV	VI	IV	V	IV
14	I-II	II	I	IIjuv.	I-II	II	II	I-III
15	III	II	I-III	II	VIII-II	II	II	II

Reference

O. Kempthorne "The Design and Analysis of Experiments". New York, J.Wiley & Sons,Inc. London, Chapman & Hall, Ltd.

Table 1. L_1 Measurements (mm)

Sample	No.	D	G	E	N	S	Sum	Sum minus D
	1	160	162	157	164	162	805	645
	2	105	115	105	112	110	547	442
	4	85	90	87	90	89	441	356
	6	135	135	137	144	137	688	553
	7	110	108	108	116	109	551	441
	10	140	145	144	150	148	727	587
	11	125	128	122	124	120	619	494
	18	110	105	108	118	111	552	442
	19	125	123	117	118	125	608	483
	26	95	95	98	102	99	489	394
14 E A 61	29	125	121	121	126	122	615	490
	32	120	128	121	126	123	618	498
	33	95	95	90	97	93	470	375
	34	160	170	165	167	167	829	669
	35	100	98	98	102	100	498	398
	36	95	97	93	99	92	476	381
	38	115	124	117	119	113	588	473
	39	120	128	123	128	124	623	503
	41	90	90	85	92	97	454	364
	43	110	108	111	113	110	552	442
	48	90	81	79	89	95	434	344
	1	95	94	92	99	95	475	380
	2	115	108	114	116	113	566	451
	6	95	100	91	98	96	480	385
	9	135	133	131	136	130	665	530
	11	150	148	150	153	151	752	602
	12	90	95	89	92	92	458	368
18 E A 61	15	145	158	150	148	150	751	606
	17	110	103	104	108	110	535	425
	19	110	114	110	113	113	560	450
	21	100	90	99	104	100	493	393
	22	90	100	91	98	94	473	383
	23	115	113	120	119	122	589	474
	24	85	81	82	85	87	420	335
	25	100	100	100	101	92	493	393
	27	95	94	90	93	95	467	372
	37	95	83	76	86	85	425	330
	39	120	125	109	126	117	597	477
	40	120	120	119	124	116	599	479
	47	120	117	116	118	119	590	470
Sum		4,495	4,522	4,419	4,613	4,523		18,077
Mean		112.38 (114.88)	113.05	110.48	115.32	113.08		112.98
	12	90	96	94	99	96	475	385
	27	170	169	162	166	174	841	671
	29	130	130	128	134	130	652	522
	31	145	143	139	144	141	712	567
	39	135	138	135	139	141	688	553
H 43	44	150	131	136	141	138	696	546
	46	150	144	145	148	148	735	585
	47	100	100	99	108	105	512	412
	48	95	98	92	97	96	478	383
	50	145	150	151	153	148	747	602
	6	170	175	175	176	175	871	701
	10	145	152	145	151	149	742	597
H 44	11	100	110	101	108	101	520	420

continued/

Table 1. continued.

Sample	No.	D	G	E	N	S	Sum	Sum minus D
H 44	17	140	146	145	145	145	721	581
	30	180	183	184	185	184	916	736
	35	135	138	139	141	138	691	556
	49	145	150	151	153	150	749	604
Sum		2,325	2,353	2,321	2,388	2,359		9,421
Mean		136.76 (139.26)	138.41	136.53	140.47	138.76		138.54
F R 22/7/58	2	150	147	150	153	150	750	600
	3	155	158	156	160	157	786	631
	5	140	140	143	150	149	722	582
	9	140	144	138	144	143	709	569
	11	150	143	138	160	142	733	583
	12	125	128	126	144	128	651	526
	13	145	146	142	138	144	715	570
	14	145	155	150	141	141	732	587
	15	160	158	159	161	161	799	639
	16	160	169	161	167	163	820	660
	17	110	111	112	113	115	561	451
	18	125	124	126	129	128	632	507
	20	135	130	133	135	134	667	532
	22	125	130	129	133	126	643	518
	23	135	145	139	143	144	706	571
	31	135	145	144	150	146	720	585
	35	145	143	144	146	146	724	579
	37	180	175	179	182	179	895	715
	39	175	170	167	173	169	854	679
	40	140	145	141	145	144	715	575
	41	155	159	161	156	159	790	635
	44	150	155	151	155	152	763	613
	46	120	126	124	124	122	616	496
	47	155	163	160	162	165	805	650
	49	150	151	151	154	154	760	610
	50	165	169	163	168	167	832	667
F R 16/8/58	1	145	149	149	147	146	736	591
	2	175	172	175	181	179	882	707
	5	175	185	181	187	185	913	738
	6	115	120	115	116	117	583	468
	12	115	112	114	118	117	576	461
	14	115	125	116	117	119	592	477
	15	100	94	98	100	99	491	391
	16	150	149	150	154	155	758	608
	19	105	105	101	106	104	521	416
	25	115	111	114	113	116	569	454
	26	125	123	128	134	132	642	517
	33	135	134	135	138	137	679	544
	37	100	117	98	103	101	519	419
	39	100	92	95	96	98	481	381
	41	145	147	147	148	152	739	594
	42	115	94	92	98	96	495	380
	43	105	104	104	110	106	529	424
	45	100	95	98	102	103	498	398
	46	110	104	102	105	104	525	415
Sum		6,115	6,161	6,099	6,259	6,194		24,713
Mean		135.89 (138.39)	136.91	135.53	139.09	137.64		137.29

Table 2. L_2 Measurements (mm).

Area	No.	D	G	E	N	S	Sum	Sum minus D
	1	225	220	221	227	220	1,113	888
	2	170	175	176	182	179	882	712
	4	180	182	184	185	188	919	739
	7	195	193	199	203	198	988	793
	10	210	212	212	219	214	1,067	857
	11	200	199	201	201	199	1,000	800
	18	180	189	187	195	195	946	766
	23	175	177	175	179	181	887	712
	26	180	197	198	202	180	957	777
14 E A 61	32	210	208	211	213	210	1,052	842
	33	190	197	197	202	194	980	790
	35	210	199	196	204	199	1,008	798
	36	175	180	179	184	179	897	722
	38	205	218	207	211	206	1,047	842
	39	185	206	208	200	210	1,009	824
	41	185	190	188	192	195	950	765
	43	185	188	187	191	188	939	754
	48	185	189	191	194	202	961	776
	1	175	176	178	182	177	888	713
	2	185	194	190	193	190	952	767
	6	195	200	191	196	194	976	781
	9	210	208	208	213	212	1,051	841
	11	215	212	216	219	216	1,078	863
	12	175	180	176	178	177	886	711
18 E A 61	15	225	228	229	238	223	1,143	918
	17	195	196	197	201	200	989	794
	19	185	183	184	192	188	932	747
	21	190	195	193	195	194	967	777
	22	190	193	190	196	192	961	771
	23	195	200	203	196	204	998	803
	24	180	175	177	179	179	890	710
	25	195	198	198	203	195	989	794
	27	180	178	179	181	182	900	720
	37	175	184	179	186	190	914	739
	39	195	200	190	203	197	985	790
	40	200	200	200	204	199	1,003	803
	47	200	197	191	200	193	981	781
Sum		7,105	7,216	7,186	7,339	7,239		28,980
Mean		192.03 (194.53)	195.03	194.22	198.35	195.65		195.81
	12	185	190	189	193	192	949	764
	27	235	234	235	238	239	1,181	946
	29	200	202	200	202	204	1,008	808
	31	215	219	214	219	214	1,081	866
	39	215	218	212	215	217	1,077	862
H 43	44	210	223	226	216	225	1,100	890
	46	235	235	236	239	234	1,179	944
	47	195	194	196	197	196	978	783
	48	190	190	190	192	190	952	762
	50	215	212	216	216	210	1,069	854
	6	235	239	237	239	236	1,186	951
H 44	10	240	242	244	247	244	1,217	977
	11	175	180	178	178	176	887	712

continued/

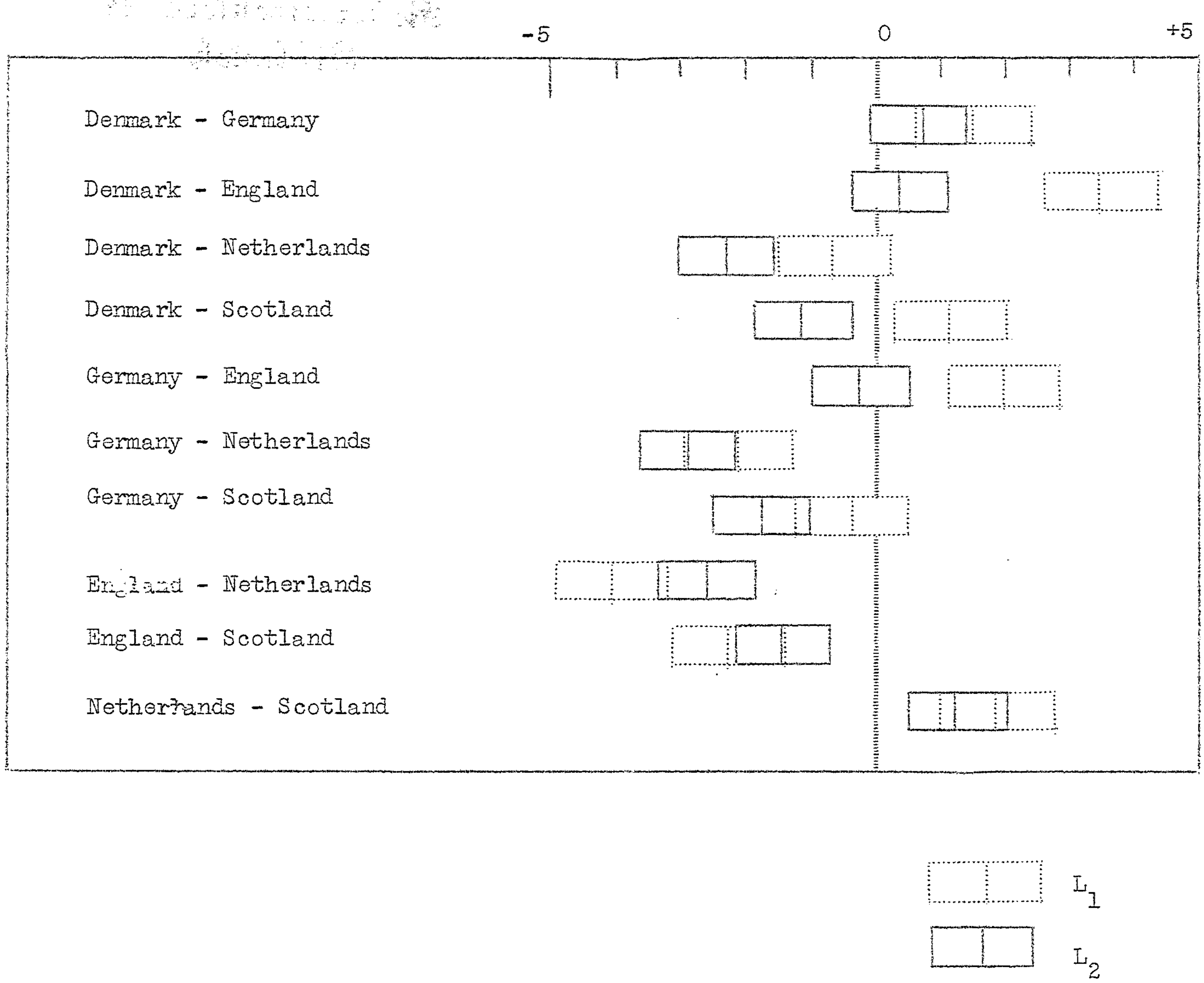
Table 2. continued

Area	No.	D	G	E	N	S	Sum	Sum minus D
H 44	17	225	213	227	229	228	1,122	897
	30	245	248	248	246	246	1,233	988
	49	215	213	217	220	215	1,080	865
Sum		3,430	3,452	3,465	3,486	3,466	17,299	13,869
Mean		214.38 (216.88)	215.75	216.56	217.88	216.62	216.24	216.70
	2	230	232	232	234	234	1,162	932
	3	235	241	241	239	239	1,195	960
	9	220	218	221	221	221	1,101	881
	12	205	207	213	219	212	1,056	851
	13	230	230	225	229	228	1,142	912
	14	225	228	227	228	229	1,137	912
	15	220	220	219	223	221	1,103	883
	16	240	245	242	245	246	1,218	978
	17	185	179	189	188	186	927	742
	18	230	228	229	228	229	1,144	914
	20	230	230	231	232	231	1,154	924
F R 22/7/58	22	205	207	209	209	209	1,039	834
	23	220	221	222	223	223	1,109	889
	31	210	221	216	219	216	1,082	872
	35	225	223	223	227	226	1,124	899
	37	235	231	238	239	239	1,182	947
	39	225	227	229	231	230	1,142	917
	40	220	225	222	221	226	1,114	894
	41	230	235	241	242	238	1,186	956
	44	220	227	227	229	229	1,132	912
	46	205	210	209	210	214	1,048	843
	47	225	230	229	231	231	1,146	921
	49	220	225	223	225	224	1,117	897
	1	215	215	218	216	219	1,083	868
	2	225	224	224	228	227	1,128	903
	3	190	195	190	197	192	964	774
	5	230	235	237	239	239	1,180	950
	6	185	187	182	186	189	929	744
	8	200	197	195	202	201	995	795
F R 16/8/58	12	210	208	213	212	215	1,058	848
	15	190	196	195	196	195	972	782
	16	220	220	227	225	224	1,116	896
	19	190	190	188	192	191	951	761
	25	190	187	188	193	194	952	762
	26	200	198	202	204	206	1,010	810
	33	210	211	207	212	212	1,052	842
	35	180	178	182	184	184	908	728
	39	180	178	179	185	184	906	726
	41	230	239	236	242	241	1,188	958
	42	170	178	175	182	178	883	713
	43	195	195	193	205	196	984	789
	45	190	181	190	187	187	935	745
	46	190	194	195	196	195	970	780
Sum		9,080	9,146	9,173	9,275	9,250		36,844
Mean		211.16 (213.66)	212.70	213.33	215.70	215.12		214.21

Table 3. Age Determinations

		S c a l e s 1.					
Sample	No.	D	G	E	N	S	Sum
14 E A 61	47	2,745	2,809	2,745	2,809	2,745	13,853
18 E A 16	44	2,955	2,955	2,909	2,932	2,886	14,637
H 43	42	3,929	4,024	3,833	3,952	3,929	19,667
H44	46	3,500	3,478	3,413	3,500	3,478	17,369
FR 22/7/58	45	3,200	3,178	3,156	3,222	3,222	15,978
FR 16/8/58	49	2,102	2,122	2,122	2,122	2,082	10,550
Sum		18,431	18,566	18,178	18,537	18,342	92,054
Mean		3,072	3,094	3,030	3,090	3,057	3,068

		O t o l i t h 2.					
Sample	No.	D	G	E	N	S	Sum
14 E A 61	47	2,766	2,766	2,745	2,745	2,766	13,788
18 E A 61	44	2,955	2,955	2,955	2,955	2,932	14,752
H 43	42	3,952	3,952	3,905	4,000	3,976	19,785
H 44	46	3,500	3,522	3,522	3,478	3,478	17,500
FR 22/7/58	45	3,244	3,289	3,200	3,289	3,200	16,222
FR 16/8/58	49	2,102	2,102	2,102	2,102	2,102	10,510
Sum		18,519	18,586	18,429	18,569	18,454	92,557
Mean		3,086	3,098	3,072	3,095	3,076	3,085


-5
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Denmark - Germany
Denmark - England
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