10

Black sea bass
Centropristis striata

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Black sea bass is an economically important serranid ranging from New England to Florida (Kendall 1977). A protogynous hermaphrodite, sex reversal from female to male occurs for at least half of the population, usually between the ages of 2 and 5 (Mercer 1978). Males are faster growing than females, attaining a maximum length and age of over 60 cm TL (24 inches) and 20 years, respectively. Females reach a maximum length and age of 38 cm and 8 years (Lavenda 1949). Female black sea bass are sexually mature by age 2; males may not mature until age 4 (Mercer 1978).

Two stocks of black sea bass have been recognized north and south of Cape Hatteras (Cupka et al. 1973). The northern stock migrates seasonally in response to temperature changes. Most of these fish overwinter along the edge of the continental shelf in the southern part of the Mid-Atlantic Bight. In the spring they move inshore and northward to depths less than 40 meters for spawning and feeding on live bottom areas during the summer months (Musick and Mercer 1977, Kendall and Mercer 1982). Spawning extends from June through October, reaching a peak progressively later further north (Mercer 1978, Kendall and Mercer 1982). The southern stock does not appear to be seasonally migratory, frequenting the live bottom areas south of Cape Hatteras (Kendall and Mercer 1982). Spawning for these fish commences in February, reaching a peak in April or May (Mercer 1978).

Several hard structures have been used for age determination of black sea bass. Lavenda (1949) and Briggs (1978) used cellulose acetate impressions of the scales to age black sea bass of New York and New Jersey waters. They identified zones of closely spaced circuli as annuli on these structures. This technique, however, was not validated and has since been questioned by other investigators (Cupka et al. 1973, Mercer 1978, Link 1984). In studies of Virginia-South Carolina fish, otoliths were preferred over scales and were found to have valid age marks. Although investigators did not find operculae or vertebrae to be useful, pelvic spine sections and impressions of scales from behind the pectoral fin have recently been cross-validated with otoliths and found to be acceptable alternate ageing structures, although not as reliable as otoliths (Dery unpubl.). In this study, "cutting-over" marks on scales and hyaline zones on spines were validated as annuli. These marks were found to form at approximately the same time as the deposition of opaque material on otoliths is completed. The outer edge of the opaque zone has been interpreted as the annulus by other investigators (Cupka et al. 1973, Mercer 1978, Link 1984, Wenner et al. 1986). In general, otoliths are preferred at Woods Hole for routine age determinations, but scales are also collected for verification purposes since checks and split zones can cause difficulties with age interpretation.

Glycerin has been used as a storage medium to enhance the clarity of hyaline zones on otoliths (Cupka et al. 1973). Mercer (1978) reported that glycerin tended to overclear the otolith's edge, and therefore used glycerin to clear only those otoliths where annuli were obscured by the overgrowth of calcium. Wenner et al. (1986) stored otoliths dry, and viewed them in water. At Woods Hole, otoliths are stored dry and examined in ethyl alcohol to avoid the overenhancement of hyaline zones. Thin transverse sections (0.20-0.23 mm thick) are removed at the nucleus and are examined instead of whole otoliths if the annuli are obscured by later calcification. Otoliths are examined distal-surface-up against a black background at 10-15× using reflected light.

Five or six scales from behind the pectoral fin are impressed in laminated plastic (Dery 1983) and viewed under a microprojector at 40×. Pelvic spines require more preparation time. The outer tissue covering the spine can usually be readily peeled off prior to sectioning, but may first require soaking in water or bleach. A thin-section, about 0.20 mm thick, is removed just above the base of the spine. This thinness is required to clearly define the annuli on the spine section. Subsequently, the spine section must be soaked in clove oil for several minutes to whiten "opaque" zones and provide the necessary contrast with hyaline zones.

Annulus formation on otoliths, pelvic spines, and scales occurs in May or June. The outer edge of the opaque zone is interpreted as the annulus on otoliths, the outer edge of the hyaline zone as the annulus on spines, and the cutting-over mark as the annulus on scales. By convention, a birthdate of 1 January is used; the annulus forming on the edge of these structures is included in the age whether or not it is completely formed. Formation of opaque material may persist on some otoliths into the early autumn and should be taken into consideration when backcalculating otoliths. The formation of hyaline zone on otoliths, which normally occurs from June through the following January (Mercer 1978), is unusual because hyaline material, indicating slow growth, generally forms during the colder months of the year. It is possible that the lack of opaque material deposited during the warmest months may be due to shifts in calcium metabolism during onshore movements into very warm coastal water in the summer. The summer flounder (*Paralichthys dentatus*) otolith shows similar seasonal calcification patterns, a species that has a migration and distribution pattern similar to that observed for black sea bass.

Otoliths show the clearest record of first-year growth. Figure 1 shows the age structures from a 22-cm, age 1+ fish collected in November. A weak hyaline core area formed after hatching occurs close to the center of the otolith (Fig. 1A). Opaque material is deposited around this central core. The deposition of this material is complete by the following spring, forming the first annulus. A wide hyaline zone then forms during the summer and autumn of the second year. This otolith shows an unusual amount of opaque edge for November. Hyaline edge would persist on most adult black sea bass otoliths until January.

The spine section (Fig. 1B) shows minimal evidence of the first annulus and first-year growth, which is generally characteristic of black sea bass spines. This annulus is located on the inner edge of the lumen and appears as a thin band of hyaline material. All the opaque material formed after the first annulus represents growth in summer and autumn of the second year. A tiny amount of hyaline material is evident on the edge. Hyaline edge normally begins to form on the spine during the winter months.

A poorly defined first annulus on the corresponding scale is typical for most black sea bass (Fig. 1C). If present it will usually appear as a zone of closely spaced circuli without a cutting-over mark. The first cutting-over or erosion mark representing the second annulus is not yet evident.

Figure 2 shows the three types of age structures for a 40-cm, age-4 fish collected from Nantucket Sound in June, the time of annulus formation. All show rapid growth typical of more northern areas. The otolith (Fig. 2A) shows prominent hyaline zones separated by wide growth increments. Four opaque zones, including the edge, are formed on this otolith. Figure 2B shows the corresponding spine section with four clearly formed annuli (hyaline zones), including the edge of the lumen and the outer edge of the spine. A check is also evident between the first and second annuli. Such checks formed during the second summer of growth are typical and can be confused with the second annulus, especially on the spine sections of age 1+ or 2 fish. However, such checks are not continuous around the lumen or visible in the indented area of the section marking the spinal groove. The scale of this 4-year-old fish (Fig. 2C) has two clear cutting-over marks representing the second and third annuli. The first annulus is vaguely indicated by the zone of compacted circuli near the focus of the scale. The outer edge of the scale is the fourth annulus.

Clear growth patterns are also characteristic of slower growing black sea bass from more southerly ranges of the northern stock. Figure 3 shows the growth patterns of a 35-cm, age-6 fish collected from off Virginia in February. Growth increments on these structures are relatively narrow. The last (sixth) annulus on the outer edge of the otolith, spine, and scale is not complete because of the February collection date. Nevertheless, we include the edge in the age of the fish because of the 1 January birthdate convention.

Although opaque zones are usually well defined on the otoliths, they may sometimes be bordered by such thin hyaline zones that annuli could be missed in the age interpretation. Figure 4 shows the age structures of a 31-cm, age-3 black sea bass sampled from Nantucket Sound in June. The second hyaline zone bordering the second annulus (opaque zone) is weakly defined on the otolith (Fig. 4A). The second annulus, however, is very strong on the spine section (Fig. 4B) and the scale (Fig. 4C).

Weak annuli are also characteristic of the central region of the otoliths for some older fish, prior to a sharp increase in growth rate after four or five years of slow growth. This pattern occurs in the age structures of a 46-cm, age-8 fish collected from Virginia waters (Fig. 5). The second, third, and fourth annuli are clearly formed, although they are closely spaced on the spine section (Fig. 5B) and scale (Fig. 5C). The third annulus is split into two rings on the spine section. On the otolith (Fig. 5A), however, these annuli (2-4), are very difficult to distinguish without referring to one of the other two structures. The change in growth rate reflected by these structures may be the result of sex reversal or migration.

The formation of strong checks and split hyaline zones (or split cutting over marks on the scale) may make annulus interpretation difficult. Figure 6 shows the age structures of a 30-cm, age 2+ fish sampled from New Jersey waters in November. Both the first and second annuli (opaque zones) (Fig. 6A) are split into two rings, but the relative spacing between them does not identify these rings as "split" zones without reference to the other two structures (Figs. 6B and 6C). Therefore, based on examination of the otolith alone, an age of 3+ or 4+ could be interpreted. It should be noted that the first hyaline zone is split into two or more rings on many otoliths. Identification of this anomaly is difficult only if there are narrow growth increments between the first several annuli.

Figure 7 shows the difficult-to-interpret age structures of a 34-cm, age 4(3)+ black sea bass sampled from New Jersey waters in November. If the second annulus is bordered by a weak hyaline zone (Fig. 7A), the age would be interpreted as 4+, otherwise the age would be 3+. The spine section (Fig. 7B) indicates an age of 4+, although the hyaline zones are somewhat close together. The most likely interpretation of the scale impression, however, would be age 3+, recognizing a false cutting-over mark formed between the first and second annuli (Fig. 7C). For such fish the final age must be determined using the strongest evidence for a particular age.

Annuli may remain relatively easy to interpret at older ages, although increasingly narrow growth increments may cause some confusion. The age structures of Figure 8 from a 57-cm, age-10 fish sampled from Virginia waters in February, show the clear annuli typical of most older fish. Annuli on the otoliths may be somewhat obscured by overgrowth of calcium, and erosion of the scale may obliterate the annuli close to the central anterior edge of the scale. Nevertheless, these structures can still be accurately aged, especially if the otolith is sectioned and the anterior corners of a scale are carefully studied.

In summary, some geographic variation in growth patterns appears to exist. For example, the growth patterns on the structures of some New Jersey fish are especially difficult to interpret because of the formation of strong checks or split zones (Figs. 6 and 7). Characteristic differences between the northern and southern stocks have not been documented, however.

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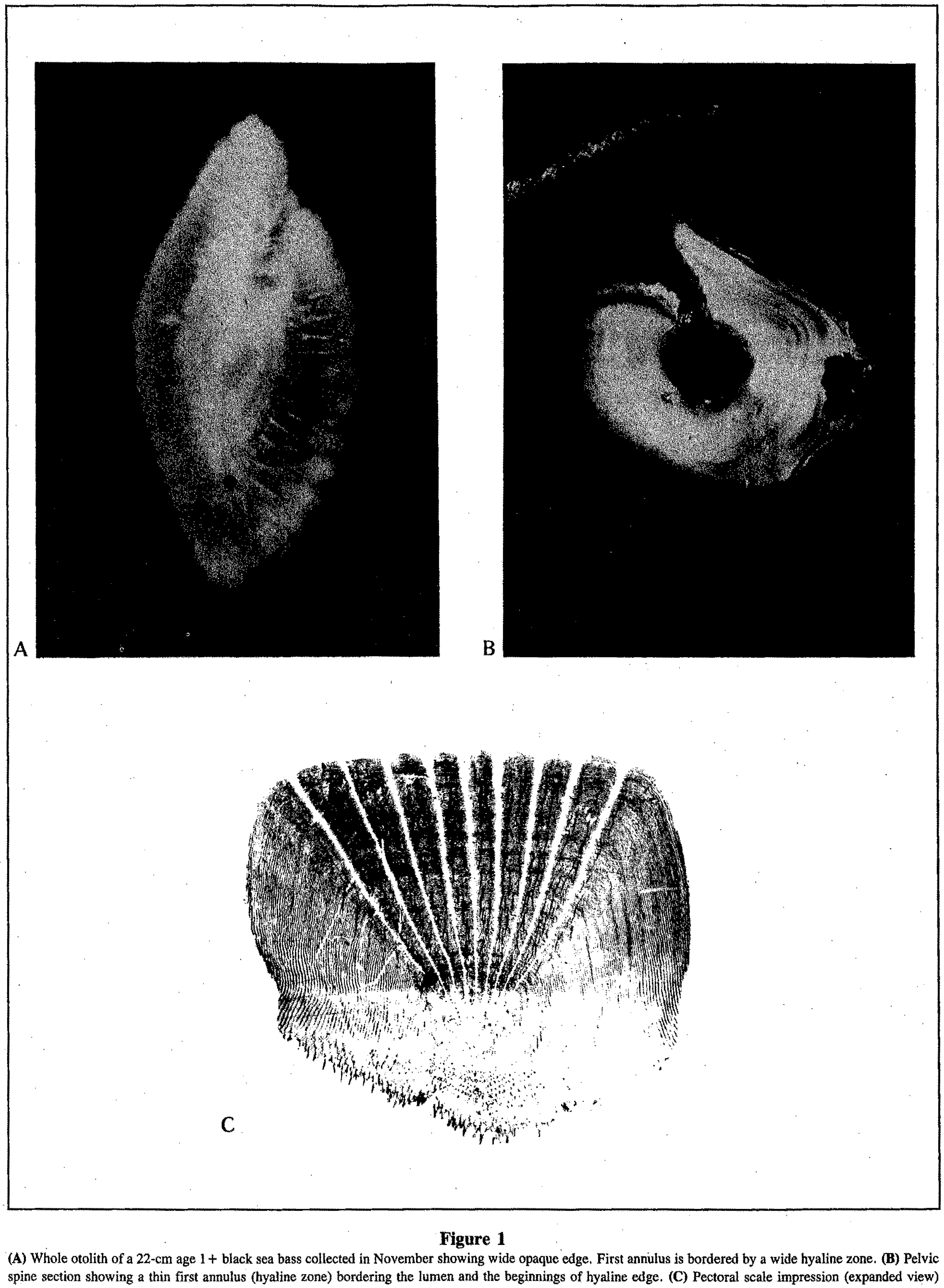

Figure 1

(A) Whole otolith of a 22-cm age 1+ black sea bass collected in November showing wide opaque edge. First annulus is bordered by a wide hyaline zone. (B) Pelvic spine section showing a thin first annulus (hyaline zone) bordering the lumen and the beginnings of hyaline edge. (C) Pectoral scale impression (expanded view) showing a zone of compacted circuli near the focus which may represent the first annulus.

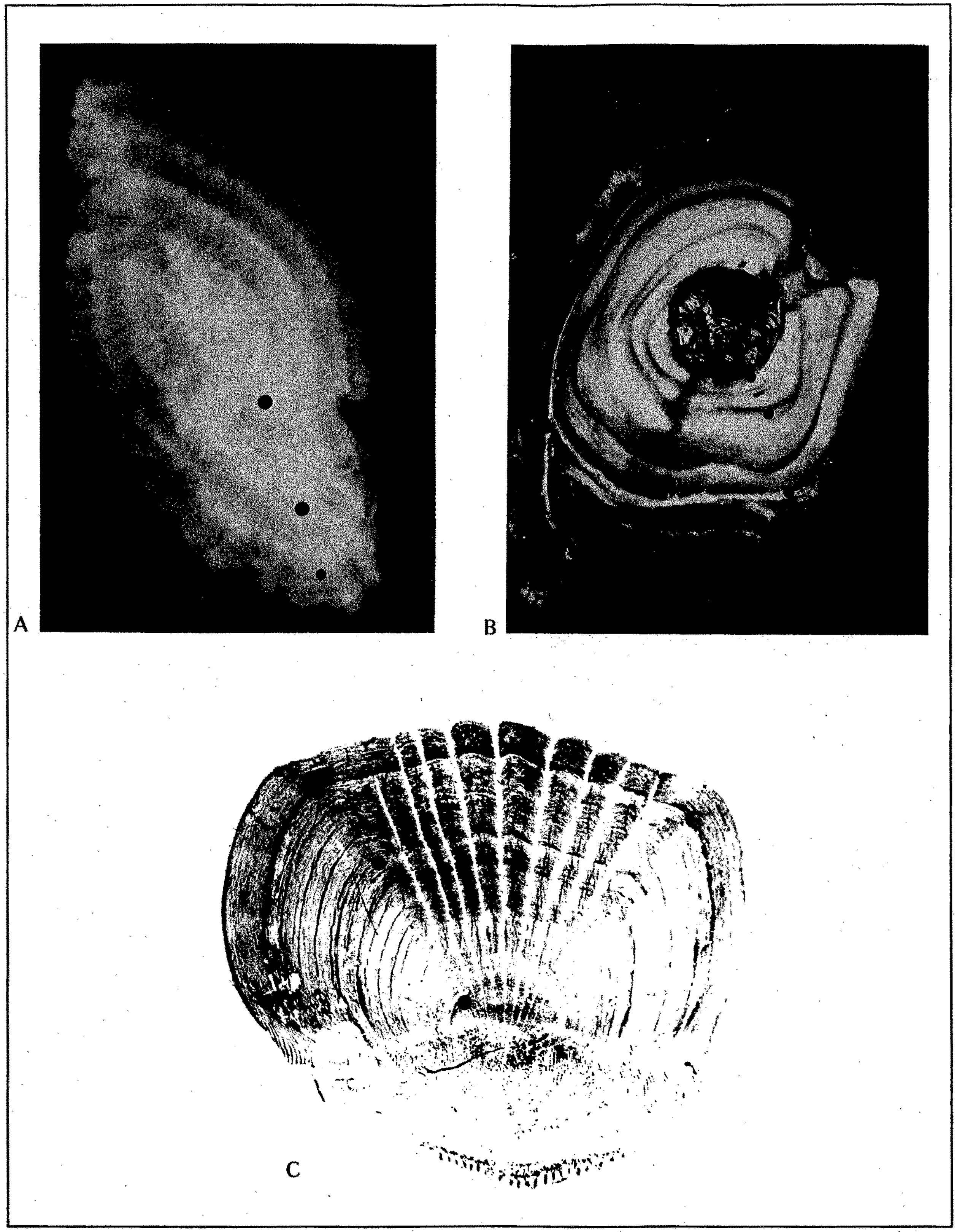

Figure 2

(A) Whole otolith of a 40-cm age-4 female black sea bass collected in June from Massachusetts waters, showing narrow hyaline edge. Clear annuli with wide growth increments are evident. (B) Pelvic spine section showing clear annuli and a hyaline to narrow opaque edge. Check between the first and second annuli is not continuous around the lumen or separate from the first annulus. (C) Pectoral scale impression from the black sea bass of Figure 2A showing two clear "cutting-over" marks at the second and third annuli and a "cutting-over" mark (annulus) at the edge of the scale included in the age.

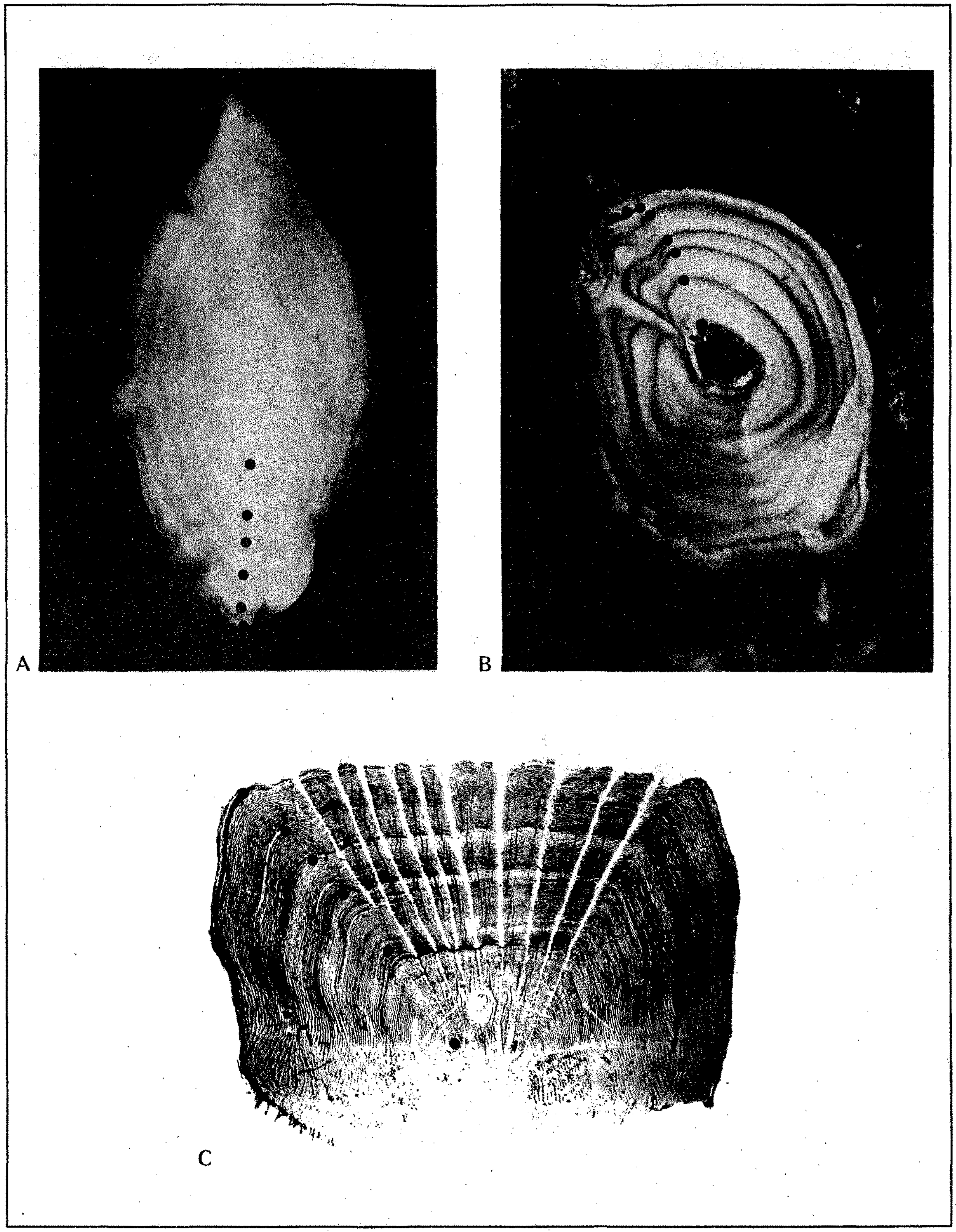

Figure 3

(A) Whole otolith of a 35-cm age 6? male black sea bass collected in February from Virginia waters. Clear annuli (opaque zones) are evident with an incomplete sixth annulus on the edge. (B) Pelvic spine section showing a sixth annulus (hyaline zone) barely evident on the edge of the section. (C) Pectoral scale impression showing split second, third, and sixth annuli.

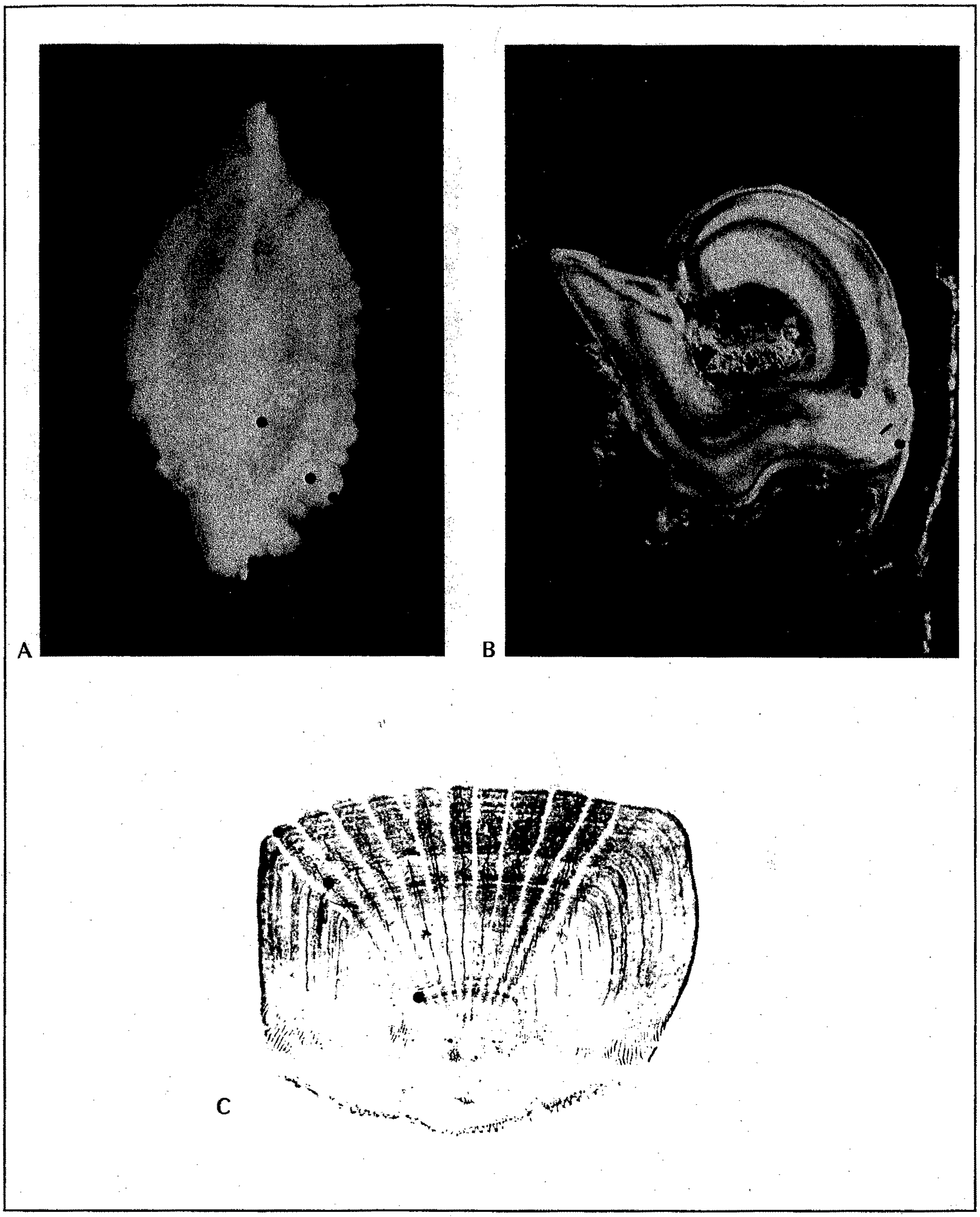

Figure 4

(A) Whole otolith of a 31-cm age-3 female black sea bass collected in June showing a narrow hyaline edge. A very thin second hyaline zone borders the second annulus. **(B)** Pelvic spine section showing three clear annuli (hyaline zones) including the edge of the section. Also evident is a split second annulus and weak check between the second and third annuli. **(C)** Pectoral scale impression showing a split second annulus and checks between the second and third annuli.

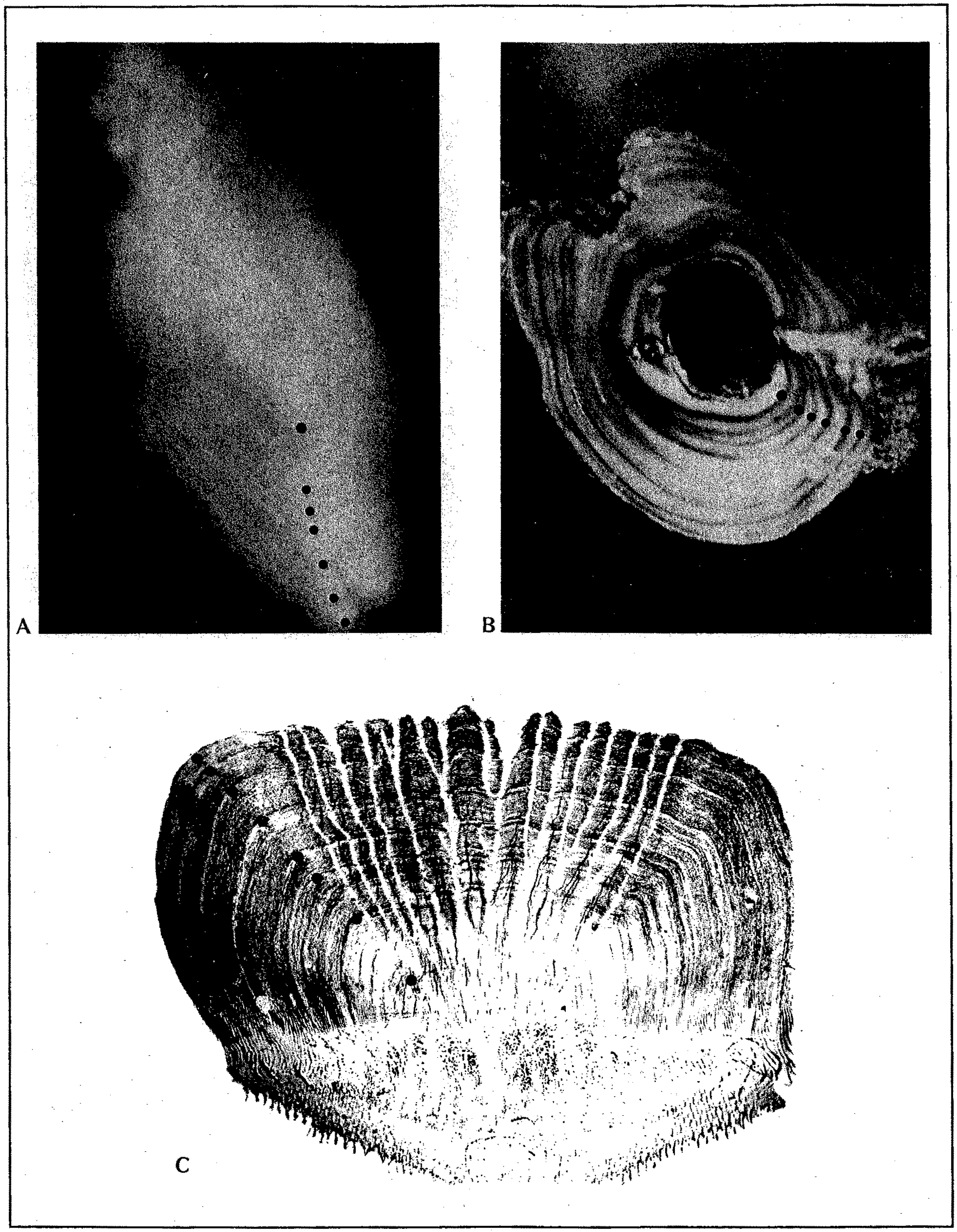

Figure 5

(A) Whole otolith of a 46-cm age-8 male black sea bass collected in February from Virginia waters showing poorly defined annuli (opaque zones). (B) Pelvic spine section showing closely spaced second, third and fourth annuli (hyaline zones). In the area beneath the lumen, the third annulus is split. (C) Pectoral scale impression showing eight clear annuli including the edge of the scale.

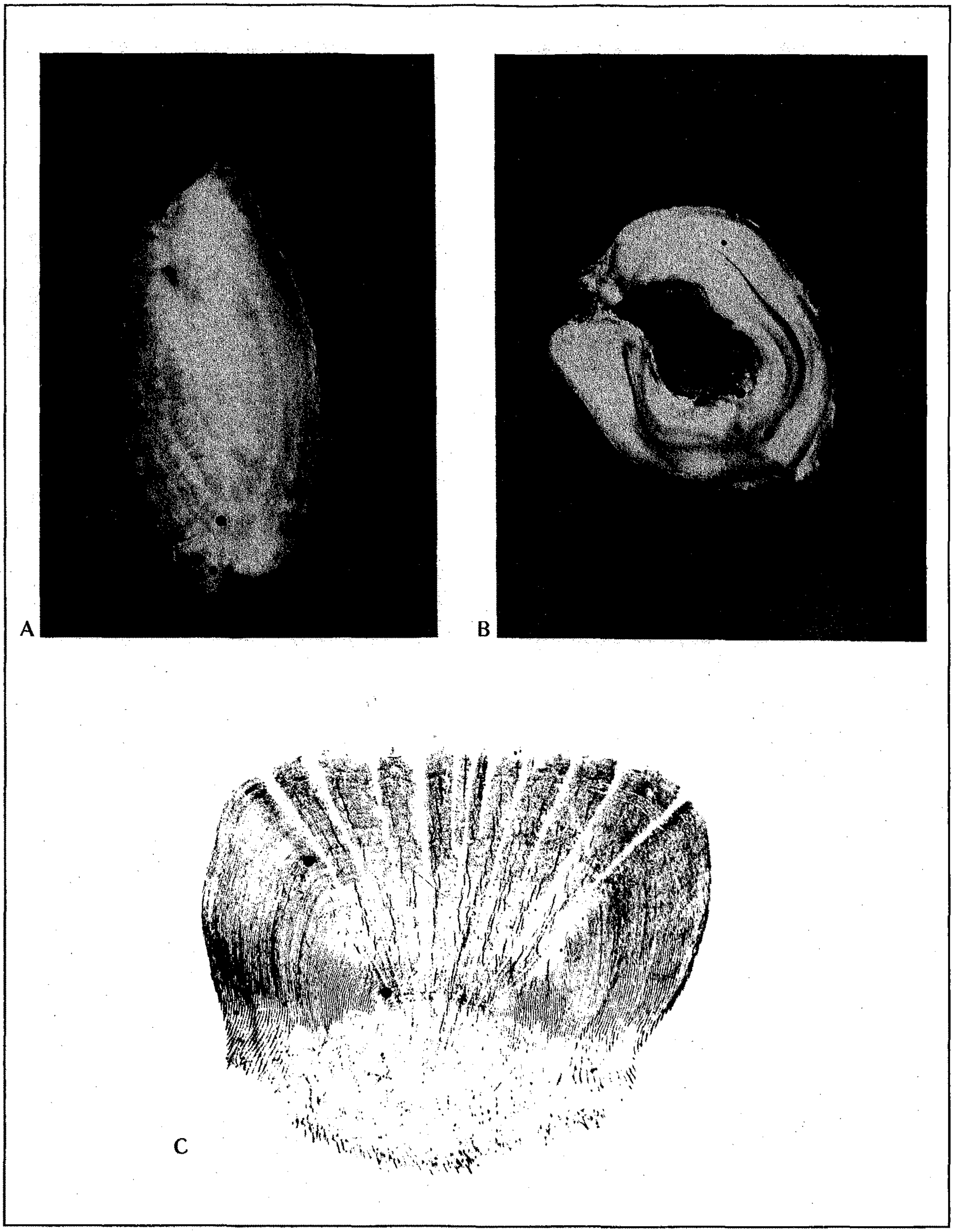

Figure 6

(A) Whole otolith of a 30-cm age 2+ female black sea bass collected in November from New Jersey waters showing a split first annulus. (B) Pelvic spine section showing two annuli (hyaline zones) not including the hyaline zone beginning to form on the edge. (C) Pectoral scale showing a discontinuous "cutting-over" mark interpreted as a check formed close to the edge of the scale.

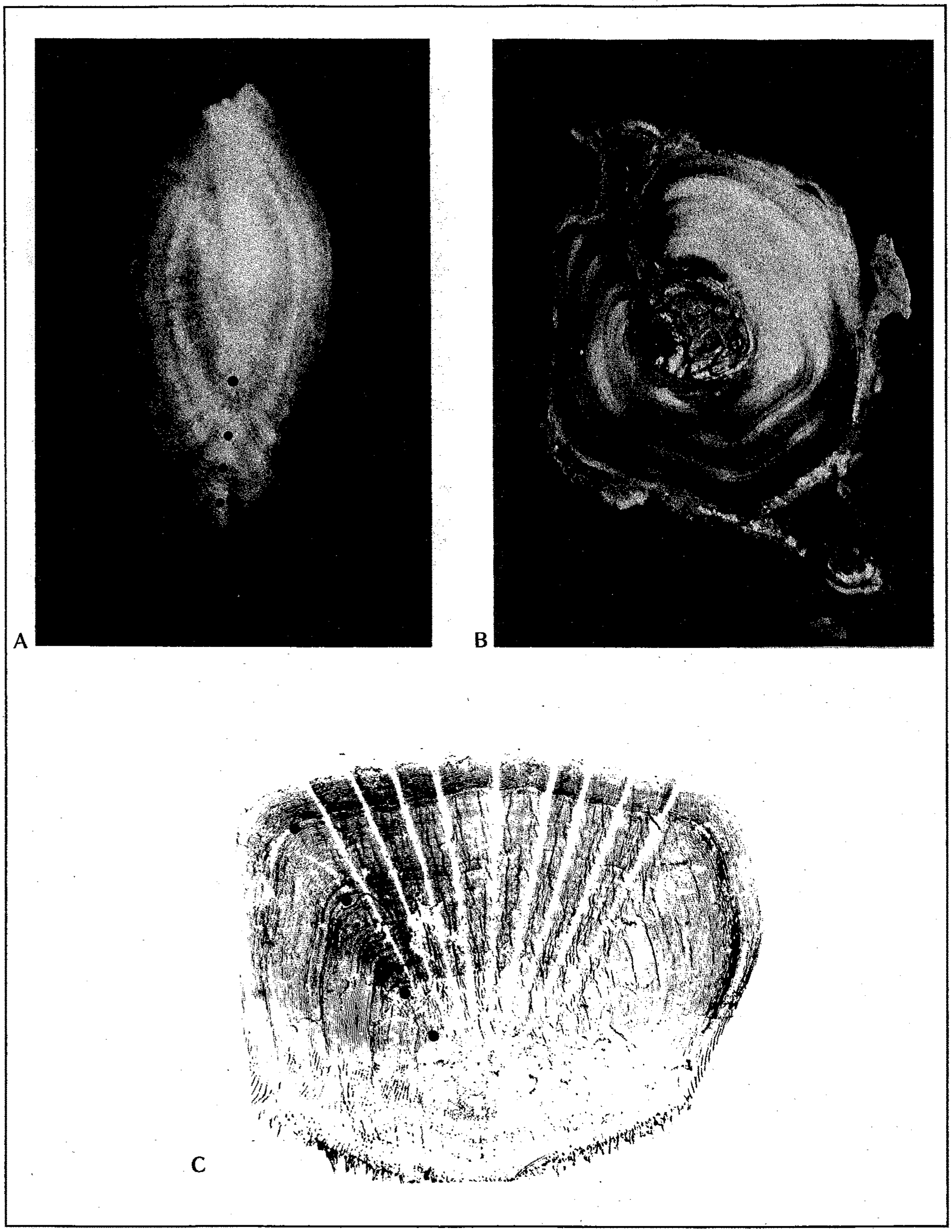

Figure 7

(A) Whole otolith of a 35-cm age 4(3)+ female black sea bass collected in November from New Jersey waters. If the (second) thin hyaline zone borders the second annulus, an interpretation of "age 4" would result. (B) Pelvic spine section showing four complete, although somewhat diffuse, annuli not including the hyaline zone near the edge. (C) Pectoral scale impression showing four annuli (not including the edge) if the first weak "cutting-over" mark is the second annulus.

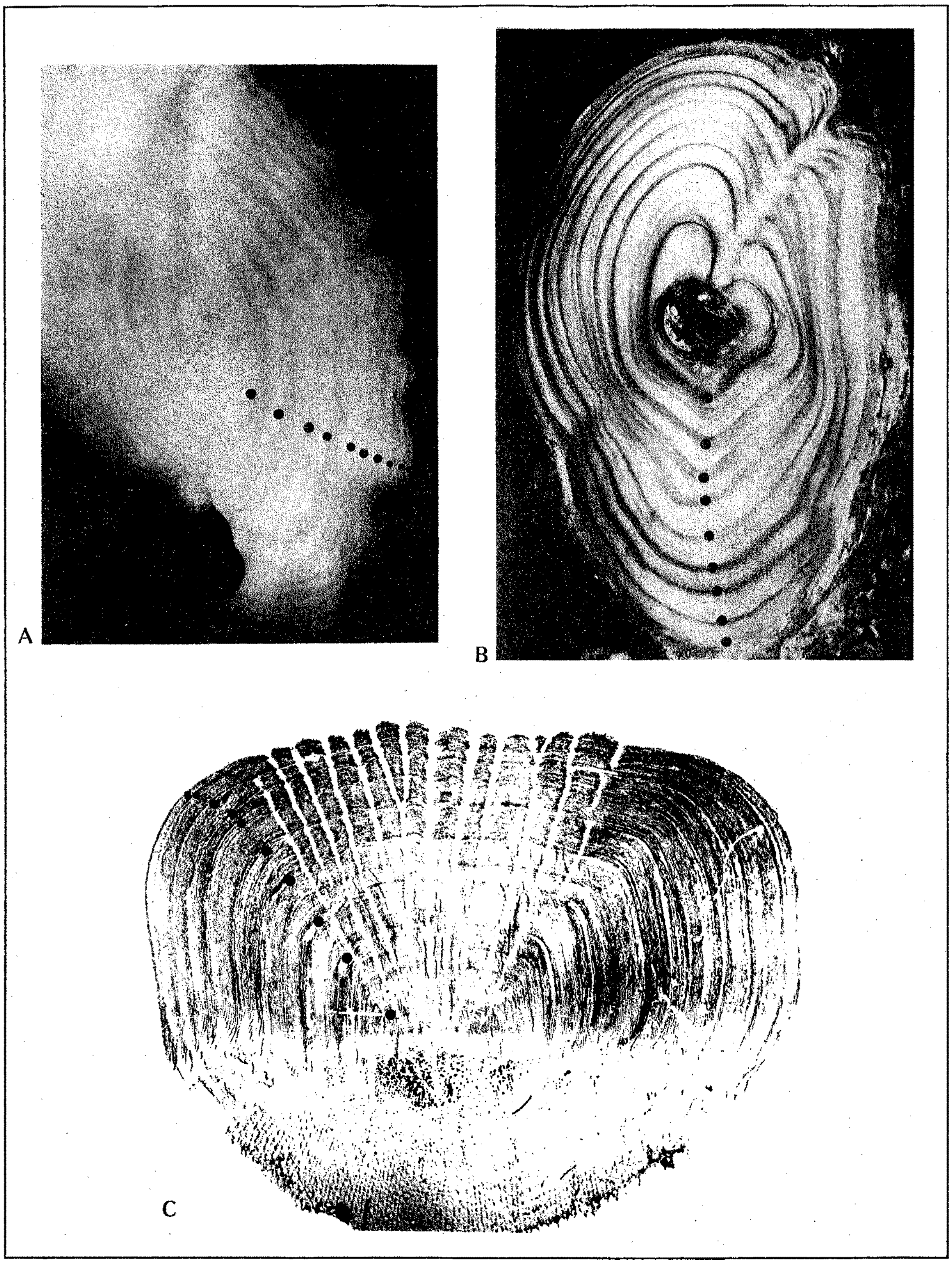

Figure 8

(A) Whole otolith of a 57-cm age-10 male black sea bass collected in February showing clear annuli. (B) Pelvic spine section showing clear annuli. (C) Pectoral scale impression showing clear annuli.