Cod Family—Gadidae

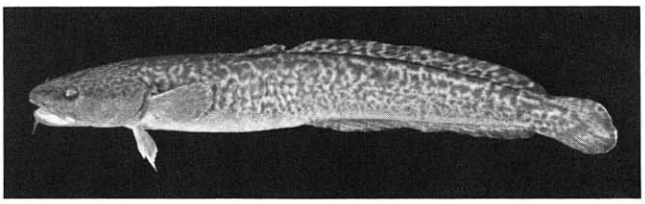
Only one species, the burbot, appears in Wisconsin. It is a truly freshwater form and is circumpolar in distribution. The family Gadidae is represented by 25 species in the United States and Canada, 23 of which inhabit the Atlantic and Pacific oceans. This is the well-known marine family which contains the cod, the haddock, and many other important food species.

The cods have large heads and wide gill openings. Their jaws are terminal or nearly so, and both jaws and vomer are equipped with numerous small teeth in wide bands; there is a small barbel at the tip of the chin. The scales are small and cycloid. All the fins are soft rayed, and the pelvic fins are set far forward. In the burbot, the pelvic fins are in the throat region and are anterior to the pectoral fins; this is the only Wisconsin species with the pelvic fins positioned in front of the pectorals. In the cods, the caudal vertebrae become smaller posteriorly, and the pneumatic duct from the swimbladder to the pharynx is lost (physoclist).

Burbot

Lota lota (Linnaeus). *Lota*—the ancient name used by Guillaume Rondelet, a French zoologist; in French, la Lotte.

Other common names: lawyer, lake lawyer, ling, ling cod, eelpout, freshwater cod, cusk, spineless catfish, gudgeon, mud blower, mother eel (Kansas), maria (Saskatchewan, Manitoba, northern Ontario), methy (northern Canada), lush (Alaska), dogfish (Minnesota).



258 mm, Beaver Cr. (Trempealeau Co.), 28 June 1977

DESCRIPTION

Body elongate, cylindrical anterior to anus; laterally compressed posterior to anus. Length 305–483 mm (12–19 in). TL = 1.08 SL. Depth into SL 6.2–7.7. Head into SL 4.4–4.8; head flattened dorsoventrally. Snout pointed; upper lip groove continuous over tip of snout. Mouth large, almost horizontal; posterior edge of upper jaw behind pupil of eye; numerous minute teeth in wide bands on upper and lower jaws. One median chin barbel, and barbel-like, tubular extensions for each nostril opening. Dorsal fins 2; first dorsal low, short with 8–16 rays; second dorsal low, long with 61–81 rays. Anal fin rays 52–76; pelvic fin rays 5–8, the second ray prolonged into a tapering filament. Scales cycloid, embedded in cheeks, opercles, and body, so small as to be almost invisible except in large adults; under microscope the scales have heavy circuli which appear like growth rings in a gymnosperm twig; lateral line complete. Pyloric caeca 31–150. Large liver without gall bladder.

Adults uniformly yellow, or light brown to black, or mottled with dark brown or black on back and sides; belly whitish. Young fish conspicuously speckled, or with dark vermiculations. Dorsal, caudal, and anal fins mottled and more or less dark edged; pectoral fins mottled; pelvic fins white to slightly pigmented.

DISTRIBUTION, STATUS, AND HABITAT

In Wisconsin, the burbot occurs in all three drainage basins and in all boundary waters. Its distribution is mainly associated with the St. Croix, Chippewa–Red Cedar, Wisconsin, Rock, and Wolf-Fox river systems. Its distribution in the unglaciated portion of the state is sporadic.

The chronology of the changes in abundance of burbot in Lake Michigan suggests that the sea lamprey was responsible for the burbot's decline in the mid-1940s, and that sea lamprey control led to an upswing in burbot numbers in the late 1960s. (Wells and McLain 1972). The burbot is uncommon in the Mississippi River, although at one time it was reported as common in Lake Pepin (Wagner 1908). It is common in the Flambeau watershed and in the tributaries to Lake Superior; it is abundant in Lakes Poygan and Winnebago. Its status in Wisconsin appears to be secure.

The burbot frequents cool waters of large rivers, and the lower reaches of their tributaries, and lakes—particularly in northern Wisconsin. It is encountered most frequently at depths over 1.5 m (immatures at lesser depths) over substrates of mud, sand, rubble, boulders, silt, and gravel. It was found in streams of the following widths: 1–3 m (13%), 3.1–6.0 m (25%), 12.1–24.0 m (25%), and more than 50 m (38%). It prefers patches of plants and trash when young, stony-bottomed riffles when half-grown, and undercut banks when adult (Hubbs and Lagler 1964).

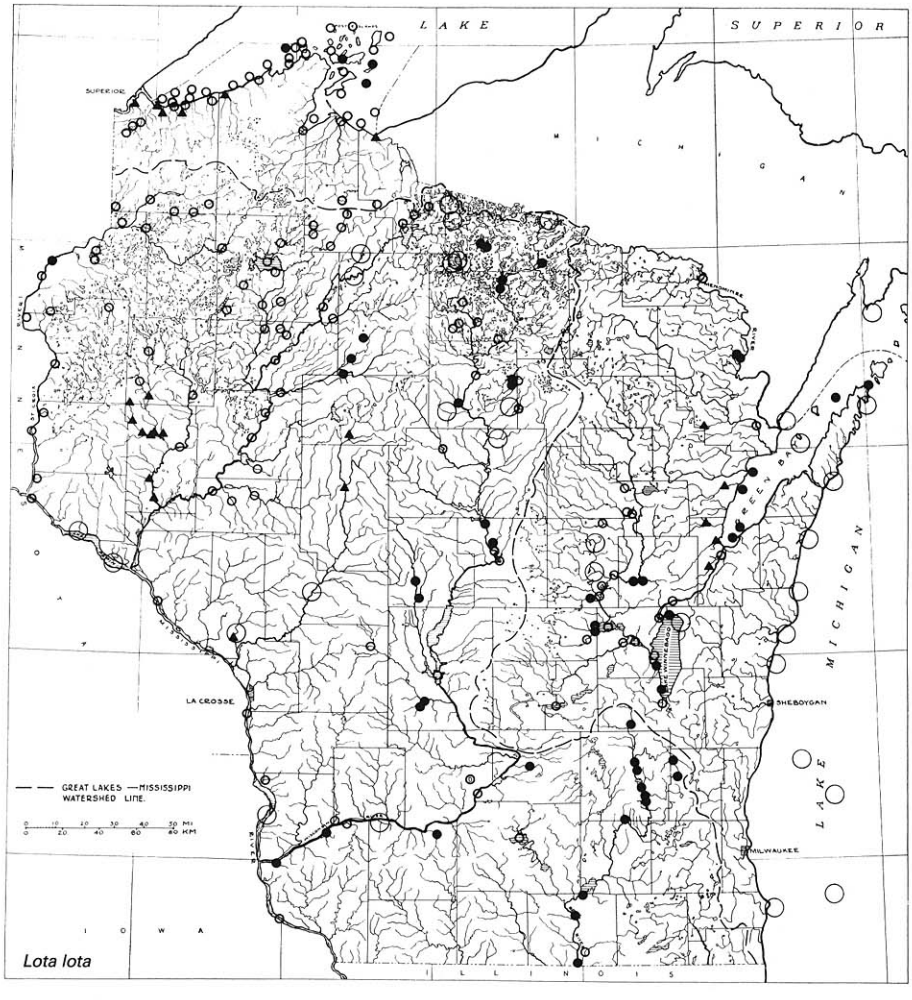
BIOLOGY

The burbot is the earliest spawner of all Wisconsin fishes. Spawning occurs in mid-winter, or in the early spring before the ice has melted. In the Lake Michigan basin, adults spawn from January to March. In Lake Winnebago, burbot spawn on rock and gravel reefs from late January to early February (Weber 1971). In the Bayfield area of Lake Superior, most burbot collected had spawned by late February and early March; spawning in the Apostle Islands region may continue into late March (Bailey 1972).

Burbot spawn in deep water in some areas, but the spawning site is usually in shallow bays in 0.3–1.2 m (1–4 ft) of water over sand or gravel, or on gravel shoals 1.5–4.6 m (5–15 ft) deep. Spawning usually takes place at night, and the spawning grounds are deserted in the daytime. The surface water temperature is close to freezing; no nest is built, and no care is given the young.

The spawning act of the burbot has been observed a number of times. E. Fabricius noted (Breder and Rosen 1966:376):

> The female slowly swam about on a sand bottom in a tilted posture, with lifted tail and her head pointed downwards, dragging the chin barbel and the prolonged second rays of the pelvics along the ground. The male approached her from



Range of the burbot
- ● Specimens examined
- ▲ Wisconsin Fish Distribution Study (1974–75)
- ○ Literature and reports
- ○ Greene (1935)

behind, swam in under her belly and placed his head under hers, so that her chin rested on his crown. In this position the couple swam about at the bottom for some minutes. The male suddenly rotated his body half a turn, pushing his belly against the vent of the female. In this mating act a cloud of eggs and sperm was released. After mating the male and female separated for a moment, the female performed a series of powerful tail beats which stirred up the sexual products and scattered the eggs. The eggs were carried about by the water movements caused by this activity, but they finally sank down to the bottom.

This activity was repeated until the female was spent.

Cahn (1936) observed probable spawning by the burbot in Minnesota (p. 164):

On the night of February 12 the interesting phenomenon of breeding was observed. . . . At first a dark shadow was noted at the edge of the ice, something which appeared to be a large ball. Eventually this moved out into view and it was seen to be indeed a ball—a tangled, nearly globular mass of moving, writhing lawyers. The fish were all intertwined, slithering over one another constantly, slowly, weaving in and out of the living ball. About a dozen fish were involved. . . .

The mass of fish, about 76 cm (30 in) diam, was in water about 1.2 m (4 ft) deep.

In Lake Superior burbot (Bailey 1972), the estimated number of eggs in the ovaries of eight females, 373–541 mm (14.7–21.3 in) long, ranged from 268,832 to 1,154,014. In New York (Robins and Deubler 1955), a 643-mm, 2.8-kg (25.3-in, 6.1-lb) female held 1,362,000 eggs. The average diameter for the semipelagic eggs varies with the region, but generally ranges from 1.25 to 1.9 mm.

The incubation period of burbot eggs is from 4 to 5 weeks, at a water temperature of 4°C (39.2°F) (Breder and Rosen (1966). Fish (1932) provided sketches from the 3.5- to 19-mm stages, along with descriptions of these and the 30.5-mm stage. The median barbel is recognizable in the 10.9-mm stage.

Many newly hatched young burbot are found on the shallow, sandy bottoms of lakes (Eddy and Surber 1947) and in trout streams which may act as nur-

sery streams (Harlan and Speaker 1956). In Lake Huron, burbot production occurs in the large bays, but, like smelt, the young disperse throughout the surface waters over deep water and display a limnetic pattern of distribution (Faber 1970). In Lake Erie, Fish (1932) noted larval and postlarval stages 3–15 mm long at 5–60 m from mid-June to mid-August.

Age is determined by counting the annular rings of the otoliths. Burbot from western Lake Superior (Bailey 1972) showed a considerable overlap in lengths from year to year, but the average estimated lengths were: 0—145 mm; I—254 mm; II—300 mm; III—340 mm; IV—376 mm; V—409 mm; VI—439 mm; VII—478 mm; VIII—513 mm; IX—551 mm; X—594 mm; XI—645 mm, and XII—711 mm. The estimated annual weight increments ranged from 27 g to 118 g through age VI, and from 163 g to 586 g from age VII through age XII.

About 59% of the Lake Superior males, but only 5% of the females, were mature at age I; all burbot of both sexes were mature at age V. The shortest mature male was 246 mm (9.7 in) long; all males more than 417 mm (16.4 in) long were mature. The shortest mature female was 272 mm (10.7 in) long, and all females longer than 404 mm (15.9 in) were mature.

Burbot specimens up to 1 m (39.4 in) long, with weights of 25–30 kg (55–66 lb) and ages of 15–20 years, have been reported, mainly from Siberia (Muus and Dahlstrom 1971). Large burbot from Lake Winnebago reach a length of nearly 76 cm (30 in) and weigh 3.6–4.1 kg (8–9 lb) (Lewis 1970).

In Lake Superior (Bailey 1972), burbot of all ages had eaten fish and crustaceans. The fish consumed in order of frequency were sculpins (slimy and spoonheads), smelt, bloater, ninespine sticklebacks, trout-perch, and lake trout. Fish eggs, probably the eggs of lake herring (*Coregonus artedii*), occurred in 21.4% of the burbot stomachs during the fall. The crustaceans *Mysis relicta* and *Pontoporeia affinis* appeared in over half of the stomachs examined, and fingernail clams occurred in 26% of the stomachs. Insects were relatively unimportant. The presence in burbot stomachs of rocks, wood chips, clinkers, plastic, and other inert materials suggests that their feeding had been rather indiscriminate.

In Lake Michigan and Green Bay (Van Oosten and Deason 1938), food consisted of fish (74% volume) and invertebrates (26%). The dominant items in southern Lake Michigan were sculpins (76%); in northern Lake Michigan, coregonid chubs (51%) and *Pontoporeia* (37%); and in Green Bay, trout-perch (34%) and *Mysis* (26%). The consumption of invertebrates decreased with increases in the size of the burbot. Fishes were eaten after burbots reached 330 mm (13 in) or more in size. One must keep in mind, however, that this study of food habits was made before the advent of the alewife brought about dramatic changes in the fish populations of these waters. The diet of the burbot today may be quite different than it was in the 1930s, and it now probably includes the abundant alewife.

According to Scott and Crossman (1973), in streams small burbot 51–305 mm (2–12 in) long feed on *Gammarus*, mayfly nymphs, and crayfish. Adult burbot become voracious, feeding on most available fishes and crayfishes, dead or alive. Perch up to 254 mm (10 in) long have been reported from Wisconsin burbot stomachs. A 559-mm (22-in) burbot, seined from Lake Winnebago, had swallowed all but the tail of a 406-mm walleye (Colburn 1946). One 483-mm (19-in) burbot contained five 76-mm perch, six 51-mm crayfish, six large burrowing mayfly nymphs, and one dragonfly nymph (Wis. Conserv. *Bull.* 1948 13[4]:31). Adams and Hankinson (1926) remarked about the burbot's capacity for food (p. 518):

> If he can procure food he will not desist from eating so long as there is room for another particle in his capacious abdomen. He is frequently taken with his abdomen so much distended with food as to give him the appearance of the globe or toad-fish.

Adult burbot do not feed during the spawning period, but begin to prey heavily on forage fish immediately after spawning. They supposedly come into shallow water to feed at night.

Optimum temperatures (Scott and Crossman 1973) for the burbot are 15.6–18.3°C (60–65°F); 23.3°C (74°F) appears to be its upper limit. The preferred temperature of young burbot as determined by laboratory experiments is 21.2°C (70.2°F) (Ferguson 1958).

During the warm summer months, and in the fall when the water temperature has declined, the larger burbot is usually found in the deepest part of a lake or stream. In the Apostle Islands region of Lake Superior the burbot shows a wide distribution from the shallowest water to 126 m, with the largest catches taken at 18–35 m. Koelz (1929) noted that the burbot was taken in numbers near Stannard Rock at a depth of 210 m. In northeastern Lake Michigan, there was a characteristic monthly inshore concentration of burbot at 13–18 m or at 19–21 m, and a second concentration at 31–34 m, or at more than 34 m (Van Oosten et al. 1946).

IMPORTANCE AND MANAGEMENT

Burbots are eaten by other fishes. At Two Rivers (Lake Michigan), a lake trout 597 mm (23.5 in) long had 76 mm (3 in) of a burbot tail projecting from its mouth;

the head had been digested, but the body was 356 mm (14 in) long without it. Young burbot are eaten by smelt, yellow perch, and other fishes.

The burbot is readily caught through the ice in late winter, with minnows used as bait at the end of hand lines, tip-ups, and conventional rods and reels. Since the goal of Wisconsin ice fishermen is generally walleyes, however, the burbots caught are unwelcome and are frequently left on the ice. In the East, burbots are said to attract large numbers of herring gulls which come down to within a few feet of fishermen; there are reports of substantial windbreaks being made of the carcasses of these fish.

The burbot is classified a rough fish by the state of Wisconsin. Liberal regulations permit fishermen to spear and to net it, and there are no restrictions on fish size or on bag size. Spearing for burbot is allowed in tributaries to Lake Superior when the spearing season for other species has been closed.

In Siberia, the skin of the burbot has been used instead of glass (Adams and Hankinson 1926). In recent years, Lake Winnebago burbot have been trucked alive to Indiana and Ohio for stocking fee fishing ponds.

In Wisconsin, the burbot has never been of great commercial importance because of its low market demand. Even in the very early commercial fishery most burbot were discarded, except for the few sent to local markets (Milner 1874a). In Lake Michigan, burbot production reached an all-time high in 1974 with a total harvest of 93,363 kg (205,826 lb) (Wis. Dep. Nat. Resour. 1976c:1):

> . . . This was 91,859 pounds greater than the 1973 harvest and 68,826 pounds higher than the previous high produced from Wisconsin waters of Lake Michigan and Green Bay in 1917. The increase may not indicate as drastic an increase in relative abundance as production figures indicate, although burbot numbers have increased tremendously in the last ten years, especially in Green Bay. The increase is definitely related to fishermen being allowed the sale of 10% lake trout as an incidental catch of their legal catch—burbot being used to increase their legal catch. The value of the burbot fishery was reported at $7,693 or less than four cents a pound.

In Lake Superior, the burbot population is at a high level of abundance, and commercial catches are considerably higher than the 455 kg (1,000 lb) reported by the fishery: "This high quality food species is capable of sustaining a fairly large annual catch but no markets are available to the Lake Superior fishermen" (Wis. Dep. Nat. Resour. 1976c). Bailey (1972) commented that, although the burbot ranks among the most nutritious of the freshwater fishes, catches by commercial fishermen have often been discarded because of the lack of a profitable market.

In the Wisconsin waters of the Mississippi River in 1973, burbot landings totaled 9,500 kg (21,000 lb) and were valued at $3,000 (Pileggi and Thompson 1976). In 1970, 10,991 kg (24,230 lb) were removed by state crews from Lake Winnebago, and 1,678 kg (3,700 lb), from Lake Poygan (Miller 1971); some were sold for domestic mink food.

The flesh of the burbot resembles that of the cod and haddock, and in flavor it is the equal of many game fishes. For best results, the fish must be skinned and used fresh since the meat gets tough when frozen and has a rubbery texture when it is thawed.

In the mid-1920s fishery biologists predicted that, as a source of human food, the burbot appeared to be a fish of the future. That prediction is still awaiting fulfillment. Canada initiated a program to promote burbot as a food fish (MacKay 1963). Burbot, cleaned and skinned, were supplied to various hotels and restaurants in Toronto, and their chefs were asked to cook the fish and to give their opinions on the burbot's quality. The results were positive—"excellent"; and, "compare very favourably with any fish which I have obtained from the wholesalers." Nevertheless, attempts to encourage public acceptance of the burbot in Canada as a quality food fish, or as a processed fish for industrial use, have not been encouraging (Scott and Crossman 1973).

In the early decades of this century, the former United States Bureau of Fisheries urged the use of burbots for food through an extensive distribution of economic circulars and display cards. Excellent recipes for preparing this fish were provided. Mattingly (1976) provided burbot recipes with such intriguing names as White Pine Pan Fried, Crispy Kinde, Goodells Golden Puffs, Jiffy Jasper Jamboree, and Lakeland Cocktail. From Montana comes a recipe for Barbecued Ling (B. Miller 1974). In Wisconsin, Poor Man's Lobster is simplicity itself (Weber 1971:23):

> Fillets are cut into small 1- to 2-inch pieces, boiled in salt water for 3 minutes and drained. With melted butter poured over them, and appropriate seasoning, the taste will delight the most delicate palate . . . similar in taste to the more expensive lobster imported to the supermarket.

Burbot roe is a delicacy and, when seasoned and served on hot buttered toast, is as attractive as any roe (MacKay 1963).

The vitamin D potency of burbot liver oil is as high as that obtained from cod liver (Scott and Crossman 1973). In many European (especially Scandinavian)

countries burbot livers are eagerly sought, and are a valuable commodity when smoked and canned. The Fisheries Research Board of Canada has experimentally canned Canadian burbot livers; the product is considered to be of high quality, especially for such uses as the making of canapes. Despite all these accolades, over much of its range this species still bears the tag of a rough fish, and, in Wisconsin, except for a small market that has developed in some eastern counties, it is a despised fish species.

Perhaps the most valuable contribution of the burbot to the ecology of lakes is its predatory nature. It is at the top of the food chain, and consumes all species of fish, large and small. In a managed ecosystem, this contribution to population control may help to prevent stunting in some fish species—a major problem in many lakes and streams. After burbot from Lake Winnebago were introduced into Shannon Lake (Vilas County), which has a large stunted perch population, the burbot were observed to be feeding heavily on the perch. Some Wisconsin fish managers look on the burbot, along with the gars and the bowfin, as possible natural biological controls; the purposeful stocking of such predators may provide a balance of fish species and a yield that could be arrived at in no other way.