5 Flesh pellucid in life; anal fin with a single thin spine; dorsal fins widely separated; body extremely elongate and partially naked, with scales confined to midline of sides; a series of 10–12 small, rounded, green spots along midline of sides. .... EASTERN SAND DARTER, *Ammocrypta pellucida* (p. 775)

Flesh opaque; anal fin with 2 spines; dorsal fins not widely separated; body usually scaled 6

6 Premaxillaries protractile, clearly separated from snout by a deep groove; a series of small, brown, oblong, or round blotches along sides, frequently joined together by a thin line. .... CHANNEL DARTER, *Percina copelandi* (p. 801)

Premaxillaries not protractile (a shallow groove may be evident in *P. shumardi*) 7

7 Snout prolonged to form a conical protuberance, projecting beyond upper jaw; lateral line scales 78–103; body with 14–16 dark, vertical bars, alternate bars being expanded and drop-like at lower ends; a distinct black spot at caudal base. .... LOGPERCH, *Percina caprodes* (p. 797)

Snout not prolonged, not projecting beyond upper jaw; lateral line scales fewer than 78; body with lateral blotches, with or without black spot at caudal base 8

8 Cheeks scaleless; midline of belly scaleless but with a bridge of scales before anus; a prominent suborbital bar; anal fin usually large, the rays long, reaching almost to base of caudal fin; sides with 9 or 10 blotches or bars. .... RIVER DARTER, *Percina shumardi* (p. 806)

Cheeks scaled; midline of belly scaled; suborbital bar present; anal fin not unusually large, not reaching to caudal base; sides with a series of black, oblong, confluent blotches, and continuous with a black band that extends across gill-cover and around snout. .... BLACKSIDE DARTER, *Percina maculata* (p. 803)

9 Premaxillaries protractile; 1 thin anal spine; body usually with X–, M–, or W–shaped markings on sides. .... JOHNNY DARTER, *Etheostoma nigrum*[2] (p. 793)

Premaxillaries not protractile, usually bound to snout by fleshy bridge (the frenum) or fused to preorbitals at sides *(E. blennioides)*; 2 anal spines, the first usually stout and stiff 10

[2]Throughout its North American range *Etheostoma (Boleosoma) nigrum* was considered for many years to be represented by 3 subspecies, all of which occurred in Canadian waters, *E. n. olmstedi* from Maritime provinces to eastern Lake Ontario drainages, *E. n. eulepis* in Great Lakes basin, and *E. n. nigrum* from Saskatchewan and Hudson Bay to western Quebec. However, Cole (1967) elevated *olmstedi* to full species status but as yet the occurrence of this species *E. olmstedi* Storer in Canadian waters is not clearly defined.

10 Gill membranes not obviously joined but meeting in a V over isthmus (*see* couplet 14, p. 31) 11

Gill membranes broadly joined by a sheet of tissue covering isthmus but free from it 13

11 Cheeks scaled (scales sometimes covered lightly with tissue); dorsal soft rays usually 10 or 11; lateral line ending under spinous dorsal fin; 10–12 dark vertical bars on sides, not extending downward to ventral surface; caudal fin distinctly speckled; males colourful in life with blue or green patches between darker bars on sides and blue and red on spinous dorsal fin. .... IOWA DARTER, *Etheostoma exile* (p. 783)

Cheeks naked; dorsal rays usually 12–13, or 8–9; lateral line variously incomplete or absent 12

12 Dorsal rays 12 or 13; dorsal spines 9 or 10; lateral line usually incomplete; 6 dark, vertical bands on body from anus to tail, each extends almost to ventral midline; males colourful in life with green, blue, and orange colouration on head, sides, dorsal, and anal fins. .... RAINBOW DARTER, *Etheostoma caeruleum* (p. 780)

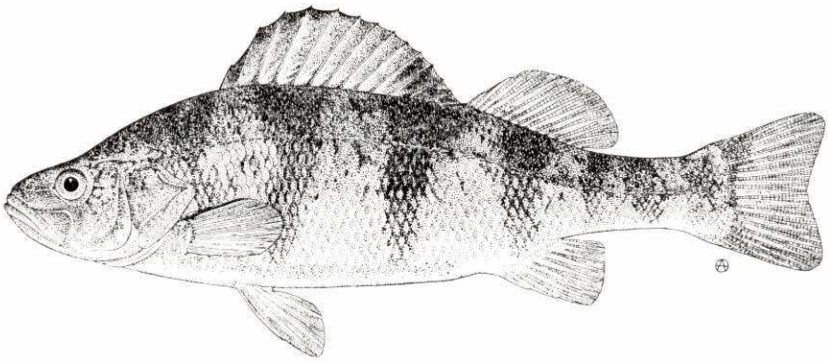
Dorsal rays 8 or 9; dorsal spines 7; lateral line completely absent or with up to 7 pored scales; sides with 7 or 8 squarish, dark patches on sides; a distinct suborbital bar; caudal fin distinctly barred or speckled. .... LEAST DARTER, *Etheostoma microperca* (p. 790)

13 Dorsal spines 6–8, short, length equal to or shorter than eye diameter, those of males often with fleshy tips; body slender, elongate; head distinctly pointed, mouth terminal; cheeks and opercles naked; colour in life brownish, with 10–12 short, vertical bars. .... FANTAIL DARTER, *Etheostoma flabellare* (p. 787)

Dorsal spines 13, not short, length obviously greater than eye diameter and never with fleshy tips; body robust; snout distinctly rounded, overhanging the small mouth; cheeks and opercles scaled; body greenish in life with V-shaped marks that extend below the midline. .... GREENSIDE DARTER, *Etheostoma blennioides* (p. 777)

YELLOW PERCH

Perca flavescens (Mitchill)



Description Meristics and proportional measurements are for populations from Nova Scotia to Alberta, *see* table in *Systematic notes* for variability. Body elongate, oval rather than tubular or subcylindrical, average length 4–10 inches (102–254 mm), laterally compressed, greatest body depth 16.3–28.1% of total length. Head moderately deep, rounded at tip, its length 23.1–29.3% of total length, narrow, interorbital distance 16.9–27.3% of head length; gill membranes extended forward, not joined, nor broadly joined to isthmus, preopercular bone serrate at least on angle; short spine at tip of operculum; eye diameter 15.8–30.4% of head length (greatest in young); snout moderately long, blunt, not extending beyond lower jaw, its length 23.4–34.2% of head length; premaxillaries protractile; mouth moderately large, terminal, slightly oblique, jaws equal; maxillary extending at least to mid-point of eye; teeth in brushlike bands on jaws, palatines and vomer, small, decreasing in size posteriorly, no canines. Gill rakers fine, comblike, and usually 12–16 on lower limb, 4–8 on upper limb. Branchiostegal rays 6:7, 7:7, 7:8 or 8:8, usually 7:7. Fins: dorsals 2, obviously separated, first dorsal spiny, high, rounded, spines strong, usually 13–15, second dorsal smaller, but of about same height, with 1 or 2 spines and 12–15 rays; caudal peduncle long and narrow; caudal shallowly forked, tips rounded; anal with 2 spines and 6–8 rays, fin about $\frac{1}{2}$ size of second dorsal, square to rounded; pelvics thoracic, space between them less than $\frac{1}{2}$ base of 1 fin, moderate length, a little longer than pectoral fins, square, 1 spine and 5 rays; pectorals broad, rounded, 13–15 rays. Scales ctenoid, cheeks scaled, opercles mostly naked, breast and belly scaled; lateral line complete, high, little arched, scales 51–61, usually 53–57. Peritoneum silvery; intestine well differentiated, 3 short, thick pyloric caeca. Vertebrae 38–41.

No nuptial tubercles.

Colour Variable with size and habitat; dorsal surface of back and head bright green to olive, to golden brown; sides to below pectoral fins yellow-green to yellow, the colour of the back extending down sides in about seven tapering bars; eye yellow to green; ventral surface of head and body grey to milk-white, dorsal and caudal fins yellow to green, edge of first dorsal often black, black on membranes between spines 1 and 2 and last four or five membranes in adults, anal and pelvic fins opaque, yellow to silver white, pectoral fins amber and transparent. Colours of spawning males more intense, bronze-green, bright yellow, bars darker, lower fins suffused with orange to bright red, females less highly coloured. The young are transparent, then silvery or dull pale green.

At times strikingly coloured individuals are seen. These are grey-blue or red, lack bars, and result from the dominance or absence of some part of the pigment compliment (*see* Dymond 1932b; Crossman 1962e). *See* colour illustration facing p. 730.

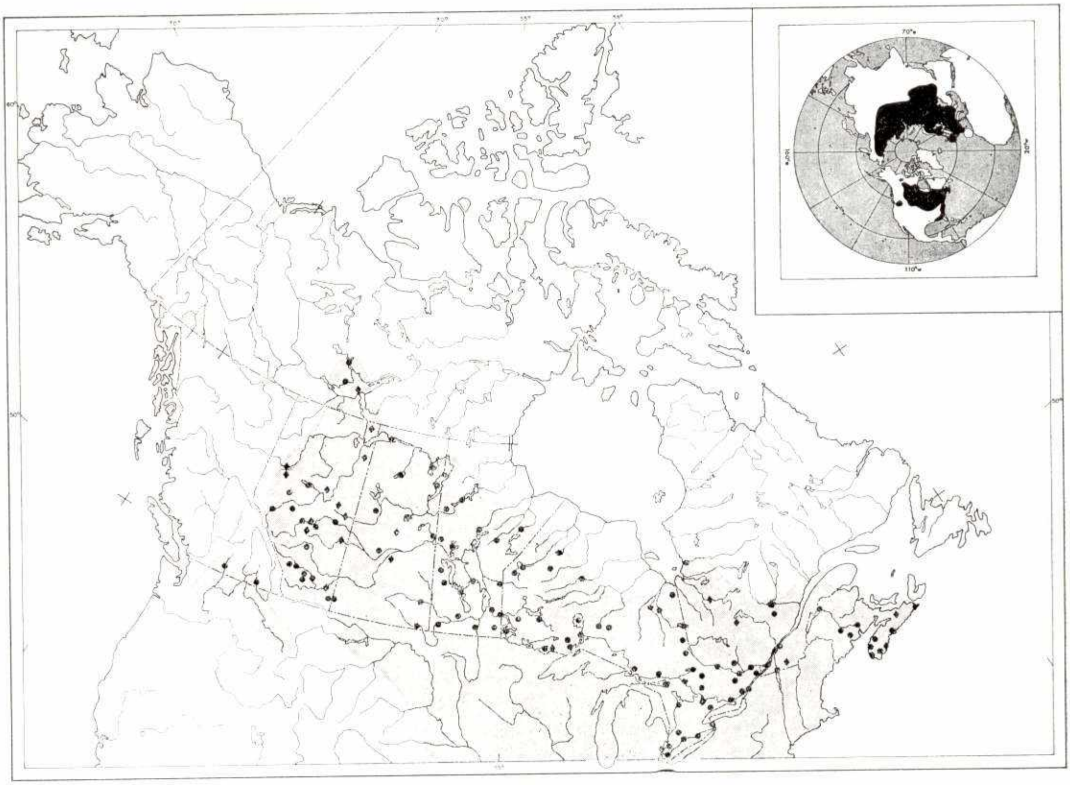
Systematic notes The perch of Eurasia and the yellow perch of North America have long been considered distinct species, *P. fluviatilis* the perch, and *P. flavescens* yellow perch. A study, published in 1963, by the Russian scienists Svetovidov and Dorofeeva concluded that there was a single, circumpolar species, for which the older name *P. fluviatilis* should be retained. They designated three subspecies, *P. f. fluviatilis* (Eurasia generally), *P. f. intermedius* (Kolyma River, Siberia), and *P. f. flavescens* (North America). This has been accepted by some North American authors (Scott and Crossman 1967; McPhail and Lindsey 1970) but rejected by others (Bailey et al. 1970) on the basis that the data (very few yellow perch examined) was not conclusive. Lack of conviction in the evidence presented, the discontinuous distribution, and differences in growth rate, body form and colour, have led to a feeling that the original name should be retained for such a well-known fish until the evidence is more convincing.

McPhail and Lindsey (1970) gave details of postglacial dispersal from the Mississippi River. The only meristic trends east to west or north to south in Canada in the material examined (*see* following table) were a slight tendency toward one more dorsal spine west from western Ontario and a slight shift westward toward fewer lateral line scales. Reexamination of yellow perch from Lake Nipigon yielded second dorsal spines counts of 2 and rarely 1, rather than the unique "3 and rarely 2" of Dymond (1926). Driver and Garside (1966) reported on the effect on meristics of this species of salinities approaching $\frac{1}{3}$ sea water in saline lakes in Manitoba. They concluded that it was not as great as would be expected and difficult to separate from that resulting from differences in water temperature of the different habitats.

Distribution The yellow perch and the Eurasian perch combined have an almost circumpolar distribution in the fresh waters (and rarely in brackish waters) of the northern hemisphere. The yellow perch occurs in North America, from Nova Scotia south along the Atlantic coast, previously to South Carolina now apparently to the Florida panhandle and Alabama, west on the west side of the Appalachian Mountains from western Pennsylvania to upper Missouri, from eastern Kansas northwest to Montana, north to Great Slave Lake, southeast to James Bay, Quebec, and New Brunswick. This species has been introduced into almost all the states to the west and south of this general area, including Washington, Oregon, California, Utah, New Mexico, and Texas.

	Dorsal fins									Anal fin						Pectoral rays		
	Spines of first dorsal					Rays of second dorsal				Spines			Rays					
	11	12	13	14	15	12	13	14	15	1	2	3	6	7	8	13	14	15
N.S.	–	6	1	–	–	–	4	2	–	–	6	–	2	4	–	–	–	–
N.B.	–	9	7	–	–	–	11	7	–	–	29	–	1	17	1	–	–	–
Que.	–	2	8	–	–	–	8	2	–	–	10	–	–	7	3	–	–	–
Ont.																		
L. Simcoe	–	1	6	–	–	5	2	–	–	–	7	–	–	5	2	4	3	–
L. Nipissing	–	4	6	–	–	3	7	–	–	–	10	–	–	4	6	–	–	–
Kenora Dist.	–	–	1	8	–	1	8	–	–	–	9	–	–	6	3	–	9	–
Man.	3	33	8	–	–	4	19	11	1	–	10	–	–	2	8	–	–	–
Sask.	–	–	1	6	–	1	6	–	–	–	7	–	–	7	–	4	3	–
Alta.	–	–	3	5	–	–	3	5	–	–	8	–	–	6	2	–	–	–

	Branchiostegal rays				Lateral line scales											Vertebrae			
	6,7	7,7	7,8	8,8	51	52	53	54	55	56	57	58	59	60	61	38	39	40	41
N.S.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	4	–
N.B.	–	7	2	1	–	–	1	1	–	1	3	2	1	–	1	–	3	8	9
Que.	–	11	1	–	–	–	–	–	–	–	–	–	–	–	–	2	9	1	–
Ont.																			
L. Simcoe	–	–	–	–	–	–	–	1	2	2	1	1	–	–	–	1	6	1	–
L. Nipissing	–	11	–	–	–	–	–	–	–	–	–	–	–	–	–	1	10	–	–
Kenora Dist.	–	–	–	–	3	1	6	2	4	1	–	–	1	–	–	–	–	–	–
Man.	1	18	–	–	–	1	4	1	2	–	1	1	–	–	–	2	25	4	–
Sask.	–	–	–	–	–	–	1	2	1	3	–	–	–	–	–	–	–	–	–
Alta.	–	–	–	–	–	–	–	2	1	1	1	–	1	1	1	–	–	–	–



In Canada it occurs from Nova Scotia (not Cape Breton Island) west across New Brunswick to Baie Comeau, Que., across Quebec to James Bay, in Abitibi Lake, west across Ontario at the latitude of the upper Albany River, north through central Manitoba but not to the Hudson Bay coast, through all of Saskatchewan, north to Great Slave Lake, and south through Alberta extending to the foothills in the south. It occurs in British Columbia in the Pend Oreille, Kootenay and Okanagan watersheds as a result of a northward spread from introductions in Washington State.

Biology As a result of its commercial and recreational importance there is considerable literature on various aspects of the life history of the yellow perch, particularly age, growth, and production. Among discussions of populations in Canadian habitats are those of Harkness (1922), Carlander (1950b), Lawler (1953), Scott (1955), Ferguson (1958), Coble (1966), Sheri and Power (1969c). There are many more on United States populations, especially Harrington (1947b), several by Jobes and Hile (*see* Jobes 1952), Herman et al. (1959), and Muncy (1962).

The yellow perch spawns in the spring, usually from April 15 to early May, but spawning may extend into July in some areas. Water temperatures of 44°–54° F (8.9°–12.2° C) have been cited. Adults migrate shoreward into the shallows of lakes, and often into tributary rivers to spawn. Where this species occurs in brackish water, they move up into fresh water to spawn. The smaller males move to the spawning grounds first, are followed by the females, and males remain longer on the spawning grounds than do the females. Spawning takes place during the night and early morning, usually near rooted vegetation, submerged brush, or fallen trees, but at times over sand or gravel. The actual spawning act appears to be undocumented but thought to involve a single larger female and many males which swim about in a long, compact queue, the first males with their snouts pressed against the female. Total number of eggs per female increases with size and has been reported at 36,600–109,000 for fish 6.8–10.0 inches (147–254 mm) total length in Maryland, and 3035–61,465 for females 5.1–10.1 inches (131–257 mm) fork length in Lake Ontario. No nest is built. The transparent eggs, which when shed and swollen are usually 3.5 mm in diameter, are extruded in a unique, transparent, gelatinous, accordion-folded string or tube. This mass, which may be as long as 7 feet (2.1 m), as wide as 2–4 inches (51–102 mm) and weigh up to 2 pounds, may contain 2000–90,000 eggs with an average of about 23,000 eggs. Aeration of the eggs is accomplished by means of water circulation through holes and a central canal. These egg masses are semi-buoyant. They undulate with water movement and adhere to submerged vegetation or, at times, to the bottom. They can be easily cast ashore by wind, waves, and current and lost. No protection is given the egg masses or young by the parents. Hatching usually takes approximately 8–10 days, but has been reported to take as long as 27 days at 47° F (8.3° C). The young, when they hatch, are transparent, about 5 mm in length and have 16–21 postanal myomeres. They are inactive for about 5 days during the absorption of the yolk. Early development was given in detail by Fish (1929, 1932) and by Mansueti (1964). Means of separating the superficially similar young of this species and the walleye were given by Norden (1961b).

Growth is rapid at first. Trautman (1957) said yellow perch in Ohio in October were 1.8–4.0 inches (46–102 mm) long. In the first summer large, compact schools of young are often seen. Growth is extremely variable depending on population size, habitat size, and productivity. Ages are usually determined from scales in North America and by scales or opercles in Europe. The validity of the scale method of aging, and the body-scale size relation, were described for Lake Michigan by Jobes (1952) and Joeris (1957). The following table, giving age–length and age–weight relations for various Canadian habitats, exhibits this variability. Yellow perch 2 years and older were, on the average, 3 inches (76 mm) longer in Lake Erie and Lake Ontario than they were in Lake Jesse, N.S.

Stunting often occurs in crowded populations with adults never exceeding 6 inches (152 mm) in length.

Females grow faster than males even at age 1 and achieve a greater ultimate size. Northern populations grow more slowly and live longer. Sexual maturity is usually achieved

		Age									
	FL	0+	1+	2+	3+	4+	5+	6+	7+	8+	9+
Lake Jesse, N.S. (Smith 1939)	*inches*	1.4	3.0	3.6	4.3	4.9	–	–	–	–	–
	mm	36	77	92	108	125	–	–	–	–	–
	Wt (*oz*)	.02	.19	.29	.49	.78	–	–	–	–	–
Bay of Quinte, L. Ontario (Sheri and Power 1969c)	FL										
	inches	–	–	6.2	6.8	7.2	8.0	8.5	8.2	10.1	–
	mm	–	–	158	172	182	202	216	209	257	–
	Wt (*oz*)	–	–	2.3	3.0	3.8	4.5	6.0	5.0	10.9	
Lake Erie, Ont. (Harkness 1922)	TL										
	inches	–	–	6.6	7.7	8.5	9.9	10.8	11.0	–	–
	mm	–	–	168	196	216	251	274	279	–	–
	Wt (*oz*)	–	–	1.5	4.3	5.7	9.2	11.6	12.8	–	–
Heming Lake, Man. (Lawler 1953)	FL										
	inches	1.9	2.8	3.4	4.9	5.6	6.7	8.4	9.1	10.2	11.9
	mm	48	71	86	124	142	170	213	231	259	302

by males at 3 years and females at 4 years of age. Yearling males in Lake Erie are often fertile. Maximum age is usually 9 or 10 years but a female from Lake Erie, 12.2 inches (310 mm) in total length, which weighed 0.78 pounds, was aged at 11+ years. Yellow perch in Ontario are most often 4–10 ounces but one taken in Baie du Doré, Lake Huron, was 14.3 inches (363 mm) in length and weighed 1 pound 8 ounces. Weights to 3 pounds have been reported from Lac la Biche in Saskatchewan, and 2 pounds 3 ounces from Baptiste Lake in northern Alberta. Another Alberta perch, from Tucker Lake, was 15 inches (381 mm) in fork length and weighed 2¼ pounds. In 1935, Ontario commercial fishermen reported maximum size for Lake Erie as 13$\frac{3}{16}$ inches (334 mm) and 1 pound 1 ounce. A 14-inch (356-mm) perch was taken in the Saugeen River (Lake Huron) in 1929, and one weighing 4 pounds 1 ounce was caught in Quebec. Trautman (1957) gave maximum size for Ohio as 13.5 inches (343 mm) and 1 pound 5 ounces. The present angler record is an individual 4 pounds 3½ ounces in weight which was caught in New Jersey in 1865. Yellow perch caught by anglers in Canada are usually 8–12 inches (203–305 mm) in length.

Yellow perch are very adaptable and able to utilize a wide variety of warm to cooler habitats from large lakes to ponds, or quiet rivers. They are most abundant in the open water of lakes with moderate vegetation with clear water and bottoms of muck to sand and gravel. Numbers will decrease in a body of water in which turbidity increases or vegetation decreases. The yellow perch is a freshwater fish but it is found in brackish water along the Atlantic coast and in saline lakes in the Prairies (to 10,300 ppm total dissolved solids). McKenzie (1959) recorded their capture near Newcastle, N.B., in the brackish water of the Miramichi River, in early summer during the American shad and alewife fishery. Salinities at Newcastle, on July 15, 1956, were 15‰ at the bottom and 6‰ at the surface. The yellow perch is apparently more tolerant of low oxygen than sunfishes. In nature yellow perch are usually found at temperatures of 66.2°–69.8° F (19°–21° C) (Ferguson 1958). Seasonal vertical movements suggest they move to follow the 68° F (20° C) isotherm. Upper lethal temperature has been experimentally determined at 79.7° F (26.5° C) in British Columbia and at 92° F (33° C) elsewhere. Final temperature preference has been experimentally determined at 69.8°–77.0° F (21°–24° C).

They are usually considered shallow-water fishes and are usually not taken below 30 feet (9.2 m) but they have been taken as deep as 150 feet (45.7 m) in May. Adults and young are gregarious, often moving about in loose aggregation of 50–200 individuals, segregated by size. The young, in shallower water and nearer shore than the adults, are often in mixed schools which include many individuals of a species of minnow, such as the spottail shiner. The discrete schools of adults are close together in summer and more separated in winter. Yellow perch are inactive at night and rest on the bottom. There are migratory movements in the spring, movements inshore and out, up and down over the day, and seasonal movements out of and into deeper water in response to temperature, and probably, to distribution of food. Yellow perch are active all winter under the ice in shallow water or in deeper water (*see* Scott 1955; Hergenrader and Hasler 1968, for greater detail).

The food of the yellow perch has been extensively studied in Canadian habitats (*see* Tharratt 1959; Keast and Webb 1966; Keast and Welsh 1968; Keast 1968b). Food changes with size and season but is largely immature insects, larger invertebrates, and fishes, taken in open water or off the bottom. In Lake Opinicon, Ont., the young feed on cladocerans, ostracods, and chironomid larvae. By the end of their first year, they have shifted to Odonata nymphs (to 40% volume), Ephemeroptera (30%), molluscs (35%), ostracods (30%), chironomid larvae (30%), and small fishes (30%). Fish over 6 inches (150 mm) length feed on decapods (to 70%), small fishes (75%), and Odonata nymphs (40%). Yellow perch apparently prey on the eggs and young of a wide variety of fishes.

Active feeding takes place morning and

evening (7 AM to 6 PM), with little to none at night. Food is actively taken all through the winter, and may include fish eggs. Feeding is said by some to be suspended just prior to spawning, but others say anglers catch large numbers during the spawning run using minnows as bait.

The yellow perch is preyed on by almost all other warm to cool water predatory fishes such as basses, sunfishes, crappies, walleye, sauger, other yellow perch, northern pike, muskellunge, and to some extent, lake trout. Even the adults do not escape this predation. Water birds such as gulls, mergansers, loons, and kingfishers eat this perch. The young and adults may compete for food with brook trout, ciscoes, lake whitefish, basses, crappies, and bluegill. Their high reproductive potential, voracious appetite, and effectiveness at feeding can in some places lead to serious competition with more valued species, such as trout and basses, and with themselves. Those characteristics are probably the cause of the many populations of stunted yellow perch.

A wide variety of parasites afflict this fish. Parasites listed by Hoffman (1967) for the whole of its range were as follows: protozoans (16), trematodes (52), cestodes (11), nematodes (17), acanthocephalans (10), leeches (6), molluscs, crustaceans (8).

Guilford (1963) described three new species of Myxosporidia, *Myxosoma neurophila, M. scleroperca*, and *Henneguya doori*, from yellow perch in Lake Michigan. Tedla and Fernando (1969a) reported in great detail on the external and internal parasite fauna of this species in Lake Ontario, and seasonal changes in incidence and intensity of infestations. The same authors (1969b, c, 1970) discussed copepod parasites and gill parasites of this species. Lawler (1969) dealt with the effect on perch of the parasite *Triaenophorus nodulosus*. Dechtiar and Loftus (1965), Bangham and Hunter (1939), Bangham and Venard (1946), Bangham and Adams (1954), and Bangham (1955) gave lists of the parasites of this species in Canadian habitats. Other than the growth reducing or mortality factors exerted by many species of parasites, parasites of the yellow perch which are of more direct interest to man are black-spot, yellow grub, and the broad tapeworm *Diphyllobothrium latum*. The first two, although harmless to man, render the fish unsightly and often cause an angler to discard his catch. The last is a parasite which could infect man if raw, or poorly cooked, infected fish were eaten. Yellow perch suffer as well from a number of fish diseases and such pathological conditions as tumors.

Relation to man The yellow perch has long been of prime importance to man. It inhabits a vast territory, a wide variety of habitats, is a schooling fish, and congregates near shore in the spring. All of these factors make it readily available to fishermen, both commercial and recreational. It is an active feeder the whole of the year so can be angled summer and winter. The yellow perch is a sport fish of variable importance from the Maritimes to British Columbia. It is taken commercially from Ohio to Alberta. Its flesh is white, flaky, delicious, and popular. This species is sold, fresh and frozen, almost everywhere. It was one of the first species to be exploited in the mid- to late 1800's by the seine fishery of the Great Lakes. Production, commercial landings, and price paid for this fish, depend on a wide variety of factors such as varying year-class strength, availability of more favoured species, availability of fishermen, presence or absence of predators, and temperature and food-dependent growth rate. The Great Lakes are the major producers of yellow perch and catches there have, at various times, suffered from all these effects. This leads to a widely fluctuating fishery. Of the total yearly production in Canada, the Great Lakes contribute all but about 1 million pounds. Annual catches varied from a low of approximately 16.5 million pounds in 1919 to a high of 72.1 million pounds in 1934, to an all time low of 3.2 million pounds in 1948, to another high of nearly 27 million pounds in 1968. The dominance of the Great Lakes is obvious from the fact that commercial fishermen in Lake Erie alone (Canada and United States) recently harvested 30 million pounds worth 3.2 million dollars. Price fluctuations have been such that the greatest catch did not always yield the greatest return, and the price is now stabilized largely by federal price support funds. The Ontario catch in 1968 was 24,968,515 pounds, worth $2,107,470. Of this, Lake Erie contributed 24,435,187 pounds (97%). The next largest catches were from lakes Ontario, Huron, and St. Clair. The Freshwater Fish Marketing Corporation listed prices per pound for yellow perch, in November, 1970, as 40¢ (over ¾ pound) and 30¢ (under ¾ pound).

Anglers usually catch yellow perch, summer and winter, by still fishing for them with minnows, worms, or cut fish as bait. The problem of bait for the winter fishery is solved by freezing or salting minnows when they are available. They do not fight hard, but the challenge of catching a species which bites so lightly, the possibility of large catches and the high quality of their flesh compensate for this. There is generally no size or bag limit for anglers.

Yellow perch are used as live bait for other fishes such as northern pike and muskellunge and as cut bait for a variety of other fishes. Use of the young as live bait is often restricted to the water in which they were captured.

The yellow perch is the study animal most commonly used to familiarize students with the internal and external anatomy of a teleost fish.

Nomenclature

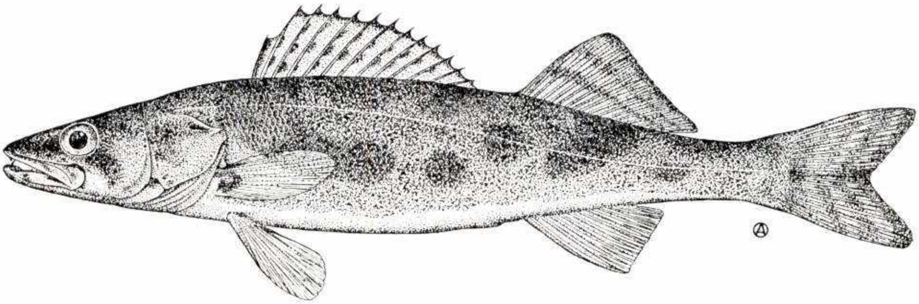
Morone Flavescens	— Mitchill 1814: 18 (type locality New York)
Perca notata	— Rafinesque 1818b: 205
Perca acuta	— Cuvier and Valenciennes 1828: 49
Perca flavescens (Cuvier)	— Richardson 1836: 1
perca fluviatilis	— Perley 1852: 82
Perca americana	— Wright 1892: 453
Perca americanus Schranck	— Cox 1896b: 70
Perca flavescens (Mitchill)	— Evermann and Goldsborough 1907a: 108
Perca fluviatilis Linnaeus	— Scott and Crossman 1967: 21
Perca flavescens (Mitchill)	— Scott and Crossman 1969: 23
Perca fluviatilis flavescens (Mitchill)	— McPhail and Lindsey 1970: 343

Etymology *Perca* — dusky, and possibly the ancient common name of the Eurasian perch; *flavescens* — yellow.

Common names Yellow perch, perch, lake perch, American perch. French common name: *perchaude*.

SAUGER

Stizostedion canadense (Smith)



Description Meristics and proportions for populations from Ontario and Saskatchewan. Body elongate, almost to quite cylindrical, average length 10–16 inches (254–406 mm), little or no lateral compression, greatest body depth at last half of first dorsal fin 12.6–16.4% of total length; caudal peduncle of moderate length, shallow, round. Head not deep, a blunt point at tip, its length 18.0–26.3% total length (greatest in young), moderately wide, interorbital distance 13.0–23.3% of head length (least in young), gill membranes extended forward, not joined nor broadly joined to isthmus; preopercle strongly serrate at least at bottom; short spine at upper edge of tip of opercle; eye large, diameter 17.8–25.5% of head length (greatest in young); snout long, pointed, not extending beyond upper jaw, its length 27.8–31.6% of head length; premaxillaries protractile; mouth large, terminal, very slightly oblique, jaws equal; maxillary very long, extending to posterior edge of pupil; teeth on jaws, head of vomer, and palatines numerous, longer, and sharp, large canines (often recurved) on vomer, palatines, and jaws; pharyngeal teeth large, sharp, recurved. Gill rakers moderately long and tooth bearing, inner edge of gill arch has short, rounded, tooth-bearing knobs, usually 6–8 rakers on lower limb, 3–5 on upper limb, but given by Paetz and Nelson (1970) as 15 and 6 for Alberta. Branchiostegal rays 6–8, 6:7, 7:7 or 7:8 (usually 7:7). Fins: dorsals 2, obviously separated, first dorsal spiny, high, long, a rounded triangle in shape, strong spines 13–15 (usually 14), second dorsal as high or higher but base a little shorter, with 1 (rarely 2) fine spine and 16–21 rays (usually 18), square to slightly emarginate; caudal of moderate size, long, not overly broad, well forked, tips rather pointed; anal with 2 spines and 11–14 rays, height greater than base, smaller than second dorsal, square; pelvics thoracic, under pectorals, widely spaced, space more than base of 1 fin (fin base is 45.7–56.7% of interfin space), long, equal to or longer than pectorals, tip rounded, 1 spine and 5 rays; pectoral fins only moderately broad, tips rounded, 12–14 rays (usually 13). Scales strongly ctenoid, cheeks mostly scaled, opercle mostly naked, breast and belly normally scaled; lateral line complete, high, slightly curved, scales rather small, 82–100 (usually 88–95) including 3 or 4 pitted scales in the area where the lateral line extends onto the scaled base of the caudal fin. Peritoneum white, intestine well differentiated, pyloric caeca 3–9 but usually 4–6, and each usually shorter than stomach; ovaries of post-spawning females reddish purple. Vertebrae 43–45.

No nuptial tubercles.

Colour Variable with habitat and, to a lesser extent, size. Background colour most often sandy or dull brown (but at times dull grey) with darker brown markings, markings usually absent on saugers from clear water; dorsal surface brown, sides paler, back with three or four dark brown saddles, some of which expand horizontally on sides, sides also with several large, round spots, ventral surface milky white; head with dark bars, eye silvery from light reflected by special light sensitive layer *(Tapetum lucidum)*; first dorsal fin with dark pigment on edge of membranes and rows of distinct black spots below (faint to absent in young), no dark blotch at posterior base; second dorsal with two narrow, dark bands of spots on membranes; caudal fin with rows of dark brown bars, lower lobe sometimes with faint white tip; anal fin white with dark speckles, sometimes with white tip, pelvic fins white with dark speckles; pectoral fins clear amber, with a black spot at base. Young with sandy-coloured background and conspicuous, dark brown, almost continuous saddle under dorsal fin.

Systematic notes Counts and proportions often considered stable over range. The sauger of the Great Lakes was at one time called *S. griseum* or *S. c. griseum*, and that of the St. Lawrence, *S. c. canadense*. There is still some tendency to consider the sauger as two subspecies, *S. c. canadense*, and *S. c. boreum* of the upper Missouri River. The following differences existed between counts for material examined for this account and those given (for Alberta?) by Paetz and Nelson (1970) and for Ohio by Trautman (1957):

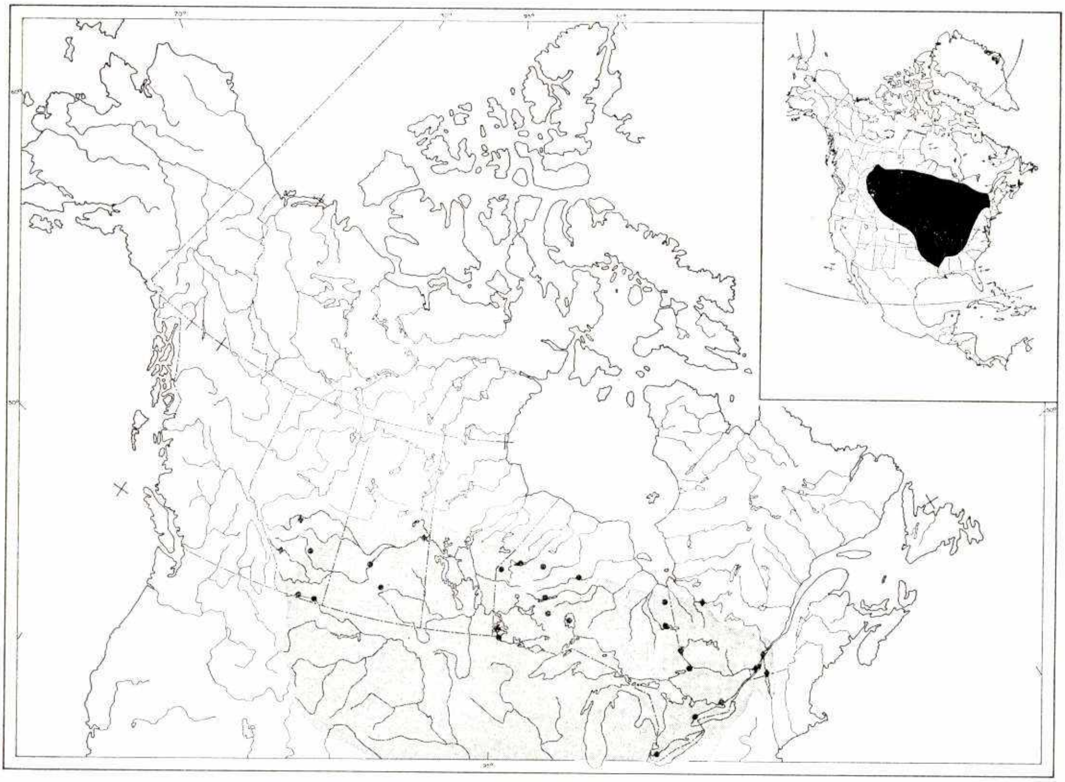
	Ont.	Sask.	Alta.	Ohio
Spines				
dorsal 1	13–15	13–14	10–14	10–14
dorsal 2	1(rarely 2)	1	2	1
Rays				
dorsal 2	16–20	18–19	17–22	17–22
Pyloric caeca	4–6	–	3–9	5–8
Lateral line scales	82–100	89–95	80–90	–

Variation within populations may be as great as differences given for populations in various areas. In many areas this species is probably mistaken for small walleyes.

Distribution The sauger is restricted to the freshwaters (and rarely brackish water) of North America. It occurs from the St. Lawrence–Champlain system south, west of the Appalachian Mountains to the Tennessee River in Alabama, southwest to northern Louisiana, northwest through eastern Oklahoma to central Montana and central Alberta, east below James Bay to Quebec.

In Canada it occurs from Quebec, in the St. Lawrence–Champlain system (and rarely downstream to brackish water, Vladykov 1949c), northward east of the Ottawa River almost to James Bay, west across Ontario south of a line from Kesagami Lake to Sandy Lake, in Manitoba south of the upper end of Lake Winnipeg, in the southern half of Saskatchewan, and north in Alberta to the North Saskatchewan River. Many recent texts (i.e., Moore 1968) repeat the statement of Hubbs and Lagler (1941–1964) that the sauger occurs in New Brunswick. There is no evidence to support this (Scott and Crossman 1959).

Biology The biology of this species in Canada is not well known. Various facets of its life history in Canada were described by Hart (1928), Doan (1941), Kennedy (1949a), and Stewart (1964). Information on United States populations came from Carlander (1950b), Carufel (1963), Priegel (1969), and Nelson (1968a). Spawning takes place for about a two-week period in the spring, often immediately after the walleye, usually the last week in May or first week in June. Both species may utilize the same shoals of gravel to rubble in large turbid lakes or turbid rivers. Spawning has been reported to begin at 39° F (3.9° C) and 43° F (6.1° C). The males arrive on the spawning ground first and are followed by the females which leave very soon after spawning. Spawning occurs at night in water 2–12 feet (61–366 cm) deep. The female is usually attended by one or more smaller males. The eggs are slightly



larger than 1.44–1.86 mm (size of embryo). Ripe eggs have been reported to be 1.0–1.5 mm in diameter and smaller than those of the walleye. The eggs are sticky when laid, but after water hardening are semibuoyant and non-adhesive. No nest is built, the eggs are shed, fertilized, and fall to the bottom where they drop between the gravel or boulders. Females will lay from 15,000–40,000 eggs per pound of fish depending on size. Total number of eggs per female has been variously given as ranging from approximately 9000 to 96,000. Hatching occurs over a range of 25–29 days at temperatures from 40°–55° F (4.5°–12.8° C). At hatching, the young are 4.5–6.2 mm long. An additional 7–9 days is spent on the bottom absorbing the yolk. The young have 21–26 postanal myomeres. The early development of this species was treated by Fish (1932), and Nelson (1968b) gave details of development and means of separating the very young of sauger and walleye.

Growth is rapid in the first year but slower than that of walleyes in the same waters. Rate of growth is variable with location, and is faster in prairie lakes than in those of the Precambrian Shield. Trautman (1957) said that in Ohio young-of-the-year in October were 3–6 inches (76–152 mm) in length. Age can be determined from scales and the body-scale size relation was determined by Priegel (1969). The following table gives the age–length (average calculated total length at end of year) relation, as converted by Priegel, and the age–weight relation, for saugers from three habitats.

Many sauger populations in northern Precambrian Shield lakes exhibit extremely slow growth, live longer, and reach an upper ultimate length of about 9 inches (229 mm). It is unlikely that any Canadian saugers surpass 21 inches (533 mm) total length, or 2 pounds weight. They grow at least to 19 inches (483 mm) in Alberta. Trautman gave maximum in Ohio as that of a gravid female which was 19.3 inches (490 mm) in length and a weight

Age	Lake Erie (Deason 1933) TL		Lake Nipigon (Hart 1928) Length		Wt	Lake of the Woods (Carlander 1950b) FL		Wt
	(inches)	*(mm)*	*(inches)*	*(mm)*	*(lb)*	*(inches)*	*(mm)*	*(lb)*
1	3.9	99	–	–	–	6.6	168	0.13
2	7.9	201	–	–	–	7.7	196	0.16
3	10.4	264	9.4	239	0.22	10.4	264	0.48
4	12.2	310	10.4	264	0.25	12.5	318	0.67
5	13.6	345	12.3	312	0.56	13.7	348	0.81
6	15.8	401	12.5	318	0.56	14.2	361	0.96
7	–	–	13.1	333	0.59	15.1	384	1.17
8	–	–	14.5	368	0.94	15.5	394	1.26
9	–	–	15.4	391	1.17	16.7	424	1.62
10	–	–	13.7	348	0.97	15.7	399	–
11	–	–	15.1	384	0.88	–	–	–
12	–	–	16.5	419	1.25	–	–	–
13	–	–	16.5	419	1.44	–	–	–

of 3 pounds 3 ounces. He said some of the larger specimens recorded may have been sauger × walleye hybrids. The present angler record is a sauger 28 inches (711 mm) long, which weighed 8 pounds 5 ounces, and was caught in the Niobrara River, Nebraska (Garrison Dam, Missouri River?) in 1961 (possibly a hybrid?). Maximum age in the north can be as high as 12 or 13 years but in the south it often does not exceed 5–6 years. Sexual maturity is achieved by males at 2–3 years, and by females at 4–6 years of age. The number of individuals of the oldest 2 or 3 years is usually extremely small.

Saugers may be less adaptable than walleyes as habitat preference seems to be for large, shallow lakes which are turbid with colloidal clay suspension, or for large, turbid, slow-flowing rivers. In Lake Nipigon and Lake Superior saugers are restricted to shallow, warm, turbid bays. They are a freshwater fish but are known on rare occasions to descend the St. Lawrence River to a point where the water is usually brackish (Vladykov 1949c).

Although adapted to turbidity, they do not do well unless temperature characteristics allow them to utilize the whole depth range. Turbidity may prevent excessive egg adhesion and thereby reduce suffocation, protect young from predators, and facilitate feeding of the young by concentrating plankton near the surface. In very turbid water saugers usually succeed over walleyes. In Ombabika Bay, Lake Nipigon, a predominantly walleye dominance changed to a sauger dominance in a period of a few years following diversion into the bay of turbid water. Water temperature may limit northward distribution. The lower reaches of such large, slow-flowing turbid rivers in Ontario as the Albany and Attawapiskat do not contain saugers, although they occur in the upper reaches. Northern distribution is apparently related to the 60° F July isotherm (Ryder et al. 1964). The temperature of the water level at which saugers are most often caught in summer is 65.5°–66.6° F (18.6°–19.2° C). Saugers are usually found in the top 20 feet of water but were present in Lake Nipigon in numbers to 45 feet, and more rarely to 63 feet.

Saugers usually move little in the summertime but there are records of individuals moving as far as 100 miles in the Mississippi River. In clearer water they are most active for short periods in the evening and early morning. In more turbid water, where light intensities are lowered, the period of activity is longer. In Canadian habitats, saugers are usually associated with goldeye, walleye, yellow perch, northern pike, and whitefishes.

Saugers are sight predators and negatively phototrophic, the light-gathering effect of the *Tapetum lucidum* of the eyes is a definite advantage in their turbid habitat. They often feed on the same shoals as do walleye. Food is variable with size and changes from zooplankton to chironomid larvae, to immature and adult mayflies. Adults feed on a variety of small fishes and various invertebrates such as leeches, crayfish, and insects. Priegel (1969) analyzed in detail food by size and season. Fry of other fishes are taken by sauger in the 12–50 mm size range. Fishes mentioned as food of the sauger are gizzard shad, trout-perch, white bass, freshwater drum, emerald shiner, black crappie, walleye, sauger, yellow perch, burbot, flathead chub, and sticklebacks. In Wisconsin, winter diet of adults is largely emerald shiners and trout-perch. If these fishes are scarce, then immature insects make up the ration. Sauger have, at times, been considered significant predators on whitefishes. This is apparently not so. It would seem they are not significant predators on any species of importance to man.

Northern pike, walleye, goldeye, and lake whitefish are the chief food competitors of the sauger. The effect of wind, waves, and temperature on hatching success and early growth is a greater control of population size than are competition and predation. Saugers of various sizes are preyed on by sauger, walleye, northern pike, and probably yellow perch.

The 23 parasites of the sauger, over the whole of its range, listed by Hoffman (1967) consisted of trematodes (6), cestodes (6), a nematode, acanthocephalans (2), a mollusc, crustaceans (6), and a leech. Many of the same species are found in the walleye also. Parasites of the sauger from Lake Erie were listed by Bangham and Hunter (1939).

The sauger and walleye are known to hybridize in nature. Artificial reciprocal hybrids of these two species were described by Nelson (1968b).

Relation to man The sauger is an important sport and commercial fish. In Manitoba it ranks third in importance, behind the walleye and whitefish in total value. The average sauger taken in the commercial catch is about 1 pound in weight. Most saugers are captured commercially by gillnets and poundnets. The gillnet fishery exploits fish both summer and winter in Manitoba. Gillnet mesh sizes used for sauger are smaller than those used for walleye, and are often responsible for the capture of many undersize walleye. Ontario and Manitoba contribute the bulk of the catch. At one time 2–6 million pounds of saugers were taken from Lake Erie annually. The catch there reported for 1968 was 70 pounds. The total catch recorded for Canada, 1965–1968, was a low of 2,834,000 pounds in 1967 and a high of 4,833,000 pounds in 1966. Landed values were 441,000 dollars and 1.46 million dollars. The Ontario catch in 1966 was only 59,202 pounds which makes the dominance of the Manitoba catch obvious. The catch in that province ranges between 3 and 5.5 million pounds a year.

The sauger has firm, white flesh which some prefer to the walleye. It is usually sold as fresh or frozen boneless fillets and in 1970 commanded a price of 63¢/pound, unprocessed.

Anglers in Canada do not regularly pursue saugers purposely and when caught they are often thought to be small walleye. Saugers are usually caught still fishing with, or drifting with, live or dead minnows. Trolling, drifting, or casting various bright artificial lures works also.

Nomenclature

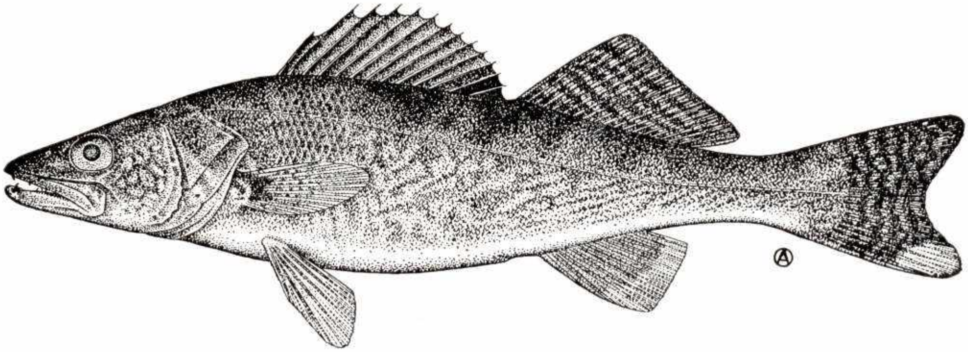
Lucioperca Canadensis	— Smith *in* Cuvier 1834: 275 (type locality Canada)
Lucio-perca Canadensis (Smith)	— Richardson 1836: 17
?*Lucioperca americana*	— Agassiz 1850: 294
Stizostethium Canadense	— Bell 1880: 7c
Stizostedion Canadense	— Small 1883: 33
Stizostedium Griseum	— Small 1883: 33
Stizostedium canadense	— Wright 1892: 453
Stizostedion canadense griseum DeKay	— Eigenmann 1895: 118
Stizostethium (Cynoperca) canadense (Smith)	— Jordan 1877a: 48
Stizostedion canadense (Smith)	— Dymond 1926: 80
Stizostedion canadense canadense (Smith)	— Hubbs and Brown 1929: 45

Etymology *Stizostedion* — pungent throat?; *canadense* — of Canada, the type locality.

Common names Sauger, sand pickerel, sand pike, sand pike-perch, blue pike, blue pike perch, blue pickerel, grey pike, grey pike perch, grey pickerel. French common name: *doré noir*.

WALLEYE*

Stizostedion vitreum (Mitchill)



Description Meristics and proportions for populations from Ontario to Alberta. Body elongate, subcylindrical when young, average length 13–20 inches (330–508 mm), slightly compressed, more so in large adults in some populations, greatest body depth under anterior half of first dorsal 12.5–19.3% of total length; caudal peduncle moderately long and deep, somewhat compressed. Head deeper than sauger, a blunt point at front, its length 23.8–28.4% of total length (greatest in young), moderately wide, interorbital distance 15.7–21.5% of head length (least in young), gill membranes extended forward, not broadly joined nor broadly joined to isthmus; preopercle bone strongly serrate, serrae sometimes curved forward; opercle with at least one short, sharp spine; eye large (larger in young), diameter 16.1–26.7% of head length; snout long, bluntly pointed, not extending beyond upper jaw, its length 25.3–33.5% of head length; premaxillaries protractile; mouth large, terminal, almost horizontal, jaws equal; maxillary very long, extending to posterior edge of eye; strong teeth on premaxillaries, jaws, head of vomer, and palatines numerous, large, often recurved canine teeth on head of vomer, palatines, jaws, and premaxillaries; pharyngeal teeth large, sharp, recurved. Gill rakers moderately long and tooth bearing on outer edge of gill arch, inner edge has short, rounded, tooth-bearing

*Mr R. A. Ryder, Ontario Ministry Natural Resources, prepared outlines on which much of the write-ups for this species and that for the sauger were based. He will be publishing expanded versions on these two species in Ontario.

knobs, 6–8 rakers on lower arch, 4 or 5 on upper arch. Paetz and Nelson (1970) gave gill rakers of 7–14 + 6–8 for Alberta and McPhail and Lindsey (1970) cited 12–15 + 4–5 (counting both sides of lower limb?). Branchiostegal rays 7,7 or 7,8. Fins: dorsals 2, obviously separated, first dorsal spiny, high, long, rounded, strong spines 12–16 (usually 14), second dorsal as high or higher, with 1 fine spine and 18–22 rays (usually 19–21), square to slightly emarginate; caudal long, not overly broad, well forked, tips rounded points; anal with 2 spines and 11–14 (usually 12 or 13) soft rays, height little greater than base, not as long as second dorsal, square; pelvics thoracic, widely spaced, base of 1 fin 58.2–74.6% of space between fins, length about equal to pectoral fins, tip rounded, 1 spine and 5 rays; pectorals only moderately broad, tips rounded, 13–16 (usually 14) rays. Scales strongly ctenoid (*see* Priegel 1964, for development of scales), cheeks scaleless or slightly scaled, opercles mostly naked, breast and belly normally scaled; lateral line complete, high, little curved, lateral line scales rather small, 83–104 (usually 86–92) including 3 or 4 pitted scales of the lateral line which extend on to the base of the caudal fin. McPhail and Lindsey (1970) extend the number to 108. Peritoneum white, short intestine well differentiated, pyloric caeca usually 3, each about same length as stomach; ovaries of post-spawning females reddish-purple. Vertebrae 44–48.

No nuptial tubercles. Differentiation of sexes difficult.

Colour Highly variable with habitat and to lesser extent with size. In turbid water paler and less marked with obvious black pattern, in clear water more vividly marked. Background usually olive-brown, to golden brown, to yellow, dorsal surface of head and back darker, sides paler, often with golden flecks on scales, ventral surface milk-white or yellow-white. In smaller fishes, 4–14 inches (102–356 mm), vague to obvious, dark, vertical bands across back and down sides, usually absent in adults; dorsal fin dusky, clear or vaguely speckled, no definite rows of spots, noticeable black blotch at base of last few membranes (except in very small); second dorsal and caudal fins with speckles or tiny spots in rather regular rows, lower lobe of caudal and tip of anal fins milk-white; pelvic fins yellow or orange-yellow; pectoral fins dark or pale olive, with dark blotch at base; eyes silvery from light reflected by light sensitive layer (*Tapetum lucidum*).

Grey-coloured walleyes (called "hards" in Lake Erie), which are the result of a bluish colour of the mucus, occur with varying frequency in most populations. Individuals of a slightly bluer colour occur in Lake Nipissing (*see* section on blue walleye in *Systematic notes*). Infrequently orange coloured mutants are taken in Ontario.

The blue walleye of lakes Erie and Ontario was distinguishable from the yellow walleye, and from these grey-blue forms, in that it was more slate-blue or steel-blue on the dorsal surface, ice-blue to silvery on the sides, and silvery to white on the ventral surface. The pelvic fins were white.

Systematic notes Variability of characters within populations is possibly as great as between populations, and characters may be rather stable over the total range of the material examined (*see* following table). Genotypic variability is apparently greater with at least three major genetic types existing in Canadian waters (*see* Uthe and Ryder 1970, for details).

This species consists, or did until recently, of two subspecies, the yellow walleye, *Stizostedion v. vitreum* and the blue walleye, *Stizostedion v. glaucum*. The blue walleye (or blue pike of the Lake Erie fishermen and the trade) was originally described by Hubbs (1926) as a separate species *Stizostedion glaucum*, but the number of fish considered to be intergrades between the two walleyes led to the change to subspecific status. The blue walleye was placed on the "Rare and Endangered" list (McAllister 1970) as "rare or perhaps even extinct." In spite of periodic reports of supposed blue walleyes it has now apparently totally disappeared from lakes

	Spines										Rays							
	1st dorsal					2nd dorsal					Anal				Pectoral			
	12	13	14	15	16	18	19	20	21	22	11	12	13	14	13	14	15	16
Peterborough, Ont.	–	–	4	5	–	–	2	4	3	–	1	–	7	1	4	5	–	–
L. Erie	1	7	2	–	–	1	2	5	2	–	1	7	2	–	–	–	–	–
L. Nipissing	–	5	5	–	–	–	8	2	–	–	–	7	3	–	–	–	–	–
L. Superior	–	2	7	1	–	–	–	1	6	3	–	4	6	–	6	4	–	–
Savanne L. (Hudson Bay system)	–	–	6	3	1	–	2	2	5	1	1	3	5	–	–	–	8	1
Sask.	–	3	5	2	–	–	6	4	–	–	–	5	5	–	–	–	–	–
Alta.	–	–	4	–	–	4	–	–	–	–	–	3	1	–	–	4	–	–

	Lateral line scales												
	83	84	85	86	87	88	89	90	91	92	93	94	104
Peterborough, Ont.	–	–	1	2	1	2	–	2	1	–	–	–	–
L. Erie	3	–	1	3	2	–	–	1	–	–	–	–	–
L. Nipissing	–	–	–	2	1	–	1	2	–	–	–	–	–
L. Superior	–	–	1	1	1	–	–	–	4	2	–	–	1
Savanne L. (Hudson Bay system)	–	–	–	–	1	2	–	1	2	2	1	1	–
Sask.	1	–	1	–	2	3	2	1	–	–	–	–	–
Alta.	–	–	–	–	1	–	1	1	–	1	–	–	–

Erie and Ontario. Consequently, it will not be treated here as a distinct entity but various comments will be made throughout the discussion of the yellow walleye, the only remaining walleye.

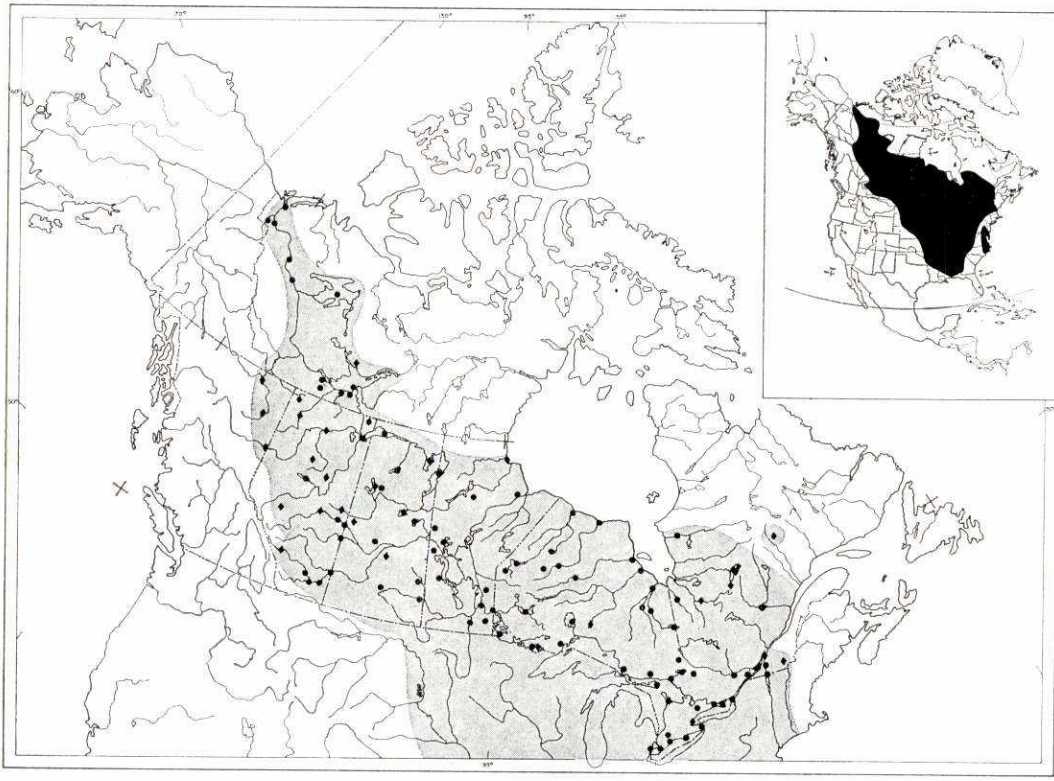
In most aspects other than colour and certain biological features, the two subspecies were difficult to separate. The eyes of the blue walleye were slightly larger, higher on the head, and consequently closer together (interorbital width less). Trautman (1957) showed a greater distance between angle of preopercle bone and branchiostegal rays, otherwise proportions and counts were very similar. The blue walleye had a different spawning time and place, a slower growth rate and smaller ultimate size, and different depth distribution.

The situation of establishing the distinction of the blue walleye was made doubly difficult by the high frequency of the supposed intergrades with the yellow walleye, the presence of grey-coloured mutants of the yellow walleye, and of supposed hybrids of both subspecies with the sauger. Stone (1948), who studied the taxonomy of these forms in lakes Erie and Ontario, concluded that the yellow and blue walleyes were separate species each with separate subspecies in each of the two lakes. This is interesting when we consider the 1970 evidence mentioned above of different genotypes.

The grey-blue walleyes seen regularly in Lake Nipissing, Ont., (and more rarely elsewhere) have long been considered by some to be blue walleyes. On the basis of characteristics available to us, this cannot be denied nor proven. They are largely undistinguishable from the blue-grey mutants of the yellow walleye seen elsewhere. One interesting fact is that they are seen there more often when there is a very successful year-class of yellow walleye dominating the fishery.

The common name of this species in Canada has long been a problem. Both the names pickerel and pike-perch allude to a supposed similarity between the head and teeth of this species and those of the northern pike. Since the name pickerel (a diminutive of *pick* or *pike*) was first applied to the smaller, new-world pikes *(Esox)*, the name walleye is more suitable and less confusing. It alludes to the smoky, silvery eye which is said to be similar to that of blinded or "walleyed" domestic animals. *See* Weed (1927) for an extensive list of common names of this species.

Distribution The walleye is limited to the fresh water (and rarely brackish water) of North America. It occurs from Quebec south to New Hampshire, southwest to Pennsylvania, southward west of the Appalachian Mountains to the Gulf coast in Alabama, northeast to eastern Oklahoma, northeast through the eastern half of the states from Nebraska to North Dakota, north to near the Arctic coast in the Mackenzie River, southeast across James Bay to Quebec. There is a residual, apparently native, stock along the central Atlantic seaboard (Pennsylvania to



North Carolina). It has been widely introduced elsewhere on the eastern seaboard and in virtually all the states to the west of its natural range.

In Canada it occurs generally in Quebec in tributaries of the St. Lawrence downstream at least to the Manicouagan River, north to rivers tributary to the east coast of upper James Bay, northwest from the Hudson Bay coast in Ontario to Athabasca, Great Slave and Great Bear lakes, north in the Mackenzie River to the delta, south through the Peace River drainage of northeastern British Columbia and south, east of the foothills, to southern Alberta (apparently much more sporadic and less abundant in northwest Alberta). It forms a dominant part of the fish fauna particularly in the boreal forest zone. Canadian stocks originate from a Mississippi and an Atlantic glacial refugium. It probably spread into northern Ontario, and Quebec via glacial lake Barlow–Ojibway and its outlets. It has been introduced in various places in Canada within its native range where barriers precluded its natural occurrence.

Contrary to a number of published range statements, it does not occur in Labrador.

The blue walleye occurred in Lake Erie, the lower Niagara River, and western Lake Ontario. It was reported as far east in Lake Ontario as the Bay of Quinte. Records of it in Long Lake, tributary to the Napanee River, and in other small inland lakes may have been based on the grey mutant of the yellow walleye. Its presence in Lake Nipissing is debatable (*see Systematic notes*).

Biology The biology of this species in Canada has been extensively studied. Information on Canadian populations was derived from Hart (1928), Kennedy (1949a), Rawson (1957), Payne (1964), Ellis and Giles (1965), Ryder (1968), and Regier et al.

(1969); and from publications on populations in the northern United States by Wolfert (1969) and Priegel (1970).

Spawning occurs in the spring or early summer (early April in southwestern Ontario, to end of June or later in far north) depending on latitude and water temperature. Northern populations do not spawn in some years when temperature is not favourable. Normally, spawning begins shortly after ice breaks up in a lake, at water temperatures of 44°–48° F (6.7°–8.9° C) but has been known to take place over a range of 42°–52° F (5.6°–11.1° C). Prespawning behaviour (courtship) may commence much earlier, when water temperature is 34° F (1.1° C). Males move to the spawning grounds first. Spawning grounds are the rocky areas in white water below impassable falls and dams in rivers, or boulder, to coarse-gravel shoals of lakes. Fish often move into tributary rivers immediately the rivers are ice free and while the lake is still ice covered. Spawning takes place at night, in groups of one larger female and one or two smaller males or two females and up to six males. Males are not territorial, and no nest is built. Prior to spawning there is much pursuit, pushing, circular swimming, and fin erection. Finally, the spawning group rushes upward into shallow water, stops, the females roll on their sides and eggs and sperm are released. Apparently most individual females deposit most of their eggs in one night of spawning. Egg diameter is 1.5–2.0 mm and eggs are sticky at first but apparently not so after water hardening. The eggs are broadcast and fall into crevices in the substrate (on mats of vegetation in flood-bench marshes in some areas of Wisconsin). Egg number has been given as high as 612,000 in females 31.5 inches (801 mm) in length, and it increases yearly at least to age 11. Eggs hatch in 12–18 days in temperatures prevalent on the spawning grounds. The yolk sac is absorbed rapidly (feeding takes place prior to disappearance of yolk) and by 10–15 days after hatching the young have dispersed into the upper levels of open water. Fish (1932), Norden (1961b), and Nelson (1968b) gave details of early development of young. Nelson also gave means of distinguishing between the young of walleye and sauger. Newly hatched fry are 6.0–8.6 mm in length and have 22–29 postanal myomeres. By the latter part of the summer, young-of-the-year move toward the bottom and are found in 20–30 feet (3.05–9.15 m) of water.

Growth is fairly rapid in the south but slower in the northern part of the range. In Lake Erie they may reach 3.5–8.0 inches (89–203 mm) by the end of the first growing season, but only 3–4 inches (76–102 mm) in the north. The following table gives the age–length and age–weight relations for various populations.

Payne (1964) gave the length–weight relation in Bay of Quinte, Lake Ontario, as Log W (pounds) = -3.690×3.271 Log L (fork length in inches). As can be seen, growth differential between Lake Erie and Lac la Ronge can be as much as 4 inches (102 mm) at any age. There is a difference in the rate of growth of females over males. This occurs from age 7 onward in Saskatchewan and is approximately 6%. In the Moon River, Ont., females can be 2–4 inches (51–

		Age														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Bay of Quinte, L. Ontario (Payne 1964)	FL *inches*	8.4	12.7	15.8	18.3	20.4	21.9	23.0	24.2	25.0	25.6	26.3	26.2	26.5	27.0	27.8
	mm	213	323	401	465	518	556	584	615	635	650	668	665	673	686	706
	Wt (*lb*)	0.22	.83	1.70	2.75	3.92	4.95	5.81	6.86	7.63	8.25	9.01	9.00	9.24	9.82	10.80
L. Manitoba (Kennedy 1949a)	Avg FL *inches*	–	–	10.9	12.3	14.2	15.5	16.3	17.0	18.7	19.1	19.8	–	21.0	–	–
	mm	–	–	277	312	361	394	414	432	475	486	503	–	533	–	–
	Avg wt (*oz*)	–	–	9.8	14.0	20.7	25.1	30.7	34.4	47.4	52.6	57.5	–	71.6	–	–
Lac la Ronge, Sask. (Rawson 1957)	Avg FL *inches*	3.9	8.8	10.6	12.3	14.2	15.9	17.5	19.0	20.5	21.8	23.0	24.2	25.3	–	–
	mm	99	224	269	312	361	404	445	483	521	554	584	615	643	–	–
	Wt (*oz*)	–	2.9	4.5	9.0	16.3	–	26.3	36.0	–	48.0	–	61	79	–	–

102 mm) longer at any age. Growth rates for other Canadian populations were given by Adamstone (1922, Lake Erie) and Hart (1928, lakes Nipigon and Abitibi). Adamstone also contrasted with that of yellow walleye the age and growth of the blue walleye. The blue walleye at its maximum age (11) did not exceed 14.7 inches (375 mm) in length. Average weight at age 7 was 17 ounces.

Walleyes seen by anglers are usually 1–3 pounds in weight and 3 years of age. In Ontario, walleyes of 12–19 pounds win annual anglers contests but the largest Ontario walleye was 42 inches (106.7 cm) in fork length, 27 inches (686 mm) in girth, weighed 23 pounds 9 ounces, and was taken in spawning operations in Moon River, Georgian Bay. A 28-inch (711-mm) walleye is the largest known from Alberta. Trautman (1957) said that the largest Lake Erie specimen was 31 inches (787 mm) long, and weighed 11 pounds 14 ounces. The present angling record is a walleye taken in Old Hickory Lake, Tenn., in 1960, which was 41 inches (104.1 cm) long, 29 inches (737 mm) in girth, and weighed 25 pounds. The previous long standing record was a walleye of 22 pounds 4 ounces caught at Fort Erie, Ont., in 1943. The blue walleye rarely exceeded 12–14 inches (305–356mm) and $\frac{3}{4}$–1 pound.

Male yellow walleyes generally mature at 2–4 years of age, over 11 inches (279 mm) in length, and females at 14–17 inches (356–432 mm) or 3–6 years of age. Maximum age varies from 10–12 years in the south to a possible 20 years in the north. Gillnets in common use by commercial fishermen ($4\frac{1}{2}$ inch or 114 mm mesh) often take females before they have contributed to the population. Walleyes taken in the Georgian Bay commercial fishery are usually about 19 inches (483 mm) total length.

Walleyes are tolerant of a great range of environmental situations, but appear to reach greatest abundance in large, shallow, turbid lakes. Optimum transparency in a shallow lake, which will allow walleye to feed intermittently throughout the day, is in the order of 1–2 m Secchi disc. They also thrive in clear lakes but the special layer of the eye (*Tapetum lucidum*, *see* Ali and Anctil 1968) is extremely sensitive to bright daylight intensities, so feeding is restricted to twilight or dark periods. Large streams or rivers, providing they are deep or turbid enough to provide shelter in daylight, are suitable habitat. This species often uses sunken trees, boulder shoals, weed beds, or thicker layers of ice and snow as a shield from the sun. They may even remain in a depth, the temperature of which is above their usual selection, if there is better protection there. In clear lakes they often lie in contact with the bottom apparently "sleeping." In these lakes, they often feed from top to bottom at night. In more turbid water they are more active during the day, swimming slowly in schools close to the bottom. Walleyes are often associated with other species such as yellow perch, northern pike or muskellunge, and smallmouth bass. White suckers often orient themselves in walleye schools and behave as a part of it. The habitat does not change in winter except for an avoidance of strong currents. They are active all winter and are taken by ice fishermen. Usually fish of moderately shallow water (to 49 feet or 15 m) they were taken as deep as 69 feet (21.04 m) in August in Lac la Ronge whereas the blue walleye was usually found below 40 feet (12.2 m).

Movements involve a spring spawning run to shallow shoals or to tributary rivers, daily movements up and down in response to light intensity, and daily or seasonal movements in response to temperature or food availability. In Lac la Ronge, greatest net catches took place at depths where temperature ranged from 55.4°–64.4° F (13°–18° C) and in Wisconsin at 69.08° F (20.6° C). Their summer wanderings are usually limited to 3–5 miles, but tagged fish have been known to travel over 100 miles. *See* Magnin and Beaulieu (1968) for movements in the St. Lawrence River. There is evidence of homing to spawning grounds year after year in Michigan (Crowe 1962). Walleyes seem to remain in loose but discrete schools with separate spawning grounds and summer territories.

The food of the walleye shifts very quickly, with increase in size, from invertebrates to fishes. This is in part a reflection of their change in habitat from surface to bottom. During the first 6 weeks of life food consists mostly of copepods, Cladocera, and fish (*see* Priegel 1963b, for details). They are highly cannibalistic if small yellow perch or another forage fish are not more readily available. Some populations, even as adults, feed almost exclusively on emerging larval or adult mayflies or chironomids for part of the year.

The relative amounts of various species of fish taken apparently depend on availability. However, when present, yellow perch and freshwater drum seem very important. Species listed have been rainbow smelt, alewife, ciscoes, ninespine stickleback, white sucker, longnose sucker, yellow perch, lake whitefish, walleye, sauger, spottail shiner, darters, white perch, freshwater drum, trout-perch, emerald shiner, common shiner, silver chub, gizzard shad, rock bass, pumpkinseed, black crappie, smallmouth bass, brown bullhead, goldeye, mooneye, cottids, burbot, and various other unidentified minnows, as well as those regularly used as bait. It would seem safe to say they utilize any species of fish readily available to them. Other items such as crayfish, snails, frogs, mudpuppies, and small mammals are taken but only rarely, and usually when fishes and insects are scarce. Food in winter is not particularly different other than possibly in species composition.

Northern pike are probably the most important predators of the walleye over much of its range. The muskellunge also preys on walleye in more restricted areas. Northern pike may also be an important competitor as it is the only other major, shallow-water predator in the north. Adult perch, walleye, and sauger prey on the young as probably do a wide variety of predatory fishes. Many fish-eating birds and mammals, as well as lampreys, prey on walleyes regularly but are probably not important predators. Yellow perch, sauger, smallmouth bass, and lake whitefish compete with walleye for food. More important in controlling populations are water temperature, stream flow and wind at spawning time, and other species which spawn over the walleye eggs or roil up the silt. A major controlling factor is fry mortality (death + predation including cannibalism) which is up to 99% to the postlarval stage in some of the Finger Lakes in New York.

The walleye is host to a wide variety of parasites. Hoffman (1967) listed the following for the yellow walleye from the whole of its range: protozoans (3), trematodes (22), cestodes (10), nematodes (10), acanthocephalans (4), leeches (2), molluscs, crustaceans (7). Parasites from Canadian habitats were given in detail by Bangham and Hunter (1939) (both yellow and blue walleyes from Lake Erie), and Bangham (1955).

In certain areas of Saskatchewan and Alberta walleye are infected with the broad tapeworm *Diphyllobothrium latum*. This parasite regularly infects sleigh dogs fed raw fish, and human infection is known to have occurred. If fish are properly cooked this parasite will not infect man.

Lymphocystis, a virus disease, is very common on spawning walleye and appears as a white, tumorlike protuberance on the body. It apparently does not cause mortality in natural populations (Ryder 1961) and usually disappears when the water reaches summer temperatures. This species is also subject to black-spot and yellow grub and while these two parasites render the whole fish unsightly they can usually be removed by filleting and skinning, are harmless to man, and are killed when the fish are cooked.

The yellow walleye hybridizes in nature with the sauger (*see* Stroud 1948; and Nelson 1968b for details). In the past, intergrades between the yellow and blue walleye were common in Lake Erie.

Relation to man The walleye is probably the most economically valuable species in Canada's inland waters. It is a major commercial and sport fish in Ontario and the Prairie Provinces, and a sport fish in Quebec. An angler survey in Ontario showed that the walleye was the game species most often fished for and was the second most abundant in anglers' catches. It is an important species in both the summer sport fishery and for ice fishermen in the winter. The walleye is usually angled by still fishing with live minnows as bait or with artificial lures such as spinners, spoons, plugs, and jigs. Drifting and trolling seek out the schools of moving walleye. The two twilight periods of sunset and sunrise are the most productive. The walleye is not a spectacular fighter but a steady battler always boring for the bottom. The average walleye caught by angling is about 1½ pounds in weight.

Canadian commercial fisheries harvest several million pounds of walleye annually. Over the years 1919–1968 there was considerable fluctuation in catch but a peak of almost 21 million pounds in 1956 had a landed value of over 3.1 million dollars. The catch record also emphasizes the rapid decline since 1956. Lake Erie formerly produced about one-half of this catch but in recent years the fishery there has declined drastically due to overexploitation and deterioration of the environment (for details *see* Regier et al. 1969). In 1956, the Canadian and American walleye production from Lake Erie was 24 million pounds (Baldwin and Saalfield 1962). As a result, the contribution of the Prairie Provinces to the total Canadian catch of 8.5 million pounds in 1968 was much higher than in previous years. The commercial fishery commonly employs gillnets and poundnets to harvest this species. Current fisheries are usually restricted by quota, minimum size, and minimum mesh-size regulations. The walleye has a firm, white to pinkish flesh, which is easily filleted and prepared. It is a prime species on the market, presently commanding as much as $1.25/pound depending on size, and type of processing and packaging. It is also highly regarded by anglers as a food fish.

Apparently competition between commercial and sport fisheries for this species has often led to heated controversy and to the necessity of a study of the walleye stocks in those areas. For extensive treatment of exploitation of such stocks, *see* Olson (1958), Ryder (1968), Regier et al. (1969), and numerous unpublished reports of various provincial governments. An extensive treatment of blue walleye fishery of Lake Erie was given by Parsons (1967).

Nomenclature

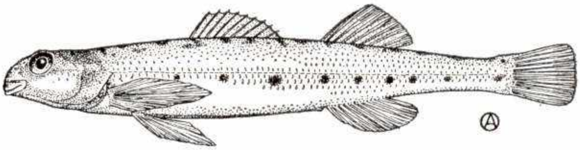
Perca vitrea	— Mitchill 1818a: 247 (type locality Cayuga Lake, N.Y.)
Perca Fluviatilis	— Pennant 1792: 298
Perca fluviatilis, var. ? L.	— Richardson 1823: 725
Lucio-perca Americana (Cuvier)	— Richardson 1836: 10
Lucioperca Canadensis	— Forelle 1857: 280
Lucioperca grisea	— Forelle 1857: 280
Lucioperca Americana	— Forelle 1857: 280
Stizostedion vitreum (Mitchill)	— Jordan and Evermann 1896–1900: 1021
Stizostedion glaucum	— Hubbs 1926: 58 (type locality Lake Erie, off Ashtabula, Ohio)
Stizostedion vitreum vitreum (Mitchill)	— Hubbs and Lagler 1941: 73
Stizostedion vitreum glaucum (Hubbs)	— Hubbs and Lagler 1941: 73

Etymology *Stizostedion* — pungent throat; *vitreum* — glassy, alluding to the nature of the large, silvery eyes.

Common names Walleye, yellow walleye, wall-eye, pickerel, yellow pickerel, yellow pike, pike-perch, yellow pike perch, walleye pike, wall-eyed pike, wall-eyed pike-perch, wall-eyed pike perch, wall-eyed pickerel. French common name: *doré*.

EASTERN SAND DARTER

Ammocrypta pellucida (Putnam)



Description Body elongate, average total length about 2.5 inches (64 mm), not noticeably compressed laterally except posteriorly, body not deep, greatest depth less than head length, 8.6–11.9% of total length; flesh of body somewhat pellucid. Head moderate, its length 17.2–20.8% of total length, gill membranes joined at an acute angle and free from isthmus, opercle with a flattened, triangular spine; eye diameter 19.4–29.6% of head length; snout length usually greater than eye diameter, and often down curved, its length 26.5–32.7% of head length; premaxillaries non-protractile but separated from snout by shallow groove; mouth moderately large, maxillary not extending to anterior margin of eye; teeth small, fine, not enlarged. Branchiostegal rays 6,6. Fins: dorsals 2, first dorsal spiny, of 8–11 weak spines, second dorsal soft rayed, of 9–12 rays, usually 10 or 11, dorsals distinctly separated; caudal only slightly forked, nearly truncate, of 19 rays; anal with 1 thin weak spine and 8–10 (usually 9) soft rays; pelvics relatively well developed; pectorals relatively well developed. Scales ctenoid, 62–77 in a lateral series, weakly developed but better developed along midline of sides, scales above midline of sides with black margin posteriorly; lateral line usually complete or nearly so. Vertebrae 40–43.

Colour Overall colouration is light, the back is slightly yellowish, becoming silvery white on the lower part of sides and on ventral surface. There is a row of 10–14 small, rounded, green spots along the midline of each side, and 12–16 spots along midline of back, which become paired at bases of dorsal fins. Only adults exhibit the yellowish colouration while young fish tend to be white or silvery.

Distribution The eastern sand darter ranges from Lac St. Pierre in the upper St. Lawrence River, and the Lake Champlain drainage in Vermont, south to West Virginia and Kentucky; west through southwestern Ontario to southeastern Michigan.

In Canada it has been reported from Quebec in the lakelike expansions of the upper St. Lawrence River and their tributaries, such as Lac St. Pierre (Cuerrier et al. 1946, who reported it common in 1941), and Lake of Two Mountains and the Chateauguay River which flows into Lac St. Louis (Vladykov 1942). In Ontario, it was found occasionally in Lake Erie tributaries, in the Thames River of the Lake St. Clair drainage, and tributary streams of southern Lake Huron. It has not been reported from the north shore of Lake Ontario.

Except as noted above for Lac St. Pierre, it is not a common species and we know of no captures in Ontario streams for over 25 years, except for records from two Lake Erie tributaries in 1955.

Biology The eastern sand darter has received no attention in Canadian waters, beyond statements of its occurrence, and, hence, we have no direct knowledge of its biology.

The preferred habitat is said to be sand-bottomed areas in streams and rivers and sandy shoals in lakes. In such locations, the sand darter can bury itself with only its eyes exposed above the sand (Trautman 1957). The Chateauguay River specimens reported by Vladykov were caught over limestone terraces covered with a thin layer of mud with water temperature about 77° F (25° C) and *p*H of 8.6. The specimens taken in Lake of Two Mountains, Que., were caught over a sand–clay bottom, while the water temperature was 75.2° F (24° C) and *p*H 8.2.

During exploratory otter trawling in Lake Erie in 1957, by the United States Bureau of Commercial Fisheries, sand darters were caught in otter trawls at depths to 48 feet (14.6 m) in the eastern basin and from 18 to 42 feet (5.5–12.8 m) in the western basin.

From its place of concealment in the sand, the sand darter is said to dash out and capture passing prey. Midge larvae were found in the stomachs of darters captured in Ohio waters of Lake Erie (Turner 1921) and we presume that various entomostracans are among the major food items in Canadian waters.

Bangham and Hunter (1939) examined 15 sand darters from western Lake Erie and found 9 infected. The parasites identified were trematodes, *Neascus* sp., *Tetracotyle* sp., *Lebouria cooperi*, and nematodes *Camallanus oxycephalus* and *Agamonema* sp.

Relation to man This is an uncommon species in Canadian waters and is probably even less common now than formerly. It seems unlikely that it could long survive the environmental onslaught from highly industrialized areas, such as those around Montreal. Sand-bottom regions in streams and rivers, which is the preferred habitat, are much less available since such areas tend to become silted over, especially in the populated regions where this species occurred. Trautman (1957) noted that the preferred habitat was much reduced in Ohio and that sand darters were much less common than before 1945.

Nomenclature

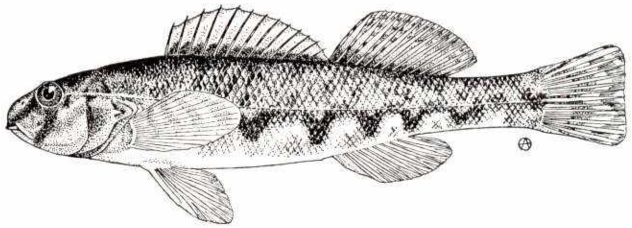
Pleurolepis pellucidus	— Baird (*in* Putnam 1863: 5) (type locality — none)
Etheostoma pellucidum Baird	— Putnam 1863: 5
Vigil pellucidus (Baird)	— Jordan, Evermann, and Clark 1930: 288
Ammocrypta pellucida (Baird)	— Dymond 1947: 25
Ammocrypta (Ammocrypta) pellucida (Agassiz)	— Collette and Knapp 1966: 60
Ammocrypta pellucida (Putnam)	— Bailey et al. 1970: 75

Etymology *Ammocrypta* — sand, concealed; *pellucida* — from *pellucidus*, meaning transparent.

Common names Eastern sand darter, sand darter. French common name: *dard de sable*.

GREENSIDE DARTER

Etheostoma blennioides Rafinesque



Description Body thick set and robust, average total length about 3 inches (76 mm), moderately deep bodied, especially adults, greatest body depth 15.1–17.9% of total length. Head moderate, triangular in cross section, its length 18.1–20.4% of total length, gill membranes broadly joined and free from isthmus, opercle with a small but sharp, conspicuous spine posteriorly; eye moderate, its diameter 23.8–28.2% of head length; snout bluntly rounded, projecting slightly beyond mouth opening, its length 23.9–30.8% of head length; premaxillaries separated from snout by a deep groove; mouth small and inferior; maxillary extending posteriorly to below nostril; posteriorly maxillary fused to preorbitals at sides, with only short groove near tip, upper lip sometimes with symphyseal knob; teeth in brushlike bands on upper and lower jaws, bands several teeth in width, outer teeth larger and more widely spaced, inner teeth small and close set, teeth on prevomer reduced, none on palatines. Branchiostegal rays 6,6(8), 6,7(1), 7,7(1). Fins: first dorsal, anal, pelvic and pectoral fins usually larger on males than females; dorsals 2, first dorsal spiny, spines strong, spines 12(7) or 13(13), second dorsal soft rayed, rays 12(4), 13(9), 14(7), fins close together, appearing to be conjoined in large males, second dorsal higher than spiny dorsal; caudal well developed, barred, weakly or shallowly forked; anal with 2 spines and 7(1), 8(11), or 9(8) soft rays, originating below origin of second dorsal; pelvics well developed, pointed on young, with rounded tips on adults; pectorals well developed, somewhat pointed, tips extending to beyond middle of spiny dorsal. Scales ctenoid, nape, cheeks, opercles and belly fully scaled; lateral line complete, 54–60 scales; swim bladder absent. Vertebrae 40(5), 41(3), or 42(1).

Colour Overall colouration olive-green or olive-brown dorsally, becoming pale green on sides, caudal, anal, and pelvic fins, and white or creamy white below. Young fish have 6 or 7 brownish saddle-shaped marks on the back which may be less obvious on the more heavily pigmented mature specimens. On the sides are 5–7 large olive-brown V-shaped marks which may be especially prominent on the latter half of the body of younger fish, and extend below the midline, but on larger fish these marks often tend to form a bandlike pattern. Two dark lines (on each side) extended downward from the eye, one forward toward the snout, and one downward and forward but passing posterior to the end of the maxillary. In life, the green colour with the peculiar lateral markings are distinctive. For a detailed account of spawning colouration *see* Fahy (1954).

Systematic notes A thorough systematic study was presented by Miller (1968) in which four subspecies were recognized. The typical subspecies, *E. b. blennioides*, formerly considered to be the form occurring in the Great Lakes region (Hubbs and Lagler 1958) was redefined and considered to occur in Ohio, upper Genesee and Potomac rivers. The Great Lakes population (including the Thames River and Lake St. Clair populations of Ontario) were assigned to a new subspecies, *E. b. pholidotum*, composed of two races, a Wabash River Great Lakes race and a Missouri race, the total range of the subspecies extending from eastern New York State, the lower Great Lakes southwestward to eastern Kansas. *See* Miller (1968) for further details.

Distribution The greenside darter ranges in east-central North America, in streams of lower Great Lakes, Potomac, and Mississippi drainage systems from eastern New York on the east to Kansas, and Oklahoma on the west, south to northern Alabama and Arkansas.

In Canada it occurs only in the Lake St. Clair drainage of southwestern Ontario and has been recorded from Lake St. Clair and the Thames and Avon River systems.

Biology The biology of the greenside darter has received considerable attention but no studies have been published on Canadian populations. In view of the extremely limited Canadian distribution, detailed treatment of the extensive literature seems unwarranted here. Therefore, the following is a brief account of the biology of this species. For additional information, *see* Turner (1921), Fahy (1954), Winn (1958a, b) or Miller (1968).

According to Fahy, spawning was initiated in Salmon Creek, Lake Ontario drainage of New York, when water temperature reached 51° F (10.6° C). This temperature is critical and spawning ceased if temperatures dropped below 51° F. Given favourable conditions, the spawning season extended from mid-April to mid-June. Actually spawning occurred in early morning and throughout the day (Winn 1958b) although Fahy suggested that the species spawned at night. The reproductive behaviour of many darters is rather unusual and the greenside darter is no exception. The male usually selects a territory but the female selects the spawning site, and, if necessary, will stimulate the male by swimming and nudging actions. The female assumes a position on an algal-covered boulder or other object, usually at a distinct angle, which apparently also stimulates the male who then assumes a position on top of her. Filamentous algae, especially *Cladophora*, is commonly a site for egg deposition. *See* Winn (1958a, b) for a complete description of spawning behaviour of this and many other darter species, and *also* Fahy (1954).

The number of eggs laid varied from 466–1832, depending upon size of female; ripe eggs averaged 1.8 mm in diameter and were adhesive when deposited. Hatching occurred in 18–20 days at temperatures of 54.4°–59.0° F (13°–15° C). The development of eggs and larvae were described in great detail and illustrated by Fahy.

Fahy found that reliable age determinations could be made from scales. Males grew faster and attained a greater size than females, but both sexes attained over 60% of their growth in the first growing season. Three years was a typical life span but a few individuals survived a fourth or even a fifth growing season.

Studies in Ohio waters of Lake Erie by Turner (1921) indicated that the young fed on midge larvae, cladocerans, and copepods, in that order. Midge larvae remain the most important food at all ages, especially in Lake Erie. The diet was more varied in Ohio streams and although midge larvae were still important, mayfly larvae and, to a lesser extent, caddisfly larvae, were significant supplementary foods. In Lake Ontario tributaries of New York State, Fahy found insect larvae to be important in the diet, especially blackfly, midge, and caddisfly larvae.

Bangham and Hunter (1939) examined 10 specimens from United States waters of western Lake Erie and found 3 infected. Parasites identified were trematodes *Allocreadium* sp. and *Tetracotyle* sp., and nematodes *Camallanus oxycephalus*. Hoffman (1967) listed only one parasite, the trematode *Phyllodistomum etheostomae* from the greenside darter.

Relation to man The greenside darter is of no known direct importance to man but indirectly it could be of considerable interest as an experimental or laboratory animal, particularly in behavioural studies. Unfortunately, the Ontario distribution is limited and the stocks could be depleted if overfished.

Nomenclature

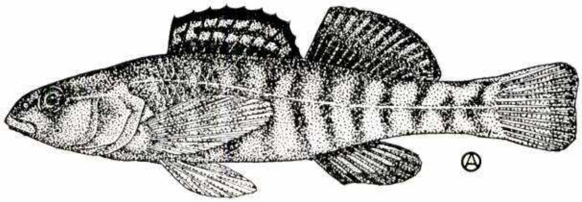
Etheostoma blennioides	— Rafinesque 1819: 419 (type locality Ohio River)
Diplesion blennioides (Rafinesque)	— Jordan and Evermann 1896–1900: 1053

Etymology *Etheostoma* — from *etheo* — to strain, *stoma* — mouth; *blennioides* — *Blennius* — blenny; likeness.

Common names Greenside darter, green-sided darter. French common name: *dard vert*.

RAINBOW DARTER

Etheostoma caeruleum Storer



Description Body short, average length about 2 inches (51 mm) robust and rather deep, greatest body depth 17–20% of total length, noticeably compressed laterally. Head triangular, its length 19.1–23.9% of total length, gill membranes joined at an acute angle and free from isthmus, opercle with small but sharp, conspicuous spine posteriorly; eye moderate, its diameter 20.5–26.2% of head length; snout rather pointed and projecting beyond lower jaw; premaxillaries bound to snout by a frenum, i.e., no groove across snout; mouth of moderate size, lower jaw overhung by snout, maxillary extending posteriorly to below anterior margin of orbit; teeth in brush-like bands in upper and lower jaws, bands several teeth in width, outer teeth larger and more widely spaced, inner teeth small and closely set. Branchiostegal rays 6,6(9), 7,6(2). Fins: dorsals 2, first dorsal spiny, spines strong, usually 10(16), sometimes 9(3) or 11(2), second dorsal soft rayed and distinctly higher than spiny dorsal, rays usually 13(15), sometimes 12(5), or 14(1), fins close together but distinctly separated; caudal well developed, speckled on females, truncate; anal with 2 spines and 6(9) or 7(12) rays, originating below origin of second dorsal, smaller than second dorsal in females, about equal to second dorsal in males; pelvics well developed, pointed; pectorals well developed, larger than pelvics, somewhat pointed, rays usually 13, sometimes 12 or 14. Scales ctenoid, cheeks appear scaleless but some scales apparent on cleared and stained specimens, opercles scaled; lateral line usually incomplete, pored scales 27–34, scales in lateral series 42–45. Vertebrae usually 35(8), sometimes 34(1).

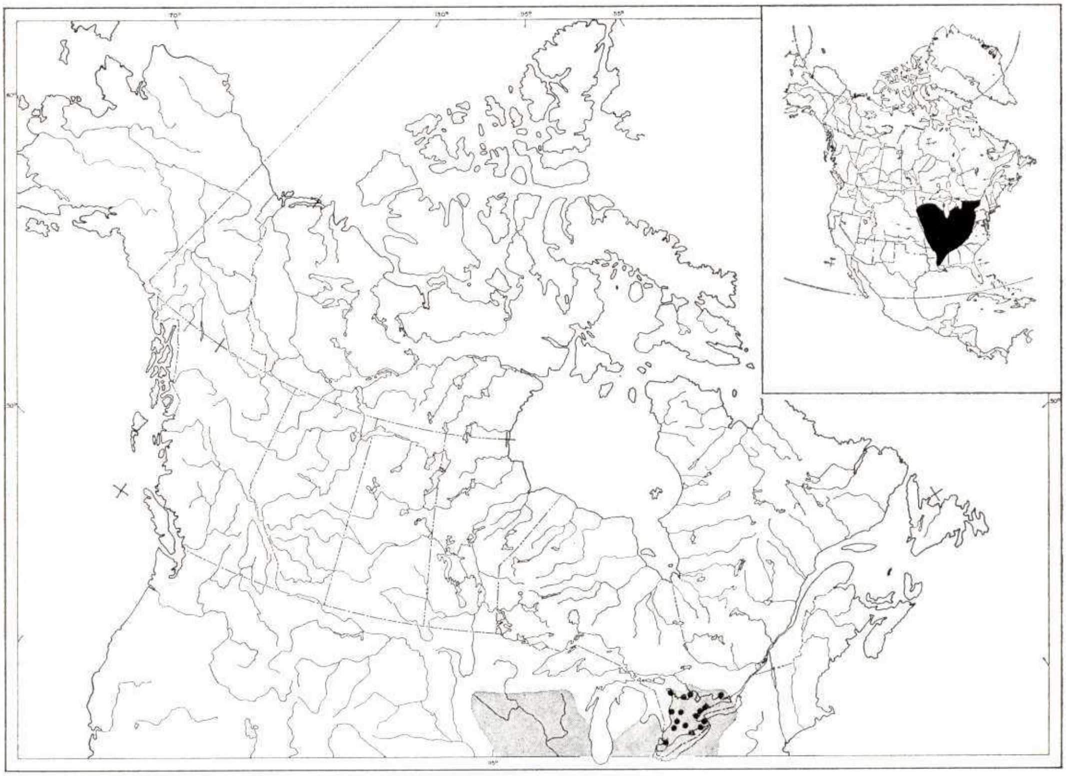
Colour The male rainbow darter, in breeding dress, is probably the most colourful of all our native fishes, but, because of its small size and limited distribution, it is infrequently seen and not well known.

Overall, the breeding male is a colourful array of brilliant blues and greens on head and breast and on the bars on flanks, with interspaces of yellow or orange; the two dorsal fins and the anal fin, especially of males, display the same tones of green, yellow, and orange but each has a narrow outer margin of brilliant blue-green.

There are 6–10 saddle marks or blotches on the back, and 9–14 vertical bars or bands on the sides; posterior to the anus the vertical bars are most pronounced and usually encircle the body but anteriorly they are weaker and often ill-defined.

The males are much more colourful and have more conspicuous vertical bars than the females. Young fish may lack the colour but display the vertical bars, although young males exhibit partial colouration. *See* colour illustration facing p. 730.

Systematic notes The rainbow darter displays little morphometric or meristic variation throughout most of its range, but the southwestern populations exhibit more variation than any others. An intensive



systematic study of this darter was completed by Knapp (1964) who proposed three subspecies, *E. c. caeruleum*, *E. c. oreium*, and *E. c. notiale*. Ours is the typical subspecies, *E. c. caeruleum*, which is wide ranging while the other two have more restricted distributions in south-central United States.

Distribution The rainbow darter ranges through the Great Lakes drainage area (except Lake Superior) west from New York State to Minnesota; south of the Great Lakes states in the Mississippi and Ohio River systems to Alabama, Mississippi and Arkansas.

In Canada, the species is found only in southern Ontario in streams entering lakes Ontario, Erie, St. Clair, and Huron.

Biology Spawning occurs in spring in coarse gravel, fine gravel, or rubble riffles in streams. In Michigan waters, males move to the riffles in late March and establish relatively small (1 foot wide by 2 feet long), shifting territories. The males attain a larger size than females and engage in much sham fighting, displaying their brilliant colours with fins erect. When ready to spawn, the female enters the riffles with its attendant ripe and rival males and after a period of courtship, wiggles, head first, into the gravel. The male moves over the female, his caudal region depressed beside hers. They vibrate briefly, the female extrudes a few eggs (less than 10), the male exudes milt, fertilizing the eggs, the female moves out of the gravel, leaving the eggs buried. The same female may move forward on the riffle, repeating the performance a few or several times, before returning to the pool below the riffles. Spawning continues until the total egg complement, averaging about 800 eggs, is deposited. Ripe eggs average 1.5–1.8 mm in diameter and hatch in 10–12 days at temperatures of 62.2°–65.3° F (17.0°–18.5° C). The development and pigmentation pattern of the larvae was described and illustrated by Fish (1932).

For additional information on reproduction, *see* Winn (1958a, b) the source for much of the above. Winn (1958b) also noted that Reeves (1907) inadvertently included two species in the otherwise detailed account of the breeding behaviour of the rainbow darter.

Age can be determined by scale examination but detailed studies of growth are not available especially for Canadian populations. In Ohio, young rainbow darters attained lengths of about 1.1–1.8 inches (28–46 mm) by October of their first year. The largest Canadian specimen examined by us was one 2.5 inches (65 mm) total length, from the Saugeen River, Ont.

Rainbow darters are inhabitants of gravel or rubble-bottomed clear water streams in glaciated regions, particularly in streams of moderate to large size. Shallow water or rocky or gravelly riffles are essential for breeding. Given suitable conditions rainbow darters may be extremely abundant.

Midge (chironomid) and mayfly larvae were of primary importance in the diet of rainbow darters of all sizes but larger insect larvae such as caddisflies, as well as snails, and small crayfish were eaten by large adults in Ohio streams studied by Turner (1921). They also eat eggs of stream-spawning minnows and lampreys (Winn 1958b).

We have no information on the utilization of rainbow darters by stream-dwelling trout and other predaceous fishes but assume that, when available, they are utilized by larger trout as food.

Only one rainbow darter was examined during the Lake Erie survey by Bangham and Hunter (1939) and it was free of parasites. Hoffman (1967), however, listed the following parasites from this species: trematodes (5), cestodes (1), nematodes (1), acanthocephalans (1), molluscs (1), and crustaceans (1).

Relation to man The rainbow darter is an exquisitely beautiful inhabitant of clean, gravelly Ontario streams and is of value for this reason alone, although we know of no direct economic importance. Perhaps it is of greatest value to man as an indicator of pollution for it is extremely sensitive to chemical pollution and silting. Its native range is documented, and it can be readily observed by competent field biologists. It is perhaps of more than passing interest that rainbow darters were noted to feed on the eggs found in brook lamprey nests in Michigan (Winn 1958b).

In our experience, it does not adapt easily to the home aquarium, although it can be retained indefinitely in a well-equipped laboratory or hatchery-type facility.

Nomenclature

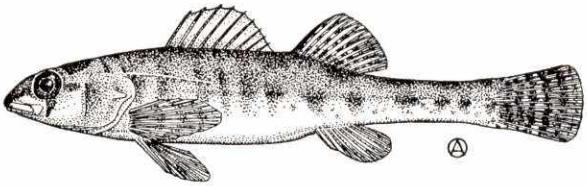
Etheostoma caerulea	— Storer 1845: 47 (type locality Fox River, Ill.)
Etheostoma coerulea	— Storer 1846: 272
Etheostoma coeruleum Storer	— Jordan and Evermann 1896–1900: 1088
	— Halkett 1913: 85
Oligocephalus caeruleus (Storer)	— Jordan, Evermann, and Clark 1930: 291
Poecilichthys coeruleus (Storer)	— Toner 1937: 17
Poecilichthys caeruleus (Storer)	— Radforth 1944: 61
Etheostoma caeruleum Storer	— Hubbs and Lagler 1958: 109

Etymology *Etheostoma* — from *etheo* — to strain, *stoma* — mouth; *caeruleum* — from *caeruleus,* meaning blue.

Common names Rainbow darter, rainbow fish, blue darter, banded darter. French common name: *dard arc-en-ciel.*

IOWA DARTER

Etheostoma exile (Girard)



Description Body slender, short, average length about 2 inches (51 mm), somewhat compressed laterally but not markedly deep bodied, greatest body depth 12.7–16.0% of total length. Head low, elongate, its length 19.8–22.8% of total length, gill membranes joined at an acute angle and barely free from isthmus, opercle with a small, sharp and rather inconspicuous spine posteriorly; eye rather large, its diameter 23.8–29.3% of head length; snout rounded, slightly projecting beyond lower jaw, its length 20.3–26.4% of head length; premaxillaries bound to snout by a frenum, i.e., no groove across snout; mouth moderate, lower jaw barely included in upper, maxillary extending posteriorly to below anterior margin of pupil; teeth in brush-like bands in upper and lower jaws, bands several teeth wide, outer teeth larger and more widely spaced, inner teeth small and closely set. Branchiostegal rays 5,5(1), 6,5(1), 6,6(15), 7,7(3), 7,6(1). Fins: dorsals 2, first dorsal spiny, spines strong, spines usually 8–10 (rarely 7), second dorsal soft rayed, slightly higher than spiny dorsal, rays usually 11(20), sometimes 10(17), or 12(4), fins distinctly separated by 2 or 3 scale lengths (*see Systematic notes*); caudal well developed, distinctly speckled, truncate; anal with 1(7) or 2(32) spines, and 7(18) or 8(22), rarely 6(1), rays, smaller than second dorsal; pelvics rather small, somewhat pointed; pectorals well developed, distinctly rounded, rays 12–14. Scales ctenoid, cheeks and opercles lightly scaled; lateral line incomplete, terminating under second dorsal, 18–28 pored scales, 45–60 scales in lateral series. Vertebrae usually 36(7) or 37(10), occasionally 35(2) or 38(2).

Colour Overall colouration is dark brown or olive-brown on back and sides, becoming yellowish or creamy white below. There is a distinct vertical, suborbital bar. On the back are about 8 narrow, saddle-shaped, darker marks, while midlaterally, on the sides, are 10–14 (usually 11) short, dark, vertical bars that do not extend to dorsal or ventral surfaces. The pelvic and anal fins are usually only lightly speckled with pigment, the pectorals somewhat more so, but the dorsal and caudal fins are distinctly pigmented; the caudal fin marking takes the form of a number of regular spots on the fin rays producing a series of arc-like lines.

The breeding male is exceedingly colourful; the first dorsal fin is blue at base, then a transparent section blending with an orange or reddish band and finally edged with a deep blue (or blue-green) band. The bands on the sides take on an intense blue or blue-green colour, the intervening spaces an orange, orange-red, or yellow, with yellow on the ventral surface; the pectoral and anal fins yellow-orange or orange-red. *See* Dymond (1926) for additional colour notations.

Systematic notes The Iowa darter has long been known to exhibit wide variability throughout its extensive range, and because of this variability, has acquired many synonyms; *see* Hubbs (1926) for a review of some of these. Many other authors, including Richardson (1938) and Carlander (1941), have remarked on the variability of the species but Gosline (1947) provided the most intensive in-depth study of meristic variation of the species. *See also* Bensley (1915) and Dymond (1926) for descriptive details of specimens from Georgian Bay and Lake Nipigon, Ont., respectively.

Although the sample sizes are small, there are indications of interesting trends in meristics when comparing Ontario and Saskatchewan specimens as the following table shows. In addition, branchiostegal rays range from 5,5 to 6,6 in Saskatchewan and from 6,6 to 7,7 in Ontario specimens.

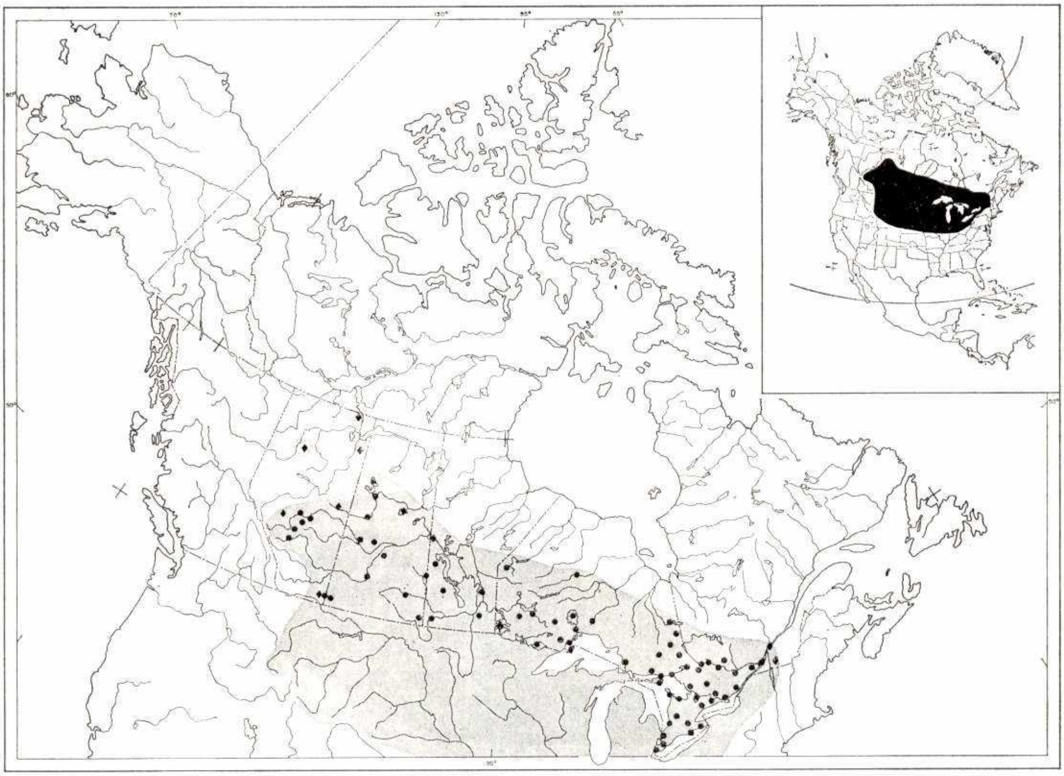
Distribution The Iowa darter occurs from southern Quebec and the Allegheny drainage of New York, west through the Great Lakes drainage area, and adjoining states to Iowa, Nebraska, Colorado, Montana, and Alberta.

In Canada it occurs from southern Quebec in the upper St. Lawrence–Lake Champlain area and Lac St. Pierre, west throughout the Great Lakes drainage of Ontario to Lake of the Woods, and north to the James Bay watershed; throughout southern Manitoba, extending north to the Saskatchewan River near The Pas; in central and southern Saskatchewan in the Churchill River and North and South Saskatchewan River systems, the Qu'Appelle valley, Antler River, and Cypress Hills area; in southern Alberta recorded from the Cypress Hills region, Square Lake (east of Lac la Biche), and from the North Saskatchewan River, Red Deer River, and recorded in 1966 from Pine Lake, northern Alberta, about 40 miles south of Fort Smith, N.W.T. (D. E. McAllister personal communication). This isolated record is the northernmost limit of range. This species has the widest Canadian distribution of any darter.

Biology Spawning occurs in southern Michigan during April and May but considerable variation in time of spawning may occur between adjacent localities. There is little published information on the time of spawning in Canadian waters but it is presumably later than in southern Michigan. For example, Dymond (1926) noted that females with nearly ripe eggs were taken in Lake Nipigon on June 19, 1924, and Bensley (1915) stated that the breeding season included the latter part of May and June, in the Georgian Bay region of Lake Huron.

In southern Michigan, Winn (1958b) observed that adults moved from the deeper waters of Lake Whitmore to the shallows near shore. Here the males established territories. The females moved in from deeper water to spawn in a male's territory, and moved from territory to territory, mating several times with different males before moving offshore into deeper water. Spawning took place, in this case, on fibrous-root material under undercut banks, usually in shallow water less than 15 inches deep. Characteristically, the species spawns in shallow water of lakes, or pondlike expansions in rivers, on bottom organic debris or on fibrous roots in mudbanks. Winn (1958b) noted that only rarely did spawning occur on sand or on organic material on sand, and this only when undercut banks were not available. The actual spawning act, under natural conditions, was not observed by Winn because of the location under banks, but from laboratory observations it is known that the male moves over the female, his caudal region depressed beside hers, in the manner characteristic of most darters. The eggs are deposited in groups of 3–7, according to Winn, and average 1.1 mm in diameter. A total

	Dorsal				Anal					Vertebrae			
	Spines				Spines		Soft rays						
	7	8	9	10	1	2	6	7	8	35	36	37	38
Ontario		4	10	8	1	21		12	10		3	8	1
Saskatchewan	1	11	9	1	6	13	1	6	12	2	4	2	1



of 550–2048 eggs may be laid, the larger and older females laying the greater number. Hatching occurred in 9–10 days at temperatures of 55.4°–60.8° F (13°–16° C). A description and illustration of a 19.5 mm stage larva from Lake Erie was presented by Fish (1932). Little information is available on rate of growth but Winn (1958a) indicated that adults may live at least 3 years. Adults normally attain lengths of 2.0–2.3 inches (51–58 mm) in Canadian waters. Females attain a larger size than males. The largest specimen examined by us was 2.7 inches (68 mm) total length, from Quetico Provincial Park, Ont.

Iowa darters are inhabitants of clear, standing, or slowly moving waters of lakes or rivers, having rooted aquatic vegetation, and a bottom of organic debris, sand, peat, or a composite of these. It is a glacial relict species that can apparently withstand cooler waters than other darters since it ranges farthest north. Like most darters it is intolerant of turbid, muddy waters of low visibility, which destroy its food supply. Trautman (1957) noted that it has become greatly reduced in numbers in many parts of Ohio since 1930.

Midge larvae, mayfly larvae, and amphipods were of primary importance in the diet of adult and juvenile Iowa darters, but small crustaceans, such as copepods and cladocerans, were the principal food of the young (Turner 1921). Additional items eaten by large adults include snails and corixid nymphs.

We have no details of predation on Iowa darters by other fishes, but, since it is an inhabitant of lakes, there is little doubt that it contributes to the diet of piscivorous fishes. During survey work in eastern Ontario watersheds, Toner (1943) remarked on the absence of northern pike in those areas where *E. exile* were caught, and suggested that it fell prey to northern pike.

Bangham and Hunter (1939) examined 7 specimens from the west end of Lake Erie and reported 5 parasitized. Parasites identified were the trematodes *Allocreadium* sp., and *Tetracotyle* sp., the larval or immature form of the cestode *Bothriocephalus cuspidatus*, nematodes *Agamonema* sp., and the acanthocephalan *Leptorhynchoides thecatus*. All 5 specimens from Lake Huron and Manitoulin Island examined by Bangham (1955) were infected. Two darters were from Lily Lake and 3 from South Bay, yet the parasites infecting the fish from the two areas were different. Parasites included 3 species of trematodes, 2 of cestodes, 2 of nematodes, and a leech, *Illinobdella* sp.

Hoffman (1967) listed protozoans (3), trematodes (6), cestodes (2), nematodes (5), acanthocephalans (4), molluscs (1), and leeches (1), from Iowa darters in North American waters.

Relation to man There is no direct information on the role of the Iowa darter in the economy of our waters. But, since it is widely distributed in Canada, and feeds mainly upon benthic organisms in lakes, there can be little doubt of its importance in the aquatic ecosystem.

Nomenclature

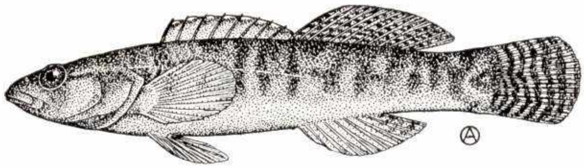
Boleichthys exilis	— Girard 1860: 103 (type locality Little Muddy River, trib. Upper Missouri)
Etheostoma iowae Jordan and Meek	— Eigenmann and Eigenmann 1892: 962
Etheostoma quappella E. and E.	— Eigenmann and Eigenmann 1892: 963
Boleichthys fusiformis (Girard)	— Dymond 1922: 71
Poecilichthys exilis Girard	— Hubbs 1926:64
Etheostoma boreale Boulenger	— Hubbs 1926: 65
Oligocephalus iowae (Jordan and Meek)	— Jordan, Evermann, and Clark 1930: 291
Etheostoma exile (Girard)	— Bailey 1951: 232
Poecilichthys borealis Jordan	— Collette and Knapp 1966: 61

Etymology *Etheostoma* — from *etheo* — to strain, *stoma* — mouth; *exile* — from *exilis*, meaning slim or slender.

Common names Iowa darter, yellowbelly, weed darter. French common names: *dard à ventre jaune*, *dard d'herbe*.

FANTAIL DARTER

Etheostoma flabellare Rafinesque



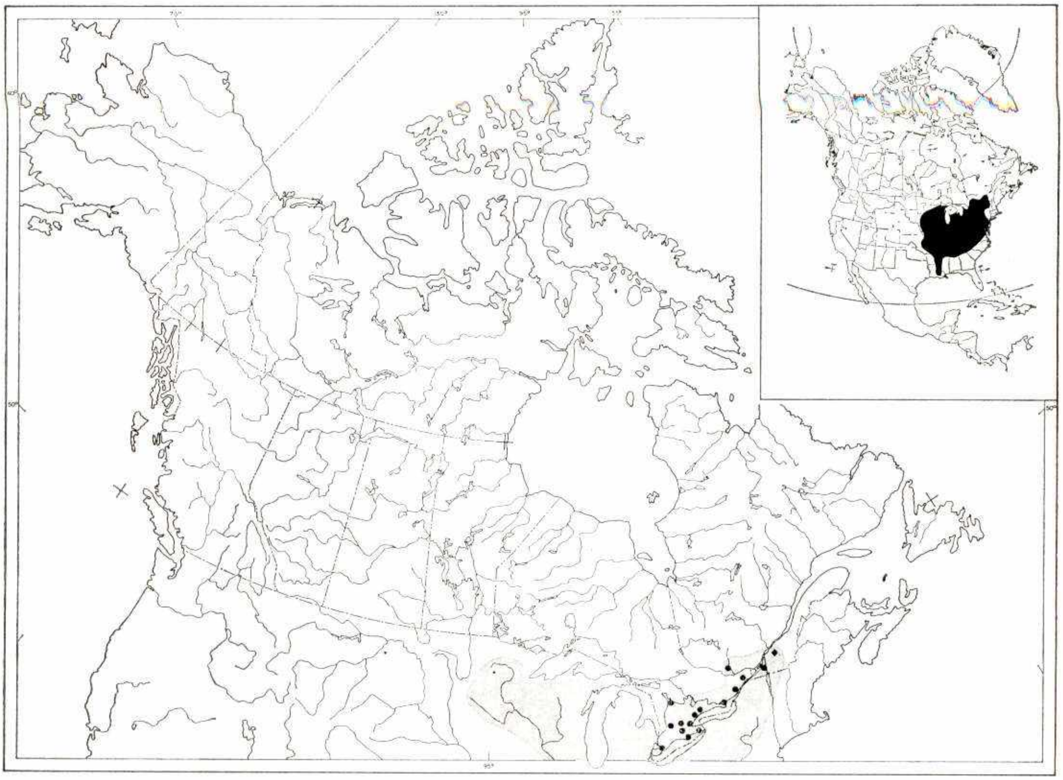
Description Body elongate, robust, average length about 2 inches (51 mm), somewhat tube-like in appearance due to deep caudal peduncle, no marked variation in body depth, especially in subadults, greatest body depth 11.6–16.8% of total length. Head low, elongate, pointed, its length 21.1–24.0% of total length, gill membranes broadly joined and free from isthmus, opercle with small inconspicuous spine posteriorly; eye moderate, its diameter 19.5–24.4% of head length; snout straight, not rounded, its length 21.9–28.3% of head length, not projecting beyond lower jaw; premaxillaries bound to snout by a frenum, i.e., no groove across snout; mouth large, upper and lower jaws about equal, maxillary extending posteriorly to below anterior margin of pupil; teeth in narrow, brushlike bands on upper and lower jaws, outer anterior teeth in both jaws enlarged, slim, pointed, remaining teeth smaller. Branchiostegal rays 6,6(13). Fins: dorsals 2, first dorsal spiny, spines strong, short, usually 7(15) or 8(7), sometimes 6(1), each spine tipped with fleshy knob on spawning males only, second dorsal soft rayed, higher than spiny dorsal, rays usually 13(12), 14(7), or 12(4), fins close together but distinctly separated; caudal well developed, distinctly barred, rounded, not truncate; anal with 2 spines and 7(3), 8(18), or 9(2) soft rays, smaller than second dorsal; pelvics small, narrow, shorter than pectorals; pectorals rounded, fanlike, rays 12 or 13. Scales ctenoid, cheeks and opercles naked; lateral line incomplete, 27–35 pored scales, 47–51 scales in lateral series; swim bladder absent. Vertebrae 32(2), 33(8), or 34(3).

Colour Overall colouration is brown or olive-brown with 9–12 short, dark, vertical bars on sides that are often vague or ill-defined. Breeding males may also exhibit lengthwise rows of broken or unbroken lines. Colour of ventral surface creamy white, yellowish, or dusky. The males lack the colourful spawning dress so typical of many darters, but become darker and have the tips of the dorsal spines topped by yellow-orange or orange coloured fleshy knobs. The fins are weakly or not pigmented, except for the second dorsal which is speckled and the caudal which is conspicuously barred with about 6 dark, narrow bands. Spawning males may also have weakly spotted pectoral and anal fins.

Systematic notes Two subspecies are described, the typical subspecies, *E. flabellare flabellare*, the barred fantail, and *E. f. lineolatum*, the striped fantail. The form occurring in our area is *E. f. flabellare*, which shows little morphological variation within the region.

Distribution The fantail darter occurs from southern Quebec and eastern New York, west through the southern Great Lakes drainage, including Lake Michigan, to Iowa and Kansas, south to North Carolina, Kentucky, Tennessee, and in the Mississippi River, to Louisiana and Mississippi.

In Canada, it is known from the tributaries of Lake St. Francis of the upper St. Lawrence River system in southern Quebec, west in the



lower Ottawa River, to the tributary streams of lakes Ontario, Erie, and southern Lake Huron, northward to Grey County at the base of the Bruce Peninsula.

Biology In the spring, fantail darters move from swift waters of riffles into slower-moving waters, in preparation for spawning. A male will set up a territory under a rock, and the females move into the territories to spawn. In the latitude of Rochester, N.Y., Lake (1936) reported that movement into the spawning area commenced in late March and extended into April, and that egg-laying and incubation extended from April 26 to June 22. No observations are available on dates of spawning in Canadian waters, and most of the following information was derived from Lake and from Winn (1958a, b).

The method of spawning and the spawning site are unusual. The undersurface of the rock is separated from the bottom gravel by a distance about equal to the body depth of the male with dorsal spines in an erect position. This distance is critical and is of the order of 15–25 mm. The male moves around under the rock, dorsal spines erect, and the fleshy bulbous tips on the spines clean off the surface of the rock in preparation for the eggs. When a female moves into the territory, she is met by a male who leads her under the rock, performing a series of movements involving circles and figure eights. Eventually after a courtship that may involve leaving the shelter of the rock and re-entering, the female turns upside down and with the male right side up, and head to tail, they move in circles and figure eights. After a time, the female presses her vent against the surface of the rock, vibrates slightly, and extrudes a single, adhesive egg which sticks to the rock. At this moment the male turns upside down, fertilizes the egg, body vibrating briefly, and then immediately turns right side up again. The female remains upside down and the egg deposition and fertilization continue until about 34 eggs, on average, are deposited. While under the rock, movement is achieved by the use of the pectoral and caudal fins. When a female has released her complement of eggs, she either leaves or is driven out of the nest, and the process repeated with another female. The male guards the nest and moves around under the eggs, brushing them with the bulbous tips of the dorsal spines and the soft dorsal fin. Lake indicated that the eggs quickly became infected if left untended and Cross (1967) suggested that mucus from the male may have bactericidal and fungicidal effects since males seem especially slimy during spawning.

Several females may deposit their eggs in the nest. Lake, by actual count, found the number of eggs in the nests to vary from 8 or ten to 562. Winn (1958a) counted 120–467 eggs per female, the greater number in the larger fish. A large female may spawn up to five times in a single season. The eggs are large and average 2.3 mm in diameter and hatch in about 21 days at a temperature of about 70° F (21.1° C). Descriptions of developmental stages were provided by Fish (1932) and Lake (1936).

Age and growth were reported for Iowa waters by Karr (1964), who used scales to determine ages. Males attained a larger size and lived a year longer (to 4 years) than females (3 years). Karr's samples ranged in total length to 2.7 inches (70 mm) and we have examined Canadian specimens to 2.5 inches (65 mm) total length.

Fantail darters require small, shallow-water, gravel and boulder-bottomed streams, usually less than 18 inches deep, for spawning, and deeper, downstream waters for overwintering. Slow to moderate currents seem to be preferred. It seems to be less sensitive to moderate turbidity and silting than the rainbow darter.

Studies by Turner (1921) in Ohio suggested that the fantail darter limited its diet primarily to mayfly larvae. Turner found surprising the size of the food items ingested, for sometimes an individual larvae eaten was almost as long as the fish. The size of the food items increased with the size of the fish, and beetle larvae, caddisfly larvae, and corixids were also taken. Amphipods were of some importance in Lake Erie but were not eaten by stream-dwelling fish.

Bangham and Hunter (1939) examined 18 specimens from the eastern end of Lake Erie, and found 10 infected. Of the 5 examined, from the west end of the lake, only one contained parasites. All were trematodes, *Clinostomum marginatum*, *Neascus* sp., and *Tetracotyle communis*.

Hoffman (1967) listed trematodes (9), cestode (1), nematodes (3), acanthocephalans (3) and molluscs (1).

Relation to man No direct economic significance is apparent but the species offers unique opportunities for behavioural study, although these are limited because of the restricted Canadian distribution of the species.

Nomenclature

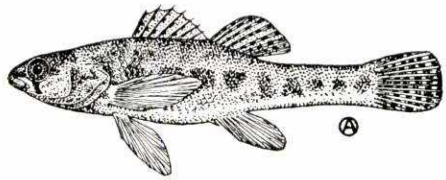
Etheostoma flabellaris	— Rafinesque 1819: 419 (type locality Ohio River)
Etheostoma flabellare Rafinesque	— Jordan and Evermann 1896–1900: 1097
Catonotus flabellaris Rafinesque	— Hubbs 1926: 68
Poecilichthys flabellaris	— Speirs 1951: 2

Etymology *Etheostoma* — from *etheo* — to strain, *stoma* — mouth; *flabellare* — *flabellaris*, meaning like a fan, from the form of the tail.

Common names Fantail darter. French common name: *dard barré*.

LEAST DARTER

Etheostoma microperca Jordan and Gilbert

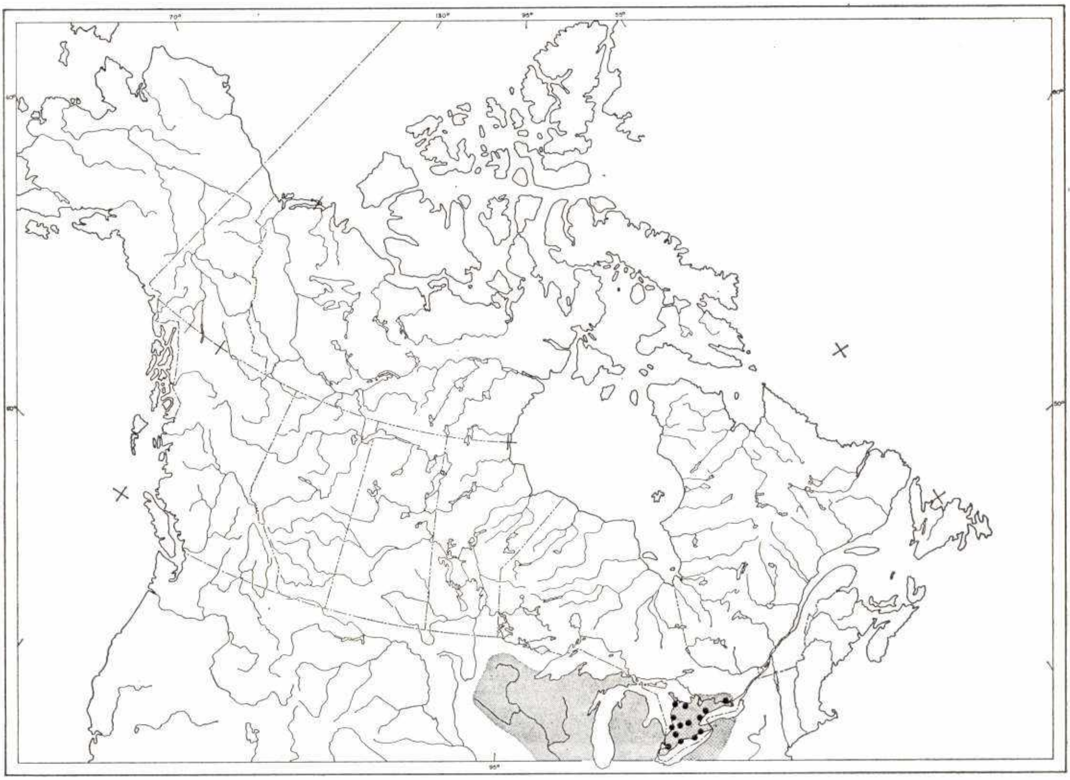


Description Body small, laterally compressed, robust, total length about 1 inch (25 mm), greatest body depth 14.0–19.1% of total length. Head triangular, its length 20.5–22.1% of total length, gill membranes rather broadly but delicately joined, free from isthmus, meeting at an obtuse angle; eye moderate to large, its diameter 22.2–28.9% of head length; snout length, less than eye diameter, 15.4–22.0% of head length; premaxillaries not protractile, bound to snout by narrow frenum; mouth small, maxillaries extending posteriorly barely to anterior margin of eye; teeth in brushlike bands on upper and lower jaws, outer teeth enlarged and widely spaced, inner teeth smaller and more crowded, size of teeth and spacing decreases toward rear of tooth band. Branchiostegal rays usually 5,5(8), sometimes 6,6(1). Fins: dorsals 2, first dorsal spiny, spines relatively strong, spines 6(9), or 7(10), second dorsal soft rayed, higher than spiny dorsal, rays 8(11) or 9(8), fins separated but very close together; caudal fin rounded and distinctly barred; anal fin well developed with 1(7) or 2(12) spines and 5(14) or 6(5) soft rays; pelvics inserted low on ventral surface, becoming enlarged on breeding males, with a sheet of skin extending outward and enlarging the width of the fin even to the outer base, this development not on females (*see* Petravicz 1936, for further details and illustration); pectoral rays relatively small, fanlike and rounded. Scales ctenoid, cheeks, opercles and breast naked; lateral line absent and only 1 pored scale in specimens examined; scales in lateral series 24–32; swim bladder absent. Vertebrae 31(4), 32(4), or 33(1).

Colour Overall colouration brownish, back and sides sprinkled with darker brown spots; a short, distinct, dorsal stripe anterior to first dorsal fin; 8–10 squarish, ill-defined blotches on sides. Ventral surface creamy with scattered brown speckling. The dorsal and caudal fins conspicuously speckled, anal and paired fins dusky. A prominent black suborbital bar. Breeding males colourful, with an orange spot on membrane between each dorsal spine, base and outer edge of spinous dorsal black; anal and pelvic fins rusty orange. Females, when breeding, may have yellowish caste to pelvic, pectoral, and anal fins.

Distribution The least darter ranges west from western part of Lake Ontario through tributaries of Lake Erie, through the Michigan–Huron basin, the southern drainage of Lake Superior, to the Mississippi River system in Minnesota; south to Kentucky, parts of Missouri and Arkansas, and southern Oklahoma.

In Canada this species has been found only in southern Ontario, in the drainages of western Lake Ontario, lakes Erie and St. Clair. It was first reported to occur in Canadian waters by Hubbs and Brown (1929) following a number of captures in the tributaries of lakes Ontario, Erie, and St. Clair. Although often overlooked in casual surveys, the least darter is not uncommon in suitable habitats within the area designated.



Biology Spawning takes place in spring, in May in Michigan (Winn 1958b) and probably May and June in Ontario although there appears to be no published observations. In Michigan, least darters move into shallow, weedy waters near shore in late April and May. The males occupy the vegetated area, while the females remain outside this area until ready to spawn. When the female enters the weedy area, she may be courted by several males, eventually one dominates, the female positions herself, almost and sometimes quite vertically, on the stem of a plant, the male mounts the female, maintaining his position atop the female by means of his modified pelvic fins which rest on the slope of the female's back, just in front of the dorsal fin. The mating fish vibrate, one egg is laid and fertilized, and the pair moves to a new site. The eggs are normally laid on the stems of plants but spawning may take place on the bottom although the fate of such eggs is unknown. After several eggs are deposited, the female retires to deeper water until again ready to spawn. The precise number of eggs deposited by a single female is not known but Winn (1958a) reported egg counts of pre-spawning females as 435–1102.

Males exhibit little territorialism and make no effort to protect the eggs, which, of course, are scattered anyway. The eggs average about 1 mm in diameter and hatch in about 6 days at temperatures of 64.4°–68.0° F (18°–20° C). Newly hatched young measured 3 mm total length. For additional details *see* Petravicz (1936).

The least darter is the smallest vertebrate in Canada and certainly the smallest fish. Adults average about 1 inch (25 mm) in total length and females, which average larger than males, may attain total lengths of 1.5 inches (38 mm). The largest female examined by us was 1.5 inches (38 mm) in total length.

Quiet, weedy waters of lakes, and slow-moving streams seem to be the preferred habitat, especially if there is a rich aquatic plant growth on a muddy bottom.

The least darter often exists undetected in a stream because of its small size and the difficulty of seining in weedy waters. As Hubbs and Brown (1929) noted many years ago, "It may often be most readily seined after the weeds have been most vigorously tramped on." A good-sized population in a Lake Erie tributary went undetected by us for 2 years despite repeated sampling, until we used a nylon seine that had a slightly smaller mesh than the standard quarter-inch cotton seine previously used.

Detailed food studies are not available but studies by Petravicz (1936) indicated that small crustaceans were readily consumed and it is assumed that other suitably small, benthic organisms are also eaten.

The four least darters examined by Bangham and Hunter (1939) from Lake Erie waters were not infected with parasites.

There are no records of parasitism of this species in Hoffman's 1967 publication.

Relation to man The least darter, the smallest Canadian fish, is of no known direct economic importance but its role and importance within its aquatic community is difficult to access because we know so little about it. Its spawning habit of laying single eggs on plant stems while in a vertical position, is certainly unusual among fishes, and indicates a niche specialization that warrants further study and better understanding.

Nomenclature

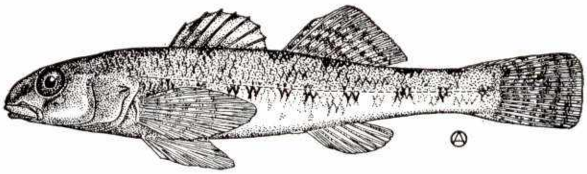
Etheostoma microperca	— Jordan and Gilbert *in* Jordan 1888: 134 (type locality Northern Indiana to Minnesota)
Microperca punctulatum Putnam	— Jordan and Evermann 1896–1900: 1104
Microperca punctulata Putnam	— Hubbs and Brown 1929: 50
Microperca microperca (Jordan)	— Speirs 1951: 16
Etheostoma microperca Jordan and Gilbert	— Bailey 1951: 195

Etymology *Etheostoma* — from *etheo* — to strain, *stoma* — mouth; *microperca* — small perch.

Common names Least darter. French common name: *petit dard*.

JOHNNY DARTER

Etheostoma nigrum Rafinesque



Description Body slender, elongate, average total length to about 2.3 inches (58 mm), body not markedly compressed laterally, greatest body depth 12.1–16.3% of total length. Head bluntly rounded, its length 19.8–21.9% of total length, gill membranes narrowly joined, meeting at an acute angle and free from isthmus, opercle with a small, sharp spine posteriorly; eye moderate, its diameter 23.0–29.4% of head length; snout blunt, rounded, projecting beyond lower jaw, snout length 23.3–29.5% of head length; premaxillaries protractile; mouth moderate, lower jaw included in upper, maxillary extending posteriorly to anterior edge of orbit; teeth in brushlike bands in upper and lower jaws, generally small, but outer teeth are largest and most widely spaced, inner teeth small and closely set, teeth not decreasing greatly posteriorly. Branchiostegal rays 6,6(18), 6,7(1). Fins: dorsals 2, first dorsal spiny, spines relatively strong, spines usually 8(12) or 9(26), seldom 10(2), second dorsal soft rayed, slightly higher than first dorsal, rays 10(1), 11(4), 12(22), 13(12), or 14(1), western counts appear to be high, dorsal fins practically conjoined, barely separated; caudal decidedly square, or truncate; anal usually with 1(40) (but rarely first ray not serially divided and could be counted as second spine) and 7(1), 8(6), 9(24), or 10(9) rays; pelvics rather small, rounded; pectorals large and fanlike, rays usually 12. Scales ctenoid, cheeks and nape usually naked, opercles usually scaled, breast usually naked, belly scaled or naked; lateral line complete, scales 41–52, counts higher in west. Vertebrae 37(5), 38(10), or 39(4).

Colour The overall body colour is generally pale brown or straw coloured, sometimes yellowish or even with a green tint, depending on habitat. On the back are about 6 saddle-like darker markings, and between them the back is variously speckled with brown or dark brown. Along the midline of the sides are a series of 7–12 dark, distinctive M-, V-, or W-shaped marks. Breeding males become very black, especially on the anterior half of the body, obscuring the distinctive lateral marks. Second dorsal, caudal, and, to a lesser extent, the first dorsal and pectoral fins are barred or speckled with brown markings. Young fish are usually pale.

Systematic notes Historically the johnny darter, *Etheostoma (Boleosoma) nigrum*, has been considered a wide-ranging, variable species, composed of many subspecies. Based largely on the work of Hubbs and Lagler (1941), Dymond (1947) outlined the proposed distribution of subspecies inhabiting Canadian waters as follows:

Boleosoma nigrum nigrum (central johnny darter) —
Saskatchewan to western Quebec

B. n. olmstedi (tessellated johnny darter) —
from Ottawa River and eastern Ontario to western limits of Maritime Provinces (there are no records of occurrence in any Maritime Province)

B. n. eulepis (scaly johnny darter) —
in lakes Erie, St. Clair, and Detroit River

The primary features distinguishing these subspecies were the presence or absence of scales on cheeks, opercles, and breast, and the number of rays and the markings on the second dorsal fin. As early as 1913, Cockerell attempted to distinguish *nigrum olmstedi* on structural characters, in this case, the apical ctenii of the scales.

In a review of the status of *E. nigrum nigrum* and *E. nigrum eulepis*, in Minnesota, Underhill (1963) concluded that it was undesirable to continue to recognize the subspecies *E. n. eulepis* noting that, although the polymorphic nature of *Etheostoma nigrum* was unquestioned, the recognition of such polymorphism with subspecific names served no useful purpose.

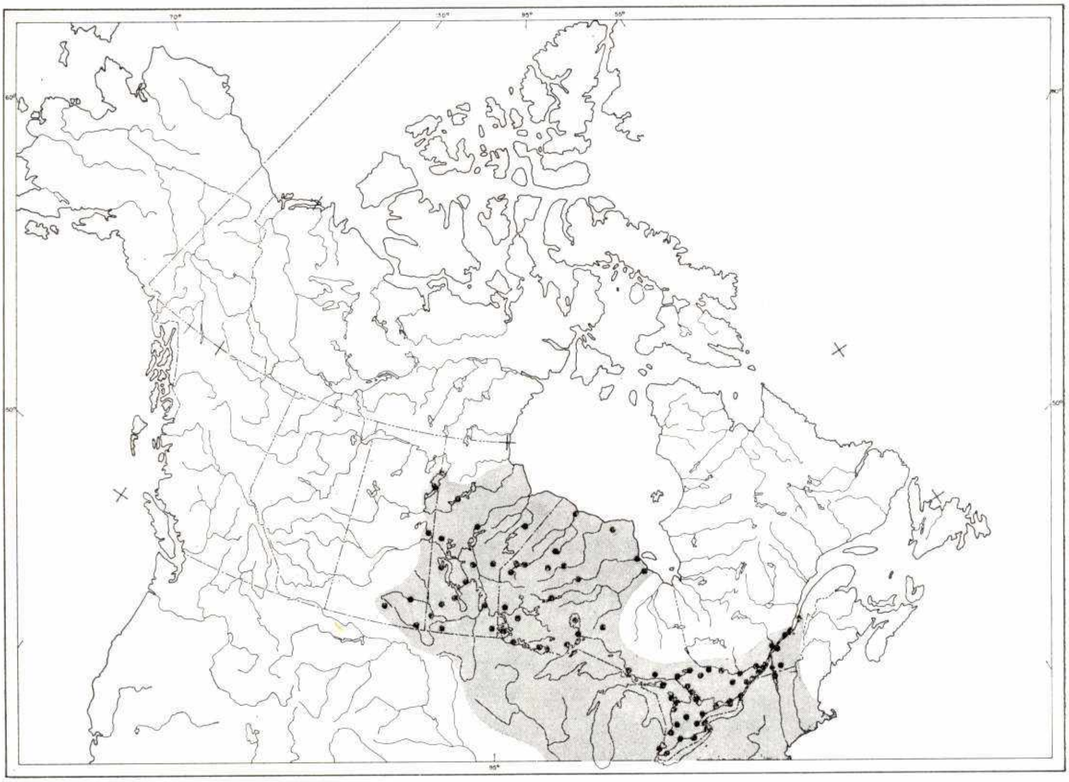
The subspecies *olmstedi* was studied by Stone (1947) and Cole (1965) both of whom considered *olmstedi* to warrant specific status. Cole (1967), in a comprehensive study of this new species, considered it to be composed of four subspecies. Few specimens were examined by Cole from Canadian waters. One sample, from the confluence of the Ottawa and St. Lawrence rivers, although identified as *Etheostoma olmstedi* (instead of *E. n. olmstedi* as formerly) was considered to consist of intergrades of two subspecies of *E. olmstedi*, *E. o. atromaculatum* × *E. o. olmstedi*. Indeed, all populations of the New York watershed of Lake Ontario and the St. Lawrence River, including the Lake Champlain drainage, were considered to be intergrades of these two subspecies.

The characters proposed by Cole (1967, p. 33) to differentiate *E. nigrum* and *E. olmstedi*, are presented in the following table.

Real difficulty is experienced, however, if one attempts to assign Canadian material to the taxonomic units proposed. Before meaningful statements about the systematics of *E. nigrum* in Canada can be made, rather thorough morphometric and meristic descriptions of the populations are required, and these have not yet been attempted. However, until such data are available, nothing is to be gained by changing names when we can still communicate effectively, with minimal confusion, by referring Canadian johnny darters to the species *Etheostoma nigrum*. The polymorphic nature of johnny darters is obvious enough, but what this means — whether the variation is somatic or genetic — is yet to be determined.

Distribution In Canada, the johnny darter ranges eastward to the mouth of Rivière Ouelle, on the south shore of the St. Lawrence River, and to St. Petronville, Ile d'Orléans, on the north shore. (J. Bergeron personal communication). It occurs in southern Quebec in the Lake Champlain area, in the Ottawa River, up the St. Lawrence River and throughout the Great Lakes area. It ranges northward in Ontario to the Hudson and James Bay drainages (not reported for the Abitibi River drainage), west to Lake of the Woods.

	E. olmstedi	*E. nigrum*
Pectoral rays	usually 13, often 12	usually 11 or 12
Second dorsal rays	usually 12–14	usually 10–12
Scales above lat. line	usually 4 or 5	usually 3 or 4
Scales below lat. line	north — usually 7 or 8 south — usually 6 or 7	usually 6 or 7
Infraorbital canal	usually complete, 8 pores	usually interrupted, 4 + 2 pores
Preoperculomandibular canal	usually 10 or 11 pores	usually 9 pores
Breeding males	darker, but not blackened	considerably blackened
Pelvic spines and rays in breeding males	ray tips slightly enlarged and whitened	tips grossly knoblike and whitened
Pectoral and pelvic fins	widely pointed	short and rounded
Mouth	slightly oblique and subterminal	horizontal and terminal
Snout	subconical, slightly inclined	rounded before eyes, almost vertical at mouth
X- and W-lateral marks on side of body	9–11	6 or 7



In Manitoba it occurs throughout the province north to the Churchill River area, in Southern Indian Lake.

In Saskatchewan it ranges from the Souris River in the south to Reindeer Lake (57°15′N, 102°40′W) of the Churchill River region in the north, but is generally restricted to eastern Saskatchewan. A collection (ROM 16624) from Loverin Lake near Chamberlain (50°50′ N, 105°34′ W) represents the western limit of range for the species.

Biology Spawning occurs in the spring, the exact time depending on local conditions. Toner (1943) wrote that he observed spawning in the flume of a hydro plant at Gananoque, Ont., as early as April 26, in 1935. Richardson (1935) did not observe spawning in the eastern townships of southern Quebec but caught gravid adults only during the latter part of May, never later, and Dymond (1926) said spawning occurred in June in Lake Nipigon. Over much of the southern part of the Canadian range, the johnny darter probably spawns in May, but possibly later farther north.

Observations on spawning in Canadian waters are few and scattered. The following information on spawning habits is derived largely from Winn (1958a,b), whose studies were conducted in southern Michigan. Males move onto the spawning grounds in April, earlier than the females. They select their territories and proceed to clean off the underside of the rock, picked as the nesting site, by moving around under the rock upside down. The males become darker during this period. Females do not enter the male's territory until ready to spawn, and when they do, they are met by a male who usually precedes the female under the rock. The male commences at once to move about under the rock, upside down. If courting is successful, the female moves in under the rock, turns upside down, and the pair move over the rock beside each other. Contact with each other is maintained by pectoral fins or other parts. The female pauses to deposit an egg every few seconds. The male, moving along beside her, apparently fertilizes the egg immediately after it is deposited. Females leave the nest when finished egg laying, which apparently consists of depositing clutches of 30–200 eggs at each of five or six spawning sessions. Larger females lay a larger number of eggs.

Males guard the eggs, moving over them, thus keeping them free of silt, and, when upright, fanning with their pectoral fins to maintain a flow of water. Eggs that develop fungus are eaten.

There may be considerable variation in the selection of nesting sites, depending on the kind available. Also, experimental evidence indicates that the male guards the place, rather than the eggs, for if the nesting stone and its eggs are removed, he will remain on site, still guarding the place where the nest had been (Atz 1940; Winn 1958a, b). The eggs are adhesive and measure about 1.5 mm in diameter. Hatching occurs in 5–8 days at temperatures of 71.6°–75.2° F (22°–24° C). A number of larval stages, up to 15 mm long, were described and illustrated by Fish (1932).

Johnny darters may be aged by scale examination as demonstrated by Raney and Lachner (1943) for New York populations and Karr (1963) for some populations in Iowa. Males grow to a larger size than females but, in the New York study, females lived longer than males, reaching age 4 while males did not live beyond age 3. Mature males larger than 2.7 inches (69 mm) total length, have not been seen by us but many specimens in the 65–69 mm range have been examined.

Johnny darters inhabit a wide variety of aquatic habitats but seem to be most common in waters of moderate or no current, over a bottom of sand, sand and gravel, or sand and silt, but do inhabit weedy areas or gravel riffles of streams. They are less demanding in habitat requirements than most other darters. Although they are usually associated with inshore waters, specimens have been recorded to depths of 138 feet in the Great Lakes.

Young johnny darters consume large numbers of copepods and small midge larvae, with lesser amounts of cladocerans. Copepods may remain an important food source but midge and mayfly larvae dominate the diet. Bottom organic debris and silt form significant dietary items for all sizes. Turner (1921) noted that the diet changed little throughout various localities in Michigan.

Johnny darters fall prey to many larger fishes and have been recorded in stomachs of lake trout, burbot, white perch, smallmouth bass, and walleye to name a few. In July, 1947, five were found in the stomach of a large whitefish caught in eastern Lake Erie. The extent to which the johnny darter contributes to aquatic food chains is not well understood but there can be no doubt that this abundant little darter makes a vital contribution to the conversion of benthic organisms and detritus to a higher life form.

Bangham and Hunter (1939) examined 7 johnny darters from the east end of Lake Erie and found 2 infected. Parasites identified were trematodes *Clinostomum marginatum*, *Neascus* sp., and the cestode *Proteocephalus pearsei*. Of the 16 they examined from the west end of the lake, 14 contained parasites as follows: trematodes *Leuceruthrus* sp., (immature form), and *Neascus vancleavei*, and nematodes *Agamonema* sp.

All 39 specimens examined by Bangham (1955) in the Lake Huron and Manitoulin Island area were parasitized. Parasites included trematodes (7), nematodes (3), acanthocephalans (2), cestodes (1), and leeches (1).

Hoffman (1967) published a long list of parasites infecting the johnny darter, which included: protozoans (3), trematodes (23), cestodes (6), nematodes (5), acanthocephalans (5), leeches (1), and molluscs (1).

Relation to man The most important role of the johnny darter is probably as a converter of small benthic materials to larger forms within the aquatic community and, thus, to serve as food for larger fishes. It is also a most useful species for behavioural studies in the laboratory and may be easily maintained in aquaria.

Nomenclature

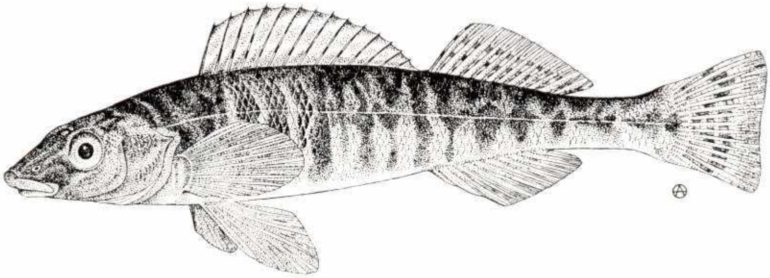
Etheostoma nigra	— Rafinesque 1820c: 37 (type locality Green River, Ky.)
Boleosoma maculatum Agass.	— Agassiz 1850: 305
Boleosoma nigrum (Rafinesque)	— Jordan and Evermann 1896–1900: 1056
	— Eigenmann and Eigenmann 1892: 962
	— Bailey 1951: 195
	— Bailey 1954: 140

Etymology *Etheostoma* — from *etheo* — to strain, *stoma* — mouth; *nigrum,* from *niger* — black.

Common names Johnny darter, central johnny darter. French common name: *raseux-de-terre.*

LOGPERCH

Percina caprodes (Rafinesque)



Description Body elongate, tubular, average length about 3.5 inches (89 mm), not noticeably compressed laterally except posteriorly, greatest body depth 12.4–17.8% of total length. Head conical, pointed, its length 19.5–23.9% of total length, gill membranes narrowly joined at an acute angle; eye diameter 22–28% of head length; snout elongate, pointed, extending beyond lower jaw, its length 29.5–36.0% of head length; premaxillaries not protractile, bound to snout by a frenum; mouth small, distinctly inferior, maxillary not extending posteriorly to anterior margin of eye; teeth in brushlike bands on upper and lower jaws, outer teeth larger and more widely spaced, inner teeth smaller and crowded; teeth decrease in size posteriorly. Branchiostegal rays 6,6(8), 6,7(2). Fins: dorsals 2, first dorsal spiny, spines strong, usually 14(23), or 15(18), sometimes 13(3) or 16(1), second dorsal soft rayed, and slightly higher than first dorsal, rays 15(19) or 16(14), sometimes 14(6), 17(3), or 18(1), fins narrowly separated by one scale row; caudal truncate or square, not forked; anal fin with 2(39), rarely 1(4), spines, soft rays 9(5), 10(23), 11(14), or 12(1), the fin about equal to second dorsal in size; pelvics moderate, much smaller than pectorals, not obviously pointed; pectorals large, fan-like, rays 13 or 14. Scales ctenoid, cheeks and opercles scaled, breast naked, belly usually naked on females, males usually with a row of scales on midline; lateral line complete, scales ranging from 71–85; swim bladder developed in posterior part of body cavity. Vertebrae 40(1), 41(7), 42(8).

Breeding tubercles on ventral scale rows of males only.

Colour The usual overall colouration is yellowish green with dark olive or black markings. Specimens taken in deeper water of large lakes are often gray-green in overall colouration. There are 8–10 saddle-shaped marks on the back, separated by lines or patches of yellow; continuous with, or seeming to alternate with the saddle marks are vertical bars that expand, droplike on their lower ends, and terminate below the middle of the sides; the bars do not extend onto the ventral surface. The dorsal and caudal fins are lightly barred, with splashes of yellow on the fin membranes. Fins on ventral surface may be colourless, or with flecks of pigment on membranes and yellow on the fin rays. A conspicuous round, black spot occurs at the caudal fin base. A vague or weak suborbital bar usually present. Colours intensify on breeding males.

Systematic notes Three subspecies of logperch have been described: the typical subspecies *P. c. caprodes* ranges generally south of the Great Lakes, *P. c. carbonaria*, occurring from Florida to Texas, the most southerly part of the range, and *P. c. semifasciata*, the northern logperch. The form occurring throughout Canada is considered to be *P. c. semifasciata.*

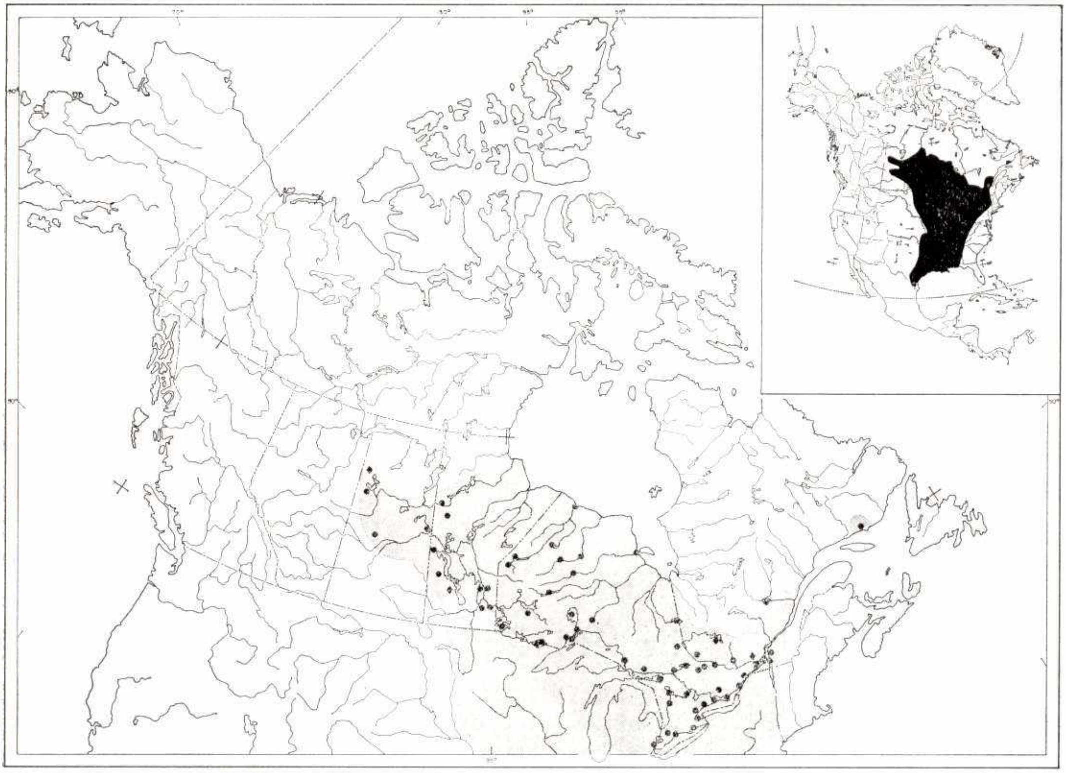
Hybrids of logperch with the blackside darter and channel darter were reported by Hubbs (1926), and with the river darter by Carlander (1941).

Distribution The logperch is a wide-ranging species in North America and occurs from St. Lawrence River tributaries of eastern Quebec (about 63° W) southeast through Lake Champlain, the Great Lakes, west to Saskatchewan and south through the Mississippi River system to the Rio Grande River in southern Texas. It was apparently inadvertently introduced into California waters in 1953.

In Canada it was reported from the Nabisipi and Aguanus rivers on the north shore of the Gulf of St. Lawrence, at 63°W, which may represent isolated eastern populations. Also reported from Lac St. Jean, Que., and west in the St. Lawrence River, Great Lakes system throughout all of Ontario, including Lake Abitibi and the Hudson Bay lowlands north to James and Hudson bays. In Manitoba throughout the southern part, north to the Churchill River drainage, and in Saskatchewan in the Churchill and Saskatchewan River areas, west to the western limit of range in Delaronde, Canoe, and Churchill lakes.

Biology Logperch spawn in late spring, usually commencing in June. There are few observations of spawning in Canadian waters but Winn (1958b) gave a detailed description of spawning in Douglas Lake, Mich., where Reighard (1913) over 40 years earlier observed spawning by the same species.

Winn noted that the logperch populations remained in deep water offshore until late June when they moved to sandy inshore shallows. A few to several hundred males gathered in a large school on the sand shoals in depths of 4–79 inches (10–200 cm). Winn stated that, in general, females remained outside the school until ready to spawn, when they swam through the school of males and out again. One female may be followed by a few or many males. When she stops on the bottom, one of the males will alight on her back, pelvic fins placed ahead of her first dorsal, his caudal fin depressed beside hers. Both fish vibrate, which tends to partly bury them in the sand, the eggs are extruded and fertilized, and a cloud of sand surrounds the vibrating pair. Winn estimated that 10–20 eggs were released at each spawning, after



which the female retired to deeper water and the male rejoined the school. The eggs were abandoned. Each female may spawn several times, each time with a different male. Although males would pursue each other, none were seen to actually attack another and no individual territorialism was exhibited. Both Reighard and Winn remarked that non-spawning males, attracted to the spawning pair, eagerly ate all eggs that were not buried. The exact number of eggs deposited is difficult to ascertain, but counts of eggs in pre-spawning females ranged from 1060 to 3085, the larger number in the larger female. The eggs are colourless and measure 1.3 mm in diameter. There are few data on developmental rates in northern latitudes but Hubbs (1961), working on Texas specimens, noted that embryos survived at temperatures between 71.6°–78.8° F (22°–26° C). Larval stages were described and four sizes of embryos (6.6, 12.1, 14.2, and 20.5 mm) were illustrated by Fish (1932).

We have no information on rates of growth in Canadian waters and few from elsewhere. Males and females attain about the same maximum size and presumably grow at about the same rate. Large adults range around 4 inches (102 mm) total length. The largest logperch examined was a female 4.8 inches (121 mm) in total length, from Lake Ontario watershed, but females over 4.5 inches (115 mm) were examined from Lake Winnipeg.

Logperch inhabit sand, gravel, or rocky beaches in lakes and over similar bottom in larger rivers, sometimes in rather swift water as Dymond (1926) noted in the Lake Nipigon region. They tend to stay offshore in water deeper than 3–4 feet and thus readily escape a survey seine and so are often said, mistakenly, to be uncommon. Indeed, they have been captured by otter trawl at depths of 131 feet in Lake Erie (Trautman 1957).

Young logperch feed on a variety of small organisms but principally upon cladocerans and copepods. As they grow, aquatic insect larvae, particularly mayfly and midge larvae, become increasingly important (Turner 1921).

The feeding ecology of adult logperch in Lake Opinicon, Ont., was studied by Keast and Webb (1966), who reported the following percentages, by volume, of various food organisms: chironomid or midge larvae (to 70% in some months), amphipods (to 40%), isopods (to 20%), dragonfly nymphs (to 15%), and mayfly nymphs (to 10%). These results are in accord with the food in other regions reported by Pearse (1918), Turner (1921), and Dobie (1959). Keast and Webb noted that the protruding and rounded snout was used to roll over small stones, leaves, and other objects on bottom to obtain the organisms beneath them.

One of the serious predators on logperch are logperch themselves, specifically the consumption by non-spawning males of unburied or lightly buried eggs. Among the earlier observers of this phenomenon were Ellis and Roe (1917), who also reported the eating of logperch eggs by white suckers *(C. commersoni)*. Logperch are undoubtedly eaten by a variety of piscivorous fishes and have been reported in stomachs of lake trout (Van Oosten and Deason 1938), walleye (Raney and Lachner 1942), and northern pike (Greeley 1927). But the extent to which they enter into the diet of Canadian fishes is unknown.

Bangham and Hunter (1939) examined 45 logperch from Lake Erie. Nine of the 13 fish from the east end of the lake were parasitized and 20 of the 32 specimens from the west end were infected. Parasites identified were trematodes *Diplostomum* sp., *Clinostomum marginatum*, *Neascus* sp., *Leuceruthrus* sp., *Allocreadium boleosomi*, *Tetracotyle* sp.; cestodes *Bothriocephalus cuspidatus*, *Proteocephalus stizostethi* (larval or immature form of both species), *Proteocephalus pearsei*; nematodes *Camallanus oxycephalus*, *Agamonema* sp.; acanthocephalan *Leptorhynchoides thecatus*; and a leech, *Piscicola punctata*.

Bangham (1955) examined one specimen from South Bay, Lake Huron, infected with Gyrodactyloidea, and the encysted larval form of the acanthocephalan, *Pomphorhynchus bulbocolli*.

Guilford (1963) described a new species of Myxosporidia, *Myxosoma scleroperca*, located within the sclerotic cartilage of logperch collected from Green Bay, Lake Michigan.

Hoffman (1967) listed many species of parasites as follows: protozoans (2), trematodes (10), cestodes (6), nematodes (4), acanthocephalans (5), leeches (2).

Relation to man The logperch is occasionally used as live bait by anglers but cannot be held alive in a minnow pail for long. It is eaten by predaceous game and commercial fishes but its importance in this role is unknown. It can easily be mistaken in stomach contents for yellow perch, and possibly, often is.

Nomenclature

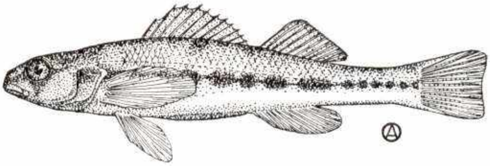
Sciaena caprodes	— Rafinesque 1818c: 354 (type locality Ohio River)
Etheostoma caprodes	— Rafinesque 1820c: 38
Pileoma semifasciatum	— DeKay 1842: 16
Pileoma zebra	— Agassiz 1850: 308
Pileoma Fasciatum	— Small 1865: 15 (taken in the Don River in great numbers)
Percina caprodes (Rafinesque)	— Jordan and Evermann 1896–1900: 1026

Etymology *Percina* — a diminutive of *Perca*; *caprodes* — pig, resemblance, in reference to snout.

Common names Logperch, zebra fish, log perch, Manitou darter. French common name: *dard-perche*.

CHANNEL DARTER

Percina copelandi (Jordan)



Description Body elongate, slender, average length about 1.5 inches (38 mm) total length, not noticeably compressed laterally, body not deep, greatest body depth 12.8–15.6% of total length, and less than head length. Head moderate, its length 20.0–21.2% of total length, opercle with a flat, inconspicuous spine posteriorly, gill membranes narrowly joined at an acute angle; eye diameter 26.8–28.3% of head length; snout distinctly downcurved, its length 24.5–28.5% of head length, projecting slightly beyond premaxilla; premaxillaries protractile, with a distinct groove across snout (but *see* Winn 1953, p. 26, who reported 13% with a frenum); mouth moderate, maxillary extending posteriorly to below pupil, jaws nearly equal or lower jaw slightly included in upper; teeth small, pointed, in brushlike bands on upper and lower jaws, bands several teeth wide, outer teeth larger and more widely spaced, inner teeth small and closely set. Branchiostegal rays 6,6(3). Fins: dorsals 2, first dorsal spiny, spines strong, spines usually 11, second dorsal soft rayed, slightly higher than spiny dorsal, rays 12, 13, or 14, dorsal fins distinctly separated by at least 4 scale rows; caudal shallowly forked, emarginate; anal with 2 spines and 9 or 10 soft rays; pelvics small, narrow; pectorals rounded, fanlike, rays about 13. Scales ctenoid, cheeks naked, opercles scaled, breast naked except for enlarged scale at apex of pelvic girdle and often between pelvics; enlarged row of scales along midline of belly, or belly naked; lateral line complete, scales usually 43–51; swim bladder usually rudimentary. Vertebrae 37 or 38.

Colour Overall colouration is light sand, back with brown speckles, and along the midline of each side is a series of small brown, round or oblong blotches usually joined together by a thin line. The fins are clear or only lightly speckled. Breeding males are dusky, becoming dark about the head.

Distribution The channel darter is found in the upper St. Lawrence River–Lake Champlain area, Lake Erie, and Lake Huron, along the eastern margin of the lower peninsula of Michigan; west of the Appalachian Mountains south to Alabama, Arkansas, Oklahoma, and southeastern Kansas.

The channel darter is rare in Canada. In Quebec it has been reported in the tributaries of the upper St. Lawrence River as far east as the Nicolet and St. Francois rivers flowing into Lac St. Pierre, and also in the Lachine Rapids and the Chateauguay River (Cuerrier et al. 1946); in Ontario from many localities along the shores of Lake Erie such as near Port Dover, Port Burwell, Erieau, and Point Pelee, and also from the Detroit River.

Biology Spawning takes place in the spring. A thorough discussion was given by Winn (1953) for a population in the Cheboygan River, Mich. Winn observed spawning between July 9 and 23, when water temperatures ranged from 69°–72° F (20.5°–21.2° C). He was able to determine that at least weakly flowing water was essential for spawning over the gravel-bottomed area, and that spawning ceased if the current flow was interrupted. The males established territories, each of which usually had at least one large rock in the centre, and maintained a station behind the rocks. The size of the territory varied greatly depending on the space available, but 30 territories were counted in a space 10 by 30 feet. When females were ready to spawn, they moved into the region where the males held territories. After initial courtship, during which the male attempted to drive the female toward the centre of the territory, spawning occurred between small rocks or in fine gravel behind the central rock, but not in fine sand. The female works herself into the gravel, and the male perches on top of her, with one pelvic fin on either side of her and his caudal fin depressed beside hers. The eggs are deposited, fertilized from this position, and the parents depart, leaving the eggs buried in the gravel. By excavating abandoned eggs Winn concluded that 4–10 eggs were extruded during one mating session. The females may mate with a number of males during the spawning season. The total number of eggs deposited by a single female would be difficult to determine but Winn reported egg number to range from 357 to 415, based on egg counts from three females. Ripe eggs measured 1.4 mm in diameter but no data were obtained on their rate of development. Larval development was described by Fish (1932) who illustrated a 6.1 mm specimen.

Rates of growth are not available but males normally grow larger than females. The largest specimen examined by us was a male 2.4 inches (61 mm) total length.

The channel darter inhabits sand and gravel beaches, and bars associated with such beaches, where the current is slow or sluggish. This is the typical habitat along Lake Erie shores (Scott, D.C. 1955; Trautman 1957).

Analyses of stomach contents of specimens from the Bass Islands region of Lake Erie by Turner (1921) indicated that the species fed primarily upon mayfly and midge larvae but ingested large amounts of algae and bottom debris as well. There was little difference in the diet of young and adults; all sizes were strongly benthic feeders.

Bangham and Hunter (1939) examined 34 specimens from the west end of Lake Erie and found only 8 parasitized. Parasites identified were trematodes *Neascus* sp., *Lebouria cooperi*, the cestode *Bothriocephalus cuspidatus*, and a nematode *Camallanus oxycephalus*.

Hoffman (1967) listed trematodes (2), cestodes (1), and nematodes (1).

Relation to man The role played by this small vertebrate in our aquatic environment is not well known. Although we know of no direct economic importance, indirectly its significance, while possibly slight, is of interest because of its benthic food habits and ingestion of algae and bottom debris.

Nomenclature

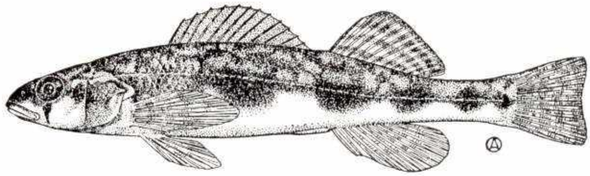
Rheocrypta copelandi	— Jordan 1877a: 9 (type locality White River, 5 miles N of Indianapolis, Ind.)
Cottogaster copelandi (Jordan)	— Jordan and Evermann 1896–1900: 1045
Hadropterus copelandi (Jordan)	— Hubbs and Lagler 1958: 107
Percina copelandi	— Bailey et al. 1954: 140
	— Hubbs and Lagler 1964: vii

Etymology *Percina* — a diminutive of *Perca*; *copelandi* — after its discoverer, H. E. Copeland.

Common names Channel darter, Copeland's darter. French common name: ***dard gris***.

BLACKSIDE DARTER

Percina maculata (Girard)

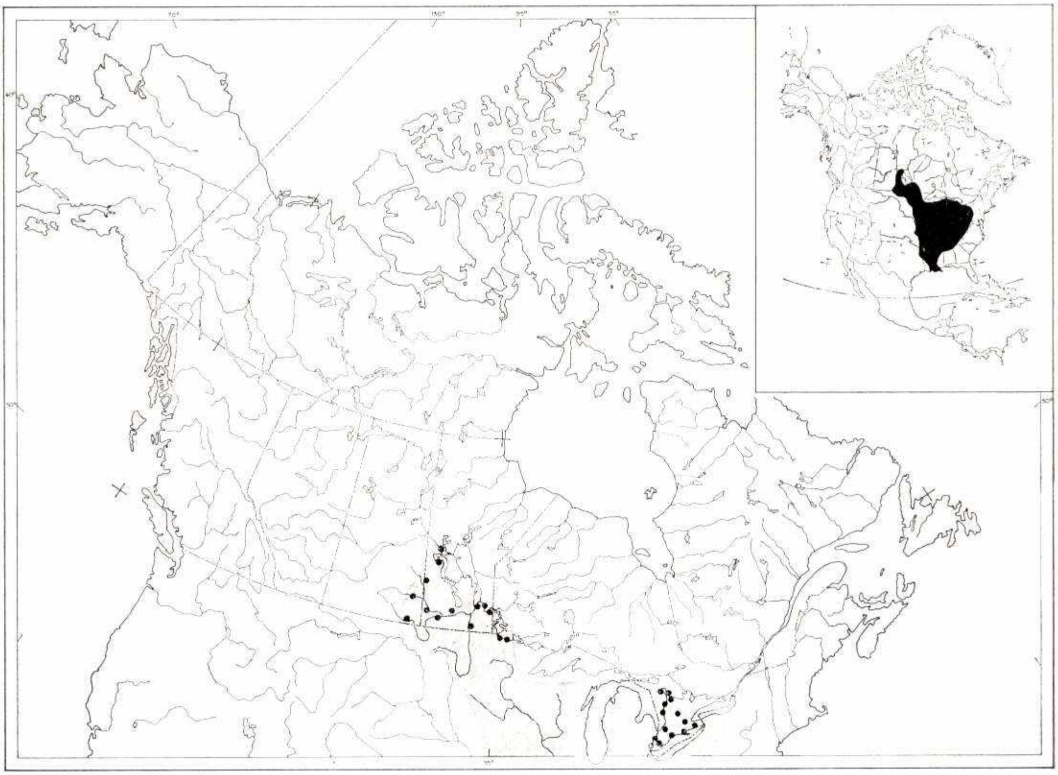


Description Body rather robust, average length about 2.3 inches (58 mm) total length, somewhat compressed laterally, greatest body depth 13.6–17.3% of total length. Head triangular, pointed, its length 20.6–24.0% of total length, gill membranes narrowly joined at an acute angle, opercle with a small, sharp spine posteriorly; eye moderate, its diameter 21.6–29.9% of head length; snout sharp, its length 22.5–27.7% of head length, projecting slightly beyond lower jaw; premaxillaries not protractile, bound to snout by a distinct frenum; mouth large, upper jaw protruding, maxillary extending posteriorly past the anterior margin of the orbit; teeth in brush-like bands on upper and lower jaws, outer teeth larger and more widely spaced, inner teeth small, crowded, all teeth decreasing in size and number posteriorly. Branchiostegal rays 6,6(10). Fins: dorsals 2, first dorsal spiny, spines strong, usually 13(18) or 14(15), seldom 12(1) or 15(4), second dorsal soft rayed, slightly higher than first dorsal, rays usually 13(14) or 14(19), sometimes 11(1), 12(3), or 15(1), fins distinctly separated by about 3 scale rows; caudal well developed, slightly forked, lightly barred, a distinct black spot at base; anal with 2 spines and 9(5), 10(24), 11(8), or 13(1) soft rays, about same size as second dorsal; pelvics long, narrow, somewhat poined; pectorals long, rather narrow, somewhat pointed, rays usually 13, sometimes 14. Scales ctenoid, cheek and opercles scaled, a single row of enlarged scales along the midline of the belly, one between bases of pelvic fins and smaller one at apex of pelvic girdle; lateral line complete, straight, scales in lateral line 56–67 (*see Systematic notes*), swim bladder present. Vertebrae 41(11) or 42(7).

Colour Overall straw coloured, light olive, or olive-brown, with numerous dark blotches. On the back are 8 or 9 indistinct, dark, saddle-shaped markings, between and below these are many irregular blotches and vermiculations. Along the midline of the sides is a series of 5–7 elongate dark or black blotches, often clearly defined; these elongate black marks tend to coalesce, and are continuous with a black band that continues forward, around the head and across the snout, and terminates posteriorly with a distinct round black spot at the caudal fin base. There is a distinct, black, suborbital bar. Ventral surface of head and body white or creamy, without pigmentation. Spinous dorsal fin membranes suffused with black pigment at bases, becoming less intense distally. Second dorsal and caudal fins lightly barred. Spawning males without colours but black areas become intensified.

Systematic notes Examination of 38 specimens suggested that blackside darters in Manitoba have fewer dorsal spines and fewer scales than those in Ontario.

Distribution The blackside darter occurs from the western part of the Lake Ontario drainage west (excluding the Lake



Superior drainage) to North Dakota, Manitoba, and Saskatchewan; southward, to the west of the Appalachian Mountains to the Ozark region, the Gulf coast in Alabama, and northeastern Texas.

In Canada, the species occurs in the southwestern part of Ontario. There are no Ontario records for Lake Ontario. It is found in the tributaries of lakes Erie, St. Clair, and southern Lake Huron and is recorded from the Rainy River district but it does not occur in Lake Superior or its tributaries.

In Manitoba, it occurs in the Winnipeg, Red, and Assiniboine River drainages and from tributaries of Swan Lake; the northernmost record is from Big Eddy, near The Pas. In Saskatchewan it occurs in the Qu'Appelle drainage system and Souris River, its westernmost limit.

Biology Spawning occurs in spring, probably in May or June in Canada, although there is no supporting evidence. Petravicz (1938) and Winn (1958b) observed spawning in early May in southern Michigan, at temperatures of about 62° F (16.5° C). Adults move upstream on the approach of spawning season, the males gathering in gravel-bottomed pools or raceways, but not in riffles. The females remain in pools or quieter water immediately downstream from the males. When a female is ready to spawn, she moves upstream and is pursued by rival males. Spawning occurred at depths of 12 inches (30 cm) or more. Petravicz noted that the female usually initiated the spawning by selecting a suitable gravelly or sandy depression. She wriggled her body partly into the gravel, the male perched on her back, his caudal region depressed beside hers, and the eggs were deposited in the gravel and fertilized from this position. After a resting period, the spawning act was repeated several times with different males. The number of eggs, as recorded by Winn (1958a) from egg counts made on two prespawning females, ranged from 1000 to 1758. The eggs are large, colourless, about 2 mm in diameter. Petravicz (1938) reported a minimum incubation period of 142 hours, or about 6 days, but incubation temperature was not given. He described and illustrated newly hatched (5.75 mm total length) and 21 day-old post-larvae. Fish (1932) also described and illustrated the larvae.

There are no growth data for Canadian populations but Karr (1963) presented growth information for an Iowa population. Males and females grow at about the same rates and attain the same size. Karr considered this to be a relatively fast-growing species, attaining a maximum age of 4 years which, with our limited knowledge, seems relatively long lived among darters. The largest specimen examined by us was a male, 3.6 inches (92 mm) total length, from Norfolk County, Lake Erie.

The blackside darter is a stream species, inhabiting the quiet regions and pools of medium-sized, gravelly streams. Although the species is said to prefer clear waters, many of the Ontario streams containing this darter are quite turbid. This species is less benthic in its mode of life than many darters, and utilizes mid-depths, particularly when young.

Turner (1921) examined the food eaten by 11 specimens from Ohio waters and noted mayfly and midge larvae, corixid nymphs, copepods, and fish remains in the stomachs. These findings are in agreement with statements by Forbes and Richardson (1920) for Illinois.

Bangham and Hunter (1939) examined 2 specimens from the west end of Lake Erie and found one infected with the nematode *Camallanus oxycephalus*.

Relation to man The role of this darter in the ecological fabric of our streams is largely unknown. It may be quite numerous at times, within its restricted Canadian distribution, and at such times doubtless plays an important ecological role, particularly since it probably feeds on aquatic insect larvae. *See also Relation to man* for channel darter and rainbow darter.

Nomenclature

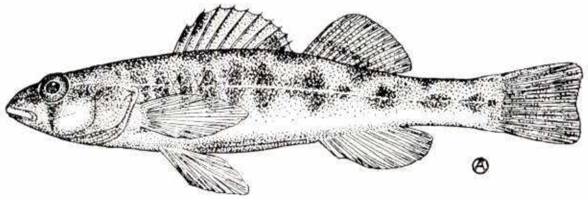
Alvordius maculatus	— Girard 1860: 67 (type locality Fort Gratiot, L. Huron, Mich.)
Etheostoma aspro	— Eigenmann and Eigenmann 1892: 962
Hadropterus aspro (Cope and Jordan)	— Jordan and Evermann 1896–1900: 1032
Hadropterus maculatus Girard	— Hubbs 1926: 59
Alvordius aspro Cope and Jordan	— Hubbs 1926: 60
Percina maculata (Girard)	— Bailey et al. 1954: 140
	— Hubbs and Lagler 1964: vii

Etymology *Percina* — a diminutive of *Perca*; *maculata* — spotted.

Common names Blackside darter, black-sided darter. French common name: *dard noir*.

RIVER DARTER

Percina shumardi (Girard)



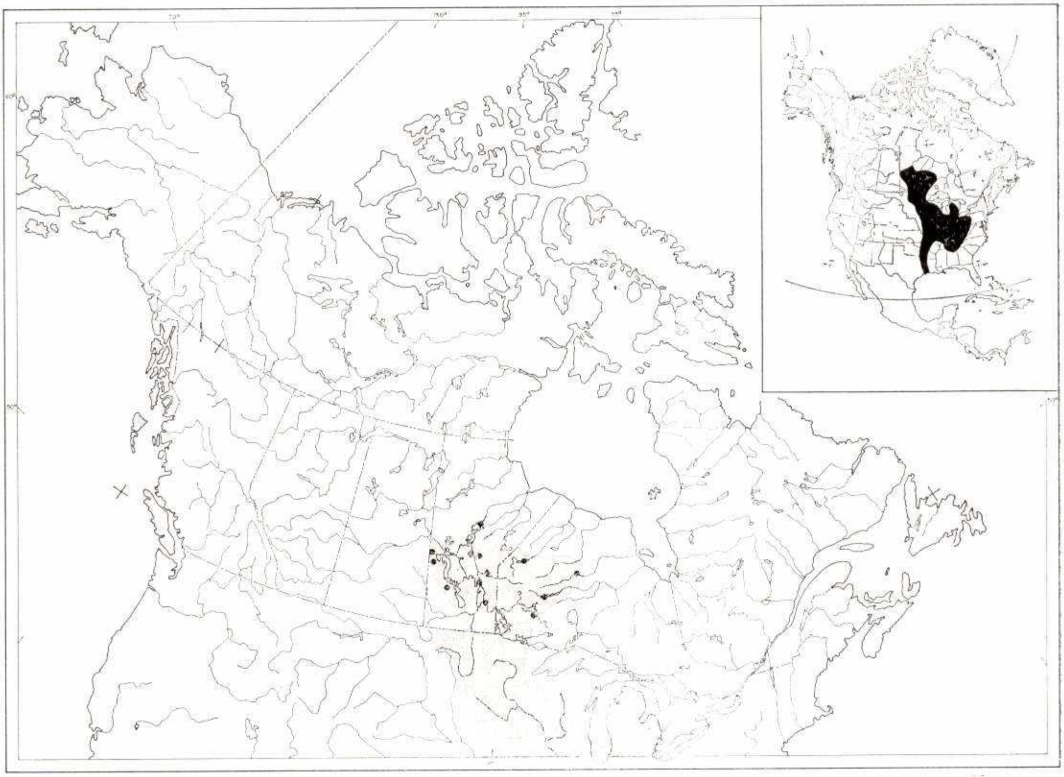
Description Body sturdy, slender, average length about 2.2 inches (58 mm) total length, somewhat compressed laterally, greatest body depth 10.3–16.0% of total length. Head length 20.2–24.6% of body length, gill membranes narrowly joined at an acute angle, opercle with a strong spine posteriorly; eye diameter 24.4–30.0% of head length; snout slightly projecting beyond lower jaw; premaxillaries usually bound to snout by a narrow frenum; mouth moderate, lower jaw barely included in upper jaw, maxillary extending posteriorly to, or slightly beyond, anterior margin of orbit; teeth in brushlike bands on upper and lower jaws, outer teeth larger and more widely spaced, inner teeth smaller and crowded; very gradual decrease in size of teeth posteriorly. Branchiostegal rays 6, 6, 6, 7, 7, 7. Fins: dorsals 2, first dorsal spiny, spines strong, usually 10(18), sometimes 9(3) or 11(4), second dorsal soft rayed, slightly higher than first dorsal, rays usually 13(11), 14(11) or 15(3), fins narrowly separated by about 1 scale row only; caudal fin shallowly forked; anal with 2 spines and usually 11(19), sometimes 10(3) or 12(2) rays, fin usually larger than second dorsal, and tip may reach almost to caudal fin on spawning males; pelvics moderate, pointed; pectorals fan-like, rounded, rays 13 or 14. Scales ctenoid, cheek and opercles scaled, breast usually scaleless, midline of belly scaled or scaleless; lateral line complete, scales 49–57. Vertebrae 37, 38, or 39.

Colour Light brown to dark olive brown overall; 7 or 8 weak, saddle marks on the back and 8–10 lateral blotches along midline of sides that often appear as short vertical bars. A distinct suborbital bar descending vertically from eye. A small, precise, caudal spot sometimes present. The most distinct markings are on spinous dorsal fin consisting of a dark blotch on membrane behind first spine and a larger and more conspicuous blotch extending over membrane connecting last three spines. Second dorsal and caudal fins only lightly speckled. Ventral surface, including anal, pelvic, and pectoral fins, without pigmentation. Spawning males darker overall and pigmented areas intensified.

Systematic notes The river darter was first reported from Canada by Eigenmann and Eigenmann (1892) on the basis of three specimens caught at Winnipeg, Man. The authors described it as a new species, *Etheostoma güntheri*. The specimens are still extant in the British Museum (Nat. Hist.), numbers 1892.12.30. 151–152–153. The first one, no. 151, a slender male 41.4 mm standard length, was designated as the lectotype by B. B. Collette. The species was first caught in Ontario in 1931 (Savage 1933).

Distribution The river darter ranges from south-central Canada southward through North Dakota (not South Dakota) and south of the Great Lakes in the upper Mississippi River system, thence to northern Alabama, Mississippi, and to eastern Kansas and Oklahoma, south in eastern Texas to the Gulf coast.

In Canada, it occurs in the Kenora district



of Ontario north to Lake Attawapiskat and Sandy Lake. There are no Lake Erie–Detroit River records for Ontario, but it is possible that it occurred in the area since it has been reported in the Detroit River. In Manitoba, it occurs in the Lake Winnipeg drainage area, in scattered localities, north to Sipiwesk Lake (55°05′N, 97°35′W), and west to Red Deer River and Lake Dauphin. The northern limit of range for the species is Sipiwesk Lake. The species does not appear to be common anywhere in Canada.

Biology There is no published information available on the biology of the river darter in Canada and little for the United States. It may be presumed that spawning occurs in the spring, possibly June or July in Manitoba and Ontario, and that the spawning behaviour does not differ greatly from that of other members of the genus *Percina*, particularly *maculata* and *copelandi*. The largest specimen examined was 2 inches (51 mm) in total length.

The habitat is primarily large rivers with a rubble- or boulder-strewn gravel bottom and a fair to moderate current. Specimens from the Lake Attawapiskat region were caught in the swift clear waters of the Drinking Martin River, over a bottom densely covered with boulders. Trautman (1957) noted that it also occurred in the silted, turbid tributaries of southwestern Lake Erie. It may also occur in lakes.

Although direct observations of its food habits are not available, it is most probable that the larvae of caddisflies, mayflies, midges, and blackflies form a significant part of its diet.

There are no published records of parasites of this species.

Relation to man Unknown, but *see Relation to man* for channel darter.

Nomenclature

Hadropterus shumardi	— Girard 1860: 100 (type locality Arkansas River, near Fort Smith, Ark.)
Etheostoma güntheri	— Eigenmann and Eigenmann 1892: 962
Cottogaster shumardi (Girard)	— Jordan and Evermann 1896–1900: 1046
Imostoma shumardi Girard	— Hubbs 1926: 62
Imostoma shumardi (Girard)	— Dymond 1947: 27
Percina shumardi	— Bailey et al. 1954: 140

Etymology *Percina* — a diminutive of *Perca*; *shumardi* — after its discoverer, Dr G. C. Shumard, surgeon of the Pacific railroad survey.

Common names River darter. French common name: *dard de rivière.*

Suggested Reading — Percidae

Pt. 1. Perch, walleye, sauger

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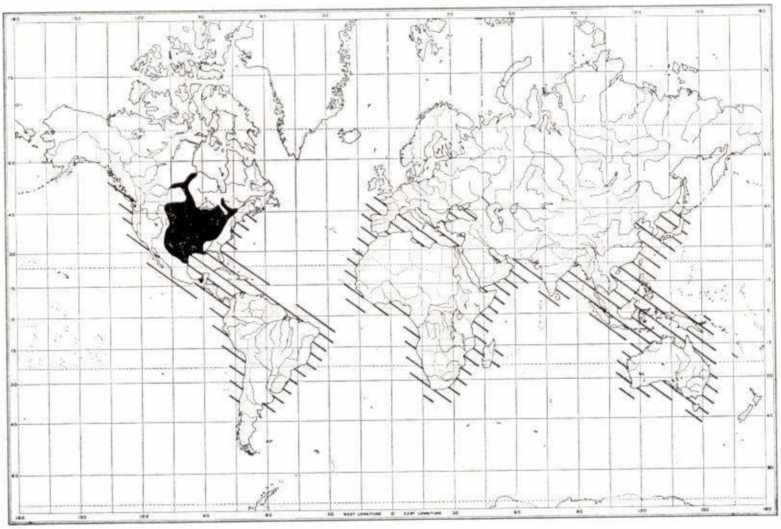
Drum or Croaker Family — Sciaenidae

A well-defined family of heavy-bodied fishes, many species compressed laterally. Skull strongly ossified and characterized by struts and cavities that are adaptations for the mucous glands of the lateral line system; jaws armed with conical or lanceolate teeth; lower pharyngeal arches sometimes fused, but armed with buttonlike, crushing teeth; the main (sagitta) otolith is well developed, large, and heavy. Branchiostegal rays 7. Spiny and soft dorsal fins distinct, only slightly connected at base; anal fin with 2 spines joined to soft rays. Scales ctenoid, on head and body; lateral line well developed and extended throughout length of caudal fin.

The drums are widely distributed on continental shelves of tropical to temperate seas throughout the world. The species range in size from a few inches to over 200 pounds, and many are important food fishes. The names drum or croaker refer to their ability to produce sounds using the swim bladder as a resonating chamber.

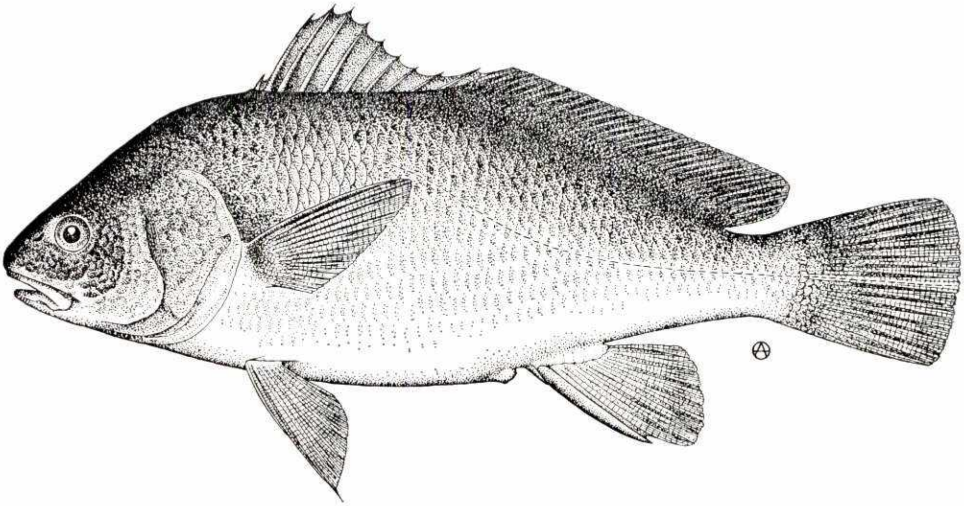
The family contains about 160 species, only 1 of which occurs in Canadian fresh waters. Paleocene to Recent.



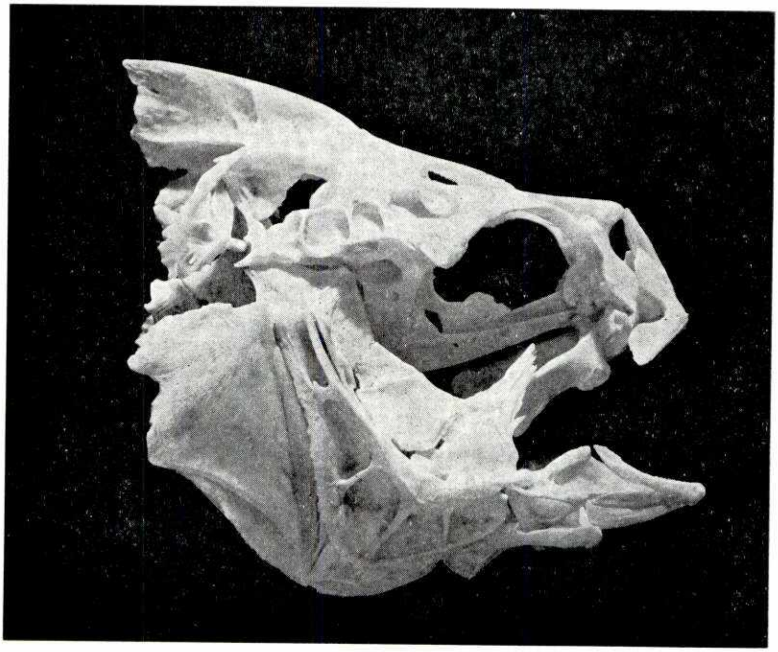
World Distribution of the Drums

FRESHWATER DRUM

Aplodinotus grunniens Rafinesque

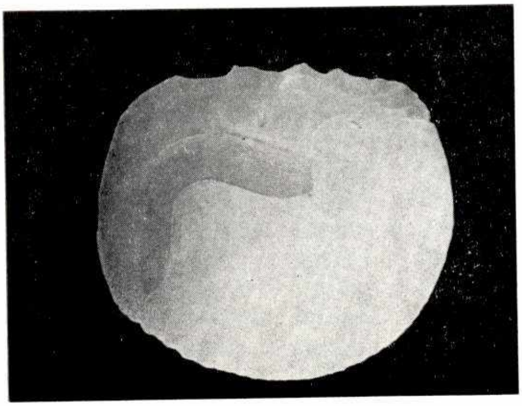


Description Body compressed laterally, deepest immediately in front of dorsal fin, its depth 21.5–28.7% of total length, average length to about 18–20 inches (457–508 mm), the anterior dorsal outline with a steep arc to the dorsal fin. Head bluntly triangular, its length 21.3–22.7% of body length, skull quite distinctive among our freshwater fishes, with many cavities and strutted supports (*see* accompanying photo);



interorbital 23.8–28.0% of head length; eye relatively small, horizontal diameter 20.8–30.4% of head length; snout blunt 23.4–28.8% of head length; maxillary slender, extending to anterior edge of eye; mouth small, and overhung by blunt snout, gape terminating in front of eye, teeth in jaws slender and in many rows; pharyngeal teeth well developed, heavy, and armed with small, rounded, crushing teeth (*see* p. 25). Gill rakers 15(14–16) + 8(7–9). Branchiostegal rays 7. Fins: dorsals 2, the first spiny and connected to the second soft-rayed fin by a narrow membrane but the 2 separated by a distinct notch; first dorsal short, 8 or 9 spines, the third spine usually longest, second dorsal long, extended to caudal peduncle, of 1 spine and 25–33 (30–32, Lake Abitibi) branched rays; caudal rounded; anal of 2 spines, the second greatly enlarged, and 7 branched rays; pelvics thoracic, of 1 spine and 5 branched rays, the first branched ray prolonged into a distinct whitish filament; pectorals inserted in advance of pelvic fins, somewhat pointed, usually 17 branched rays. Scales ctenoid, large, growth lines readily visible with magnification, covering head and body and extending to base of soft dorsal fin, pored scales in lateral line 48–53 (to anterior margin of hypural plate), but pores extend in median line along length of caudal fin. Vertebrae 24.

Certain skeletal features of this species are uniquely characteristic among Canadian freshwater fishes, especially the fused pharyngeal arches with their teeth, the large saccular otoliths (*see* accompanying photo), the greatly enlarged second anal spine and the peculiarly strutted skull.



Colour Overall colouration silvery, back dark green to olive brown, sides silvery and the belly usually white. The pelvic fins are white to cream in colour, pectoral fins clear and remaining fins dusky.

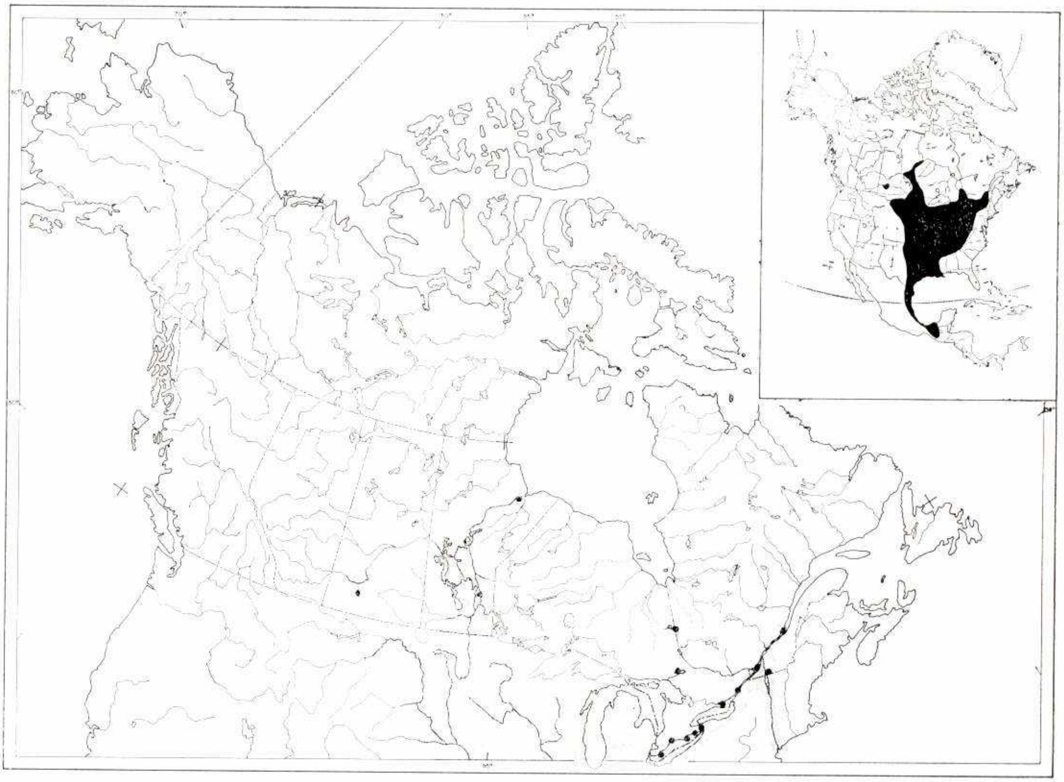
Systematic notes Krumholz and Cavanah (1968) concluded that this species displays remarkable stability in meristic values. Their critical study involved specimens from Kentucky and Wisconsin. Specimens from the northern limits of range have not been critically appraised, although Dymond and Hart (1927) presented morphometric and meristic data for specimens from Lake Abitibi, Ont. It should be noted that although meristic values are stable, rates of growth vary greatly throughout the range.

Distribution The freshwater drum is generally distributed throughout the Mississippi drainage basin, from Pennsylvania to Montana and Nebraska, south to the Gulf states, eastern Mexico, to the Rio Usumacinta system in Guatemala. It is found also in Lake Champlain.

In Canada the species occurs in the upper St. Lawrence River, Ottawa River, north to Lake Abitibi, and in the Great Lakes, except Lake Superior. Common in Lake Erie. It is found in the Hudson Bay drainage of Manitoba, and southwestern Saskatchewan, and reaches the northern limit of its range in the Nelson River in Manitoba (Scott and Kooyman 1952).

Biology It is strange that the spawning or breeding behaviour of the freshwater drum has not been documented, particularly since the species is credited with having the greatest latitudinal range of any North American freshwater species. Yet in the northern part of its range at least this appears to be the case.

Many aspects of the life history of the drum in Lake Erie have been investigated. One such study (Daiber 1953) indicated that spawning in the western basin probably occurred in



July although recently spent females were taken as late as September 11. Daiber used ovary weight: body weight ratios to determine time of spawning. He did not observe spawning and was unable to produce conclusive evidence to indicate where it occurred, but, on the basis of collections of young fish, concluded that spawning may have occurred in bays and lower portions of rivers and in the open lake, possibly over a bottom of sand and mud and to a depth of about 6 feet. The characteristic drumming sounds, made by the action of muscles connected to the swim bladder, are heard more frequently during the summer and may be a component part of the spawning ritual. The fish owes its name to this sound-producing ability.

Daiber calculated the number of eggs in the ovaries of nine females. The extreme ranges in egg number were 43,000–508,000 eggs but the remaining seven ovaries ranged from 209,000 to 341,000 eggs. Extruded eggs measured 1.15–1.7 mm in diameter, had a large oil globule 0.64–0.72 mm in diameter, and are unique among North American fishes since the egg is buoyant and floats right at the surface. Hatching takes place probably in about 25–30 hours at a temperature of about 71.6° F (22° C). *See* Davis (1959) for further details of this planktonic egg. As Davis has remarked, it seems extraordinary considering the abundance of freshwater drum in Lake Erie, that the egg was not observed and described prior to 1959. The evidence was available but apparently not appreciated, for Langlois (1954) reported observations made on three specimens in the Toledo (Ohio) Aquarium that spawned every year and whose floating eggs were partially lost (50%) via the overflow. The floating egg, which can be carried by currents, is probably one of the more significant factors responsible for the extremely wide range of the drum, but *see* Barney (1926) for a thorough but dated discussion of distribution.

Lake Erie populations exhibit a rapid

rate of growth in the first year but the rate in subsequent years is slower than for populations in more southern waters. It must be assumed that rates of growth for populations in such Canadian lakes as Nipissing, Winnipeg, and Abitibi are even slower than for those in Lake Erie. The following figures are total lengths and the weights for males and females at the end of each year of life for Lake Erie populations (modified from Edsall 1967):

Year of life	Length (*inches*)	Length (*mm*)	Wt (*oz*) Males	Wt (*oz*) Females
1	5.1	130	0.8	0.9
2	7.9	201	3.3	3.3
3	10.1	257	7.0	6.7
4	11.5	292	10.2	10.2
5	13.0	330	12.7	13.7
6	13.9	353	15.2	17.5
7	15.3	388	17.5	20.6
8	16.0	406	20.2	24.0
9	16.7	424	23.0	28.4
10	17.6	447	25.6	33.2
11	–	–	28.4	37.9
12	–	–	32.0	40.8

After the sixth or seventh year annual increments were small and hence fish must live to an advanced age in order to reach a large size. Various texts often contain statements suggesting that the drum formerly attained very large sizes, such as 100 or even 200 pounds. But Witt (1960) investigated sizes of drum in ancient times using otoliths found in Indian middens, some dating to 6000 B.C., and concluded that the maximum size for the species in earlier times was probably well under 100 pounds. Average sizes in Ontario waters of Lake Erie are about 1.5–3.0 pounds, but larger specimens are occasionally caught in other Canadian waters as follows: Ottawa River, 1959, to 7.5 pounds; Hay Bay, Lake Ontario, 1964, to 24 pounds (a Canadian record?); Lake Nipissing, at least to 17 pounds, and fish of about 10 pounds are not unusual; Lake Abitibi, to 14 pounds (Dymond and Hart 1927).

The drum is a resident of large, shallow bodies of water and although it apparently prefers clear water it can obviously adapt to relatively high turbidity levels. Little information is available on movements and depth preferences although available evidence suggests that it lives mostly in shallows, i.e., to 40–60 feet.

The freshwater drum is adapted to bottom feeding, as the position of its mouth suggests. Studies in Ohio, Wisconsin, and other United States waters indicate that young-of-the-year eat mostly zooplankton and chironomids; young drum (to 30 mm) eat entromostracans, but as they grow larger aquatic insects become increasingly important. Mayflies *(Hexagenia)* and amphipods *(Gammarus)* are important food items at all sizes. As drum grow larger, fish and crayfish appear more frequently in the diet. Daiber (1952) recorded darters and lake emerald shiner in stomachs of Lake Erie specimens. Although molluscs such as snails and clams are natural foods, they appear to be more important in the diet of river-dwelling than of lake-dwelling populations. The large fused pharyngeal arches are particularly well adapted for crushing mollusc shells.

The freshwater drum appears to have few natural enemies, except during the vulnerable young-of-the-year stage. The covering of heavy ctenoid scales affords considerable protection for Great Lakes populations against attack by sea lamprey.

Bangham and Hunter (1939) considered that the freshwater drum in Lake Erie displayed an unusually high degree of parasitic infestation since all but 4 of 48 individuals examined showed varying degrees of infestation by an unusually diversified list of parasite species. Among the forms identified were trematodes, cestodes, nematodes, acanthocephalans, and myxosporidians. *See* Bangham and Hunter (1939) for further details. *See also* Hoffman (1967) for list of parasites of this species in North American waters.

Relation to man The freshwater drum is a commercial rather than a sport fish although it is taken incidentally by anglers fishing for other species. The Canadian commercial catch has exceeded 1 million pounds (Ontario, in 1966, landed over 1 million pounds) of which about 75% is caught in Lake Erie, and smaller quantities in Lake

Winnipeg and Lake Ontario (Bay of Quinte). The total annual catch from the Great Lakes (United States and Canada) fluctuates from 3 to 5 million. The Lake Winnipeg yield is utilized largely as mink food, and is considered highly desirable for this purpose.

Although Canadian anglers are prone to scorn this fish, it does put up a good fight when hooked, and grows to a large size, therefore warranting greater exploitation by anglers. As proof, perhaps, of its game qualities it has successfully masqueraded as a smallmouth bass! In 1964 a freshwater drum, weighing 11 pounds, 8 ounces, was entered in a big fish contest in Ontario as a smallmouth bass, and due to a misunderstanding and misidentification, won the contest. This erroneous record is still listed (1970) as a record smallmouth bass.

The edibility of the freshwater drum seems to vary from lake to lake, and small fish of 1–2 pounds are usually more palatable than large fish. The flesh is white, with large coarse flakes. In the central part of its range, it is sometimes marketed as "white perch."

Nomenclature

Aplodinotus grunniens	— Rafinesque 1819: 418 (type locality Ohio River)
Sciaena oscula	— LeSueur 1822b: 252
Sciaena (Corvina) oscula (LeSueur)	— Richardson 1836: 68
Corvina Richardsonii	— Forelle 1857: 280
Corvina oscula DeKay	— Bean 1903b: 590

Etymology *Aplodinotus* — simple or single; back; *grunniens* — grunting.

Common names Freshwater drum, sheepshead, drum, sunfish, silver bass, Red River bass, grunter, "gray bass," "white perch." French common name: *malachigan*.

Suggested Reading — Sciaenidae

BARNEY, R. L. 1926. The distribution of the fresh-water sheepshead, *Aplodinotus grunniens* Rafinesque, in respect to the glacial history of North America. Ecology 7: 351–364.

DAIBER, F. C. 1952. The food and feeding relationships of the freshwater drum, *Aplodinotus grunniens* Rafinesque in western Lake Erie. Ohio J. Sci. 52: 35–46.

1953. Notes on the spawning population of the freshwater drum (*Aplodinotus grunniens* Rafinesque) in western Lake Erie. Amer. Midland Natur. 50: 159–171.

EDSALL, T. A. 1967. Biology of the freshwater drum in western Lake Erie. Ohio J. Sci. 67: 321–340.

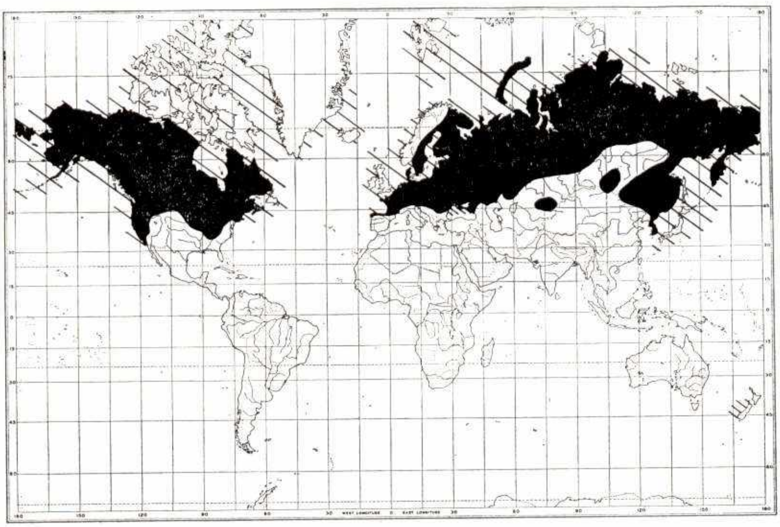
KRUMHOLZ, L. A., and H. S. CAVANAH. 1968. Comparative morphometry of freshwater drum from two midwestern localities. Trans. Amer. Fish. Soc. 97: 429–441.

Sculpin Family — Cottidae

The sculpins form a distinctive group of perciform-like fishes although the ordinal relationships of related families are not clear. For convenience, we have chosen to include the sculpins in the order Perciformes. The sculpins form a rather distinctive group of fishes and many of the morphological features reflect the bottom-living habits which are so characteristic of the group. Sculpins are large-headed and heavy-bodied fishes, the body tapers from the head to a relatively narrow caudal peduncle; skull low, generally broad, composed usually of thin bones; the preopercular bone often variously armed with spines; the second suborbital prolonged posteriorly to form a narrow, bony plate across the cheek, usually articulating with preoperculum; eyes dorsal in position, prominent; jaws strong, teeth well developed, premaxillae toothed and forming border of upper jaw; post-temporal not enlarged. Branchiostegal rays 5–7. Fins with spines; dorsal fins usually 2, usually narrowly divided, first dorsal spiny, second dorsal soft rayed; 1 anal fin without spines; pelvics in advanced thoracic position, of 1 spine and 4, 3, or 2 soft rays; pectoral fins large and fanlike. Scales ctenoid type but usually reduced and tuberculate and reduced to lateral line or scattered rows on body, body not normally covered with overlapping scales; lateral line variously developed. Vertebrae 23–50.

The sculpins are bottom living, primarily marine fishes, of arctic and temperate seas but 1 genus in particular, *Cottus,* is widely distributed in fresh waters of the northern hemisphere.

Although small fishes of 7 inches or less in fresh water, some marine species may attain lengths of 24 inches or more. The family contains at least 300 species of which 8 occur in Canadian fresh waters. Oligocene to Recent.

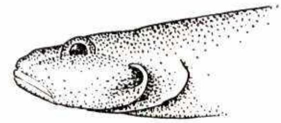


World Distribution of the Sculpins

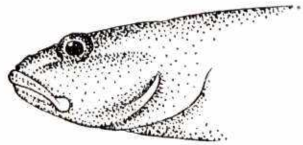
1 Margin of gill membrane free from isthmus (*see* couplet 14, p. 31) second preopercular spine directed backwards, conspicuous; dorsal fins separated by a distinct gap. .... DEEPWATER SCULPIN, *Myoxocephalus quadricornis* (p. 842)

Margin of gill membrane attached to isthmus; second preopercular spine skin covered, and directed downwards; dorsal fins touching or narrowly joined. 2

2 Lateral line complete to base of caudal without deflection; upper preopercular spine usually longer than two-thirds eye diameter and curved strongly upward; mandibular pores large, 1 mandibular pore on midline at tip of chin. .... SPOONHEAD SCULPIN, *Cottus ricei* (p. 839)



Lateral line incomplete, or if complete, deflected downwards on caudal peduncle; upper preopercular spine equal to one-half eye diameter and curved gently upward; 1 or 2 mandibular pores on midline at tip of chin. 3



3 Two pores on tip of chin; lateral line complete or incomplete; first 2 dorsal spines not noticeably close together (associated with separate basals); caudal vertebrae 20–24. 4

One pore on tip of chin; lateral line complete; first 2 dorsal spines noticeably close together (associated with single basal); caudal vertebrae 24–28. 7

4 Lateral line complete; palatine tooth patch long, and in contact with vomerine tooth patch; head length 3 times or less in standard length; prickles on body usually extending onto sides and back, base of prickle serrate; usually 2 dark, narrow, forward-slanting bars under second dorsal fin. .... TORRENT SCULPIN, *Cottus rhotheus* (p. 837)

Lateral line incomplete; palatine tooth patch absent or short, not in contact with vomerine tooth patch; head length usually 3 times or more in standard length; prickles restricted to a small area behind pelvic fin, base of prickle not serrate; either 3 dark bars or none under second dorsal fin. 5

5 Palatine teeth absent; anal fin rays usually 10–12; pelvic fin rays 3 or 4, when present the fourth ray usually less than two-thirds length of longest pelvic ray; last 2 dorsal and anal rays often separated, arising from separate basals. .... SLIMY SCULPIN, *Cottus cognatus* (p. 830)

Palatine teeth present; anal fin rays usually 12–14; pelvic fin rays 4, the fourth about three-quarters length of the longest ray; last 2 dorsal and anal rays close together, arising from same basal. 6

6 Head length usually 2.9–3.2 in standard length; pectoral fin rays usually 14–16; lateral line incomplete and usually of 28–36 pores; preopercular spines 3. .... MOTTLED SCULPIN, *Cottus bairdi* (p. 826)

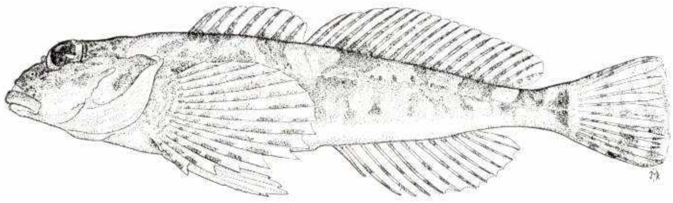
Head length usually 3.2–3.9 in standard length; pectoral fin rays usually 13 or 14; lateral line incomplete and usually of 22 or 23 pores; preopercular spines 2. .... SHORTHEAD SCULPIN, *Cottus confusus* (p. 835)

7 Anal fin rays 15–19; pectoral fin rays 15–18; palatine teeth present; dark, oval spot on upper posterior portion of first dorsal fin; posterior nostril not tubular. .... PRICKLY SCULPIN, *Cottus asper* (p. 823)

Anal fin rays 12–14 (rarely 15 or 16); pectoral fin rays 13–16; palatine teeth absent; dark, oval spot absent on first dorsal fin; posterior nostril tubular. .... COASTRANGE SCULPIN, *Cottus aleuticus* (p. 820)

COASTRANGE SCULPIN

Cottus aleuticus Gilbert



Description Body elongate, average total length 3–4 inches (76–102 mm), typically cottoid, heaviest forward, decreasing in size posteriorly to a moderately deep caudal peduncle, posterior portion noticeably compressed laterally. Head moderate, its length 24–30% of total length, maxillary extends posteriorly to below anterior edge of orbit, well-developed preopercular spine directed upward and backward, preoperculo-mandibular pore count 10–1–10, one pore on tip of chin; eye small; mouth moderate; teeth well developed in upper and lower jaws, and vomer, but no teeth on palatines. Branchiostegal rays 6,6(4), 6,7(1). Fins: dorsals 2, the first with a short base, spiny with 8–10 spines, the second dorsal longer and higher than first, soft rayed, with 16–20 rays, 2 dorsals distinctly but narrowly separated; caudal slightly rounded; anal with long base, soft rayed, 12–16 rays but 15,16 rare; pelvics small, of 1 spine and 4 soft rays; pectorals moderately large and fanlike, 13–16 rays. Typical scales absent, small prickles restricted to a patch behind each pectoral fin; lateral line usually complete, deflecting to midline on the caudal peduncle with 34–44 pores. Vertebrae 34–38, caudal vertebrae 24–27.

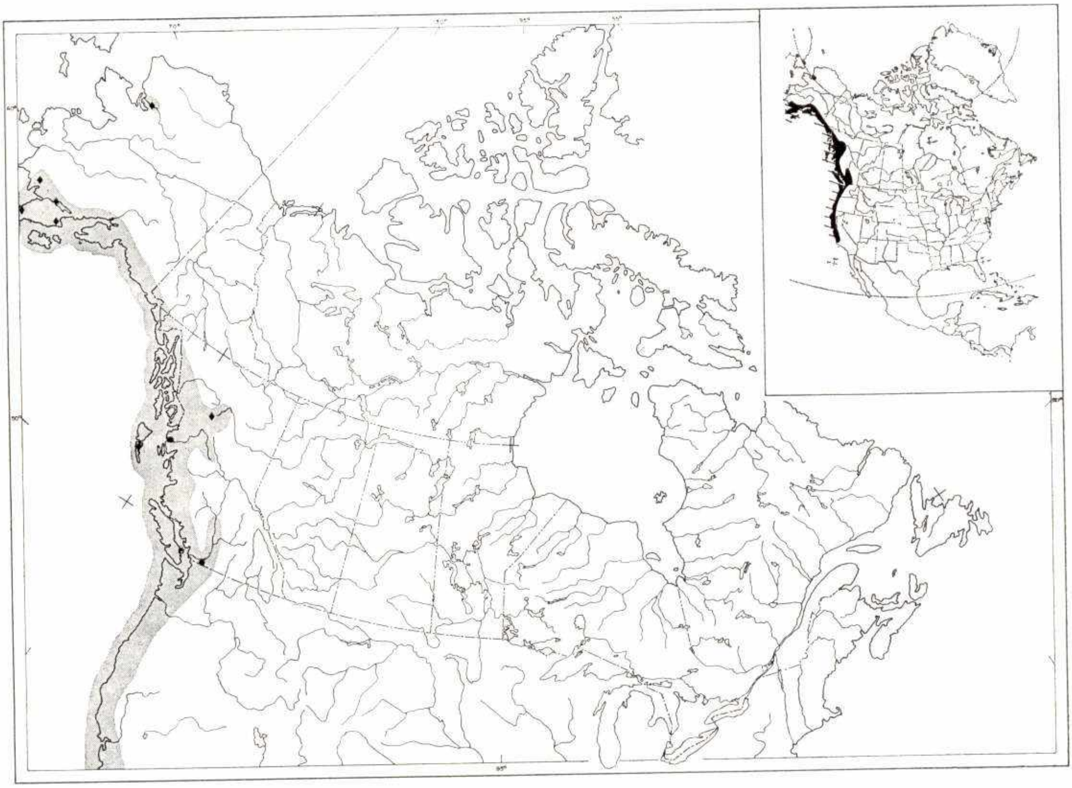
Colour Overall colouration brown or grey with darker blotches, lighter on sides and white below. Two or three dark, saddle-like marks usually developed under second dorsal fin. Pigment on dorsal, caudal, anal, and pectoral fins usually in form of bars. Chin evenly speckled. Sometimes there is a light patch or bar on caudal peduncle behind the soft dorsal. Young fish may not have pigmentation on fins. Spawning males are generally darker overall, and have an orange band on edge of the first dorsal fin.

Systematic notes The original description by Lockington (1880) as *Uranidea microstoma* and the subsequent redescription by Gilbert was reviewed by Robins and Miller (1957). These authors also re-examined the form described by Schultz and Spoor (1933) as *Cottus protrusus*, so-named because of its protruding eyes, and reduced *C. protrusus* to the synonymy of *C. aleuticus*.

Ricker (1960) documented a population of dwarf coastrange sculpins dwelling, throughout their lives, in the deeper waters of Cultus Lake, B.C.

Geographic variation was discussed by McAllister and Lindsey (1961) who considered only pectoral rays to vary significantly between coastal and inland populations, and by McPhail and Lindsey (1970), who remarked upon the difference in anal ray counts of British Columbia specimens (usually 14 rays) compared with Bristol Bay, Alaska, specimens (usually 12 or 13 anal rays). The latter authors also discussed the postglacial dispersal of the species in the northern part of its range.

Distribution The coastrange sculpin occurs from San Luis Obispo County, Calif.,



northward, mainly in coastal streams, along the west coast of North America to Kiska Island, near the western extremity of Alaska's Aleutian Islands. An isolated population occurs in the Kobuk River, just north of the Arctic Circle, in the Chukchi Sea drainage, 500 miles north of the Bristol Bay population of southern Alaska.

In Canada, it occurs in coastal streams and nearby inland lakes from the Fraser River and its tributaries as far upstream as Lillooet, north in such rivers as the Skeena, Nass, and Stikine, and on Vancouver and Queen Charlotte islands.

Biology The coastrange sculpin spawns in streams in spring, probably between February and mid-June. The orange-coloured adhesive eggs, less than 1.5 mm in diameter, are deposited on the undersurface of a rock, in adhesive masses, and are guarded by the male. Over 7000 eggs in different stages of development have been observed in a single nest and it is assumed that a male may spawn with more than one female. A large female may deposit as many as 800 eggs.

A deep-dwelling lake population of coastrange sculpins from Cultus Lake was described by Ricker (1960), who estimated that spawning occurred from late May or early June to August and even September.

On hatching, the young become planktonic in the stream estuary or in lakes and do not take up a bottom-dwelling or benthic life until about 32–35 days after hatching. The movement and fate of planktonic coastrange sculpins was discussed by Heard (1965) and McLarney (1968).

The preference for a flowing water environment develops after they become bottom living.

As noted by McPhail and Lindsey (1970) growth data for Canadian populations is minimal but a maximum age of 4 years was reported for Oregon. Ricker (1960) discussed the possible age structure of a deepwater population but the ages used were approximations based on size groups. The maximum size is apparently about 4.5 inches (115 mm) according to figures presented by Ricker.

The coastrange sculpin characteristically occurs in the fast water of coastal streams and rivers, usually on a gravel bottom. It may also move downstream to estuaries and is tolerant of brackish water. It also occurs in inshore, quiet waters of lakes, over sandy or muddy bottoms. The population of unusually small *aleuticus* (maximum length about 50 mm) described by Ricker (1960) apparently spends its entire life (except as limnetic larvae?) living in the deeper waters of Cultus Lake, not entering the shore waters even to spawn. An unusual aggregation in an Alaskan lake was described by Greenbank (1957) who observed 100–125 fish clustered on a single large boulder, 2 or 3 fish deep.

The food of this sculpin varies with the habitat and time of year. McPhail and Lindsey (1970) noted that feeding usually occurs at night. Aquatic insects and other benthic invertebrates, especially molluscs, are principal foods but in autumn salmon eggs may be eaten extensively. *Daphnia*, chironomid larvae, and ostracods were eaten by the Cultus Lake deepwater sculpins and one had consumed a smaller *aleuticus*, 14 mm long. Consumption of eggs and fry of salmon, particularly those of pink salmon, was noted by Pritchard (1936). Predation on salmon in general in California waters was discussed by Shapovalov and Taft (1954).

The effect of predation by sculpins upon production of pink and chum salmon was discussed by Hunter (1959), although his results probably apply mostly to the prickly rather than the coastrange sculpin. He calculated an average of about two salmon fry per cottid stomach.

The complexity of predator–prey relations was emphasized by Heard (1965) in a paper describing the feeding by young sockeye salmon upon the planktonic larvae of *C. aleuticus*. Most reported predation involving cottids and salmonids concerned consumption of salmon by cottids.

Coastrange sculpins are also eaten by other fishes, such as coho salmon, cutthroat trout, and Dolly Varden char. Ricker (1960) reported as many as 100 sculpins in a single char stomach.

Hoffman (1967) listed only two parasites from the coastrange sculpin, the protozoans *Cryptobia lynchi* and *C. salmositica*. McAllister and Lindsey (1961) noted that the tubercles reported to occur on the pelvic fins of some Alaskan specimens by Evermann and Goldsborough (1907b) on re-examination were shown to be encysted parasites. There are no other reports of parasites in this sculpin in Canadian literature.

Relation to man The coastrange sculpin, although not used directly by man, serves as a forage fish for some valued salmonids, but in turn feeds upon the eggs and larvae of some species of salmon. As in the case of *Cottus asper*, this species is probably of most interest because of its complex but poorly understood food relations with the salmons (*Oncorhynchus* spp.).

Nomenclature

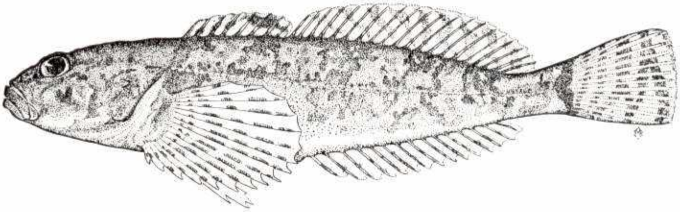
Cottus aleuticus sp. nov.	— Gilbert 1895: 418 (type locality streams of Unalaska, Alaska)
Uranidea microstoma	— Lockington 1880: 58 (name preoccupied)
Cottus protrusus n.sp.	— Schultz and Spoor 1933: 142

Etymology *Cottus* — an old European name; *aleuticus* — of the Aleutians.

Common names Coastrange sculpin, Aleutian sculpin. French common name: *chabot côtier*.

PRICKLY SCULPIN

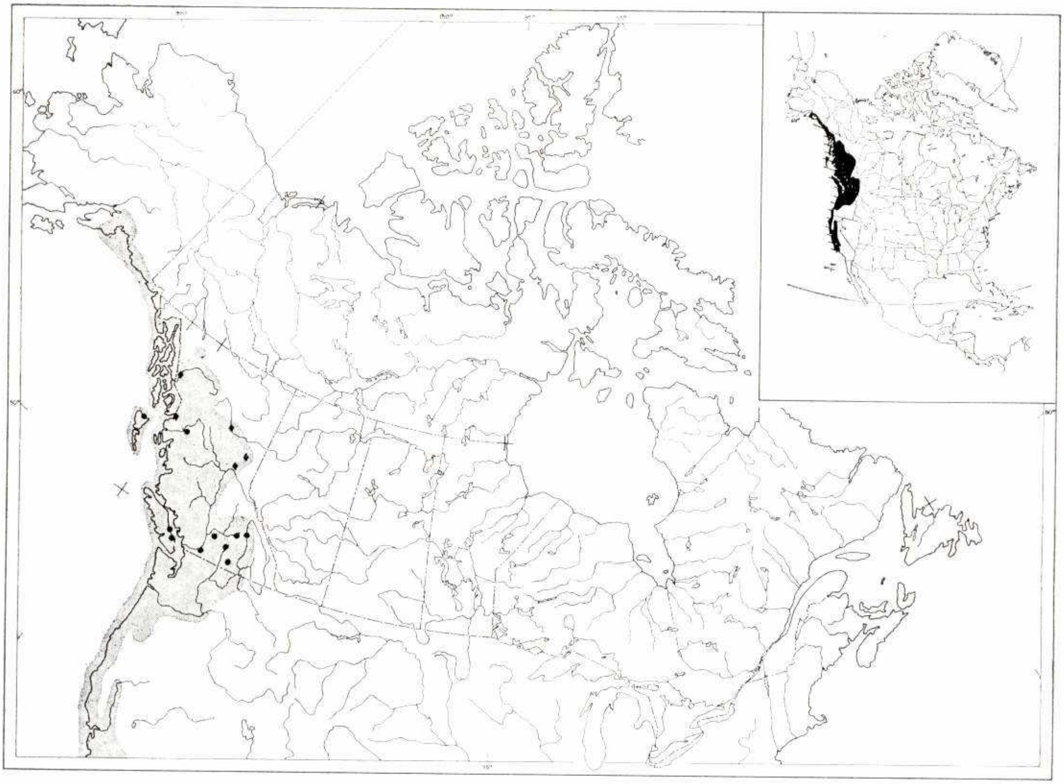
Cottus asper Richardson



Description Body typically cottoid, heaviest forward, decreasing in size posteriorly, compressed laterally from about the junction of the 2 dorsal fins to the obviously compressed caudal peduncle. Head large, its length 25.5–31.8% of total length, maxillary extends posteriorly to middle of eye or beyond in adults, large preopercular spine directed posteriorly, 1 or 2 below it pointing downwards, preoperculo-mandibular pores 10–1–10, with a single pore on chin tip; gill membranes joined to isthmus although superficially may appear to be free from isthmus; eye relatively large, its diameter 18.0–33.3% of head length; mouth large (*see* Northcote 1954, for comparative measurements); teeth well developed on upper and lower jaws, strong on palatine and vomer, the latter tooth patches not in contact. Branchiostegal rays usually 6,6(14), but sometimes 6,5(1), 7,6(3), 7,7(1). Fins: dorsals 2, the first with short base, spiny, 8(17), 9(12), or 10(1) spines (McAllister and Lindsey 1961, gave range of 7–11), second dorsal longer and higher than first, soft rayed, rays 18(1), 19(4), 20(13), 21(9), 22(1), first and second fins lightly joined at base and separated by a distinct notch; caudal slightly rounded; anal with long base, soft rayed, rays 14(2), 15(1), 16(14), 17(9), 18(2); pelvics with 1 spine and usually 4 soft rays (may be 3 or 5); pectorals large, fanlike, with 15–18 rays. Typical scales absent but prickles may occur over whole body (except abdomen) or be restricted to axil of pectoral fin; lateral line usually complete, with 32–43 pores, sometimes a few missing on caudal peduncle. Vertebrae 34(2), 35(4), 36(4), caudal vertebrae 24–28.

Colour Olive to dark brown or grey overall above and on sides, becoming yellowish white or white below; usually with three dark bands under the second dorsal and the sides with vague black mottling. Chin usually lightly pigmented. Dorsals, caudal, anal, and pectoral fins usually barred (except on very young) and first dorsal fin with a distinct black oval mark posteriorly. Spawning males dark; both sexes have a thin orange band on edge of first dorsal at spawning time.

Systematic notes The early nomenclature is confused and misleading in part because of misidentification but due also to the variability exhibited by this sculpin. The nomenclature was thoroughly reviewed by Krejsa (1967a) but *see also* Robins and Miller (1957) and McPhail and Lindsey (1970). The geographic variation exhibited by the degree of prickle development on the body and also by such meristic characters as fin rays and vertebrae was presented by McAllister and Lindsey (1961). In general, inland populations are more densely prickled over a higher percentage of the body than are coastal populations. McPhail and Lindsey noted that Krejsa had evidence that suggested the two forms, coastal and inland, are genetically distinct, but that the coastal form had penetrated further inland in the northern part of the range.



Distribution The prickly sculpin ranges along the Pacific slope of North America from Seward, Alaska, south to Ventura River, Calif.

In Canada, it occurs in numerous coastal rivers, and widely in lakes and rivers of the Stikine, Nass, Skeena, Dean, Fraser, and Columbia River systems; on Queen Charlotte and Vancouver islands. East of the Continental Divide it is reported only in the upper Peace River (Mackenzie River system). For additional details on distribution, *see* Krejsa (1967a) and McPhail and Lindsey (1970).

Biology A detailed study of the life history of the prickly sculpin in British Columbia was published by Krejsa (1967a, b). The following information is derived largely from his work.

Spawning occurs usually in spring, and may be as early as February in the California part of its range. In British Columbia spawning usually takes place from about mid-March to as late as July 22 on Queen Charlotte Islands. Inland populations usually spawn later than coastal ones. Freshwater spawning is usual but coastal populations may spawn in brackish water. A downstream migration is usually associated with prespawning behaviour of coastal populations.

Streams having a boulder, cobble, and flat rock bottom, and a current flow of about 1 cubic foot per second, seem to be preferred. Males move onto spawning grounds before females and select a nesting site under a boulder or flat rock, preferably with a rough under surface. Females remain upstream until ready to spawn, when they move onto the spawning grounds and, following courting behaviour outside the nest, a female selected by a male enters the nesting site. Further courtship under the rock precedes deposition and fertilization of a jelly-enclosed cluster of 700–4000 eggs on the ceiling of the spawning chamber. After spawning, the spent females leave the nest. Males may spawn with as many as 10 females, each egg mass discernible and in a different stage of development, until many thousands of eggs are deposited (Krejsa 1967b, counted 25,000–30,000 in one nest). The eggs are less than 1 mm in diameter, orange in colour and adhesive. The males guard the eggs and fan them with alternating strokes of their pectoral fins. Laboratory studies indicated that they hatched in 15–16 days at a temperature of 53.6° F (12° C), when the larvae were 5–7 mm total length. They begin swimming at once and may form schools (Northcote and Hartman 1959) but remain pelagic for 30–35 days before metamorphosing and settling on bottom.

McPhail and Lindsey (1970) have already noted the absence of any growth data from the Canadian area but noted that a maximum age of 7 years has been recorded from Oregon. The maximum-sized female noted by Krejsa (1967b) was 7 inches (192 mm) standard length, but Carl et al. (1967) gave a possibly dubious overall maximum size of up to 12 inches (305 mm).

The prickly sculpin lives in coastal and inland streams, may occur along lake shores, and is also tolerant of salt water. It is usually an inhabitant of quiet waters and avoids strong currents. It is usually more active at night.

Aquatic insect larvae, especially chironomid and trichopteran larvae, and other bottom invertebrates, such as molluscs, apparently form the major food supply. Planktonic crustaceans are an important component in the diet of young up to 29 mm (Northcote 1954) but even at this stage aquatic insect larvae form the major part. Over 70 mm long, fish become increasingly important. Larger sculpins may consume a variety of items, such as fish eggs, and young of their own as well as of other species such as sockeye salmon (Ricker 1941; Robertson 1949).

A number of species have been reported to prey on prickly sculpins, including lake trout, Dolly Varden, lake whitefish, squawfish, and American mergansers (Munro and Clemens 1936).

Bangham and Adams (1954) examined 344 specimens from 25 locations in British Columbia and found 275 infected. They provided a detailed list of the parasites identified and noted that over half of the parasites reported were from a few fish taken in just one or two of the 25 locations surveyed.

Hoffman (1967) listed trematodes (2), cestodes (5), nematodes (4), acanthocephalans (1), molluscs (1), crustaceans (2).

Relation to man The importance of species with such a wide range, that occur in considerable numbers, is difficult to assess. It is not used directly but may be of considerable importance as food of, or predator on, other species.

Pritchard (1936), Munro and Clemens (1937), and Hunter (1959) presented data indicating that it did prey on the eggs and young of salmon (*Oncorhynchus* spp.) and rainbow trout. It is probably a significant predator upon the former although the full effect of such feeding activities is not known. Anglers, using worms or roe as bait, not infrequently catch prickly sculpins.

Its role in trout and salmon production in California has been discussed by Shapovalov and Taft (1954) who also suggested control methods.

Nomenclature

Cottus asper	— Richardson 1836: 295 (type locality Columbia River, probably at Fort Vancouver, Washington Territory)
Trachidermus richardsonii	— Heckel 1840: 162
Cottopsis asper	— Girard 1852: 61
Cottopsis parvus, G.	— Girard 1856c: 144
Centridermichthys asper	— Lord 1866a: 130

Centridermichthys parvus — Lord 1866b: 352
Centridermichthys gulosus — Lord 1866b: 352

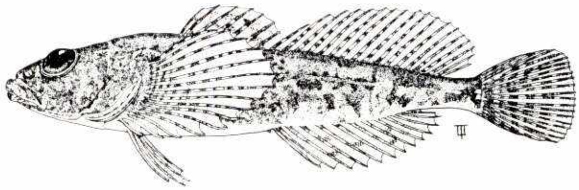
(*see* Krejsa 1967a, for complete synonymy)

Etymology *Cottus* — an old European name; *asper* — rough.

Common names Prickly sculpin, prickly bullhead, bullhead. French common name: *chabot piquant*.

MOTTLED SCULPIN

Cottus bairdi Girard



Description Body of characteristic cottoid shape with flattened and laterally expanded head, average lotal length around 3 inches (76 mm), body depth about equal to body width anteriorly, but posterior portion strongly compressed laterally, the caudal peduncle of moderate depth. Head flattened dorsoventrally and expanded posteriorly, the eyes on top of head, head length 22.2–28.9% of total length, maxillary extends posteriorly to below eye, large preopercular spine directed upward and posteriorly, 2 small spines directed downward, all covered by skin; gill membranes broadly joined to isthmus, operculo-mandibular pores 10–10 or 11–11 (2 on tip of chin); eye relatively large, its diameter 20.6–37.5% of head length; snout moderate, rounded in dorsal view; mouth moderate, upper lip protruding beyond lower; fine teeth developed on upper and lower jaws, on palatines and on vomer, vomer tooth patch separated from palatines. Branchiostegal rays 6,6(70), 5,5(1). Fins: dorsals 2, the first small, spiny, of 7(14), 8(52), or 9(2) spines, base short, the second with long base, soft rayed, 16(17), 17(37), 18(14) or 19 (McAllister 1964a) rays; caudal slightly rounded; anal with long base, soft rayed, 10(2), 11(3), 12(20), 13(36), or 14(7) rays, sometimes range 12–16 (McAllister 1964a); pelvics small, of 1 spine and 4(38), rarely 3(1), rays; pectorals large, fanlike, rays 13–17. Typical scales absent but small prickles present on patch behind pectoral fins, sometimes extending onto back; lateral line incomplete, terminating under posterior part of second dorsal fin. Vertebrae 31(7), 32(16), or 33(8), caudal vertebrae usually 21–23.

Colour Overall colouration light to dark brown with darker (sometimes almost black) mottling on back and sides, becoming light or even white below. Two, sometimes three, dark saddle marks may be evident under second dorsal fin. Chin usually irregularly speckled. The dorsal, caudal, anal, and pectoral fins marked with pigment, the first dorsal with spot fore and aft, which become continuous in breeding males to form a dark band with a broad orange distal edge, second dorsal spotted and banded, caudal more or less randomly speckled, anal usually darkly speckled, and pectorals banded.

Systematic notes The very considerable geographic variation exhibited by this species has given rise to a number of synonyms and to the recognition of a number of subspecies. The subspecies occurring in Canada were listed by Dymond (1947) based on Hubbs and Lagler (1941) as *C. bairdi bairdi*, the northern mottled sculpin, and *C. bairdi kumlieni*, the Great Lakes mottled sculpin. Additional subspecies have been described for populations in the southern United States.

Cottus bairdi and *Cottus cognatus* are closely related, both are members of the *bairdi* species group within the genus (Bailey and Bond 1963), and are exceedingly similar in most morphometric and meristic characters. In a study of the fishes of Isle Royale, Lake Superior, Hubbs and Lagler (1949) enumerated a number of characters considered most useful to distinguish *C. b. kumlieni* and *Cottus cognatus gracilis*. However, when specimens were compared from widely separated parts of Ontario and Quebec, McAllister (1964a) demonstrated that none of the characters previously enumerated or others listed in various keys would permit 100% separation of the two species, *C. bairdi* and *C. cognatus*, let alone two subspecies. The caudal peduncle length in *C. cognatus* always exceeded the distance from the eye to the bony edge of the operculum, while in *C. bairdi* it was always less than the postorbital length.

We suggest that the recognition of subspecies for *Cottus bairdi* populations in Canada implies a degree of detailed knowledge that has not yet been attained, since we know of no characters that will consistently permit separation of the described subspecies. A review of the literature treating the degree of variation observable in a single population of *Cottus bairdi*, such as that of Savage (1962), reinforces this viewpoint.

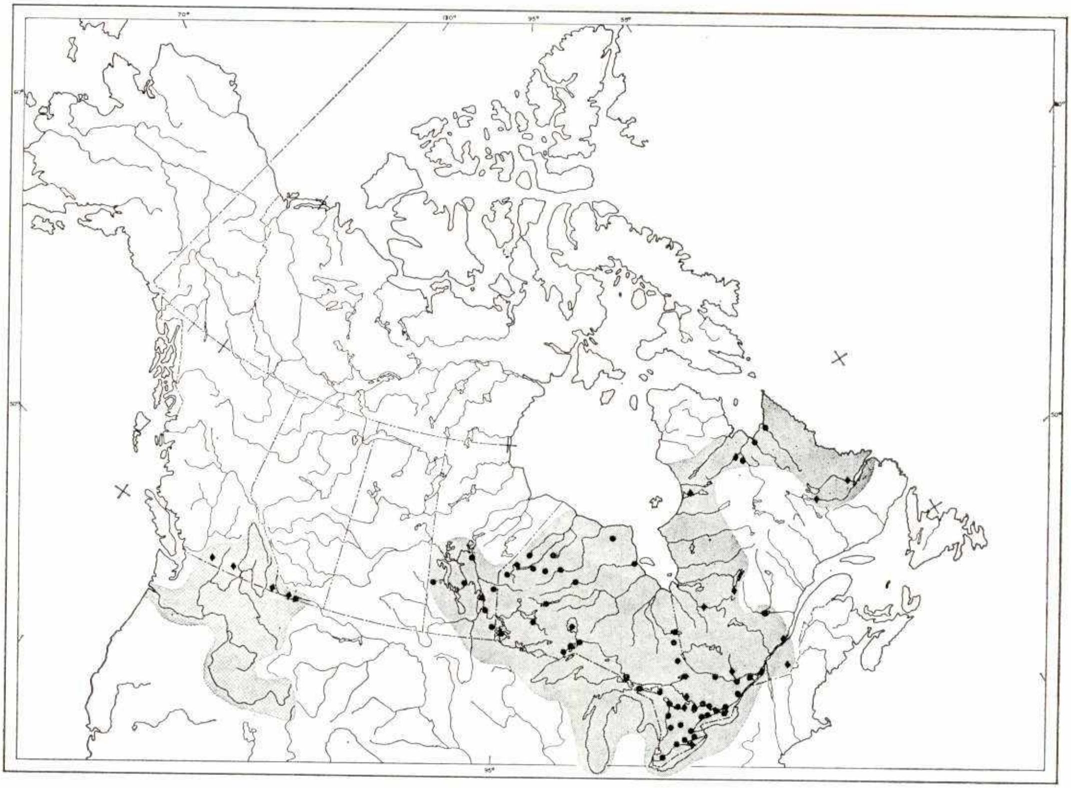
Distribution The mottled sculpin ranges widely but discontinuously through North America from at least the Tennessee River system of Georgia and Alabama to Labrador on the north, and west to the Great Lakes basin. From there, the distribution is discontinuous but includes parts of the Missouri River and the Columbia River systems, in southern Canada, Utah, Montana, Idaho, and Washington.

In Canada, the mottled sculpin occurs from the Lake Melville region of Labrador, Ungava Bay region of northern Quebec, west to Hudson Bay drainages; thence, through the intervening St. Lawrence–Great Lakes system and James and Hudson Bay drainages of almost all Ontario (except the extreme northwest), to southern Manitoba, including Lake Winnipeg and its tributaries, north at least to off the mouth of the Mukatawa River. The distribution becomes discontinuous west from Manitoba.

It occurs in the Milk River system of southern Alberta, and in the Similkameen River system and the Kettle River in southern British Columbia.

Biology There are few detailed observations on spawning activities or behaviour of the species in Canadian waters, but a number has been made in United States waters.

The mottled sculpin spawns in spring, but the exact date varies with geographic location. While engaged in field studies on brook trout on the Mad River, a branch of the Nottawasaga River, Ont., Ricker (1934) observed that spawning probably occurred about mid-May in 1930. Females with nearly ripe eggs were taken on May 3 and 10, but females were spent by June 14. On May 30, eyed eggs and small sculpins were found in brook trout stomachs. And, on July 3, young-of-the-year,



15 mm long, were abundant on a mud bottom at depths of 2–10 inches.

The spawning behaviour in general follows that of most members of the genus. The male becomes dark headed, selects a spawning or nesting site under a rock or ledge, the female enters the nest after suitable courting, deposits the adhesive eggs in a mass on the ceiling of the nest while upside down, and departs or is driven off. More than one female usually deposits eggs in the nest. The male remains to guard the eggs against predation and by alternately fanning his pectoral fins, maintains a current flow, or the nesting site is so positioned in flowing water that a natural current is maintained. Koster (1936) gave water temperature at time of spawning in upper New York State of 50° F (10° C). Koster suggested that hatching did not occur until about a month after deposition, but this would depend on temperature.

Details of behaviour during spawning, for populations in the United States, were given by Koster (1936), Bailey (1952), and Savage (1963).

Koster apparently successfully used otoliths to obtain ages of his specimens, and determined that spawning occurred at age 3, sometimes at age 2. Although the sexes are approximately equal in size, males are usually darker, have a larger head, and higher second dorsal and anal fins than females. A specimen from St. Ignace Island, Lake Superior, is the largest examined and measures 5.2 inches (132 mm) total length.

The mottled sculpin occurs in cool streams and lakes across Canada. In eastern Ontario, Toner (1943) noted that it was caught most often over a sand bottom in lakes and streams. In a study of the invertebrate and vertebrate fauna in southern Ontario streams, Hallam (1959) reported that the mottled sculpin was most often associated with the brook trout, *Salvelinus fontinalis*, a relation usually attributed to the slimy sculpin, *C. cognatus*. The average summer water temperature at stations where *C. bairdi* was caught, was given at 61.9° F (16.6° C). Hallam gave a description of the average *C. bairdi–S. fontinalis* habitat as follows: "Shaded source waters of low temperature and small volume of flow with many rapids." However, it does not usually occur as far up headwater streams nor as deep in lakes as *Cottus cognatus* (Deason 1939; Hubbs and Lagler 1949), which also has the more extensive northern range. However, Keleher (1952a) reported a specimen of *C. bairdi* taken in 54 feet of water in Lake Winnipeg. Its probable susceptibility to a sudden change in temperature was noted by Emery (1970) in Lake Huron, where a number were observed to have died following exposure to an underwater seiche which lowered the water temperature from 65.7° F (18.7° C) to 44.6° F (7° C) in a matter of seconds.

Like other members of the genus, the mottled sculpin is a benthic feeder subsisting mainly on aquatic insect larvae. Ricker (1934) examined stomach contents of 56 fish from the Mad River, Ont., and found chironomid larvae and mayfly nymphs to be most important in the diet of small sculpins under 2 inches (51 mm) long, but sculpins over 2 inches (51 mm) long ate fewer chironomids and more mayfly nymphs, especially nymphs of larger species. The larger fish supplemented their diet with stonefly nymphs, caddisfly larvae, and crayfish. Ricker noted that in this particular location, the sculpin's abundance and consumption of nymphs was probably responsible for the great reduction of mayflies of that species throughout the summer.

Food studies in United States waters show essentially the same feeding habits with emphasis on aquatic insect larvae and nymphs but crustaceans, annelids, fishes, fish eggs, and plant material may be consumed when available. Winter food habits in New York were studied by Daiber (1956) but differ little from those of summer.

A few cases have been reported of sculpins eating trout eggs (Greeley 1932; Koster 1937) but in fact they are not considered to be destructive of brook trout eggs, eating the odd egg that was improperly covered with gravel by spawning trout.

Sculpins are known to form a part of the diet of large brook trout, *S. fontinalis* (Ricker 1934), but seldom are *bairdi* differentiated from *cognatus* when removed from stomachs, hence it is not possible to evaluate the role of *C. bairdi* as food for trout. Utilization of lake-dwelling mottled sculpins is similarly poorly documented although it is undoubtedly eaten by smallmouth bass at times (Tester 1932a). Six specimens were reported eaten by water snakes, *Natrix sipedon*, in Lake Michigan (Deason 1939).

Bangham and Hunter (1939) examined 7 mottled sculpins from western Lake Erie, and reported only 2 infected, each with a single larval cestode (*Proteocephalus ambloplitis* and *Proteocephalus* sp.).

Bangham (1955) examined 8 specimens from Lake Huron and Manitoulin Island. Seven were infected with parasites identified as larval trematodes *Tetracotyle* sp., and *Diplostomum* sp.

Rabb and McDermott (1962), in a survey of southern Ontario streams for *Aeromonas salmonicida*, the bacterium causing furunculosis in fishes, found that *C. bairdi* was a carrier along with the brook trout, *Salvelinus fontinalis*, but the importance of this discovery is not known.

Hoffman (1967) gave a long list of parasites infecting this species in North American waters as follows: protozoans (1), trematodes (12), cestodes (5), nematodes (2), acanthocephalans (4), molluscs (1), and crustaceans (1).

Relation to man Hallam (1959) suggested that *C. bairdi* was a useful indicator of waters suitable for brook trout, but confirming evidence is lacking and this role seems more usually associated with *C. cognatus*. However, in southern Ontario waters this role may well be valid and deserves further study. *C. bairdi* may also serve as a supplementary forage fish for game species besides brook trout, but confirming evidence is also lacking.

From time to time, both *C. bairdi* and *C. cognatus* have been regarded as more or less serious predators on trout eggs but such views are not supported by facts. Both species may compete with trout for food but such competition is unlikely to be serious except under marginal conditions for trout.

Lake dwelling populations of mottled sculpins can be most easily sampled by night seining.

Nomenclature

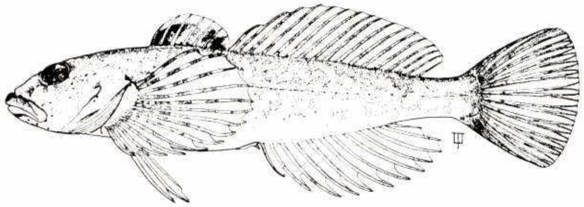
Cottus Bairdii	— Girard 1850: 410 (type locality Mahoning River, Ohio)
Cottus Richardsoni Agass.	— Agassiz 1850: 300
Uranidea Richardsoni Jordan and Gilbert	— Cox 1896a: 48
Cottus ictalops (Rafinesque)	— Bean 1903b: 635
	— Hubbs 1926: 75
Cottus bairdii Girard	— Hubbs and Lagler 1958: 118
Cottus meridionalis	— Hubbs 1926: 75
Cottus hubbsi	— Bailey and Dimick 1949: 2
	— McAllister and Lindsey 1961: 83
Cottus bairdi Girard	— Bailey 1951: 196
Cottus girardi Robins	— Savage 1962: 848
Cottus bendirei	— Bailey and Bond 1963: 1

Etymology *Cottus* — an old European name; *bairdii* — named for Spencer Fullerton Baird, first United States Fish Commissioner.

Common names Mottled sculpin, Miller's thumb, Columbia sculpin, blob, gudgeon, freshwater sculpin. French common name: *chabot tacheté*.

SLIMY SCULPIN

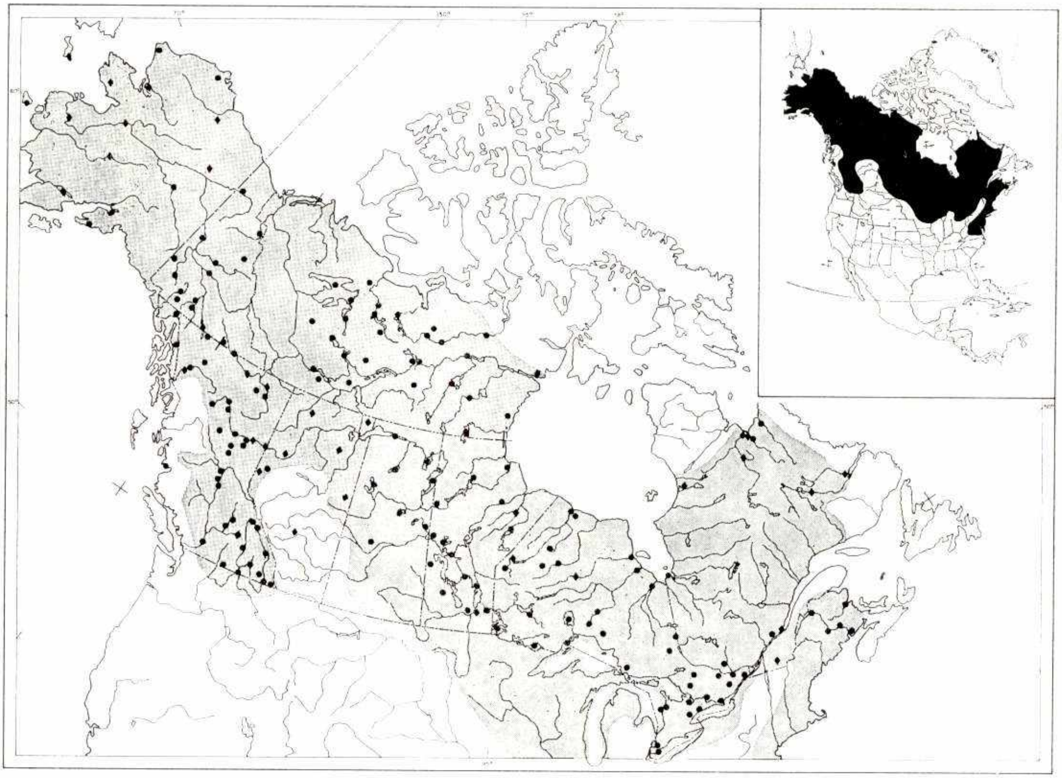
Cottus cognatus Richardson



Description Body of characteristic cottoid shape with flattened and laterally expanded head, average total length about 3 inches (7 mm), body depth about equal to body width anteriorly, but posterior portion strongly compressed laterally; the caudal peduncle of moderate depth. Head flattened dorsoventrally and expanded posteriorly, the eyes on top of head, head length 22.0–27.9% of total length, maxillary extends posteriorly to below eye, 1 large preopercular spine directed upward and posteriorly, 2 small spines directed downward, all covered by skin; gill membranes broadly joined to isthmus, operculo-mandibular pores 10–10 or 11–11 (2 on tip of chin); eye relatively large, its diameter 20–30% of head length; snout moderate, rounded in dorsal view; mouth moderate, upper lip protruding beyond lower; fine teeth developed on upper and lower jaws and on vomer, but no teeth on palatines. Branchiostegal rays 6,6(57), 6,5(1). Fins: dorsals 2, the first small, spiny of 7(5), 8(58), or 9(5) spines, base short, the second dorsal with long base, soft rayed, 14 (McPhail and Lindsey 1970), 15 (McPhail and Lindsey 1970), 16(24), 17(40), 18(5), or 19 (McAllister 1964a) rays; caudal slightly rounded; anal with long base, soft rayed, 10(3), 11(23), 12(39), 13(4), or 14 (McAllister 1964a) rays; pelvics small of 1 spine and 3,3(41) soft rays, only 1 (Manitoba) occurrence of 1 spine and 4,4 rays but fourth ray usually reduced when present, as in British Columbia and northwestern populations (*see* McPhail and Lindsey 1970 and *also* Walters 1955, who noted 4 pelvic fin rays in 13 Alaskan specimens); pectorals large, fanlike, rays 12(1), 13(10), 14(24), 15(11), or 16(1). Typical scales absent but small prickles may be present behind pectoral fins; lateral line incomplete, terminating below centre of second dorsal fin. Vertebrae 31(9), 32(8), 33(3), 34 (McPhail and Lindsey 1970) or 35 (McPhail and Lindsey 1970), caudal vertebrae 20–24 (McAllister 1964a).

Colour Overall colouration usually dark brown with darker mottling, lighter on the sides and white or nearly so on ventral surface but considerable variation is exhibited depending upon background and other factors (*see* Miller and Kennedy 1946). Often with two, dark, oblique saddle marks, one under each of anterior and posterior portions of second dorsal fin, and a less well-defined bar at base of caudal fin. First dorsal fin darkly pigmented basally, almost clear marginally, second dorsal, caudal, and anal may be lightly barred, pectoral fins usually with wide bands. Chin uniformly pigmented, not noticeably mottled. Breeding males dark overall, with a broad reddish orange edge on spinous dorsal fin.

Systematic notes Throughout its extensive North American range, *C. cognatus* exhibits even more morphological variation than *C. bairdi*. *See* McAllister (1964a) for a detailed discussion of the variability of these two species, *C. cognatus* and *C. bairdi*, in eastern Canada, and *see also* under *Systematic notes* for *C. bairdi*. (For regional morphometric and meristic data *see also* Dymond 1926; Walters 1955; Lindsey 1956; McAllister and Bleakney 1960; McAllister and Lindsey 1961; McAllister 1964a, 1968; and McPhail and Lindsey 1970). This plasticity has resulted in part, in the allocation of at least two subspecies to Canadian waters: *Cottus cognatus cognatus*, said to occur in western North America from the Columbia River through British Columbia to the Territories and Alaska; and *C. c. gracilis*, the form occurring in eastern North America from the Great Lakes and from Virginia, north to Ungava. The implications of the morphological variability as related to subspecific designation have been discussed by McAllister and Lindsey (1961) and more recently by McPhail and Lindsey (1970). These authors used, among other characters, the occurrence of a double fin ray on the last anal fin basal element, and the four rays in the pelvic fin (although this fourth ray is often reduced). These features were considered characteristic of the northern type, while the single anal ray on the last basal element and three rays in the pelvic fin were characteristic of the southern type, of the Great Lakes and eastward. Note that the pelvic fin ray count is a frequently used key character for distinguishing *C. cognatus* (3 pelvic rays) and *C. bairdi* (4 pelvic rays), a useful character in eastern Canada, but much less reliable in the west. However, as McPhail and Lindsey noted, wide areas in northern Canada are occupied by populations that have the split anal fin ray but are intermediate



in pelvic ray counts, while in the Columbia, Fraser, and Peace rivers of British Columbia are populations intermediate in both characters. These British Columbia populations also present problems in the development of theoretical paths of postglacial redispersal, which further discourages the acceptance of subspecific designations.

Under the circumstances, the allocation of subspecific names to Canadian populations seems undesirable.

Distribution The range of this species extends through northern North America to extreme northeastern Siberia where it occurs on the Chukot Peninsula and east to the Anadyr River (as *Cottus kaganowskii* Berg, but *see* Walters 1955; McAllister and Lindsey 1961; and McPhail and Lindsey 1970; for reviews of the status of this species). In its extensive North American range, it occupies more northerly waters than its close relative *C. bairdi*. It occurs from Virginia, Labrador, and Ungava on the east, westward through most of northern North America to Alaska, and on St. Lawrence Island in the Bering Sea.

In Canada, the slimy sculpin occurs in scattered localities in New Brunswick, in Labrador from Northwest River and Flour Lake of the Hamilton River system, thence through most of Quebec north to Ungava. From these eastern and northern limits the species occurs widely, in suitable habitats, throughout Ontario, Manitoba, most of Saskatchewan, and the Territories (but not in the main Mackenzie River). It is apparently absent from the Cypress Hills region of Saskatchewan, much of southern Alberta, and most of the lower portions of coastal British Columbia drainages.

There appear to be no positive records for Nova Scotia.

Biology The spawning habits of this sculpin are not well known in Canada and, although some studies have been conducted, few have been published. The earliest account is that of Richardson (1836) who first described the species. He noted that he took the species in considerable numbers in the clear waters of Great Bear Lake in May, when it resorted to stony shallows to spawn. He also noted that some individuals were full of eggs and were only 2½ inches long. However, we have much more information on the morphological and meristic variation of the species than of its ecology, not illogically, because *C. bairdi* and *C. cognatus* are difficult to distinguish and there would be little point in attempting to study ecology until identities were established. An M.A. thesis concerning the biology of this species in the waters of northern Saskatchewan was prepared by the late W. Van Vliet (1964), but has not been published. It contains a wealth of information which should be made available in published form.

The following outline of the spawning procedure is taken largely from Koster (1936), who discussed the spawning of both *C. cognatus* and *C. bairdi* in northern New York waters. The procedure is basically the same for both species and essentially similar to the spawning behaviour of other members of the genus. Koster (1936) gave average temperatures of 41° F (5° C) for the onset of spawning in Cayuga Lake, and 50° F (10° C) for a spring stream, tributary to Fall Creek, N.Y. The ripe male selected a spawning site under a rock or ledge (or sometimes under a submerged tree root), the female was courted and entered the nest and, presumably after additional courting, deposited adhesive eggs in a mass on the ceiling of the nest, then left or was driven out. The nest usually contained eggs from more than one female. The male guarded the nest and young, at times continuing in this duty, according to Koster (1936) even after the young had begun to feed. (*See also* spawning of *C. bairdi.*)

Details concerning egg sizes, rate of development, appearance of the larvae and growth rates are largely unavailable in published form but were determined by Van Vliet (1964) for northern Saskatchewan populations. Diameters of water hardened eggs were 2.3–2.6 mm. Age 3 females, at lengths of about 4 inches (100 mm), produced approximately 1400 eggs. In Montreal River, spawning occurred during early May at about 46° F (8° C) and the eggs hatched in about 4 weeks.

McPhail and Lindsey (1970) reported size to 4.7 inches (120 mm) but specimens available to us measured only to 4.3 inches (109 mm).

The habitat occupied seems to vary greatly depending, probably, upon available substrate and temperature. In general, it occupies deeper waters of lakes and cooler streams and occurs further north than *C. bairdi*. It frequents rocky or gravelly streams and lake bottoms, darting swiftly from place to place when disturbed. In Ungava, Dunbar and Hildebrand (1952) reported it abundant in tide pools in company with threespine sticklebacks. Although common in rocky shallows of lakes in the north (as indicated by Richardson's 1836 account) slimy sculpins are frequently found in cool spring-fed streams in the south and east. Descriptions of habitat and capture were provided by Dymond (1926), Harkness and Hart (1927), Fowler (1948), and Harper (1948, 1961). In Lake Michigan Deason (1939) concluded that it was more abundant in the northern part of the lake where it occurred from near shore to about 300 feet (91.4 m) but was found at least as deep as 420 feet (128 m). It should be noted that Deason's specimens were obtained from stomachs of lake trout and burbot and the depths are those at which these predators were caught.

The exploratory surveys conducted in the Great Lakes by the United States Fish and Wildlife Service in the late 1950's and early 1960's yielded much useful information on depth distribution and abundance. The data for Lake Michigan tend generally to indicate shallower depths than those given by Deason. There appeared to be little seasonal variation in depth. Slimy sculpins were taken in numbers from 18–270 feet (5.5–82.3 m), most commonly in depths of 120–240 feet (36.6–73.2 m), while the deepwater sculpin *(Myoxocephalus quadricornis)* occurred more commonly below these depths. Dryer (1966) analysed the exploratory data for Lake Superior and noted that the largest catches of slimy sculpins were made at 300–354 feet (91.4–107.9 m).

Detailed food studies for Canadian populations have not been published but available evidence suggests that the primary food is invertebrate bottom fauna, particularly aquatic insect larvae; the species eaten depends upon availability which, in turn, is related to habitat, but a wide range of insect groups are involved. Studies to the mid-1930's were summarized by Koster (1937), who quoted Richardson's (1836) findings in the stomach of one of the type specimens from Great Bear Lake, which contained "fragments of *dytisci* and other fresh-water insects and *crustaceae*, and also of some small fish." Studies conducted in upper New York State showed that aquatic insects, crustaceans, small fishes, and some plant materials were consumed, but, aquatic insect larvae and nymphs made up more than 50% of the diet and often 85% or more. The more important insect groups were mayflies, caddisflies, dipterous larvae, stoneflies, and dragonflies. Large fish tended to eat the larvae of larger species.

A number of larger, predaceous fishes, such as lake trout, speckled trout, northern pike, and burbot feed upon this sculpin to a greater or lesser degree, depending upon its availability. Its role in the diet of lake trout and burbot in the Great Lakes was discussed by Dymond (1928b), Van Oosten and Deason (1938), Deason (1939), and Dryer et al. (1965), but the importance of this role vanished with the disappearance of the lake trout from most of the Great Lakes. It is eaten by lake trout, northern pike, and other species in inland lakes in various parts of the country, such as British Columbia (Clemens et al. 1945), and Saskatchewan (Rawson 1959, 1960, 1961).

Cooper (1918) reported the cestode *Schistocephalus solidus*, from a Lake Ontario specimen of this sculpin (using the name *Uranidea formosa*). Lawler (1952) reported finding the cestode *Triaenophorus nodulosus* encysted in the liver of a specimen from Heming Lake, Man., the first record of this parasite in the slimy sculpin in North America.

Van Vliet (1964) discussed the parasites and diseases of the slimy sculpin in Saskatchewan waters. His studies included Myxosporidian cysts (the author suggested that these were caused by *Myxobolus* sp.) *Ligula* sp., and *T. nodulosus*.

Bangham and Adams (1954), in their survey of the parasites of freshwater fishes from British Columbia, reported the following parasites from *C. cognatus* (which they called "mottled sculpin"), trematodes Gyrodactyloidea; nematodes *Rhabdochona cotti* and *Haplonema* sp.; and encysted fluke metacercaria.

Relation to man Inexperienced brook trout fishermen are sometimes startled to see a small, grotesque creature, with a large head and large pectoral fins and bulging eyes, dangling from the end of their line — more than likely their first and perhaps only contact with this sculpin, for they are occasionally caught on small hooks.

The use of the slimy sculpin as a bait fish for trout dates back at least 50 years, for Dymond (1926) remarked that it was a favourite bait, under the name "cockatouch," for brook trout in Nipigon waters. Many of the trout that won the "Nipigon Trophy" were caught on "cockatouch." It is also used occasionally as live bait for trout in other parts of eastern Canada.

The slimy sculpin is a common associate of both lake trout and brook trout and forms part of the food supply of both. It may also compete with the brook trout for food, since both eat aquatic invertebrates, but the extent of such competition is unknown. (*See* Koster (1937) for a discussion of the question.)

Predation by slimy sculpins on eggs deposited by lake trout and brook trout was discussed also by Koster (1937) but there was virtually no evidence that sculpins fed upon eggs of either species and only rare instances of predation on young brook trout.

Nomenclature

Cottus cognatus (Richardson)	— Richardson 1836: 40 (type locality Great Bear Lake, N.W.T.)
Cottus gracilis	— Heckel 1840: 148
Uranidea quiescens	— DeKay 1842: 61
Cottus Franklini Agass.	— Agassiz 1850: 303
Cottus formosus	— Girard 1852: 58
Cottus philonips E. and E.	— Eigenmann and Eigenmann 1892: 963
Uranidea boleoides (Girard)	— Cox 1896a: 48
Uranidea formosa Girard	— Cox 1896a: 49
Uranidea gracilis (Heckel) Putnam	— Cox 1896a: 51
Uranidea franklini (Agassiz)	— Jordan and Evermann 1896–1900: 1967
Uranidea hoyi Putnam	— Jordan and Evermann 1896–1900: 1969
Cottus chamberlaini Evermann and Goldsborough	— Evermann and Goldsborough 1907b: 308

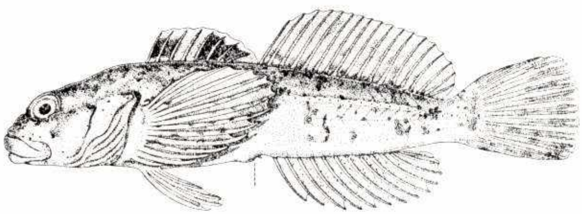
(*see* McAllister and Lindsey 1961, for additional synonyms)

Etymology *Cottus* — an old European name: *cognatus* — related (to the European species, *C. gobio*).

Common names Slimy sculpin, Miller's thumb, cockatouch, slimy muddler, common slimy muddler, northern sculpin, stargazer, Bear Lake bullhead. French common name: *chabot visqueux.*

SHORTHEAD SCULPIN

Cottus confusus Bailey and Bond



Description (This description is based upon the original description by Bailey and Bond (1963) and that of McAllister and Lindsey (1961) for *Cottus* sp.) Body typically cottoid, heaviest forward, decreasing in size posteriorly to a medium caudal peduncle, posterior portion of body noticeably compressed laterally. Head short, 26.3–33.8% of standard length, rather round when viewed from above, maxillary extends posteriorly to below pupil of eye, 2 or 3 preopercular spines, preoperculo-mandibular pores variable, 8–1–8 to 10–10 (only 3% with median chin pore); eye moderate; mouth large, round in dorsal aspect; teeth well developed on upper and lower jaws, moderately developed and widely spaced on palatines and separated from vomerine tooth patch. Fins: dorsals 2, the first with short base, spiny, 7–10 spines, the second dorsal longer and higher than first, soft rayed, of 15–19 (usually 16–18) rays; caudal slightly rounded; anal with moderately long base, soft rayed of 12–14 rays; pelvics small, usually 1 spine and 4 (or 5) soft rays; pectorals large and fanlike, 13–15 rays. Typical scales absent and prickles, if present, restricted to an area behind pectoral fin insertion; lateral line never complete, terminates below ray 10–16 of second dorsal fin. Vertebrae 33–35, caudal vertebrae 22, 23, or 24.

Colour McAllister and Lindsey (1961) described the colour of a form listed as *Cottus* sp., but which referred to this species, and the following colour description is from their account. Body light brown-yellow with dark mottlings. Sides usually pale, without bars, sometimes three dark, mottled bars under second dorsal fin. Post-interorbital region dark. Chin lightly and evenly speckled. First dorsal fin dark anteriorly, and posteriorly between the rays, sometimes with a median band.

Systematic notes This species is very difficult to distinguish from *Cottus bairdi.*

Distribution This sculpin occurs in the Pacific drainage area of North America, in the Puget Sound and Columbia River basins only.

In Canada, the shorthead sculpin has an exceedingly restricted range, and is to be found only in the Flathead River in southeastern British Columbia.

Biology The shorthead sculpin has only recently been recognized as a distinct species and, hence, little is known of its life history or habits. The only information readily available is that published by Bailey and Bond (1963) in their original description, and McAllister and Lindsey (1961).

It inhabits the riffles of small cold streams, usually farther upstream than other cottids, but may also inhabit large rivers, such as the Columbia. It occurs sympatrically with *C. cognatus* in the Flathead River, B.C. It may grow to a length of 4.1 inches (105 mm).

Relation to man It is of minor importance in the Canadian fauna because of its very restricted distribution.

Nomenclature

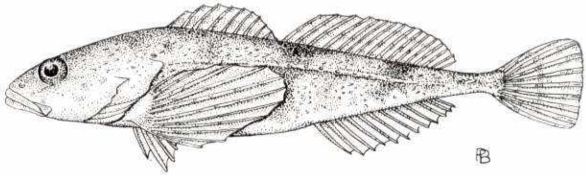
Cottus confusus	— Bailey and Bond 1963: 12 (type locality Salmon R., tributary to Snake R., Idaho)
Cottus sp.	— McAllister and Lindsey 1961: 84

Etymology *Cottus* — an old European name; *confusus* — clouded, referring to the irregular and indistinct body pigmentation.

Common names Shorthead sculpin. French common name: *chabot à tête courte.*

TORRENT SCULPIN

Cottus rhotheus (Smith)



Description Body typically cottoid, heaviest forward, decreasing in size posteriorly to a narrow caudal peduncle, body noticeably compressed laterally on posterior portion only, average size about 4 inches (102 mm). Head large 26.8–30.1% of total length, maxillary extends posteriorly to below eye, 3 preopercular spines, operculomandibular pores 11–11, 2 pores on tip of chin; eye moderate, its diameter 20.2–26.8% of head length; mouth large (larger than *asper* at all sizes; *see* Northcote 1954, for comparative measurements); teeth strong and well developed on upper and lower jaws, palatines, and vomer, palatine tooth patches long and in contact with vomer tooth patch. Fins: dorsals 2, the first with short base, spiny, of 7, 8 (usually), or 9 spines, the second dorsal longer and higher than first, soft rayed, of 15 (usually), 16, or 17 rays; caudal rounded; anal with long base, soft rayed, 11, 12 (usually), or 13 soft rays; pelvics small, reduced, of 1 spine and 4 rays; pectorals large and fanlike, rays 15–18. Typical scales absent, but well-developed prickles usually on back, sides, and sometimes on caudal peduncle, but prickles may be restricted to patch behind pectoral fin; lateral line usually complete, sometimes extending onto caudal fin. Vertebrae, caudal 20–23.

Colour Overall colouration brown or greyish brown with darker mottling. There are two distinct and dark saddle-like blotches that angle down and forward on the back under the second dorsal fin; lighter on lower sides and white below. Chin distinctly mottled. Dorsal, caudal, and, sometimes, anal and pectoral fins with bands or bars of pigment. Outer edge of the first dorsal fin thickened and orange coloured on spawning males.

Systematic notes Extensive geographic variability of *C. rhotheus* throughout its range was discussed by Bailey and Dimick (1949) and McAllister and Lindsey (1961). The latter authors provided tables of comparative meristics to show the range of values for fin rays, chin pores, and vertebrae. *C. rhotheus* is considered to be most closely related to *C. carolinae* of the southeastern United States but is also similar to *C. ricei* in having prickles, a wrinkled chin, slender caudal peduncle, and semitubular nostrils. *See* McAllister and Lindsey for additional information.

Distribution The torrent sculpin occurs in the west coast of North America in the Columbia River and Puget Sound drainages, and in North Thompson River (Fraser system).

In Canada, it occurs only in British Columbia where it is known from the following regions: in the Similkameen system; in the Kettle River; in the main Columbia River from Kinbasket Lake through the Big Bend, the Arrow lakes and south to the U.S. border; in Kootenay Lake and upper Kootenay system in the Cranbrook area. Recently found in the North Thompson system near Little Fort and at Heffley (Carl et al. 1967).

Biology Spawning is thought to occur about June. Northcote (1954) observed that fish caught in June were inactive and in spawning condition but no spent fish were found. He considered that the species did not spawn until at least late spring of its second year. McAllister and Lindsey (1961) stated that it attains a total length of 6.1 inches (155 mm).

The torrent sculpin is primarily a stream species but may also occur over beaches in large lakes. Northcote observed that it inhabited the upper littoral zone of the Arrow Lakes and was taken by beach seine (with *Cottus asper*) on several occasions.

Young and partly grown (to 55 mm) torrent sculpins ate planktonic crustaceans in very early stages but mainly aquatic insect larvae, particularly of midges and mayflies. Above this size range, fish became increasingly important in the diet until it was almost the exclusive food of sculpins 70 mm or larger. Minnows, particularly redside shiners and squawfish, were most frequently eaten. Northcote demonstrated that it has a proportionally larger mouth than *C. asper* and at comparable lengths can eat larger food items. Predation on coho salmon fry by torrent sculpins was studied by Patten (1962) but the sculpin was considered to feed only incidentally on salmon fry.

Bangham and Adams (1954) examined 38 specimens from Dry Lake in the Columbia drainage. All specimens were infected with larvae of the trematode *Diplostomulum* sp.; some with the larvae of trematodes *Tetracotyle* sp., and adult Gyrodactyloidea; acanthocephalans, *Neoechinorhynchus rutili* and *Pomphorhynchus bulbocolli*; and in the digestive tract, the immature form of the cestode *Proteocephalus* sp.

Hoffman (1967) listed the protozoan *Cryptobia lynchi*, cestode *Proteocephalus* sp., and the acanthocephalan *N. rutili*.

Relation to man This species is of no known direct importance. Possibly its feeding habits and early ability to consume other fishes may bring it into conflict with man's interests but this cannot be said to be the case at present.

Nomenclature

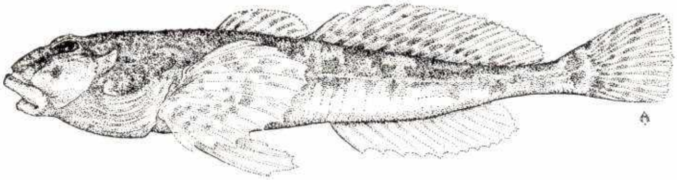
Uranidea rhothea	— Smith 1882: 347 (type locality Spokane Falls, Wash.)
Cottus rhotheus Rosa Smith	— Jordan and Evermann 1896–1900: 1946
Cottus rhothea (Rosa Smith)	— Jordan, Evermann, and Clark 1930: 383
Cottus rhotheus (Rosa Smith)	— Carl and Clemens 1948: 107
Cottus rhotheus (Smith)	— Bailey et al. 1970: 58

Etymology *Cottus* — an old European name; *rhotheus* — rushing of the torrent, referring to habitat.

Common names Torrent sculpin. French common name: *chabot de torrent*.

SPOONHEAD SCULPIN

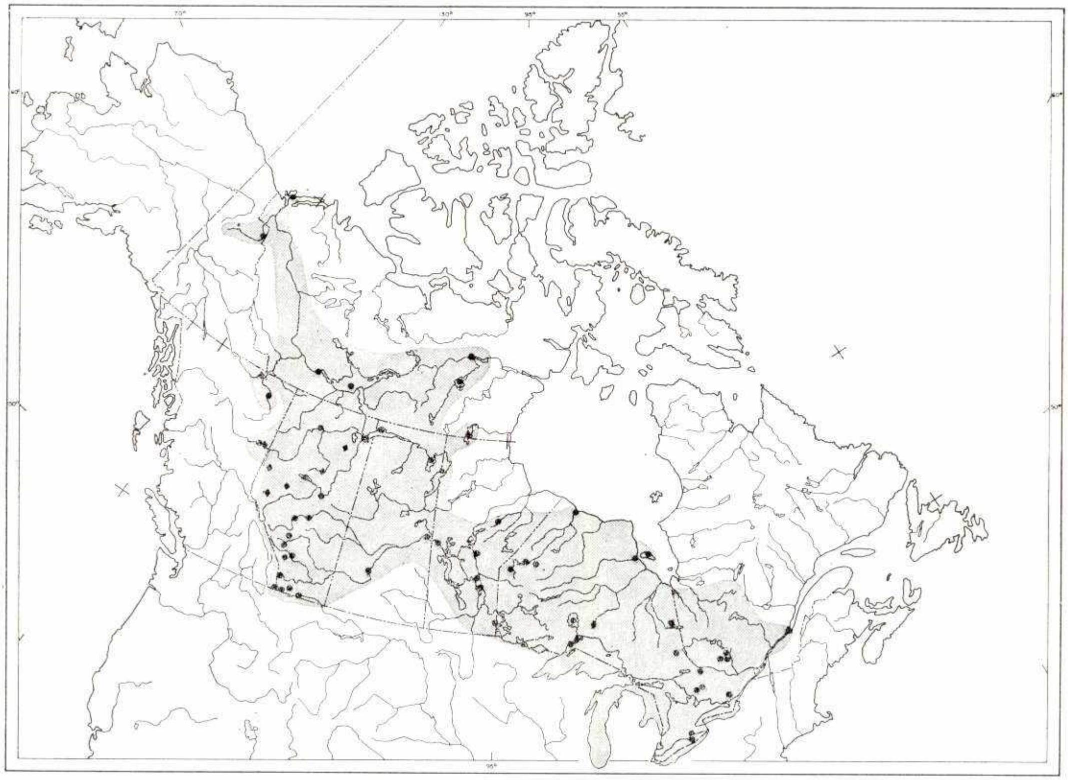
Cottus ricei (Nelson)



Description Body of peculiar shape, with flattened head, almost tubular body (especially of adults), laterally compressed posteriorly and with a narrow caudal peduncle, average total length about 2.0–2.5 inches (51–64 mm). Head decidedly flattened dorsoventrally, and spatulate in dorsal view, the eyes noticeably on top of head, head length 23.4–30.0% of total length, maxillaries extending posteriorly to a point in front of eye, dorsally a distinctive W-shape to posterior margin of premaxillary groove, 2, 3, or 4 preopercular spines, but uppermost well developed and hooked or curved upward and backward; gill membranes broadly joined to isthmus, operculo-mandibular pores 10–1–10, a single pore at tip of chin; eye diameter 19–30% of head length; snout blunt, mouth relatively small, teeth developed on upper and lower jaws and on vomer but no palatine teeth. Fins: dorsals 2, the first rather small, spiny, 7(2), 8(43), 9(3), 10 (McAllister and Lindsey 1961) spines, base short, the second dorsal with a long base, soft rayed, 15(3), 16(16), 17(13), or 18(16) rays; caudal slightly rounded; anal with long base, soft rayed, of 11 (McAllister 1957 personal communication), 12(15), 13(24), 14(8), or 16(1) rays; pelvics small, ventral in position, of 1 spine and 4 rays; pectorals very large and fanlike, rays 14–16. Typical scales absent, body more or less covered with small prickles, sometimes restricted to head region only on large females; lateral line complete. Vertebrae 34 or 35, caudal vertebrae 23–25.

Colour Overall colouration light brown or tan in lower Great Lakes, but distinctly darker northward. Darker saddle-like blotches on back. Often four in number, the first three occurring through the base of the second dorsal fin, the fourth on the peduncle, but these dorsal markings not necessarily present especially on large Great Lakes specimens. Remainder of back variously speckled with light or dark brown spots that also occur on pectoral, both dorsal and caudal fins and also faintly, at times, on the anal fin. Pelvic fins and ventral surface generally immaculate but populations on inland lakes may exhibit scattered pigmentation on ventral surface including chin and especially caudal peduncle. Small specimens may have a distinct vertical bar at caudal base. Fish (1932) provided a detailed description of the first Lake Erie specimen, which was 27.5 mm long.

Systematic notes The spoonhead sculpin is rather stable in its meristic and morphometric characters and is the most distinctive member of the genus *Cottus* in North America, with *C. rhotheus* as perhaps its closest relative on this continent. Its possible relationship to another prickly sculpin, *C. sibiricus* of northern Asia, was noted by Wynne-Edwards (1952) and McAllister and Lindsey (1961), who also suggested *C. spinulosus* and *C. gobio* as possible Eurasian relatives; *see also* Walters (1955). For additional systematic information *see* Dymond (1926), McAllister (1962b), and McAllister and Lindsey (1961).



Distribution North American distribution is almost entirely restricted to Canadian waters except in the Great Lakes basin where it occurs throughout the Great Lakes, including Lake Michigan, and in inland United States waters in Lake Charlevoix, Mich., and in lakes on Isle Royale.

In Canada, the spoonhead sculpin ranges widely. The known eastern limit is the St. Lawrence River, Que., near Neuville, Saint Nicolas, and St. Petronille, Ile d'Orléans (Vladykov 1949b). West from this, it is found in lakes in Gatineau County and in southwestern Quebec (Delisle and Van Vliet 1968). Throughout Ontario, it occurs in suitable habitats, from lakes Ontario, Erie, Huron, Superior, and Nipigon, north to Lake Abitibi, Fort Severn (on Hudson Bay) and the James Bay shore waters of Akimiski Island. In Manitoba, it has been reported from a few localities in the Lake Winnipeg region, in the Saskatchewan River, and the mouth of the Nelson River at York Factory (Keleher and Kooyman 1957), and in Nueltin Lake on the northern boundary. In Saskatchewan, it has been recorded from the Saskatchewan River, and from lakes Wollaston and Athabasca. Recorded from many parts of Alberta, from the Milk (a questionable record) and Bow rivers and Waterton Lakes region in the south, to the North and South Saskatchewan rivers, Lesser Slave Lake and the Athabasca River in the north. It occurs in the Peace River below the canyon, and in the Mackenzie River system of northeastern British Columbia; in the Northwest Territories in Great Slave Lake and the lower Mackenzie River (McAllister 1962b) and the Thelon River system (Beverly and Dubawnt lakes) of the Hudson Bay drainage.

Wynne-Edwards (1952) erroneously recorded *C. ricei* in Alaska, but there are no valid records (Walters 1955).

Many, perhaps most, of the locality records for *Cottus ricei* are based upon one or two specimens, these often from lake trout or burbot stomachs, or those washed up on shore. Indeed, the original description was of a specimen found on the shore of Lake Michigan. Hence, the species may be more widely distributed than our present records indicate.

Biology Little is known of the biology of this sculpin. Even our knowledge of its distribution is most inadequate and only rarely are enough specimens found in any one locality to warrant life history studies.

The time of spawning is not known but recent evidence suggests that spawning occurs in late summer or early fall. Delisle and Van Vliet (1968) reported that milt was exuded, under slight pressure, from males caught August 1, 1967, at a depth of 140 feet (42.7 m) in Pemichangan Lake, Gatineau County, Que. The temperature at 140 feet was 40.1° F (4.5° C). Ovaries examined by us from Ontario specimens contained larger eggs in August than in June or July and exceedingly small eggs in December.

The size attained is relatively small. Most specimens range from about 1.6–2.4 inches (40–60 mm) but many of these are possibly immature. Specimens in excess of 3 inches (76 mm) are not uncommon, particularly when trawls are used for sampling. Dymond (1926) reported 3.25 inches (82 mm) as the maximum size seen at Lake Nipigon. A number of specimens in excess of 4 inches (102 mm) have been taken in Lake Erie by otter trawls; one of these, a female, measured 4.7 inches (120 mm) in total length. The maximum size known is 5.3 inches (134 mm) total length, caught in gillnets in Pemichangan Lake, Que. (Delisle and Van Vliet 1968).

Habitat and depth distribution are almost as poorly known as other aspects of its biology. Inland and northward it has been caught in small swift streams, turbid rivers, or the inshore shallows of and deeper waters of lakes (Dymond and Scott 1941; Ryder et al. 1964; Delisle and Van Vliet 1968; and McPhail and Lindsey 1970). In lakes, its relative depth distribution is probably intermediate between *C. cognatus* and *Myoxocephalus quadricornis*, at least in the Great Lakes area. Dymond (1926) and Greene (1935) noted that it was usually found at shallower depths than the deepwater sculpin, *M. quadricornis*. Exploratory fishing in the Great Lakes by vessels of the United States Bureau of Commercial Fisheries yielded much new information on depth distribution of many species, cottids included. Brief accounts of the results were reported in cruise reports of the MV *Siscowet* and MV *Cisco*. Captures of *C. ricei* in Lake Superior to depths of at least 62 fathoms (372 feet; 114.4 m) were reported. Occasional specimens were caught in otter trawl tows at depths of 12–25 fathoms (72–150 feet; 21.9–45.7 m), but up to 25 specimens were taken at 36 fathoms (216 feet; 65.8 m). These were July and August samples and suggest that the optimum depth might be in the vicinity of 200 feet, if the field records are not distorted by spawning movements. Deason (1939) gave a depth range in Lake Michigan of "... from shore to about 75 fathoms" (i.e., to 450 feet).

Some of the literature on depth range is confused and misleading. Trautman (1957) gave the depth for the first Lake Erie record as "22 metres (132 feet)." The 22 metres is correct. McPhail and Lindsey (1970) gave a depth range in the Great Lakes to "200 m (600 ft)." The 200 metre depth is possibly in reference to *Myoxocephalus quadricornis*, which inhabits depths to 100 fathoms (Deason 1939; Eddy and Surber 1960; and others). We were unable to validate a depth of 600 feet for *C. ricei* and suggest that Deason's 75 fathoms (450 feet) is possibly more realistic.

There is no detailed information on food, and we can only assume that planktonic crustaceans (in deep lakes) and aquatic insect larvae (in inshore regions) figure prominently in the diet.

The spoonhead sculpin has been demonstrated to be a regular item in the diet of Great Lakes fishes. Deason reported 347 specimens from the stomachs of Lake Michigan lake trout and burbot, and as many as 33 from a single stomach. However, the number of specimens in a single stomach was usually less than 10. Deason also reported that 3 specimens were removed from the stomach of a whitefish caught in Charlevoix Lake, Mich. Rawson (1959) reported one from the stomach of a lake trout caught in Wollaston Lake, Sask.

Predation on *C. ricei* by lake trout and burbot in Lake Michigan and Lake Superior is perhaps only of historical interest since these predators have entirely disappeared or been greatly reduced in numbers. How *ricei* has responded to this reduction in predator pressure is unknown.

The parasitic fauna of the species is unknown.

Relation to man The spoonhead sculpin is of interest zoogeographically, since its presence in a body of water provides information on the geological or glacial history of the region. Economically, it is of interest because it was a natural food of lake trout and burbot in the Great Lakes and is still a natural food of these species in inland lakes.

Nomenclature

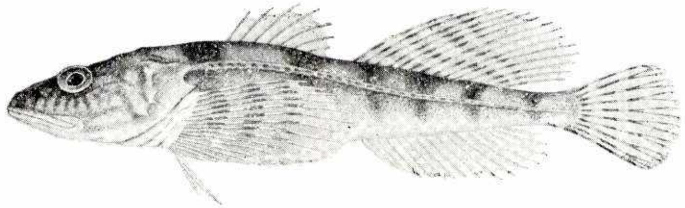
Cottopsis ricei	— Nelson 1876: 40 (type locality Lake Michigan off Evanston, Ill.)
Uranidea pollicaris	— Jordan and Gilbert 1883b: 222
Cottus onychus	— Eigenmann and Eigenmann 1892: 963
Cottus ricei Nelson	— Jordan and Evermann 1896–1900: 1952
Cottus pollicaris (Jordan and Gilbert)	— Jordan and Evermann 1896–1900: 1953

Etymology *Cottus* — an old European name; *ricei* — after its discoverer, M. L. Rice.

Common names Spoonhead sculpin, Rice's sculpin, spoonhead muddler. French common name: *chabot à tête plate.*

DEEPWATER SCULPIN

Myoxocephalus quadricornis (Linnaeus)

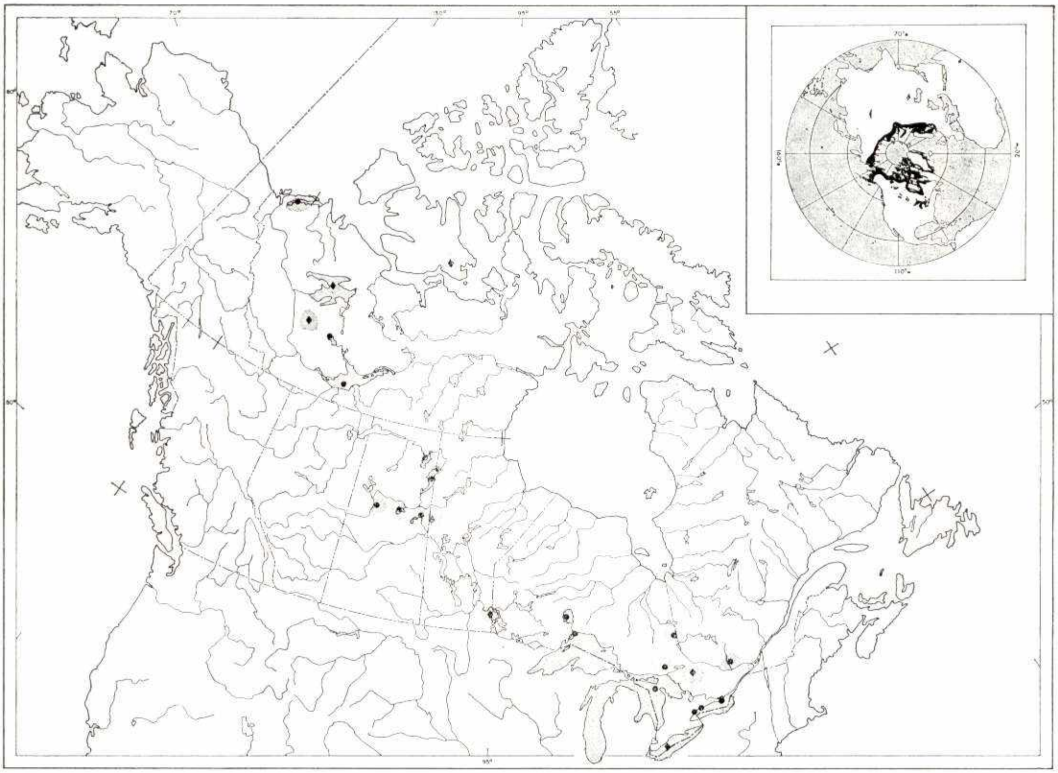


Description Body elongate, average total length 2–3 inches (51–76 mm), heaviest forward, body depth and width about equal below first dorsal, decreasing steadily posteriorly to a slender caudal peduncle. Head distinctly flattened dorsoventrally and expanded, its greatest width at the origin of the uppermost preopercular spines, head length 25.9–30.2% of total length, maxillary extending posteriorly to below middle of eye or beyond, gill membranes meeting at an acute angle and free from isthmus, preoperculo-mandibular pores absent, 4 preopercular spines in all, the upper 2 large and slender, appearing as 1 enlarged bifurcate spine, pointing upward and posteriorly, the remaining 2 smaller, directed downward (preopercular spines most useful in identification especially for partially digested specimens), the frontal and parietal spines, so obvious in most adult marine *M. quadricornis*, are absent. Eyes on top of head, close together, eye diameter relatively small, 18.1–23.8% of head length; snout broadly rounded in dorsal view; mouth large, more or less terminal; teeth fine, in brushlike bands on upper and lower jaws, larger on palatines, vomer, and even tongue. Branchiostegal rays 6,6(16), 7,7(1). Fins: dorsals 2, the first small, spiny, of 7(19), 8(27), 9(13), or 10(2) spines (data combined with McAllister 1961), base short, second dorsal with long base, soft rayed, 11(3), 12(13), 13(25), 14(19), 15(9), 16(1) rays (data combined with McAllister 1961), second dorsal often greatly enlarged on males (Jacoby 1961), dorsal fins distinctly separated by distance about equal eye diameter; caudal more or less square or truncate; anal with long base, soft rayed, 11(1), 12(13), 13(23), 14(21), 15(11), or 16(1) (data combined with McAllister 1961); pelvics small, of 1 spine and 3(17) soft rays, rarely 4(1), spine concealed in fleshy sheath with first ray; pectorals large, fanlike, 15 (McPhail and Lindsey 1970), 16(9), 17(8), or 18 (McPhail and Lindsey 1970). Typical scales absent, spines or prickles present only above lateral line, usually fewer than 30; lateral line complete or nearly so, many specimens in eastern Canadian inland populations have incomplete lateral lines. Vertebrae 37(3), 38(3), or 39(4) (marine populations in Hudson Bay ranged 39–42).

Colour Overall colouration grey-brown (when freshly caught); back and upper part of sides grey-brown, becoming lighter about midline of sides, and light below. Back and sides with light speckling or mottling, back with four to seven thin, dark, saddle-like marks. Pelvic fins lightly pigmented or immaculate, remaining fins variously barred. *See* colour illustration facing p. 90.

Systematic notes The taxonomy and postglacial distribution of the deepwater sculpin in North America has received considerable attention in recent years. The interested student should see papers by Walters (1955), Ricker (1959), McAllister (1961), Johnson (1964), and, especially, McPhail and Lindsey (1970). Hubbs and Lagler (1964) and others have proposed a subspecific designation, *Myoxocephalus quadricornis thompsonii*, for the North American freshwater form. McPhail and Lindsey also accepted this subspecies concept and, in addition, proposed adoption of the familiar common name, "deepwater sculpin." This common name is appropriate because this freshwater form does regularly live at greater depths than the marine form, which McPhail and Lindsey suggested might be designated *Myoxocephalus quadricornis quadricornis*, the fourhorn sculpin. The common name, deepwater sculpin, is at variance with the name fourhorn sculpin, proposed in the *Checklist of Common and Scientific Names of the American Fisheries Society* (Bailey et al. 1970), but we recommend its use because it is descriptive, it does distinguish the North American freshwater populations from the marine ones, and it has been in general use in North American literature for decades.

The deepwater sculpin is usually referred to as a glacial relict in both Europe and North America because, theoretically, it, together with the relict crustaceans *Mysis relicta* and *Pontoporeia affinis*, all originally occupying arctic, marine, or brackish waters, was pushed southward, along with the salt water, in front of the advancing ice sheets. Eventually the ice retreated, forming proglacial lakes as it did so, and leaving behind the deepwater sculpin and its ever-present invertebrate associates that form its food supply. Other theories proposed to explain this sculpin's freshwater distribution, which even now must be considered incompletely known, involve the voluntary migrations of marine sculpins into fresh water, and finally, dispersal by invasions of



sea water up the St. Lawrence and inland from Hudson Bay. These theories were thoroughly discussed by McAllister (1961). The proglacial lake theory proposed by Ricker (1959) has gained general acceptance to explain adequately most of the inland occurrences. Modification of this theory, however, may be required to account for some inland occurrences. Martin and Chapman (1965) suggested that sculpins moved downstream in the Fossmill outlet channel of the Algonquin stage of the Great Lakes, as the glaciers retreated. Delisle and Van Vliet (1968) considered that to be the most logical explanation for the occurrences in Heney Lake in the Gatineau region of southwestern Quebec. Voluntary movements into fresh water by marine forms may have taken place and may be on-going, especially in the arctic. But all populations have not necessarily been derived in the same way. The extremely large size formerly attained in Lake Ontario (to at least 9.2 inches (234 mm)) compared with the 4–5 inch (102–127 mm) length in the other Great Lakes and the even smaller size attained northwestward, suggests the possibility of a different origin. This view is strengthened by the size of individuals being found in the Gatineau region of Quebec. Unfortunately, the origin of the Lake Ontario population will probably remain forever a mystery for the species has been extirpated, possibly a result of DDT pollution.

Distribution *Myoxocephalus quadricornis* is circumpolar in distribution. It occurs in two forms, one marine and the other fresh water. The marine populations live in cold, salt, and brackish water in the northern hemisphere. Freshwater populations are found in Europe, Asia, and North America, where in the Great Lakes region they extend south to about the 42nd parallel of latitude, the southern limit of world distribution. North American freshwater populations, generally regarded as glacial relicts, are confined entirely to Canadian waters except for Torch Lake, Mich., and the Great Lakes.

The freshwater form is distributed from western Quebec and the lower Great Lakes region of Ontario through the upper Great Lakes and, thence, in a wide arc through Manitoba, Saskatchewan, and the Northwest Territories to Great Bear Lake and Victoria Island. The range in Quebec and Ontario has been considerably extended by the work of M. J. Dadswell, who, following Van Vliet, has most successfully employed a small bottom trawl in a number of inland lakes. In many inland lakes, deepwater sculpins were known previously only from stomach contents of burbot and lake trout. The species is now known to occur in Quebec in Heney Lake, Gatineau District; in Ontario in Raven Lake, south of Abitibi; Cedar Lake, Algonquin Park; Fairbank Lake near Sudbury; in all the Great Lakes and Lake Nipigon; in Manitoba in West Hawk Lake in the southeast, and Athapapuskow, south of Flin Flon; in Saskatchewan in Reindeer, Mirond, MacKay, la Ronge, la Plonge and Wollaston lakes; in the Northwest Territories in Great Slave, La Martre, Keller, and Great Bear lakes. A freshwater form, possibly separately derived from the marine form, is known in at least three lakes in the eastern half of Victoria Island.

In Lake Ontario, the deepwater sculpin was once so abundant that it was considered to be a nuisance when caught in the gillnets set for lake trout. It now appears to have been extirpated, for not a single specimen has been seen in 10 years and even extensive experimental trawling has failed to capture it.

Biology We know next to nothing about the breeding biology of the deepwater sculpin because of the considerable depths it inhabits, but available evidence indicates that spawning occurs in summer, or early fall. Some evidence suggests year-round spawning, at least in the Great Lakes.

Spawning probably took place in late August or early September in Lake Ontario, for Dymond et al. (1929) recorded large masses of nearly ripe eggs in specimens caught August 12, 1927. Females containing large eggs have also been caught in July in Great Bear Lake and in Keller Lake, N.W.T. The care afforded eggs and young by related cottids suggests that parental care is practised by the deepwater sculpin also. McPhail and Lindsey remarked on the presence of a large clump of eggs in the mouth of one of the Lake Ontario specimens caught July 18, 1927, and queried if this was accidental or if it implied parental care. The second dorsal fin of males is much enlarged but its function, although probably related to breeding, is unknown. This fin and the pectoral bear small, hard, rough tubercles in the mature male. In Lake Erie, Fish (1932) described and illustrated specimens 12.5 and 16.2 mm long, caught from the latter part of July to mid-August, 1928, indicating earlier spawning in Lake Erie than in Lake Ontario.

Hopefully, more will be learned by studying populations in smaller, inland lakes, such as Heney Lake in the Gatineau region of Quebec. The need for great care in working in deep water with Scuba gear is emphasized by the unfortunate death of William Van Vliet in Heney Lake in 1968, while engaged in a study of this species.

Growth data is also lacking but reference has already been made to the comparatively large size formerly attained in Lake Ontario. One specimen on hand in the ROM collection measures 9.2 inches (235 mm) in total length. Deason (1939) reported two Lake Michigan specimens 4.0 and 4.3 inches (102 and 109 mm) standard length, considered to be exceptionally large. The largest specimen reported from Great Slave Lake was 2.7 inches (69 mm) standard length.

Considerable evidence on depth distribution in the Great Lakes has been gathered. On October 3, 1927, Dymond et al. (1929), using $1\frac{1}{2}$-inch gillnets, caught specimens at depths of 300–411 feet (91.4–125.3 m) and as many as 655 individuals at 370 feet (112.8 m). Exploratory surveys in Lake Michigan in 1961 by United States Fish and Wildlife Service reported deepwater sculpins ranged from 150 to 600 feet (44.7–182.9 m) but were most abundant at 240–300 feet (73.2–91.4 m). Yields as high as 130–200 pounds for 30-minute hauls of a commercial balloon trawl at these depths were recorded.

The greatest depths of capture reported for deepwater sculpins is probably 1200 feet (365.9 m), by trawl in Lake Superior (Dryer 1966). McPhail and Lindsey reported specimens removed from two lake trout netted at 1200 feet (365.9 m) in Great Bear Lake.

Information on the food of deepwater sculpins is scattered. In Lake Nipigon, *Pontoporeia affinis* and chironomid larvae were found in the stomachs of this species (Dymond 1926). Stomachs of Great Bear Lake specimens were reported to contain *Mysis*, the copepod, *Limnocalanus,* and chironomid larvae (McPhail and Lindsey 1970), and Lake Ontario specimens, caught in 1926 and 1927, on re-examination, were found to contain *P. affinis*, *Mysis relicta*, and chironomid larvae (McAllister 1961). Since *Mysis* and *Pontoporeia* are always associated with this sculpin, they might be expected to form a fairly regular part of its diet.

The deepwater sculpin is a regular prey of only the lake trout and the burbot. In Lake Ontario, Dymond (1928b) recorded as many as 27 deepwater sculpins from a single lake trout stomach, the average number per stomach being 5.4; as many as 32 were recorded from a single burbot stomach while the average for 64 stomachs was 11.2. In Lake Michigan, the deepwater sculpin was formerly a most significant item in the diet of lake trout and burbot. Deason (1939) reported a total of 1215 specimens removed from 65 collections of stomachs of these two species, and as many as 139 specimens from a single stomach collection. In a review of the lake trout of Lac la Ronge, Sask., Rawson (1961) remarked that the deepwater sculpin was one of the first fish of suitable size and in suitable location to provide food for young trout.

The acanthocephalan *Echinorhynchus salmonis* occurred in the intestine of one specimen caught in a gillnet in Lake Huron in 96 feet (29.3 m) of water, southwest of South Bay (Bangham 1955).

Relation to man The deepwater sculpin is obviously of considerable interest to those biologists concerned with Canadian problems involving postglacial dispersal and zoogeography.

There is little doubt that this small fish was an important food for lake trout before the virtual disappearance of this latter commercial species from much of the Great Lakes. Rawson (1961) considered it to be important in the diet of lake trout in certain lakes in Saskatchewan.

Nomenclature

Cottus quadricornis	— Linnaeus 1758: 264 (type locality Baltic Sea)
Triglopsis thompsonii	— Girard 1852: 65, 66, 67, 71
	— Evermann and Kendall 1901: 488
Triglopsis Stimpsonii	— Hoy 1873: 319
Triglopsis thompsoni	— Nash 1908: 103
	— Halkett 1913: 32
	— Hubbs 1926: 74
	— Radforth 1944: 86
	— Scott 1954: 113
Triglopsis ontariensis	— Jordan and Thompson 1910a: 75
Myoxocephalus quadricornis	— Jacoby 1953: 1
Myoxocephalus thompsoni	— Walters 1955: 318
Myoxocephalus quadricornis thompsonii (Girard)	— Hubbs and Lagler 1958: 118
Myoxocephalus thompsonii	— McAllister 1961: 44
	— Delisle and Van Vliet 1968: 2733

(*see* McAllister 1961 for more detailed synonymy)

Etymology *Myoxocephalus* — head like a dormouse; *quadricornis* — four horned.

Common names Deepwater sculpin, fourhorn sculpin, scorpion fish, sculpin, lake sculpin, deep-water blob, Great Lakes fourhorn sculpin. French common name: *chabot de profondeur*.

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GLOSSARY

GLOSSARY

Abdomen — the lower surface of the body, especially the part between the pectoral fins and the anus.

Abdominal pelvic fins — said of pelvic fins when located on abdomen, far removed from head.

Accessory caudal rays — short rays on the upper and lower anterior portions of the caudal fin.

Accessory pectoral scale — an enlarged or elongated scale at dorsal base of pectoral fin in some herringlike fishes.

Adipose eyelid — transparent tissue around margin of eye.

Adipose fin — a fleshy fin on the back behind the dorsal fin, as in trouts, salmons, whitefishes, smelts, and catfishes.

Alevin — newly hatched, incompletely developed fishes (usually salmonids) still in nest or inactive on bottom, living off stored yolk.

Allopatric — living in geographically separated places *(cf. sympatric).*

Ammocoete — a name applied to the larval form of lampreys.

Amphicoelous — concave both before and behind, the usual condition of fish vertebrae.

Amphipods — crustaceans belonging to the group that includes freshwater shrimps.

Anadromous — ascending rivers from the sea to spawn, as do shad and some salmonid fishes.

Anal — referring to the anus or vent.

Anal fin — the fin on the median ventral line behind the anus.

Anal papilla —an appendage or protuberance in front of the genital pore and behind the vent in sculpins (*cf. genital papilla*).

Annulus (plural *annuli*) — a mark or marks formed on a fish scale or bone each year.

Anterior — the front portion; in front.

Antrorse — turned forward (of maxillary).

Anus — the posterior external opening of the alimentary canal: the vent.

Articulated — attached by means of a movable joint: jointed.

Asymmetrical — not symmetrical: one side not the mirror image of the other, as in the head of a flatfish or flounder.

Axillary process — a daggerlike projection at the base of the pectoral or pelvic fins.

Barb — hooklike serration, as on pectoral and dorsal fin spine of carp and catfishes.

Barbel — an elongated, hairlike projection, usually about the mouth, chin, or nose, as in the cods and sturgeons.

Basal — (of fins) skeletal support of fin ray(s).

Basibranchials (or *hyoid*) — the three median bones on the floor of the gill chamber, joined by the ventral ends of the five gill arches.

Basihyal — the median bone which joins the basibranchials posteriorly and which forms the "tongue" anteriorly, in the floor of the mouth.

Benthic — living on or near to the bottom (*cf. pelagic*).

Bifid — see bifurcate.

Bifurcate — divided into two branches.

Branchial — of the gills.

Branchiostegal rays — bony rays supporting the membranes which close the branchial or gill cavity under the head.

Breast — *see pectoral.*
Buccal — of the mouth.

Caecum (plural *caeca*) — a blind sac connected with the alimentary canal.
Canines — conical teeth which are larger than the rest.
Cardiform — brushlike, said of fine teeth of uniform length in brushlike bands or patches.
Cardiod scales — notched, specialized scales, *see* p. 347.
Carinate — keeled: having a sharp median ridge as on the belly of certain herring-like fishes.
Catadromous — going down rivers to the sea to spawn as does the American eel.
Caudal — pertaining to the tail or caudal fin.
Caudal peduncle — the fleshy end of the body behind the anal fin and before the caudal or tail fin: the tail minus the tail fin: the "wrist."
Centrum — the body of a vertebra.
Ceratohyal — anterior bone to which the bases of the branchiostegal rays are attached.
Chin — anterior ventral portion of the lower jaw.
Chironomids — true flies belonging to the midge family.
Chondrocranium — the cartilagineous brain case in fishes around which covering bones are laid down in higher (bony) fishes.
Cladocera — a group of small crustaceans called water fleas, which includes *Daphnia.*
Cline (adjective *clinal*) — progressive change or gradient in structure or feature of animals that follows a geographic gradient such as latitude or altitude (e.g. increase in number of fin rays in a species northwards).
Cloaca — a chamber in the lower part of the gut into which empty the ducts from the kidney and reproductive organs. It has one external opening, cloacal aperture, instead of separate anal (vent) and urinogenital openings.
Compressed — laterally: flattened from side to side.
Copepoda (or *copepods*) — a group of small crustaceans which includes *Cyclops* and *Argulus.*
Crenate — with a scalloped or notched margin (as on opercular flap at edge of gill cover of sunfishes).
Crustaceans — members of the large class, Crustacea, of the phylum Arthropoda (all of which have a hard jointed external skeleton), including shrimps, crayfish, and water fleas.
Ctenoid — said of scales of most spiny-rayed fishes having posterior margin of scale with needle-like projections.
Cusp — a point or projection on a tooth.
Cycloid — said of the scales (having smooth margins) of typical soft-rayed fishes.

Deciduous — said of scales that are easily rubbed off and thus not firmly attached.
Decurved — bent downwards.
Dentary — a bony element of the lower jaw usually bearing teeth.
Dentate — with toothlike notches.
Denticulated — having fine toothlike projections.
Dentition — said of teeth, their arrangement and structure.
Depressed — flattened from above downwards, i.e. dorsoventrally, as in head of cottids.

Depth — the vertical diameter or distance through, as of the body of fishes.
Dimorphism — existing in two forms.
Distal — farthest from the centre; peripheral.
Dorsal — pertaining to the back.
Dorsal fin — a fin on the back, usually central in position supported by rays or spines.

Emarginate — said of caudal fin having a slight notch or indentation.
Epihyal — posterior bone to which the bases of the branchiostegal rays are attached.
Estuarine — said of fishes that occupy estuaries.
Euryhaline — able to tolerate a wide range of osmotic pressures in the environment; a fish that can move freely from a saltwater to a freshwater environment.
Eye diameter — the horizontal diameter of the eye ball — in contrast to iris diameter, which is the distance across the black aperture in the centre of the eye, or orbit diameter, which is the horizontal distance between anterior and posterior margins of the socket.

Falcate — scythe-shaped.
Falciform — *see falcate.*
Fauna — the assemblage of animals inhabiting a region.
Filament — slender or threadlike, said of certain elongated fin rays in some fishes.
Filamentous — *see filament.*
Fimbriate — having a frilled edge.
Fingerling — young fish, usually late in first year.
Fork length — distance from the anteriormost margin of head to tip of middle ray of the caudal fin.
Frenum — fold of skin that limits the movements of an organ, e.g. membrane across snout of some darters.
Frontal spines — those on the head between the posterior margins of the eyes.
Fry — young fish, newly hatched, after yolk has been used up and active feeding commenced.
Fulcrum (plural *fulcra*) — spinelike structures bordering the anterior rays of the fins in some fishes.
Fusiform — spindle-shaped; referring to the form of fishes that have the body tapering both anteriorly and posteriorly, and slightly or not at all compressed.

Gape — (of the mouth), the distance from the front to the angle of the mouth, crude index of size of mouth, habit of spawning fishes of opening mouth very widely.
Gastropoda — a class of the phylum Mollusca, including snails, that usually have coiled shells.
Genital papilla — a projection near the anus that carries the external opening to the reproductive system (*cf. anal papilla*).
Genotypic — refers to hereditary characteristics (*cf. phenotypic*).
Gill arches — the bony supports of the gills.
Gill cover — the bony covering of the gill cavity, composed of opercular bones (*see operculum*).
Gill membrane — the thin wall of skin supported by the branchiostegals, and closing the gill cavity below.
Gill rakers — a series of bony projections along the anterior edge of the gill arch. Gill-raker counts are usually made on the left anterior arch. Every raker is counted, including the

bony rudiments at the ends of the series that may be difficult to see except under magnification.

Graduated — regular or steady increase in length, as of the spines in the fins of some fishes.

Gular plate — bony plate or plates located behind the chin and between the sides of the lower jaw.

Haemal spine — the lower or ventral spine of a caudal vertebra.

Head length — distance from the most anterior point of the head to the posterior edge of the opercle.

Hemibranch — a rudimentary gill on the inner face of the operculum.

Hermaphrodite — having both male and female reproductive organs in one body.

Heterocercal — unequally lobed; said of the tail or caudal fin of a fish where the upper lobe is larger than the lower, and in which the last few vertebrae of the vertebral column are bent upward.

Homocercal — equally lobed; said of the tail or caudal fin when upper and lower lobes are more or less equal, and the backbone or vertebral column ends at the middle of the base of the fin.

Hyoid — *see basibranchial.*

Hypurals — the expanded haemal spines of the posterior vertebrae, which support the rays of the caudal fin.

Ichthyology — the scientific study of fishes.

Imbricated — overlapping, like shingles on a roof.

Immaculate — without spots or pigment pattern, usually white or colourless.

Inferior — used in reference to mouth when snout projects beyond lower jaw.

Infraoral — below the mouth; used in reference to the teeth immediately below the oesophageal opening in lampreys.

Insertion — (of a fin) the posterior end of the base, the part of the base farthest from the head.

Interneurals — the bones to which the dorsal fin rays are attached.

Interopercle — a bone of the lower part of side of the head; a part of the operculum.

Interorbital space — narrowest distance across the head, between the bony edges of the orbits or eye sockets.

Isocercal — with the vertebrae becoming progressively smaller backward, as in the codfishes.

Isospondylous — with the anterior vertebrae simple; said of the herringlike fishes which lack the Weberian apparatus.

Isthmus — the fleshy space beneath the head and between the gill openings.

Jugular — pertaining to the throat; said of the pelvic fins when located in advance of the point of attachment of the pectorals.

Keel — a sharp compressed edge on the ventral surface between the paired fins, or the lateral surface of the caudal peduncle.

Keeled — *see carinate.*

Kelt — a dark, thin, recently spawned-out (or spent) Atlantic salmon or trout.

Larva (plural *larvae*) — the young of an animal when differing markedly from the adult.
Lateral line — series of porelike openings (to sensory canal) along the sides of a fish.
Laterally compressed — flattened from side to side.
Lateral teeth or *tooth plates* — in lampreys, those tooth plates lying on either side of the opening to the pharynx.
Leptocephalus — a name applied to the larval form of the eels.
Lingual — pertaining to the tongue.
Lingual teeth — teeth on tongue: the serrated teeth on the tongue of lampreys.
Littoral — inhabiting the bottom of a lake near shore.
Lunate — crescentlike, in reference to shape of caudal or tail fin.

Major rays (or *principal rays*) — longer (at least $\frac{3}{4}$ height of fin) obvious fin rays as opposed to anterior rudiments often not visible (*see* p. 24); often comprise all branched rays plus one anterior unbranched ray.
Mandible — the lower jaw.
Mandibular (or *submandibular*) *pore* — small sensory opening in the undersurface of the bones of the lower jaw.
Maxillary — the posterior and lateral element of the upper jaw.
Median — lying in the midline that divides an animal into right and left halves.
Melanophore — black pigment cell.
Metamorphosis — period of transformation from larval to adult form.
Molar — with a flattened, grinding surface; said of teeth.
Mouth — (inferior) — mouth below snout, snout obviously overhanging mouth;
(oblique) — line of the mouth (when closed) at an angle of 45° or greater;
(subterminal) — mouth slightly overhung by snout, not quite terminal;
(terminal) — tips of upper and lower jaw forming foremost part of the head;
(ventral) — mouth on ventral surface of head, as in sturgeons.
Myomere — *see myotome.*
Myotome — a muscle plate, a section of the repeated muscle units corresponding to the flakes of a cooked fish.

Nape — part of body immediately behind head on dorsal surface.
Nasal — one of the paired bones on front of a fish's head, usually beside the nostril.
Neural spine — the upper or dorsal spine of a vertebra.
Notochord — the embryonic cartilagineous vertebral column persistent in lampreys, sharks, and rays.
Nuptial tubercles — small, often pimple-like projections that occur on head or body or lower fins of males of some species (e.g. rainbow smelt) during breeding period.

Obsolete — only faintly apparent, or absent.
Occiput — the extreme back of the head on dorsal surface.
Ocellus — an eyelike spot.
Oesophagus — the beginning of the digestive tract immediately after the mouth.
Opercle — the large rectangular bone of the gill cover.
Opercular flap — a backward prolongation of the posterior angle of the opercle.
Opercular gill — a rudimentary gill on the inner face of the operculum as in gars and sturgeons (= *hemibranch*).

Operculum (also called *gill cover*) — the bony covering of the gill cavity composed of opercular bones, i.e. preopercle, interopercle, subopercle, opercle.

Opisthocoelous — convex in front, concave behind, the condition in the vertebrae of gars alone.

Orbit — the bony eye socket.

Origin — (of a fin) the anterior end of the base; the end of base nearest the head.

Ostracoda — a group of invertebrate animals enclosed in bivalve shells; includes *Cypris.*

Oviparous — said of fishes that lay eggs that develop usually in the external environment.

Ovoviviparous — said of those animals that retain the eggs within the body of the female in a brood chamber where development of the embryo takes place, the eggs perhaps deriving some nourishment from the female, but without the strong umbilical attachment to a placenta as in mammals; the true condition of so-called "live-bearing" fishes.

Paired fins — pectoral and pelvic fins, in contrast to vertical fins.

Palatines — paired bones on roof of mouth.

Papilla (plural *papillae*) — a small fleshy projection or ridge.

Papillose (or *papilate*) — covered with papillae.

Parietal — one of the roofing bones of the skull.

Parr — life stage of salmonid fishes, usually in first or second year, body marked with parr marks.

Parr marks — dark vertical marks on the sides of young salmonid fishes.

Pectinate — having teeth like a comb.

Pectoral — the anterior ventral portion of a fish; the breast.

Pectoral arch — shoulder girdle; the complex of bones usually connected with the skull, to which the pectoral fins are attached.

Pectoral fins — the most anterior or uppermost of the paired fins, usually dorsal to pelvic fins.

Pectoral girdle — *see pectoral arch.*

Peduncle — the fleshy end of the body behind anal fin (*see caudal peduncle*).

Pelagic — living in open waters, in contrast to bottom-living or inshore species.

Pelvic arch (or *girdle*) — the bones to which the pelvic fins are attached; pubic bones.

Pelvic axillary process (*scale*) — a slender scale-like process or tab of tissue that develops at the base of the pelvic fins of many salmonid and other bony fishes.

Pelvic fin — ventral, paired fin lying below the pectoral fin or between it and the anal fin.

Percomorph — used in reference to those fishes in the order Percomorphi.

Peritoneum — the membranous inner lining of the abdominal cavity.

Pharyngeal teeth — bony toothlike projections from the fifth or pharyngeal gill arch. In Cyprinidae they consist of a vertical arc of bone with the teeth projecting at right angles toward the midline. Teeth are easily broken off while the arch is being removed; tooth counts should be made under magnification, and empty sockets or broken tooth bases included in the counts.

Pharynx (adjective *Pharyngeal*) — the first portion of the digestive tract behind the mouth.

Phenotypic — characteristics that result from modification of the individual by the environment (*cf. genotypic*).

Physoclistous — having the swim bladder isolated from the oesophagus.

Physostomous — having the swim bladder connected to the oesophagus by an open duct.

Piscivorous — fish-eating.

Plankton — small aquatic plants and animals, sometimes microscopic.

Plate — hard, bony shield in various places on body, usually larger than scales, found especially in sturgeons and sticklebacks.

Plicate — with wrinkle-like folds.

Posterior — behind.

Prefrontal — a roofing bone of the skull.

Premaxillary — the paired bones usually bearing teeth that form the front of the upper jaw in troutlike fishes, and the entire lower border of the upper jaw in higher percomorph fishes.

Preopercle — the most anterior of the opercular series, the bone of the cheek.

Preorbital — a large bone lying in front of the eye.

Prickles — small, fine, sometimes curved spines, on, or in place of, scales.

Principal rays — longer (at least $\frac{3}{4}$ height of fin) obvious fin rays as opposed to anterior rudiments often not visible (*see* p. 24); often comprise all branched rays plus one anterior unbranched ray.

Procurrent — name applied to the stiff rays at base of caudal fin.

Protractile — a term used in reference to the premaxillaries when they can be extended forward; such premaxillaries are separated from the sloping front of the head (forehead) by a groove.

Proximal — nearest the point of attachment.

Pyloric — used in reference to pylorus; that section of the intestinal tract immediately following the stomach.

Pyloric caeca — fingerlike extensions attached to the pylorus.

Ray — an articulated or jointed rod that supports the membrane of a fin.

Redd — the gravel nest of salmonid fishes.

Retrorse — turned backward (of maxillary).

Rhombic (or *rhomboid*) *scale* — the type of heavy, bony, diamond-shaped, nonoverlapping scales found in gars.

Rudimentary — undeveloped or poorly developed.

Scale radius — line radiating from the focus of a scale. The angle subtended by the outer two is used to distinguish between species.

Scute — a bony or horny plate.

Serrate — saw-toothed; like a saw.

Shoulder girdle — the complex of bones usually connected with the skull, to which the pectoral fins are attached (*see pectoral girdle*).

Smolt — life stage in salmonid fishes, individual usually 1–3 years of age, turning silvery, preparing to migrate out of stream or lake to sea, or out of stream to large lake.

Snout — technically that part of the head of a fish in front of the eyes.

Snout length — distance from the most anterior point of the head or upper jaw, to the front margin of the eye socket.

Soft dorsal — the dorsal fin or portion of it that consists of soft rays only (*cf. spinous dorsal*).

Spine — fin rays that are not branched, are without obvious segments, and are more or less stiffened and sharpened at the apex; or similar straight or curved, sharp structures on other parts of the body (operculum, cheek).

Spinous dorsal — the dorsal fin or portion of it which consists of spines only.

Standard length — distance from the most anterior part of the head to the posterior margin of the last whole vertebral centrum.

Stay (or *membranous connection*) — a fleshy bridge from side of body to upper base of pelvic fin.

Stenohaline — unable to tolerate a wide range of osmotic pressures in the environment; i.e. cannot move freely from salt to fresh water.

Striations — grooves or streaks.

Subequal — nearly but not quite equal.

Subopercle — the bone below the opercle (*see operculum*).

Suborbitals — a series of small bones below the eye.

Subspecies — a group of local populations of a species, inhabiting a geographic subdivision of the range of the species, and differing taxonomically from other populations of the species.

Supplemental maxillary — a small bone lying on the upper posterior edge of the maxillary.

Supraoccipital — the unpaired bone at the back of the skull usually with a crest above.

Supraoccipital crest — the posterior median ridge on the back of the skull.

Supraoral — above the mouth.

Swim bladder (also called *gas bladder, air bladder*) — gas-filled sac in dorsal portion of body cavity of most fishes which aids in buoyancy, and in respiration in some.

Sympatric — living in overlapping ranges and not denied the opportunity to interbreed by any geographic barrier (*cf. allopatric*).

Symphysis — the point of junction of two bones as in the two parts of the lower jaw in front; the tip of the chin.

Synonym — an additional scientific name for the same animal. When the same species is described by two different writers and given different names, one of these will be retained and used, the other one is called a synonym. A list of disused names is called the synonymy of a species.

Teleost — a name applied to fishes having the skeleton fully ossified, in other words a "bony fish" in contrast to a shark which is a cartilagineous fish.

Terete — cylindrical and tapering.

Terminal — at the end (*see mouth*).

Thoracic — pertaining to the chest or thorax; anterior to the abdomen.

Thoracic pelvic fins — pelvic fins which are attached far forward below the pectorals; the pelvic bones usually connected with the shoulder girdle.

Tooth formula — numerical expression of the number of teeth, usually pharyngeal, in each of one or more rows.

Truncate — cut squarely off.

Tubercle — a soft or hardened lump or projection on the surface; usually a modified scale (*see nuptial tubercle*).

Tuberculate — covered with tubercles.

Type — term used in systematics referring to the first-named species in a genus ("type species"), or to the individual specimen on which a taxonomic description is based ("type specimen").

Unicuspid — with a single point or cusp.
Urostyle — the last vertebral segment usually modified (pointed) and reduced.

Velar tentacle — a membranous fingerlike projection that, in lampreys, lies at the junction of the respiratory tube and oesophagus.
Vent — the external opening of the alimentary canal; the anus.
Ventral — on the lower surface; pertaining to the abdomen or belly.
Ventral fins — *see pelvic fins.*
Vermiculations — markings resembling worm tracks.
Vertebra (plural *vertebrae*) — a single bone of the spinal column.
Vertical fins — the fins (dorsal, anal, and caudal) on the median (centre) line of the body, in contrast to the paired fins (pectorals and pelvics).
Villiform — in the form of villi (fingerlike projections); said of teeth that are slender and crowded closely together in bands.
Vomer — the anterior bone on the roof of the mouth.

Weberian apparatus — the modified first four or five vertebrae in minnows, suckers, carps, catfishes, and their relatives (Ostariophysi), that connect the swim bladder to the inner ear by a series of small bones or ossicles.

INFORMATION ON SPECIMENS USED FOR SPECIES ILLUSTRATIONS

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(Line drawings and photographs)

Pattern and shape of fishes often vary with sex, size, location, and time of year. Usually a single individual, thought by the authors to be characteristic, was used as a basis for both body proportions and pattern in the illustrations. For that reason, information, when available, on sex, total length, locality of capture, date of capture, and catalogue number of the specimen used for the line drawing or photograph is given here. ROM = collection of the Royal Ontario Museum; BC = collection of the Institute of Animal Resource Ecology, University of British Columbia.

41 *Ichthyomyzon castaneus* — Photograph — 380 mm; Manitoba, Red River; Apr. 1957; ROM 19839.

41 *Ichthyomyzon fossor* — Photograph — 150 mm; Ontario, Norfolk Co., Big Creek; June 15, 1955; ROM 17610.

41 *Ichthyomyzon unicuspis* — Photograph — 328 mm; Ontario, Halton Co., Bronte Creek; 1954; ROM 17666.

41 *Lampetra ayresi* — Photograph — British Columbia, Malaspina Strait, Sechelt area; June 21, 1958; BC58-310.

41 *Lampetra lamottei* — Photograph — 187 mm; Ontario, York Co., Highland Creek; Apr. 24, 1957; ROM 19047.

41 *Lampetra richardsoni* — Photograph — 154 mm; British Columbia, Cultus Lake; May 24, 1954; ROM 18557.

42 *Entosphenus tridentatus* — Line drawing borrowed from FRB Bull. 173. Photograph, p. 41 — British Columbia, Port John; 1957; BC57-403.

58 *Lampetra japonica* — Line drawing borrowed from FRB Bull. 173. Photograph, p. 41 — 220 mm; Northwest Territories, Peel River; Oct. 20, 1951; ROM 15143.

69 *Petromyzon marinus* — Line drawing by E. B. S. Logier, no data. Photograph, p. 41 — Ontario, Lake Erie; Dec. 12, 1936; ROM 9603.

80 *Acipenser brevirostrum* — 665 mm; New Brunswick, King's Co., public landing; July 1967; ROM 26419.

82 *Acipenser fulvescens* — 760 mm; Ontario, Leeds Co., St. Lawrence River; May 19–20, 1968; ROM 25887.

90 *Acipenser medirostris* — Borrowed from FRB Bull. 180.

92 *Acipenser oxyrhynchus* — Borrowed from FRB Bull. 155.

96 *Acipenser transmontanus* — Borrowed from FRB Bull. 180.

103 *Lepisosteus oculatus* — Female; 661 mm; Ontario, Kent Co., Lake Erie; Apr. 23, 1955; ROM 17607.

105 *Lepisosteus osseus* — Male; 925 mm; Ontario, Simcoe Co., Georgian Bay; June 3–4, 1967; ROM 25425.

112 *Amia calva* — Female; 470 mm; Ontario, Essex Co., Point Pelee National Park; Aug. 20, 1958; ROM 19960.

120 *Alosa pseudoharengus* — Female; 328 mm; New Brunswick, Charlotte Co., Moores Mill Lake; June 2, 1958; ROM 19680.

128 *Alosa sapidissima* — Male; 528 mm; Ontario, Prescott Co., Ottawa River; Aug. 13, 1936; ROM 10109.

133 *Dorosoma cepedianum* — Male; 325 mm; Ontario, York Co., Lake Ontario; Apr. 20, 1967; ROM 25389.

148 *Oncorhynchus gorbuscha* — Borrowed from FRB Bull. 173.

153 *Oncorhynchus keta* — Borrowed from FRB Bull. 173.

158 *Oncorhynchus kisutch* — Borrowed from FRB Bull. 173.

165 *Oncorhynchus nerka* — Line drawings borrowed from FRB Bull. 173. Upper photo, kokanee — about 508 mm; British Columbia, Kootenay Lake (Courtesy B.C. Game Branch). Lower photo, kokanee — Male; 257 mm; Ontario, Hastings Co., Boulter Lake; ROM 27630. Introduced, stock from Kootenay Lake. (Courtesy Bruce Fallis)

172 *Oncorhynchus tshawytscha* — Borrowed from FRB Bull. 173.

177 *Salmo clarki* — Male; 302 mm; British Columbia, Comox Dist., Anderson Lake; Sept. 1926; ROM 3437.

184 *Salmo gairdneri* — Rainbow trout — Male; 22 pounds; British Columbia, Duncan River. Steelhead trout — Male; 9 pounds; British Columbia, Vancouver Island, Big Qualicum River. Photos by F. T. Pletcher.

192 *Salmo salar* — Borrowed from FRB Bull. 155.

197 *Salmo trutta* — Male; 472 mm; Ontario, Leeds Co., Jones Creek; Apr. 6, 1966; ROM 24051.

201 *Salvelinus alpinus* — Male; 400 mm; Northwest Territories, Tree River Area; Colour pattern taken from film strip.

208 *Salvelinus fontinalis* — Male; 295 mm; Ontario, Ontario Co., Claremont Conservation Area; November 1969.

214 *Salvelinus malma* — Borrowed from FRB Bull. 173.

220 *Salvelinus namaycush* — 625 mm; Ontario.

236 *Coregonus artedii* — Drawing by E. B. S. Logier, no data.

244 *Coregonus autumnalis* — Borrowed from FRB Bull. 173.

255 *Coregonus laurettae* — Borrowed from FRB Bull. 173.

262 *Coregonus sardinella* — Borrowed from FRB Bull. 173.

269 *Coregonus clupeaformis* — Female; 364 mm; Quebec, Koksoak River; July 9–17, 1957; ROM 18921.

278 *Coregonus nasus* — Borrowed from FRB Bull. 173.

281 *Coregonus canadensis* — Male; 328 mm; Nova Scotia, Tusket River Falls; Oct. 27, 1954; ROM 16675.

282 *Prosopium coulteri* — Borrowed from FRB Bull. 173.

286 *Prosopium cylindraceum* — Adult — From FRB Bull. 173; Young — Ontario, Lake Nipigon.

291 *Prosopium williamsoni* — Drawing by E. B. S. Logier, no data.

295 *Stenodus leucichthys* — Borrowed from FRB Bull. 173.

300 *Thymallus arcticus* — Drawing by E. B. S. Logier, no data.

308 *Hypomesus olidus* — Borrowed from FRB Bull. 173.

310 *Osmerus mordax* — Drawing by E. B. S. Logier, no data.

318 *Spirinchus thaleichthys* — Borrowed from FRB Bull. 180.

320 *Thaleichthys pacificus* — Borrowed from FRB Bull. 180.

327 *Hiodon alosoides* — 242 mm; Northwest Territories, Great Slave Lake; 1944; ROM 13621.

333 *Hiodon tergisus* — 320 mm; Ontario, Norfolk Co., Lake Erie; Oct. 26, 1961; ROM 21638.

338 *Dallia pectoralis* — Male; 157 mm; Alaska, Koskokwim River; June 1956; ROM 18500.

341 *Umbra limi* — Female; 90 mm; Ontario, Peterborough Co., Connelly's Lake; Sept. 17, 1958; ROM 19830.

348 *Esox a. americanus* — Male; 190 mm; Quebec, Godfroy River.

352 *Esox a. vermiculatus* — Male; 219 mm; Ontario, Leeds Co., Jones Creek.

356 *Esox lucius* — Composite; 430 mm; 554 mm; Purchased; ROM 25777.

363 *Esox masquinongy* — Male; 663 mm; Ontario, Kenora Dist., Hogans' Pond; July 9, 1965; ROM 23575.

370 *Esox niger* — Female; 409 mm; Quebec, Lake Champlain; Apr. 8, 1967; ROM 25395.

386 *Acrocheilus alutaceus* — Male; 663 mm; British Columbia, Missizoula Lake; July 24–25, 1959; BC 60-221.

389 *Carassius auratus* — Composite; Ontario; ROM 15008 and 25405.

392 *Chrosomus eos* — 58.5 mm; Ontario, Timiskaming Dist., Jordan Lake; July 10, 1958; ROM 20030.

396 *Chrosomus neogaeus* — 65 mm; Ontario, Thunder Bay Dist., Pickerel Lake; July 20, 1964; ROM 23029.

399 *Clinostomus elongatus* — Female; 96 mm; Ontario, Lincoln Co., Twelve Mile Creek; Summer 1958; ROM 24663.

401 *Couesius plumbeus* — Female; 129 mm; Ontario, York Co., Mimico Creek; Apr. 6, 1951; ROM 14692.

407 *Cyprinus carpio* — Male; 245 mm; Ontario, York Co., Holland River; Summer 1965; ROM 24447.

412 *Exoglossum maxillingua* — Female; 84 mm; Ontario, Leeds Co., St. Lawrence River; Sept. 30, 1936; ROM 9213.

414 *Hybognathus hankinsoni* — 65 mm; Ontario, Grand River; June–July 1966; ROM 25228.

417 *Hybognathus nuchalis* — 123 mm; Ontario, Leeds Co.; June 13, 1967; ROM 25494.

420 *Hybopsis storeriana* — Female; 182 mm; Ontario, Norfolk Co., Lake Erie; June 13, 1946; ROM 18342.

423 *Hybopsis x-punctata* — 71 mm; Ontario, Thames River; Aug. 1958; ROM 20018.

424 *Mylocheilus caurinus* — Male; 238 mm; British Columbia, Thompson River; May 28, 1954; BC 54-78.

427 *Nocomis biguttatus* — Male; 119 mm; Ontario, Perth Co., Nith River; June 21–23, 1966; ROM 25088. Head, ROM 9214.

431 *Nocomis micropogon* — Male; 123 mm; Ontario, York Co., Humber River; Apr. 11, 1926; ROM N2454. Head, ROM 13263.

434 *Notemigonus crysoleucas* — Female; 95 mm; Ontario, Nipissing Dist., Costello Lake; June 3, 1937; ROM 19046.

438 *Notropis anogenus* — 40 mm; Ontario, Norfolk Co., Point Pelee National Park; ROM 14055.

440 *Notropis atherinoides* — 85 mm; Ontario, Manitoulin Island, Georgian Bay; May 13, 1968; ROM 25822.

444 *Notropis bifrenatus* — Female; 53 mm; New York, Thompkins Co., Fall Creek; Apr. 25–26, 1941; ROM 21671.

446 *Notropis blennius* — Female; 86 mm; Alberta, South Saskatchewan River; July 13, 1964; ROM 25923.

448 *Notropis cornutus* — Female; 134 mm; Ontario, Waterloo Co., Conestogo River; June 20, 1966; ROM 25175.

453 *Notropis emiliae* — 50 mm; Ontario, Thames River; Oct. 1968; ROM 26480.

454 *Notropis heterodon* — 53 mm; Ontario, Manitoulin Island, Wicket Lake; July 8, 1967; ROM 25868.

456 *Notropis heterolepis* — 65 mm; Ontario, Kenora Dist., Lake of the Woods; Summer 1963; ROM 23359.

459 *Notropis hudsonius* — Female; 98 mm; Ontario, Manitoulin Island, Georgian Bay; May 13, 1968; ROM 25820.

463 *Notropis rubellus* — 78 mm; Ontario, Haldimand Co., Grand River; June–July 1966; ROM 25205.