A RAPID NON-INVASIVE TECHNIQUE FOR DISTINGUISHING HARBOR SEALS (*PHOCA VITULINA*) IN THEIR FIRST YEAR FROM OLDER AGE CLASSES

Studies of the behavioral or physiological development of young, free-living phocids require accurate assessment of the age of individual seals. For some species this problem may be overcome by permanently marking cohorts at, or shortly after, birth (e.g., Hindell 1991). However, this method is often impractical, for species which breed in more dispersed groups or at inaccessible sites and particularly when studies are initiated during the postweaning period.

A range of alternative methods has been employed to assess the age of individual phocids recovered or captured after weaning. The most commonly used method involves the counting of annual growth rings laid down in the cementum of the teeth (Laws 1953). Where this method is carried out on live animals it requires the extraction of a tooth while the animal is sedated (Arnborn *et al.* 1992), increasing both handling time and the risk to the seal. In addition, estimates of age based upon this method are often subject to error (Bowen *et al.* 1983, Mansfield 1991).

Growth curves may be produced based upon the lengths and weights of known-age animals (McLaren 1993) and used to predict the age of other individuals. However, such estimates are limited, firstly because both body weight and length are continuous variables, with no clear distinction between age classes, and secondly because between-year variations in growth rate may result in significant differences in both weight and length between year classes (Härkönen and Heide-Jørgensen 1991; Corpe and Thompson, unpublished data).

In some species, pelage patterns and coloration may be used to distinguish between certain age classes, e.g., for harp seals (*Phoca groenlandica*) (Stewart and Lavigne 1980, Reeves *et al.* 1992). Thompson and Rothery (1987) used
the very pale, unpatterned pelage of yearling harbor seals (*Phoca vitulina*) to distinguish them from other age classes. However, once these seals had undergone their first annual molt, they could not reliably be distinguished from weaned pups of the year. During the course of studies involving capture of harbor seals, we examined pelage condition more closely, and differences were noted between the earliest age classes.

Harbor seals usually shed their first coat, or lanugo, prior to birth (Boulva 1975, Shaughnessy and Fay 1977) and then undergo their first true annual molt at one year of age (Bigg 1981). During the course of the present study, a number of seals were clearly identifiable as being less than one year old, on the basis that they made mother-attraction calls (Perry and Renouf 1988) when captured. These individuals were observed to have softer, denser hair than others considered to be more than one year old, indicating that the coat prior to the first true moult may differ from that which follows the first true molt. Such differences have been documented in the past; for example, Scheffer (1964) noted that the density was lower and mean basal diameter of primary hairs (as determined from skin samples) was higher for adult than for immature animals. A decrease in density during postnatal growth was attributed to the dilution of the hair population as a result of body growth, while increased mean basal diameter of the primary hairs reflected the maturation and increased coarseness of the hairs. The aim of the present study was to determine whether differences between the pre- and post-first-true-molt coats could be quantified and thus provide a rapid noninvasive method of distinguishing seals in their first year from older age classes.

The study was based on hair samples taken from harbor seals caught at one of four main haul-out sites in the Moray Firth, NE Scotland (see Thompson et al. 1994). Seals were first weighed, using a spring balance, to the nearest 0.5 kg. Each was then secured to a restraining board and dorsal standard length (McLaren 1993) was measured to the nearest cm. Hair samples were either plucked or cut from a standard site on the midline of the dorsal surface, 60% down the length of the seal. Each sample was removed close to the skin, so that at least 5 mm of the hair was available for analysis. During the molt period, when seals had begun to grow a new coat but still retained some of the old, samples of hair from both coats were taken. These are subsequently referred to as old and new hair. Old coats were generally pale and worn in appearance, while newly molted animals had darker coats with clearer markings.

In order to provide independent estimates of age, we removed an incisor tooth from a subsample of 14 seals, focusing on animals captured in May and August that might be confused as either one- or two-year-olds. Teeth were extracted under sedation with tiletamine hydrochloride and zolazepam (Zoletil, Reading, Z.A.C., 17 rue des Marronniers, 94240 L’Hayes-roses, France) (Arnborn et al. 1992, Baker et al. 1990) and stored in 10% buffered formalin. The nails of the foreflippers were examined for wear to the tips. A number of individuals were observed to have a length of flexible white tissue running along the underside of each nail and extending beyond the tip. This feature,
referred to as "white-tips," has been observed in fetuses and neonates, but not in adults (H. Corpe, personal observation), presumably due to the fact that the soft, flexible white-tips break off as the nails become worn. Their presence on the foreflipper nails of seals captured during the course of this study was noted. Prior to release, seals were marked using individually numbered plastic cattle ear tags (Dalton Supplies Ltd., Henley-on-Thames, RG9 5AB, UK) placed in the webbing of either one or both hindflippers.

Each hair sample consisted of two types of fiber: coarse primary hairs and finer secondary hairs (Scheffer 1964). Only primary hairs were used in this analysis. These hairs were flat and tapered to a point, similar to a blade of grass. Ten hairs were selected at random from each sample. These were fixed to a petri dish, flat side down, using clear adhesive tape. The dish was then placed over a grid of 1-mm squares and viewed under a binocular microscope at 35× magnification. Each hair was aligned with the grid and its width measured 3 mm from the tip. Widths were measured using an eyepiece graticule to the nearest 0.5 graticule unit. Values were converted from graticule units to mm and a mean hair width was calculated for each seal. A note was also made of whether the hairs were damaged, i.e., whether the tips had broken off.

Teeth were decalcified using Decal Rapid (National Diagnostics, Unit 3, Chamberlin Road, Aylesbury, Buckinghamshire, HP19 3DY, UK). Longitudinal and transverse root sections were then cut using a freezing microtome. The sections were mounted on glass slides and stained using a solution of 50% toluidine blue. Photographs were taken of each section, using a high-contrast film. The number of primary rings present in the cementum of each tooth was counted from the positives or negatives and was used as an independent estimate of each seal’s age (see Dietz et al. 1991 for further details of method). In the Moray Firth, pups are born during June and early July, with the first births occurring in early June. Each of the seals was therefore aged to the nearest 0.1 yr, on the assumption that they were born on 1 June.

The mean hair widths fell into two distinct groups (Fig. 1), subsequently referred to as the "narrower" and "wider" groups. When considering only those samples in which the hairs were undamaged, the mean hair widths of the narrower group ranged from 0.10 to 0.13 mm, while those of the wider group ranged from 0.16 to 0.21 mm. Due to the tapering nature of the hairs, mean hair width increased when the tips of the hairs had broken off. When samples with hairs damaged in this way were included in the analysis, the range of the narrower group was thus extended to 0.15 mm, but the distribution remained distinctly bimodal. In contrast, the lengths and weights of the seals from which the samples were taken both overlapped to some extent. The lengths and weights of seals with mean hair widths that fell into the narrower group ranged from 83 to 114 cm and 13.6 to 39.9 kg, respectively. Those of seals with mean hair widths that fell into the wider group ranged from 100 to 155 cm and 26.0 to 125.5 kg, respectively.

The age estimates and mean hair widths of the seals from which a tooth was taken are presented in Table 1. Ten of these seals were estimated to have
Figure 1. Frequency distribution of mean hair widths for harbor seals.

Table 1. Estimates of age from teeth and mean hair widths for a subsample of young harbor seals.

<table>
<thead>
<tr>
<th>Seal ID</th>
<th>Date of capture</th>
<th>Age from tooth (yr)</th>
<th>Hair width (mm)</th>
<th>State of coat†</th>
</tr>
</thead>
<tbody>
<tr>
<td>516</td>
<td>11/08/94</td>
<td>1.2</td>
<td>0.14</td>
<td>old</td>
</tr>
<tr>
<td>516</td>
<td>11/08/94</td>
<td>1.2</td>
<td>0.16</td>
<td>new</td>
</tr>
<tr>
<td>440</td>
<td>28/05/93</td>
<td>1.0</td>
<td>0.12</td>
<td>old</td>
</tr>
<tr>
<td>442</td>
<td>28/05/93</td>
<td>1.0</td>
<td>0.11</td>
<td>old</td>
</tr>
<tr>
<td>455</td>
<td>08/08/93</td>
<td>1.2</td>
<td>0.14</td>
<td>old</td>
</tr>
<tr>
<td>501</td>
<td>02/08/94</td>
<td>1.2</td>
<td>0.14</td>
<td>old</td>
</tr>
<tr>
<td>503</td>
<td>02/08/94</td>
<td>1.2</td>
<td>0.14</td>
<td>old</td>
</tr>
<tr>
<td>509</td>
<td>05/08/94</td>
<td>1.2</td>
<td>0.15</td>
<td>old</td>
</tr>
<tr>
<td>513</td>
<td>11/08/94</td>
<td>1.2</td>
<td>0.14</td>
<td>old</td>
</tr>
<tr>
<td>519</td>
<td>12/08/94</td>
<td>1.2</td>
<td>0.14</td>
<td>old</td>
</tr>
<tr>
<td>518</td>
<td>11/08/94</td>
<td>1.2</td>
<td>0.17</td>
<td>new</td>
</tr>
<tr>
<td>401</td>
<td>02/08/94</td>
<td>2.2</td>
<td>0.19</td>
<td>old</td>
</tr>
<tr>
<td>248</td>
<td>11/08/94</td>
<td>3.2</td>
<td>0.17</td>
<td>old</td>
</tr>
<tr>
<td>313</td>
<td>11/08/94</td>
<td>3.2</td>
<td>0.16</td>
<td>new</td>
</tr>
<tr>
<td>93</td>
<td>29/05/93</td>
<td>3.0</td>
<td>0.18</td>
<td>old</td>
</tr>
</tbody>
</table>

*Old = pre-moul, new = newly molted.
Table 2. Mean hair widths of two seals recaptured during the course of the study.

<table>
<thead>
<tr>
<th>Seal ID</th>
<th>Date of 1st capture</th>
<th>Hair width (mm)</th>
<th>Date of 2nd capture</th>
<th>Hair width (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>459</td>
<td>09/08/93</td>
<td>0.14 0.02</td>
<td>19/05/94</td>
<td>0.17 0.02</td>
</tr>
<tr>
<td>401</td>
<td>13/10/92</td>
<td>0.12 0.01</td>
<td>02/08/94</td>
<td>0.19 0.01</td>
</tr>
</tbody>
</table>

been approximately one year old at the time of capture. Of these, eight had not yet begun to molt and had old coats, with mean hair widths that ranged from 0.11 to 0.14 mm; all were within the narrower group (Fig. 1). Those with values greater than 0.12 mm had hair samples with damaged tips. One of the seals (518) had completed its molt and the mean width of its new hairs was 0.17 mm, which fell into the wider group (Fig. 1). The tenth seal (516) was in the middle of its molt and had patches of both old and new hair. The mean width of the old hairs fell into the narrower group, while that of the new hairs fell into the wider group and was significantly greater than the mean width of the old hairs (Old: \( \bar{x} = 0.14, n = 10, SD = 0.01 \); New: \( \bar{x} = 0.16, n = 10, SD = 0.02, t = 3.055, df = 18, P < 0.01 \)). Of the remaining seals, one was estimated to be two years old and the others three years old. Three of these seals had not yet begun their annual molt and had old coats, while the fourth had a new coat. All four had mean hair widths (0.16 to 0.19 mm) that fell into the wider group.

Two young seals were recaptured once during the course of the study. Their mean hair widths on each of the two dates of capture are presented in Table 2. The first (459) was initially captured in August 1993. It had not yet molted and had an old coat. Its mean hair width was 0.14 mm, a value which fell into the narrower group. When recaptured the following May it had molted and mean hair width had increased to 0.17 mm, a value which fell into the wider group. The second seal (401) was first captured in October 1992 and had new hair with a mean width of 0.12 mm, which fell into the narrower group. When recaptured nearly two years later, in August 1994, mean hair width had increased to 0.19 mm, a value which fell into the wider group. All of the seals recorded with white-tips to their foreflipper nails fell into the narrower group.

The results of this study indicate that the mean hair width of harbor seals increases following the first true molt, i.e., that the hairs become coarser, and that this may thus be used as a method for distinguishing seals in their first year from older age classes.

The distinctly bimodal distribution of mean hair widths (Fig. 1) permitted the division of the seals into two groups. Those with a mean hair width that fell into the wider group included all of the adults sampled, while those with a mean hair width that fell into the narrower group included all of the seals with white-tips to the nails of their foreflippers. These white-tips have been observed in fetuses and newborns but not in adults (H. Corpe, personal observation). Their soft, flexible nature suggests that their presence may not
persist for long, as they are likely to break as the nails become worn. This is borne out by the fact that they were most frequently noted in young seals captured in the autumn and winter, during the months following the summer pupping period. Although white-tips were sometimes noted for young seals captured in the spring, they had usually begun to break. It seems reasonable to suggest, therefore, that the presence of white-tips to the foreflippers nails is indicative of the fact that a seal is in its first year.

There was some overlap between the lengths and weights of seals with a mean hair width that fell into the narrower group and those with a mean hair width that fell into the wider group. However, seals with a mean hair width that fell into the narrower group were generally smaller than those with a mean hair width that fell into the wider group. The overlap in length and weight between the two groups may be attributed in part to the fact that individual body size varies within an age class and that lengths and weights may, therefore, overlap between age classes. In addition, overlap may arise due to the fact that, within an age class, some hair samples were taken from seals that had not yet undergone their annual molt, i.e., from an old coat, while others were taken from seals that were recently molted, i.e., from a new coat. Measurements of hair samples taken from yearling seals that had not yet moulted would represent the mean hair width of a pre-first-molt coat, while those of hair samples taken from newly molted yearlings would represent the mean hair width of a post-first-molt coat. Yearling seals, with similar body size, might therefore fall into different mean hair width groups.

Confirmation that differences in mean hair width are not the result of individual differences, but that hair width changes between coats within individuals, is provided by comparing the mean hair widths determined for two seals sampled on more than one date (Table 2). The relative timing of captures and the state of the coat at each capture were such that both seals had undergone one annual molt between capture dates. Mean hair width increased between capture dates, from a value which fell into the narrower group to a value which fell into the wider group (Fig. 1). Further confirmation is provided by seal 516 (Table 1), which was in the middle of its annual molt at the time of capture and thus had a coat consisting of patches of both old and new hair. The mean width of the new hair fell into the wider group, and was significantly greater than that of the old hair, which fell into the narrower group.

Confirmation that such an increase in mean hair width occurs at the first true molt, i.e., when a seal is approximately one year of age, is provided by the seals for whom an independent estimate of age was made on the basis of counts of primary rings laid down annually in the cementum of teeth. Estimates of age based upon this method are subject to error (Bowen et al. 1983, Mansfield 1991). However, Dietz et al. (1991) found that the teeth of seals between the ages of 2 and 10 were the most difficult to examine. They refer to growth layer groups (GLGs) in the cementum consisting of a wide translucent band and a narrow opaque band. This latter band is the primary ring. Yearlings sampled by Dietz et al. (1991) between April and June had one well-defined translucent layer and a very thin opaque layer. This first GLG
was considerably thicker than subsequent GLGs. Each of the seals from which a tooth was taken in the present study were sampled either in May (shortly before the summer pupping season) or in August (shortly after the pupping season) (Table 1). The seals estimated to be one year old in the present study included seal 516 (see above). Of the remaining one-year-olds, eight had old coats and therefore had not undergone their first true molt. The mean hair widths of all of these seals fell into the narrower group. One had new hair, indicating that it had completed its first true molt. The mean hair width of this seal fell into the wider group. The remaining seals from which a tooth was taken were estimated to be either two or three years old. Each of these had therefore already undergone its first true molt and had a mean hair width that fell into the wider group.

It is proposed that further confirmation that hair width increases between the pre- and post-first-true molt coats might be based upon hair samples taken from known-age seals in captivity. However, the results of the present study suggest that measurement of hair samples provides a quick and reliable method for distinguishing harbor seals in their first year (pre-first-true molt) from older age classes (post-first-true moult). The removal of a hair sample does not require sedation and consequently carries no increased risk to the seal while helping to minimize handling time. Furthermore, the collection and measurement of hair samples is a quick and simple technique and could therefore be used in the field to determine the age of a young seal prior to tagging or the deployment of telemetric equipment.

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LITERATURE CITED


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