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Age determination of harbour seals *Phoca vitulina* by cementum growth layers, X-ray of teeth, and body length

by
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Med et dansk resumé:
Aldersbestemmelse af spættet sæl *Phoca vitulina*
på grundlag af vækstlag i tandcement, røntgenfotografering
af tænder, samt kropslængde

Резюме на русском языке:
Определение возраста пятнистого тюленя
Phoca vitulina на основании ростовых
слоев зубного цемента, рентгеновских
снимков зубов и длины тела.

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Abstract

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X-ray photos of canine teeth from harbour seals (*Phoca vitulina*) were used to age determine seals ≤2 years old. It made it possible to eliminate the younger age classes from the more time and work consuming age determination procedures. For seals 3-15 years old, X-ray photos may be used to give an approximate age. Among 58 seals with a pulpa cavity of less than 5% of the largest width of the tooth, 55 (95%) were over 15 years old. Application of polarized light facilitated the readings of tooth growth layers deposited during the first three to five years of life. Pups two to three months old have one cementum growth layer. One-year-old seals have three growth layers, and in each subsequent year two additional growth layers are deposited. An age classification of 597 seals as pups (< ½ year old), subadults (½-3½ years old) and adults (>3½ years old) on the basis of body length lead to the same age class as found by dental examination for 89.9%, 82.7% and 93.1% of the seals, respectively.

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INTRODUCTION

A prerequisite in almost all mammalian ecology studies is a reliable method of age determination which will make it possible to distinguish at least between adults, subadults and pups.

For many mammalian species the tooth-annulation method is the most accurate means of age determination (Thomas 1977, Grue and Jensen 1979).

At least 21 seal species have been age determined by counting incremental lines (growth layers) of either dentine or cementum (McLaren 1958, Mansfield and Fisher 1960, Laws 1962, Klevezal and Kleinenberg 1967, Smith 1973, Stirling et al. 1977, Bowen et al. 1983).

In harbour seals (*Phoca vitulina*) growth layers in the dentine become increasingly irregular and indiscrete when the seals exceed four years of age, and thus difficult to count (Bishop 1968). Consequently, age determination of harbour seals is based on growth layers in the cementum (Mansfield and Fisher 1960, Bishop 1968, Bigg 1969, Møhl cited in Søndergaard et al. 1976, Stirling et al. 1977, Marsh and Scheibel 1989, Dietz et al., in press). Mansfield and Fisher (1960) analysed dental structures by use of transmitted light and reported an annual deposition of two cementum layers: one translucent and one opaque.

The decalcifying, sectioning and staining methods preliminary to the actual analysis are time and work consuming. Doutt (1942) and Morris (1972) suggested that juveniles might be age determined on the basis of X-ray photos of teeth, thus eliminating the youngest age classes from the time consuming procedure. Laws (1962), Smith (1973) and Bowen et al. (1983) measured the dentine thickness, but did not relate the results to age determination. It is hypothesized that if the annual growth of dentine + cementum exceeds interindividual variations within the population, age determination based upon measurements of these tissues will be possible.

During the epizootic within the Danish harbour seal (*Phoca vitulina*) population in 1988 (Bøgebjerg et al. 1991; Dietz et al., in press), canine teeth from 489 carcasses in the Danish Wadden Sea and 199 carcasses in the Limfjorden were collected during the months May-October and July-October, respectively. The use of X-ray photos of these teeth as a method of age determination is examined and the results are compared with the ages found by counting the number of growth layers in the cementum. Furthermore, body lengths are related to ages found by dental examination, and the reliability of body length measurements as a method for age determination is evaluated.

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MATERIAL AND METHODS

When determining the age of the 688 seals, it is presumed that all seals are born on 1 July, which is the peak pup production date found in the Wadden Sea by Drescher (1978). To categorize the age of seals, pups < 6 months were grouped in »age class 0«, seals ≥ 6 and < 18 months in »age class 1«, seals ≥ 18 and < 30 months in »age class 2«, etc.

The dissected canine teeth were kept in tap water when not used in analysis.

Radiography

Before decalcifying, the right or left lower canine tooth from each of the 688 seals was placed on »Kodak X-Omat MA« X-ray films (18 × 24 cm). After processing, the films were cut and photos of individual teeth were mounted in 4 × 4 cm slide frames, which were then subjected to measurements of dentine + cementum thickness, largest width of the tooth, and width of the pulpa opening when one such was present. Measurements of dentine + cementum thickness were made at the outer and inner curvatures of the tooth, and at the site where the pulpa cavity was widest (Fig. 1). The thickness of dentine + cementum was expressed as the average of the two measurements, and dentine + cementum percentage was expressed as

$$100 \times \frac{\text{(dentine + cementum thickness)} \times 2}{\text{largest width of the tooth}}$$

A combination of dentine + cementum thickness and dentine + cementum percentage (Modified DC-thickness) was calculated among seals with a dentine + cementum percentage > 66% as

$$\text{MDC} = \tfrac{1}{2} \times (\text{dentine + cementum thickness} + (-0.7 + 0.44 \times \text{dentine + cementum percentage}))$$

(see p. 24).

In other cases Modified DC-thickness was equal to dentine + cementum thickness.

A Wild stereoscope (6-50 ×) was used for all measurements, which were carried out with an accuracy of 1/10 mm.

Dentine + cementum thickness and dentine + cementum percentage were plotted as frequency curves. As the material originated from animals that all died during the same 6-month period (May-October), discrete peaks in the frequency curves were interpreted as discrete age classes according to the hypothesis presented in the introduction.

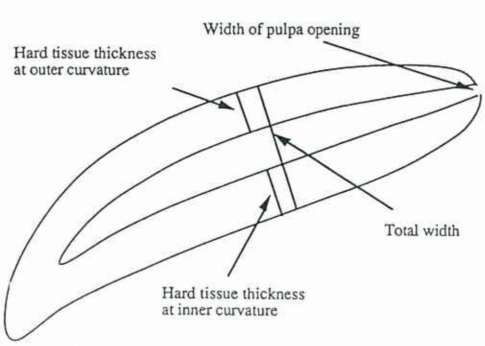

Fig. 1. Indication of where to measure: dentine + cementum thickness at inner and outer curvature, largest width of the tooth and size of the pulpa opening.

Decalcification, sectioning and staining

After radiography of the teeth, the basal 8-10 mm of the roots were cut off. The roots were placed in separate gauze nets, 30 at a time, in a constantly stirred 2.4 l nitric acid (HNO_3) solution.

Pilot projects had indicated that a solution temperature of 19-21 °C in combination with a stronger HNO_3 solution than the one described by Jensen and Nielsen (1968) facilitated the total removal of calcium and reduced the time needed for decalcifying, while the use of the proposed concentration reduced the risk of damaging the teeth. Accordingly, the first 24 hours of decalcification were carried out in 9% HNO_3, the succeeding 36-48 hours in 5.6% HNO_3, and temperature was kept between 19 and 21 °C.

After decalcification, each root was washed in tap water for one minute, and left in 100 ml tap water for 24-48 hours before dehydrating and embedding in paraffin wax. From each tooth four longitudinal sections of 15-20 microns were prepared on a Leitz microtome. Application of water to the paraffin block immediately before cutting facilitated handling the tissue.

Staining was carried out in a 2:2:1 mixture of 1% toluidine blue, 2% Borax (sodium borate) and 1% Pyronin (Allen and Melfi 1985). After staining for 90-100 seconds, specimens were successively rinsed in distilled water, 70% ethanol, 93% ethanol, 99% ethanol, for 30, 15, 15, and 2 × 300 seconds, respectively, and sealed with cover slips before analysis.

Reading

Reading of growth layers in the root cementum of stained sections was carried out with transmitted light in a polarization microscope. All sections were read both with and without the use of polarization filters. As observed by Hewer (1960) and Laws (1962) the layers deposited during the first 3-5 years of life were more diffuse than layers deposited later on in life.

Cementum growth layers of each tooth were counted on both sides of the root in at least two sections. When discrepancies were found, age was determined from the largest number of layers counted. All teeth were read twice by the same person, on two different days. In cases of diverging results in the two readings, a third reading was carried out before the age was finally established.

Lower canines from six free-ranging seals of known age (1, 2, 4, 4, 5, and 7 years, respectively) were prepared and used as reference. Five of the seals were freeze branded and released from the Sealarium in Esbjerg at the age of 3 months, whereas the last one was caught and freeze branded in the open.

Body length measurements

The body length was measured and the sex determined in the field by local collectors, and later on the seals were aged by dentine + cementum measurements or by the decalcifying procedure. To evaluate the reliability of the body length as an indication of age in Danish harbour seals, the relation between body length and age of 597 carcasses was analysed. The data sets were fitted to the growth equations of

Von Bertalanffy: $L_t = L\infty\,(1 - a \times \exp(-kt))$
and Gompertz: $L_t = L\infty\,(\exp(-a \times \exp(-kt))$

(Kaufmann 1981), where L_t = total length from tip of nose to end of hind flippers of an animal at age t, $L\infty$ = the asymptotic total length, k = growth coefficient, determining the rate of increase in length and »a« is a constant (see Table 4). t = 0 indicates the day of birth (fixed at 1 July).

Curve fits were performed using the programmes: »KaleidaGraph« and »Systat« on a Macintosh computer.

For age determination purposes, the lengths found by use of the Bertalanffy equation on a ½ year old and a 3½ year old seal were used to separate pups from subadults and subadults from adults, respectively.

The conversion factor between total length and standard length (tip of nose to end of tail) (Committee on marine mammals 1967) of Danish harbour seals was calculated on the basis of measurements of 203 seals, measured by the same person at a post-mortem examination and aged by dental examination.

RESULTS

Age determination based on radiography

Dentine + cementum thickness peaked around 0.3, 1.0-1.2, and 1.9 mm (Fig. 2) and these peaks were interpreted as representing seals belonging to »age class 0«, »age class 1« and »age class 2«, respectively. Less distinct peaks were observed in the frequency curve showing dentine + cementum percentage, and age separation by this curve is possible only for the two youngest age classes (Fig. 3).

The teeth were classified in four groups on the basis of the two frequency curves (Table 1). A random selection of fifteen teeth in each of the groups 2 and 3 and three teeth in group 1 were picked for additional age determination by the decalcifying-staining procedure; for all 33 teeth the obtained age was identical for the two methods. Therefore, no further age determination was considered necessary for the teeth in groups 1, 2 and 3. Teeth in group 4 were all age determined by the decalcifying-staining method.

Of the seals with a pulpa opening visible on X-ray photos, 99% (n=353) turned out to be ≤4 years old. When the pulpa opening exceeded 40% of the largest width of the tooth, the examined seals were pups.

Among teeth with a dentine + cementum percentage between 66% and 95%, a linear regression between age and dentine + cementum thickness on one hand and age and dentine+cementum percentage on the other hand gave correlation coefficients of 0.68 and 0.71, respectively. However, it was empirically found that Modified DC-thickness gave a better correlation to the obtained age than did either of

Table 1. Classification of the 677 examined seals in four groups, according to the specified criteria on dentine + cementum thickness and dentine + cementum percentage. The corresponding age classes are based on an interpretation of the frequency curves in Figs 2 and 3 (see text). N is the number of seals in each group. All seals were recorded between May and October 1988.

Dentine + cementum thickness	Dentine + cementum percentage	Group	Age class according to the frequency curves	N
<0.5 mm	<13%	1	0	104
0.9-1.3 mm	20-35%	2	1	119
1.7-2.0 mm	40-55%	3	2	69
Teeth that do not fit into group 1, 2 or 3		4		385
Total				677

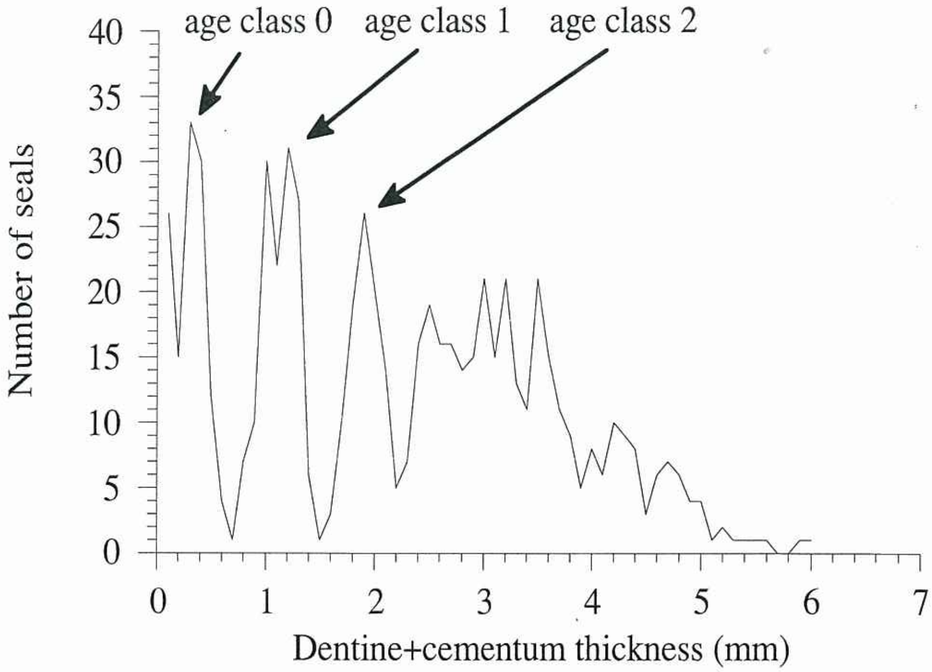

Fig. 2. The frequency curve of dentine+cementum thickness in canine teeth for 677 harbour seals recorded from May-October 1988 in the Danish Wadden Sea and in the Limfjord area.

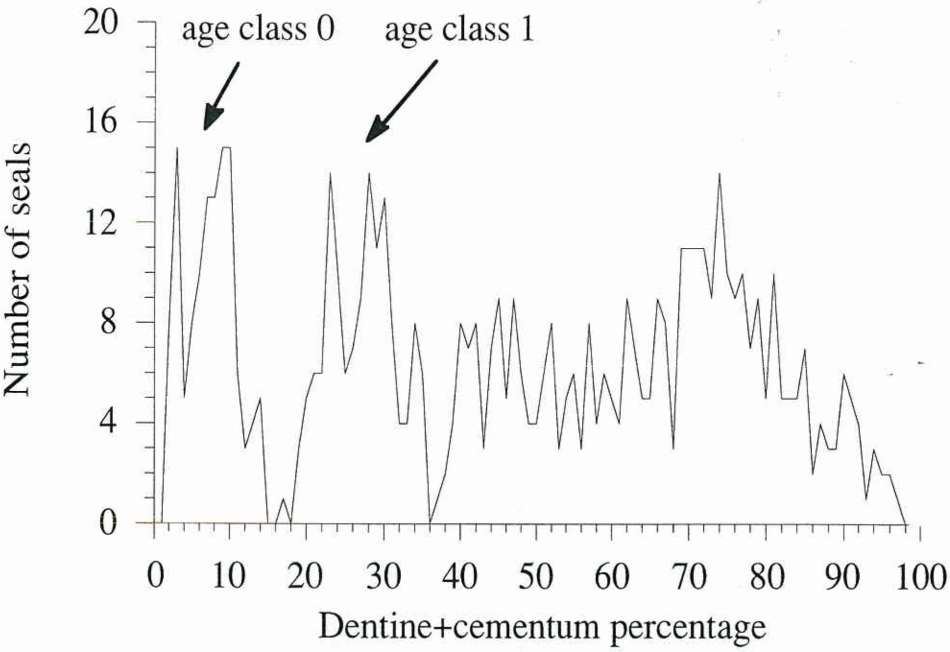

Fig. 3. The frequency curve of dentine+cementum percentage in canine teeth for 677 harbour seals recorded from May-October 1988 in the Danish Wadden Sea and in the Limfjord area.

the two above measurements separately (R=0.74).

The formula »– 0.7 + 0.44 × (dentine + cementum percentage)« was the result of a linear regression on dentine + cementum thickness as a function of dentine + cementum percentage among teeth with a dentine + cementum percentage between 66% and 95%.

The age distribution of the examined seals with a Modified DC-thickness of ≤ 0.6, 0.7-1.5, 1.6-2.3, 2.4-2.7, 2.8-3.2, 3.3-3.9 and ≥4.0 was concentrated around the age classes 0, 1, 2, 3, 4-6, 7-10 and >15, respectively (Table 2).

More than 96% of the examined seals with a Modified DC-thickness index between 0 and 2.3 were identically aged by the use of Modified DC-thickness and by a combination of dentine + cementum thickness and stained sections.

As the pulpa cavity narrows the correlation between the two methods decreases (Fig. 4). When the pulpa cavity is filled, a further increase in thickness of dentine + cementum is caused only by increased cementum, leading to a weak correlation between age and dentine+cementum among seals ≥15 years (R=0.25, df=58).

Among 58 seals with a dentine + cementum percentage ≥95%, 55 were between 16 and 37 years old. The last three were 13, 14 and 15 years old, respectively.

Age determination based on sections of teeth

Stained sections of teeth from three pups collected in October all had a layer of cementum outside the neonatal line. The layer appeared as a light band. Based on the 15 examined seals in group 2 (one year old) and 3 (two years old) it was found that two additional layers, one dark and one light,

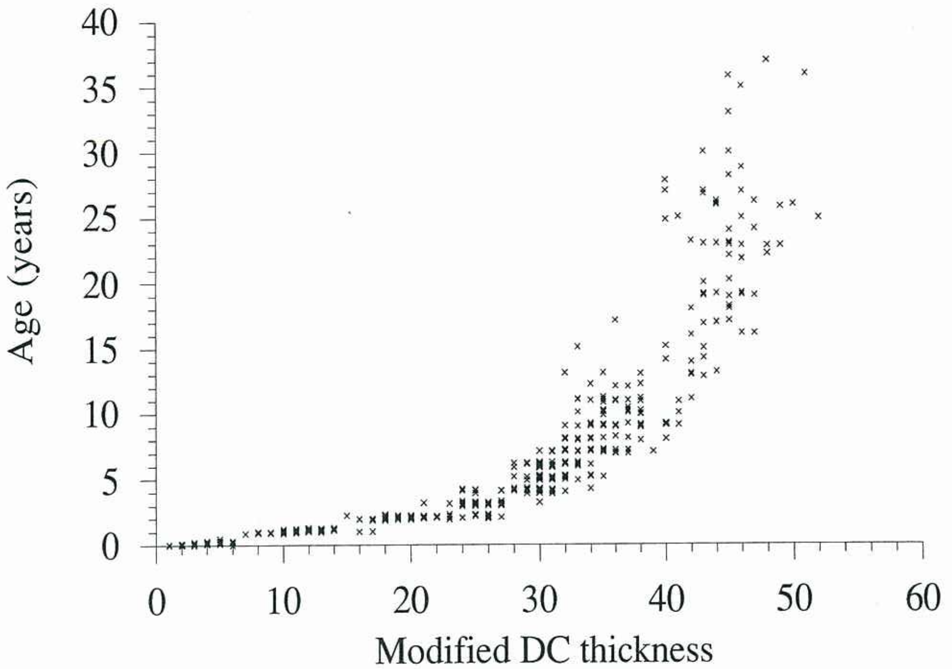

Fig. 4. The relation between Modified DC-thickness and the obtained age for 677 harbour seals recorded from May-October 1988 in the Danish Wadden Sea and in the Limfjord area.

Table 2. Separated age distributions of 677 examined seals according to the index of Modified DC-thickness (MDC).

MDC	Age classes 0	1	2	3	4-6	7-10	11-15	>15	N
	%	%	%	%	%	%	%	%	
0-0.6	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	120
0.7-1.5	0.0	99.3	0.7	0.0	0.0	0.0	0.0	0.0	135
1.6-2.3	0.0	2.0	96.1	2.0	0.0	0.0	0.0	0.0	102
2.4-2.6	0.0	0.0	15.3	69.5	15.3	0.0	0.0	0.0	59
2.7-3.2	0.0	0.0	0.0	1.1	84.9	12.9	1.1	0.0	93
3.3-3.9	0.0	0.0	0.0	0.0	14.1	65.2	18.5	2.2	92
4.0->	0.0	0.0	0.0	0.0	0.0	9.2	11.8	78.9	76
Total	17.7	20.1	16.0	6.5	14.9	11.7	4.0	9.2	677

were deposited per year (Fig. 5). This pattern was confirmed by the number of growth layers counted in the six seals of known age. An outer dark band was observed among some of the seals, but it could not be determined whether it was a deposition of a new dark cementum layer or an artifact from an extra uptake of stain at the edge of the section.

Age determination based on body length measurements

The asymptotic length of males ($n=341$) was significantly greater than that of females ($n=256$) (t-test, using the results of the Von Bertalanffy curve fits, $t=6.9$, $p<0.001$) (Table 3, Figs 6 and 7). Females and males reach 95% of their asymptotic length at the age of 4.9 and 5.8 years, respectively. The difference between the lengths predicted by the two growth equations was for no age class more than 0.9 cm, and the R-values obtained did not differ (Table 3).

The conversion factor between total length and standard length was significantly higher for pups than for older seals (t-tests, $t=9.7$, $p<0.001$), but not significantly different for subadults and adults (t-test,

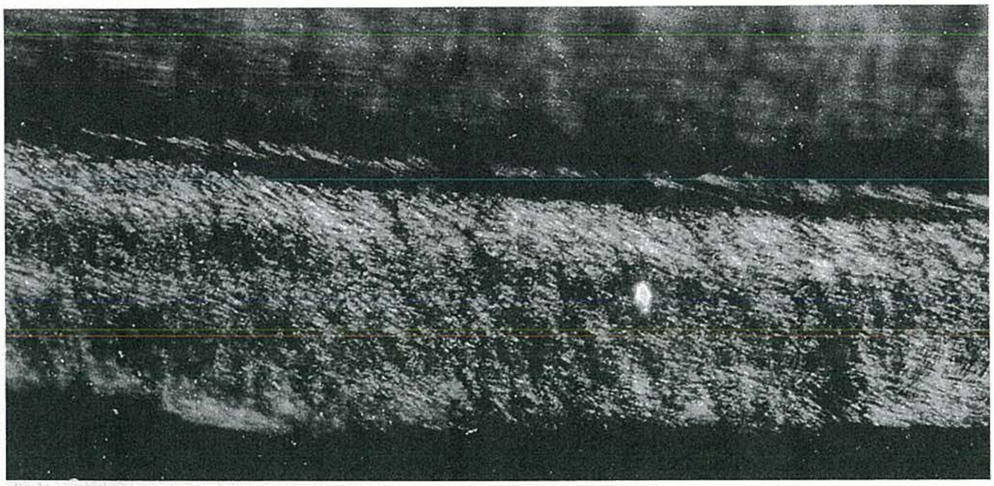

Fig. 5. Growth layers in the cementum of a canine tooth from a harbour seal, age determined to two years.

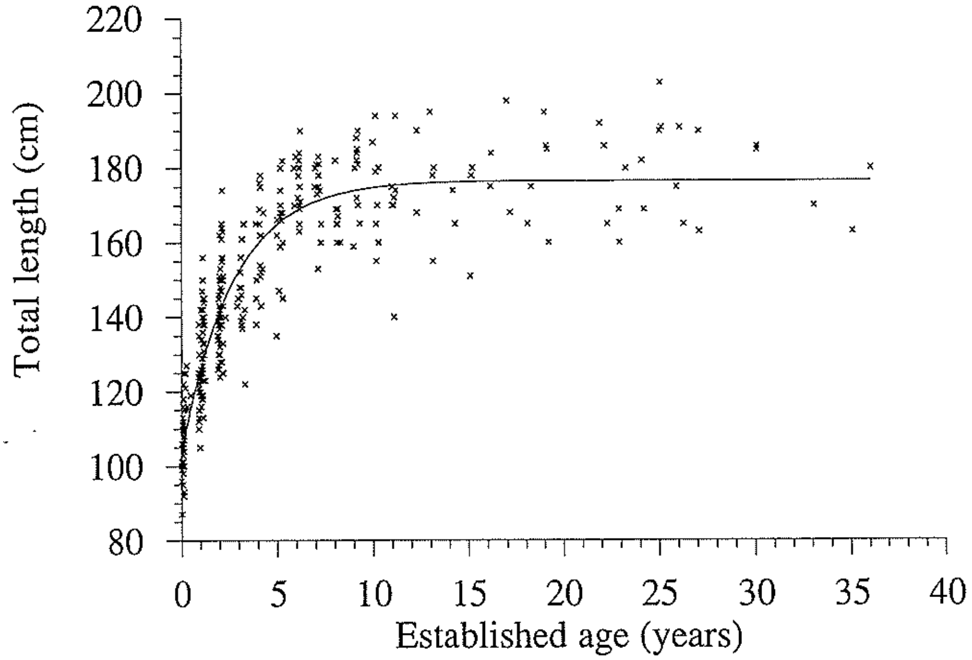

Fig. 6. Age/length relation for 341 male harbour seals recorded in the Danish Wadden Sea and the Limfjord area. The fitted curve is based on the Von Bertalanffy growth equation.

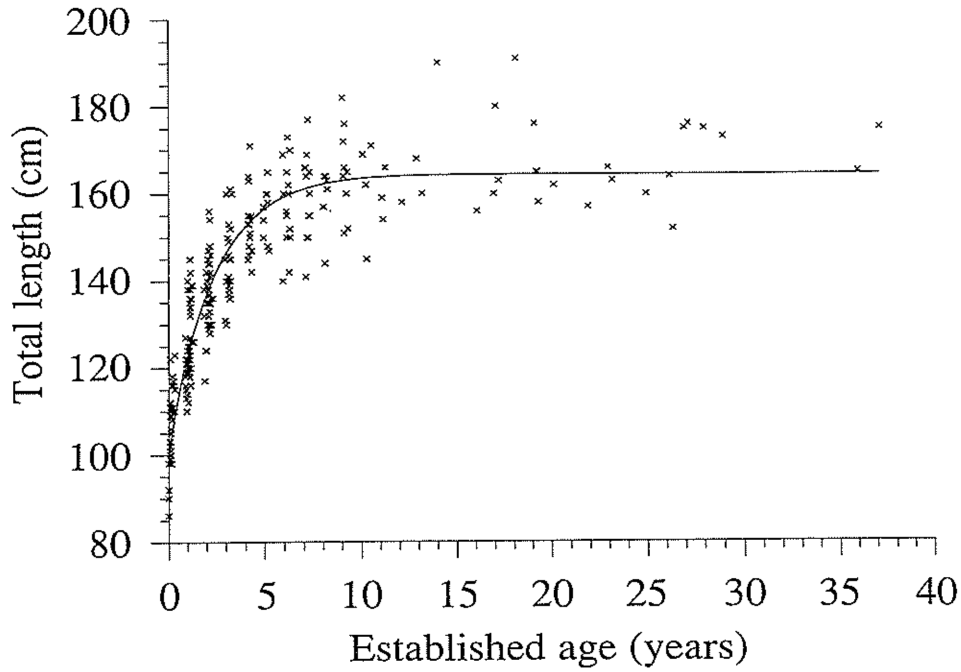

Fig. 7. Age/length relation for 256 female harbour seals recorded in the Danish Wadden Sea and the Limfjord area. The fitted curve is based on the Von Bertalanffy growth equation.

$t=0.65$, $p>0.25$) (Table 4). No difference was observed between males and females (all ages, t-test, $t=0.66$, $p>0.25$).

On the basis of the obtained conversion factors, an asymptotic standard length ($L\infty$) of 157 cm and 146 cm was found for males and females, respectively. The standard length of new-born female and male pups was 87 cm and 90 cm, respectively.

Of the seals categorized by body length measurement as pups, subadults and adults, 89.9%, 82.7% and 93.1%, respectively, were aged to the same categories by dental examination (Table 5).

Table 3. Growth parameters of the Von Bertalanffy and the Gompertz growth equations, fitted to age and length data of 341 male and 256 female harbour seals. All seals were recorded between May and October 1988. Numbers in brackets indicate standard error.

Sex	Equation	$L\infty$, Total (cm)	Lt_0, Total (cm)	a	k	R
Males	Bertalanffy	176.7 (1.2)	103.5	0.415 (0.008)	0.367 (0.02)	0.92
	Gompertz	176.0 (1.2)	104.3	0.524 (0.012)	0.433 (0.022)	0.92
Females	Bertalanffy	164.5 (1.2)	100.8	0.387 (0.009)	0.418 (0.031)	0.93
	Gompertz	163.9 (1.2)	101.6	0.478 (0.013)	0.486 (0.033)	0.93

Table 4. Conversion factors between standard length and total length of pup (age class 0), subadult (age class 1-3) and adult (age class >3) harbour seals, and of males and females (all ages). All seals were recorded between May and October 1988. The measurements were made by the same person at a post-mortem examination. N is the number of seals in each age class.

Category	Total/Standard length	SE	N
Age class 0	1.157	0.016	77
Age class 1-3	1.129	0.018	62
Age class >3	1.127	0.020	59
Males, all ages	1.139	0.021	111
Females, all ages	1.141	0.023	98

Table 5. Relation between total body length according to growth equations, and age based on examination of the teeth, for pups (0-½ years old), subadults (½-3½ years old) and adults (>3½ years old).

	A		B			
Age in years	Total body length according to growth equations (cm)		age class based on examination of teeth (%)			N
	Female	Male	0	1-3	>3	
0-½	<113	<116	89.9	10.1	0.0	99
½-3½	113-149	116-156	6.8	82.7	10.5	266
>3½	>149	>156	0.0	6.9	93.1	232

DISCUSSION

Based on the peaks in the frequency curves, a correlation between Modified DC-thickness and age was found among seals in age classes 0, 1 and 2. The interpretation of the peaks was confirmed by the decalcifying-staining method. The peaks in the frequency curves (Figs 2 and 3) may have been caused by the high growth rate of dental tissue in young seals (Laws 1962, Smith 1973), and by the fact that all examined seals died during a restricted period (May-October). Interindividual variation in growth of dentine+cementum layers, combined with the smaller annual increase in thickness of dentine in older seals (Laws 1962, Bowen et al. 1983) meant that peaks could not be distinguished for dentine + cementum thicknesses >2.2 mm.

The correlation between Modified DC-thickness and age among seals with a dentine+cementum thickness >2.2 mm was based on the ages established by the decalcifying-staining method. Accordingly, for seals older than two years, radiography as a means of age determination is compared only to the decalcifying-staining method.

The good agreement between the ages obtained in the age classes 0, 1 and 2, using radiography and the decalcifying-staining method, indicates that radiography might be used as a cheap and fast method to eliminate the younger age classes from the more time and work consuming decalcifying-staining method.

As all seals examined in this study died within the period May-October, caution should be taken if the described relation between Modified DC-thickness and age is to be used on seals which die outside this period, or on seal populations with a different pupping season.

The number of annual cementum growth layers of the six seals of known age was in agreement with previous works of Mansfield and Fisher (1960), Hewer (1964), Bishop (1968), Bigg (1969), Marsh and Scheibel (1989) and Dietz et al. (in press) except for their first year, where three instead of two growth layers were observed. From British Columbia, Bigg (1969) reported that the first cementum is deposited at 2-3 months of age, and that it appears as a dark band. However, among the three pups examined in this study, the first layer of cementum was well developed at the age of 2-3 months, indicating that the deposition had started earlier and probably already during the suckling period. Furthermore, the layer appeared as a light band. It is not clear why this innermost cementum layer has not been observed in other studies.

As sections of teeth from seals of known age were used for reference in interpreting growth layers, estimation of reliability of the used age determination method was not possible. However, based on the reference teeth and the agreement in obtained age by X-ray and the decalcifying-staining method, it was estimated that sections of good quality in the age classes 0, 1 and 2 were correctly aged. Among older seals, the divergence between the number of growth layers counted in two independent readings demonstrated that for the age classes 3-10, 11-20 and >20 years, the age cannot be determined with an accuracy better than ± one year, ± two years and ± three years, respectively.

Hewer (1960), Laws (1962) and Mansfield (1991) stated that doubt about the age often arose due to difficulty in interpreting the innermost and the outer layers. The increased uncertainty in age determination of old animals was due to difficulties in counting the increasingly narrower outermost bands.

The bands in the cementum are often

widest on the concave side of the tooth, but the narrower and more distinct bands at the convex side may be more easy to read. In some teeth the cementum layers were very ondulating due to varying thickness within the single layers, which made them difficult to read.

Application of cross polarized light made the appearance of pale or diffuse dark bands deposited during the first three to five years of life more distinct. For seals older than 10 years, thinner and more distinct layers are deposited, which are most easily read without polarization.

The asymptotic standard length of females and males observed in this study are in good agreement with the results presented by Boulva and McLaren (1979), Bigg (1981), Drescher (1979), Markussen et al. (1989), and Härkönen and Heide-Jørgensen (1990) (Table 6).

As indicated by the good agreement obtained between body length and age (Table 5), body length measurements may be used to classify the seals as pups, subadults and adults when a gross estimate of age is sufficient. The length measurements, as a means to indicate age, are advantageous when the age of live seals is needed, because they are easy to obtain and do not demand any costly equipment.

DANSK RESUMÉ

Aldersbestemmelse af spættet sæl *Phoca vitulina* på grundlag af vækstlag i tandcement, røntgenfotografering af tænder, samt kropslængde.

Røntgenoptagelser af hjørnetænder fra spættet sæl (*Phoca vitulina*) kan bruges til at aldersbestemme 0-, 1- og 2-årige sæler. Det er derved muligt at frasortere disse aldersklasser før aldersbestemmelse med den mere tids- og arbejdskrævende metode med farvede tyndsnit. For sæler mellem 3 og 15 år kan røntgenfotos bruges til at estimere alderen (tabel 2, Appendix 1). Af 58 sæler med en pulpahule på mindre end 5% af tandens største diameter var 55 (95%) over 15 år.

Anvendelse af polariseret lys gør det nemmere og mere sikkert at aflæse antallet af vækstlag i hjørnetænderne fra de første 3-5 år.

Undersøgelser af farvede tandsnit viser, at der i de første 2-3 måneder afsættes ét lag tandcement, og at yderligere to lag afsættes for hvert af de efterfølgende år, således at en etårig sæl har tre lag og en toårig har fem lag.

En aldersopdeling i unger (< ½ år), subadulte (½-3½ år) og adulte (> 3½ år) på grundlag af længdemål henførte henholdsvis 89,9%, 82,7% og 93.1% af de undersøgte sæler til samme aldersgruppering som blev opnået ved tandundersøgelsen.

Резюме на русском языке:

Определение возраста пятнистого тюленя Phoca vitulina на основании ростовых слоев зубного цемента, рентгеновских снимков зубов и длины тела.

Рентгеновские снимки клыков пятнистого тюленя Phoca vitulina могут использоваться для определения возраста 0-, I- и 2-летних тюленей. Таким образом возможно отсортировать эти возрастные классы до определения возраста требующим больше времени и труда способом окрашенных тонких разрезов. Для оценки возраста тюленей от 3 до I5 лет могут использоваться рентгеновские снимки (Табл. 2, Приложение I). Из 58 тюленей с пульповой полостью меньше 5% максимального диаметра зуба, 55

(95%) были старше I5 лет.

Применение поляризированного света облегчает и повышает точность считывания числа ростовых слоев в клыках с первых 3 - 5 годов.

Исследования окрашенных разрезов зубов показывают, что в первые 2 - 3 месяца отлагается один слой зубного цемента, и что за каждый последующий год отлагаются еще два слоя, так что у однолетнего тюленя имеются три слоя, а у двухлетнего пять слоев.

Подразделение по возрасту на детенышей (<I/2 года), полувзрослых (I/2 до 3 I/2 года) и взрослых (>3 I/2 года) на основании измерения длины отнесли соответственно 89,9%, 82,7% и 93,I% тюленей к той-же группировке по возрасту, как по исследованию зубов.

REFERENCES

Allen, D. and Melfi, R. C. 1985. Improvements in techniques for ageing mammals by Dental Cementum Annuli. - Proc. Iowa Acad. Sci. 92(3): 100-102.

Bigg, M. A. 1969. The harbour seal in British Columbia. - Bull. Fish. Res. Board Can. **172**. 33 pp.

Bigg, M. A. 1981. Harbour seal. - In: Ridgeway, S. H. and Harrison, R. J. (Eds.): Hand book of marine mammals. Vol. 2. Seals. Acad. Press Lond., N.Y. 359 pp.

Bishop, R. H. 1968. Reproduction, age determination, and behaviour of the harbour seal (*Phoca vitulina L.*) in the Gulf of Alaska. - M. Sc. thesis, Univ. of Alaska, College, Alaska. 121 pp.

Boulva, J. and McLaren, I. A. 1979. Biology of the harbor Seal (*Phoca vitulina)* in eastern Canada. - Bull. Fish. Res. Board Can. **200**. 24 pp.

Bowen, W. D., Seargent, D. E. and Øritsland, T. 1983. Validation of age estimation in the harp seal (*Phoca groenlandica*) using dental annuli. - Can. J. Fish. Aquat. Sci. **40**: 1430-1441.

Bøgebjerg, E., Tougaard, S., Madsen, J. and Nørgaard, N. 1991. Status of the harbour seal *Phoca vitulina* populations in the Danish waters, 1976-1989, and short-term effects of the epidemic in 1988. - Dan. Rev. Game Biol. **14**(4): 1-16.

Committee on marine mammals, 1966-1967. Ed.: Scheffer, V. B.: Standard measurements of seals. - J. mammal. **48**: 459-462.

Dietz, R., Heide Jørgensen, M.P., Härkönen, T., Teilmann, J. and Valentin, N. Age determination of European harbour seals. - In press.

Doutt, J. K. 1942. A review of the genus Phoca. - Ann. Carnegie Mus. **29**(4): 61-125.

Drescher H. E. 1978. Pup production, whelping and nursing season of the harbour seal (*Phoca vitulina*) in the Waddensea of Schleswig-Holstein. - ICES, Mar. Mam. Comm., C.M. 1978/N:12: 1-10.

Drescher, H. E. 1979. Biologie, Ökologie und Schutz der Seehunde im schleswig-holsteinschen Wattenmeer. - Beiträge zur Wildbiologie, Meldorf 1979. Heft 1: 1-73.

Jensen, B. and Nielsen, L. B. 1968. Age determination in the red fox. - Dan. Rev. Game Biol. 5(5): 1-15.

Grue, H. and Jensen, B. 1979. Review of the formation of incremental lines in tooth cementum of terrestrial mammals. - Dan. Rev. Game Biol. **11**(3): 1-48.

Hewer, H. R. 1960. Age determination of seals. - Nature (London) **187**: 959-960.

Hewer, H. R. 1964. The determination of age, sexual maturity, longevity and a life table in the grey seal (*Halichoerus grypus*). - Proc. Zool. Soc. Lond. **142**: 593-634.

Härkönen, T. and Heide-Jørgensen, M. P. 1990. Comparative life histories of East Atlantic and other harbour seal populations. - Ophelia **32**: 211-235.

Kaufmann, K. W. 1981. Fitting and using growth curves. - Oecologia **49**: 293-299.

Klevezal, G. A. and Kleinenberg, S. E. 1967. Age determination of mammals from annual layers in teeth and bones. - Fish. Res. Board Can. Transl. Serv. No. 1024 (1969). 142 pp.

Laws, R. M. 1962. Age determination of pinnipeds with special reference to growth layers in the teeth. - Z. Säugetierkunde **27**: 127-146.

Mansfield, A. W. 1991. Accuracy of age determination in the grey seal *Halichoerus grypus* of Eastern Canada. - Mar. Mam. Sci. **7**(1): 44-49.

Mansfield, A. W. and Fisher, H. D. 1960. Age determination in the harbour seal (*Phoca vitulina L.*). - Nature (London) **186**: 92-93.

Markussen, N. H., Bjørge, A. and Øritsland, N. A. 1989. Growth in harbour seals (*Phoca vitulina*) on the Norwegian coast. - J. Zool. Lond. **219**: 433-440.

Marsh, S.-L. and Scheibel, W. 1989. Untersuchungen zum Altersaufbau eines Seehundebestands. Analysen an Totgefunden aus Schleswig-Holstein. - Institut für Haustierkunde der Christian Albrechts-Universität. Zoologische und Ethologische Untersuchungen zum Robbensterben: 61-86.

McLaren, I. A. 1958. The biology of the ringed seal (*Phoca hispida* Schreber) in the eastern Canadian arctic. - Bull. Fish. Res. Board Can. **118**. 97 pp.

Morris, P. 1972. A review of mammalian age determination methods. - Mammal rev. **2**(3): 69-104.

Smith, T.G. 1973. Population dynamics of the ringed seal in the Canadian eastern arctic. - Bull. Fish. Res. Board Can. 181, 55 pp.

Stirling, I., Archibald, W. R. and DeMaster, D. 1977. Distribution and abundance of seals in the Eastern Beaufort Sea. - J. Fish. Res. Board Can. **34**(7): 976-988.

Søndergaard, N.-O., Joensen, A. H. and Hansen, E. B. 1976. Sælernes forekomst og sæljagten i Danmark. - Danske Vildtundersøgelser **26**: 80 pp.

Thomas, D. C. 1977. Metachromatic staining of dental cementum for mammalian age determination. - J. Wildl. Man. **41**(2): 207-210.

Appendix I.

Mean age (birth date fixed to 1 July) and standard deviation (SD) of 677 seals with a Modified DC-thickness between 0.1 and 5.2. The seals were recorded between May and October 1988. N is the number of seals with the specified Modified dentine + cementum thickness.

Modified DC-thickness	Mean age (years)	SD	N
0.1	-0.05	0.05	26
0.2	0.04	0.07	15
0.3	0.09	0.05	33
0.4	0.15	0.08	30
0.5	0.24	0.11	12
0.6	0.19	0.14	4
0.7	0.89		1
0.8	0.94	0.04	7
0.9	0.93	0.03	10
1.0	1.00	0.07	30
1.1	1.06	0.08	22
1.2	1.13	0.06	31
1.3	1.14	0.06	27
1.4	1.21	0.06	6
1.5	2.26		1
1.6	1.66	0.55	3
1.7	1.86	0.29	10
1.8	2.06	0.11	19
1.9	2.07	0.08	26
2.0	2.11	0.07	20
2.1	2.23	0.29	14
2.2	2.15	0.05	4
2.3	2.31	0.45	6
2.4	3.09	0.56	16
2.5	3.26	0.55	18
2.6	2.89	0.47	15
2.7	3.35	0.65	10
2.8	4.80	0.87	8
2.9	4.99	0.93	16
3.0	5.14	0.95	30
3.1	5.50	1.05	18
3.2	6.83	1.93	21
3.3	7.93	2.50	19
3.4	7.95	2.21	15
3.5	9.10	1.95	20
3.6	9.74	2.88	12
3.7	9.39	1.64	13
3.8	10.22	1.49	12
3.9	7.15		1
4.0	15.45	8.12	10
4.1	13.88	7.55	4
4.2	15.55	4.09	7
4.3	20.35	5.46	12
4.4	21.03	5.06	8
4.5	24.08	6.05	13
4.6	23.78	5.52	10
4.7	21.47	4.64	4
4.8	27.45	8.37	3
4.9	24.44	2.11	2
5.0	26.11		1
5.1	36.10		1
5.2	25.05		1