rocky shores and sometimes in weedy areas of tributary streams. All movement seems to cease by July and the large fish penetrate to the deep water where adult burbot share the hypolimnic habitat with lake trout, whitefishes, and sculpins.

The burbot is a voracious predator and night feeder. Small burbot, 2–12 inches (51–305 mm) in length, in streams feed on *Gammarus,* mayfly nymphs, and crayfish. The diet of young burbot, to approximately 19.7 inches (500 mm) in length, consists mainly of immature aquatic insects, crayfish, molluscs, and other deepwater invertebrates, especially *Mysis relicta,* but relatively few fishes. Burbot over 19.7 inches (500 mm) long feed almost exclusively on fishes such as ciscoes, yellow walleye, yellow perch, alewife, kokanee, smelt, sculpins, trout-perch, sticklebacks, freshwater drum, logperch, and white bass, depending on what species are available. In summer large burbot sometimes feed exclusively on *M. relicta* in rivers, and the winter food of adults consists of invertebrates browsed from the bottom, even though (presumably) fish are as available as in the summer. Burbot captured on cisco spawning grounds are often gorged with cisco eggs. The literature contains many detailed analyses of the food of burbot (Van Oosten and Deason 1938; Clemens 1951a; McCrimmon and Devitt 1954).

Since the burbot shares the hypolimnion with such commercially important species as lake trout and the whitefishes, since it eats the same food, and since individual burbot have been reported to consume as many as 179 fish, it is an important direct competitor of these species. Of the deepwater fauna it would appear that the burbot is a predator only on eggs and young of the cisco. In the Susquehanna River, of the northeastern United States, where burbot occur with large numbers of brown and brook trout, it was considered a negligible predator of these sport fishes. In their turn young burbot are known to be part of the food of smelt, yellow perch, and other fishes.

In general, burbot harbour a wide variety of parasites including protozoans, trematodes, cestodes, nematodes, acanthocephalans, leeches, molluscs, and crustaceans. The burbot, throughout its range of distribution, is one of the important second intermediate hosts of *Triaenophorus nodulosus.* Detailed accounts of the parasites found in or on burbot from various parts of Canada have been published by Bangham and his co-workers: for Lake Erie by Bangham and Hunter (1939), for Algonquin Park lakes by Bangham (1941), Lake Huron and Manitoulin Island by Bangham (1955), and from British Columbia by Bangham and Adams (1954).

For a summary of parasites of this species in North America, *see* Hoffman (1967).

Relation to man In Canada the burbot populations are not exploited commercially and the species is almost universally regarded as a coarse fish by management agencies and fishermen alike. Records of commercial catches are not usually entered in statistical summaries (except in Ontario) and thus current or potential yields are difficult to assess. The species may occur in considerable numbers in inland waters but not in the Great Lakes where conditions have changed drastically in recent years. The writings of Dymond (1926), Dymond et al. (1929), and Kolbe (1944), among others attested to the former abundance of the burbot and also that it was once considered to constitute a serious nuisance to the commercial fishery in the Great Lakes. In other Canadian lakes it is sometimes thought to be a serious predator of more valuable species and to compete with such species for food.

Provincial agencies engaged in coarse fish removal programs occasionally harvest burbot from inland lakes during the winter months. One such operation in Manitoba (Anon. 1964), using trapnets, yielded 50,000 pounds of burbot in 3 days' fishing, indicating that high yields may be obtained if the fish are harvested during the winter months, when concentrated because of spawning activities.

Although the white, flaky flesh is palatable and nutritious it is not highly esteemed in most parts of Canada and even early reports concerning its palatability are often contradictory. As early as 1836, Richardson stated that the "flesh was eaten only in times of great

scarcity . . . ," although Melvill (1915) noted that along the east coast of James Bay the flesh was considered to be excellent for food purposes by both Europeans and Indians. In Wyoming it was said by Bjorn (1940) to have long been regarded as a source of food. Nevertheless, attempts to encourage public acceptance of the burbot in Canada as a quality food fish or processed for industrial use have not been very encouraging to date.

When available in sufficient quantities burbot may be used for animal food on fur ranches and in the production of fish meal and oil. The vitamin A potency of burbot liver oil is stated to be about 500 units or more per gram and analyses of the Vitamin D potency of the oil obtained from the large liver have shown it to be as good as that obtained from cod liver (Branion 1930). When the burbot was abundant in Lake Erie, poundnet fishermen, who regularly handled tar-soaked netting, sometimes used the liver oil on their hands as a protection against the ravages of the tar. Burbot livers are eagerly sought in many European (especially Scandinavian) countries and are a valuable commodity when smoked and canned. Heavy infections of *T. nodulosus* in the liver however often prohibits this use. The Fisheries Research Board of Canada has experimentally canned Canadian burbot livers and the product is considered to be of high quality especially for such use as the making of canapes.

In Canada the burbot is caught incidentally by anglers while "ice-fishing" for lake trout. In recent years fishing through the ice for burbot has become a popular sport in some areas of British Columbia and in the state of Wyoming (Simon 1946), and in the latter case a closed season has been established. In parts of Europe and Asia the subspecies *L. l. lota* is a recognized food fish and is commercially exploited.

Nomenclature

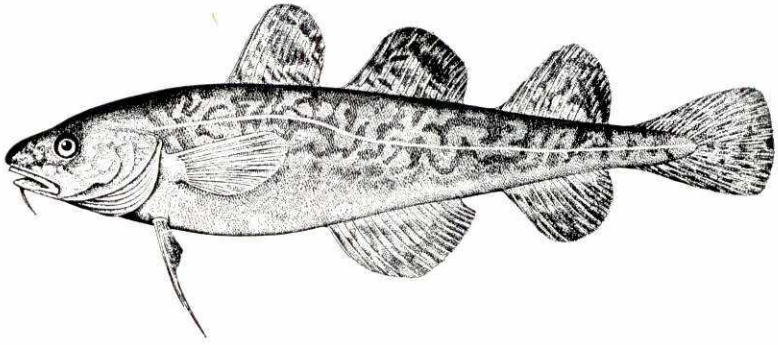
Lota lota	— Linnaeus 1758: 255 (type locality Europe)
Gadus Lota Linn.	— Forster 1773: 152
Gadus lacustris	— Walbaum 1792: 144
Gadus maculosus	— LeSueur 1817b: 83
Gadus (Lota) maculosus (Cuvier)	— Richardson 1836: 248
Lota maculosa (LeSueur)	— Jordan and Evermann 1896–1900: 2550
Lota lota maculosa (LeSueur)	— Hinks 1943: 85
Lota lota (Linnaeus)	— Dymond 1947: 32
Lota lota lacustris (Walbaum)	— Speirs 1952: 100

Etymology *Lota* — the ancient name used by Rondelet.

Common names Burbot, American burbot, ling, eelpout, loche, freshwater cod, maria (Saskatchewan, Manitoba, northern Ontario), methy (northern Canada), lush (Alaska), lawyer (Great Lakes states). French common name: *lotte*.

ATLANTIC TOMCOD

Microgadus tomcod (Walbaum)



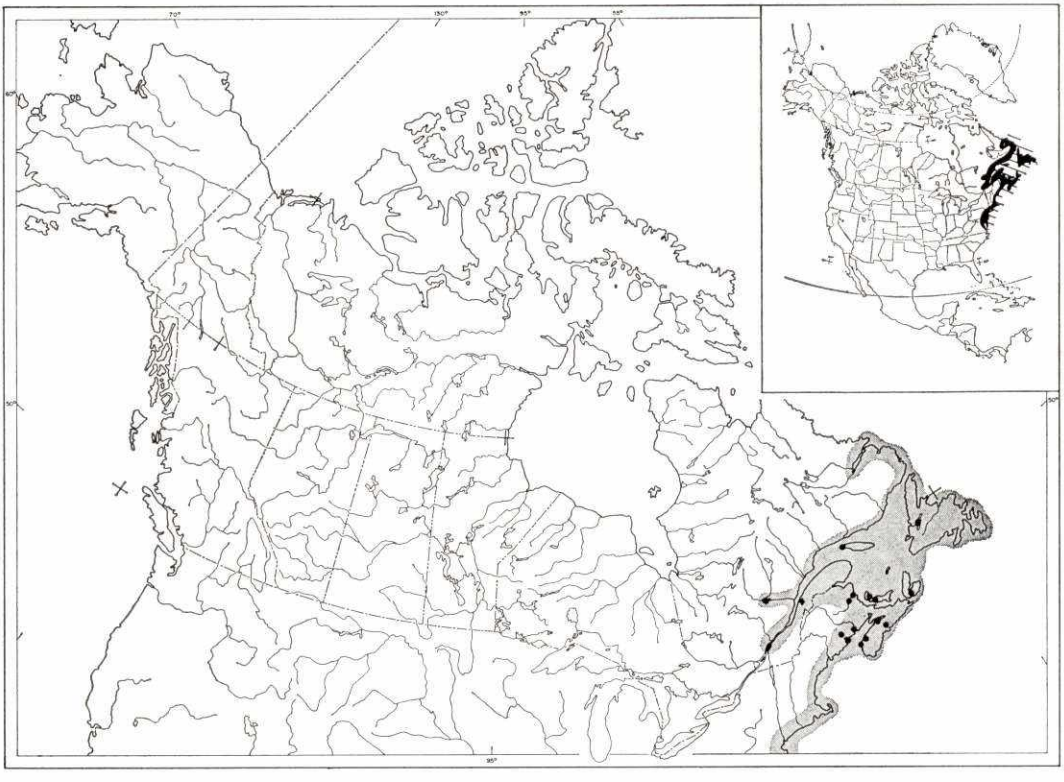
Description Body elongate, length usually 12–13 inches (305–330 mm); robust, not strongly compressed, thickest about origin of first dorsal fin. Head triangular, not markedly depressed, its length 20.1–22.2% of total length; eye moderate, its diameter 14.8–19.7% of head length; snout moderate, its length 33.3–38.5% of head length; interorbital width broad, 29.4–33.3% of head length; maxillary extending to below eye; teeth in jaws and vomer, fine and numerous, somewhat brush-like in both jaws; a slender barbel on underside of lower jaw, its length about equal to eye diameter, about 14–19% of head length. Gill rakers 16–21. Branchiostegal rays 7. Fins: dorsals 3, all more or less rounded; first dorsal in advance of first anal, rays 11–15, second dorsal rays 15–19, third dorsal rays 16–21; caudal rounded; anals 2, inserted below first dorsal and second dorsal, first anal rays 12–21, second anal rays 16–20; pelvic fins thoracic, originating slightly in advance of pectoral fins, the second rays prolonged to almost twice the length of other rays, rays 6; pectorals rounded, inserted just below midpoint of side, rays 16–19. Scales small, somewhat embedded; lateral line white, with slight arch over pectoral fin. Vertebrae 53–57.

Colour The Atlantic tomcod is generally brown or olive-brown with yellow or green tinges on the upper parts, the back is darkest, and the sides paler, and there are indefinite black spots or blotches on the upper part of sides, back, and dorsal fins. The belly is greyish or yellowish white. Anal fins are olive at the margins and all fins are more or less dark mottled.

Distribution A North American marine species, the Atlantic tomcod is distributed in coastal and brackish waters from southern Labrador (Hamilton Inlet–Lake Melville) to Virginia, and is occasionally a permanent resident in fresh water. A related species, *Microgadus proximus,* occurs on the Pacific coast of North America.

Along the Canadian Atlantic coast this species regularly enters fresh or brackish waters. Jeffers (1932) reported it from Pistolet Bay, Nfld., where it is abundant in winter months. In the provinces of Nova Scotia, New Brunswick, and Prince Edward Island it moves into estuarial waters, sometimes ascending streams or rivers well above tidal influence, into fresh water (Scott and Crossman 1959, 1964). In the St. Lawrence it was once abundant in the vicinity of Trois-Rivières and occurred occasionally upstream to Lac St. Pierre, but its numbers have since declined upstream from Trois-Rivières.

In fresh water the Atlantic tomcod has become landlocked in Lake St. John, Que.



(Legendre and Lagueux 1948), and in Deer Lake, Humber River system, Nfld., and is possibly resident in other freshwater areas of coastal Canada.

Biology The tomcod shares with its close relative, the burbot, the characteristic of midwinter spawning, usually beneath an ice cover. The spawning movement pattern is basically the same in all regions in which the tomcod occurs, that is, the ripening adults may spawn in salt water but apparently prefer to move into estuaries and rivers, when available, to spawn over sandy or gravel bottoms in brackish or freshwater shallows. Leim (1924) observed that eggs would hatch in both fresh and saline water, but that the larvae would live only in the latter. However, the existence of entirely landlocked populations, at least in Quebec and Newfoundland, attests to the ability of the species to survive when restricted entirely to fresh water. The area of distribution through the Maritime Provinces and Quebec is rather scattered and it is apparent that spawning does not occur at the same time in all places. Throughout the range along the Atlantic coast spawning possibly occurs from mid-November to about the end of February.

McKenzie (1959), in a discussion of the species in the Miramichi River, N.B., reported that, "The spawning run into the lower freshwater parts of the main branches takes place during the last half of November and early December, with the return movement reaching a peak the last half of January." In Quebec, especially in the vicinity of Trois-Rivières, Vladykov (1955a) reported that active spawning took place from the end of December to the end of January. Details of spawning of Canadian freshwater populations appear to be nonexistent.

The spherical eggs, about 1.5 mm in diameter, are unlike those of the Atlantic cod in that they possess a distinct oil globule, they

sink, are adhesive, and readily become attached to the gravel or sand on the bottom. The number deposited depends on the size of the female, but Vladykov reported that a 7-inch (180-mm) fish will deposit 6000 eggs, a 9-inch (230-mm) fish nearly 14,000 eggs, and a 14-inch (355-mm) fish an estimated 65,780 eggs. Schaner and Sherman (1960), in a critical account of fecundity in Massachusetts waters, gave figures of average egg-production for mature tomcod of 20,000 eggs, with a range of 6,000–30,000. The ova they examined showed an average increase in diameter from 0.6 mm in October to 1.4 mm in December. Although we are unaware of reports of actual observation on the spawning grounds, temperatures probably vary between 32° and 39° F (0.0° and 3.9° C) depending on local conditions. Such low temperatures retard incubation but at temperatures of 40° and 43° F (4.4° and 6.1° C) hatching is said to occur in 30 and 24 days, respectively. On hatching, the young are thought to move or drift down river and into the estuaries where the larvae can be caught in the spring. Bigelow and Schroeder (1953) stated that the fry were said to remain through the first summer in the waters where they hatch and grow to a length of 2.5–3.0 inches (65–78 mm) by the following autumn. Although we do not have figures on rate of growth, Vladykov (1955a) reported that three tomcod caught in the St. Lawrence River near Neuville June 19, 1948, measured 1.5–2.0 inches (40–53 mm) in their first year. The following figures on the length–weight relation are also taken from Vladykov (1955a).

Length		Wt	
(*inches*)	(*mm*)	(*oz*)	(*g*)
4	101.6	⅛	
6	152.4	1	28
8	203.2	2	56
10	254.0	4	
12	304.8	7	
14	355.6	14	

Accurate figures on maximum sizes have not been reported, but 15 inches (381 mm) in length and 20 ounces (570 g) in weight are usually offered as maximum sizes.

Under normal conditions, excluding landlocked populations, the Atlantic tomcod appears to be an inshore or shallow water marine species that regularly enters fresh or brackish waters during the spawning migration in late fall and winter. It is during the November–February period that it is most vulnerable to exploitation. Studies of movements of Gulf of St. Lawrence populations suggest that many local populations exist, and although some may migrate distances up to 150 miles, others remain in a smaller home territory. Vladykov (1955a) noted that tomcod at Ste. Anne de la Pérade remain throughout their lives in that section of the St. Lawrence River between Rivière Ouelle and Trois-Rivières.

Although it is one of the smallest species in the cod family, the tomcod is as voracious as its larger relatives. Small crustaceans, especially shrimps and amphipods, are its principal food, but it consumes a wide variety of other animals as well, including marine worms, small molluscs, and squid. Fishes are also eaten, especially smelt, sticklebacks, the young of striped bass, alewives, shad, herrings, and sculpins.

The parasite nematode *Porrocaecum* has been identified in the flesh of the tomcod in the Newfoundland area (Templeman et al. 1957), and an acanthocephalan, *Leptorhyncoides thecatus*, was reported by Pigeon and Valée (1937) in the digestive tract of tomcod from the St. Lawrence River.

Much of the available information relating to spawning and early life history of tomcod was gathered many years ago for waters of the Gulf of Maine and southward, and hence should be applied with caution to Canadian populations, especially those of the Gulf of St. Lawrence region, which seem to be the most utilized. Despite the fact that tomcod are angled from Labrador to Ste. Anne de la Pérade and also support a small but worthwhile fishery of about one million pounds, details on rates of growth and other biological aspects seem not to be available.

Relation to man The Atlantic tomcod is sought, both as a sport fish and a commercial fish, in various parts of eastern Canada. The tasty white flesh and the readiness of the species to take a baited hook during its winter

spawning aggregations formed under the ice in late December and January, combine to make tomcod fishing a popular winter activity in various parts of the country, particularly in Quebec and New Brunswick. The winter fishery in the Trois-Rivières–Ste. Anne de la Pérade region of the St. Lawrence River has been vividly described by Vladykov (1955a) who noted that night fishing was best and that 500–600 tomcod could be caught by one person between 7:00 PM and 7:00 AM. This fishery has been seriously affected by pollution, especially in the vicinity of Trois-Rivières, where catches have been drastically reduced.

In New Brunswick the principal fishery is in the lower Miramichi River and is largely a bagnet fishery conducted in the late November–January period between Loggieville and Newcastle. This catch is processed mainly for animal food.

In the inshore waters of the Northwest Atlantic a commercial catch of 240 metric tons was reported for 1967.

Wherever the Atlantic tomcod occurs in sufficient numbers it may become the object of a small fishery but few such fisheries are documented. The tomcod is particularly susceptible to various types of industrial wastes, produced particularly by pulp and paper mills, many of which discharge accumulated wastes into rivers after the ice cover is formed. Such discharges are less conspicuous and their deleterious effects often go unnoticed. Tomcod, however, spawn only after the ice cover is formed. Their eggs and larvae are extremely sensitive and quickly succumb in the presence of chemical pollution and low oxygen levels created by industrial waste discharge. Whereas some other fish species may be able to move out of the region, to return when pollution ceases, the tomcod is unable to reproduce and soon disappears entirely from the affected region.

Nomenclature

Gadus tomcod	— Walbaum 1792: 133 (type locality Long Island, after Schöpf)
Gadus frost	— Walbaum 1792: 134
Morrhua pruinosa	— Perley 1852: 211
Gadus pruinosus Mitchill	— Adams 1873: 305
Gadus tomcod (Walbaum)	— Cox 1893: 38
Microgadus tomcod (Walbaum)	— Bailey et al. 1960: 22

Etymology *Microgadus* — small; Latin name, akin to English word cod; *tomcod* — a vernacular name.

Common names Atlantic tomcod, tomcod, winter cod, frostfish, tommy cod, snig, tommycod, petite morue, loche, poisson des chenaux. French common name: *poulamon atlantique.*

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THE SILVERSIDES AND FLYINGFISHES — Order Atheriniformes

Virtually the only way to describe or delineate this order, as presently organized, would be to list the distinctive characteristics of each of the diverse suborders, Atherinoidei, Exocoetoidei, and those of some of the many families contained in them. The complexity of the group is obvious when we consider that the present arrangement includes fishes that, in the past, were placed in such groups as Synentognathi, Beloniformes, Cyprinodontiformes, Percesoces, Mugiliformes, Phallostethiformes, and Perciformes (Greenwood et al. 1966). However, the Cyprinodontiformes are treated as a separate order here p. 630.

By means of extensive and penetrating anatomical and morphological studies Rosen (1964) was able to demonstrate that the halfbeaks, the silversides, and those forms related to each, should be more closely aligned with the killifishes than with the mullets and barracudas, as they were prior to the study. He suggested, on the basis of similarities shown by these superficially diverse forms, that the families probably had "a common (Eocene) ancestry in fresh and brackish waters of Australia and from this region they subsequently spread around the world into virtually all of the tropical temperate, marine, and freshwater environments."

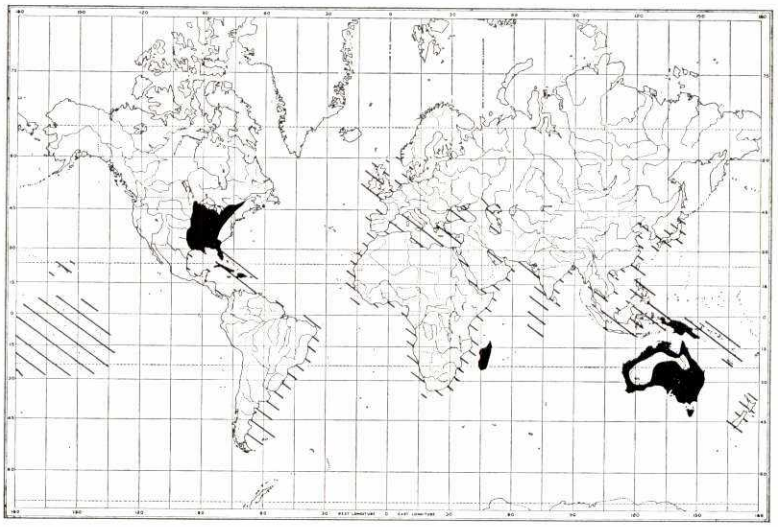
For this discussion we are concerned with only a single silverside, family Atherinidae.

Silversides Family — Atherinidae

Usually small, silvery, somewhat translucent fish with a pronounced lateral stripe. They are laterally compressed, fusiform; the head is scaled, the mouth is terminal with the appearance of being directed upward, and the eyes are large. Teeth are usually present on the jaws, often on the palatines and vomer. The superior pharyngeals are united and bear teeth. There are 2 well-separated dorsal fins, the first smaller, inconspicuous with 3–8 spines. The pectoral fins are high on the body; and the pelvic fins, of 1 spine and 5 rays, are abdominal. The anal fin, which has a weak spine, is short or long, square or falcate; and the caudal fin is forked. The lateral line is absent or restricted to a few tubes; the scales are cycloid. There are no pyloric caeca; the swim bladder is present and physoclistous.

Although the majority are 2–6 inches long and from tropical surface and shore waters, some temperate New World forms reach 1–2 feet. They are distributed around the world between 50°N and 50°S, in salt, brackish, and fresh water, including lakes and mountain torrents.

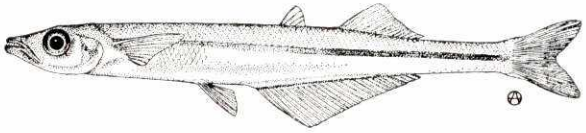
There are 50 genera and about 160–170 species, and silversides are known from the lower Eocene to Recent.



World Distribution of the Silversides

BROOK SILVERSIDE

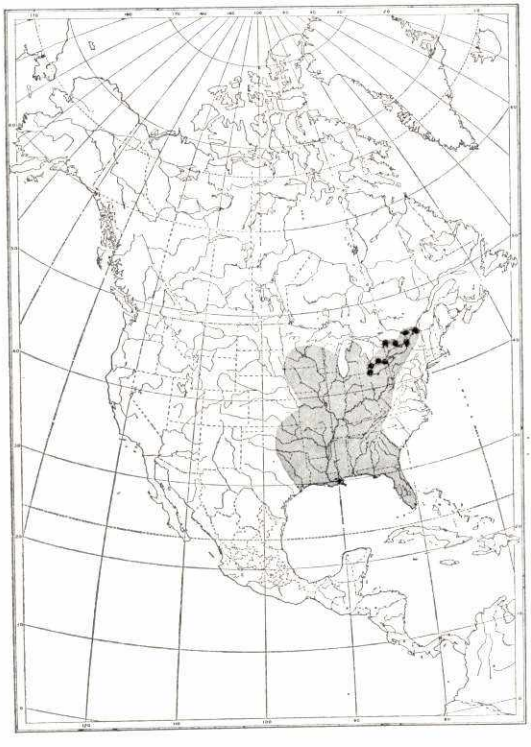
Labidesthes sicculus (Cope)



Description A slender, translucent, pikelike fish; body slender, elongate, average length usually 3 inches (76 mm), only slightly compressed laterally, deepest in front of first dorsal fin. Head somewhat long, distinctly flattened above, 17.8–19.7% of total length; eye diameter 27.3–34.8% of head length; interorbital wide, 27.3–34.8% of head length; snout long, pointed, jaws nearly equal, or lower jaw projecting slightly; mouth relatively large, somewhat beaklike, gape terminating in advance of eye; teeth long, sharp, conical, slightly recurved, in 3 rows on jaws. Gill rakers long and slender, 24–29 (Indiana). Branchiostegal rays 6, aciniform. Fins: dorsals 2, first spiny, second soft rayed, first dorsal of 4 spines, second dorsal of 1 spine and 10 or 11 branched rays; caudal distinctly forked; anal fin of 1 spine and 23–27 branched rays; pelvic fins abdominal, of 1 spine and 5 rays; pectoral fins well developed, tips reaching almost to origin of pelvics, pointed, inserted about midlaterally, behind head, of 12 or 13 rays. Scales small, cycloid,

in lateral series about 95; lateral line incomplete, often only a few pores. No pyloric caeca. Vertebrae 40–43.

Colour Overall colouration of the brook silverside is pale green, sometimes olive; the body is rather transparent and the swim bladder and vertebral column can often be seen through the muscle, particularly in small fish 1.5–2.0 inches (38–51 mm) long. Scales on back usually outlined with fine dark spots. There is a brilliant silvery lateral band along the sides.



Distribution The brook silverside is widely distributed throughout the fresh waters of central North America. In the United States it is found in lakes and streams in the Mohawk River system of New York (presumably a canal immigrant), the Alleghany River system, west to the lower peninsula of Michigan, through Wisconsin and Minnesota, and thence south to the Gulf states, Texas, and Oklahoma.

In Canada it occurs in the drainages of the upper St. Lawrence River, the lower Ottawa River, and in lakes Ontario, Erie, and St. Clair, in Georgian Bay and in some tributary streams. This species appears to be restricted mainly to clear, weeded lakes.

Biology Canadian populations of brook silversides, which are confined to a small region in south-central Canada, have received scant attention except for the observations by Bensley (1915), and Keast and Webb (1966). Consequently much of the following information has been obtained from observations of the species made in waters of the northern United States.

Spawning occurs in spring and early summer. In southeastern Michigan Hubbs (1921a) observed that spawning commenced in May and extended into July in 1920. In a marl lake in northern Indiana, Nelson (1968b) noted that spawning extended from June 17 to August 5 in 1966. Spawning takes place in and around aquatic vegetation, especially *Scirpus* and *Potamogeton,* but apparently may also occur over gravel in a moderate current. Possibly the large numbers reported by Bensley in the flowing water near the falls of the Go Home River, Georgian Bay, Lake Huron, Ont., were engaged in spawning. The eggs are orange in colour, 0.8–1.2 mm in diameter, with numerous oil globules, and each egg has a long filament whose length is many times the diameter of the egg. This filament is adhesive, although the egg is not, and functions as an anchoring device for the egg.

Growth of young silversides is extremely rapid. Nelson (1968b) noted that the rate at which maximum size is attained exceeds that of all but one species in the list of species presented by Beverton and Holt (1959) in their discussion on aging of fishes. It lives for 1½ years only, rarely completing 2 years. The young hatch, grow to their maximum size the same year, overwinter, spawn the following spring and summer, and die. Nelson noted that in an Indiana lake population, some fish reached the modal size of the 12-month-old spawning group of their own

year-class in only 3 months. Nelson presented a comprehensive discussion of the growth characteristics of this Indiana population. The observed maximum total length of Ontario specimens is 3.5 inches (89 mm), but most adults average about 3 inches (76 mm) in their second year.

The brook silverside is adapted for living in the surface layers. On hatching, the young move offshore over deep water but remain in the upper layers, usually with their flattened head in contact with the surface film. The young remain offshore, apparently as a result of a negative response to large objects or bodies. Hubbs (1921a) suggested that this characteristic functions as a predator-avoidance mechanism, keeping the vulnerable young out of contact with such predatory groups as centrarchids and percids. They form large schools during daylight hours but tend to disperse at night. As they increase in size the aversion to large bodies declines and they move in over shoals, usually in August and September.

In Ohio it has been noted that the species tended to disappear from waters that became turbid, which is a condition that has become more widespread in southern Ontario as a result of construction and agricultural activities. We have few observations to indicate that the brook silverside attains an abundance comparable to that in lakes of the northern United States, where, for example, at least 11,500 specimens were used in Nelson's study in Indiana. But in Crippen Lake, Leeds County, in eastern Ontario, Toner (1943) noted that immense numbers could be caught by seine at night, but not in daytime. Toner also noted that large numbers were occasionally observed from the dock at Kingston, Ont.

The predaceous food habits of this delicate little fish have been reported by Bensley (1915) and more recently by Keast and Webb (1966). The latter noted that it is a specialized feeder, consuming Cladocera (often to 80% by volume), small flying insects (to 40%), and *Chaoborus* (phantom midge) larvae (to 50%). The smaller the fish the larger the amount of Cladocera eaten. Bensley's observations of Georgian Bay specimens, although more general, are in agreement.

It feeds in a snapping fashion, for which its beaklike, toothed jaws are ideally suited. Numerous authors noted that it may frequently leap out of the water to catch flying insects.

Parasites of brook silversides from Lake Erie have been recorded by Bangham and Hunter (1939) who noted that specimens from eastern Lake Erie were relatively unaffected although those from the west end of the lake harboured cestodes, trematodes, and nematodes.

Relation to man The brook silverside is an ideal forage fish and when abundant it may be an important prey for game fishes. It is undoubtedly of very minor importance in most Canadian waters because of its low numbers and limited distribution. Larger specimens are occasionally used for bait by sports fishermen.

Nomenclature

Chirostoma sicculum — Cope 1865: 81 (type locality Grosse Isle, Detroit River)
Labidesthes sicculus — Cope 1870: 455

Etymology *Labidesthes* — a pair of forceps; to eat; *sicculus*, *siccus* — dried; found in half-dry pools.

Common names Brook silverside, skipjack, silverside, brook silversides, brook-silverside. French common name: *crayon d'argent*.

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THE STICKLEBACKS AND RELATIVES — Order Gasterosteiformes (Thoracostei)

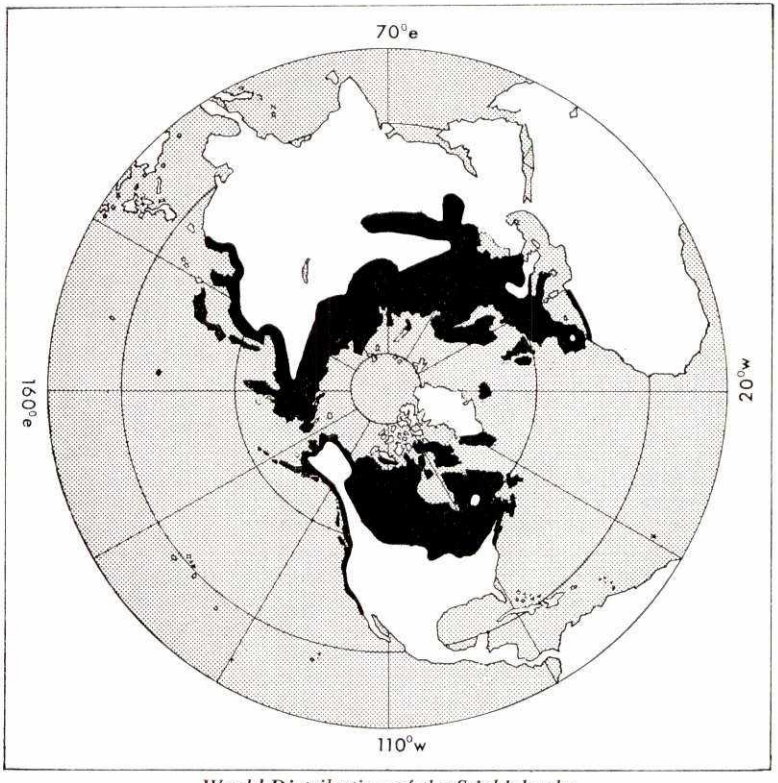
This order includes the sticklebacks, tube-snouts, pipefishes, seahorses, and snipefishes, a mixed group of spiny-rayed, principally warmwater, marine fishes. Members of the order are without a duct to the swim bladder; fin spines may be present or not; the pelvic fin when present is abdominal or thoracic and may possess a stout spine; pelvic bones are not attached to cleithra. Branchiostegal rays 1–5.

As herein defined the order includes about 50 genera and approximately 200 species.

Stickleback Family — Gasterosteidae

The sticklebacks are small, laterally compressed fishes with slender caudal peduncles; the head is moderate, the skull elongate; the mouth is small, the teeth also small, but well developed; upper jaw bordered by premaxillary, the maxillary being slender and articulating anteriorally with the premaxilla. Branchiostegal rays 3. The well-developed dorsal and pelvic fin spines are characteristic of the group; the soft dorsal fin is preceded by 3–16 isolated, well-developed spines, each with a triangular membrane; usually a short spine is closely associated with a soft dorsal fin of 6–14 rays; the caudal fin is rounded to slightly forked, with 12 soft rays; anal fin, usually about as long as soft dorsal, of 6–12 rays, preceded by a short but strong spine; pelvic fins thoracic in position, usually posterior to pectoral fin base, of a single, strong well-developed spine and 0–3 soft rays; pelvic bones not attached to cleithra; pectoral fins somewhat fanlike, inserted laterally, and with base in a vertical line, of 10–12 rays. Physoclists. Vertebrae 27–42.

The members of the family occur in shallow, inshore areas of marine and fresh waters of North America, northern and central Asia, Europe, and Algeria.



World Distribution of the Sticklebacks

Key to Species

1 Dorsal spines usually 9 (7–12), short and inclined alternately to left and right; gill membranes united, but entirely free from isthmus; no distinct bony plates on sides ..... NINESPINE STICKLEBACK, *Pungitius pungitius* (p. 671)

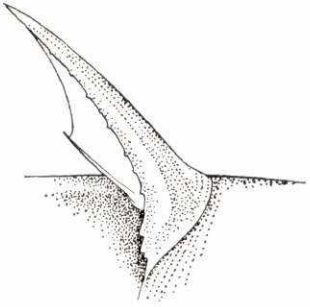
Dorsal spines 3–6; gill membranes united to isthmus (membranes united but free from isthmus in *Culaea*); lateral bony plates present or absent 2

2 Dorsal spines 4, 5, or 6, spines may be long or short; no distinct bony plates on sides; pelvic skeleton without large, wide, median posterior processes 3

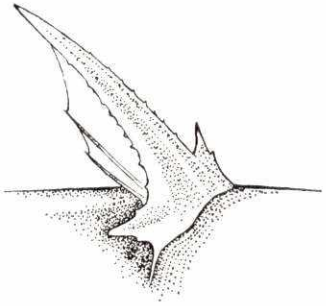
Dorsal spines 3 (rarely 2 or 4), usually with distinct vertical bony plates along sides; pelvic skeleton with large, wide, median posterior processes 4

3 Dorsal spines 4, 5, or 6, short; pelvic spines also short; length of all spines usually less than eye diameter; pelvic skeleton, if present, with narrow median posterior processes ..... BROOK STICKLEBACK, *Culaea inconstans* (p. 661)

Dorsal spines 4 (rarely 5), of varying lengths and long, inclined alternately to left and right; length of first and second dorsal spines and pelvic spines distinctly greater than eye diameter; pelvic skeleton with lateral posterior processes ..... FOURSPINE STICKLEBACK, *Apeltes quadracus* (p. 658)



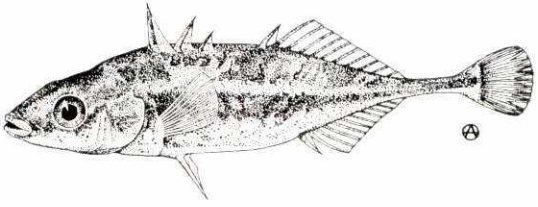
4 Pelvic fin of 1 spine and 1 soft ray, spine with 1 pointed cusp at base; caudal peduncle usually with a keel; body without round black spots; colour in life green, blue or silvery ..... THREESPINE STICKLEBACK, *Gasterosteus aculeatus* (p. 665)



Pelvic fin of 1 spine and 2 soft rays, spine with 2 well-developed pointed cusps at base; caudal peduncle keel-less; many round black spots along sides; colour in life lemon-yellow .... BLACKSPOTTED STICKLEBACK, *Gasterosteus wheatlandi* (p. 669)

FOURSPINE STICKLEBACK

Apeltes quadracus (Mitchill)



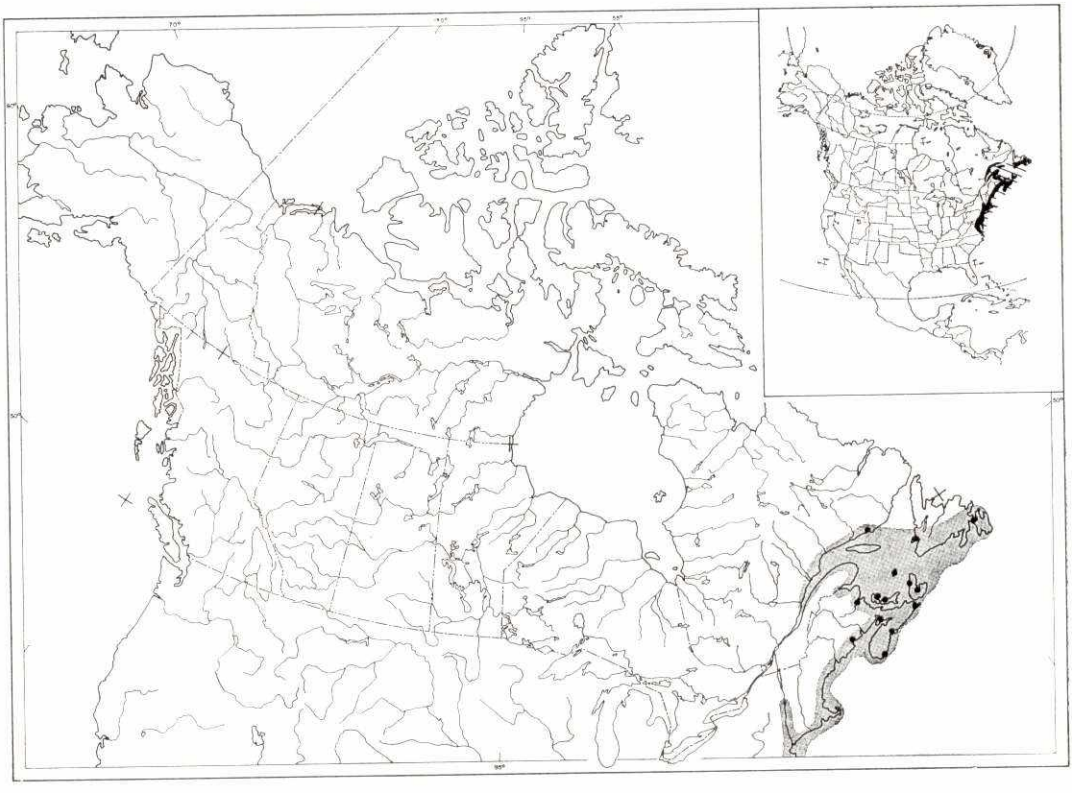
Description Body moderately elongate, somewhat compressed laterally, length 2.0–2.5 inches (51–64 mm), greatest depth in front of the soft-rayed dorsal fin, body depth 16.2–20.0% of total length; in cross section body somewhat triangular; caudal peduncle slender and without a keel. Head compressed, pointed, 22.2–26.3% of total length; eye diameter 25.0–33.3% head length; mouth terminal, small; lower jaw projecting slightly; single series of slender teeth in each jaw. Gill membranes broadly united to isthmus. Branchiostegal rays 3. Fins: dorsal of 3 or 4 isolated spines, inclined to left or right, first and second spines about equal, about 33.3% length of head, third and fourth about one-half length of first, followed by 10–13 soft rays that are preceded by 1 spine attached to the anterior edge of soft dorsal rays; soft dorsal origin about midpoint of body slightly in advance of anus; caudal truncate, rounded corners; anal of 1 spine and 7–10 soft rays, the spine equalling spine on soft dorsal, attached by membrane to anterior edge of fin, fin terminating under posterior end of soft dorsal; pelvics with 1 spine and 2 slender, soft rays, spine heavy, lightly serrated, about one-half length of head; pectorals inserted on sides short distance behind gill opening, one-half length of head, moderate, rounded, rays usually 11, rarely 12. Skin naked, without scales or bony plates; a ridge on each side of lower abdomen behind pelvic fins due to separate posterior processes, no united median posterior processes between pelvic fins; lateral line present, not obvious. Vertebrae 29–33.

Colour Adults olive-green to brownish olive above, with dark mottlings on sides; lower sides and belly silvery; males may be almost black. Pelvic spine and membrane red on ripe males at spawning time. General colour of body of newly hatched larvae dark brown.

Systematic notes In a review of the species throughout its relatively small range, Krueger (1961) concluded that vertebral numbers tended to decrease from north to south, but that dorsal and anal rays and dorsal spines varied irregularly, although dorsal spines appeared to be correlated with salinity.

Distribution The fourspine stickleback is generally confined to coastal areas of eastern North America, from the Gulf of St. Lawrence south to Virginia. Typically a marine species, it rarely inhabits fresh water and commonly inhabits brackish, estuarial waters.

In Canada it is present in estuarial environments in southern Newfoundland (where it probably reaches its northern limit of range in western Newfoundland and nearby eastern Quebec), Prince Edward Island, Nova Scotia, New Brunswick, and the Gulf of St. Lawrence shore region of Quebec. An exception to the typical habitat exists in Nova Scotia where the fourspine stickleback is well established in a number of lakes and streams, far removed from the sea.



Biology The fourspine stickleback spawns in spring or early summer (May–July). Males and females appear on the spawning grounds where they separate, and the males, alone in shallow drainage channels, begin to construct the nests. The nest is made up of aquatic plants and twigs, bound together in an intricate manner to resemble a cup-shaped basket, by a threadlike material from kidney secretion (Breder 1936a). The secretion hardens into a tough thread on contact with water. When the nest is partially completed, the male approaches the female and performs a mating dance, swimming in extremely fast circling movements around, or in front of, her. At intervals he stops and displays both red pelvic spines. Eventually the female is lured onto the partially completed nest where she is induced to spawn (Reisman 1963).

The amber-coloured eggs, each about 1.5 mm in diameter, are deposited in the shallow nest in clusters of about 40 and adhere to each other. If by chance the eggs miss the nest the male will pick up the egg mass and place it in the nest. The eggs are liberally fertilized and then covered completely by the construction of an inverted nest or roof. The female is always driven off. The male leaves a hole on each side of the nest just large enough for him to insert his snout to aerate the eggs. By putting his snout into the hole and expelling water from the gill chamber, he draws water into the nest through the hole on the opposite side. He may then construct another nest on top of the first one. The increasing responsibility of the male, which includes aerating nests, building additional nests, chasing away enemies, and occasionally eating, keeps him extremely active. The male is known to build as many as four successive nests, one on top of another. The eggs and young are guarded by the male whose zealous adherence to duty evoked the following from Seal (1932): "There is probably no form of animal life

more fiercely devoted to the protection of its progeny. The eggs are aerated by drawing water through the orifices in the nest at intervals of not over a minute. In the intervals he scouts the neighbourhood of the nest looking for enemies and devouring such acceptable food as he encounters."

Newly hatched larvae are 4.2–4.5 mm in length. Growth is rapid and when 3 days old they have grown to a length of 6.2–6.5 mm. At 8 days they are approximately 7 mm long (Kuntz and Radcliffe (1917). Male fish 24.0–41.4 mm in total length, have a one-calendar-year life span (Schwartz 1965). Some females can live through a second winter to spawn the following season.

As noted above, the fourspine stickleback is usually found in salt or brackish waters but does occur in fresh water occasionally.

In eastern Canada food of this stickleback consists mainly of planktonic plants and animals.

There are few published records of parasites infecting this species, but *see* Hanek and Threlfall (1970) for helminth parasites.

Relation to man The fourspine stickleback can be used as bait in areas where it is abundant. Schwartz (1965) suggested this species might be useful as an experimental animal because of its rapid growth and relatively short life span.

Nomenclature

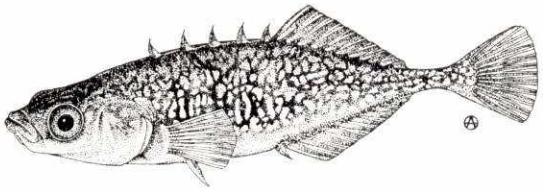
Gasterosteus quadracus	— Mitchill 1815b: 424 (type locality New York)
Gasterosteus millepunctatus Ayres	— Bean 1903b: 342
Apeltes quadracus Goode and Bean	— Bean 1903b: 342
Apeltes quadracus Mitchill	— Halkett 1913: 73
Gasterosteus quadracus Mitchill	— Jordan, Evermann, and Clark 1930: 239
Gasterosteus apeltes Cuvier and Valenciennes	— Jordan, Evermann, and Clark 1930: 239

Etymology *Apeltes* — privative, shield; *quadracus* — four spine.

Common names Fourspine stickleback, stickleback, pinfish, mud-pouch, mud-perch, bloody stickleback. French common name: *épinoche à quatre épines.*

BROOK STICKLEBACK

Culaea inconstans (Kirtland)



Description Body deep and compressed laterally, length about 2 inches (51 mm), tapering to a moderately slender caudal peduncle, also compressed laterally, and keelless, body depth 14.9–23.5% of total length. Head regularly conical, obliquely truncated by the lower jaw, head length 23.1–29.0% of total length; eye large, diameter 21.4–37.5% of head length; teeth on jaws small, well developed. Gill membranes united but free from isthmus. Branchiostegal rays 3. Fins: dorsal of 5 (range 4–7) short, isolated spines with backward curve, free from each other and each with individual membrane, and with a cartilagineous ridge along base of fin, spines depressible in a groove, followed by 9 or 10 (rarely 8, 11, or 12) soft dorsal rays; caudal rounded, 12 rays; anal of 1 short spine, situated directly beneath last dorsal spine, followed by 9–11 (rarely 12) soft rays, originating slightly behind origin of soft dorsal; pelvic 1 strong, spine and 1 ray (pelvic skeleton absent in some populations); pectorals of 9–11 soft rays, large, almost one-half length of head. Body smooth, scaleless, but with minute bony plates about lateral line pores. Vertebrae 29–35.

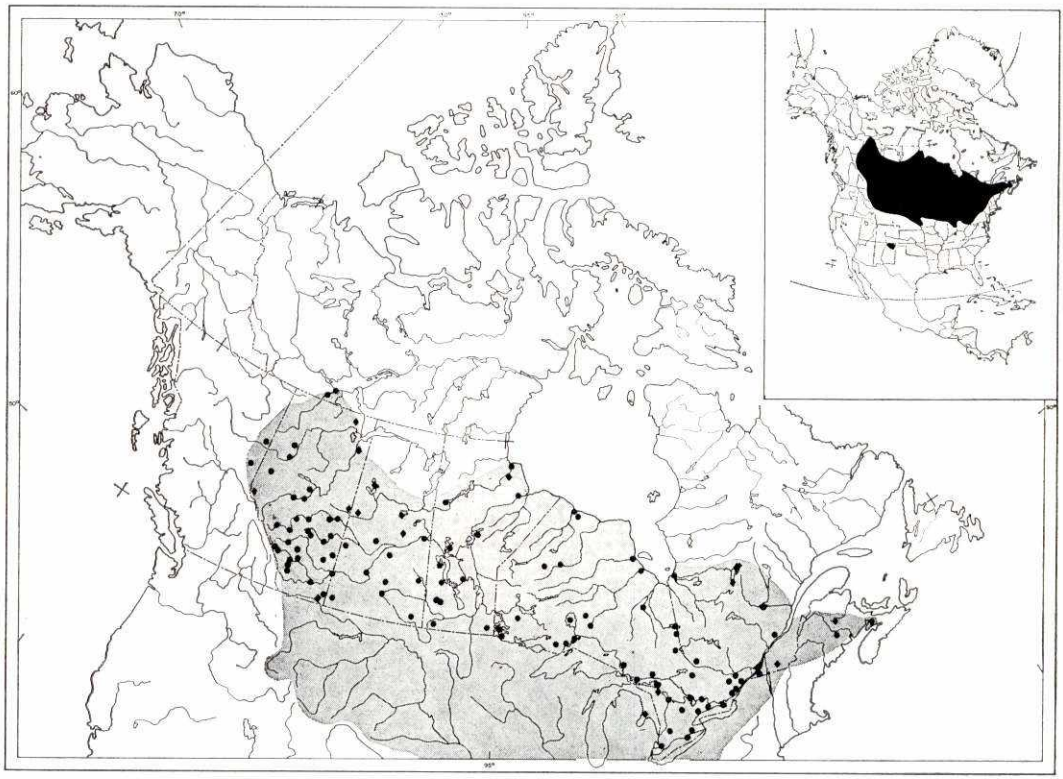
Colour Overall colour of adults olive-green to dark, soft, olivaceous black of spawning males, with numerous light spots on sides, on some individuals replaced by light, wavy, vertical lines. During spawning season, body and fins of males may be jet black, sometimes tinged with copper; females usually dusky. Males may have faint reddish tinge on pelvic membranes.

Systematic notes The brook stickleback was known for many years by the name *Eucalia inconstans*. Whitley (1950) noted that the genus *Eucalia* was preoccupied in entomology and proposed the genus *Culaea*, a name that is slowly becoming established since brought to North American notice by Bailey and Allum (1962).

Nelson (1969) noted that dorsal and pelvic spine lengths on this stickleback exhibit clinal variation, and are longest in Wisconsin, decreasing in length from this centre. In some Alberta and Saskatchewan localities, the entire pelvic skeleton is absent in a high proportion of the individuals (Nelson and Atton 1971).

Distribution The brook stickleback ranges widely in cool, clear waters through north-central North America; from Nova Scotia and Maine on the east, through New York, Pennsylvania and west through Iowa, but not Kansas (Cross 1967: 328), to Montana; north to the Hudson Bay drainage and the southern Northwest Territories. Relict populations are known to occur outside this range, such as in New Mexico (*see* Nelson 1969).

In Canada, it occurs from Nova Scotia and New Brunswick west, barely entering



British Columbia, and north to the Hudson and James Bay drainages of Quebec, Ontario, and Manitoba, and the Hay River region of Great Slave Lake.

Biology The brook stickleback spawns in shallow water from late April to July, depending upon the water temperature. Laboratory experiments reported by Winn (1960) suggested that spawning is inhibited if the temperature of the water is above 66.2° F (19° C). In southern Minnesota, where this species spawns from late April or early May to the middle of June, Jacobs (1948) stated that the water must attain a minimum temperature of 46.4° F (8° C) before spawning begins. Spawning is reported to occur later in more northerly latitudes (Winn 1960). On July 1, 1929, in Little Wonder Pond, a spring-fed pond in southwestern Ontario, Harkness and Ricker (1929) found nests and eggs of sticklebacks, presumably this species.

Winn (1960) and Thomas (1962) gave good accounts of the spawning and behavioural activities of this species. The males arrive first in the shallow water, establish territories, and begin nest construction. A male may construct two successful nests in one season. The nest is built on stems of reeds or grass close to, and sometimes on, the bottom. Dead grass and fine fibres are used in the early nests, but as the season advances, green algae is used. These fragments are bound together with a kidney secretion, as with other members of the stickleback family. The nest is more or less round in shape, about three-quarters of an inch in diameter, with a single opening. A second opening is made when the female, on depositing her eggs, leaves the nest. Repair of this second opening is attempted by the male. As eggs are added (from more than one female), the nest size is increased by the male. Some males attain a jet black breeding colour prior to nest building, others after

completion of the nest. Female sticklebacks also change colour when ready to spawn from uniform pale green to a variegated, dark and light pattern.

The male entices the female into the nest by a series of nips, butts, and nudges. By prodding her ventral and caudal peduncle areas after she has entered the nest, he induces the deposition of eggs, each nearly 1 mm in diameter, transparent, light yellow, demersal, and adhesive. She is then driven off, the eggs are fertilized and cared for by the male. At the entrance, the male fans with his pectoral fins, increasing this activity as the eggs develop. Hatching takes place in 8–9 days at 65° F (18.3° C) (Breder and Rosen 1966). The male defends his territory against intruders of his own size, or slightly larger, until the young swim away from the remains of the nest.

Indications are that the brook stickleback grows rapidly, and attains sexual maturity in 1 year. Maximum size is 3.5 inches (87 mm).

This stickleback inhabits the clear, cold, densely vegetated waters of small streams and spring-fed ponds, and is found along the swampy margins of beach ponds of larger lakes. Salinity tolerance experiments were reported by Nelson (1968a) and indicated that brook sticklebacks had considerable tolerance to salt water, at least for short periods, and continued to feed in salinities of 50% sea water (17.5‰) but ceased all activity at 70%. Nelson also noted that tolerance was greater at 46.4° F (8° C) than at 60.8° F (16° C). Natural occurrence in salt or brackish water is unusual, but Cox (1922), reporting on such a case in a discussion of the Hudson Bay collections of 1920, quoted Johansen regarding a collection from a "brackish land-locked pool." Miller and Thomas (1957) reported that it inhabits the alkaline lakes ("potholes") in the prairies of Alberta. It is found occasionally in well-protected coves and bays of large lakes, and in sluggish, stagnant water, and has been caught by trawl in Lake Huron at all depths to 30 fathoms. The apparent preference of the brook stickleback for cool water limits distribution southward, and it is usually found only in cooler waters at the southern limits of the range.

Migratory movements for such small species are not spectacular and are not well documented but Lamsa (1963) reported downstream movements of brook sticklebacks involving large numbers of individuals. In 1 week, June 8–14, 1958, 2851 specimens were trapped in a downstream trap in Silver Creek, which flows into Georgian Bay, Lake Huron, Ont. From June 28 to July 4, 1959, 908 were caught in the same stream. The mean water temperature was 66.2° F (19° C) during this week. The cause of the movement is unknown but the activity was concentrated during the 1 week of each year.

This species is mainly carnivorous, its food consisting of the larvae of a wide variety of aquatic insects and crustaceans, and also the eggs and larvae of other fishes (sometimes of its own species), as well as snails, oligochaetes, and algae. Dymond (1926) reported its food in Lake Nipigon consisted of midge and caddisfly larvae and ostracods.

The brook stickleback is preyed upon by many species of fishes but probably as an incidental or occasional item rather than a regular one. Ricker (1932) noted that it was eaten occasionally by brook trout in hard-water streams and ponds. It may be an important item in the diet of smallmouth bass and also is eaten occasionally by northern pike. It undoubtedly falls prey to fish-eating birds, such as kingfishers, herons, and mergansers.

Parasites of the brook stickleback are many and varied. Studies were published by Bangham and Hunter (1939) for Lake Erie, Bangham and Venard (1946) for Algonquin Park, Bangham and Adams (1954) for British Columbia, and Bangham (1955) for Lake Huron. The trematode *Bunoderina eucaliae* was a common parasite in fish from all areas except Algonquin Park, where none of the seven fish examined contained parasites of any kind. Lawler and Watson (1958) found the cestode *Schistocephalus solidus* in the brook stickleback in Heming Lake, Man., and Paetz and Nelson (1970) noted that *Schistocephalus* may account for

more than one third of an infected fish's weight in Alberta. Hoffman (1967), in a review of parasites of the species in North American waters, listed two protozoans, nine trematodes, five cestodes, four nematodes, four acanthocephalans, one leech, one mollusc, and one crustacean.

Relation to man The brook stickleback, although occasionally used for bait, is not of direct commercial importance. Dawson (1859), in an account of the species in the vicinity of Montreal, noted "it is easily taken with a dipnet, and great numbers are captured by young anglers for bait." Nor is it a forage fish of significance, except perhaps in lakes on the Precambrian Shield that lack other forage fishes. It is an interesting aquarium species and could be used in laboratory studies of behaviour, but a supply of live food, such as the brine shrimp *Artemia,* is desirable. Frozen brine shrimp may also be used. Like most sticklebacks, it is a pugnacious little creature and will harass, and eventually kill, other small fishes kept with it.

Nomenclature

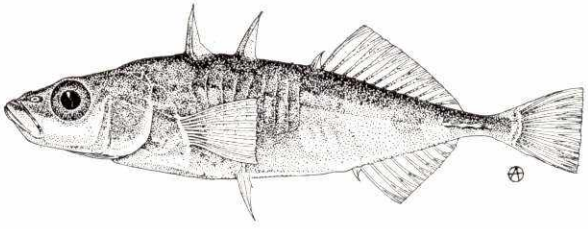
Gasterosteus inconstans	— Kirtland 1841a: 273 (type locality Trumbull Co., Ohio)
Gasterosteus gymnetes	— Dawson 1859: 321
Gasterosteus inconstans Kirtland	— Cox 1896b: 68
Eucalia inconstans pygmaea (Agassiz)	— Jordan and Evermann 1896–1900: 744
Gasterosteus globiceps Sauvage	— Jordan and Evermann 1896–1900: 744
Eucalia inconstans Kirtland	— Evermann and Goldsborough 1907a: 106
Gasterosteus pygmaeus Agassiz	— Halkett 1913: 72
Eucalia inconstans (Kirtland)	— Forbes and Richardson 1920: 222
Eucalia pygmaea (Agassiz)	— Jordan, Evermann, and Clark 1930: 238
Culaea, nov.	— Whitley 1950: 44
Culaea inconstans	— Bailey and Allum 1962: 93

Etymology *Culaea* — a coined name; *inconstans* — meaning variable.

Common names Brook stickleback, five-spined stickleback, variable stickleback, common freshwater stickleback, common stickleback, pinfish, six-spined stickleback. French common name: *épinoche à cinq épines.*

THREESPINE STICKLEBACK

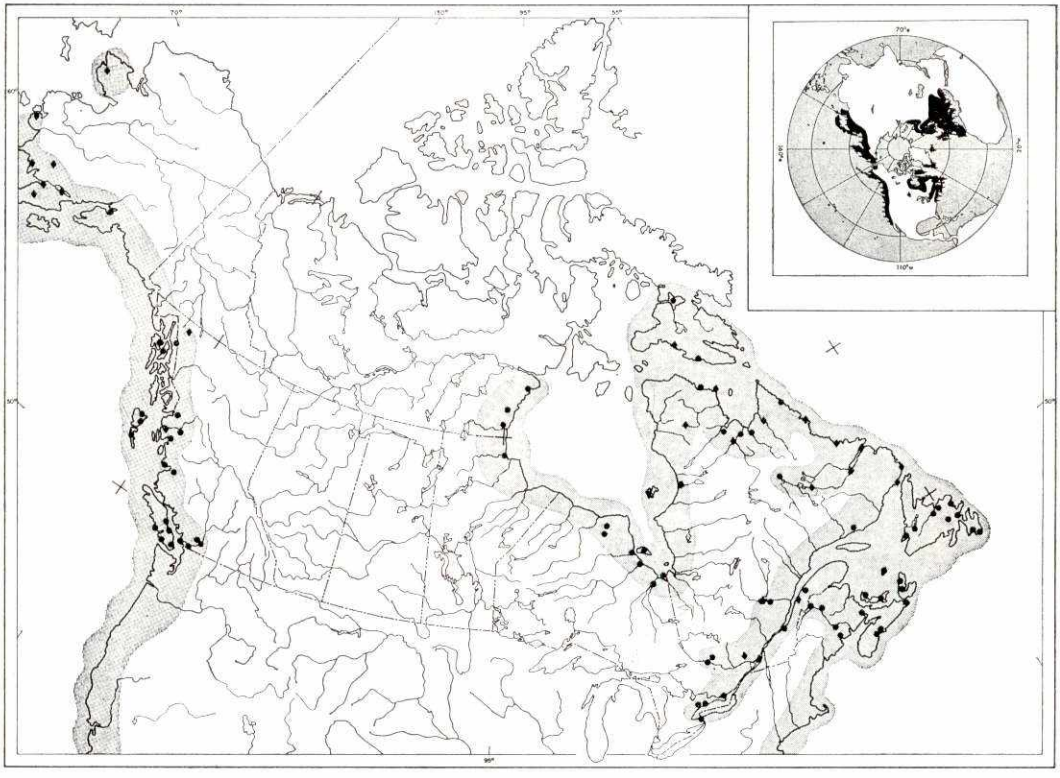
Gasterosteus aculeatus Linnaeus



Description Body compressed laterally, elongate, average length 2 inches (51 mm), tapering to a slender, depressed caudal peduncle that is usually keeled in marine forms, body depth 20–22% of total length. Head 23.8–26.3% of total length, pointed; eye diameter 25% of head length; teeth on jaws slender, sharp. Gill covers finely striated. Gill membranes broadly joined to isthmus. Branchiostegal rays 3 (rarely 4). Fins: dorsal of 3 (rarely 4) isolated, stout, serrated spines, each with triangular fin membrane, length of longest spine variable, usually 33.3–50.0% of head length, last spine very short, preceding, but not attached to soft rays, soft rays 11–13 (rarely 10 or 14), originating over or slightly in advance of anus; caudal with 12 rays, moderate and slightly forked; anal of 1 spine and 8–10 soft rays, the spine slightly shorter than last dorsal spine, lightly serrated and free from soft rays, origin of fin behind origin of soft dorsal fin and terminating under last soft dorsal ray; pelvics thoracic, situated on ventral surface below middle of pectorals, each with 1 strong spine and 1 soft ray, spine slightly longer than longest dorsal spine; pectorals large, length one-half that of head, situated a short distance behind gill opening. All fin spines can be rigidly locked in an erect position. Body naked, or plated, with variable number of vertical, oblong, bony plates on each side; up to 30 or more in saltwater specimens, few or none on specimens from fresh water; single, ventral, bony plate between and behind pelvic fins; lateral line high, complete. Vertebrae 31–33, rarely 29 or 30.

Colour Colour of adults variable above, silvery green, grey, olive, greenish brown, or sometimes mottled with dark markings, males (in British Columbia) occasionally almost black; sides paler and with silvery reflections, belly silvery. Fins pale but membranes often red. During breeding season, ripe males become brilliantly coloured with red on belly and flanks, and have bright blue eyes, whereas females assume pink tints on throat and belly. Body of the newly hatched larvae yellowish. Young fish bright silvery.

Systematic notes *Gasterosteus aculeatus* has been intensively studied in recent years and is now known to be separable into two distinct forms or possibly subspecies, or even species. Both are here regarded as forms of the species *G. aculeatus*. The marine form, called *trachurus*, has a complete series of lateral bony plates, is silvery coloured and of large size; the freshwater form, called *leiurus*, has few lateral bony plates, is olive coloured but mottled with light bars, and of smaller size. *Leiurus* remains in fresh water throughout its life, whereas *trachurus* migrates into fresh water in spring to spawn. The following biological information was derived from studies involving both forms, although it is now believed



that the two are reproductively isolated. For further information on this aspect *see* Hagen (1967). In some British Columbia populations the pelvic skeleton is absent or much reduced. The enormous variability within the species is mentioned by Hagen and McPhail (1970). In order to retain all the units in one category, as seems best because of the many taxonomic problems, Nelson (1971a) referred to the group as *Gasterosteus aculeatus* complex.

Distribution The threespine stickleback is nearly circumpolar (it is absent from the arctic Siberian coast and most of the arctic North American coast), widely distributed in the northern hemisphere in both salt and fresh waters. An anadromous and freshwater species, it is found in Europe from southern Greenland, Novaya Zemlya, northern Norway, and Iceland, southward to Spain, in the Mediterranean, and the Black Sea. It does not inhabit waters of the Caspian or Aral seas, nor the waters off the north coast of Siberia.

In North America it ranges from Chesapeake Bay north to the Hudson Bay region and Baffin Island, is apparently absent from arctic coasts of Northwest and Yukon territories and Alaska, but then occurs down the Alaskan and British Columbian Pacific coast to lower California.

In Canada it is a common species in Newfoundland waters and is generally distributed throughout the waters of the Atlantic provinces. Inland, it occurs in the St. Lawrence River, Ottawa River, the Lake Ontario basin, and in protected bays and rivers, but does not occur in the Great Lakes above Niagara Falls. It is present in many lakes, and most rivers and streams of the coastal area of British Columbia, and in the Fraser valley as far upstream as Kawkawa Lake, near Hope, B.C. It does not range north of Bering Strait in the Pacific but does occur on most offshore islands such as Queen Char-

lotte (where it reaches a very large size in one lake), Kodiak, and St. Lawrence islands.

It is absent from Saskatchewan and Alberta.

Biology The threespine stickleback spawns in fresh water, generally in June or July, but breeding occurs throughout the summer months, from April to September inclusive, in the Cowichan River in British Columbia. In central Europe, spawning takes place in waters of very low salinity from April to the end of July.

This species, unlike other members of the gasterosteid family, builds its nest on the bottom, preferably on a sandy area, in shallow water (Fish 1932). The nest is constructed of small twigs and plant debris, held together, as in the case of other sticklebacks, by the mucilaginous kidney secretion emitted by the male. The nest is barrelshaped, hollow, and with a smooth, circular opening in each end.

The male entices the female into the nest, carrying out his courtship dance in a series of zigzag motions, and touching the opening of the nest with his snout. When the nest is full of eggs, perhaps as a result of spawning with several females, the top of the nest is loosened, apparently for better ventilation. As many as 600 eggs have, on occasion, been found in one nest. The eggs are yellowish, and semiopaque, each 1.5–1.7 mm in diameter, although the size does vary somewhat with locality (Vrat 1949). They are laid in clusters, adhesive to each other. Hatching occurs in 7 days at 66.2° F (19° C) (Breder and Rosen 1966). The male guards and fans the nest, and continues to guard the newly hatched fish until they are able to care for themselves.

Newly hatched larvae vary slightly in size in different localities. Massachusetts specimens measured 4.2–4.5 mm in length (Kuntz and Radcliffe 1917), those from California locations 4.71–4.91 mm standard length (Vrat 1949), and Jones and Hynes (1950) noted that newly hatched fish were 5 mm long in England.

In the Birket River in England, studies of the otoliths indicated that the stickleback probably does not live longer than 3½ years and that growth is rapid during the first year, slowing considerably in the second year. At the end of the first summer, size ranged approximately 15–33 mm in total length; at the end of the second summer 25–50 mm total length; and at the end of the third summer 35–55 mm total length (*see* Jones and Hynes 1950, for further data). Sexual maturity is attained during the first year. Maximum size attained is about 3 inches (76 mm) in fresh water, but some specimens may grow to 4 inches (102 mm) in length. Lengths in excess of this are said to be attained by St. Lawrence Island fish. Studies of this species in Alaska revealed that the life span in Karluk and Bare lakes is about 2½ years, during which time they spawn once, and possibly twice.

In Newfoundland the threespine stickleback is found in most shallow waters, and is tolerant of marine, brackish, and fresh water. It is common in drainage areas of tidal marshes and has been found on some banks off Nova Scotia and the Maine coast, where they have been swept out to sea. Greenbank and Nelson (1958) reported evidence of large numbers along shoals and some on the surface in the centre of Karluk and Bare lakes, and even a few in deep water. In Hudson Bay this stickleback lived not only in the tidal pools, creeks, estuaries, or shore waters, but occurred as far as 1 mile from the mainland (Cox 1922).

The threespine stickleback is a voracious creature, feeding on various kinds of worms, small crustaceans, aquatic insects, and larvae, drowned aerial insects, and eggs and fry of fish, including their own species (Hynes 1950). They will eat essentially any available animal foods.

Despite its forbidding dorsal and pelvic spines, the threespine stickleback is preyed upon by a variety of creatures, such as fish-eating birds (e.g., American mergansers), as well as larger inshore fishes, such as salmon and trouts (British Columbia). The presence of lateral, armourlike plates, particularly on marine representatives, is thought to provide a measure of protection against predation.

The threespine stickleback seems prone to

parasitic infestations, some of which are intermediate stages of parasites that reach maturity in predatory ducks and other fish-eating birds. Wardle (1933) reported *Ligula intestinalis* and *Schistocephalus solidus* from this species. Bangham and Adams (1954) examined 35 specimens from three localities in British Columbia. They found parasites only in those from Lakelse Lake, 31 of the 32 fish examined being infected. Parasites included trematodes, copepods, nematodes, molluscs, acanthocephalans, and cestodes. Dechtiar (personal communication) reported infection in a specimen from Hawley Lake, Ont., (near Hudson Bay) as follows: infections in eyes by larvae of strigeid fluke *Diplostomulum* sp. (such an infection can result in blindness), and specimens of the pleurocercoid stage of the tapeworm *Schistocephalus solidus* in the body cavity. Hoffman (1967) listed many species of parasites in the threespine stickleback from waters of North America, England, Europe, and the USSR.

Relation to man The threespine stickleback is well known to behaviourists and psychologists, as well as fishery biologists, because of its wide use as a laboratory animal. Not only will this small fish build a nest and spawn in an aquarium but sexually mature males and females can be induced to perform their mating rituals by being presented with appropriately shaped dummies simulating the opposite sex.

Threespine sticklebacks may, when abundant, serve as an important forage species for trout and other predaceous fishes, and also for fish-eating birds.

Nomenclature

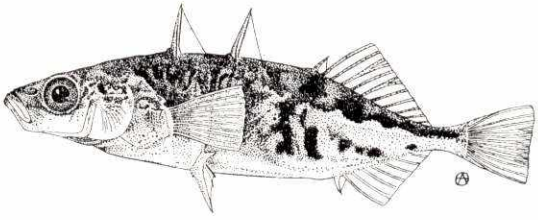
Gasterosteus aculeatus	— Linnaeus 1758: 295 (type locality Europe)
Gasterosteus aculeatus Fabricius	— Richardson 1836: 54
Gasterosteus biaculeatus (Pennant)	— Richardson 1836: 56
Gasterosteus serratus	— Lord 1866a: 127
Gasterosteus Atkinsii	— Bean 1880a: 67
Gasterosteus cataphractus Pallas	— Bean 1884b: 353
Gasterosteus microcephalus Girard	— Bean 1884b: 353
Gasterosteus bispinosus Walbaum	— Bean 1903b: 340
Gasterosteus cuvieri Girard	— Halkett 1913: 73
Gasterosteus atkinsii Bean	— Halkett 1913: 73
Gasterosteus insculptus Richardson	— Jordan, Evermann, and Clark 1930: 237
Gasterosteus atkinsi Bean	— Jordan, Evermann, and Clark 1930: 238

Etymology *Gasterosteus* — belly bone, referring to the bony ventral plate; *aculeatus* — spined.

Common names Threespine stickleback, twospine stickleback, banstickle, spantickle, saw-finned stickleback, pinfish, tiddler, common stickleback, European stickleback, eastern stickleback, New York stickleback. French common name: *épinoche à trois épines.*

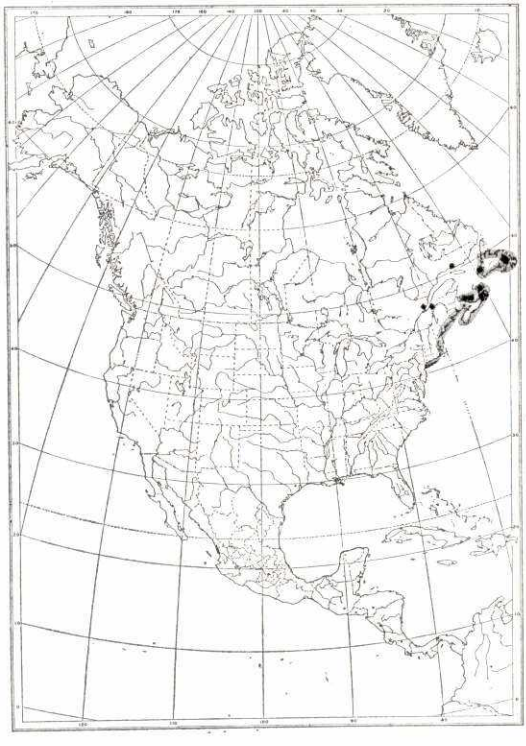
BLACKSPOTTED STICKLEBACK

Gasterosteus wheatlandi Putnam



Description Body rather stout, compressed, average length 2 inches (51 mm) long, body depth 20–25% of total length; caudal peduncle slender, without lateral keel. Head 22.2–28.6% of total length, compressed; eye diameter 28.6–33.3% of head length; mouth small, lower jaw projecting; teeth on jaws minute, sharp. Gill rakers 15, long, slender; gill membranes united to isthmus. Branchiostegal rays 3. Fins: dorsal of 3 isolated, and lightly serrated, spines, each with triangular membrane, first 2 spines long, second usually longest, 33.3–50.0% length of head, third very short and immediately in advance of, but not attached to soft rays of dorsal fin, soft rays 9 (occasionally 10 or 11), longest at origin of fin and about equal to length of second dorsal spine, origin of soft rays immediately over anus; caudal moderate, truncate, 12 rays; anal fin of 1 spine and 7 soft rays, the spine strongly curved, equal to or shorter than third dorsal spine, immediately preceding and joined to the soft rays, origin behind that of soft dorsal fin and terminating below end of soft dorsal rays; pelvic of 1 strong spine and 2 rays, the spine strongly serrated and with strong basal cusps on each side, these pointed cusps situated dorsally and ventrally at base of spine; pectorals large, 9 or 10 rays, over one-half length of head, inserted on sides a little behind gill opening. All spines can be locked in erect position. No scales; 6–11 vertical, bony plates, anteriorly on sides of body, none posteriorly; a single, ventral, bony plate on lower surface, between and behind pelvic fins, a lateral plate extending dorsally from anterior base of pelvic fins; lateral line high. Vertebrae 27–29.

Colour Adult fish are yellow, or greenish yellow, with dark spots on the sides; belly silvery. Colour is more conspicuous on spawning fish; ripe males have orange pelvic fins and become gold in colour.



Distribution The blackspotted stickleback, a North American species, occurs in marine coastal localities along the Atlantic coast from Newfoundland south to New York. It tolerates brackish water and in one instance was recorded from fresh water—from inside the mouth of the Jacquet River, Restigouche County, N.B.

In Canada it has been reported from various sites in Quebec, Anticosti Island, other localities in the Gulf of St. Lawrence, New Brunswick and in southern Newfoundland. A record from Rivière Gethsémanie, Que., on the north shore of the Gulf of St. Lawrence (a location 100 miles north of Port au Port, Nfld.) appears to be the northern limit of range. Although not specifically reported, it undoubtedly occurs in Nova Scotia and Prince Edward Island.

This species has frequently been confused with the threespine stickleback, *G. aculeatus*, with the result that distributional records are sometimes in doubt. It occurs sympatrically with *G. aculeatus*, whose range overlaps that of *G. wheatlandi*.

Biology Accounts of the biology of the blackspotted stickleback have long been confused with those of the threespine stickleback, *G. aculeatus*, and little was definitely known of its life history until quite recently. Breder and Rosen's (1966) account of the behaviour of this species refers to the above-mentioned threespine stickleback. However, McInerney (1969) presented a fine descriptive account of the breeding of *G. wheatlandi* and noted that although the reproductive biology closely parallels that of *G. aculeatus*, it differs in at least three significant ways, thus ensuring reproductive isolation: *wheatlandi* spawns in brackish water; males have a different colour pattern; and the leading–following reactions of males and females are different and apparently incompatible.

It is assumed that spawning takes place in late spring, slightly later than that of the threespine stickleback, whose habitat it shares. Both the blackspotted and the threespine sticklebacks were taken in spawning condition in collections made during the period May 5–June 9, 1961, when it was observed that the threespine stickleback was perhaps nearing the end of the spawning process, and the blackspotted stickleback just beginning to spawn (Perlmutter 1963). Scott and Crossman (1964) noted that in natural conditions in Newfoundland, brightly coloured, breeding females were found in brackish waters.

A nest is constructed as with the other gasterosteids. The courtship display is similar to that of the threespine and includes the zigzag motion described for that species. The male leads the female to the nest, places his snout in the entrance, retreats and allows the female to enter. He induces spawning by running his snout along the sides of the female, who deposits her ova and exits. Fertilization is quickly accomplished for the male releases the sperm as it swims through the nest. The female swims away and the male cares for the nest and aerates the eggs (fanning).

Results from a sample of 20 ripe females indicated that the number of eggs for each female ranged from 171 to 272, and the egg size varied from 1.2 to 1.5 mm in diameter. The possibility that some of the females were spawning at the time of capture and that some had not commenced to deposit eggs could account for the variation in the number of eggs per female noted by Scott and Crossman (1964).

Rate of growth of this species is relatively unknown, as is its life span. The mature female is larger than the male (Reisman 1968). The largest specimen collected in Newfoundland measured 2.5 inches (64 mm) total length. Maximum size reported for the Atlantic coast area is 3 inches (76 mm).

The blackspotted stickleback frequently leads a semipelagic existence, swimming near floating seaweed. Perlmutter (1963) notes that in the waters of Long Island, New York, this species was found in company with the threespine stickleback in 3 feet or less water, over a coarse, gravelly bottom.

Information on the food of this species appears to be rare or nonexistent; and neither is there reliable information regarding parasitic infections.

Relation to man The blackspotted stickleback could be used as a laboratory animal for experimental purposes as demonstrated by McInerney, but is less suitable for this purpose because of its restricted distribution and availability.

Nomenclature

Gasterosteus Wheatlandi	—Putnam 1866: 4 (type locality Nahant, Mass.)
Gasterosteus gladiunculus	— Kendall 1896: 623
Gasterosteus bispinosus cuvieri (Girard)	— Jordan and Evermann 1896–1900: 749
Gasterosteus biaculeatus Shaw	— Jordan and Evermann 1896–1900: 748
Gasterosteus bispinosus	— Cox 1923: 147
Gladiunculus wheatlandi (Putnam)	— Hubbs 1929: 2
Gasterosteus biaculeatus Penn., Sh. et Mitch.	— Hubbs 1929: 3 (as used by Cuvier and Valenciennes)
Gasterosteus bispinosus Walbaum	— Hubbs 1929: 5

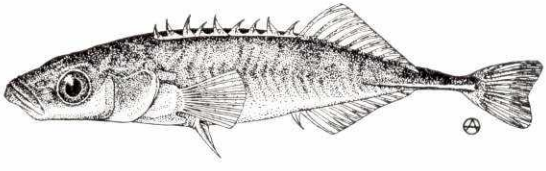
For a discussion of the nomenclature of this species, *see* Hubbs (1929).

Etymology *Gasterosteus* — belly bone, referring to the bony ventral plate; *wheatlandi* — after Dr R. H. Wheatland, who collected the first specimens at Nahant, Mass., in 1859.

Common names Blackspotted stickleback, twospined stickleback, twospine stickleback, blackspot stickleback. French common name: *épinoche tachetée.*

NINESPINE STICKLEBACK

Pungitius pungitius (Linnaeus)



Description Body small, slender, and compressed, length 2.5 inches (64 mm), greatest depth 15.4% of total length, tapering to a very slender caudal peduncle, which is broader than deep; caudal peduncle usually with a well-developed, lateral keel on each side, but keel may be poorly developed or absent. Head quite large, about 25% of total body length; eye large, its diameter 22.2–28.6% of head length; mouth small, oblique, with fleshy lips, lower jaw projecting; teeth slightly curved, sharp, in single

series. Gill membranes united but entirely free from isthmus. Branchiostegal rays 3. Fins: dorsal of 9 (8–11), short, isolated spines, directed backward, each with triangular fin membrane, spines usually 1.0–1.5 mm long, inclined alternately to left and right, nearly uniform in height, last spine slightly larger, spines begin above gill opening, and extend back to soft dorsal rays, depressible in shallow groove along back, soft rays 9–11, first rays twice height of spines, tapering off posteriorly; caudal rounded, 12 (rarely 13) soft rays; anal with 1 spine and 8–10 (rarely 11), soft rays, tapering off posteriorly like soft dorsal rays, located under soft dorsal rays, the spine slightly longer than dorsal spines; each pelvic fin reduced to single, strong spine, 25.0–33.3% of length of head, and usually 1 soft ray located under middle of pectorals; pectorals large, located on sides behind gill openings and extending to sixth dorsal spine. All spines can be locked in an erect position. No true scales; small, bony plates usually along anterior portion of lateral line and at bases of dorsal and anal fins and on caudal peduncle keels; a single, small, bony plate on ventral surface between and behind pelvic fins; lateral line inconspicuous. Vertebrae 32–34 (rarely 30, 31, or 35).

Colour Pale green, grey, or olive above, strongly pigmented with irregularly arranged dark bars or blotches; silvery below. During breeding season reddish tints appear, particularly about the head. Breeding males may have jet black belly and white pelvic fin membranes.

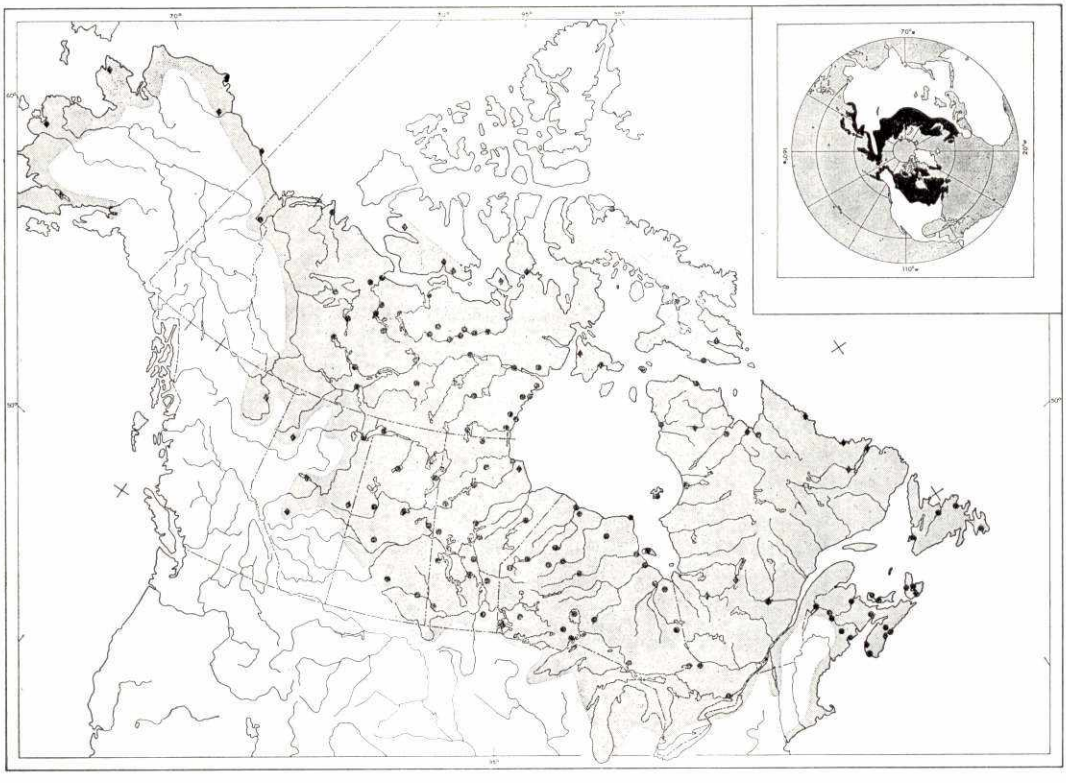
Systematic notes McPhail (1963), in an intensive study of the North American species, concluded that two distinguishable forms existed, a Bering Strait form, which occurs in coastal waters throughout arctic Canada south along the Atlantic coast, including the Maritime Provinces; the second is the Mississippi form which occurs throughout the inland fresh waters. He concluded that the degree of difference did not warrant subspecific distinction. In some localities in the Wood Buffalo National Park region, the pelvic skeleton is absent in a high proportion of the individuals (Nelson 1971b).

Distribution The ninespine stickleback is generally distributed in fresh and salt waters throughout the northern hemisphere. In marine situations it is usually confined to shore areas. It is found along the coasts of northern Europe, along the shores of the Baltic, and is also common in inland waters.

In North America, the ninespine stickleback ranges from the New Jersey Atlantic coast, north along the entire Atlantic and arctic coasts, westward to the Aleutian Islands of Alaska, and south on the Alaskan Pacific coast to the Kenai Peninsula side of Cook Bay, but not south on the Pacific coast. Inland it ranges from the southern Great Lakes basin, (and Crooked Lake, Indiana, in the Mississippi River drainage basin) north in central Canada to the arctic coast.

In Canada, it occurs in all provinces and territories. It is found more or less throughout each of the four Atlantic provinces, and is restricted to southern and western portions of inland Quebec but occurs in all coastal waters; throughout Ontario, Manitoba, most of Saskatchewan, and eastern and northern Alberta, northern British Columbia, north to the Arctic Ocean. It is often very abundant in salt water or brackish pools along the shores of Hudson and James bays.

Biology The ninespine stickleback spawns in fresh water in summer and is reported on occasion to spawn more than once in a season. No evidence, however, of autumn spawning has been found. Nelson (1968a) noted that it spawned only in fresh water although it has a relatively high salinity tolerance, but not as high as that of *Gasterosteus*. Both sexes are aggressive in breeding season. The male, all black in colour and less aggressive than the female when he begins his nest building, selects a site among the weeds and constructs a nest, usually off the bottom, in the plants, using fragments of aquatic vegetation bound together (gluing) by the threadlike, kidney secretion that hardens on contact with water,



as with other gasterosteids (McKenzie and Keenleyside 1970).

The nest is tunnel-shaped and has an opening at each end. When construction is completed, the male begins his courtship of the female, with a series of quick dancing movements. The female is enticed into the nest, pauses to deposit a cluster of eggs, numbering 20–30, and departs from the opposite exit. She is chased away by the male, who immediately enters the nest and fertilizes the eggs, swimming without stopping through the tunnel. The nest is guarded by the male who engages in considerable fanning at the entrance, causing a current to flow through the nest and aerate the eggs within.

As the young hatch, the male has been observed removing the egg cases from the nest (Morris 1958). As many as seven females may be encouraged to deposit eggs in one nest. While caring for the incubating young, the male may build a second nest. When the young fish are about 2 weeks old and about 15 mm long, the male can no longer control their wanderings and the small fish move into open water.

Jones and Hynes (1950), in their comprehensive study of the age (using otoliths) and growth of this species in two rivers in England, found that most mature in their first year. Growth is very rapid during the first year, slowing considerably in following years. Length of life is about $3\frac{1}{2}$ years. Maximum length of first-year fish has been recorded as 38–46 mm, second-year fish 45–48 mm, and third-year fish 48–55 mm.

In the Atlantic coast region the ninespine can grow to a size of 3 inches (76 mm), but is not usually over 2 inches (51 mm) long.

The ninespine stickleback may move freely into open water. During dragging operations in the Shelter Bay region of Lake Superior, Ont., a large number were taken at 38–42 fathoms (few at other depths). Although this species can survive in waters

of relatively high salinity, in Newfoundland, where it is widespread, it was found only in fresh water. In coastal regions it is usually an estuarine species, moving into creeks and streams to spawn.

The food of this small, pugnacious species consists of aquatic insects and small crustaceans. Hynes (1950) study of the food of this species in England revealed that the diet is similar to that of *Gasterosteus aculeatus*, consisting of crustaceans and aquatic insects, and, during breeding season only, eggs and larvae of their own species. In fresh water, small fish fry and fish eggs are eaten.

Bangham (1955) recorded the acanthocephalan *Neoechinorhynchus rutili* in the one specimen he examined from South Bay on Lake Huron. Cooper (1918) recorded *Schistocephalus solidus* from specimens caught in Bernard Harbour, N.W.T. Hoffman (1967) listed many species of parasites from the species, mainly records from Russia and Europe.

Relation to man When in abundance the ninespine stickleback is of considerable importance, forming a large part of the diet of other fishes. The reports by Dryer (1966) of large numbers in Lake Superior, suggested that it may be a more important forage species than had previously been supposed. Dymond (1926) noted that "In Lake Nipigon it is one of the most abundant of the smaller fishes, and appears to form no inconsiderable part of the food of the pike perch." He also noted that it was eaten by brook trout, lake trout, yellow perch, and ling or burbot. Ninespine sticklebacks (and ciscoes) were the main food items in the diet of walleyes in Lac la Ronge, Saskatchewan (Rawson 1957).

It may occur in great abundance in sloughs and shallow shore waters of northern Canada. Richardson (1836) noted that "in 1820 many sledge loads were taken from a small pond in the vicinity of Cumberland House for the purpose of feeding the dogs."

Nomenclature

Gasterosteus pungitius	— Linnaeus 1758: 296 (type locality Europe)
Gasterosteus concinnus (Richardson)	— Richardson 1836: 57
Gasterosteus occidentalis (Cuvier)	— Richardson 1836: 58
Gasterosteus occidentalis Brevort	— Adams 1873: 255
Pygosteus Dekayii Brevort	— Adams 1873: 305
Gasterosteus pungitius L.	— Cox 1896b: 68
Gasterosteus dekayi Agassiz	— Jordan and Evermann 1896–1900: 746
Pygosteus pungitius (Linnaeus)	— Bean 1903b: 338
Gasterosteus nebulosus Agassiz	— Bean 1903b: 338
Pygosteus pungitius Eigenmann	— Bean 1903b: 338
Gasterosteus occidentalis (Cuvier and Valenciennes)	— Jordan, Evermann, and Clark 1930: 239
Pungitius pungitius (Linnaeus)	— Jordan, Evermann, and Clark 1930: 239

Etymology *Pungitius* — meaning pricking.

Common names Ninespine stickleback, nine-spined stickleback, stickleback, ten-spine stickleback, pinfish, tiny burnstickle. French common name: *épinoche à neuf épines*.

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THE TROUT-PERCHES — Order Percopsiformes (Salmopercae, Amblyopsiformes)

These are small, robust-bodied fishes with relatively large heads, weak to moderately strong jaws and small teeth. The upper jaw is bordered by the premaxillaries. Branchiostegal rays 6 or 7. The dorsal and anal fins are preceded by 0–4 spines that, when present, may be quite soft; caudal fin supported by a somewhat peculiar hypural structure consisting only of 3 hypurals and in which the last 2 vertebral units are fused and slightly upturned; pelvic fins with or without a small spine and with 7 or 8 soft rays, abdominal to subabdominal in position, the pelvic bones attached to the postcleithra (when present). Physoclists.

The percopsiform fishes constitute a small group of North American freshwater fishes currently considered to embrace 3 genera and 5 species, grouped into 3 families: Amblyopsidae, Aphredoderidae, and Percopsidae. Only 1 family, Percopsidae, occurs in Canadian waters.

North American Distribution of the Trout-perches

TROUT-PERCH FAMILY — Percopsidae

The trout-perches, so-called because they possess characteristics exhibited by both the salmons and the perches, have large heads; subterminal lower jaws; premaxillaries nonprotractile, forming border of upper jaw; dorsal and anal fins each preceded by 1 or 2 spines; an

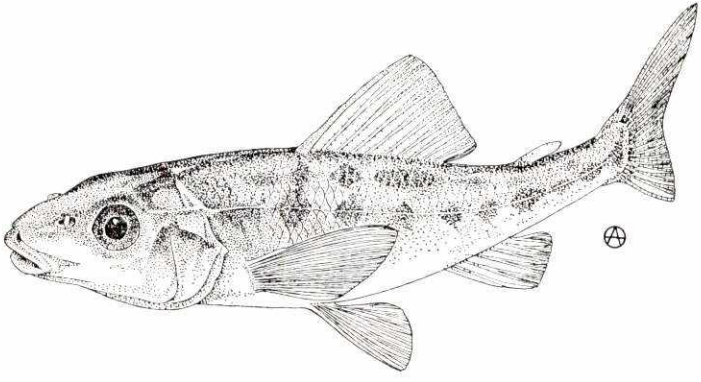
adipose dorsal fin inserted posteriorly, over caudal peduncle; pelvic fins each with a weak spine and 7 or 8 soft rays, the anterior portion of the pelvic fin overlapped by pectoral fin. Scales are small, and weakly ctenoid.

These are small, dark-spotted, silvery fishes, essentially bottom feeders, living in streams and lakes of temperate and northern North America. The family contains only 1 genus, *Percopsis*, and 2 species, *P. transmontanus (Columbia transmontanus* is a synonym) and *P. omiscomaycus*. Only the latter species occurs in Canadian waters.

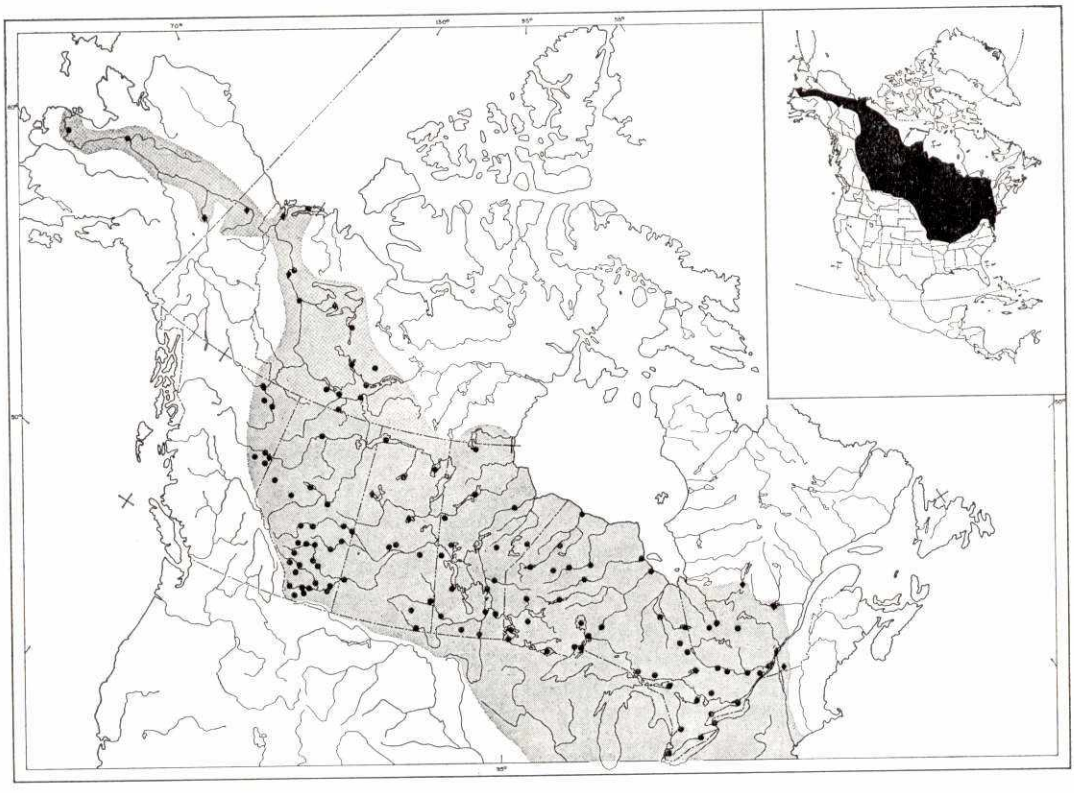
Known in North America from Eocene to Recent.

TROUT-PERCH

Percopsis omiscomaycus (Walbaum)



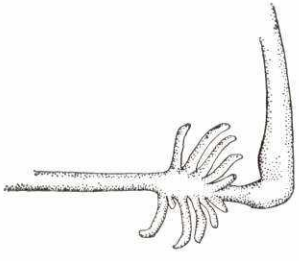
Description Body small, average length 3–4 inches (76–102 mm), terete, distinctly thicker anteriorly. Head relatively large and somewhat conical, 22.5–26.6% of total length; eye relatively large, its diameter 22.1–27.2% of head length; snout long, 29.6–38.0% of head length, and overhanging small mouth; interorbital wide, 17.5–28.9% of head length; mouth ventral, adapted for bottom feeding, the gape terminating well in advance of eye; teeth brushlike, in bands on upper and lower jaws only, band several teeth wide anteriorly, outer teeth larger and more widely spaced than inner teeth, longest tooth about 0.4 mm. Gill rakers short, mere mounds of tissue with embedded teeth, 2–4 on upper arm, 6–9 on lower arm. Branchiostegal rays 5,5 (1 specimen), 6,6 (18 specimens), but McAllister (1968) examined 50 specimens and reported 6(48), 7(2). Fins: small adipose dorsal present; dorsal 1, height 16.8–20.8% of total length, originating behind origin of pelvic fins, rays 2 undivided (soft spines), and 9(2), 10(26), or 11(21) soft rays; caudal distinctly forked, principal rays 17(1) or 18(18); anal 1, its base moderate, height less than dorsal, 1 undivided ray and 5(1), 6(18), 7(8), or 8(1) divided, soft rays; pelvics thoracic, inserted behind dorsal origin, and broadly overlapped by pectorals, rays 8(5) or 9(25); pectorals well developed, length 15.9–19.7% of total length, rays 12(3), 13(8), 14(18), or 15(1). Scales weakly ctenoid, with a single row of ctenii,



43–60 (usually 44–50) in lateral line. Pyloric caeca 10–14. Vertebrae 33 or 34.

Colour Overall colouration silvery, often appearing to be partially transparent; 5 distinct rows of black spots overlay the background colour, the first row of some 9–12 vague or diffuse marks occur along the midline of the back, these sometimes diffuse into each other; a row of 7–12 spots, sometimes only weakly developed, also occur high on the side, between the lateral midline and the back, and finally, the most conspicuous row of 10 or 11 marks along the midline of the side.

Systematic notes The trout-perch is unique among Canadian freshwater fishes in the number and arrangement of the pyloric caeca. These vary from 10–14 and are arranged along the gut as shown in the accompanying figure.



The number of caeca appears to be very stable. Studies of specimens from lakes Erie, Superior, Attawapiskat, Ont., and Heming, Man., revealed no differences between sexes, sizes, or localities. The pyloric caeca can be useful in identifying trout-perch remains in stomach contents since, being resistant to digestive enzymes, they are resistant to the digestive system of their predator and are recognizable after most other ingested tissues are in an advanced state of digestion.

Distribution The trout-perch is widely distributed in lakes and streams throughout

central and northern North America. It ranges from Quebec, north and west to Alaska. In the United States, it ranges northwest from West Virginia, Kentucky, Missouri, and Kansas on the south, but is generally not common south of the Great Lakes.

In Canada it occurs from central and western Quebec, through Ontario, in all of the Great Lakes, in Manitoba, Saskatchewan, Alberta, and northeastern British Columbia to the Yukon and Northwest territories. In Alaska it occurs only in the Porcupine River and the Yukon River, and from about Eagle to the mouth of the Andreafsky River, but not in the upper Yukon River system in Yukon Territory.

The trout-perch is thought to have repopulated North America in postglacial times from a refugium in the Mississippi valley.

Biology Trout-perch usually spawn in the early spring, most often in May in inland waters, although few precise observations have been reported. Magnuson and Smith (1963) noted that first spawning runs occurred in Red Lake, Minn., after mean air temperature remained above 50° F (10° C) for 44–46 days. Lawler (1954) provided observations of fish aggregating in shallow rocky streams in north-central Manitoba and we have captured ripe fish in May in the lower reaches of streams in Ontario. But spawning has also been reported to occur over a sand and gravel bottom in the shallow (0–4 feet) shore waters of Lake Erie and Red Lake, Minn. The lake-spawning populations seem unique in that spawning was prolonged and in Lake Erie, in 1946, was observed to extend from May to August. Ripe males and females were caught as early as May 9, and partly spent males and females were caught on August 15, 1946. In Red Lake, spawning was considered to have extended from June 5 to August 23 in 1956 and 1957, and the peak of the run occurred from June 25 to July 4, 1956 (Magnuson and Smith 1963). In our opinion most eastern Canadian populations spawn in streams in May and return to the lakes after spawning. We noted that at Beaverlodge Lake, east of Great Bear Lake, in the Northwest Territories, specimens of trout-perch taken on June 24–29 were sexually mature but had not spawned. The specimens were smaller than those found in southern Canada.

The eggs are relatively large for such a small species. Fish (1932) gave egg diameters of 1.36–1.85 mm for Lake Erie specimens and noted that unfertilized eggs contained numerous oil globules but that fertilized eggs usually contained only a single, consolidated, oil globule of about 0.7 mm diameter. Lawler (1954) gave egg diameters of 1.25–1.45 mm for Manitoba specimens. He also reported that egg numbers for 11 fish varied from 240 to 728 eggs, with an average of 349 eggs per individual. There is little information on the rate of development, although Langlois (1954) noted that eggs hatched within 20 days. Fish (1932) figured and described four stages in the development of larval *Percopsis* from 6.0–35.5 mm long.

Kinney (1950) suggested that males and females can be sexed externally, using the diameters of, and the distances separating, the anal and urinogenital apertures, but we have been unable to employ successfully this character, particularly with ripe or spawning trout-perch.

The growth characteristics of trout-perch have not been well studied, except by Magnuson and Smith, who successfully used scales for calculating growth, although Kinney (1950) was unable to age trout-perch using scales. No one seems to have published on the use of otoliths for aging trout-perch, although the otolith is large and would seem to offer promise for this purpose but Lawler (personal communication) used otoliths and considered them not useful for age determinations. He also obtained satisfactory results using scales. Kinney used arithmetic probability paper to age Lake Erie specimens and concluded that spawning occurred at age 1, that large females and most males die after spawning, but that a few females and very few males live to spawn twice. Magnuson and Smith have shown that females are larger than males at all ages and live longer than males. Males live to age 3, females to age 4.

Magnuson and Smith provided data on total lengths (in mm) at each age group of 1 to 4, for both sexes. The following figures were derived from their data: age 1 (M=50.8, F=51.4); age 2 (M=88.2, F=92.2); age 3 (M=103.5, F=108.3); age 4 (F=114.7).

The largest specimens known to us occur in Lake Ontario where total lengths to 6 inches (152 mm) are attained.

In Ontario and Quebec the trout-perch is found mainly in lakes, resorting to streams only to spawn (with exceptions already noted). Under these conditions the species is seldom seen, for it appears to stay in deeper water during the day, moving into shallow shore waters after dark. It is seldom caught during lake surveys, except by night seining, although it can be caught by otter trawls in daytime. Density figures or population estimates in Heming Lake, Man., were given by Lawler and Fitz-Earle (1968), who obtained estimates of numbers of trout-perch of 711,451 and 883,148, or 1186–1472 per acre.

Although typically a lake species in the east, it occurs in shallow, sometimes turbid, streams in Manitoba, Saskatchewan, and possibly in Alberta and the Northwest and Yukon territories.

We know little about the food of the trout-perch since few studies have been undertaken. We assume that the characteristic inshore movement after dark is for purposes of getting food. Those studies that have been undertaken, primarily by Kinney in Lake Erie, indicate that insect larvae, especially of midges (Chironomidae), and of mayflies (Ephemeroptera), were prominent in the diet during July, although in January and February large trout-perch had eaten darters and minnows. In Lake Nipigon, Dymond (1926) noted that insect larvae and amphipods were the chief food items in stomachs.

Trout-perch should be regarded as a most important forage fish. Yellow walleye, northern pike, burbot, lake trout, brook trout, sauger, yellow perch, and even freshwater drum have been reported to eat them. Possibly the first four are the more important natural predators. Magnuson and Smith regarded the yellow walleye as the most important predator in their studies at Red Lake, Minn., and northern pike was the most important predator (63 trout-perch in a single stomach) in the study at Heming Lake, Man., reported by Lawler (1954).

Trout-perch harbour a wide variety of parasites, including trematodes, cestodes, nematodes, acanthocephalans, and crustaceans, which were listed in detail by Bangham and Hunter (1939), Bangham (1955), and Hoffman (1967). Bangham and Hunter's observations were made on Lake Erie populations and they remarked that the trout-perch was the natural host of a relatively large number of parasites and many specimens had moderately heavy infestations.

The trout-perch is also the most important second intermediate host of the cestode parasite *Triaenophorus stizostedionis* (*see* Miller 1945). The eggs of the adult tapeworm are shed into the water, hatch and become coracidia, and are eaten by the copepod *Cyclops bicuspidatus* to become procercoids within the copepod. If the copepod is ingested by a trout-perch, the parasite encysts in the visceral and parietal peritoneum and is then known as a pleurocercoid. The life cycle is completed when the infected trout-perch is consumed by a yellow walleye.

Mortalities or die-offs of trout-perch are occasionally reported after spawning. One such mortality was observed in late May, 1960, in Lake Mindemoya, Manitoulin Island, Ont. The mortality was considered to have been caused by a protozoan infection *Myxoboliosis* (A. M. McCombie, personal communication).

Relation to man The trout-perch is probably of little direct importance except when used occasionally as bait but it is of very great importance as a forage fish for a wide range of predator species. Since it moves into shallows of lakes to feed in evening, and back into deeper water at the approach of dawn, it probably serves an important role as a nutrient transporter as noted by McPhail and Lindsey (1970).

The facts that it has large eggs and that

lake populations have a prolonged spawning period, suggest that it might be a useful laboratory species where eggs are required, and indeed it has been used in a limited way for such studies.

Nomenclature

Salmo Omisco Maycus	— Walbaum 1792: 65 (type locality Hudson Bay)
Percopsis guttatus	— Agassiz 1850: 286
Salmoperca pellucida	— Thompson 1853: 33
Percopsis omiscomaycus (Walbaum)	— Kendall 1911: 51
Percopsis omisco-maycus Walbaum	— Hubbs 1926: 54

Etymology *Percopsis* — perch like; *omiscomaycus* — probably an Algonkian Indian name that includes the root "trout" (McPhail and Lindsey).

Common names Trout-perch, silver chub, troutperch. French common name: *omisco*.

Suggested Reading — Percopsidae

KINNEY, E. C. MS 1950. The life-history of the trout perch, *Percopsis omiscomaycus* (Walbaum), in western Lake Erie. M.Sc. Thesis. Ohio State Univ., Columbus, Ohio. 75 p.

LAWLER, G. H. 1954. Observations on the trout-perch *Percopsis omiscomaycus* (Walbaum), at Heming Lake, Manitoba. J. Fish. Res. Bd. Canada 11: 1–4.

MAGNUSON, J. L., and L. L. SMITH. 1963. Some phases of the life history of the trout-perch. Ecology 44: 83–95.

THE PERCH-LIKE FISHES — Order Perciformes (Percomorphi)

Spiny-rayed fishes of exceedingly variable size and shape, many conspicuously compressed laterally; the body shapes of perches, sunfishes, and mackerels are characteristic. Skull elongate, strongly ossified; jaws strong, usually with well-developed teeth; upper jaw bordered by premaxillae; post-temporal usually forked, articulating with skull; orbitosphenoid and hypocoracoid absent. Gill rakers usually stubby and toothed. Branchiostegal rays 4–7. Fins with pungent spines; dorsal fins usually 2, first dorsal spiny, second dorsal soft rayed; caudal with 17 principal rays (15 branched) or fewer; soft-rayed anal preceded by 2 or 3 spines; pelvics, when present, thoracic or jugular, of 1 spine and 5 or fewer soft rays; the pelvic girdle usually attached to cleithra; pectoral fin position elevated on side, the base more or less vertically oriented. Scales ctenoid, sometimes cycloid, or variously modified. Physoclists. Vertebrae typically 24.

The perciforms are widely distributed in tropical and subtropical waters, and less abundantly in temperate seas throughout the world; they have also successfully invaded fresh waters of all continents except Australia. This is the largest order of fishes, containing at least 135 families and over 6000 species; represented in Canadian fresh waters by 4 families and 28 species. Upper Cretaceous to Recent.

Temperate Bass Family — Percichthyidae

These are laterally compressed, deep-bodied, percoid fishes, with the skull somewhat elevated and strongly ossified and with lateral canals of head at least partially enclosed in bone; jaws well developed, armed with numerous teeth; maxillary expanded posteriorly. Branchiostegal rays 7. Spiny and soft-rayed dorsal fins usually distinct or only slightly joined at base. Pelvic fins thoracic, of 1 spine and 5 soft rays, no axillary process, or scaly process, in axil of pelvic fin. Scales ctenoid; lateral line well developed and complete. Vertebrae 24 or more.

The fishes included in this family were formerly considered to form a part of the family Serranidae, a large and poorly defined group of fishes referred to as the sea basses. Gosline (1966) attempted to provide a more rational grouping for the serranids and proposed expansion of the family Percichthyidae to include the genus *Morone (=Roccus).* Three species occur in Canadian fresh waters.

1 Dorsal fins slightly joined at base by membrane; soft anal rays 8–10, usually 9; anal spines stout, not graduated in length, second and third spines subequal; no teeth on base of tongue; no lateral stripes. ..... WHITE PERCH, *Morone americana* (p. 684)

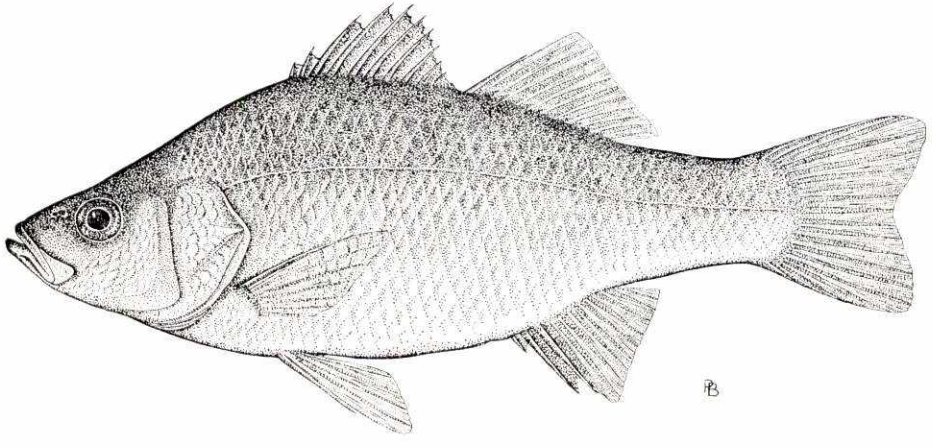
Dorsal fins entirely separated at base; soft anal rays 9–13; anal spines graduated in length, fine teeth at base of tongue; 4–7 lateral stripes 2

2 Soft anal rays 12 or 13; anal spines slender, the longest spine equal to or greater than one-half height of fin. .... WHITE BASS, *Morone chrysops* (p. 689)

Soft anal rays 9–11; anal spines more slender, longest spine less than one-half height of fin. ..... STRIPED BASS, *Morone saxatilis* (p. 693)

WHITE PERCH

Morone americana (Gmelin)



Description Body deep, usually 5–7 inches (127–178 mm) long, compressed laterally, sloping steeply from eye to dorsal origin, distinctly heaviest anteriorly, deepest near origin of spinous dorsal fin, its depth 24.4–29.0% of total length. Head large, triangular, its length 26.3–29.7% of total length; eye diameter 18.9–28.6% of head length; snout moderate, 28.6–30.9% of head length; interorbital 24.5–27.9% of head length; mouth moderately large, gape extending to below eye, jaws about equal; teeth

in jaws and vomer small, sharp, and numerous; no teeth on base of tongue but a band of small teeth around distal periphery of tongue. Gill rakers 19–22. Branchiostegal rays 7. Fins: dorsals 2, combined base of both fins long, 32.4–37.5% of total length, first dorsal spiny, 9 spines, weakly joined to anterior part of second dorsal by membrane, second dorsal of 1 spine and 11 or 12 branched rays; caudal weakly forked, rays 17 (15 branched); anal of 3 spines and 8–10 branched rays, usually 9; pelvics thoracic, 1 spine and 5 branched rays; pectorals somewhat rounded, rays 15. Scales large, ctenoid, 46–51 in lateral line, on opercles, cheeks, and interorbital. Vertebrae 24.

Colour The colour of the white perch is variable, from olivaceous, dark greyish green, dark silvery grey, or dark brown to almost black on the dorsal surface, becoming paler olive or silvery green on the sides, and silvery white on the belly. In fresh water the colour is quite dark and less silvery. There is a bluish lustre on the head and lower jaw of spawning adults. The fins are generally dusky, the pectoral fin lightest. Pelvic and anal fins occasionally have a rosy tint.

Systematic notes The current name is employed because of the revision of this group by Whitehead and Wheeler (1967) who selected the generic name *Morone*.

Distribution The white perch is distributed, usually in brackish waters, along the Atlantic coast of North America from the upper St. Lawrence River and southern Gulf of St. Lawrence to South Carolina. It is abundant in the Chesapeake Bay region. In fresh water it inhabits ponds and lakes close to the sea, especially in the northern part of its range. It is a common species in the Hudson River below Albany, and in many lakes in the lower Hudson River drainage. Larsen (1954) reported the capture of 3 specimens in the Pennsylvania waters of Lake Erie but no further captures in Lake Erie have been reported.

In Canada the white perch is found in Prince Edward Island, Nova Scotia, and

New Brunswick (rare in Gulf of St. Lawrence region), and recently was reported from the vicinity of Quebec City and Montreal in the St. Lawrence River (Vladykov 1952). It is a relative newcomer to Ontario, is now resident throughout Lake Ontario, and is the dominant species in the Bay of Quinte region. Populations are also present in the lower Niagara River and in the Welland Canal.

In their discussion of the invasion of the lower Great Lakes by the white perch, Scott and Christie (1963) stated that "available evidence suggests that the white perch gained access to Lake Ontario via the Oswego River, as a result of movement by the Hudson River populations northward and westward through the Mohawk River Valley and Erie Barge Canal," and they suggested it is inevitable that this species will become established in Lake Erie.

Biology The white perch spawns in the spring. Studies of Bay of Quinte, Lake Ontario populations by Sheri and Power

(1968) indicated that spawning commences about mid-May and may extend to the end of June. During this period water temperatures are in the range of 51.8°–59.0° F (11°–15° C). Details such as site selected, dates, and time of day, etc., of spawning seem not to have been recorded for white perch populations in the Maritime Provinces nor in Quebec. This is particularly true of anadromous populations. However, collections by the authors in North Lake of the Upper St. Croix River watershed in New Brunswick, indicate that a large number of adults were spawning in shallow (0–12 feet, 0–3.7 m) water, May 25–27, 1958. In nearby Maine spawning is said to occur mainly in June but may extend from May 27 to July 22 (Foster 1918) at temperatures around 59°–60° F (15.0°–15.6° C). No information is available on the time of spawning of anadromous populations in Canadian waters, but in the Chesapeake Bay region spawning occurs in April and early May.

For most populations reported in the literature, spawning is prolonged and continues for 1–2 weeks and does not take place all at once. Foster (1918) and Mansueti (1961) noted that only a portion of the total number of eggs in the ovaries of an individual are released at one time, and suggested that the eggs ripen progressively and may be released during two or three separate spawning acts. Foster estimated that only 10% of the eggs of spawners were ripe at the height of the season.

Spawning takes place in shallow water and is said to occur over any and every bottom type with little evidence of preference. Large numbers of adult fish mill about in shallow water, the females and males seeming to release their eggs and sperm, more or less randomly. The eggs are rather small, 0.79 mm in diameter before fertilization and 0.92 mm after fertilization. A. N. Sheri (unpublished information) obtained a range of 0.55–0.70 mm for egg diameters of eggs removed from ovaries of white perch caught in Bay of Quinte. The eggs are adhesive and become attached to vegetation, rocks, and other bottom objects. The total number of eggs have been shown to vary from 20,000 to over 300,000 depending, in part at least, on the size of the female; this is a large number of eggs for such a relatively small fish. Many texts describing U.S. populations quote figures of 50,000–150,000 eggs per female, some as high as 321,000, but Sheri and Power (1968), in a study of 50 specimens of the rather recently established Lake Ontario (Bay of Quinte) populations, provide the only known figures for Canadian waters. Number of eggs for various size groups of females, using data selected from Sheri and Power (1968), are as follows:

No. fish	FL (*mm*)	No. of Eggs	
		Range	Mean
4	151–160	15,740–26,770	21,180
14	171–180	18,598–61,488	36,687
3	201–210	91,448–98,556	95,752
2	241–250	221,003–247,681	234,342

These authors noted that they sampled the population before spawning ("the fish were about to spawn when collected, . . ." p. 2225) and hence possibly avoided the problems in variation involved in sampling specimens that had already released some of their total complement of eggs, although they did remark on the wide variation in egg number in fish of similar size and age. Fecundity of white perch is of considerable interest because of the proven ability of this species to dominate quickly a favourable habitat despite the presence of other established species, as was demonstrated in Lake Ontario. However, because of the propensity to increase in number rapidly, white perch tend to become over-populated and large populations of stunted or dwarfed individuals result.

The small eggs hatch in 4–4½ days at the expected spawning temperature of 59° F (15° C) but at higher temperatures hatching time is decreased and eggs will hatch in about 30 hours at 68° F (20° C). Thoits (1958) noted that the embryology of the white perch has not received attention and this situation has apparently not changed. He noted that young white perch are 2.3 mm long on hatching and grow rapidly, reaching 1.5–2.5 inches (40–65 mm) in length by July and August.

Growth rates of white perch vary widely depending on the region and also on the state of the population under study. Old landlocked populations in small oligotrophic lakes in the Atlantic coastal region will possibly have a slower rate of growth than newly expanding populations, such as those in Lake Ontario.

The annulus of Lake Ontario (Bay of Quinte) white perch is formed rather late in the year, usually in July, according to Sheri and Power (1969a). Mansueti (1960) demonstrated that the most satisfactory place on the body to take scale samples is the area under the posterior two-thirds of the base of the dorsal fin, above and below the lateral line.

Comparative growth rates of white perch are presented in the following table. In general, females average slightly larger than males after the second year and the percentage of females to males tends to increase with age, suggesting that males have a higher mortality rate than females.

The average life span for most populations seems to be 5–7 years. The oldest white perch reported was 17 years old, caught in Maine (Cooper 1941), and Raney (1965) mentioned a New York specimen that was 15 years old. Large-sized white perch are not well recorded in Canada since the white perch is only a marginal sport fish. However, Mr W. J. Christie informed us that the largest fish caught in Bay of Quinte waters was a female, 12 years old, caught in the fall of 1969; it was 13.2 inches (335 mm) long and weighed 1.72 pounds (780 g). Raney (1965) stated the maximum size in estuaries and large rivers approached 6 pounds but provided no evidence. For U.S. waters Thoits (1958) noted that fish up to 3 pounds have been caught in Quabbin Reservoir, Massachusetts, and Carlander (1953) listed a 4.75-pound fish, 19 inches long, caught in Maine.

White perch thrive in a variety of habitats but seem to be more successful in waters that reach 75.2° F (24° C) or more in summer. Although good production is achieved by anadromous populations along the Atlantic seaboard of the northern United States, particularly in the Chesapeake Bay region, sea-run populations in the Maritime Provinces are not common and consist of small fish where they do occur. There are virtually no anadromous stocks in the Bay of Fundy, possibly because of the low temperatures. However, in the La Have River, N.S., a seaward migration in summer has been reported by provincial fishery survey workers.

White perch have generally been observed to move onshore at night and offshore into deeper water at dawn.

A vertical diel movement of migration was tested by Sheri and Power (1969b) who demonstrated a movement toward the surface at night and withdrawal to deeper water during daylight hours. At times very dense schools may be formed. This movement is apparently associated, in part at least, with feeding.

The white perch is a well-adapted predaceous species. Young white perch consume microplankton; as they grow larger, aquatic insect larvae become a significant part of the diet, whereas large white perch

	L. Jesse, N.S. (Smith 1939)		L. Ontario (Sheri 1968)	Oneida L., N.Y. (Alsop and Forney 1962)	
Age	Observed FL	Observed Wt	Calculated FL	Calculated TL	
	(*mm*)	(*oz*)	(*mm*)	(*inches*)	(*mm*)
1	9.1	9.1	7.9	3.49	8.9
2	11.0	17.2	12.6	7.46	19.0
3	12.7	25.1	16.2	8.86	22.6
4	13.8	32.7	18.6	9.59	24.4
5	15.5	47.1	20.6	10.12	25.7
6	–	–	22.1	10.58	26.9
7	–	–	23.9	12.10	30.7
8	–	–	25.9	–	–
9	–	–	27.3	–	–

consume a high percentage of fishes including young of their own species.

A study of the summer food and feeding habits of the Lake Ontario (Bay of Quinte) populations was carried out by Leach (1962) in 1959, 1960, and 1961. His studies indicated that there were two peak feeding periods daily — noon, and about midnight, the latter being the more important — but there were indications that sporadic feeding sometimes took place in the intervals. The importance of evening feeding was also noted by Webster (1943) for a Connecticut population, but the time was earlier — up to 8:30 PM.

The principal foods consumed in the Bay of Quinte were insect larvae and fishes whereas invertebrates such as crustaceans, molluscs, and oligochaetes made up less than 10%. Dipterous larvae, especially chironomids, were significantly more important than any other insect types, and the fishes consumed were yellow perch, white perch, and johnny darters. Fish became an increasingly important food item of larger white perch, constituting about 35% of the diet of 7-inch (178-mm) fish, and 70% of the diet of 8.5–10-inch (216–254-mm) ones. In a study of food of white perch in relation to supply in Tedford Lake, N.S., Smith (1947) stated that pelagic and bottom-haunting microcrustaceans were found in white perch up to 5.9 inches (150 mm), the pelagic species eaten "to the greatest extent by the smaller fish, the latter in increasing numbers as the size of the fish increased to 15.0 cm," and he stated further that above this size microcrustaceans were not eaten. Smith found that only white perch over 4 inches (110 mm) had eaten other fishes of small size (killifish, yellow perch, and occasionally a stickleback). A detailed list of the organisms eaten is presented by Smith. In a study of Maine white perch, Cooper (1941) also emphasized the importance of insect larvae and noted that smelt, yellow perch, and white perch were the fishes most often consumed.

The diet of salt water populations appears to have received scant attention, although Goode (1903) wrote the following in reference to U.S. populations: "They feed greedily on the spawn of other fish, particularly that of the shad; on insects, crabs, minnows and on the migratory schools of young eels ...."

Studies involving food of game fishes in Maine waters (Cooper 1941) indicated that young white perch provide forage for predator species; but Thoits (1958) noted that data in the files of the Massachusetts Division of Fisheries and Game revealed little evidence of use there by game fish such as smallmouth and largemouth bass, or chain pickerel. Leach (1962) stated that in the Bay of Quinte region of Lake Ontario, white perch were seldom preyed upon by other species (except white perch).

Thoits (1958) concurred with other workers that the white perch is only lightly affected by parasites. However lightly infected they may be, the list of known parasites is long for Maine, Massachusetts, and Connecticut specimens and includes leeches, copepods, glochidia (of molluscs), acanthocephalans, trematodes, cestodes, and nematodes (*see* Thoits for further details).

Studies on white perch in the Bay of Quinte region reveal that this species is not heavily infested by parasites or disease organisms (Dechtiar, personal communication).

Hoffman (1967) also listed parasites infecting this species in North American waters.

Relation to man The white perch is a good food fish and the white flaky flesh is highly regarded, especially in the eastern United States. Canadian white perch are equally delicious as we can personally attest, but unfortunately they seldom attain a size in Canadian waters large enough to attract anglers.

Along the U.S. Atlantic coast it is relatively abundant and is fished commercially, especially in the Chesapeake Bay region.

Because of the abundance of this species in certain areas, particularly in the Bay of Quinte region of Lake Ontario, the competition with game fishes for food could be a serious problem. Although the white perch is

an excellent pan fish, there is no established fishery in Canada except in the Bay of Quinte and, since the species is not often exploited as a game fish, the result is that the populations continue to increase. Where over-population in fresh water occurs, the species tends to become stunted and, is undesirable, largely because of its adverse effect on more desirable species by competition, if not direct predation.

Nomenclature

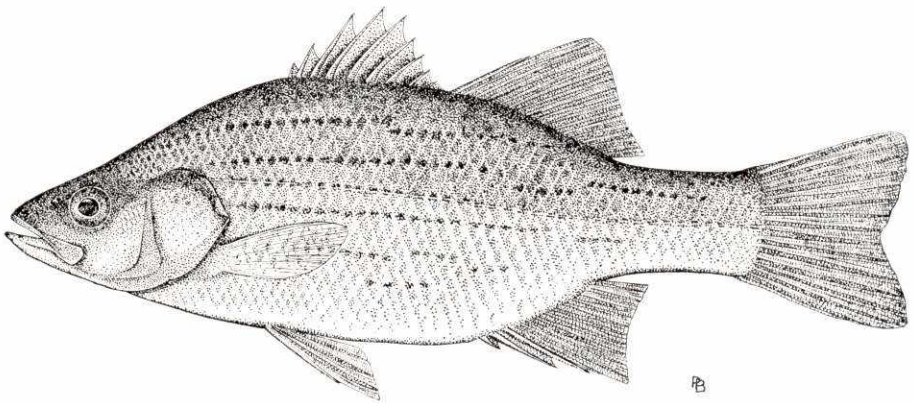
Perca americana	— Gmelin 1788: 1308 (type locality New York)
Labrax pallidus	— Perley 1852: 182
Morone Americana Gill	— Adams 1873: 304
Roccus americanus	— Jordan and Gilbert 1883a: 530
Morone	— Whitehead and Wheeler 1967: 23

Etymology *Morone* — (etymology unknown); *americana* — American.

Common names White perch, narrow-mouthed bass, silver perch, perch, bass, sea perch, gatte, "little white basse." French common name: *bar-perche*.

WHITE BASS

Morone chrysops (Rafinesque)



Description Body robust, usually 10–12 inches (254–305 mm) in total length, deep, compressed laterally, greatest depth mid-dorsally rather than at dorsal origin as for *M. americana*, body depth 24.8–26.8% of total length. Head triangular, smaller than in *M. americana*, its length 24.5—27.3% of total length; eye diameter 21.4—26.5% of

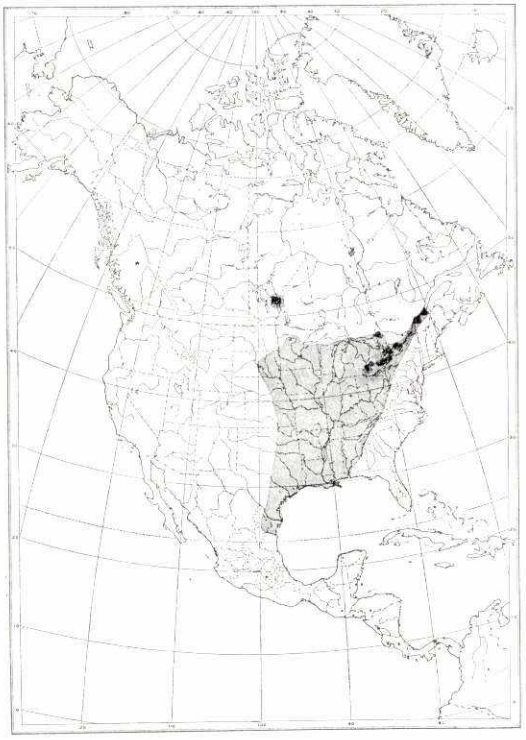
head length; snout length 25.0–29.4% of head length; interorbital 21.2–27.8% of head length; mouth moderate, maxillary extending to middle of eye or beyond, lower jaw slightly protruding; teeth in jaws and vomer small, sharp, and in many rows, a single patch of teeth on anterior surface of tongue. Gill rakers 23–25. Branchiostegal rays 7. Fins: dorsals 2, combined base of both fins 31.7–35.2% of total length, first dorsal spiny, 9 spines, entirely separate from second dorsal, second dorsal of 1 spine and 12–14 branched rays; caudal distinctly forked, rays 17 (15 branched); anal of 3 spines and 12 or 13 branched rays; pelvics thoracic, 1 spine and 5 branched rays; pectorals somewhat pointed, rays 15–17. Scales large, ctenoid, 52–60 in lateral line, on opercles, cheeks, and interorbital. Vertebrae 24.

Colour Less variable than the white perch. Overall colouration silvery. The back is dark green or grey, shading to silvery on the sides, becoming white below. The sides have 5–7 horizontal dark stripes. The eye is tinted with yellow.

Systematic notes The current name is employed because of the revision of this group by Whitehead and Wheeler (1967) who selected the generic name *Morone*.

Distribution The white bass ranges from the St. Lawrence River west through the Great Lakes to Lake Huron. South, it occurs in most of the Great Lakes states from New York to Minnesota, westward to South Dakota and south in the Ohio and Mississippi valleys to the Gulf of Mexico. Its range in the United States has been greatly increased by transplanting.

In Canada the white bass has long been known to occur in Lake Ontario, Lake Erie, Detroit River, Lake St. Clair, Lake Huron, and Lake Nipissing. It apparently has recently extended its range into the Quebec waters of the St. Lawrence River and was first captured at Saint-Vallier, 20 miles east of Quebec City, in June 1944. In 1963 a specimen of white bass was caught in Lake Winnipeg, the first capture of the species



for Manitoba waters. It is presumed access was gained via the Red River from North Dakota.

In Canada white bass have traditionally attained greatest abundance in Lake Erie.

Biology Studies of the biology of the white bass, including time and place of spawning, have not been conducted by Canadian biologists or, if so, have not been published, but the results of a number of studies in U.S. waters are available and have been the source for much of the information that follows. Unfortunately most of these studies relate to rate of growth and food, few to reproductive behaviour.

The white bass spawns in spring, like its close relatives the white perch and striped bass.

Sexually mature fish form schools, often unisexual schools, and move onto shoals or into estuaries for spawning, these inshore movements usually occurring when water temperature rises to 55°–60° F (12.8°–15.6° C). Precise dates of spawning un-

doubtedly vary slightly from season to season but in Lake Erie spawning usually takes place in May, at temperatures of 58°–70° F (14.4°–21.1° C), extending into June in cool years. In Lake Nipissing spawning probably takes place in late June. Riggs (1955) presented comparative data for spawning times in various parts of the United States, indicating that spawning may commence in April in southern states, in late May or June in northern ones.

The actual spawning act takes place in daylight (but has been reported to occur at night also), usually nearer the surface than the bottom and, within a population, may last for 5–10 days. The eggs are released near the surface or in midwater, both eggs and sperm are released simultaneously, the eggs becoming fertilized as they sink. The eggs measure about 0.8 mm, are heavy and adhesive, and on sinking, become attached to gravel, boulders, or vegetation on the bottom. Riggs (1955) reported that the number of eggs varied from 242,000 to 933,000 and averaged 565,000. The number of eggs presumably varies directly with the size of the female.

No parental care is given eggs or young; after spawning is completed the adults move offshore and over deeper water but usually remain near the surface. During this movement they may form schools, for schooling is characteristic of white bass both before and after spawning and even before attaining sexual maturity.

Eggs are said to hatch in 46 hours at 60° F (15.6° C). Fish (1932) reported the capture of larvae, 3.7–13.5 mm long, in western Lake Erie on June 29, 1929. She also figured and described larvae to a length of 18.5 mm. Growth is rapid and young white bass may attain total lengths of 5–6 inches (127–162 mm) by the fall of their first year. Van Oosten (1942) demonstrated that maximum growth occurred in the first year. The following calculated age–length relations are taken from Van Oosten (1942) and apply to fish caught in Lake Erie in 1927, 1928, and 1929 when conditions were markedly different than they are today. For comparison, figures are shown for rate of growth in Oneida Lake, N.Y., using 1948 through 1960 year-classes (Forney and Taylor 1963).

Year	Lake Erie calculated TL & Wt at end of year of life				Oneida Lake, N.Y. calculated TL at end of annulus	
	(*inches*)	(*mm*)	(*oz*)	(*g*)	(*inches*)	(*mm*)
1	4.7	119	0.7	20	5.3	135
2	8.2	208	3.8	108	10.3	262
3	10.9	277	9.4	266	12.3	312
4	12.4	315	14.1	401	13.3	238
5	13.2	335	17.1	486	14.0	356
6	13.6	345	18.8	533	14.7	373
7	14.0	356	20.3	577	15.4	391
8	–	–	–	–	16.0	406
9	–	–	–	–	17.4	442

Forney and Taylor noted that the growth of females is more rapid than that of males but the difference was slight. Van Oosten's data also demonstrated that females were slightly larger than males of the same age, but he did not consider the difference to be significant.

The greatest increment in weight in the Lake Erie study occurred in the third year. On the basis of this and the attainment of sexual maturity Van Oosten stressed that the legal-size limit should be 11 inches (279 mm). The majority of the Lake Erie white bass studied by Van Oosten did not mature sexually until age 3 when they averaged 10.9 inches (277 mm) total length. This species does not live as long as the white perch and seldom lives beyond 7 years. The scales, incidentally, usually show well-marked annuli and are easy to read.

White bass in Ontario waters average from $\frac{3}{4}$ to $1\frac{1}{2}$ pounds. We have seen 3-pound bass from Lake Nipissing, but documented size records for Canadian caught fish over 2 pounds are rare.

The world record is said to be 5 pounds 4 ounces. A female weighing 4 pounds 6 ounces (1985 g) was caught in an Oklahoma impoundment in 1950 and a 4-pound 9-ounce (2070-g) fish caught in Arkansas in 1967 was considered to be a new state record.

White bass appear to prefer clear water rather than turbid or silty conditions. Indeed, there is experimental evidence suggesting

that they are visual feeders (Greene 1962) and are not attracted to their prey by scent, hence, low turbidity levels may be essential for their survival. The schooling tendency is also sight dependent. They tend to occupy the upper water layers or epilimnion, usually to a depth of about 20 feet. Tagging and marking experiments in U.S. waters suggest that they may move considerable distances, up to 6.9 miles in a day.

White bass are carnivorous. The younger, smaller fish feed on microscopic crustaceans, insect larvae, and fishes; but fishes, especially yellow perch, become increasingly important in the diet with increase in size. Food studies of adult white bass in Iowa lakes indicate that fish (yellow perch, bluegills, carp, black crappies) constitute two-thirds of the total volume, the remainder consisting of aquatic insects, especially mayflies, and crustaceans. Similar studies in Oneida Lake, N.Y., by Forney and Taylor (1963) also showed fish, especially yellow perch, and aquatic insects (principally mayflies, chironomids in fall) to be primary food items. Small gizzard shad may dominate in the diet, as demonstrated by Bonn (1953) for Lake Texoma, Texas. Cyprinids or minnows may also form a significant portion of the diet.

Bangham (1955) examined three white bass from South Bay, Lake Huron, for parasites and reported a number of trematodes, nematodes, cestodes, and a species of acanthocephalan. Bangham and Hunter (1939) reported that many adults of the cestode tapeworm *Bothriocephalus cuspidatus* were found in one fish, but only larvae in seven others. Hoffman (1967) listed additional parasites found in white bass.

Relation to man The white bass is an important game fish in many parts of the central U.S., especially in the Great Lakes drainage, but is of less importance in Canada because of its more restricted distribution. At times, however, it may provide excellent sport fishing, especially in Lake Nipissing and in river mouths along the northern shore of Lake Ontario, especially in spring when the schools move into inshore waters. At such times spinning with streamer flies can be most effective, and catches of 2 or 3 dozen fish in an hour were not uncommon in the 1950's. In Lake Erie the white bass has supported, at times, a small but important fishery, as the following figures indicate:

	Catch (*lb*)	
Year	Lake Erie	Total for Ontario
1964	1,722,000	1,836,208
1965	2,610,948	2,733,247
1966	1,756,888	1,805,932
1967	822,000	857,000
1968	819,495	819,495

Nomenclature

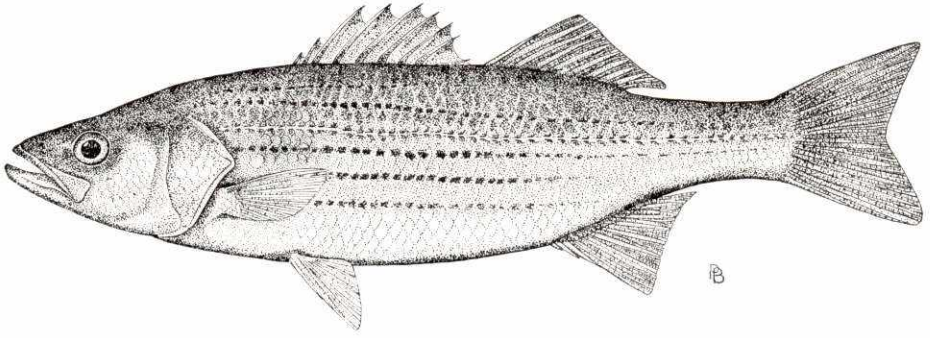
Perca chrysops	— Rafinesque 1820a: 370 (type locality Falls of Ohio)
Labrax notatus (Smith)	— Richardson 1836: 8
Labrax albidus	— Cox 1896b: 71
Labrax osculatii Filippi	— Jordan and Evermann 1896–1900: 1132
Lepibema chrysops Rafinesque	— Hubbs 1926: 55
Morone	— Whitehead and Wheeler 1967: 23
Roccus chrysops (Rafinesque)	— Scott and Crossman 1969: 22

Etymology *Morone* — (etymology unknown); *chrysops* — gold; eye.

Common names White bass, silver bass, white lake-bass. French common name: *bar blanc*.

STRIPED BASS

Morone saxatilis (Walbaum)

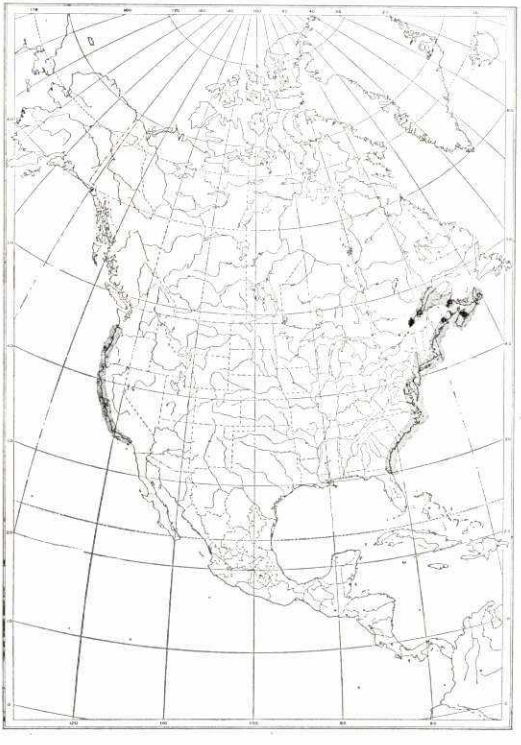


Description Body elongate, usually 16–18 inches (406–457 mm) in length, compressed laterally, depth greatest below posterior portion of spinous dorsal fin, its depth 21.3–24.2% of total length. Head large, triangular, its length 24.5–27.4% of total length; eye large, its diameter 15.7–22.9% of head length; snout long, 29.4–31.4% of head length; interorbital 22.1–26.7% of head length; mouth large, maxillary extending to middle of eye or beyond, lower jaw distinctly protruding; teeth in jaws and vomer small, sharp, and numerous, 2 elongate patches of teeth on each side of tongue. Gill rakers 21–26 (Canadian range — Lewis 1957), 20–29 over whole range. Branchiostegal rays 7. Fins: dorsals 2, entirely separated, combined base of both fins 30.9–36.4% of total length, first dorsal spiny, 9 spines (over whole range 7–12), second dorsal of 1 spine and 12 branched rays (over whole range 8–14); caudal distinctly forked, rays 17 (15 branched); anal of 3 spines, graduated, the third and longest less than one-half longest branched ray, and 9–11 branched rays (over whole range 7–12); pelvics small, thoracic, 1 spine and 5 branched rays; pectorals small, narrow, somewhat pointed, of 31–34 branched rays (over whole range 28–37). Scales large, ctenoid, 58–64 (Canadian range only) in lateral line, on opercles and cheeks. Vertebrae 24 (excluding urostylar vertebra).

Colour The striped bass is dark olive-green (rarely pale green) to steel-blue or black above, paling on sides to silvery, sometimes with brassy reflections, becoming white on belly. There are 7 or 8 prominent, horizontal, dark stripes along the sides, more or less interrupted, following scale rows; usually 3 or 4 above lateral line, 1 along lateral line, and 3 below it; the 2 above, the stripe on the lateral line, and the 1 below are generally longest, extending almost to caudal base, lowest stripe ending before anal fin. All stripes except lowest are above level of pectoral fins. No stripes extend onto the head. Young striped bass 2.4–2.8 inches (60–70 mm) do not usually have the longitudinal stripes; fish 2.0–3.2 inches (50–80 mm) often have 6–10 dusky, vertical crossbars.

Systematic notes The current name is employed because of the revision of this group by Whitehead and Wheeler (1967) who selected the generic name *Morone*. The distinctness or integrity of populations along the Atlantic seaboard have been studied by many biologists (Vladykov and Wallace 1952; Raney and deSylva 1953; Raney et al. 1954; Raney 1957; Lund 1957;

Lewis 1957) using meristic and morphometric characters. The results suggest that discrete populations exist in some regions, such as the Hudson River, but that Chesapeake Bay may contain as many as four populations during the overwintering period. Studies of body depth and caudal peduncle depth values suggested the existence of north–south clinal variations. The St. Lawrence River population was considered to be distinctive but is now seriously depleted.



Distribution The striped bass is a coastal species, seldom found more than a few miles from shore except during spring and fall migrations. It is distributed along the North American Atlantic coast from the St. Lawrence River to the St. Johns River in northern Florida, and is found in the Gulf of Mexico, in fresh and brackish tributaries in western Florida, Alabama, Mississippi, and Louisiana.

Introduced on the Pacific coast of North America in 1879 and 1882, it occurs from the Columbia River, Oregon, to southern California.

In Canada the striped bass occurs in the coastal waters of the Maritime Provinces. It has been reported from Malpeque Bay, Tignish, and Summerside, P.E.I.; Cheticamp, River Philip, Canso, Mira Bay, Chedabucto Bay, Mahone Bay, the Minas Basin area of the Bay of Fundy, the shores of Yarmouth County, Shubenacadie and Annapolis rivers, and Shubenacadie and Grand lakes, N.S.; in New Brunswick, primarily restricted to fresh water, it is found in the Richibucto River, Miramichi River and estuary, Tabusintac, Tracadie, and Pokemouche rivers, in the Saint John River watershed in the Aroostook River, below Beechwood Dam, in the Fredericton area in Grand Lake, Long Reach (Oak Point area), Nerepis, Hammond, and Kennebecasis rivers, Grand Bay, and at the Reversing Falls. Scott and Crossman (1959) could find no record of its occurrence in the Nepisiguit or Restigouche rivers.

It occurs sparingly in the Gulf of St. Lawrence, and in the St. Lawrence River as far up as about Sorel. Cuerrier et al. (1946) reported that striped bass were caught in hoopnets at the entrance of Saint-François and Nicolet rivers, lac Saint-Pierre, in small quantities in the month of May.

It is not found north of the Laurentian Channel.

Attempts have been made to establish striped bass in a number of freshwater areas in the U.S. with limited success.

Biology Canadian populations of striped bass have not been studied with the intensity given to the species in the United States, probably because of its limited distribution in Canada and the great fluctuations in numbers in the regions that it does inhabit. St. Lawrence River populations have received more attention than those of Nova Scotia and New Brunswick but even the St. Lawrence River populations have stimulated the writing of relatively few scientific papers. Furthermore, these populations, which once supported a fishery, are now severely deci-

mated. Nevertheless, the following information applied primarily to the following Canadian regions — the St. Lawrence River, the southern or southeastern coastal area of Nova Scotia, and the Bay of Fundy.

Throughout its range the striped bass spawns in fresh water. In the St. Lawrence River there is a fall migration upriver, the potential spawners spend the winter in the river, then swim up to their spawning grounds in the spring, usually spawning in June. Prespawning fish may travel long distances upriver, in fresh water. In former years some large fish have been taken as far inland as lac Saint-Pierre and a very few individuals have been caught at lac Saint-Louis at Montreal. In spring large, mature fish migrate up such rivers as the Saint John and Miramichi in New Brunswick, and the Shubenacadie and Annapolis rivers in Nova Scotia.

Although direct observations of spawning fish in these rivers seem not to be available, indirect evidence suggests that spawning occurs in early June. In some rivers spawning occurs just above the head of tide, but in most cases the ripe fish seem to move well into fresh water before spawning.

Fecundity of United States populations has received considerable attention. The average number of eggs per female is well documented and is more or less proportional to the weight. Raney (1952) cited records of egg numbers with weight of spawning females and noted that reports gave a range of 14,000 eggs for a 3-pound female to 3,220,000 eggs for a 50-pound female. Records from fish cultural work in North Carolina indicated that most fish yielded 180,000–700,000 eggs each. Although females spawn more than once, they do not necessarily spawn every year.

The eggs are relatively large, have a large oil globule, and measure 1.0–1.35 mm before extrusion, and about 3.6 mm a few hours after they are fertilized and have undergone swelling. The eggs are semibuoyant and may be swept along with the current. They hatch in 70–74 hours at 58°–60° F (14.4°–15.6° C) and in about 48 hours at 64°–67° F (17.8°–19.4° C). The development of the larvae at 120 hours (5.2 mm), 144 hours (5.8 mm), and 192 hours (6.0 mm) was illustrated and described by Pearson (1938). The early larval stages have also been described by Scofield and Coleman (1910). Raney (1952) provided a most useful review of works on the egg and larval stages. Leim (1924, p. 52) gave some figures on larval abundance in the Shubenacadie River, N.S., which flows into the Minas Basin "in 1922 three plankton tows yielded 516, 977, and 422 larvae of the striped bass, *Roccus lineatus,* which was practically the only fish which spawned in the Shubenacadie River at nearly the same time as the shad and whose larvae were found in greatest abundance near the head of the tidal zone."

We seem to know very little of the movements of young-of-the-year, and one- or two-year-old striped bass in Canadian waters. However, McKenzie (1959) noted that many young bass 2.7–5.5 inches (70–140 mm) were found in recent years (1945+) among the tomcod caught during the late autumn and early winter. McKenzie (personal communication) later elaborated on this statement, indicating that these small bass were taken formerly in considerable numbers in the Miramichi River between Loggieville and Newcastle in New Brunswick. Fishing in the river ceased in January. The size of these fish would suggest that they were young-of-the-year or possibly yearlings. After the first summer the young have been observed to form small schools (in Hudson River) and apparently prefer sand and gravel bottom and at least some current. The tendency to form schools is most characteristic and young bass of 2–3 pounds may migrate over great distances. In New Brunswick streams flowing into the Bay of Fundy, young bass can sometimes be seen entering the lower reaches of rivers with the incoming tide, rolling, and flashing at the surface and chasing all small fishes. They leave inconspicuously before ebb tide.

Growth is rapid during the first year or two. The only rate of growth figures for Canadian populations are those provided by Magnin and Beaulieu (1967) for St. Lawrence River populations. The 95% ranges

for fork lengths calculated for the time of last annulus formation are as follows:

Age	FL (*mm*)
1	69–124
2	165–268
3	276–359
4	343–433
5	380–485
6	431–532
7	461–596
8	507–626
9	479–681

St. Lawrence River striped bass averaged 5–12 pounds (Vladykov 1947), and Raney (1952) quoted Vladykov (1949) as saying that the largest he had seen was 24 pounds and the largest taken by fishermen was 32 pounds. Vladykov and McKenzie (1935) reported that fish up to 50 pounds were caught in Grand Lake, N.S. Davidson (1949, 1950, 1951), however, made no mention of such large fish in her studies in Shubenacadie Lake in 1949–51. Most fish caught were of 3.0- to 4.5-pound size range, but a 15- to 18-pound fish was trapped in a pool and killed, and a 17.5-pound one was found dead in Shubenacadie River. Large runs and good angling catches of striped bass averaging 3–4 pounds were reported in tidal streams emptying into Bay of Fundy in July and August 1960. Similar runs were reported for Northumberland Strait and Prince Edward Island streams for the same year.

Raney (1952) gave a comprehensive review of sizes attained in various United States waters. Apparently the largest ever reported were caught in North Carolina in 1891 and several weighed 125 pounds each.

The striped bass is a voracious carnivore, consuming a variety of food including many kinds of living fishes, crustaceans, and other invertebrates such as annelid worms and insects.

Detailed studies of the food of the striped bass have been undertaken in the United States, and Merriman (1941), Raney (1952), and Hollis (1952) gave detailed accounts and summaries of the literature.

Larval striped bass feed on zooplankton. Young bass eat primarily small shrimps *(Gammarus* and *Crago)* and other crustaceans, annelid worms, and insects. LeCompte (1926), studying Atlantic coast populations, noted that marine worms composed 50% of the food, crustaceans and other marine species 48%, and small fish only 2%, that young bass begin feeding on small species of crustaceans and worms, and as they grow in size consume shrimp and young fish.

The diet of adult bass in rivers and lakes is principally of small fishes, such as herring, menhaden, smelt, alewives, shad, silversides, and mummichogs. Although shad is commonly reported as a food item of striped bass in rivers in the United States, it is noteworthy that Leim (1924) was unable to establish that striped bass up to 9.9 inches (250 mm) preyed upon young shad in Shubenacadie River, N.S. Davidson (1950), however, examined the stomachs of 32 striped bass in Shubenacadie Lake, N.S., and found that 13 were empty, 3 contained partly digested elvers, and the rest small fishes. She stated that American shad were the chief food during shad migration. Although anglers suspected that bass preyed on salmon, she could find no supporting evidence.

Along rocky, open shores striped bass prey upon crustaceans such as small crabs, shrimps, and lobsters.

Striped bass do not eat steadily, but appear to gorge themselves, then stop feeding until digestion is completed. Individuals in a school feed simultaneously. For a very short period before spawning, and during the actual spawning process, they cease to eat (Trent and Hassler 1966).

Unfortunately, there is little information available on the food of this species in Canadian waters where there is need of further study.

When small, striped bass may be preyed upon by any larger fishes with which they come in contact, such as tomcod and, later, cod, silver hake, and even larger striped bass. Adult striped bass, however, have few enemies except man — who, indeed, is enemy enough.

Although striped bass are attacked by various external and internal parasites, there is no evidence that their general well-being

is seriously affected. Merriman (1941) and Raney (1952) provided summaries of parasites and diseases affecting striped bass in United States waters, but we have no information on this phase of the biology of the species in Canadian waters. Raney listed monogenetic and digenetic trematodes, cestodes, acanthocephalans, and a few records of ectoparasites, such as copepods, lernaeopodids, and ergasilids. Merriman also noted a high incidence of cataracts on the eyes of Connecticut specimens. *See also* Hoffman (1967) for additional information.

Relation to man Canadian populations of striped bass seem not to be highly valued, at least in comparison with their United States counterparts. It is of importance as a game and commercial fish when found in sufficient numbers. A commercial fishery in Nova Scotia yielded 15,000 pounds in 1963, but this declined in 1967 to landings of 4000 pounds (Fisheries Statistics of Canada, Nova Scotia 1967). In July and August, 1960–61, large runs and good angling catches were reported from the tidal streams emptying into the Bay of Fundy and along Yarmouth County, the fish averaging 3–4 pounds. The numbers of striped bass were reported to have increased in the Gulf of St. Lawrence areas around Prince Edward Island and in the Northumberland Strait during the same period. In earlier years (1964+) the striped bass was fished commercially, and also as a sport fishery, in the St. Lawrence River around Sorel, Que. However, St. Lawrence River stocks are now reported to be seriously depleted (V. Legendre, personal communication).

In New Brunswick, striped bass are caught in various rivers, including the Miramichi, but are not utilized by sportsmen and have little or no commercial significance.

In the United States it is an important game and commercial fish on both the Atlantic and Pacific coasts, and is highly valued as a food fish.

Nomenclature

Perca saxatilis	— Walbaum 1792: 330 (type locality New York)
Labrax notatus (Smith)	— Richardson 1836: 8
perca labrax	— Perley 1852: 22
Labrax Lineatus	— Perley 1852: 181
Labrax lineatus	— Fortin 1864: 60
Roccus lineatus	— Adams 1873: 248
Roccus Lineatus Gill	— Adams 1873: 304
Roccus lineatus (Bloch) Gill	— Cox 1896b: 70
Morone	— Whitehead and Wheeler 1967: 23
Roccus saxatilis (Walbaum)	— Scott and Crossman 1969: 22

Etymology *Morone* — (etymology unknown); *saxatilis* — living among rocks.

Common names Striped bass, striper bass, rockfish. French common name: *bar rayé*.

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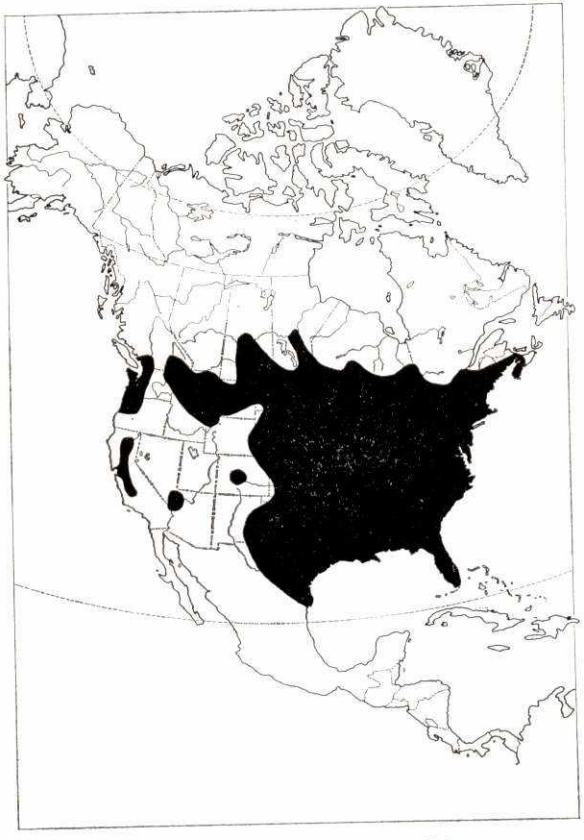
Sunfish Family — Centrarchidae

These are, generally speaking, small to moderate-sized, spiny-rayed, gibbous, laterally-compressed, physoclistous fishes. The head and mouth are small to large; the eyes are large. Bands of villiform teeth are borne on the jaws, vomer, palatines, and tongue of most species. In some, the lower pharyngeal bones bear conical or flat teeth. The dorsal fin consists of a spinous portion (6–13 spines) and a soft-rayed portion, to a varying degree joined as 1 fin. The 2 parts are always more closely connected than in the closely related perches. The pectoral fins are moderately high on the body; the pelvic fins, of 1 spine and 5 rays, are thoracic. The anal fin is preceded by 3–9 spines and in some species equal in size to the dorsal fin. The caudal fin is, to a varying extent, forked.

This family includes some of the most highly coloured and attractive North American warmwater fishes, and several species are important sport fishes. Although originally restricted to eastern North America, various species, especially the basses, have been widely introduced elsewhere. Sunfishes inhabit the shallows of warm, rocky, and vegetated lakes, ponds, and slowly moving streams.

The family is composed of 30 species in 10 genera, generally grouped as sunfishes, crappies, and basses, and are known from the Miocene to Recent.



World Distribution of the Sunfishes

Key to Species

1 Dorsal spines 10–12; branchiostegal rays 6 (rarely 5 or 7); base of anal fin into base of dorsal fin 1.5–3.0 times 2

Dorsal spines 6–8; branchiostegal rays 7; base of anal fin equal to, or slightly longer than base of dorsal (crappies, *Pomoxis*) 9

2 Anal spines 6, spines arise in a scaled groove; body with 7–9 horizontal rows of black spots below lateral line; base of anal fin about 1.5 times into base of dorsal. ..... ROCK BASS, *Ambloplites rupestris* (p. 703)

Anal spines 3, not in groove; no horizontal rows of spots below lateral line; base of anal fin into base of dorsal 2.1–3.3 times 3

3 Lateral line scales more than 55; greatest depth into length from tip of snout to end of scales 3.0–3.3 times (basses, *Micropterus*) 4

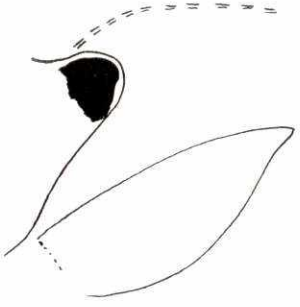
Lateral line scales fewer than 50; greatest depth into length from tip of snout to end of scales 2.0–2.5 times (sunfishes, *Lepomis*) 5

4 Upper jaw extends at least to mid-pupil, but not beyond eye; connection between dorsal fins higher, shortest posterior spine more than one-half the longest; 68–78 scales in lateral line; pelvic fins joined by membrane, membrane connecting fins to body hidden; young with conspicuous orange and black bands on caudal fin. ..... SMALLMOUTH BASS, *Micropterus dolomieui* (p. 728)

Upper jaw extends beyond eye; connection between dorsal fins lower, shortest posterior spine less than one-half the longest; 60–68 scales in lateral line; pelvic fins not joined by membrane, membrane connecting fins to body obvious; young without colourful pigment on caudal fin but with prominent lateral band. ..... LARGEMOUTH BASS, *Micropterus salmoides* (p. 734)

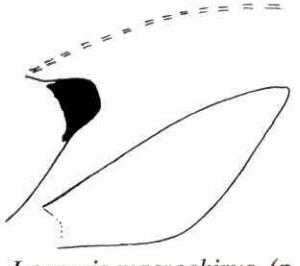
5 Opercular flap in life with black centre, yellow, orange, or red spots or band around margin (in preserved specimens the once coloured areas are white or colourless) 6

Opercular flap in life all black, not marked or edged by yellow, orange, or red in life (not edged with white or colourless in preserved specimens) 7



6 Pectoral fins longer, 3 times in standard length, pointed at leading edge; gill rakers very short and knobbed; opercular flap short, black in centre, edged with white or yellow, with a prominent well-defined red spot at posterior edge. ..... PUMPKINSEED, *Lepomis gibbosus* (p. 713)

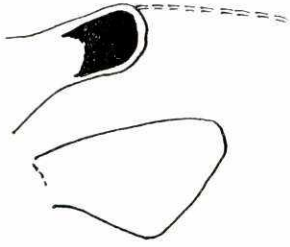
Pectoral fins shorter, 4 times in standard length and rounded; gill rakers short but not knobbed, or moderately long; opercular flap longer, black in centre, edged with yellow, orange, or red, no prominent, precise, red spot. 8



7 Black area of opercular flap usually as deep as long, bony edge of flap entire, not crenate; gill rakers long and slender; pectoral fin long and pointed; base of anal fin into base of dorsal fins 2.0–2.3 times; ventral edge of preopercle finely serrate; black spot at posterior base of second dorsal fin. ..... BLUEGILL, *Lepomis macrochirus* (p. 719)

Black area of opercular flap usually longer than deep, bony edge of flap crenate; gill rakers short and stout; pectoral fin short and rounded or somewhat pointed; base of anal into base of dorsals 2.3–2.6 times; preopercle not serrate; no black spot at posterior base of second dorsal fin. ..... REDBREAST SUNFISH, *Lepomis auritus* (p. 707)

8 Opercular flap as deep as long, black area edged with red and/or yellow, most prominently on bottom and end; bony edge entire, not crenate; scales smaller, 44 or more in lateral line, 8–10 diagonal rows of scales between lateral line and dorsal origin. ..... GREEN SUNFISH, *Lepomis cyanellus* (p. 710)



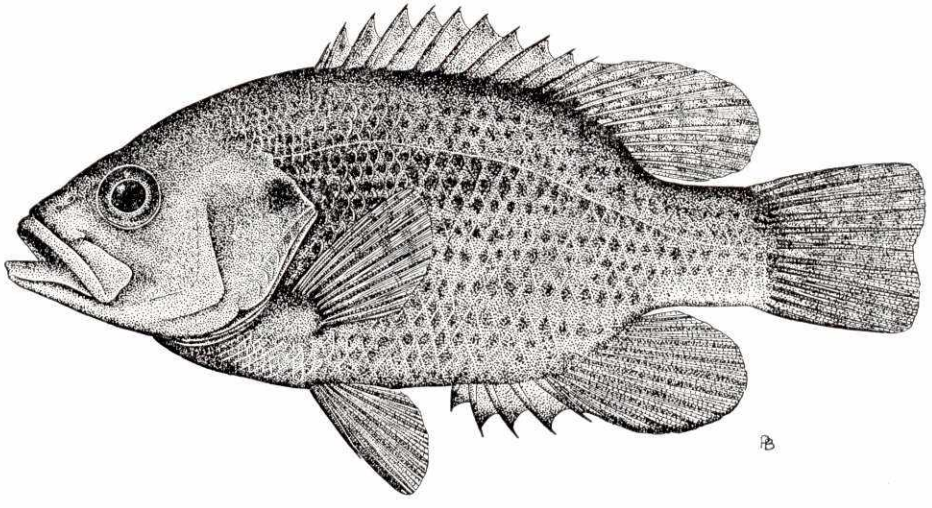
Opercular flap long, moderately wide, and turned up, black area completely edged with red and/or yellow; bony edge crenate; scales larger, 39 or more in lateral line, 4–6 diagonal rows between lateral line and dorsal origin. ..... LONGEAR SUNFISH, *Lepomis megalotis* (p. 724)

9 Dorsal spines 6; base of anal fin longer than base of dorsal fins; eye diameter 5–6 times in head, 2 times in snout; body pale with vertical bars (prominent in life). ..... WHITE CRAPPIE, *Pomoxis annularis* (p. 741)

Dorsal spines 7 or 8; base of anal fin almost equal to base of dorsal fin; eye diameter 4–5 times in head, less than 2 times in snout; body darkly and irregularly blotched with black. ..... BLACK CRAPPIE, *Pomoxis nigromaculatus* (p. 745)

ROCK BASS

Ambloplites rupestris (Rafinesque)



Description Body deep, greatest depth at origin of dorsal fin 31.8–36.7% of total length, laterally compressed but less so than most other sunfishes (*Lepomis*, *Pomoxis*); individuals usually 6–10 inches (152–254 mm) in length; caudal peduncle almost as deep as long, depth about 12–14% of total length; angle from snout to dorsal fin not steep. Head rather large, narrow, and deep, length 30.4–34.5% of total length, mostly scaled, opercular flap (or ear flap) short, stiff, not brightly coloured; eye very large, diameter 26.7–40.9% of head length, high, well ahead of centre of head; snout moderately long, about 20% of head length, bluntly pointed; mouth terminal, slightly oblique, lower jaw slightly longer, maxillary long, 33.3–45.5% of head length, wide at tip and reaching to middle or posterior edge of pupil, gape reaching to pupil; fine brushlike teeth on palatines, vomer, tongue, and both jaws, those on lower jaw the largest, pharyngeal teeth numerous, short, fine and pointed, lower pharyngeal pad long and narrow. Gill rakers about 16, often 4 knoblike rudiments on upper limb, 6 long, fingerlike rakers and 6 rudimentary knobs on lower limb. Branchiostegal rays 6, or rarely 5. Fins: dorsals 2, but broadly joined and appear as 1, base of dorsal fins almost twice as long as anal base, first dorsal long and spiny, 10(1), 11(32), or 12(7) spines, fifth spine highest, edge rounded, last spine about $\frac{1}{2}$ height of second dorsal, second dorsal soft rayed, higher, but with base about $\frac{1}{2}$ that of first dorsal, rays 11(21) or 10(19), edge round; caudal only moderately broad and long, little to moderately forked, tips rounded; anal with long base (but only $\frac{1}{2}$ length of dorsal base), 5(2), 6(36), or 7(2) rather short spines, and 10(33) or 9(7) soft rays, soft-rayed part dorsal, second dorsal soft rayed, higher, but bases of soft and spiny portions about equal, edge round; pelvics thoracic, origin under first or second dorsal spine, 1 spine and 5 rays, long, tip a blunt point, edge square to slightly rounded; pectorals moderately high, length about 18% of total length, broad and rounded, usually 13 rays but sometimes 12 or 14. Scales moderately large, ctenoid, dorsally

somewhat crowded forward; lateral line complete, high on body, shallowly arched, lateral line scales 37–51. Peritoneum colourless; intestine long; 9 long, slim pyloric caeca on the single animal examined. Vertebrae 29 or 30 in Ontario.

No nuptial tubercles, but colour intensifies at spawning time.

Colour General colouration of dorsal surface of head, body, and upper sides golden brown, to olive; lower head, body below pectoral fins, and ventral surface silver to white; several vague saddle marks, bars, blotches or mottling over dorsal surface to lateral line; each scale below lateral line with black spot, forming 8–10 horizontal rows, less prominent in older and in smaller individuals; eye usually bright red to orange (hence common names redeye, goggle eye); opercular flap with vague black spot not reaching edge; dorsal and anal spines darker than membranes, some black pigment creating mottling or vermiculations on membranes of second dorsal, caudal, soft part of anal, and pelvic fins; edge of pelvic often white, pectoral fin dusky. At 2 inches (51 mm) length, pattern of sides is a general black marbling. The saddle marks of adults, inconspicuous during the day, become very obvious at night.

Systematic notes There seems to be no obvious meristic trends in the Canadian material examined (Quebec to Manitoba) except toward fewer lateral line scales in Manitoba.

Canadian populations are usually considered part of a form referred to as the northern rock bass, *A. r. rupestris*, distinct from the Gulf coast form *A. r. ariommus*. These two intergrade in Missouri and Arkansas.

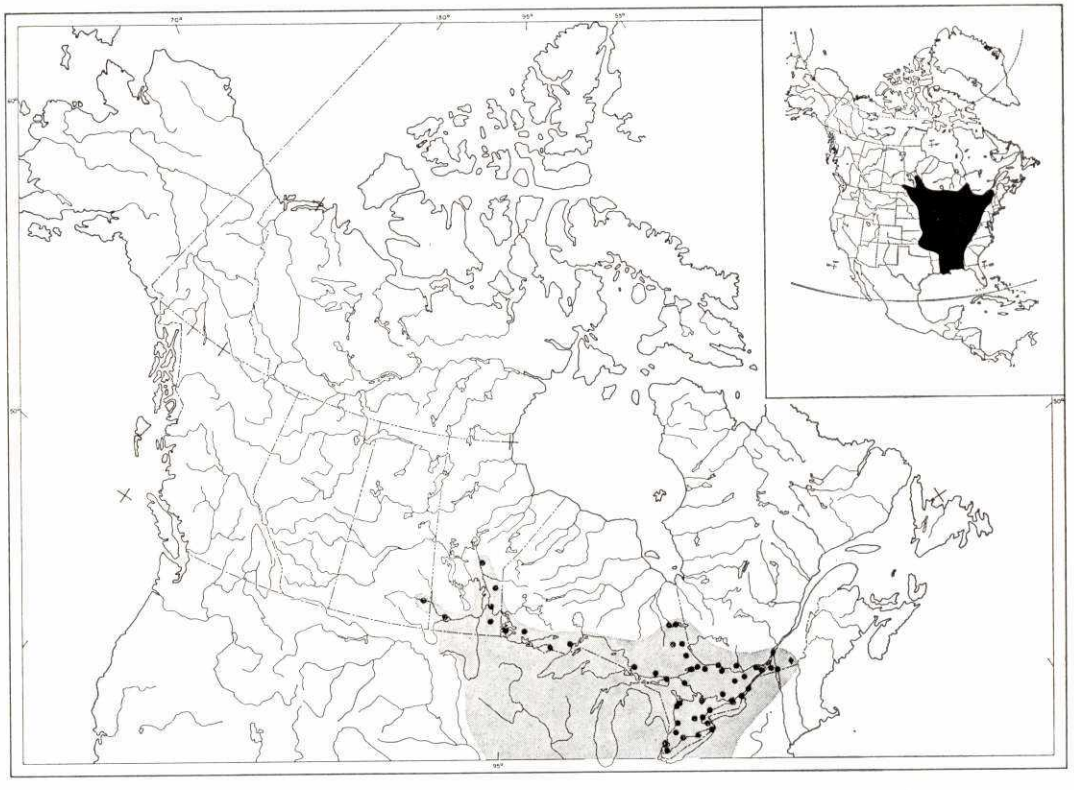
There is a superficially similar species, the warmouth, *Lepomis gulosus* (Cuvier) which occurs south of the Great Lakes, and has been often erroneously recorded in early Canadian lists and should be watched for in southwestern Ontario. The warmouth has only three anal spines.

Distribution The native range of the rock bass is restricted to the fresh waters of east-central North America. It occurs in the St. Lawrence River–Lake Champlain system, south, west of the Appalachian Mountains, to northwest Georgia, south to the Gulf coast from Florida panhandle to eastern Louisiana, north through central Arkansas, northeast Oklahoma, and southern Kansas (rare or introduced), north through the eastern parts of the states from Nebraska to North Dakota, in Saskatchewan, to central Manitoba and east to Quebec. Canal migrant to, and introduced into, the eastern coastal plain, introduced into Colorado, Wyoming, and probably other western states.

In Canada it occurs in southern Quebec, in the St. Lawrence–Lake Champlain system and in the Ottawa River system (introduced in Gatineau Lakes); throughout Ontario, north generally to a line below Lake Nipigon but including Lake Abitibi (Hudson Bay drainage), all the Great Lakes, absent from Lake Nipigon but present in Whitewater Lake (Ogoki River) now a tributary of that lake as a result of the Ogoki River diversion; west in the Hudson Bay drainage of western Ontario and eastern Manitoba; in the Red River system of Manitoba, north to central Lake Winnipeg; the Assiniboine River and in the Qu'Appelle River in eastern Saskatchewan.

Biology Although abundant in Canada, one must resort to Bensley (1915) and Hallam (1959) for scraps of first-hand information on biology of Canadian populations. Much of the following was taken from Breder (1936b), Breder and Rosen (1966), Beckman (1949), Carlander (1953), and Snow (1969).

Spawning takes place in the late spring and early summer, probably June in Canada, when the water temperature is 60°–70° F (15.6°–21.1° C). The male digs a shallow nest, up to 2 feet in diameter, in areas as diverse as swamps and gravel shoals. Often nests are very close together in an area heavily used at spawning time and defence of territory and attempts to attract and hold females are very aggressive. When spawning,



the male and female remain very near each other, the male upright but the female gradually reclining on her side. There is considerable vibration and the fish seem to rock back and forth while in a head to tail position. Spawning takes place at short intervals over a period of an hour or more but only a few eggs are laid at a time. More than one female may spawn in the same nest and one female may spawn in more than one nest. Egg number varies with size of female from 3000 to 11,000. The eggs are adhesive, and hatched in 3–4 days in aquaria at 68.9°–69.8° F (20.5°–21.0° C) (Breder 1936b). The female leaves the nest after spawning. The male guards and fans the eggs and later broods the young for a short period. Fish (1932) gave details of early development. Average number of fry, resulting from a nest in Michigan, was 800.

Growth is rapid and young-of-the-year in Ohio were 0.8–2.0 inches (20–51 mm) in October. There is apparently no available growth data for Canadian populations, but the following figures for 126 Michigan lakes and 6 Wisconsin lakes probably approximate the age–length relation in southern Canada.

TTL

Age	Michigan (Beckman 1949) (*inches*)	(*mm*)	N Wisconsin (Snow 1969) (*inches*)	(*mm*)
0+	1.5	38	–	–
1+	3.2	81	1.8	46
2+	4.3	109	3.4	86
3+	5.2	132	4.7	119
4+	6.2	157	6.5	165
5+	7.3	185	7.5	190
6+	7.9	201	8.7	221
7+	8.8	224	–	–
8+	9.0	229	–	–
9+	9.9	251	–	–
10+	10.5	267	–	–
11+	–	–	–	–

A length–weight relation for Michigan has been given as log W = −4.44406+3.025

log SL. It would appear that maximum age in nature is 10–12 years but ages of 18 years in aquaria have been recorded. Size in Canada is usually 6–8 inches (152–203 mm) with some individuals to 10 inches (254 mm). Weights rarely exceed $\frac{1}{2}$ pound. Trautman (1957) gave maximum size as 12.8 inches (325 mm) and 1 pound 4 ounces. He stated that adults were usually 4.3–10.5 inches (109–267 mm) in length and weighed 1–14 ounces. There is a record of an individual 13.4 inches (340 mm) in length weighing 3 pounds 10 ounces. In crowded ponds or smaller streams rock bass are often stunted and rarely exceed 9 inches (229 mm).

The rock bass, as indicated by its common name, generally inhabits rocky areas in shallow water in lakes, and the lower, warm reaches of streams. Adults are usually found in aggregations and most often in association with other sunfishes such as the smallmouth bass and pumpkinseed. The young are littoral to limnetic in various lakes. Extensive information on physical conditions in streams and fauna associated with the rock bass was given by Hallam (1959).

Food of this species is largely aquatic insects (immature and adult), crayfish, and small fishes, especially minnows, yellow perch, and at times their own young. Some food is taken at the surface. Keast and Webb (1966) listed the food in Lake Opinicon, Ont., as follows: up to 2.7 inches (70 mm)—chironomids (found in 50% of specimens examined), Ephemeroptera (35%), Odonata (30%), Cladocera (40%), Amphipoda (30%), Isopoda (15%), surface insects (35%), Copepoda and Hydracarina; more than 3 inches (76 mm)—Odonata (to 75%), Ephemeroptera (35%), Trichoptera (35%), fish fry (30%), crayfish (15% and over); between 4.7 and 7.8 inches (120–200 mm) —almost entirely crayfish and Anisoptera.

Keast and Welsh (1968) described details of food uptake and diel dietary changes in this species. Keast (1968b) described feeding in winter.

The young and smaller adults are probably preyed upon by large basses, by northern pike and muskellunge, and possibly by walleyes. They, no doubt, compete with smallmouth bass for food.

Bangham and Hunter (1939) listed the parasites of this species in Lake Erie.

Parasites listed by Hoffman (1967) were: Protozoa (5), Trematoda (35), Cestoda (8), Nematoda (13), Acanthocephala (9), leeches (3), Crustacea (9).

One parasite seen regularly on this species is black-spot — the resting stage of a trematode of which the belted kingfisher is the final host. It causes the development of small black spots on the fins, but cannot harm humans.

Relation to man This species may be important in an indirect way in its ecological association with other species more valued by man, such as the basses. It is a commercial species in the Great Lakes and Mississippi River and is an important sport fish elsewhere. It is not often directly sought by Canadian anglers, except children, and rarely eaten if caught incidental to other fishes. Its flesh is firm, white, flaky and delicious. A concern over the effort required to clean such small fish has lost many an angler a delicious meal. Rock bass strike live or artificial bait hard, fight hard, and provide good sport on light tackle. They can be readily taken on live bait, flies, small spinners, plugs, and poppers. They are often caught when stillfishing, casting, or trolling at depths too shallow for bass, northern pike, or walleye.

Commercial production of this species in Canada is significant in Ontario only. The catch of rock bass is combined in the statistics with that of the crappies, but the rock bass must contribute the bulk. The Ontario catch in 1966 was 271,411 pounds, with a value of $60,417.45. The major areas, in descending order of catch, were lakes St. Clair, Erie, and Ontario, northern inland lakes, southern inland lakes, North Channel, and Lake Huron.

Nomenclature

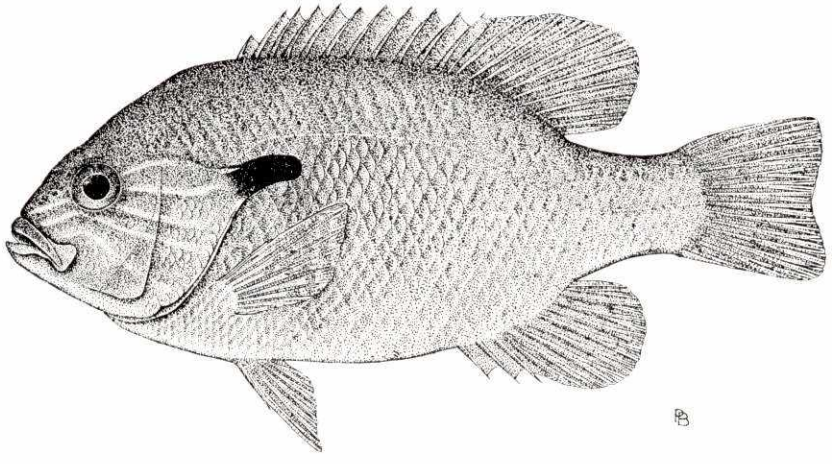
Bodianus rupestris	— Rafinesque 1817b: 120 (type locality lakes of New York, Vermont and Canada)
Cichla aenea	— LeSueur 1822a: 214
Centrarchus aeneus (Cuvier)	— Richardson 1836: 20
Ambloplites rupestris (Rafinesque)	— Jordan and Gilbert 1883a: 466
Ambloplites rupestris rupestris (Rafinesque)	— Hubbs 1947: 94

Etymology *Ambloplites* — blunt armature; *rupestris* — living among rocks.

Common names Rock bass, northern rock bass, redeye, redeye bass, goggle eye. French common name: *crapet de roche*.

REDBREAST SUNFISH

Lepomis auritus (Linnaeus)



Description Body very deep, depth at dorsal origin 32.2–39.9% of total length; individuals usually 5–7 inches (127–178 mm) long; strongly laterally compressed, angle from snout to dorsal moderately steep, convex, back somewhat flattened under dorsal fin, caudal peduncle longer than deep, its depth 12–14% of total length. Head very deep, long, length 28.2–30.3% of total length, narrow, angle steep, hump over the eye; opercular flap soft, quite long in adult males, shorter in females and juveniles, twice as long as wide, black (no coloured border), bony edge well removed from edge of flap and crenate; eye moderately large, diameter 20.4–26.9% of head length, well

ahead of centre of head, moderately high; snout length 21.9–27.7% of head length; mouth terminal, somewhat oblique, not large, lower jaw somewhat longer than upper, gape not reaching anterior edge of eye, maxillary short, length 30.3–34.9% of head length, reaching only to anterior edge of eye; many short needle-like teeth on jaws, and palatine, lower pharyngeal teeth on long, narrow pads, short and pointed. Gill rakers short and stout, knoblike only at upper and lower ends of series, about 8 on lower limb, 5 on upper limb. Branchiostegal rays 5 on material examined, but said by McAllister (1968) to be 6 or 7 and rarely 5. Fins: dorsals 2, but broadly joined and appear as one, base of dorsal fins 43.4–49.4% of total length and about $2\frac{1}{2}$ times as long as base of anal fin; first dorsal fin long, spiny, rather low, 10 or 11 spines, little difference in length, edge almost flat, length of last spine about $\frac{1}{2}$ that of soft dorsal fin; second dorsal fin soft rayed, higher but with base only a little over $\frac{1}{2}$ that of first dorsal fin, rays 10–12, usually 11, edge round; caudal only moderately broad, long, and forked, tips rounded; anal with only moderately long base, 21.6–25.0% of total length, but less than $\frac{1}{2}$ dorsal base, usually 3, but rarely 4, short, sharp spines followed by 9 or 10 soft rays, base and height of spiny portion about $\frac{1}{2}$ those of soft-rayed portion, edge of soft portion rounded; pelvics thoracic, origin under first dorsal spine, 1 small spine and 5 rays, fin not long, tip pointed, edge square; pectorals moderately high on body, short, length 15.5–19.7% of total length, edge rounded, usually 14, but rarely 13 rays. Scales ctenoid, rather small, crowded anteriorly (dorsal) and posteriorly; lateral line complete, high on body except on peduncle, flatly arched beneath base of dorsal fins, 43–49 lateral line scales. Peritoneum colourless, intestine well differentiated, usually 7 moderately long pyloric caeca. Vertebrae usually 29 or 30.

No nuptial tubercles but colours intensify considerably in breeding males.

Colour Body usually golden brown to olive, dorsal surface darker, sides lighter with inconspicuous reddish spots and vague, blue streaks, breast yellow to bright orange-red, hence previous and present common names, yellowbelly sunfish and redbreast sunfish; opercular flap blue-black to black to tip, no white or bright colours around margin; fins dusky to mottled with darker pigment, leading edge and tip of pectoral fins dark.

Systematic notes There is often confusion between this species and the longear sunfish. The "ear" flap or opercular flap is longer in mature male redbreast sunfish than in longear sunfish, but may be shorter in females and juveniles. The two are readily separated in that only *L. auritus* has palatine teeth, opercular flap without white or coloured border, gill rakers short but not blunt knobs in centre of series.

Until recently this species was called yellowbelly sunfish. *See* Scott and Crossman (1959) concerning confused synonymy in New Brunswick.

Distribution The redbreast sunfish occurs only in eastern North America. Its range extends from New Brunswick south, east of the Appalachian Mountains, to central Florida, west to the Apalachicola River, apparently not in Mississippi but introduced into Texas and Oklahoma.

In Canada, it is known only in New Brunswick. It occurs there in the systems of the Canaan, Kennebecasis and Oromocto rivers, Oromocto Lake, Anne Lake and possibly in Yoho Lake and the Magaguadavic River. It may occur more widely but goes unreported, as a result of being mistaken for the more common pumpkinseed. This species has been entered in New Brunswick checklists from as early as 1896 (Cox 1896a) on the basis of its presence in Maine or confusion with the pumpkinseed. The first authentic record, however, was a specimen from the Canaan River, Queens County, captured by H. C. White on September 3, 1948.

Biology There is no published information available on the biology of this species in Canada. The redbreast sunfish spawns in the spring or early summer (*see* Breder 1936b; Breder and Rosen 1966). Redbreast

sunfish spend the winter in deeper water in a wintering school or hibernium (Breder and Nigrelli 1935). This aggregation breaks up when the temperature reaches 50° F (10° C) and individuals (males first) make their way to the shallows along the shores. Males defend territories and dig a nest, sometimes as large as 24–40 inches (61.0–101.6 cm) in diameter, and in water 6–18 inches (152–457 mm) deep. In ponds or lakes, the nests are often close together and in the open; in streams they are in the current but usually on the downstream side of a protective rock. Apparently this species will occupy the unused nests of other centrarchids including largemouth bass. Nests have been found from June 6 to August 12 in New York, and the peak in spawning activity generally occurs in mid- to late June when water temperatures are 62°–82° F (16.7°–27.8° C). Richmond (1940) described what was apparently successful nesting in tidal water in Virginia (brackish?) where water temperature, water depth (almost exposed at low tide), and salinity varied drastically. The eggs are moderate in size, amber to yellow, and adhesive. The female leaves the nest after the eggs are laid and fertilized. The male guards the nest, fans the eggs to prevent suffocation by silting, and may even guard the newly hatched young for a short time.

Nothing is apparently available on the age–length relation of this rather small and uncommon sunfish. They are said to grow only to 6 inches (152 mm) in Maine, but are known to 9.4 inches (239 mm) and 11 ounces in Connecticut. In New Brunswick they grow at least to 8 inches (203 mm) but those usually seen are 5–7 inches (127–178 mm) in length.

The habitat of this species is variable over its range. In New Brunswick they appear to inhabit the rocky areas of streams and lakes and are fairly abundant on shores of loose rock. In streams with rapids, they occur in the slower, deeper areas of rock and gravel. In lakes they occur in quiet, deeper water over bottoms of sand to mud with abundant emergent vegetation. They apparently live rather independent lives in the summer but when water temperatures drop below about 41° F (5° C) they aggregate in schools in deeper holes and remain there all winter. Amount of activity in summer shows a direct relation to amount of sunshine and to water temperature. This sunfish, in New Brunswick, apparently darts under rocks when disturbed, much as rock bass do, but unlike the other species of sunfish, such as the pumpkinseed, which occur there.

Food of the redbreast sunfish is mainly immature aquatic insects but adult insects, molluscs, other bottom invertebrates, and possibly small fishes make up a minor part of their diet.

The chain pickerel, the brown bullhead, and the eel, may consume smaller redbreast sunfish and are the only likely predatory species in the Canadian range of this sunfish. A wide variety of fishes including minnows and other redbreast sunfish will eat the eggs in an unguarded nest.

Parasites listed by Hoffman (1967) were: Trematoda (2), Nematoda (1), Acanthocephala (1), leeches (1), Crustacea (1).

Natural hybrids are known between this species and the warmouth, the pumpkinseed, green sunfish, and bluegill.

Relation to man This species would appear to be one of the least important sunfishes over the whole of its range. This is no doubt due to the fact that larger species of sunfishes occur throughout its range.

Warmwater fishes are not highly regarded in New Brunswick so it is not surprising that this uncommon sunfish is of little importance. Its flesh is white, flaky and as good to eat as any. Some are caught by anglers, mainly boys, but are small and rarely kept. They are locally abundant, will readily take live bait and can be caught on flies and small "bugs." If fished with light tackle, they would provide fair sport.

Nomenclature

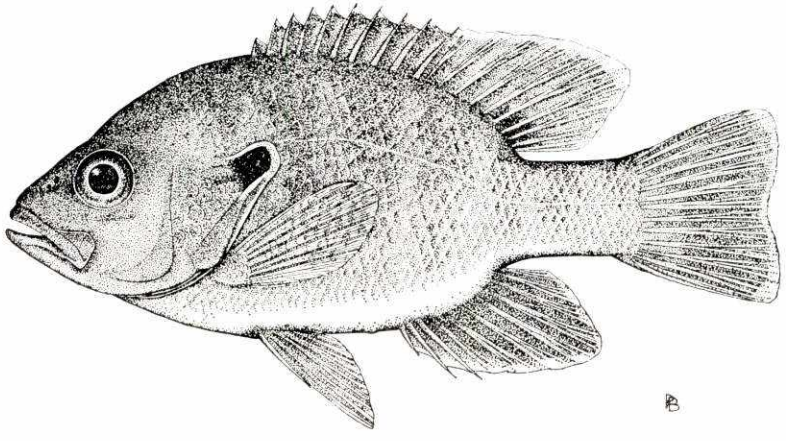
Labrus auritus	— Linnaeus 1758: 283 (type locality Philadelphia, Pa.)
Lepomis auritus (Linn.) Raf.	— Cox 1896b: 70
Pomotis appendix Storer	— Cox 1896b: 70
Pomotus rubricauda Storer	— Jordan and Evermann 1896–1900: 1001
Lepomis auritus Linnaeus	— Halkett 1913: 82
?Apomotis cyanellus (Raf.)	— Cox 1924: 85
Eupomotis auritus Linn.	— Cox 1924: 86
Pomotis rubri-cauda Storer	— Jordan, Evermann, and Clark 1930: 299

Etymology *Lepomis* — scaly operculum, a character supposed to distinguish this genus from *Sparus*; *auritus* — eared, alluding to the long opercular flap.

Common names Redbreast sunfish, yellowbelly sunfish, longear sunfish, longears. French common name: *crapet rouge*.

GREEN SUNFISH

Lepomis cyanellus Rafinesque



Description A deep-bodied, laterally compressed fish, usually not over 5 inches (127 mm) in length in Canada. Body not so deep as, and thicker than, other sunfishes. Greatest depth at origin of dorsal fin 30.3–34.1% of total length; caudal peduncle a little longer than deep, depth 12–13% of total length; angle from snout to dorsal fin not steep, back only shallowly arched. Head rather large, length 27.8–31.9% of total

length, deep and heavy, but narrow, mostly scaled, depression over eye, opercular flap long but almost as deep as long, stiff to margin, black in centre with coloured margin; eye large, diameter 18.6–31.3% of head length, in advance of centre of head, moderately high; snout bluntly pointed, moderately long, about 30–35% of head length (including bony part of opercular flap); mouth terminal, oblique, large, gape reaching to anterior edge of eye, jaws usually equal, lips large; maxillary long, 30.0–41.9% of head length, reaching to centre of pupil; fine teeth on palatines, vomer and both jaws, absent on tongue; pharyngeal teeth larger, less numerous, conical, lower pad much longer than wide. Gill rakers in centre of arch long and thin, about 14 on lower limb and 4 or 5 on upper limb (including rudiments). Branchiostegal rays usually 6, but rarely 7. Fins: dorsals 2, but broadly joined and appear as one, base of dorsal fins about $2\frac{1}{2}$ times anal base, first dorsal long, spiny, 9–11 but usually 10 spines, edge only slightly rounded, almost flat, longest spine less than $\frac{1}{2}$ height of second dorsal, second dorsal soft rayed, higher, base length over $\frac{1}{2}$ that of first dorsal, rays 10–12, usually 10 or 11, edge rounded, to slightly pointed in breeding males; caudal rather broad, shallowly forked, tips rounded; anal with base less than $\frac{1}{2}$ length of dorsal base, 3 sharp spines and 9 or 10 soft rays, soft-rayed part not greatly higher than third spine but base of soft portion over 3 times that of spiny portion, edge round, to slightly pointed in breeding individuals; pelvics thoracic, origin under first dorsal spine, rather long, 1 spine and 5 rays, spine about $\frac{1}{2}$ length of fin, tip pointed, edge square to slightly rounded; pectorals moderately high, not long, length 17.9–21.2% of total length, broad, tip round, usually 13 rays but sometimes 12. Scales rather small, ctenoid, somewhat crowded both anterior (dorsally) and posterior; lateral line complete, high, shallow arch over pectoral fin, lateral line scales 40–50, 8–10 scale rows above lateral line. Peritoneum white to silvery; intestine long, well differentiated, 6–8 pyloric caeca. Vertebrae 28 or 29 on material examined.

No nuptial tubercles but colour and pattern intensify at spawning time.

Colour Body generally brown to olive with an emerald sheen, darker on dorsal surfaces and upper sides, sides light yellow-green, upper sides with 7–12 dark but vague, vertical bars; ventral surface yellow to white, breast not conspicuously coloured; head with emerald spots, and at times, wavy, radiating, emerald lines; opercular flap with squarish black centre, entirely edged with pale red, pink or yellow, brightest at tip and below; in spawning males, the dorsal, caudal, and anal fins dusky to olive, membranes darker, and edged with white, yellow, or orange border; sometimes the body of these fins has small, light spots, usually a vague, dark spot at base of last rays of dorsal and anal fins; paired fins clear, or pelvic fins dusky to olive. Young without emerald colouring, dark bars, or fin spots.

Distribution The green sunfish is restricted to the fresh waters of east-central North America. It occurs south from southwest New York, west of the Appalachian Mountains, to Georgia, Alabama (west of the Escambia River), absent until recently, from the Florida panhandle, west and south to Texas and northeastern Mexico, north through the eastern parts of the states from New Mexico to Wyoming, to eastern North Dakota, east below the Red River system (but in the Hudson Bay drainage of western Ontario) to Michigan and Ontario. Introduced elsewhere, and, as a result, known to occur at least in Utah and California.

In Canada, this species is restricted to Ontario where it has a disjunct distribution, and, although abundant in certain restricted areas, is not well known even in those areas. It occurs in southwestern Ontario in the Thames–Avon system tributary to Lake St. Clair and in northwestern Ontario in several lakes in Quetico Provincial Park (Hudson Bay drainage). In the Lake St. Clair system it is abundant in Irish Lake (Avon River), Grey Co., and Fanshawe Lake (Thames River), Middlesex Co., Ont. As a result of its proximity in New York State, it should be

watched for in the Niagara District.

An early report of *Apomotis cyanellus* from Yoho Lake, Oromocto Co., N.B., (Cox 1924) was probably based on a redbreast sunfish.

Biology Information on the biology of the green sunfish in Canada is not available. *See* Hunter (1963) for details of sexual dimorphism and reproductive behaviour in ponds in Wisconsin. This species spawned in late spring and summer. Multiple spawnings occurred every 8 or 9 days from mid-May to early August. The peak in activity occurred over a range of water temperatures from 68.0°–82.4° F (20°–28 °C). Males were territorial and each built one or more shallow nests very close together in a nesting colony, in sunlit water 1.5–13.7 inches (40–350 mm) deep, in areas sheltered by rocks, logs, and clumps of grass, or they utilized abandoned nests. Fish, gathered about a digging male, were stimulated by its activity and began to nest nearby. Each spawning took place over a period of 1 or 2 days. Male and female swam around in the nest, came to rest with male upright and the female inclined, and during vibrations, eggs were laid and fertilized.

The male guards and fans the eggs, and probably guards the newly hatched young for a short period. The eggs are yellow, adhesive, and probably hatch in 3–5 days. An interesting spawning relation apparently exists, at least in Wisconsin, between redfin shiners and green sunfish. Spawning of green sunfish triggers spawning in the shiner and the latter lay their eggs in occupied nests of the former (Hunter and Wisby 1961; Hunter and Hasler 1965).

Growth is rapid, young-of-the-year in Ohio were 0.8–2.5 inches (20–64 mm) long by October. There is no complete growth data for Canada but the following table with relation between age and average standard length for green sunfish in Michigan (Hubbs and Cooper 1935) probably approximates it.

Age	SL (*inches*)	(*mm*)
0+	0.8	19
1+	1.7	43
2+	2.5	63
3+	3.4	86
4+	4.0	102
5+	4.9	125
6+	5.2	132
7+	6.0	152

Trautman (1957) gave 10.8 inches (274 mm) length and a weight of 14.5 ounces as the maximum in Ohio. There is a record of an individual from Kansas which was 12 inches (305 mm) long and weighed 2 pounds 2 ounces. Specimens from Belles Lake (Grey Co.), Ont., between 6.7 and 7.5 inches (170–190 mm) in fork length, were estimated to be 5 years of age. Green sunfish, therefore, probably grow to at least 8 inches (203 mm) total length in Ontario. It would appear that life expectancy in nature is 7–9 years. Stunting occurs readily in crowded ponds and, in places, green sunfish are mature at 3 inches (76 mm).

In Ontario this species has been found in the shallows of moderate-sized, clear to somewhat turbid lakes, and an impoundment (Fanshawe Lake). Elsewhere it is found in small streams, ponds, impoundments, temporary drainage ways, and lakes, with no noticeable preference for bottom type. They frequent brush piles and dense growths of emergent vegetation. The green sunfish is apparently more tolerant of turbidity than the other species of sunfish occurring in Canada. Certain physical characteristics of habitats containing green sunfish (Thames River), and the species associated with them were given by Hallam (1959).

The food of this species, like the other sunfishes, is probably largely insects, molluscs and small fishes. Carp and bass have also been reported. The large, heavy mouth would suggest the ability to eat large and hard-bodied organisms.

Green sunfish, rarely very large, probably fall prey to a wide variety of warmwater fishes with which they live, the basses *(Micropterus)* in particular.

Parasites of the green sunfish listed by Hoffman (1967) were as follows: Protozoa (4), Trematoda (29), Cestoda (5), Nematoda (7), Acanthocephala (2), leeches (1), Mollusca (1), Crustacea (4).

This species is known to hybridize in nature with longear sunfish, bluegill, orangespotted sunfish, pumpkinseed and redbreast sunfish.

Relation to man In Canada the green sunfish bears little relation to man. In areas in southwest Ontario where they are locally abundant they may be angled for by children. They can be taken with live bait, flies, or small spinners and poppers. They apparently strike hard but struggle little. They are doubtless good eating although small. In some areas of the United States, they are an important game fish.

Nomenclature

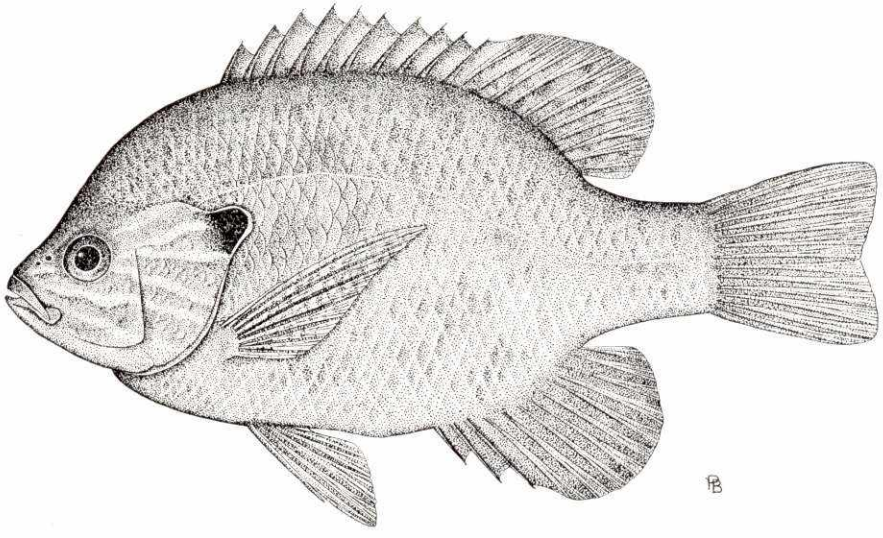
Lepomis cyanellus	— Rafinesque 1819: 420 (type locality Ohio River)
Apomotis cyanellus (Rafinesque)	— Jordan and Evermann 1896–1900: 996

Etymology *Lepomis* — scaled operculum; *cyanellus* — blue.

Common names Green sunfish, green perch. French common name: *crapet vert.*

PUMPKINSEED

Lepomis gibbosus (Linnaeus)



Description This is the common sunfish for all but a few locations of Canada. A very deep-bodied, laterally compressed, almost disc-like fish, usually 7–9 inches (178–229 mm) in length; greatest body depth at the fifth or sixth dorsal spine,

27.8–42.5% of total length, angle from snout to origin of dorsal fin steep, back humped, rounded even under dorsal fins; caudal peduncle longer than deep, its depth 10.7–15.1% of total length. Head quite deep, rather long, length 26.1–31.5% of total length, narrow, angle steep, pronounced hollow over eye, opercular flap flexible only at tip, black at centre with narrow, coloured border and red spot; eye moderately large, diameter 21.7–36.1% of head length, ahead of centre of head and moderately high; snout length 19.5–29.0% of head length; mouth terminal, only slightly oblique, rather small, gape reaching only to anterior nostril; maxillary short, 27.3–36.0% of head length, reaching to posterior nostril or anterior edge of eye; many short needle-like teeth in brushlike patches on jaws, and a single row on vomer, no palatine teeth; lower pharyngeal teeth, on pads at least $\frac{1}{2}$ as wide as long, fewer, low, blunt and paved. Gill rakers short, stubby, about 8 on lower limb, 4 on upper. Branchiostegal rays 6, 6 and 7, or 7. Fins: dorsals 2, broadly joined and appear as one, base of dorsal fins 45.6–49.6% of total length, usually at least twice length of anal base; first dorsal long, spiny, moderate height, 10 or 11 spines but usually 10, not greatly different in length, last spine about $\frac{2}{3}$ height of second dorsal; second dorsal soft rayed, higher, but with base only $\frac{2}{3}$ that of first dorsal, rays 10–12, usually 11, edge shallowly rounded; caudal only moderately broad, somewhat longer, shallowly forked, tips rounded; anal fin with base 22.8–25.7% of total length, less than $\frac{1}{2}$ dorsal base, 3 sharp spines precede the 8–11 (usually 9) soft rays, base of spiny portion about $\frac{1}{3}$ length of base of soft part, but height is over $\frac{1}{2}$ height of soft part; pelvics thoracic, origin under first or second dorsal spine, 1 spine and 5 soft rays, fin moderately long, tip pointed, edge square; pectorals moderately high on body, not overly broad but long and pointed, length 20.5–30.0% of total length, 12–14, but usually 13 rays. Scales usually ctenoid, not large, crowded dorsally front and rear; lateral line complete, high with long shallow arch over pectoral fin, 35–47 lateral line scales. Peritoneum silvery; intestine well differentiated, usually 7 or 8 moderately long pyloric caeca. Vertebrae almost always 29, rarely 28.

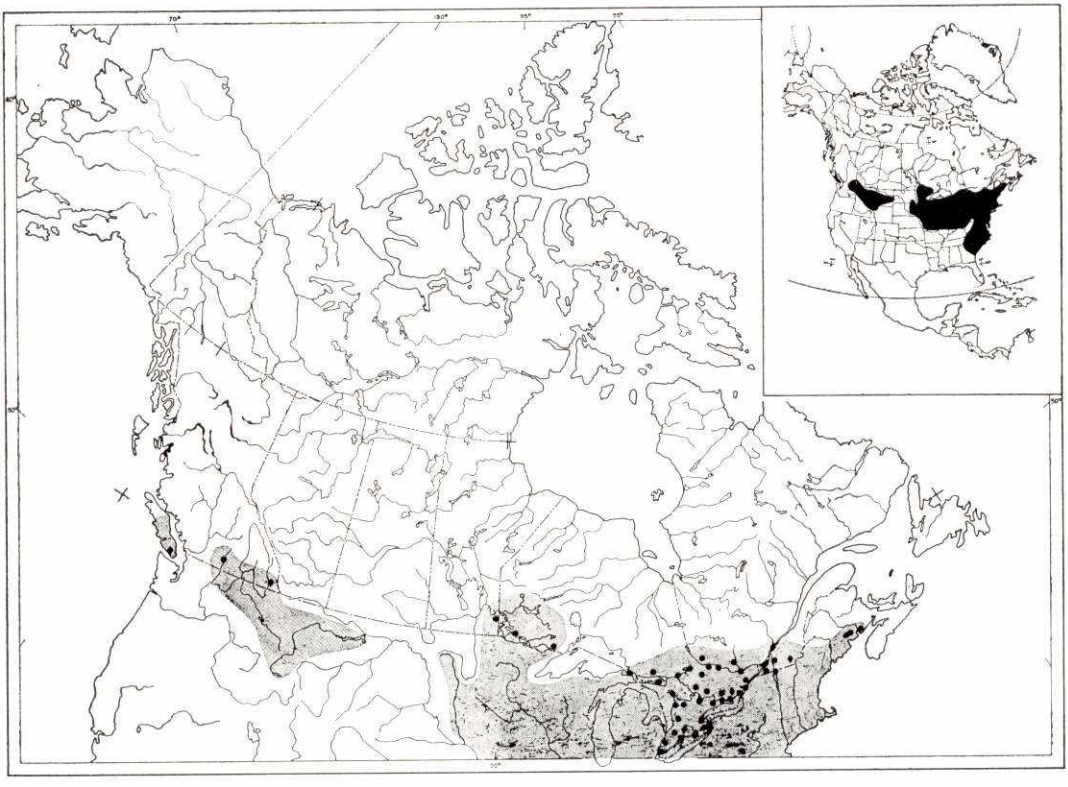
No nuptial tubercles but colours intensify at spawning time.

Colour Dorsal surface of head, body, and upper sides golden brown to olive, lower sides golden with irregular, wavy, interconnecting blue-green lines, ventral surface bronze to red-orange; sides of body and head flecked with spots of olive, orange, or red and with blue, emerald, or green reflections. Sides with several vague vertical bars; sides of head with prominent, wavy, blue-green stripes; pupil of eye black, a narrow, iridescent, golden ring around this and larger area brownish dorsally, blue-green ventrally; opercular flap with wide, black centre, a narrow border of white, yellow, orange, or blue with small halfmoon spot of bright red (sometimes orange, pink, or yellow) at tip; leading edge of dorsal spines black, membranes of second dorsal, caudal, anal, and pelvic fins black but no pronounced or distinct large black spots, small vague orange to olive spots on membranes of second dorsal and caudal fins, leading edge of pelvic whitish, trailing edge of second dorsal, caudal, and anal with narrow, iridescent yellow or blue-green edge; pectoral fins amber and clear.

Females paler; vertical bars more prominent. Hue of pattern variable depending on state and condition of individual, water clarity, and background. All colours intensified in breeding males. Young with much less colour pattern and only green to olive background colour.

The very common hybrid between this species and the bluegill more closely resembles this species in colour and opercular flap pattern. The hybrid usually has a vague suggestion of the spot at the posterior base of the second dorsal characteristic of the bluegill.

Systematic notes This species is not usually divided into subgroups. In the material examined the only suggestion of meristic variability was a slight tendency for western populations to have one more dorsal and anal soft ray.



Distribution The native distribution of the pumpkinseed is restricted to the fresh waters of eastern North America. It has, however, been widely introduced elsewhere in North America, England, France, the Low Countries, Germany, and the basin of the Danube River.

In North America it occurs from New Brunswick south along the Atlantic seaboard to northeastern Georgia. West of the Appalachian Mountains it occurs from southern Quebec to southern Ohio, west to northern Missouri, north through eastern South Dakota to eastern Manitoba, east through western Ontario, Minnesota to Michigan and across southern Ontario. Introduced at least into California, Wyoming, Montana, Washington, and Oregon, and probably many other states west of its natural range.

In Canada it occurs from southwestern New Brunswick, southern Quebec including the St. Lawrence River and tributaries, Lake Champlain, eastern Townships and the Ottawa River and its tributaries (introduced northward in Quebec). This is the common sunfish in Ontario, occurring generally north to a line from the Ottawa River, north of Lake Nipissing to Sault Ste. Marie. It is absent west to the height of land but present in the Nelson River drainage of western Ontario and southwestern Manitoba. It occurs in southeastern British Columbia as natural migrants from individuals introduced in the Columbia River in the United States, and in southern Vancouver Island as a result of introductions.

Biology One of a very few published studies of the biology of this species in Canada is that of Reid (1930) in New Brunswick. Spawning of this very decorative sunfish usually begins in late spring to early summer, although nests were occupied as late as July 11 in New Brunswick, and Bensley (1915) stated that spawning continued to the end of August in Georgian Bay. The nest, constructed by the male, is in the shallow

water of ponds, lakes, or slow moving streams, usually in depths of 6–12 inches (152–305 mm) near shore. Nest building by males begins when water temperature reaches approximately 68° F (20° C) but nesting has been noted in August at 82° F (27.8° C). Nests are shallow depressions 4–16 inches (102–406 mm) in diameter, (usually 2 × length of adult), are found in areas of submerged aquatic vegetation, and often are numerous and very close together. Bottom type can be clay to sand, gravel or rock, as the male sweeps only deep enough to expose a clean, hard bottom. Often exposed roots are used for egg attachment. Sex recognition, courtship, and spawning behaviour were described by Noble (1934) and Breder (1940), and summarized by Breder and Rosen (1966). There is considerable display and swimming in a circular path during courtship and mating. Mutual bunting and nipping also stimulates spawning. Egg laying takes place during these circulations with the male upright and the female at a 45° angle, so that their ventral surfaces are together. Small numbers of eggs and small quantities of sperm are emitted at irregular intervals. Males may spawn more than once in the same season, in the same nest, with the same or different females. Eggs, which are pale amber in colour and about 1 mm in diameter, adhere to the bottom of the nest on soil particles, small stones, roots, and sticks. Egg number increases with size and has been given (Ulrey et al. 1938), for females 2–5 years of age and 2.9–3.7 inches (61–92 mm) in length, as 600–2923 with the average number per female ranging between 1684 and 2923. Elsewhere it was estimated to be as high as 5000. Obviously more than one female may spawn in one nest as Carbine (1939) counted the fry associated with individual nests and reported the numbers to range from 1509–14,639, with an average of 8074. The male guards the eggs and fans them, and guards the newly hatched young for a period of a few days. Hatching takes place in as little as 3 days at 82.4° F (28° C). The newly hatched young are minute and transparent, for some time only the dark eyes are visible. Fish (1932) gave details of the development of the young. For a period of up to eleven days the male guards the young, returning them to the nest in his mouth if they stray. After this time, the young leave the nest and the male may begin to clean the nest in preparation for a second spawning. Shoemaker (1947) reported what appears to be a case of mutualism in the association of a chain pickerel and pumpkinseed. The chain pickerel remained undisturbed over the pumpkinseed's nest and fed on golden shiners which moved in to eat the sunfish eggs in the absence of the male pumpkinseed.

Growth is moderately fast, with young-of-the-year in Ohio reaching 0.8–3.2 inches (20–81 mm) in length in October. The following table gives age–length relation for pumpkinseeds in New Brunswick (Reid 1930), and Ontario (MacKay 1963) and compares these with that for Michigan (Bailey and Lagler 1938).

Age	Welch Lake N.B. Avg SL		Various Ontario lakes FL		Michigan pond TL	
	(*inches*)	(*mm*)	(*inches*)	(*mm*)	(*inches*)	(*mm*)
0	1.0	25	–	–	2.0	51
1	2.9	74	3.5	89	2.9	74
2	3.5	89	4.2–6.0	107–152	4.1	104
3	4.1	105	4.7–7.2	107–183	4.9	124
4	4.4	111	4.8–8.2	122–208	5.7	145
5	4.6	116	6.3–8.0	160–203	6.2	157
6	4.7	120	7.0–8.7	178–221	6.8	173
7	4.9	125	7.5–9.0	190–229	7.3	185
8	–	–	8.7–9.1	221–231	7.8	198
9	–	–	8.5–9.5	216–241	–	–

Weights in the Lake Simcoe area of Ontario increased from 1–2 ounces at age 3, to 8–12 ounces at age 7. The larger, older Ontario fish were from the St. Lawrence River. Comparisons are difficult from the table as a result of the different lengths used, but Smith (1952) said that growth in Welch Lake, N.B., was somewhat faster to 4 years of age than that for particular habitats in Michigan, after that, growth in Michigan was faster. In small productive bodies of water with large populations, stunting takes place and maximum length may not exceed

4–5 inches (102–127 mm). Sexual maturity is usually achieved by age 2.

Maximum size and age in Ontario would appear to be about 10 inches (254 mm), 17 ounces, and 8–10 years. This is interesting in light of the fact that Trautman (1957) gave maximum length for Ohio as 8.8 inches (224 mm) and weight of 11 ounces. The pumpkinseed has dispersed farther north than the other lepomid sunfishes and may do better in Canada than in the southern part of its range.

This sunfish is usually found in small lakes, ponds, shallow, weedy bays of larger lakes, and in the quiet water of slow-moving streams. It prefers clear water and the cover of submerged vegetation or brush, and ranges over various type of bottom. They are usually seen in large numbers and often near, or at, the surface of areas exposed to the sun. It is one of the most widely distributed fishes in Ontario and often makes up the largest part of the fish population of small bodies of warm water. Black (1953) determined the upper lethal temperature for pumpkinseeds, acclimated at 64.4° and 75.2° F (18° and 24° C), to be 82.4° and 86.4° F (28.0° and 30.2° C). Brett and Sutherland (1965) gave figures on respiratory metabolism in relation to swimming speed.

In virtually the only published study of a Canadian population of this species, Reid (1930) said that food taken in Welch Lake, N.B., was, in descending order of frequency, as follows: dragonfly nymphs, ants, larval salamanders, amphipods, mayfly nymphs, midge larvae, roundworms, snails, water boatman, and other insect larvae. Food is mainly a variety of insects and, secondarily, other invertebrates with some shift according to size and season. Small fishes or other vertebrates (such as the larval salamanders mentioned above) can at times contribute as much to the diet of the adults as the most frequently eaten insects. Food is taken at the surface as well as off the bottom and in the water mass. Keast and Welsh (1968) described details of food uptake and diel dietary changes in this species. Keast (1968b) described feeding in winter.

Small pumpkinseeds form part of the food of almost all predatory fishes, and to a lesser extent of the pumpkinseed and other sunfishes. They are eaten by the basses, walleye, yellow perch, northern pike, and muskellunge.

Bangham and Hunter (1939) listed parasites of this species from Lake Erie, Bangham and Venard (1946) from Algonquin Park, Ont., and Bangham (1955) from Lake Huron.

Parasites listed for this species over the whole of its range by Hoffman (1967) were: protozoans (5), trematodes (60), cestodes (8), nematodes (14), acanthocephalans (7), leeches (3), molluscs, crustaceans (6), and linguatulans (1).

One parasite seen regularly on this species is black-spot — the resting stage of a trematode of which the belted kingfisher is the final host which causes small black spots on the fins.

The pumpkinseed is known to hybridize in nature with the warmouth, and the redbreast, green, orangespotted, bluegill, and longear sunfishes. Hybrid sunfishes are often fertile and recross with other hybrids as well as with one or both parents. Hybridization occurs between the pumpkinseed and the bluegill to such an extent that in some eastern Ontario lakes it is virtually impossible to designate true parental types. Hybridization in sunfishes was extensively studied by Hubbs and co-authors in the 1920's and 1930's and by Bailey and Lagler (1938). *See* the latter for various literature references.

Relation to man It would not be an exaggeration to say that the capture of this sunfish has probably delighted more children than that of any other Canadian freshwater fish. They occur in large numbers in shallow, sheltered situations, close to shore, attack even small pieces of live bait viciously, and fight strongly if erratically. Because of their size, they are usually ignored by the adult angler. Their flesh is white, flaky, sweet, and delicious. On light tackle with flies, "bugs," or poppers they can provide considerable sport and may be readily available when and where larger fish are not. There are usually

no regulations covering size or bag limits for this species.

In some areas of Ontario and Quebec the pumpkinseed constitutes a commercial fish of some importance. They are usually caught in hoopnets set in the shallows. The catches of this species and the bluegill are recorded and marketed together in Ontario as sunfishes. In 1966, the total catch there was 253,015 pounds, worth nearly $29,000. The major producers in order of production were: Lake Ontario, southern inland lakes, Lake St. Clair, and Lake Erie.

Nomenclature

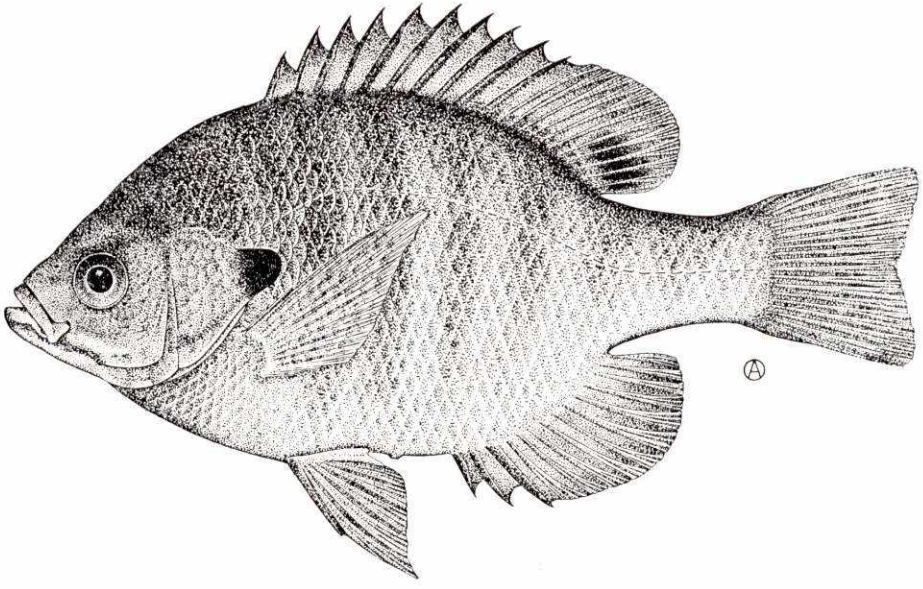
Perça gibbosa	— Linnaeus 1758: 292 (type locality the Carolinas)
Pomotis vulgaris	— Richardson 1836: 24
Lepomis gibbosus	— Kendall 1895: 48
Lepomus gibbosus	— Cox 1896b: 70
Eupomotis gibbosus (Linnaeus)	— Jordan and Evermann 1896–1900: 1009
Lepomis gibbosus Jordan and Gilbert	— Bean 1903b: 483
Lepomis gibbosus (Linnaeus)	— Hubbs and Lagler 1939: 34

Etymology *Lepomis* — scaled operculum; *gibbosus* — gibbous, or like a full moon, referring to body shape.

Common names Pumpkinseed, pumpkinseed sunfish, yellow sunfish, common sunfish, sunfish, sunny, punky, sun bass, pond perch. French common name: *crapet-soleil.*

BLUEGILL

Lepomis macrochirus Rafinesque



Description This, the largest but second most common sunfish (other than the basses) in Canada, has a very deep, compressed body and individuals are usually 7–8 inches (178–203 mm) in length. Greatest depth, at third dorsal spine, 29.4–37.4% of total length; angle from snout to dorsal fin moderately steep, back rounded under dorsal fin; caudal peduncle rather long and narrow, its depth about 12% of total length. Head deep, moderately long, length 24.7–26.8% of total length, head narrow, angle of dorsal surface moderately steep, slight notch in dorsal surface before, and often behind, eye, head bluntly pointed; opercular flap rather long and deep, bone extends almost to tip and is fimbriate, but flap quite flexible over much of its length, totally black with no pale or coloured margin or spots; eye rather large, diameter 26.9–35.7% of head length, ahead and above centre of head; snout rather long, 20–25% of head length; mouth terminal, slightly oblique, rather small, lower jaw a little longer than upper jaw, lips prominent, gape reaching to anterior nostril, maxillary rather short, 26.3–31.6% of head length, reaching almost to anterior edge of eye; brushlike teeth present on jaws and vomer, lower pharyngeal teeth on longer, narrower pad than pumpkinseed, are numerous, conical and bluntly pointed. Gill rakers moderately long, slender, blunt, usually 12 on lower limb, and 4 on upper limb. Branchiostegal rays usually 6, rarely 6 and 5. Fins: dorsals 2, but broadly joined and appear as one, base of dorsal fins about 40% of total length and twice the length of the anal base, first dorsal fin long, spiny, moderately high, usually 10 but rarely 11 spines, edge rounded, length of last spine almost equal to height of second dorsal; second dorsal fin soft rayed, very little higher than first dorsal, base a little less than $\frac{2}{3}$ base of first dorsal, rays usually 11, but frequently 10–12, edge rounded; caudal moderately broad, shallowly

forked, tips rounded points; anal with moderately long base, about 20% of total length, about $\frac{1}{2}$ dorsal base, 3 graduated, sharp spines and usually 11 rays, rarely 8–10, base of spiny part $\frac{1}{3}$ that of soft part and third spine about $\frac{4}{5}$ height of soft part of anal fin; pelvics thoracic, origin under second dorsal spine, base with broad membranous connection to abdomen, 1 small spine and 5 rays, fin rather long, overlaps anal origin, moderately broad, tip pointed to produced, edge square; pectorals moderately high on body, rather long, length 20.7–24.7% of total length, edge square to slightly round, tip pointed, usually 13, but rarely 14 rays. Scales mostly ctenoid, rather small, less crowded except on breast than in some sunfishes (*see* Potter 1925, for detailed discussion of scales of this species); lateral line complete, high except on peduncle, long, shallow arch over pectoral fin, 40–44 lateral line scales. Peritoneum silvery, intestine well differentiated, usually 6 prominent caeca. Vertebrae usually 28 or 29.

No nuptial tubercles but colour intensifies in breeding males. At other times sexes can be differentiated externally by the nature of the urogenital opening (McComish 1968).

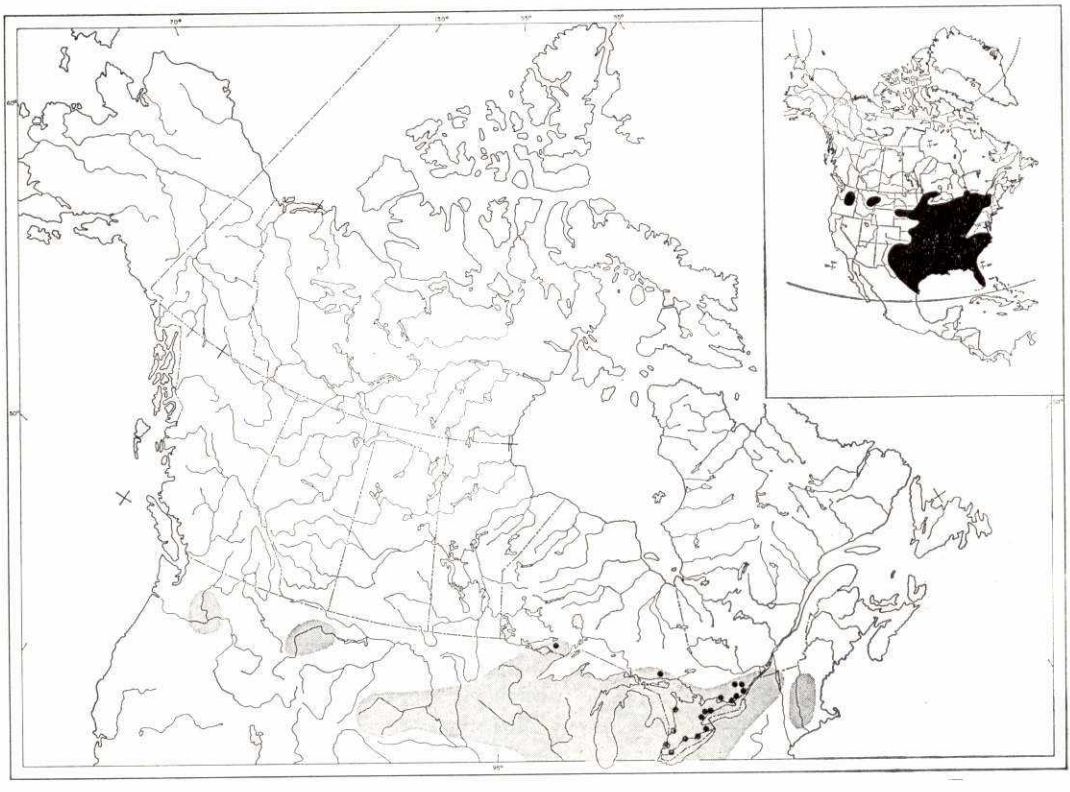
Colour Dorsal surface green, olive to almost brown, with several vague vertical bands extending down sides; upper sides brown to green, shading into brown, orange or pink; lower sides and abdomen behind pelvic fins, silver to white; breast yellow in females and in males most of year, copper-orange in males during breeding season; sides of head brown to green with metallic green and blue overtones, especially on ventral edges of opercular bones; opercular flap black only, often iridescent blue at anterior edge; all fins except pectorals with some black on lower parts of membranes, several membranes at posterior base of second dorsal blending into prominent rounded patch as big as, or bigger than, the eye, often white on leading edge of pelvic and anal fins, pectoral fins usually transparent yellow or amber. *See* colour illustration facing p. 442 for colours of breeding males.

Systematic notes Canadian populations are often listed as part of a northern subspecies, the common bluegill *L. m. macrochirus*, which is considered to intergrade in Arkansas with a form *L. m. speciosus* of Texas and Mexico. Another form, *L. m. purpurascens*, which may be a separate species, is thought to be present in the Atlantic coast streams from Virginia to Florida (Hubbs and Lagler 1964).

Distribution The native range of the bluegill is restricted to the fresh waters of eastern and central North America. It occurs south from the St. Lawrence River west of the Appalachian Mountains to the region of Chattahoochee River in Georgia. A form, usually called *L. m. purpurascens*, occurs in coastal rivers from Virginia to Florida. From Georgia it extends west to Texas and south into northeastern Mexico, north along a line from eastern New Mexico to eastern Minnesota and western Ontario, east, south of Lake Superior, to southern Ontario and Quebec, and into western New York. It has been introduced almost everywhere east and west of this area and definitely in Connecticut, Washington, Montana, Utah, Wyoming, and California. It has been introduced into Africa and possibly other areas off the North American continent.

In Canada it occurs in Quebec, in the upper St. Lawrence, Richelieu–Champlain, and Ottawa systems, generally through all of southern Ontario including the lower Great Lakes, but more abundant in eastern Ontario, absent west in Ontario to the lakehead, but present in the Quetico–Rainy River section of the Nelson River–Hudson Bay drainage. It is probably best known, most abundant, and larger in the Rideau Lake system of eastern Ontario.

Biology There is no detailed account of the life history of a Canadian population of this species. Spawning takes place in late spring to early and mid-summer in Canada, with the peak of activity probably in early July. Spawning in various locations in the



United States is described in detail by Breder (1936b), Carbine (1939), and summarized by Breder and Rosen (1966). Winter aggregations break up when water temperature reaches 50° F (10° C). The males appear first in the shallow water of spawning areas, become aggressive, territorial, begin nest building, and then the females appear. Nesting is colonial, with as many as 30 nests crowded into 160 square feet of suitable territory, in about 2.5 feet (814 mm) of water. By rigorous fanning with the fins the male clears an area, often 18–24 inches in diameter, making a shallow depression down to a firm bottom of gravel, sand, or mud. The same nest may be used by one or more males, with one or more females, over a spawning period extending as late as August with water temperatures as high as 76° F (24.5° C). The male defends the nest, before and after spawning, against all species but most vigorously against other male sunfishes. Many intermittent periods of spawning take place. Prior to spawning the parents swim about the nest in a circular path. They eventually come to rest with the male upright and the female at a 45° angle with their ventral surfaces touching. A few eggs and some milt are released and the pattern begins again. Egg number varies greatly with size of female. Mayhew (1956) estimated egg number for females 5.5–7.2 inches (140–183 mm) standard length and 142–269 g weight, to range from 7200 to 38,184. The eggs are small, amber in colour, demersal, and adhesive. Hatching takes place in approximately 3–5 days. Several females usually spawn in one nest and hatching success is high, since it has been determined that the number of fry resulting from a single nest can be from 4670 to 224,900. Obviously mortality rate of fry and young is correspondingly high. The nesting male probably guards the newly hatched young for a short period. Newly hatched fry are 2–3 mm in length.

Growth is rapid and Trautman (1957) said that young-of-the-year in Ohio were 0.7–3.2 inches (18–81 mm) long. Validation of the scale method of determining age and growth in this species was summarized by Regier (1962). There is no available analysis of age and growth in a Canadian population. That given in the following table for Michigan lakes by Beckman (1949) and for eight northern Wisconsin lakes by Snow (1969) may be slightly higher than the probable relation in Canada.

TTL

Age	Michigan lakes (*inches*)	(*mm*)	Wisconsin 8 northern lakes (*inches*)	(*mm*)
0+	1.7	43	–	–
1+	3.1	79	1.5	38
2+	4.3	109	3.1	79
3+	5.4	137	4.3	109
4+	6.6	168	5.6	142
5+	7.3	185	6.5	165
6+	7.7	196	7.2	183
7+	8.2	208	7.9	201
8+	8.4	213	8.0	203
9+	8.7	221	8.3	211
10+	8.9	226	–	–

In the Wisconsin data, length was given as completed years growth i.e., read age "n+" as "n".

This species sometimes attains lengths of 10–12 inches (254–305 mm) in the Rideau River system connecting the St. Lawrence and Ottawa rivers in eastern Canada. Elsewhere in Canada it often does not exceed 6–8 inches (152–203 mm) in length. This is the only species of the smaller sunfishes for which angling records are kept. The present record is one 15 inches (381 mm) long and 18¼ inches (463 mm) in girth which weighed 4 pounds 12 ounces, and was caught in Ketona Lake, Ala., in 1950.

Trautman (1957) gave maximum size in Ohio as 11.8 inches (300 mm) in length and 1 pound 3 ounces in weight. Maximum age would appear to be 8–10 years. Sexual maturity in Canada is probably attained by age 2 or 3 for males and 3 or 4 for females.

The bluegill inhabits the shallow, weedy, warm water of large and small lakes, ponds, and the heavily vegetated, slowly flowing areas of small rivers and large creeks. Groups of them retreat to deeper water in winter where they congregate in colonies but continue feeding. In summer they utilize small territories, move little, and an individual can be observed in the same place for hours. In the hottest periods of summer the largest individuals may move down as deep as 20 feet (610 m).

The food of this species is generally considered to be insects, crustaceans, and plant material. Keast and Webb (1966) considered the bluegill the most generalized feeder in Lake Opinicon (Rideau system) since up to 9 types of food formed 5% or more of its diet and it fed on the surface, in the water mass, and off the bottom. Only proportion and not composition varied with size, age, and season. The major foods of this species in Lake Opinicon were chironomid larvae (to 50% of the food volume of any individual), Cladocera (30%), amphipods and isopods (10%), flying insects (35%), Odonata nymphs (20%), Ephemeroptera nymphs (10%), Trichoptera larvae (15%), molluscs (15%), fish fry (10%). Small quantities of ostracods, copepods, and algae were also present. Keast and Welsh (1968) gave details on feeding times and rate of uptake of food in Lake Opinicon. Moffett and Hunt (1943) gave details on winter food. In other areas, plant material constituted as high as 22% of the diet of larger bluegills in late summer when insects were not as abundant. An argument has long been waged about the role of ingested plants and the ability of this species to derive nutrition from them. Kitchell and Windell (1970) showed that fish fed algae alone lost less weight than unfed fishes, those fed algae and animal protein gained weight faster than those fed animal protein alone. They determined that a 30-g bluegill would have to consume an amount of the algae *Chara* comparable to 5.5–5.9% of body weight per day to support maintenance alone.

Keast and Welsh (1968) described details of food uptake and dietary changes in this species. Keast (1968b) described feeding in winter.

The young and smaller adults of the bluegill are common in the diet of a wide variety of predaceous fishes as is evidenced by their use as the prey species in pond cultures of largemouth bass and northern pike. In lakes containing large populations of bluegills, they can be serious competitors for bottom organisms with other fishes. It has been calculated that they often consume up to 6 times their own weight and seriously deplete the bottom fauna.

The parasites listed by Hoffman (1967) for this species, over the whole of its range, were as follows: protozoans (9), trematodes (56), cestodes (8), nematodes (11), acanthocephalans (5), leeches (6), molluscs (1), crustaceans (12). Parasites of this species in Lake Erie were listed by Bangham and Hunter (1939). One parasite seen regularly on this species is black-spot — the resting stage of a trematode, of which the belted kingfisher is the final host — which causes the development of small black spots on the skin. These are harmless to humans.

This species is known to hybridize with the longear, orangespotted, green, redbreast, redear, and pumpkinseed sunfishes, and the warmouth. In many cases the hybrids are fertile and able to mate with both parents and with hybrids. The hybrid of this species and the pumpkinseed occurs virtually wherever these two live together in Canada. The degree of hybridization is so great and the range of characters so confusing as to make it almost impossible to separate hybrids from backcrosses with parental species, or even to designate pure parental forms.

Relation to man The bluegill is enjoyable simply as an active, colourful, and obvious part of the life of our fresh waters. They are inquisitive, fearless fish which come readily to the surface, or near the shore, to be fed with crumbs or oatmeal. They test the edibility of everything on or in the water, such as floating debris and even bathers' toes or fingers. Because of their colour, activity, and habitat the bluegill and the pumpkinseed are more often seen, recognized, and enjoyed by large numbers of people than any other species. They might almost be called free-living "ornamental" fishes. They are also sport fish and commercial fish but less so in Canada than in the central United States where they constitute one of the main sport fishes. The combination of very light fly rod, wet flies, dry fles, small poppers or "bugs," and bluegills are an angling delight. They attack the bait in groups, bite hard and fight hard. A large bluegill on a fly, pressing its deep body in a circular path, is hard for a fly fisherman to control. They can provide considerable enjoyment for young anglers using a small hook and small pieces of live bait. Bluegills are marketed usually by fishermen who set hoopnets in the shallows of lakes and rivers in Ontario and Quebec. They are marketed, with the pumpkinseed, simply as sunfish. The combined catch in Ontario in 1966, was 253,015 pounds with a value of nearly $28,812.48. The fishing grounds in descending order of catch in that year were: Lake Ontario, southern inland lakes, Lake St. Clair, and Lake Erie. The flesh is white, flaky, sweet, and delicious, but this species is most often ignored by Canadian anglers as a food fish.

The bluegill is one of the commonest forage fishes stocked with largemouth bass or northern pike in ponds and lakes managed for angling.

Nomenclature

Lepomis macrochira

?*Lepiopomus pallidus* (Mit.) Gill and Jor.
Lepomis Auritus
Lepomis pallidus (Mitchill)
Helioperca incisor Cuvier and Valenciennes
Helioperca incisor (Cuvier and Valenciennes)
— Rafinesque 1819: 420 (type locality Ohio River)
— Jordan 1877a: 35
— Small 1883: 36
— Jordan and Evermann 1896–1900: 1005
— Hubbs 1926: 72
— Hubbs and Greene 1928: 392

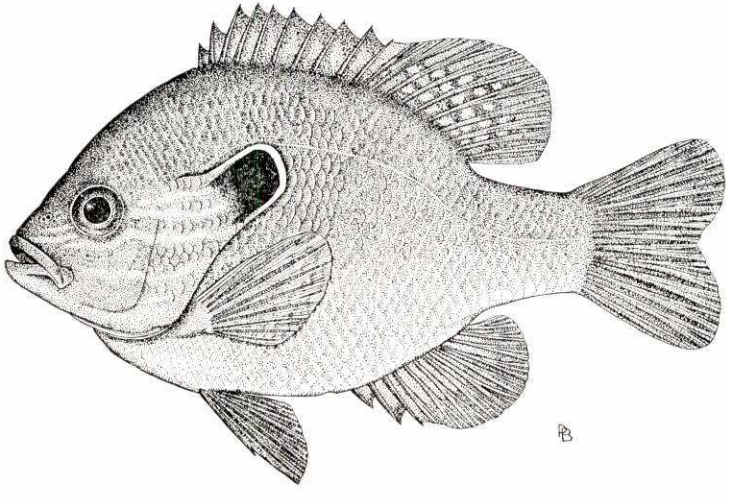
Helioperca macrochira (Rafinesque) — Dymond 1939: 39
Lepomis macrochirus macrochirus Rafinesque — Hubbs and Lagler 1941: 79
Lepomis macrochirus — Radforth 1944: 61

Etymology *Lepomis* — scaled operculum; *macrochirus* — large hand, possibly in reference to body shape.

Common names Bluegill, blue-gill, bluegill sunfish, northern bluegill sunfish, common bluegill, blue sunfish, sunfish, bream, blue bream, bluegill bream, roach. French common name: *crapet arlequin.*

LONGEAR SUNFISH

Lepomis megalotis (Rafinesque)



Description A very deep-bodied, laterally compressed, usually short fish; individuals in Canada usually only 3–6 inches (76–152 mm) in length; greatest depth at first to third dorsal spine, usually 31.4–41.5% of total length, greater in some populations and in smaller individuals, angle from snout to dorsal fin rather steep, back flat to rounded, caudal peduncle moderately deep. Head deep, moderately long, 27.5–32.2% of total length, head narrow, dorsal angle rather steep, depression over eye in males, often absent in females; opercular flap long, wide, turned-up, black, with pale red to yellow margin particularly at tip and along ventral edge, bone extends to near edge and

is crenate, but flap flexible; eye diameter 25.0–38.5% of head length, eye well ahead and above centre of head; snout moderately short; mouth terminal, slightly oblique, moderately large, jaws equal, gape reaching posterior nostril maxillary reaching to, or just past, anterior edge of eye, length 29.4–39.3% of head length; many fine teeth on jaws, teeth absent from palatines, lower pharyngeal pad narrow, teeth less numerous, short, and pointed. Gill rakers moderately short, thick, and blunt, usually 12 on lower limb, 5 on upper limb. Branchiostegal rays usually 6 but at times 6 and 7, or 7. Fins: dorsals 2, but broadly joined and appear as 1, base of dorsal fin greater than twice anal base, base of first dorsal fin little longer than that of second, first dorsal with 10 or 11, rather low, even spines, last spine less than $\frac{1}{2}$ height of second dorsal fin, second dorsal higher, almost as long, edge rounded, 10–12, usually 11, soft rays; caudal broad, well forked, tips round; anal base less than $\frac{1}{2}$ that of dorsal, 3 graduated, but rather short spines and 10–12, usually 10, soft rays, base of soft portion almost as long as second dorsal, not high and quite rounded; pelvics thoracic, origin under second dorsal spine, length overlaps origin of anal fin, 1 small spine and 5 rays, edge square to rounded, tip pointed; pectorals rather high, short, length 16.4–23.4% of total length, and round, 10–13 rays, usually 12. Scales mostly ctenoid, rather small, crowded on nape and breast; lateral line complete, very shallow arch under dorsal fins, 33–38, usually 35, lateral line scales. Peritoneum silvery, intestine well differentiated, usually 7 prominent pyloric caeca. Vertebrae 28–30, usually 29.

No nuptial tubercles, pattern and colours considerably intensified in breeding males. Young with much smaller opercular flap and much less colour.

Colour Body usually highly colourful, upper surface olive to rusty brown, sides of body and head spotted or mottled with orange and emerald to turquoise, 8–10 vertical bars conspicuous to absent, cheeks orange, with wavy blue streaks or bars radiating back from mouth and eye, breast and ventral surface of body pale red, orange to yellow, fins other than pectorals brownish to orange, with some black pigment near bases of membranes, pectoral fins clear to dusky. The ear flap is usually long, wide, turned up, and black, edged with pale red to yellow, at least in adults.

Systematic notes The Canadian populations are usually included within the form *L. megalotis peltastes* Cope. Its counterpart, *L. m. megalotis,* occupies the southeastern area of the distribution of the species. The two were said by Trautman (1957) to intergrade along the Lake Erie–Ohio River divide. Other subspecies such as *breviceps* and *haplognathus* have been described from other parts of the range. Gruchy and Scott (1966) suggested the number of diagonal scale rows from the origin of the anal fin to the lateral line was lower (average 12.2) in specimens from northwest Ontario, than that given for the species farther south (14).

There appears to be little variation over its limited Canadian range. Material examined yielded lateral line scale counts of 33–37, but Legendre (1954) listed 33–39 for Quebec, and American authors listed 36–45.

Distribution This sunfish is restricted to the fresh waters of east-central North America. It occurs from southern Quebec south, west of the Appalachian Mountains, to the Gulf coast in Alabama. Moore (1968) included the east coast as far north as South Carolina. It extends west through eastern Texas and the Rio Grande tributaries in northeast Mexico, north through the eastern parts of the states from Oklahoma to central Minnesota, and in western Ontario; east, south of Lake Superior, through Wisconsin, Michigan, part of southern Ontario and Quebec, and into western New York. Less widely introduced outside its native range than most other sunfishes.

In Canada the longear sunfish occurs in the extreme upper St. Lawrence River system in Quebec, absent southwest to Ontario tributaries of central Lake Erie, occurs in

tributaries of Lake St. Clair, Lake Huron, and Georgian Bay north to near the French River. Its presence in Ontario west of Lake Superior was unknown until reported by Gruchy and Scott (1966). It has since been taken in several more localities in Quetico Park in the Hudson Bay watershed. The populations in western Ontario are apparently isolated by some distance from the nearest populations in Minnesota. Possible explanations for this isolation were given by Gruchy and Scott.

Apparently the first authentic Canadian records of this species were those from tributaries of lakes Erie, St. Clair, and Huron by Hubbs and Brown (1929). Previous listings in Canadian works were on the basis of United States records for southern tributaries of the Great Lakes.

Biology Nothing is known of the biology of this species in Canada. Spawning habits were summarized by Breder and Rosen (1966) and those of the southern form were given by Witt and Marzolf (1954). Spawning probably takes place from late June to August, when water temperatures are 74°–77° F (23.4°–25.0° C). The males build saucer-shaped nests in gravel if available but otherwise in sand or hard mud. The nests are about 18 inches (457 mm) in diameter, close together, and in about a foot (305 mm) of water. The males are very territorial, aggressive, (*see* Huck and Gunning 1967) and defend nest, eggs, and young against much larger fishes, particularly bottom-swimming species. The circular swimming, vibrations, the vertical position of the male and 45° position of the female during the brief, intermittent spawning acts is typical of the family. The eggs are 1 mm in diameter, demersal, adhesive, amber to pale yellow in colour, and from 2360 to 22,119 in number for females 2–4 years of age. The male fans and guards the eggs during the 3–5 days they take to hatch. He also guards the tiny young for a few days. In Ohio the young-of-the-year in October were 0.8–1.8 inches (20–46 mm) in length (Trautman 1957).

There are no available growth rates for Canadian populations. Those given by Hubbs and Cooper (1935) for a 110–150 day growing season in Michigan probably approximate growth in Canada.

	TL	
Age	(*inches*)	(*mm*)
0+	0.9	23
1+	2.2	56
2+	2.9	74
3+	3.9	99
4+	4.5	114
5+	5.5	140
6+	5.5	140

Sexual maturity is probably attained at 2–4 years of age, and by males before females. Trautman (1957) gave maximum length in Ohio as 4.8 inches (122 mm) and a weight of 2 ounces. The largest individual taken in Canada was 5.9 inches (150 mm) long. Maximum age is probably 8 years. Many authors claim there is considerable dwarfing of this species in the northern part of its range. This species is very small in Canada but large population size cannot be the cause of dwarfing here, if it is such.

The locations from which this species has been taken in Canada vary from moderate-sized, shallow rivers, to ponds, to small lakes. Longear sunfish are usually found in shallow, clear, nearly still, moderately warm water, in or near areas of aquatic vegetation.

This species apparently feeds more extensively at the surface of the water than do some other sunfishes, and mature insects constitute a large percentage of their food. Insects in general and other invertebrates are the main food items. However, some authors record small fishes as a minor part of its diet.

The longear sunfish is nowhere abundant enough in Canada to form either a serious competitor of, nor a prominent food of, other fishes.

Parasites listed for this species, over the whole of its range, by Hoffman (1967) were: protozoans (1), trematodes (17), cestodes (2), nematodes (2), acanthocephalans (2), and crustaceans (2). In Canada it no doubt carries black-spot, the resting stage of

trematodes so common in other sunfishes, which is harmless to man.

Bangham and Hunter (1939), listing parasites of fishes of Lake Erie, gave only cysts of *Neascus vancleavei* for this species.

The longear sunfish is known to hybridize in nature with the bluegill, green, and orange-spotted sunfishes.

Relation to man This sunfish is too small, and not abundant enough in Canada to be of any economic importance. The true extent of its distribution in Ontario has only been known for a few years. It is, however, one of the most colourful and attractive freshwater fishes that we have. Its size, bright colour, and still-water habitat would make it a very pleasing aquarium species.

Nomenclature

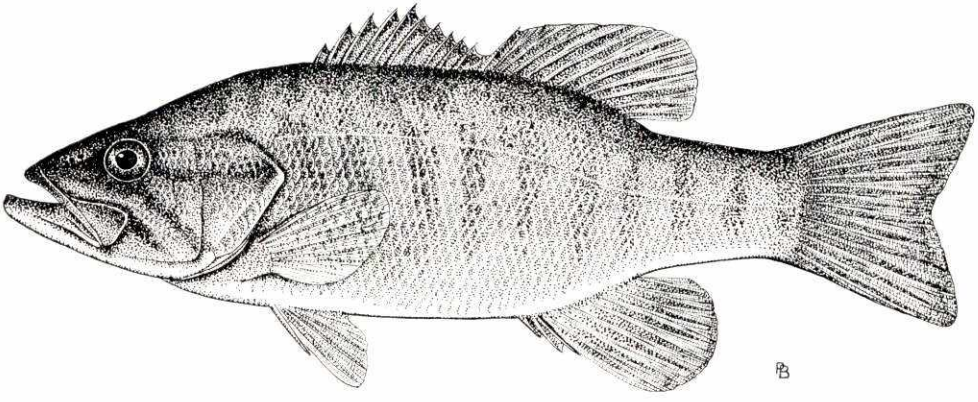
Icthelis megalotis	— Rafinesque 1820b: 49 (type locality Licking and Sandy rivers, Ky.)
Lepomis megalotis Rafinesque	— Halkett 1913: 82
Lepomis megalotis (Rafinesque)	— Dymond 1922: 69
Xenotis megalotis peltastes Cope	— Hubbs 1926: 72
Lepomis megalotis peltastes Cope	— Hubbs and Lagler 1941: 79
Lepomis megalotis	— Radforth 1944: 61

Etymology *Lepomis* — scaled operculum; *megalotis* — great ear, in reference to long, wide opercular flap.

Common names Longear sunfish, long ear or long-eared sunfish, northern longear, Great Lakes longear. French common name: *crapet à longues orielles.*

SMALLMOUTH BASS

Micropterus dolomieui Lacépède



Description A moderately large and robust fish, in the family only the largemouth is larger; body laterally compressed, less so than other sunfishes, cross section a narrow oval. Most individuals seen in Canada are 8–15 inches (203–381 mm) in length. The following percentages and counts are for individuals from Ontario and Quebec. Greatest depth, at origin to middle of first dorsal fin, 20.3–28.2% of total length; angle from snout to back low, back flat to rounded; caudal peduncle long and rather deep. Head large, long, 26.6–30.5% of total length, deep, moderately wide, dorsal surface rounded or with a shallow depression over the eyes, operculum bony to edge, pointed but not extended into a flap, usually a vague black spot near its tip; eye large, its diameter 14.1–30.0% of head length, larger in young; snout long, its length about 35% of head length, deep, bluntly pointed, scales on cheek in diagonal row, from eye downward 14–18 (9 or 10 in largemouth bass); mouth terminal, slightly oblique, lower jaw slightly longer than upper, gape reaching to near front of eye; maxillary long, 40.0–46.7% of head length, but usually reaching just to middle of eye (beyond eye in largemouth bass), posterior edge rounded; fine, brushlike teeth on both jaws, palatines, and vomer; lower pharyngeal teeth on long, narrow pad, numerous, fine, uniform in size. Gill rakers usually 8 on lower limb and 3 on upper limb. Branchiostegal rays 6, 6 and 7, or 7. Fins: dorsals 2, but joined and appear more like one than do those of largemouth bass, first dorsal rather low, with 10 stout spines not markedly different in length, the last appearing to be part of second dorsal; separation between dorsal fins not deep, shortest posterior spine longer than $\frac{1}{2}$ length of longest spine; second dorsal higher, 12–15 soft rays, edge rounded; caudal not markedly long but broad, moderately forked, tips blunt points to rounded; anal with base less than that of second dorsal fin, 3 graduated spines and 10–12 (usually 11) soft rays, edge rounded; pelvics thoracic, origin ahead of origin of dorsal fin, joined by membrane (not so in largemouth bass), less conspicuously joined to body by membrane than in largemouth bass, pelvics not long, 1 spine and 5 rays, tip rounded; pectorals not long, but broad and rounded, 13–15 rays. Scales ctenoid, slightly smaller than in largemouth bass, usually 11–13 rows from lateral line to dorsal origin and 19–23 rows from lateral line to anal origin, a few minute scales on membranes of dorsal and anal fins; lateral line complete, high and little arched, 68–78 lateral line scales. Peritoneum silvery, intestine well differentiated,

7–10 thicker pyloric caeca, few if any branched. Vertebrae 31 or 32.

No nuptial tubercles but colours darken on spawning males and colour pattern of females intensifies.

Colour Variable with size, condition and habitat. In clear, vegetated water or stained water they are darker with pronounced, contrasting markings, in turbid water lighter with vague markings; dorsal surface of back and head brown, golden brown through olive to green, sides lighter, more golden with golden flecks on most scales, ventral surface cream to milk-white; sides of adults with 8–15, pronounced to vague, thin, vertical bars, sometimes broken; head with dark bars radiating backwards from eyes, eye usually red or orange; fins dusky to amber, pectorals clear, others opaque with some black on rays, spines, or membranes.

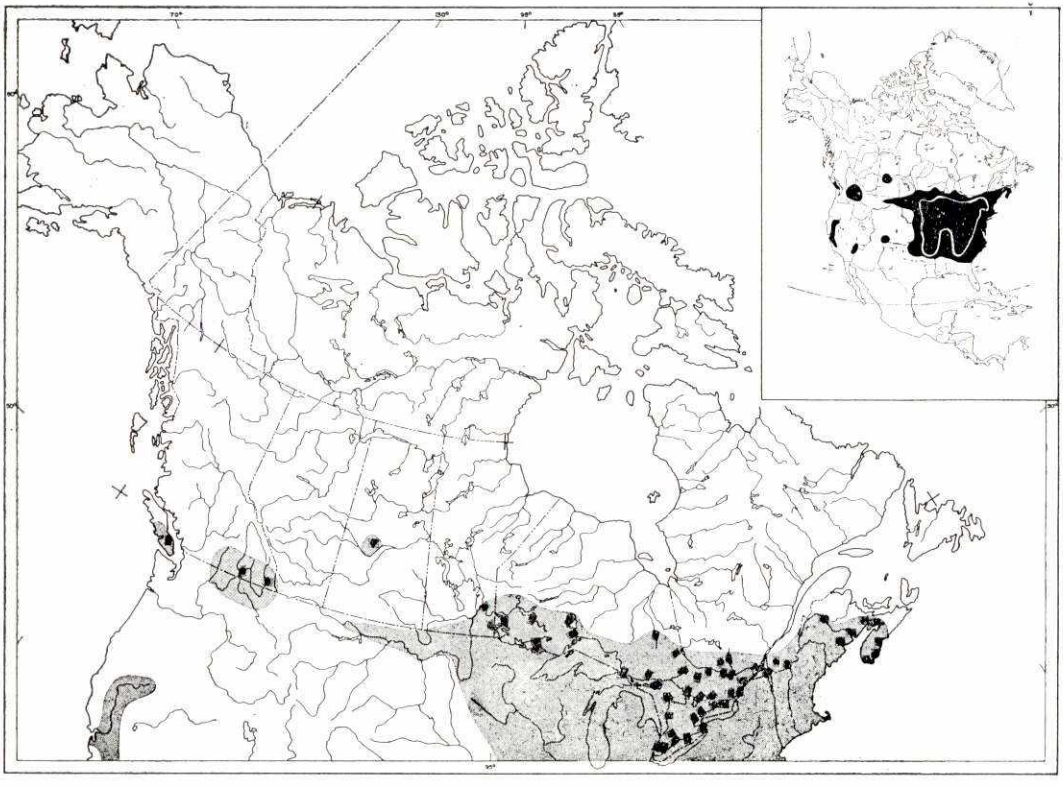
Young much like adults but vertical bars or rows of spots very prominent and caudal fin unmistakably marked orange at base, followed by a black band, and white to yellow tips. *See* colour illustration facing p. 730.

Systematic notes Canadian populations often included in a subspecies *M. d. dolomieui*, and southwestern populations are designated *M. d. velox*. The extent of introduction and artificial culture of this fish would now make it virtually impossible to detect morphometric trends in Canadian populations.

Distribution Originally the smallmouth bass was restricted to the fresh waters of eastern central North America. Its range was expanded starting in the mid-1800's until now it occurs almost everywhere in the United States, many places in England, Europe, Russia, and Africa. Its original range was limited to the Great Lakes–St. Lawrence system (apparently excluding Lake Nipigon but including nearby lakes tributary to the Nipigon River and the north shore of Lake Superior, Dymond 1926) and the systems of the Ohio, Tennessee, and upper Mississippi rivers (white line on inset map, from Hubbs and Bailey 1938). It now occurs generally from Nova Scotia south to Georgia and eastern Alabama, west to northeastern Oklahoma, north, through eastern Kansas to Minnesota, west through North Dakota, in central Saskatchewan, east from southern Manitoba to Quebec and Maine.

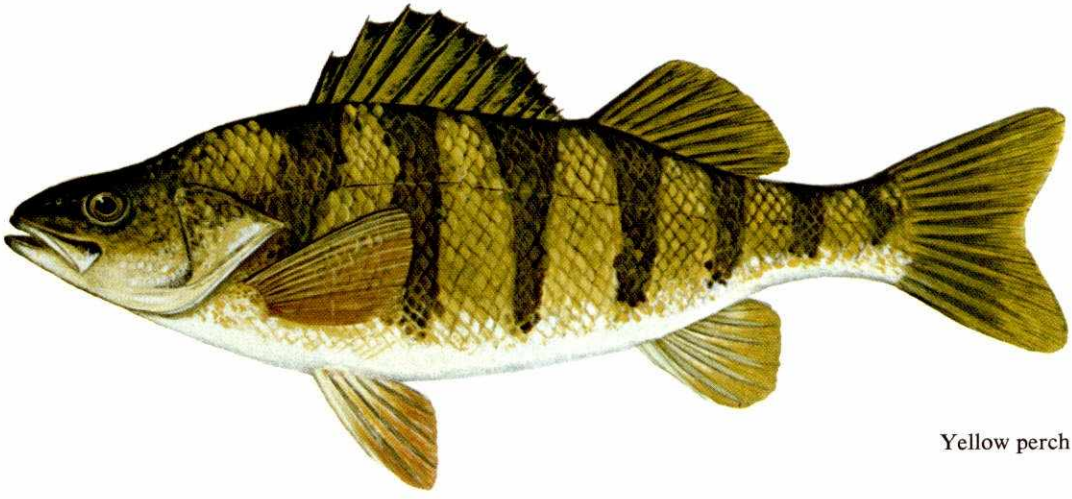
In Canada it occurs in lakes in southern Nova Scotia, southern and western New Brunswick, southern Quebec from Hull upstream in the St. Lawrence River and its tributaries, throughout the eastern townships including Lake Champlain, the Gatineau River, and the Ottawa River system as far north as Temiskaming; through Ontario approximately at the latitude of Timmins and Lake Nipigon (absent from that lake), Manitoba north to the south end of Lake Winnipeg, and in central Saskatchewan. It occurs in eastern British Columbia in lakes of the Columbia River system, and on Saltspring Island and southern Vancouver Island as a result of invasion from introductions in Washington State and by direct introduction. Dates of first Canadian introductions beyond the natural range are: Nova Scotia 1908 (Catt 1949), New Brunswick 1894 and 1901 (Cox 1896b; Dom. Dep. Fish. 1902), Ontario 1901 (MacKay 1963), Manitoba 1900–1942, Saskatchewan 1900–1942, Alberta early 1900's (failed) (Rawson 1945), British Columbia 1901 (Dymond 1936).

Biology Contrary to the case for many Canadian fishes, published information on the biology of the smallmouth bass in Canada is very extensive and dates from 1876. Some of these publications are Wilmot (1876), Loudon (1910), Bensley (1915), Tester (1930), Dymond (1931a), Tester (1932a, b), Rawson (1938), Doan (1939, 1940), Smith (1942), Fraser (1955), Fry and Watt (1957), Rowan (1962), Coble (1967), Turner and MacCrimmon (1970), and several unpublished manuscripts in the Great Lakes Library, Department of Zoology, University of Toronto, Toronto, Ont. A very extensive bibliography of the literature on this species exists in the Division of Research,

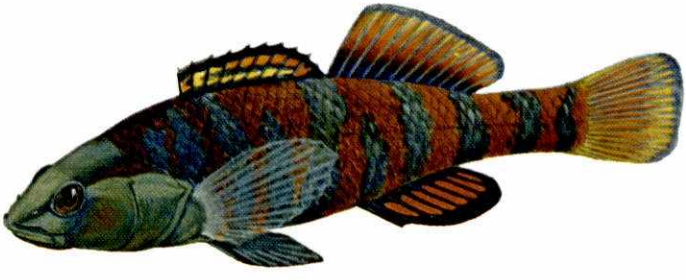


Ontario Department of Lands and Forests. The following information was derived from the works mentioned.

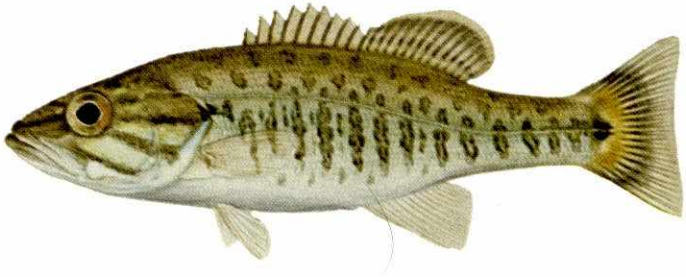
Smallmouth bass spawn, usually over a period of 6–10 days, in the late spring and early summer, most often late May to early July. Nest building and spawning (in some areas) commences over a range of temperatures 55°–68° F (12.8°–20.0° C) but egg deposition takes place mostly at 61°–65° F (16.1°–18.3° C). The male builds a nest 1–6 feet (30.5–18.3 cm) in diameter in 2–20 feet (61–610 cm) of water on a sandy, gravel, or rocky bottom, of lakes and rivers, usually near the protection of rocks, logs, or, more rarely, dense vegetation. Some males return to the same nest in subsequent years and over 85% of them return to within 150 yards of where they nested in previous years. After nest building, there is considerable prespawning activity, display, rubbing, and nipping. The male and female swim about the nest and eventually come to rest on the bottom, their ventral surfaces nearly in contact, with the male vertical and the female at a 45° angle. Actual egg deposition and fertilization takes place for about 5 seconds, and repeated acts take place for a period of about 2 hours with intervening periods of nest-circling lasting 25–45 seconds. Egg number in females, depending on size, apparently ranges from 5000 to 14,000 and is said to approximate 7000 per pound of female. They are light amber to pale yellow in colour, demersal, adhesive, and 1.2–2.5 mm in diameter. They are usually found attached to clean stones near the centre of the nest. After spawning, the female leaves the nest and may spawn in another nest with another male. The male guards the nest, fans the eggs, and guards the young after they hatch. Often 40% of the nests are failures and approximately 2000 fry result from most successful nests. Sudden shifts of temperature upward or downward, changes in water level, and fungal infections kill many eggs. The larger the female and



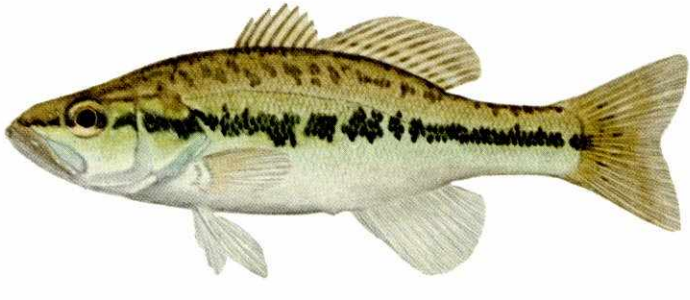
Yellow perch



Rainbow darter



Smallmouth bass



Largemouth bass

guarding male, the greater the hatching success. Hatching usually takes place in 4–10 days over the temperatures common in Canadian situations. The young at this time are 5.6–5.9 mm in length. In an additional 12 days the young have absorbed the yolk and rise off the bottom. At this time they are 8.7–9.9 mm in length. After 5–7 days, they begin to leave the nest but are still guarded by the male for several days. Reighard (1906), Fish (1932), and Doan (1939) gave details of eggs, embryology, and development of young.

Growth is rapid at first and in Lake Nipissing, near the northern limit of distribution, they are 3.2–36.6 mm in length by July and are 2–4 inches (51–102 mm) in length by decline of temperatures in the fall. In Lake Erie, growth of young is 0.8–0.9 mm per day. The age–length and age–weight relations in various Canadian habitats are shown in the following table.

Rowan (1962) gave experimental length–weight relation at 74° F (22.5° C), a temperature common in Canadian habitats, as Log W(g) = −3.1176 + 3.0699 Log L(FL mm). Growth of older fish is variable from place to place and year to year. Sexual maturity is usually attained by males in their third to fifth year and females in their fourth to sixth year. Females probably spawn every year. Many factors, including summer temperature, water levels, wind, nest desertion, predation, angling, and the bass tapeworm greatly affect reproduction and survival of young, resulting in large and small year classes with vastly different contributions to the population and harvest (Fry and Watt 1957; White 1970).

Maximum age in Canada would appear to be about 15 years. Maximum known size in Canada is probably either a female 13 years old, 23 inches (584 mm) in fork length, 17¼ inches (437 mm) in girth, 9 pounds 2 ounces in weight, captured by an angler in McCauley Lake, near Madawaska, Ont., in September, 1951, or one said to be 9 pounds 13 ounces that was caught in Birchbark Lake near Kinmount, Ont., in 1954. A record of 11 pounds in Canada is probably an error. Fish over 23 inches (584 mm) were more common in 1906–1936, but prize winning fish of 5–7 pounds are taken almost every year. Those most frequently caught by anglers, however, are 8–15 inches (203–381 mm) in length and usually not over 3 pounds. Some supposed "records" are based on misidentifications as possibly was the 20-pounder reported speared in Ashbridges Bay, Toronto, in 1842 (*Canadian Sportsman and Naturalist* 1882, 2(4): 122). Trautman (1957) recorded fish to 22.5 inches (572 mm), and 6 pounds 10 ounces in Ohio, and said maximum weights of 10–14 pounds had been recorded elsewhere. The present *Field and Stream* angler record is one 27 inches (686 mm) long, 21⅔

		Age														
		0+	1+	2+	3+	4+	5+	6+	7+	8+	9+	10+	11+	12+	13+	14+	15+
Potter's L., N.B. (Smith 1942)	FL *inches*	1.5	4.9	7.8	9.6	10.9	11.9	12.8	13.5	–	–	–	–	–	–	–	–
	mm	38	124	198	244	277	302	325	343	–	–	–	–	–	–	–	–
	Wt *oz*	0.03	1.0	4.5	8.2	12.2	14.2	16.7	20.4	–	–	–	–	–	–	–	–
L. Erie, Ont. (Doan 1940)	TTL *inches*	–	–	–	6.5	9.9	10.5	12.5	13.6	14.8	15.6	–	–	–	–	–	–
	mm	–	–	–	165	251	267	318	345	376	396	–	–	–	–	–	–
	Wt *oz*	–	–	–	2.9	9.8	23.1	27.3	29.9	32.5	34.4	–	–	–	–	–	–
Baie du Doré, L. Huron, Ont. (White 1970)	FL *inches*	–	5.5	7.0	8.3	9.7	10.8	12.0	13.0	13.8	14.5	15.4	15.6	16.2	16.3	–	18.0
	mm	–	140	178	211	246	274	305	330	351	368	391	396	411	414	–	457
	Wt *oz*	–	–	1.9	3.8	8.2	12.5	17.8	24.6	34.1	34.9	36.8	37.6	–	–	–	–
L. Nipissing, Ont. (Tester 1932b)	FL *inches*	–	–	8.1	9.4	10.9	11.7	13.4	14.0	14.8	15.5	16.2	16.3	–	–	–	–
	mm	–	–	206	239	277	297	340	356	376	394	411	414	–	–	–	–
	Wt *oz*	–	–	6	8	13	17	25	28	34	40.5	43.5	56	–	–	–	–

inches (549 mm) in girth and 11 pounds 15 ounces, caught in Dale Hollow Lake, Ky., in 1955.

Habitat varies with size and time of year. In the spring, adult fish congregate on the spawning grounds. Later they are usually found in rocky and sandy areas of lakes and rivers, in moderately shallow water. In the heat of summer they usually retreat to greater depth. Usually they are to be found around the protection afforded by the rocks of shoals and talus slopes, or submerged logs. They are much less often associated with dense growths of aquatic vegetation than are largemouth bass and they prefer a lower temperature than that species. Final preferred temperatures under experimental and field conditions have been given as 82.4° F (28° C), and 68.5°–70.3° F (20.3°–21.3° C) respectively in Wisconsin (Ferguson 1958). Average summer temperatures of many Ontario bass habitats was 70.6° F (21.4° C). Diet and seasonal movements are partly in response to attempts to remain in the preferred temperature. Upper lethal temperature has been determined experimentally to be as high as 95° F (35° C), but it is usually considered that this species cannot stand high environmental temperatures as well as the largemouth bass. Most studies have shown that movements are usually limited to ½–5 miles from place of capture. However, bass tagged in the Chateauguay River, Que., migrated up and down the St. Lawrence River for distances up to 30 miles (Cuerrier 1943). There is evidence of homing to spawning ground and summer territory. Hallam (1959) gave extensive details on physical, chemical, and faunal characteristics of the habitat of this species. In winter, smallmouth bass aggregate near the bottom, are very inactive, eat little, and are rarely taken by anglers. They begin feeding in the spring when water temperature reaches 47.3° F (8.5° C) (Keast 1968b).

In general, the food of adults of this species consists of insects, crayfish, and fishes. The smallmouth bass takes this variety of food from the surface, in the water mass, and off the bottom. There is a progression with increase in size from plankton, to immature aquatic insects, to crayfish and fishes. The importance of various items within size groups shifts, with availability, from place to place. Tester (1932a) gave an extensive summary of the food from several Ontario habitats by season, size, and location. By 20 mm length, insects replace the previous plankton dominance and by 50 mm fishes and crayfish are the important items. For adults in most habitats, crayfish form approximately 60–90% of the food volume, fishes 10–30%, and aquatic and terrestrial insects 0–10%. Frogs, tadpoles, fish eggs, and plant material are often present as well. If any particular fish can be said to dominate, it is the yellow perch. This may, however, be a result of the ease with which they are identified. Most cyprinids are listed simply as unidentified. The following are among those which have been recorded: yellow perch, johnny darter, Iowa darter, log perch, northern pike, sculpins, sticklebacks, white sucker, bluntnose minnow, emerald shiner, spottail shiner, cyprinids, yellow walleye, white bass, freshwater drum, trout-perch, sunfishes, rockbass, ciscoes, and smallmouth bass.

Young smallmouth bass are probably eaten by many predators. Groups of rock bass, as predators, apparently cause a significant loss of eggs and fry. While the guarding male is chasing one rock bass the others feed in or over the nest. Other predator species mentioned are yellow perch, sunfishes, catfishes, gar pike, suckers, and turtles.

Competition for food involves interaction with a wide variety of fishes with similar habitat requirements, but does not seem to be a serious limiting factor. Competition for nesting areas seems to be exerted by rock bass and, in shallower nests, by sunfishes.

Parasites of this species over the whole of its range, listed by Hoffman (1967) were: protozoans (12), trematodes (49), cestodes (12), nematodes (13), acanthocephalans (9), leeches (9), molluscs (1), crustaceans (9). Parasites of this species from Lake Erie, Algonquin Park, Ont., and Lake Huron were listed by Bangham and Hunter (1939), Bangham and Venard (1946), and Bangham (1955). Of these parasites, three are of the most concern to man: the bass tapeworm *Proteocephalus ambloplitis*, which can cause

sterility or seriously limit reproduction of this species, and black-spot and yellow grub which, when present, often deter anglers from eating their catch. None of these parasites is harmful to man.

The smallmouth bass is known to hybridize in nature with the spotted bass *M. punctulatus*.

Relation to man The magnitude and antiquity of interest in this bass is obvious in the fact that angling results were mentioned in Fothergill's 1816–1837 *Account of the natural history of eastern Canada* (Black 1934), that introductions in North America began in the 1850's, and fish culture practice in Canada in 1884. Rawson (1930a) summarized the history of the fishery in Lake Simcoe, Ont., from the time of Champlain to 1930. Smallmouth bass in Canada were taken by the ton by hook and line and by nets, at least until 1936. It sold for as little as 6–8¢/pound in 1898–1902. As early as 1893 complaints were made to the Dominion Fisheries Commission about the depletion in Lake Simcoe caused by the commercial catch. An International Anglers Commission meeting in Niagara Falls, Ont., in 1894 spoke of rapid extinction of the basses and recommended a closed season during spawning and prohibition of sale. After that, it was universally restricted as a sport fish and its capture is now controlled by season and bag limits.

Angler enjoyment, success, and harvest have been extensively studied (*see* Budd 1961).

Its attraction for anglers and its sporting quality are now almost legendary. That and techniques of its capture are the subject of many popular books and articles in sporting magazines. It suffices to say here that the smallmouth bass is still one of three or four fishes which are the mainstay of the gigantic sport fishery and associated tourist industries in eastern Canada. Good populations of bass still yield limit catches and, on average, 0.5–1.1 fish per man hour.

Smallmouth bass are usually taken still fishing with crayfish, minnows, or frogs as bait; by casting live bait, spinners, or plugs; by trolling live bait or artificial lures; or by fly fishing with wet or dry flies. The flesh of large or small individuals is white, flaky, and delicious when prepared in any of a variety of ways.

The most important areas of angler success for this species, Lake Erie, the Thousand Islands section of the St. Lawrence River, and Georgian Bay, are seriously threatened by domestic, industrial and possibly thermal pollution.

Nomenclature

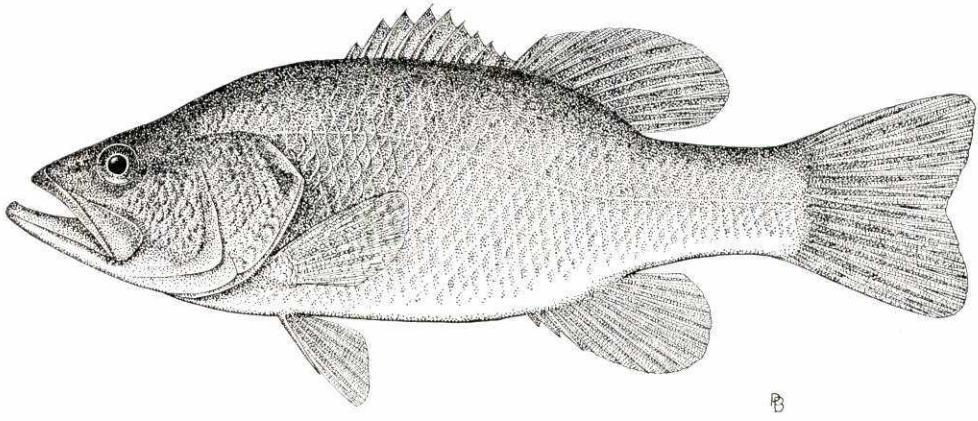
Micropterus dolomieu	— La Cepède 1802: 324 (type locality unknown)
Bodianus achigan	— Rafinesque 1817b: 120
Cichla fasciata	— LeSueur 1822a: 216
Cichla minima	— LeSueur 1822a: 220
Cichla fasciata (LeSueur)	— Richardson 1836: 23
Cichla minima (LeSueur)	— Richardson 1836: 24
Grystes nigrisans	— Forelle 1857: 278
Gristes nigricans	— Roosevelt 1884
Centrarchus fasciatus	— Small 1865: 19
Micropterus dolomieu dolomieu Lacépède	— Hubbs and Lagler 1941: 78
Micropterus dolomieui dolomieui Lacépède	— Hubbs and Lagler 1958: 113
Micropterus dolomieui Lacépède	— Scott 1967: 89

Etymology *Micropterus* — small or short fin, a damaged second dorsal led Lacépède to think there was a short fin at the rear of it; *dolomieui* — after M. Dolomieu, a French mineralogist and friend of Lacépède, after whom dolomite was named.

Common names Smallmouth bass (previously the hyphenated or unhyphenated combinations of the separate words small and mouth or mouthed with any or all of the following), northern smallmouth bass, smallmouth black bass, black bass, brown bass, green bass (more often used for largemouth bass), white or mountain trout, in the south. French common name: *achigan à petite bouche.*

LARGEMOUTH BASS

Micropterus salmoides (Lacépède)



Description A moderately large, robust fish, body less laterally compressed but deeper than the smallmouth bass, cross section a broad oval. Most individuals seen in Canada are 8–15 inches (203–381 mm) in length. The following percentages and counts are for bass from Ontario and Quebec. Greatest depth, under base of first dorsal fin, 20.9–29.7% of total length; angle from snout to dorsal fin low, back flat; caudal peduncle long and deep. Head large, long, 26.6–31.7% of total length, deep, wide, dorsal surface almost always with long, deep notch over the eyes; operculum bony to edge, pointed, not extended in a flap, usually a vague dark spot near tip; eye large, its diameter 12.8–20.5% of head length, larger in young; snout long 25–28% of head length, not deep as in smallmouth bass, bluntly pointed, scales on cheek, diagonal from eye, 9 or 10 (14–18 in smallmouth bass); mouth terminal, little oblique, large, wide, lower jaw slightly longer than upper, gape reaching to middle of eye; maxillary very long (less so in young), 45.7–54.3% of head length but reaching at least to posterior margin of eye in adults; posterior edge usually square; fine brushlike teeth on both jaws, palatines, and vomer; lower pharyngeal teeth on long, narrow pad, numerous, fine, uniform in size. Gill rakers usually stiffer, 6–8 on lower limb and 2 rudiments on upper limb. Branchiostegal rays 6, 6 and 7, or 7. Fins: dorsals 2, joined, but separation more obvious, first dorsal rather low, 10 stout

spines, short front and rear, last spine appearing to be part of second dorsal; separation between dorsals deep, shortest posterior spine less than $\frac{1}{2}$ height longest spine; second dorsal higher, 12 or 14 (usually 12) rays, rounded; caudal, not long but broad, shallowly forked, tips rounded; anal with base less than that of second dorsal, 3 spines and 10–12 (usually 11) soft rays, rounded; pelvics thoracic, origin under that of first dorsal fin, fins not joined by membrane but conspicuously joined to body by membrane, pelvics short, rounded, 1 spine and 5 soft rays; pectorals rather short, broad, tip rounded, 13–15 rays. Scales ctenoid, larger than smallmouth bass, usually about 8 rows from lateral line to dorsal origin and 14–18 rows from lateral line to anal origin, usually no scales on membranes of dorsal and anal fins; lateral line complete, high, little arched, 60–68 lateral line scales. Peritoneum silvery, intestine well differentiated, 24–28 thinner pyloric caeca, at least 6–10 branched. Vertebrae 30–32. Shufeldt (1900) gave osteological differences in largemouth and smallmouth basses.

No nuptial tubercles but colours darken on spawning males.

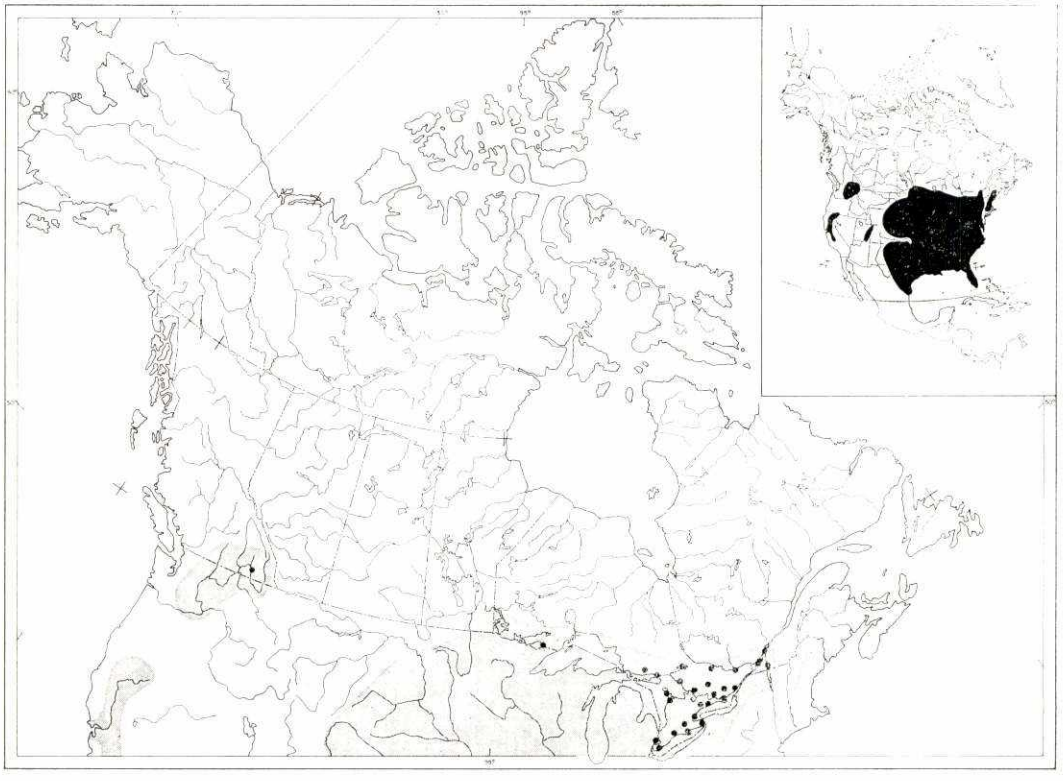
Colour Dorsal surface of body and head bright green to olive, sides almost as dark in largest, to lighter green or golden green, ventral surface milk-white to yellow, a pronounced wide, solid black lateral band sometimes continuous across opercle through eye to snout, particularly in young, broken or inconspicuous to absent in adults, sides of head olive to golden green with some scattered black pigment, inside of mouth milk-white, eye brownish, dorsal and caudal fins opaque, green to olive, anal and pelvic fins green to olive with some white, pectoral fins amber and clear. Populations in clear, weedy water darker and black pigment more obvious, those in darker or turbid water overall pale green. Caudal fin of young like that of adult, no bright colours. *See* colour illustration facing p. 730.

Systematic notes Canadian populations are often included as part of a subspecies, *M. s. salmoides*, the northern largemouth bass. The other form is *M. s. floridanus* in Florida. Meristics for populations in various localities north to south were given by Bailey and Hubbs (1949), Hart (1952) and Bryan (1969). Canadian material examined is insufficient to detect meristic or proportional differences in Canada.

Distribution The native range of this bass included the fresh waters of the lower Great Lakes, the central part of the Mississippi River system south to the Gulf Coast, Florida, and north on the Atlantic coast to Virginia. As a result of extensive introductions it now occurs over virtually the whole Atlantic coast (rarely into brackish water) from Maine to Florida, west to Texas and northeastern Mexico, north through the eastern parts of the states from New Mexico to North Dakota, and east across southern Canada to western New York. It occurs by introduction in isolated locations in almost the whole United States west of this, and has been introduced into such places as England, Scotland, Germany, France, South Africa, Hong Kong, the Philippines, and Brazil.

In Canada it occurs in the St. Lawrence River and its tributaries from Lac St. Pierre upstream, the Richelieu–Champlain system, the Ottawa system north to Temiskaming, west across the north shore of Lake Superior, but excluding that lake, to southeastern Manitoba. It was introduced in Saskatchewan in 1950 but failed. It occurs in southeastern British Columbia in several lakes in the Columbia River system to which it spread after its introduction in Idaho in 1916. It is probably commonest, most abundant, and best known in the Kawartha and Rideau lakes in Ontario. The overall range of this bass is almost equal to that of the smallmouth bass but it is common and abundant only in a much smaller, more southern area.

Biology There is much less published information on this species in Canada than on the smallmouth bass. *See* Bensley (1915), Curran et al. (1947), Hart (1952), Lewis (1965), Keast and Webb (1966), Johnson and McCrimmon (1967), supplemented by



information on populations in the northern United States given by Bennett (1954), Kramer and Smith (1960a, b, 1962), Mraz et al. (1961) and Mraz (1964b).

The largemouth bass spawns from late spring to mid-summer (sometimes as late as August) with the peak of spawning usually early to mid-June. Nest building by males usually begins within a few days of the time the mean water temperature reaches 60° F (15.6° C), but spawning usually takes place at 62°–65° F (16.7°–18.3° C). In water containing both largemouth and smallmouth basses, the largemouth will spawn a little sooner, because the shallower, protected spawning sites in quiet bays, among emergent vegetation, warm to the optimum temperature sooner than do the deeper, rockier, sites used by the smallmouth bass. Spawning grounds vary from gravelly sand (more rarely) to marl and soft mud in reeds, bullrushes, or water lilies. The very aggressive, territorial males sweep clean an area 2–3 feet (61.0–91.5 cm) in diameter and, depending on the hardness of the bottom, 1–8 inches (25–203 mm) deep, usually in 1–4 feet (30.5–122.0 cm) of water. Often the bottom of the nest includes the exposed roots of emergent vegetation. Nests are usually at least 30 feet (9.15 m) apart. The spawning behaviour is much like that of the smallmouth bass, involving nudging, nipping, parallel swimming, the vertical and 45° positions of male and female, and repeated spawnings separated by short intervals. A female may spawn with several males on different nests. *See* Reighard (1906) and Breder and Rosen (1966) for detailed account. Females probably spawn yearly between the ages of 5 and 12 years. Egg number per female varies with size and has been reported to be from 2000–109,314 per female or 2000–7000 per pound of female. The eggs are demersal, adhesive, amber to pale yellow in colour, and when fertilized are 1.5–1.7 mm in diameter (*see* Kelley 1962, for details of fecundity). Eggs

are often laid over the whole of the bottom and lip of the nest, not as compactly as those of the smallmouth bass. Changes in water temperature, wind, waves, nest desertion, predation by rock bass, by other sunfishes, and by the guarding male himself, limit the success of the hatch. Apparently golden shiners and lake chubsuckers often spawn in active nests of this species which are being guarded by a male. The male guards and fans the eggs. Hatching takes 3–5 days at water temperatures prevalent in Canadian habitats. On hatching, the young are transparent and 3 mm long. The number of fry resulting from a single nest has been determined at 751–11,457, with an average of 5000–7000. They remain in the bottom of the nest until the yolk is absorbed, usually 6 or 7 days, then they rise, begin feeding and schooling. At this time they are 5.9–6.3 mm in length. They may remain in a brood as long as 31 days and are guarded over part or all of this time by the male. The young of this species are at this time a very pale green rather than the black of smallmouth bass. Reighard (1906), Fish (1932), and Carr (1942) gave details of eggs and early development of the young. Survival rate is low and usually only 5–10 live to reach 10 inches (254 mm) length.

Growth is rapid at first. Trautman (1957) said that young-of-the-year in October in Ohio were 2–5 inches (51–127 mm) in length. Availability of quantities of invertebrate food of appropriate size for fry rising off nests, and water temperature and its effect on rate of growth before mid-August of the first year seem to determine the ultimate growth history. (*See* Kramer and Smith 1960b, for details of growth in first year in Minnesota). Spawning success, growth, and survival in the first year determine strength of the year-classes. As in smallmouth bass, good and poor year-classes make strikingly different contributions to the population and angler harvest. Growth is extremely variable but that in Ontario does not fall behind that in the northern United States. The following table gives the age–length and age–weight relations of a population in Lake Opinicon (St. Lawrence–Ottawa system), Lake Simcoe (Great Lakes system), and a generalized average for Ontario.

Lewis (1965) gave the length–weight conversion as Log W (in pounds) = –3.8384 + 3.4859, Log TL (in inches). Present known maximum size in Canada is an individual of 14 pounds 2 ounces caught in Stoney Lake, Peterborough Co., Ont., in 1948. Fish of 6–8 pounds are the prize winners yearly in Ontario and Quebec, but those taken by anglers usually do not exceed 2–3 pounds in weight. The present angler record is a fish which was 32½ inches (827 mm) long, 28½ inches (724 mm) in girth, 22 pounds 4 ounces in weight, and was caught in Montgomery Lake, Ga., in 1932.

In Canada sexual maturity is reached in 3–4 years by males and 4–5 years by females. Growth rate and ultimate size are greater in females.

Growth increases steadily southward over the range of this species with increased

		Age														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
L. Opinicon (Lewis 1965)	TL *inches*	–	–	9.4	11.1	12.1	13.0	14.3	15.8	16.6	17.1	17.8	18.8	19.7	–	–
	mm	–	–	239	282	307	330	363	401	421	434	452	478	500	–	–
	Wt (*lb*)	–	–	0.4	0.7	0.9	1.2	1.6	2.3	2.6	3.1	3.5	4.0	4.9	–	–
L. Simcoe (MacCrimmon and Skobe 1970) (pers. comm.)	TL *inches*	4.0	8.0	10.0	12.0	13.5	14.5	16.0	17.0	17.5	18.0	19.0	19.8	20.4	21.0	21.4
	mm	102	203	254	305	343	368	419	432	445	457	483	503	518	533	544
	Wt (*lb*)	–	0.4	0.8	1.7	2.1	–	–	–	–	3.5	–	–	–	5.0	–
Ontario avg (MacKay 1963)	TL *inches*	6.7	8.7	11.3	12.6	13.7	15.4	16.8	17.7	18.0	19.3	18.2	19.8	21.0	–	–
	mm	170	196	287	320	348	391	427	450	457	490	462	503	533	–	–
	Wt (*lb*)	0.1	0.5	1.0	1.1	1.5	2.5	3.2	3.2	3.9	4.0	–	6.3	–	–	–

temperature and almost year-round growth. Viosca (1943) indicated that in Louisiana, fingerlings 7–9 inches (178–229 mm) in length and 5.3–12.0 ounces in weight were produced in $6\frac{1}{2}$ months. He gave other extreme increments for growth in fertilized ponds stocked with forage fishes. The giants of this species are always found in Florida and Georgia.

The habitat of the largemouth is the upper levels of the warm water of small, shallow lakes, shallow bays of larger lakes, and, more rarely, larger, slow rivers. This species is rarely caught at depths over 20 feet. It is almost universally found in association with soft bottoms, stumps, and extensive growths of a variety of emergent and subemergent vegetation, particularly water lilies, cattails, and various species of pond weed. It is rarely found in rocky situations characteristic of the smallmouth bass. The habitat of the largemouth bass usually contains a variety of other sunfishes, the muskellunge or northern pike, yellow perch, brown bullhead, and a variety of minnows. The habitats of the smallmouth and largemouth basses seldom overlap even though the two species often occur in the same lake.

Movement is not extensive, usually less than 5 miles, summer territories are small, and there is some indication of homing to spawning area and summer territory.

The largemouth bass can tolerate higher water temperatures than the smallmouth bass. Temperature preferendum in the field is usually in the range of 79.8°–81.9° F (26.6°–27.7° C) but that determined experimentally ranged from 86.0° to 89.6° F (30° to 32° C) and depends on acclimation temperature (Hart 1952; Ferguson 1958). At higher temperatures in August, largemouth bass become inactive and rest in the shade of aquatic or shore vegetation. Upper lethal temperature shows interesting geographic variation (Hart 1952) and was determined by Black (1953) at 84° F (28.9° C) for bass from British Columbia acclimated at 68.0°–69.8° F (20°–21° C), and by others as high as 97.5° F (36.4° C) for fish acclimated at 86° F (30° C). This bass apparently has a low tolerance of low oxygen conditions and in experiments avoided levels of 1.5 mg/litre and lower. This and their weedy habitat often subjects them to winterkill, and at times summerkill (depletion of oxygen by utilization and decay of plants). Largemouth bass move to the bottom in winter, are more active than smallmouth bass, and are taken by ice fishermen in several northern U.S. states.

Adult largemouth bass are largely fish-eating predators but food type changes with size from plankton, to insects, to fish, crayfish, and frogs. Food is taken at the surface (morning and evening), in the water mass (during day), and from the bottom. This bass is a sight feeder and often feeds in schools near shore and usually close to vegetation. Feeding is restricted at water temperatures below 50° F (10° C) and decreases in winter and during spawning. It has been calculated that it requires 4 pounds of food to produce 1 pound of fish (3.5:1 in the case of smallmouth bass).

There are many detailed analyses of food by size and season in the United States (Turner and Kraatz 1921; Ewers 1933; Cooper 1937; Kramer and Smith 1960b). The food of this species at various lengths, in Lake Opinicon, Ont., was given (Keast and Webb 1966) as follows: 1.2–2.0 inches (30–50 mm) total length — Cladocera (to 50% of the stomach volume), mayfly nymphs (60%), amphipods (25%), chironomid larvae (20%), small quantities of copepods, bugs, and caddisfly nymphs; 2.0–3.8 inches (50–70 mm) — mayfly nymphs (to 40%), dragonfly and damselfly nymphs (20%), crayfish (20%), small quantities of amphipods, chironomid larvae and small fishes; over 3 inches (80 mm) — small fishes (50–90%) and crayfish (10–40%). Frogs, worms, molluscs, and large insect nymphs make up a varying percentage of the food of adults.

Fishes enter in the diet from about 2 inches (50 mm) in length. Fishes mentioned as food of the largemouth bass are gizzard shad, carp, bluntnose minnow, silvery minnow, golden shiner, carp, yellow perch, pumpkinseed, bluegill, largemouth bass, and silversides. Doubtless almost any species of fish of appropriate size is eaten. Cannibalism

is higher in this species than in the smallmouth bass. It has been reported that up to 10% of the food of largemouth bass 8 inches (203 mm) and over is the fry of the same species. Largemouth bass 1.5–1.8 inches (40–47 mm) in length are known to have eaten bass as large as 0.9–1.2 inches (24–30 mm) in length.

The young and small adults are doubtless part of the food of other predaceous fishes which share the habitat, such as yellow perch, walleye, northern pike, and muskellunge, as well as such birds as heron, bittern, and kingfisher. Adult largemouth, as a result of size, spines and swimming speed, seem largely to escape predation. Crayfish, dragonfly larvae, predaceous diving beetle larvae, other sunfishes, and golden shiners are significant egg and fry predators. Young largemouth bass compete for food with a wide variety of other bottom-feeding warmwater fishes. Adults compete for food with all other shallow-water predaceous fishes in their habitat, and with other sunfishes for spawning sites. However, water temperature at spawning time, wave action, nest desertion, parasite sterility, and availability of food for newly rising fry are said to be more operative in controlling recruitment than is predation or competition.

The parasites listed by Hoffman (1967) for this species over the whole of its range were: Protozoa (13), Trematoda (45), Cestoda (11), Nematoda (14), Acanthocephala (5), leeches (4), Mollusca (1), Crustacea (10). There is extensive literature on the parasites of the black basses and certainly one of the earliest papers on parasites of Canadian fishes was that of Wright (1884) on a parasitic copepod of this species. Bangham (1955), Bangham and Hunter (1939), and Bangham and Adams (1954), listed them for Canadian habitats. One of the early studies of the bass tapeworm was carried out in Canada by Cooper (1915).

As with the smallmouth bass, the parasites of most concern to man are the bass tapeworm, black-spot, and yellow grub. The tapeworm, by causing sterility reduces yield, the other two are unsightly. None of them is dangerous to man, especially in cooked fish.

Hester (1970) gave details of a number of artificial hybrids of this species but apparently none are known in nature.

Relation to man Like the smallmouth bass, this species is one of the major sport fishes in eastern Canada. The area in which it is important in Ontario is smaller (mainly Rideau and Kawartha Lake systems), but there and in southern Quebec the fishery for it is as intense and as important to the local economy as that for smallmouth bass elsewhere. Like the smallmouth bass, this species was taken commercially by the ton until about 1936. The catch statistics generally listed only black basses or basses, the two were not separated. The largemouth formed a smaller but significant part of this catch in Ontario and Quebec. After that time they were generally restricted as a sport fish. This species is caught still fishing with worms, minnows, or frogs or by casting, particularly in the evening, in weedy, stumpy areas with large, often noisy, surface plugs or with bass "bugs" or poppers. Largemouth bass take surface lures more frequently and flies less frequently than do smallmouth bass. The flesh is excellent and the fish easily filleted to obtain large pieces of skinless, flaky meat. There are many detailed accounts of the sport fishery for this species in the United States (*see* Mraz and Threinen 1957; and Maloney et al. 1962) but few in Canada. A study of the fishery in Lake Opinicon, Ont., (Lewis 1965) gave extensive information on availability, catch, size etc. It indicated that the best catches were obtained by guided parties and in July, success varied from year to year and decreased over the summer but that average rates of 0.5–0.3 fish per hour indicated good fishing.

The largemouth bass, with its tolerance for high temperature and slight turbidity, its fast growth rate, and fish diet have made it a favourite for stocking warmwater farm ponds for food and sport. Such ponds have received considerable attention in the United States (*see* various papers by Swingle and *also* Regier 1963a) and now in Canada (*see* Johnson and McCrimmon 1967). They are usually stocked with bass and a forage fish such as bluegills or golden shiners.

Nomenclature

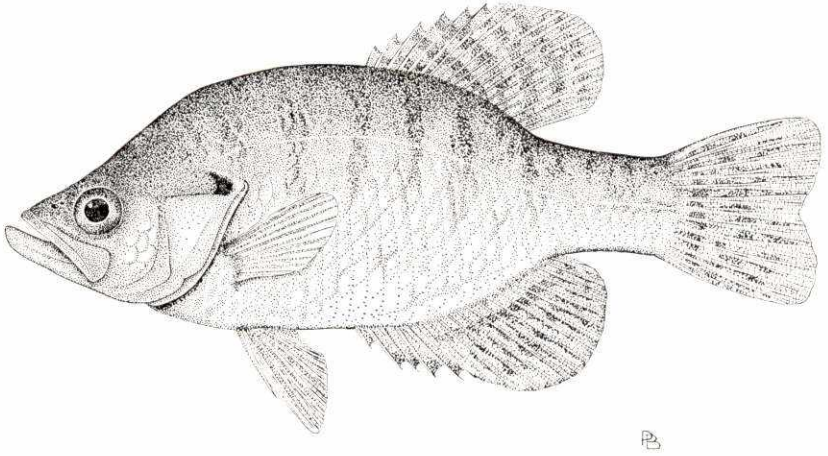
Labrus salmoides	— La Cepède 1802: 716 (type locality South Carolina)
Huro nigricans	— Cuvier and Valenciennes 1828: 108
Perca (Huro) nigricans (Cuvier)	— Richardson 1836: 4
Grystes nigrisans	— Forelle 1857: 278
Grystes megastoma	— Garlick 1857: 108
Micropterus salmoides (Lacépède)	— Jordan and Evermann 1896–1900: 1012
Aplites salmoides Rafinesque	— Hubbs 1926: 71
Aplites salmoides Lacépède	— Hubbs and Greene 1928: 391
Aplites salmoides (Lacépède)	— Dymond et al. 1929: 30
Huro salmoides (Lacépède)	— Hubbs and Lagler 1941: 78
Micropterus salmoides (Lacépède)	— Hubbs and Lagler 1947: 93

Etymology *Micropterus* — small or short fin, a damaged second dorsal led Lacépède to think there was a short fin at the rear of it; *salmoides* — trout-like, the original came from southern United States, where it was, and still is, referred to as green trout.

Common names Largemouth bass, northern largemouth bass, large mouth or large-mouth bass, large mouthed or large-mouthed bass, largemouth, black bass, largemouth black bass, green bass, bass. French common name: *achigan à grande bouche.*

WHITE CRAPPIE

Pomoxis annularis Rafinesque



Description A moderately large, deep-bodied sunfish, more elongate than the black crappie, with extreme lateral compression. Individuals in Canada are usually not over 8–10 inches (203–254 mm) in length. Greatest depth far back but at origin of dorsal fin, 23.8–29.0% of total length, less than in black crappie, angle from snout to dorsal fin only moderately steep, less so than in black crappie, back somewhat flattened; caudal peduncle rather long, somewhat narrower than black crappie. Head long, 25.3–27.9% of total length, rather deep but shallower than black crappie, very narrow, marked depression over eye, operculum bony to edge and rather pointed, flap not extended, but small, vague, black spot in from edge of operculum; eye large, 24.5–29.4% of head length, well ahead of centre of head and high; snout short, not so deep as black crappie, rather sharply pointed; mouth terminal, somewhat oblique, large, rather large lower jaw longer than upper, gape reaching to posterior nostril; maxillary very long, 36.8–41.5% of head length, reaching to posterior margin of eye; fine teeth on both jaws and palatines; lower pharyngeal pads very long and narrow with fine, brushlike teeth. Gill rakers very numerous, long, and thin, usually 22–24 on lower limb and 6–8 on upper limb. Branchiostegal rays 7. Fins: dorsals 2, but so joined and rays so graduated in length as to appear as 1, base of dorsals less than base of anal fin, also shorter than and farther back than in black crappie, base length equals distance from dorsal origin to opercular root, and distance from tip of snout to dorsal origin is 36.5–40.2% of total length, base of first dorsal shorter than that of second dorsal, first dorsal with 6 (rarely 7) spines of graduated length, last spine almost as high as second dorsal, second dorsal fin longer, higher, soft rayed, with 13–15 (but usually 14 or 15) rays, edge rounded; caudal moderately long, shallowly forked, tips rounded; anal with long base, longer than dorsals, 6 or 7 graduated spines followed by 16–18 soft rays (usually 6 spines and 17 rays), edge squarish to rounded; pelvics thoracic, origin under pectoral fins far in advance of origin of dorsal fin, base with broad attachment to body, moderately long, tip overlaps origin of anal fin, edge square to rounded, tip a blunt point, 1 spine and 5 rays; pectorals high, not long nor

overly broad, and rounded, usually 13 rays. Scales mostly ctenoid, rather large, markedly smaller and crowded on anterior dorsal surface; lateral line complete, high, shallowly arched over pectoral fin, 34–44 lateral line scales. Peritoneum silvery, intestine well differentiated, usually 10 thin, but well-marked caeca. Vertebrae 30–32.

No nuptial tubercles but dark pigment and iridescent colours intensify on males at breeding time.

Hofstetter et al. (1958) gave skeletal characteristics by which white and black crappies can be distinguished.

Colour Dorsal surface of body and head dark green, olive, to brownish, with blue-green or silver overcast; upper sides lighter, more iridescent green, shading to silver; with 5–10 vague, vertical bands of black sometimes extending down to anal fin but more obvious on lower back and upper sides; ventral surface silvery to milk white; sometimes iridescent pink or green on opercular bones; eye yellow to green; amount of black pigment variable with location and size; dorsal, caudal, and anal fins with black vermiculations or rows of distinct black spots, pelvic fins opaque white, pectoral fins transparent amber to yellow, no black on paired fins.

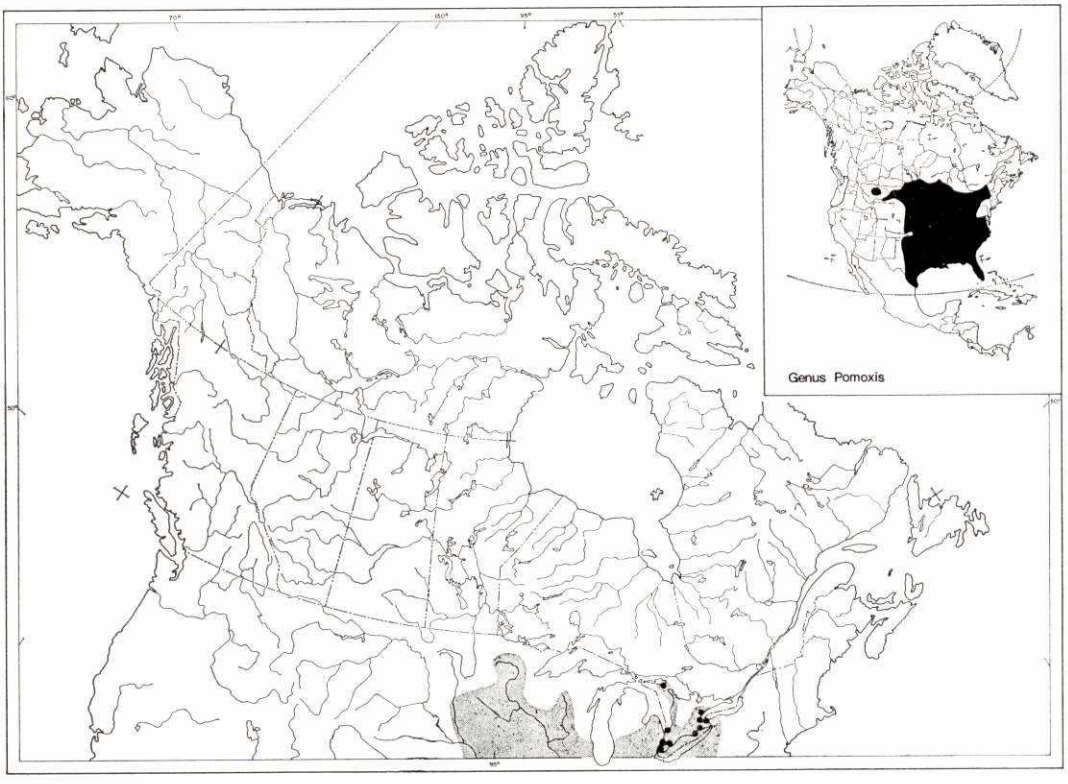
The young have much less black pigment and the black on head, chin, and breast intensifies on breeding males.

Distribution The natural range of this sunfish is restricted to the fresh waters of east-central North America. It now occurs from southwestern New York, south, west of the Appalachian Mountains to the Gulf coast area of Alabama, north in the Atlantic coast states to North Carolina, from Alabama west to eastern Texas, north through the eastern halves of the states to South Dakota and southern Minnesota, east across lower Michigan into southern Ontario. It is apparently widely introduced outside of this area in the United States, including Washington, Oregon, California, and Connecticut.

In Canada this species occurs only in Ontario in the area of western Lake Ontario, all of Lake Erie, Lake St. Clair, and Lake Huron as far north as Manitoulin Island. The latter is the most northerly record in Canada and, possibly, of its entire range. In the Great Lakes area and in Ontario, in general, this crappie is much less abundant, and less frequently seen than the black crappie, for which it is no doubt often mistaken.

Biology There is virtually no information available on the biology of this species in Canada. Excellent summaries of United States populations were written by Hansen (1951, 1965) and Siefert (1968) from which the following was derived.

Spawning takes place for approximately a 29-day period in late spring to early summer when water temperatures are 57.2°–73.4° F (14°–23° C) and is most active at 60.8°–68.0° F (16°–20° C). The aggressive, territorial males come on to the spawning grounds first and clean ill-defined nests of a diameter of 11.8 inches (300 mm), with no depression, over a variety of bottom types, in about 8–38 inches (200–970 mm) of water. Rooted plants or algae are usually beside or in the nest. At times, nests are established in the protection of undercut banks. Nests are isolated or sometimes in colonies of 35–50, 2–4 feet (50–122 cm) apart. Spawning takes place in the mornings with little of the active, circular swimming characteristics of other sunfishes. Spawning acts are short, with the same pair taking part in as many as 50, with 0.5–20 minutes separating them. Only a small part of the eggs is released at any time and the same females may spawn in the nests of several different males. Egg number per female is probably similar to the 27,000–68,000 noted for black crappies of the same size. One female in Ohio, 4.3 inches (109 mm) long, contained 14,750 eggs. Eggs are 0.89 mm in diameter, colourless, demersal, and adhesive. They adhere to the substrate, especially to algae, and to one another. The male guards the nest and fans the eggs. At a water temperature of 57.9° F (14.4° C) eggs hatch in about 4 days, with a range of 2–4½ days depending on temperature. The tiny, transparent, young remain on the nest for only a short period and in some cases only 4 days elapse from start of hatching to depar-



ture of the young. Siefert (1969) gave characteristics for separating the very similar young of the white and black crappies.

Growth is rapid at first and Trautman (1957) said that young-of-the-year, in October, in Ohio were 1.0–3.8 inches (25–97 mm) long. Later growth is quite variable depending on habitat. The following age–length relation given by Roach and Evans (1948) for Ohio, will probably be slightly higher than that for Ontario.

Age	Length (*inches*)	Length (*mm*)
0+	–	–
1+	2.6	66
2+	5.4	137
3+	7.6	193
4+	9.0	229
5+	10.4	264
6+	11.8	300
7+	13.7	348
8+	15.7	399

Sexual maturity is attained in the second to fourth year and fish on nests are usually 6–8 inches (152–203 mm) in length. Stunting occurs. In Ontario, white crappies may reach 10–12 inches (254–305 mm) and a pound in weight, but are usually 7–10 inches (178–254 mm) long. Adults in Ohio are usually 5–14 inches (127–356 mm). Trautman (1957) quoted maximum size as 17.2 inches (437 mm) and a weight of just over 3 pounds. The present angler record is either one which weighed 5 pounds 3 ounces, was 21 inches (533 mm) long, and was caught at Enid Dam, Miss., in 1957, or one of 6 pounds from Louisiana. Maximum age would appear to be 8–10 years.

In Ontario this fish is usually found in rather silted streams, lakes, ponds, and muddy, slow-moving areas of larger rivers. In the Great Lakes it is most often captured in the mouths of tributary streams, or in warm, weedy, sheltered bays.

The food of the young is a variety of

plankton crustaceans but adult white crappies eat aquatic insects, some crustaceans, and a large number of small fishes. Hansen (1951) gave the following percentage volumes for white crappies in Illinois: fishes (57.8%), aquatic insects (34.9%), unidentified animal matter (5.06%), other aquatic invertebrates (1.17%).

Young white crappies probably fall prey to the same variety of predaceous fishes as do other sunfishes including largemouth bass, and larger white and black crappies. The larger individuals with their deep bodies may be fairly free of predation. Their numbers in Canadian waters preclude the possibility of them being of any significance as predators or competitors.

The parasites of this species, over the whole of its range, listed by Hoffman (1967) were: Protozoa (5), Trematoda (9), Cestoda (2), Nematoda (5), Acanthocephala (2), leeches (4), Crustacea (5).

Bangham and Hunter (1939) listed, for this species, from Lake Erie, nematodes *Spinitectus gracilis*, *Camallanus oxycephalus*, and *Agamonema* sp., the acanthocephalan *Leptorhynchoides thecatus*, the copepod *Ergasilus centrarchidarum*, and an encysted myxosporidian.

Bangham (1955) listed only *Camallanus oxycephalus* and *Proteocephalus pearsei* for South Bay, Lake Huron.

The white crappie is known to hybridize in nature only with the black crappie.

Relation to man This crappie is too uncommon to be of any real significance as a commercial or sport fish in Canada. It probably contributes, to a minor extent, to those fish marketed in Ontario and recorded in the statistics as rock bass and crappies. Anglers recognize crappies but rarely distinguish between this rarer form and the more common black crappie. A small number of this species is probably taken by anglers still fishing with worms or minnows in rather shallow water. The flesh is white, flaky, and highly suitable as food but their heavy, compressed, bony bodies make preparation difficult for some people. It is an important sport fish over much of its range in the United States. Anglers use small minnows for still fishing or small silvery spoons, spinners, or jigs to cast or troll.

Nomenclature

Pomoxis annularis — Rafinesque 1818d: 41 (type locality Ohio River)

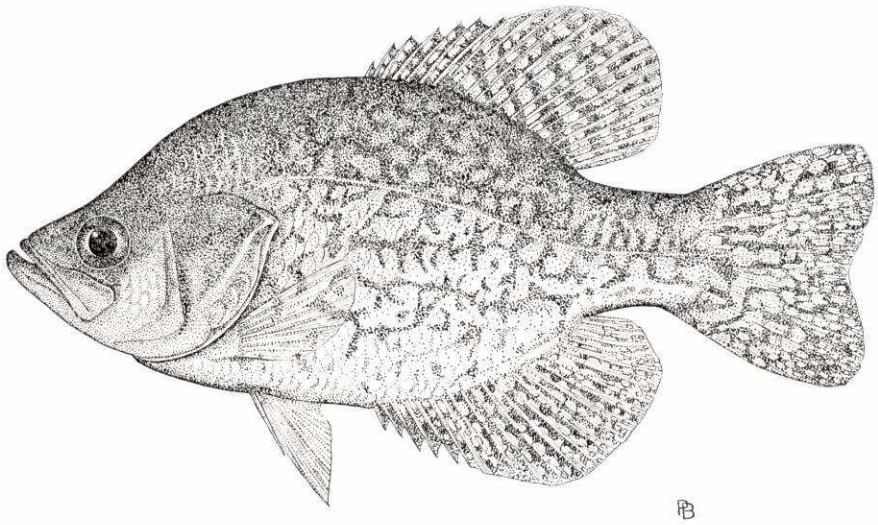
It would appear that the scientific name of few species of North American freshwater fishes have enjoyed the stability that this one has. There are few synonyms and all Canadian records found to date have used this name.

Etymology *Pomoxis* — sharp opercle, alluding to the fact that the opercle ends in a point rather than a flap; *annularis* — having rings, the vague vertical bars of the body.

Common names White crappie, crappie, crawpie, silver bass, white bass. French common name: *marigane blanche.*

BLACK CRAPPIE

Pomoxis nigromaculatus (Lesueur)



Description A large, deep-bodied sunfish, less elongate than the white crappie, with extreme lateral compression. Individuals in Canada are usually 7–10 inches (178–254 mm) in length. Greatest depth far back, at origin of dorsal fin, 29.7–33.3% of total length, greater than in white crappie, angle from snout to dorsal fin steeper than white crappie, back rounded; caudal peduncle appears shorter and deeper. Head long, 26.6–28.3% of total length, deeper than white crappie, very narrow, marked depression over eye, operculum bony to edge and rather pointed, no extended flap, rather large, diffuse, black spot at edge of operculum; eye usually larger than white crappie, diameter 25.0–31.6% of head length, eye ahead of centre of head and high; snout short, somewhat deeper than white crappie, bluntly pointed; mouth terminal, oblique, large, large lower jaw slightly longer than upper, gape reaching to posterior nostril; maxillary long, 40.9–45.8% of head length, reaching to posterior edge of pupil; fine teeth on both jaws and palatines; lower pharyngeal pads very long, very narrow, with fine, brushlike teeth. Gill rakers very numerous, long and slender, usually 22 or 23 on lower limb and 5 or 6 on upper limb. Branchiostegal rays 7. Fins: dorsals 2, but so joined and rays so graduated in length as to appear as 1, length of base of dorsal fins very little less than base of anal fin, dorsals with longer base and not so far back compared to white crappie, base length equals distance from dorsal origin to middle of eye, and distance from tip of snout to dorsal origin is 32.3–39.1% of total length, first dorsal with base shorter than that of second, with 7 or 8 spines of graduated length, last almost as high as second dorsal fin, second dorsal fin longer, higher, soft rayed with 14–16 rays (most often 8 spines and 14 rays), edge rounded; caudal long, broad, shallowly forked, tips rounded; anal with long base but little longer than that of dorsals, 6 or 7 graduated spines followed by 16–18 soft rays (usually 6 spines and 17 rays), edge rounded to squarish; pelvics thoracic, origin under pectoral fins, less advanced from origin of dorsal fin than in white crappie, base with broad attachment to

body, moderately long, tip overlaps anal fin origin, edge square, tip a rounded point, 1 fine spine and 5 rays; pectorals moderately high on body, moderately long, broad, and rounded, usually 13–15 rays. Scales mostly ctenoid, rather large, but smaller and crowded on anterior dorsal surface and breast; lateral line complete, high, shallowly arched over pectoral fin, 36–41 lateral line scales. Peritoneum silvery, intestine well differentiated, usually 8 caeca. Vertebrae 31–33.

No nuptial tubercles but dark pigment and iridescent colours intensify on males at breeding time.

Hofstetter et al. (1958) gave skeletal characteristics by which the black and white crappies can be distinguished.

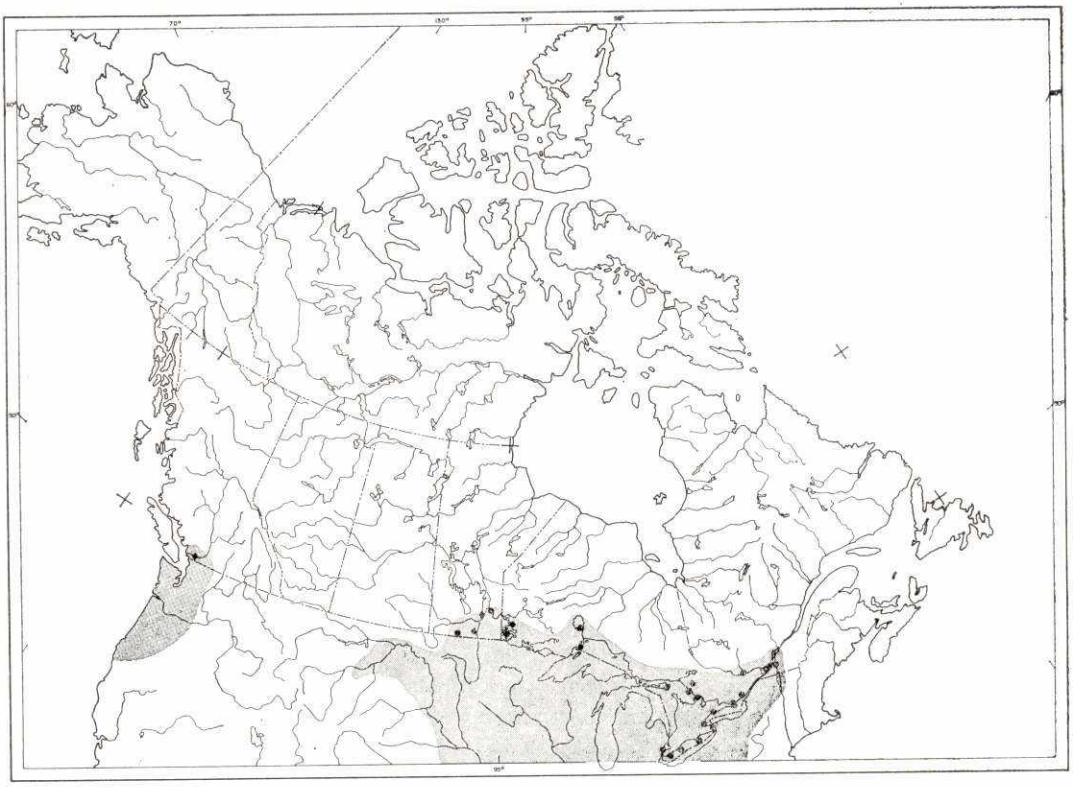
Colour Dorsal surface of back and head olive, metallic green to golden brown with overcast of silver or blue; sides lighter, iridescent green to silvery; head and sides with an irregular mosaic of black blotches, no vertical rows but vague horizontal grouping of body pigment; intensity of pigment varies with habitat and size; dorsal, caudal, and anal fins strikingly vermiculated with black, forming round or oblong yellow to pale green spots in centres of vermiculations, pelvic fins opaque with some black on tips of membranes, pectoral fins dusky and transparent. Individuals from clear, vegetated water with darker, contrasting pattern, fish from turbid waters bleached looking. Young with less dark pigment and pattern.

In breeding males the black, particularly on the head, becomes darker and velvety in colour. Most of the eye is marked in this way.

Distribution The natural range of this species is restricted to the fresh waters (and rarely brackish water) of eastern and central North America. It occurs from Quebec south through western New York, west of the mountains to the Gulf coast in Alabama, east through all of Florida and north along the Atlantic coast to Virginia, west from Alabama to central Texas, north through the eastern half of the states from Oklahoma to South Dakota, most of North Dakota and in eastern Montana, east through southern Manitoba, Ontario, and Quebec. It has been so widely introduced almost everywhere in the United States, west and east, that it is now virtually impossible to define the western limit of natural distribution.

In Canada this species occurs in Quebec in the St. Lawrence and its tributaries, downstream to at least brackish waters at a point near Rivière Ouelle (Vladykov 1949c), the Richelieu–Champlain system, and the Ottawa River, generally throughout Ontario north to a line from Temiskaming to Sault Ste. Marie, the Great Lakes, now including Lake Superior (as a result of spread from introduction in a nearby lake), west through Lake of the Woods to central southern Manitoba in the Red and Assiniboine rivers (rare). This sunfish is also present in backwaters and tributaries of the lower Fraser River in British Columbia. Black crappies are probably most abundant in eastern Ontario, in the Rideau Lakes, the upper St. Lawrence River, and in certain areas of Georgian Bay.

Biology Other than on food and feeding, very little is known of the biology of this sunfish in Canada. Much of the following was derived from Pearse (1919), Breder (1936b), and Breder and Rosen (1966). The black crappie spawns in late spring and early summer starting when water temperature is 66°–68° F (19°–20° C). This is usually in late May to mid-July. Occupation of spawning territory and nest building by males can begin slightly earlier. Males clear shallow depressions or just clear a section of the bottom of sand, gravel, or mud, in water 10 inches to 2 feet (254–610 mm) deep, where there is some vegetation. At times nests are cleared in the protection of an undercut bank. Males guard the nest, guard and fan the eggs till they hatch, and guard the young for a short time. Nests are 8–15 inches (203–381 mm) in diameter, colonial but 5–6 feet (152–183 cm) apart. The spawning activity of the male and female of this species is similar to that of the white crappie. Females probably spawn with different males in more than



one nest. Eggs are slightly less than 1 mm in diameter, whitish, demersal, and adhesive. Egg number for females 7.6–9.0 inches (195–230 mm), 3 and 4 years of age, are 26,700–65,520, with the average number of 37,796 per female (Ulrey et al. 1938). Eggs hatch in 3–5 days, the minute, transparent young are guarded by the male for a few days and then they desert the nest. Siefert (1969) gave characteristics for separating the very similar young of the white and black crappies. The young of the black crappie are more elongate at first, like those of largemouth bass.

Growth is rapid at first and young-of-the-year in Ohio are 1–3 inches (25–76 mm) in October (Trautman 1957). The following table shows the age–length relation for black crappies from Lake of the Woods, in Ontario, and for lakes in Michigan given by Beckman (1949).

Growth varies tremendously with size of population and with size and productivity of the habitat.

Age	Lake of the Woods, Ont.			Michigan lakes	
	FL		Wt	TL	
	(inches)	*(mm)*	*lb*	*(inches)*	*(mm)*
0	–	–	–	–	–
1	4.4	112	0.1	–	–
2	6.6	168	0.2	5.9	150
3	8.4	213	0.4	8.0	203
4	10.0	254	0.7	9.0	229
5	10.5	267	0.7	9.9	251
6	11.1	282	0.9	10.7	272
7	11.4	290	1.0	11.3	287
8	12.0	305	1.1	11.6	295
9	12.5	318	1.3	–	–

Maximum size in Ontario is usually 12–14 inches (305–356 mm) and some may reach a weight in excess of 2 pounds. Individuals over 1 pound weight are regularly caught in Lake of the Woods and Georgian Bay. Trautman (1957) listed 15.1 inches (384 mm) and 2 pounds 4 ounces as maximum size. The present angling record is one of 5 pounds, $19\frac{1}{4}$ inches (489 mm) in length, $18\frac{5}{8}$ inches (470 mm) in girth, and was caught in the

Santee–Cooper Reservoir, S.C., in 1957. Sexual maturity is attained in the second to fourth year. Maximum age would appear to be 8–10 years.

The black crappie is usually found in the clear, quiet, warm water of large ponds, small lakes, bays and shallower areas of larger lakes, and areas of low flow of larger rivers. They are almost always associated with abundant growths of aquatic vegetation, sandy to mucky bottoms, and are less often found in turbid situations than the white crappie. This species is usually found in discrete, moderately large schools.

The food of this sunfish is widely treated in the literature and that of Canadian populations is discussed in detail by Keast and Webb (1966), Keast and Welsh (1968), and Keast (1968a, b). Feeding is most active in the open water mass, in the early morning and between midnight and 2 AM. Diet changes with size and age. In Lake Opinicon the smaller, younger crappies feed on planktonic crustacea and free-swimming, nocturnal, dipterous larvae *(Chaoborus* and *Procladius).* This invertebrate diet continues into the third year of life and for individuals as large as 6.3 inches (160 mm). The ability to effectively utilize small invertebrates as a result of the numerous, fine, long gill rakers probably accounts for this diet in such large individuals of what is usually considered a piscivorous species. Beyond that size a variety of very small fishes makes up an increasing proportion of the diet. In Lake Opinicon the following were eaten: yellow perch, bluegill, pumpkinseed, black crappie (rare), blackchin shiner, golden shiner, bluntnose minnow, largemouth bass, and smallmouth bass. Perch, which share their open water habitat, were most often eaten and the prey usually ranged from 1.3–2.4 inches (35–60 mm) in length and were never over 2.5 inches (65 mm). The main foods in Lake Opinicon lumping all sizes of crappies were: *Chaoborus* larvae (up to 70% of stomach volumes), cladocerans (to 50%), copepods (20%), fishes (25%), flying insects (15%), chironomid pupae and larvae (25%), ephemeropteran nymphs (10%). The literature and ice fishery suggest that crappies are active and feed all winter but stomachs of fish taken from under the ice suggest they feed little before mid-April.

The young of the black crappie are probably the prey of a variety of warmwater predaceous fishes such as largemouth bass, smallmouth bass, larger sunfishes including black crappies, northern pike, and muskellunge. The spines and gibbous body of the larger adults probably make predation negligible. Their long planktivorous period and their open water feeding reduce the degree to which they compete for food with other valued species.

The parasites listed by Hoffman (1967) for the black crappie over the whole of its range were: protozoans (14), trematodes (19), cestodes (5), nematodes (9), acanthocephalans (4), leeches (1), crustaceans (5). For Canadian habitats the parasites were listed for Lake Erie (Bangham and Hunter 1939), for British Columbia (Bangham and Adams 1954), and for Lake Huron (Bangham 1955).

The black crappie is known to hybridize in nature only with the white crappie.

Relation to man This is another of the abundant species which is both a commercial fish and a sport fish and for which there are no size, catch, or season regulations. They are taken by commercial fishermen in gillnets and trapnets. This sunfish often has attracted a price (as round fish) equal to or in excess of the highly valued walleye. In 1965 price paid was 33¢/pound and one fisherman in Lake of the Woods landed $2500 worth in one day. The Ontario statistics lump both crappies with rock bass. It is probable, however, that the black crappie made up a considerable share of the 271,411 pounds of fish so listed and worth $60,417.45 in 1966. The productive areas, in descending contribution, were: northern inland lakes (Lake of the Woods?), lakes St. Clair, Erie, and Ontario, southern inland lakes, North Channel of Lake Huron, and Lake Huron.

The black crappie is an important sport fish over the whole of its range. This shallow-water, schooling, highly edible fish can often be caught in the period just before sunset as fast as the hook can be rebaited. Since many

are over 1 pound weight, they provide considerable fun and food to anglers in eastern Ontario, Georgian Bay, and Lake of the Woods. The flesh is white, flaky, and very tasty. There is also a significant and successful winter fishery for them in certain specific areas of Lake of the Woods (Chambers 1966).

Nomenclature

cantharus nigro-maculatus	— LeSueur 1829 *in* Cuvier and Valenciennes 1828–1849: 88 (type locality Wabash River, Ohio)
Pomoxys sparoides	— Wright 1892: 455
Pomoxis sparoides (Lacépède)	— Jordan and Evermann 1896–1900: 997
Pomoxis nigro-maculatus (LeSueur)	— Bailey 1941: 22
Pomoxis nigromaculatus (LeSueur)	— Bailey 1951: 194

Etymology *Pomoxis* — sharp opercle; as opposed to extended in a flap as in some other sunfishes; *nigromaculatus* — black spotted.

Common names Black crappie, crappie, crawpie, calico bass, strawberry bass, speckled bass, grass bass, Oswego bass, shiner, moonfish. French common name: *marigane noire*.

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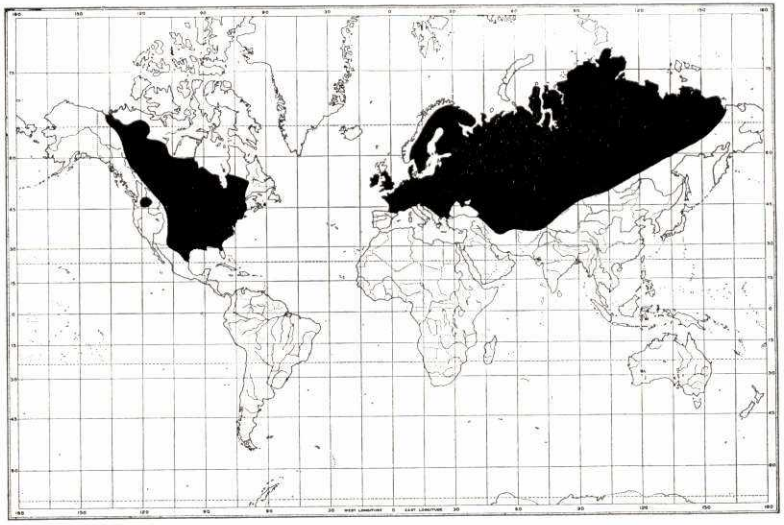
Perch Family — Percidae

This is the typical family of the order Perciformes. The members of the family are usually elongate, terete, and somewhat laterally compressed. The mouth may be large or small, terminal or inferior, and the premaxillary may or may not be protractile. Teeth present on jaws, vomer, and palatines usually villiform and in bands, but canines present in some forms. The lower pharyngeals bear sharp teeth. The two dorsal fins are well separated in contrast to dorsal fins of the sunfishes, family Centrarchidae. The first dorsal has 6–15 spines. The pectoral fins are moderately long and the pelvic fins are thoracic and have 1 spine and 5 rays. The anal fin is small with 1 or 2 spines, and the caudal fin lunate, truncate, or rounded. The preopercle is entire or serrate, usually ending in a single, flat spine. Swim bladder if present is physoclistous.

The family Percidae consists of 2 subfamilies, 9 genera and 121 species, the subfamily Percinae of 6 genera and about 16 species, and the subfamily Etheostomatinae, the darters, of 3 genera and 107 species. The darters are restricted to North America.

In North America the perches inhabit warm temperate to cold, subarctic streams and lakes. The darters flourish in a variety of environments from warm to cool temperate waters. The family is circumpolar in distribution, but most species are restricted to North America.

Percids have been known from Upper Cretaceous and the Oligocene of Europe, and from the Eocene of North America.



World Distribution of the Perches

1 Mouth large, maxillary extending to mid-point of eye or beyond; lower borders of preopercle obviously serrate; branchiostegals 7 or 8 (rarely 6); moderate to large fish. 2

Mouth small, maxillary usually not extending beyond anterior margin of eye; lower borders of preopercle smooth, not serrate; branchiostegals 6 or 7 (rarely 5); small, bottom dweller, never over 6 inches (152 mm) in length. (darters) 4

2 Anal fin with 2 spines and 6–8 soft rays; teeth in lower jaw all about equal height, no canines on tip; space between pelvic fins less than width of base of 1 fin; body deeper and laterally compressed, with 6–8 wide, dark, vertical bars. ..... YELLOW PERCH, *Perca flavescens* (p. 755)

Anal fin with 2 spines and 12 or 13 soft rays; canine teeth present, usually 2 on tip of lower jaw; space between pelvic fins equal to or greater than base of 1 fin; body shallower and subcylindrical 3

3 Rays of second dorsal fin usually 18–22, membrane of first dorsal dusky without definite spots, a large black blotch at posterior base of spinous dorsal in adults; lower lobe of caudal fin with white tip; in adults cheek scales small, hard to see, cheek and operculum naked at 6 inches (152 mm) in length; 3 pyloric caeca each about as long as stomach; 5–7 dark saddles on back. ..... WALLEYE, *Stizostedion vitreum*[1] (p. 767)

Rays of second dorsal fin usually 17–20; membrane of first dorsal clear with definite spots; in young pigment absent or confined to upper edge, no large blotch at posterior base; lower lobe of caudal fin usually without white tip; in adults cheek scales more apparent, cheek naked but scales on operculum obvious at 6 inches (152 mm) in length; usually 5 (3–9) pyloric caeca, each shorter than stomach; back with 3 or 4 saddles which become patches below fins and on peduncle. ..... SAUGER, *Stizostedion canadense* (p. 762)

4 Anal fin large, equal to or larger than soft dorsal fin; pelvic fins well separated; caudal fin usually slightly forked; lateral line usually complete; space between pelvic base and along belly either naked or with enlarged ctenoid scales, females sometimes with only 1 enlarged scale between pelvic fins; body usually elongate and shallow 5

Anal fin smaller than soft dorsal fin; distance between pelvic fins variable, from width of pelvic base to one-half pelvic base; caudal fin slightly forked, square, or rounded; lateral line complete or incomplete; space between pelvic fins and along belly either naked or with scales, but scales never enlarged; body usually somewhat compressed laterally 9

[1]No attempt is made here to separate the subspecies *Stizostedion vitreum glaucum*, the blue pike. The species occurred only in Lakes Erie and Ontario and apparently has been extirpated. Specimens of a dull grey form reported from various inland lakes have proven to be colour mutants of the walleye, *S. v. vitreum*.