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AGE DETERMINATION AND THE GROWTH AND AGE DISTRIBUTION FROM CEMENTUM GROWTH LAYERS OF BEARDED SEALS AT SVALBARD

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ABSTRACT

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Material for this study was collected from 177 bearded seals on a sealer at Svalbard in 1968 and from 18 seals studied by biologists at Svalbard and in the Barents Sea in 1968 and 1970.

Bearded seal teeth degenerate and are lost at an early age, but canines in the upper jaw remain, apparently throughout life. They wear down at a linear rate. Dentine cannot be used for age determination, but cementum growth layers are added annually and permit age determinations also of adult seals. Growth layers in claws wear off after about 10 years. Bearded seals grow to a mean adult length of 225 cm at about 10 years. Females are slightly, but not significantly, larger than males. At Svalbard age-groups are fully recruited at 9 years and live to an age of about 31 years. A total annual mortality of 0.14 has provisionally been estimated for adult bearded seals at Svalbard.

INTRODUCTION

The circumpolar boreoarctic bearded seal, *Erignathus barbatus* (Erxleben, 1777), is found as far south as to the White Sea and the Gulf of St. Lawrence in the Atlantic and to the Sea of Okhotsk, even to Sakhalin and Hokkaido, in the Pacific, Occasional stragglers go further south, but the main distribution is at the pack ice in areas with moderate water depths. It moves seasonally with the edge of the ice, but does not perform regular migrations in open water (SCHEFFER 1958, KING 1964). According to POTELOV (1966) the bearded seal has been seen close to the North Pole.

Evidence for segregation between age groups has been found by POTELOV (1966) and by BURNS (1967) who suggests that the tendency to remain near the ice is more fixed in adults than in juveniles.

Two slightly different geographical forms are recognized. These forms have been given the rank of subspecies: *E.b. barbatus* in the Atlantic and *E. b. nauticus* in the Pacific (SCHEFFER 1958). However, a recent comparative study of more than four hundred crania from the White, Kara, Barents, Okhotsk and Bering Seas showed no significant differences in growth rates of cranial bones between the different populations (KOSYGIN and POTELOV 1971).

The bearded seal is not a very abundant species, but it is hunted by aborigines all around the Arctic and is quite important in the economy of local communities. World wide catch statistics have not been compiled.

Norwegian sealers have on the average taken some 1 600 bearded seals per year in North Atlantic waters since 1945. About two thirds of these seals were caught by small ships hunting in Svalbard waters and in the northern Barents Sea during summer. However, prices for bearded seal skins have decreased, and in the last few years only occasional catches, mostly taken by expeditions, have been landed.

Annual zones in the cementum and the dentine have been used for age determination in several species of mammals since the technique was described in the early 1950-ies (LAWS 1962). In studies of seals a lower canine tooth usually has been selected for ageing, but the method was found to be inapplicable for bearded seals in the Arctic America because the teeth in this species are degenerated and often missing (MCLAREN 1958, BURNS 1967). In those studies the growth ridges on the claws were used for age determination. By this method only a minimum age can be obtained for older seals because wear at the tip of the claw eliminates the first growth ridges after 9 to 16 years (MCLAREN 1958). However, POTELOV (1964) points out that the cementum layers in the upper canines of the bearded seal are useful for age determinations because these teeth have more cementum than lower canines and are not so often missing.

In this paper methods for age determination are studied and data on growth, age distribution, longevity and mortality of bearded seals at Svalbard are presented. Age determinations are based on growth layers in the cementum of the upper canines.

MATERIAL AND METHODS

This study is based mainly on data from 177 bearded seals caught by a sealing vessel in the pack ice of eastern Svalbard waters in May and June 1968. The material was collected by a sealer trained by a technician from the Institute of Marine Research on a previous sealing voyage.

For each animal sex was recorded, the upper jaw collected and the standard length measured along a straight line from tip of nose to end of tail with the animal lying on it's back on a flat surface. Material from 8 and 10 bearded seals collected by biologists in the Barents Sea in the spring of 1968 and at Svalbard in July 1970 has also been examined.

Both the jaw and a claw from the middle digit of one of the fore flippers was collected from 16 of these seals.

Jaws and claws were stored in brine. After boiling for about 30 minutes in water the teeth could be extracted without damage. Inspection of a few longitudinal tooth sections showed that all cementum layers were represented and well defined at about 1 cm from the basal end of the root, and therefore the teeth were cut in transverse sections, 0.1—0.3 mm thick, at this position. The claws were cut in 0.5—0.8 mm thick longitudinal sections. Sections were washed in 96% alcohol, dried and permanently mounted on glass slides with Eukitt (Heinrich Vogel, Giessen).

Cementum layers were most easily counted in a phase microscope, but a binocular microscope could also be used. Growth layers in the claws could be counted by the naked eye.

The annual mortality was calculated by the equation

$$Z = 1 - \bar{x} / (1 + \bar{x} - 1/n)$$

where

Z = annual mortality
$\bar{x}$ = mean age, beginning with age of full recruitment as zero.
n = number of animals in the fully recruited age groups in the sample,

(Chapman and Robson, 1960).

RESULTS

AGE DETERMINATION

Jaws collected for this study confirm earlier findings by other workers that bearded seal teeth are worn down, degenerate and fall out before the animals are very old. However, the roots of the canine teeth in the upper jaw apparently remain throughout most of the seal's life. Only one out of 194 upper jaws examined, had lost the canine roots.

Because of wear at the tip, length growth of the upper canines stops when the seal is a couple of years old. Canine tooth lengths (straight line distance from tip of crown to tip of root) are shown in relation to age in Fig. 1. A linear rate of tooth wear is suggested although individual differences are clearly indicated.

Dentine deposited in the upper canines during the first year nearly closes the basal opening of the pulp cavity. In the next few years new dentine is added inside the dentine of the first year and does not contribute to the growth of the tooth. The basal opening is closed, the pulp cavity filled, and no more dentine is deposited after the bearded seal

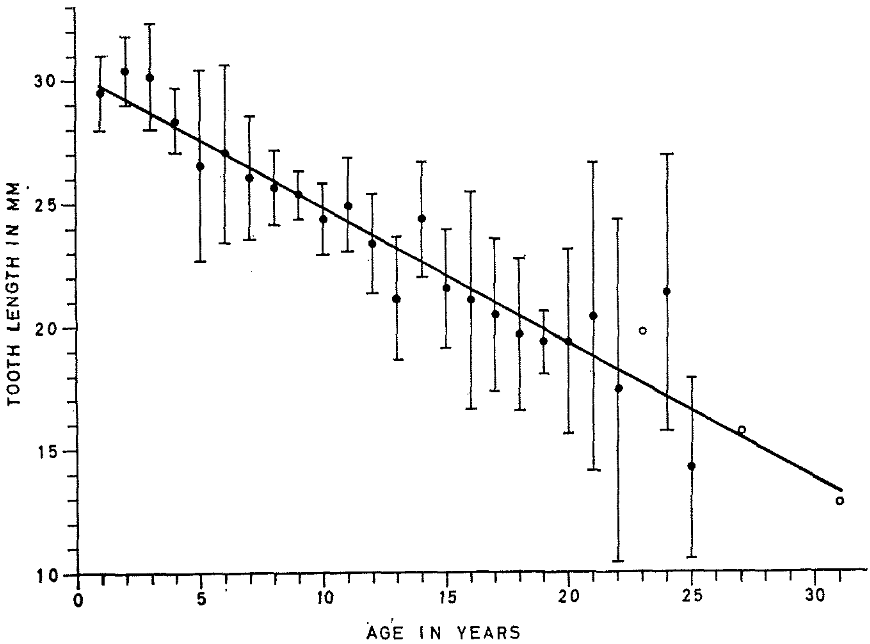

Fig. 1. Lengths of upper canine teeth of bearded seals in relation to age as determined from cementum growth layers. Means and 95 per cent confidence intervals, open circles indicate single measurements. The regression line: $y = -0.55\ x + 30.3$.

is about four years old. Secondary lamination within the annual dentine layers also complicate the interpretation of the layers. Dentine growth layers therefore are not satisfactory as a basis for age determinations.

However, laminated cementum is deposited on the outside of the roots of the teeth as long as they remain in the jaw. The cementum lamina on the upper canines are parallell to the long axis of the tooth, but varying in thickness both around the root and along its length. Lamina can not be distinguished at the basal end of the root.

The cementum of a standard transverse section from an upper canine tooth as is appears in transmitted light is shown in Fig. 2. Alternating translucent and opaque lamina appear as light and dark bands. One light and one dark band together are interpreted as one annual growth layer. Cementum layers usually are sufficiently distinct to be easily counted, but diffuse lamina impeded an exact age determination in about 10 per cent of the sections.

In claws the laminated structure in a longitudinal section is oritented as indicated in Fig. 3.

New lamina are formed underneath and behind the old ones and push the claw forwards while old lamina are removed by wear at the

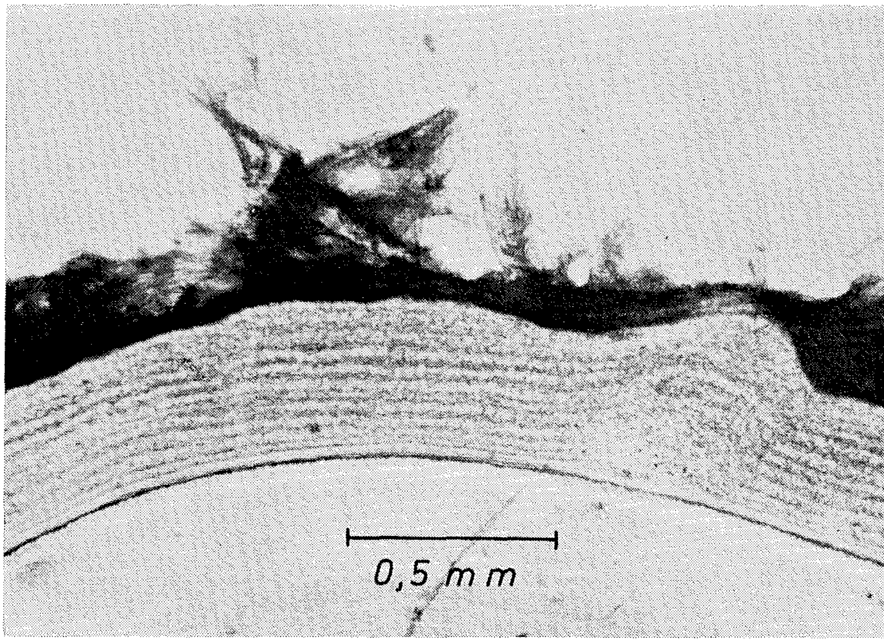

Fig. 2. The laminated structure of cementum in a transverse section from a bearded seal upper canine tooth shown by transmitted light.

tip of the claw as the seal grows older. Part of a longitudinal claw section is shown by transmitted light in Fig. 4. The lamination appears as alternating dark and light bands, one dark and one light band together forming one annual growth layer.

All material used in this study was collected in the spring and summer so the formation of layers in the teeth and the claws could not be followed through the year. However, the relative position of lamina suggests that the light bands in the claws and the opaque lamina in the cementum are deposited during the summer season, and the dark bands and translucent lamina during winter and spring.

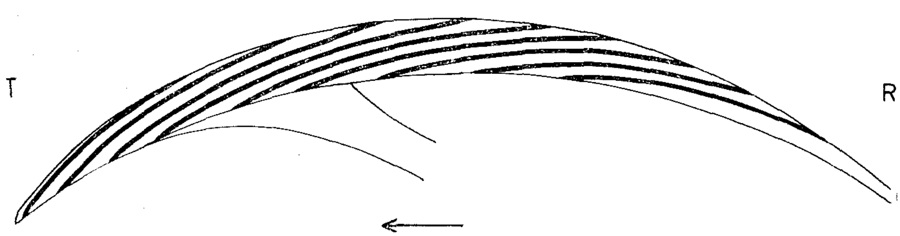

Fig. 3. The orientation of the laminated structure in a longitudinal section of a claw from a bearded seal fore flipper. R)root and T)tip of the claw. Arrow shows direction of growth.

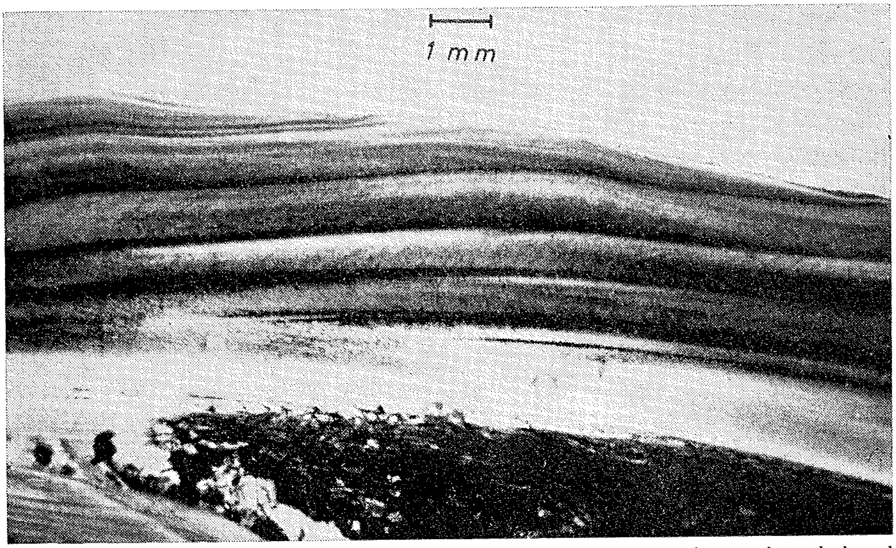

Fig. 4. The laminated structure in a longitudinal section of a claw from a bearded seal fore flipper shown in transmitted light.

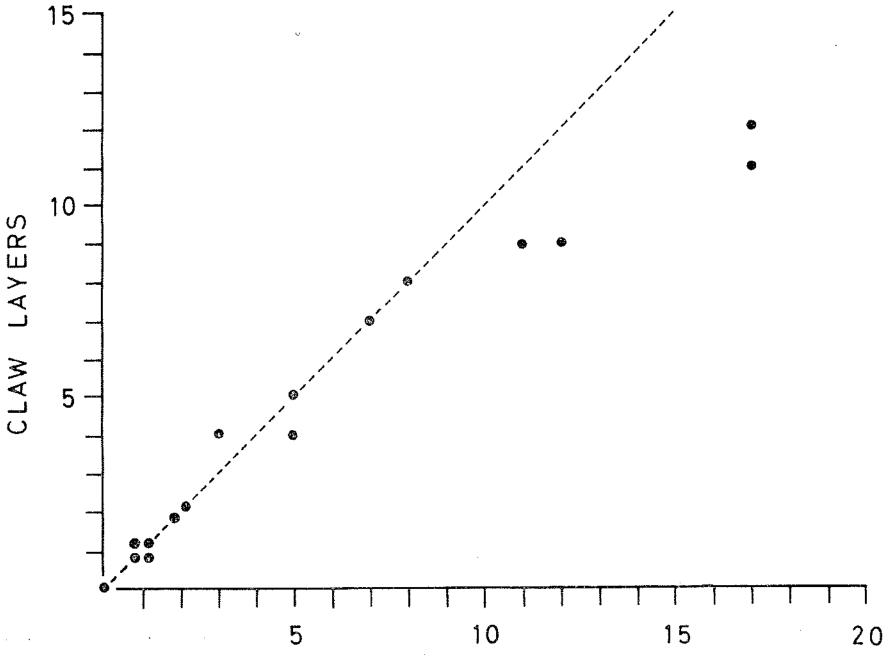

Fig. 5. The number of annual growth layers in the cementum of the upper canine teeth compared to the number of annual layers in claws from 16 bearded seals sampled at Svalbard and in the Barents Sea. The 1:1 relationship is indicated by a broken line.

Age determinations from cementum and claw layers are compared for 16 bearded seals in Fig. 5. Up to an age of about 8 years there is a good correlation between the number of layers in cementum and claws. Two animals — 3 and 5 years old from cementum layers — are exceptions from this rule. In both cases the deviation is explained by obscure bands in the claws. Wear has removed growth layers at the tip of the claw in four 11 years old and older seals.

GROWTH

The relationship between age and standard length for 191 bearded seals is shown in Fig. 6. The mean length at birth (131.3 cm) given by BURNS (1967) has been used as a starting point for the growth curve. A mean adult length of 224.7 cm (standard deviation 14.5 cm) is reached at an age of about 10 years. For adult seals 10 years old and older the standard lengths range from 180 cm to 252 cm.

The mean lengths of adult females and males were 226.6 cm and 222.5 cm respectively. A t-test showed that this difference between the sexes was not significant at the 5 per cent level ($t = 1.48$, $0.1 < p < 0.2$).

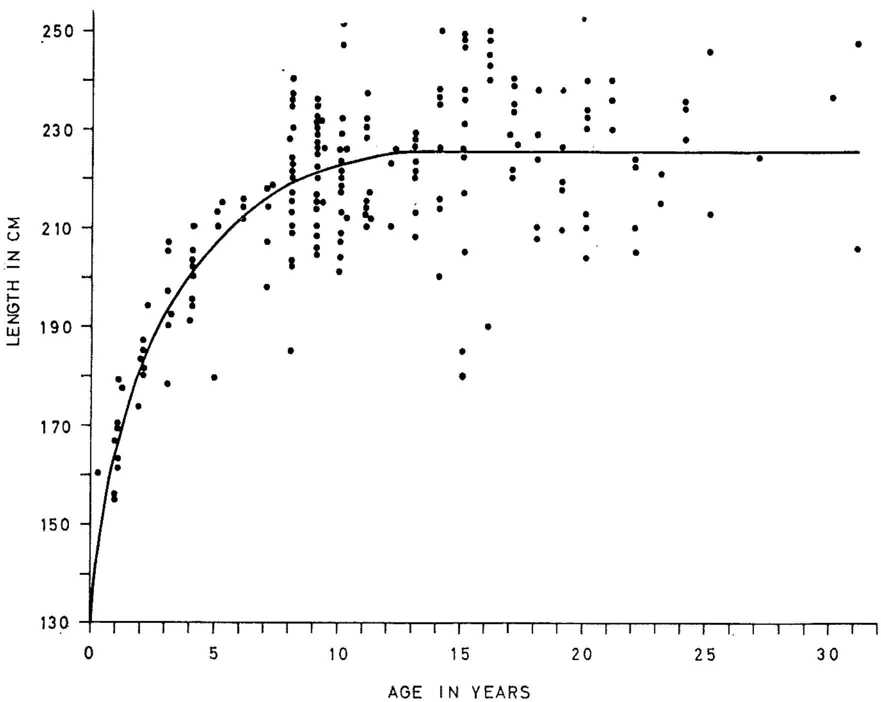

Fig. 6. The growth of bearded seals at Svalbard and in the Barents Sea based on standard length measurements and age determinations from cementum growth layers.

AGE DISTRIBUTION AND MORTALITY

The age distribution as determined from cementum growth layers of 175 bearded seals, all caught in eastern Svalbard waters in May and June 1968, is given in Fig. 7. In this sample age groups are not fully recruited until they are 8 or 9 years old. The oldest male and the oldest female in the sample were 25 and 31 years old respectively.

When 9 years is taken as the age of full recruitment, the total annual mortality rate for 9 years old and older bearded seals in the sample as calculated from the equation

$$Z = 1 - \bar{x} / (1 + \bar{x} - \frac{1}{n})$$

is 0.14.

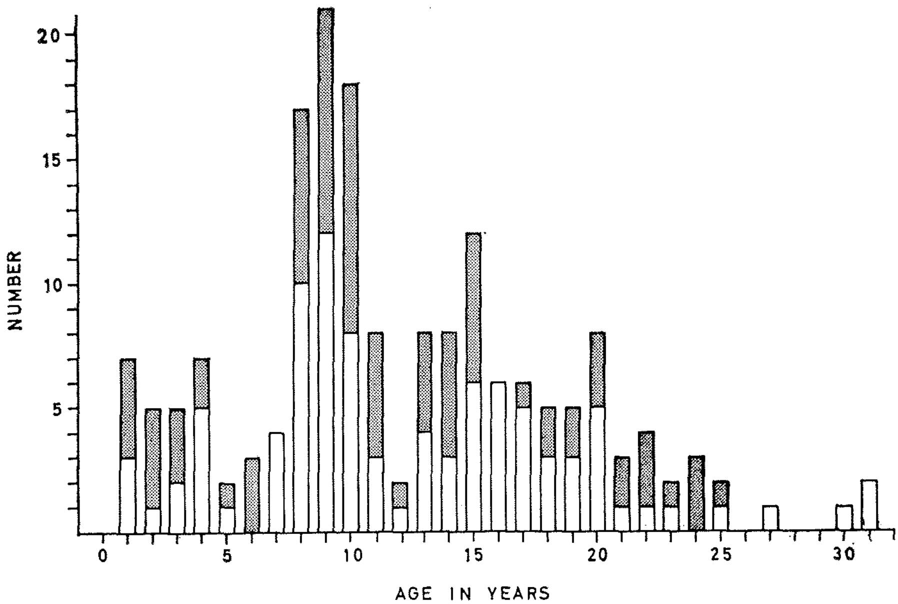

Fig. 7. The age distribution of 175 bearded seals caught in eastern Svalbard waters in May—June 1968. Open columns are females, hatched columns are males.

DISCUSSION

AGE DETERMINATION

The rapid wear and loss of the teeth in bearded seals has been attributed to evolutionary degeneration in tooth structure and to the perhaps conflicting fact that the species is feeding on abrasive benthic invertebrates like clams and crabs as well as ingesting quantities of sand (POTELOV 1964, BURNS 1967). The discovery that the upper canine teeth can be used for age determination was first published by POTELOV (1964) who concluded that the number of cementum growth layers in these teeth reflects the age of the bearded seal.

Evidence in this study for the annual formation of the cementum growth layers may be found in the close structural resemblace to annual cementum layers in other species (LAWS 1962), in the fairly good fit of length data to a normal growth curve (Fig. 6) and in the age distribution of adult seals (Fig. 7).

The growth layers in the claws were found to be deposited annually in bearded seals in Arctic America by MCLAREN (1958) and BURNS (1967) who both studied the surface structure of the claws and found the same pattern of band deposition as indicated by this study. Even if few data are available, the close correlation between the number of growth layers in the claw and in the cementum in young and subadult animals (Fig. 5) therefore gives additional evidence that the cementum growth layers are formed annually.

The deviation between cementum and claw layers in the few adult seals examined (Fig. 5), strongly suggests that studies of age distribution and mortality, perhaps also studies of growth and maturity, should be based on age determinations from cementum growth layers rather than from growth layers in the claws.

GROWTH

MCLAREN (1968) and BURNS (1967) found that the mean length of adult bearded seals in the American Arctic was about 235 cm and 233.7 cm respectively. It is not clearly stated how their measurements were taken, and if zoological lengths were used (measured over curvature of body from tip of nose to end of tail), their data are not strictly comparable to the growth data from this study. A t-test also shows that their mean adult lengths differ significantly from the mean standard length of adults (224.7 cm) found in this study ($t = 2.78$, $p < 0.01$).

In Fig. 6 the lengths plotted for four animals are so much shorter than all others in their age groups that *rigor mortis* contractions may be suspected (one 8 years old male 185 cm, two 15 years old males 180 and 185 cm and one 16 years old female 190 cm). If these animals are omitted from the calculations, the mean standard length of adults changes to 225.8 cm and the range of adult lengths changes to 200 cm—252 cm, but the difference between this mean length and the American Arctic means is still significant at the 5 per cent level ($t = 2.53$, $0.02 < p < 0.03$).

A slightly longer length of adult females than of males (3.1 per cent) was also found by BURNS (1967). Omitting the four animals mentioned above, the mean lengths in this study are 227.3 cm for adult females and 224.1 cm for adult males. The difference is still not significant at the 5 per cent level ($t = 1.23$, $0.2 < p < 0.3$).

AGE DISTRIBUTION AND MORTALITY

The poor representation of age groups from 0 to 7 years in the Svalbard area (Fig. 7) may be explained by a segregation between mature and immature seals in summer. According to BURNS (1967) and POTELOV (1972 b) female and male bearded seals attain sexual maturity at about five and six years of age respectively. POTELOV (1972 a) suggests that bearded seals in the Barents, White and Kara Seas all belong to one population which concentrates in the southern parts of the Barents Sea and the northern White Sea during winter. In summer and autumn the mature seals move north while the immatures and a very few adults remain in the south. A similar pattern of distribution during summer has been demonstrated for bearded seals in the Bering and Chukchi Seas by BURNS (1967) who also found a peak at 8—9 years in the age distribution in the Bering Strait during the spring hunting season.

Mortality estimates from the equation used here are based on the following assumptions: 1) Reproduction occurs every year, 2) the number of young born in any year balances the number of seals of all age groups that have died during the previous year, i.e. the population is at equilibrium, 3) the age distribution of fully recruited age groups in the sample represents the age distribution in the population, and 4) the mortality rate is constant in all fully recruited age groups (CHAPMAN and ROBSON 1960).

Although it has been suggested that females which have recently given birth may forego ovulation until after the mating season and thus establish a two year cycle (McLAREN 1958). BURNS (1967) found a pregnancy rate of 83—85 per cent among bearded seals in Alaska. A regular one year cycle of reproduction therefore seems likely, and all investigators have found a definite breeding season in late spring (BURNS 1967, POTELOV 1972 b). The exact timing may differ, but there is a general agreement that young are produced annually.

The other assumptions may be more doubtful. Norwegian catches in the Svalbard area have varied between nil (1967) and 3600 (1951) since 1945 with corresponding changes in hunting mortality. No attempt has been made to assess the influence of hunting on the total mortality of bearded seals at Svalbard or in the Barents Sea, but Norwegian catches have not exceeded 600 animals since 1965. It therefore seems possible that the population nearly was at equlibrium when the sample was collected.

However, there is no reason to believe that natural mortality has changed through the years. Changes in hunting mortality therefore may have influenced the total annual mortality in the population in earlier years.

The small number of specimens in the age sample also makes estimates of mortality somewhat dubious, but most age-groups older than 8 years seem to be fairly well represented. Even with the reservations above which mean that 0.14 can only be used as a provisional estimate of annual mortality, this estimate is called for. Particularly so because no other estimates of mortality are yet available for bearded seals.

It might also be mentioned that decreasing catches at Svalbard and a protection of bearded seals in the southeastern Barents Sea since 1970 (Norwegian—Soviet Sealing Commission) may have produced an increasing survival and a lowered adult mortality in the most recent years.

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