

Freshwater Eel Family— Anguillidae

One species of freshwater eel is known from Wisconsin and North America. Its entire range lies east of the Rocky Mountains; there are no freshwater eels along the Pacific Coast of the United States. About 16 species, all in the single genus *Anguilla*, occur widely throughout the world, particularly in the region of southeast Asia and the southwestern Pacific Ocean, including Australia and New Zealand. The fossil record is from the Upper Cretaceous to Recent.

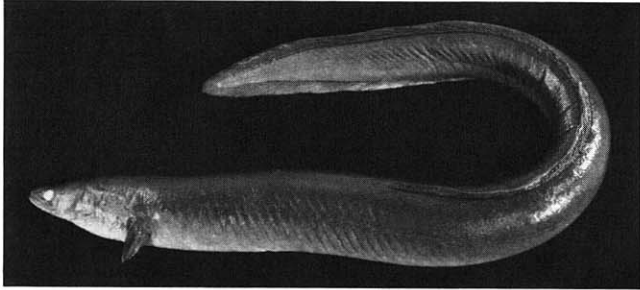
The body is excessively elongated and almost round in cross section. The gill openings are small, the pelvic fins absent, and the scales, when present, are small and embedded.

The Anguillidae or freshwater eels spawn in the sea, but early in life they move into fresh water, where they grow into adults. They are catadromous fishes: they run downstream to breed.

American Eel

Anguilla rostrata (Lesueur). *Anguilla*—eel; *rostrata*—beaked.

Other common names: common eel, freshwater eel, Boston eel, Atlantic eel, silver eel, elver.



850 mm, Zumbro R., Minnesota, 1977

DESCRIPTION

Body much elongated, snakelike. Lower jaw protruding beyond upper; mouth large, extending to below or beyond eye; jaws and vomer with numerous teeth somewhat unequal in length. Gill opening a small slit, about the length of base of pectoral fin. Fins: all soft-rayed; pelvic fins absent; dorsal fin beginning far behind head and in front of anal fin; dorsal, caudal, and anal fins continuous; caudal fin bluntly rounded. Scales minute and mosaic, separated from one another or meeting at their margins. Anterior nares at tips of short tubes close to upper lips near tip of snout. Chromosomes $2n = 38$ (Roberts 1967).

Larval eel or leptocephalus ("thin-head") shaped like willow leaf and transparent. Transformed or "glass eels" with general shape of an eel, eyes pigmented but body transparent. In fresh water, immature eels yellowish, greenish or olive-brown; back darker, belly lighter. Mature adult at time of seaward migration with metallic sheen, back bronze or almost black and belly light or silvery (called "silver eel").

DISTRIBUTION, STATUS, AND HABITAT

The American eel occurs in the Mississippi, Lake Michigan, and Lake Superior drainage basins. In the Mississippi system, there are the following records and reports of eels outside the Mississippi River mainstem: Walworth County—Whitewater Lake (*Milwaukee Journal*, July 1950) 1950, Cravath Lake (*Janesville Gazette* 16 July 1974); Waukesha County—Lac La Belle (D. Mraz, pers. comm.) 1959, Lac La Belle and its outlet (Greene 1935), Upper Nemahbin

Lake (L. Christenson, pers. comm.) 1951; Dodge County—Beaver (Dam ?) Lake (Greene 1935), Rock River between Hustisford and Watertown (H. Neuenschwander, pers. comm.) up to 1943; Jefferson County—Lake Koshkonong (*Janesville Gazette* 16 July 1974) 1954, Rock River at Watertown (D. Becker, pers. comm.) 1975; Dane County—Lake Monona (Neuenschwander 1946) 1880, Salmo Pond of Black Earth Creek (C. Brynildson, pers. comm.) 1976; Dane and Rock counties—Yahara River (Mackenthun et al. 1948) 1946; Rock County—Rock River below Monterey Dam at Janesville (*Janesville Gazette* 16 July 1974) 1965, lower Pecatonica River (C. Brynildson, pers. comm.) 1950s; Columbia County—Crawfish River T10N R12E Sec 13 (*Columbus Journal Republican* 7 July 1976) 1976; Sauk County—Baraboo River (*History of Sauk County* 1880); La Crosse County—Neshonoc Lake (L. Christenson, pers. comm.) early 1950s; Dunn County—Lake Menomin (B. Apelgren, pers. comm.) about 1963; St. Croix County—Lake St. Croix (B. Apelgren, pers. comm.) 1964.

Lake Michigan records and reports: Ozaukee County—Lake Michigan off Port Washington (Greene 1935), Lake Michigan at Harrington State Park (UWSP 5666) 1977; Brown County—Green Bay at Red Banks (UWSP 2777) 1968, Fox River (Kernen 1974) 1974; Marinette County—Green Bay at Peshtigo Point (*Marinette Eagle-Star* 30 June 1974) 1974.

Lake Superior reports: Douglas County—Lake Nebagamon (W. Weiher, pers. comm.) 1966, 1970, 1973; Brule River at mouth (W. Weiher, pers. comm.) 1970; Superior harbor area (W. Weiher, pers. comm.) 1974. Additional Lake Superior basin areas outside Wisconsin: Minnesota shore Lake Superior (*Milwaukee Journal* 14 November 1971, Eddy and Underhill 1974) 1966–1971; Beaver Lake Creek in Upper Michigan (Moore and Braem 1965) 1957.

Wisconsin Fish Distribution Study (1974–1978) records and reports: Green County—Sugar River at Albany 1974; Dane County—Yahara River above Lake Mendota 1977; Sauk County—Wisconsin River T8N R4E Sec 3 1977; Grant County—Wisconsin River near Bridgeport 1977; Jackson County—Black River T22N R3W Sec 3 1975; La Crosse County—Black River T17N R8W Sec 4 1976; Dunn, Pepin, and Buffalo counties—three Red Cedar River collections 1963 and 1975, five Chippewa River collections 1977.

Eels reaching Wisconsin undoubtedly follow two routes: (1) the Mississippi River from the Gulf of Mexico and (2) the St. Lawrence Seaway. M. W. Smith and Saunders (1955) noted that eels avoid cool-water habitats. This may be responsible for their late



Range of the American eel

- Specimens examined
- ▲ Wisconsin Fish Distribution Study (1974-78)
- Literature and reports
- Greene (1935)

entry into the upper Great Lakes, especially Lake Superior.

The American eel is rare to uncommon in the Mississippi River and its tributaries. At one time it was common, but it has declined during the past half century. In recent years there has been little change in its status and its numbers do not appear to be diminishing. In the Lake Michigan and Superior basins this species is still an oddity. A capture off Peshtigo Point of Green Bay in 1974 was headlined "Fisherman Nets Strange Creature" (*Marinette Eagle-Star*). It is thought that the construction in 1974 of an eel ladder on the St. Lawrence River at Cornwall, Ontario, may increase the numbers of eels in the upper Great Lakes (Whitfield 1975). In Wisconsin this species has watch status (Wis. Dep. Nat. Resour. Endangered Species Com. 1975, Les 1979).

The eel inhabits large streams and lakes, seeking muddy bottoms and still waters. To reach these waters the eel has to traverse swift-flowing, medium-

sized streams over a wide variety of bottoms. A prime requirement is sufficient food. The eel can tolerate habitats over a wide range of temperatures (Bigelow and Welsh 1925).

BIOLOGY

When she leaves fresh water to spawn, the female is very fat, with a very high oil content. This reserve of fat and oil undoubtedly sustains her on her journey to the breeding grounds thousands of miles away (Angel and Jones 1974). As the female eel leaves fresh water and enters the brackish estuaries, she is joined by the male eel. Presumably they leave North American shores and over a period of 2 or 3 months swim into the spawning area.

Schmidt (1922) says that breeding occurs in the Atlantic's Sargasso Sea between Bermuda and the Bahamas, but Vladykov (1964) makes a strong case for a breeding area much farther south than the Sargasso Sea. Assuming the Sargasso Sea center, it is difficult

to explain the presence of adults of the American eel over their southern limits, i.e., Trinidad and Dutch Guiana, since the weak leptocephali would not be able to reach those sites against the strong North Equatorial Current.

The breeding season starts in late winter or early spring and extends into the summer (Breder and Rosen 1966). Spawning occurs in deep water and nothing is known of the mating activity. Presumably spawning occurs once, and is followed by the death of the adults. Males mature at 279–305 mm (11–12 in) and females at 457 mm (18 in) and at 5–20 years of age (Carlander 1969). The number of eggs has been reported at 5–20 million per female. It is presumed that the eggs and larvae require water of high temperature and high salinity for development.

The eel larvae (leptocephali) once considered distinct and separate fishes, are cigar-shaped in outline but very flat from side to side. They are usually as thick as an ordinary blotter and highly transparent, so much so that when laid on a printed page they offer practically no obstruction to reading.

The leptocephali arrive off our coastal waters in 1 year, at which time they assume the adult form and are 60–65 mm (2.4–2.6 in) long. As soon as they come under the influence of fresh water in our brackish bays, they become heavily pigmented and are nearly black. At this point they are 65–90 mm (2.5–3.5 in) long, and are called elvers (Scott and Crossman 1973).

Migration into fresh water occurs in spring. Most eels entering North American estuaries are females, although to the south of the American eel's range (from North Carolina to the Gulf of Mexico) a few males may be present (C. Huver, pers. comm.). The sex of this species is determined from a microscopic inspection of the gonads.

The males rarely move much above tidewater, and grow to maturity after spending years in brackish estuaries. The females, however, migrate into fresh water, some only a few kilometers and others hundreds or thousands of kilometers upstream. According to Dintaman (1975), elvers migrate upstream during the night, generally following the bank of the river or stream in very shallow water. When they approach a swift-running part of the stream, they move closer to the shoreline, often coming out of the water by clinging to wet grass or to the surface of wet rocks. They move overland until they have passed the swift section and can again enter the water to continue their upstream migration. They penetrate upstream by climbing, clinging, and crawling up the sides of

rocks and, occasionally, of vertical fishways and dams. Walden (1964) noted that they surmount dams, negotiate tunnels, aqueducts, and underground streams, sometimes traveling over flooded or even dew-wet fields and turning up eventually in a pond or lake with no apparent access to any sea-connected river.

Scales do not form on young eels until they attain lengths of 16–20 cm (6.3–7.9 in) at about age III. In a length-frequency study, Hildebrand and Schroeder (1928) found lengths of 64 mm (2.5 in) at age I and 127 mm (5 in) at age II. By examining scales of eels in New Brunswick, M. W. Smith and Saunders (1955) determined age III at 241 mm (9.5 in); IV, 292 mm (11.5 in); V, 348 mm (13.7 in); VI, 368 mm (14.5 in); VII, 386 mm (15.2 in); VIII, 462 mm (18.2 in); IX, 500 mm (19.7 in); X, 549 mm (21.6 in); XI and older, 612–744 mm (24.1–29.3 in). Smith and Saunders read 10 scales for each fish but in the older fish many differences were noted in annulus counts, sometimes as much as 5 years in one individual. The highest reading was used as the age for that individual. Gunning and Shoop (1962) reported that in two Louisiana streams, eels were smaller in the stream with the higher population density. Of two eels tagged at lengths of 360 mm (14.2 in), one grew at least 138 mm (5.4 in) and the other, 325 mm (12.8 in) during 1 year of growth.

Female American eels 122 cm (48 in) TL and 7.26 kg (16 lb) have been recorded (Eales 1968). Male eels longer than 51 cm (20 in) are rare, but female eels up to 91 cm (3 ft) long are common, and they can reach a length of 152 cm (5 ft) (Angel and Jones 1974). In Wisconsin a number of eels of 91 cm (36 in) TL or longer and weighing 1.4–1.8 kg (3–4 lb) have been reported. On 30 April 1951 one was taken from Upper Nemahbin Lake (Waukesha County) 112 cm (44 in) TL, weighing 3.52 kg (7 lb 12 oz). Scott and Crossman (1973) reported the case of a European eel (*Anguilla anguilla*) kept in captivity from 1863, when 3 years old, to 1948, a life span of 88 years. No similar authentic records are known for North American eels.

Eels are voracious carnivores, feeding mainly at night and consuming a wide variety of fishes and invertebrate creatures. Contrary to earlier thinking, eels seek living rather than dead creatures and are not habitual eaters of carrion, although they do attack and partly consume fishes gilled in nets (Scott and Crossman 1973). They have also been known to feed on dead livestock that has washed into the stream (Harlan and Speaker 1956). Their snakelike

movements permit them to move into extremely shallow waters and even overland for short distances in marshy or damp situations, and they have been observed in damp lowlands near streams, presumably in search of frogs, crayfish, and other foods. Ranthum (1969) reported an eel taken from Pool 19 of the Mississippi River that contained three small clams and a large number of *Hexagenia* naiads. A 676-mm (26.6-in) eel had eaten two crayfish; a 269-mm (10.6-in) eel had eaten a heptageniid mayfly naiad. In New York eels were found feeding mostly on fish, and also on chironomid larvae. It was observed that mayfly naiads and adults made up over half the food of 20 eels from the Delaware River in New York.

Freshwater eels can survive for more than a year without taking food (Lagler et al. 1962). The intestines of such starved fishes become nonfunctional and partly degenerate.

Eels, being nocturnal, usually spend the day hidden under rocks or logs or buried in the mud with only their snouts protruding. Adams and Hankinson (1926) noted that during the daytime they were caught in water from 9 to 18 m (30–60 ft) deep.

In winter, in cold regions like New England, the eel burrows in soft mud and hibernates. At Cape May eels burrow 152–203 mm (6–8 in), sometimes a little further, and often become more or less quiet or dormant (Adams and Hankinson 1926).

Eels make chirping or sucking noises, which Scott and Crossman (1973) report are frequently heard on warm August evenings in Canada. When highly excited, they produce high-pitched sounds by release of air from the bladder through the pneumatic duct (Lagler et al. 1962).

Eels have a remarkably acute sense of smell. The perceptual threshold for B-phenylethyl alcohol in the best-trained experimental eels (*Anguilla anguilla*) was a dilution of 1:2,857 trillion (Teichmann 1957). Teichmann estimated that 1–2 molecules of the scent in the nasal chambers could be detected by the eel. This sensitivity may operate as a homing device through which the mature adult seeks out ancestral spawning grounds.

Captive eels in the University of Minnesota aquariums lie quietly on the bottom while resting, sometimes upside down. They have occasionally escaped from their tanks and remained out of water for 24 hours without any apparent injury (Eddy and Underhill 1974).

The hardiness of the eel is almost proverbial, a view that has arisen largely because the eel can live out of water longer than most freshwater fish. Its gills are protected from dessication, and it appears to live at a low metabolic level.

IMPORTANCE AND MANAGEMENT

This species is host to the glochidia of the mollusks *Megaloniaias gigantea*, *Arcidens confragosa*, *Actinonaias carinata*, and *Ligumia recta* (Hart and Fuller 1974).

The eel has been suggested as a biological control for lampreys. Perlmutter (1951) noted that the eel explores openings and crevices and roots through the mud for its prey. In an aquarium experiment, eels destroyed a considerable number of larval lampreys. The eel is too rare, however, in Lakes Michigan and Superior to have any effect on sea lamprey populations.

Adult eels appear to be well able to take care of themselves (Adams and Hankinson 1926), but young eels are eaten by walleye, great blue heron, American merganser, bald eagle, double-crested cormorant, black-crowned night heron, otter, mink, and water snake.

Catching an eel in Wisconsin by hook and line is generally a matter of chance, occurring usually while the angler is fishing for something else. Any bait will do to catch an eel. The eel is a fighter, pulling vigorously, tugging, and shaking. The simplest way to kill eels is to put them in a deep container, sprinkle them with salt, and add enough water to cover them. This method of killing eels helps to remove the slime layer (Berg et al. 1975).

The eel is an exceptionally good food fish. Whatever the season, and even in countries like the United States where most people are not accustomed to eating eel, it is considered a luxury food. In some countries, eel is traditionally served on certain days. In Italy, it is the traditional dish on Christmas Eve. In Japan, one day in July is set aside as "eel day," and great quantities are sold (Bardach et al. 1972).

The flesh is white and has a good flavor. It can be fried, baked, sauteed, jellied, made into chowder, smoked, and served with a variety of sauces. Smoked eel is by far the most popular mode of preparation. Berg et al. (1975) suggested that eels be skinned, rolled in crumbs, dipped in egg and deep-fried for 3–5 min.

At one time eels served to a limited extent as a source of oil, which was extracted and sold largely as a grease for harnesses and for medicinal purposes. Occasionally, eel skins were preserved and stretched over thin, narrow boards about a yard long to dry; the dried skins were used for lining buggy and riding whips. Skins also went into the production of fine bookbindings, and were shaped into suspenders and other items (Adams and Hankinson 1926).

In the Mississippi River adjacent to Wisconsin, eels are taken by setlines, bait nets, buffalo nets, and slat nets. During the 10-year period 1956–1965, a total of

435 kg (960 lb) was harvested from Wisconsin waters; during 1966–1975, 2,056 kg (4533 lb). The largest yearly catch was 343 kg (756 lb) in 1974 (Fernholz and Crawley 1976). Its value to the commercial fisherman of \$0.51 per kilo in 1975 was exceeded only by the price for the catfish (\$0.81) and the shovelnose sturgeon (\$0.64).

During the 1970s, because of European demand, eels were bringing prices to commercial fishermen on the East Coast of \$1.10 per kilo, and over 226,800 kg (500,000 lb) have been flown overseas in a single year. Most of them are shipped alive, and the demand is greater than the supply (Angel and Jones 1974).

