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Atlantic mackerel
Scomber scombrus

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Atlantic mackerel is a pelagic schooling species found on both sides of the North Atlantic; in the Northwest Atlantic it occurs from Labrador to North Carolina. Males and females grow at about the same rate, reaching a maximum age of about 20 years and a maximum fork length of about 47 cm (19 inches). Most mackerel are sexually mature by age 3.

The Northwest Atlantic population of mackerel consists of two major components which follow different migratory patterns but do not appear to be genetically distinct. Mackerel of both components overwinter along the edge of the continental shelf from Cape Sable, Nova Scotia, to Cape Hatteras, North Carolina. The southern component moves inshore and northward to spawn in the Middle Atlantic Bight in spring and then move further northward into the Gulf of Maine in summertime. The northern component reaches Southern New England waters in late May and then moves northward to the Gulf of St. Lawrence where spawning occurs in June and July. Fish of both groups move southward en route to overwintering areas during the autumn (Anderson and Paciorkowski 1980).

Ageing methods for this species were first described by Steven (1952) for mackerel of the English Channel and Celtic Sea. Growth patterns on mackerel otoliths are not as complex as some other fish species, but can be difficult to interpret if viewed in water or alcohol. Several types of growth pattern anomalies, such as checks, may cause difficulty with age interpretation. In addition, older mackerel (>10 years) can be difficult to age because annuli are extremely thin and closely spaced near the edge of the otolith.

The whole otolith, mounted in clear Permount resin, is used to age this species. The resin enhances definition of the finely detailed growth patterns and provides a protective, long-term storage medium. Pairs of otoliths are mounted in circular depressions on black plastic trays distal-surface-up with the rostra of both otoliths aligned together. This enables a detailed comparison of zone formation and ring counts on each otolith. Magnification of as much as 60X under reflected light is required to distinguish annuli formed near the edge of otoliths from older mackerel.

Young-of-the-year mackerel are fast growing, usually completing about 20 cm (8 inches) of growth by the first autumn after hatching (Anderson and Paciorkowski 1980). The first annulus begins to form as early as August (Dery and Anderson 1983) and is deposited after a large amount of opaque material has formed around the nucleus. For that reason, the first strong hyaline zone after the nucleus is interpreted as the first annulus. Subsequent hyaline zones are counted as annuli. By convention, a birthdate of 1 January is used. As of this date, the hyaline zone forming on the edge of the otolith is included as an annulus until seasonal growth resumes.

Annulus formation is completed by March or April for a few young fish (ages 1-3), but for most individuals it may not be complete until May or June (Dery and Anderson 1983). Seasonal growth resumption (opaque edge) may not be apparent on older fish otoliths until late August or September. This is partly an artifact of the relatively narrow growth increment formed, which is not easily detectable when first deposited. On most otoliths, opaque edge is first evident on the tip of the rostrum rather than on the posterior edge (Fig. 1). This is because the rostrum is usually part of the longest axis of growth on the otolith, and forms wider growth increments relative to other parts of the structure.

Age interpretations should be based upon the examination of more than one part of the otolith. It is possible to interpret different numbers of annuli on the rostrum, subrostrum, and postrostrum, due to close spacing or weak formation of zones on various parts of the otolith. The rostrum usually affords the widest separation of hyaline zones unless it is truncated, with most otolith growth shifted to the posterior end of the otolith. In Figure 2, hyaline zones are well spaced and clearly defined on both the rostrum and the posterior edge of an otolith from a 41-cm, age-11 fish. Figures 3A, 3B, and 3C show different parts of an otolith from a 39-cm, age 16+ fish with a truncated rostrum. No age can be determined using the rostrum (Fig. 3A), but 16 hyaline zones can readily be interpreted on the subrostrum (Fig. 3B) and the postrostrum (Fig. 3C).

As previously mentioned, the tip of the rostrum may be more reliable for edge interpretation, and checks usually appear weaker on the rostrum than on other parts of the otolith. Generally, if the number of annuli interpreted on various axes of the otolith differ, and the cause of the difference cannot be identified as a check, split, or weakly formed zone, the "best" age may be assigned on the basis of the highest ring count. This is because ageing error for older individuals has been found to be biased toward underinterpretation of age.

On most mackerel otoliths, the first hyaline zone, representative of the first annulus, is generally well defined. A large first annulus is evident on an otolith from a 16-cm, age 1+ fish sampled in July (Fig. 4). The first hyaline zone is clear and distinct around the entire periphery of the otolith. In contrast, Figure 5 shows an otolith from a (young-of-year) age 0+ mackerel sampled in October that could be interpreted as age 1+. However, the weak incomplete hyaline zone was interpreted as a check and not an annulus.

During the second year of growth following the first annulus, a check can form on the otolith during the summer months which could lead to overinterpretation of age, especially if strongly formed on the postrostrum (Dery and Anderson 1983). If such otoliths are collected in late summer or early autumn after the check has formed they could be interpreted as age 2+ rather than 1+ (Fig. 6). Normally, the check is not continuous around the otolith, and is faint or absent on the rostrum (Fig. 7). Frequently, it appears as a diffuse stippling of hyaline material and does not form a discrete hyaline zone. In Figure 8, showing an otolith from a 26-cm, age 2+ fish sampled in July, the second hyaline zone, although weak and diffuse, is the second annulus. This zone is very strong on the rostrum, confirming it as an annulus.

On otoliths from older fish, the identity of the hyaline zone as a check is more obvious because of the relative spacing of annuli and the contrast of the check with the more strongly formed second, third, or fourth annuli. Frequently, such checks are also formed during the third or fourth summers (Fig. 9).

After formation of the third annulus, age interpretation may be complicated by an irregular spacing of annuli. In Figure 10, showing an otolith from a 42-cm age-9 fish, the third, fourth, fifth, and sixth annuli are separated by very narrow growth increments, but the increment between the sixth and seventh annuli is wide. Anomalous spacing of annuli tends to be quite typical of mackerel otoliths. On some otoliths, annuli may be spaced very close together and may seem to constitute one split annulus. If the "split" zone is traced along the pararostrum or examined on the rostrum, it may be resolved into two separate annuli. The pararostral area is therefore very important in distinguishing annuli. An otolith from an age 5+ fish has very closely spaced third and fourth annuli on the posterior edge of the otolith, but the same annuli are spaced more widely apart on the rostrum (Fig. 11).

For age-10 or older mackerel, thickening of the otolith may partially obscure the first several annuli. Outer annuli are difficult to interpret because the hyaline zones are often thin, weak, split, or closely spaced. Figures 12A and 12B show the rostrum and postrostrum of an otolith from a 42-cm mackerel which was aged as a possible 16+ after multiple age readings. Although the rostrum is well developed, the annuli are poorly formed and diffuse (Fig. 12A). On the postrostrum (Fig. 12B), several annuli are so weak and obscured by calcium that they can easily be overlooked in the age interpretation.

Contrast between hyaline and opaque zones tends to deteriorate toward the outer edge of otoliths of older mackerel. This results from a decrease in the relative amount of calcium aragonite deposited during the summer months, causing the "opaque" zones to appear more translucent. Figure 13 shows an otolith from a 40-cm age 9+ fish collected in December. All the annuli (not including the edge) can be readily interpreted on both the rostrum and postrostrum, but after the sixth annulus there is less contrast between the hyaline and opaque zones. Figures 14A and 14B are more extreme examples, showing the rostrum and postrostrum of an otolith from a 42-cm mackerel. It could not be aged because of the increasing translucence of the otolith toward the edge, and because of poorly formed hyaline zones.

No significant differences in growth patterns between mackerel otoliths of the northern and southern components have thus far been established. Individual variation in the shape of otoliths and relative length and thickness of the rostrum relative to the postrostrum are considerable.

Citations

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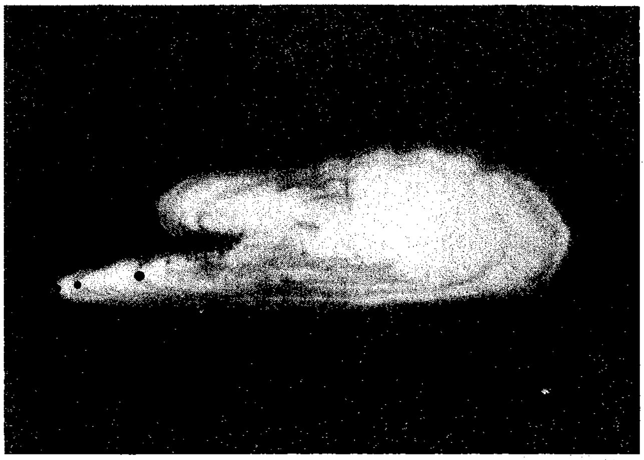


Figure 1
Whole embedded otolith of a 34-cm age 3+ Atlantic mackerel collected in August showing a tiny amount of opaque material visible on the tip of the rostrum.

Figure 2
Whole embedded otolith of a 41-cm age-11 Atlantic mackerel collected in July showing clearly defined annuli and persistent hyaline edge.

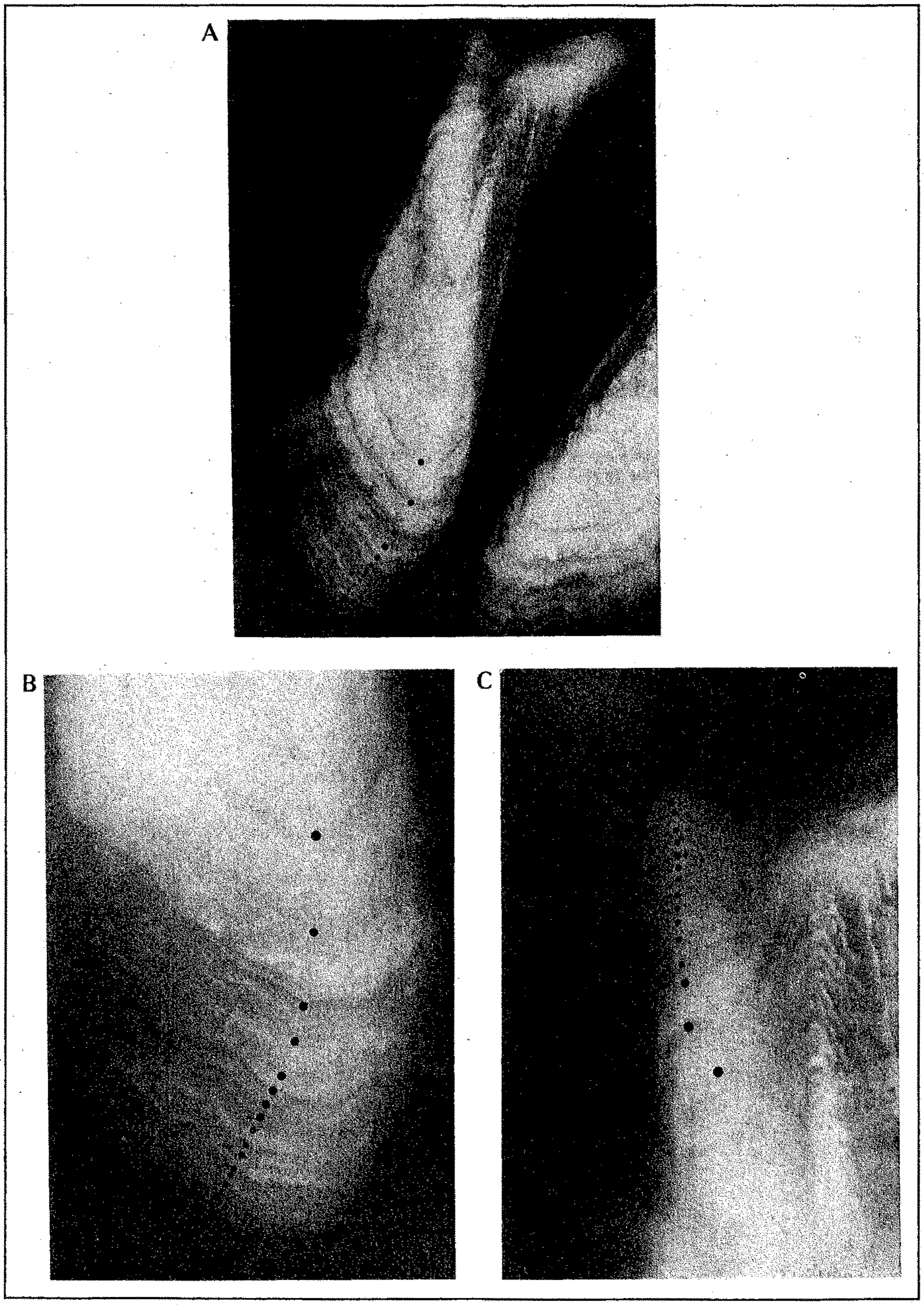


Figure 3

(A) Whole embedded otolith of a 39-cm age 16+ Atlantic mackerel collected in August with a truncated rostrum, unsuitable for age interpretation. **(B)** Subrostrum showing 16 clear annuli and narrow opaque edge. **(C)** Posterior part of the otolith showing 16 clear annuli and narrow opaque edge.

Figure 4
Whole embedded otolith of a 26-cm age 1+ Atlantic mackerel collected in July showing a large first annulus.

Figure 5
Whole embedded otolith of a 20-cm age 0+ Atlantic mackerel collected in October showing a first summer check formed close to the edge of the otolith.

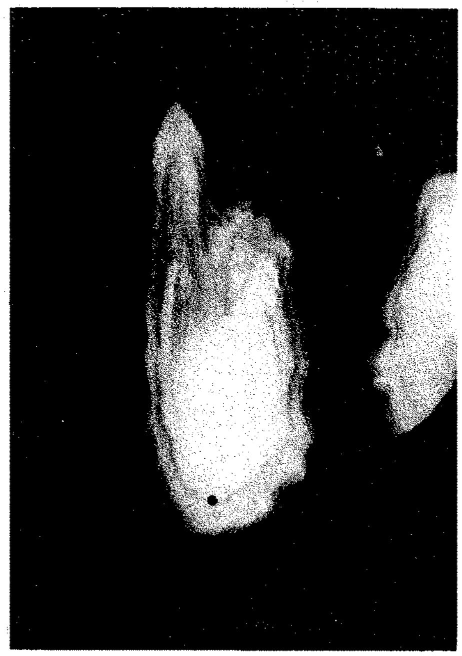


Figure 6
Whole embedded otolith of a 25-cm age 1+ Atlantic mackerel collected in August showing a thin summer check formed just inside the posterior edge.

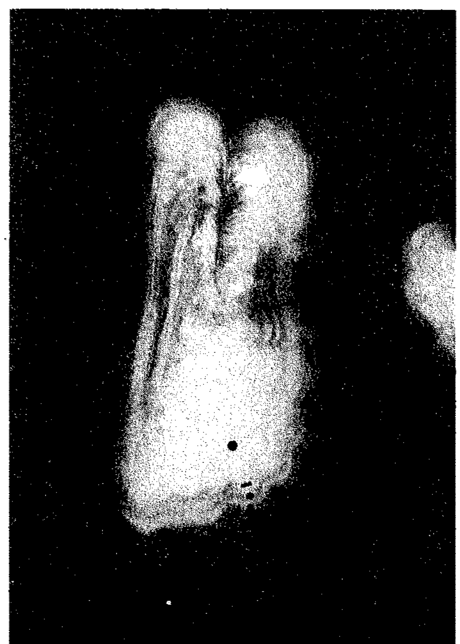


Figure 7
Whole embedded otolith of a 39-cm age 4+ Atlantic mackerel collected in December showing a weak check formed between the first and second annuli.

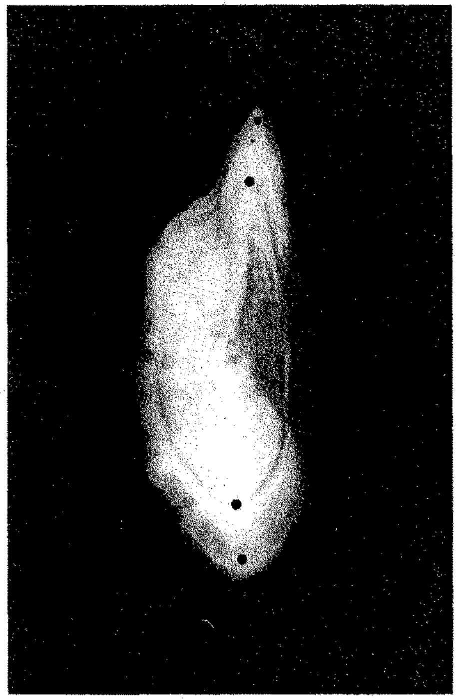


Figure 8
Whole embedded otolith of a 26-cm, age 2+ Atlantic mackerel collected in July showing a weak second annulus strongest on the rostrum.

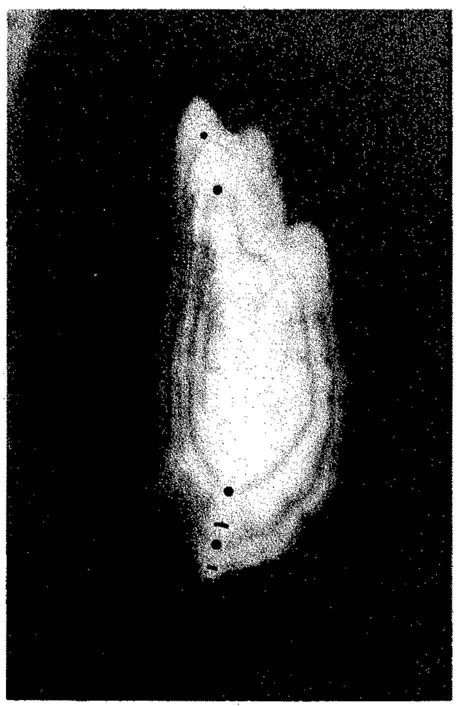


Figure 9
Whole embedded otolith of a 32-cm age 2+ Atlantic mackerel collected in November showing a small first annulus and second and third summer checks.

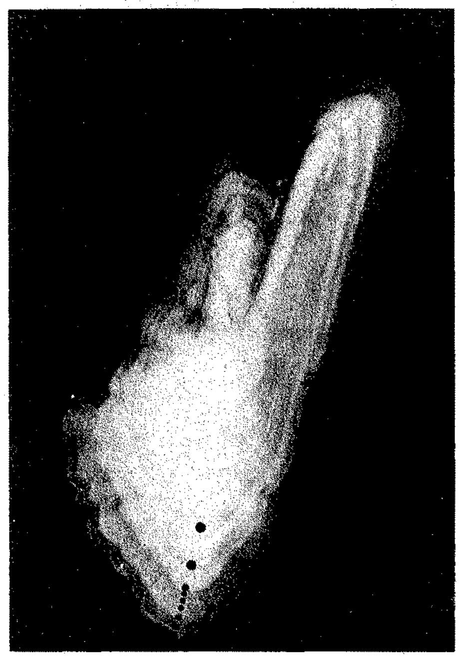
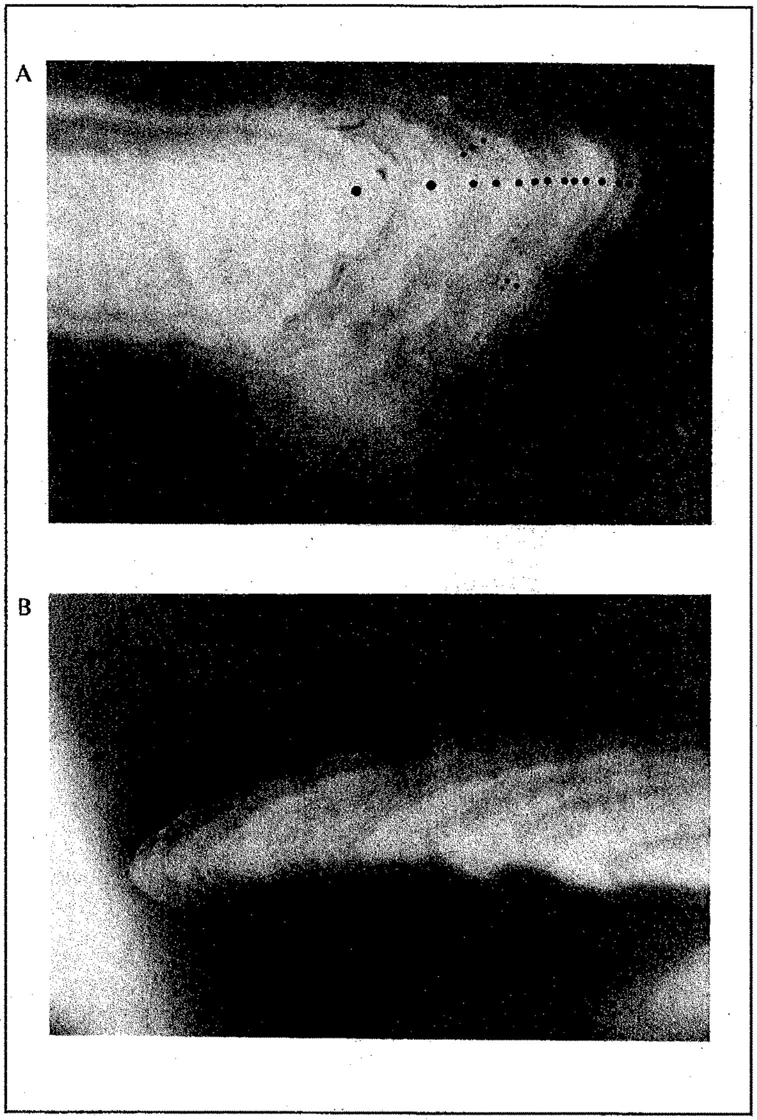


Figure 10
Whole embedded otolith of a 42-cm age-9 Atlantic mackerel collected in August showing persistent hyaline edge. Annuli 3-6 are spaced closely together.

Figure 11
Whole embedded otolith of a 41-cm age 5+ Atlantic mackerel collected in December showing the third and fourth annuli spaced closely together on the posterior part of the otolith, but spaced more widely apart on the rostrum.



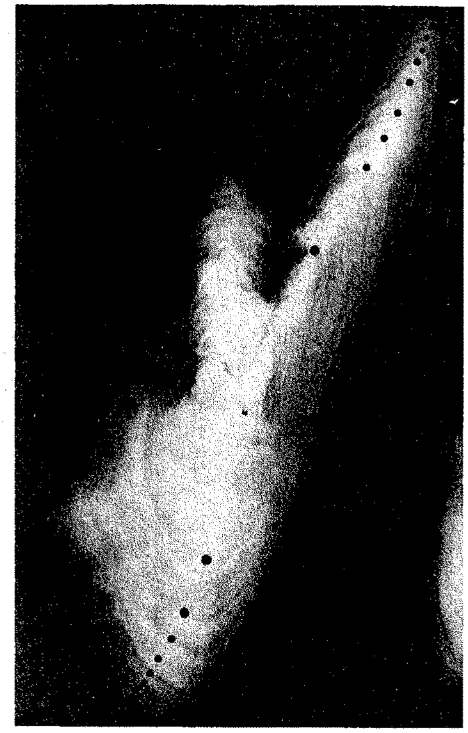


Figure 13
Whole embedded otolith of a 40-cm age 9+ Atlantic mackerel collected in December showing clear annuli, but decreased opaque/hyaline zone contrast after the sixth annulus.

Figure 12
(A) Whole embedded otolith rostrum of a 42-cm age 16+ Atlantic mackerel collected in August showing weak, diffuse annuli. (B) Postrostrum showing a second summer check and split twelfth annulus. Calcium overgrowth obscures annuli 3-5, 9, 10 and 13.

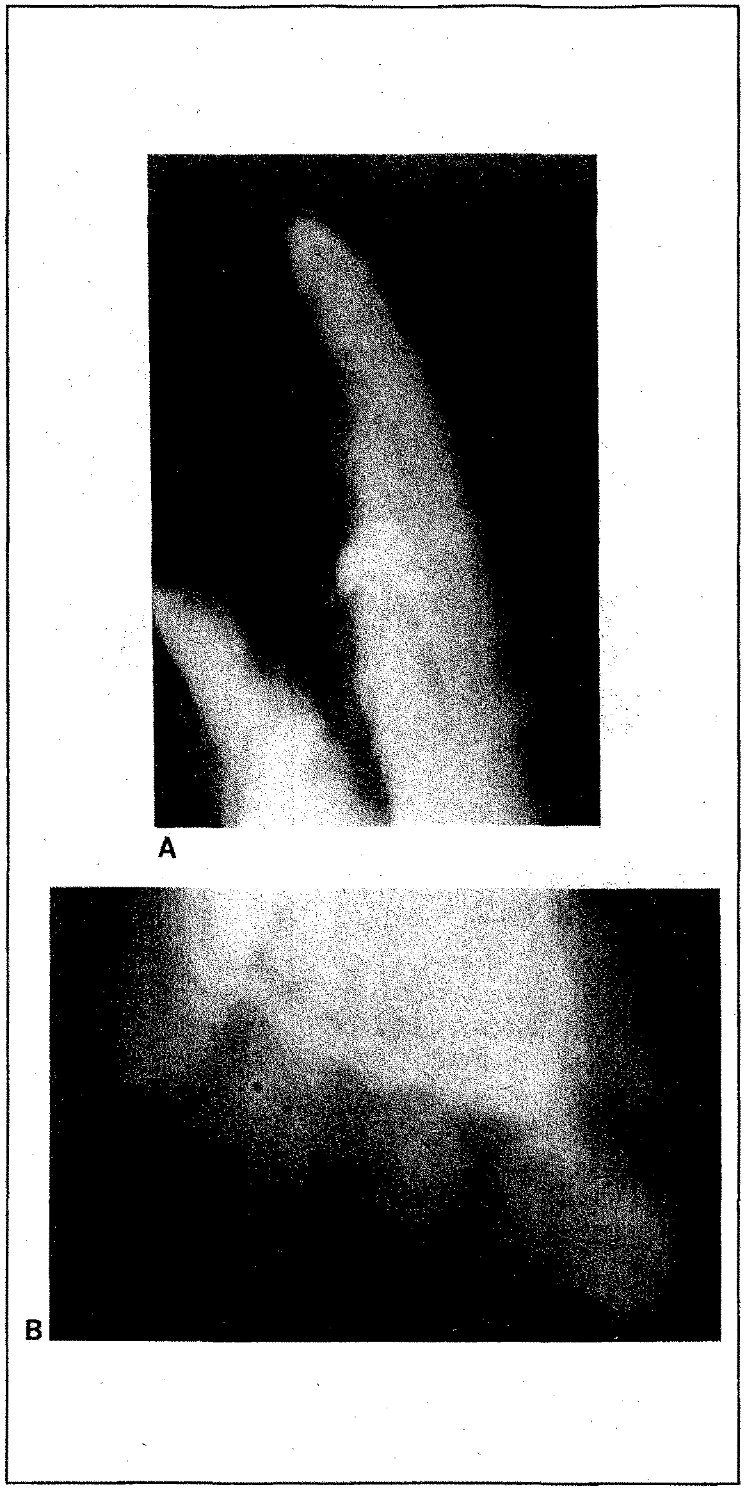


Figure 14

(A) Whole embedded otolith rostrum of a 42-cm age ? Atlantic mackerel collected in January showing very poor annulus definition due to poor calcification. (B) Postrostrum of the otolith showing poor annulus definition due to poor calcification.