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Yellowtail flounder
Limanda ferruginea

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Yellowtail flounder are found in the Northwest Atlantic from Labrador to Chesapeake Bay; they prefer sandy bottom at water depths of 37-73 m (20-40 fathoms) (Bigelow and Schroeder 1953). Yellowtail tend to be relatively sedentary although seasonal movements have been documented. In U.S. waters, commercially important concentrations occur on Georges Bank, off Cape Cod, and in the Southern New England-Middle Atlantic region.

The growth rate to age 2 is the same for both sexes, but thereafter females grow faster than males and also live longer (Lux and Nichy 1969). Growth rates differ by geographical area, with fish from Georges Bank generally growing more rapidly than those from other areas. Both males and females become sexually mature at age 2 or 3; males tend to mature at a younger age and at a smaller size than females. Spawning occurs during spring and summer, with peak activity in May. Ages to 17 years have been documented, although individuals more than 7 years old are uncommon. Yellowtail attain lengths of up to 47 cm (18.5 inches) and weights up to 1.0 kg (2.2 pounds).

Historically, scales have been used for age determinations. Royce et al. (1959) and Lux and Nichy (1969) have validated procedures for age determinations based on scales. These procedures give good results over the range of ages normally present in the population (ages 0 to 7).

Scales are removed from the eyed side of the fish along the lateral line immediately anterior to the caudal peduncle for dry storage. About 5 or 6 scales from each fish are impressed on a laminated plastic slide using a roller press and viewed on a microprojector at a magnification of 52× with transmitted light. Regenerated scales are discarded.

The scales are ctenoid and radial grooves extend from the focus to the forward margin of the scale (Fig. 1). Scanning electron microscopy shows the outer surface is sculptured with concentric rings of circuli comprised of individual platelets, while the inner surface is smooth. The spacing of the circuli indicates periods of rapid and slow growth. Rapid summer-type growth is characterized by circuli which are spaced relatively far apart; slow winter-type growth is characterized by circuli spaced relatively close together (Fig. 2).

The annulus is defined as a zone of close winter circuli marking the end of a year of growth, i.e., the winter growth zone. The first annulus is a small, central zone of closely spaced circuli found very close to the focus of the scale (Figs. 1 and 3). The following characteristics, following the criteria of Jensen and Wise (1962) for haddock, also identify annuli on yellowtail scales: an annulus 1) can be traced entirely around the anterior portion of the scale; 2) can be traced, by careful scrutiny if necessary, entirely around the scale; 3) is clearly separated from other such zones, either by a zone of summer-type growth or because of "cutting over" marks on the scale, and does not ordinarily meet other annular zones at any point on the anterior portion of the scale; and 4) if present, is found on all the normal scales from that particular fish. Many of the criteria used for distinguishing annuli on yellowtail scales are also used for scales from other species (e.g., haddock).

By convention, the birthday of all fish in the northern hemisphere is 1 January; therefore, a winter growth zone forming on the edge of the scale is designated as an annulus on 1 January, even though the zone is not complete. Summer-type edge generally forms during spring and summer (Fig. 3) with winter-type growth predominating during fall and winter (Figs. 1 and 4). Older fish begin putting down summer-type edge growth later than younger fish do and start winter-type growth earlier.

A major pattern feature which determines annuli is the number of circuli per unit area. The number increases during slow winter growth and decreases during rapid summer growth. Measurement of the distance between circuli shows relatively wide interspaces during rapid summer growth, and as the interspace decreases, compaction of the circuli forms the broad dark-appearing rings that represent the period of slow winter growth. The end of an annulus (i.e., the last true winter circulus in the winter growth zone) is generally followed by a rapid transition from narrow to widening interspaces, signifying the start of the next period of rapid summer growth. This usually occurs in the spring of the year, but can vary in different geographical areas. Number of circuli per unit area and circuli interspaces are useful in determining the first few annuli, but after the third or fourth annulus, there is a gradual reduction in the number of the circuli formed during a year's growth. This diminishes the usefulness of these criteria. Cutting-over marks are often helpful in determining annuli for older fish.

Checks may be distinguished from annuli by general appearance, relative width, and location. Checks usually begin abruptly, whereas annuli generally have a transition zone showing a relative decreasing of the interspace between circuli before the true winter zone is reached. Absence of a rapid transition to summer growth after the check may also help to distinguish it from an annulus. Checks may also be distinguished by following them towards the sides of the scale to determine if they merge with an annulus to form one zone. This method is generally applicable for only the first few annuli. Later annuli may be too crowded together for easy separation on the sides of the scale. Checks may be stronger on some scales and weaker, or even absent, on others, while annuli are present on all scales from a particular fish. Thus several scales are examined from each fish for a verification of the assigned age. It is sometimes necessary to make two or three impressions, with five or six scales each, before a clear "composite" picture of the fish's growth can be determined.

Spacing of the annuli relative to each other and to the focus of the scale may be used to differentiate between annuli and checks. For example, if two winter growth zones are found relatively close together on a scale from a younger fish, and all the other winter zones on the scale are relatively far apart, then one of the two close zones will probably be called a check and not an annulus. This type of annulus construction (i.e., two close zones) is generally described as a split annulus, since it is usually difficult to determine which zone is the check and which is the annulus (Fig. 3). On scales from older fish, annuli formed after the third or fourth year are expected to be fairly close together.

General patterns based on the geographic origin of the fish are also used as an aid in identifying annuli. For example, a characteristic check, called the third summer check, is often apparent in the spring or summer growth zone of the third year of life for fish from Southern New England (Figs. 4 and 5). This check is generally strong on scales from fish from the Southern New England area, but it is usually weak or absent on scales from fish from the eastern part of Georges Bank (Figs. 6 and 7). Southern New England fish also grow more slowly than do fish from other areas so that annuli formed after the third year are composed of few circuli and are very close together. Cutting-over marks are often helpful in determining annuli for older Southern New England fish. A rule of thumb for older fish from this area is to count as annuli all "possible" zones delineated by cutting-over after the fourth annulus, especially if the specimen is a male. Females from this area, being faster growing, show slightly better separation of annuli up until the fifth or sixth annulus, after which annuli are closely compacted on the scale.

Fish from the southwestern area of Georges Bank generally show only a weak third summer check, if it is present at all. Because of their more rapid growth rate, their scales show a better separation of annuli which are fairly distinct through the sixth year of life for both sexes. (Note the pronounced alteration of summer and winter growth zones in Figures 6 and 7).

Fish from the northern and eastern parts of Georges Bank generally lack the third summer check and, because of their rapid growth rate, also have distinct, well-separated annuli (Fig. 8). Sometimes, however, growth is so rapid that winter zones do not contain closely spaced circuli and consequently annuli are often indistinct. With these fish it sometimes helps to actually move back from the microprojector screen to gain a better perspective of the overall pattern of growth when assigning an age.

Yellowtail taken on the Cape Cod grounds generally show slower growth in the first two years, followed by more rapid growth in the third and fourth years. There may sometimes be a distinctive check immediately after the second annulus (Fig. 9).

Yellowtail from the Browns Bank region on the Scotian Shelf grow even more slowly in the first three years of life, although growth in the fourth through sixth years is more rapid. A gradual slowdown in growth is evident in subsequent years (Fig. 10).

A consistent problem involves distinguishing checks caused by damage or injury to the fish. In these cases, the scale is physically shifted in the scale pocket so that subsequent circuli are not quite in line with previous circuli and "lost" circuli and irregular spaces result. Circuli in the damaged area may disappear when an attempt is made to follow them around the scale. These marks on the scale correspond with the area of regeneration on lost scales. The effect is similar to that of cutting-over, a condition caused by erosion of the scale edge, and can create a good deal of confusion in determining annuli. One way to distinguish between damage and cutting-over marks is to identify marks occurring at the end of a winter zone. If this occurs, then it can usually be assumed to be cutting-over (Fig. 8).

Another major problem is in determining the type of growth present on the edge of the scale. The thinness of the scale edge often results in an impression with a light coloration that may appear to be summer edge (Fig. 5). However, the only true difference between summer and winter edge is seen in the relative spacing between circuli. A simple way of improving impressions to lessen this optical problem is by angling the upper roller of the press. This applies slightly more pressure to the edge of the scale.

The most reliable general criterion for distinguishing checks from annuli for yellowtail scales is the relative location of the annuli. In first looking at a scale, an attempt is made to mentally superimpose a regular growth pattern, based on prior knowledge of typical patterns for the geographic origin of the fish. Any zone not fitting the pattern is closely scrutinized to determine if it is a check or a split (Fig. 7). Particular year-classes may also exhibit peculiar growth characteristics which assist in determining age. Some year-classes may exhibit a certain split annulus, or a strong check between two particular annuli, or perhaps two close annuli. Recognition of a characteristic growth pattern for a difficult specimen may be used to help assign the most probable age for the fish.

Citations

Bigelow, H., and W. Schroeder
1953. Fishes of the Gulf of Maine. U.S. Fish Wildl. Serv., Fish. Bull. 53(74):271-275.

Jensen, A.C., and J.P. Wise
1962. Determining age of young haddock from their scales. U.S. Fish Wildl. Serv., Fish. Bull. 195(61):439-450.

Lux, Fred E.
1963. Identification of New England yellowtail flounder groups. U.S. Fish Wildl. Serv., Fish. Bull. 63:1-10.

Lux, F.E., and F.E. Nichy
1969. Growth of yellowtail flounder, *Limanda ferruginea* (Storer), on three New England fishing grounds. Int. Comm. Northwest Atl. Fish., Res. Bull. 6:5-25.

Royce, W.F., R.J. Buller, and E.D. Premetz
1959. Decline of the yellowtail flounder (*Limanda ferruginea*) off New England. U.S. Fish Wildl. Serv., Fish. Bull. 146(59):169-267.

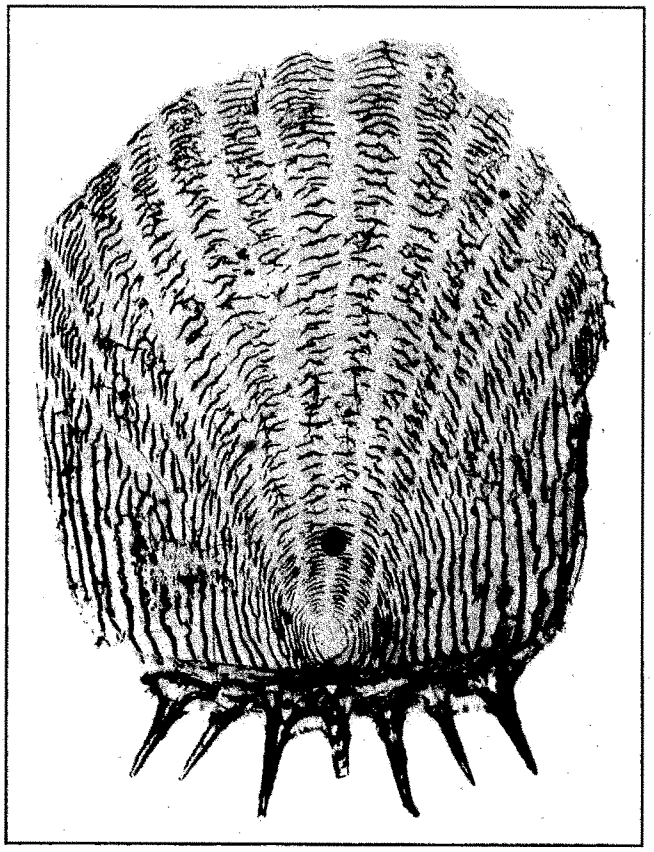

Figure 1
Scale impression from a 20-cm age-1 immature yellowtail flounder collected in the fall from Southern New England, with winter edge just beginning to form.

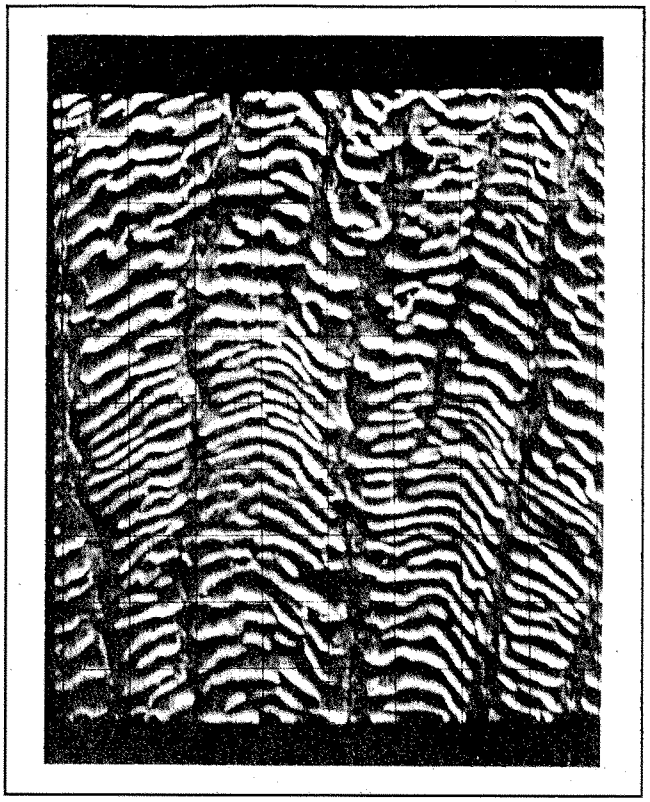

Figure 2
Scanning electron microscope photograph of an actual yellowtail flounder scale (magnification 166×) showing the difference between summer and winter platelets.

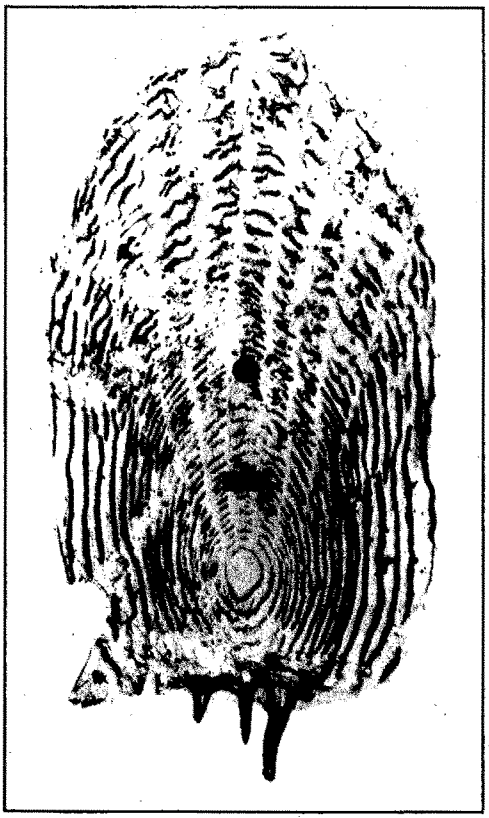

Figure 3
Scale impression from a 12-cm age-1 immature yellowtail flounder collected in the spring from Southern New England showing a split first annulus, with summer edge forming.

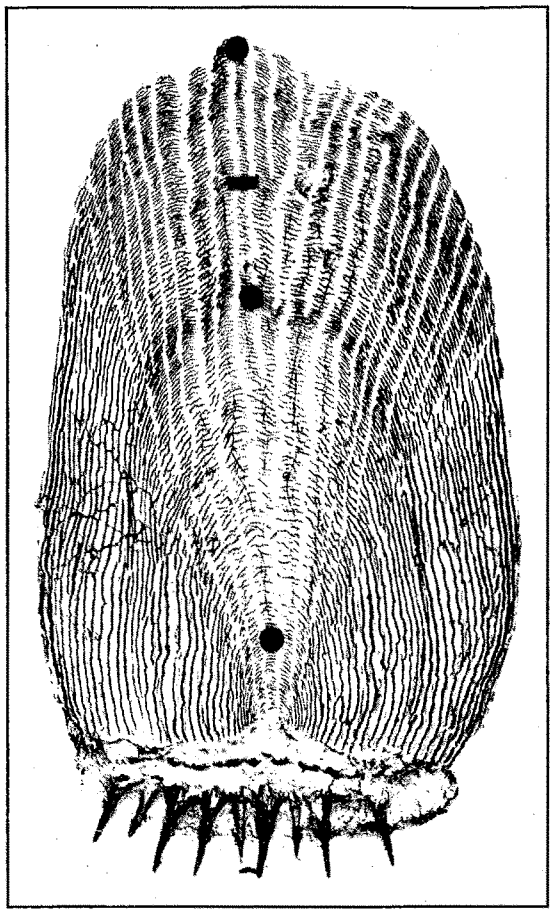

Figure 4
Scale impression from a 30-cm age-3 female yellowtail flounder collected in the spring from Southern New England showing a third summer check.

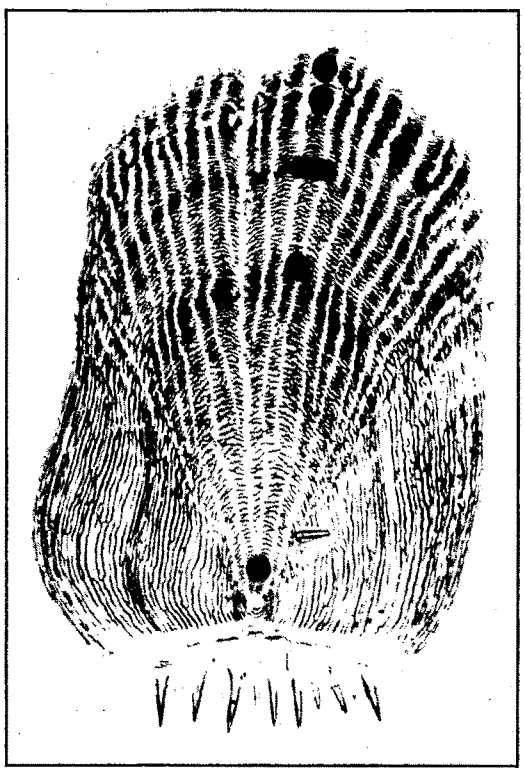

Figure 5
Scale impression from a 32-cm age-4 male yellowtail flounder collected in February from Southern New England showing a strong third summer check, with possible summer edge forming.

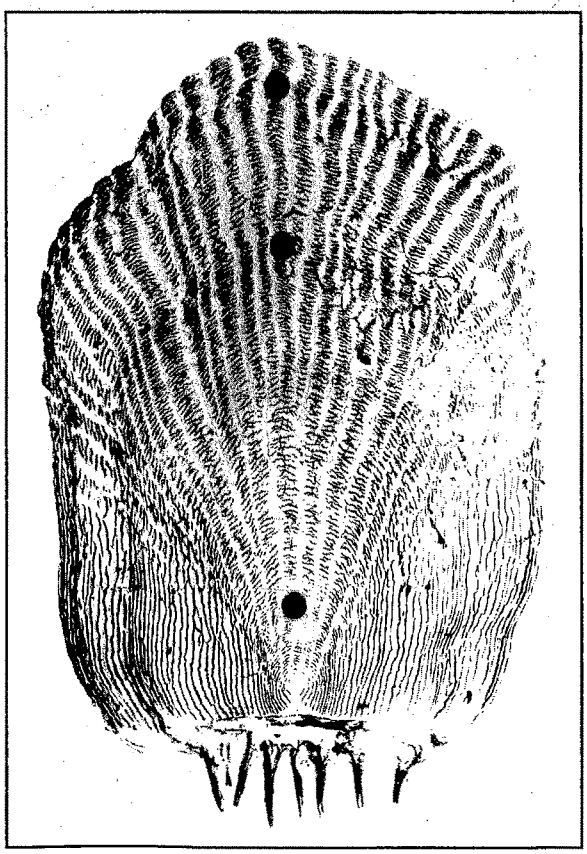

Figure 6
Scale impression from a 38-cm age-3 female yellowtail flounder collected in the fall from southwestern Georges Bank showing well-separated and defined annuli, with no third summer check.

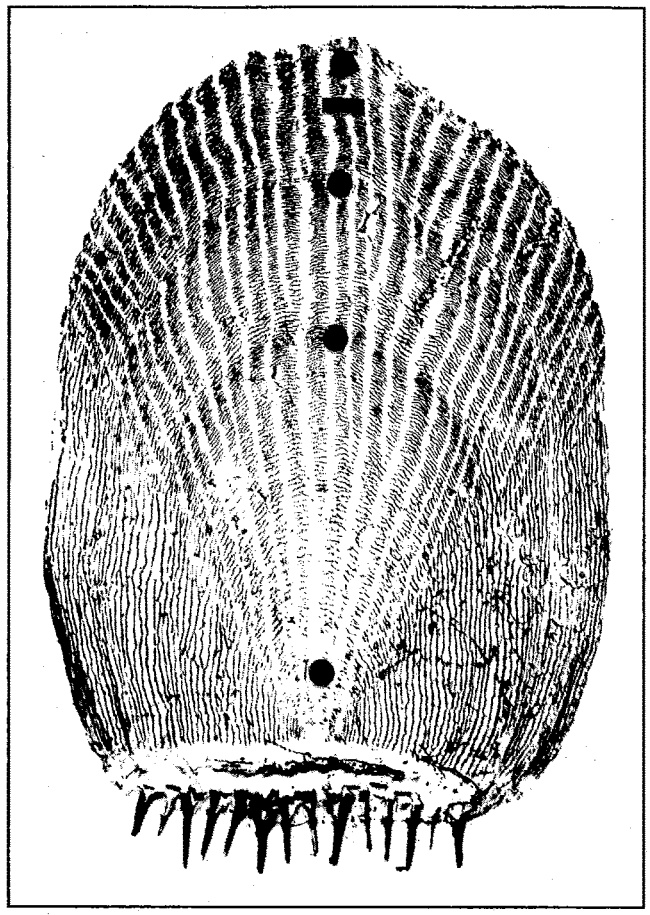

Figure 7
Scale impression from a 38-cm age-4 male yellowtail flounder collected in October from southwestern Georges Bank showing a split fourth annulus, with no third summer check.

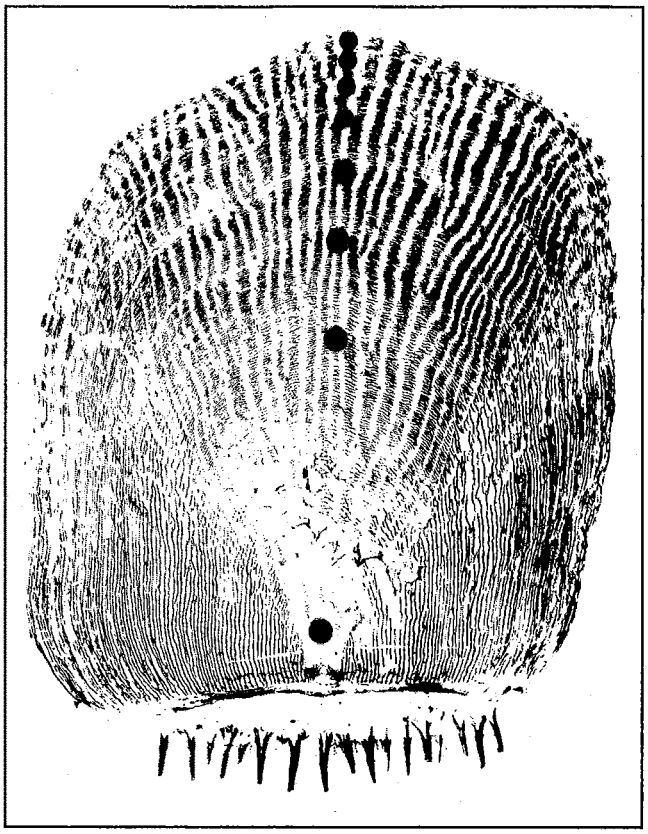

Figure 8
Scale impression from a 54-cm age-8 female yellowtail flounder collected in May from northern Georges Bank showing distinct annuli with strong cutting-over.

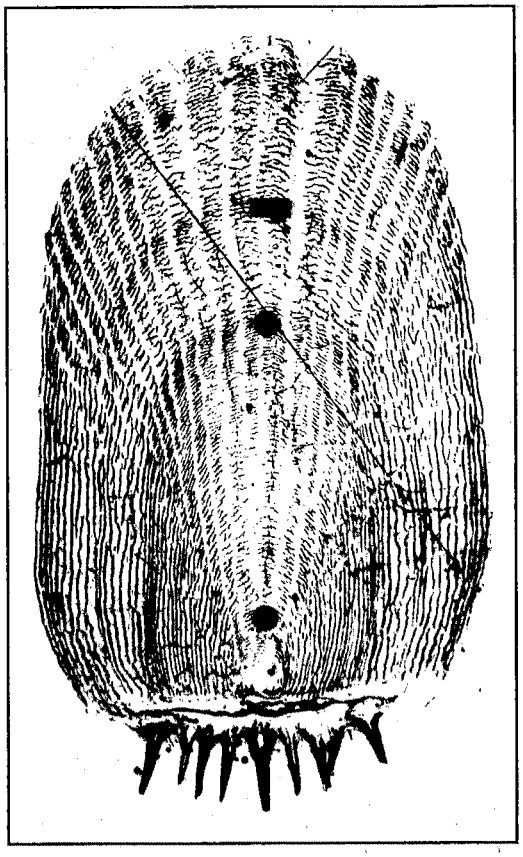

Figure 9
Scale impression from a 31-cm age-2 yellowtail flounder collected in November from the Cape Cod area showing the distinctive check after the second annulus.

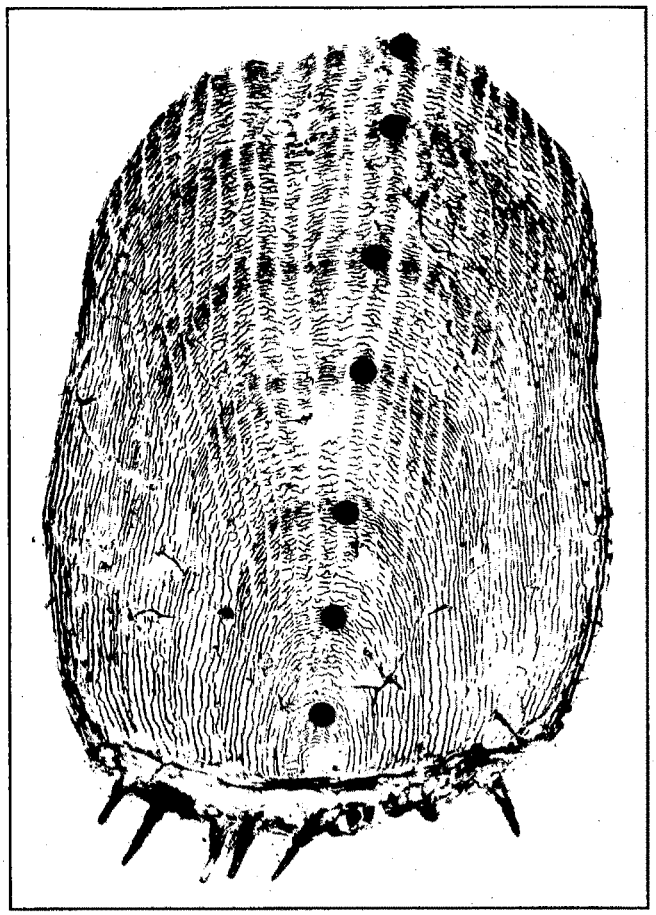

Figure 10
Scale impression from a 36-cm age-7 male yellowtail flounder collected in the spring from Browns Bank showing the close first, second, and third annuli typical for this area.