were 2 years old, 30% 3 years old, and the remainder 4, 5, and 6 years old. Lengths for each age group are given in the table below; males and females are listed separately since females grow faster and larger, and live longer than males. The figures apply to fish caught in spring. Sources are McKenzie (1964) for Miramichi River, Baldwin (1950) for Lake Huron, Bailey (1964) for Lake Superior.

The size of fish varies from place to place but smelt landlocked in small inland lakes often attain a maximum size of about 4 inches (102 mm), whereas 14 inch (356 mm) fish have been taken in Lake Ontario and maritime coastal waters.

Smelt are essentially schooling, pelagic fishes, inhabiting midwaters of lakes or inshore coastal waters. They do not inhabit the flowing waters of streams or rivers except at spawning time. They are sensitive to both temperature and light, especially the latter. Ferguson (1965) noted that, in Lake Erie, most smelt were at or near the bottom, at depths of 80 feet or more during daylight hours. *See* Ferguson for a discussion of bathymetric distribution. Preferred temperatures are rather vague but Hart and Ferguson (1966) suggested most of the population in Lake Erie occupied water of about 45° F (7.2° C) although they would enter 60° F (15.6° C) water for brief periods. Many populations exhibit a pronounced postspawning mortality, and windrows of dead smelt may be cast up on shore, as occurs in Lake Erie in May or June. Lake Erie also suffered a severe mortality of young-of-the-year in the fall of 1969.

In some inland lakes in Quebec or the Maritime Provinces, the presence of a few dead smelt on shore may be the only evidence of indigenous populations. The fish are often very small in size, 3–4 inches (76–102 mm) long, and few in number.

Great Lakes smelt populations suffered one of the most catastrophic natural mortalities ever recorded for a North American animal when the huge stocks in Lake Huron and Lake Michigan died off, presumably as a result of some communicable disease, possibly a virus. The mortality commenced in the fall of 1942 in Lake Huron and spread progressively throughout that lake and into Lake Michigan. The total loss from 1942 through to 1946 was estimated at about 50 million pounds (Van Oosten 1947).

Smelt are carnivorous fishes, feeding on a wide variety of smaller creatures, a feature of their life history that has been of intense interest to biologists and fishermen alike. Food studies of freshwater populations have been conducted for many populations but studies in the Great Lakes have shown that *Mysis relicta*, a shrimp-like crustacean, is a primary food. Other invertebrates eaten include amphipods, ostracods, aquatic insect larvae, and aquatic worms. Fish seldom occurs in a high percentage of stomachs but constitutes about 6–10% of the volume. In the Great Lakes, sculpins of the genus *Cottus*, and small smelt, are commonly eaten but, in addition, small burbot, white bass, whitefish, and emerald shiner have also been reported. Young perch, rock bass, and emerald shiners have been found in smelt stomachs from inland Michigan lakes (Creaser 1925, 1927). Despite the fact that studies have not exposed the smelt as

			Age (*years*)					
		Length	1	2	3	4	5	6
Miramichi R.	M	*inches*	–	5.3	6.0	6.7	7.2	–
		mm	–	135	152	169	183	–
	F	*inches*	–	5.5	6.3	7.2	8.1	–
		mm	–	139	160	183	206	–
South Bay, L. Huron		*inches*	–	5.4	6.1	7.2	–	–
		mm	–	117	155	183	–	–
L. Superior	M	*inches*	2.6	6.0	7.3	7.9	8.6	–
		mm	66	152	185	201	218	–
	F	*inches*	2.6	5.9	7.7	8.7	9.4	9.8
		mm	66	150	196	221	239	249

a heavy predator of other fishes, it is still regarded with suspicion by many biologists and fishermen. It is said that lake trout populations decline when smelt enter a lake and indeed this seems generally to be true, although no evidence of direct predation on young trout by smelt has been demonstrated (Kendall 1927; Schneberger 1937). Studies must be conducted throughout the year, however, to be effective and winter is a difficult time to sample, although smelt appear to be more piscivorous during winter months. Also, they occur in such huge numbers (McKenzie estimated 375 million fish in Miramichi stock) that predation by even a very small percentage could be significant.

Smelt, in turn, are preyed upon by a variety of creatures, including their own species, but especially by lake trout. It is a most important prey of landlocked salmon in Maine lakes (Rupp 1968) and undoubtedly in Canadian coastal waters containing landlocked salmon. It is of interest to note that smelt were introduced into Michigan waters in the early 1900's as food for introduced landlocked salmon. In coastal regions large brook trout also feed on smelt. Other species known to feed on smelt include burbot, walleye, and perch, and during the postspawning mortality, a wide variety of birds such as gulls and crows.

The smelt is host to a number of parasites but one species in particular, *Glugea hertwigi* Weissenberg has become obvious in some North American populations. This is a microsporidian parasite that infects smelt in Europe and North America. An acute epidemic of microsporidiosus caused by this parasite occurred in Loon Pond, N.H., in September and October, 1951 (Haley 1952). The parasite is not known to be a human pathogen, but is aesthetically undesirable. The infection appears as white cysts, 0.2–3.5 mm in diameter, attached to the gonads, intestinal tract, or elsewhere in the body cavity. In extreme cases, the cysts may invade the muscle. It has been reported from Lake Erie, and many parts of Quebec, and exhibits seasonal abundance. For further information on the infection of smelt by *Glugea see* Dechtiar (1965), Delisle (1969), and Delisle and Veilleux (1969). The latter authors mapped the distribution of the occurrence of this parasite on smelt in Quebec.

In a study of the parasites of smelt from Lake Huron, Bangham (1955) found that all 50 smelt examined were parasitized, some with acanthocephalans and some with numerous flukes (*Diplostomulum* sp.) in the lenses of the eyes. He did not record *Glugea*.

In a summary of parasites of smelt in North America, Hoffman (1967) listed *Diphyllobothrium osmeri* (from *Osmerus dentex*) and a number of species of trematodes, cestodes, nematodes, acanthocephalans, plus a leech, *Piscicola punctata*, and a crustacean, *Argulus alosae*, and, of course, *Glugea hertwigi*.

Relation to man Marine smelt in Canadian Atlantic coastal waters have supported a commercial fishery for over 100 years. As early as 1852, Perley reported that "The smelt . . . is found in excessive abundance in all the rivers and streams flowing into the Gulf." He also noted that they were often called "frost fish" when angled through the ice, and that after the ice disappears, ". . . they rush in almost solid columns up the brooks and rivulets to spawn and are then taken by cart loads."

The major fishery for smelt in the eastern Canadian provinces is in the Gulf of St. Lawrence region of New Brunswick, especially in the Miramichi River and estuary. The history and conduct of this fishery was fully documented by McKenzie (1964). A few thousand to a few hundred thousand pounds are landed in Nova Scotia, Prince Edward Island, Newfoundland, and Quebec each year. A summary of the catches, in thousands of pounds, by provinces for the years 1964–68 inclusive is shown in the accompanying table.

	1964	1965	1966	1967	1968
Nfld.	29	20	35	51	17
P.E.I.	488	463	631	435	479
N.S.	298	277	338	279	318
N.B.	2584	2978	2630	2148	1920
Que.	742	641	764	761	1036
Ont.	12,886	11,918	16,056	12,661	12,490

A surprisingly successful smelt fishery developed in the late 1950's and early 1960's in the Canadian waters of the Great Lakes, particularly in Lake Erie. The fishery in the Ontario waters of Lake Erie has expanded into a multimillion-pound catch in less than 20 years, from 65,750 pounds in 1950 to 15,913,984 pounds in 1966. These large catches are taken mainly by otter trawls.

The smelt is also a very popular sport fish in many parts of the country. In Newfoundland, Quebec, and parts of the Maritime Provinces, smelt are caught either by winter angling through the ice, or by dipnetting or seining during the spring spawning run, or both. In the Great Lakes region of Ontario, smelting expeditions on spring evenings for spawning smelt have become increasingly popular. Ontario smelt fishermen are permitted to use a 6-foot square dipnet or a seine up to 30 feet long. In 1960, Roseborough (1962) estimated that 68,000 smelt fishermen caught 5.3 million pounds of smelt in Lake Erie alone. To the present, unknown thousands of smelt fishermen try their luck in April and May all through the Great Lakes region. They also fish the many inland lakes where it has been recently introduced, but particularly the Muskoka and Parry Sound regions of Ontario. Smelt is the only fish, other than bait fishes, that can legally be taken from Ontario waters at night by means other than angling.

The smelt was not always considered to be an asset in the Great Lakes. In the 1930's it was heartily condemned as a nuisance by gillnet fishermen because it was caught in their nets in such large numbers and created a serious removal problem. Some gillnets were boiled in large vats to assist in freeing them of smelt. It is ironic that from a position of such low esteem the smelt should rise to first place, by weight, among all Great Lakes fishes in Canadian commercial landings in 1966.

Smelt has been renowned as a food fish for decades and is in high demand. The larger but scarcer Atlantic smelt commands the higher price and is often sold whole or in the round. Great Lakes smelt, which are caught in large numbers by midwater trawls, are usually mechanically processed (headed and gutted) and sold fresh, frozen, and precooked.

Smelts have a most characteristic odour, a smell that is usually likened to the odour of freshly cut cucumbers. The odour, which is particularly strong when large numbers are caught during the spawning runs, is undoubtedly the feature responsible for the common name.

Nomenclature

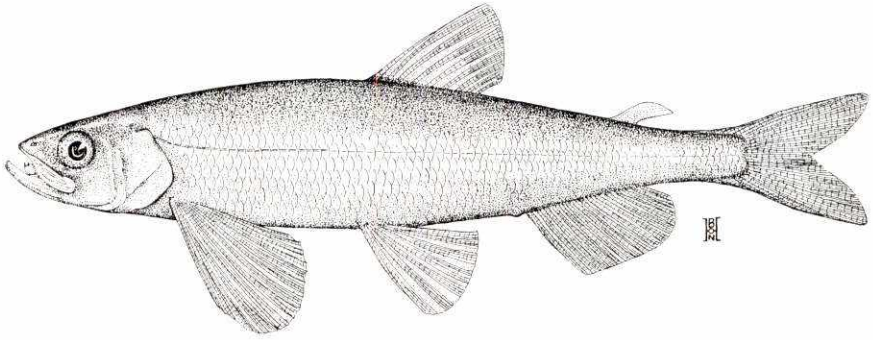
Salmo Eperlanus	— Linnaeus 1758: 310 (type locality Europe)
Atherina mordax	— Mitchill 1814: 15
Osmerus viridescens	— LeSueur 1818a: 230
Salmo (*Osmerus*) *eperlanus* (Artedi)	— Richardson 1836: 185
Osmerus eperlanus	— Fortin 1863: 120
Osmerus mordax Gill ex Mitch.	— Gill 1865: 259
Osmerus sergeanti	— Norris 1868: 93
Osmerus dentex	— Steindachner 1870: 429
Osmerus spectrum	— Cope 1870: 490
Osmerus mordax Mitchill	— Cox 1896b: 66
Osmerus mordax (Mitchill)	— Jordan and Evermann 1896–1900: 523
Osmerus eperlanus dentex	— Wynne-Edwards 1952: 17

Etymology *Osmerus* — *osmé* — smell or scent; *mordax* — biting.

Common names Rainbow smelt, smelt, American smelt, leefish, freshwater smelt, frost fish. French common names: *éperlan arc-en-ciel, éperlan du nord.*

LONGFIN SMELT

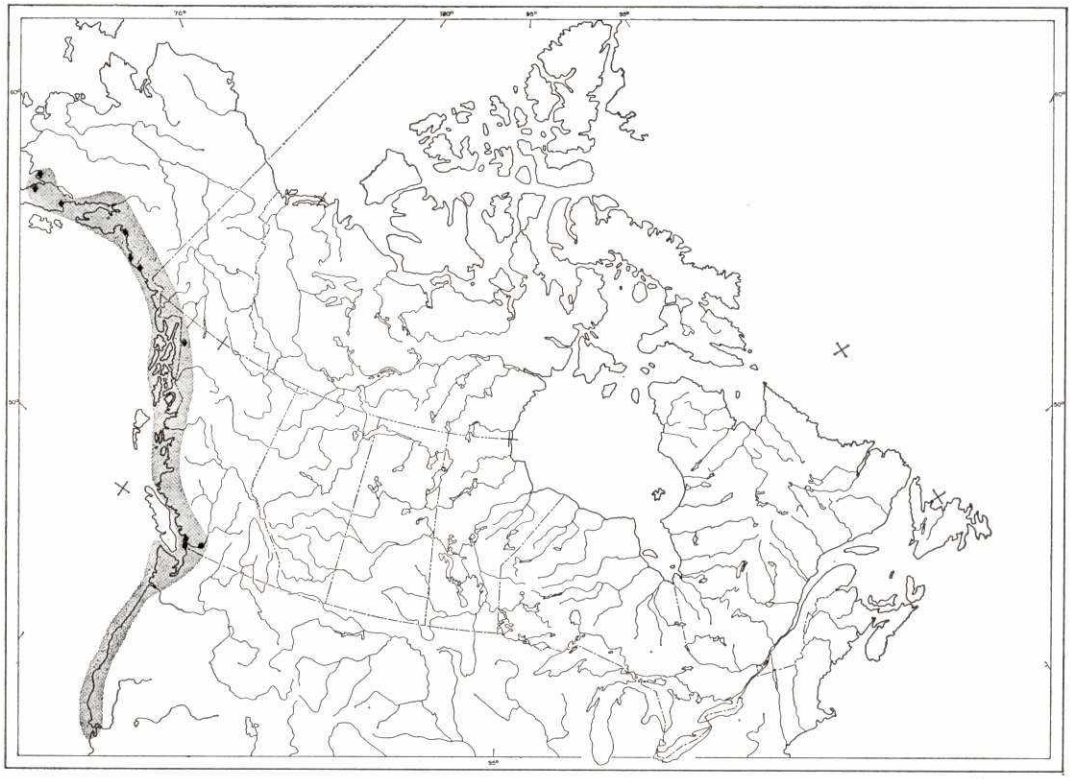
Spirinchus thaleichthys (Ayres)



Description Body elongate, laterally compressed, cross section a long narrow oval, depth 15.1–19.6% of standard length; a small fish rarely over 6 inches (150 mm) in length. Head short 21.7–27.0% of standard length, eyes moderately large about equal to snout, 22.2–27.7% of head; mouth large, oblique, maxillary extending short of or to posterior edge of orbit in adults, shorter in young; angle of premaxillaries to forehead 68–90°; snout obtuse, 0–3 horizontal striae on operculum; small teeth on both jaws, tongue, vomer, palatine, mesopterygoid, pharyngeal plates, and basibranchial bones. Gill rakers long and slender, 38–47 (10–13 + 27–34). Branchiostegal rays 7 or 8. Fins: single, soft-rayed dorsal at midpoint of body, moderately high, with 8–10 principal rays, tip squarish; adipose rounded, base 1.7 times diameter of orbit; caudal forked, with 19 principal rays; anal with long base, 15–19 principal rays, longest ray 45.4–71.4% of head length; pelvics under dorsal, insertion sometimes anterior to origin of dorsal, long, with 8 rays; pectorals long, about equal to head length, reaching to just short of, or past the pelvic insertion, with 10–12 rays, the common name is based on the long paired fins; first ray of paired fins and rays of dorsal and anal fins enlarged and stiffened in males, upper surface of paired fins tuberculate in ripe males. Scales cycloid, moderately large, 54–63 in lateral series, tuberculate in ripe males; lateral line incomplete, with 14–21 pored scales extending about a head length along body; lateral line region is dilated by a swelling on the underlying muscles in males; pyloric caeca 4–6; gut physostomous, duct attached to anterior end of swim bladder. Vertebrae 55–61. (McPhail and Lindsey 1970; McAllister 1963).

Colour Adults dusky or olive-brown above, silvery below, fins usually stippled along the rays, but interray membranes clear, young (to 2.8 inches or 70 mm) translucent with 2 rows of large black spots, one on each side of the midline of the back, from head to caudal peduncle; peritoneum silver with light speckling. The backs of males at spawning time are moss-green in colour. There is dense black speckling on head and dorsal surface of body, particularly marked in spawning males. The peritoneum is silvery with black speckling.

Systematic notes In 1934 Schultz and Chapman described a new smelt, *S. dilatus*, examining specimens from the Puget Sound, Wash. area, and one from Harrison Lake, B.C., (ROM 6359). They distinguished this new species from Ayres' (1860) more southerly *S. thaleichthys* on the basis of scales, anal rays, and pectoral length. The longfin smelt retained this name until McAllister, as quoted by Dryfoos in 1961 and in the revision of the genus in 1963, showed there was only clinal



variation and synonymized the two forms under the older name.

Distribution Restricted to the west coast of North America from San Francisco, Calif., to Gulf of Alaska (McAllister 1963) or Bristol Bay, Alaska (McPhail and Lindsey 1970). Occurring in fresh water in rivers close to the sea except for apparently nonmigratory populations in Harrison Lake and lower Fraser River valley in British Columbia and Lake Washington near Seattle, Wash.

In Canada it is known in fresh water only from Harrison Lake, the Fraser River below New Westminster, B.C., and the Taku River.

A Harrison Lake specimen, taken in 1921, constitutes the first record of this species in Canada (ROM 6359).

Biology The longfin smelt is an anadromous species. It is so limited in range in Canada that very little is known of its biology here. Spawning in anadromous populations in British Columbia takes place from October to December in freshwater streams close to the ocean (Clemens and Wilby 1961). A landlocked population in Lake Washington spawns from December to mid-February. Females 4.7 inches (120 mm) long lay about 18,000 eggs which are about 1 mm in diameter. Eggs hatch experimentally in 40 days at 44.5° F (6.9° C). The newly hatched larvae are between 7 and 8 mm in length. Young have been observed moving down the spawning streams in April.

In the southern part of their range longfin smelt mature and spawn in their second year regardless of size at that time. Only a few survive this spawning and most of these are females 3 years old.

Hart and McHugh (1944) reported individuals from Burrard Inlet 3.66–5.28 inches (93–134 mm) in standard length. Average

length of males (4.17 inches or 106 mm) was only slightly less than that of females (4.33 inches or 110 mm). Scales showed these fish were in their second year of life.

The food of the young in fresh water was said by Hart and McHugh (1944) to consist solely of *Neomysis mercedis*, a shrimp. Other small crustaceans, particularly euphausiids, copepods, and occasional Cumacea, constitute the food of larger individuals in brackish or salt water.

Relation to man Although apparently abundant and readily obtainable on the annual spawning migration up coastal rivers, this species is not utilized commercially or otherwise. The flesh is edible but is soft, oily, and spoils easily.

Nomenclature

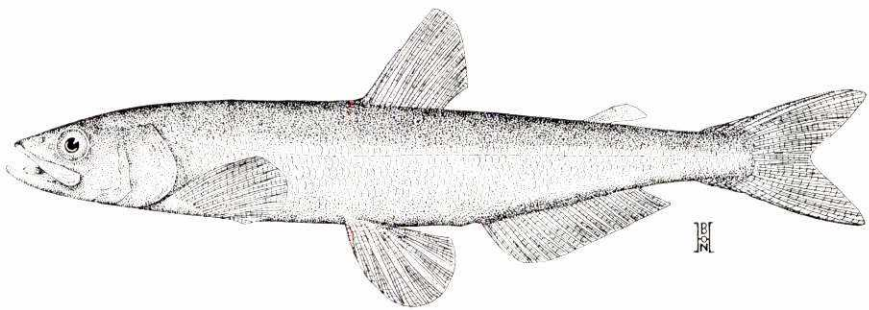
Osmerus thaleichthys	— Ayres 1860: 62 (type locality San Francisco)
Spirinchus dilatus	— Schultz and Chapman 1934: 67
Spirinchus thaleichthys	— Dryfoos 1961: 476

Etymology *Spirinchus* — probably from a Dutch word *spiering* for smelt; *thaleichthys* — rich fish, referring to a high oil content.

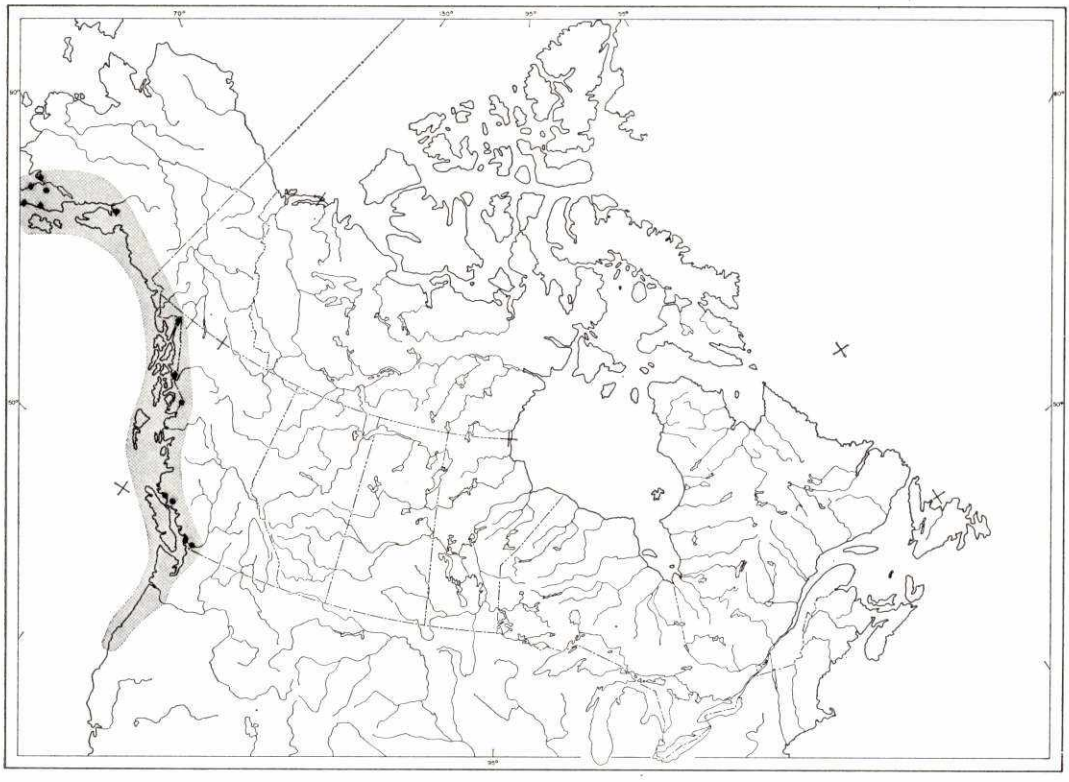
Common names Longfin smelt, long-finned smelt, Sacramento smelt, Pacific smelt. French common name: *éperlan d'hiver*.

EULACHON

Thaleichthys pacificus (Richardson)



Description Body elongate, laterally compressed, cross section an oval; greatest depth, at dorsal fin, 14.7–20.0% of standard length; usually no longer than 8 inches (203 mm); in spawning males there is a distinct raised ridge along the midlateral area of the body. Head short, 20.0–26.3% of standard length, bears tubercles in ripe males; eye small, about 50% of snout length; snout pointed, jaws equal; mouth large, oblique, maxillary extending to or past posterior margin of orbit in adults; small pointed teeth on



both jaws, tongue, palatine, mesopterygoid, pharyngeal plates, and basibranchial bones, 2 canines on the vomer, teeth tend to be lost in spawners. Gill rakers long, about 66% of orbit, and slender, 17–23 (4–6 + 13–18) in number. Branchiostegal rays 6–8; strong concentric striae on operculum and subopercular. Fins: a single, soft-rayed dorsal at midpoint of back, moderately high, tip lunate, with 10–13 principal rays; adipose rounded, base shorter than diameter of orbit; caudal forked, 19 principal rays; anal with long base, almost equal to head length, with 18–23 rays, edge somewhat lunate; pelvics moderately long, 17.6% of standard length in males, 14.3% in females, often reaching anus in males, much shorter in females, origin anterior to dorsal origin, 8 rays; pectorals only moderately long, 15.8% of standard length in males, 14.3% in females extending 52–74% of the distance to the pelvic insertion, 10–12 rays, tip rounded; all fins with well-developed tubercles in ripe males. Scales cycloid, small, tuberculate in ripe males, 70–86 in lateral series; lateral line complete; 8–12 long pyloric caeca. Vertebrae 65–72. (McPhail and Lindsey 1970; McAllister 1963; Hart and McHugh 1944).

Colour Adults are brown to blue-black on the back and top of the head, the sides are lighter to silvery white, and the ventral surface white; speckling is fine, sparse and restricted to the back. The fins are usually immaculate but the caudal and pectoral fins can be dusky. The peritoneum is light with black speckles.

Distribution The eulachon occurs only on the west coast of North America, from the Klamath River in California to the eastern Bering Sea in Bristol Bay, Alaska, and the Pribilof Islands.

In Canada it is common along the whole coast of British Columbia, particularly in the larger inlets. The eulachon was first recorded

from Canada in 1866 by Günther on the basis of specimens collected near Vancouver Island by C. B. Wood, surgeon of HMS *Plumper* and forwarded to the British Museum (Clemens and Wilby 1961).

Biology The eulachon is an anadromous smelt that moves short distances up coastal freshwater streams, often just as the ice is breaking up, in order to spawn. Mixing between the populations using different spawning rivers is not extensive as there are significant differences in meristic characters between various river populations (*see* Hart and McHugh 1944). The spawning migration lasts from mid-March to mid-May, duration of run decreasing south to north. Males predominate early in the run and appear to be more numerous at all times than the females, which arrive later. In the Fraser River the main spawning areas seem to be in 8 miles of river between Chilliwack and Mission, B.C., in 25 feet of water, in areas of coarse sand. They travel a maximum of 15–20 miles up the Nass River. Water temperature at spawning time is 40°–46° F (4.4°–7.8° C). No nest is built, the eggs are scattered and abandoned. Females between 5.7 and 7.3 inches (145–185 mm) in standard length produce 17,000–40,000 eggs, with 25,000 the average number (apparently as high as 60,000 in Columbia River). The eggs are irregular in shape, and preserved eggs vary in size from 8 to 10 mm in diameter. There are numerous oil globules in the yolk (Hart and McHugh 1944). Most adults die after spawning but a few survive, return to the sea, and may return to spawn a second time (Barraclough 1964). The eggs are adhesive and stick to the coarse sand particles. The egg, as it leaves the female, has a double outer membrane. The outer layer breaks, turns inside out but remains attached to the inner membrane at one spot. This forms a short stalk and the free edges of the adhesive outer membrane stick to the sand. Eggs take 2–3 weeks to hatch and the newly hatched young are about 4–5 mm long; they are slender, transparent, and closely resemble young herring. The yolk sac is attached farther back and the vent is more anterior than in herring. The larvae, which are feeble swimmers, are carried downstream and out to sea shortly after hatching. Some seen in salt water in April were 23 mm long. By December they have grown to 1.8–2.0 inches (46–51 mm) in length. The young, carried by currents, become widely distributed in areas like the Strait of Georgia. As they grow, they move into deeper water and are most often caught by trawls fishing in the food-rich echo-scattering layer. Age–length relation in the sea, based on length frequency data given by Barraclough (1964), is as follows:

Age	FL	
	(inches)	*(mm)*
0+	0.7–2.8	18–71
1+	2.8–3.7	71–95
2+	2.8–4.4	72–111
3+	4.1–5.7	104–144
4+	5.1–6.1	129–155
5+	6.5	165

Developing sexual maturity is first noticed in eulachon 2 years old in late summer to winter. They do not spawn for the first time until they are 3 years of age. Barraclough's (1964) figures would put them between 4.1 and 5.7 inches (104–144 mm) fork length at this time. Hart and McHugh (1944) listed standard length of spawning males as 5.5–7.4 inches (140–189 mm) and of spawning females as 5.5–7.7 inches (140–195 mm), but these figures could include older fish spawning for a second time. Apparently some live as long as 5 years but most die after the first spawning in their third year.

Clemens and Wilby (1961) gave length as up to 12 inches (305 mm) but 8 inches (203 mm) would appear to be the average maximum length. It is the largest of the west coast smelts.

Most of the life of the eulachon is spent in the moderate depths of the ocean not far from shore, apparently in the echo-scattering layer. They apparently remain in the depths on their spawning migration until very close to the mouths of the rivers. Those adults that survive the spring spawning migration spend little time in fresh water. The newly hatched young remain in fresh water only as long as it takes them to be passively carried downstream from the spawning grounds to the sea.

Little was known of them in the sea until publication in 1964 of Barraclough's data, obtained from trawls hauled in the echo-scattering layer.

Juvenile and adult eulachon in the sea have been shown to feed primarily on euphausiids, crustaceans, and cumaceans. Feeding ceases when they enter fresh water. The young probably do not feed on their downstream passage to the sea, but live off the yolk.

Eulachons are competitors of other plankton feeding fishes dwelling in the food-rich echo-scattering layer of the sea. As plankton feeders they are not predators on other fishes. They constitute an important food item of a wide assembly of intermediate and terminal predators, especially when they concentrate in vast numbers during the spring migration. They have been reported as making up the principal food at that time of spiny dogfish, *Squalas acanthias*; white sturgeon, *Acipenser transmontanus*; the various Pacific salmons, *Oncorhynchus*; Pacific halibut, *Hippoglossus stenolepis*; Pacific cod, *Gadus macrocephalus*; such marine mammals as harbour seals, sea lions, porpoises, killer whales, finback whales, and a wide variety of sea birds, such as ducks and gulls. Swan (1881) quoted an 1863 account that said the cloud of gulls hovering over the migrating eulachon resembled a heavy fall of snow.

Relation to man Today the eulachon is taken commercially by drift gillnets, principally in the Fraser River. It is utilized as human food and as food for commercially reared fur-bearing mammals. The flesh is oily, rich, and has the usual smelt odour said to resemble the scent of cucumbers or the wild syringa shrub, *Philadephus*. The flavour is good and the eulachon ranks highly among North American food fishes. Eulachon, like other smelts, are usually cleaned and fried whole, sometimes after having been rolled in crumbs. This species was first taken commercially in 1877 in the Nass River for its oil for export, but most of it was sold to local Indians instead. Some was shipped to England in later years, but no export market ever developed. The oil, which has the consistency of soft butter below 70° F (21.1° C), was for some time looked upon as a substitute for cod liver oil as a tonic.

Preparation of salted and smoked eulachons developed later, chiefly on the Nass River. It reached its peak about 1903, short of 2 million pounds, with 4070 barrels salted, 45,200 pounds smoked, and over one million pounds sold as fresh fish at a total value of $96,436 (Hart and McHugh 1944). In 1912 the eulachon was fifth in market value at $78,950 but since that time has declined steadily to minor importance. Most of the catch today goes to fur farms.

Use by white men has always been secondary to that by the native peoples. The eulachon arrived in vast numbers in the early spring when other foods were not yet available and stored foods had been largely used up. The native eulachon fishery was tremendous, extensively governed by ritual, traditional ownership of good sites, rivalry, and an extensive trade network to the interior of British Columbia. The name of the Nass River is supposed to be a Tlingit word meaning food depot. The oil or "grease" (*kleena*) from the eulachon was held in high regard as a food item for cooking and as a curative. The fish were left in piles for several days, then heated in water, and the oil skimmed off the surface. The pulp was later pressed to get the remaining oil. In times of low availability eulachon oil sold for $1.25/gallon. At other times the price was 50¢/gallon. Trails used by Indians to get to the coastal fishing grounds, and over which the oil was carried for trade, were known as "grease trails." Around 1881, 5000 members of the Tsimshian tribe alone moved annually to fishing locations on the coast. Between 1935 and 1940 crude statistics were kept of the Indian fishery, which exceeded the commercial catch in those years by as much as 7000 cwt. Lord (1866) and Swan (1881) both described in interesting detail the pole, basket, and net fishery, some of the ritual associated with pacifying the eulachon so it would come again, and the drying, smoking, and preparation of oil by the Indians. The native fishery still exists and the number taken probably exceeds the commercial catch.

The second common name of this fish, candlefish, was derived from its unique use. The oil content is so high that, after drying, the whole fish can simply be ignited by setting flame to the tail to produce light. Prior to the availability of wax candles and inexpensive oil lamps in the coastal region, light was obtained by forcing a rush or cloth wick down into an eulachon through the mouth. This wick was then lit like that of a candle.

Nomenclature

Salmo (*Mallotus*) *pacificus*	— Richardson 1836: 226 (type locality Columbia River)
Thaleichthys stevensi	— Girard 1859: 325
Osmerus pacificus	— Swan 1881: 258
Osmerus albatrossis	— Jordan and Gilbert (1898) *in* Jordan and Evermann 1896–1900: 2823
Thaleichthys pacificus (Richardson)	— Jordan and Evermann 1896–1900: 2823
Lestidium (*Bathysudis*) *parri*	— Chapman 1939: 522

Etymology *Thaleichthys* — oily fish; *pacificus* — of the Pacific.

Common names Eulachon. There are at least a dozen different attempts at the phonetics of the Chinook spoken name for this species. These range from hooligan to uthlecan to yshuh through the obvious variables of oolichan and ulichan. Candlefish, oilfish, small fish, salvation fish, and fathom fish are others. French common name: *eulakane*.

Suggested Reading – Osmeridae

BAILEY, M. M. 1964. Age, growth, maturity, and sex composition of the American smelt, *Osmerus mordax* (Mitchill), of western Lake Superior. Trans. Amer. Fish. Soc. 93: 382–395.

BIGELOW, H. B., and W. C. SCHROEDER. 1963. Family Osmeridae, p. 553–597. *In* Fishes of the western North Atlantic (Acipenseroidei, Lepisostei, Isospondyli). Mem. Sears Mar. Res. 1(3): 630 p.

DYMOND, J. R. 1944. Spread of the smelt (*Osmerus mordax*) in the Canadian waters of the Great Lakes. Can. Field-Natur. 58: 12–14.

FERGUSON, R. G. 1965. Bathymetric distribution of American smelt *Osmerus mordax* in Lake Erie. Great Lakes Res. Div. Univ. Mich. Publ. 13: 47–60.

FISK, M. 1913. A review of the fishes of the genus *Osmerus* of the California coast. Proc. U.S. Nat. Mus. 46(2027): 29–297.

GREENE, C. W. 1930. The smelts of Lake Champlain, p. 105–129. *In* A biological survey of the Champlain watershed. Suppl. 19th Ann. Rep. N.Y. Conserv. Dep. 1929, Pt. IV.

HAMADA, K. 1961. Taxonomic and ecological studies of the genus *Hypomesus* of Japan. Mem. Fac. Fish. Hokkaido Univ. 9(1): 1–55 + 9 pl.

HART, J. L., and J. L. MCHUGH. 1944. The smelts (Osmeridae) of British Columbia. Fish. Res. Board Can. Bull. 64: 27 p.

HOOVER, E. E. 1936. The spawning activities of fresh water smelt, with special reference to the sex ratio. Copeia 1936: 85–91.

HUBBS, C. L. 1925. A revision of the osmerid fishes of the North Pacific. Proc. Biol. Soc. Wash. 38: 49–56.

KENDALL, W. C. 1927. The smelts. Bull. U.S. Bur. Fish. 42: 217–375.

MACKAY, H. H. 1963. Fishes of Ontario. Ont. Dep. Lands Forests, Toronto, Ont. 300 p.

MARCOTTE, A., et J.-L. TREMBLAY. 1948. Notes sur la biologie de l'eperlan (*Osmerus mordax*, Mitchill) de la province de Quebec. Contrib. Sta. Biol. Saint-Laurent, P.Q. 18: 107 p.

MCALLISTER, D. E. 1963. A revision of the smelt family, Osmeridae. Bull. Nat. Mus. Can. 191: 53 p.

MCKENZIE, R. A. 1964. Smelt life history and fishery in the Miramichi River, New Brunswick. Fish. Res. Board Can. Bull. 144: 77 p.

RUPP, R. S. 1965. Shore-spawning and survival of eggs of the American smelt. Trans. Amer. Fish. Soc. 94: 160–168.

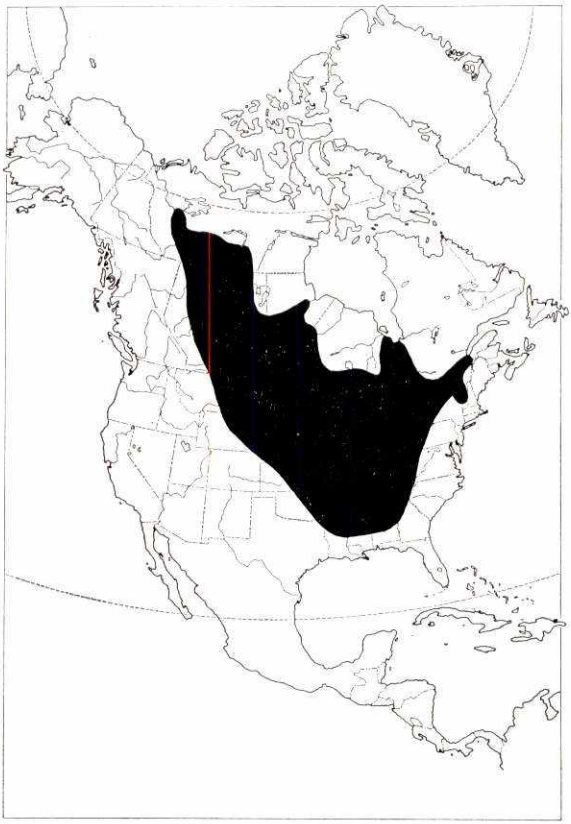
VAN OOSTEN, J. 1937. The dispersal of smelt, *Osmerus mordax* (Mitchill), in the Great Lakes region. Trans. Amer. Fish. Soc. 66: 160–161.

1947. Mortality of smelt, *Osmerus mordax* (Mitchill), in lakes Huron and Michigan during the fall and winter of 1942–1943. Trans. Amer. Fish. Soc. 74: 310–337.

Mooneye Family — Hiodontidae

Moderate-sized, deep-bodied, laterally compressed, silvery to golden fishes, resembling herrings. The head is naked; the snout rounded; the eyes large and far forward. The lower jaws, maxillary, premaxillary, palatines, parasphenoid, and tongue are all armed with strong teeth. The dorsal fin is situated over the anal fin, distinctly behind the pelvic fins; the anal always has a longer base; the caudal is forked; there is no adipose fin. The body is covered with large, silvery, cycloid scales. The lateral line is present but indistinct. The pectoral girdle has a prominent, expanded coracoid. The swim bladder is connected to the skull.

The family consists of a single genus, *Hiodon*, with two living species restricted to the fresh waters of northern North America. Mooneyes are usually placed with the notopterids in the suborder Notopteroidei and ranked among the early clupeiform fishes.



World Distribution of the Mooneyes

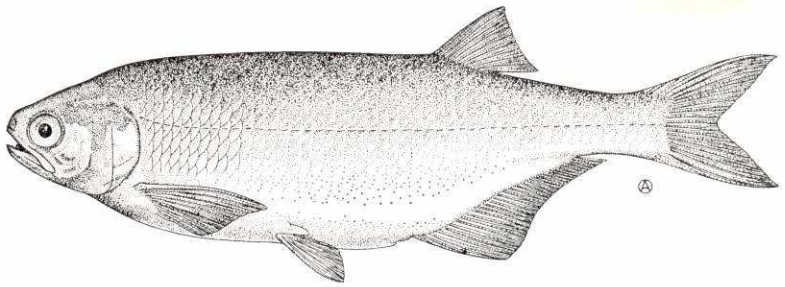
Key to Species

1 Ventral surface keeled from isthmus to anal fin; origin of dorsal fin opposite or behind origin of anal fin; maxillary extends beyond middle of pupil ..... GOLDEYE, *Hiodon alosoides* (p. 327)

Ventral surface keeled from pelvic fins to anal fin; origin of dorsal fin well ahead of origin of anal fin, maxillary short of, or just to, middle of pupil ..... MOONEYE, *Hiodon tergisus* (p. 333)

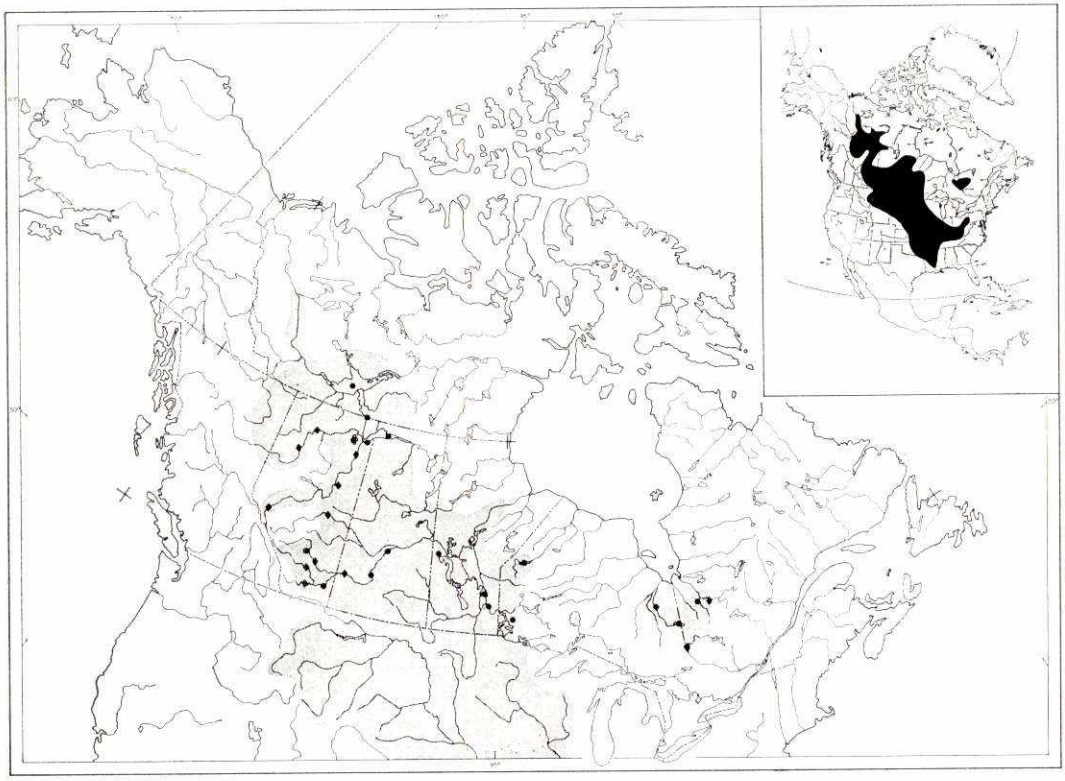
GOLDEYE

Hiodon alosoides (Rafinesque)



Description Body very deep, greatest depth at origin of anal fin 30.2–36.0% of standard length, strongly compressed, greatest width 8.4–12.0% of standard length; ventral edge forming keel (but not serrate) from behind pectoral fins to anus; caudal peduncle moderately short and deep, length (to end of vertebrae) 8.5–12.0% of standard length, least depth 8.7–10.6% of standard length; usually 12–15 inches (305–381 mm) long. Head naked, short, 20.0–23.4% of standard length, narrow, interorbital width 5.4–6.5% of standard length, moderately deep, 15.8–18.7% of standard length; eye far forward, high, and large, 5.2–7.1% of standard length, iris large and a bright golden colour, hence name, supposedly reflect light like those of a cat; snout very short, 3.8–4.5% of standard length, very bluntly rounded, noticeably upturned; mouth large, somewhat oblique, maxillary long, reaching past middle of orbit, 9.6–12.4% of standard length, lower jaw equal to or slightly in advance of snout; teeth rather small, sharp, stronger in males, a large series of canines on each side of parasphenoids, 1 or 2 smaller series between, 2 posteriorly, vomer toothless, palatines with series of canines, pterygoids with bands of villiform teeth, premaxillary with single row of small teeth, maxillaries with minute series at front, dentaries with 3 parallel series of small teeth. Gill rakers 15–17 (6 + 9–7 + 10), short and thick. Branchiostegal rays 8–10. Fins: a single, short, rather low, soft-rayed dorsal beyond midpoint of body, well behind origin of anal, base 8.0–10.1% of standard length, height 11.0–15.1% of standard length, 9 or 10 principal rays, border slightly concave; caudal deeply forked, tips pointed, moderately broad; anal long and falciform, base covered by 1–3 rows of small scales, its border in mature males notched with greatly expanded, rounded anterior lobe, concave in females, length of base 24.6–30.0% of standard length, greatest height in males 15.3–17.5% and in females 13.4–16.1% of standard length, 29–34 principal rays, posterior rays very short; pelvics short, squarish, length 12.8–15.0% of standard length, 7 rays; long, narrow pelvic axillary process, its length almost 50% of length of fin; pectorals broad, long, pointed, length 19.2–22.4% of standard length, 11 or 12 rays. Scales cycloid, large, 57–62 in lateral series; lateral line complete, almost straight. A single pyloric caecum. Vertebrae 56–61 (largely from Kerswill 1937).

Colour In life, goldeyes have a typical herring colour, dark blue to blue-green on the back and upper sides, sides and ventral surface silver, shading to white. The scales are said to have a golden lustre forward and blue to pink near the tail. The eyes are prominent, and the large pupils are bright



yellow. The scales of preserved specimens are golden in colour and the back is brown. The popular commercially brined and smoked goldeye, familiar to many people, is bright red through orange to golden (*see* frontispiece in Kennedy and Sprules 1967). This colour, once achieved by preparing them with the smoke of willow wood only, is now largely produced by harmless aniline dyes.

Systematic notes Measurements of head length, head depth, eye snout, interorbital width, and maxillary differ in populations from lakes Winnipeg, Abitibi, Athabasca, and Lesser Slave Lake. Kerswill (1937) attributed this to phenotypic variability only. There are significant sexually dimorphic characters as well. A small sample from the isolated eastern population showed no major meristic differences from goldeye in Manitoba.

Distribution The goldeye occurs only in North America. In the northeast there is an isolated pocket of distribution in Quebec and Ontario immediately south of James Bay. The main area of distribution stretches northwest from western Ontario to the Mackenzie River as far down as Fort Norman[1]. In the east it extends southwest below the Great Lakes, through the Ohio and Mississippi River drainages, through Ohio, Pennsylvania, Indiana, Kentucky, Alabama, and Mississippi. In the west it occurs southeast from western Alberta, through eastern Montana and Wyoming, to Oklahoma.

In Canada the isolated area, thought to result from an early connection above the Great Lakes of glacial lakes Agassiz and Barlow–Ojibway, consists of the waters between Lake Waswanipi, Que., Lake Temiskaming (Ottawa River), and Lake Abitibi, including the Nottaway River, flowing into James Bay. The main area starts in Ontario at Rainy Lake, runs north to Sandy Lake, then through the major lakes of Manitoba, down the Nelson

River as far as Limestone Rapids, in the Churchill River in western Manitoba, north in Saskatchewan to the North Saskatchewan River, west in Alberta in the Bow and Red Deer rivers as far as Jasper, north in the North Saskatchewan, Lesser Slave, Athabasca, and Peace drainages, Lake Athabasca, and Great Slave Lake, down the Mackenzie to Fort Norman[1] at the confluence of the Great Bear River and down the Liard River to northeastern British Columbia (Kennedy and Sprules 1967).

Biology In contrast to so many Canadian fishes, it is encouraging to note that the biology of this species in Canada is well documented. Much of the following is derived from the studies or summaries published by Battle and Sprules (1960), Kennedy and Sprules (1967), and McPhail and Lindsey (1970).

Spawning occurs in the spring from May to the first week in July, starting just after the ice breaks up and continuing over a period of 3–6 weeks. During this period temperature is 50°–55° F (10.0°–12.8° C). It takes place in pools in turbid rivers or in backwater lakes and ponds of these rivers. The spawning act has never been seen because of the turbidity of spawning sites, but it is assumed to take place at night. The small amount of sperm produced by the males suggests close approximation of single pairs during spawning. Females from 12 to 15 inches (305–381 mm) fork length contain 5761–25,238 eggs, which are approximately 4 mm in diameter after fertilization. Eggs contain a single, large oil globule, are steel-blue in colour when near maturity, translucent when shed and, unique among North American freshwater fishes, are semibuoyant. They hatch in about 2 weeks. Newly hatched larvae are just over 7 mm long and at first float vertically at the water surface. Growth is slow until July, but by September young goldeye in the Saskatchewan River are approximately 4 inches (102 mm) in length and 11 grams in weight. Growth is slower after September, slower in subsequent years, growth rate decreases from south to north, and, in older individuals, is greater in females than in males in some habitats. Maximum length in July of the first year is as low as 1.1 inches (28 mm) in Lake Abitibi and as high as 2.7 inches (69 mm) in Baptizing Creek, Man. Ages are readily determined from scales, and, based on data from Kennedy and Sprules (1967), the table on p. 330 shows the average age, fork length, and weight relation for males and females from different areas.

Age at sexual maturity varies with sex and increases from south to north. In Lake Claire, Alta., it is 6–9 years for males and 7–10 years for females, and the differential for Manitoba is 2–3 years less. Some males mature at age 1 in South Dakota. It is now assumed female and male goldeye spawn annually after maturity is reached. At the same age goldeye in the Bow River, southern Alberta, weigh almost twice as much as those in Lake Claire, northern Alberta. The largest goldeye recorded by Kennedy and Sprules (1967) was a female from Lake Claire, Alta., that was 17.2 inches (437 mm) in fork length, 2 pounds, 2 ounces in weight and 14 years of age. Trautman (1957) cited a maximum size of 20 inches (508 mm) and a weight of 3 pounds, 2 ounces in Ohio.

Goldeye habitat is most frequently quiet, turbid water of large rivers, the small lakes, ponds, and marshes connected to them, and the muddy shallows of larger lakes. They overwinter in deeper areas of lakes and rivers and move toward the shallow, firm-bottomed spawning sites as the ice is breaking up in the spring. Movement into the Saskatchewan River near Edmonton does not occur until the water is 50°–54° F (10.0°–12.2° C). The underyearling and old fish may utilize separate habitats. In the North Saskatchewan River there is a yearly upstream migration in the spring; after spawning the adult fish continue upstream apparently to feed. There is downstream migration in the fall (Paterson 1966). They are probably inactive in winter as growth, in Canada, ceases during that period. Goldeye are apparently mainly nocturnal and the eyes, which have rods only, no cones, and reflect light, are

[1]Since this was written goldeye have been taken as far down river as Aklavik.

			Age (*years*)														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
L. Winnipegosis, Man.	F	FL	–	7.2	8.7	10.8	–	12.4	13.6	12.8	–	–	–	–	–	–	–
		Wt	–	3.0	4.3	9.3	–	14.5	15.7	16.5	–	–	–	–	–	–	–
	M	FL	–	6.2	8.6	10.4	11.7	11.9	12.0	12.4	–	–	–	–	–	–	–
		Wt	–	1.5	4.2	8.4	11.8	11.9	12.1	12.5	–	–	–	–	–	–	–
Saskatchewan Delta, Man.	F	FL	6.2	8.4	10.1	11.3	12.0	12.8	13.4	13.8	14.2	15.5	14.5	17.0	–	–	–
		Wt	1.4	3.4	7.0	10.1	13.1	15.8	17.3	18.7	20.0	33.0	20.0	34.0	–	–	–
	M	FL	6.5	8.3	9.9	11.1	11.7	12.3	12.9	13.4	13.9	14.5	–	–	–	–	–
		Wt	1.6	3.2	6.0	8.9	11.6	12.6	14.1	15.5	16.0	21.0	–	–	–	–	–
L. Claire, Alta.	F	FL	–	5.2	7.0	8.3	10.0	10.4	12.0	13.2	13.7	14.8	15.2	15.3	16.0	17.2	–
		Wt	–	0.9	2.0	3.5	4.8	7.5	11.8	15.0	18.0	20.9	24.0	25.8	27.4	34.0	–
	M	FL	–	5.4	7.0	8.2	9.2	10.3	12.1	13.1	13.8	14.3	14.5	14.5	14.2	–	–
		Wt	–	0.9	2.1	3.0	5.7	7.7	11.9	15.1	17.4	19.2	20.0	20.1	18.0	–	–
Sandy L., Ont.	F	FL	–	–	–	–	–	10.4	11.4	11.0	11.9	12.2	12.0	–	–	13.2	14.5
		Wt	–	–	–	–	–	7.6	9.9	9.0	12.0	11.8	11.6	–	–	18.0	25.0
	M	FL	–	–	–	–	9.5	10.2	11.2	11.2	11.5	11.7	11.8	11.9	12.2	12.0	–
		Wt	–	–	–	–	5.0	7.0	9.0	10.0	10.5	11.1	11.3	12.7	13.3	13.0	–

According to Kennedy and Sprules (1967), weight–length relation for the various areas is $Y = 3.20X–2.37$ where $Y = \log_{10}$ of weight (oz) and $X = \log_{10}$ of fork length (inches).

adapted to dim light conditions and to their turbid habitat.

The food of goldeye was extensively analyzed by Kennedy and Sprules and expressed qualitatively, quantitatively, by size, date, and area. The following generalization is derived from their data. The food is of a great variety, consisting of almost any organism encountered. Whatever is most available predominates and there is no indication of any strong food preference. During summer a large part of the food is taken at the surface. Food items range from surface insects (corixids dominate) to aquatic insects (mature and immature), other insects, other invertebrates including crustaceans and molluscs, limited numbers of small fishes, and other vertebrates (green frogs, shrew, and mice). Corixids, other aquatic insects and other insects make up the bulk of the food. Fishes eaten by goldeye were as follows: northern pike, trout-perch, spottail shiner, yellow perch, log perch, other darters, and ninespine and brook sticklebacks. Each of 9 fish examined at Sandy Lake, Ont., in September of 1953, contained a single mouse only. Food of young-of-the-year goldeye is mainly microcrustaceans (*Daphnia*, *Diaphanosoma*, *Acroperus*, *Bosmina*, *Moina*, *Diaptomus*, and *Cyclops*) with minor amounts of insects and other invertebrates.

Principal predators of goldeye in order of importance are northern pike, walleye, sauger, and inconnu. Cormorants, *Phalocrocorax auritus*, eat many goldeye, and it is assumed several other birds and mammals are minor predators.

Since goldeye feed so extensively at the surface in summer, they would appear to compete with few other fishes for food but probably do compete for space. Their apparent selection of, and adaptation to, turbid waters possibly limits their competition with other fishes, most of which are less so adapted.

Parasites listed by Kennedy and Sprules included Cestoda (3), Trematoda (3), Nematoda (1), and Crustacea (1). Hoffman (1967) listed only 2 trematodes and 2 cestodes. Self (1954) stated that goldeye in Lake Texoma harboured large numbers of cestodes but mentioned no serious effect of them.

Relation to man Commercial landings of goldeye in Canada were reported as early as 1876. Until the early 1900's these fish were taken haphazardly in gillnet catches of lake whitefish, walleye, and northern pike.

Goldeyes have never been very acceptable as fresh fish and their early use was as dog food for which they earned about 1¢/pound. Taste of fresh goldeye was said to be insipid, muddy, and like that of salted brown paper; the flesh is soft and an unattractive grey colour. As early as 1890 its improved eating quality when smoked was noted. After 1911 the market for the smoked product increased rapidly; fishermen began fishing for them directly, and by 1926–29 annual catches of one million pounds were achieved. From 1931 to 1965 the catch declined and the 5-year average never again exceeded 454,000 pounds (1936–40) and was as low as 180,000 pounds in 1965. Production was once predominantly from Lake Winnipeg (hence name) but catches declined so badly that 1938 was the last year substantial quantities were taken there. Most of the present Canadian production comes from the Saskatchewan River in Manitoba and Saskatchewan, to a lesser extent from an Indian fishery in Sandy Lake, Ont., from Alberta and from Quebec.

Its appearance on the menus of transcontinental trains did much to popularize smoked or Winnipeg goldeye, and it quickly became a gourmet item in price and was promoted as a Canadian delicacy. Since 1930, demand has regularly exceeded the supply. This is one of the few commercial fishes taken in Canada that is almost exclusively prepared and consumed in Canada. Goldeye were even imported to Canada from the United States for processing and sale here. The present yield is almost totally consumed in the region around Winnipeg where they are processed. The 1965 catch in Ontario of 6897 pounds had a marketed value to the fishermen of $1846.00 or about 27¢/pound. The whole, processed fish has sold for as much as $1.30/pound wholesale, and a retail price of approximately $2.00/pound. The retail price in Winnipeg in 1930 was 27¢/pound, and in 1970 $1.49/pound.

Originally the smoking, over willow fires, was carried out at the fishing ports. Willow smoke apparently imparted both the colour and flavour, but the colour faded with storage. With increased commercial production and decreased availability of willow, oak fires were used and the colour added by means of tasteless aniline dyes, which colour the skin but not the flesh. The fish are frozen fresh, then, as needed, thawed, brined, dyed, and smoked for 5–7 hours. After processing they are kept cool but not frozen and must be consumed within a few days. Kennedy and Sprules wrote that "A 'Winnipeg goldeye' represents the triumph of art over nature. Its characteristic color results from an aniline dye. Its characteristic taste is essentially that of oakwood smoke. Its texture has been improved by freezing. Its name is derived from a lake where it is no longer caught in appreciable quantities." Its popularity has led to attempts to substitute mooneye and even tulibee (cisco). There is an excellent colour photograph of a whole, processed Winnipeg goldeye in Kennedy and Sprules (1967).

Goldeye constitute a sport fish in the Mississippi valley and in the Saskatchewan River and its tributaries. It will take wet or dry flies and small spinners. The usual angling method in Canada is a hook baited with insects or a small fish, and held by a float about one foot below the surface. On light tackle they are said to provide good sport.

Nomenclature

Amphiodon alveoides	— Rafinesque 1819: 421 (type locality Falls of the Ohio)
Hiodon Clodalis	— Richardson 1823: 716
Hiodon chrysopsis	— Richardson 1836: 232
Hyodon alosoides	— Jordan and Gilbert 1883a: 259
Hyodon chrysopsis Richardson	— Jordan and Evermann 1896–1900: 413
Hiodon alosoides	— Nash 1908: 51
Elattonistius chrysopsis (Richardson)	— Jordan and Thompson 1910b: 353
Amphiodon alosoides Rafinesque	— Hubbs 1926: 9
Cyprinus (*Abramis?*) *smithii* Richardson	— Jordan, Evermann, and Clark 1930: 41

Rafinesque's *alveoides* is almost always cited as a misprint and given as "*alosoides* (misprinted *alveoides*)." There seems little reason for this decision of later authors. Under genus *Amphiodon* — Rafinesque said fin placement was similar to clupeids and cited the common name yellow herring. In describing *A. alveoides* he said the common name on the Ohio River was Shad but does not use the term shadlike in the description.

The generic name was so regularly changed by later authors on the pretext of "corrected orthography" that many authors, including Kennedy and Sprules (1967), cited Richardson's 1836 description as *Hyodon crysopsis*, misquoting the trivial name as well.

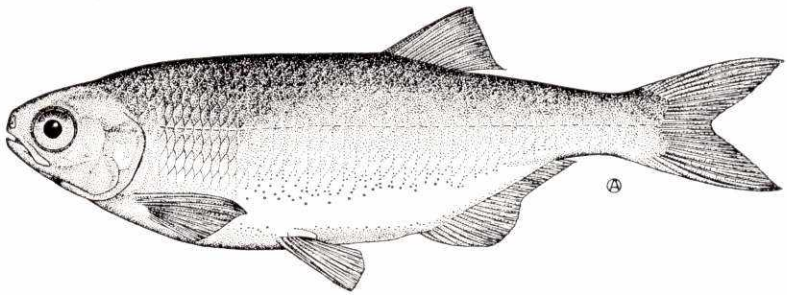
A species described by Richardson (1836: 110) as *Cyprinus* (*Abramis*?) *smithii* (Nob.) La Quesche, from the Richelieu River at the St. Lawrence River is a composite, probably of the mooneye *H. tergisus* and the golden shiner *Notemigonus crysoleucas* (3 branchiostegal rays, 60 lateral line scales, toothed tongue). This name was wrongly referred to *H. alosoides* by Jordan, Evermann, and Clark (1930). The goldeye has never occurred at that location but the mooneye and the golden shiner do. *Cyprinus smithii* was placed in the synonymy of *H. tergisus* by Jordan and Evermann in 1896–1900.

Etymology *Hiodon* — toothed hyoid; *alosoides* — shadlike, referring to its general shape and similarity to shad (*Alosa*, Clupeidae).

Common names Goldeye, Winnipeg goldeye, western goldeye, yellow herring, toothed herring, shad mooneye, la Queche, weepicheesis (Anglicized Indian name). French common name: *laquaiche aux yeux d'or*.

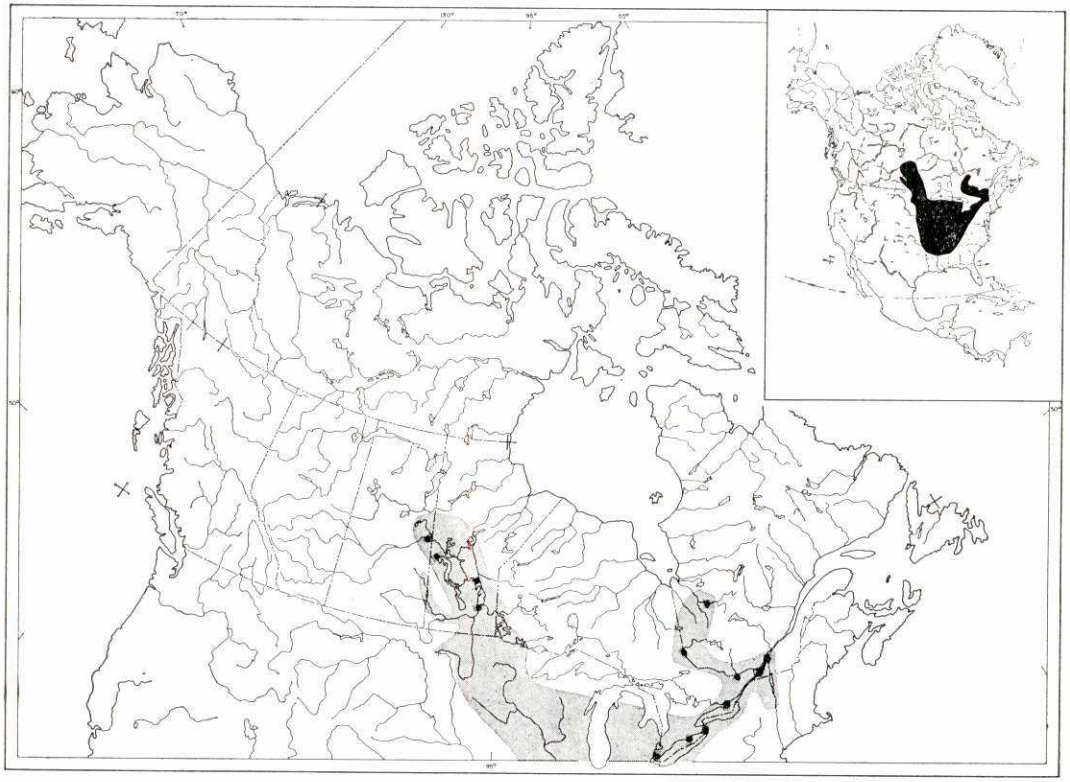
MOONEYE

Hiodon tergisus Lesueur



Description Body very deep, greatest depth at origin of dorsal fin 29.6–36.6% of standard length, laterally compressed but less so than goldeye, body width 11.3–14.5% of standard length; ventral edge keeled (but not serrate) only from pelvic fins to anus; caudal peduncle (to end of vertebrae) moderately long, 11.5–13.4% of standard length, depth less than length, 9.8–11.0% of standard length; fish usually 10–12 inches (254–305 mm) in length. Head naked, short, compressed, and conical, length 20.8–23.9% of standard length, depth 16.5–18.3% of standard length, interorbital width 5.5–6.3% of standard length, less concave over eyes than goldeye; eye far forward, high, and large, 6.6–7.2% of standard length, iris large, golden but not so bright as goldeye, reflects light; snout very short, 4.4–5.2% of standard length, less noticeably upturned and less blunt than in goldeye; mouth smaller, oblique but less oblique than goldeye, maxillary falls short of middle of orbit, 8.8–10.0% of standard length; teeth, smaller and more delicate than goldeye, consisting of a large series of canines on each side of parasphenoids, 1 or 2 small series between them, vomer toothless, palatines with series of canines, pterygoids with bands of villiform teeth, premaxillaries with single row of small teeth, maxillaries with minute series at front, dentaries with 3 parallel series of small teeth. Gill rakers short and thick, 15–17 (6–7 + 9–10). Branchiostegal rays 7–9, usually 8. Fins: a single, short, rather low, soft-rayed dorsal behind midpoint of body, origin in front of origin of anal fin, base 9.8–13.8% of standard length, height 13.0–14.7% of standard length, 10–14, but usually 12 principal rays; caudal moderately long, deeply forked, tips pointed; anal long, base 21.6–25.6% of standard length, falciform, base usually covered by 2 or 3 rows of small scales, origin at midpoint of dorsal fin, in mature males its lower border notched and anterior expanded in rounded lobe, greatest height in females and young 11.4–13.2% of standard length, greater at lobe in mature males, 26–29 principal rays, posterior rays very short; pelvics short, square, length 13.4–17.0% of standard length, usually 7 rays; pelvic axillary scale large, prominent, approximately 50% of pelvic length; pectorals narrower and shorter than goldeye, length 16.0–19.1% of standard length, 13–15 rays. Scales cycloid, large, thin, flexible, 52–57 in lateral series; lateral line complete, almost straight. A single pyloric caecum. Vertebrae 53–57. (Largely from Kerswill 1937.)

Colour Pale olive to brown above with faint steel-blue lustre, sides more silvery than goldeye, silver to whitish below, fins clear to dusky. Eyes golden but usually not so bright as in goldeye. Preserved specimens silvery, not so golden as preserved goldeye.



Distribution Restricted to North America. It extends from James Bay, Ottawa River to the Lake Champlain and St. Lawrence watershed, southwest of the Appalachian Mountains through western New York and Pennsylvania to Arkansas and Oklahoma, northward through the eastern half of the states from Kansas to North Dakota to southeastern Saskatchewan and southern Manitoba. True distribution in doubt because older records often untrustworthy as a result of misapplication of common name.

In Canada, the mooneye has a horseshoe-shaped distribution around the Upper Great Lakes. Starting with the Nottaway River in Quebec, the eastern arm includes the Ottawa, St. Lawrence, and Richelieu rivers, and Lake Champlain in Quebec, the lower Great Lakes excluding Georgian Bay, the North Channel, and Lake Superior. Rare in lakes Huron and Michigan. The western arm includes Lake of the Woods, the southern half of Manitoba and southeastern Saskatchewan as far north as the North Saskatchewan River, west to Cumberland House, Sask., and almost to the headwaters of the Assiniboine River.

Van Oosten (1961) gave records for lakes Huron and Michigan correcting records of Radforth (1944) which he surmised were based on the erroneous application, in the literature and catch statistics, of the name mooneye to several other Great Lakes fishes, especially gizzard shad. Records of its occurrence in the Moose River of Ontario were based on a single ROM specimen for which the locality data is now known to be in doubt.

There is evidence that both the range and density of this species in the United States is shrinking as a result of increased silting. It is apparently not highly adapted to turbid water as is the goldeye. It is much less abundant now in Lake Erie and the Ohio River than in the early 1900's.

Biology This species, unlike the goldeye, has never been of commercial importance and, as a result, very little is known of its biology in Canada. One of few sources of Canadian information may be a study of Lake St. Clair mooneye by Johnson (1951).

Spawning is in the spring (April–May), but possibly in early June in Lake Erie. In areas to the south, mooneye migrate in large numbers up large, clear streams. Females carry 10,000–20,000 eggs. By October young-of-the-year mooneye have reached 4.5–6.5 inches (114–165 mm) in length. (For details and drawings of early development of young *see* Fish 1932). Growth has been interpreted from the scales, and Van Oosten (1961) gave the following age–length and weight relations for Lake Erie mooneye:

Age	Mean calculated TL		Mean wt
	(*inches*)	(*mm*)	(*oz*)
1	8.4	213	2.9
2	9.6	244	4.3
3	11.6	295	8.1
4	12.2	310	10.3
5	12.6	320	11.2
6	–	–	–
7	13.1	333	12.8
8	14.9	378	14.8

Sexual maturity is reached by at least two-thirds of the males at 3 years of age, earlier than females, which often do not mature before 5 years of age. Males die earlier than females and, in later years, the sex ratio is biased toward females. Different ages dominate in different lakes and there are successful and unsuccessful year-classes.

Maximum age in Lake St. Clair, would appear to be 8 years. Trautman (1957) indicated that maximum known size was 17.5 inches (445 mm) long and 2 pounds 7 ounces in weight.

Trautman said (1957) that south of the Great Lakes, mooneye were abundant only in the clearest, largest waters of Ohio. Although often found in nonflowing waters, it feeds mostly in swift waters. It is less tolerant of silted habitats than the goldeye. Its abundance in Ohio rivers has decreased steadily since 1935 and is very low compared to the numbers known in 1850. This is probably a result of increased turbidity. It migrates up rivers in spring to spawn, lives in shallow water and is rarely taken in gear set below 35 feet (10.7 m).

Johnson (1951) said that mooneye in Lake St. Clair had been feeding on aquatic and terrestrial invertebrates, mainly insects. Trautman (1957) described their habitat as being where there is an abundant supply of small fishes on which they feed. Scott (1967) listed insects, molluscs, crayfish, small fishes, and plankton.

They would be competitors for food only of other surface insect feeders, but they compete with many other species for space and spawning sites. The young are probably forage for several predatory species with which they occur. They have not, however, been often reported as part of the food of such fishes.

Hoffman (1967) summarized the parasites, listing trematodes (7), cestodes (1), nematodes (3), and acanthocephalans (1).

Relation to man Any discussion of this topic is clouded by two problems. The flesh of the mooneye, said by many to be dry, tasteless, and too filled with small bones, has precluded its becoming an important food fish. Several Great Lakes fishes, including gizzard shad, alewife, and various ciscoes, have been called mooneye and so entered in annual statistical summaries of commercial catches. Van Oosten (1961) made an effort to sort out some of these errors. There is no entry in recent Ontario commercial catch summaries for mooneye, but they have been taken commercially by United States fishermen on Lake Erie. Langlois (1954) said that they were smoked and marketed as smoked shiners. In times of shortages of goldeye, the mooneye is often smoked and sold as the more valuable species.

It is nowhere an important sport fish but, like the goldeye, will take a variety of artificial flies and lures and will provide good fun on light tackle.

Nomenclature

Hiodon tergisus — LeSueur 1818a: 366 (type locality Lake Erie at Buffalo and Ohio R. at Pittsburg)
Hyodon tergisus — Günther 1868: 375
Hiodon chrysopsis Richards. — Günther 1868: 376
Cyprinus (Abramis?) smithii Richards. — Günther 1868: 376
Hiodon clodalis of Richardson 1823 — Evermann and Goldsborough 1907a: 98

In 1823, Richardson used Lesueur's name *Hiodon clodalis* (= *Hiodon tergisus*) for a fish caught at Cumberland House, Sask. He said the fish was called *"goldeye."* In 1836 he referred this specimen to his new species *H. chrysopsis* (= *H. alosoides*). Cumberland House is within the distribution of both the mooneye and the goldeye but it seems obvious that Richardson's fish was a goldeye. Richardson's (1836) species *Cyprinus smithii* has been referred by various authors to both *H. alosoides* and *H. tergisus*. It would appear that this species is a composite of *Notemigonus crysoleucas* and *Hiodon tergisus*.

Hiodon selenops Jordan and Bean, the southern mooneye, long considered a separate species, is now looked upon as conspecific with *H. tergisus*.

Etymology *Hiodon* — toothed hyoid; *tergisus* — polished, probably alluding to its silvery colouring.

Common names Mooneye, moon-eye, toothed herring, toothed herring of the lakes, river whitefish, notch-finned Hiodon, fresh-water herring. French common name: *laquaiche argentée*. The common name mooneye was apparently often mistakenly applied to goldeye, gizzard shad, alewife, and even some chubs or ciscoes in the Great Lakes.

Suggested Reading – Hiodontidae

GROSSLEIN, M. D., and L. L. SMITH, JR. 1959. The goldeye, *Amphiodon alosoides* (Rafinesque), in the commercial fishery of the Red Lakes, Minnesota. U.S. Fish Wildl. Serv. Fish. Bull. 157, vol. 60: 33–41.

JOHNSON, G. H. 1951. An investigation of the mooneye (*Hiodon tergisus*). Abstr. 5th Tech. Sess. Res. Counc. Ont. 16 p.

KENNEDY, W. A., and W. M. SPRULES. 1967. Goldeye in Canada. Fish. Res. Board Can. Bull. 161: 45 p.

KERSWILL, C. J. MS 1937. A taxonomic and distributional study of *Amphiodon alosoides* and *Hiodon tergisus*. M.A. Thesis Univ. Western Ontario, London, Ont. 67 p. + 10 pl.

VAN OOSTEN, J. 1961. Records, ages, and growth of the mooneye, *Hiodon tergisus*, of the Great Lakes. Trans. Amer. Fish. Soc. 90: 170–174.

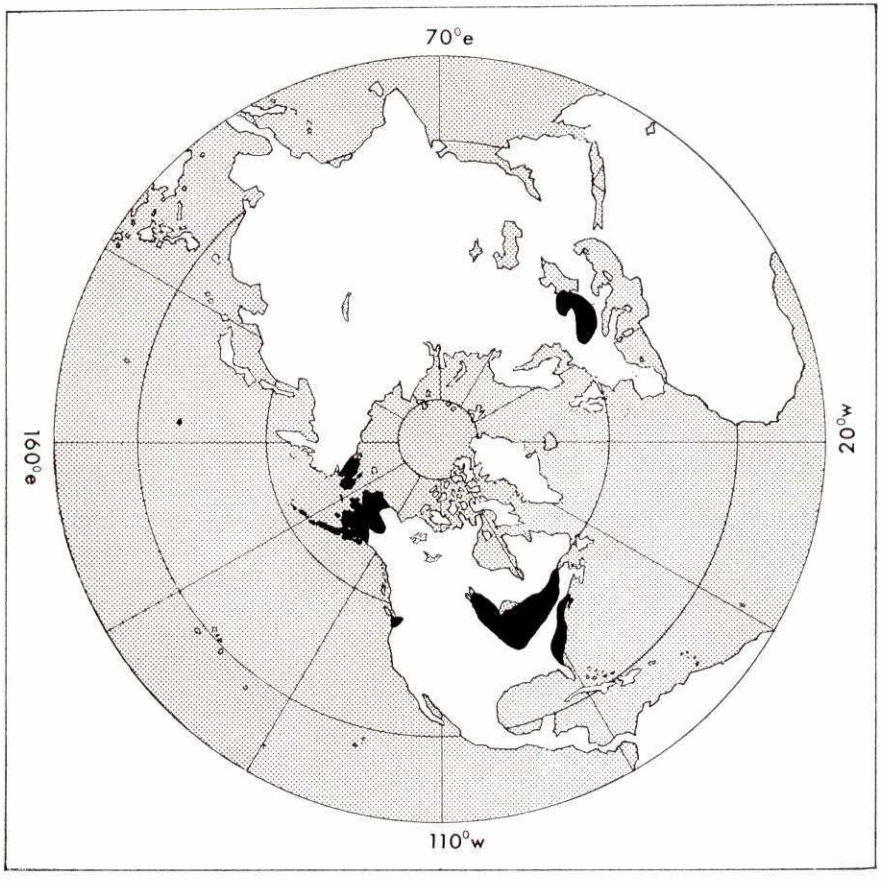
Mudminnow Family — Umbridae

The mudminnows are small, ovate to laterally compressed fishes; with rounded caudal fins; short snouts; and square, to somewhat flattened heads. The infraorbital and nasal bones are missing. The pectoral girdle is normal and ossified, or not ossified and platelike, the mesacoracoid characteristically absent. The pectoral fins are small to large and fanlike; the pelvic fins small and abdominal. The dorsal and anal fins, subequal or anal much smaller, are far back and opposite one another. The mudminnows are physostomous and capable of breathing atmospheric oxygen.

These fishes are characteristic of small, muddy ponds, slow, vegetated streams and stagnant pools of Europe, Asia, and subtropical to arctic North America.

Now considered to include 5 species in 3 genera previously placed in 2 or 3 separate families, Dalliidae, Umbridae, and Novumbridae.

Known from the Lower Eocene to Recent in Europe and Oligocene to Recent in North America.



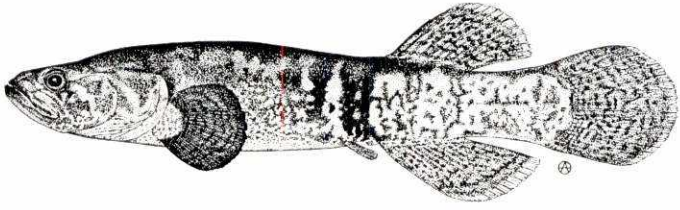
World Distribution of the Mudminnows

1 Pelvic fin small, half as long as pectoral; anal fin of 11 or 12 rays with base about as long as base of dorsal; area between dorsal and anal fins blotched; caudal fin spotted ..... ALASKA BLACKFISH, *Dallia pectoralis* (p. 338)

Pelvic fin large, as long as pectoral; anal fin of 8 or 9 rays with base about half as long as base of dorsal; area between anal and dorsal fins with vague, vertical bars; prominent vertical black bar at base of caudal; caudal fin not spotted ..... CENTRAL MUDMINNOW, *Umbra limi* (p. 341)

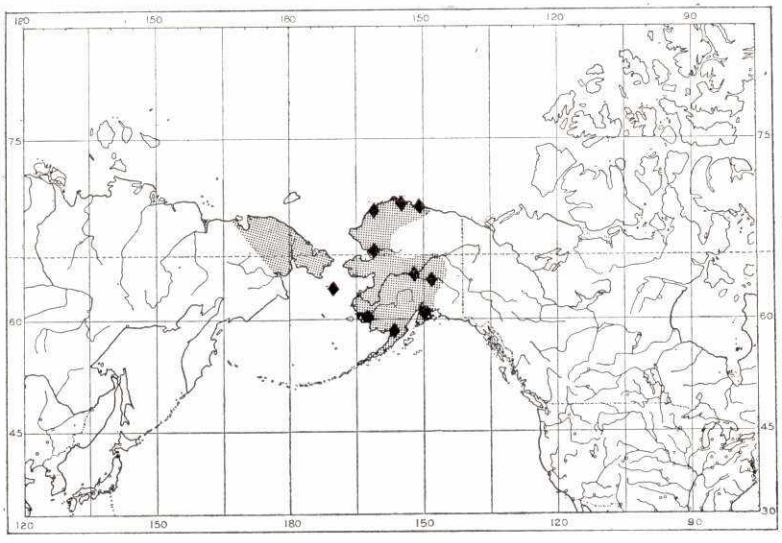
ALASKA BLACKFISH

Dallia pectoralis Bean



Description Body cylindrical, round in cross section, greatest depth (at midpoint of body) about 16% of total length; caudal peduncle moderately long, and deep, length equals depth, equals about 50% of head length; individuals usually 3–6 inches (76–152 mm) in length. Head short, about 20% of total length, depth moderate, about 40% of length; eye small, diameter about 20% of head length; snout short, about 20% of head length, pointed, lower jaw projecting slightly beyond tip of snout; mouth moderately large, maxillary extending at least to posterior edge of pupil; small but well-developed teeth on premaxillary, vomer, palatine and dentary but absent from maxillary, tongue, and basibranchial. Gill rakers short 9–12 (1–2 + 8–10). Branchiostegal rays 14–18. Fins: a single, soft-rayed dorsal far back, origin opposite origin of anal fin, length of base about equal to fin length, less than base of anal fin, edge rounded, 10–14 rays, fin height less in females; caudal broad and rounded; anal below dorsal, immediately behind anus, base longer than that of dorsal fin, about 13% of total length, height greater than base length and about equal to head length, height less in females, edge rounded, 12–16 rays; pelvics small, abdominal and close to anus, usually with 3 rays; pectorals very large, vertical, broad, round, and fanlike with wide base, 32–36 rays. Scales small, cycloid, embedded, 76–100 in lateral series; lateral line complete but pores inconspicuous. No pyloric caeca; physostomous. Vertebrae 40–42.

Colour Adults dark brown to olive-green above and on sides, with four to six dark bars and blotches or spots on sides, underside paler, marked with dark speckling; fins speckled with red-brown, vertical fins



edged with white to colourless in adults and pale red in spawning males. Young similar but paler and without white edge on vertical fins. Up to about 1 inch (25 mm) the young have three dark spots at the caudal base.

Distribution This species is restricted to arctic and subarctic fresh water in the northeastern tip of Siberia, the Bering Sea islands of St. Lawrence, St. Matthew, and Nunivak, and in Alaska.

In Alaska it extends throughout the lowlands from the central Alaska Peninsula (near Chignik) north along the arctic coast to the Colville River. It extends inland in the Yukon–Tanana River system as high as Fairbanks, Alaska. It has been introduced on St. Paul Island in the Pribilofs and Hood Lake near Anchorage.

Blackfish from the Kuskokwim River near Bethel, Alaska, were brought to Ontario in 1956 and introduced in a few farm ponds. It was hoped they could survive the drastic oxygen depletion in winter and provide recreation from these shallow ponds. The introduction was unsuccessful.

This species does not now occur in Canada but since it is the only freshwater fish occurring in Alaska that does not occur in Canada as well, it would seem foolish to exclude it from our treatment of the Canadian fauna.

Dall's 1871 discussion of *Cottus*? sp.–Blackfish is probably the earliest North American record of this species.

Biology Other than comments on the vast numbers of this fish that occurred in tiny, weed-choked pools, its use by natives, and the oft-repeated erroneous story, traceable to Turner (1886), about its ability to withstand freezing, virtually no information on the biology of this species was available prior to the work of Ostdiek and Nardone (1959) and that of Blackett (1962).

There is an upstream migration of adult blackfish in the spring into swampy potholes, coincident with a 10°–15° F (5.6°–8.3° C) rise in water temperature after the ice breaks up in May. Only small numbers of small fish are present in these pools under the ice in winter. Spawning may extend from May to August and is estimated by some to occur mainly in July. Females carry eggs of two sizes and stages of development. The ripe eggs are approximately 2 mm in diameter, the recruitment eggs 0.6–1.0 mm in diameter. Egg number (ripe) was given by McPhail and Lindsey (1970) as 100–300 and it is possible they are shed in very small numbers over a protracted period. Eggs are demersal and adhesive and doubtless adhere to the heavy vegetation of these pools. It is unlikely

that a nest is built. At 54° F (12.2° C) in experimental situations, eggs hatch in about 9 days.

Growth is rapid in the first summer and the young often reach a length of 20 mm by September. Age determination by scales is possible and Blackett gave an age–length relation as follows:

Age (*years*)	Length (mean in parentheses) (*inches*)	(*mm*)
1	2.0–3.6 (2.5)	52–92 (64)
2	3.0–5.7 (4.2)	78–146 (108)
3	3.7–6.5 (5.0)	96–166 (128)

Increment in growth is much smaller after the first year. Length–weight relation is curvilinear, the largest and oldest fish (males) weighed about 35 grams. Males apparently increase in weight at a slightly faster rate than females. Blackett's largest fish was 6.5 inches (165 mm) (total length?) but Bean's (1880b) original specimens included a specimen 8 inches (205 mm) in length. It is probably on the basis of this specimen that the length is most often reported as up to 8 inches. Some females reach maturity in their second year but most blackfish spawn first in their third year. McPhail and Lindsey (1970) gave maximum age as 8 years. If this is so, many females must spawn more than once.

The summer habitat is usually the weed-choked, lowland swamps and ponds of the area, but blackfish occur also in streams, rivers, and large lakes where vegetation is abundant. This species is most abundant in the tundra but does occur in forested areas, where habitat is suitable. Nothing is known of the winter habitat prior to the spring upstream migration but the species is known to be active at 39° F (3.9° C).

The blackfish is a sluggish bottom dweller and remains hidden in the vegetation most of the time. It moves about searching for food by a paddling action of the large pectoral fins. It moves up slowly on individual food items, which it takes with a quick dart. Food is largely dipterous insect larvae, ostracods, cladocerans, and snails. Fishes are not often recorded in its natural diet, but in captivity they will take small minnows. *See* Ostdiek and Nardone (1959) for a detailed analysis of habitat and food.

Very few fishes, possibly excepting sticklebacks, occur in the habitat so there are probably no predators other than bears, mink, otter, birds, and man.

Rausch (1956) described a new cestode, *Diphyllobothrium dalliae*, from this species, Blackett (1962) added a trematode *Tetracotyle* sp., and Hoffman (1967) listed Protozoa (3), Trematoda (1), Cestoda (1), Nematoda (1), and Acanthocephala (1).

This species has long been of interest to man as a result of its ability to live in vast numbers in tiny stagnant ponds where dissolved oxygen is as low as 2.3 ppm and to survive for extended periods out of the water, if moist. Interest over the years in the supposed ability of this fish to withstand freezing is traceable to Turner (1886) who said "The vitality of this fish is astonishing. They will remain in . . . grass-baskets for weeks, and when brought into the house and thawed out they will be as lively as ever. The pieces which are thrown to the ravenous dogs are eagerly swallowed; the animal heat of the dog's stomach thaws the fish out, whereupon its movements soon cause the dog to vomit it up alive. This I have *seen* . . . ." Several properly controlled experiments have shown that this species is definitely cold-adapted, can be active at very low temperatures, but cannot withstand actual freezing, or survive when bound in the ice.

Relation to man Although apparently available in vast numbers in certain places in summer and said to be rich, oily, good tasting, and yielding a good quality oil, the blackfish has never been taken commercially nor is apparently eaten by white people. It was long a staple part of the diet of native peoples in Alaska. It had always afforded them abundant food in the early spring when other types of food were not available. Nel-

son (1887) said they were also caught in the fall as the ice formed, packed 50–100 pounds in woven grass bags and stored frozen for the winter. He estimated 69 tons were so stored in one area alone, in one fall. It is still captured for food for sled dogs. Turner described the spruce wood traps used to catch this species and the fact that tons of the fish were taken. He stated that the natives sold the fish by the basket, and that a few cents would pay for three-fourths of a bushel. They were stored frozen in the open while cold weather prevailed, and sufficient quantity for food, or to feed dogs, was broken off when needed. They are no longer taken in such quantity for human food.

Nomenclature

Dallia pectoralis — Bean 1880b: 358 (type locality St. Michael's, Alaska. Holotype USNM 23498)

Cottus sp.? — Dall 1871: 388

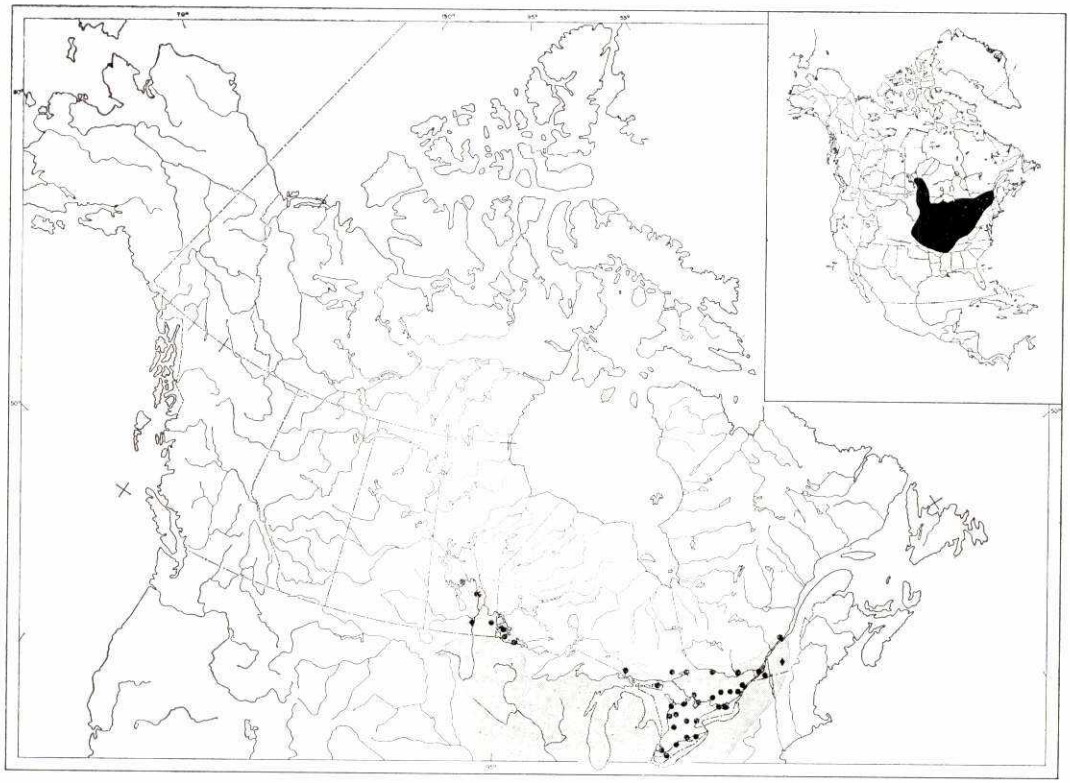
Etymology *Dallia* — in honour of Dr W. H. Dall, naturalist of the Alaska Telegraph Expedition; *pectoralis* — alluding to its broad, fanlike pectoral fins.

Common names Alaska blackfish, blackfish, devilfish, grassfish, Eskimo — *I-mäñ'-ûk*, Russian — *Chernaya ryba*. French common name: *dallia*.

CENTRAL MUDMINNOW

Umbra limi (Kirtland)

Description Body robust, almost round in cross section behind head, more compressed beyond dorsal fin, greatest depth (at rear of pectoral fin) 14.3–20.6% of total length; caudal peduncle long, about 20% of total length; moderately deep, almost as deep as head, about 11% of total length; individuals usually 2–4 inches (51–102 mm) in length. Head moderately long, 20.4–26.1% of total length, eye large, about 18.6–28.9% of head length, pupil black; top of head, cheeks, and opercles scaled; snout short, equal to eye diameter, 21.4–29.1% of head length, bluntly rounded; mouth moderate, premaxillary not protractile, maxillary extending to anterior edge of pupil, lower jaw projecting slightly; small villiform teeth on the premaxillary, 2–7 on the vomer, a double row on each palatine, basibranchials, and some suprapharyngeals, infrapharyngeals, and dentaries. Gill rakers 13–15 (5–6 + 8–9) short, stout, triangular. Branchiostegal rays 4 or 5 on each side. Fins: a single, soft-rayed dorsal, moderately high, fin height



about equal to head length, length of base about 20% of total length, edge square to rounded, 13–15 rays; caudal round, only slightly expanded, 12 or 13 rays; anal with origin posterior to origin of dorsal, moderately long, about 18% of total length, higher in males than in females, base length a little over 50% of that of dorsal fin, 7–9 rays; pelvics abdominal, under origin of dorsal, short but broad, rounded, 6 or 7 rays; pectorals low, vertical, broad, rounded, 14–16 rays. Scales large, cycloid, 34–37 in lateral series; no lateral line, naked neuromasts scattered over body; no pyloric caeca; physostomous. Vertebrae 35–37.

Colour Upper parts of head and body dark olive-green, through brown, to brown-black, sides mottled or marbled with dark brown, coalescing in some habitats into as many as 14, distinct or vague, vertical bars, ventral part of body yellow to white, a prominent, narrow, vertical, black bar at base of tail; all fins dusky to brownish. Colour of females at spawning time supposedly brighter than males, both with green iridescence at this time, particularly on anal fin. Young similar to adults except vertical bars inconspicuous to absent.

Systematic notes There are no apparent significant differences in meristic characters across Canada. The only proportional difference is in the relation of body depth to total length. There is an increase in body depth toward either the north or the west or in both directions.

Distribution Restricted to central North America west of the Appalachian Mountains from Quebec east of Montreal, Lake Champlain, western New York, the glaciated portion of Ohio, south to Tennessee and eastern Arkansas, north through eastern parts of Missouri (not in Kansas as

usually stated), Iowa, the Dakotas, to southern Manitoba and Ontario.

In Canada it occurs south of a line from about Trois Rivières, Que., through Sault Ste. Marie, and in the Nelson River drainage of southwestern Ontario and southern Manitoba.

Distribution in Ohio and other states said to be shrinking as a result of siltation.

Biology Most of the solid information on the biology of the mudminnow comes from a study by Peckham and Dineen (1957) in Indiana, and an unpublished thesis by Westman (1941) on a New York State population. Other information is scattered. Virtually no information is available for Canada except feeding data by Keast and Webb (1966).

Mudminnows spawn in early spring. A migration of pairs of mudminnows upstream and into shallow water was reported in the past, but later authors noted only lateral movement from the main stream channel to flooded benches after rains in March. Westman gave spawning in New York as April 18–25, at a water temperature of 55.4° F (13° C). Spawning in Ontario takes place in mid- to late April, as judged by the large number of young 18–23 mm in total length, taken on June 1 in Jones Creek, Leeds County, Ont., when the water temperature was 55° F (12.8° C). Early reports of these fish running up swift hillside brooks to spawn seem contrary to more recent information. However, Toner (1943) stated that they penetrated the springs that are the headwaters of the creeks in which they were found. Water temperature at spawning time has been given as 60° F (15.6° C), but this seems high. Mature females from 2.0 to 3.7 inches (52–94 mm) long contain 220–2286 eggs, 1.6 mm in diameter. All ripe eggs in the ovaries appear to be much the same size, so spawning period may be short. No nest building is reported for this species except by Westman who said the female guards the nest, in contrast to the other species in the genus. Most say that in this mudminnow the eggs are laid singly, are adhesive, and stick to the heavy vegetation of the habitat. No care is provided eggs or young. Eggs hatch in about 6 days and the young when hatched are about 5 mm long. Up to the time they are 25 mm long the young have a notochordal lobe above the developing caudal fin, similar to that in *Lepisosteus*. It is thought that it helps orient the fish before feeble movement takes place with the poorly developed fins. The young move back to the main stream when they are about 1.2 inches (30 mm) in length. Fish (1932) gave details of the early development of young and a photograph.

Details of growth with age are hard to determine as the scales apparently do not give an accurate age estimate. Size frequency was used by Applegate (1943) to estimate that two age-groups were represented in individuals up to 100 mm in length. Young-of-the-year are 0.7–1.4 inches (19.5–37.5 mm) in standard length and 1-year-old fish are 1.4–3.5 inches (37.5–90.0 mm). One or more of the very low modes in Applegate's size frequency data, distributed about 2.3 inches (58 mm), 3.1 inches (79 mm), and 3.9 inches (99 mm) probably represent older fish, especially since Westman (1941) cited four age-groups and gave 3.3 inches (85 mm) as size at age 4. Age–length relation, from otoliths, given by Westman, does not differ greatly from that of Peckham and Dineen and is as follows:

Age (*years*)	Mean TL (*inches*)	Mean TL (*mm*)
0 (Sept.)	0.9–2.1	25–53
1	2.0	51
2	2.5	64
3	3.0	76
4	3.3	85

Westman also suggested that females grew faster than males. Males mature at age 1, some females mature at age 1 but most at age 2. The larger fish are females, which probably live longer than males. Trautman (1957) gave 5.2 inches (132 mm) as maximum size. It is interesting that specimens as large as this were obtained from Jones Creek, Leeds County, Ont. This size is 45 mm greater than Westman's 4-year-old mudminnows, a differential greater than that between his 1- and 4-year-old fish. The growth increment between

3 and 4 years in Westman's data is 9 mm. This would suggest either that mudminnows live at least to 7 or 9 years of age or that his age interpretation was in error. No age in excess of 4 has been suggested in the literature. It would seem likely that at least some females spawn several times.

The summer habitat of this species is usually heavily vegetated ponds or pools of small creeks, where the bottom has a thick layer of organic material. These pools often become isolated, stagnant, and, in Ontario, as warm as 84° F (28.9° C) in August. It occurs elsewhere though, as Toner (1943) said they were found further upstream than any other fish, penetrating to the springs and swamps of the uplands. He said they were taken from 31% of the warm brooks, 19% of the creeks, and 9% of the bog creeks. Hallam (1959) stated that in a stream situation in Ontario they were associated more often with such cool-water forms as *Cottus bairdi* and *Salvelinus fontinalis* than they were with warmwater species such as *Micropterus dolomieui* and *Ambloplites rupestris*. The spawning site on flooded benches possibly protects the newly hatched young but also subjects them to possible mortality when the water recedes and benches dry up.

Mudminnows have usually been described in early reports as burrowing quickly into the mud, tail first, to escape predation, or to survive drought conditions, and as hibernating in the mud in winter. Later observations show that they do flee into the thick detritus and flocculent ooze but do not burrow into the mud. Black (1945) showed that the swim bladder does have a respiratory capability and that mudminnows do gulp air at the surface when oxygen is low. At times, however, numbers of them are killed by low oxygen in winter. Peckham and Dineen showed that throughout the winter they were active and fed under the ice.

Movements upstream and downstream were, in the past, thought to be extensive. Peckham and Dineen (1957) noted only lateral movement within the habitat and on to the flooded stream banks to spawn. The young move off these benches back into the main pond or stream when about 1 inch (30 mm) in length. None were seen or captured in nets in a study area in Ontario on April 26, 2 weeks after the ice melted, when water temperature was 46° F (7.8° C). By May, however, when water temperature was 56° F (13.3° C), mudminnows were plentiful and possibly spawning.

Mudminnows are carnivorous and feed generally on the bottom. Most of the time they remain motionless in cover and move up on individual larger food items by means of a quick dart using the whole body, or slowly on small bottom items by paddling with the pectoral fins. The food of young mudminnows is largely ostracods and some newly hatched snails, but insect larvae and adults, molluscs, amphipods, isopods, and arachnids are the principal food after 20 mm. Fish rarely appear in the diet and Peckham and Dineen, who gave a detailed quantitative and qualitative food analysis, listed only a single blacknose dace and two unidentified fishes.

Mudminnows are preyed on by a variety of larger stream forms including grass pickerel, chain pickerel, northern pike, sunfishes, and catfishes. What seemed like food selection occurred in a predator–prey relation between grass pickerel and mudminnows in a particular Ontario stream (Crossman 1962b). Birds, muskrats, and foxes have been reported to eat them. Mudminnows probably compete for food with a wide variety of stream-dwelling minnows as well as with the invertebrate-feeding young of species that, when larger, may be their predators.

Hoffman (1967) listed 26 parasites as follows: Protozoa (3), Trematoda (14), Cestoda (1), Nematoda (3), Acanthocephala (4), Crustacea (1). His list did not include the trematode *Clinostomum complanatum* reported by Peckham and Dineen.

Relation to man This species is a small, rather secretive inhabitant of small creeks and isolated ponds. It bears little relation to man other than serving as bait for sport fishes and as food for other species of little apparent interest to him. Mudminnows are hardy and capable of taking in atmos-

pheric oxygen, so they are considered good bait fish. This species enters into the baitfish definition for regulations in Ontario and they are sold as such in Ontario, Quebec, and the United States. They also make very attractive and interesting aquarium fishes.

Nomenclature

Hydrargira limi — Kirtland 1841a: 277 (type locality Yellow Creek, Mahoning Co., Ohio. (according to Trautman 1957))

Hydrargyra fusca — Thompson 1842: 137

Hydrargyra atricada — DeKay 1842: 220

Hydrargyra atricauda — Fortin 1866: 76

Etymology *Umbra* — a shade, or dark, possibly referring to its habitat, they were once thought to inhabit caves; *limi* — mud.

Common names Central mudminnow, western mudminnow, mud minnow, Mississippi mud-minnow, mudfish, dogfish. French name: *umbre de vase.*

Suggested Reading – Umbridae

APPLEGATE, V. C. 1943. Partial analysis of growth in a population of mudminnows, *Umbra limi* (Kirtland). Copeia 1943: 92–96.

BLACKETT, R. F. 1962. Some phases in the life history of the Alaskan blackfish, *Dallia pectoralis.* Copeia 1962: 124–130.

CHAPMAN, W. M. 1934. The osteology of the haplimous fish *Novumbra hubbsi* Schultz with comparative notes on related species. J. Morphol. 56: 371–405.

DINEEN, C. F., and P. S. STOKELY. 1954. Osteology of the central mudminnow, *Umbra limi.* Copeia 1954: 169–179.

GILL, T. N. 1903. A remarkable genus of fishes — the umbras. Smithson. Misc. Collect. 45: 295–305.

OSTDIEK, J. L., and R. M. NARDONE. 1959. Studies on the Alaskan blackfish *Dallia pectoralis.* I. Habitat, size and stomach analyses. Amer. Midland Natur. 61: 218–229.

PECKHAM, R. S. MS 1955. Ecology and life history of the central mudminnow, *Umbra limi* (Kirtland). Ph.D. Thesis. Univ. Notre Dame, Notre Dame, Ind. 71 p.

PECKHAM, R. S., and C. F. DINEEN. 1957. Ecology of the central mudminnow, *Umbra limi* (Kirtland). Amer. Midland Natur. 58: 222–231.

SCHULTZ, L. P. 1929. Description of a new type of mudminnow from western Washington with notes on related species. College Fish. Univ. Wash. Publ. Fish. 2(6): 73–81.

STARKS, E. C. 1904. A synopsis of characters of some fishes belonging to the order Haplomi. Biol. Bull. (Woods Hole) 7: 254–262.

1905. The osteology of *Dallia pectoralis.* Zool. Jahrb. Abt. Syst. 21: 249–262.

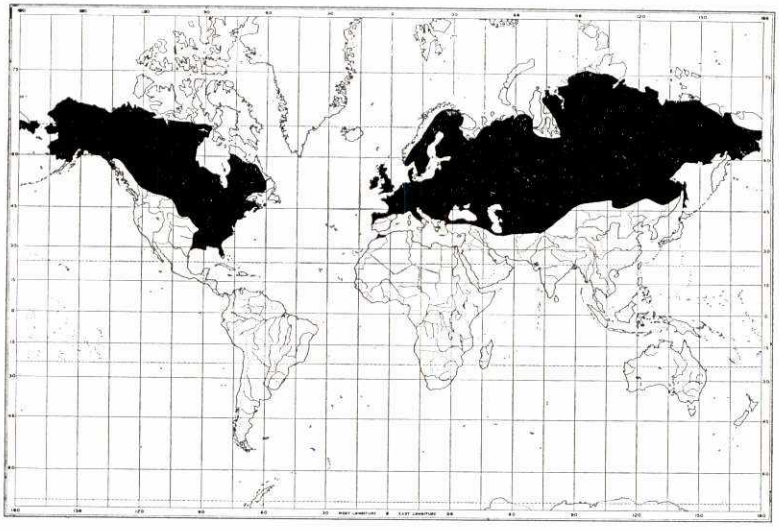
WESTMAN, J. R. MS 1941. A consideration of population life-history studies in their relation to the problems of fish management research, with special reference to the small-mouthed bass, *Micropterus dolomieu* Lacépède, the lake trout, *Cristivomer namaycush* (Walbaum), and the mudminnow, *Umbra limi* (Kirtland). Ph.D. Thesis. Cornell Univ., Ithaca, N.Y. 182 p.

Pike Family — Esocidae

Body elongate, laterally compressed; tail forked; dorsal and anal fins far back, equal to subequal in size, and situated opposite one another. Head large; snout elongate, flat, and somewhat like a duck's bill. Jaw articulated behind the posterior edge of orbit. Teeth on jaws, large and prominent. Large patches of cardiform teeth on vomer, palatines, and tongue. Inframandibular present in contrast to mudminnows. Gill rakers reduced to patches of sharp denticles. Pectoral fins low; pelvic fins abdominal. Mesocoracoid absent from pectoral girdle (the so-called simple shoulder characteristic, previously used to classify the pikes and mudminnows in the order Haplomi). The pikes are physostomous, but there is no known ability to breathe atmospheric oxygen.

Small to large fishes of small streams, ponds, rivers, lakes, and to a minor degree, brackish waters, from subtropical to arctic North America and Eurasia. One genus of 5 species. One species, *Esox lucius*, circumpolar, 1 endemic to Siberia, and 3 endemic to eastern North America.

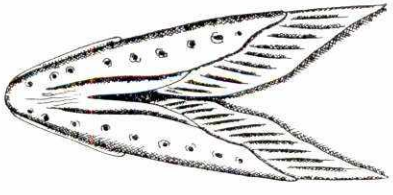
Known from the Middle Eocene to Recent in Eurasia and Pliocene to Recent in North America.



World Distribution of the Pikes

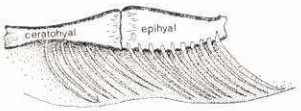
Key to Species

1 Submandibular pores 10 or more; cheeks and/or opercula not fully scaled 2



Submandibular pores 8 or fewer (rarely 9); both cheeks and opercula more or less fully scaled 3

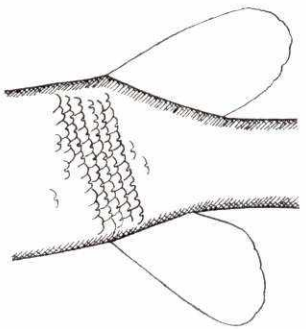
2 Submandibular pores 12–20; branchiostegal rays 16–19 on each side, most often 8 + 10 (8 on ceratohyal, 10 on epihyal) on each side; pattern silvery or light ground colour with dark spots, blotches, or vertical stripes; neither cheeks nor opercula completely scaled .... MUSKELLUNGE, *Esox masquinongy* (p. 363)



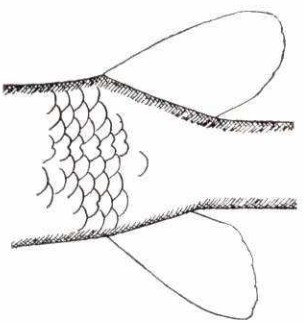
Submandibular pores 10 or 11 (rarely 9); branchiostegal rays 13–16, most often 7 + 8 on each side; pattern dark ground colour with white to yellow, wavy, vertical stripes in young, or horizontal rows of yellow bean-shaped spots in adults; cheeks full scaled, opercula not so ..... NORTHERN PIKE, *Esox lucius* (p. 356)

3 Submandibular pores 7 or 8 (rarely 9) and branchiostegal rays 14–17, most often 6 + 9 (6 on ceratohyal, 9 on epihyal) on each side; pattern dark ground colour with pale wavy, vertical stripes in young, and golden chainlike markings in adults ..... CHAIN PICKEREL, *Esox niger* (p. 370)

Submandibular pores 7 or 8 and branchiostegal rays 11–13 on each side 4



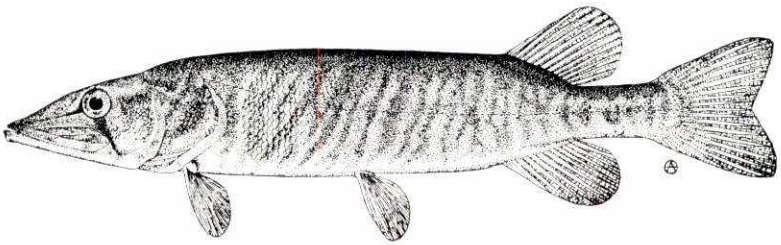
4 Branchiostegal rays usually 5 + 7 or 5 + 8 on each side; snout short, convex in upper profile; cardioid scales between pelvics more than 5, and more than 5 in a line from origin of anal fin to dorsal surface; lower fins red to orange ..... REDFIN PICKEREL, *Esox a. americanus* (p. 348)



Branchiostegal rays usually 4 + 7 or 4 + 8 on each side; snout longer and concave in upper profile; cardioid scales between pelvics fewer than 5, and fewer than 5 in a line from origin of anal fin to dorsal surface; lower fins dusky to yellow-green ..... GRASS PICKEREL, *Esox a. vermiculatus* (p. 352)

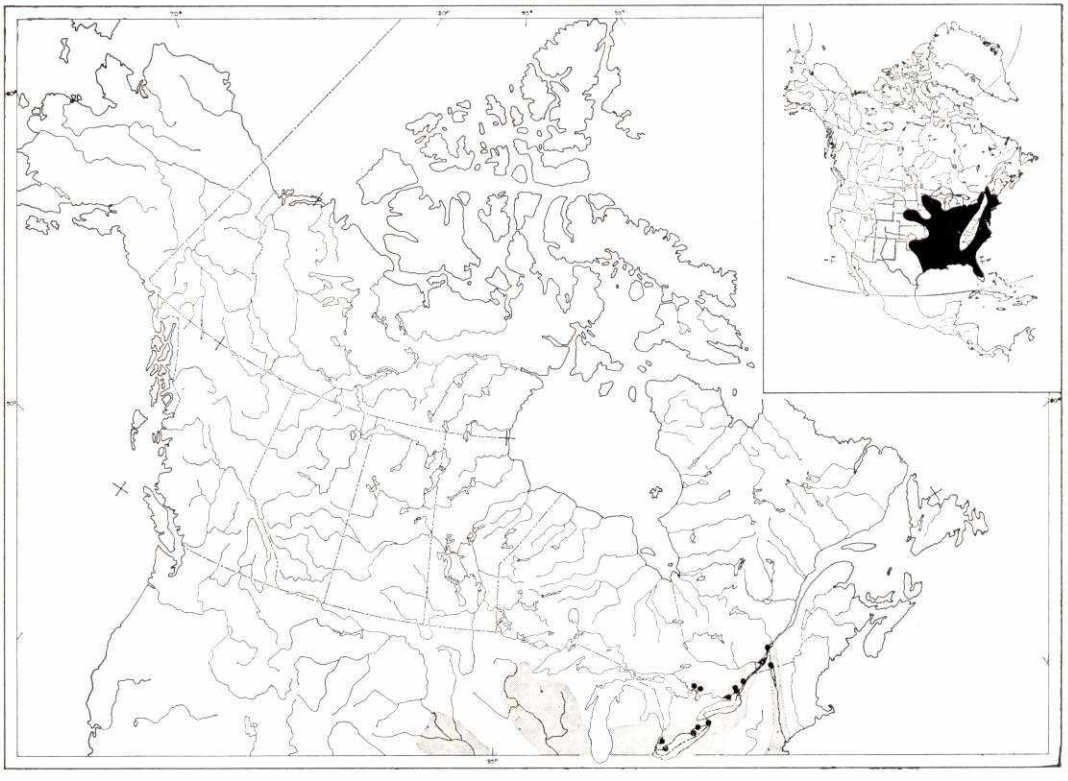
REDFIN PICKEREL

Esox americanus americanus Gmelin



Description Body long, cylindrical, little compressed laterally, flattened dorsally before dorsal fin, greatest depth (between paired fins) 13.6–18.3% of total length, body width 7.7–10.5% of total length, cross section almost round; caudal peduncle length 13.1–14.8% of total length, caudal peduncle depth 13.6–18.3% of total length. Individuals are usually 6–8 inches (152–203 mm) in length. Head moderately long, 24.2–25.7% of total length, flat and naked on top, broad, interorbital width 20.2–23.1% of head length; cheeks and opercula fully scaled; eyes high, moderately large, eye diameter 13.4–14.5% of head length; snout very short, length 33.8–38.6% of head length and 70.9–83.3% of postorbital head length, convex, not concave, between eye and tip and very broad; mouth large, horizontal, maxillary reaching at least to middle of pupil or to suborbital bar and sometimes to the posterior edge of pupil; short, sharp, recurved cardiform teeth along the premaxillary and in patches on tongue, basibranchials, last two pharyngobranchials, vomer, and palatines; large, strong canines on head of vomer inner edge of palatine patches and on the dentaries, those on dentaries flattened with sharp edges as well as tips, other canines pointed but round and peglike. Lower jaw slightly longer than snout, undersurface pierced by 4 pores on each side (rarely 3 or 5 on one side only). Gill rakers reduced to patches of sharp, radiating denticles on both sides of arches. Branchiostegal rays 12 or 13 on each side, usually 5 or 6 on ceratohyal and 7 rarely 8 on epihyal. Fins: dorsal 1, soft rayed, far back, distance from nape (or occiput) to dorsal origin 43.8–47.8% of total length, base shorter than height of fin, less than 50% of head length, upper edge rounded, 15–18 principal rays; caudal shorter, forked, tips rounded; anal under dorsal, base shorter than that of dorsal, height less than that of dorsal, edge rounded, 13–17 principal rays; pelvics abdominal, low, at midpoint of body, rounded, 8 or 9 rays; pectorals low, arising under edge of opercular flap, rounded, 14 or 15 rays. Scales rather small, cycloid, 102–116 in lateral series; lateral line complete, lateral line scales notched not pierced or tubed, many notched scales bordering sensory cells elsewhere on body, 7–16 such scales in triangle between pelvic fins, 13–22 in the row from origin of anal to dorsal surface; intestine long and undifferentiated, no pyloric caeca. Physostomous. Vertebrae 49 or 50.

Colour Adult pattern first appears at about 4–6 inches (102–152 mm) length. The dorsal surface of back, head, and upper sides are uniform light brown to olive-green. There is a very inconspicuous pale, mid-dorsal band from the nape to the origin of the dorsal fin. The sides are marked by 20–36 olive to dark brown, wavy, vertical bars separated by paler extensions of what had been a lateral band in the young of about 4 inches (100 mm) in length. The pale area between adjacent bands is narrower than the bands. The ventral surface is pale amber to milky white. Suborbital and preorbital black bars pronounced, suborbital recurved, off vertical, postorbital horizontal, lateral edges of jaws heavily pig-



World Distribution of *Esox americanus* (both Subspecies)

mented as is tip of area between lower jaws, and isthmus. The amount and intensity of submandibular pigment (greater in females) can be used to separate the sexes with about 75% accuracy. The pupil of the eye is yellow to yellow-green. The dorsal fin is darkly pigmented, all others are bright amber to orange in Canada, orange to red elsewhere, hence the common name. Young-of-the-year at 2-inches (50-mm) length are uniformly darker brown almost to the level of the paired fins without apparent interruption of light pigment. From 4 inches (100 mm) in length, vertical extensions of an inconspicuous, light, midlateral band begins to break the dark sides into vertical dark bars.

Systematic notes This species at different times has been considered a separate species distinct from the grass pickerel, and as the typical form of which the grass pickerel is a subspecies. We treat the two here as subspecies following the opinion expressed by many authors and documented by Crossman (1966). Populations in the Gulf states from Mississippi to Florida possibly constitute intergrades of the two subspecies.

Distribution Restricted to fresh water and infrequently brackish water of eastern North America. This is characteristically a fish of the coastal plain of the eastern United States. Its distribution extends from the St. Lawrence River (Lac St. Pierre) south through the Richelieu–Champlain–Hudson system into New York, east through southern Vermont and New Hampshire to Long Island, south along the coastal plain east of the Allegheny–Appalachian mountains to Georgia. The species as a whole continues as intergrades with the grass pickerel, south to Lake Okeechobee, Florida, and west to near the Mississippi–Louisiana border where it is replaced by the grass pickerel. It has been

introduced west of the mountains in Maryland and possibly Pennsylvania.

In Canada the distribution is limited to Quebec. Redfin pickerel occur in the St. Lawrence River, in the immediate area of Lac St. Pierre, the Richelieu and its tributaries including Lake Champlain, Yamaska River, St. Francois River, the Godefroy River, and Lac St. Paul. It is isolated from the other subspecies, the grass pickerel, by about 75 miles, part of which is badly polluted habitat around Montreal. This barrier may prevent contact of the two forms.

Its distribution in the United States does not seem to be shrinking but the numbers of this species in the St. Lawrence in and around Lac St. Pierre, seem to have been drastically reduced as a result of possible habitat changes subsequent to the construction of the St. Lawrence Seaway.

Its presence in Canada was first discovered in 1944 (Cuerrier 1947). Since it was found in Canada so recently and since it still has such a limited distribution here, it seems likely that the man-made connection between the Hudson River and the Lake Champlain–Richelieu River system built in 1819, rather than the Lake Champlain–Hudson River discharge of the Great Lakes in glacial times, provided the access to Canadian waters.

Biology Unlike its counterpart the grass pickerel, virtually nothing is known of the biology of the redfin pickerel in Canada. Other than sketchy discussions in Kendall (1917) and Weed (1927) there was little concrete biological data for this species until a 1959 study in North Carolina (Crossman 1962c).

The redfin pickerel is basically a spring spawner, but, as is the case for the other pickerels, adequate investigation may indicate fall spawning as well. Spawning takes place in spring when water temperatures approach 50° F (10° C) probably in April in Canada, and spawning may take place over a period of 2 weeks in the north or as long as a month in the south. No record of spawning activity is available but it undoubtedly spawns in the very shallow, heavily vegetated flooded margins of the stream habitats. No nest is built; the eggs are broadcast and abandoned to adhere to the bottom and vegetation. Average total egg number is 3716 of which 186–542 are mature. This is approximately one-third the total number contained in a grass pickerel of equal size. Eggs in two other recruitment stages are present with the mature eggs, at any time prior to spawning. Eggs are transparent, golden yellow in colour, and average 1.9 mm in diameter. They hatch in 10–14 days and the inactive young, which at this time are 5.8–6.1 mm in total length, exist on the yolk for 10–12 days before they commence active feeding. Mansueti and Hardy (1967) illustrated and described larval changes in the Chesapeake Bay region. Growth is very rapid in the first summer, as much as 20–30 mm in each month. The age–length relation for redfins in North Carolina is as follows:

Age	Mean FL		Range of FL	
(*years*)	(*inches*)	(*mm*)	(*inches*)	(*mm*)
1	4.3	111.1	3.6–5.0	92–129
2	5.5	140.3	4.6–6.3	117–162
3	7.0	177.9	5.5–8.0	140–205
4	8.4	210.5	7.5–9.5	192–241
5	9.2	235.0	8.3–10.7	210–273
6	11.2	285.0	11.2	285

Growth in length seems to be straight line in nature, continuous and sexually dimorphic. Females grow faster, live longer and, achieve greater maximum size. Length–weight relation is curvilinear. Maximum size in Canada would appear to be approximately 12.3 inches (312 mm) total length. Maximum length on Long Island has been given by Greeley (1938) as 13 inches (330 mm). A record of 19 inches (483 mm) given by Westman (1952) was probably a redfin pickerel × chain pickerel hybrid.

Maximum age is probably 5–7 years in Canada.

The habitat of redfin pickerel is sluggish, heavily vegetated, usually acid water streams. They occur less frequently in ponds and in the weedy backwaters and quiet bays of larger lakes and rivers.

Redfin pickerel, like the other members of the family, are basically piscivorous preda-

tors. Food of young-of-the-year (under 50 mm) is entirely invertebrates such as cladocerans, amphipods, isopods, and the immature stages of such aquatic insects as dragonflies, mayflies and caddisflies. Larger fish feed mostly on other fishes, probably a wide spectrum of warmwater species, but minor amounts of aquatic insects are part of the diet as well.

Where they occur together this species is probably preyed on by larger sunfishes, pikes, perches, and possibly catfishes. As young, they compete for food with other fishes that feed on invertebrates. As adults, they compete with a wide variety of piscivorous predators. Some competition and predation may be limited by the nature of the habitat.

The redfin pickerel hybridizes in nature with the northern pike and the chain pickerel and intergrades with the grass pickerel in the south. The last two hybrids are fertile, the first is sterile (Crossman and Buss 1965).

Hoffman (1967) summarized the parasites of this species as follows: Protozoa (1), Trematoda (3), Cestoda (2), Nematoda (1).

Relation to man This species is small but often locally abundant. In the past it appeared regularly in the fresh-fish markets of the eastern United States and was said to be worthwhile food. Until recently it was caught and marketed, in small quantities, by commercial fishermen around Lac St. Pierre in Quebec. It appears no longer to be abundant enough to do so there.

On the coastal plain of the United States it is often sought after specifically by anglers with light rods and very small spinners. It is said to provide good sport. Older literature attested to its gamey nature and the fact that it would leap out of the water after artificial flies. There is no record of anglers fishing specifically for it in Quebec. They do not often angle in the type of habitat in which it occurs.

Nomenclature

Esox lucius β americanus	— Gmelin 1788: 1390 (type locality vicinity of New York City)
Esox americanus	— Cuerrier 1947: 62
Esox americanus americanus	— Legendre 1952: V

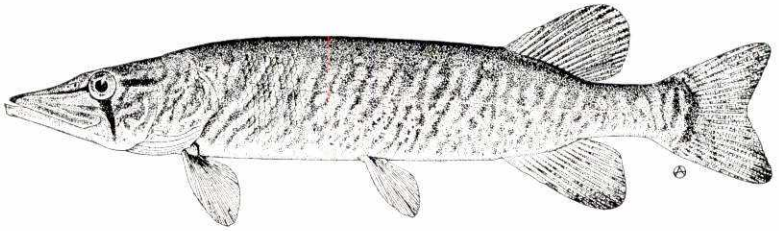
Etymology *Esox* — an old European name for the pike; *americanus* — from America.

Common names Redfin pickerel, banded pickerel, trout pickerel, grass pickerel, mud pickerel, bulldog pickerel, pickerel, red-finned pike (*see* Weed 1927: 42–43 for list). French common name: *brochet d'Amérique*.

The common name pickerel (the diminutive of pike) should be restricted to the three small members of the pike family, redfin, grass, and chain pickerels. Pickerel is a misnomer when applied to the walleye, a member of the perch family.

GRASS PICKEREL

Esox americanus vermiculatus Lesueur



Description Body long, cylindrical, little compressed laterally, somewhat flat dorsally, shallow, greatest depth (between paired fins) is 12.1–17.4% of total length, cross section almost round; caudal peduncle moderately long 14–16% of total length, and narrow; depth 5.6–6.3% of total length. Individuals are usually 6–8 inches (152–203 mm) in length. Head moderately long, 27.9–31.4% of total length, flat and naked on top, moderately broad; interorbital width 20.5–23.6% of head length; cheeks and opercula fully scaled; eyes high, moderately large, 13.4–16.0% of head length, snout short, 37.0–41.6% of head length, 80.2–94.0% of post-orbital head length, rounded and concave on top, snout only moderately broad; mouth large, horizontal, maxillary usually not reaching beyond middle of pupil nor to the suborbital bar; short, sharp, recurved cardiform teeth along the premaxillary and in patches on tongue, basibranchials, last two pharyngobranchials, vomer, and palatines; large, strong canines on head of vomer, inner edge of palatine patches and on the dentaries, those on dentaries flattened with sharp edges as well as tips, other canines pointed but round and peglike; lower jaw slightly longer than snout, undersurface of lower jaw usually pierced by 4 pores on each side (sometimes 3 or 5 on one side only). Gill rakers reduced to patches of sharp, radiating denticles on lateral and medial surfaces of arches. Branchiostegal rays 10–14 on each side, usually 12, 5 on the ceratohyal, 7 on the epihyal. Fins: dorsal 1, soft rayed, far back, distance from occiput (or nape) to dorsal origin 42.0–44.8% of total length, base shorter than height of fin, less than 50% of head length, upper edge square to slightly rounded, 14–17 principal rays; caudal moderately long, deeply forked, tips rounded; anal directly under dorsal fin, near anus, base shorter than that of dorsal, height less than that of dorsal fin but greater than snout length, edge more rounded than dorsal, 13–15 rays; pelvics abdominal, low, at midpoint of body, rounded, 9 or 10 rays; pectorals low, arising under edge of opercular flap, rounded and paddle-like, 14 or 15 rays. Scales rather small, cycloid, 97–118 in lateral series; lateral line complete, lateral line scales notched not pierced or tubed, single notched scales bordering sensory cells scattered elsewhere on body, fewer than 3 such scales in the triangle between the pelvic fins, no more than 5 in the row from origin of anal to dorsal surface; intestine long and undifferentiated, no pyloric caeca. Physostomous. Vertebrae 42–47.

Colour Adult pattern first appears at about 5 inches (130–140 mm) in length. The dorsal surface and upper sides are uniform pale to dark green, there is a rusty brown mid-dorsal stripe, the sides show 15–23 olive to black, thin, wavy, vertical bars separated by lightly pigmented extensions of what had in the young been a prominent golden green lateral band. The pale area between adjacent bars is wider than the bars. The ventral, vertical, suborbital and horizontal, preorbital, black bars obvious, sometimes postorbital, horizontal bar obvious; lateral

edges of both jaws lightly pigmented; the pupil is yellow; the leading edge of all fins is black, the rest of the fins dusky to amber.

Young-of-the-year up to about 4 inches (100 mm) are much darker; they have a prominent golden mid-dorsal stripe from the tip of the snout to the origin of the dorsal fin, the flanks are marked with two long, dark green to black horizontal areas separated by a golden green, wide, midlateral band; the ventral surface is buff to white. (*See* Crossman 1962a, for more details.)

Systematic notes This species has at different times been considered a full species, *Esox vermiculatus*, and a subspecies of the redfin pickerel *Esox americanus*. We treat it here as a subspecies, *E. a. vermiculatus*, following the opinion expressed by many authors and documented by Crossman (1966). Populations in the Gulf states from Mississippi to Florida possibly constitute intergrades with the redfin pickerel *E. a. americanus*.

Distribution *See* map for species included in redfin pickerel, *E. a. americanus*. Restricted to the fresh waters of central North America, mainly in the Mississippi and Great Lakes drainages. The range extends from near the confluence of the Ottawa and St. Lawrence rivers south, west of the Allegheny Mountains, in the Lake Ontario and Finger Lakes drainages of New York, through the western part of the states from Pennsylvania to Louisiana, west in Gulf of Mexico drainages to the Brazos River in eastern Texas, north through the eastern parts of Oklahoma, Kansas, Iowa, to southeastern Wisconsin and southern Michigan to the lower Great Lakes in Ontario. Populations in northeast Nebraska are relicts of a wider distribution in the past. Introduced in Colorado, Washington, and California.

In Canada it is limited to tributaries of the St. Lawrence River and Lake Ontario as far west as Belleville, absent from there to the lower Niagara River, present in tributaries of the upper Niagara River, Lake Erie, Lake St. Clair, and lower Lake Huron. An isolated population in the Severn River–Muskoka Lakes area (Georgian Bay drainage) may be a relict or the result of unintentional introduction.

Previously more abundant and more widely distributed in the United States, its distribution was curtailed after 1900 as a result of drainage, loss of vegetation, and siltation.

The earliest recorded capture of grass pickerel in Canada is that of Reighard (Hubbs and Brown 1929) in Long Point Creek in 1899.

Biology The grass pickerel is not well known in Canada. It is moderately abundant wherever it occurs but is usually mistaken for the young of northern pike. The following information is based largely on a study of this species in Jones Creek, Leeds County, Ont. (Crossman 1962a).

Grass pickerel, like the other esocids, are basically spring spawners, but the evidence of low intensity fall spawning is available for this species in Michigan, Oklahoma, Wisconsin, and Ontario. It is therefore probable that changing water temperature, upward in spring, downward in fall, is the stimulus to spawning, not just the increase in temperature. In spring adults proceed upstream and on to flooded stream margins or marshes where vegetation is plentiful. This movement takes place shortly after the ice is gone, and male grass pickerel, which precede females, may be the first species to move up the streams. Spawning takes place in late March to early May when water temperature is around 45°–53° F (7.2°–11.7° C). The spawning behaviour has not been observed, but it is assumed it is the same as in the other esocids. No nest is built; the eggs are broadcast and abandoned; they are demersal, slightly adhesive, and adhere to the vegetation. Eggs of three developmental stages are present in the ovaries and total egg count has been estimated at 15,732 for a 6.2-inch (157-mm) female in Michigan. Of these, about 800 were ready for spawning and 4000 and 11,000 were in two different recruitment stages. Mature eggs are transparent amber to yellow in colour and about 1.4 mm (to 2.5 mm elsewhere) in diameter. Eggs hatch in 11–15 days at water temperatures 46°–48° F

(7.8°–8.9° C), the young, at this time are 6.2 mm long, are inactive, remain near the bottom possibly attached to vegetation, and live 10–14 days on the yolk. After that time, they begin active feeding. Growth is rapid and by early June the young are 1.0–1.4 inches (26–36 mm) in length. Hubbs (1921) gave growth per day as 0.96 mm. By mid-September average length for Jones Creek young was 3.4 inches (87.9 mm). Age can be interpreted from the scales. Growth seems continuous and straight-line in nature, faster for females, which live longer and have a greater potential maximum size. Over ages 1–6, annual increment varies from 30 to 14 mm. Age–length relation for Jones Creek grass pickerel is as follows:

Age	Range of FL		Mean	
(*years*)	(*inches*)	(*mm*)	(*inches*)	(*mm*)
1	1.0–5.0	26–126	4.0	103.0
2	4.0–6.3	102–160	5.1	131.8
3	4.9–8.0	124–205	6.5	166.0
4	4.9–8.4	124–215	7.1	108.4
5	6.7–9.2	170–235	7.9	201.5
6	7.7–10.2	196–259	9.0	229.3
7	9.9–10.6	252–269	10.2	260.0

Sexual maturity is attained in females at a minimum of 6.2 inches (157 mm) fork length and by males at 5.5 inches (141 mm), which is usually at 2 years of age.

Maximum age in Canada would appear to be 6 or 7 years. Maximum size in Canada, a female from the Severn River populations, is 12.9 inches (328 mm) total length and a weight of 7.3 ounces (204 g). Trautman (1957) recorded maximum size in the United States as 15 inches (381 mm) in length and 14 ounces (397 g) in weight.

In Canada, the grass pickerel is a resident of small, slow moving, muddy, heavily vegetated lowland streams and the small pondlike expansions of the streams (often isolated) or overflow ponds of larger streams. It populates such streams, wherever habitat is suitable, anywhere from the mouth to the headwaters. More rarely it is found in quiet, weedy bays of lakes. The tolerance level of oxygen concentration has been recorded as 0.4–0.3 ppm in Michigan. The range of *p*H in Canadian habitats is 8.32–6.26.

The final preferred temperature was experimentally determined as 78° F (25.6° C); maximum temperatures of some habitats are as high as 84° F (28.9° C), and cruising speed was demonstrated experimentally to increase with increased acclimation temperature. The grass pickerel is therefore high-temperature adapted and this enables it to be successful in the conditions of high temperature, drastic decrease in water level, and minimum flow typical of its habitat. Young-of-the-year live in the shallows along the shore, but older fish are found in the deeper portions of the streams and ponds.

Food of very young grass pickerel (to 50 mm total length) is cladocerans, amphipods, osterocods, isopods, and immature or adult insects from the orders Diptera, Plecoptera, and Hemiptera. In the size range 2–4 inches (50–100 mm) they begin to prey on fishes, but the diet is mainly Trichoptera, Odonata, and crayfish. Beyond 4 inches (100 mm) the diet is almost exclusively fish and crayfish, but dragonfly nymphs form part of the food of even the largest individuals. *See* Crossman (1962a) for a complete analysis of stomach contents. In the Jones Creek habitat, 22 species of fishes were present, but grass pickerel fed on only 9 species in the following descending order of importance: central mudminnow, golden shiner, grass pickerel, white sucker, pumpkinseed, common shiner, creek chub, yellow perch, johnny darter. There was some evidence of selection of mudminnow over other more abundant species of fish (Crossman 1962b). Cannibalism was not extensive.

A broad complex of warmwater species (24 in Jones Creek) is usually associated with the grass pickerel. As young-of-the-year, they compete with most of them for food; as larger individuals they compete for food with other piscivorous predators such as catfishes, sunfishes, and the yellow perch. In turn, the young grass pickerel are preyed on by these same piscivorous predators, including grass pickerel to a slight extent. The adults may have few predators as the habitat largely precludes predation by birds and mammals.

The following parasites were listed by Crossman (1962a) for the Jones Creek popu-

lation: Fungi — *Saprolegnia parasitica*; Protozoa—Myxosporidia, *Scyphidia micropteri, Trichodina renicola;* Trematoda — *Macroderoides flavus, Azygia angusticauda, Centrovaruim lobotes, Crassiphiala bulboglossa*; Cestoda — *Proteocephalus pinguis*; Nematoda — *Spinitectus gracilis;* Mollusca — *Spinitectus* glochidia of *Scyphidia micropteri.* Only protozoan parasites seemed dense enough to endanger the well-being of individuals.

Hoffman (1967) listed the following for this species over the whole of its range: Protozoa (1), Trematoda (7), Cestoda (4), Nematoda (2), Acanthocephala (2), leeches (1).

The grass pickerel is known to hybridize in nature with the northern pike (infertile) and to intergrade with the redfin pickerel (fertile).

Relation to man This species, although abundant in certain localities (as high as 111 per acre in Ohio), is not often seen by man. Its small size and the nature of its habitat preclude it from becoming a sport fish in Canada. When seen, they are usually mistaken for the young of the northern pike and they are rarely, if ever, retained or eaten. They will take baited hooks and could provide enjoyable sport on very light tackle.

They are easily maintained in aquaria and make handsome aquarium fishes but usually require live fishes or crayfish as food.

Nomenclature

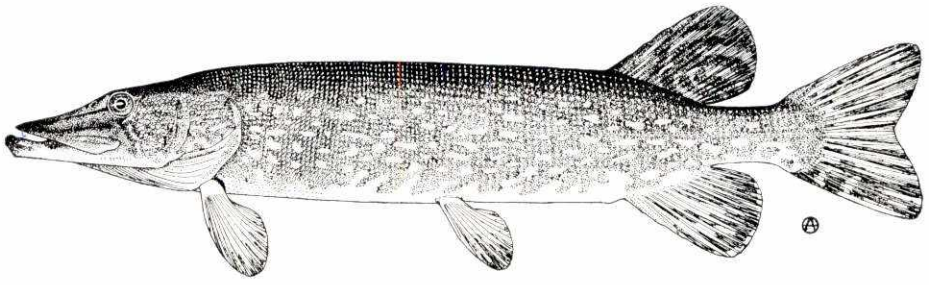
Esox vermiculatus	— LeSueur 1846 (*in* Cuvier and Valenciennes): 333 (type locality tributaries of the Wabash River near New Harmony, Ind.)
Esox umbrosus	— Kirtland 1854b: 79
Lucius vermiculatus	— Dymond 1922: 68
Esox americanus umbrosus	— Weed 1927: 23
Esox americanus vermiculatus	— Legendre 1952: V

Etymology *Esox* — an old European name for the pike; *vermiculatus* — vermiculated alluding to the wavy bars of the colour pattern.

Common names Grass pickerel, western grass pickerel, mud pickerel, little pickerel, pickerel, central redfin pickerel, grass pike, mud pike. (*See* Weed 1927: 42–43 for list.) French common name: *brochet vermiculé.*

NORTHERN PIKE

Esox lucius Linnaeus



Description Body very long, laterally compressed, only moderately deep, greatest body depth between paired fins 11.0–16.7% of total length, adults not so deep bodied as muskellunge, body cross section a deep oval, more or less flat on top behind head; caudal peduncle moderately long, 10.1–15.0% of total length, but not deep, 4.5–6.0% of total length; individuals are usually 18–30 inches (457–762 mm) in length. Head long, 25.2–30.4% of total length, flat and naked on top, very broad, interorbital width 18.6–25.1% of head length, cheeks usually fully scaled, operculum usually scaled on top half only but variable; eyes large, high and at centre of head, eye diameter 10.7–20.6% of head length; snout long, 42.5–46.8% of head length, but longer than postorbital head length, snout moderately broad and rounded on top; mouth large, horizontal, maxillary usually reaching at least to midpupil; short, sharp, recurved, cardiform teeth along the premaxillary and in patches on tongue, basibranchials, last two pharyngobranchials, vomer, and palatines, large, strong canines on head of vomer, inner edge of palatine tooth patches and on dentaries, those on dentaries flattened with sharp edges as well as points, other canines pointed but round and peglike; lower jaw often extends slightly beyond snout, undersurface of lower jaw usually pierced by 5 pores on each side (rarely 3, 4, or 6 on one side only). Gill rakers reduced to patches of sharp, radiating denticles on one or both sides of the arches. Branchiostegal rays usually 14 or 15 on each side, usually 7 on ceratohyal and 8 on epihyal. Fins: dorsal 1, soft rayed, far back, nape to dorsal origin 38.1–46.0% of total length, base shorter than height and about equal to snout length, upper edge rounded, 15–19 principal rays; caudal long, moderately forked, tips more rounded than the muskellunge; anal origin slightly behind that of dorsal fin, length of base less than height, less than base of dorsal fin, tip rounded, 12–15 principal rays; pelvics abdominal, low, and at middle of body, long, tips rounded and paddle-like, 10 or 11 rays; pectorals low, arising under edge of opercular flap, rounded and paddle-like, 14–17 rays. Scales cycloid and moderately small, 105–148 in the lateral series; lateral line complete, more or less straight, lateral line scales notched not tubed or pierced, very few notched scales elsewhere although golden fleck on exposed edge of most scales make them appear so; intestine long and undifferentiated, no pyloric caeca. Physostomous. Vertebrae 57–65.

Colour The basic colour arrangement of the northern pike is a pattern of light spots on a dark ground coat in contrast to the muskellunge, which is a pattern of dark markings on a lighter background. The dorsal surface, upper sides, and the top and upper parts of the head are dark, brilliant green through olive-green, to almost brown. The ground colour of the flanks is lighter, and in pike over 15 inches (381 mm) long, conspicuously marked with 7–9 irregular,

longitudinal rows of yellow to whitish, bean-shaped spots, some as long as the eye diameter. The body has the appearance of being flecked with gold, which results from a tiny gold spot on the tip of the exposed edge of most body scales. The ventral surface of body and head is cream to milk white with fingers projecting up into the ground coat of the flanks. These fingers are all that remain of the characteristic juvenile pattern of this species, long, wavy, white to yellow, vertical bars extending almost to the lateral line. It is these vertical bars that break up into the rows of spots in the adult pattern. Because of the distinctly different pattern, juvenile northern pike are often thought to be a different species and called grass pike. This leads to confusion with the smaller species, the grass pickerel.

The sides of the head are vermiculated with bright golden marks, the eye bars are inconspicuous. The eyes are a bright yellow. The dorsal, caudal, and anal fins are green to yellow or sometimes orange or pale red, blotched with large irregular black markings. The paired fins are usually unmarked and buff to dusky.

Juveniles have similar ground colour but the white of the ventral surface is carried dorsally in 8–12 irregular vertical bars. A mid-dorsal gold to green stripe and subocular bar present as in other esocids but less obvious.

Systematic notes The pike of Europe and of North America were long thought distinct. This concept resulted in many North American synonyms. The variability between eastern North America and western Europe is understandable when one considers its total distribution and the history of its dispersal. Northern pike in North America exhibit two morphological forms (Morrow 1964; McPhail and Lindsey 1970) probably resulting from postglacial expansion from both the Mississippi and Yukon–Alaska glacial refugia.

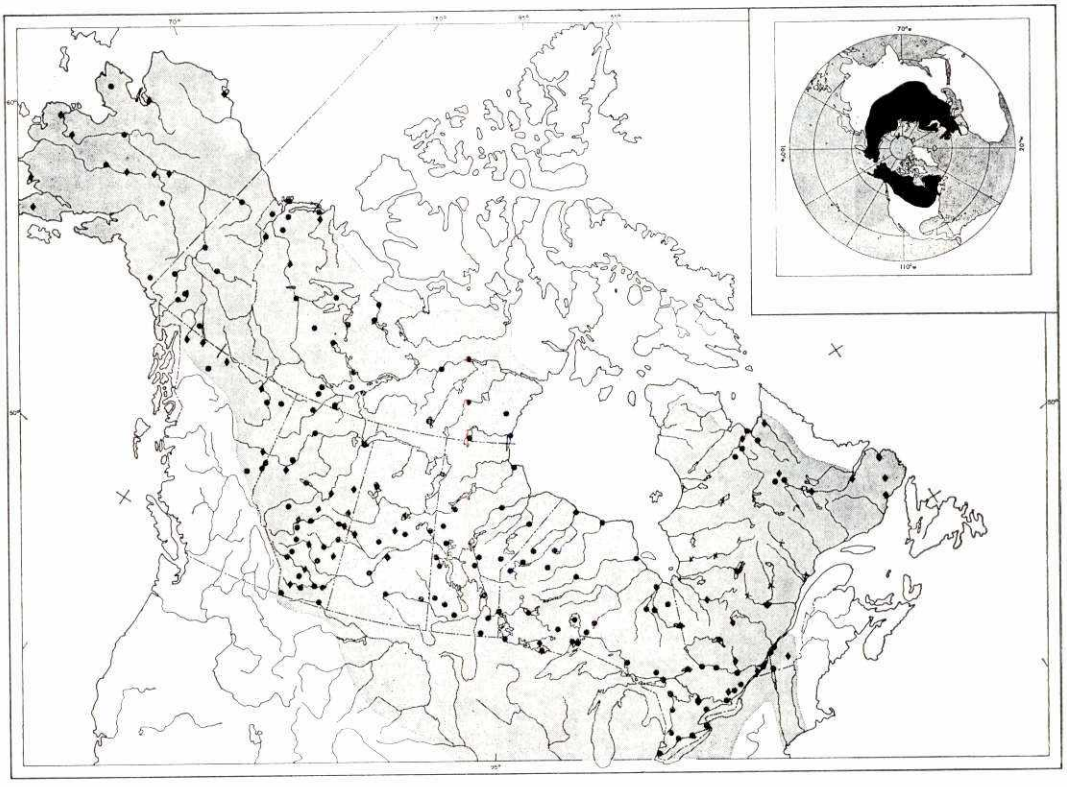
There was considerable confusion in the identity of the northern pike and the muskellunge in North America in the 1800's, and it is only with extreme care that one is able to determine which species was intended when such names as *Esox estor*, *E. nobilior* (and *E. nobilis*), and *E. lucioides* were used.

Distribution The northern pike has a circumpolar distribution in the northern hemisphere. It is primarily a freshwater fish but penetrates very weak brackish water in the Baltic Sea and elsewhere. It occurs in North America from Alaska south to Missouri and Nebraska east of the Rocky Mountains and west of the Appalachian Mountains. It occurs in Lake Champlain and the Hudson River and penetrates south, east of the Appalachian Mountains in the Connecticut River (introduced) in Vermont, New Hampshire, and central Massachusetts. It occurs generally in the United Kingdom and Ireland, all of Europe south to northern Italy, around the Dead and Caspian seas, northeast into Siberia, through the levels of lakes Balkhash and Baikal, and east to the Chukchi Penninsula. Absent from areas of northern and Arctic coastal plains in the USSR, Scandinavia, Canada, and Alaska. Replaced in certain watersheds in eastern North America by the muskellunge and in the Amur River, Siberia, by the Amur pike, *Esox reicherti*.

In Canada, it occurs from Labrador south of Ungava Bay, absent from the Maritime Provinces, present throughout Quebec, upstream in the St. Lawrence from the Nicolet River, throughout Ontario, Manitoba, Saskatchewan, and Alberta, in British Columbia restricted to the extreme northeastern corner, throughout the Yukon and Northwest Territories except for the northern and eastern coastal areas and the arctic islands. *See* McPhail and Lindsey (1970) for details of the distribution in northwestern Canada. It is one of the few species that can be said truthfully to occur throughout Canada.

It has been widely introduced outside its native range in North America to provide a large sport fish and as a control predator.

Biology The northern pike is a spring spawner and spawning takes place immediately after ice melts in April to early May, when water temperatures are 40°–52° F



(4.4°–11.1° C). The 1970 spawning run in Sibley Park (Lake Simcoe), Ont., began on April 11 with a single female, rose rapidly to a peak in numbers of fish by April 18, declined rapidly and ended by April 20. Mean water temperature over that period was 48.2° F (9° C). In general, this species spawns during daylight hours on the heavily vegetated floodplains of rivers, marshes, and bays of larger lakes. A spawning run of 6000 mature pike was tabulated in a single creek tributary to Waskesiu Lake, Sask. (Schultz 1955). The sexes pair at spawning time and a larger female is usually attended by one or

		Age (*years*)						
	TL	1	2	3	4	5	6	7
Georgian Bay, Ont.	*inches*	10.0–21.5	12.0–29.5	18.0–31.0	19.0–35.0	20.5–37.0	25.5–41.0	27.5–41.0
(Wainio 1966)	*mm*	245–546	305–749	457–787	483–890	521–941	648–1041	698–1041
	Wt (*lb*)	–	1.0–7.5	1.5–8.5	2.0–8.0	2.5–12.0	3.5–16.0	4.5–16.5
Waskesiu L., Sask.	*inches*	5.5–7.1	8.0–11.4	13.4–15.0	15.9–18.1	17.7–21.2	18.1–21.4	19.9–23.4
(Rawson 1932)	*mm*	140–180	205–290	340–380	405–460	450–540	460–545	505–595
	Wt (*lb*)	–	–	–	1.5	2.5	–	3.2
L. Athabasca,								
Sask. and Alta.	*inches*	3.6–5.0	5.2–7.8	7.1–11.2	9.9–13.6	11.4–15.3	13.7–18.9	15.7–20.4
(Miller and	*mm*	92–128	132–198	180–286	253–346	290–390	350–480	400–520
Kennedy 1948b)	Wt (*lb*)	.08	0.12	0.18	0.5	0.6	1.1	1.3
Great Bear L., N.W.T.	*inches*	3.3–4.3	4.6–6.9	6.5–10.4	9.1–13.1	11.8–16.2	13.4–18.5	15.7–20.9
(Miller and	*mm*	85–109	117–175	165–264	232–334	300–411	340–470	400–532
Kennedy 1948b)	Wt (*lb*)	0.1	0.3	0.4	0.6	1.0	1.4	2.0

two smaller males. They swim through and over the vegetation in water often no deeper than 7 inches (178 mm). At irregular intervals the male and female roll, approximate the vents, and eggs and milt are extruded simultaneously during rapid vibration of the bodies. Each spawning act is usually followed by a thrust of the tails, which moves the fish on and scatters the settling eggs. The act is repeated many times during the day for 2–5 days. No nest is built; the eggs are scattered at random, usually in numbers of 5–60 at each spawning act. The eggs, which are 2.5–3 mm in diameter, are clear, amber in colour, demersal, very adhesive, and remain attached to the vegetation of the spawning area. Egg numbers as high as 595,000 have been reported, egg number increases with size of female and has been estimated as 9000/pound female, with 32,000 eggs the average number for mature females. The number of eggs deposited is high, and egg fertility rate in nature is usually over 50%; the number of young resulting from them is very low. In one habitat in Michigan, this was estimated at 1800 young leaving the spawning grounds per million eggs laid, or 99.8% mortality.

Eggs usually hatch in 12–14 days at prevailing water temperatures but can hatch in 4–5 days at 64°–68° F (17.8°–20° C). At hatching, the young are 6–8 mm in length. They remain inactive, often attached to vegetation by means of adhesive glands on the head, for 6–10 days, and feed on the stored yolk. For details of eggs and early development of young, including drawing, *see* Fish (1932). Growth is very rapid, by the end of a month they are $1\frac{3}{4}$ inches (43 mm) in length and 6 inches (152 mm) by the end of the first summer. Growth in length continues rapidly during the first 1–3 years. Growth in length slows after sexual maturity is attained, but increase in weight rises. Growth is extremely variable from place to place over the extensive Canadian range depending on length of growing season, water temperature, and availability of food (*see* table pages 358 and 359). Many recent studies of growth and age determination by scales demonstrated that age interpretation is made very difficult as a result of local conditions, rate of growth, circuli number and presence of several types of false annuli (*see* Williams 1955; Wainio 1966; Casselman 1967).

Opercular bones and possibly other cranial investing bones may give more reliable results. Published figures on age–length and age–weight relations for several Canadian habitats are below.

There is a decrease in growth rate northward and a corresponding increase in longevity. Females grow faster than males in the south but this trait is not as apparent in the north. However, females over the whole range live longer and achieve a greater maximum size than males. There is a corresponding northward and sexual difference in age at attainment of sexual maturity. In the south of Canada, females mature at 3–4 and males at 2–3 years of age whereas in the north it is

Age (*years*)									
8	9	10	11	12	13	14	15	20	24
29.5–41.0	–	38.8–42.5	–	–	–	–	–	–	–
749–1041	–	990–1080	–	–	–	–	–	–	–
11.0–14.5	–	–	–	–	–	–	–	–	–
21.6–26.3	24.8–27.5	26.3–29.9	27.9–31.4	29.5–32.6	31.8–35.8	–	36.9–37.7	–	–
550–670	630–700	670–760	710–800	750–830	810–910	–	940–960	–	–
–	–	6.5	–	–	12.0	–	17.0	–	–
17.7–23.2	18.5–25.6	20.4–27.9	22.8–28.3	25.2–31.8	26.7–33.8	28.3–35.4	30.3–36.5	40.4–40.9	45.9
450–590	470–650	520–710	580–720	640–810	680–860	720–900	770–930	1020–1050	1160
2.3	3.2	4.0	5.2	6.3	7.6	8.7	9.6	21.0	31.2
18.9–24.0	21.6–26.3	23.6–29.1	25.2–29.9	27.1–30.1	29.5–31.0	30.7–32.6	31.8–34.2	–	–
480–610	550–670	600–740	640–760	690–765	750–790	780–830	810–870	–	–
2.8	3.7	4.5	5.6	6.8	7.3	9.0	10.0	–	–

age 6 for females and age 5 for males. Life expectancy in fast-growing southern Canadian populations can be as low as 10–12 years and in slow-growing arctic populations as high as 24–26 years.

The angler record for northern pike in North America is one of 46 pounds 2 ounces weight and 52½ inches (133.3 cm) length, which was caught in Scanandaga Reservoir, N.Y., in September 1940. In notes of the late J. R. Dymond, written in the 1940's, there was a comment that "Dr. R. B. Miller said he had an authentic record of a 55 pound pike from an Alberta lake." Keleher (1961) reported the largest Canadian pike as 49 pounds, taken from Lake Tschotogama, Que., in 1890. The angler record for Canada is often cited as one caught in Stoney Rapids, Sask., in 1954, which weighed 42 pounds 12 ounces.

Pike are considered to grow much larger in Europe than in North America. European stories of ancient pike and of individuals over 100 pounds are largely fanciful and in the same category as stories of pike that pulled mules and milk maids into ponds. The most legendary is the Mannheim Hoax or Emperor's Pike. This story first related by Gesner in 1558, told of a pike 19 feet (579.5 cm) long, weighing 550 pounds, which was caught in a lake at Württemberg in 1497. This monster was said to have an engraved copper ring *around the gill region* that told of its release there 267 years earlier by Emperor Friederick II. The skeleton, preserved in the Cathedral at Mannheim, was found to contain vertebrae of several individuals. Because of the difficulty of authenticating records of large pike, the world record is contested by the following: a pike that weighed 53 pounds, was 51 inches (129.5 cm) in length and 36 inches (915 mm) in girth, caught in Lough Conn, Ireland, in 1920; a reportedly authentic, Scandinavian pike of 57.2 pounds caught in 1892, and the 74.8-pound pike reported by Berg (1948). Berg also recorded the maximum weight of this species as 143 pounds. This is doubtless an uncritical quotation of some of the fanciful individuals in the European literature. Buller's (1971) list of large British pike included at least eight individuals that equal or exceed the North American record.

In Canada, the habitat of the pike is usually clear, warm, slow, meandering, heavily vegetated rivers or warm, weedy bays of lakes. They do, however, occur in a wide range of habitat over the whole of their extensive distribution. They generally occur in shallower water in spring and fall but move to deeper cooler water at the height of summer temperatures. The young remain in the shallow spawning areas for several weeks after hatching. Some published reports have related to extensive movement of pike in spring (spawning migration) and fall. In general, northern pike are fairly sedentary, establishing a vague territory where cover and food are adequate. Most often, northern pike, especially the young, are taken in the top 15 feet of water. They have been taken in Lake Nipigon, Ont., in late summer from depths over 100 feet. They are active and feed (to a lesser degree) in winter and are an important ice fishing quarry. They occur in alkaline lakes with total alkalinities as high as 1000 ppm and *p*H as high as 9.5 in Nebraska, and salinities as high as 1.6% in Saskatchewan. High alkalinity can reduce or prevent spawning and has a greater effect on the young than on adults. The northern pike is usually classified as a primary freshwater species but salinities of 18‰ will kill it. It is known to occur in salinities as high as 10‰ in the Baltic Sea and to be able to reproduce in salinities as high as 7‰.

After the yolk is absorbed, young pike feed heavily on larger zooplankton and some immature aquatic insects, for 7–10 days. At this point, small fish enter the diet and by the time the young reach 2 inches (50 mm), fish assume predominance. Adult pike can be classed best simply as omnivorous carnivores in that they eat virtually any living vertebrate available to them within the size range they can engulf. The optimum food size has been calculated at between one-third and one-half the size of the pike. Food selection by species is not apparent and the direct relation between size of food item and size of northern pike is apparently not so pronounced as in the case of the muskellunge. The northern

pike would seem to be an opportunist and to feed on whatever is most readily available. Whereas the food of adults over the whole season is over 90% fish, adults do at times feed heavily on frogs and crayfish. Other vertebrates such as mice, muskrats, and ducklings often enter the diet. Lawler (1965b) gave a complete analysis of the food of this species in Heming Lake, Man. The amount of food consumed seems staggering. Toner (1959) estimated that 2594 pike ate, in one year, 112.5 tons of brown trout as well as a smaller amount of perch. Lagler (1956) estimated that an average of 1.5 million water fowl were eaten by northern pike on a single wildlife refuge in Michigan although fish were the main item of food. It has been estimated that it takes 5–6 pounds of food for each pound increase in body weight of a northern pike. This figure and the potential maximum weight indicates the effect by predation of this species on the other vertebrates in its habitat.

Earlier spawning, faster growth, early dominance of fish in its food, and better food conversion are cited as the contributing factors in the success of the northern pike over the muskellunge when they occur together. Young and older pike consume the young muskellunge, and the pike at all ages is a direct and more successful competitor of the muskellunge for space, food, and spawning sites. It is also a predator on, or a competitor for food with, many other predaceous, sometimes economically more important, fishes such as the basses (*Micropterus* spp.) and walleyes (*Stizostedion* spp.).

The eggs and young of the northern pike are prey to a wide variety of other fishes, including northern pike, minnows, and perches; of the large larvae of various aquatic insects; of waterfowl and other diving birds, and of aquatic mammals. Mortalities on the spawning grounds of eggs and young by predation, or by stranding due to lowering water levels, have been estimated as high as 99%. Adult pike are large enough and secretive enough that lampreys and man are probably their only important enemies. During spawning when the adults are in very shallow water and are unwary, the smaller ones are taken by bears, dogs, eagles, and ospreys.

The northern pike is host to a vast assemblage of parasites. Toner (1966) in his summary of information on the pike listed almost a full page of published records. Hoffman (1967) listed the following parasites for this species in North America: fungi (1), Protozoa (19), Trematoda (48), Cestoda (13), Nematoda (23), Acanthocephala (18), leeches (4), Mollusca (2), Crustacea (10). (*See also* Hunter and Rankin 1939.)

The parasite most often seen and of concern to anglers is the strigeid fluke *Uvulifer ambloplitis*. The externally encysted stage of this trematode, called black-spot (Crossman 1962d), is often present in extreme numbers on individual pike. This parasite is not transferrable to man, is readily killed by adequate cooking or removed by skinning rather than scaling the fish.

This species also suffers from a septicaemic "red sore" disease caused by the bacterium *Pseudomonas hydrophila*, which is also responsible for the condition in frogs known as "red leg." In northern pike it results in ugly red necrotic lesions involving the muscle tissue (Margolis 1951). The pike also are subject to neoplastic tumors that are true cancerous lymphosarcoma. Both render the fish very unsightly and cause great concern to those who catch infected fish. Neither of these "diseases" is known to be transferrable by contact to man. Infected fish should not, however, be returned to the water. Two tapeworm parasites, *Diphyllobothrium latum* and *Triaenophorus crassus* have a direct and indirect effect on man (*see Relation to man* section).

In various parts of North America, the northern pike hybridizes with the muskellunge, the chain pickerel, the redfin pickerel, and the grass pickerel. If there is any fertility in such hybrids it is only in the females. The northern pike × muskellunge hybrid, now known as tiger muskellunge, is said to demonstrate hybrid vigor in growth, body proportions, and activity. For these reasons it is a better sport fish and is now cultured and released for this purpose.

A mutant form of the northern pike, now called silver pike, first reported by Prince

(1898) from the area near Sharbot Lake, Ont., is now known to occur sporadically throughout the world distribution of the northern pike. It is unique in that it has none of the white to yellow spots characteristic of this species, the ground colour is metallic blue, metallic green, or bright silver. It is otherwise indistinguishable from the northern pike except in apparent increased hardiness (*see* Lawler 1960).

Relation to man Few fishes enjoy as ambiguous a relation to man as does the northern pike. In most areas of Canada, it is both a commercial fish and a sport fish and consequently not protected by game laws. In some areas, it is looked upon as a nuisance and a destroyer of more important species, whereas in others it is one of the sport fishes that annually attract large numbers of anglers and dollars. It is a delicious food; the flesh is sweet, white, and flaky. If properly prepared, best after skinning, there is rarely any so-called muddy flavour often attributed to it in summer. This unwanted characteristic may result from the heavy pigment and mucus of the skin if the fish is prepared for cooking by superficial and hurried scaling. The northern pike is also the host of two troublesome parasites. The broad fish tapeworm *Diphyllobothrium latum* in certain areas infects this species and if the flesh of the fish is inadequately cooked, then eaten, this parasite can be transferred to man (*see* Roussow 1960). Another parasite, the cestode *Triaenophorus crassus*, for which the northern pike is the final host, encysts at an earlier stage in the musculature of the lake whitefish rendering the flesh of that species unacceptable by law for human consumption. Annually, thousands of pounds of whitefish, most often after capture and processing, must be discarded as a result of this parasite (*see* lake whitefish; Lawler and Scott 1954).

The northern pike has always been an important commercial fish but a small percentage of the total commercial catch. As is the case with most Canadian fishery products, often as much as 80% of the annual Canadian landings are exported to the United States. The marketed catch in the years 1913–24 fluctuated between 3.7 and 7.7 million pounds with an average of 5.58 million pounds. The annual commercial catch in the United States at this time ranged between 3.22 and 6.06 hundred thousand pounds.

The price to the fisherman in 1924 fluctuated between 3.6 and 5.8¢/pound. In 1967 the commercial catch in Canada was approximately 7.4 million pounds with a landed value of $481,000, which represents 15.5¢/pound.

In 1966 the total commercial catch of this species in Ontario alone was just over one million pounds with a market value of $84,962.05. It ranks fourth by weight (after whitefish, lake trout, and walleye) in the list of commercial species taken in Saskatchewan where approximately 1 million pounds are marketed annually; 2–3 million pounds are harvested annually in Manitoba. They are part of the summer commercial catch in most areas and in the northwest they are taken by gillnets under the ice in winter. Northern pike are usually sold commercially fresh, either live, in the round, or headed and gutted, rather than as fillets.

Standing crop of pike in various habitats across North America probably ranges from 8 to 25 pounds per acre. The maximum standing crop is that of 50.3 pounds per acre reported from an unexploited, newly flooded impoundment in Iowa (Threinen et al. 1966).

As a sport fish, the northern pike can provide considerable enjoyment. It is usually taken by trolling with large spoons, plugs, bucktail spinners, large bait fishes, or worm harness. Casting the same types of lures into or near weed beds yields good results and still fishing in deeper water off the edge of weed beds is usually best in the middle of summer. Angler success is usually rated at 1.8–2.2 fish/hour in good areas. The usual size caught by anglers is 18–22 inches, but in northern Canada numbers of northern pike up to 42 pounds are caught annually. In some northern areas, catches of 10–20 fish weighing in the aggregate over 200 pounds can easily be taken in a few hours. Unlike the muskellunge, hooked pike fight in the depths rather than by jumping out of the water. They are an important sportfish in the winter

fishery through the ice as well. They are caught ice fishing with live or salted baitfish or by jiggling artificial lures.

Pike are also used as a farm pond species in warmer water, often in combination with bluegills. They are looked upon as good natural control of the numbers of smaller species to prevent overpopulation and stunting. They are propagated and reared in enclosed areas for food in Europe.

Nomenclature

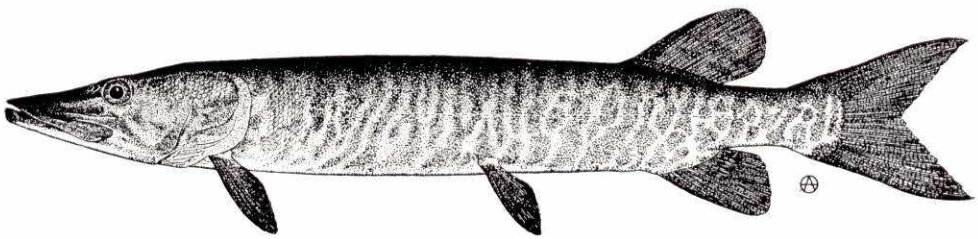
Esox Lucius	— Linnaeus 1758: 313 (type locality Europe)
Esox estor	— LeSueur 1818b: 413
Esox Lucius	— Richardson 1823: 716
Esox lucius (Linn.)	— Richardson 1836: 124
Esox Boreus	— Aggasiz 1850: 317
Esox lucioides	— Aggasiz and Girard 1850: *in* Herbert (1850): 154
Esox lucius var. *estor*	— Jordan 1876: 255
Lucius lucius	— Jordan and Evermann 1896–1900: 628

Etymology *Esox* — an old name for the pike in Europe; *lucius* — the supposed latin name for this species.

Common names Northern pike, pike, great northern pike, jack, jackfish, pickerel, great northern pickerel. *See* Weed (1927), and Buss (1961) for lists of regional common names. French common names: *brochet, grand brochet.*

MUSKELLUNGE

Esox masquinongy Mitchill



Description Next to sturgeons this is Canada's largest freshwater fish. Previously known to exceed 6 feet (183 cm) in length and 100 pounds in weight, muskellunge are now most often seen in the length range of 28–48 inches (711–1220 mm) and weights of 5–36 pounds. Body long, moderately laterally compressed, moderately deep and wide in large adults, greatest depth 10.3–16.3% of total length (young-of-the-year are longer and more slender), cross section a long oval, flat on top ahead of dorsal fin; caudal

peduncle fairly deep for length, depth 4.6–7.1% of total length. Head long, 23–25% of total length, massive in large individuals and wide, interorbital width 18.1–23.7% of head length, flat to concave and naked on top; cheeks and opercles usually scaled only on upper half but variable; eyes high, large, 9.7–13.1% of head length, at centre of head; snout long, 42.9–47.2% of head length, broad, appears longer and narrower in first 2 or 3 years; mouth horizontal, large, maxillary extending to midpoint or posterior edge of pupil; short, sharp, recurved cardiform teeth along the premaxillary and in patches on tongue, basibranchials, last two pharyngobranchials, vomer, and palatines, large, strong canines on head of vomer, inner edge of palatine tooth patches, and dentaries, those on dentaries flattened with sharp edges as well as tips, other canines pointed, but round and peglike; lower jaw often slightly longer than snout, undersurface of lower jaw pierced by 6–9 pores on each side (rarely 5 or 10 on one side only). Gill rakers reduced to patches of sharp, radiating denticles on one or both sides of arches. Branchiostegal rays 16–19 on each side, usually 8 on the ceratohyal and 10 on the epihyal. Fins: dorsal 1, soft rayed, far back, nape to dorsal origin 40.6–50.6% of total length, base shorter than height of fin, fin height slightly greater than snout length, tip rounded, 15–19 principal rays; caudal long, deeply forked, tips pointed; anal origin slightly behind origin of dorsal, near anus, base and height less than those of dorsal fin, edge less rounded, principal rays 14–16; pelvics abdominal, at midpoint of body, low, pointed, 11 or 12 rays; pectorals low, arising under edge of opercular flap, rounded, paddle-like, 14–19 rays. Scales rather small, cycloid, 132–167 in the lateral series; lateral line present, complete, lateral line scales notched not pored or tubed, few if any notched scales elsewhere; intestine long, undifferentiated, no pyloric caeca. Physostomous. Vertebrae 64–66.

Colour The overall colour scheme in the muskellunge can be generally characterized as extremely variable, but with consistent dark markings on a light background, in contrast to the northern pike, which has light markings on a dark background. There is considerable variability between individuals in the same area, and between areas, in ground colour and in the nature of the dark markings.

In adult muskellunge the back, head, and upper sides are iridescent green-gold to light brown, the flanks range from green, through green-gold to brownish, to grey or very silvery. Often in very silvery specimens, no dark markings, or only vague suggestions of dark markings, are visible. In the others the brown to black markings of the flanks take the form of spots, prominent vertical bars, blotches, vermiculations, or combinations of two or more of these.

All dark patterns are represented with different frequencies in all areas. The only distinctions that can be made are that muskellunge in the St. Lawrence River–Great Lakes exhibit the spotted pattern with far greater frequency than those in the other areas; and there is a slight tendency for western fish to be clear of markings. This latter tendency is greater everywhere in the largest specimens, a silvery overlay hides the pattern. The pattern, however, is present and is more obvious after death or preservation. *See* Hourston's (1955) complete analysis of the relative occurrence of pattern types in three Canadian areas and the difficulty of assigning any pattern to any area.

The ventral surface is cream coloured to milk-white with small brown to grey spots or blotches. The head, dark above, paler on the sides, is marked with spots or by several dark bars radiating from the eyes. The fins are greenish or buff to red-brown, with dark blotches, blotches more prominent on unpaired than on paired fins. Unpaired fins are often bloodred on capture from nets or angling as they apparently hemorrhage very easily during the vigorous activity associated with boating a large individual.

Young-of-the-year, less than 6 inches (152 mm) in length, which are pencil shaped, are distinctively marked on the sides with scalloped black to blue-green on back, head, and upper sides, and white to buff below. They also have the characteristic gold to gold-

green mid-dorsal stripe so characteristic of the young of this family.

Systematic notes The muskellunge exists in semidiscrete populations: (1) St. Lawrence River–Great Lakes and tributaries; (2) Ohio River and tributaries; (3) Wisconsin, Minnesota, northwestern Ontario, and southeastern Manitoba. As a result of supposed morphological differences and supposed distinct patterns, muskellunge in these areas were originally described and considered as distinct species and later considered subspecifically distinct: (1) *E. m. masquinongy* — spotted; (2) *E. m. ohioensis* — barred or diffuse spots and blotches; and (3) *E. m. immaculatus* — no pattern or barred. A study published by Hourston (1955), which did not include the Ohio River form, suggested differences in the populations in the St. Lawrence and in western Ontario but emphasized the difficulty in recognizing subspecies in the muskellunge. The tendency since that time has been to treat it as a single variable species.

The situation is greatly clouded now as a result of fish cultural activities and extensive plantings. The Ohio River type has been liberated in Lake Erie and in Quebec.

The literature on this species in the late 1800's is a morass of confusion. The muskellunge was poorly known; descriptions were fragmentary; the muskellunge was repeatedly confused with, and scientific and common names interchanged with, the northern pike; and figure captions were repeatedly reversed. It is only with great care that one is able to sort out what was intended by various early authors when they used such names as *Esox estor*, *Esox nobilior* (or *nobilis*), and *Esox lucioides*.

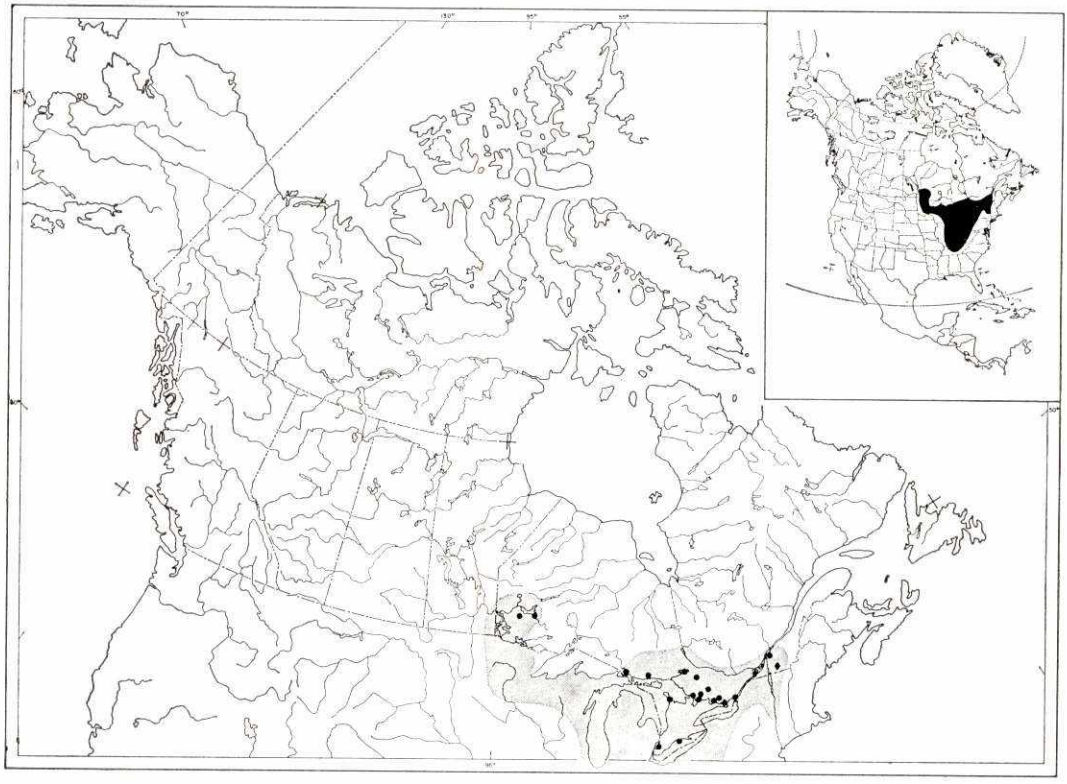
Another name, *Esox amentus*, was introduced in the sporting literature (Godfrey 1945) as that of the True Tiger Muskellunge from lakes in the Sioux Lookout area of northwestern Ontario. The fish in question was a northern pike × muskellunge hybrid with the characteristics and pronounced bars of that combination. The true muskellunge in Minnesota had long been called tiger musky. As a result of Godfrey's popular account, a study was carried out and Cameron (1948) described and documented the hybrid from the Sioux Lookout locality. Bishop (1946) commented on the introduction of the name into the literature.

Distribution This species is restricted to the fresh waters of eastern North America. Its range extends south from Quebec, through western Vermont, south, west of the mountains to Tennessee; north, avoiding the main stem of the Mississippi, through eastern Illinois (rare) into Wisconsin, Minnesota, western Ontario, and extreme southeastern Manitoba. Liberated elsewhere to the south and west in the United States but not always successful.

In Canada the muskellunge occurs in lakes and rivers from southern Quebec, the St. Lawrence and its north and south tributaries from the area of Trois Rivières (Rivière Bécancour) upstream; the Ottawa River and some of its tributaries north to about the level of Lake Nipissing; throughout the lower Great Lakes and parts of such tributary systems as the Trent and Severn rivers; north, including Lake Nipissing to near Sault Ste. Marie. Absent from the north shore of Lake Superior (present in some south shore tributaries) and from the area west to Rainy Lake. Present but less abundant in the area from Rainy Lake to Lake of the Woods, more abundant in Lake of the Woods and the English River, north to the Sioux Lookout area. It has been introduced in eastern Manitoba and has recently spread naturally into that province.

Older records (Radforth 1944) for the north shore of Lake Superior near Schreiber, and north in the Ottawa River to Lake Abitibi were probably based on sporting magazines and unauthenticated replies to a questionnaire.

Biology The muskellunge is a spring spawner. Unlike the smaller members of the family there has been no report of its spawning in the fall. It spawns shortly after the ice has melted (but later than the northern pike) usually in late April or early May when the water temperature is 49°–59° F



(9.4°–15°), but optimum temperature is 55° F (12.8° C). Spawning takes place in water 15–20 inches deep in heavily vegetated flooded areas. During the spawning period the fish pair off, usually a larger female is accompanied by one, or at times two, smaller males. They swim about over the vegetation during the day, and at intervals the fish roll so that the anus of male and female are approximated; a small number of eggs and sperm are shed simultaneously during rapid vibration of the bodies; the lashing of the tails spreads the fertilized eggs and the pair swim on. The spawning act is carried out many times at irregular intervals over several days. No nest is built, the semidemersal, apparently nonadhesive eggs, are scattered at random and drop into the vegetation. Spawning usually lasts no more than a week. The number of eggs increases with size of the female and ranges from about 6000 to 265,000 with the usual number about 120,000. Fertilized eggs are 2.5–3.5 mm in diameter, clear, and amber coloured. Hatching occurs in 8–14 days at water temperatures of 53°–63° F (11.7°–17.2° C). Often only 34% of the eggs spawned naturally are fertile whereas fertility of eggs reared in a hatchery is often as high as 95%.

On hatching, the young are 9.5–10.3 mm in length and may, in nature, remain dormant in the vegetation for about 10 days or until the yolk is consumed, at which time they become active and begin feeding. For details of egg and early development of the Ohio River type (Chautauqua Lake) including drawings, *see* Fish (1932).

Growth in the first season is rapid, by 10 weeks of age muskellunge are approximately 6 inches (152 mm) in length. By November of the first year they are 10–12 inches (254–305 mm) in length. Growth is rapid in the first few years also. Rate of increase in length slows as sexual maturity is achieved, but rate of increase in weight continues virtually into old age. Growth rate varies from locality to

locality depending on the availability of food fishes of the appropriate size. Growth rate in various Canadian localities was given by Hourston (1952). Mean fork length at various ages for the St. Lawrence River population was given as follows:

Age (*years*)	Mean FL (*inches*)	Mean FL (*mm*)	Avg wt (*lb*)
2	18.4	476	1.4
3	23.1	587	3.2
4	27.2	692	5.8
5	31.4	798	8.7
6	32.4	824	9.9
7	34.5	876	11.8
8	37.6	956	15.8
9	41.6	1056	21.3
10	44.7	1137	25.3
11	44.3	1125	28.0
12	43.0	1093	24.9

There is striking sexual dimorphism in growth; females grow faster than males, are larger at any age, live longer, and consequently all the notable-sized muskellunge are females. Sexual maturity is reached between 3 and 5 years, with the males maturing at a smaller size but with no apparent difference between the sexes in age at attainment of maturity. Most growth tables are limited by adequate representation to 12–15 years of age, but the record catches are all much older. The present angler record is a muskellunge 64.5 inches (163.8 cm) in length, 31.75 inches (80.6 cm) in girth, which weighed 69 pounds, 15 ounces. This fish was caught in the St. Lawrence River in September 1957. Extrapolating Hourston's (1952) age–length curve yields an estimated age of 22 years. Smaller muskellunge have been aged at 21 years and Oehmcke et al. (1958) referred to age determinations in excess of 30 years. Most fish seen by anglers are in the range of 30–46 inches (76.2–116.8 cm), weigh 8–36 pounds, and are 3–15 years old. The oft-quoted but unauthenticated maximum size is said to be a muskellunge that weighed 102 pounds, netted in the early 1900's in Wisconsin. Carlander (1969) stated that the report of a muskellunge purported to have weighed 109.7 pounds and to have been 88 inches (223.5 cm) in length was a hoax.

The habitat of the muskellunge in Canada is warm, heavily vegetated lakes, stumpy, weedy bays, and slow, heavily vegetated rivers. It is so regularly found among dense growths of one or more of several species of pondweed (*Potamogeton* spp.) that anglers refer to these aquatic plants as "lungeweed". Other than the largest individuals, the muskellunge is rarely found far from the protection of growths of emergent and sub-emergent plants such as water lilies, pickerel weed, arrow leaf, coontail, cattail, and pondweed, or areas of drowned timber and stumps. Water temperature up to 78° F (25.6° C) would appear to be optimal but this species can withstand water temperatures as high as 90° F (32.2° C). They can apparently withstand the low summer oxygen levels of these sluggish, shallow habitats. Very large individuals are often found in or over deeper, less vegetated water and to a depth of 50 feet. Other than at spawning time, muskellunge are solitary, sedentary animals lurking in concealment in the vegetation or near stumps. They move little, other than to dart swiftly after single prey fishes, which they often carry back to the protective area before swallowing.

The young, as soon as they become active, begin feeding voraciously on larger zooplankton, usually cladocerans. This ration continues for 1–3 weeks and the fish then utilize some plankton and some small fishes. Usually after a length of 1.5 inches (38 mm) is attained the diet is fish alone. There appears to be a direct relation between size of muskellunge and the size of food fish selected. Growth and survival of larger muskellunge is often impaired if food of an adequate size is not available, in spite of vast numbers of smaller fishes. A wide variety of warmwater fishes such as perches, suckers, larger minnow species, mooneyes, catfishes, and sunfishes are usually represented in the diet depending on the fauna associated with the muskellunge in any habitat. As with other pikes they seem invariably to strike prey fishes so as to take them sideways in the mouth. They often retreat to protection with the fish so impaled on the large canines. The food item is then rotated and swallowed head first. Since a large part of the food is large

spiny-rayed fishes, this habit facilitates the collapse of the spiny rays during the process of engulfing the food. Fishes form by far the largest part of the diet of larger muskellunge but practically any living animal, including crayfish, frogs, muskrats, mice, shrews, and a variety of waterfowl (young and adult) have been recorded from the stomachs of this species. *See* Hourston (1952) for a quantitative and qualitative analysis of food. The supposed voracity of muskellunge, which have been, like northern pike, referred to as water wolves, is legendary.

Many species of fishes prey on the very young, nearly immobile muskellunge and these include northern pike, muskellunge (rarely), yellow perch, basses (*Micropterus* spp.), rock bass, and sunfishes. In hatchery situations, and possibly in nature as well, diving beetles, electric light bugs, and the large larvae of some aquatic insects are significant predators on newly hatched muskellunge. In situations where earlier-hatching northern pike and muskellunge cohabit and utilize the same spawning areas, predation of muskellunge hatchlings by pike fingerlings is considered to be a major reason for the failure of the muskellunge to survive this contact. Larger muskellunge are nearly free of predation except possibly by large birds of prey and bears. The great size of some spawners, the high regard in which the fish is held, the shallow water of spawning sites, and the loss of wariness at spawning time make the muskellunge easy prey to disastrous reduction of numbers by poaching. This is an annual problem in many areas.

The habit of spawning on flood plains may, at times, constitute a serious limiting factor for this species. Even slight decreases in water level in those areas can result in the stranding and death of spawners or young. More drastic changes in level can expose the developing eggs.

The muskellunge and the northern pike often hybridize in nature, producing a shorter, more robust fish with very pronounced barred marking of the muskellunge parent. The males are always sterile but female hybrids are often fertile. This fish is now referred to as the tiger muskellunge, a term previously used for the prominently striped muskellunge characteristic of some areas of Wisconsin and Minnesota. Hybrid vigor in this cross is said to result in a fish of better sporting qualities than the northern pike, but able to live where the muskellunge cannot, and it is being cultured and liberated in the United States. A study of this hybrid in western Ontario was carried out in 1946 (Cameron 1948).

Hoffman (1967) listed the described parasites of the muskellunge as follows: Protozoa (8), Trematoda (9), Cestoda (4), Nematoda (6), Acanthocephala (4), Mollusca (1), Crustacea (4).

Both the muskellunge and the northern pike are subject to lymphosarcoma which, at times, result in large, most unsightly, open, red, cancerous tumors. The role of the tumors in the spread of the condition is not fully known. Care should be taken handling tumorous fishes and they should not be returned to the water.

Relation to man The anticipation of the possibility of capturing a world's record muskellunge (which now would have to exceed 70 pounds) or even a single, legal-size fish (30 inches or 762 mm total length), annually draws thousands of anglers and their families to the known haunts of this species. To a vast and devoted coterie of avid muskellunge anglers, pursuit of Canada's largest true freshwater sport fish provides the peak of aesthetic enjoyment in beautiful outdoor surroundings. To a wide variety of others — guides, boat and motor sales and rental agencies, tourist operators, and merchants — the pursuit of the muskellunge means cash incomes. There has never been an accurate economic appraisal of the muskellunge fishery, but it would be safe to say that it contributes several million dollars annually. It is usually estimated that the capture of a legal muskellunge requires 100 man-hours of angling. The yearly catch in Pigeon Lake (Kawartha Lakes, Ont.) alone was estimated (Spangler 1968) at 895–2505. It has been reported that in 1955, 75,000 pounds of muskellunge were captured by anglers in Ontario

alone. These figures readily yield estimates of both the enjoyable, and sometimes frustrating, hours of recreation and the cash benefit derived from the fishery for muskellunge. The good possibility of a 10- to 49-pound catch, the excitement of the strength and the aerial acrobatics of a hooked muskellunge, which may take up to an hour to land, is a thrill no angler forgets. Muskellunge are usually sought by trolling a very large artificial lure (up to 12 inches in length) such as a plug, bucktail spinner or spoon, or a large, live bait fish such as a perch or sucker. The other chief and often more enjoyable means used is casting such artificial lures or live bait in and around the weeds or stumps of a typical muskellunge habitat. The muskellunge moves very little so still fishing is usually of no avail.

Muskellunge were not always exclusively sport fish. The size of the fish and the high quality of its flesh made it very acceptable as a commercial species. Between 1870 and 1900 thousands of pounds were marketed annually in Quebec and Ontario. The Ontario statistics for 1890 listed a commercial catch of 651,406 pounds and noted that most of the catch was from Lake Scugog. A commercial catch record for Lake Simcoe in 1868 listed 229,050 pounds.

Commercial fishing was ended by 1904 in Ontario in the face of drastic increase in angling interest and intensity and decrease in catch. It continued in Quebec at least until 1936 (Dymond 1939). Over the years, legislation gradually added season, size, daily bag, and possession limits until today this species can be taken generally only in July–October, in excess of 30 inches (762 mm) total length and in numbers no greater than two per day per angler. In addition to protective regulations, a hatchery in Quebec and one in Ontario attempt to support the number of muskellunge available to the angler. Eggs and milt are taken from wild fish, the eggs reared in the hatchery, and the young in hatchery ponds. The problems of providing the live fishes required for food by young pond-reared muskellunge — 6 million food fish to produce 8000 muskellunge averaging 9 inches (229 mm) in length — dictate that they be released into natural waters as quickly as possible.

The flesh is highly flavourable, white, and flaky. Larger muskellunge, if not saved for mounting, are usually baked, poached in butter, or steaked and fried, but the smaller ones are said to be more flavourful if fried fish is desired. The best results are achieved if the fish is skinned, for the heavy mucus over the skin probably contributes what some people term a muddy flavour in midsummer.

Nomenclature

Esox masquinongy	— Mitchill 1824: 297, *from* DeKay 1842: 222 (type locality Lake Erie)
Esox estor (LeSueur)	— Richardson 1836: 127
Esox nobilior	— Thompson 1850: 163
Esox nobilis	— Kirtland 1854b: 79
Lucius masquinongy (Mitchill)	— Jordan and Evermann 1896–1900: 629
Esox immaculatus Garrard	— Weed 1927: 30
Esox masquinongy masquinongy Mitchill	— Hubbs 1926: 53
Esox amentus	— Godfrey 1945: 36

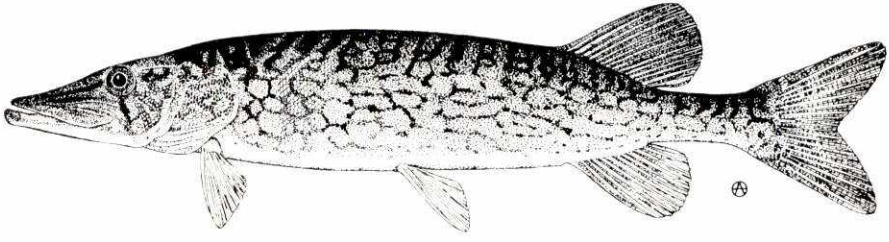
Etymology *Esox* — a European name for the pike; *masquinongy* — variously given as from the Indian through French phonetic spelling. The two most often quoted derivations are mashk — deformed, and kinonjé — a pike —; and mis or mas — large, and kenosha — a pike.

Common names Muskellunge, maskinonge, Great Lakes, Ohio, Wisconsin muskellunge, musky, lunge, tiger muskellunge. French common name: *maskinongé*.

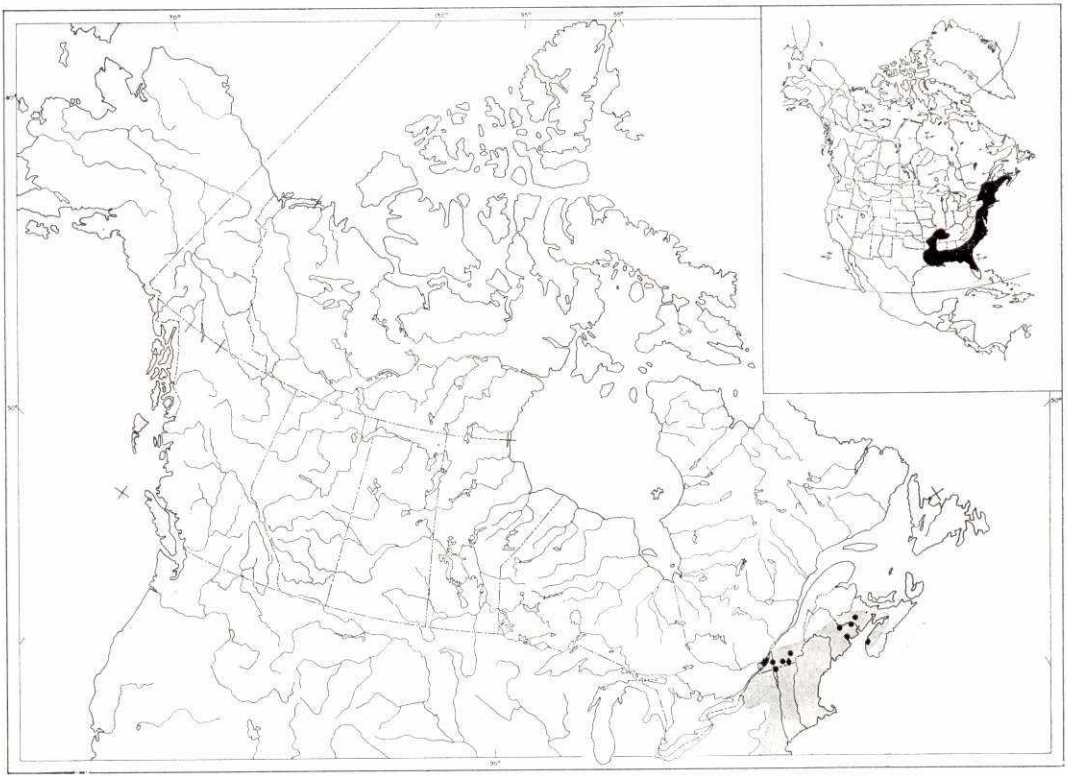
Muskellunge is now the standard common name but maskinonge is a statute name in Ontario and Quebec, in an attempt to retain the French version of the supposed Indian name. Among two pages of common names used in the literature for this species, Weed (1927) gave 41 variations of the "original Indian" name. The name tiger muskellunge was common in Wisconsin and Minnesota but this name has now been more or less transferred to the hybrid northern pike × muskellunge.

CHAIN PICKEREL

Esox niger Lesueur



Description Body long, narrow, moderately compressed, somewhat flat dorsally, shallow, greatest depth between paired fins 11.5–15.5% of total length, cross section a long oval; caudal peduncle moderately long, 13.4–17.8% of total length, and narrow, depth 4.3–5.9% of total length. Individuals usually 15–20 inches (381–508 mm) in total length. Head long, 26.1–28.5% of total length, flat and naked on top, narrow, interorbital width about 20% of head length, somewhat concave between eyes; cheeks and opercula fully scaled; eyes high on head, moderately large, diameter about 14% of head length; snout very long, 44.3–48.0% of head length, rounded and concave, often likened to a duck's bill, narrower than other species; mouth large, maxillary reaching anterior edge of the pupil; short, sharp, recurved cardiform teeth along the premaxillary and in patches on tongue, basibranchials last two pharyngobranchials, vomer, and palatines; large, strong canines on head of vomer, inner edge of palatines, patches and on the dentaries, those on dentaries flattened with sharp edges as well as tips, other canines pointed but round and peglike; lower jaw very slightly longer than snout, undersurface of lower jaw pierced by 4 pores on each side (sometimes 5 on one side only). Gill rakers reduced to patches of sharp, radiating denticles on lateral and medial surfaces of arches. Branchiostegal rays 14–17 on each side, usually 15 (6 on ceratohyal and 9 on epihyal). Fins: dorsal 1, soft rayed, far back, occiput (or nape) to dorsal origin 40.3–44.4% of total length, base short, about 33% of head length, a little less than height, fin moderately high, height about 50% of head length, edge square to slightly rounded, 14 or 15 principal rays; caudal long and deeply forked, tips pointed; anal under dorsal fin, base slightly shorter than dorsal fin, not so high as dorsal fin, slightly shorter than snout, edge more rounded, 11–13 principal rays; pelvics abdominal and low, in advance of vent, narrow, long and with rounded edge, 9 or 10 rays; pectorals with base starting



under edge of opercular flap, low, moderately long, rounded on the edge, and paddle-like, 12–15 rays. Scales rather small, cycloid, long, and narrow, usually 3 lobes on embedded edge, 117–135 in lateral series, usually about 125; lateral line complete, lateral line scales notched not pierced or tubed and single notched scales bordering sensory cells scattered elsewhere on body; intestine long and undifferentiated; no pyloric caeca. Physostomous. Vertebrae 52–54.

Colour Ground colouration of adults bright green, through olive-green to nearly brown on dorsal surface and upper sides, flanks prominently marked by yellow-green to yellow areas broken by dark, interconnecting markings resembling links of a chain (hence common name), scattered tiny gold flecks on exposed edges of some scales; ventral surface creamy white; pronounced, black, horizontal preocular and vertical subocular bars, less obvious in very large individuals. Dorsal and anal fins with dark pigment on rays, contrasting with little to no pigment on membrane, pectoral and pelvic fins much less marked, caudal fin base marbled with dark pigment, tips dusky. Pupil of eye yellow. Young are bright green through brown to almost black on the dorsal surface, with a pronounced golden mid-dorsal stripe. The upper flanks are bright green to almost black. This colour extends in wedges or bars down to the lower flanks, rest of flanks and belly white, fins clear to dusky, chain markings not developed in individuals less than 6–8 inches (152–203 mm) in length.

Distribution Restricted to eastern and south-central North America south from Digby County, N.S., east of the Allegheny–Appalachian mountains, to central Florida, west in the Gulf states to Caddo Lake in eastern Texas and north in the Mississippi River drainage to Missouri and the Tennessee River system in Alabama. Introduced

elsewhere in the states west of the mountains such as Colorado, Ohio, Pennsylvania, as well as in the Lake Erie drainage of New York State. Typically a freshwater fish of the coastal Plain (below the fall-line) but known to penetrate brackish water in the eastern and Gulf states.

In Canada it occurs only in Nova Scotia (Digby County only, and introduced there from the United States), western New Brunswick, and the Eastern Townships of Quebec south of the St. Lawrence River, including Lake Champlain. Records in the early 1900's from Toronto Harbour and Kingston are in error. The young of chain pickerel and northern pike bear a superficial resemblance.

Biology Probably as a result of its limited distribution in Canada, and the fact that it is of virtually no commercial importance and is considered of little importance as a sport fish even in those areas where it does occur, there is virtually no published information on Canadian populations of this species. Published information on populations in the New England and other states is more abundant, and the literature has been drawn together in summaries by Wich and Mullan (1958), McCabe (1958), and Carlander (1969). The information below is based, wherever possible, on populations in the northern United States, in environmental conditions similar to those in Canada where this species occurs.

The chain pickerel, like the other esocids, is basically a spring spawner but in the United States some individuals may spawn in the fall (Miller 1962). In the spring, adults enter the spawning areas, flood benches of streams, lakes, or ponds, very shortly after the ice melts. Spawning takes place in water 3–10 feet deep when water temperatures reach 47°–52° F (8.3°–11.1° C) in April or May and probably lasts no more than 7–10 days. No nest is built. A single female, accompanied closely by one or two usually smaller males, swims slowly about in a random way, usually over flooded vegetation. Periodically during the daytime, the female and a male roll inward slightly in a sharp body flexure so that the vents approximate, eggs and milt are shed simultaneously and a violent lash of the tails spreads the fertilized eggs over the substrate. The spawning act is carried out at various intervals over 1 or 2 days. There is an erroneous record, often repeated, that the eggs are emitted in a long, gelatinous string. Eggs are about 2 mm in diameter, light yellow in colour, demersal, and slightly adhesive, sticking to the vegetation. The number of ripe eggs in Rhode Island females 12–14 inches (305–356 mm) in length has been estimated as 6102–8140 although a 1920 paper by Needham gave the number as 30,000 in a 2-pound female. Since eggs of three sizes are present in the ovary at any time, this latter may have been an estimate of all eggs. No care is given the eggs, which hatch in 6–12 days depending on temperature. The newly hatched young are 4.2–7.0 mm in length, with poorly developed mouths. They sink to the bottom where they attach themselves to vegetation by an adhesive gland on the tip of the snout. They subsist on yolk for about a week. By the time the yolk is absorbed, the young are about 10 mm long, the mouth is fully formed, and they begin active feeding. Mansueti and Hardy (1967) illustrated and described larval stages in the Chesapeake Bay region.

Growth is rapid in the first year. By the end of June in New York, young-of-the-year were 1.0–1.5 inches (25–38 mm) in length and by the end of September averaged 4 inches (102 mm) with some reaching nearly 5 inches (127 mm). Growth rate of young is extremely variable and in crowded situations considerable cannibalism may take place. McCabe (1942) recorded the age–length and age–weight relations for chain pickerel in Massachusetts as follows:

Age	Mean length		Mean wt
	(*inches*)	(*mm*)	(*oz*)
1	6.8	173	1.1
2	10.0	254	2.3
3	11.7	297	5.6
4	15.2	386	16.8
5	21.0	533	40.0
6	19.7	500	40.0
7	24.1	612	56.3
8	23.4	594	53.6

Comparable data for Cassidy Lake, N.B., is as follows:

Age	Range of TL (*mm*)	Wt
0	81–154	3.2–29.0 g
1	195–336	2.1–8.4 oz
2	240–392	3.6–18.5 oz
3	368–446	15.0–25.4 oz
4	429–450	25.1–29.0 oz
5	443	29.0 oz
6	519	48.0 oz

Average yearly growth increment in Massachusetts is 2.5 inches and 6.7 ounces.

Growth rate varies considerably from place to place and from year to year. Females apparently grow faster, mature sooner, live longer, and achieve a greater length.

Sexual maturity is reached by some in the first year in the south but most individuals mature in their third or fourth year in the north.

Average life span is 3 or 4 years with a maximum at 8 or 9 years depending on conditions and growth rate. Stroud (1955) cited chain pickerel from Massachusetts as large as 38.9 inches (922 mm) in standard length and 9 years of age.

Most chain pickerel seen are 15–18 inches (381–457 mm) in length, maximum length is usually cited as 30 inches (762 mm) and maximum weight about 6 pounds. Migdalski (1962) said that the largest authenticated chain pickerel was 29.5 inches (749 mm) in length and weighed 9 pounds 5 ounces. The angling record was an individual 31 inches (787 mm) in length and 9 pounds 6 ounces in weight, caught near Homerville, Ga., on February 17, 1961. A record in 1965 of a chain pickerel from Quebec that weighed 10 pounds 4 ounces might actually represent a hybrid chain pickerel × northern pike.

Chain pickerel are solitary fish, hiding almost motionless in the vegetation most of the time. The usual habitat is sluggish streams and heavily vegetated lakes and ponds with water often no deeper than 10 feet and summer surface water temperatures of 70°–86° F (21.1°–30.0° C). They may be able to live in water as warm as 98° F (36.7° C). Larger fish move into shallow water in the night, and into deeper water during the day. In summer they may establish a definite station or territory and leave it only when in pursuit of food. They sometimes move into brackish water in winter and are known to be able to live in water with salinities as high as 15‰, and in water as acid as *p*H 3.8. They are active and take food during the winter under the ice in slightly deeper water than in summer.

Chain pickerel are predaceous carnivores but type of food changes with size. The newly hatched feed exclusively on plankters for a week or more then on a wide variety of invertebrates but mostly immature aquatic insects and some small fish. After they reach a length of 4–6 inches (102–152 mm) fish become the principal item in the diet but larger invertebrates, such as crayfish, are still eaten. The fishes eaten will depend on what is most readily available, no selection is shown and one study reported 37 species. These were mainly minnows, sunfishes, and catfishes, but usually include chain pickerel and redfin pickerel. Other vertebrates such as snakes, mice, and frogs are eaten periodically, as is almost anything alive and small enough to be engulfed. Larger chain pickerel usually exhibit a direct size relation with the fishes eaten. Winter food is not greatly different from that taken in summer.

For chain pickerel the number of predators is limited by the habitat. Pickerel living in highly acid water and reaching 5.9 inches (150 mm) in length probably have few predators other than chain pickerel. In other habitats, and when smaller, a wide variety of fishes including basses, sunfishes, and yellow perch prey on them. Frogs, mergansers, grebes, loons, kingfishers, and herons are also listed as predators, along with man. When young, chain pickerel compete for food with all fishes in the habitat that depend on invertebrates. As predaceous piscivorous adults they may have few competitors especially in the acid water and smaller, shallow habitats. The choice of a spawning site probably is a limiting factor as eggs or young, or both, can be stranded by receding water levels.

Hoffman (1967) listed in detail 36 parasites that have been reported from this spe-

cies. In summary these were Protozoa (4), Trematoda (17), Cestoda (5), Nematoda (5), Acanthocephala (3), leeches (1), Crustacea (1).

The chain pickerel hybridizes in nature with the redfin pickerel and the northern pike. The former cross is fertile and backcrosses of the F_1 and each parent have been described from several United States locations. Nonfertile hybrids between chain pickerel and northern pike are known from Quebec and New York (Crossman and Buss 1965).

Relation to man In Canada this species is not considered of great importance even in areas where it is abundant. In Quebec and New Brunswick a few find their way to local markets from the catches of hoopnet fishermen and are sold fresh. In Quebec the chain pickerel is not highly regarded as a sport fish, is rarely sought directly, but often kept if caught when fishing for other species. In New Brunswick chain pickerel are looked upon as something to tide the avid angler over the winter until better species are available or in season.

In some eastern seaboard states the chain pickerel is one of the most abundant species in ponds, favoured as a sport fish often second only to largemouth bass and actively sought after with small spoons, plugs, or live bait, by trolling, casting, still fishing, or skittering. They often constitute 4% by weight of the fish found in Massachusetts ponds. Production usually varies up to about 10 pounds/acre but can go as high as 67 pounds/acre when they are stocked in barren ponds with suitable forage fishes. In many places it is thought to taste weedy in summer; in winter it is considered a table delicacy. The flesh is good, tasty, white, and flaky, but best if skinned before cooking as it may be the mucus or pigments that contribute the unsatisfactory taste in summer. The value of this species as a control of the numbers of smaller fishes has never really been proven.

Chain pickerel are usually listed as sport fish and are covered by size and bag limits, if not by a closed season.

Nomenclature

Esox reticulatus	— LeSueur 1818b: 414 (type locality Philadelphia. Holotype MNHN Paris 44.1.3.1 No. B961)
Esox reticulatus	— Richardson 1836: 123
Lucius reticulatus (Le Sueur)	— Jordan and Evermann 1896–1900: 627
Esox tridecemlineatus	— Hubbs 1926: 53

No actual type locality is given for *Esox reticulatus* in Lesueur 1818, but Philadelphia is mentioned. The type locality has usually been cited in subsequent accounts as Saratoga Lake (New York) or South Carolina. The label with the type specimen says Philadelphia. This confusion resulted from the nomenclatorial problem that arose from the uncertainty over which species described by Lesueur in the same paper, *reticulatus* or *niger*, actually was the chain pickerel. Although *reticulatus* was the type, the name *reticulatus* was preoccupied, so *niger* was the next available name. Unfortunately it is not a good one as it was based on young specimens.

Etymology *Esox* — old European name for the pike; *niger* — black. The original description was based on young individuals which are often very dark in colour.

Common names Chain pickerel, pickerel, eastern pickerel, mud pickerel, grass pickerel, lake pickerel, reticulated pickerel, federation pickerel, pike, green pike, black chain pike, duck-billed pike, jack, snake, picquerelle. (*See* Weed 1927 for list.) French common name: *brochet maillé*.

BUSS, K. MS 1960. The muskellunge. Pa. Fish Comm. Benner Spring Fish Res. Sta. Spec. Sci. Rep. 14 p. (Mimeogr.)

MS 1961. The northern pike. Pa. Fish Comm. Benner Spring Fish Res. Sta. Spec. Sci. Rep. 58 p. (Mimeogr.)

MS 1962. A literature survey of the life history of the redfin and grass pickerels. Pa. Fish Comm. Benner Spring Fish Res. Sta. 12 p. (Mimeogr.)

CARBINE, W. F. 1942. Observations on the life history of the northern pike, *Esox lucius* L., in Houghton Lake, Michigan. Trans. Amer. Fish. Soc. 71: 149–164.

CROSSMAN, E. J. 1960. Variation in number and asymmetry in branchiostegal rays in the family Esocidae. Can. J. Zool. 38: 363–375.

CROSSMAN, E. J., and K. BUSS. 1965. Hybridization in the family Esocidae. J. Fish. Res. Bd. Canada 22: 1261–1292.

FABRICIUS, E., and K.-J. GUSTAFSON. 1958. Some new observations on the spawning behaviour of the pike, *Esox lucius* L. Rep. Inst. Freshwater Res. Drottningholm 39: 23–54.

FRANKLIN, D. R., and L. L. SMITH, JR. 1963. Early life history of the northern pike, *Esox lucius* L., with special reference to the factors influencing the numerical strength of year classes. Trans. Amer. Fish. Soc. 92: 91–110.

HOURSTON, A. S. 1955. A study of variations in the maskinonge from three regions in Canada. Contrib. Roy. Ont. Mus. Zool. Palaeontol. 40: 13 p. + 4 tables, 16 pl.

KARVELIS, E. G. 1964. The true pikes. U.S. Dep. Fish. Wildl. Serv. Fish. Leafl. 569: 11 p.

KENDALL, W. C. 1917. The pikes: their geographical distribution, habits, culture, and commercial importance. Rep. U.S. Fish. Comm. (1917), Bur. Fish. Doc. 853: 1–45.

KLEINERT, S. J., and D. MRAZ. 1966. Life history of the grass pickerel (*Esox americanus vermiculatus*) in southeastern Wisconsin. Wis. Conserv. Dep. Tech. Bull. 37: 40 p.

LINCOLN, R. P. 1953. The pike family. The Stackpole Co., Harrisburg, Pa. 274 p.

LIND, J. A. 1964. Muskie! McCormick and Henderson, Inc., Chicago, Ill. 204 p.

MING, A. D. 1968. Life history of the grass pickerel, *Esox americanus vermiculatus*, in Oklahoma. Okla. Fish. Res. Lab. Bull. 8: 66 p.

OEHMCKE, A. A., L. JOHNSON, J. KLINGBIEL, and C. WISTROM. 1958. The Wisconsin muskellunge. Its life history, ecology, and management. Wis. Conserv. Dep. Publ. 225: 12 p.

SMITH, O. W. 1922. The book of pike. Stewart Kidd and Co., Cincinnati, Ohio. 197 p.

SOLMAN, V. E. F. 1945. The ecological relations of pike, *Esox lucius* L., and waterfowl. Ecology 26: 157–170.

THREINEN, C. W., C. WISTROM, B. APELGREN, and H. SNOW. 1966. The northern pike, its life history, ecology, and management. Wis. Conserv. Dep. Publ. 235: 16 p.

WEED, A. C. 1927. Pike, pickerel, and muskalonge. Field Mus. Natur. Hist. Zool. Leafl. 9: 52 p.

THE MINNOWS OR CARPS — Order Cypriniformes (Ostariophysi)

Fishes of variable size and shape, resembling, in most basic respects, the clupeiform fishes but differing from them in one very special character: the first 4 anterior vertebrae are modified to form a complex known as the Weberian apparatus, which consists of a series of bony ossicles connecting the swim bladder with the inner ear. The skull, like the body form, varies widely but is basically of the clupeiform type; orbitosphenoid, and usually mesocoracoid, present; jaws may be weak and toothless or strong with well-developed teeth, upper jaw often bordered by premaxillae and maxillae. Branchiostegals 3–20. All fins usually without spines, but 1 or 2 specially derived spines occur in certain groups in dorsal, anal, or pectoral fins; always one, rayed dorsal fin but some groups also have an adipose dorsal fin; caudal fin homocercal; no vertebrae upturned; 1 anal fin; pelvic fins abdominal and many rayed (when present), pelvic girdle not attached to cleithrum; pectoral fins located more or less ventrally, behind head, the bases nearly or quite horizontal. Scales cycloid, modified into bony plates, or absent. Physostomes. Vertebrae numerous and modified anteriorly (*see* above).

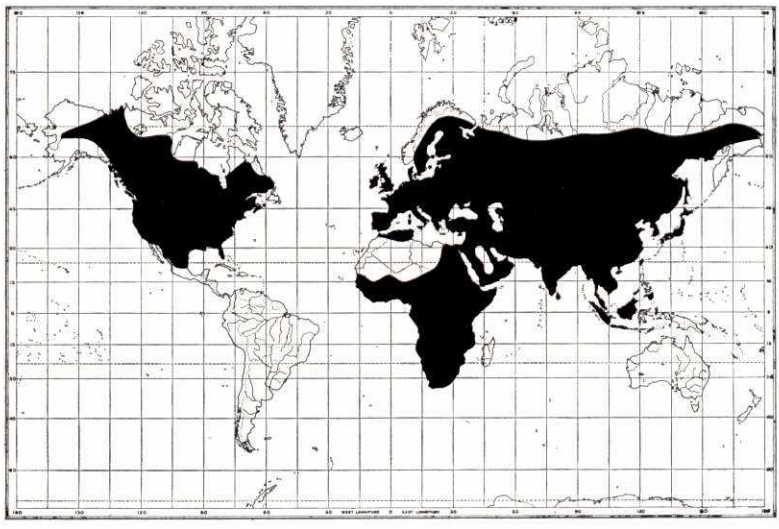
The cypriniform fishes are one of the largest and most important groups of fishes in the world, second only in numbers and faunal dominance to the Perciformes, and whereas the latter dominate the seas, the cypriniforms dominate the fresh waters. They are usually of prime importance in the fresh waters of all continents except Australia. In Canada, they occur in large numbers in the southern parts where they have managed to gain access in postglacial times, but the salmonoid fishes dominate the cool, boreal, fresh waters of northern Canada.

The order is usually classified in 2 suborders, 33 families, and about 5000 species. Three families and 68 species occur in Canadian fresh waters.

Minnow or Carp Family — Cyprinidae

The minnows or carps are small to large fishes of variable body shape, but North American forms are generally elongate and resemble each other in general appearance. Mouth small or large, terminal, subterminal or inferior in position; jaws toothless; upper jaw bordered by premaxilla only; 1 or 2 pairs of barbels sometimes present; lower, pharyngeal bones with 1–3 rows of teeth, which grind food against a pair of horny pads attached to the basioccipital. Gill membranes united. Branchiostegals 3. Fins of North American forms all soft rayed (except the stiffened first or second rays of dorsal and anal fins of genera *Meda*, *Lepidomeda*, and *Plagopterus*, and the introduced *Carassius* and *Cyprinus*); no adipose fin. Scales cycloid, restricted to body; lateral line usually present. Sexual dimorphism often conspicuous, breeding males may display bright colours and have nuptial tubercles on head, body, and fin rays.

The minnows and carps, freshwater fishes of Africa, Europe, Asia, and North America, include some 275 genera and over 1500 species, and thus make the Cyprinidae the largest of all fish families. They are frequently called primary freshwater fishes, in reference to their dependence on a freshwater environment and their intolerance of salt water. Forty-four species (3 introduced from Europe) occur in Canadian waters. Known from Paleocene of Europe, Eocene of Asia, and Miocene of North America.



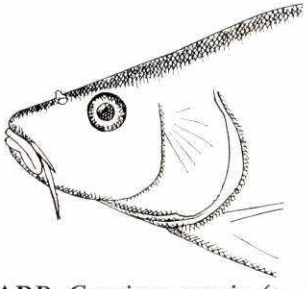
World Distribution of the Minnows or Carps

Ichthyologists, like other life scientists, are constantly seeking to improve classifications and, especially, to uncover evidence of closer relationships between genera or species, but sometimes decisions are made before all the evidence is in. In recent years the monotypic genus *Hyborhynchus* gave way to critical study and was demonstrated to be not significantly different from *Pimephales*. Similar action took place with *Pfrille*, which was submerged in *Chrosomus* in recent years. At the time of writing the American Fisheries Society publication (1970), *A list of common and scientific names of fishes from the United States and Canada* places *Chrosomus* in the synonymy of *Phoxinus*, a widely distributed genus of Eurasian cyprinid. However such action seems unwarranted, at least until a reasonably thorough study has been undertaken and the results made available for all to consider. Snap decisions based on insufficient evidence do not make for good science especially if urgent action is unnecessary. The names of many North American fishes have been subjected to such changes, yoyo fashion, all too frequently in recent years (viz *Couesius* to *Hybopsis* to *Couesius*; *Nocomis* to *Hybopsis* to *Nocomis*) to the confusion of all but systematic ichthyologists and even some of them have to resort to common names to communicate.

KEY TO SPECIES[1]

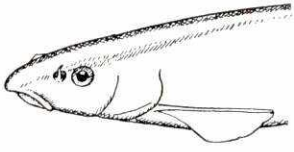
1 Dorsal fin base long, more than 11 soft dorsal rays; dorsal and anal fins each with strong spine, serrated on trailing edge 2

Dorsal fin base short, fewer than 11 soft dorsal rays (except *Acrocheilus alutaceus* and *Richardsonius balteatus*, which may occasionally have 11 rays); no spines in fins 3

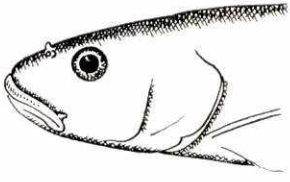


2 Two pairs of long barbels on upper jaw; pharyngeal teeth molarlike (1,1,3–3,1,1); gill rakers 21–27; scales in lateral line usually more than 32 (mirror and leather carp are only partially scaled) ..... CARP, *Cyprinus carpio* (p. 407)

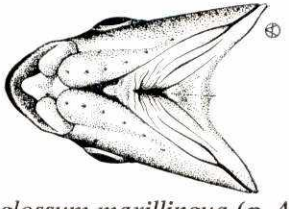
Barbels absent; pharyngeal teeth not molarlike (4–4); gill rakers 37–43; scales in lateral line usually less than 32 ..... GOLDFISH, *Carassius auratus* (p. 389)



3 Premaxillaries not protractile (i.e., no groove across snout in midline) 4



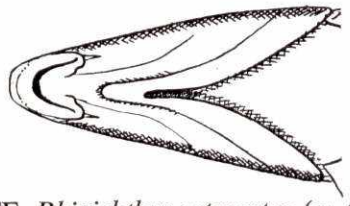
Premaxillaries protractile (i.e., with groove across snout) 6



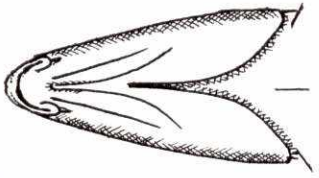
4 Lower jaw conspicuously trilobed, its centre lobe tongue shaped; body not obviously speckled or blotched; body stout ..... CUTLIPS MINNOW, *Exoglossum maxillingua* (p. 412)

Lower jaw of normal shape; body flecked with darkened scales or speckled; body streamlined 5

[1]*Campostoma anomalum*, the stoneroller, was reportedly caught in the Lake St. Clair drainage of Ontario in 1972.



5 Snout long, projecting far beyond mouth; lateral band indistinct or absent (except on young-of-the-year) ..... LONGNOSE DACE, *Rhinichthys cataractae* (p. 494)

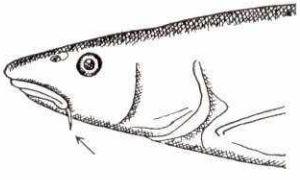


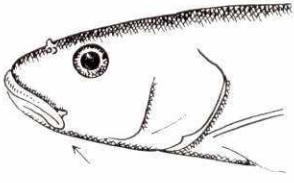
Snout scarcely projecting beyond mouth; lateral band prominent; rusty red lateral band on spawning males ..... BLACKNOSE DACE, *Rhinichthys atratulus* (p. 491)

6 Maxillary with barbel (sometimes concealed in maxillary groove) 7

Maxillary without a barbel 16

7 Barbel terminal and slender, at or near end of maxillary (*below, left*) 8





Barbel in front of posterior end of upper jaw, often hidden in groove above maxillary (*above, right*) 23

8 Scales in lateral line very small, 90 or more; body deep, about 25% of total length ..... TENCH, *Tinca tinca* (p. 519)

Scales in lateral line fewer than 80; body depth moderate, 20% or less of total length 9

9 Mouth large, gape extending to below anterior margin of eye; pectoral fins long, narrowed, and pointed, tips reaching to anterior base of pelvic fins or nearly so; lateral line scales 48–59 ..... FLATHEAD CHUB, *Platygobio gracilis* (p. 484)

Mouth moderate to small, gape not extending to anterior margin of eye; pectoral fins rounded or bluntly pointed, not reaching base of pelvic fins 10

10 Lateral line scales 52 or more 11

Lateral line scales less than 50 13

11 Lateral line scales 68–79; pelvic axillary scale well developed .....
..... PEAMOUTH, *Mylocheilus caurinus* (p. 424)

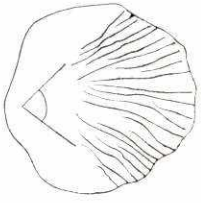
Lateral line scales 52–65; pelvic axillary scale absent or weakly developed 12

12 No fleshy stays on dorsal aspect of pelvic fins; lateral line scales 54–65; body sometimes with specialized darkened scales .....
..... LAKE CHUB, *Couesius plumbeus* (p. 401)

Conspicuous fleshy stays on dorsal aspect of pelvic fins, joining fin rays to body; body conspicuously speckled; lateral line scales 52–57 .....
..... LEOPARD DACE, *Rhinichthys falcatus* (p. 498)

13 Snout projecting only slightly beyond mouth 14

Snout projecting considerably beyond mouth 15



14 Angle enclosed by scale radii about 70–75°; caudal spot large and distinct; snout length into standard length more than 9 times; distinct mid-dorsal line and lateral band ..... HORNYHEAD CHUB, *Nocomis biguttatus* (p. 427)

Angle enclosed by scale radii 95–105°; no caudal spot; snout length into standard length 8 times or less; no mid-dorsal line; lateral band indistinct .....
..... RIVER CHUB, *Nocomis micropogon* (p. 431)

15 Body with X-shaped dark spots, only faintly evident on Ontario specimens ....
..... GRAVEL CHUB, *Hybopsis x-punctata* (p. 423)

Body without definite spots; scales large and deciduous; lower 3 or 4 rays of caudal fin unpigmented ..... SILVER CHUB, *Hybopsis storeriana* (p. 420)

16 Lateral line scales more than 55 17

Lateral line scales 54 or fewer 25

17 Mouth terminal, not overhung by snout; gape small or large 18

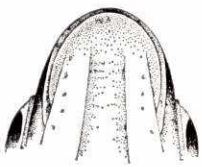
Mouth inferior, overhung by snout; gape small 22

18 Peritoneum black; lateral line incomplete; body robust, not noticeably compressed; size small, to about 3 inches (76 mm) 19

Peritoneum silvery or speckled, not black; lateral line complete; body laterally compressed or elongate, and pike-like; size larger, to 3.5 inches (89 mm) or more 20

19 Intestine with 2 crosswise coils in addition to main loop; mouth small, terminating distinctly in advance of eye; a dark line, entire or broken, between lateral band and back ..... NORTHERN REDBELLY DACE, *Chrosomus eos* (p. 392)

Intestine shorter, with single main loop; mouth larger, extending almost to below anterior margin of eye; back uniformly pigmented ..... FINESCALE DACE, *Chrosomus neogaeus* (p. 396)



20 Pelvic fin origin not in advance of dorsal fin, dorsal inserted over pelvic fin origin; body elongate, not markedly compressed; young with small but precise black spot at caudal base ..... NORTHERN SQUAWFISH, *Ptychocheilus oregonensis* (p. 487)

Pelvic fin origin in advance of dorsal fin origin; body laterally compressed; no black spot at caudal base 21

21 Dorsal rays 9 or 10 (seldom 8); anal rays 10–22, usually 15; snout short, less than eye diameter ..... REDSIDE SHINER, *Richardsonius balteatus* (p. 503)

Dorsal rays 8, rarely 7; anal rays 9 (seldom 8 or 10); snout long and pointed, greater than eye diameter .... REDSIDE DACE, *Clinostomus elongatus* (p. 399)

22 Lower jaw with a hard and almost straight cutting edge (like a chisel); anal rays 9 or 10; peritoneum jet black .....

..... CHISELMOUTH, *Acrocheilus alutaceus* (p. 386)

Lower jaw with fleshy lip, mouth suckerlike; anal rays 6 or 7; peritoneum dark brown ..... SPECKLED DACE, *Rhinichthys osculus* (p. 501)

23 Scales in lateral line fewer than 50; young with distinct mid-lateral black band; each scale with dense pigment anteriorly .....

..... FALLFISH, *Semotilus corporalis* (p. 511)

Scales in lateral line more than 50; scales without black pigment anteriorly **24**

24 A black spot near anterior base of dorsal fin, sometimes indistinct in young; upper jaw extending to vertical through front of eye; lateral line scales 52–62; silvery, no distinct spawning colour .....

..... CREEK CHUB, *Semotilus atromaculatus* (p. 507)

No black spot on dorsal fin; upper jaw not reaching a vertical through front of eye; barbel often small or absent; lateral line scales 65–75; sides often with scattered, darkened scales; spawning males with red on flanks and belly .....

..... PEARL DACE, *Semotilus margarita* (p. 515)

25 Abdomen behind pelvic fins with a fleshy keel lacking scales; lateral line strongly decurved, following ventral outline of body; anal fin rays 12 or 13 ....

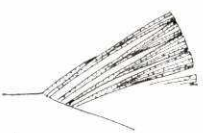
..... GOLDEN SHINER, *Notemigonus crysoleucas* (p. 434)

Abdomen behind pelvic fins rounded over and scaled; lateral line not strongly decurved; anal fin rays usually less than 12 ..... **26**

26 A dark spot (sometimes faint) at front of dorsal fin, slightly above base; back flattish; first dorsal ray separated by membrane from first well-developed ray; predorsal scales small, crowded .....

27

No dark spot at front of dorsal fin above base (a dark pigmented area at anterior base in *Notropis umbratilis*); back scarcely flattened; first dorsal ray closely attached to first well-developed ray; predorsal scales usually large and distinct .....



28

27 Lateral line incomplete; caudal spot faint; mouth terminal but small ..... FATHEAD MINNOW, *Pimephales promelas* (p. 480)

Lateral line complete; a distinct caudal spot; mouth subterminal ..... BLUNTNOSE MINNOW, *Pimephales notatus* (p. 476)

28 Mouth very small and nearly vertical; dorsal fin rays typically 9 ..... PUGNOSE MINNOW, *Notropis emiliae* (p. 453)

Mouth larger; dorsal fin rays typically 8 29

29 Anal fin rays 9–12 (rarely 8, but 25% of *Notropis cornutus* populations may have only 8 rays) 30

Anal fin rays 7 or 8 (rarely 6 or 9) 33

30 Origin of dorsal fin over, or in front of, vertical through insertion of pelvic fins; lateral scales twice as high as wide; lower fins of males red during spawning ..... COMMON SHINER, *Notropis cornutus*[2] (p. 448)

Origin of dorsal fin behind vertical through insertion of pelvic fins; scales round or nearly so 31

31 Body deep, depth equal to, or more than, length of head; dorsal fin with black pigmented area at anterior base; sides stippled with pigment; spawning males have bluish body, and rosy lower fins ..... REDFIN SHINER, *Notropis umbratilis* (p. 472)

Body slender, depth equal to or less than length of head; no black spot at base of dorsal fin 32

32 Snout sharp, its length more than two-thirds distance from posterior margin of eye to posterior margin of gill cover; pigmentation on sides usually bordered below by lateral line ..... ROSYFACE SHINER, *Notropis rubellus*[3] (p. 463)

Snout blunt, its length less than two-thirds distance from posterior margin of eye to posterior margin of gill cover; pigmentation on sides terminating above lateral line ..... EMERALD SHINER, *Notropis atherinoides* (p. 440)

[2]*Notropis chrysocephalus* has been described as a species distinct from *N. cornutus* — chin usually pigmented; predorsal, dorsolateral scale rows 13–16 in *chrysocephalus*: chin usually unpigmented; predorsal, dorsolateral scale rows 18–24 in *cornutus*. *See* C. R. Gilbert (1964), Bull. Fla. State Mus. Biol. Ser. 8(2): 95–194, and R. J. Miller (1968), Copeia 1968: 640–647, for opposing opinions.

[3]The silver shiner *Notropis photogenis* was reportedly caught in the Grand River, Ont. in 1971. A report by C. G. Gruchy, R. H. Bowen, and I. M. Gruchy is now in press. *N. photogenis* resembles *N. rubellus* and *N. atherinoides* but may be distinguished from them in having the origin of the dorsal fin directly above the insertion of the pelvic fin.

33 Intestine short, with single main loop; mouth usually terminal (subterminal for *Notropis blennius* and *Notropis hudsonius*) 34

Intestine elongate, coiled on right side; mouth subterminal 42

34 Dorsal fin with black blotch on membranes between posterior rays (except in young); eye usually less than one-quarter, always less than one-third, length of head in adults; snout sharp or pointed .....
..... SPOTFIN SHINER, *Notropis spilopterus* (p. 466)

Dorsal fin without black blotch on membranes between posterior rays; eye more than one-quarter length of head in adults; snout not sharp or pointed 35

35 Lateral band indistinct or absent, sometimes diffuse posteriorly; body somewhat compressed and deep; mouth subterminal 36

Lateral band usually distinct (less so on *Notropis volucellus* and *Notropis stramineus*), often extending onto head; body slender; mouth usually terminal 37

36 A large, conspicuous black spot at base of caudal fin (particularly obvious on young); scales in lateral line 38–42; anal rays 8 .....
..... SPOTTAIL SHINER, *Notropis hudsonius* (p. 459)

No black spot at caudal base; scales in lateral line 38–45; anal rays 7 .....
..... RIVER SHINER, *Notropis blennius* (p. 446)

37 Lateral band usually dark and obvious, continued forward through eye and onto snout; lateral line complete or incomplete 38

Lateral band weakly developed or dusky, not continued forward through eye; lateral line complete 41

38 Mouth very small, almost vertical; upper jaw extending only to vertical through nostril; lateral line nearly or quite complete; peritoneum black .....
..... PUGNOSE SHINER, *Notropis anogenus* (p. 438)

Mouth larger, upper jaw reaching beyond a vertical through nostril almost to below eye; peritoneum silvery 39

39 Lateral band on chin (chin black), and on premaxillaries .....
..... BLACKCHIN SHINER, *Notropis heterodon* (p. 454)

Lateral band on snout, but not on chin (chin not black) 40

40 Anal rays typically 8, sometimes 7; dorsal fin located over or behind a vertical through pelvic insertion; lateral line complete ..... BLACKNOSE SHINER, *Notropis heterolepis* (p. 456)

Anal rays typically 7, sometimes 8; dorsal fin inserted over or before a vertical through pelvic insertion; lateral line incomplete ..... BRIDLE SHINER, *Notropis bifrenatus* (p. 444)

41 Anal rays usually 8 (sometimes 9); black pigment about anus and base of anal fin; pigmentation extending below lateral line; no distinct mid-dorsal stripe ..... MIMIC SHINER, *Notropis volucellus*[4] (p. 473)

Anal rays usually 7; little or no black pigment about anus or base of anal fin, nor below lateral line, thin but distinct mid-dorsal stripe ..... SAND SHINER, *Notropis stramineus*[4] (p. 469)

42 Dorsal fin rounded; scales with about 20 radii in adult; colour brassy ..... BRASSY MINNOW, *Hybognathus hankinsoni* (p. 414)

Dorsal fin somewhat falcate; scales with about 10 radii in adult; colour silvery ..... SILVERY MINNOW, *Hybognathus nuchalis* (p. 417)

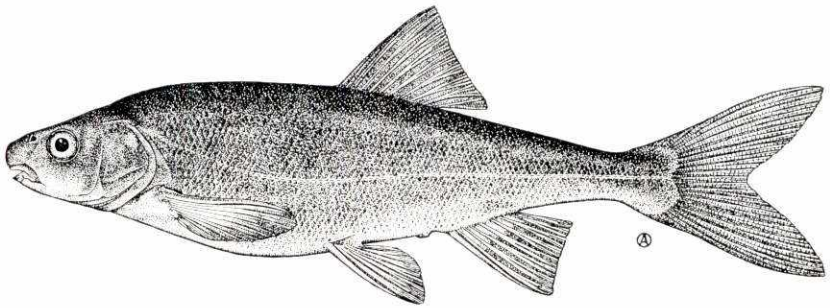
Table of meristics for the species of *Notropis*

	No. and range of rays					
	Dorsal	Anal	Pelvic	Pectoral	No. of vertebrae	Pharyngeal tooth formula
Notropis anogenus	8(7–8)	8(7–8)	8(7–8)	12(11–13)	32–36	0,4–4,0
Notropis atherinoides	8(7–8)	11(10–13)	8(8–9)	15(13–17)	38–41	2,4–4,2
Notropis bifrenatus	8(7–8)	7(7–8)	8(7–8)	12(11–13)	34–36	0,4–4,0
Notropis blennius	8(7–8)	7	8	14(13–15)	36–37	2,4–4,2
Notropis cornutus	8	9(8–10)	8(8–9)	16(15–17)	38–43	2,4–4,2
Notropis dorsalis	8	8	8	14–15	34–37	1,4–4,1
Notropis emiliae	9	8	8	15	37–38	0,5–5,0
Notropis heterodon	8(7–8)	7(7–8)	8(7–8)	12–14	35–36	1,4–4,1
Notropis heterolepis	8(7–9)	8(7–8)	8(7–8)	12(12–14)	34–36	0,4–4,0
Notropis hudsonius	8(8–9)	8(7–8)	8(7–8)	14(12–17)	37–39	2,4–4,2
Notropis rubellus	8(7–8)	10(9–11)	8	12(11–14)	37–41	2,4–4,2
Notropis spilopterus	8(7–8)	8(7–9)	8(7–9)	13(12–15)	37–39	1,4–4,1
Notropis stramineus	8	7(6–8)	8	13(12–16)	33–36	0,4–4,0
Notropis umbratilis	8(7–8)	11(10–12)	8(7–9)	12–13	35–36	2,4–4,2
Notropis volucellus	8	8(8–9)	9(8–10)	15(12–16)	34–37	0,4–4,0

[4]If mouth large, dorsal stripe heavier than a thin line, and anal rays 8, specimen may be *Notropis dorsalis*, recently recorded from southern Manitoba.

CHISELMOUTH

Acrocheilus alutaceus Agassiz and Pickering



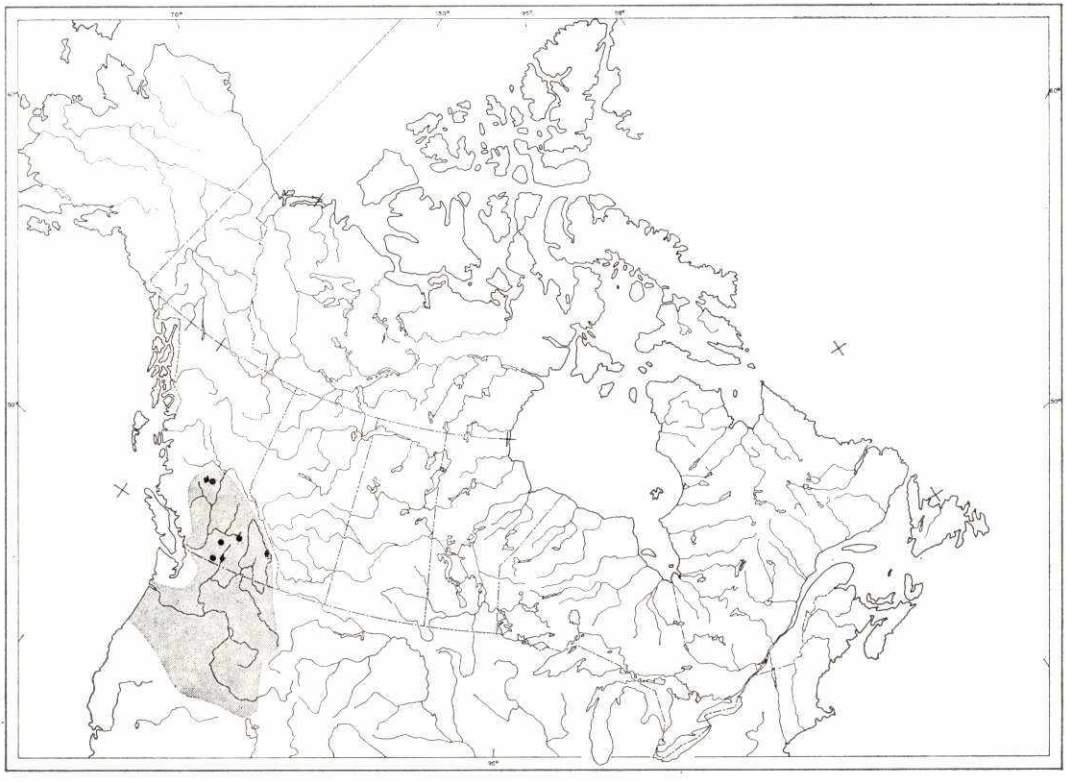
Description Body elongate, average total length 6–7 inches (152–178 mm), robust, only slightly compressed, body depth 17–20% of total length, caudal peduncle slender, appearing as if pinched posteriorly, its least depth 5.3–6.3% of total length. Head blunt, its length approximating body depth, 17.4–18.9% of total length; eye relatively large, especially in immatures, its diameter 20.9–32.1% of head length; snout bluntly rounded, its length 28.5–33.3% of head length; interorbital broad, its width 37.2–42.8% of head length; mouth inferior, overhung by snout, fleshy upper lip covers small cartilagineous plate in upper jaw, but lower lip covered with a hard cartilagineous sheath, with an almost straight-cutting edge (like a chisel), except in young; pharyngeal teeth stout, hooked, grinding surface dependent on age, Carl et al. (1967) said 4–5 or 5–5, but La Rivers (1962) gave 5–4, seldom 5–5. Gill rakers about 13–17. Fins: dorsal 1, origin behind origin of pelvic fin, rays usually 10; caudal distinctly forked; anal fin origin behind insertion of dorsal fin, rays 9(5) or 10(1); pelvics well developed, rather narrow, 9 or 10 rays; pectorals with 15–18 rays. Scales cycloid, small, embedded, 85–93 in lateral line; lateral line complete. Peritoneum intensely black; intestine at least twice body length. Vertebrae 44 or 45.

Colour Overall colouration rather drab, dark brown above, sides lighter but with many small black dots, and lighter below; young fish with a vague black spot at caudal fin base. Sometimes with orange colouration in axils of pectoral and pelvic fins.

Systematic notes Miller and Smith (1967) described a new species, *Acrocheilus xestes*, from fossil remains recovered from a Cenozoic locality in Idaho. It possibly ranged in Idaho during the late Pliocene and early Pleistocene. *See* Miller and Smith for details.

Distribution The chiselmouth is confined to the Pacific drainage systems of the Fraser and Columbia rivers, and Malheur Lake in Oregon. It occurs in Nevada, Idaho, Oregon, Washington, and British Columbia.

In Canada it has been reported only from British Columbia as follows: Euchiniko and Nazko rivers, and Nicola Lake of the Fraser River system; Missezula, Wolfe, Skaha, Gallagher, and Tugulnuit lakes, and the Okanagan River of the Okanagan–Columbia system; and Windermere Lake in the Kootenay–Columbia system (Carl et al. 1967). In Canada, it occurs more often in lakes than rivers.



Biology There appears to be little information available on reproduction or growth rate of the chiselmouth.

G. E. E. Moodie (1966) studied the chiselmouth in British Columbia waters as part of a M.Sc. program and his work provides the only detailed account of this species in Canadian waters. The following biological information has been derived primarily from Moodie's unpublished report, which resulted mainly from study of a population in Wolfe Lake, near Princeton, on the Similkameen River system, B.C.

Spawning of lake populations occurred in tributary streams as far as 1.5 km upstream, usually in late June and early July, but only at a temperature of about 62.5° F (17° C) or higher. Moodie was unable to observe actual spawning, but found eggs on the open bottom and also buried among boulders. The mean egg count for six females was 6200.

Newly hatched larvae are about 8.1 mm long. From the time of yolk absorption until 15 mm long, they are difficult to distinguish from other cyprinids, but over this size the characteristic mouth is apparent. The identification of young may be complicated further by the occurrence of hybrids (Patten 1960).

Growth data obtained by Moodie were not entirely satisfactory. Otoliths were used for age determination but a high percentage were considered to be unreadable. Males probably attain sexual maturity and spawn at age 3, females sometimes at age 3 but usually age 4. The maximum age noted was 6 years, when a fork length of about 8.8 inches (225 mm) was attained.

Feeding by adults is very specialized and consists of scraping the chisel-like lower jaw along rocks or other bottom substrate, usually for only a short distance of 2.0–2.5 cm. The unique feeding behaviour consists of very quickly executed darting dives on algae-covered substrates. Large quantities of filamentous green algae and diatoms are ingested by the chiselmouth, but Moodie found no

evidence that filamentous algae was digested, even to a minor degree. He concluded that diatoms constitute the major food of adults. Young chiselmouths, from 0.8 to 3.9 inches (20–100 mm) long, feed largely on surface insects.

Moodie noted that the diet of young chiselmouths and young squawfish is similar and, hence, some competition might occur at this stage in the life history.

The only published report on the parasites of the chiselmouth in Canada seems to be that of Bangham and Adams (1954), who examined a total of 32 specimens from British Columbia waters, 24 of these from the Okanagan River. The nematode *Rhabdochona cascadilla* was the most common parasite, then the trematodes *Posthodiplostomum minimum*, *Neascus* sp., and Gyrodactyloidea. Additional information on parasites was provided by Hoffman (1967).

Relation to man Although direct information appears to be lacking, the chiselmouth seems to be of little economic significance. Biologically it is of considerable interest because of the peculiar adaptation of the upper and lower jaw, which permits it to make a living in a unique manner by scraping algae from stones.

La Rivers (1962) reported that in former times it was said to have been used for aboriginal food.

Nomenclature

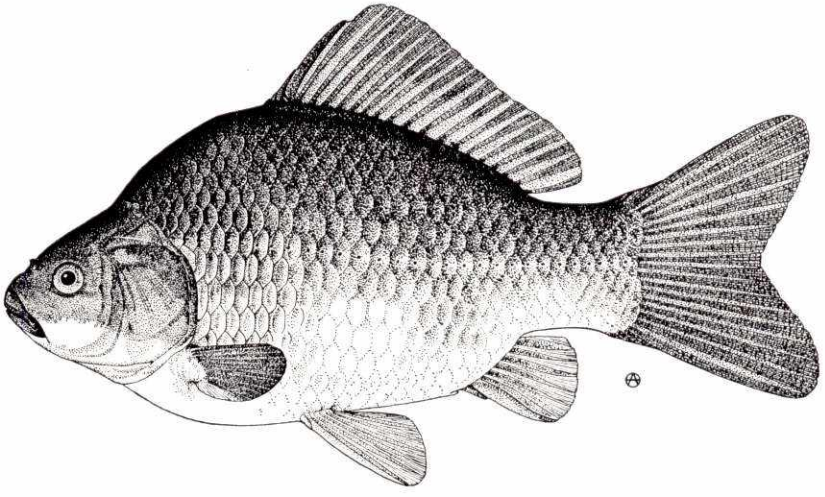
Acrocheilus alutaceus Agass. and Pick. — Agassiz 1855: 99 (type locality Willamette Falls and Wallawalla River, Ore.)
Lavinia alutacea — Girard 1857a: 184
Acrochilus alutaceus — Günther 1868: 276
Acrocheilus alutaceum — La Rivers 1952: 98

Etymology *Acrocheilus* — sharp; lip; *alutaceus* — leathery.

Common names Chiselmouth, hardmouth, squaremouth. French common name: *bouche coupante*.

GOLDFISH

Carassius auratus (Linnaeus)



Description Body stout, thickset, average total length about 5–10 inches (127–254 mm), caudal peduncle thick and short (stockier than carp of same length), body depth 28–34% of total length. Head broadly triangular, its length 24.1–26.4% of total length; eye moderate, its diameter 19.0–31.8% of head length; snout relatively short, 25.0–36.8% of head length; interorbital broad, its width 35.7–42.8% of head length; mouth relatively small, protrusible, without barbels; pharyngeal teeth 0,4–4,0. Gill rakers 37–43. Fins: heavy, translucent, usually same colour as body; dorsal 1, base long, of 1 stout spine with serrated trailing edge, and 15–18 (usually 17) soft rays; caudal broadly forked; anal 1, base short, of 1 stout spine with serrated trailing edge and 5 or 6 (usually 5) soft rays; pelvics short, broad, thoracic in position, the soft rays 8 or 9 (usually 9); pectorals broad, 15–17 soft rays. Scales cycloid, large, rather firmly attached, 27–30 in the lateral line; lateral line complete. Vertebrae usually 28 or 29.

Nuptial tubercles fine, on opercles, sometimes on back, and a few on pectoral fins of breeding male.

Colour Overall colouration variable, from olive-green through gold (often with black blotches) to creamy white. Young fish are green, brown, greyish bronze, or almost black. The young of cultured, gold-coloured stock are not gold, but often very dark, almost black, attaining the golden colour in 8–12 months. Goldfish are selectively bred for colour, but when such stock is released and allowed to "go wild," they usually revert to olive-green colouration, although some fish show patches of gold, white or black or both, and some may be almost all white. As interbreeding continues, the highly coloured fish become more rare, partly as a result of selective predation by fish-eating birds, such as herons.

Systematic notes Goldfish hybridize readily with carp, and such individuals may be difficult to identify for they may show a blending of parental characters. The major features distinguishing goldfish from carp are: absence of barbels, pharyngeal teeth not molarlike and in a single row, and gill rakers about 37–43.

Distribution Native to eastern Asia, goldfish originated in China. Hervey and Hems (1968), in their extensive study of this species, stated that they appeared as pets in the early days of the Sung Dynasty, about the year 960, and from the 11th century onward they were popular household pets. There appears to be some doubt of the time of introduction to Japan. Some authorities say about the year 1500, but Okada (1959–1960) discussed this question and showed that the available evidence suggests dates ranging from 1502 to 1748. In the early years of the 18th century, or late 17th century, they were introduced into England, and by the middle of the 18th century were widespread there. Introductions into other parts of Europe took place about the same time.

It is not known definitely when goldfish were brought to America, but by 1889 a goldfish farm was established in Maryland, and they are now widespread throughout the United States.

In Canada distribution is sporadic. They are unknown in the Maritime Provinces, and, according to V. Legendre (personal communication 1967) they had not become established in Quebec waters.

They are reported to occur in Ontario in Lake St. Clair, Detroit River, and various parts of Lake Erie, and may occur in any small, shallow lake in southern Ontario (such as Musselman's Lake) and in ponds in High Park, Toronto, as a result of release of domestic stock (Scott 1967). A population has persisted in Gillies Lake, near Timmins, Ont., for many years.

Thus far, there are no reports of occurrences in Manitoba, but it is to be expected that goldfish will find their way into that province from the Cheyenne River, N.D., a tributary of the Red River (Fedoruk 1969).

It has not been reported from Saskatchewan waters to date.

Paetz and Nelson (1968) stated that several releases of goldfish have been made in Alberta, and that there is a population in Henderson Lake, at Lethbridge.

In British Columbia they are known to be present in a large pond at Salmon Arm, and in a small lake in the Kamloops district. Carl et al. (1967) stated that the Salmon Arm population was first noted in 1935 and had increased tremendously by 1941.

Biology Like the carp, the goldfish is a spring-spawning species and seeks warm, weedy shallows in May or June to deposit its eggs. Battle (1940) found developing eggs as late as August 17 in Lake Erie. The spawning behaviour of the goldfish is generally not accompanied by as much splashing as that of the carp, in part because of the smaller size of the goldfish. The female may be accompanied by two or more males, and the eggs released over submerged aquatic plants or willow roots. Spawning most often occurs on bright sunny mornings.

The eggs are adhesive, 1.2–1.5 mm in diameter, and hatch in about 3 days or more, depending on temperature. Battle (1940) provided a thorough description of the embryology and development and gave the following incubation times: 3–4 days at 65.3°–85.1° F (18.5°–29.5° C); 64–72 hours at 75.2°–82.4° F (24°–28° C); 76 hours at 77° C (25° C). Young goldfish vary greatly in colour but are often green or brown. Mansueti and Hardy (1967) also illustrated and described larval stages in the Chesapeake Bay region.

The artificial culture of goldfish has been practiced by man for centuries and is the subject of extensive literature in many languages. For comprehensive coverage *see* especially Hervey and Hems (1968).

Goldfish have not been so successful as carp in establishing themselves in natural waters. They seem to have been most successful in small bodies of water, such as ponds, and often where there is a good growth of aquatic plants. They do not grow nearly so large as carp but are heavier at a given length. The following figures were obtained from wild specimens taken from Silver Lake, Port Dover, Ont.:

Fork Length		Weight	
(*inches*)	(*mm*)	(*oz*)	(*g*)
8.75	222	12	340
9.0	229	14	397
10.25	260	18	510
10.5	267	24	680

Goldfish are omnivorous feeders consuming a variety of larvae and adult aquatic insects, molluscs (such as small clams and snails), crustaceans, aquatic worms, and aquatic vegetation.

There are many reports treating the parasite fauna of European and Asiatic goldfish but these are of little concern here. For Lake Erie wild goldfish, however, Bangham and Hunter (1939) reported nematodes and acanthocephalans. Goldfish retained in artificial ponds are often more prone to parasites and to diseases than wild fish, possibly due in part to crowding and minimal predation.

Relation to man The use of goldfish as pets or to provide colour in ornamental ponds has been a part of man's culture for so many hundreds of years that no elaboration is necessary. Almost every dime store has a goldfish counter and a supply of variously shaped goldfish bowls and, with almost equal frequency, a supply of unsuitable food. For information on this aspect *see* especially Innes (1947), Sterba (1962), Hervey and Hems (1968). The most recently advertised use of goldfish to stock ornamental ponds occurred in 1969–1970 when wild goldfish from ponds in High Park, Toronto, were sent to Japan to stock the large pool in Canada's pavilion at Expo 70.

Goldfish are widely used as laboratory animals, for example, in physiological work developing techniques in measuring sensitivity to, and rate of uptake of, various dissolved gases such as carbon dioxide and oxygen, sensitivity to temperature, measuring swimming speeds, and toxicity to various industrial wastes. The goldfish is the aquatic counterpart of the guinea pig and the rabbit.

Although not usually regarded as a commercial species, they hybridize with carp and such hybrids and large (green-coloured) goldfish are marketed along with carp. In parts of Canada, where laws concerning live bait or baitfish exist, both the goldfish and carp are expressly prohibited for use as bait, but this is not so in parts of the southeastern United States. Dobie et al. (1956) provided information on raising goldfish for live bait use in such regions.

Nomenclature

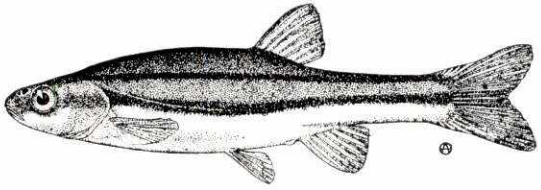
Cyprinus auratus — Linnaeus 1758: 322 (type locality China, Japan, rivers)
Carassius auratus — Günther 1868: 32

Etymology *Carassius* — Latinization of the vernacular names Karass or Karausche, applied to the European crucian carp *C. carassius*; *auratus* — gilded.

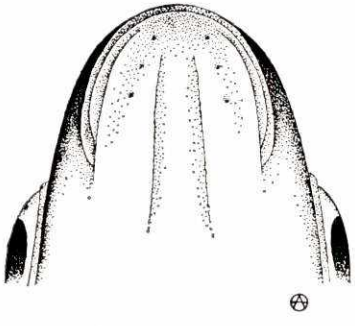
Common names Goldfish, golden carp. French common name: *poisson doré*.

NORTHERN REDBELLY DACE

Chrosomus eos Cope



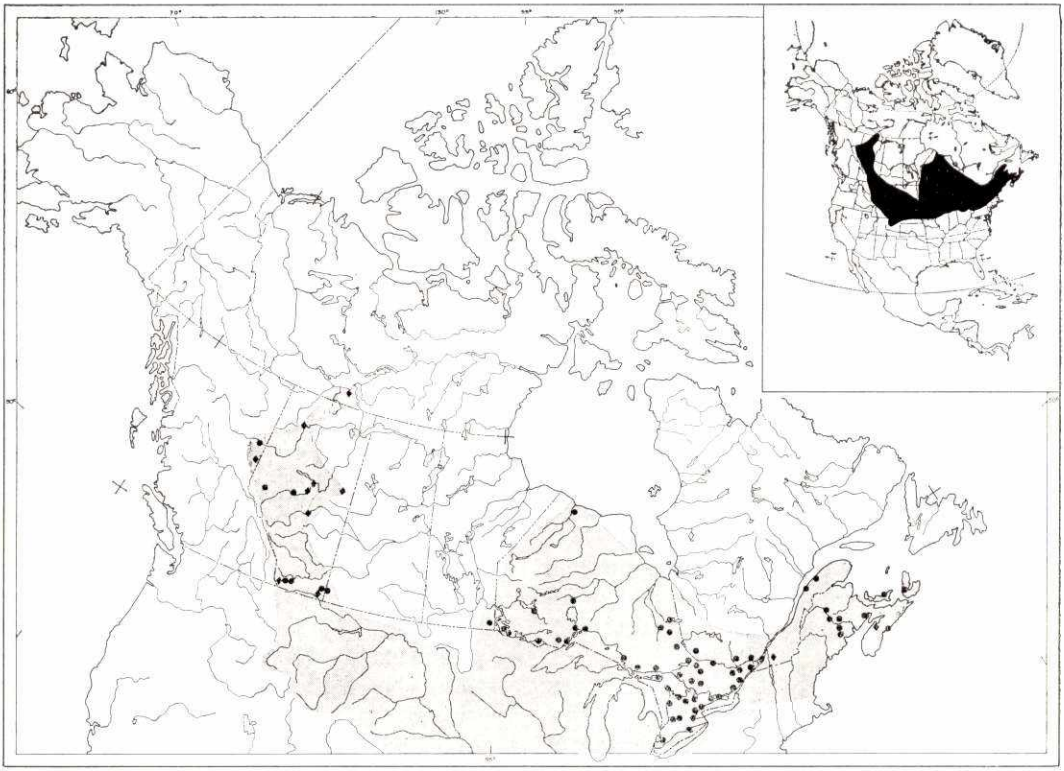
Description Body elongate and tending to be somewhat rounded in cross section, small, average total length about 2 inches (51 mm), body depth 16.0–22.7% of total length. Head moderate, its length 19.5–22.6% of total length; eye large, its diameter 23.0–37.5% of head length; snout comparable to eye diameter, its length 25.0–38.5% of head length; interorbital wide, 33.3–46.1% of head length.



Mouth small, oblique, not reaching a vertical through anterior margin of eye, almost S-shaped when viewed laterally, premaxillaries protractile; pharyngeal teeth usually 0,5–5,0 (sometimes 0,5–3,0 or 0,5–4,0). Fins: dorsal 1, its origin distinctly posterior to pelvic fin origin, rays usually 8(55), sometimes 7(2), or 9(1); caudal distinctly forked, lobes more or less rounded; anal 1, its origin slightly posterior to a vertical dropped from dorsal insertion, rays usually 8(43), sometimes 7(12), but McPhail and Lindsey (1970) said 8 or 9; pelvics moderate, origin in advance of dorsal fin origin, rays 8(38); no pelvic axillary process; pectorals larger than pelvics, rays usually 14(19), but sometimes 13(9), 15(6), or 16(4). Scales cycloid, very small, 70–90 in lateral series; the focus in each scale more nearly centred than in *C. neogaeus*; lateral line not distinct and usually terminating before pelvic fin origin. Peritoneum uniformly black, sometimes dark brown; intestine longer than body, coiled (*see* p. 381). Vertebrae 35(1), 36(8), 37(13), 38(2); Legendre (1969) obtained the following for some Quebec populations: 35(14), 36(33), 37(26), these latter modified for comparison with ours.

Nuptial tubercles, 4 or 5 rows of comblike nuptial organs on the "breast" in front of pectoral origin, and immediately below opercular margin; also a few fine and scattered tubercles on lower surface of head, below cheek.

Colour Back olive to dark brown, sometimes black in deeply stained water; below the lower dark, midlateral band the flanks may be silvery, cream through yellow to brilliant red, depending on sex and proximity to spawning. Fins yellowish when in breeding dress. The brilliant red colouration of males is characteristic through midsummer in most areas. The brilliantly coloured portion of the ventral surface, that is, the red "belly," is bordered above by the lower margin of this black lateral band providing a striking colour contrast. Preserved or immature specimens are usually olive-green on the back, with an interrupted or broken mid-



lateral stripe, flanked on each side by a vaguely defined stripe formed by dots; below each line of dots, an unpigmented area bordered below by the first of two midlateral bands, which commences above the lateral line and above the opercular opening and proceeds posteriorly, terminating on the caudal peduncle; the central and dominant lateral band commences on the snout and extends posteriorly through the eye, cheek, and along the length of the body as a distinct and heavy black band, terminating at the base of the caudal fin, sometimes as a black spot. *See* colour illustrations facing p. 250.

Systematic notes Considerable difficulty in identification is sometimes experienced because of the frequent occurrence in survey collections of *Chrosomus eos* × *C. neogaeus* hybrids, and often in the apparent absence of one of the parental species. The hybrid was reported and discussed in detail by Hubbs and Brown (1929) and more recently by New (1962). A most detailed report was prepared by Legendre (1969) who also showed that the hybrids were fertile and that introgression occurred. Hybrids are often larger than either parent and present a bewildering variety of intestinal track patterns, which have been illustrated by Legendre.

We have not accepted the proposal to merge the North American genus *Chrosomus* in the Old World genus *Phoxinus*, as proposed by Bănărescu (1964) and more recently by the American Fisheries Society (1970), because, in our opinion, this relationship has not been clearly demonstrated. Communication between scientists and the public will not be aided or enhanced by overeager adoption of new names until the old ones have been shown to be inadequate.

Chrosomus erythrogaster, the southern redbelly dace, is a distinct species and does not occur in Canada. (*See also Systematic notes* for *C. neogaeus*.)

Distribution The northern redbelly dace occurs in boggy lakes, creeks, and

ponds, from Nova Scotia south to New York and Pennsylvania on the east, west through the Great Lakes drainage (except from Lake Erie in Ohio) to Colorado, and northern British Columbia.

In Canada, it is found in Nova Scotia from Windsor, Hants County, to Lake Ainslie in Cape Breton Island (Livingstone 1953); in New Brunswick in the Saint John River system north to Grand Falls (but not above), in the Meduxnekeag, Digdeguash, Magaguadavic, and Petitcodiac rivers, and has been reported from the Miramichi River. Scott and Crossman (1959) recorded a single specimen, the only record, from the St. Croix River system. First recorded in Prince Edward Island when four specimens were collected in a tributary of the Morell River, King's County (Woronecki 1969). It occurs in Quebec, in Gaspé and through the St. Lawrence River drainage and probably northward to James Bay drainage; throughout Ontario, north to James and Hudson bays; recorded from Goose Creek (55°57′N, 87°22′W), but probably in bog situations throughout the Patricia Portion of Ontario. It has been taken in Manitoba only in the Whiteshell Forest Reserve; reported also from southwestern Saskatchewan in the Cypress Hills. In Alberta, from a few locations in the South Saskatchewan drainage, the Athabasca, and Peace rivers. In British Columbia, only in the northeast, the westerly record from Charlie Lake and its outlet near Dawson Creek (Peace–Mackenzie system); most northerly record is from Fuller Lake in Wood Buffalo Park, N.W.T. (McPhail and Lindsey 1970).

Biology The redbelly dace commences spawning activities in spring or early summer, the exact time depending on latitude and local environment. Precise observations of time and place of spawning in Canadian waters are not readily available. Ripe males and females, taken in mid-June to late June, have been reported for Quebec and Ontario from various areas, and McPhail and Lindsey (1970) reported females containing large eggs caught August 24 in northern Alberta. In Michigan, spawning activities commenced in late May and extended to August, as reported by Cooper (1935) and Hubbs and Cooper (1936), who also presented evidence suggesting that a single female may spawn at least twice in the summer season. Spawning, as reported by Cooper, consisted of the deposition of nonadhesive eggs within masses of filamentous algae. The female, accompanied by one or more males, would dart from one algae mass to another. The males appeared to be attracted to the ripe female by her darting movements. Upon diving into the mass of algae, the spawning pair or group would struggle against the algae, the actual spawning act seeming to take 2–4 seconds. Eggs were deposited and fertilized in each mass. The eggs hatched in 8–10 days at water temperatures of 70°–80° F (21.1°–26.7° C). Hubbs and Cooper considered that those hatching early in the summer probably spawned the following summer, whereas those hatching late in the season probably did not spawn the following summer, but the summer after, i.e., in their third year.

Age determinations using the right opercular bone, were made by Legendre for some Quebec populations. From the growth curves provided, fish grew to the following approximate standard lengths at ages 1–5: age 1, 21 mm; age 2, 1.5 inches (38 mm); age 3, 1.8 inches (46 mm); age 4, 2.1 inches (53 mm); and age 5, 2.3 inches (58 mm). The oldest male he examined was 6 years old, the oldest female, 8; the largest female 2.4 inches (60.9 mm) standard length, the largest male 2.1 inches (53 mm).

This dace seems to prefer the quiet waters of beaver ponds, bog ponds, small lakes, or quiet pool-like expansions of streams, often over a bottom of finely divided brown detritus or silt. In such locations the water is often stained the colour of tea and may be slightly acid. The lethal temperature relations of this and the finescale dace were investigated by Tyler (1966).

Food of the redbelly dace consists mainly of algae such as diatoms and filamentous algae but included in the diet are zooplankton and aquatic insects. Cooper (1936a) observed that redbelly dace 2.0–2.5 inches (51–

64 mm) long would eat smallmouth bass fry 8–9 mm long when held in aquaria.

The redbelly dace probably has a host of predators, such as other fishes, kingfishers, and mergansers, since it is so small and often occurs in large numbers. Presumably, they are consumed by brook trout in our waters but Ricker (1932) found no such evidence although Sibley and Rimsky-Korsakoff (1931) reported this dace in trout stomachs in New York State waters.

Bangham (1955) examined 17 specimens from Rogers and McKim creeks near South Bay, Manitoulin Island, Ont., and found 9 infected with 3 species of larval trematodes and 2 with Gyrodactyloidea. He added that 2 of 10 fish examined from Rogers Creek contained only *Diplostomum* sp.

Bangham and Venard (1946) studied parasites of this species in Algonquin Park lakes and reported 14 of 88 fish were infected. Parasites listed included 2 species of trematodes, 2 species of nematodes and 1 cestode, *Ligula intestinalis*.

Hoffman (1967) listed larval forms of 5 species of trematodes, and the immature adult form of the nematode *Spiroxys* sp., from the northern redbelly dace in North American waters.

Relation to man The tea-coloured, acid waters of eastern Canada, where this colourful little minnow is most abundant, are often the haunt of the brook trout; in such locations, the northern redbelly dace serves as an excellent forage fish, and, being mainly herbivorous, does not compete with the trout for food.

It is rather small for a bait minnow but it is hardy and readily available in the less densely populated portions of Quebec and Ontario, where it is used for bait, often with finescale dace.

Cooper (1935) demonstrated that the redbelly dace could be reared successfully in ponds, but best results were obtained when there was some freshwater flow. He obtained yields of 128,000 fish, or approximately 256 pounds, per acre of water surface in one summer.

Nomenclature

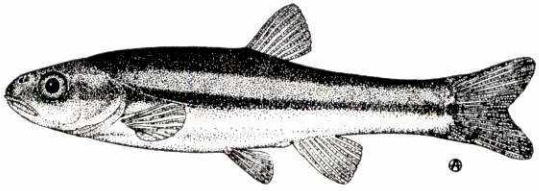
Chrosomus eos	— Cope 1862: 523 (type locality Meshoppen Creek, Pa.)
Chrosomus dakotensis	— Evermann and Cox 1896: 395
Chrosomus erythrogaster Agassiz	— Cox 1896b: 64
Chrosomus erythrogaster Rafinesque	— Halkett 1913: 61
	— Dymond 1926: 42
	— Dymond et al. 1929: 21
Phoxinus eos (Cope)	— Bailey et al. 1970: 23

Etymology *Chrosomus* — colour; body; *eos* — sunrise.

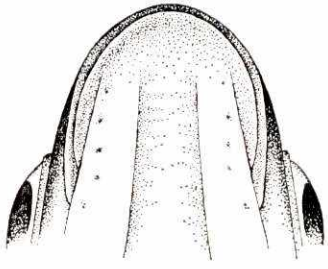
Common names Northern redbelly dace, redbelly dace, red-belly dace, red bellied dace. French common name: *ventre rouge du nord.*

FINESCALE DACE

Chrosomus neogaeus (Cope)



Description Body stout, average length about 3 inches (76 mm), not strongly compressed laterally except latter half of body, maximum body depth occurring about midpoint to tip of pectoral fin, body depth 15.4–22.4% of total length.



Head large, broad, its length 20.0–26.5% of total length; eye moderate, its diameter 21–35% of head length; snout broad, its length 26.3–38.3% of head length; interorbital broad, its width 33.3–45.4% of head length; mouth large, terminal, extending back to below anterior margin of pupil of eye; pharyngeal teeth in two rows, 2,5–4,2 or 2,5–5,2 or 1,5–4,1. Fins: dorsal 1, its origin distinctly posterior to pelvic fin origin, rays usually 8(51), seldom 7(3), or 9(2); caudal with shallow fork, lobes rounded, a distinct round, black spot at caudal base; anal 1, origin under or slightly behind insertion of dorsal fin, rays 8(45), occasionally 7(6), or 9(5); pelvics small, origin distinctly in advance of dorsal fin origin, rays 8(39), seldom 7(2); no pelvic axillary process; pectorals rather fanlike, rays usually 14(24), but may be 15(7), 13(6), 12(2), or 16(2); on spawning males, the first 4 or 5 rays are darkly pigmented, thickened, and strengthened, becoming almost like spines in their degree of rigidity, and appearing as if deformed from fin clipping at a point about three-quarters along length of fin; on the same individuals, nuptial tubercles are developed on "breast" and flanking anal fin base. Scales cycloid, small, 63–85 in lateral series, focus eccentric; lateral line incomplete, extending from behind dorsal part of gill cover, quickly curving downward to follow ventral margin of lateral band, terminating usually above pelvic fin origin. Peritoneum uniformly black; intestine short, a single S curve. Vertebrae 37–39.

Nuptial tubercles in 4 or 5 rows of comb-like structures on breast in front of pectoral fin origin and below posteroventral margin of operculum; 4 or 5 rows of tubercles on scales above the base of the anal fin and extending posteriorly almost to the beginning of the lower lobe of the caudal fin.

Colour Back dark brown, almost black in dark peat-stained water; the darkly pigmented back extends downwards about halfway between midline of back and free dorsal edge of operculum, this black cap on the back ending sharply; below this, a sparsely pigmented area, a lateral stripe, olive-green or gold in life, immediately above the densely pigmented and distinct lateral band, which commences on snout (lips pigmented but chin immaculate), proceeds through eye, across opercle,

along length of body, and terminates in a distinct caudal spot. On breeding males, the whole ventral surface, from lower margin of the lateral band on each side, flushed with chrome yellow, at times strikingly intense, to brilliant red. Subadults and nonbreeding adults are silvery white below. Fins usually have an amber or light yellow tint, the rays pigmented, more intensely at spawning time. *See* colour illustrations facing p. 250.

Systematic notes Morphological and anatomical variations of the finescale dace throughout its range have not been examined, and to our knowledge, geographic races have not been proposed.

Considerable discussion, however, has arisen concerning the most appropriate generic placement.

Most North American workers followed Bailey's (1951) proposal to merge the genus *Pfrille* with *Chrosomus*. Some favour placement of *neogaeus* in the Old World genus *Phoxinus*, a view that was expressed by Bănărescu (1964) and has gained partial favour with some, notably McPhail and Lindsey (1970) who reviewed this question. But, the casual placement of *neogaeus* in *Phoxinus* proves nothing, since without adequate documentation (one might almost say, without the application of the usual scientific procedures) we are no wiser than before. Compilers and biogeographers, being unaware of this weakness, will not be better served.

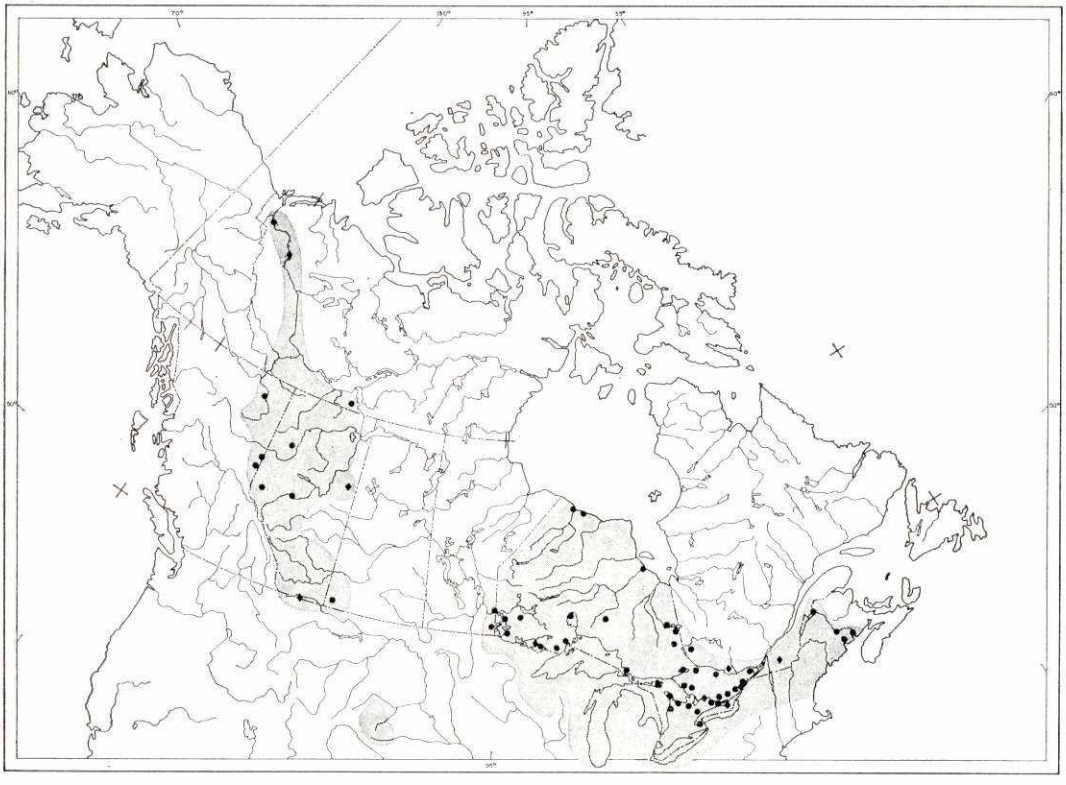
Whatever the decision, the closeness of the relationship of *Chrosomus eos* and *neogaeus* can surely not be denied. Most field biologists experience considerable difficulty in distinguishing the two species, especially since they hybridize rather freely, producing fertile hybrids, according to Legendre (1969), who also noted that both species carry 50 diploid chromosomes (as do *Semotilus margarita* and *Couesius plumbeus*). In fact, Legendre considered it reasonable to transfer *margarita* from the genus *Semotilus* to *Chrosomus*. (*See also Systematic notes* for *C. eos*.)

Distribution The finescale dace occurs in bog ponds, streams, and lakes from New Brunswick, Maine, and New Hampshire on the east, through southern Quebec and northern New York State, north of the lower Great Lakes to Michigan, and northwest to the Arctic Circle in the Mackenzie River system. Isolated populations reported in South Dakota, Nebraska, Colorado, and Wyoming (Bailey and Allum 1962).

In Canada, this dace is reported from scattered locations in New Brunswick, through southern Quebec including lower Gaspé, throughout Ontario (excepting southwestern Ontario), north to Hudson Bay; in Manitoba from Brereton Lake, Telford Pond, and Rennie River, all in southern Manitoba; in Saskatchewan from the Cypress Hills region in a tributary to Frenchman River of the Missouri drainage, and also in a tributary of the South Saskatchewan River; in Alberta in tributaries of the Milk River in the south, and from the vicinity of West Pierre, Grey's Lake, Horne Lake, and East Hawk Hills Lake. It occurs in British Columbia in the Mackenzie River system (Fort Nelson River and One Island Lake) and downstream in the Mackenzie River system of the Northwest Territories to the Arctic Circle. McPhail and Lindsey (1970) specified that it did not occur in the upper Liard or Peace River basins.

It is absent from Newfoundland, Nova Scotia, and Prince Edward Island.

Biology Spawning presumably occurs in the spring, probably in June in northern Ontario. Dymond (1926) reported taking females with nearly ripe eggs on June 24, 1924. We also have at hand field sketches by T. M. Shortt of brightly coloured males taken on Albany Island, James Bay, on June 15, 1942. But details such as place of spawning, number of eggs, spawning behaviour, and so forth, have not been documented, or at least not published. Presumably the modified pectoral fins of the male in spawning condition are important in some phase of the spawning procedure. The rays of the pectoral fins, especially the first five or six, are thickened and stiffened and develop a swelling on each ray about one-quarter of the length of the ray from the tip. The outer part of the fin curls



upward, the whole fin giving the impression that it was deformed by fin clipping. The fins also stand out stiffly from the body and cannot be readily depressed.

Preferred habitats seem to be the cool bog lakes, streams, and some larger lakes of the central and northern part of the continent. It seems most often to be found in stained, boggy waters. Dymond (1926) noted that *p*H readings of two such lakes near Lake Nipigon showed them to be neutral or slightly acid (6.9–7.0).

The finescale dace is usually found in association with *C. eos*, *Semotilus margarita*, and *Culaea inconstans*. It seems to hybridize readily with *C. eos*, the resulting hybrids are fertile (Legendre 1969); it is probable that introgression is common. Legendre gave a few data on the growth of the hybrids but not for this parent species.

The few stomachs that have been examined suggest that insects form a major part of the summer diet, but crustaceans and plankton are also consumed. In the absence of information, further speculation seems pointless.

There are apparently no records in Canadian literature of the parasites of this dace.

Hoffman (1967) listed the protozoans *Myxosoma parellipticoides*, *M. pfrille*, and *Thelohanellus notatus*, and the larval forms of the trematodes *Echinochasmus donaldsoni* and *Uvulifer ambloplitis* from the finescale dace in North American waters.

Relation to man The role of the finescale dace in the ecology of our aquatic communities is not known; indeed we know next to nothing about the life history of the species.

Because of its size, hardiness, and availability, it is used as a bait minnow in parts of Quebec and northern Ontario, most often sold under the name "chub."

Nomenclature

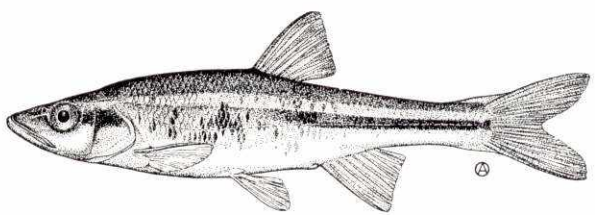
Phoxinus neogaeus	— Cope 1869: 375 (type locality New Hudson, Mich.)
Leuciscus neogaeus (Cope)	— Jordan and Evermann 1896–1900: 240
Pfrille neogaeus Cope	— Hubbs 1926: 34
Pfrille neogaea (Cope)	— Jordan, Evermann, and Clark 1930: 121
Chrosomus neogaeus	— Legendre 1953: 246
	— Hubbs and Lagler 1958: 80
Phoxinus neogaeus Cope	— Bailey et al. 1970: 23

Etymology *Chrosomus* — colour; body; *neogaeus* — new; world.

Common names Finescale dace, fine-scale dace, fine-scale minnow, bronze minnow. French common name: *ventre citron.*

REDSIDE DACE

Clinostomus elongatus (Kirtland)



Description Body slender, elongate, averaging about 3 inches (76 mm) long, distinctly compressed laterally, the greatest depth 17.1–20.0% of total length. Head pointed, triangular, its length 21.8–23.3% of total length; eye moderate, its diameter 23.6–29.6% of head length; snout sharply pointed and long, its length 32.0–42.8% of head length; interorbital width somewhat greater than eye diameter, 26.6–33.3% of head length; mouth very large, terminal, lower jaw distinctly projecting, gape extending to below anterior half of eye; pharyngeal teeth well developed, slightly hooked, usually 2,5–4,2 (occasionally 1,4–3,1). Fins: usually transparent; dorsal 1, its origin clearly posterior to pelvic fin origin, rays usually 8(21), rarely 7(1); caudal distinctly forked; anal 1, rays usually 9(17), occasionally 8(4), rarely 10(1); pelvics originating in advance of dorsal fin origin, rays always 8; pectorals elongate, tips reaching origin of pelvics, rays 14–16. Schwartz and Norvell (1958) noted that pectorals of males are longer than those of females. Scales cycloid, persistent, 63–70 in lateral line; lateral line complete, slightly decurved. Peritoneum silvery, speckled. Vertebrae 38–41, usually 40 or 41.

Nuptial tubercles on breeding males small or minute and distributed over nearly all of body, but larger on dorsal surface of head, body, and pectoral fins; females also develop tubercles but these are smaller and not so widely distributed as on males.

Colour Adult redside dace are usually highly colourful, with iridescent reflections of blue, green, purple, and violet; back usually dark green or blue-green, below which is a thin, golden stripe along sides, level with the eye and extending posteriorly to caudal peduncle. Below the gold stripe is an orange or red band, extending from opercle or gill cover to below dorsal fin or beyond. Preserved specimens dark on back, below this on each side is a narrow light stripe and beneath the light band is a dark lateral band, vague in its beginnings but usually originating below dorsal fin and continuing posteriorly to caudal peduncle. The sides are usually sprinkled with specialized darkened scales and rather distinct spots of pigment.

Distribution The redside dace has a limited distribution in North America. It occurs in the United States in the upper Mississippi drainage system from New York State, south to Kentucky, and west to Wisconsin, Iowa, and Minnesota (Moore 1968).

In Canada it is found only in clear streams flowing into western Lake Ontario, in the counties of Brant, Bruce, Halton, Ontario, Peel, Wentworth, and York.

Biology No studies of this species in Ontario waters have apparently been made, all the more unfortunate since the redside dace is much less common now than 30 years ago.

Spawning in northern New York State was recorded by Koster (1939), who observed spawning fish in a stream south of Ithaca in 1936. Spawning was observed May 22, 24, 25, and 26, close to the bottom, and usually in or near the gravelly nests of creek chub. The lowest temperature at which spawning was observed was 65° F (18° C). In one closely studied area, Koster noted that the adults foraged in an upstream pool and moved downstream to a gravel area to spawn. With the approach of spawning time, males tended to defend small, poorly defined, territories, but abandoned these when spawning actually commenced. During spawning, the males would congregate in dense schools downstream from creek chub nests, the females positioned on the lateral and posterior margins of a school. Spawning would commence when a female moved upstream toward the creek chub nest, to be joined on the way by two or more males. Spawning occurred in the pit of the creek chub nest, often when the male creek chub was present. On a number of occasions, the spawning act was repeated four to six times within 1 minute, but Koster noted that usually several minutes elapsed between matings. Koster described the movements and general behaviour of the prespawning and spawning dace in considerable detail.

The number of eggs per female varied from 409 to 1526 by direct count on 15 females. When water hardened, eggs measured 1.2–2.4 mm in diameter and were nonadhesive.

Koster made age determinations from scales, although he considered the scales difficult to read. *See also* details on scale reading by Schwartz and Norvell (1958). Koster concluded that spawning first occurred in the third year; the oldest specimens found were in their fourth year. The largest specimens seen by Koster had total lengths of 3.5 inches (89 mm) for males and 3.8 inches (97.5 mm) for females. The largest Ontario specimens are about 4 inches (100 mm) total length. Koster presented the following standard lengths (in millimeters) for May-caught specimens:

Age	M	F
1	38.0 ± 2.5	37.3 ± 2.8
2	55.6 ± 2.9	57.0 ± 2.7
3	61.7 ± 3.4	69.1 ± 3.2

Redside dace prefer clear, cool, flowing water with gravel or stoney bottom. According to Trautman (1957) they are apparently quite sensitive to turbidity.

Food consists mainly (95%) of insects. Terrestrial insects make up the bulk of in-

gested material, constituting 76.9% of all food eaten. Many of these are caught in flight by leaping dace. The large mouth is ideally suited to this kind of feeding. The more common insects were Diptera (flies), Ephemeroptera (mayflies), and Odonata (dragonflies). Spiders are also eaten (Schwartz and Norvell 1958).

There are no reports of parasitic infestation of the redside dace in Ontario waters. Hoffman (1967) listed only two parasites, the trematodes *Dactylogyrus extensus* and *Neodactylogyrus confusus*, from the species in North American waters.

Relation to man The redside dace is of little direct importance to man because of limited distribution. However, it is of biological interest because of its unique adaptations for feeding on insects, such as its large mouth and jumping ability. Its present restricted Canadian distribution and sensitivity to turbidity suggest that this dace will become increasingly rare.

Nomenclature

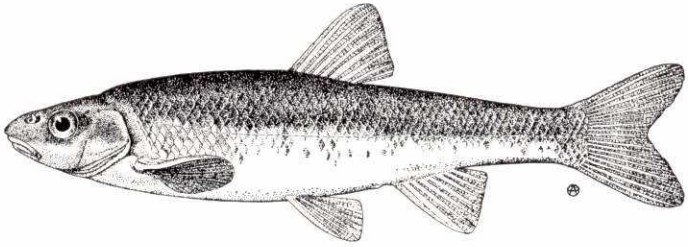
Luxilus elongatus	— Kirtland 1838: 193 (type locality Lake Erie, near Cleveland, and Mahoning River, Ohio)
Leuciscus elongatus (Kirtland)	— Jordan and Evermann 1896–1900: 240
Richardsonius elongatus (Kirtland)	— Bailey 1951: 191
Gila elongata (Kirtland)	— Bailey 1956: 331
Clinostomus elongatus	— Hubbs and Lagler 1958: 80

Etymology *Clinostomus* — to incline; mouth; *elongatus* — lengthened.

Common names Redside dace, red-sided shiner. French common name: *méné long.*

LAKE CHUB

Couesius plumbeus (Agassiz)



Description Body elongate, average length about 4 inches (102 mm) not noticeably compressed laterally, greatest body depth 14.4–20.7% of total length; caudal peduncle long and rather slender. Head rather short, its length 18.8–22.2% of total

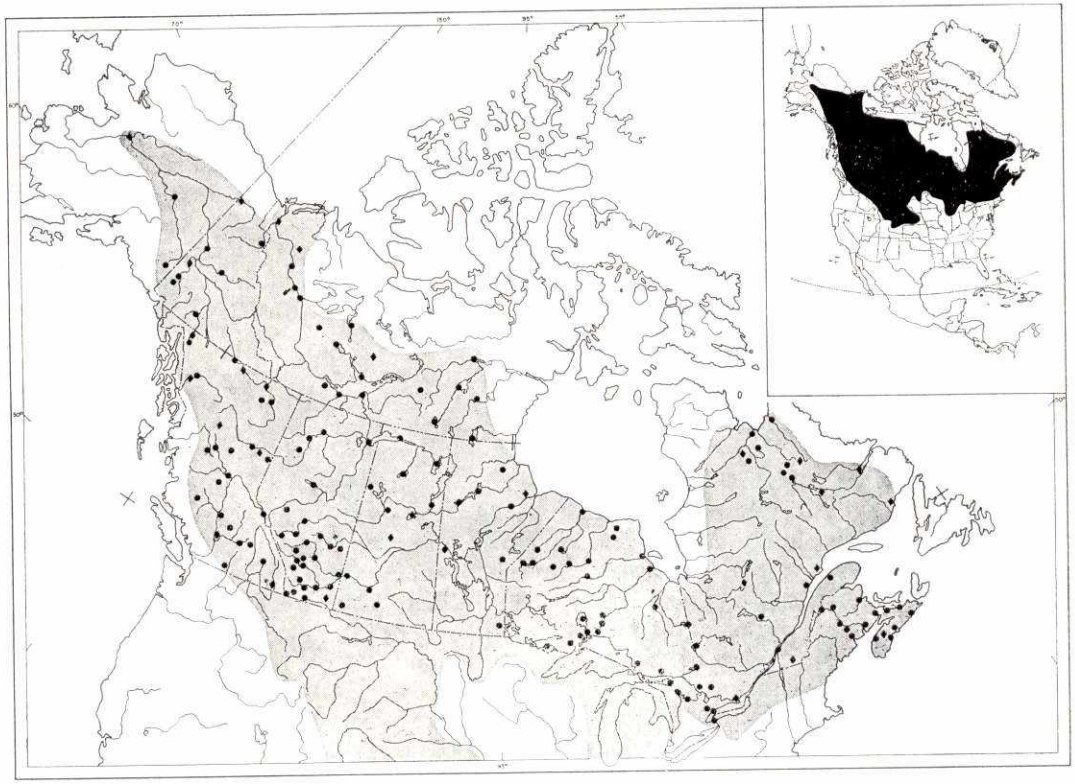
length; eye size variable, its diameter 20.4–33.3% of head length; snout bluntly rounded, its length 26.6–40.0% of head length, usually projecting slightly beyond upper lip, particularly in eastern Canadian populations; interorbital width 33.3–42.8% of head length; mouth moderately large, upper jaw almost reaching anterior margin of eye, a well-developed, threadlike barbel at each corner of the mouth, its base affixed very slightly in advance of end of maxillary, but the tip appearing at end of maxillary; pharyngeal teeth usually 2,4–4,2, but variable, 2,4–4,0, 2,5–4.2 (McPhail and Lindsey 1970, gave extremes of 0,4–4,0 and 2,5–4,2), flattened and hooked. Fins: dorsal 1, its origin slightly posterior to pelvic fin origin; Hubbs (1942) noted that dorsal fin origin was sex dependent, at least in part, and McPhail and Lindsey suggested that origin was age dependent, but the relative positions of dorsal and pelvic fin origins seem also to be geographically variable, rays consistently 8(87); caudal moderately well forked, lobes rounded; anal 1, origin below posterior free margin of depressed dorsal fin, rays usually 8(83), seldom 9(3), or 7(1); pelvics well developed, origin usually slightly in advance of dorsal fin origin, rays usually 8(56), seldom 7(3), or 9(1); pelvic axillary process not developed or, at best, a simple ridge; pectorals broad, well developed, rays usually 15(15) or 16(28), sometimes 13(2), 14(4), 17(8), or 18(3). Scales cycloid, persistent, somewhat elongate, isolated darkened scales common on eastern and northeastern specimens, less so in northwest; lateral line complete, total number of pored scales usually given as 53–79 but 58 samples yielded range of 56–69 and McPhail and Lindsey had 58–65 in their area. Peritoneum silvery, speckled; intestine short, proportional length of digestive tract 0.9–1.2 in total length (Dymond 1926). Vertebrae usually 40 or 41, total range 39–43. McPhail and Lindsey said 39–44.

Nuptial tubercles small but well developed on males, slightly less so on females, on top of head, scattered on sides of head, around orbits, scattered lightly on back from nape to dorsal origin, well developed on dorsal surface of pectoral rays, and well developed on scales on breast from around pectoral bases forward to cleithrum on eastern Canada specimens as well as those in northwest. A few tubercles developed on first two rays of pelvic fin.

Colour The overall general colouration is leaden silvery (from which the scientific name is derived). The colour of the back may be pale olive to olive-brown, brown, dark brown, or almost black, becoming leaden silvery on the sides and silvery white below. The lower sides and belly are often sprinkled with dark pigment. Specialized, darkened scales, comparable to those of the pearl dace, are often present on the sides. The midlateral band is not usually evident in life but is pronounced in young fish to lengths of about 2 inches (51 mm), and in eastern Canadian populations may persist throughout adult life. McPhail and Lindsey (1970) stated that it is indistinct and only on posterior half of the body of adults.

Bright colours are less flamboyantly displayed than in *Chrosomus* or *Semotilus margarita*, except for dashes of brilliant red or red-orange on breeding males, at the bases of the pectoral fin, sometimes also at pelvic fin bases and at the corners of the mouth. The presence and amount of colour seems to vary with region. McPhail and Lindsey specified that colour was absent on breeding males of the Pacific form. On the other hand, Dymond (1926) found Lake Nipigon specimens to be highly coloured with red not only at bases of paired fins but also on snout between eye and maxillary and below the upper posterior margin of opercle at origin of lateral line. Richardson (1944) made similar observations in Quebec, but, in an earlier account (Richardson 1935) he reported that no marked sexual differences were apparent among spawning adults taken at Lac Saugay, Que., and that both sexes were coloured.

Systematic notes For many years *Couesius plumbeus* was considered by many authors to be represented throughout its wide



range by three subspecies, all of which occurred in Canada: *C. p. plumbeus* of eastern North America, the Great Lakes, and the northwest; *C. p. dissimilis* of the upper peninsula of Michigan and west on either side of the international boundary to the eastern foothills of the Rocky Mountains; and *C. p. greeni* of the Pacific slope. But with the merging of the genus *Couesius* in *Hybopsis*, which was proposed by Bailey (1951), the name *dissimilis* became unavailable since it was preoccupied in *Hybopsis*. Subspecies designations for *Couesius plumbeus* have been questioned and were thoroughly discussed by Lindsey (1956). At present, the status of subspecies for *C. plumbeus* are in doubt and are not employed here, which is not to deny the existence of many differences between populations but to indicate that the application of names implies a degree of understanding that does not exist.

The proposed merging of *Couesius* with *Hybopsis* was accepted by many workers but not by all. It was accepted, however, and published by the American Fisheries Society in its Special Publication no. 2 (Bailey et al. 1960). But the genus *Couesius* was employed in the 1970 revision of the names list. *See* McPhail and Lindsey (1970) for a discussion of the generic placement of *Couesius* and *Platygobio* in *Hybopsis*.

A comprehensive study of the systematics of *Couesius plumbeus* in Saskatchewan was recently completed by J. H. Brown and U. T. Hammer, University of Saskatchewan, but has not yet been published.

Distribution The lake chub occurs widely throughout Canada and in scattered localities in the northern United States, from northern New England to New York, in Michigan, relict populations in Iowa, scattered distribution in Wisconsin, Minnesota, the Dakotas, Montana, Wyoming, Colorado, and in Idaho south to Lake Pend Oreille.

In Canada, the species is found in streams, rivers and lakes throughout the mainland of Nova Scotia from the Moser River, Halifax County, to Bear River, Annapolis County. It is wide ranging throughout New Brunswick, particularly in the northern part. It has been reported from many parts of Labrador by Backus (1951) and others, in Hamilton Inlet basin and Grand Lake system, more often in streams and lake-like expansions of rivers. It is widely distributed in Quebec, north to Ungava where it is known to be widely distributed, east to about Gethsemani, and in many of the streams, rivers, and lakes of the Ungava Bay drainage (Power and Oliver 1961; Harper 1961), sometimes downstream to the head of tide, and it was reported from Indian House Lake, far upstream in the George River system by Legendre and Rousseau (1949); on both sides of the St. Lawrence, including Gaspé, on the north shore east to about Gethsemani, uncommon in the Lac St. Pierre–Lac St. François region of the upper St. Lawrence system, occurring only in tributary streams. The lake chub occurs throughout Ontario in streams and lakes, including the Great Lakes (except in lakes Erie and St. Clair), north to Hudson Bay.

In Manitoba, Saskatchewan, and Alberta it is common in many streams and rivers in the southern parts and in lakes in the north. In Manitoba it occurs widely, and Keleher and Kooyman (1957) recorded it from many localities north to South Knife Lake at 58°10′N, 96°28′W, although we now know it ranges into the Northwest Territories. In Saskatchewan and Alberta it occurs widely from the Cypress Hills region in the south to Lake Athabasca in the north, and northward into the territories (Henderson and Peter 1969; McPhail and Lindsey 1970). In British Columbia, it ranges widely throughout the province, in the Columbia and Fraser River systems, the Skeena, the Peace, the Liard (Mackenzie system), and the Yukon. In the Northwest Territories it ranges from Chesterfield Inlet tributaries and Nueltin Lake, westward through the major watersheds of the territories, downstream in the Yukon River in Alaska at least to Nulato (McPhail and Lindsey 1970).

Biology Despite the wide distribution of this species throughout Canada, relatively few serious studies of its biology have been conducted, and fewer still have been published. (Geen, unpublished MS; Brown, unpublished MS.)

The data available are from widely scattered regions and, hence, generalizations could be misleading. A species that spawns in April in Lake Ontario might not reproduce until July or August in the Northwest Territories.

The lake chub usually undergoes a spawning migration from lakes to tributary streams early in the spring. In the Great Lakes, this takes place about the same time as, or earlier than, the smelt runs (usually April). In Lake Nipigon, spawning is said to occur in June (Dymond 1926). Richardson (1935) caught many ripe females and a few males in a tributary stream to Lac Saugay, Que., early in June when water temperature in the stream was 57° F (14° C) and in the lake 66.2° F (19° C). At Lac la Ronge, Sask., they were observed spawning among large rocks in the shallows of the Montreal River in middle or late May, without building a nest or guarding eggs, according to McPhail and Lindsey (1970) who obtained this information from the field observations of J. H. Brown, University of Saskatchewan. McPhail and Lindsey also noted that spawning commenced in some lakes of the Caribou District of central British Columbia in late May or early June. During surveys on the Barren Grounds of the Northwest Territories in 1959, well-tuberculated ripe males and females were caught as late as August. The eggs are yellowish in colour and Richardson (1935) estimated 500 eggs in a female 2.8 inches (70 mm) long, but additional details such as time to hatching and rate of development are apparently not available.

Details of growths are also unavailable but Geen's (1955) study in central British Columbia indicated that fish matured in their third or fourth year and probably seldom survived beyond 5 years, and that females grew faster and lived longer than males. Richardson (1935) also observed large numbers of dead lake chub, most of

which had spawned, in a stream in southwestern Quebec, suggesting that postspawning mortalities occur.

The lake chub is a large minnow, commonly reaching sizes in excess of 4 inches (102 mm). The largest specimens we examined were from Lake Mattagami, Nottaway River drainage, Que., and measured 227 mm in total length, or over 8.9 inches. In a sample of seven spent females provided by Vianney Legendre, six were about 8 inches (over 200 mm) in total length. All were caught by gillnets from August 13 to 31, 1963. Sizes to 6.25 inches (158 mm) were not uncommon in the Severn River (Dymond and Scott 1941) and Dymond (1926) gave the length of the largest specimen in Lake Nipigon as 5.25 inches (133 mm) (probably standard length). Large minnows of this size are not usually captured easily in shore seines and it seems worth noting that the large fish from Mattagami Lake were taken by gillnet and the 6.25-inch specimens from the Severn River were caught by seining at night. Large specimens may be more common than the present sampling methods would suggest.

Appraisals of habitat preference are, to date, dependent on capture, and conclusions based on these captures are biased since most of the available observations relate to fish migrating into streams for spawning. The lake chub seems to resort to lakes, whenever these are available, and move into the deeper parts of lakes during summer, or so gillnet capture would indicate. In the northern parts of the range, if large lakes are not available, they can successfully live in large rivers such as the Severn, the Mackenzie, and the Yukon and are, therefore, highly adaptable.

Extensive food studies have not been made but stomach analysis for some Ontario populations indicates that chironomid larvae and other aquatic insect larvae form the major part of the diet with small amounts of cladocerans and algae. Studies in British Columbia, reported by McPhail and Lindsey, showed that terrestrial and aquatic insects, zooplankton and algae were the main food items, and some large chub had eaten small fishes. It was classified as a sight feeder by Davis and Miller (1967) because it has large optic lobes and only a moderate number of taste buds.

Predation on lake chub by larger predaceous fishes, such as lake trout, burbot, or walleye is probably considerable but direct evidence is meagre. Northern pike were observed preying upon lake chub in Northwest Territory lakes in July, 1959. Predation on lake chub by mergansers and particularly by kingfishers was documented by White (1953, 1957) for the Maritime Provinces.

The lake chub seems to harbour a rather rich parasite fauna. Bangham (1955) examined lake chub from Lake Huron, Ont., and recorded the larval form of two trematodes, *Diplostomulum* sp. and *Posthodiplostomum minimum*, the adult form of nematode, *Rhabdochona* sp., and an acanthocephalan *Echinorhynchus salmonis*. Bangham and Adams (1954) examined 161 specimens of lake chub from three localities in the Columbia River drainage of British Columbia and from two areas of the Fraser River drainage. They found 160 fish infected, and recorded 18 species of parasites, over one-half of which were larval or encysted forms. They noted that in many cases, the fish acted as an intermediate host, final development taking place in fish-eating birds and in other fishes.

In a review of the parasites reported for the species in North America, Hoffman (1967) listed one protozoan, seven species of trematodes, four cestodes, two nematodes, two acanthocephalans, glochidia, and one crustacean, *Ergasilus caeruleus*.

Relation to man The role of the lake chub in the bioeconomy of our aquatic environments is really not known. Its extremely wide distribution in Canadian fresh waters, when considered with what we know of its food habits, suggests that it is a forage fish of considerable importance.

Lake chub have been tested by a cold-smoke process by the Fisheries Research Board of Canada, and the resulting product considered satisfactory (Lantz 1962).

In the Lake Superior drainage of Ontario, Allin (1953) reported that lake chub (designated in this instance by Allin as *C. p. dissimilis*) interferes with brook trout angling, particularly in Nishin Lake, for "it is almost impossible to make a cast without catching one of these minnows."

It is frequently caught by sportsmen stream fishing for smelt in Lake Ontario and Lake Huron drainages, is usually unrecognized, and is mistakenly taken and eaten for smelt. In the same regions, the spring-spawning runs are fished by bait dealers, usually in early April, and the chub are held for sale as walleye bait. Allin (1953) noted that it was also used for live bait in lake trout fishing in the vicinity of Rossport, Lake Superior.

Nomenclature

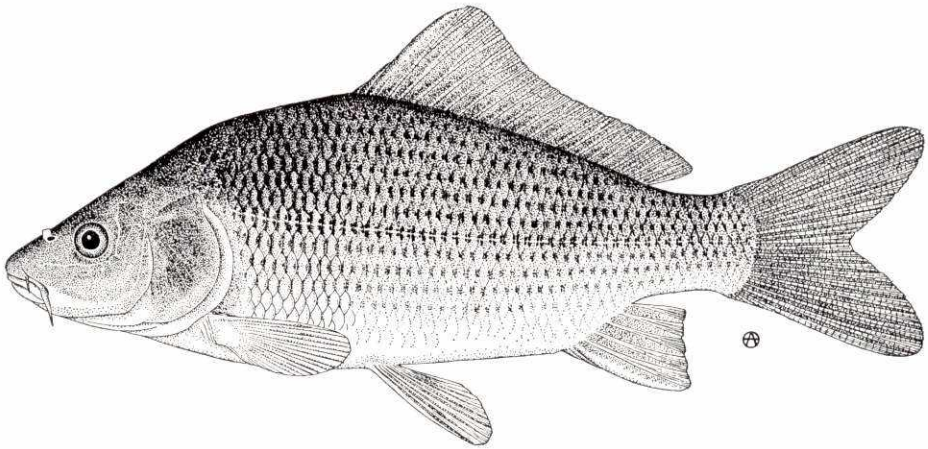
Gobio plumbeus	— Agassiz 1850: 366 (type locality Lake Superior)
Leuciscus cephalus	— Perley 1852: 194
Nocomis milneri	— Jordan 1877a: 64
Couesius greeni	— Jordan 1893: 313
Couesius prosthemius Cope	— Cox 1896b: 65
Ceratichthys prosthemius	— Cox 1896b: 65
Ceratichthys Plumbeus Günther	— Cox 1899: 146
Couesius plumbeus (Agassiz)	— Scott and Crossman 1959: 20
Hybopsis plumbea	— Bailey et al. 1960: 14
Couesius plumbeus	— Bailey et al. 1970: 19

Etymology *Couesius* — after Dr E. Coues, American ornithologist, collector of type specimens; *plumbeus* — lead coloured.

Common names Lake chub, northern chub, lake northern chub, creek chub, chub minnow, plumbeus minnow, Moose Lake minnow, bottlefish. French common name: *méné de lac.*

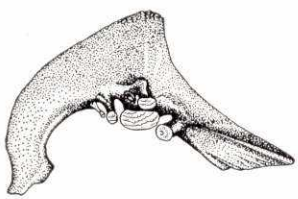
CARP

Cyprinus carpio Linnaeus



Description Body robust, compressed laterally, usually 15–18 inches (381–457 mm) long, body depth 25.8–32.8% of total length. Head triangular, its length 23.3–27.2% of total length; eye small, its diameter 17.7–23.3% of head length; snout long, 33.3–42.8% of head length; interorbital 31.5–42.8% of head length; mouth of moderate size, toothless, upper jaw slightly protruding. Two pairs of barbels about the mouth, posterior pair at the corners of the mouth most conspicuous; pharyngeal teeth distinctly molarlike 1,1,3–3,1,1. Gill rakers 21–27. Fins: all fins opaque; dorsal 1, long, of 1 stout, toothed spine and usually 18–20 soft rays; caudal forked; anal 1, of 1 stout heavy spine with serrations on trailing edge, 5 branched rays; pelvics thoracic, originating beneath origin of dorsal fin, of 8 or 9 rays; pectorals of 15 or 16 rays, occasionally 14–17. Scales cycloid, large, thick, 35–39 in lateral line; occasionally scales enlarged and scattered (mirror carp), or absent (leather carp); lateral line complete. Vertebrae 35 or 36.

Nuptial tubercles fine and scattered.



Colour Colouration variable; adults usually olive-green on the back, becoming yellowish on the belly. Lower half of the caudal fin and the anal fin often with reddish hue, with stronger colouration on large adults.

Systematic notes For information on hybridization with goldfish, *see Systematic notes* for goldfish, p. 389.

Distribution The carp was indigenous to temperate portions of Asia before

the Christian era and also occurred naturally in Europe. It was introduced into England during the reign of Henry VIII and, because of its suitability for pond culture and its popularity as a food fish, it was introduced into North America. DeKay (1842) quoted a letter from Capt. Henry Robinson, of New York, stating that in 1831 and 1832 he brought 6 or 7 dozen carp from France and put them into his private pond near the village of Newburgh, N.Y. He further stated that he had released carp into the Hudson River after rearing them in his pond. Some doubt exists as to whether these fish were *Cyprinus carpio*, goldfish, or hybrids (McCrimmon 1968). Introductions into American waters by the U.S. Fish Commission followed and, after initial failures to establish the fish, success was achieved in 1877. Distribution by the United States Government was made from Washington, on request from applicants in the United States and Canada, until 1896 when there was no need for further distribution of parent stock (Smallwood and Smallwood 1929).

In Canada, carp are now widely distributed through Quebec, Ontario, Manitoba, Saskatchewan, and British Columbia. They are known to occur in brackish waters of the Atlantic coast.

An attempt was made to establish carp in New Brunswick in 1880 (McCrimmon 1968), but this was apparently unsuccessful and it is unknown from this area (Scott and Crossman 1959) or from Newfoundland (Scott and Crossman 1964). There are no records from Prince Edward Island or Nova Scotia.

The easternmost limit of range is Rivière Ouelle, below Quebec City, reported in 1960. McCrimmon (1968) stated that carp were present in the St. Lawrence basin as early as 1910.

In 1880, carp were brought into Ontario by Messrs S. and B. F. Reesor, and established in a pond in Cedar Grove area, near Markham. In the upper branches of the Holland River, several mill ponds were stocked (MacKay 1963). In 1896 a dam broke at Dykes Pond, Newmarket, and it is assumed that carp escaped into public waters in Ontario in this way. MacKay (1963) suggested, however, that the species could have entered the Great Lakes from other sources. Dymond (1955) stated carp are widely but not universally distributed throughout southern Ontario, including shallow bays of lakes Ontario, Erie, and Huron, and are spreading northward wherever progress is not barred by waterfalls, and other obstacles.

In 1889, a shipment was received from the United States and planted in a mill pond near Rapid City, and in Lake Minnewawa near Glenboro, southern Manitoba, introducing the species into water tributary to the Assiniboine system at Rapid City. This planting also appears to have met with no success for, in 1943, Hinks recorded the first record of carp in Manitoba in 1938, in the Red River at Lockport, 49 years after the 1889 planting, and at a site well removed from Rapid City. After 1938, carp spread through the Nelson River drainage and are now caught in commercial fishing operations in the southern part of Lake Winnipeg. They also occur in many other inland waters in this province, including lakes Manitoba, Winnipegosis, Dauphin, Playgreen, Cedar, and Split. Split Lake is the most northerly record of carp in North America (McCrimmon 1968).

Atton (1959) stated that in 1885, 100 carp were received from St. Paul, Minn., and planted in ponds at Springfield, Portage la Prairie, and Minnedosa, Manitoba, and a further supply received and planted the following year. These attempts to establish populations were apparently not successful.

Carp were recorded in 1953 from Kamsack, Sask., in the Assiniboine River. The earliest acceptable record of carp there is from the Frenchman Creek in the southwestern corner of the province.

Atton (1959) stated populations of carp existed in the Milk River (Missouri system) in Alberta since 1921, but these populations did not spread because of the lack of permanent waters. McCrimmon (1968), however, noted that there appears to be no evidence of carp in the waters of Alberta. Further, he observed there appears to be no evidence of

the species from the area of Manitoba and Ontario between Lake Winnipeg and Lake Superior.

Population of carp as a result of introduction into a pond on Vancouver Island, B.C., possibly around 1897, existed until recent years. The populations now present in British Columbia, in the Columbia and Fraser River systems, probably result from a northward spread of carp established in the Columbia River system in the State of Washington during the 1880's, moving through the Okanagan watershed (first recorded in Okanagan Lake in 1917), thence through creeks or irrigation ditches to Fraser valley (*see* Carl et al. 1967, for detailed distribution in British Columbia).

McCrimmon (1968) gave detailed accounts of introduction and distribution of carp in Canada.

Biology Carp spawn in the spring and early summer. As the waters warm, adults move into weedy or grassy shallows, at first gathering in rather large numbers, often near the surface where they are readily visible to the alert observer. As warming trends continue, the potential spawners commence to form smaller groups of 1–3 females and 2 or 3–15 males. Spawning does not commence in earnest until temperatures reach a level of at least 62.6° F (17° C) and may continue for several weeks. Spawning activities begin to decline when temperatures reach 78.8° F (26° C) and cease altogether at 82.4° F (28° C) (Swee and McCrimmon 1966; McCrimmon 1968).

In Lake St. Lawrence, Swee and McCrimmon observed that spawning may be interrupted if cooler weather prevails and the temperature drops below 62.6° F (17° C), but will recommence when the water warms up again. Spawning is usually extended when temperatures permit and in the Great Lakes region may extend from May to August (Swee and McCrimmon 1966). On a warm sunny morning, spawning carp may be seen and heard swimming about, splashing and thrashing in the shallow water, their backs sometimes completely exposed. Usually a female will be accompanied by 2 or 3 males and the noise and splashing is made by fish of 5 pounds or more racing about madly in shallow water. Many an early morning, the bass fisherman, casting into weedy shallows, has been startled by the sudden arrival of one or more groups of spawning carp.

It is a very prolific species. Swee and McCrimmon observed egg numbers ranging from 36,000 eggs in a 15.5-inch (394-mm) fish to 2,208,000 eggs in a 33.5-inch (851-mm) fish. The latter weighed 22.3 pounds (10.1 kg). The adhesive eggs, each about 1 mm in diameter, are deposited randomly and become attached to submerged weeds, grasses, or roots. Swee and McCrimmon observed spawning in Lake St. Lawrence and provided a series of observed water temperatures and hours to hatching of fertilized eggs. They concluded that eggs laid on the marsh vegetation would normally hatch within 3–6 days after fertilization depending on water temperature. Fish (1932) described larval stages from 10 mm to 30.75 mm and provided figures of 10 and 13.3 mm stages. McCrimmon (1968) provided additional information on larval development, including scale formation (McCrimmon and Swee 1967). Scale formation becomes evident at lengths of 16–18 mm and is apparently completed at lengths of 22–25 mm. *See also* Mansueti and Hardy (1967) for additional illustrations and description of larval stages in the Chesapeake Bay region.

Growth rates depend on many factors, such as availability of food and temperature, but carp usually attain lengths of 5.1–7.5 inches (130–190 mm) in southern Ontario waters during the first growing season. Scales are most often used for age determination but fin spines (English 1952) and opercular bones (McConnell 1952) have also been shown to be useful in age determination. McCrimmon noted that males became mature at ages 3 and 4, females at ages 4 and 5.

The spawning population in Lake St. Lawrence was composed of carp ranging from age 2 to age 16.

McCrimmon (1968) observed that the normal life span of carp in North America seldom seems to exceed 20 years, although

in Europe and Asia they have been credited with much greater life expectancy and Regan (1911) considered that they live to ripe old age but noted that claims to ages of 150 years had not been substantiated.

Carp caught commercially frequently exceed 10 and even 15 pounds in weight, depending on the area. Trautman (1957) recorded a weight of 58 pounds for one caught in the Ohio waters of Lake Erie. McCrimmon (1968) reported that he had been advised that, in recent years, commercially caught carp ranging from 35 to 50 pounds were caught in Georgian Bay, Lake Ontario, Lake Simcoe, and the Trent Canal system. The largest carp observed by the present authors was a 39-pound fish caught in a poundnet near Port Dover on Lake Erie.

Carp are omnivorous and consume a variety of plant and animal tissues. The grinding of plant tissues is greatly facilitated by the molarlike surfaces of the pharyngeal teeth. A carp will suck up a mouthful of bottom ooze and detritus, expel it into the water, and select the food items. Many kinds of aquatic insects, crustaceans, annelids, and molluscs are prominent among the animals eaten; plant tissues include many kinds of weed and tree seeds, wild rice, aquatic plants, and algae. Carp will even feed directly at the surface on floating animal organisms or algae.

Young carp must fall prey to a variety of predaceous fishes and birds, although there is little direct evidence. Certainly, once carp attain a weight of 3 or 4 pounds they probably have few enemies other than man for they are exceedingly wary, and the heavy covering of thick scales provides a most effective external armament against such predators as the sea lamprey.

The parasites of carp in Canadian waters or United States Great Lakes waters have been studied and reported upon by Bangham and co-workers. These reports covered populations in Lake Erie (Bangham and Hunter 1939), South Bay, Lake Huron in Ontario (Bangham 1955), and the Fraser and Columbia rivers in British Columbia (Bangham and Adams 1954). The carp carried a small parasite fauna of trematodes, cestodes, nematodes, and acanthocephalans but, as noted by Bangham and Adams, carp were usually free of parasites and those they did carry were often gill flukes or external forms.

Hoffman (1967) provided a long list of parasites, in many groups, but with particular reference to species found in European carp populations.

Relation to man The first comprehensive review of the effects of carp populations on the Canadian aquatic environment and the associated faunas was provided by McCrimmon (1968). From this and other publications, such as Sigler (1958) on the ecology and use of the carp in Utah, it is apparent that there is a great need for imaginative and intelligent approaches to the utilization and management of carp populations. Carp are tolerant of, and indeed thrive in, waters rendered unsuitable by accelerating eutrophication for the more traditionally desirable species, such as yellow perch and smallmouth bass. Hence, they are probably increasing in numbers.

Carp are considered detrimental to native fish populations because they increase the turbidity of the water and uproot and destroy submerged aquatic vegetation that is essential for the survival of native species, since such growth provides cover, food, and sometimes spawning sites. They also adversely affect duck populations by the destruction of rooted aquatic plants in marshes, and control measures, such as fencing, have been applied in western Canada.

On the positive side, young carp are probably consumed by such game fishes as northern pike, muskellunge, and largemouth bass, although to what extent is not known. Little angling pressure is applied to carp in Canadian waters so far as we are aware, although in some parts of the United States, notably Iowa, carp angling may be an important recreational resource.

The summer habit of rising to the surface and even feeding on the floating algae, recently gave rise to some fanciful newspaper accounts in the Lake Ontario region. The large dorsal fins of surface-cruising carp,

projecting from the surface of inshore waters of Lake Ontario, were seen by noted author–naturalist Farley Mowat, who, according to newspaper accounts, declared them to be shark fins!

As McCrimmon noted, the control of carp by various provincial and state agencies employing commercial fishing gear has not provided long term benefit except in confined local situations. Usual control measures involve the use of traditional commercial fishing gear, but other methods, such as electric shockers and stomach poisons, have also been tried and the methods and results were described by Loeb (1955, 1960a). The use of poison bait offers promise as a method of inexpensive control in controlled access areas. Coarse-fish removal programs are usually directed at carp, and occasionally carp may be harvested commercially by private enterprise. In Ontario, 800,000–1,000,000 pounds are landed annually, with a market value of about $70,000–$100,000. The wholesale price ranges from a few cents per pound to 18 or even 20¢ depending on market conditions, whereas the price of smoked, boneless carp exceeds $1.00/pound. Estimates of the quantity of carp marketed in North America in recent years ranges as high as 19 million pounds annually (McClane 1965).

As a food fish, small and medium-sized carp are marketed alive, cleaned and iced, or smoked. The smoked product is usually skinless, reddish or orange in colour, cut in strips, and is sometimes highly spiced.

Nomenclature

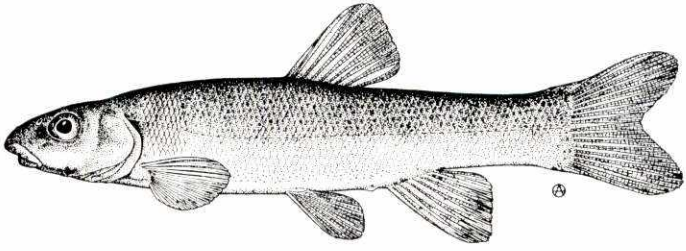
Cyprinus Carpio — Linnaeus 1758: 320 (type locality Europe)
Cyprinus carpio — Scott and Crossman 1969: 15

Etymology *Cyprinus* — ancient name of the carp, probably derived from *Cyprus*, abode of Venus, in allusion to its fecundity; *carpio* — Latinized form of carp.

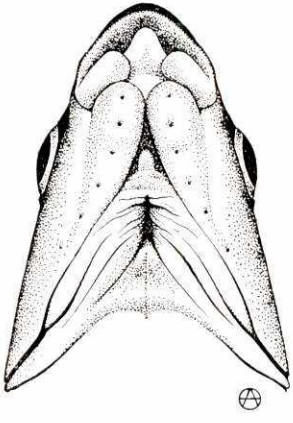
Common names Carp, German carp, European carp, mirror carp, leather carp. French common name: *carpe*.

CUTLIPS MINNOW

Exoglossum maxillingua (Lesueur)



Description Body stout, thick, its depth 15.9–21.4% of total length, average total length 3.5–4.5 inches (89–114 mm); caudal peduncle especially heavy. Head short, its length 18.7–21.9% of body length; eye diameter 27.2–37.5% of total length; snout bluntly rounded, its length 31.2–38.4% of head length; interorbital broad, its width 38.4–44.4% of head length;



mouth unique, the lower jaw of 3 lobes, the centre lobe tongue-like, raised, and lying within the upper jaw, making a distinct gape (or depression when viewed ventrally) between the lateral lobes of lower jaw; premaxillaries not protractile; pharyngeal teeth 1,4–4,1. Fins: generally opaque, not clear; dorsal 1, its origin over pelvic fin origin, rays 8; caudal shallowly forked; anal 1, rays 7; pelvics small, origin below dorsal origin, rays normally 8, sometimes 9; pectorals short, broad, rays 13–16. Scales cycloid, small, persistent, 50–53 in lateral line; lateral line complete. Peritoneum silvery white. Vertebrae 38(2).

Colour Overall colouration rather dusky, olive-green on the back becoming leaden silvery on sides and light below. Fins generally dusky, a distinct round spot at the base of caudal rays that becomes indistinct on specimens over 3 inches (76 mm) long.

Distribution The cutlips minnow is confined to northeastern North America, ranging from the upper St. Lawrence River and eastern Lake Ontario drainage south in the northeastern United States, east of the Appalachian Mountains to the Roanoke River drainage of Virginia.

In Canada, the cutlips is confined to warm, clear, gravelly streams of the St. Lawrence River and its tributaries from at least the Saint-François River drainage of Lac St. Pierre, in Quebec, upriver in the St. Lawrence River system, including the Lake Champlain drainage, to the vicinity of Ivy Lea on the north shore of Lake Ontario basin in eastern Ontario.

Biology The cutlips minnow spawns in spring, but no observations have been reported from the Canadian range. However,

Evelyn Van Duzer (1939) published detailed observations on its spawning activities in the Susquehanna drainage of New York State which are the source for most of the following.

Spawning takes place in May, June, and July over a gravel nest. In the year of observation no nests were built before May 15, and nest building was carried on in earnest during June but terminated by July 11. The nests, which are more or less circular, flat-topped mounds of stones, may measure 12–18 inches (305–457 mm) in diameter and are 3–6 inches (76–152 mm) deep. They are composed of stones measuring $\frac{1}{2}$–$\frac{3}{4}$ inch (13–19 mm) and built by a single male, each stone being selected and carried in the mouth. The search for suitable stones sometimes leads to stealing from other nests. The larger the male, the larger the stone he may carry. The nest is always built in a section of stream with sufficient current to maintain constant change of water, never in an area having a growth of rooted aquatic plants, but preferably near or under a protecting log or large rock. Flat stones on a stream bed are apparently highly desirable for nesting.

Mating occurs when the nest is completed to the satisfaction of the male, who will drive off females as readily as other fishes until the nest is built. The female approaches the nest, the two align themselves side by side, the female slightly behind on the upstream slope of the nest, the bodies are curved in a characteristic manner very close to the gravel, and the release of eggs and sperm takes place in 2–4 seconds. A single male may mate with the same female more than once and with many females during the spawning period, which lasts up to 6 days early in the season but for as few as 3 days in late-season spawning.

The males rework the nest vigorously during spawning, but after spawning their activities on the nest cease in 2–4 days. The females take little part in the care of the nest except occasionally between mating acts, when they may rework the gravel a little.

The eggs become lodged only in the gravel on the upstream part of the nest to a depth up to 3 inches. They measure about 2 mm in diameter when deposited, or shortly after, and are yellowish in colour. The time to hatching is apparently not known, but the young remain in the nest for about 6 days after hatching, until they reach lengths of 9–10 mm.

The males attain a larger size than the females. Van Duzer stated that the majority of spawning males observed by her were 4.5–5.5 inches (114–140 mm) long. The largest specimen in the ROM collection measures 4.6 inches (117 mm) total length.

Most observers agree that the cutlips is a slow-moving, bottom-living minnow, preferring clear, warm, gravelly bottom streams relatively free of rooted plants and silt, but dwelling mostly under stones in quiet pools. Food consists mainly of aquatic insect larvae and molluscs, although detailed food studies have not been conducted.

Possibly the greatest enemy of the cutlips minnow is the degradation of the aquatic environment since, in order to survive, they require clear, silt-free streams without excessive plant growth. The common shiner *Notropis cornutus* may also be considered an enemy, since prespawning males and even spawning pairs will harass the sluggish but aggressive cutlips males during the latters' spawning activities, for the common shiner habitually uses the nests of other minnows for spawning sites. Prolonged harassment can apparently cause cessation of spawning by the cutlips. Thus a deterioration in the habitat requirements of the cutlips in the presence of a stable population of common shiners could be disastrous for this sluggish and peculiar minnow. In 1943, Toner reported that bait dealers considered it to be not uncommon in the St. Lawrence around Ivy Lea and in the Delisle River below Alexandria, but that was 30 years ago and may not apply today.

Hoffman (1967) listed only trematodes, five species in all, from this minnow in North American waters. Wagner (1969), studying a collection of fishes from Spring Creek, Centre County, Pa., recorded two leeches, *Illinobdella alba* and *I. moorei* on the cutlips minnow.

Relation to man The cutlips is occasionally used as a bait minnow but many years

ago Dymond (1937) noted that local fishermen in the Ivy Lea region of Ontario called it "eye picker" because of the belief that it would pick out the eyes of other fishes held in the same bait pail. Presumably, this belief is related to the peculiarly shaped lower jaw, but we can offer no opinion on the validity of the claim.

Nomenclature

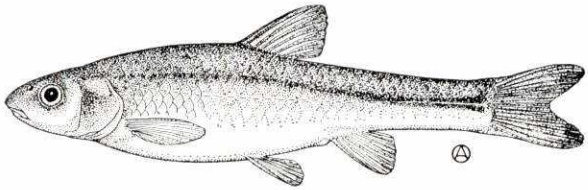
Cyprinus maxillingua	— LeSueur 1817c: 85 (type locality Pipe Creek, Md.)
Exoglossum Lesurianum	— Rafinesque 1818e: 420
Exoglossum maxillingua	— Scott 1967: 70

Etymology *Exoglossum* — outside; tongue; *maxillingua* — *maxilla* — jaw; *lingua* — tongue.

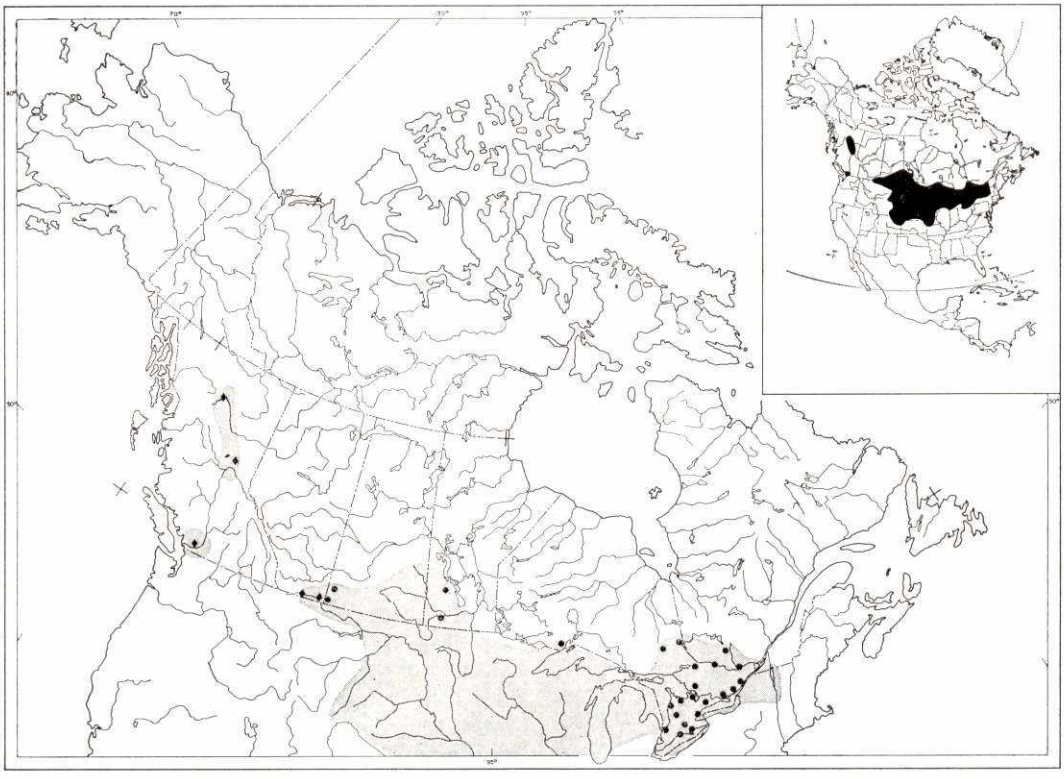
Common names Cutlips minnow, cutlips, eye-picker, little sucker. French common name: *bec-de-lièvre.*

BRASSY MINNOW

Hybognathus hankinsoni Hubbs



Description Body slender, not strongly compressed laterally, elongate, average length 2.5 inches (64 mm), body deepest before dorsal fin, depth 16.1–25.0% of total length. Head wide, bluntly triangular, its length 19.2–24.3% of total length; eye moderate, its diameter 21.4–33.3% of head length; snout rounded, slightly overhanging upper jaw, long, its length 27.2–36.3% of head length; interorbital wide, its width 35.7–44.4% of head length; mouth small, subterminal, slightly overhung by snout, gape extending to about below nostril; pharyngeal teeth 0,4–4,0, not hooked, with oblique grinding surfaces. Fins: dorsal 1, its origin slightly in advance of pelvic fin origin, rounded, rays 8(65), rarely 7(1); caudal forked; anal 1, its origin slightly behind or equal to margin of depressed dorsal, rays usually 8(36), sometimes 7(18), rarely 6(1), or 9(1); pelvics originate behind dorsal fin origin, rays 8(56); pectorals rather small, rays usually 13(23), occasionally 14(9), but rarely 15(2). Scales cycloid, with about 20 radii of varying lengths; lateral line complete, lateral line scales 36–41. Peritoneum uniformly black;



intestine elongate, distinctly coiled on right side. Vertebrae 35(4), 36(7), 37(1) in Ontario and Quebec; 35(2), 36(2), 37(6) in Saskatchewan.

Nuptial tubercles fine, on middle rays of pectoral fins of males only.

Colour Back olive-green to brown with distinct brassy reflections on the sides and creamy white below. No special breeding colours are known.

Distribution The brassy minnow occurs from the upper St. Lawrence River and Lake Champlain region of New York, west through southern Ontario and Michigan, west through the Arkansas and Missouri rivers to Colorado, Wyoming and Montana, north to Alberta; in British Columbia in the Fraser River and the headwaters of the Peace River. The known distribution was discussed and plotted by Bailey (1954) before range increases in the northwest were known.

In Canada, this species occurs in the upper St. Lawrence River of Quebec and Ontario, through southern Ontario north at least to Temiskaming District and Thunder Bay but there are no records for northern Lake Huron or eastern Lake Superior drainages; southern Manitoba, Saskatchewan (Scott 1957a), and Alberta, in Milk River and tributaries (McAllister 1962a; Willock 1968; Henderson and Peter 1969), and from several localities in British Columbia, including the lower Fraser valley, the upper Fraser near Prince George, and Parsnip River, of the Peace River system. It was first discovered in British Columbia in 1952 in the lower Fraser valley and reported by Carl and Clemens (1953).

Although originally thought to have been introduced to British Columbia waters, its widely scattered distribution indicates that it is a native species.

Biology The breeding habits of the brassy minnow are apparently unknown; at

least details of spawning have not been reported. Spawning probably occurs in May or June and it is assumed that the pattern resembles that reported for *Hybognathus nuchalis*, and that eggs are deposited in quiet water over a silt bottom. Dobie et al. (1956) suggested that adhesive eggs (which seems unlikely) were deposited over sand, weed, or debris when water temperatures reach 50°–55° F (10.0°–12.8° C). McPhail and Lindsey (1970) noted that females taken in the Peace River drainage June 16 had not spawned and some taken June 28 in the same region had not completed spawning.

Dobie et al. suggested that maturity is reached in 2 years at a length of 2.5—3.0 inches (64–76 mm). The largest specimen seen by us measured 3.8 inches (97 mm).

As noted by Dymond (1939), and as its distribution would suggest, the brassy minnow lives in cooler water than the silvery minnow. In eastern Canada, especially in Ontario, it does occur in creeks and brooks, but it is often more abundant in the cool, dark acid waters of silt-bottomed bog ponds, where it usually occurs in association with *Chrosomus eos*, *Chrosomus neogaeus*, *Pimephales promelas*, and *Semotilus margarita*. Toner (1943) noted that wherever it occurred in numbers, predatory fish were absent. In the northwestern part of its range, McPhail and Lindsey noted that brassy minnows occur in slow streams, boggy lakes, and shallow bays.

Its food is believed to consist mainly of phytoplankton and other algae, zooplankton, and some aquatic insects. The long, looped intestine and black peritoneum suggest that it is adapted to feeding on plant material.

We have no information about predators of the brassy minnow but assume that natural enemies would include brook trout, and such fish-eating birds as mergansers and kingfishers.

There are no reports of parasitism of the brassy minnow in Canadian literature. Hoffman (1967) listed only trematodes, *Octobothrium* sp., and the larval forms of *Neascus* sp., *Posthodiplostomum minimum*, and *Uvulifer ambloplitis*.

Relation to man The brassy minnow is considered to be a valuable bait and forage minnow in many parts of the United States. The statement by Dobie et al. (1956) that it was one of the most common and widespread bait fishes of the Great Lakes region seems extravagant since this does not apply to Canadian waters where, in our experience, its use as a bait species is uncommon. However, in defence of this opinion is the statement by Underhill (1957) that it was probably the most abundant minnow in Minnesota. With the possible exception of small, isolated ponds, it has never been so abundant in Canada.

Nomenclature

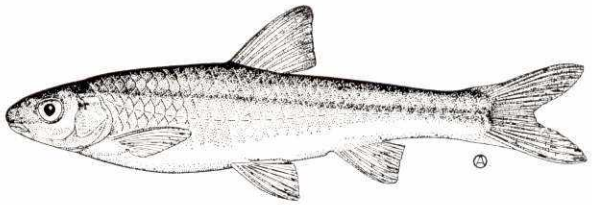
Hybognathus hankinsoni — Hubbs and Greene 1928: 382, 389 (lectotype, UMMZ 84266, L. Superior watershed, Marquette Co. Mich.)
A specimen caught at Clarkson, Ont., (ROM 3662) was designated a paratype by Hubbs in correspondence, November 9, 1927. *See also* Dymond et al. (1929)

Etymology *Hybognathus* — protruding jaw; *hankinsoni* — after T. L. Hankinson of Michigan.

Common names Brassy minnow. French common name: *méné laiton*.

SILVERY MINNOW

Hybognathus nuchalis Agassiz



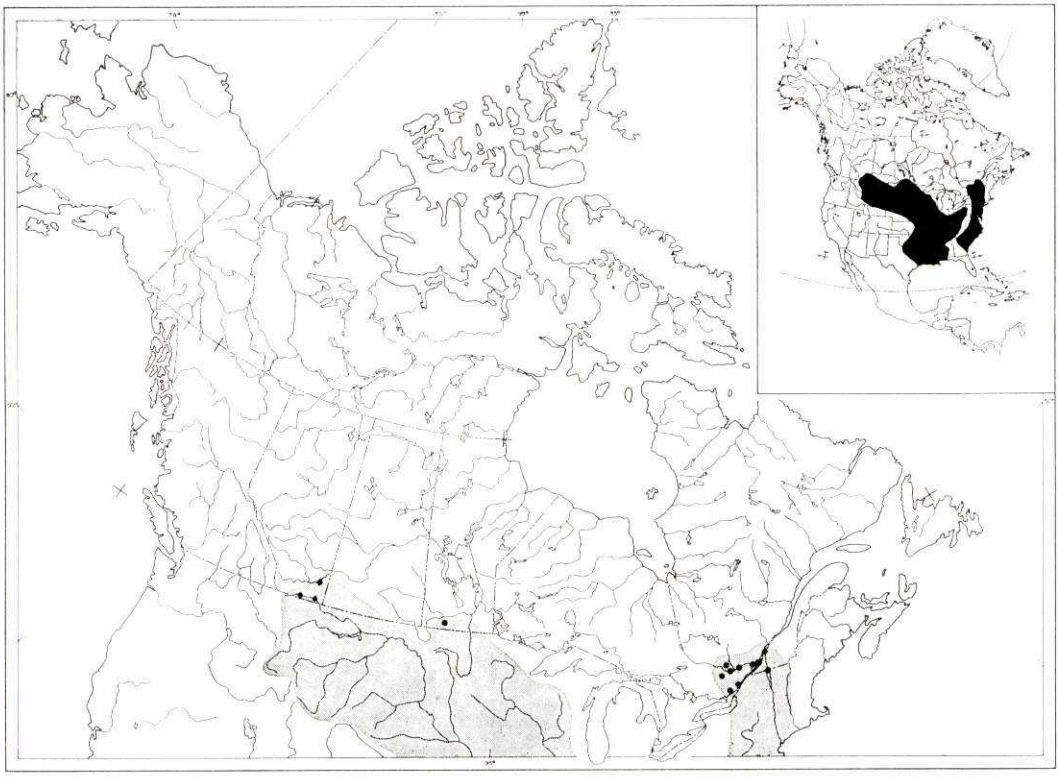
Description Body moderately laterally compressed, elongate, average length about 3 inches (76 mm), body deepest in front of dorsal fin, its greatest depth 17.3–20.8% of total length; caudal peduncle rather stout. Head bluntly triangular, short, its length 18.3–21.0% of total length; eye moderately large, its length 25.0—33.3% of head length; snout rounded, overhanging mouth, its length 30.7–35.7% of head length; interorbital wide, its distance 35.7–44.4% of head length; mouth subterminal, slightly overhung by snout, the gape extending to below nostril, not to anterior margin of eye; pharyngeal teeth 0,4–4,0; not hooked but with distinct grinding surface. Fins: dorsal 1, its origin slightly in advance of pelvic fin origin, posterior margin somewhat falcate, rays 8(42); caudal distinctly forked; anal 1, its origin behind posterior margin of depressed dorsal, rays usually 8(38), occasionally 9(4); pelvics originate slightly posterior to dorsal fin origin, rays usually 8(19), seldom 7(1); pectorals relatively short, rays 15(10), or 16(10). Scales cycloid, with 8–11 long radii; lateral line complete, lateral line scales 38–40. Peritoneum uniformly black; intestine elongate, distinctly coiled on right side. Vertebrae usually 37(11), sometimes 36(3), or 38(8).

Nuptial tubercles small but numerous on males, sparse on females, on top and sides of head, on scales of back and sides especially anteriorly, and on fins, particularly on upper sides of paired fins.

This description is based on examination of Quebec and Ontario specimens.

Colour Both males and females are strikingly silvery creatures, whence the common name, but during the spawning season the males exhibit light yellow along the sides and on the lower fins. Raney (1939) noted that the males were much darker than females and that the differences in colouration of Cayuga Lake, N.Y., specimens were sufficiently great to cause local bait fishermen to regard them as different species.

Systematic notes Two subspecies have been described, *Hybognathus nuchalis nuchalis* Agassiz, the western silvery minnow, and *H. n. regius* Girard, the eastern silvery minnow. Both subspecies are represented in Canada (*see Distribution*) since the Alberta populations have been ascribed to the western subspecies, although not all ichthyologists are agreed on this point. Indeed Alberta populalations warrant further study, particularly in view of recent work on the genus. Pflieger (1971) noted that *nuchalis* and *regius* could be considered as distinct species (p. 365). He also recognized *H. argyritis* Girard for the form of *Hybognathus* from the Missouri River system, not identifiable as *H. placitus*. Significantly, Pflieger noted that the seven type specimens of *H. argyritis* were taken from the Milk River in Montana. The first published specimens of *H. nuchalis* from Alberta were caught in the Milk River



(Willock 1968). Willock's specimens, and all Alberta *nuchalis*, should be re-examined to confirm their identity.

For further information regarding western *Hybognathus* species *see* Bailey and Allum (1962), Al-Rawi and Cross (1964), and Pflieger (1971).

Distribution The silvery minnow is a central North American form and has a peculiar distribution, being found from southwestern Quebec and southeastern Ontario on the northeast, south to Georgia, Louisiana, and Mississippi; north and west in the Mississippi and Missouri River systems, excluding all of the Great Lakes except eastern Lake Ontario, to Montana and southern Alberta.

In Canada, it is restricted to the waters of the upper St. Lawrence River from at least the Nicolet River of eastern Lac St. Pierre, upriver through Lac St. Louis to the Ottawa River at least to about Ottawa, upstream in the St. Lawrence River to at least Gananoque. It is not known to occur elsewhere in Canada except in southern Manitoba and southern Alberta. It gained entry to Alberta probably via the Milk River, a tributary of the upper Missouri River. The first Alberta specimen known to us was one, 3.65 inches (93 mm) in standard length, caught in the South Saskatchewan River in 1963 (Henderson and Peter 1969), but the first Alberta records were published by Willock (1968), based on specimens taken in the Milk River. Willock also provided a discussion of the probable history of its occurrence in the area.

Biology The spawning habits of the silvery minnow were described in detail by Raney (1939) from a study of populations in the Cayuga Lake drainage of New York State. There, spawning occurred in late April and early May 1938 at temperatures of 55.4°–68.9° F (13.0°–20.5° C).

Although there are no observations published for Canadian waters, it is presumed that spawning would take place when water temperatures were about the same, possibly in May. Prior to spawning, the adults migrate from the inshore waters of the lakes or larger rivers to well-vegetated lagoons or slow-moving lower reaches of tributary streams. Raney noted that the silvery minnow was unique among northeastern minnows in that it laid its nonadhesive eggs on the bottom ooze in quiet backwaters. Water depth was about 1 foot, and the shallow shore waters heavily vegetated with emergent grasses and reeds provided effective cover.

Spawning commenced about 10 AM, continued until 4 PM, but did not continue after dark. The ripening female remains in deeper water, moving into inshore shallows when ripe, where she is joined by 1 to 10 males who align themselves one on either side, the remainder ranging around, above and below, all swimming swiftly. Those on either side of the female press tightly against her. Raney noted that the eggs and sperm were usually released when the three vibrated for a second or two, most often in water 2–6 inches deep, near newly sprouted grasses. Some evidence suggested that the spawning period may be extended or prolonged.

The eggs measured 1 mm in diameter and their number varied from 6600 in a 90-mm female (standard length) to 3000 in 68- to 70-mm ones and 2000 in a 60-mm female. Raney found that the eggs were well developed in females caught in late fall.

Newly hatched larvae measured 6 mm total length. Both newly hatched and 14-mm fry were illustrated by Raney. About 2 weeks after hatching, the young appear in small schools near shore among emergent vegetation. Raney found them to be 1.5 inches (38 mm) total length by July 15 and about 2 inches (51 mm) by August 5. Some females are thought to spawn when 50–55 mm long (standard length) and only 1 year old, but males probably do not spawn until their second year. Mansueti and Hardy (1967) illustrated and described larval stages in the Chesapeake Bay region.

The largest spawners examined by Raney (1939) were a male 3.3 inches (83 mm) and a female 3.9 inches (100 mm) standard length, whereas the largest specimen seen by the present authors was 4.7 inches (120 mm) total length.

The usual habitat is the quiet, weedy inshore waters of lakes and large rivers. It apparently prefers wide waters.

Detailed food studies have not been conducted but bottom ooze and algae have been reported from the stomachs and apparently constitute the main food. In the propagation experiments reported by Raney (1942) the fish were not fed.

The young of the silvery minnow possibly constitute important forage for the young of game species inhabiting the same weedy, inshore waters although direct evidence is lacking. Raney (1942) noted that they were regarded as important bait for pickerel (*Esox niger*), and northern pike.

Hoffman (1967) listed three species of trematodes, one protozoan, and the larval form of the cestode *Ligula intestinalis* as parasites of the silvery minnow in North American waters.

Relation to man The silvery minnow is considered to be a good bait minnow and is widely used in parts of the United States such as central New York State, but less so in others such as Iowa where it is said to die quickly in minnow pails. Raney (1942) described a method of pond propagation and noted that it offered promise as a food fish in the artificial culture of muskellunge.

It was seined by bait dealers in the Ottawa River (Toner 1943), and possibly also in the St. Lawrence River in the Gananoque–Brockville region. In the latter region it is abundant at times and is probably an important forage fish.

Although not eaten in Canada, Schwartz (1963) remarked that in Maryland it was esteemed by many when deep-fried in oil.

Nomenclature

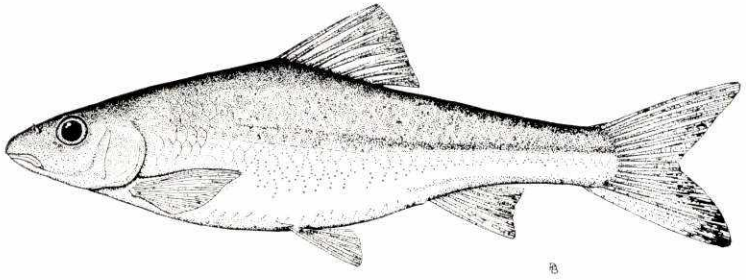
Hybognathus nuchalis	— Agassiz 1855: 224 (type locality Quincy, Ill.)
Hybognathus regius Girard	— Girard 1857a: 209
Hybognathus nuchale Agassiz	— Evermann and Goldsborough 1907a: 94
Tirodon amnigenus Hay	— Hubbs 1947: 176

Etymology *Hybognathus* — protruding; jaw; *nuchalis* — pertaining to the nape.

Common names Silvery minnow. French common name: *méné d'argent.*

SILVER CHUB

Hybopsis storeriana (Kirtland)

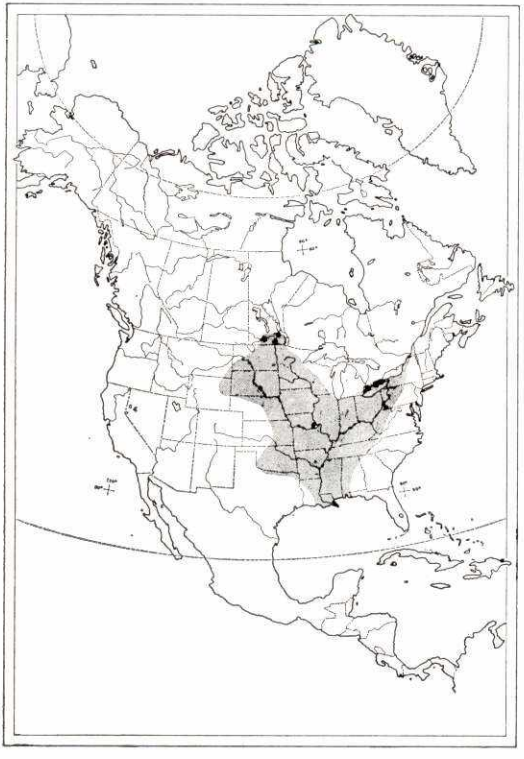


Description Body stout and rather thick, total average length about 4–6 inches (102–152 mm), body depth 17.0–24.1% of total length. Head length relatively short, 16.3–20.8% of total length; eye rather large, its diameter 23.5–33.3% of head length; snout relatively long, 31.5–40.0% of head length; interorbital broad, its width 30.0–37.2% of head length; mouth moderate, the gape terminating before anterior margin of eye, a well-developed barbel at posterior end of maxillary nearly always present; pharyngeal teeth 1,4–4,1. Fins: dorsal 1, its origin distinctly in advance of pelvic fin origin, rays 8 (23 specimens); caudal well developed, distinctly forked (*see* section on *Colour*); anal 1, moderate in size, its origin behind tip of depressed dorsal, rays usually 8(21), rarely 7(2); pelvic rays usually 8(17), rarely 9(1), a distinct pelvic axillary scale present; pectorals relatively small, pointed, rays usually 17(14), occasionally 16(2), or 18(2). Scales cycloid, large, conspicuous and deciduous, 38–41 in lateral line; lateral line complete, only slightly decurved. Peritoneum silvery. Vertebrae 38(3), 39(10), 40(3), or 41(1).

Nuptial tubercles apparently present on males but no specimens or data available for description.

Colour Dorsally pale grey-green, becoming silvery on sides and silvery white below. Dark pigment or melanophores are not

conspicuous but a faint dusky lateral band is usually present. Caudal fin lightly pigmented overall but with the lower three or four rays completely unpigmented and immaculate white (this character usually remains apparent even on preserved specimens).



Distribution The silver chub occurs in large sandy or silty rivers and in lakes in east-central North America; Lake Erie in the northeast, thence south throughout the Mississippi and associated river drainage systems, such as the Ohio, Alabama, the Mississippi proper, the Red (in Arkansas), the Kansas, Missouri (and tributaries), and Red River (of North Dakota and Manitoba).

In Canada this species occurs in Ontario in Lake Erie where it was common in earlier years. However, attempts to obtain specimens, with the cooperation of the Ontario Department of Lands and Forests and of commercial fishermen, over the latter part of the 1960's were in vain. The last positive record known to us was a report of capture off Cleveland during exploratory fishing by the United States Fish and Wildlife Service vessel *Cisco*, in 1957 (Cruise II, May 21–June 3, 1957). The present status of the species in Lake Erie is in doubt but obviously it is rare.

In Manitoba, it is recorded from the Red River system and the Assiniboine River at Winnipeg. Keleher and Kooyman (1957) stated the known northern limit of range had been extended to include St. Andrews Locks near Selkirk.

Biology Published information on the biology of this species is extremely limited. One of the most extensive studies of interest to Canadians is E. C. Kinney's unpublished Ph.D. thesis (1954) at Ohio State University.

For Lake Erie populations, the exact time and place of spawning is not known but statements by McCormick (1892) quoted by Trautman (1957), Fish (1932), and Kinney suggest that spawning occurred in June, possibly in late May, in Ohio waters. Kinney considered that most spawning took place at temperatures above 69.8° F (21° C). Spawning is thought to occur in open water, but there is no direct evidence. Trautman reported that spawned adults were frequently found on the beach in June and July and it seems probable that spawning mortalities were not unusual although we know of no evidence of such mortalities on the Canadian side of Lake Erie.

The number of eggs was given by Kinney as 365 + 746 times the ovary weight, in grams. Time to hatching is not known but Fish (1932) described and figured four larval stages from 5 to 21 mm and noted that larval stages to 7.5 mm were taken in Lake Erie from Buffalo to Rondeau in bottom hauls, at 18–20 metres in the latter part of June and early July.

Age can be determined from scales according to Kinney, who gave the time of annulus formation as May to mid-June. For the period of July to December, the following standard length ranges, in mm, were found: age 1, 55–145; age 2, 110–155; age 3, 145–170. A few individuals apparently reach age 4 but die after spawning. Trautman gave the length of the largest specimen as 9.1 inches (231 mm),

weight 6 ounces (170 g). Total length of longest specimen on hand from Canadian waters of Lake Erie is 7.9 inches (201 mm).

Trautman (1957) reported that the silver chub occurred in greatest abundance in Lake Erie waters at depths of 3–60 feet. It is said also to inhabit pools in slow-moving streams having clean sand or gravel bottom. Extensive day and night seining on the Canadian shores of Lake Erie in the late 1940's and early 1950's, failed to yield a single specimen in waters of even 6 feet in depth and rarely were specimens taken in the fall commercial seining operations in inshore waters of Long Point Bay. Specimens caught in Canadian waters were usually taken in small mesh gillnets.

Young silver chub consumed cladocerans, copepods, and chironomids, but the major food supplies of adults were mayflies of the genus *Hexagenia*, until these disappeared from the Lake Erie fauna, when greater use was made of chironomids and *Gammarus*.

Bangham and Hunter (1939) examined 31 specimens of silver chub from Lake Erie, 20 of which were parasitized by some or all of trematodes (3), cestodes (1), nematodes (1), and acanthocephalans (1). Hoffman (1967) listed one parasite only, the trematode *Dactylogyrus texomonensis*.

Relation to man Since the silver chub had, at best, only marginal distribution in Ontario, its contribution to the economy of our waters was small. Its apparent disappearance from Lake Erie is regrettable, since it suggests an ever-narrowing faunal base in that woefully abused body of water.

Nomenclature

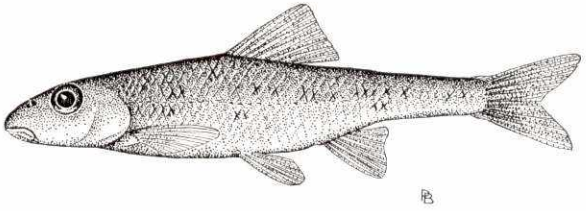
Rutilus Storerianus	— Kirtland 1844a: 71 (type locality Lake Erie)
Leuciscus Storerianus	— Kirtland 1844b: 199–200 (description)
Hybopsis storerianus (Kirtland)	— Jordan and Evermann 1896–1900: 321
Erinemus storerianus Kirtland	— Hubbs 1926: 30
Hybopsis storeriana	— Speirs 1951: 18

Etymology *Hybopsis* — gibbous; face; *storeriana* — after D. H. Storer.

Common names Silver chub, Storer's chub. French common name: *méné à grandes écailles.*

GRAVEL CHUB

Hybopsis x-punctata Hubbs and Crowe



Description Body slender, small, average total length about 3 inches (76 mm), only slightly compressed, body depth 14.6–16.7% of total length. Head elongate, its length 20.0–21.3% of total length; eye comparatively large, its diameter 30.0–33.3% of head length; snout rounded, overhanging mouth, comparatively long, 37.9–46.7% of head length; interorbital width moderate, 22.2–27.6% of head length; mouth small, inferior, overhung by snout, a slender, small but conspicuous barbel near the end of the maxillary; pharyngeal teeth 0,4–4,0. Fins: all fins more or less clear; dorsal 1, base short, its origin distinctly in advance of pelvic fin origin, rays 8; caudal distinctly forked; anal small, its origin behind insertion of dorsal fin, rays 7; pelvics comparatively small, rays 8; pectorals narrow, their tips reaching a point under dorsal fin origin, rays 13–16. Scales cycloid, large, about 43–45 in lateral line (Ontario specimens apparently have higher counts than those in USA); lateral line complete. Peritoneum uniformly dark brown. Vertebrae 37–39.

Nuptial tubercles very small, even minute, on head and branchiostegals and sometimes on most scales on anterior part of body.

Colour Overall colouration silvery, but olive-green dorsally, silvery on sides and silvery white below. Scale margins somewhat randomly outlined with black pigment along sides expressed in the form of X- or Y-shaped marks, usually only faintly evident on Ontario specimens (which do not show a prominent caudal spot, either).

Systematic notes As numerous authors have noted, this species was long confused with at least one other form. The Ontario population was reported by Radforth (1944), Dymond (1947), and Scott (1954) as *Erimystax dissimilis* (Kirtland). Hubbs and Crowe (1956) described the new species *H. x-punctata*, assigning the northeastern Ohio basin and Ontario populations to the subspecies *H. x-punctata trautmani*.

Distribution The gravel chub occurs only in east-central North America from Pennsylvania on the east, through the Ohio River basin in Ohio, Kentucky, Indiana, and Illinois; and in the Mississippi River system from Wisconsin and Minnesota south to Arkansas and Oklahoma; and an apparently isolated population in the Thames River, Ont.

Trautman (1957) noted that there were no acceptable Lake Erie drainage records but that the species has been reduced or extirpated from many parts of its former range in Ohio because of the silting over of gravel in streams. We know of no reports of the continued existence of the Thames River population since the capture of four specimens by D. Roseborough in August 1958.

Biology There seems to be little available biological information on the gravel chub. As the name suggests, it prefers gravel-bottomed streams and rivers, preferably slow-moving, deep ones, but if the gravel there becomes silted over, they will move into faster, shallow regions. *See* Trautman (1957) for a discussion of its habitat in Ohio.

Its food probably consists of aquatic insect larvae but detailed studies are not available.

Relation to man The gravel chub is much too rare to be of economic significance, but it and other rare forms are valuable in that their very presence tells much about the history of the continent and drainage connections in postglacial times. Their demise should serve as a warning that the environmental changes are sufficiently drastic to deny life to them.

Nomenclature

Hybopsis x-punctata — Hubbs and Crowe 1956: 6 (type locality Gasconade River, Missouri)

Luxilus dissimilis — Kirtland 1841b: 341

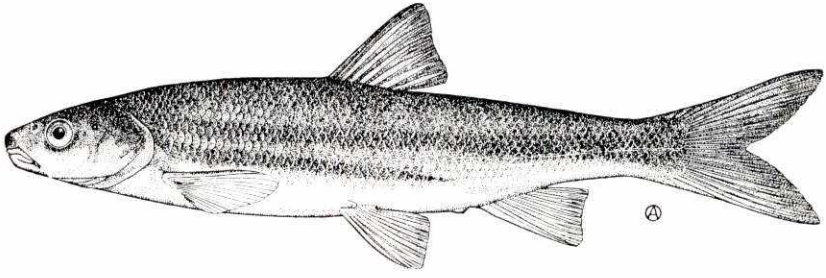
Erimystax dissimilis (Kirtland) — Hubbs and Brown 1929: 24
— Radforth 1944: 49
— Dymond 1947: 20
— Scott 1954: 57
— Scott 1958: 16

Etymology *Hybopsis* — gibbous; face; *x-punctata* — *punctatus* — dotted.

Common names Gravel chub, spotted chub. French common name: *gravelier*.

PEAMOUTH

Mylocheilus caurinus (Richardson)



Description Body elongate, averaging 4–6 inches (102–152 mm) long, not strongly compressed laterally, body depth greatest just before dorsal fin, the depth 15.2–17.7% of body length. Head relatively short, its length 17.4–19.3% of total length; eye moderate, its diameter 19.5–27.7% of head length; snout long, slightly overhanging mouth, its length 30.0–36.3% of head length; interorbital broad, its width 34–38% of head