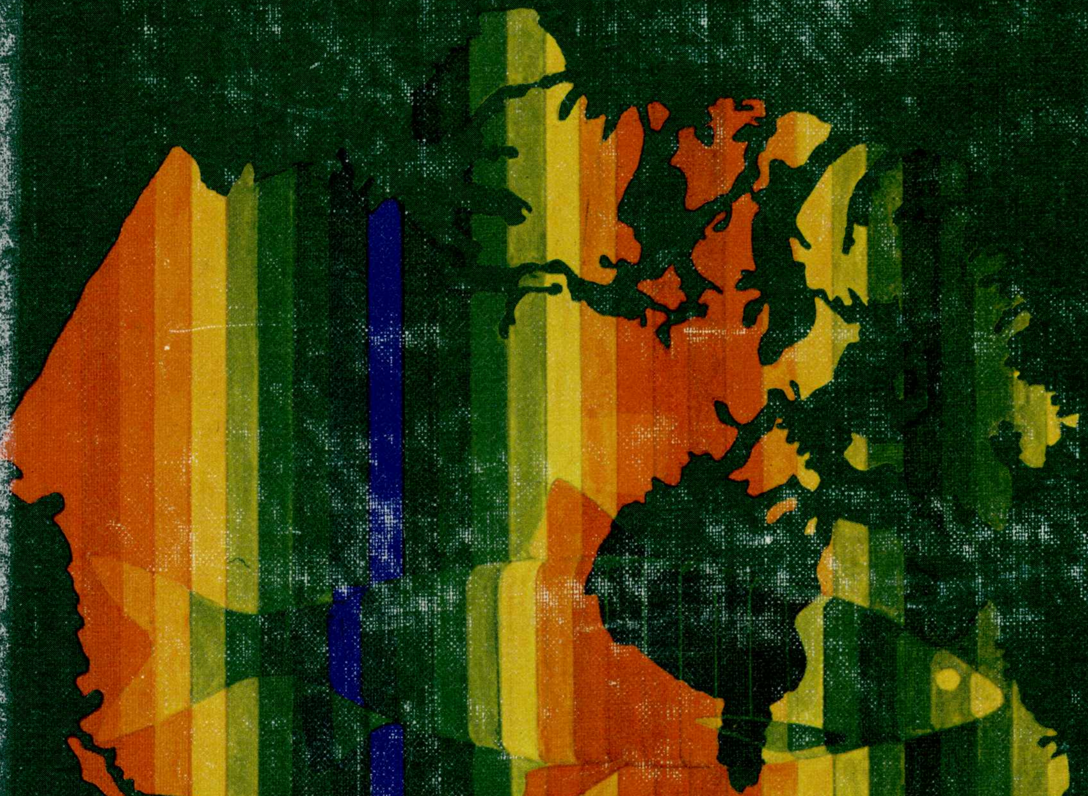
W. B. Scott * E. J. Crossman

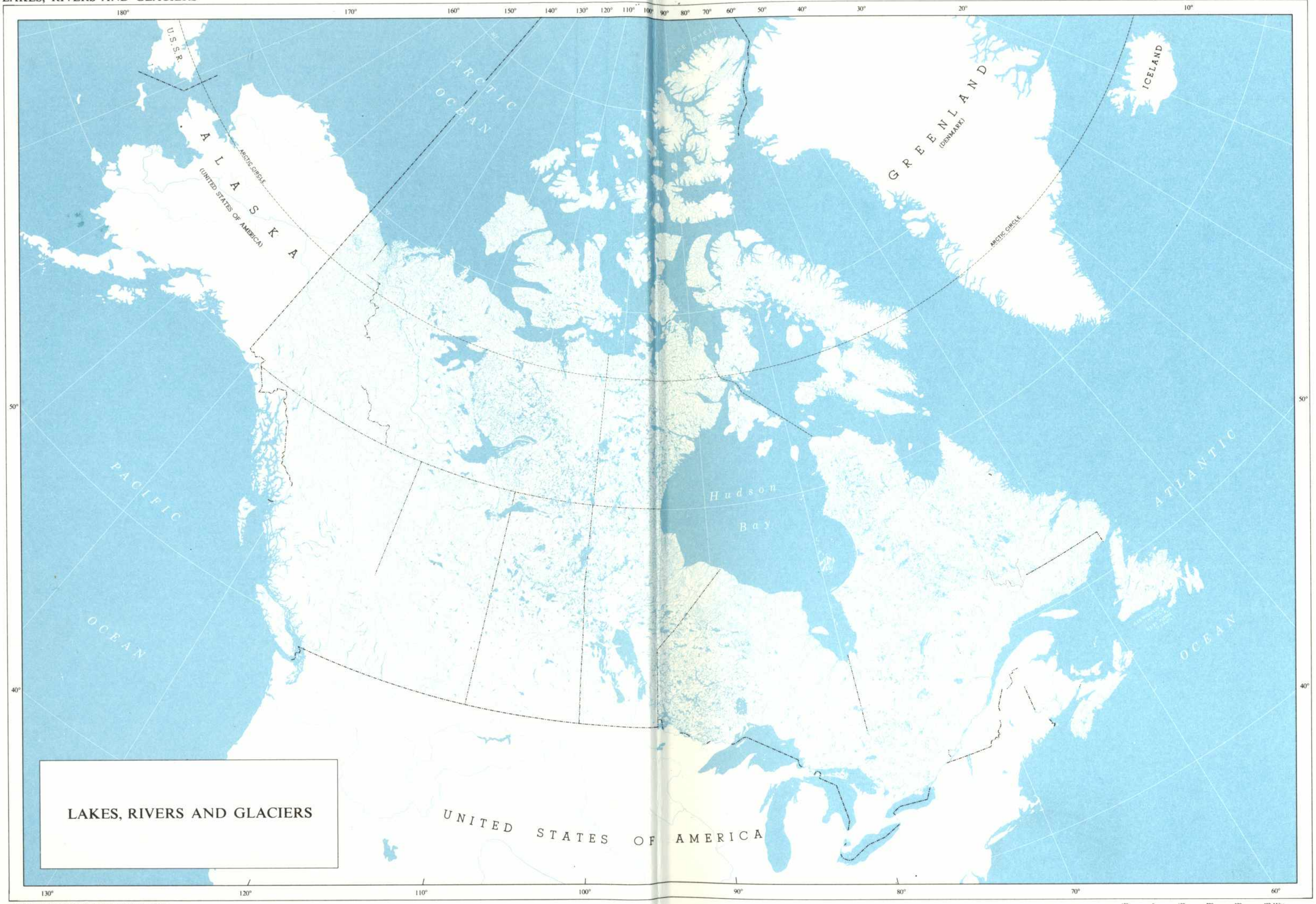
FRESHWATER FISHES OF CANADA



Bulletin 184

Fisheries Research Board of Canada, Ottawa 1973

LAKES, RIVERS AND GLACIERS



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Scale 1:15,000,000 or One Inch to 236.73 Miles

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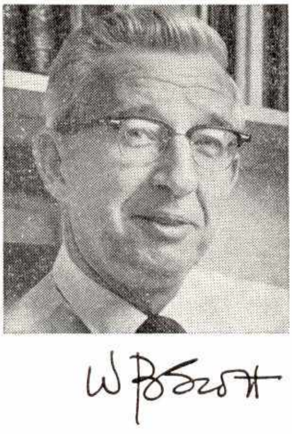
FRESHWATER
FISHES OF
CANADA

ABOUT THE BOOK . . .

For many years there has been an acute need for a publication on the identification, distribution, biology, and economic importance of the freshwater fishes of Canada. This book provides facts and figures on all species occurring in Canadian fresh waters. The descriptions are based on examinations of specimens carried out expressly for the preparation of this book. For many species the maps will be the first graphic presentation of their Canadian range, and the world distribution is given if the natural range extends beyond Canadian boundaries. Most of the drawings were prepared especially for this book, using typical examples of each species for reference. The artists have been unusually successful in achieving a high degree of accuracy and realism. The keys to the identity of the various fishes were prepared specifically for Canadian fishes and have been tested for more than three years. They include more than one character in each choice in an attempt to separate all of the fishes occurring over the whole of such a large country. Over 1400 references and special Suggested Reading sections cover most of the literature on Canadian freshwater fishes.

THE AUTHORS . . .



W. B. Scott was born in Toronto, Ontario, and received his Doctor of Philosophy degree from the University of Toronto in 1950 for his studies on Lake Erie fishes. He has conducted research on freshwater fishes in many parts of Canada from the Great Lakes to Hudson Bay and from Newfoundland to the Barren Grounds of the Northwest Territories. His studies on marine fishes have been carried out in many parts of the Atlantic Ocean from the Grand Banks to the Caribbean. He has written numerous scientific papers and books including *Freshwater Fishes of Eastern Canada*, now in its third edition. He is a member of the Canadian Society of Zoologists, the American Society of Ichthyologists and Herpetologists and the American Fisheries Society. He is also a Fellow of the American Institute of Fishery Research Biologists and a Director of the Ontario Council of Commercial Fisheries. He joined the permanent staff of the Royal Ontario Museum in 1947 where he is Curator in charge of the Department of Ichthyology and Herpetology. He is also a Professor in the Department of Zoology, University of Toronto.

E. J. Crossman was born in Niagara Falls, Ontario, and received his Doctor of Philosophy from the University of British Columbia in 1957. Work on Canadian freshwater fishes has carried him throughout Canada, the United States, and Europe. Dr. Crossman's research at this time largely concerns the systematics, biology, and distribution of freshwater fishes, in particular the northern pike, muskellunge and related species. The results of his various studies have appeared in scientific journals and books. He is a member of several international and national professional organizations including the American Society of Ichthyologists and Herpetologists and the Canadian Society of Wildlife and Fishery Biologists. He is now Curator in the Department of Ichthyology and Herpetology, Royal Ontario Museum, and Associate Professor in the Department of Zoology, University of Toronto.

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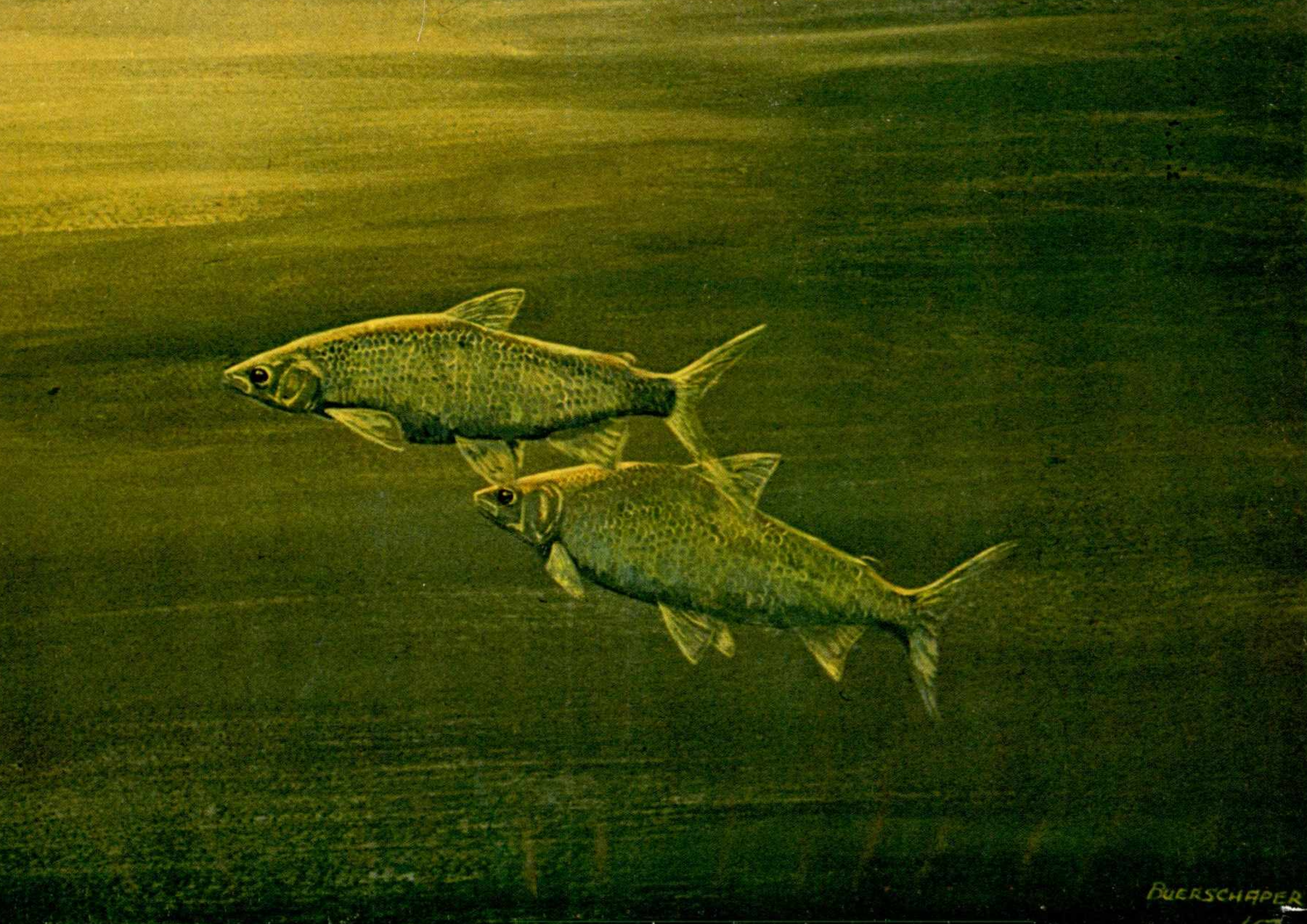
BUERSCHAPER

FRESHWATER FISHES OF CANADA

W. B. SCOTT • E. J. CROSSMAN
Department of Ichthyology and Herpetology
Royal Ontario Museum, Toronto

BULLETIN 184

Fisheries Research Board of Canada, Ottawa 1973

Frontispiece: Lake Whitefishes

Bulletins of the Fisheries Research Board of Canada are designed to assess and interpret current knowledge in scientific fields pertinent to Canadian fisheries.

The Board also publishes the *Journal of the Fisheries Research Board of Canada* in annual volumes of monthly issues, an *Annual Report*, and a biennial *Review* of investigations. The *Journal* and *Bulletins* are for sale by Information Canada, Ottawa. Remittances must be in advance, payable in Canadian funds to the order of the Receiver General of Canada. Publications may be consulted at Board establishments located at Ottawa; Nanaimo, Vancouver and West Vancouver, B.C.; Winnipeg, Man.; Ste. Anne de Bellevue, Que.; St. Andrews, N.B.; Halifax and Dartmouth, N.S.; and St. John's, Nfld.

Department of the Environment
Fisheries Research Board of Canada
Office of the Editor, 116 Lisgar Street
Ottawa, Canada
K1A 0H3

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EDITOR'S FOREWORD

For some considerable time the Fisheries Research Board has been aware of the need for a thorough study of the freshwater fishes of Canada. The main difficulty was to find qualified scientists who had at their disposal both the necessary resources and the required time. It was not until 1966 that the fortunate arrangement, of which this monograph is the result, was worked out between the Fisheries Research Board and Dr W. B. Scott, Dr E. J. Crossman, and the Royal Ontario Museum (then a part of the University of Toronto).

The Fisheries Research Board, initiator of the project, contributed a large measure of financial support as well as the services of its publications and editorial sections. The Royal Ontario Museum made available the services and facilities, not only of the entire Department of Ichthyology and Herpetology, but also of the highly qualified staff and resources of its library and photography department. It also permitted the Department to make this study its major research project over a period of several years and sponsored the library, laboratory, and field research necessary. Drs Scott and Crossman directed the research, evaluated the results, and wrote the report.

The Fisheries Research Board is proud to present this volume, a tribute to the cooperation between the government agency that initiated and supported the work and the research organization that carried it out. It also expresses its appreciation of the generous outlook of the Director and Board of Trustees of the Royal Ontario Museum that made such cooperation possible.

J. C. Stevenson, Editor and
Director of Scientific Information

Ottawa 1973

BACKGROUND INFORMATION

INTRODUCTION

The preparation of a monograph on the freshwater fishes of Canada was first suggested to Dr Scott in 1956 by Dr J. L. Kask, at that time Chairman of the Fisheries Research Board. It was not possible then to accept Dr Kask's offer although there was considerable interest in the idea. Ten years later the question was raised again, this time by the Editor of the Fisheries Research Board, Dr J. C. Stevenson. After much deliberation and discussion within the Royal Ontario Museum (ROM), at that time a part of the University of Toronto, a contract was drawn up in 1966 between the Fisheries Research Board on the one hand and the authors, the Royal Ontario Museum, and the University of Toronto on the other.

It was logical to select the Royal Ontario Museum as the site for such a project since it houses the largest collection of Canadian freshwater fishes available anywhere. Also available were artists, research assistants, photographic services, trained clerical assistants, and graduate students from the University of Toronto and other universities. The graduate students were especially important for they played a most valuable role in appraising and testing various parts of the project such as keys, distribution maps, and descriptions of fishes, as well as in providing ideas.

It was the authors' decision to work toward a three-year target date for completion of the project, and they specified the completion date as March 31, 1970. They were overly optimistic, perhaps, but were unaware at the time that the Museum was entering upon the most active period in its history, that their involvement in university teaching and graduate programs would treble, and that professional demands upon their time and energy would increase manyfold. It appears to be a common misconception that museum laboratories are quiet, secluded places, where bearded scholars quietly pursue their studies. Such is far from the truth. Museum laboratories are exciting places where specimens, information, and requests for assistance pour in from all parts of the globe from colleagues, teachers, former students, would-be-students, and interested public. Research programs must be planned, replanned, and executed, and routine studies on the collection continued. In such conditions, the authors feel fortunate to have been able to complete the project.

Preparation of much of the material in this book has been a depressing experience. Time after time when gathering the material for the write-up of a particular species, it would be found that the species had either disappeared from much of its former range (as is the case of the striped bass in the St. Lawrence, the whitefish and the lake trout in the Great Lakes, and the arctic char in Frobisher Bay) or that it had been completely extirpated from the North American scene (as in the case of the blue walleye). It also became apparent that many species now rare or absent were once more widely distributed, particularly in the lower Great Lakes region. This is particularly true of many of the minnows that prefer clear water and low turbidity.

Texts of this type become more useful with revisions based on constructive criticisms. The keys used were published separately as a Miscellaneous Publication of the Royal Ontario Museum entitled, *Checklist of Canadian Freshwater Fishes with Keys for Identification.* Many colleagues provided useful criticisms of that work and these have been embodied in this text.

It is the hope of the authors that this text will perform a useful service by highlighting the lack of information on many aspects of the biology of many Canadian fish species. Particularly glaring is our ignorance of the basic life history of many common species. Some of these would make useful subjects for university studies rather than the exotic species now used so frequently by behaviourists. The darters would seem to be most promising candidates for behavioural studies but cottids, minnows, and centrarchids also have much to offer in this field.

While materials for this Bulletin were being prepared and written, four prominent ichthyologists, P. H. Greenwood, D. E. Rosen, S. H. Weitzman, and G. S. Myers, prepared a radically new classification of fishes entitled, *Phyletic Studies of Teleostean Fishes, with a provisional classification of living forms.* Although preferring to follow, with modifications, the more traditional classifications of Regan, Norman, and Berg, the authors are cognizant of the pertinence of the new approach. They have not adopted it in the present text largely because they believe a number of modifications will be made to it in its early years, indeed, some of these have already appeared, *see* Weitzman, Copeia 1967(3), and also since it was thought that the present text would be more useful to Canadians if presented in a more or less familiar form. Subsequent editions of *Freshwater Fishes of Canada* will undoubtedly be more in line with the new classification.

It is anticipated that this work will be revised so that new knowledge, which accumulates so rapidly, can be added. Readers are, therefore, urged to bring to the attention of the writers errors or omissions found in the following pages. Simply write to either author at the Department of Ichthyology and Herpetology, Royal Ontario Museum, Toronto, Canada M5S 2C6.

Acknowledgments

We are indebted to a great many individuals and organizations for information and assistance in the preparation of the volume.

We are especially grateful to the Canadian National Sportsmen's Show, the Toronto Anglers' and Hunters' Association and, particularly, the late Frank H. Kortright for financial support in 1956 and 1958. A total of $1500 was made available to begin preparation of the distribution maps.

To the many people who gave so willingly of their time to provide specimens, data, information, to check keys, read manuscripts, and to assist in a host of other ways, we extend our sincere appreciation: K. R. Allen, C. Armstrong, F. M. Atton, R. M. Bailey, R. A. Baxter, R. J. Beamish, G. Beaulieu, J. Bergeron, J. Brubacher, D. G. Buchwald, K. Chambers, D. S. Christie, W. J. Christie, C. F. Clark, A. Courtemanche, C. F. Cole, B. B. Collette, F. B. Cross, A. Dechtiar, K. H. Doan, D. P. Dodge, A. R. Emery, P. F. Elson, B. W. Fallis, J. M. Fraser, C. Gamble, E. T. Garside, J. Gilhen, C. Gruchy, J. D. Hall, J. L. Hart, G. F. Hartman, Wm. C. Hooper, R. E. Jenkins, L. Johnson, R. P. Johnson, J. J. Keleher, W. A. Kennedy, Burt Kooyman, E. Kuyt, G. H. Lawler, A. H. Lawrie, Vianney Legendre, J. Leggett, W. C. Leggett, Gaston LeMay, C. C. Lindsey, K. H. Loftus, H. R. MacCrimmon, R. L. MacIntyre (formerly Chief of Production, FRB), E. Magnin, N. V. Martin, R. G. Martin, A. W. May, D. E. McAllister, R. A. McKenzie, Robt. Rush Miller, J. S. Nelson, S. Nepszy, T. G. Northcote, T. H. Northcote, J. R. Nursall, R. R. Parker, C. Paterson, R. J.

Paterson, J. H. C. Pippy, F. T. Pletcher, Geoff Power, Mrs Isobel Radforth, M. Richardson, W. H. Robbins, R. A. Ryder, J. W. Saunders, Howard Savage, F. K. Sandercock, D. M. Scott, D. P. Scott, J. D. Sheppard, S. B. Smith, E. H. Taylor, W. R. Taylor, S. N. Tibbo, S. Toole, E. H. Vernon, A. Wainio, J. C. Weir, T. A. Willock, D. E. Woronecki, R. E. Zurbrigg.

We are particularly grateful to R. A. Ryder who, with the help of Miss R. Viitanen, prepared summaries of information on which much of the accounts on the walleye and sauger were based.

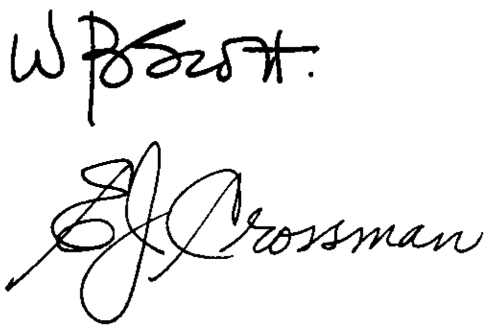
The majority of the drawings have been most skillfully executed by two exceedingly capable ROM artists: Anker Odum, who innocently agreed to prepare drawings for us, not knowing what hard task masters we were, and Peter Buerschaper, who did know but agreed anyway. The colour illustrations were prepared by Peter Buerschaper, Anker Odum, Terry Shortt, and E. B. S. Logier, the latter now retired from the Royal Ontario Museum.

We sincerely appreciate the loan of drawings from R. M. Bailey and R. R. Miller, Museum of Zoology, University of Michigan; D. E. McAllister, National Museums of Canada; J. D. McPhail, University of British Columbia; C. C. Lindsey, University of Manitoba; John L. Hart, St. Andrews, N.B.; and the photograph of the alewives from the *Toronto Telegram.*

Many individuals worked on the project on a part-time basis or as summer assistants during the period 1966–1970. Some of these were students whose interest and concern we especially appreciate; some were graduates, and some were teachers, but the services of all were invaluable: Christopher Arden, Barbara Atkinson, Neville Bodsworth, Stephen Campbell, Christine Carter, Mrs Margaret Crossman, Margaret Emery, Thelma Fleming, Stuart T. Gresham, Andrew Hemphill, Gretchen Markle, Fred Meth, A. Morris, Murray Rowan, Rebecca Rowlandson, Elaine Rutke, Gary Sinclair, Michael Singleton, Jill Stephens, J. Walsh.

We owe a debt of gratitude to our staff in the Department of Ichthyology and Herpetology that can never be fully repaid but whose patience, perseverance, and skill are most sincerely appreciated: Peter Buerschaper, Mrs Lois Casselman, Mrs Monica Hunter, Elizabeth Perry, Kathy Ribbans, Mrs Milly Scott, Eldon Smith.

We are most grateful for the services provided by other departments in the Royal Ontario Museum, especially those of Leighton Warren and his staff in Photography, and of the staff of the Library who cheerfully and successfully accepted and fulfilled our endless requests for literature.



CANADA AND ITS FISH FAUNA

Canada, the largest country in the western hemisphere and the second largest country in the world, has an area of more than 3,850,000 square miles, compared with over 8,600,000 square miles of the Union of Soviet Socialist Republics. It occupies the northern half of the North American continent, exclusive of Alaska and Greenland. In latitude, it extends from Middle Island, Lake Erie, at 41°41′N, to the North Pole, but the northernmost point of land is Cape Columbia, on Ellesmere Island, a straight-line distance of 2875 miles from Middle Island. Longitudinally it extends from Cape Spear, Newfoundland, at 52°37′W, to Mount St. Elias, Yukon Territory at 141°W, a distance of 3233 miles.

Of Canada's total area, 291,571 square miles, or 7.6% are exceedingly important fresh waters, which rank among the most valuable freshwater reserves in the world. They include not only the extensive Great Lakes, which, with the exception of Lake Michigan, are shared with the United States, but also such huge northern lakes as Great Slave and Great Bear that have areas of approximately 11,000 and 12,000 square miles, respectively, compared to Lake Erie's 10,000 square miles, and mighty rivers such as the St. Lawrence, the Nelson, and the Mackenzie with lengths of 1900, 1600, and 2635 miles, respectively.

Although relatively rich in supplies of fresh water, Canada is not rich in species of fishes, but rather, is depauperate, largely as a result of the relatively recent retreat of the Pleistocene ice. The total freshwater fish fauna consists of 24 families and 177 species, 181 if we include the introduced and established brown trout, carp, goldfish, and tench. Some appreciation of Canada's lack of richness of species can be gained by comparing it with the Great Lakes state of Ohio which has approximately 170 species. Actually, 5 families, the Salmonidae, Cyprinidae, Catostomidae, Percidae, and Cottidae contribute 70% of the fauna.

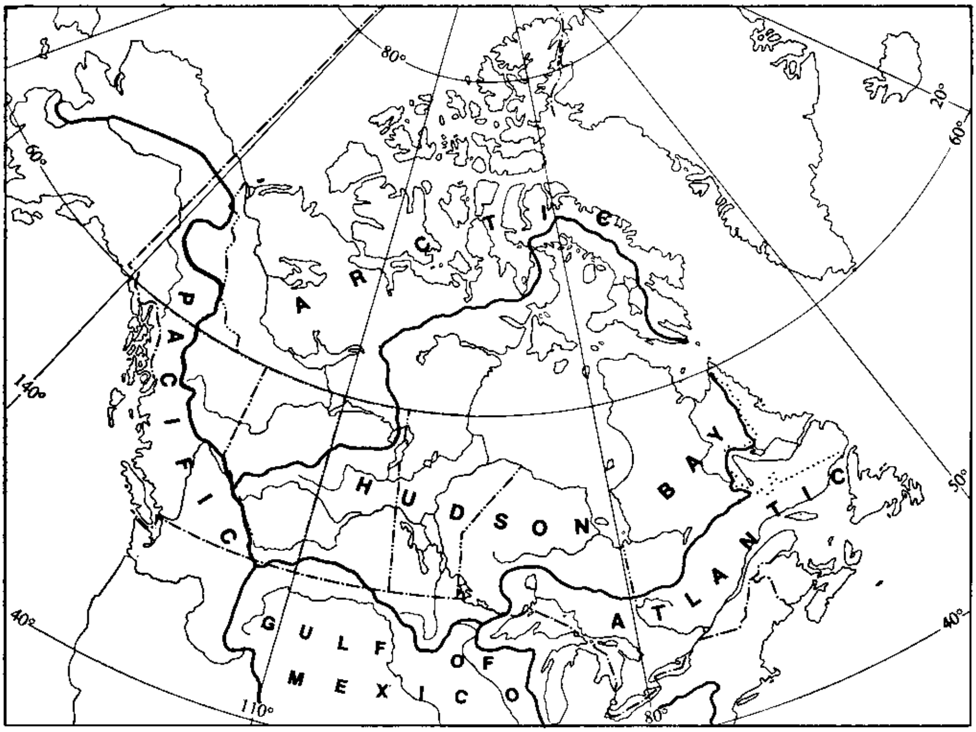
However, from a fisherman's viewpoint, what Canada lacks in quantity is compensated for in quality. The country has some of the finest salmon, trout, and char populations available anywhere, although the inroads of resource development and so-called technological advance threaten the continued existence of even the most remote.

The following summary shows the distributions of 181 species by province and by major watershed.

Number of Species by Geographic Area and Drainage Basin in a Fauna of 181 Species, 1971

By Geographic Area

Insular Newfoundland	20	Manitoba	79
Labrador (Nfld.)	21	Saskatchewan	60
Nova Scotia	34	Alberta	51
Prince Edward Island	19	British Columbia	71
New Brunswick	48	Northwest Territories	41
Quebec	105	Yukon Territory	31
Ontario	132	Alaska	40



Drainage Basins of Canada

By Drainage Basin

Atlantic	142
Hudson Bay	94
Arctic	55
Pacific	67
Gulf of Mexico	27

Atlantic Drainage Basin — 142 Species

(*indicates an introduced species)

Lampetra lamottei
Ichthyomyzon fossor
I. unicuspis
Petromyzon marinus
Acipenser brevirostrum
A. fulvescens
A. oxyrhynchus
Lepisosteus oculatus
L. osseus
Amia calva
Alosa aestivalis
A. pseudoharengus
A. sapidissima
Dorosoma cepedianum
Coregonus alpenae
C. artedii
C. canadensis
C. clupeaformis
C. hoyi
C. johannae

C. kiyi
C. nigripinnis
C. reighardi
C. zenithicus
*Oncorhynchus gorbuscha**
*O. kisutch**
*O. nerka**
*O. tshawytscha**
Prosopium coulteri
P. cylindraceum
*Salmo clarki**
*S. gairdneri**
S. salar
*S. trutta**
Salvelinus alpinus
S. fontinalis
S. namaycush
Osmerus mordax
Hiodon alosoides
H. tergisus
Umbra limi
Esox americanus
E. lucius
E. masquinongy
E. niger
*Carassius auratus**
Chrosomus eos
C. neogaeus
Clinostomus elongatus
Couesius plumbeus
*Cyprinus carpio**
Exoglossum maxillingua
Hybognathus hankinsoni
H. nuchalis
Hybopsis storeriana
H. x-punctata
Nocomis biguttatus
N. micropogon
Notemigonus crysoleucas
Notropis anogenus
N. atherinoides
N. bifrenatus
N. cornutus
N. emiliae
N. heterodon
N. heterolepis
N. hudsonius
N. rubellus
N. spilopterus
N. stramineus
N. umbratilis
N. volucellus
Pimephales notatus
P. promelas
Rhinichthys atratulus
R. cataractae
Semotilus atromaculatus
S. corporalis
S. margarita
Carpiodes cyprinus
Catostomus catostomus
C. commersoni
Erimyzon sucetta
Hypentelium nigricans
Ictiobus cyprinellus
Minytrema melanops
Moxostoma anisurum
M. carinatum
M. erythrurum
M. hubbsi
M. macrolepidotum
M. valenciennesi
Ictalurus melas
I. natalis
I. nebulosus
I. punctatus
Noturus flavus
N. gyrinus
N. miurus
Anguilla rostrata
Fundulus diaphanus
F. heteroclitus
Lota lota
Microgadus tomcod
Labidesthes sicculus
Apeltes quadracus
Culaea inconstans
Gasterosteus aculeatus
G. wheatlandi
Pungitius pungitius

Percopsis omiscomaycus
Morone americana
M. chrysops
M. saxatilis
Ambloplites rupestris
Lepomis auritus
L. cyanellus
L. gibbosus
L. macrochirus
L. megalotis
Micropterus dolomieui
M. salmoides
Pomoxis annularis
P. nigromaculatus
Ammocrypta pellucida
Etheostoma blennioides
E. caeruleum
E. exile
E. flabellare
E. microperca
E. nigrum
Perca flavescens
Percina caprodes
P. copelandi
P. maculata
Stizostedion canadense
S. vitreum
Aplodinotus grunniens
Cottus bairdi
C. cognatus
C. ricei
Myoxocephalus quadricornis

Hudson Bay Drainage Basin — 94 Species

Ichthyomyzon castaneus
I. unicuspis
Acipenser fulvescens
Coregonus artedii
C. clupeaformis
C. nigripinnis
C. zenithicus
*Oncorhynchus gorbuscha**
*O. keta**
*O. nerka**
*O. tshawytscha**
Prosopium cylindraceum
P. williamsoni
*Salmo clarki**
*S. gairdneri**
S. salar
*S. trutta**
Salvelinus alpinus
S. fontinalis
S. malma
S. namaycush
Thymallus arcticus
Hiodon alosoides
H. tergisus
Umbra limi
Esox lucius
E. masquinongy
*Carassius auratus**
Chrosomus eos
C. neogaeus
Couesius plumbeus
*Cyprinus carpio**
Hybognathus hankinsoni
H. nuchalis
Hybopsis storeriana
Nocomis biguttatus
Notemigonus crysoleucas
Notropis atherinoides
N. blennius
N. cornutus
N. dorsalis
N. heterolepis
N. hudsonius
N. rubellus
N. stramineus
N. volucellus
Pimephales notatus
P. promelas
Platygobio gracilis
Rhinichthys atratulus

R. cataractae
Semotilus atromaculatus
S. corporalis
S. margarita
Carpiodes cyprinus
Catostomus catostomus
C. commersoni
C. platyrhynchus
Ictiobus cyprinellus
Moxostoma anisurum
M. macrolepidotum
Ictalurus melas
I. nebulosus
I. punctatus
Noturus flavus
N. gyrinus
Fundulus diaphanus
Lota lota
Culaea inconstans
Gasterosteus aculeatus
Pungitius pungitius
Percopsis omiscomaycus
Morone chrysops
Ambloplites rupestris
Lepomis cyanellus
L. gibbosus
L. macrochirus
L. megalotis
Micropterus dolomieui
M. salmoides
Pomoxis nigromaculatus
Etheostoma exile
E. nigrum
Perca flavescens
Percina caprodes
P. maculata
P. shumardi
Stizostedion canadense
S. vitreum
Aplodinotus grunniens
Cottus bairdi
C. cognatus
C. ricei
Myoxocephalus quadricornis

Arctic Drainage Basin — 55 Species

Lampetra japonica
Coregonus artedii
C. autumnalis
C. clupeaformis
C. laurettae
C. nasus
C. nigripinnis
C. sardinella
C. zenithicus
Oncorhynchus gorbuscha
O. keta
O. nerka
O. tshawytscha
Prosopium coulteri
P. cylindraceum
P. williamsoni
Salmo gairdneri
*S. trutta**
Salvelinus alpinus
*S. fontinalis**
S. malma
S. namaycush
Stenodus leucichthys
Thymallus arcticus
Hypomesus olidus
Osmerus mordax
Hiodon alosoides
Dallia pectoralis
Esox lucius
Chrosomus eos
C. neogaeus
Couesius plumbeus
Hybognathus hankinsoni
Mylocheilus caurinus
Notropis atherinoides
N. hudsonius
Pimephales promelas
Platygobio gracilis
Ptychocheilus oregonensis
Rhinichthys cataractae

Richardsonius balteatus
Semotilus margarita
Lota lota
Culaea inconstans
Pungitius pungitius
Catostomus catostomus
C. commersoni
C. macrocheilus
Percopsis omiscomaycus
Etheostoma exile
Perca flavescens
Stizostedion vitreum
Cottus asper
C. cognatus
C. ricei
Myoxocephalus quadricornis

Pacific Drainage Basin (+ Bering Sea) — 67 Species

Entosphenus tridentatus
Lampetra ayresi
L. japonica
L. richardsoni
Acipenser medirostris
A. transmontanus
*Alosa sapidissima**
Coregonus autumnalis
C. clupeaformis
C. nasus
C. sardinella
Oncorhynchus gorbuscha
O. keta
O. kisutch
O. nerka
O. tshawytscha
Prosopium coulteri
P. cylindraceum
P. williamsoni
Salmo clarki
S. gairdneri
*S. trutta**
*Salvelinus fontinalis**
S. malma
S. namaycush
Stenodus leucichthys
Thymallus arcticus
Hypomesus olidus
Osmerus mordax
Spirinchus dilatus
Thaleichthys pacificus
Dallia pectoralis
Esox lucius
Acrocheilus alutaceus
*Carassius auratus**
Couesius plumbeus
*Cyprinus carpio**
Hybognathus hankinsoni
Mylocheilus caurinus
Notropis atherinoides
Ptychocheilus oregonensis
Rhinichthys cataractae
R. falcatus
R. osculus
Richardsonius balteatus
*Tinca tinca**
Catostomus catostomus
C. columbianus
C. commersoni
C. macrocheilus
C. platyrhynchus
*Ictalurus melas**
*I. nebulosus**
Lota lota
Gasterosteus aculeatus
Percopsis omiscomaycus
*Lepomis gibbosus**
*Micropterus dolomieui**
*M. salmoides**
*Pomoxis nigromaculatus**
*Perca flavescens**
Cottus aleuticus
C. asper
C. bairdi
C. cognatus
C. confusus
C. rhotheus

Gulf of Mexico Drainage Basin — 27 Species

Prosopium williamsoni
*Salmo clarki**
*S. gairdneri**
*S. trutta**
Esox lucius
*Carassius auratus**
Chrosomus eos
C. neogaeus
Couesius plumbeus
*Cyprinus carpio**
Hybognathus hankinsoni
H. nuchalis
Pimephales promelas
Platygobio gracilis
Rhinichthys cataractae
Semotilus margarita
Catostomus catostomus
C. commersoni
C. platyrhynchus
Moxostoma macrolepidotum
Noturus flavus
Lota lota
Culaea inconstans
Etheostoma exile
Perca flavescens
Stizostedion canadense
Cottus bairdi

The following fishes have not heen included among the "Canadian freshwater fishes," either hecause the species involved are tropical exotics that have heen introduced into an extremely restricted locality in one province, or hecause the species are essentially marine forms sometimes found in the lower reaches of coastal streams:

— five species of tropical aquarium fishes have hecome estahlished in Cave and Basin Hotspring, Banff National Park, Alta., apparently since ahout 1954 (McAllister 1969; Paetz and Nelson 1970). These include five species in two families, as follows:

Poeciliidae — live hearers
Poecilia latipinna (Lesueur) — sailfin molly
Poecilia reticulata Peters — guppy
Xiphophorus helleri Heckel — green swordtail
Gambusia affinis (Baird and Girard) — mosquitofish
Cichlidae — cichlids
Cichlasoma nigrofasciatum (Günther) — convict cichlid

— a numher of species of marine fishes have heen reported hy many authors from fresh or hrackish waters of Canadian streams or rivers flowing into the Atlantic, Arctic or Pacific hasins. The following list does not purport to he complete hut does include all species mentioned in the recent literature:

Squalidae — dogfish sharks
Squalus acanthias Linnaeus — spiny dogfish
Clupeidae — herrings
Clupea harengus pallasi Valenciennes — Pacific herring
Emhiotocidae — surfperches
Cymatogaster aggregata Gihhons — shiner perch
Cottidae — sculpins
Clinocottus acuticeps (Gilhert) — sharpnose sculpin
Leptocottus armatus Girard — Pacific staghorn sculpin
Myoxocephalus quadricornis (Linnaeus) — fourhorn sculpin

Cyclopteridae — lumpfishes and snailfishes	
Cyclopterus lumpus Linnaeus	— lumpfish
Ammodytidae — sand lances	
Ammodytes americanus DeKay	— American sand lance
Bothidae — lefteye flounders	
Scophthalmus aquosus (Mitchill)	— windowpane
Pleuronectidae — righteye flounders	
Liopsetta putnami (Gill)	— smooth flounder
Platichthys stellatus (Pallas)	— starry flounder
Pseudopleuronectes americanus (Walbaum)	— winter flounder

SOME IMPORTANT PUBLICATIONS ON THE CANADIAN FISH FAUNA

The most comprehensive history of ichthyology in Canada was prepared by the late J. R. Dymond for the 50th anniversary of the American Society of Ichthyologists and Herpetologists and was published by that society in 1964. Dymond included a chronological history and a list of the contributions made by federal and provincial governments, universities, and museums. The growth of distributional information was traced to 1961, the locations of major collections of fishes were given, and a chronological list of important fishery publications was presented. This list, modified to emphasize freshwater fishes and updated to 1970, is as follows:

1771	Forster, J. R.	Catalogue of the animals of North America containing an enumeration of the known quadrupeds, birds, reptiles, fish.
1792	Pennant, T.	Arctic zoology. Fishes. 2nd ed.
1836	Richardson, J.	Fauna Boreali-Americana; or the zoology of the northern parts of British America: part third *The fish.*
1850	Agassiz, J. L. R.	Lake Superior. Its physical character, vegetation, and animals, compared with those of other and similar regions.
1852	Perley, M. H.	Reports of the sea and river fisheries of New Brunswick.
1858	Ure, G. P.	Fishes. *In* The handbook of Toronto, by a member of the press.
1862	Gill, T. N.	Catalogue of the fishes of the eastern coast of North America from Greenland to Georgia.

1863	Fortin, Pierre	List of the cetacea, fishes, crustacea and mollusca, which now inhabit and have been inhabiting the Canadian shores of the Gulf of St. Lawrence and are objects of fishing operations, whether on a large or small scale, and which are used as bait, etc.
1864	Fortin, Pierre	Continuation of the list of fish of the Gulf and River St. Lawrence.
1865	Fortin, Pierre	Continuation of the list of fishes found in the Gulf and River St. Lawrence.
1865	Gill, T. N.	Synopsis of the fishes of the Gulf of St. Lawrence and Bay of Fundy.
1865	Small, H. B.	The animals of North America. ser. 2. Fresh-water fish.
1866	Fortin, Pierre	Continuation of the list of fishes taken in the Gulf and River St. Lawrence.
1866a, b	Lord, J. K.	The naturalist in Vancouver Island and British Columbia.
1866	Knight, T. F.	Fishes of Nova Scotia. Descriptive catalogue of fishes of Nova Scotia.
1873	Adams, A. L.	Field and forest rambles, with notes and observations on the natural history of eastern Canada.
1875	Provancher (l'Abbé)	Faune canadienne. Les poissons. vol. 7.
1876	Provancher (l'Abbé)	Faune canadienne. Les poissons. vol. 8.
1882	Jones, J. M.	List of the fishes of Nova Scotia.
1886	Whiteaves, J. F.	Catalogue of Canadian Pinnipedia, Cetacea, fishes and marine Invertebrata.
1892	Wright, R. R.	Preliminary report on the fish and fisheries of Ontario.
1895	Eigenmann, C. H.	Results of explorations in western Canada and the northwestern United States.
1896	Low, A. P.	Report on explorations in the Labrador Peninsula along the East Main, Koksoak, Hamilton, Manicuagan and portions of other rivers in 1892–93–94–95. *In* Ann. Rep. Geol. Surv. Canada, 1895, App. III.
1896b	Cox, Philip	Catalogue of the marine and freshwater fishes of New Brunswick.
1897	Montpetit, A. N.	Les poissons d'eau douce du Canada.
1898	Thompson, E. S.	A list of the fishes known to occur in Manitoba.

1907a	Evermann, B. W., and E. L. Goldsborough	A check list of the freshwater fishes of Canada.
1908	Nash, C. W.	Manual of vertebrates of Ontario.
1909	Kendall, W. C.	The fishes of Labrador.
1910	Evermann, B. W., and H. B. Latimer	The fishes of the Lake of the Woods and connecting waters.
1913	Halkett, A.	Check list of the fishes of the Dominion of Canada and Newfoundland.
1915	Bensley, B. A.	Fishes of Georgian Bay.
1919	Whitehouse, F. C.	Notes on some fishes of Alberta and adjacent waters.
1922	Dymond, J. R.	A provisional list of the fishes of Lake Erie.
1926	Dymond, J. R.	The fishes of Lake Nipigon.
1927	Dymond, J. R., and J. L. Hart	The fishes of Lake Abitibi (Ontario) and adjacent waters.
1929	Dymond, J. R., J. L. Hart, and A. L. Pritchard	The fishes of the Canadian waters of Lake Ontario.
1933	Dymond, J. R.	The coregonine fishes of Hudson and James bays. *In* Biological and oceanographic conditions in Hudson Bay.
1933	Vladykov, V. D.	Biological and oceanographic conditions in Hudson Bay. 9. Fishes from the Hudson Bay region (except the Coregonidae).
1934	Dymond, J. R., and V. D. Vladykov	The distribution and relationship of the salmonoid fishes of North America and North Asia.
1935	Vladykov, V. D., and R. A. McKenzie	The marine fishes of Nova Scotia.
1936	Mélançon, C.	Les poissons de nos eaux.
1939	Dymond, J. R.	The fishes of the Ottawa region.
1943	Hinks, David	The fishes of Manitoba.
1947	Dymond, J. R.	A list of the freshwater fishes of Canada east of the Rocky Mountains, with keys.
1949	Rawson, D. S.	A check list of the fishes of Saskatchewan.
1952	Wynne-Edwards, V. C.	Fishes of the Arctic and subarctic. *In* Freshwater vertebrates of the Arctic and subarctic.
1952	Legendre, V.	Clef des poissons de pêche sportive et commerciale de la Province de Québec.
1953	Livingstone, D. A.	The fresh water fishes of Nova Scotia.

1953	Walters, V.	The fishes collected by the Canadian Arctic Expedition, 1913–1918, with additional notes on the ichthyofauna of western Arctic Canada.
1955	Walters, V.	Fishes of the western Arctic America and eastern Arctic Siberia. Taxonomy and Zoogeography.
1956	Lindsey, C. C.	Distribution and taxonomy of fishes in the Mackenzie drainage of British Columbia.
1957	Backus, R. H.	The fishes of Labrador.
1959	Scott, W. B., and E. J. Crossman	The freshwater fishes of New Brunswick: a checklist with distributional notes.
1963	MacKay, H. H.	Fishes of Ontario.
1964	Ryder, R. A., W. B. Scott, and E. J. Crossman	Fishes of northern Ontario, north of the Albany River.
1964	Scott, W. B., and E. J. Crossman	Fishes occurring in the fresh waters of insular Newfoundland.
1964	Hubbs, C. L., and K. F. Lagler	Fishes of the Great Lakes region.
1967	Scott, W. B.	Freshwater fishes of eastern Canada. 2nd ed.
1967	Carl, G. C., W. A. Clemens, and C. C. Lindsey	The fresh-water fishes of British Columbia.
1969	Scott, W. B., and E. J. Crossman	Checklist of Canadian freshwater fishes with keys for identification.
1970	Paetz, M. J., and J. S. Nelson	The fishes of Alberta.
1970	Lindsey, C. C., and C. S. Woods (Ed.)	Biology of coregonid fishes.
1970	McPhail, J. D., and C. C. Lindsey	Freshwater fishes of northwestern Canada and Alaska.

INSTRUCTIONS ON PREPARING AND FORWARDING SPECIMENS FOR IDENTIFICATION

Maintaining up-to-date information on the distribution of freshwater fishes in Canada is an integral part of the activities of an ichthyologist or a department of fishes at a Natural History Museum or at certain universities. Such individuals or departments are interested in receiving preserved specimens of fishes from remote areas or from localities on the extremes of the known range of a species, as well as unidentifiable fishes thought to be new or strange in any area. The best ways of preparing specimens for shipment are as follows:

1. *Formalin preservation* — formalin is obtainable from most hardware stores, drug stores or farm supply agencies. One part of the fluid, as supplied, is diluted with nine parts of water. The fish is immersed in this solution as quickly after capture as possible and left there 5–7 days depending on size. Fish over 6 inches in length should be slit (2 one-inch slits, in lower right side of fish) in order to allow the preservative to enter the body cavity. After several days in this 10% formalin, the fish will be hard. It can then be removed, wrapped in a wet cloth, placed in some light but waterproof container such as a heavy plastic bag, plastic bottle, small tin with tight lid, packaged adequately for mailing, and mailed to the nearest interested institution or individual. In preparing the specimen, care should be taken to avoid, as much as possible, contact with the corrosive poisonous formalin or its fumes. The 10% solution will harden skin and the fumes can cause unpleasant nasal inflammation. Great care should be taken to protect the eyes from splashes.
2. *Other liquid preservation* — other liquids with high alcoholic content, such as rubbing alcohol or full strength liquor can be used. If placed in these fluids, specimens should be left longer before shipment and will not become hard as in formalin.
3. *Freezing* — specimens can be hard frozen, packed in dry ice (solid carbon dioxide) in an insulated container such as a picnic cooler. This method can be used only when delivery can be guaranteed in less than 3 days, otherwise the carrier will abandon the thawed, wet package and the specimens will be of no value if ever delivered. Frozen shipments are expensive, dangerous, and should be forwarded only after prior arrangement with the recipient. He should be given, by phone or telegram, such information as method of shipment, flight number, waybill number, date, place, and time of consignment to shipper.
4. *Salting* — fish can be preserved by packing the body cavity with salt, packing the specimens in salt in a waterproof container as above, and mailing for fast delivery. Also, fish can be immersed for several days in a strong brine solution (at least 1 pound of salt to 1 gallon of water), then proceed as with formalin or alcohol specimens. Body cavity must be opened to allow rapid entry of salt solution. If the fish is large, the head, the backbone in several segments, the fins, and skin from one side can be shipped after treatment.

Each lot of specimens from a different location or body of water should have with it a label. The label should be of the highest quality paper or fibre, and the notations printed clearly in pencil (the fluids will remove ball point ink). Such information as precise location of capture, the major river of which the body of water is a part, distance to nearest feature readily found on a map, date of capture, name of collector is desirable. If possible, notice of date and method of shipment, method of preservation and the information on the labels should be sent separately to the addressee.

The following institutions maintain permanent research collections of fishes:

- — Nova Scotia Museum, Halifax
- — Laboratoire de Recherches, Service de la Faune du Québec, 5075 rue Fullum, Montreal 178
- — Centre Biologique, Quebec City
- — National Museums of Canada, Ottawa
- — Royal Ontario Museum, Toronto
- — Alberta Provincial Museum, Edmonton
- — Institute of Animal Resource Ecology, University of British Columbia, Vancouver
- — British Columbia Provincial Museum, Victoria.

In addition to the staffs of the above institutions, the following individuals could provide identifications or additional information, especially on local fauna:

- — C. C. Lindsey, Dept. of Zoology, University of Manitoba, Winnipeg
- — F. M. Atton, Saskatchewan Fisheries Laboratory, Saskatoon
- — J. S. Nelson, Dept. of Zoology, University of Alberta, Edmonton
- — Martin Paetz, Dept. of Lands and Forests, Edmonton
- — J. D. McPhail, Dept. of Zoology, University of British Columbia, Vancouver 8.

OUTLINE OF A SPECIES ACCOUNT

Description

The same sequential arrangement is used throughout the book and, hopefully, will help the reader to find a particular measurement or meristic value. Except where specified otherwise, we have followed the methods of measurement outlined by Hubbs and Lagler (1964). One such exception is in the body length measurement. Instead of the standard length used by ichthyologists we have in most cases employed total length, i.e. snout to tip of tail, since we believe this measurement is most frequently used by fishery biologists, students, anglers, and commercial fishermen. Legal-size limits, where employed, are usually based on total length. We recognize the necessity of using standard length measurements for scientific studies but believe its use in this text would have imposed unnecessary restrictions on the reader. However, in certain cases (such as the mooneyes) where published measurements were available in percentage of standard length, we gave them in this way rather than converting them. Ichthyologists will still, of course, use a standard length, although there are a number of ways to take a "standard" length. When used herein by us, standard length means the length from the anteriormost part of the head to the posterior margin of the last whole vertebral centrum (which is also the last vertebra counted).

In tables throughout this text, the following abbreviations have been used: FL = fork length, SL = standard length, TL = total length.

Fin ray counts, vertebrae number, and other meristic data vary because of genetic and environmental influences. The total range of values for these characters is shown but, when possible, the number of specimens displaying a particular count is shown in parentheses immediately following the count. If a meristic value appears to vary from province to province, an attempt was made to show the range of values by province.

The descriptions are based, in the great majority of cases, upon the examination of Canadian specimens. Consequently much meristic and morphometric data are available on file in the ROM and, in addition to collections of preserved specimens, there are good representative collections of cleared and stained specimens and a large file of x-rays.

Colour

Emphasis is placed on colours of living fishes and wherever possible, colours of young and spawning fish are included when these differ markedly from normal adults.

Systematic notes

Discussions of taxonomic history, subspecific designations, problems concerning common names, and often hybridization (*see also Biology* section) are included here. Whenever possible an attempt has been made to include controversial aspects of the systematics of a species.

Distribution

Information on distribution is presented both in written form and on maps. So far as the Canadian distribution is concerned an attempt has been made to follow a consistent pattern, working from east to west, and south to north. Thus, Newfoundland, Nova Scotia, and Prince Edward Island will always appear before Manitoba, if included in the range of a particular species. Similarly the Northwest Territories will usually be mentioned last. In preparing the maps, it was deemed impractical to attempt to identify each dot. Round spots indicate the existence of a specimen in the collections of the Royal Ontario Museum or another institution such as the University of British Columbia or the National Museums of Canada, diamond-shaped spots represent literature references. In both cases emphasis has been placed on marginal or peripheral locality records in order to define the outer limits of range. For those especially interested, more detailed information for each distributional record is available from the master maps on file in the Department of Ichthyology and Herpetology, Royal Ontario Museum. The shaded portion represents the total range of the species. The insert maps represent the range of the species in North America, the northern hemisphere or the world, whichever is pertinent.

Biology

Again a sequential arrangement has been followed, commencing with spawning and egg characteristics, and proceeding through developmental rates, growth, habitat, food, predators, and parasites. For some species notes on hybrids appear here. Canadian studies have been emphasized whenever these exist and are known to us. It was surprising to us that so many species have been ignored by biologists, while other species have been studied, restudied, and studied again. We have tended to avoid reference to unpublished theses whenever possible. Comparative growth rates are provided whenever these were available. We have attempted to include in the tables, growth rates from different areas east to west, and north to south, to illustrate the differences over the whole of the range. It was not always possible to find all the growth rates for any species in the same length measurement nor to be sure in some cases what length the author intended. When available, the maximum known size and recent angler size record are included at the end of the discussion on growth. The reader is also advised to consult Carlander (1969), McPhail and Lindsey (1970), and pertinent regional texts for additional information and references.

The section on parasites is intended as a preliminary guide to the better-known studies on parasites of our freshwater fishes. It was prepared primarily by reference to the works of Bangham and co-workers; Lawler and co-workers; Price and Arai (1967); Sandeman and Pippy (1967); Hoffman (1967); and the many recent papers by Dechtiar (1965–1970).

Relation to man

The title is really self-explanatory. An attempt has been made to indicate how commercial species are caught, processed, and marketed; in some cases the poundage landed is also given. Sport or game fishes are also evaluated, when possible. Flavour and edibility are usually described. Special features such as marked reduction in numbers, excessive mortalities, or use as experimental animals are also included.

Nomenclature

We have provided a partial synonymy only, giving emphasis to Canadian references and to those for international waters such as the Great Lakes and Lake Champlain. It was our intention to list most of the other scientific names used in Canadian literature to describe a species, so that early historical literature might be more readily interpreted. Thus, a reader is enabled to discover that the deepwater sculpin, now called *Myoxocephalus quadricornis,* appeared in the literature, just a few years ago, as *Triglopsis thompsoni,* and that these two names apply to the same species. We have not attempted to trace all the combinations of names used as subspecies of the various fishes nor to follow the shifting attitude toward the use of *i* or *ii* endings on scientific names.

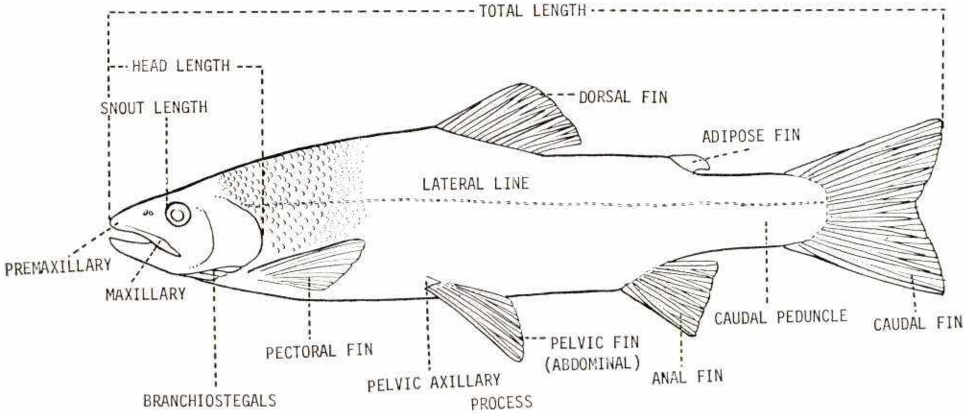
The common and scientific names used are in general accord with those recommended by the American Fisheries Society in its recent Special Publication No. 6, *A list of common and scientific names of fishes from the United States and Canada* (1970). We are indebted to Vianney Legendre, Director, Research Laboratory of the Quebec Wildlife Service, and his colleagues for the French common names.

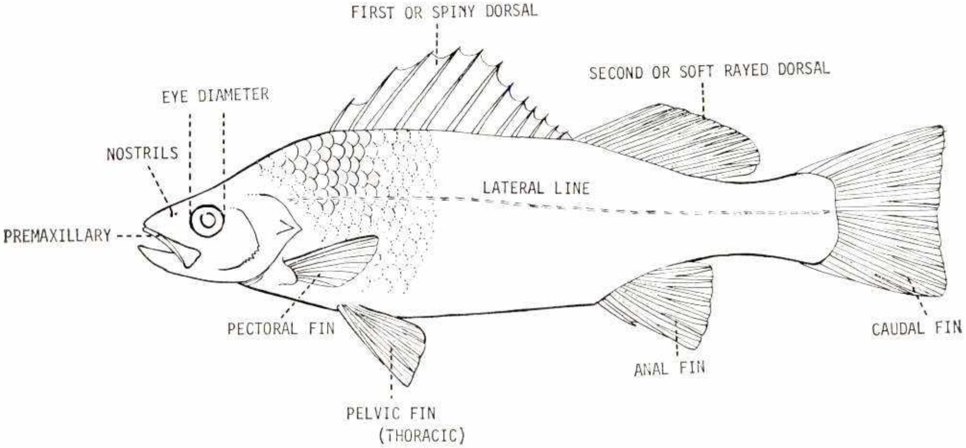
Suggested reading

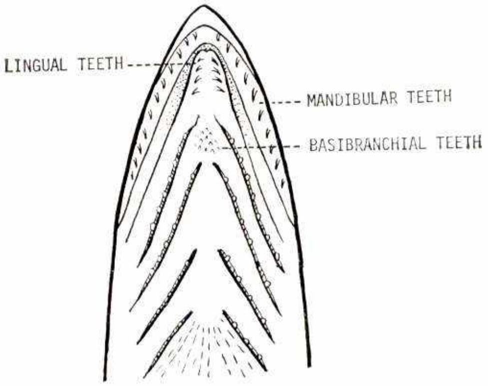
For further information about the family or individual species, *see* the section entitled Suggested Reading at the end of each family account.

SKETCHES OF ANATOMICAL FEATURES

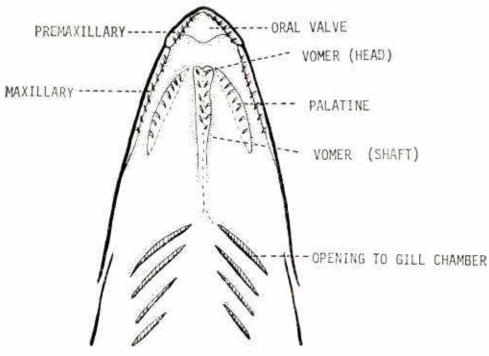
SKETCHES OF ANATOMICAL FEATURES



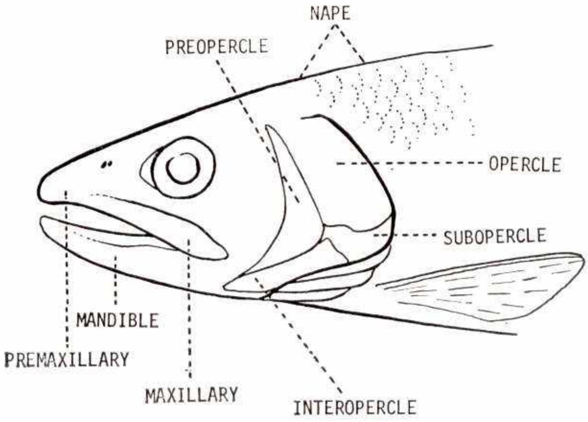


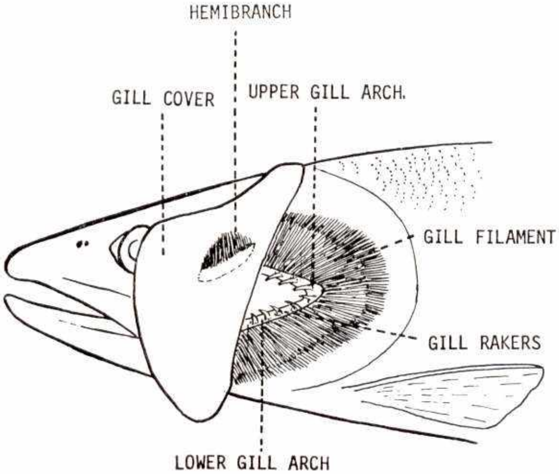


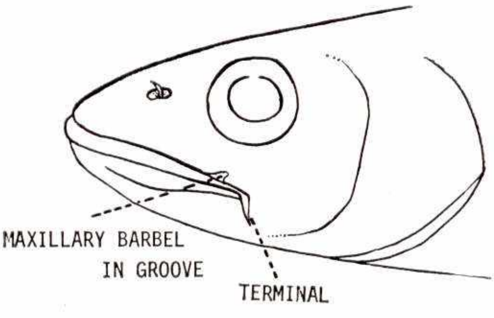
FLOOR OF MOUTH AND PHARYNX



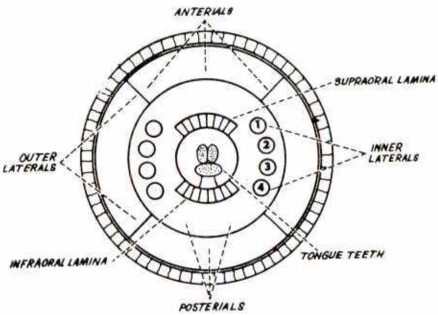
ROOF OF MOUTH AND PHARYNX



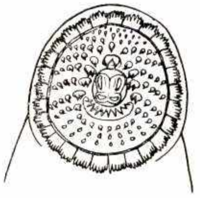




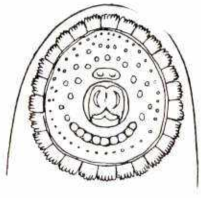
MAXILLARY BARBELS



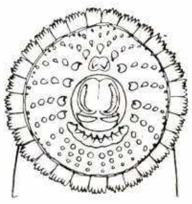
SCHEMATIC REPRESENTATION OF LAMPREY BUCCAL FUNNEL SHOWING GROUPS OF TEETH



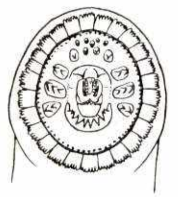
Chestnut lamprey



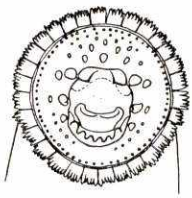
Northern brook lamprey



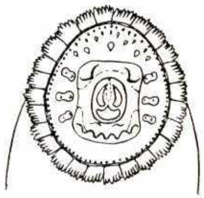
Silver lamprey



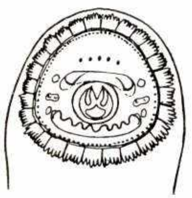
River lamprey



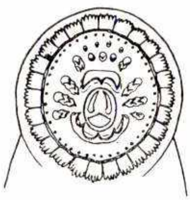
Arctic lamprey



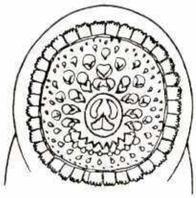
American brook lamprey



Western brook lamprey

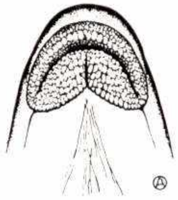


Pacific lamprey

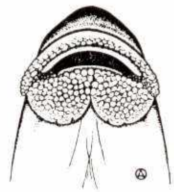


Sea lamprey

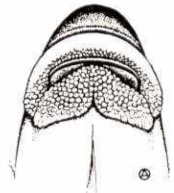
LAMPREY BUCCAL FUNNELS



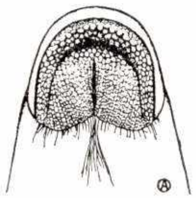
White sucker



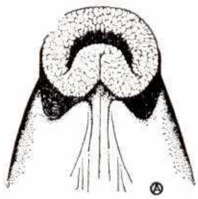
Bridgelip sucker



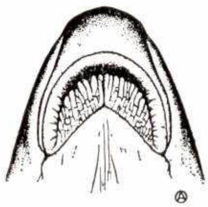
Mountain sucker



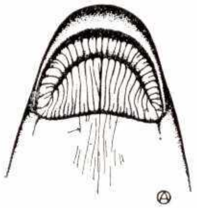
Largescale sucker



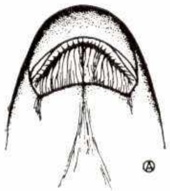
Northern hog sucker



Silver redhorse

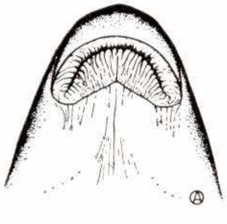


River redhorse

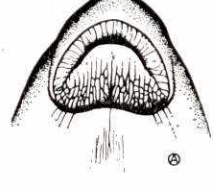


Black redhorse

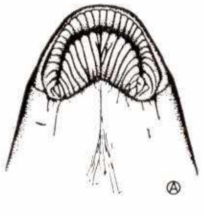
Golden redhorse



Copper redhorse



Shorthead redhorse



Greater redhorse

MOUTHS OF SOME SUCKERS

Black bullhead (*left*)

Yellow bullhead (*left*)

Brown bullhead (*left*)

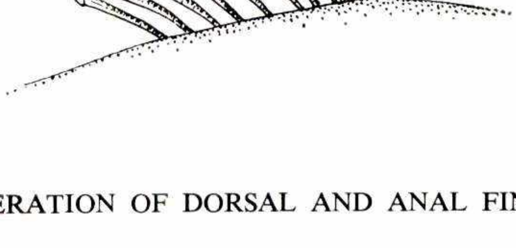
Channel catfish (*left*)

Stonecat (*left*)

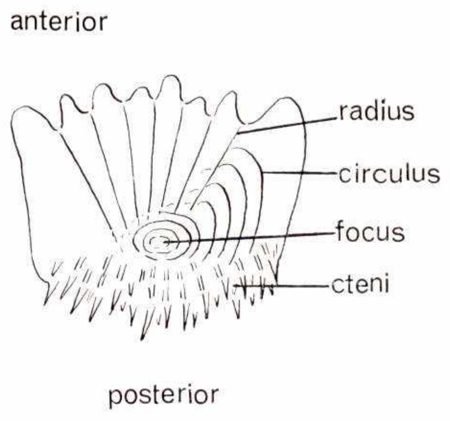
Tadpole madtom (*right*)

Brindled madtom (*right*)

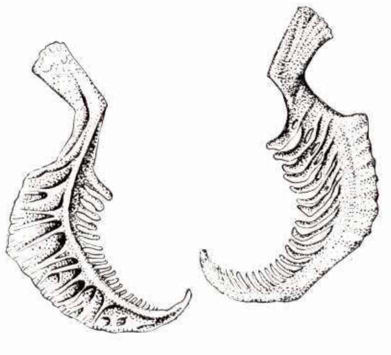
PECTORAL SPINES OF CATFISHES



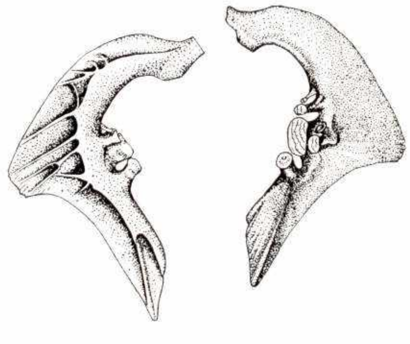
ENUMERATION OF DORSAL AND ANAL FIN RAYS



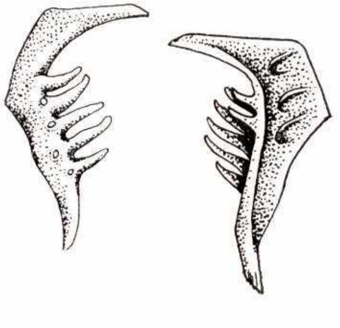
PARTS OF A CTENOID SCALE



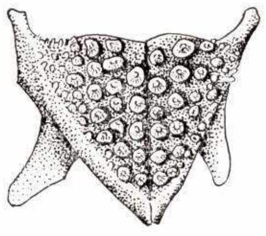
White sucker



Carp



Creek chub



Freshwater drum

PHARYNGEAL ARCHES WITH TEETH

KEY TO THE FAMILIES OF FISHES OCCURRING IN THE FRESH WATERS OF CANADA

KEY TO THE FAMILIES OF FISHES OCCURRING IN THE FRESH WATERS OF CANADA

1 Mouth without true jaws, instead a circular, suctorial disc; no paired fins; 7 pairs of gill openings. .... LAMPREYS, family Petromyzontidae (p. 36)

Mouth with true jaws (i.e., upper and lower jaws present); with paired fins; opercles (or gill covers) overlying gills 2

2 Upper and lower lobe of caudal (tail) fin, when present, of about equal size; body covering of overlapping scales or naked; no barbels before mouth; skeleton bony 3

Upper lobe of caudal (tail) fin distinctly larger than lower lobe; mouth inferior; snout well developed; 5 rows of bony plates arranged longitudinally along body; 4 pairs of barbels before mouth. .... STURGEONS, family Acipenseridae (p. 78)

3 Under surface of head, between lower jaws, with strong bony plate ("gular" plate). .... BOWFINS, family Amiidae (p. 111)

Under surface of head (i.e., between the lower jaws) soft and not protected by large bony plate 4

4 Pelvic fins present 5

Pelvic fins absent; body cylindrical, long, and snakelike; dorsal, caudal, and anal fins continuous; no distinct caudal fin. .... EELS, family Anguillidae (p. 623)

5 Adipose fin present 6

Adipose fin absent 11

6 Body scaleless; strong pectoral and dorsal spines; long barbels about mouth. .... CATFISHES, family Ictaluridae (p. 588)

Body scaled; no strong spines in fins; no long barbels about mouth 7

7 Pectoral fin overlaps anterior pelvic base; scales (weakly) ctenoid. .... TROUT-PERCH, family Percopsidae (p. 677)

Pectoral fin tip never reaches anterior base of pelvic fin; scales cycloid 8

8 Pelvic axillary process absent. .... SMELTS, family Osmeridae (p. 306)

Pelvic axillary process present 9

9 Mouth usually large, extending to middle of eye or beyond; teeth strong. .... SALMONS AND TROUTS (Salmoninae), family Salmonidae (p. 138)

Mouth usually small and not extending beyond middle of eye; teeth weak or absent 10

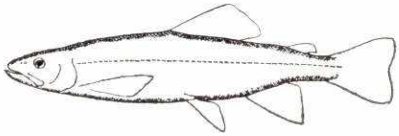
10 Dorsal fin shorter than head, dorsal rays 16 or fewer. .... WHITEFISHES, CISCOES (Coregoninae), family Salmonidae (p. 138)

Dorsal fin base longer than head, fin very high, rays 17 or more. .... GRAYLING (Thymallinae), family Salmonidae (p. 138)

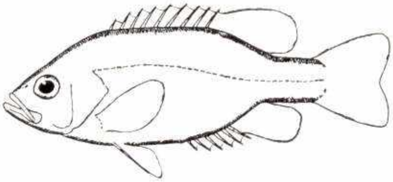
11 Soft (or second) dorsal fin preceded by 2–10 isolated, sharp spines or by a separate spiny dorsal of 4 slender and soft, inconspicuous spines; small fishes, less than 6 inches long 25

Soft (or second) dorsal fin not preceded by isolated spines, but spines, if present, joined together by fin membrane; small and large fishes 12

12 Pelvic fins abdominal and well developed; one rayed dorsal fin; all fins soft rayed and without spines 13



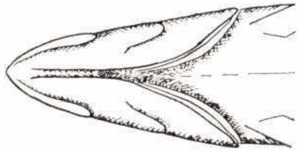
Pelvic fins thoracic or jugular, often reduced; dorsal fin usually 2, but if only 1, the anterior portion composed of well-developed spines 20



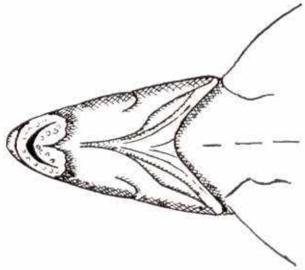
13 Body covered with thick, hard, glossy rhomboid scales. .... GARS, family Lepisosteidae (p. 101)

Body normally scaled or with scattered prickles 14

14 Gill membranes not attached to isthmus (gill openings wide) 15



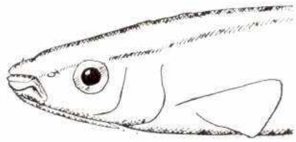
Gill membranes broadly joined to isthmus (gill openings narrow) 18



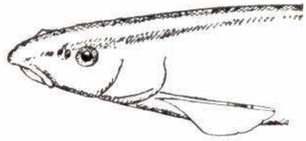
15 Head with some scales; body elongate; spotted, barred, or dark coloured 16

Head without scales; body laterally compressed; silvery 19

16 Upper jaw protractile. .... KILLIFISHES, family Cyprinodontidae (p. 630)



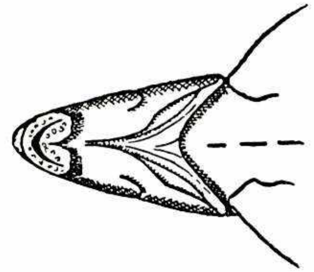
Upper jaw not protractile. 17



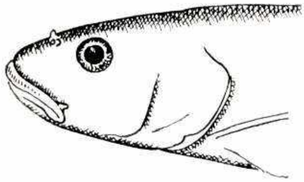
17 **Jaws well developed; teeth strong; caudal fin forked.** .... PIKES, family Esocidae (p. 346)

Jaws short; teeth small; caudal fin rounded. .... MUDMINNOWS, BLACKFISH, family Umbridae (p. 337)

18 Lips usually thick and mouth inferior (except *Ictiobus* where it is oblique and with normal lips; however, in *Ictiobus* the long dorsal fin has over 28 rays, and the longest unbranched ray is not a serrate, heavy spine, thus separating it from the 2 cyprinids with long dorsal rays, *Cyprinus* and *Carassius*); pharyngeal teeth numerous and in 1 row, comblike; swim bladder of 2 or three chambers. .... SUCKERS, family Catostomidae (p. 523)



Lips thin, mouth seldom inferior (except in *Rhinichthys* where scales are minute and much smaller than in suckers); if dorsal fin long, no more than 22 rays and second unbranched element a heavy, serrate spine; pharyngeal teeth in 2 or 3 rows, fewer than 9 per side; swim bladder of 2 chambers. .... MINNOWS, family Cyprinidae (p. 376)



19 Lateral line absent; teeth absent; belly with sharp, pointed scales (scutes); dorsal fin situated over pelvic fins and well in advance of anal fin; never more than 23 anal rays. .... HERRINGS, family Clupeidae (p. 117)

Lateral line present, at times indistinct; teeth present; no sharp, pointed scales on belly, scales smooth; dorsal fin over anal fin and well behind pelvic fins; always more than 25 anal rays. .... MOONEYES, family Hiodontidae (p. 326)

20 Body plated, naked, or with prickles; pectoral fins large and conspicuous. .... SCULPINS, family Cottidae (p. 817)

Body scaled (scales small and somewhat embedded in Gadidae); pectoral fins of moderate size, not conspicuous 21

21 Chin with small but distinct median barbel. .... CODS, family Gadidae (p. 640)

Chin without small median barbel 22

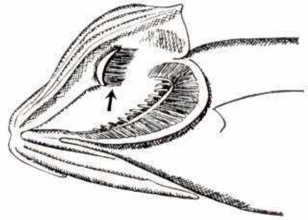
22 Anal spines 1 or 2 23

Anal spines 3 or more 24

23 Second anal spine strong, stout, and conspicuously larger than first; lateral line extending onto caudal fin. .... DRUMS, family Sciaenidae (p. 811)

Second anal spine slender and not conspicuously larger than first; lateral line not extending onto caudal fin. .... PERCHES, family Percidae (p. 751)

24 Opercle with a spine; 3 anal spines; hemibranch well developed and obvious. .... TEMPERATE BASSES, family Percichthyidae (p. 683)



Opercle without a spine; 3 or more anal spines; hemibranch concealed or absent. .... SUNFISHES, family Centrarchidae (p. 699)

25 Strong pelvic spines present; first dorsal spine arising well in advance of anal fin origin. .... STICKLEBACKS, family Gasterosteidae (p. 656)

Pelvic fins without spines; first dorsal spine arising approximately over anal fin origin; slender silvery fishes. .... SILVERSIDES, family Atherinidae (p. 651)

SPECIES ACCOUNTS

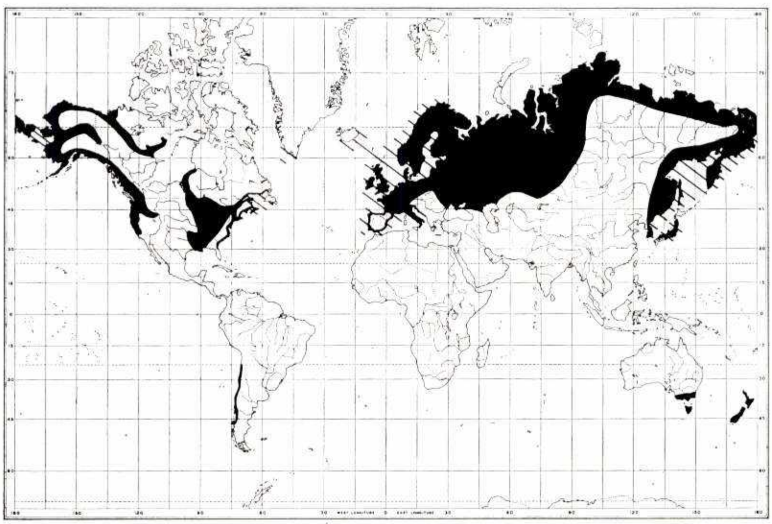
THE LAMPREYS — Order Petromyzontiformes

Body naked, eel-like; with round, suctorial mouth armed with horny teeth, often sharp, on funnel and tongue. A long dorsal fin, often of two parts; no paired fins and no paired fin girdles. No bone in the skeleton; skull cartilagineous; vertebrae without centra. A single median nasal opening between the eyes, not connected to the pharynx. Seven pairs of gills in the form of gill pouches, each pouch opening to the outside by an individual opening. Muscle blocks or myotomes not divided by a horizontal septum into dorsal and ventral parts. Characteristic metamorphosis from blind, toothless larva or ammocoete to toothed, sighted adult in 1–4 years.

A single living family, Petromyzontidae, and no reliable fossil representative other than the specimen of *Mayomyzon pieckoensis* described by Bardack and Zangerl (1968) from the Pennsylvanian of Illinois.

Lamprey Family—Petromyzontidae

There are about 30 species in 8 genera of living lampreys. Five genera *Caspiomyzon*, *Entosphenus*, *Ichthyomyzon*, *Lampetra*, and *Petromyzon* occur in the northern hemisphere whereas *Exomegas*, *Geotria*, and *Mordacia* occur in the southern hemisphere. They are generally distributed in temperate marine and fresh water, some anadromous. Life span from 2 to 5 years, involving metamorphosis. The time to metamorphosis varies with species, from 1 to 4 or 5 years. All larvae or ammocoetes live in fresh water, usually in burrows in the soft bottom of streams and lakes. Eyes are present in the ammocoetes, but are covered and sightless; teeth are absent and the mouth has an oral hood. After transformation, the adult possesses the characteristic fringed, well-toothed, circular, suctorial mouth. Many species are externally parasitic, attaching themselves to other fishes with the suctorial mouth and using a rasping tongue to break the surface of the host in order to consume the blood slowly. Some freshwater species that are not parasitic, mate and spawn soon after transformation, and then die.



World Distribution of the Lampreys

Key to Species

(This key is intended only for transformed individuals. The identification of immature lampreys (larvae or ammocoetes, with an oral hood) requires much more detail.)

1 Dorsal fin composed of 2 obvious lobes; lobes separated or joined by very low and inconspicuous connection 2

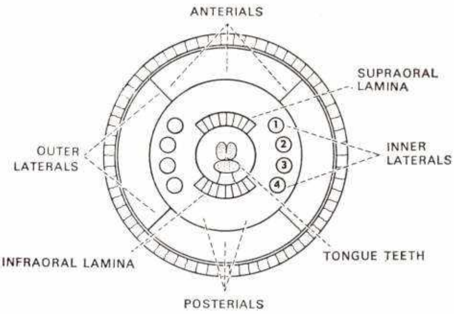
Petromyzon marinus

Ichthyomyzon fossor

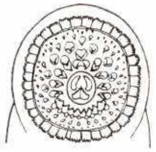
Entosphenus tridentatus

Dorsal fin single but notched; notch never reaching dorsal surface of body 7

2 Supraoral teeth on broad curved bar (lamina) 3

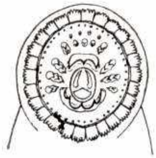


Supraoral teeth not on broad curved bar (lamina) but consisting of a single, median, large, bicuspid tooth, with pointed cusps; laterals 4, bicuspid, pointed cusps, trunk myomeres 67–74; parasitic; to 22.8 inches (860 mm) in length. .... SEA LAMPREY, *Petromyzon marinus* (p. 69)



3 Supraoral lamina with 2 lateral cusps, no median cusp 4

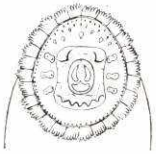
Supraoral lamina with 3 prominent, sharp cusps, one median; lateral teeth 3 or 4 with at least the middle 2 on each side tricuspid, others bicuspid, or tricuspid; semicircular row of small teeth below infraoral bar; trunk myomeres usually 64–74; parasitic; to 26.8 inches (680 mm) in length. .... PACIFIC LAMPREY, *Entosphenus tridentatus* (p. 42)



4 Inner lateral teeth 3, all bicuspid, or at least middle one or both sides bicuspid 5

Inner lateral teeth 3, at least middle tooth on both sides tricuspid 6

5 Inner lateral teeth prominent, bluntly pointed, all bicuspid; teeth above supraoral lamina prominent, pointed; tongue with sharp teeth *and* trunk myomeres usually 64–70, non-parasitic, to 7.4 inches (187 mm), Great Lakes and eastward. ....



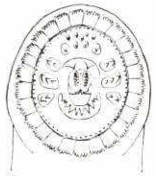
.... AMERICAN BROOK LAMPREY, *Lampetra lamottei* (p. 62)

or

trunk myomeres usually 68–74, parasitic?; at least to 11.8 inches (300 mm), Great Slave Lake and northwestward. ....
.... ARCTIC LAMPREY, *Lampetra japonica* (p. 58)

Inner lateral teeth poorly defined, knoblike, some may be unicuspid; teeth above supraoral bar (anterials), if apparent, very small and peglike; no sharp teeth on tongue; trunk myomeres 60–67; non parasitic; length to 6 inches (154 mm). ....

.... WESTERN BROOK LAMPREY, *Lampetra richardsoni* (p. 65)

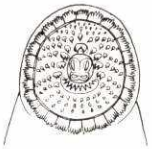


6 Teeth above supraoral lamina (anterials) prominent and sharp; sharp teeth on tongue; trunk myomeres 60–71; parasitic; length to 12 inches (311 mm). ....
.... RIVER LAMPREY, *Lampetra ayresi* (p. 55)

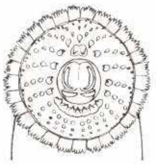
Teeth above supraoral lamina (anterials), if apparent, very small and peg-like; no sharp teeth on tongue; trunk myomeres 60–67; nonparasitic; length to 6 inches (154 mm). ....
.... WESTERN BROOK LAMPREY, *Lampetra richardsoni* (p. 65)

7 Lateral teeth all unicuspid 8

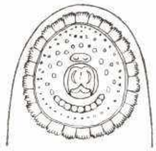
At least 1 or more bicuspid, inner, lateral teeth on each side; supraoral a single, sharp, bicuspid tooth; trunk myomeres usually 51–54; parasitic; to 15 inches (380 mm) in length. ... . CHESTNUT LAMPREY, *Ichthyomyzon castaneus* (p. 46)



8 Supraoral usually a single, bicuspid tooth (1 cusp rarely doubled), cusps sharp; infraoral lamina with prominent triangular cusps; diameter of sucking disc greater than that of branchial region; trunk myomeres 47–55; parasitic; length to 13 inches (328 mm). .... SILVER LAMPREY, *Ichthyomyzon unicuspis* (p. 52)



Supraoral a single, weak, bicuspid tooth, cusps knob-like; infraoral lamina with low, knob-like cusps; diameter of sucking disc less than that of branchial region; trunk myomeres usually 51–58; nonparasitic; length to 6 inches (150 mm). .... NORTHERN BROOK LAMPREY, *Ichthyomyzon fossor* (p. 49)



The nine species of lampreys in Canada. Known maximum length in Canada is given in parentheses after the name.

Entosphenus tridentatus (27 inches, 682 mm)

Ichthyomyzon castaneus (15 inches, 380 mm)

I. fossor (5.9 inches, 150 mm)

I. unicuspis (12.9 inches, 328 mm)

Lampetra ayresi (12.2 inches, 311 mm)

L. japonica (16.2 inches, 411 mm)

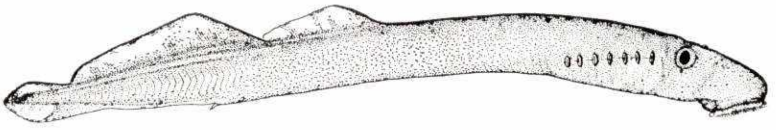
L. lamottei (8 inches, 203 mm)

L. richardsoni (6 inches, 154 mm)

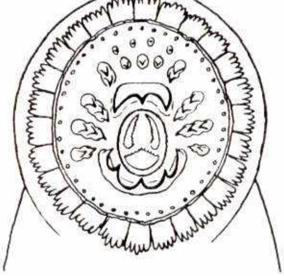
Petromyzon marinus (34 inches, 865 mm)

PACIFIC LAMPREY

Entosphenus tridentatus (Gairdner)



Description The parasitic Pacific lamprey is an elongate, almost cylindrical animal, round in cross section from head to dorsal fins, beyond this point gradually more laterally compressed. Usual length to 26.8 inches (680 mm). In transformed individuals the short, jawless head has a large, nearly circular, buccal funnel fringed with leathery, marginal appendages called fimbriae.



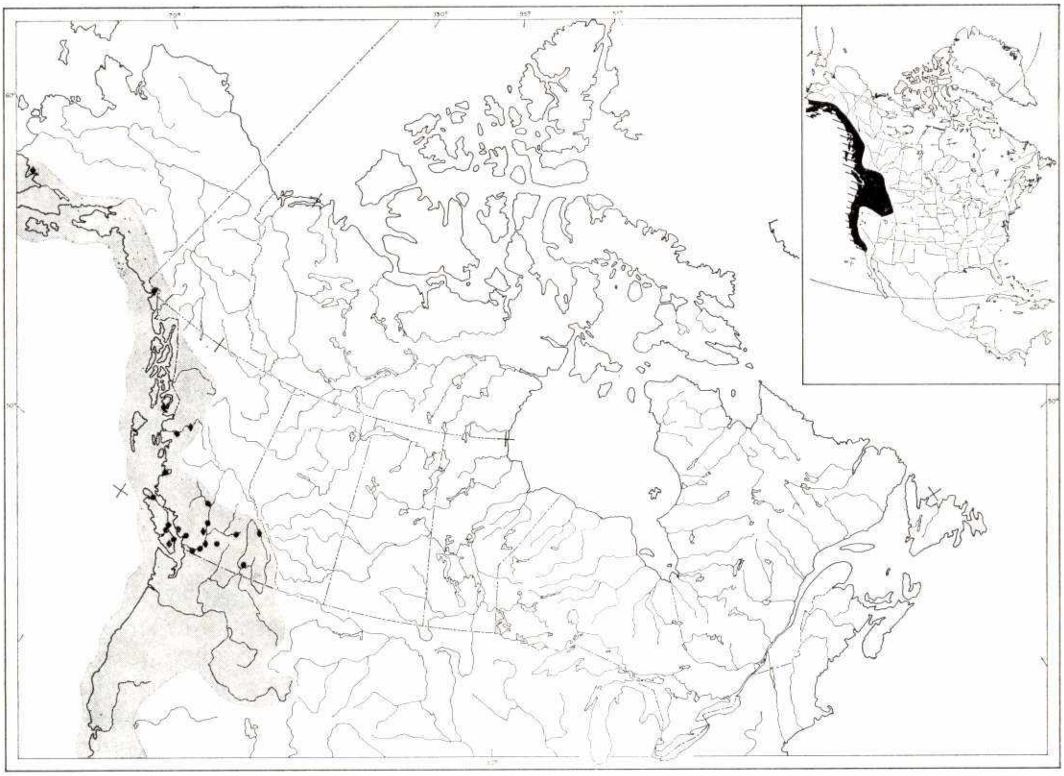
The inner part of the funnel around the mouth has many series of sharp teeth; supraoral lamina, or bar, of 3 large cusps, infraoral lamina with 5–8 cusps, 3 pairs of inner lateral teeth some tricuspid, scattered bicuspid and single teeth, and a ring of small, marginal teeth. The tongue is also armed with sharp teeth. Beyond the mouth there are 13–16 velar tentacles. The eyes are small and high, with a median, single nostril between and ahead, and 7 pairs rounded, lateral gill openings behind. Fins: dorsals 2, separated by complete cleft; first dorsal low, flat to rounded; second dorsal longer, higher, rounded to pointed; small, spade-shaped caudal confluent with second dorsal and anal; anal very low, inconspicuous; no paired fins or their skeletal supports. No scales or denticles, skin smooth and leathery; no lateral line but 58–74 vertical myomeres obvious externally, at least on small individuals. Skeleton cartilagineous throughout, no vertebrae, notochord persists.

Colour Overall colour of transformed adults blue-black to dark brown, lighter below, no pattern, burrowing ammocoetes paler. Teeth usually yellow to orange in life.

Systematic notes The populations were, at one time, split into two groups (Creaser and Hubbs 1922) as *E. t. tridentatus* Richardson, from Columbia River to Alaska, and *E. t. ciliatus* Ayres, from the Klamath River southward. This division on basis of myomere number no longer holds.

A major work, edited by Hardisty and Potter (*see Suggested Reading*), contained a paper by Hubbs and Potter that reduced *Entosphenus* to a subgenus of *Lampetra*.

Distribution Restricted to the Pacific coast and coastal islands of North America, from Unalaska Island (Aleutians) to Baja California. In Asia, at least as far south as the Yuhutu River, Hokkaido, Japan. Penetrating all major rivers, often to headwaters, including the Columbia River in British Columbia and the Fraser–Thompson up stream as far as Shuswap Lake. For detailed distribution in British Columbia *see* Carl et al. (1967). First recorded from Canada in 1891 (Clemens and Wilby 1961).



Biology The spawning migration from the sea of adult Pacific lamprey usually begins during the period July to September. These lampreys are not sexually mature at this time and spend from October to the following March hidden under stones. Feeding appears to cease during early stages of the upstream migration. Nest building and spawning take place from April to July (Pletcher 1963). The lampreys move up rivers and streams, sometimes several hundred miles, to the headwaters, where they spawn in sandy gravel at the upstream edge of riffles. Moderately strong swimming ability and capacity to cling to rocks, dams, and fishways by means of the suctorial disc, enable them to surmount most obstacles. The males may arrive first, and both sexes dig the shallow nest 21–23 inches (533–584 mm) in diameter with body movements and by moving stones with the suctorial disc. The female attaches to a rock and orients across the nest, the male carries out a type of prespawning courting called "gliding–feeling" by moving or rubbing along the body of the female posterior to anterior with slight contact of the disc. When the male reaches the head of the female he attaches to it, coils around the female, eggs and sperm are emitted together, the fertilized eggs fall to the nest, are adhesive for 2 hours and cling to stones in the nest. A pair observed for 5 hours deposited 100–500 eggs regularly every 2–5 minutes. In the interval they continued nest building, which covers the eggs. Mean calculated egg number is 34,000 but can go as high as 106,000 in a 16-inch (406-mm) female. Eggs are oval, 1.06–1.09 mm wide and 1.12–1.24 mm long (Pletcher 1963). Most eggs are laid over a period of 12 hours. Males spawn with more than one female in different nests (Pletcher 1963). The adults do not migrate downstream and usually die 1–14 days after spawning. In certain landlocked populations living adults were found as late as September (Carl 1953). Eggs hatch in

2–3 weeks (19 days at 59° F (15° C)) as ammocoetes have been seen as early as June 27 (Carl 1953).

The ammocoetes, pale brown in colour, with a fleshy, toothless, oral hood instead of a sucker disc, mere fin folds, and undeveloped eyes, burrow into the mud downstream from the nest. Here they spend a maximum of 5 or 6 years. At transformation the animal moves out of the burrow. The many features of the adult, which enable it to lead a parasitic life, have developed, and large numbers move downstream in late summer during flood conditions, eventually reaching the sea or a lake. Apparently large numbers of incompletely transformed individuals accompany the movement of fully transformed lampreys (Applegate and Brynildson 1952). There are landlocked populations over the whole of the range that metamorphose and remain in fresh water to prey on freshwater fishes throughout their adult life (Coots 1955). Dwarf races are known to occur in certain rivers (Carl et al. 1967). The greater percentage move down to the sea or to river estuaries where, in the spring and summer following downward migration, they begin a parasitic life and spend 12–20 months as parasites before migrating upstream to spawn. There are populations of landlocked, nonparasitic Pacific lampreys known in Oregon and California (Hubbs and Miller 1948).

Minute when hatched, ammocoetes grow to about 4 inches (101 mm) in the first year. Age–total length relation for Pacific lamprey ammocoetes in the Thompson and Nicola rivers was calculated by Pletcher (1963) to be as follows:

Age (*years*)	TL(*mm*)	
	Mean	Range
0	17.5	0.2–21
1	39.0	26–49
2	52.5	40–62
3	67.5	56–75
4	78.5	70–83
5	97.0	74–118

If ammocoete life is 5 or 6 years, then total life span is at least 7 years. They are usually about 4.8–12.0 inches (122–303 mm) at transformation, an average of 21.2 inches (537 mm) total length when migrating inward from the sea, and attain a maximum length of 27 inches (682 mm) (Carl et al. 1967). The landlocked populations apparently rarely exceed 8 inches (202 mm) in length (Carl 1953).

As an external parasite, the Pacific lamprey lives on the blood and fluids of fish and other marine vertebrates. By means of the suctorial disc and disc teeth they attach themselves, usually to the side or undersurface of fishes. The toothed tongue rasps through scales and skin, and the fluids are consumed. This type of feeding is facilitated by the production of an anticoagulating agent that prevents the host's blood from solidifying. When the disc is attached to a host, oxygen-bearing water is pumped both in and out through the gill openings.

The Pacific lamprey and other lampreys do not apparently have many predators; they appear only infrequently in the stomach contents of other animals. On rare occasions they have been found in the stomachs of fur seals and sperm whales, and may have been on a host fish when it was consumed by the whale (Pike 1951). Experiments (Pfeiffer and Pletcher 1964) indicated that their low incidence in the diet of salmonines may be the result of distasteful secretions of granular or club cells in the skin. Salmonines in captivity would eat skinned Pacific lampreys but not the isolated skin. The Pacific lamprey probably competes for food with the other Pacific coast parasitic lampreys *Lampetra ayresi* and *L. japonica*, as well as for suitable spawning grounds with these and *L. richardsoni*.

The incidence of parasites in Pacific lampreys is unusually low. At Lakelse Lake 6 out of 10 lampreys examined were infected by only two parasites, *Eustrongylides* sp. and *Phyllobothrium* sp., both of which occur in their hosts and from which they probably got them (Bangham and Adams 1954).

Relation to man This and other parasitic lampreys usually bear only an indirect relation to man as a result of the potential destruction of their hosts. Egocentric man considers this predation destructive only when the host is a species that he favours for food or sport. The only known use of this lamprey as food is that reported for British Columbia Indians who for centuries have used it smoked, sun-dried, or salted. Indians on the Skeena and Fraser rivers line salmon dipnets with finer webbing to scoop lampreys from the river's canyon wall. A few people, recently arrived from Europe, catch them at Alberni with hooks attached to long poles. The ammocoetes are used as bait by trout fishermen, and some commercial fishermen say they are the best bait for sturgeon in the Fraser River (Pletcher 1963). A small, commercial fishery for this species took place, after 1941, at the falls of the Willamette River in Oregon. For some years 200 tons were taken annually for reduction (Pike 1953).

It is known that the landlocked population in Cowichan Lake, B.C., was considerable, that as many as three lampreys were found on one trout, and that 8 out of 10 game fish bore fresh or old scars (Carl 1953). A survey of predation on Pacific salmon showed it varied between species, more important for sockeye than for pinks. Williams and Gilhousen (1968) calculated that, for one particular stock of sockeye (Adams River) seen at the Fraser River mouth, as a consequence of predation of Pacific lamprey, 1.8% of the whole population and 37% of those most severely wounded by lampreys would die during upstream migration. As high as 76% of the rainbow trout in impounded Elsie Lake near Alberni showed scars of this lamprey (Pletcher 1963). There is no way of calculating the destruction of fishes by this lamprey in the open ocean. Marks of the teeth and disc of this species have been found on 25–89% of finback, sei, blue, humpback, and sperm whales examined off the coast of British Columbia (Pike 1951). Some scars showed obvious parasitism, others may indicate only transport of the lamprey by the host. In the western Pacific it was found that, for pink salmon in the Amur estuary, 21–44% of the fish examined were scarred by this species of lamprey. There were as many as five marks on 4.6% of the pinks. In coho salmon, 20% had marks of parasitism by Pacific lamprey (Birman 1950).

Nomenclature

Petromyzon tridentatus	— Gairdner (MS) *in* Richardson 1836: 293 (type locality Falls of Walamet, now Willamette, Oregon)
Lampetra tridentata	— Green 1891: 32
Entosphenus tridentatus tridentatus	— Creaser and Hubbs 1922: 10
Entosphenus tridentatus (Richardson)	— Vladykov and Follett 1958: 47
Lampetra tridentata (Gairdner)	— Scott and Crossman 1967: 3

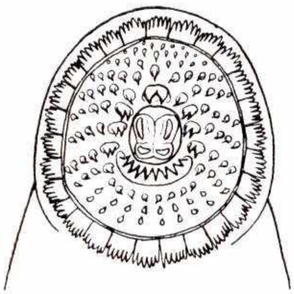
Etymology *Entosphenus* — within wedge, after the wedge-shaped tongue tooth; *tridentatus* — three-toothed, since many of the teeth have 3 cusps.

Common Names Pacific lamprey, sea lamprey, three-toothed lamprey, tridentate lamprey. French common name: *lamproie du Pacifique.*

CHESTNUT LAMPREY

Ichthyomyzon castaneus Girard

Description The chestnut lamprey is a small, parasitic lamprey with a cylindrical body to the dorsal fins where it becomes laterally compressed. In mature males the body is deeper over the whole length than that of immature lampreys. In the branchial region the body of the mature male is deeper and greater in cross section than even the mature female. The mature female differs from the immature largely in the swelling of the egg-filled abdominal section of the body (Hall 1963). Usual length to 14.9 inches (380 mm). In transformed individuals, the short head terminates in a circular, buccal funnel fringed with fimbriae. Oral disc not noticeably greater in diameter than branchial area, length equal to 5–9% of total length.

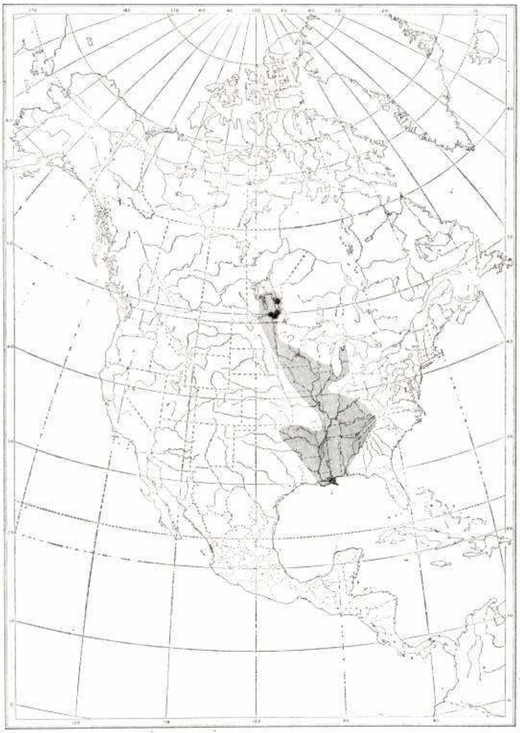


The inner surface of funnel is armed with many, strong, slender, sharp, curved teeth; supraoral lamina a single, bicuspid or tricuspid tooth; infraoral lamina a broad, curved bar with 6–11 sharp cusps; inner lateral (or circumoral) teeth 4, usually bicuspid sometimes tricuspid; several rows of unicuspid anterial (or maxillary labial) teeth; several rows of smaller, unicuspid posterial (or mandibular labial) teeth; marginal ring not obvious. Tongue teeth on paired plates, sharp but not large. Eyes small, high, with single median nostril ahead, 7 pairs of lateral gill openings behind. Fins: first and second dorsals connected, very shallow notch between, referred to as single dorsal, first dorsal lower, flat to rounded, very little distinction in height of first dorsal and second dorsal in mature males, second dorsal higher shallow curve, second dorsal connected to short, round caudal; "anal fin swelling" of the mature male is as prominent as, or more prominent than, that of the mature female; no paired fins or supports. No scales, skin smooth, leathery; no lateral line in usual position but 51–54 trunk myomeres in adults. No vertebrae, skeleton cartilagineous, notochord persists.

Colour The specific name refers to chestnut colour but more usually the adults are dark grey to olive (Cross 1967) or yellow-brown above and lighter below; no obvious pattern. Adults become blue-black at spawning time. The ammocoetes are generally paler.

Systematic notes This species was long grouped by many authors with the silver lamprey, *I. unicuspis* of which it is a probable derivative. This was largely the result of working with material from south of the Great Lakes where the two occur together and where they may intergrade to a slight degree. The southern brook lamprey, *I. gagei*, is looked upon as a dwarf, degenerative derivative of *I. castaneus*, as *I. fossor* is of *I. unicuspis*.

Distribution Restricted to central North America. Southeast from west-central Manitoba, south of the Great Lakes to western Michigan, through the eastern parts of the state, from North Dakota to Texas and Louisiana. North in the Alabama system of Mississippi and Alabama, west to a line through central Illinois and then east to Michigan.



In Canada it is known from Manitoba only, from lakes Manitoba and Winnipeg and the Red and Assiniboine rivers (Keleher and Kooyman 1957). In the area south of the Great Lakes it overlaps the distribution of *Ichthyomyzon unicuspis*, but the two species are separated in Manitoba.

Ernest Seton Thompson's 1898 record of this species from the Assiniboine River at Portage la Prairie is probably the earliest Canadian record.

Biology This largely stream-living lamprey spawns in rivers from early to mid-June but possibly as late as early July. The peak of activity is in mid-June. Almost nothing is available on the spawning activity of the chestnut lamprey. Hall (1963) reported seeing, during a single night, 8–10 spawners on one nest in 2 feet of moderately swift water, well hidden under a log. Nest building and spawning would seem to take place at night. The adults die soon after egg laying is completed.

Ammocoetes of the chestnut lamprey, unlike other species, apparently prefer areas of moderate current, stable bottom of sand and silt with light growth of *Chara*. Larger ammocoetes found in quiet backwater areas of black muck and silt were only in areas where rooted vegetation was dense.

The length of ammocoete life is unknown but presumed to be 5–7 years. Metamorphosis or transformation begins in August or September of their final ammocoete year at a total length of 3.6–4.0 inches (90–100 mm) and is completed in January. They may be briefly parasitic that fall. The adults are inactive over the winter and commence active predatory feeding the following spring. Adults in the Manistee River in June ranged from 3.3 to 5.9 inches (84–150 mm) total length. In March the adults varied from 3.3 to 4.7 inches (83–119 mm) total length with an average of 4.1 inches (105 mm). In October of that same year adult size ranged from 4.7 to 8.3 inches (120–212 mm) total length with the average at 6.8 inches (172 mm) total length. Maximum size appears to be less than 12 inches (305 mm) total length.

Adults are predaceous in streams from April to October but the greatest feeding activity is in July. The adults are inactive once more the following winter during commencement of sexual maturity. They mate, spawn, and die in June or July of the following year. The adult life span is a maximum of 18 months. At one time or another in any calendar year there may be three year-classes of adults present in a stream.

The habitat of the ammocoetes differs from that of the sea lamprey and other lampreys in that the ammocoetes of this species prefer firmer bottom in swifter water, or softer bottom and denser vegetation. Adult chestnut lampreys appear to inhabit the main course of moderate-sized rivers and are not found in the smaller tributaries. Marked lampreys in Michigan moved up and downstream 12 and 24 miles but did not move into lakes.

Food of filter-feeding ammocoetes of the chestnut lamprey is the minute invertebrates, and possibly plants, common to all lampreys. Desmids, diatoms, and protozoans predominate. The predaceous adults attack a wide range of stream fishes and, like other predaceous lampreys, rasp into the flesh, consuming body fluid and muscles. Size of prey alone seems to limit choice. Those fishes reported by Hall (1960) as attacked by this species were as follows: brook trout, brown trout, rainbow trout, northern pike, chain pickerel, carp, creek chub, white sucker, smallmouth buffalo, channel catfish, burbot, green sunfish, largemouth bass, and smallmouth bass.

The ammocoetes probably compete for their invertebrate food with the young of all stream fishes and, in Canada, possibly with ammocoetes of the silver lamprey, *I. unicuspis*, the only other lamprey that occurs with it. Similarly, the adults may compete with the silver lamprey for hosts although their adult habitat usually separates these two species.

The chestnut lamprey is often preyed on by such fishes as trouts, especially brown trout. The ammocoetes have been reported as the bulk of the diet of the burbot, at times.

Relation to man No records were seen of the use by man of this smaller species as food or of the ammocoetes as bait for other fishes.

The indirect relation to man, their parasitism of economically important species, is possibly negligible in Canada. This species is not abundant even where it occurs, and is only of moderate size. The wounds are shallow and it is unlikely they cause mortality in larger fishes.

Its habitat in middle-size streams and its size preclude it doing any significant harm to commercial fishes. It is relatively less lethal than the sea lamprey and the silver lamprey but in some areas it definitely destroys trout by its feeding. In a study in Michigan, 18–19% of the trout in a stream, and up to 35% creel census, had been attacked by one or more lampreys. Larger fish survived attacks except those of the most prolonged period. Maximum time of attachment noted by Hall (1960) was 18.3 days and this killed the host trout, and attacks of 5 days' duration killed small trout. The smallest fish scarred was 6.2 inches (157 mm) long. A prey over 200 grams weight died only after 40 hours of parasite feeding under experimental conditions. Hall estimated that an 80-gram lamprey killed 130 grams of fish for each gram of lamprey growth and that, at this rate, populations of chestnut lampreys were a significant mortality factor in stream sport fish populations.

Nomenclature

Ichthyomyzon castaneus — Girard 1859: 381 (type locality Galena, Minn.)
Ichthyomyzon argenteus — Nelson 1876: 52
Ichthyomyzon concolor — Halkett 1913: 11
Ichthyomyzon bdellium (Jordan) — Huntsman 1917: 25

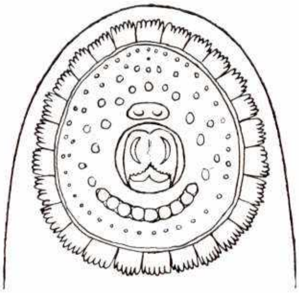
Etymology *Ichthyomyzon* — sucker of fish; *castaneus* — a chestnut, from chestnut colour.

Common names Chestnut lamprey, northern lamprey, western lamprey, silver lamprey, lamprey eel, river lamprey. French common name: *lamproie brune*.

NORTHERN BROOK LAMPREY

Ichthyomyzon fossor Reighard and Cummins

Description A small, nonparasitic, cylindrical lamprey with some lateral compression from the dorsal fins to tail. Usual length to 5.9 inches (150 mm). The short, jawless head, in adults, terminates in a buccal funnel that is always narrower than the width of the body at the gill openings. The buccal fimbrae are vestigial.



All teeth in the buccal funnel are small, blunt, and peglike. The supraoral lamina is a single, bicuspid tooth; the infraoral lamina has 6–11 blunt cusps; there are 4 pairs of single, unicuspid inner lateral (or circumoral) teeth. The rest of the funnel is varyingly filled with radiating rows of unicuspid, anterial, and posterial teeth, no obvious ring of small marginal teeth. Mouth small. On the tongue, the transverse lamina is bilobed, the longitudinal lamina is weakly developed and all lingual teeth are minute. The eyes are small (1.4–1.5% of total length) and high, with a single, median nostril ahead and 7 pairs of gill openings lateral and behind. Fins: first and second dorsals joined, referred to as a single dorsal fin, notched to varying extent but notch never reaching the back; second dorsal higher, connected to broadly oval caudal; anal visible in mature males, more prominent in mature females, otherwise absent, but when apparent, obviously joined to caudal; no paired fins or their supports. No scales, skin smooth, leathery, no prominent lateral line in normal midlateral position, trunk myomeres 51–58. No vertebrae, skeleton cartilagineous (Vladykov (1949a; Hubbs and Trautman 1937).

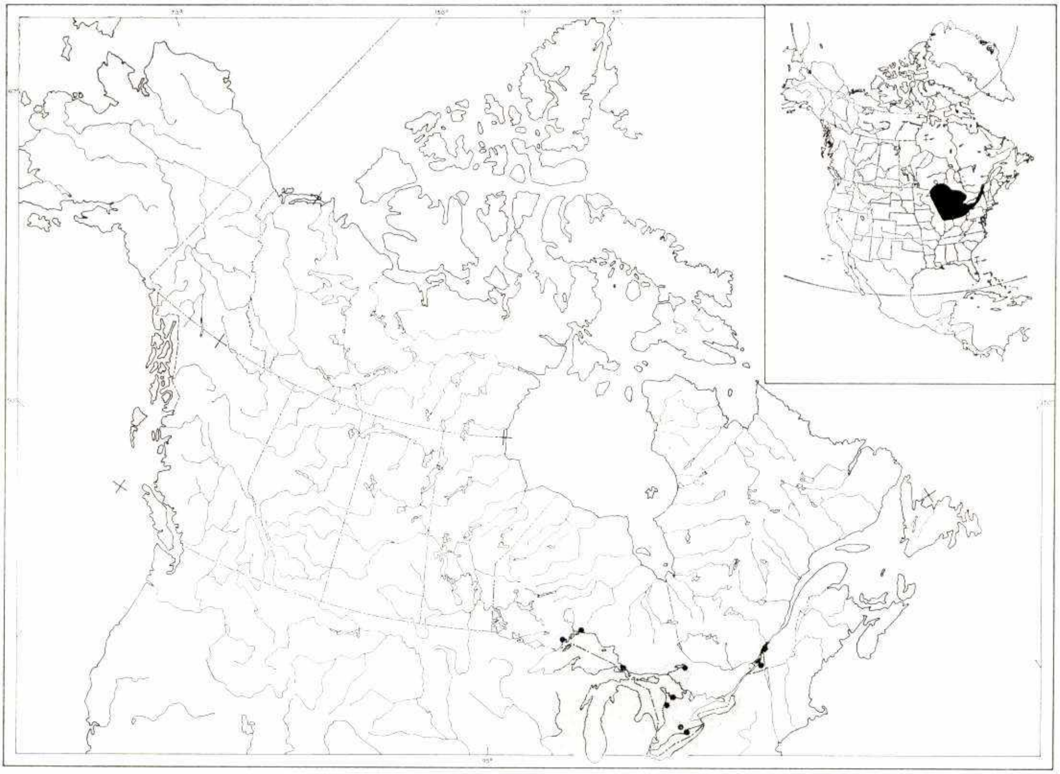
Colour Adults dark grey to brown on back and sides, lower parts grey or silvery white, ventral surface near pharynx often orange or silver, the posterior part of the tail, not caudal fin, dark grey to black, dorsal fin base tan; iris of eye bluish (Vladykov 1949a).

Systematic notes Hubbs and Trautman, in their 1937 revision of the genus *Ichthyomyzon*, considered *I. fossor* to be a degenerative, nonparasitic, brook form, derived from the larger, parasitic form *I. unicuspis*, the silver lamprey. *See Nomenclature* for problems in the synonymy of this species.

Distribution In general, this species occurs in the Mississippi and Great Lakes basins from western New York, Quebec, Ontario, Michigan, and eastern Wisconsin; from the north shore of Lake Superior to northern Indiana and Ohio. Nowhere is it known to be particularly abundant.

Its distribution in Canada extends from the Yamaska and St. Francis rivers of southern Quebec to the Thames River system, Georgian Bay, Lake Nipissing, and the north shore tributaries of Lake Superior.

Biology In Canadian waters, the northern brook lamprey spawns in the month of May or June when water temperatures are 55°–60° F (12.8°–15.6° C) (Vladykov 1949a). There is no conspicuous spawning migration of large numbers of adults (Leach 1940). Spawning takes place in streams and small rivers, on a bottom of coarse gravel, shingle, and stones 1–6 inches (25–152 mm)



in diameter. All spawners are usually in a restricted area, not randomly distributed. The lampreys take up positions in water 8–18 inches (203–457 mm) deep in chinks beneath the larger stones, enlarging the cavities by removing gravel with their suctorial funnel and the sand by vigorous activity of the body. This species makes extensive use of its sucker to move stones during nest preparation. At times a nest 3–4 inches (76–102 mm) in diameter and a maximum of 4 inches (102 mm) deep is excavated in sand or mud but no spawning was ever seen to take place in such a nest. During nest building the body of this species is generally oriented vertically rather than horizontally as in many other species. In the cavity under the rocks, the male attaches to the female, approximates the vent but does not entwine the female, and spawning is accompanied by a vigorous vibration of the two animals (Reighard and Cummins 1916). A few days (Leach 1940) after egg laying is completed, the adults die. Egg size is reported to be about 1.0–1.2 mm in diameter and this species is said to have an average of 1200 eggs (Vladykov 1949a). The eggs, which develop in a gluelike mass, hatch in 2–4 weeks (Leach 1940), and the ammocoetes dig a U-shaped burrow into areas of silt and sand in eddies (Reighard and Cummins 1916).

Length of ammocoete life is, in all lampreys, difficult to determine with assurance, as age must be assumed from length frequency alone. The following age–length relation was recorded for Michigan (Okkelberg 1922; Carlander 1950a):

Age (*years*)	TL(*mm*) Mean	Range
3 months	20	10–30
1	50	35–60
2	65	60–70
3	75	70–80
4	85	80–90
5	95	90–100
6	110	100–120

Allowing for variability, it is assumed that the ammocoete stage of this species lasts from 5 to 7 years depending on location and food. Ammocoetes as large as 6 inches (152 mm) were taken in Indiana (Leach 1940).

Transformation takes place in individuals 4.7–5.9 inches (120–150 mm) in length, but as few as one-third of the ammocoetes of the same year-class transform at the same time. Some transform a year later, remaining in a full-grown, resting period over that time. Time of onset of a 2–3-month period of transformation is from August to mid-September. During transformation sexual development begins, the oral hood becomes a toothed, buccal funnel, the intestine becomes degenerate and functionless, the eyes become much better developed, and length decreases. Much of this takes place while the ammocoete is still in the burrow. The many changes accompanying metamorphosis were well described by Leach in 1940. As transformation proceeds, the animal leaves its burrow more and more. From January on, the nonfeeding adults retreat to burrows only to hide. Transformation is complete by February, and full sexual maturity is attained in May, just before spawning time.

The habitat of this species is creeks and small rivers. It apparently avoids both small brooks and large rivers, and is never taken in lakes or ponds (Leach 1940). The creeks are usually warmer than those suitable for brook trout (Vladykov 1949a).

In this nonparasitic species the adults, and possibly the larger ammocoetes in the resting stage, do not feed. The intestine is nonfunctional. The midsummer food of ammocoetes of most lampreys consists of diatoms, desmids, protozoans, green algae, detritus, and pollen (Creaser and Hann 1929) and they can survive long periods of starvation (Moffett 1966).

Since the ammocoetes are used as bait it would seem logical that larger ammocoetes, once out of the burrow, and adults are probably preyed on by a number of stream fishes. The only record of a predator, however, is the rock bass (Hubbs and Trautman 1937). Lowering of water level is probably a significant ammocoete mortality factor.

Relation to man Since this species is not parasitic it does not have the indirect effect of endangering or destroying fishes. There appear to be no published records of the use by man of this very small lamprey for food. In Quebec, the larger ammocoetes are sold to anglers as bait.

Nomenclature

Ichthyomyzon fossor	— Reighard and Cummins 1916: 1 (type locality Michigan)
Ammocoetes unicolor	— DeKay 1842: 381
Ammocoetes borealis	— Agassiz 1850: 252
Ichthyomyzon (*Reighardina*) *unicolor* DeKay	— Creaser and Hubbs 1922: 8
Reighardina unicolor (DeKay)	— Jordan, Evermann, and Clark 1930: 9

The synonymy of this species is perplexing. There is considerable confusion involved in uses of the names *unicolor* and *concolor* prior to the revision in 1937 of the genus *Ichthyomyzon* by Hubbs and Trautman. Many of the records were based on unidentifiable ammocoetes and many published records under these names probably refer to more than one species. Records of *unicolor* were often treated by different authors as synonyms of different species. Synonyms given here are those usually attributed to *fossor* but *A. borealis* of Agassiz could just as easily be *I. unicuspis*.

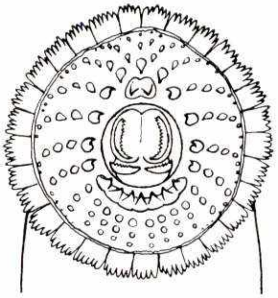
Etymology *Ichthyomyzon* — to suck fish, based on the parasitic feeding habit; *fossor* — a digger.

Common names Northern brook lamprey, Michigan brook lamprey, brook lamprey, blood sucker. French common name: *lamproie du nord*.

SILVER LAMPREY

Ichthyomyzon unicuspis Hubbs and Trautman

Description A moderately large, parasitic, freshwater lamprey, somewhat more laterally compressed than other species. Usual length to 12.9 inches (328 mm). The head is somewhat longer, eyes moderately large (1.8–2.3% of total length); single, median nostril ahead; 7 pairs of gill openings behind; sucking disc definitely greater in diameter than branchial area (9.1–11.4% of total length).



Buccal funnel fringed with fimbriae and well armed with long, curved, sharp teeth; supraoral lamina usually a single, large bicuspid tooth; infraoral lamina rather short with 5–11 short, sharp teeth; inner laterals (or circumorals) 4, unicuspid, not separated nor differentiated, except larger, from other radiating lateral teeth; anterials (or maxillary labials) radiating rows of sharp, unicuspid teeth fill the area, as do the posterials (or mandibular labials) which are smaller; marginal ring inconspicuous. Teeth on tongue small, transverse lamina bilobed with about 35 cusps; longitudinal lamina 2, with 33–40 cusps on each. Fins: dorsals 2, first and second dorsals joined, cleft between them not deep, referred to as a single fin, second dorsal higher, not highly pointed even in mature females; second dorsal connected to rounded caudal; anal not well developed in either sex; no paired fins or supports. No scales, skin smooth, leathery; no lateral line in usual position; trunk myomeres broad and 47–55 in adults, 50–53 in ammocoetes. No vertebrae, skeleton cartilagineous (Vladykov 1949a; Hubbs and Trautman 1937).

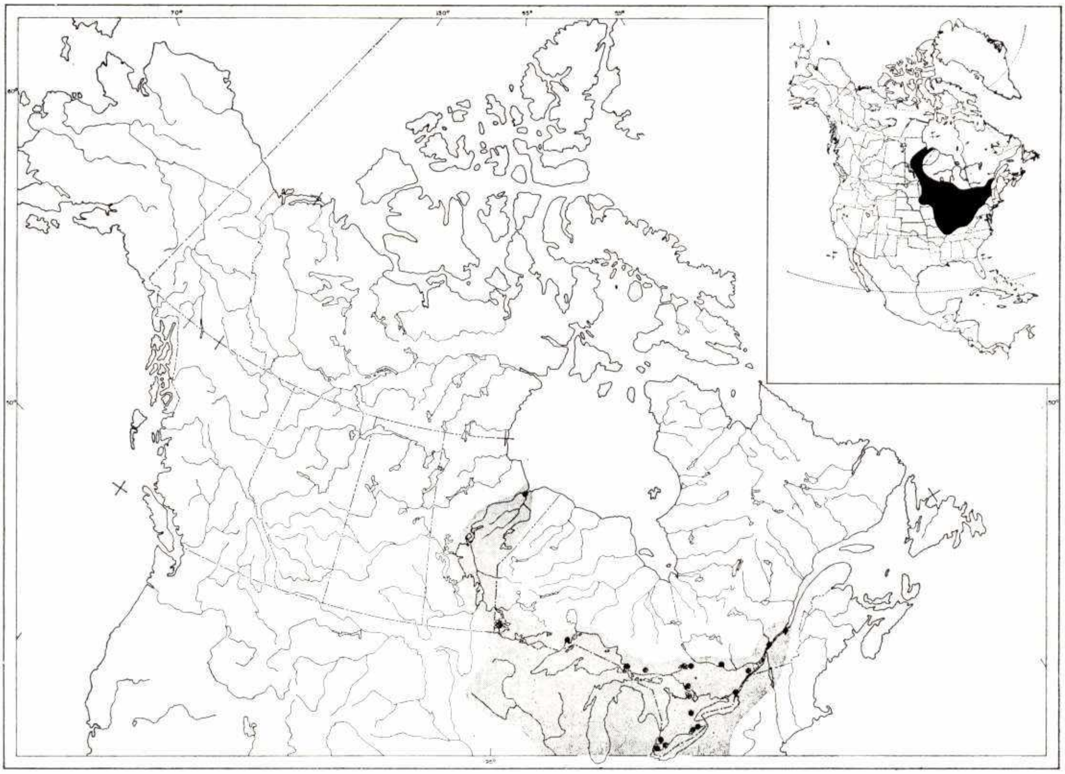
Colour In adults the dorsal surface and upper sides range from brown through silver-grey to blue, shading to lighter blue-grey or silver below. Silver colouration not usually apparent in Quebec. Transformed individuals up to 6.7 inches (170 mm) are without grey or silver pigment and are light yellow to tan below, darker above. Ammocoetes generally paler in colour.

Distribution Restricted to eastern North America, from the St. Lawrence River as far down as Montmagny, Que., west through all the Great Lakes, through the upper Mississippi valley from Wisconsin, to eastern Manitoba; from Manitoba tributaries of Hudson Bay (Nelson River) in the north to the Ohio River basin as far south as Kentucky (Hubbs and Lagler 1964).

Specific localities in Canada other than those mentioned above are Lake Champlain, Lake Ontario (rare), Lake of the Woods, Lake Nipissing (Scott 1967), Nelson and Hayes rivers in Manitoba.

Small's 1883 record of this species, as *Ichthyomyzon Argenteus*, from the Ottawa district, is probably the first record from a truly Canadian locality. Earlier records simply list various Great Lakes.

Biology This species spawns in the St. Francis River, a tributary of the St. Lawrence near Pierville, Que., in May and June. Adults ascend larger rivers where they construct shallow nests in gravelly riffles by transporting stones in the mouth and by sweeping away sand and silt by vigorously lashing the tail. The male attaches to the head of the female, coils around her so as to



approximate the anus; eggs and sperm are released simultaneously during a rapid vibration of the bodies of the mating pair. After spawning all adult silver lampreys die. Egg size is approximately 1 mm diameter. Egg number averages 10,800 (Vladykov 1949a). The eggs hatch in a few weeks and the ammocoetes burrow into the mud and silt of the margins of the river. Here they live 4–7 years. Metamorphosis probably begins in ammocoetes about 3 inches (76 mm) long, in late fall. Transformation is completed in the early spring, as recently transformed individuals found in May were 3.5–4.3 inches (89–110 mm) in length and weighed 1–2 grams. In this parasitic species, increase in eye size and development of the sharp teeth and a functional intestine, take place during transformation. After transformation the lampreys migrate downstream to a lake. Life span of the adult is probably 12–20 months depending on growth and maturation of eggs. During this period they parasitize lake fishes. Growth of transformed, parasitic individuals from May to November has been given as an increase from 4.3 to 10.0 inches (107–255 mm) and 2.5 to 42.0 grams.

This species may feed over the winter of its parasitic year as well, since maximum size at spawning in Canada appears to be 12.5 inches (318 mm) for females and 11.3 inches (288 mm) for males (Vladykov and Roy 1948) and 12.9 inches (328 mm) in the United States (Hubbs and Trautman 1937). It is stated, however, that length and weight decrease and the intestine becomes progressively less functional as the eggs develop during the winter before spawning occurs.

The silver lamprey inhabits larger rivers and lakes, migrating farther upstream than the chestnut lamprey, *I. castaneus*, in areas where the two occur together. They do not utilize the smaller streams inhabited by the brook lampreys. All species of the genus *Ichthyomyzon* are intolerant of salt water.

Their low abundance in Lake Ontario and greater abundance in the upper Great Lakes may be the result of the long presence of the sea lamprey, *Petromyzon marinus*, in Lake Ontario and the inability of the silver lamprey to succeed in its presence. The nonparasitic northern brook lamprey, *I. fossor*, is believed to be a degenerate derivative of the silver lamprey.

The burrowing ammocoetes are filter feeders who feed on microscopic plants and animals such as algae, pollen, diatoms, and protozoans. The parasitic adults probably feed on a wide range of lake fishes. Scars of this species were noted on 11 species of fishes in Quebec (Vladykov and Roy 1948) including the lake sturgeon, Atlantic sturgeon, and the longnose gar (Bensley 1915). Other species they have been reported to attack are: paddlefish, lake trout, rainbow trout, lake whitefish, northern pike, white sucker, black buffalo, brown bullhead, rock bass, and walleye (Hubbs and Trautman 1937).

The ammocoetes and smaller adults are doubtless preyed on by a variety of stream fishes as they are used as bait for sport fish. Where the silver lamprey and the chestnut lamprey occur together in the United States, they probably compete both for spawning grounds and for food. Stream size, temperature selection, and the apparent absence of *I. castaneus* from lakes, may negate this.

Relation to man This species has obviously been used as food, as the literature refers to material caught in Lake Erie seen in various fish markets (Hubbs and Trautman 1937).

The indirect relation as a result of its predation on economically important commercial and sport fishes is not so significant as that of the sea lamprey. The silver lamprey is smaller, the wound usually shallower and smaller, and it is doubtful that a single lamprey would bring about the death of any large, heavily scaled fish that it might attack. On naked species such as burbot and catfish they often penetrate the body wall and kill the individual.

The ammocoetes may be sold as bait for sport fish.

Nomenclature

Ichthyomyzon unicuspis	— Hubbs and Trautman 1937: 53 (type locality Toledo, Ohio)
Petromyzon argenteus	— Kirtland 1841b: 343
Ammocoetes concolor	— Kirtland 1841b: 473
Ammocoetes borealis	— Agassiz 1850: 252
Petromyzon	— Fortin 1864: 71
Petromyzon hirudo	— Jordan and Copeland 1876: 161
Ichthyomyzon castaneus	— Provancher 1876: 262
Ammocoetes hirudo	— Jordan 1878a: 120
Ammocoetes argenteus	— Jordan 1878a: 120
Lampetra fluriatitis	— Ward 1878: 222
Petromyzon nigricans	— Ward 1878: 222
Ichthyomyzon Argenteus	— Small 1883: 47
Petromyzon concolor	— Jordan and Fordice 1886: 282
Ichthyomyzon concolor	— Cox 1897: 9
Ichthyomyzon bdellium	— Huntsman 1917: 24

Most authors prior to 1937 were using Kirtland's name *concolor*, which was based on unidentifiable ammocoetes. Other names in use up to 1933, as recorded here, are names actually attributable to other forms of North American lampreys, but used by various authors in records that Hubbs and Trautman in 1937 considered, for various reasons, were of the silver lamprey.

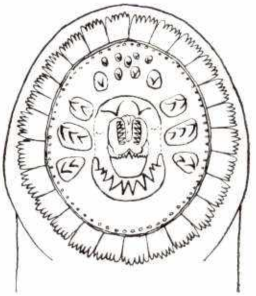
Etymology *Ichthyomyzon* — sucker of fish; *unicuspis* — characteristic single cusps of the inner lateral or circumoral teeth.

Common names Silver lamprey, northern lamprey, brook lamprey, lamprey eel, lamper eel. French common name: *lamproie argentée.*

RIVER LAMPREY

Lampetra ayresi (Günther)

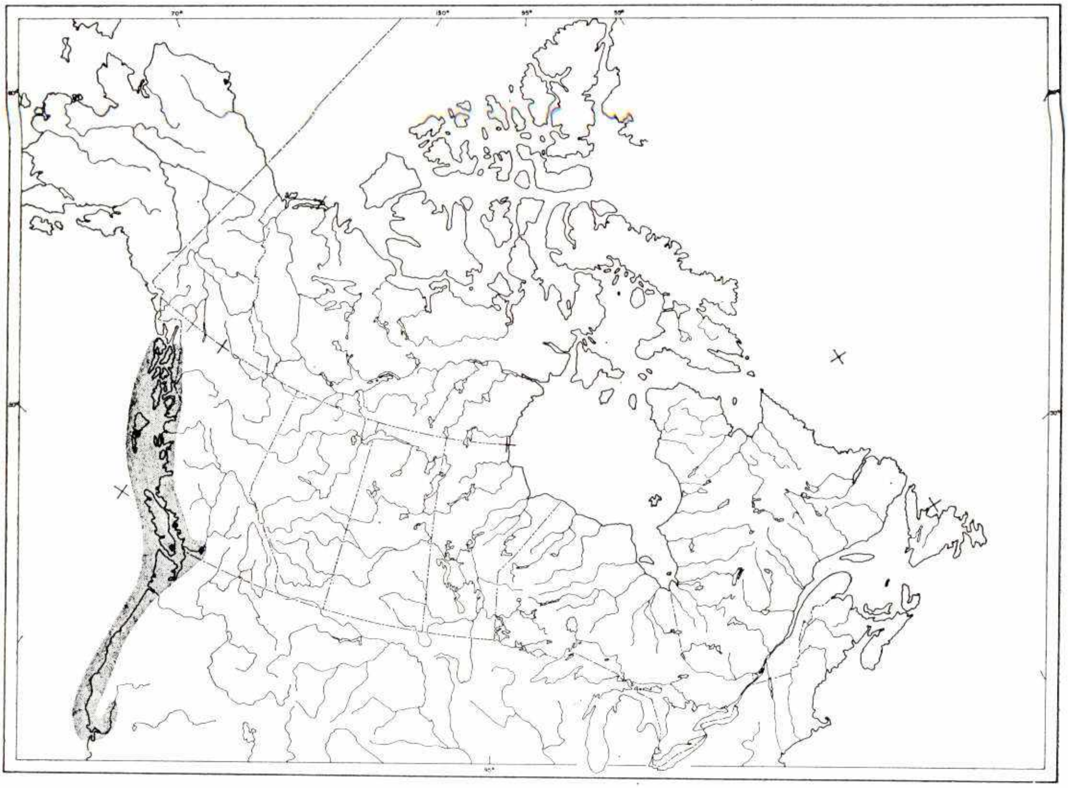
Description The parasitic river lamprey is elongate, nearly cylindrical to the dorsal fins where it becomes laterally compressed. Usual length to 12.2 inches (311 mm). In transformed individuals the short, jawless head has a turned-down buccal funnel edged with leathery fimbriae.



In feeding adults the teeth, which are hooked and sharp, consist of a supraoral lamina of 2 lateral cusps, each usually a single cusp but both sometimes bicuspid; infraoral lamina of 7–10 cusps, at each end often bicuspid; 3 pairs of inner lateral teeth, the centre pair tricuspid, the others usually bicuspid; many scattered, anterial (or maxillary labial) teeth, no posterial (or mandibular labial) teeth; a ring of small, marginal teeth present. On the tongue there are 12–17 transverse cusps, the median cusp much enlarged; and 19–22 longitudinal cusps. Beyond the mouth there are 5 or 6 velar tentacles. The eyes are moderately large and central in adults, with a single, median nostril ahead and 7 pairs of lateral gill openings behind. Fins: dorsals 2, separate but touching, second dorsal higher than first dorsal with pointed apex forward, second dorsal somewhat pointed to flat; pointed caudal forming an acute angle at apex, conspicuously joined to second dorsal and to anal; anal a mere ribbon in males but obvious in spawning females. No paired fins or their skeletal supports. No scales, skin smooth and leathery; no lateral line in usual position, trunk myomeres 60–71 in adults and 65–71 in ammocoetes. No vertebrae, skeleton cartilagineous (Vladykov and Follett 1958).

Colour Body dark brown to lead-grey on top and upper sides, silvery around head, gill openings, and lower sides, white on the undersurface. In ammocoetes most of the head is unpigmented, the bulb and ridge of the precursor of the tongue white and without pigment. In both ammocoetes and adults there is a prominent, symmetrical, dark spot on the posterior three-quarters of the tail, hence the French common name, which translated means "blacktailed lamprey" (Vladykov and Follett 1958).

Systematic notes This species, like *L. richardsoni*, was for a long time confused



with a superficially similar European brook lamprey, *L. fluviatilis* (Linnaeus). It was originally described as *Petromyzon plumbeus* by Ayres, but Günther realized *plumbeus* had already been used for a European lamprey, and substituted *ayresii*. This name was later relegated to the synonymy of another European lamprey, *L. fluviatilis*, until re-examination by Vladykov and Follett in 1958 showed that the river lamprey was a distinct form restricted to the Pacific coast of North America and Günther's name for it was revived.

Distribution Restricted to the Pacific coast of North America, from the Sacramento River, Calif., to Tee Harbour near Juneau, Alaska. In fresh and salt water. Probably uncommon in British Columbia although more abundant to the south.

The first record of this species in Canadian waters was a specimen taken in 1942 off Discovery Island, B.C. (Clemens and Wilby 1961).

Biology Very little is known of the life history of this lamprey, and what follows is mainly from Vladykov and Follett (1958). They are parasitic and anadromous. They ascend southern rivers considerable distances (Sacramento River as high as Mill Creek, Tahama County) to spawn. They probably spawn in gravel, with an activity similar to that given for the arctic lamprey, from the end of April through May in California. Egg number in two specimens, 6.9 and 9.0 inches (175 and 230 mm) weighing 20.2 and 24.0 grams, was estimated at 37,288 and 11,398. The eggs were 0.7 and 0.6 mm in diameter. Ammocoetes doubtless burrow into the mud where they live for an unknown period. Transformation is known to have taken place in specimens as small as 4.6 inches and 4.8 inches (117 and 122 mm). A specimen 6.4

inches (162 mm) was found on a fish, indicating that parasitism takes place at least by that size. Transformed lampreys migrate to the sea, are predatory for an unknown period of time and then return to fresh water to spawn. Maximum size is not known but adult females to 12.2 inches (311 mm) and males to 11.1 inches (281 mm) have been taken.

The ammocoetes, as in other lampreys, doubtless feed on microscopic plants and animals. Adults probably prey on a wide variety of fishes. They have been reported as attacking coho salmon (Withler 1955) as small as 3.6 inches (92 mm) in length, and kokanee. The river lamprey is probably preyed on by a number of fishes and birds. The only literature record seen for predators is one that stated that a river lamprey was found in the gullet of a lingcod.

The river lamprey was long referred to as *L. fluviatilis* and thought to be the same as those of rivers of western Europe. Vladykov and Follett (1958) demonstrated the differences between these two and the need to revert to the name *L. ayresi* for western North America.

No definite records of the parasites of this species are available. Those listed for *L. fluviatilis* in 1968 by Ronald and Wilson are doubtless for the European form and not this species.

Relation to man As with most other lampreys, the relation of this species to man is indirect. These lampreys are small, probably never exceeding 13 inches (330 mm). Reports of parasitism are sparse and it seems likely parasitism is of little consequence to economically important fishes. No records of their capture for food are known.

Nomenclature

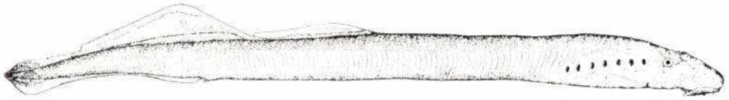
Petromyzon ayresii	— Günther 1870: 505 (type locality British Columbia)
Petromyzon plumbeus	— Ayres 1855: 28
Lampetra cibaria (Girard)	— Jordan and Evermann 1896–1900: 13
Lampetra ayresii (Günther)	— Jordan, Evermann, and Clark 1930: 10
Lampetra fluviatilis (Linné)	— Berg 1931: 112
Lampetra ayresi (Günther)	— Carl, Clemens, and Lindsey 1967: 29

Etymology *Lampetra* — a sucker of stone; *ayresi* — after W. O. Ayres who first described the species from California.

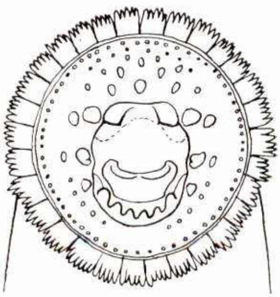
Common names River lamprey, western lamprey, western brook lamprey, parasitic river lamprey. French common name: *lamproie à queue noir.*

ARCTIC LAMPREY

Lampetra japonica (Martens)



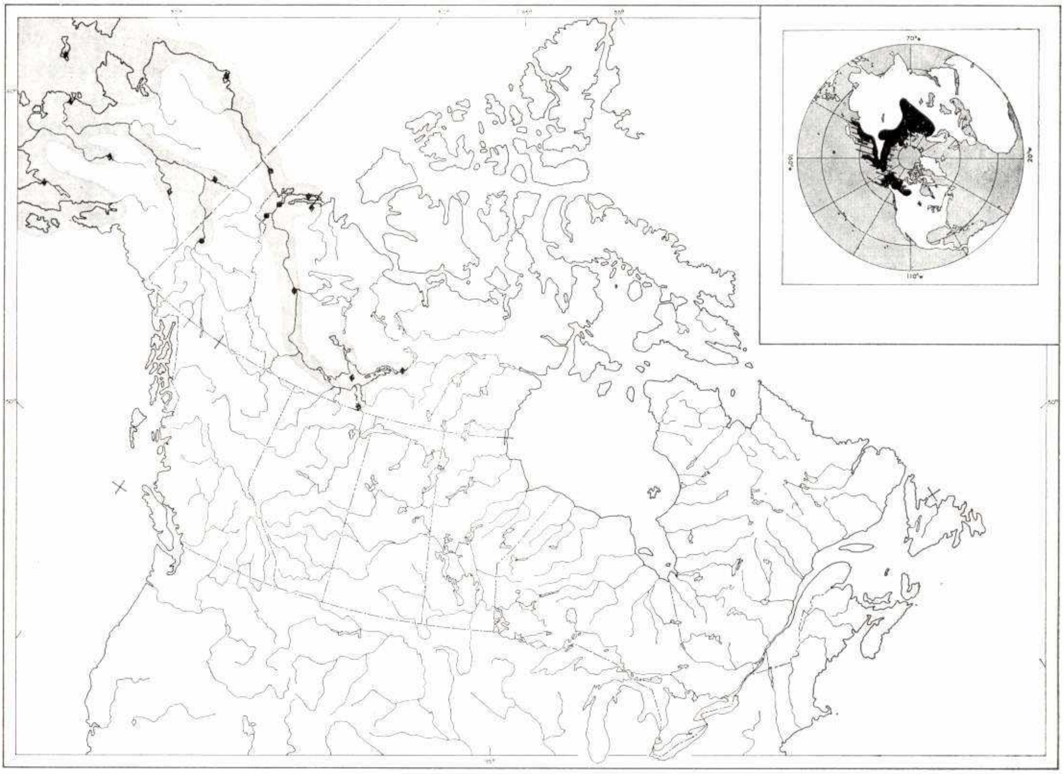
Description The body of the Arctic lamprey is long and cylindrical, somewhat laterally compressed beyond the dorsal fins. Usual length to 11 inches (280 mm). Head short, surrounded by a circular sucking disc edged with leathery fimbriae, eyes small, 7 pairs of gill openings, a single, median nostril.



The teeth in this species consist of a supraoral lamina of 2 (rarely 3) single cusps; infraoral lamina of 5–10 cusps; 2 or 3 pairs of inner lateral (or circumoral) teeth, usually bicuspid; a series of simple posterial (or mandibular labial) teeth; several series of simple anterial (or maxillary labial) teeth. Tongue with several, pointed cusps. In the parasitic form these teeth are strong and sharp, in the non-parasitic populations they are smaller and blunt. At the junction of the oesophagus and respiratory tube there are 5 or 6 velar tentacles (McPhail and Lindsey 1970). Fins: dorsals 2, prominent, higher in males, almost continuous in adults and continuous with the caudal. First dorsal lower, rounded to pointed, second dorsal higher more pointed; anal often a mere fold, can be prominent in mature females. There are no paired fins or girdles. There are no scales; no lateral line in the usual position. Skin smooth, leathery, and marked by 65–80 grooves between the last gill opening and anus in adults and 60–74 in ammocoetes (Buchwald 1968). Skeleton entirely cartilagineous, no vertebrae.

Colour In fresh water, adults are dark brown to blue-black, light brown or grey below. Fins are generally brown and translucent. Ammocoetes are brown to grey, paler below, but have a distinctive pigment pattern by which they can be distinguished from those of other lampreys. In the sea, or newly migratory, adults are steel-blue above, pale to silvery below.

Systematic notes There are both anadromous and dwarf freshwater forms of this species, at least in Alaska. There is a controversy as to whether the smaller, nonmigratory form is parasitic. These factors have led to confusion in the systematics and nomenclature of the Arctic lamprey, such that the Arctic lamprey was long considered synonymous with the small, nonparasitic, American brook lamprey, *Lampetra lamottei*, of eastern North America. The anadromous parasitic form of the Arctic lamprey has been referred to as *L. lamottei japonica* and the nonanadromous, nonparasitic form as *L. l. lamottei* (Wilimovsky 1954). Heard (1966) suggested that both forms are parasitic and should be referred to as *L. japonica*. McPhail and Lindsey (1970) stated that the areas of distribution of the Arctic lamprey and the American brook lamprey are separated by 1500 miles but that ranges and mean number of velar tentacles and of teeth on the infraoral bar are virtually identical. They gave range and mean myomere counts as 64–76 (67.4) in *L. lamottei* from Ontario and Michigan, 68–74 (71.7) in *L. japonica* from the Mackenzie River and 65–80 (69.4) from Alaska. In fact there appears to be no



suitable external characters by which the two can be adequately separated in a key. McPhail and Lindsey suggested that further study may indicate that the eastern and western forms do not warrant specific separation but, pending such study, the two names should be retained.

Distribution This lamprey is said by various authors to occur, as different subspecies, in rivers flowing into the arctic from Norway (Tambs-Lyche 1963) or the White Sea (Walters 1955) to the Ob basin (*L. japonicus septentrionalis* Berg), rivers of Siberia (*L. j. kessleri* (Anikin)), in the Amur River, the Kamchatka Peninsula, rivers of the Sea of Japan, and as far south as Fusan, Korea (*L. j. japonica*).

In North America it occurs in the Anderson River near the coast, in Artillery Lake (northeast of Great Slave Lake into which it drains by a circuitous route) (Buchwald 1968), in Slave River (upstream to Fort Smith), Great Slave Lake, the Mackenzie River, Yukon River (to Dawson, Yukon Territories), and in Alaska from the Kenai Peninsula north.

Biology The life history of this lamprey is clouded by the presence, often in the same habitat, of a larger, parasitic, migratory population and a dwarf, freshwater population considered by some as parasitic (Heard 1966) and by others nonparasitic (McPhail and Lindsey 1970). The Arctic lamprey in North America has been treated by some authors as synonymous with the nonparasitic American brook lamprey, *Lampetra lamottei*, of eastern North America (Wilimovsky 1954; McPhail 1960). The presence of populations of nonparasitic lamprey in Alaska very similar to *L. lamottei* led to this conclusion. Heard's 1966 discussion of the life history of lampreys of the Naknek River, Alaska, led him to conclude that all the lampreys in that system were parasitic and *L. japonica* as distinct from *L. lamottei.* McPhail and Lindsey (1970) said that although the eastern and arctic forms are almost identical, they should be considered separate, pending further work. Most of the available data on this species were given by Heard (1966) and Buchwald (1968) and were the bases for much of the following.

Arctic lampreys spawn from late May to early July in areas out of the main current in streams with moderate flow. Water temperature at spawning time was recorded to vary from 54°–59° F (12.2°–15.0° C). The nests, built in areas of gravel 0.5–2.0 inches (13–51 mm) in diameter, are 6–10 inches (152–254 mm) in diameter and vary from a mere depression in the gravel to a pit 3 inches (76 mm) deep. Both sexes work at nest building by thrashing the anchored body and by carrying individual stones. From 2 to 8 spawners are active on a single site. The sex ratio on the spawning grounds is 1:1 but one female may spawn with more than one male. By means of his sucker, the male attaches to the head of the female and wraps completely around her, the pair vibrate rapidly, and eggs and sperm are emitted simultaneously. Egg number varies from 9790 to 29,780 in various size females in the Slave River. Eggs hatch within a few weeks and the ammocoetes burrow into the soft stream margins. Growth of ammocoetes is variable and confusing, possibly since there are, among any catch, ammocoetes of the anadromous form with greater potential maximum size, and ammocoetes of the dwarf freshwater form. This variability may explain why Buchwald, on the basis of length frequencies of ammocoetes, suggested a 4-year ammocoete period with the following age–length relation:

Year	TL *(inches)*	TL *(mm)*
1	0.13	0–35
2	1.2–2.5	30–65
3	2.3–6.1	60–155
4	5.9–8.6	150–220

Heard suggested that immature adults taken in limnetic samples may have represented transformed lampreys-of-the-year. He also said, however, that length frequencies of ammocoetes migrating downstream in spring indicated that more than one age-group was represented. Transformation of both forms apparently takes place in the fall at 6.0–8.25 inches (150–210 mm). Transformed lampreys move downstream from August to November, the anadromous ones to the sea and the freshwater ones to a lake. After an indefinite period in the larger bodies of water where they are parasitic, the adults migrate upstream in the spring to spawn. For at least the freshwater form, it was postulated that adult life lasted only from transformation in August to spawning in the following spring, and that feeding ceased in the winter and the intestine degenerated.

The migrating adults are often seen in vast swarms, particularly at places where their upstream passage is obstructed. Buchwald reported that transformed lampreys found in the Hay River in September might not enter Great Slave Lake until late fall.

Anadromous Arctic lampreys may grow to 24.6 inches (625 mm) and weigh up to ½ pound in the USSR (Berg 1948), but in North America maximum size would appear to be 16.2 inches (411 mm). The freshwater form apparently rarely exceeds 7 inches (180 mm). The length–weight relation for this species (in mm and g) in the USSR (Berg 1948) was as follows:

Total length *(mm)*	380	490	520	540
Weight *(g)*	90	110	145	146

As in other species, the sedentary burrowing ammocoetes feed on microscopic plants and animals. If, as suggested, all adults regardless of size are parasitic, then their food will consist of the body fluids, probably of fishes alone. In Alaskan fresh water this lamprey is known to parasitize sockeye salmon, rainbow trout, pygmy whitefish, and threespine stickleback. A pygmy whitefish of 2.6 inches (65 mm), carried a *L. japonica* of 5.4 inches (137 mm) and a stickleback of only 2.4 inches (60 mm) had been attacked by an Arctic lamprey of 5.8 inches (148 mm). Wounds attributable to this lamprey were reported on lake trout and lake whitefish in Great Slave Lake (Rawson 1951). This lamprey is also known to have attacked chinook salmon, a smelt (Osmeridae), starry flounder (McPhail and Lindsey 1970), ciscoes (*Coregonus* spp.), longnose sucker, and burbot.

Arctic lamprey have been reported as preyed on by several species of fishes including inconnu, northern pike, burbot, and walleye. In Buchwald's Great Slave Lake study, 0.5% of the individuals of five species of predatory fish had *L. japonica* as part of the stomach contents. They are also eaten by various species of gulls, particularly when in migratory concentrations in shallow streams. Sculpins (Cottidae) and other fishes probably prey on the eggs of this species. A probable significant ammocoete mortality factor is lowering stream levels in late spring or summer which strand burrowed ammocoetes in dry stream edges. Adult Arctic lampreys in the sea may compete for hosts with the Pacific lamprey in the area off the Kenai Peninsula.

Parasites listed for *L. japonica* are as follows: Cestoda — *Eubothrium crassum*, *Nybelinia* sp., *Pseudophyllidea* sp., *Scolex pleuronectis*; Trematoda — *Brachyphallus crenatus* and *Lecithaster gibbosus*; Nematoda — *Anisakis* sp., *Contracaecum aduncum*, *Terranova decipiens*; Acanthocephala — *Corynosoma semerme* (Ronald and Wilson 1968), *Triaenophorus crassus* (Buchwald and Nursall 1969).

Relation to man It has been reported (Evermann and Goldsborough 1907b) that native peoples took this species in large numbers in spring through the ice with salmon dipnets. They caught them mainly for dog food, and apparently ate them themselves only when other food was scarce.

As with other parasitic lampreys their greater relation is indirect, in their parasitic habit. Apparently freshwater parasitism on the various life stages of the various species of Pacific salmon is negligible. This is not necessarily so for the marine-dwelling adult. Some attacks causing probable mortality to pink and chum salmon in weirs off the Amur River, USSR, have been recorded (Birman 1950). This species is smaller and therefore probably causes less damage than the Pacific lamprey.

It preys on economically important species other than salmon, such as lake trout and lake whitefish, but probably with little detrimental effect.

It has reportedly been used as bait for sturgeon in the USSR.

Nomenclature

Petromyzon japonicus	— Martens 1868: 3 (type locality Japan)
Petromyzon fluvialis (Linn.)	— Richardson 1823: 705
Petromyzon borealis	— Girard 1859: 377 (type locality Great Slave Lake)
Ammocoetes aureus	— Bean 1882: 159
Lampetra aurea (Bean)	— Jordan and Evermann 1896–1900: 13
Entosphenus japonicus Martens	— Creaser and Hubbs 1922: 11
Lampetra borealis (Girard)	— Jordan, Evermann, and Clark 1930: 10
Entosphenus japonicus septentrionalis	— Dymond 1947: 4
Lampetra (Entosphenus) japonica	— Wynne-Edwards 1952: 5
Entosphenus lamottei lamottei (LeSueur)	— Wilimovsky 1954: 281
Entosphenus lamottei japonicus (Martens)	— Wilimovsky 1954: 281
Lethenteron (japonica)	— Vladykov and Follett 1967: 1074
Entosphenus lamottenii (LeSueur)	— McPhail and Lindsey 1970: 53

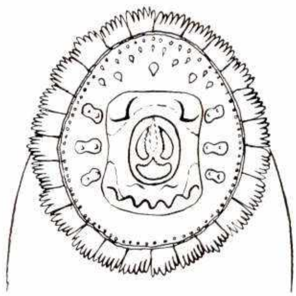
Etymology *Lampetra* — a sucker of stone; *japonica* — of Japan, described by Martens from Japan.

Common names Arctic lamprey, northern lamprey, lamprey eel, Pacific river lamprey. French common name: *lamproie arctique*.

AMERICAN BROOK LAMPREY

Lampetra lamottei (Lesueur)

Description This lamprey is long, cylindrical, and laterally compressed beyond dorsal fins. Usual length to 7.3 inches (187 mm). In adults the short, jawless head ends in a moderately small sucking disc, the diameter, less than that of the branchial region, is 3.6–4.8% of total length. The disc is fringed with leathery fimbriae.

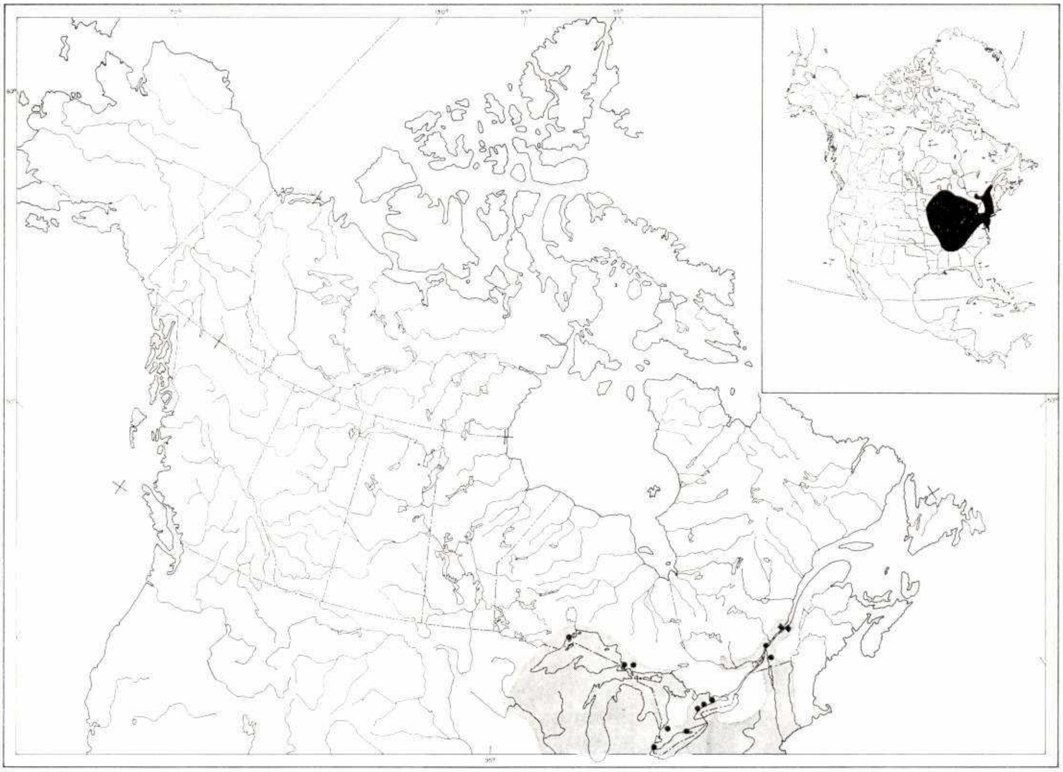


The inner surface of the disc or funnel weakly toothed, teeth not in radiating series; supraoral lamina broad with 2 large, blunt cusps, rarely a third centre cusp; infraoral lamina broad with 6–10, wide, low, blunt cusps; 3 pairs of weak, blunt, bicuspid, inner lateral (or circumoral) teeth, no lateral teeth beyond these; many scattered, somewhat sharper, anterial (or maxillary labial) teeth; a single, curved row of inner posterial (or mandibular labial) teeth connecting the lower, inner lateral pair; marginal ring present but teeth tiny; tongue toothed, transverse lingual lamina not bilobed, with a denticulate ridge and 15 rather large cusps; longitudinal lamina with 5–8 small cusps. The eyes are high and moderate in size in adults, diameter 1.9–2.2% of total length, poorly developed in ammocoetes; a single, mid-dorsal nostril ahead and 7 pairs of round gill openings behind. Fins: dorsals 2, first dorsal and second dorsal narrowly separated, cleft reaches dorsal surface of body (except in spawning males), but referred to as 2 dorsal fins, first dorsal shorter, rounded, often with square edge at insertion, second dorsal higher, rounded in males, pointed in females, connected to spade-shaped caudal; caudal in mature females connected to obvious anal, not apparent in males; no paired fins or their skeletal supports. No scales or denticles; skin, smooth and leathery; no lateral line in usual position; trunk myomeres, 64–70 in adults and 63–70 in ammocoetes. No vertebrae, skeleton cartilagineous, notochord persists.

Colour Dorsal surface of body blue-grey in spawners, through slate-grey to muddy brown, shading down sides, much paler on ventral surface; fins with a dirty yellow tinge; dark blotch on base of caudal fin around the notochord. Ammocoetes a pale brown colour. Gage in 1928 described a vivid, red spot on the leading edge of second dorsal which he said was an oedema suffused with blood.

Systematic notes Alaskan populations of lampreys with many superficially similar characteristics were once considered to be this species. A parasitic form was referred to as *L. lamottei japonica*, and another form, thought to be nonparasitic, as *L. l. lamottei* (Wilimovsky 1954). The recent tendency is to look upon both the forms in Alaska and northern Canada as *Lampetra japonica* and as distinct from *L. lamottei* of eastern North America, and to regard *L. lamottei* as a nonparasitic derivative of *L. japonica*. There would appear to be no external characteristics which would adequately separate the two species in a key.

In an important work on lampreys edited by Hardisty and Potter (*see Suggested Reading*), Hubbs and Potter used the name *L. lamottenii* stating that *L. lamottei* is an amendation not presently authorized.



Distribution Restricted to east-central North America, on the eastern seaboard from the Connecticut River south to Maryland; in the St. Lawrence River and tributaries from Montmagny southwest throughout the Great Lakes basin, west to southeastern Minnesota. South of the Great Lakes it occurs in the Mississippi River drainage from New York to Minnesota in the north, south to Tennessee and Missouri.

In Canada it occurs in streams flowing into the St. Lawrence River, Lake Champlain, in the Great Lakes, other than the eastern portion of Lake Ontario, and in the Noire, Ste. Anne de la Pérade, and St. Maurice rivers of Quebec.

Biology This species spawns in spring, usually from early May to early June in Canada, in cold brooks and small rivers. The peak of spawning activity is usually at a water temperature of 62° F (16.7° C) (Vladykov 1949a). Nests, constructed in gravel by the adults (males arrive and begin first), are small gravel-filled pockets less than 1 foot (305 mm) in diameter, between large, round stones. Groups of lampreys up to 3 or 4 dozen may spawn in an area of a few square metres with 3–25 in a single nest (Young and Cole 1900). Males outnumber females 5:1. There is extensive carrying of gravel in the mouths, but this activity often appears random and aimless as if part of a ritual rather than real nest clearing. The spawning act is at irregular intervals and each lasts only 3 seconds. The female attaches to a stone, the male attaches to the head of the female, coils half around her in one left-hand turn, the vents approximate, the tails are turned down and eggs and sperm emitted during vigorous vibration, which stirs up sand (Dean and Sumner 1897). The eggs, which are sticky, adhere to the sand and fall to the nest rather than being carried downstream. Nest activity between spawning acts covers the eggs. After spawning the adults die. Estimates of egg number vary from a low of 860 (Dean and Sumner 1897) to 3276 for a female of 8.5 gram weight (Gage 1928), depending on size. Eggs are about 1 mm in diameter. They hatch in a few days to a few weeks, depending on water temperature. The ammocoetes are thought to live in the sand of the nest until the yolk is absorbed, then they burrow into the sand and silt. The nonparasitic American brook lamprey has a 5- or 6-year life span.

There is a sixfold increase in size over the first season and the range of ammocoete total length (mm) at each age has been calculated by Hubbs (1925a) as follows: age 1(20–40); age 2(40–75); age 3(75–100); age 4(120–140); age 5(140–180).

Growth rate decreases over this range with a second increase immediately before metamorphosis and a decrease in actual size accompanying transformation and sexual maturity. Transformation usually takes place, in the burrow, in the fall and winter of the fifth year at lengths of 4.4–7.4 inches (112–187 mm) (Vladykov 1949a). Not all ammocoetes of one year-class metamorphose in the same year, some may starve, grow little more, but live to transform the following year. Adults were observed to range in length from 7.3 to 7.9 inches (185–200 mm). Transformation and sexual maturity are completed only shortly before the spring spawning season and the adults are not capable of feeding, the intestine having become nonfunctional. This species is not known to grow larger than 8 inches (203 mm).

The habitat of this brook lamprey is the colder brooks and small rivers where it is usually associated with the slimy sculpin and the brook trout. It spends its whole life in the streams and never migrates to lakes. This species prefers cooler streams than the northern brook lamprey, *Ichthyomyzon fossor*.

Summer food of the burrowing ammocoetes of this species is microscopic plant and animal life, probably diatoms, desmids, protozoans, filamentous green algae, pollen, and detritus (Creaser and Hann 1929). Since this is a nonparasitic species, the adults, who live no more than 5 or 6 months, do not eat at all. The intestine is nonfunctional.

Since this species is utilized as bait for sport fish, it would seem likely that the ammocoetes and possibly the adults are fed on by many fishes, such as speckled trout, which cohabit the cool streams. This species may compete with other species of lampreys for spawning grounds, adequate areas for ammocoetes to burrow, and for food. Variation in stream level could be a significant ammocoete mortality factor.

The only parasites recorded for this species were *Aeromonas liquifaciens* (Schizomycetes) and *Cucullanus* sp. (Nematoda) (Ronald and Wilson 1968).

Relation to man Since it is small, secretive, and exists as an adult only long enough to spawn, it is unlikely this species was ever used as food by humans. Since it is a nonparasitic lamprey it has no indirect relation through destruction or impairment of economically important species of fishes.

In Quebec, the ammocoetes of this species, with others, are sold as bait for such sport fishes as walleye, smallmouth bass, muskellunge, and striped bass. Even in 1947–1948 lamprey ammocoetes were sold for 50¢ to $1 a dozen and close to 100,000 were sold around Quebec City (Vladykov 1949a).

Nomenclature

Petromyzon Lamottenii	— LeSueur 1827: 9 (type locality Missouri)
Petromyzon appendix	— DeKay 1842: 381
Lampetra wilderi Gage	— Jordan and Evermann 1896–1900: 13
Entosphenus appendix DeKay	— Hubbs 1926: 7
Lethenteron appendix (DeKay)	— Jordan, Evermann, and Clark 1930: 9
Entosphenus lamottenii (LeSueur)	— Hubbs and Lagler 1941: 26
Entosphenus lamottei lamottei (LeSueur)	— Wilimovsky 1954: 281
Entosphenus lamottei (LeSueur)	— Scott 1958: 3

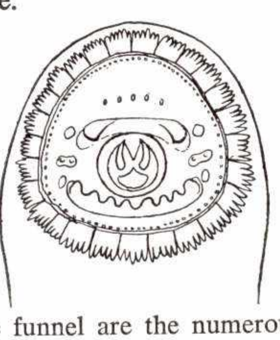
Etymology *Lampetra* — sucker of stone; *lamottei* — after Lamotte, a French explorer, who in 1720 discovered a mine in Jackson Co., Missouri, near where the type specimens were discovered by Lesueur in 1820.

Common names American brook lamprey, brook lamprey, small black brook lamprey, small black lamprey, lamper, lamper eel. French common name: *lamproie de l'est.*

WESTERN BROOK LAMPREY

Lampetra richardsoni Vladykov and Follett

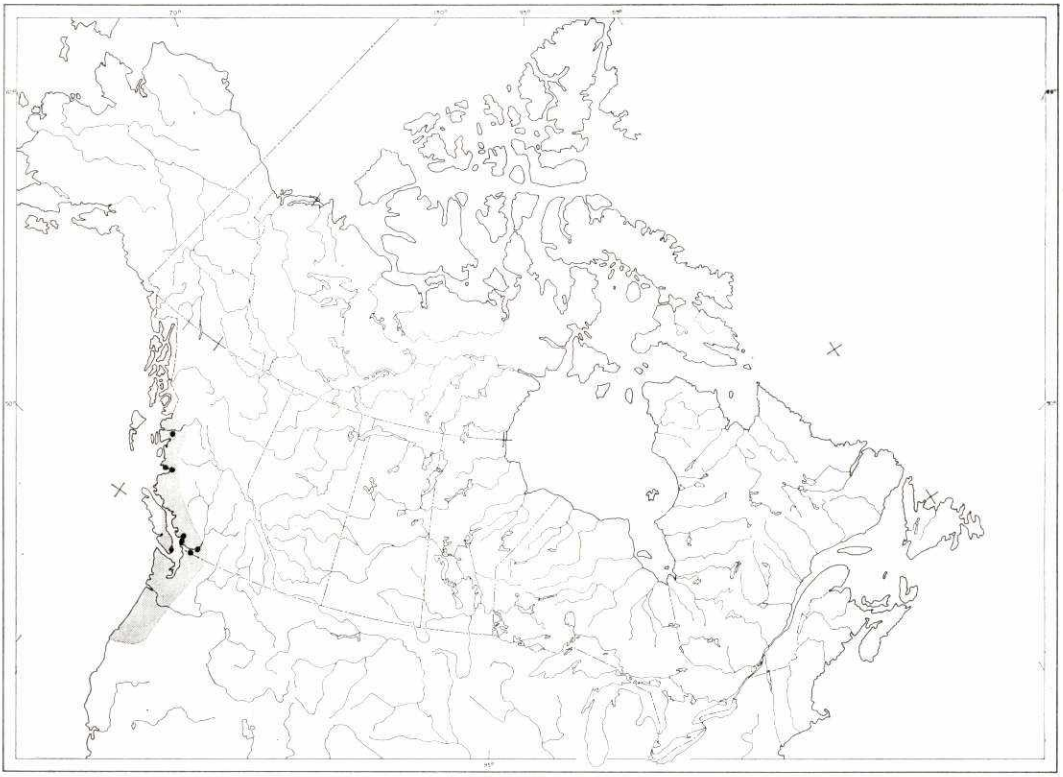
Description This nonparasitic species, as with all lampreys, is nearly cylindrical to the dorsal fins where it becomes laterally compressed. Usual length to 6 inches (154 mm). In adults the short head has a moderately large, buccal funnel fringed with leathery fimbriae.



Within the funnel are the numerous, small, blunt teeth; a broad supraoral lamina of 2 prominent, blunt, single cusps; infraoral lamina of 7–10 rounded, blunt cusps; 3 pairs of small, inner lateral (or circumoral) teeth, the outer ones unicuspid or bicuspid, the centre one usually bicuspid but at times tricuspid, the anterials (or maxillary labials) tiny, peglike, and scattered; no posterials (or mandibular labial); marginal ring present, but tiny and inconspicuous. On the tongue the cusps of the transverse and longitudinal lamina are small and irregular. Beyond the mouth are 5 or 6 velar tentacles. The eyes in adults are moderately large and high; a single, median nostril ahead; 7 pairs of gill openings behind. Fins: dorsals 2, first dorsal lower and flat to pointed, second dorsal touching first dorsal but distinctly separate, second dorsal higher than first dorsal and pointed in females. At spawning time there is a significant swelling of the anterior edge of second dorsal in females but not in males (Pletcher 1963); caudal forms obtuse angle at apex, obviously joined to second dorsal and to anal; anal a mere ribbon in males to an obvious lobe in females; no paired fins or supports. No scales, skin smooth, leathery. No lateral line in usual position, 57–65 myomeres in ammocoetes and 60–67 in adults. No vertebrae, skeleton cartilagineous. Many of the above details were derived from Vladykov and Follett (1965).

Colour Adults are brown through olive to black on the upper surfaces, paler below. The fins are a translucent olive-green and the caudal conspicuously marked with diffuse black pigment. The characteristic pigment pattern of ammocoetes was extensively described in Vladykov and Follett's original description of 1965.

Systematic notes The western brook lamprey was long confused with the superficially very similar European brook lamprey



L. planeri (Bloch). It was not recognized as a distinct species, *L. richardsoni*, limited to the Pacific coast of North America until so described by Vladykov and Follett (1965).

Distribution Limited to western North America; in freshwater streams of the Pacific coast (including Vancouver Island and King Island), possibly from Alaska, from British Columbia south to Oregon and possibly California. McPhail and Lindsey (1970) and Carl et al. (1967) listed British Columbia only, but Vladykov and Follett (1965) said they identified ammocoetes from Alaska as *Lampetra richardsoni*. Vladykov and Follett (1965) said to Oregon; Schultz (1930) quoted Hubbs (1925a) on specimens at San Jose, Calif. In British Columbia it is known to occur in the Cowichan River, Vancouver Island; streams entering the Fraser River; and Hooknose Creek, King Island.

Biology Very little was known of the biology of this species prior to the work of Pletcher (1963) and McIntyre (1969). Much of what is given below is from these sources. This nonanadromous lamprey spawns during the day and night in fresh water in the spring and early summer, over a temperature range of 46°–68° F (7.8°–20.0° C). Greatest activity was observed at temperatures of 48°–52° F (8.9°–11.1° C). Time of spawning, depending on local temperatures, is from late April to early July, and is more protracted than for other lampreys. The nests, crude and ill-defined, 2 inches (51 mm) in depth and 4–5 inches (102–127 mm) in diameter, are made, mostly by the males, in coarse gravel ($\frac{1}{16}$ – 4 inches diameter) and sand at the head of a riffle in quiet water (2.3 ft/sec) of smaller rivers and creeks. Aquarium experiments showed that the presence in the tank, for 5 minutes, of ripe females quickly initiated in males nest digging up to 2 hours' duration. Nests are made mainly by vibrating the body and tail; stones are apparently only rarely carried in the mouth, and then only for short distances. McIntyre observed that $\frac{3}{4}$-inch (19-mm) stones were carried up to 6 inches (152 mm) by both sexes digging the nest, and that stones were pushed in front of the head or carried in the disc when covering eggs after spawning. A single nest may contain as many as 12 spawning lampreys and may be occupied by several different groups of lampreys over the whole spawning period. At spawning, the male carries out a short prespawning "sliding–feeling" courtship during which it slides gently up the body of the female with the disc in light contact with her body, then attaches itself to her head, and coils around her so that the vents approximate. The shedding of eggs and sperm takes place during rapid vibration of the pair. Egg number varies with size of the female. For females 4.4–7.7 inches (111–196 mm) in total length, egg number ranges from 1100 to 3700. Eggs are slightly oval, 1.05–1.13 mm long and 0.98–1.09 mm wide. The spawning act lasts for only a minute. McIntyre noted that 10–12 eggs were released during each spawning act and that spawning acts were separated by periods of egg covering or nest construction. He noted that one pair spawned six times and then abandoned the nest. More eggs must be laid each time or this female had spawned elsewhere previously. Eggs are adhesive and cling to sand swept up in the violent vibration during spawning. The sand carries the eggs down into the nest preventing them from being swept away by the currents. Violent thrashing of the body of the female also probably frees more mature eggs from the ovary in preparation for shedding. The adults live for a very short time after spawning, as dead adults are often found on the banks near the nests.

Eggs probably hatch in 10 days in water 50°–60° F (10.0°–15.6° C) in Oregon (15 days at 60°–68° F or 15.6°–20.0° C in tanks) and the ammocoetes have by 30 days burrowed into the silt at the stream margin. Spawning success and survival is apparently high, as ammocoetes of this species are said to be one of the most abundant forms of life in the lower courses of streams in the northwestern United States, 170 per square metre. This is in spite of the fact, noted by McIntyre, that superimposition of nests of successive pairs occurs, and that the digging of later pairs frees earlier eggs which drift downstream. This may occur only where suitable spawning sites are limited. It is apparently a frequent occurrence in Cultus Lake, B.C. There is little movement of ammocoetes, as individuals 0.3–5.2 inches (8–132 mm) in length were found in the same location, and newly transforming ammocoetes were as abundant upstream as down. Ammocoete life in this species was once thought to span 3–5 years with modal sizes in Washington given by Schultz (1930) as follows:

Age	Length	
(years)	*(inches)*	*(mm)*
1	1.6–2.0	40–50
2	2.8–3.2	70–80
3	3.9–4.3	100–110
4	5.5–5.9	140–150

Age–length relation derived by Pletcher from length frequency polygons of ammocoetes from the Salmon River, B.C., indicated an ammocoete life of at least 6 years, as follows:

Age	Mean TL		Range TL	
(years)	*(inches)*	*(mm)*	*(inches)*	*(mm)*
0	0.7	17.5	0–0.9	1–22
1	1.4	36.0	1.1–1.8	28–45
2	1.9	47.5	1.6–2.2	40–50
3	2.3	58.0	2.0–2.6	52–65
4	2.8	72.0	2.6–3.2	65–80
5	3.7	95.0	3.0–4.6	76–116

Pletcher also postulated an ammocoete rest period of almost a year, prior to and during transformation.

From August to November the larger ammocoetes metamorphose and adults vary in length from 5 to 8 inches (130–200 mm). The mean size of adults is different in the various rivers, e.g. Salmon River 120 mm, Smith Creek 143.8 mm, and Hooknose Creek 167.2 mm. These overwinter without feeding, start to mature sexually in March, spawn, and die. The largest recorded Canadian specimens were an ammocoete 6.1 inches (156 mm) and an adult 6.4 inches (163 mm) in length.

This species is nonparasitic, the adults do not feed at all, and the intestine is degenerate. They doubtless exist from transformation to spawning on body reserves. Like other lampreys, the burrowing ammocoetes live on microscopic plant and animal matter, including desmids, diatoms, algae, and detritus. Diatoms make up more than 20 times the volume of other items of food consumed.

This brook lamprey may compete in places with *L. ayresi* and *E. tridentatus* for nesting space; however, they probably nest in smaller bodies of water and not so far upstream as the parasitic lampreys. Various sculpins, especially the torrent sculpin, and salmonids prey on the eggs at spawning time. Since they are used as bait, one would assume that this species is preyed on by other fishes. In experimental situations the smallest ammocoetes were readily eaten by coho salmon fry. However, larger ammocoetes were tasted and rejected by as many as 50 cohos in 30 minutes. If skinned, the ammocoetes were readily eaten and the isolated skin rejected. This reaction, similar to that noted in the case of the Pacific lamprey, is thought to be the result of secretion of granular cells in the skin. Since they are used as bait, then the reaction is obviously exhibited by only some species.

The only other animal reported seen eating the spawning adults was a raven, *Corvus corax*.

Ronald and Wilson in 1968 listed parasites of *L. planeri*, but their sources all appear to be European and do not refer to those North American populations long referred to by that name.

Relation to man Since this is a nonparasitic lamprey it does not have the indirect relation of destruction of economically important fishes.

The larger ammocoetes or newly transformed adults were at one time extensively gathered for bait in Washington. They were used by anglers fishing for bass and trout and were said to be better than salmon eggs or sculpins (Cottidae). One bait dealer is said to have sold $3000 worth, at $1.50–$1.75 per dozen, in a single year. There are no recorded sales as bait in British Columbia but sport fishermen dig ammocoetes and collect adults which they use as bait for sturgeon in the Fraser River.

Nomenclature

Lampetra richardsoni	— Vladykov and Follett 1965: 139 (type locality Smith Creek, Cultus Lake, B.C. Holotype NMC 64-57)
Petromyzon branchialis	— Günther 1870: 505
Lampetra planeri Bloch	— Creaser and Hubbs 1922: 13

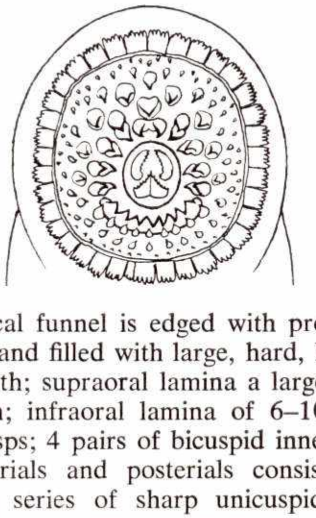
Etymology *Lampetra* — a sucker of stone; *richardsoni* — after Sir John Richardson, British surgeon-naturalist, and author of many important early works on North American fishes.

Common names Western brook lamprey, nonparasitic brook lamprey, lamprey eel. French common name: *lamproie de l'ouest.*

SEA LAMPREY

Petromyzon marinus Linnaeus

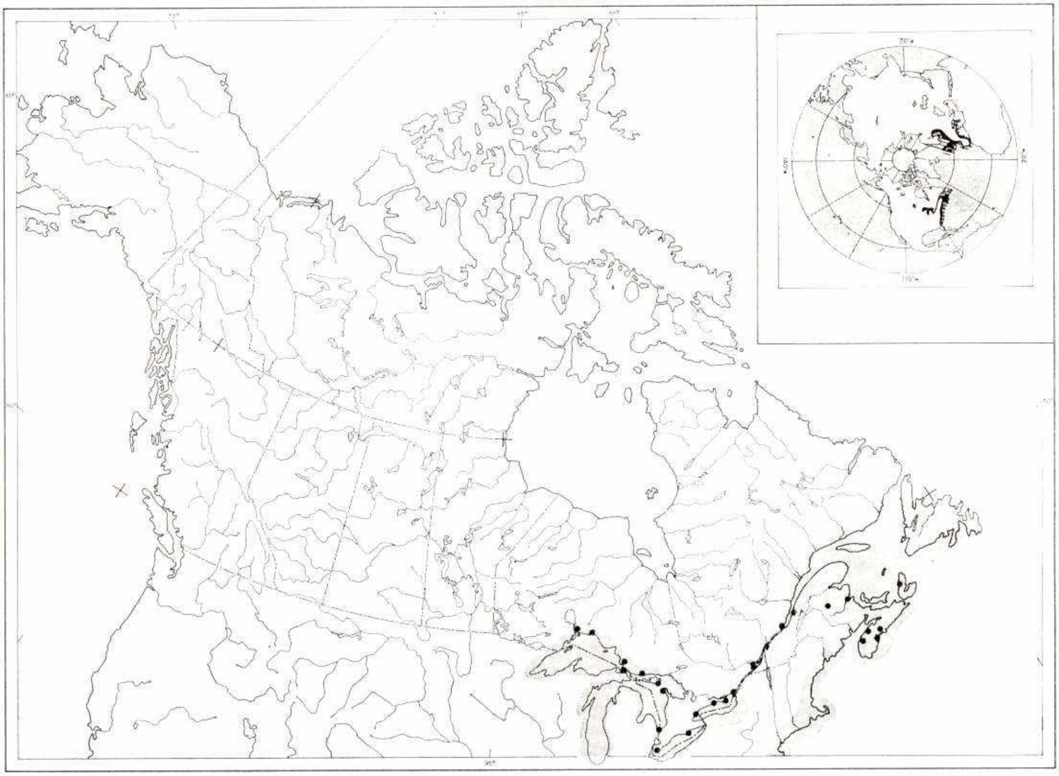
Description This species, the largest and most predaceous of the lampreys, is long, nearly cylindrical to the dorsal fins where it becomes more laterally compressed. Usual length to 33.8 inches (860 mm). The short head terminates in a large sucking disc, diameter as great or greater than diameter of branchial region, 6.1–9.3% of total length varying with body length; eyes large, particularly in newly transformed adults, 2.7–3.6% of total length at 5.1–5.8 inches (131–148 mm); a single mid-dorsal nostril; 7 pairs of conspicuous gill openings laterally.



The buccal funnel is edged with prominent fimbriae and filled with large, hard, hooked, sharp teeth; supraoral lamina a large bicuspid tooth; infraoral lamina of 6–10 large, sharp cusps; 4 pairs of bicuspid inner laterals; anterials and posterials consisting of radiating series of sharp unicuspid teeth, posterials (mandibular labials) somewhat smaller; marginal ring present. The tongue is heavily armed with teeth, the large bilobed transverse lamina has 15 cusps and each of the paired longitudinal laminae has 12–14 large cusps. Fins: dorsals 2, first and second dorsals distinctly separate in ammocoetes and small adults, separate but closer in spawning adults, more widely separated in breeding males of anadromous lampreys than in landlocked ones, considered as two fins; first dorsal lower, flat on top, height 20% of base length, preceded by ropelike ridge in spawning males of landlocked form; second dorsal higher, height more than 20% of base length, base length twice that of first dorsal, pointed. Second dorsal narrowly connected to broadly pointed caudal; caudal in spawning individuals connected to low anal in females; no paired fins or their skeletal supports; no scales, skin smooth and leathery, 67–74 trunk myomeres; no lateral line in usual position; no vertebrae, skeleton cartilagineous, notochord persistent.

Colour Colour differs with sexual development and between the anadromous and landlocked populations. Newly transformed adults 5.3–6.9 inches (135–175 mm) long are grey-blue above, grading gradually to a metallic violet on sides to silver-white on ventral surface.

In adults over 17.7 inches (450 mm), body and first dorsal marbled or blotched with dark brown to black patches. Body of landlocked form is grey-blue in the parasitic phase and golden brown when spawning, a dark blotch at the end of the caudal fin. Increased size (between 14 and 18 inches or 350 and 450 mm) and increased sexual development affected colour changes from blue-black through dark olive, bronze and sienna to xanthine orange in landlocked specimens in Cayuga Lake, N.Y. (Wigley 1959). The supplement to the 1972 annual report of the N.Y. State Conservation Department (1928)



has good colour plates of a spawning male and female of the landlocked form.

The ammocoetes are pale grey to pale brown on top and sides, lighter below. *See* Vladykov (1950) for distinctive pigment pattern and distinguishing characteristics of ammocoetes.

Systematic notes The landlocked populations of smaller lampreys were long considered a distinct species. Jordan and Fordice, as early as 1885, concluded that the "lake lamprey" was not separable from the sea lamprey. It was, however, considered to be subspecifically distinct as late as 1922 (*P. m. unicolor, P. m. dorsatus*). It was also at times confused with the other common lamprey in Lake Ontario, the silver lamprey *Ichthyomyzon unicuspis.* Wright in 1892 illustrated a sea lamprey buccal funnel, called it *P. concolor* (a synonym of *unicuspis*), gave it the common name silvery lamprey, and seemed at times to be describing both species.

Distribution The larger anadromous form is common on both sides of the Atlantic Ocean; in the east, from Iceland, the Faeroe Islands, and northern Norway, south to northwestern Africa, including the Baltic, Mediterranean, and Adriatic seas; in the west, from southwestern Greenland and the Grand Banks, the Gulf of St. Lawrence, and as far up the St. Lawrence River and its tributaries as Sorel, Que., south to northeastern Florida (Vladykov 1949a; Bigelow and Schroeder 1948; Scott and Crossman 1964; Leim and Scott 1966). Although common in all other Maritime Provinces, rare in the fresh waters of Newfoundland.

Populations of smaller, landlocked or nonanadromous lampreys were known to occur, prior to 1920, in the upper St. Lawrence River, Lake Champlain, the Finger Lakes, N.Y., and Lake Ontario and its tributaries. The destructive effect of the explosive increase in numbers of this parasite when it gained access to new territory in the upper Great Lakes is now a biological legend, along with the water hyacinth, the prickly pear, and the rabbit in Australia. The opening of the Welland Canal in 1829 first gave this species access to the upper Great Lakes but it was not discovered in Lake Erie until 1921, Lake St. Clair 1934, Lake Michigan 1936, Lake Huron 1937, and Lake Superior 1946. It now occurs throughout the Great Lakes watershed and spawns in all suitable, gravelly rivers to which it has access. The sea lamprey took almost 100 years to invade Lake Erie, but in the following 25 years it spread throughout the system, explosively developing large populations everywhere except in warmer Lake Erie, which also has fewer suitable spawning rivers (Hubbs and Pope 1937; Applegate 1950).

Biology Sea lampreys spawn in the spring. Adults congregate in the estuaries of rivers during late winter, starting to move upstream during the dark hours, at a rate of $\frac{1}{3}$–1 mile/day (Wigley 1959), once stream temperature exceeds 40° F (4.4° C). As many as 25,000 adults may migrate into the same river, moving upstream as much as 49 miles for landlocked lampreys and up to 200 miles for anadromous populations, to areas where the bottom is a mixture of sand, gravel, and rubble, water depth is 15–24 inches (381–610 mm) and there is a moderate current. Migrating adults can manage rapids easily by alternately swimming and attaching to stones. They can surmount nearly vertical barriers of 5 or 6 feet (152–183 cm), over which the current is not excessive, by creeping up the face with the suctorial disc. Early migrants can be on the grounds 6–8 weeks before spawning begins. Nest building is usually begun, in late May or early June, by the males, the females joining them 48–72 hours later. Small stones are carried or dragged out of the chosen site, by means of the sucking disc, and lighter material cleared by the thrashing action of the body. The nest is usually 10.0–39.5 inches (254–1003 mm) in diameter and as much as 25 pounds of gravel, rubble, and sand are moved in such a way that this material forms a downstream, crescentric lip often as high as 10 inches (254 mm). Spawning activity starts when stream temperature reaches 52° or 53° F (11.1°–11.7° C), usually in mid-June, and is at its peak when temperature is 58°–60° F (14.4°–15.6° C), but late migrants can spawn as late as end of July when the temperature is as high as 76° F (24.4° C).

In 77% of 338 nests observed in a Michigan study (Applegate 1950), a single pair spawned in the nest and remained mated for the entire spawning period. Polygamous and polyandrous combinations involving from one to five individuals were also noted, but polygamous and promiscuous pairing seemed to take place only after the peak of spawning activity, when females outnumbered males. Males of single pairs would aggressively drive intruding males off the nest.

During the spawning act the female anchors herself to a stone at the anterior edge of the bottom of the nest, the male carries out an "approaching–sliding" action, moving the disc anteriorly along the body of the female, attaches to the forward dorsal surface of the female and wraps the posterior third of his body in an abrupt, half-spiral about the female in such a way that the vents approximate. Extrusion of eggs and milt is preceded and accompanied by rapid vibration of the two bodies for 2–5 seconds and then the two part. This is repeated after intervals of 1–5 minutes. About 20–40 sticky eggs are released and fertilized during each act, adhere to sand disturbed by the thrashing, and are carried by the current to spaces between the stones in the high posterior lip of the nest where they adhere. In the intervals, male and female move about moving more stones and sweeping more sand onto the lip. Spawning may continue from 16 hours to $3\frac{1}{2}$ days, during the peak of activity spawning is completed in 16–48 hours.

Egg production varies directly with length and weight of female. Calculated mean total egg numbers for females in Michigan between 12.5 and 21.5 inches (318–546 mm) were

34,000–110,300. In the larger anadromous populations, egg number can be as high as 236,000. Ripe eggs were from 0.80 to 1.25 mm (mean = 1.10) in diameter in Michigan lampreys.

Feeding ceases prior to migration and over the period of migration, and most rapidly during the peak of spawning the following changes take place in adults: intestinal tract reduces in size until it is a mere hollow thread; sight deteriorates to complete blindness; colour of liver changes from reddish orange to green; large patches of epidermis and mucal coat slough off and flesh becomes discoloured.

After completion of spawning, females drop downstream from the nest almost immediately and die very quickly. Spent males may cling to the nest in a curled position for 1–3 days before dropping downstream where they die.

Hatchery rearings of eggs showed that Cayuga Lake eggs hatched in 13–14 days at 57°–65° F (13.9°–18.3° C) (Wigley 1959) and 65° F (18.3° C) was the optimum for most rapid and successful artificial hatching (Piavis 1961). It was estimated in Michigan that larval production was a maximum of 1.1% of the reproductive capacity (total eggs laid) of the female, or 662 larvae leaving the nest from a deposition of an estimated 56,600 eggs. Ammocoetes burrow out and leave the nest in 18–21 days at 71° F (21.7° C) after completion of spawning, or 4–8 days after hatching, and are at that time 6.25–9.75 mm total length (mean = 8.54). They very quickly drift downstream to eddies or pools with areas of sandy silt and mud into which they immediately burrow, tail first, about 13 mm deep, often in densities of 6–17 per square foot. Here, in U-shaped burrows, they remain throughout their ammocoete life, coming to the surface to feed.

Ammocoete period, including the period of transformation prior to leaving burrow, was long thought to be a maximum of 4 years but work in the 1960's in the Great Lakes and Cayuga Lake now makes 7 years (age-groups 0–6) a more likely figure with age–length relation (for Cayuga Lake) from Wigley (1959) as follows:

Age group	Modal TL (inches)	Modal TL (mm)	Approx range TL (mm)
0	0.47	12	7–16
1	1.46	37	22–50
2	2.36	66	50–75
3	3.23	81	75–95
4	4.21	106	95–118
5	5.00	127	118–137
6	5.59	140	137–162
7	5.39	136	112–167

Transformation takes place in the burrows and starts in mid-July to September of the eighth year (age-group 7) at lengths of 4.4–6.6 inches (112–167 mm) and is externally completed in a period of 1 or 2 weeks. Internal changes may not be completed until March of the following year. The parasitic phase begins almost immediately if prey is available. During transformation there are such changes as: length and weight decrease; oral hood transforms into sucking disc; rasping tongue develops; strong, sharp teeth develop in disc and on tongue; deeply embedded, rudimentary eyes appear at surface as large, functional eye; dorsal fins become more pronounced; body colour changes from pale brown to blue-grey above and silver-white below.

Downstream movement of the newly transformed adults to a lake or the sea takes place in a lesser peak in October and November, in small numbers through the winter, and with the major peak in the following April, and seems to be associated with onset of increased stream flow.

As parasites in the larger bodies of water, growth is rapid during the 12–20 months of adult life. Growth rate over the first 7 months of this period, expressed as length range and mean size in various months in the Great Lakes, from Applegate (1950), is as follows:

	Mean TL (inches)	Mean TL (mm)	Range TL (inches)	Range TL (mm)
June	8.2	208	5.5–11.6	149–295
July	10.0	254	6.7–15.5	170–394
Aug.	12.6	320	9.5–16.8	241–427
Sept.	13.6	345	9.9–20.4	251–518
Oct.	16.0	406	13.6–19.3	345–490
Nov.	16.7	424	14.7–18.5	373–470
Dec.	17.3	439	12.8–21.1	325–536

Size ranges of samples in fall months are extended by the arrival of newly transformed adults of the next year-class. Little growth appears to take place over the winter and feeding probably ceases sometime in this period, during which sexual maturity commences, although they have been seen attached to fish caught under the ice. Simple attachment is, however, no indication of feeding. Lampreys are known to attach themselves to inanimate objects such as boats, apparently for passive transport as do sharksuckers, Echeneidae. In the spawning run of the following spring the adults will range in total length from 12.0 to 22.8 inches (305–579 mm).

Maximum size of landlocked sea lampreys appears usually to be approximately 20 inches (528–536 mm) and 363 grams but can reach 30 inches (762 mm) (MacKay and MacGillivray 1949) and anadromous adults are known as large as approximately 34 inches (860 mm) (Vladykov 1949a).

Knowledge of the habitat of the adult is scanty. In the Great Lakes it is presumed by the known habitat of the hosts on which they are taken at different times in the year, that they migrate first to deep water, moving shoreward as they grow, and that in fall they are in shallow water. They have been taken over a depth range of 2.5–540 feet in Lake Huron. It is assumed that in the sea most remain close to shore in shallow water. They have, however, been taken on the Grand Banks and as deep as 547 feet (Bigelow and Schroeder 1948).

The ammocoetes are sedentary filter feeders and their midsummer diet consists largely of minute plant and animal material such as: filamentous green algae, detritus, pollen, diatoms, desminds, and protozoans (Creaser and Hahn 1929). They can withstand extremely long periods of starvation. The adults live as external parasites of fishes in fresh water, and of fishes and possibly other aquatic vertebrates in the ocean. As soon after transformation as a host is available they attach themselves to it by means of the suctoral disc, usually low on the body between the positions of the paired fins in the case of a fish. The teeth of the tongue rasp a hole in the skin of the host and its body fluids and blood are consumed. A secretion, called lamphredin, produced by a pair of buccal glands, assists by (*a*) preventing or slowing coagulation of the host's blood and (*b*) a cytolotic action that breaks down muscle tissue to a state ingestible by the lamprey. Usually the parasite penetrates only part way through the body wall but at times they penetrate the wall and consume eggs or penetrate the gut and take the gut content of the host (Moffett 1966). Length of time feeding on a host varies with lamprey size. Experimental results were from 220.2 hours for newly transformed lampreys to 38.7 hours for lampreys 12.9 inches (328 mm) in total length (Lennon 1954). If concentrations of ammocoetes migrating downstream encounter fish in the estuary as many as four can become attached to the same host. Among the species the sea lamprey attacks in fresh water are: lake trout, lake whitefish, chubs (*Coregonus* spp.), white sucker, longnose sucker, redhorse, yellow perch, rainbow trout, burbot, channel catfish, northern pike, carp, and walleye. The anadromous lampreys are reported to have attacked Atlantic mackerel, American shad, Atlantic cod, haddock, American pollock, squirrel hake, Atlantic salmon, basking shark, Atlantic herring, swordfish, sturgeons, and American eel (Bigelow and Schroeder 1948).

Lampreys are particularly abundant, concentrated, and vulnerable as blind spawners in shallow, freshwater streams. They are most extensively preyed on by several species of gulls, by various herons, hawks, owls, and bitterns, water snake, racoon, muskrat, mink, weasel, fox, and by other fishes such as: northern pike, walleye, brown trout, and Atlantic cod. Minnows of the genera *Notropis* and *Rhinichthys* are known to feed on lamprey eggs as they are being laid; probably other small stream fishes do also. The 90% mortality between deposition of eggs and ammocoete emergence is the most serious mortality factor affecting recruitment. Next is drying of stream areas containing ammocoetes and prespawning predation on adults. Adult sea lampreys may compete for host fishes and for spawning sites with the silver lamprey, *Ichthyomyzon unicuspis*, but since they are larger and more aggressive they have a distinct advantage. Ammocoetes may compete with other lampreys for suitable areas in which to burrow, and for food.

Parasites of the lamprey, too extensive to list here, and references to publications on the parasites of this species were given by Applegate (1950), McLain (1952), Bangham (1955), Hoffman (1967), Wilson and Ronald (1967), and Ronald and Wilson (1968).

Relation to man This species has more direct and indirect relation to man than any other species of North American lamprey. Directly, its importance as food to man is far greater in Europe, where it has long been considered a delicacy, than it is in North America. It is said King Henry I of England died of a surfeit of it. In North America, it is popular only with people newly arrived from Europe. Attempts to popularize it have failed largely because of its appearance and the fact that in the spring adult migrations, when it is readily available in large numbers and easily caught, its physiological state renders it not very palatable. In Europe lampreys for food are caught in winter and grilled, fried, marinated, steamed, salted, or canned. The sea lamprey was at one time an important food along the Connecticut River and was salted down in barrels for winter use (Vladykov 1949a), or sold for $5.00 per hundred fish. In 1961 the only North American commercial fishery for sea lampreys was operated by a Mr T. Roze on the Saugeen River at Southampton, Ont. Lampreys were caught in willow baskets set in a weir, roasted, canned, and sold in Toronto (Thomas 1961).

Sea lamprey ammocoetes are sold as bait for other fishes on the east coast of the United States and possibly in Quebec.

In the Great Lakes the sea lamprey has been known to attach itself to long distance swimmers but is quickly and easily dislodged. It will not attach itself to humans until long submersion has lowered skin temperature. At this point it will attach itself and begin to rasp. No human has apparently been willing to see if it would continue to the point of feeding. It would no doubt do so, as the Pacific lamprey, *Entosphenus tridentatus*, has been recorded found attached to warm-blooded, marine mammals.

Its indirect relation is more significant in its destruction of fishes economically and aesthetically important to man. Prior to its entry into the upper Great Lakes its destruction of fishes in the Finger Lakes led to comment about the necessity for controls. In the sea it is rarely seen and the destruction of fishes there goes unnoticed; in Lake Ontario some natural control must have kept its depredations below the level demanding attention. It was not until this species made its way into lakes Huron, Michigan, and Superior, between 1936 and 1946, that the catastrophic results of its parasitism were seen. It developed tremendous populations in very short periods and quickly decimated, or contributed significantly to the decline of one after another of the stocks of important commercial fishes such as lake trout and whitefish in these lakes. Before the lamprey, the combined annual United States and Canadian catches of lake trout in the three upper lakes was approximately 15 million pounds. By the early 1960's the catch had fallen to 300 thousand pounds. The catch in Lake Huron fell from 3.4 million pounds in 1937 to virtual failure of the fishery in 1947. The United States catch in Lake Michigan fell from 5.5 million pounds in 1946 to 402 pounds in 1953. The Lake Superior catch dropped from an average of 4.5 million pounds to 368 thousand pounds in 1961. This decline was probably not due solely to the sea lamprey, but the role of the lamprey is easy to imagine when you consider the following: (1) up to 85% of various species of fishes not killed by lampreys had been attacked one to five times and had somehow survived the loss of blood and opportunity for secondary infection; (2) the average lamprey destroys 19.6 pounds of fish during its parasitic period (Parker and Lennon 1956) and up to 25,000 adults have been counted entering a single river.

Attempts to control lamprey parasitism of fishes of the Great Lakes began in the late 1940's. It progressed from studies of the biology of the lamprey to mechanical weirs, then to electrical barriers to block upstream migration of spawners, and finally, to the use of a selective poison to kill the ammocoetes in their burrows. Attempts to control the sea lamprey and rehabilitate the fishes led to the forming, in 1955, of the International Great Lakes Fishery Commission, to the large scale hatchery rearing of lake trout and to the selective breeding and rearing of a then little-known hybrid between the lake trout and the brook trout now called the *splake*. It was hoped that this latter fish would use areas of the lakes where it might avoid the lamprey and mature fast enough to spawn at least once before it could be destroyed by lamprey parasitism.

The control measures, in particular the use of the chemical lampricide TFM, have reduced lamprey numbers by over 90% of the 1961 high. The control is, however, a constant and costly one as the level of lamprey numbers now is about equal to what it was when controls were first initiated in the early 1950's.

The public and scientific literature on the biological and socioeconomic consequences of the sea lamprey invasion of the Great Lakes is voluminous. The scientific literature is found primarily in the publications of the Fisheries Research Board of Canada, the Canada Department of Fisheries, the U.S. Fish and Wildlife Service, the Transactions of the American Fisheries Society, and the International Great Lakes Fishery Commission.

Nomenclature

Petromyzon marinus	— Linnaeus 1758: 230 (type locality European seas)
Petromyzon Americanus	— Perley 1852: 225
Petromyzon nigricans	— Provancher 1876: 262
Petromyzon concolor	— Wright 1892: 439
Petromyzon marinus unicolor	— Halkett 1913: 11
Petromyzon marinus var. *dorsatus* Wilder	— Huntsman 1917: 25
Petromyzon marinus unicolor (DeKay)	— Dymond 1922: 60

Etymology *Petromyzon* — sucker of stone; *marinus* — of the sea.

Common names Sea lamprey, great sea lamprey, landlocked sea lamprey, lake lamprey, lamprey, lamprey eel, lamper eel. French common name: *lamproie marine.*

Suggested Reading – Petromyzontidae

Applegate, V. C. 1950. Natural history of the sea lamprey, *Petromyzon marinus*, in Michigan. U.S. Fish Wildl. Serv. Spec. Sci. Rep. Fish. 55: 1–237.

Bardack, D., and R. Zangerl. 1968. First fossil lamprey: a record from the Pennsylvanian of Illinois. Science 162: 1265–1267.

Berg, L. S. 1931. A review of the lampreys of the northern hemisphere. Akad. Nauk SSSR Zool. Mus. Ann. 32: 87–116 + 8 plates. Leningrad.

Buchwald, D. G. MS 1968. The Arctic lamprey of Great Slave Lake, N.W.T. M.Sc. Thesis. Univ. Alberta, Edmonton, Alta. 84 p.

Carl, G. C., W. A. Clemens, and C. C. Lindsey. 1967. The fresh-water fishes of British Columbia. B.C. Prov. Mus. Handb. 5: 192 p.

Clemens, W. A., and G. V. Wilby. 1961. Fishes of the Pacific coast of Canada. 2nd ed. Fish. Res. Board Can. Bull. 68: 443 p.

GAGE, S. H. 1928. The lampreys of New York State — life history and economics, p. 158–191. *In* A biological survey of the Oswego River System. Suppl. 17th Annu. Rep. N.Y. Conserv. Dep. 1927: 248 p.

HARDISTY, W. M., and I. C. POTTER (ed.) 1971. The biology of the lampreys, Vol. I. Academic Press, N.Y. 423 p.

HUBBS, C. L., and M. B. TRAUTMAN. 1937. A revision of the lamprey genus *Ichthyomyzon.* Univ. Mich. Mus. Zool. Misc. Publ. 35: 1–109.

HUSSOKOF, L. 1913. Sea lampreys and their nests. Amer. Mus. J. 13: 323–325.

LAWRIE, A. H. 1970. The sea lamprey in the Great Lakes. Trans. Amer. Fish. Soc. 99: 766–775.

LENNON, R. E. 1954. Feeding mechanism of the sea lamprey and its effect on host fishes. U.S. Fish Wildl. Serv. Fish. Bull. 98, vol. 56: 247–293.

MOFFETT, J. W. 1966. The general biology of the cyclostomes with special reference to the lamprey, p. 255–262. *In* Phylogeny of Immunity. Univ. Florida Press, Gainesville, Fla.

NEWTH, H. G. 1930. The feeding of ammocoetes. Nature 126(3168): 94–95.

PARKER, P. S., and R. E. LENNON. 1956. Biology of the sea lamprey in its parasitic phase. U.S. Fish Wildl. Serv. Res. Rep. 44: iii + 32 p.

PLETCHER, F. T. MS 1963. The life history and distribution of lampreys in the Salmon and certain other rivers in British Columbia, Canada. M.Sc. Thesis. Univ. British Columbia, Vancouver, B.C. 195 p.

REGAN, C. T. 1911. A synopsis of the marsipobranchs of the order Hyperoartii. Ann. Mag. Natur. Hist. 8th ser. vol. 7: 173–204.

RONALD, K., and K. A. WILSON. MS 1968. A check list of the parasites of the order Petromyzontiformes (lampreys). Fish. Res. Board Can. Tech. Rep. 48: 23 p.

SURFACE, H. A. 1898. The lampreys of central New York. Ext. U.S. Fish. Comm. Bull. 1897: 209–215 + pl. 10, 11.

VLADYKOV, V. D. 1949. Quebec lampreys (Petromyzonidae). 1. List of species and their economical importance. Dep. Fish. Prov. Que. Contrib. 26: 67 p.

1950. Larvae of eastern American lampreys (Petromyzonidae). I. Species with two dorsal fins. Natur. Can. 77: 73–94.

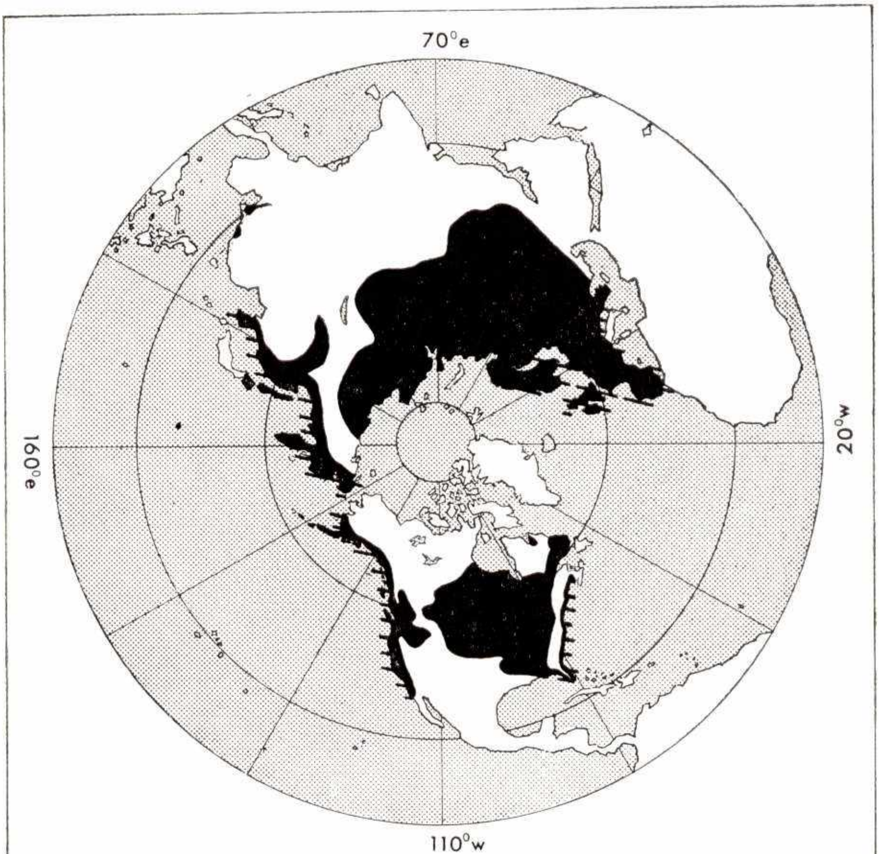
WIGLEY, R. L. 1959. Life history of the sea lamprey of Cayuga Lake, New York. U.S. Fish Wildl. Serv. Fish. Bull. 154, vol. 59: 561–617.

THE STURGEONS AND PADDLEFISHES—
Order Acipenseriformes (Chondrostei)

Body heavy and almost cylindrical; tail heterocercal but in some so even and deeply forked as to appear homocercal. Skeleton, including the cranium, cartilagineous. Some superficial bones of the head and pectoral girdle ossified. Upper jaw does not articulate with the skull. Paired fins well developed; pelvics abdominal and without true spines. Skin appears largely naked except for rows of large plates or bucklers in some species but in most species (at least in the young) the skin is variously covered with denticles; axes of fins of some species with spinelike scales called fulcra. Vertebrae without centra. Notochord persistent, extending into the upper lobe of the tail.

These fish inhabit temperate, marine and fresh water, and the marine forms spawn in fresh water.

The order consists of one fossil family, and 2 living families, Acipenseridae and Polyodontidae, that contain 6 genera. The extinct family Chondrosteidae is known from the Lower Jurassic to the Lower Cretaceous.



World Distribution of the Sturgeons

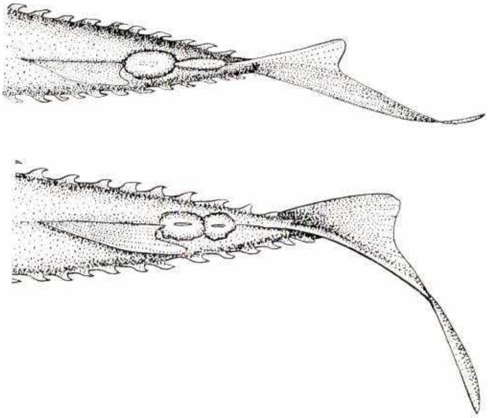
Sturgeon Family — Acipenseridae

The sturgeons are heavy, subcylindrical fishes with extended, hard snouts; and a ventral, protrusible mouth preceded by 4 barbels. Prominent body covering of large, bony scutes in 5 rows, 1 dorsal, 2 lateral, and 2 lateroventral. Sharp and obvious in the young, these plates become smoother with age and in some species gradually disappear by absorption. The rest of the skin appears naked but has small patches of denticles. The head is covered by bony plates. The unpaired fins are preceded by fulcra; the first ray of the pectoral fin is enlarged and ossified. The tail is broad and heterocercal; the dorsal and anal fins are approximately opposite and far back on the body. The 4 gills, and, in some, an accessory pseudobranch, are covered by an expanded subopercle bone. The opercle bone and branchiostegal rays are absent.

The sturgeons are anadromous, and freshwater fishes of the northern hemisphere known from the Upper Cretaceous. The family includes 23 species in 4 genera: *Huso*, 2 species, Pliocene to Recent; *Acipenser*, 16 species, Upper Cretaceous to Recent; *Scaphyrhynchus*, 2 species; *Pseudoscaphyrhynchus*, 3 species.

Key to Species

1 Obvious plates, other than fulcra, between anal fin and caudal fin (*top figure*), and between dorsal fin and caudal fin (*bottom figure*) 2



No obvious plates behind dorsal or anal fin other than fulcra; 6–9 plates, mainly in 2 rows, between anus and anal fulcra; dorsal plates 11–14; lateral plates 38–48; usually to 20 feet and 1800 pounds. .... WHITE STURGEON, *Acipenser transmontanus* (p. 96)

2 One large plate between anal fin and caudal fulcrum 3

Four smaller plates usually as 2 pairs, between anal fin and caudal fulcrum, first pair may overlap base of anal fin, second pair may look like one plate; 6–9 plates, mostly in pairs, behind dorsal fin; dorsal plates 7–16; lateral plates 24–35; usually to 10 feet and 300 pounds. .... ATLANTIC STURGEON, *Acipenser oxyrhynchus* (p. 92)

3 Distance from tip of snout to line of barbels equal to, or slightly less than, one-half the distance from tip of snout to anterior edge of mouth, lip excluded; snout to barbels no more than 1.5 times distance from posterior margin of mouth, lips excluded, to isthmus; gill rakers 22–40 4

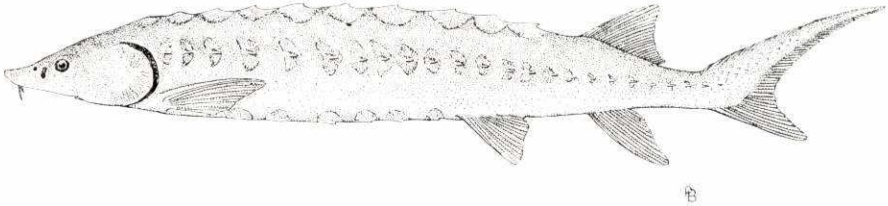
Distance from tip of snout to line of barbels more than one-half the distance from tip of snout to anterior edge of mouth, lip excluded; snout to barbels over twice the distance from posterior edge of mouth, lip excluded, to isthmus; gill rakers 18–20; dorsal plates 8–11; lateral plates 23–30; to 7 feet and 350 pounds. .... GREEN STURGEON, *Acipenser medirostris* (p. 90)

4 Anal fin rays 25–30; insertion of anal fin plainly behind insertion of dorsal fin; gill rakers 25–40 but usually 32–35; caudal peduncle longer, tip of anal fin reaching only to anterior edge of caudal fulcral plate; dorsal plates 9–17; lateral plates 29–42; to 3–5 feet and 310 pounds. .... LAKE STURGEON, *Acipenser fulvescens* (p. 82)

Anal fin rays 19–22; insertion of anal fin opposite insertion of dorsal fin; gill rakers 22–29; caudal peduncle shorter, tip of anal fin reaching origin of caudal fin; dorsal plates 8–13; lateral plates 22–33; to 36 inches and 9 pounds. .... SHORTNOSE STURGEON, *Acipenser brevirostrum* (p. 80)

SHORTNOSE STURGEON

Acipenser brevirostrum Lesueur



Description A moderate-sized, heavy-bodied fish, small compared to other sturgeons. Usual length 36 inches (912 mm). Body pentagonal in cross section. Head short, 22–28% of fork length, snout short, blunt, rounded, 70% of postorbital length in adults 15–28 inches (381–711 mm) but longer than postorbital length in young; mouth wide, width (excluding lips) 69–81% of interorbital width, no teeth; 4 barbels in front of mouth, somewhat closer to snout than to mouth; gill rakers moderately long, triangular, 22–29 (mean = 25.5) on first arch. Fins: single dorsal far back, opposite anal, trailing edge crescentric, 38–42 rays; caudal markedly heterocercal, lower lobe shorter and broad, upper long and pointed, no notch at lower tip, difference between fork length and total length is 11% of fork length; caudal peduncle short, tip of depressed anal reaching base of caudal fin; anal base about 60% of dorsal fin base, trailing edge emarginate, 19–22 rays; paired fins with heavy, ossified first ray, pelvics abdominal, far back, pectorals large. The body is not covered with scales but with patches of minute denticles and with rows of large, bony plates, scutes, or bucklers, 8–13 dorsal plates, 22–33 lateral plates, 7–11 ventral plates, at least 2 plates between dorsal fin and caudal fulcrum, at least one between anal fin and caudal fulcrum, usually a single row (sometimes 2 + 1) of plates between vent and anal fulcrum (preanal plates); no lateral line. Skeleton is cartilagineous except for membrane bones of skull, jaws, and pectoral girdle; vertebral centra absent, notochord persistent (largely from Vladykov and Greeley 1963).

Colour Body colour dark brown to nearly black on head, back, and sides to level of lateral plates, lighter brown to yellowish below, lower edge of head and body and entire ventral surface and barbels white; all fins pigmented but paired fins outlined in white; plates much paler and lateral plates obvious against dark background; viscera black, peritoneum pigmented; young with black blotches. Preserved specimens acquire a green colour in the skin, especially ventral surface and lower sides of head (Vladykov and Greeley 1963). A good colour illustration of an adult male was given (plate no. 2) in Greeley (1937).

Distribution Restricted to the eastern seaboard of North America from the Saint John River in New Brunswick to the St. Johns River of eastern Florida. Nowhere abundant now. It was probably most abundant, in the past, in rivers from the Connecticut to the Potomac.

In Canada it is known only from the Saint John River, upstream to Gagetown, where it is apparently more abundant than previously thought. Numbers of individuals in recent collections indicate the probable presence of a spawning population there. Records of the shortnose sturgeon in the St. Lawrence River were erroneous and based on *A. fulvescens* and *A. oxyrhynchus*.

Biology Spawning takes place in the spring, in the middle reaches of large tidal rivers from April to early June, depending on location. Adults apparently return to a parent stream. The eggs are dark brown in colour, small, and less numerous per pound of fish than in other sturgeons.

As with most sturgeons very little is known of the spawning and early life history, the young are rarely seen. Apparently the smallest specimen known was one 7.3 inches (185 mm) total length from North Carolina (Vladykov and Greeley 1963). Growth expressed as age–length relation for Hudson River shortnose sturgeon between 3 and 14 years (= no. of winters) was given by Greeley (1937) as follows:

Age	Range TL		Mean TL	Mean wt
(years)	*inches*	*(mm)*	*inches(mm)*	*(oz)*
3	–	–	21.9(556)	47.0
4	–	–	21.2(538)	31.0
5	21.9–23.7	(556–602)	22.6(574)	41.8
6	23.3–28.0	(592–711)	25.7(653)	55.3
7	22.9–31.4	(582–797)	26.1(663)	59.7
8	22.6–25.5	(574–648)	24.2(615)	51.3
9	31.4–33.6	(797–853)	32.5(827)	119.0
10	–	–	24.4(620)	87.5
11	–	–	26.9(683)	78.5
12	–	–	32.8(834)	134.5
13	–	–	34.8(885)	143.0
14	–	–	30.5(775)	116.0

However, Magnin (1963a) gave an account for the age–length relation of older sturgeon in the Saint John River as follows:

Age	TL	
(years)	*(inches)*	*(mm)*
14	28.7	730
15	31.5	800
16	27.2	690
17	30.3	770
18	31.1	790
19	29.5	750
20	32.3	820
22	30.3	770
23	34.6	880
27	31.5	800

These data indicate a probable maximum total length in the Hudson River of 34.8 inches (885 mm) for 14-year-old fish, weighing 8 pounds 15 ounces. The largest on record is an individual 39.5 inches (997 mm) total length from the Connecticut River. Canadian specimens from the Saint John River are usually 18–24 inches (457–610 mm) in total length, but have been taken as large as 31.5 inches (870 mm) total length. More recently specimens up to 4 feet (122 cm) from the Saint John River have been reported but not authenticated. In early March 1972 a female specimen 42.9 inches (109 cm) in total length and 13.25 pounds in weight was captured in Grand Lake, N.B., near the mouth of the Jemseg River.

This is a slow growing species. Prior to 1963 the maximum age was thought to be 15 years. Magnin extended this to at least 27 years and possibly 30 years. Magnin's (1963a) ages overlap and fit conveniently to the upper end of Greeley's data. Magnin interpreted age from pectoral fin rays, Greeley from otoliths. If their ages are correct, either the larger fish were not present in the Hudson River or were missed by the gear, or the Saint John River sturgeon grow much more slowly and live almost twice as long.

Growth rate of the shortnose sturgeon in early years is apparently similar to that of the Atlantic sturgeon, *A. oxyrhynchus*, so part of the difference in ultimate size may result from the greater tendency of the shortnose sturgeon to remain longer in rivers where food is less available. This species assumes adult characteristics at 2 feet (610 mm) in length.

Sexual maturity is achieved in U.S. populations by males at approximately 20 inches (508 mm) total length and females at approximately 24 inches (610 mm) and 3–5 pounds. They are capable of spawning more than once but Canadian fish may not be able to do so unless they achieve maturity at a smaller size than the more southerly populations.

This species is seen most often in large tidal rivers but is also taken in brackish and salt water. Captures in the Gulf of Maine indicate that it goes to sea and travels distances from the parent stream, but it is not so strongly migratory as other species.

The protrusible tube mouth obviously adapts sturgeons to feeding off the bottom. Hudson River specimens had eaten sludgeworms, chironomid larvae, small crustaceans, and plants.

Nothing is known of the predators of the larger fish. Even the young may be adequately protected from predation by their plates. Young and adult alike compete for food with other bottom-feeding fishes such as suckers, but their random, suctorial feeding off the bottom may have some advantage over the many species of fishes that browse on individual bottom organisms in the same turbid rivers. The main limitation would appear to be their extreme slow growth and late maturation.

Relation to man The flesh is of good quality, the eggs, although not great in number, are suitable for caviar. The present small size and low availability of this species make it of only incidental commercial importance today. In the 1800's this species was apparently preferred by fishermen in the Delaware River to the larger Atlantic sturgeon, as it commanded a higher price. In the early 1900's it was taken with gillnets and by hook and line in the various rivers. It is possible that this species, as well as the Atlantic sturgeon, is still taken infrequently in drift gillnets set for American shad, *Alosa sapidissima*, in east coast rivers of the U.S. Since they are small, commercially unimportant, and destructive to nets, they are probably destroyed when taken. Commercial fishermen at Long Reach, Saint John River, N.B. say they catch about equal numbers of shortnose and Atlantic sturgeons. These are apparently marketed in New York City.

The shortnose sturgeon is on the list of rare or endangered Canadian fishes. This may reflect the lack of knowledge of its true abundance or that the total Canadian population may be in an endangered habitat.

Nomenclature

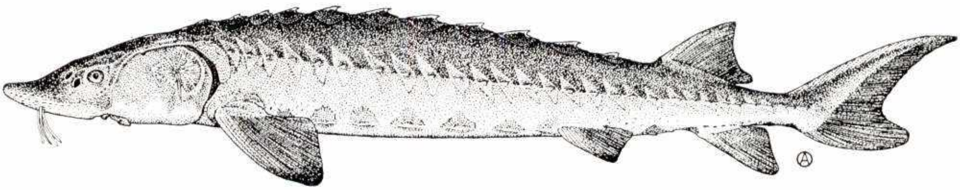
Acipenser brevirostrum — LeSueur 1818c: 390 (type locality Atlantic coast)
Acipenser brevirostris LeSueur — Richardson 1836: 278

Etymology *Acipenser* — an old world name for sturgeon; *brevirostrum* — short snout.

Common names Shortnose sturgeon, shortnosed sturgeon, small individuals called pinkster in New York. French common name: *esturgeon à museau court.*

LAKE STURGEON

Acipenser fulvescens Rafinesque



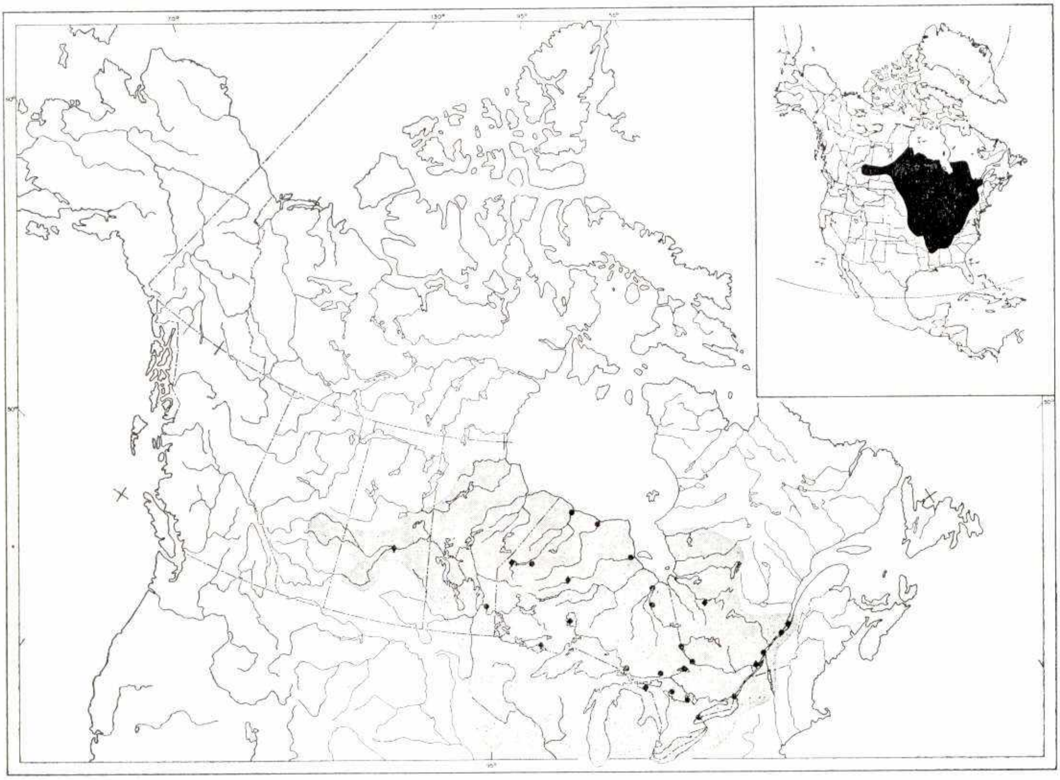
Description Heavy, torpedo-shaped body, markedly pentagonal in cross section in young but round in adults. As a result of minimum total length, weight, and mesh regulations, sturgeon seen today are usually 3–5 feet (91.5–142.5 cm) in total length and 10–80 pounds in weight. Most notable characteristic of the young is the bony plates or shields in 5 rows. Head appears long in young, shorter in adults due to relative length of snout, head length usually 24% of fork length in specimens 16–17 inches (400–700 mm) fork length. Snout length in individuals less than 19 inches (500 mm) fork length is greater than postorbital length, but less than postorbital length in larger individuals; skull broad, interorbital width 21.6–40.0% of head length, no fontinella; eyes midway between mouth and barbels, appear small in very large specimens. The characteristic protrusible, suctorial mouth is ventral, far back, posterior to the eyes, and large, its width (excluding lips) 66–93% of interorbital width; no teeth; gill rakers 25–40, but usually 32–35, short and blunt; 4 moderately short, prominent, ventral barbels well in advance of mouth. Fins: a single, moderately large dorsal, far back near caudal, 35–40 stiff rays, posterior edge only slightly falcate; caudal heterocercal, average difference between total length and fork length 9% of fork length, no notch in ventral edge of tip of upper lobe, lower lobe broad and rounded; anal under dorsal, base shorter than dorsal, tip rounded, 25–30 stiff rays; pelvics close to anal, approximately the size of the anal, trailing edge emarginate; pectorals low, large, and round at the tip, first ray ossified. No simple scales, body largely covered by minute, dermal denticles on a very tough skin; prominent rows of bony plates or shields, dorsal row 9–17, lateral row 29–42, ventral row 7–12, plates prominent, sharp, adjacent plates touching in very young, separated and more rounded or inconspicuous in larger individuals, 1 or more obvious plates between all posterior fins and between anus and anal fin. Vertebrae cartilagineous, centra absent, notochord persistent (partly from Vladykov and Greeley 1963). Plate number and arrangement were treated in detail by Vladykov and Beaulieu (1946).

Colour In young less than 12 inches (300 mm) total length, two large black blotches on upper surface of snout and between dorsal and lateral shields, one opposite base of pectoral fin, one below dorsal fin; smaller black spots on head, back, sides, and caudal peduncle; large blotches disappear when individuals reach 24 inches (610 mm) total length; larger individuals olive-brown to grey on back and sides, white below. Dorsal and lateral shields are the same colour as the body, lower surfaces of ventral shields white. Fins dark brown or grey. In preserved specimens lower surfaces green. Intestines dark, nearly black, swim bladder and fat grey, peritoneum clear to slightly pigmented (Vladykov and Greeley 1963). A good colour illustration is available in Vladykov (1955b). *See* colour illustration, this text, facing p. 90.

Systematic notes Roussow in 1955 described two morphae of this species *A. f. acutirostris*, the brown or lake sturgeon, and *A. f. obtusirostris*, the black or rock sturgeon.

Distribution In larger rivers and lakes from the St. Lawrence River near Cap Brulé to Hudson Bay and west to the North Saskatchewan River in Alberta, south through Lake Champlain, the Mississippi River to the Tennessee River in Alabama and in northern Mississippi. From lakes Winnipeg and Manitoba south through the eastern Dakotas, northeastern Nebraska and Kansas to eastern Missouri and Arkansas (Vladykov and Greeley 1963).

In Canada, Harkness and Dymond (1961) reported it from Hudson–James Bay as far north as Fort George River on the east and Seal River on the west; in North Saskatchewan River of Alberta almost to Edmonton; South Saskatchewan River of Saskatchewan; Lake Winnipeg, Assiniboine and Red rivers of Manitoba, less abundant to rare in lakes Manitoba and Winnipegosis; all of the Hudson Bay and Great Lakes drainages of Ontario, including all the Great Lakes; east to Cap Brulé or freshwater termination in the St. Lawrence River. Vladykov and Greeley (1963) suggested it may be in Labrador. It



is taken only occasionally from brackish water of the St. Lawrence River, and at Moose Factory on James Bay; and no sea residence known (Vladykov and Greeley 1963). Harkness and Dymond (1961) gave a very detailed account of the distribution in North America.

Biology The lake sturgeon spawns from early May to late June depending on locality. Optimum spawning temperature appears to be between 55.4° F (13° C) and 64.4° F (18° C). Sturgeon generally leave lakes on the spawning migration not long after the spawning rivers are free of ice and sometimes move under the ice. Migration seldom, if ever, exceeds 250 miles (Vladykov 1955b) but feeding ceases for the whole of the spawning period. They spawn in depths of 2–15 feet and in areas of swift water or rapids often even at the foot of low falls that prevent further migration. Richardson (1836), who spent the winter of 1819–20 in northern Saskatchewan, reported that the great rapid (Grand Rapids) of the North Saskatchewan River, where it empties into Lake Winnipeg, appeared quite alive with sturgeons in June. Where suitable spawning rivers are not available, such as in the lower Great Lakes, sturgeon are known to spawn in wave action over rocky ledges or around rocky islands. Males reach the spawning grounds first and the fish congregate before spawning temperatures are reached. Many observations of sturgeon rolling near the bottom and then leaping completely out of the water to fall back with considerable splash and noise have been recorded during spawning or the prespawning congregation.

The females are in spawning condition for only a brief period and females with free-running eggs are seldom seen. During spawning they lie in groups of two or three, one or two males to each female; the males are much smaller. No nest is constructed and the adhesive eggs are scattered and adhere to rocks and logs. All the eggs are not shed at once but probably over a period of one or more days. The ripe eggs are black in colour and 2.7–3.5 mm in diameter. Roussow (1957) gave coloured illustrations of ovarian maturation stages. After maturation, egg number increases with the weight of the female, but is variable in fish of the same weight; one can have twice as many eggs as another. Calculated total egg numbers and number per pound of fish as given by Cuerrier were quoted in Harkness and Dymond (1961) as follows:

Female wt(*lb*)	Total eggs	Eggs per lb sturgeon
11.5	49,835	4333
36.0	184,913	5136
57.0	323,817	5681
79.0	370,910	4695
112.0	667,472	5960

Cuerrier (1949) gave the minimum and maximum calculated number of eggs in lake sturgeon as 107,510 and 885,360. Calculated egg numbers have often been extrapolated to indicate that 200-pound females could carry as many as 3,000,000 eggs.

At temperatures of 60°–64° F (15.6°–17.8° C) some eggs hatched in 5 days and all had hatched by 8 days. The young, 8 mm long, are nourished by a large yolk sac for 9–18 days. By 2 weeks the young are miniatures of the adult and the paired fins are well developed and by 16 days they are approximately 21 mm long at which time they begin to feed. By September of the first year they have grown to 4.8 inches (123 mm) total length. Growth is somewhat slower from this point and the age–length and age–weight relations, as given by Harkness (1923) for Lake Nipigon, is shown in the following table. From this table it can be seen that, in the first 5 years, sturgeon increase rapidly in length but little in weight. Between 5 and 15 years, there is a decrease in rate of length increment whereas weight increases at a faster rate. After 20 years and the onset of sexual maturity, rate of increase in length is even slower but more uniform and the increase in weight becomes more rapid.

Age	TL		Wt
	(*inches*)	(*cm*)	(*lb*)
1	7.7–11.1	19.7–28.1	0.1–0.2
2	11.8	30.0	0.3
3	13.0–14.4	33.0–36.5	0.3–0.4
4	15.9–19.1	40.3–48.4	0.8–1.1
5	19.0–20.5	48.2–52.0	1.1–1.3
6	21.3–21.7	54.2–55.1	1.5–1.7
7	22.0–23.8	56.0–60.5	1.9–2.3
8	23.7–23.8	60.2–60.5	2.1–2.4
9	22.1–24.8	56.1–62.9	1.7–2.7
10	23.6–29.4	60.0–74.7	2.1–4.1
12	30.4	77.2	5.1
13	29.2	74.2	4.2
15	30.1–31.3	76.5–79.6	4.0–5.7
17	34.3	87.3	6.5
18	35.0	89.0	6.4
19	35.6	90.5	9.8
22	35.0	89.0	8.4
25	39.6	100.0	12.0
37	53.8	136.0	42.0
38	58.3	147.5	45.0
40	52.4	132.4	29.0
47	63.0	165.5	64.0
50	61.5	156.0	50.0

Harkness (1923) tabulated this data as the number of summers, i.e., third summer equals 2 years of age.

The interpretation of age in sturgeon, from otoliths, opercula, and pectoral fin ray sections has not been easy or uniform. In a fish with such a long life span and variability of growth rate in different environments, age of older fish, accurate within 5 or 6 years, is a most difficult decision. Since this is so, tables of comparative age–length relation for various localities are of limited value. Harkness and Dymond (1961) gave graphic comparison for populations in Quebec, Ontario, Wisconsin, and Manitoba. Consequently, age at sexual maturity, age at first spawning, and interval between successive spawnings has long been a debatable point. In this large, slow-growing species, sexual maturity is very late. In 1923 Harkness felt that sexual maturity was not reached by sturgeon in Lake Nipigon until age 22 or later. Harkness and Dymond (1961) gave the following comparison of age at sexual maturity for various locations:

	Males	Females
Ottawa River, Que.	19–20	26
Lake St. Francis (St. Lawrence R.)	15	23
Quebec	12–19	14–23
Nelson River, Man.	15–20	25–33

Roussow (1957) considered that maturity was reached by 8–13 years but that first spawning took place at 12–19 years for males and 14–23 years for females. Magnin (1966a) estimated that sexual maturity was reached by females in northern Quebec at 20–23 years, 35.4–39.6 inches (90–100 cm) total length, and 9.5–19.8 pounds weight. For males he gave 18–20 years, 33.4–37.4 inches (85–95 cm) total length and 8.6–11.4 pounds weight.

Roussow in 1957 estimated as did most earlier authors that interval between spawnings only sometimes increased with age, and was 4–7 years in males and as high as 7–9 years in females. With more and more refinement of the aging techniques, this interval has decreased so that, in 1966, Magnin (1966b) felt that, depending on locality south to north, females spawned every 4–6 years and males every year to every 2 or 3 years. Total length at first spawning varies in Canada from 30 to 40 inches (76.2–101.6 cm) for males and 33 to 47 inches (83.9–119.5 cm) for females.

As with all interpretations involved with age, the maximum age of lake sturgeon is open to question. Females do live longer than males. Magnin (1966a) gave 55 years as the usual maximum age for males and 80 years for females in Quebec, stating that, in the oldest fish, there were only 4 males over the age of 55 compared to 26 females. Maximum age is greatest in the more northern, slower-growing populations.

Most sturgeon seen today come from the commercial fishery, which is governed by minimum total length, minimum weight or net mesh size. As a result, the sturgeon are usually 3–5 feet (91.5–142.5 cm) in total length, and 10–80 pounds in weight. Small numbers of very large sturgeon are still seen each year. A sturgeon weighing 234 pounds was caught in Lake of the Woods in 1965 and one 154 pounds in the Bay of Quinte in October 1969. The latter, 7 feet, 5 inches (226.2 cm) long, probably should have weighed about 200 pounds but was in very poor condition. Harkness and Dymond (1961) listed records for 36 Canadian sturgeon over 100 pounds. Apparently the largest lake sturgeon recorded is one of 310 pounds, 7 feet, 11 inches (241.4 cm) long, caught in Batchewana Bay, Lake Superior, June 29, 1922. A photograph of this fish appeared in the *North Bay Nugget*, June 5, 1936, in an article, by Harkness and Dymond, on the fishes of Lake Nipissing. Because of the difficulty of determining the age of single, very large specimens, ages are not often included. There is, however, a record of 154 years of age for a sturgeon of 208 pounds caught in Lake of the Woods in 1953 (MacKay 1963) — it had, therefore, been born in 1801, 4 years before the battle of Trafalgar!

This species is not often considered a sport fish so is rarely entered in the usual lists of angling records. The list of large sturgeon in Harkness and Dymond (1961) cited many, from areas where there are no commercial fisheries, which may have constituted angled fish. One in particular, weighing 230 pounds and 6 feet, 8 inches (203.3 cm) in length, was caught in the Niagara River on October 28, 1946, by Harding Miller of Fort Erie North. A photograph of this fish appeared in Harkness and Dymond. A caption to an earlier notice, in the *Toronto Daily Star* October 30, 1946, stated that it was entered in the New Jersey Governor's fishing contest, so it may constitute an authentic angler record.

The usual habitat of the lake sturgeon is the highly productive shoal areas of large lakes and large rivers. Most captures are made at 15–30 feet (4.6–9.2 m) but they have been taken, rarely, as deep as 140 feet (42.7 m). They are bottom dwellers, adapted to feeding on the bottom, which consists of mud or gravel and mud. Small sturgeon, 7.7–30.0 inches (19.6–76.2 cm) in length, in Lake Nipigon were most often found on gravelly shoals near the mouths of rivers. It is primarily a freshwater fish but is known from brackish water in the lower St. Lawrence

River, and Hudson and James bays (Harkness and Dymond 1961).

Seasonal movements, other than spawning migrations, are not well known but thought to consist of a move from shallow waters when these warm, into deeper water, a return to the shoals in autumn, and a return movement to moderate depths in winter. In Wisconsin, where there is a winter sport fishery at a maximum of 21 feet (6.4 m), lake sturgeon are active all winter. Spawning migrations out of lakes and up rivers to suitable grounds are often as long as 80 miles but are not known to exceed 250 miles. Strong homing has been described but there are also cases of fish wandering from lake to lake.

Like some very large, marine, filter-feeding fishes, the sturgeons are large fishes that feed almost exclusively on very small organisms they obtain from the bottom by means of the protrusible, tubelike mouth.

Food is searched by constant movement close to the bottom and by the sensory ability of the barbels. Virtually anything edible that will enter the mouth, is sucked up and consumed. Nonedible materials such as mud, sticks, and stones pass out under the opercula or are cast out of the mouth. The food is worked or pulped in the mouth, often partly ejected and sucked in again. Consequently food type ranges widely and composition depends on availability. Harkness (1923) listed the following: crayfish, molluscs, insect larvae (mainly chironomids), nymphs (mainly Ephemeroptera, Trichoptera, and Neuroptera), fish eggs, fishes (rarely), nematodes, leeches, amphipods, decapods, and a few plants. For a complete summary of percent composition, by date, *see* Table 4, p. 35, of that paper and an extensive section in Harkness and Dymond (1961). The only fish identified in the stomach contents by Harkness (1923) was the ninespine stickleback. Sculpins (Cottidae) are another said to occur. Vladykov and Greeley (1963) gave fish as 24% of the stomach contents of lake sturgeon in the St. Lawrence River. They added that the best bait with which to catch lake sturgeon on hooks was American shad, or banded killifish. Algae is apparently eaten at times, and lake sturgeon caught near grain elevators have stomachs filled with wheat, barley, and corn. Feeding ceases during the spawning migration but apparently takes place all winter in some localities.

Lake sturgeon and other bottom feeders such as lake whitefish, consume the same food items but are often not competitive as they feed in different places. The white and longnose suckers are probably its strongest food competitors. The predatory role of the lake sturgeon is known to have been greatly exaggerated in the past. It was assumed from its bottom feeding and the periodic appearance of fish eggs in gut contents that it decimated the eggs of other economically more important species. It is now known that fish eggs form a very small and inadvertent part of its food, probably since it feeds on bottoms not particularly good as spawning locations.

Predators on the lake sturgeon are limited by the scutes of the young and the size of the adults, and Harkness and Dymond (1961) stated that there were no records of the young in the stomachs of other fishes or other animals. Lampreys (*Petromyzon marinus* and *Ichthyomyzon unicuspis*) are known to attack and possibly kill even large sturgeons. The sturgeon of 154 pounds, caught in the Bay of Quinte in October 1969, said above to be in poor condition and low in weight, carried, when captured, 15 large sea lampreys and scars of many other attacks. It was very sluggish and when dressed bled very little. Lamprey attacks may have contributed to its low weight and vulnerability to the very light nets in which it became entangled.

Extensive information on the biology of this species in Quebec was given by Magnin (1963b).

Comparatively few parasites have been recorded from lake sturgeon. Harkness and Dymond (1961) listed the following: Trematoda, 6 species; Acanthocephala, 4 species; Nematoda, 5 species; Cestoda, 1 species; Crustacea, *Argulus canadensis* reported once. The list given by Hoffman (1967) included the following: Trematoda — *Allocreadium* sp., *Crepidostomum lintoni*, *Diclyobothrium armatum*, *D. hamulatum*, *Diplostomulum* sp., *Skrjabinopsolus manteri*; Nematoda —

Cucullanus clitellarius, Rhabdochona cascadilla; Acanthocephala — *Echinorhynchus salmonis, Tanaorhamphus ambiguus*; Crustacea — *Argulus canadensis, A. stizostethi.*

Relation to man No other Canadian freshwater fish has had such a kaleidoscopic relation to man. The lake sturgeon was once looked upon with scorn by fishermen as a worthless nuisance that destroyed gear set for "valuable fish" but has at other times commanded a higher price per pound than any other freshwater commercial fish. Before 1860, this species, taken incidental to catches of other fishes, was killed and dumped back in the lake, piled up on shore to dry and be burned, fed to pigs, or dug into the earth as fertilizer. It was even stacked like cordwood on the wood dock at Amherstburg, Ont., and used to fire the boilers of steamboats plying the Detroit River. They were highly prized as food by some groups of Indians, but only small numbers of sturgeon were sold for food by white fishermen. These went for 10¢ each and were smoked, dried, or brined like corned beef. The eggs were considered fit only as food for hogs or bait for other fishes. Sturgeon were boiled down for the oil which was used in paints. By 1860, North Americans realized the value of the flesh, smoked or fresh, of the eggs for caviar, and of the high quality gelatin isinglass (a word derived from the middle Dutch word *huysenblasse*, meaning sturgeon bladder). This gelatin, extracted from the swim bladder, once sold for $1.00 per pound (10 fish) and was used as a clarifying agent in the making of wine and beer, as a cement for pottery, to size and stiffen textiles, to set jams and jellies, and for waterproofing. The sturgeon skins were even tanned for leather. The fishery for this species then became so intense as to eventually contribute to the reduction of the populations to a level from which they have never recovered. They were taken by every available means from spearing and jigging to set lines of baited or unbaited hooks laid on the bottom, to trapnets, poundnets, and gillnets.

The beginning of commercial preparation of caviar and, later, smoked sturgeon at Sandusky, Ohio, in 1855 and 1860 was the principal reason for the sudden intensification of the fishery for sturgeon in Canada as well as in the United States. In the 10 years between 1885 and 1895, the catch showed the classic course of events often associated with an intense fishery on a slow-growing fish. The Lake Erie catch was initially high, over 5,000,000 pounds, but had dropped by 80% by 1895. In Lake of the Woods the decline in catch was 90% over the 7 years 1893–1900. By 1957 the catch in Lake of the Woods, once known as the largest sturgeon hole in the world, stood at 0.005% of the 1893 maximum. In 1895 that lake alone had contributed 39% of Ontario's total catch of 1.8 million pounds. The Ontario catch has never exceeded 200,000 pounds since 1925. The biology of the fish, the early, intense, indiscriminate fishery, and the effects of dams and pollution on the opportunity and ability of the species to reproduce, have all contributed to the present low levels of populations of lake sturgeons. Most of the sturgeon caught in Canada have been sold to the United States for processing and the sole attempt to produce caviar in Canada was short lived as a result of the declines in stocks.

Although the catches are low, each sturgeon still commands a very high price per pound for flesh and eggs. Since 1959 the yearly catch has fluctuated from a high of 194,638 pounds in 1961 to the level of 85,723 pounds in 1966 with a steady decline over that period. The meat earned a market value of $187,565 or 96.4¢ per pound in 1961 and has risen steadily to the price of $1.22 per pound in 1966. Once used as fertilizer or fed to hogs, the smoked flesh of lake sturgeon is now a gourmet item that few can afford. The price paid for eggs for caviar rose rapidly also. In 1925 it was $1.50 per pound and the highest price paid was in 1952, when it reached $4.33 per pound. Price declined slightly and from 1962 to 1966 it fluctuated between $3.30 and $3.97 per pound. Usually eggs of the lake sturgeon command a higher price than those of other North American sturgeons.

The flesh, especially when smoked, is delicious although rich and oily. It is said that unsmoked sturgeon, not favoured by most people, when properly prepared and properly cooked, is excellent. It is usually made into steaks and fried and is said to taste more like veal than fish. Vladykov (1955b) quoted the Quebec fishermen as saying it has five kinds of meat from different parts of the body.

It is not an important sport fish in Canada, but its size always attracts some attempts to catch it by hook and line. There is an important winter spear fishery by anglers in Michigan and Wisconsin. The regulations governing the commercial and sport fisheries for this species in various places were summarized by Harkness and Dymond (1961).

Nomenclature

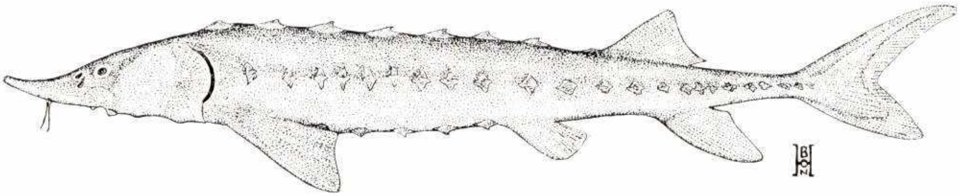
Acipenser fulvescens	— Rafinesque 1817a: 288 (type locality Great Lakes)
Acipenser rubicundus	— LeSueur 1818c: 383
Acipenser Rupertianus Richardson	— Richardson 1836: 311
Acipenser laevis	— Agassiz 1850: 267
Acipenser carbonarius	— Agassiz 1850: 271
Acipenser rhynchaeus	— Agassiz 1850: 276
Acipenser maculosus Lesueur	— Günther 1870: 339
Acipenser athracinus	— Duméril 1870: 126
Acipenser megalaspis	— Duméril 1870: 135
Acipenser lamarii	— Duméril 1870: 139
Acipenser atelaspis	— Duméril 1870: 141
Acipenser rosarium	— Duméril 1870: 152
Acipenser kirtlandi	— Duméril 1870: 161
Acipenser buffalo	— Duméril 1870: 231
Acipenser sturio	— Eigenmann 1895: 107
Acipenser fulvescens obtusirostris	— Roussow 1955: 79
Acipenser fulvescens acutirostris	— Roussow 1955: 79

Etymology *Acipenser* — latin name for a sturgeon; *fulvescens* — dull yellow colour.

Common names Lake sturgeon, freshwater sturgeon, Great Lakes sturgeon, rock sturgeon (usually the long snouted, obviously plated young), stone sturgeon, red sturgeon, ruddy sturgeon, common sturgeon, shell back sturgeon, bony sturgeon, smoothback. French common names: *esturgeon de lac* or *Camus* for adults, and *escargot maillé,* or *charbonnier* for the young.

GREEN STURGEON

Acipenser medirostris Ayres



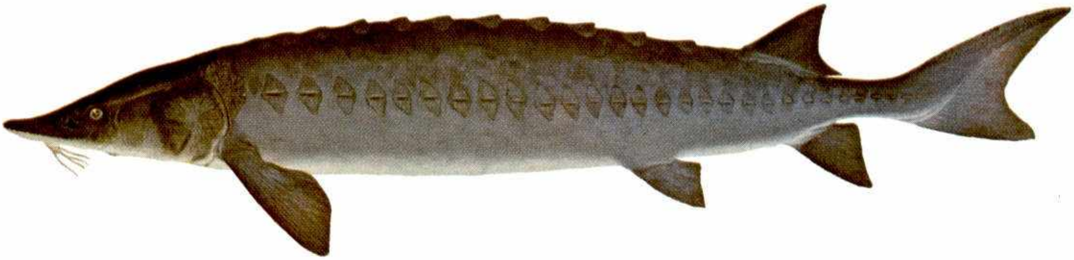
Description This little known, rarely seen species is much smaller than the other Pacific sturgeon, the white sturgeon. Usual length 7 feet (2.13 m). The green sturgeon has a robust rounded body, pentagonal in cross section, greatest depth about 14% of total length, head moderately long, large, broad, without fontanelle, about 23% of total length; eyes small; snout in adults blunt and rounded but sharp, longer than postorbital length, and concave on top in young; mouth ventral, toothless, about 61% of interorbital width; 4 barbels anterior to mouth, nearer to mouth than to tip of snout; gill rakers scarcely longer than broad, 18–20 on first arch. Fins: dorsal 1, far back, over anal, not high nor deeply emarginate, 33–35 rays; caudal markedly heterocercal, upper lobe long, broadly pointed, lower lobe about half as long, difference in total length and fork length is 11% of fork length; caudal peduncle in small animals short, tip of anal reaching or passing base of lower lobe of caudal; anal longer than dorsal but base $\frac{1}{2}$ base of dorsal fin and origin opposite last $\frac{1}{3}$ of dorsal, 22–28 rays; pelvics near anus, pectorals large, rounded; paired fins with heavy ossified first ray; no scales, body covered instead with series of large, hooked plates with interspersed series of smaller stellate plates; tail with scattered plates; dorsal plates 9–11, large, hooked; lateral plates 23–30 not touching; ventral plates 7–10; 1 plate between dorsal fin and caudal fulcrum; 1 plate between anal and caudal fulcrum; 3 plates in single row between anus and anal fin; no lateral line. Skeleton cartilagineous except for membrane bones of skull, lower jaw and pectoral girdle; no vertebral centra, notochord persistent.

Colour Body and head at all sizes definite dark green to olive-green colour; lower edge of head, body, and all ventral surfaces paler to whitish green; in life a marked olive-green longitudinal stripe midventral and lateral between lateral and ventral plates, ending at anus; lateral plates slightly paler than body colour; fins dusky grey to pale, opaque green; viscera pale, without pigment.

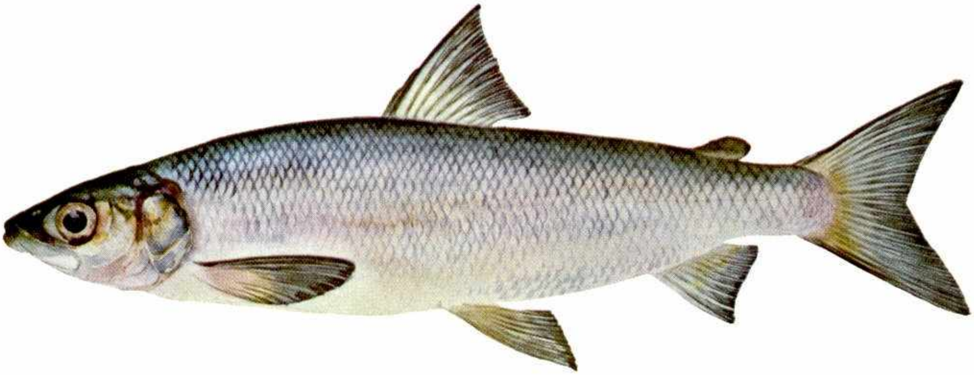
Distribution The North Pacific coasts of Korea, China, northern Japan, the USSR to the Amur River (Berg 1948), and North America from the Gulf of Alaska at least to Petersburg, Alaska (Migdalski 1962) to San Francisco. Usually about the mouths and in the lower reaches of large rivers.

In Canada it is known to occur at Victoria, off Kyuoquot Sound, west coast of Vancouver Island, and in the Fraser and Skeena rivers. In North America it is much less common than the white sturgeon, *A. transmontanus*, and apparently rarely found in fresh water (Carl et al. 1967). In the USSR this sturgeon is said to be rather abundant in the Datta River.

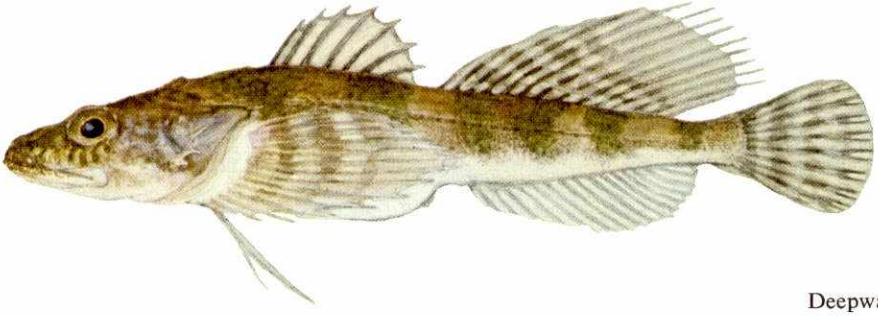
The first Canadian record of this species was a specimen 13.5 inches (343 mm) total length caught in 1908 near Victoria and now in the British Columbia Provincial Museum.



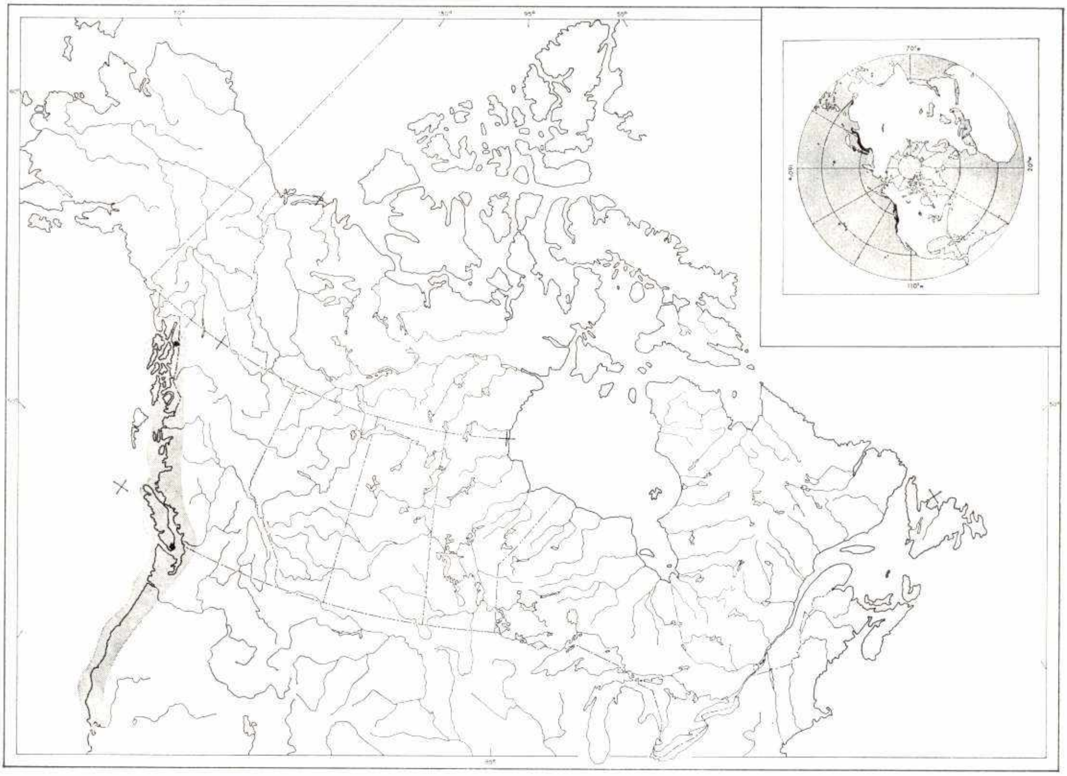
Lake sturgeon



Blackfin cisco



Deepwater sculpin



Biology Virtually nothing is known of the life history of this animal. It is always reported in the literature as rare in fresh water, preferring the mouths of large rivers where it is seen in August and September. Its capture in nets set for salmon (*Oncorhynchus* spp.) in the late summer and early fall in lower Fraser River would indicate that it is anadromous and moves into fresh water through the fall and winter to spawn in the spring. Records from fish tagged in California indicate that at least some individuals travel in the sea distances as great as 660 miles (Chadwick 1959).

Beyond this point various accounts of this species in the literature simply repeat that its life history is assumed to be similar to that of the white sturgeon, said to spawn from the middle of June to the middle of July in the Datta River, USSR.

The largest specimen known from Canadian waters weighed approximately 350 pounds. It is estimated that most green sturgeons seen on the North American coast weigh 50–100 pounds.

Relation to man The flesh of this fish, once thought to be poisonous, has been said to be edible, but dark, with a strong disagreeable taste, and an unpleasant odour. It is considered quite inferior to white sturgeon, bringing only a nominal price and, in the past, the roe was not utilized at all (Jordan and Evermann 1908). Magnin (1959) quoted Russian authors for the fact that it is taken commercially in the Bering Sea. The green sturgeon is taken in nets set for salmon in the Fraser River but there is no statement of its utilization in British Columbia.

Nomenclature

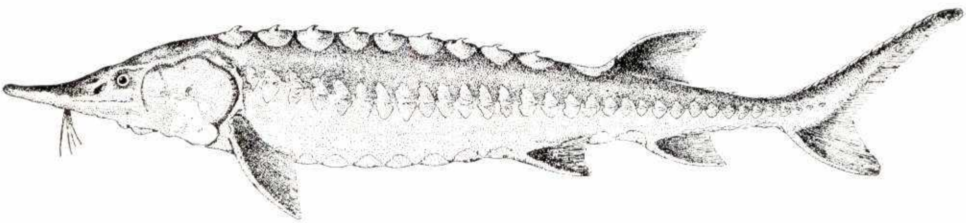
Acipenser medirostris — Ayres 1854: 15 (type locality San Francisco)
Acipenser acutirostris Ayres — Jordan, Evermann, and Clark 1930: 34

Etymology *Acipenser* — an old world name for sturgeon; *medirostris* — moderate snout, alluding to a supposed intermediate snout length.

Common names Green sturgeon, Sakhalin sturgeon or *sterlyad* in USSR. French common name: *esturgeon vert.*

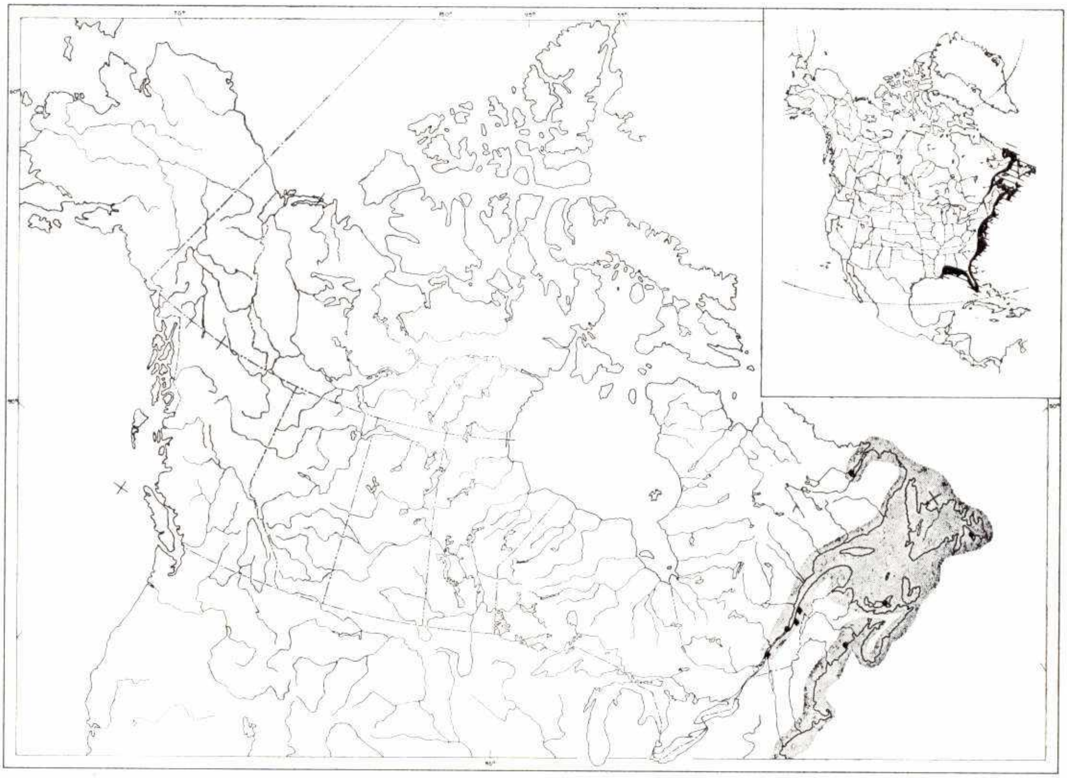
ATLANTIC STURGEON

Acipenser oxyrhynchus Mitchill



Description A large, heavy-bodied fish giving the impression of a pentagon in cross section. Usual length 10 feet (3.05 m). Head elongate as result of longer snout; snout, pointed in young, slightly upturned, flat on bottom, length greater than postorbital distance in fish up to 37 inches (941 mm), but shorter than postorbital distance in larger, older individuals; mouth opening narrow, 55% of interorbital width; no teeth; 4 ventral barbels ahead of mouth midway between tip of snout and mouth; gill rakers long, 15–27 (mean = 21.5). Fins: dorsal 1, far back, opposite anal, high, trailing edge deeply crescentric, 38–46 rays; caudal markedly heterocercal, long, pointed, upper lobe with notch under tip, lower lobe shorter, mean difference between total length and fork length 14% of fork length; anal slightly longer than dorsal, base 66% of base of dorsal, trailing edge little emarginate, 26–28 rays; pelvics abdominal, far back, pectorals large somewhat square at tip, both with heavy, ossified first ray. The body is not covered with scales but with patches of heavy denticles and large, hooked plates, 7–16 dorsal plates, 24–35 lateral plates, 8–12 ventral plates, 6–9 plates behind dorsal in pairs, usually 4 plates behind anal each smaller than anal fulcrum, no lateral line. Skeleton cartilagineous, except for membrane bones of skull, jaws, and pectoral girdle; vertebral centra absent, notochord persistent (Vladykov and Greeley 1963).

Colour Dorsal surface of body and head blue-black, paling on sides, lower edge and lower surface of body and head white, ventral plates white. Spines of dorsal and lateral plates white, contrasting with dark colour of skin; iris of eye golden; leading edge of paired fins and lower lobe of caudal



white, contrasting with dark grey of the rest of the fins, anal fin white, dorsal fin and upper lobe of caudal grey to blue-black with white trailing edge. Viscera and peritoneum white; in preserved specimens unpigmented skin of ventral surface and lower sides of head white to pink, never green. A good colour illustration in Vladykov (1955b).

Systematic notes Although described as a separate species by Mitchill in 1815, by the late 1800's it was being considered as synonymous with, or a variety or subspecies of, *A. sturio*, the European sea sturgeon. This tendency continued into the 1950's in some publications. *See* Magnin (1963a, 1964) for comparisons of, and distinctions between, *A. sturio* and *A. oxyrhynchus*. Vladykov (1955d) described the Gulf of Mexico populations of the Atlantic sturgeon as a subspecies, *A. o. de sotoi*. He strangely attributed to this species old records from Bermuda.

Distribution Limited to the Atlantic coast of North America from Hamilton Inlet, Labrador, or George River, Ungava Bay, to eastern Florida. Early records will include eastern Atlantic as a result of the confusion of this species with *A. sturio*, the common sea sturgeon of Europe. It is replaced in the Gulf of Mexico, according to Vladykov (1955d), by a subspecies, *A. o. de sotoi*, the Gulf of Mexico sturgeon. Old records of *A. oxyrynchus* from Bermuda, Vladykov said, were probably this latter form, which seems odd.

In Canada from George River(?), Ungava Bay, or Hamilton Inlet, Labrador, Blanc Sablon on the Quebec side of the Strait of Belle Isle, throughout the Gulf of St. Lawrence, Gaspé, Bay Chaleur, the St. Lawrence River upstream to Trois-Rivières regularly, and Lac St. Pierre occasionally; rare records off Newfoundland (northwest coast and Hermitage Bay), none from fresh water; better known in Nova Scotia and New Brunswick — Cheticamp, Aspy Bay, Bay of Fundy, Minas Basin, Annapolis River, Avon River, Passamaquoddy Bay, Saint John River, Oromocto and Grand lakes, and Miramichi estuary (Vladykov and Greeley 1963; Leim and Scott 1966).

Biology The Atlantic sturgeon is anadromous, spending much of its life in the sea but returning to fresh water to spawn. The move to fresh water is made actually in advance of spawning time. In the southern part of the range this is apparently in February, becoming later northward where, in the St. Lawrence River, it is late May to early July. In the Delaware River the sturgeon congregated for spawning in the upper reaches in 36–42 feet (10.97–12.80 m) of water over a hard, clay bottom. Spawning occurred at 56°–64° F (13.3°–17.8° C). Virtually nothing is known of the spawning activity of this species, particularly in Canada. Vladykov and Greeley (1963) assumed that it spawned in pools below waterfalls in such tributaries of the St. Lawrence River as Batiscan River and Rivièreaux-Outardes, and that the spent fish return randomly to sea, the greatest number during September–November. Spawning is probably yearly in some females and ceases only with extreme age or death.

When laid, the eggs are light to dark brown, heavy, and absorb water and quickly become sticky, attach to vegetation and stones as they are randomly distributed over a wide area by the spawning pair. Egg size is 2.5–2.6 mm and calculated egg numbers range from 800 thousand to 2.4 million per female and an estimate of 3,755,745 eggs in a female 8 feet 9 inches (2.65 m) long weighing 352 pounds, with an ovary weighing 91 pounds.

At a water temperature of 64° F (17.8° C) the eggs hatch in about 1 week, the yolk sac lasting a further 6 days. Newly hatched fry are about 11 mm long. Mansueti and Hardy (1967) illustrated and described larval stages in the Chesapeake Bay region.

Little is known of the early growth of the Atlantic sturgeon as the young are rarely seen. Young specimens 2.5–4.3 inches (65–110 mm) total length and 0.7–4.2 grams in weight caught in fresh water of the St. Lawrence River, were considered to be less than a year old. From August to October size of small individuals increased from 5.1 to 7.9 inches (130–201 mm) fork length and weighed from 6.8 to 47.7 grams. The young may spend as long as 3 or 4 years in fresh water before migrating to sea where growth accelerates. Hudson River Atlantic sturgeon 11–34 inches (27.9–86.5 cm) total length were 2–8 winters old as determined from otoliths, but 11- and 12-year-old specimens ranged from 75 to 100 inches (190.7–254 cm) total length. Specimens tagged in the St. Lawrence River over the size range of 27.8–33.3 inches (70.6–84.7 cm) fork length and 4.8–8.8 pounds yielded an estimated annual increment in length of 6.3–14.4% and in weight of 28.8–47.0%. Magnin (1963b) gave the following age–length–weight relation for sturgeon in the St. Lawrence River:

Age	Mean TL (*inches*)	Mean TL (*cm*)	Mean wt (*lb*)
1	8.6	22	0.06
2	11.0	28	0.15
3	13.7	35	0.2
4	16.5	42	0.6
5	19.3	49	0.9
6	22.8	58	1.5
7	26.0	66	2.3
8	29.5	75	3.8
9	34.2	87	5.7
10	35.4	90	6.8
11	38.6	98	9.9
12	41.5	105	11.4
13	42.9	109	12.7
14	45.2	115	15.1
15	47.2	120	16.7
20	63.8	162	47.9
46	102.4 (8.5 ft)	260	330.0
60	105.1 (8.8 ft)	267	352.0

This species retains juvenile characteristics up to 4 feet (122 cm) in length.

No female has been reported sexually mature and capable of spawning at a weight less than 150 pounds or an age less than 10 years. Males as small as 69 inches (175.3 cm) total length and a weight of 70 pounds are capable of spawning. In the St. Lawrence River sexual maturity is achieved by males at 22–24 years and by females at 27–28 years. This is at an approximate total length of 65 inches (165 cm) and 74.7 inches (190 cm).

Atlantic sturgeon of 200–300 pounds are not uncommon in the annual catches in Quebec. The largest Atlantic sturgeon known is apparently a 14-foot female, 811 pounds, caught at Middle Island, Maugerville, N.B. about 65 miles off the estuary of the Saint John River, in July 1924. The largest St. Lawrence River specimen was 8 feet 9 inches (266.9 cm) total length and weighed 352 pounds. Magnin (1963b), judged this fish to be 60 years old. The largest individuals are always female.

This species is anadromous so the young are hatched in fresh water and spend up to 4 years there but descend gradually to the sea. Nothing is known of their detailed habitat or activities. They are bottom dwelling fish but are seen at times jumping out of the water. Behaviour in the sea is poorly known; they can adjust without apparent stress to abrupt changes from salt to fresh to salt water. The bulk of the fish produced in any river spend most of their life in the estuary and immediate environs of that river. Tagged individuals have, however, travelled up to 900 miles and this species is taken at sea as far off the continental shelf as Georges and Brown banks.

The young sturgeon in fresh water eat a wide variety of bottom-dwelling plant and animal material, which is taken into the protruded, tubelike suctorial mouth, along with a good deal of mud, while the fish is rooting on the bottom with its snout and sucking in the material. Sludgeworms (*Limnodrilus*), chironomid larvae, mayfly larvae, isopods, amphipods, and small bivalve molluscs have been recorded. In the sea, the larger sturgeon feed on molluscs, polychaete worms, gastropods, shrimps, amphipods, and isopods and small fishes, particularly sand lances, *Ammodytes*. Adults apparently do not eat during migration and spawning and as a result are in poor condition by that time. They do eat in fresh water after spawning is completed and apparently quickly rebuild themselves.

Very little is known of the predators of such large fish. It is known to be attacked and even killed by the sea lamprey. It is possible that its size and protective plates protect it from most predaceous fishes and its habitat and secretiveness from other predators. Since several species of sturgeon inhabit the same rivers, the young compete for food with one another and with other bottom-feeding fishes.

Relation to man This sturgeon provides food of good quality but less so than the lake sturgeon. Actually only large adult Atlantic sturgeon provide tender rich flesh most suitable for smoking, etc., but the bulk of the catch is of half-grown individuals. The price paid in Quebec is 35¢/per pound dressed compared to over $1.00 for the lake sturgeon, and Atlantic sturgeon dress out to only 40–50% of live weight. The flesh was long referred to in New York as "Albany Beef." The eggs are as suitable for caviar as those of the lake sturgeon, and a 352-pound female will yield 91 pounds of eggs. In 1888, a single dealer on the Delaware River shipped 50 tons of eggs for the German market of caviar. The fishery for this sturgeon in Canada is small, 57,000 pounds in 1962 worth $11,000 (Leim and Scott 1966). The catch in Quebec around 1955 was 160,000 pounds with a value of $20,000 (Vladykov 1955b). The catch in the United States today is greater, but only half as large as it was in the 1880's. In colonial New England these sturgeon were an important fish. They were pickled and shipped to England as early as 1628.

Numbers declined seriously in the United States, but the Atlantic sturgeon has been seen more often recently in the Hudson River. It is thought to be as abundant as ever in Quebec waters. Many factors contributed to the declining catch; sale of the young; destruction of young (less than 5 pounds), thought to be another species, since they damaged shad nets; no longer fishing types of gear that take them; and decrease in popularity at prices demanded. In Quebec they are taken in gillnets and in weirs. There is presently no known sport fishery for this species but some are taken incidental to other species. If their haunts were known they could provide sport as the white sturgeon does.

Nomenclature

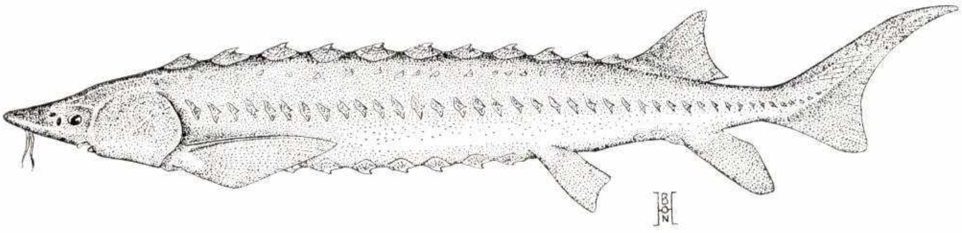
Acipenser oxyrhynchus	— Mitchill 1815a: 462 (type locality New York)
Acipenser sturio (variety *oxyrhynchus*) Linnaeus	— Cox 1896b: 64
Acipenser sturio oxyrhynchus Mitchill	— Halkett 1913: 44
Acipenser sturio L.	— Huntsman 1922: 10
Acipenser oxyrhynchus oxyrhynchus Mitchill	— Vladykov and Greeley 1963: 46

Etymology *Acipenser* — the sturgeon; *oxyrhynchus* — sharp snout.

Common names Atlantic sturgeon, sea sturgeon, common sturgeon, the young are called sharpnose sturgeon or pelican. French common names: *esturgeon noir*, and the young, *escargot* or *escaille*.

WHITE STURGEON

Acipenser transmontanus Richardson



Description The largest North American sturgeon and probably the largest fish found in the fresh waters of Canada. Usual length 20 feet (6.10 m). Body of adult less pentagonal, more rounded than in other species of sturgeons, greatest depth about 14% of total length. Head large, broad, without fontanelle, about 25% of total length, eyes small; snout in adults short, depressed, bluntly rounded, shorter than postorbital length, in young sharper, longer than postorbital length; mouth toothless, wide (74% of interorbital distance), on ventral surface; 4 barbels anterior to mouth, slightly closer to tip of snout than to mouth; gill rakers long, 34–36 on first arch. Fins: dorsal 1, far back, over anal, high, trailing edge deeply notched, 44–48 rays; caudal markedly heterocercal but lower lobe longer, more pointed than in other sturgeons, difference between total length and fork length 16% of fork length; caudal peduncle long, tip of anal not reaching lower lobe of caudal; anal with origin under middle of dorsal base, short, little emarginate, 28–30 rays; pelvics near anus; pectorals large, rounded; both paired fins with heavy, ossified first ray. No scales, body covered with patches of very minute dermal denticles and isolated rows of large bony plates, in largest individuals may be inconspicuous, dorsal plates large, pointed, 11–14; lateral plates large, diamond-shaped, 38–48; ventral plates 9–12; no