Freshwater Fishes of Connecticut

BY WALTER R. WHITWORTH,
PETER L. BERRIEN, and WALTER T. KELLER

STATE GEOLOGICAL AND NATURAL HISTORY SURVEY
OF CONNECTICUT

DEPARTMENT OF ENVIRONMENTAL PROTECTION

Originally published 1968
Reprinted 1976

BULLETIN 101

STATE GEOLOGICAL AND NATURAL HISTORY SURVEY
OF CONNECTICUT

DEPARTMENT OF ENVIRONMENTAL PROTECTION

Freshwater Fishes of Connecticut

BY WALTER R. WHITWORTH,
PETER L. BERRIEN, and WALTER T. KELLER
University of Connecticut

BULLETIN 101

Originally published 1968
Reprinted 1976

STATE GEOLOGICAL AND NATURAL HISTORY SURVEY
OF CONNECTICUT

DEPARTMENT OF ENVIRONMENTAL PROTECTION

Honorable Ella T. Grasso, *Governor of Connecticut*

Joseph N. Gill, *Commissioner of the Department of Environmental Protection*

STATE GEOLOGIST
DIRECTOR, NATURAL RESOURCES CENTER
Hugo F. Thomas, Ph.D.
Hartford, Connecticut

EDITOR
Lou Williams Page, Ph.D.

DISTRIBUTION AND EXCHANGE AGENT
Charles E. Funk, *State Librarian*
State Library, Hartford

PREFACE

This publication, the first of two concerned with the fishes found in Connecticut waters, describes the fishes that live in or may enter the freshwaters of the state. (The saltwater-fish fauna will be described in a forthcoming bulletin of the Connecticut Geological and Natural History Survey, *Salt Fishes of Connecticut* by K. S. Thomson, W. H. Weed III, and A. G. Taruski, all of Yale University.)

A key is presented to aid in the identification of the families of fishes that may be found in the freshwaters of Connecticut. Information included for each family is the approximate number of species, their world distribution, and a key to those species found in the state. Information generally included for each species reported in freshwaters is its distribution in North America, a map showing its distribution in Connecticut, a line drawing, a description, and a general life history. *Salt Fishes of Connecticut* should be consulted for more information about the fishes that may enter freshwaters.

This study was supported by grants from the Research Foundation, University of Connecticut. Part of the travel funds was provided by a National Science Foundation grant (GB-4306X) to the University of Connecticut for graduate studies in environmental and systematic biology. Funds for travel and for obtaining line drawings and photographs were provided by the Connecticut Geological and Natural History Survey. Bernice Wheeler, Connecticut College, worked closely with us in obtaining drawings and funds to complete the study and offered many valuable suggestions concerning the manuscript. Information and materials obtained from the State Highway Department, the Water Resources Commission, and the U. S. Geological Survey were used to correct a waterbase map of Connecticut. Line drawings of fishes were either drawn, mainly from Connecticut specimens, by Sibyl Hausman, Stephani Schaefer, and Lauren Smalle, or obtained from the U.S. National Museum, Smithsonian Institution, through the courtesy of Stanley Weitzman. Personnel of the Connecticut State Board of Fisheries and Game, especially Cole Wilde, Robert Jones, David Green, John Orintas, and Peter Minta, provided information, suggestions concerning the manuscript, and lent equipment. W. R. Taylor of the U.S. National Museum, Smithsonian Institution, verified the identification of the black bullhead. G. A. Moore, Emeritus Professor of Zoology at Oklahoma State University, verified some of our other identifications. He and Keith Thomson (Yale University), Ralph Wetzel, and William Lund (both at University of Connecticut) criticized the manuscript. Dennis Walsh, Richard Biggins, George Kaminski, Louis Sileo, Richard Voyer, Joseph Valentine, Arthur Krueger, Gordon Ulstch, Robert McDowell, and members of the senior author's ichthyology classes at the University of Connecticut assisted at various times in the field work. Dennis Walsh made a comprehensive study of selected meristic characteristics of the two species of dace in Connecticut and Donald Hagen, Yale University, made available to us his meristic work with *Apletes quadracus*.

Numerous landowners allowed us to sample the fishes in their streams. The following individuals allowed us to examine the fish collections and records in their care: Myvanwy M. Dick (Museum of Comparative Zoology, Harvard University), Ernest Lachner (U.S. National Museum, Smithsonian Institution), William Lund, Joseph Loesch, and George Kissel (all of the University of Connecticut Marine Laboratory), Ralph Wetzel (University of Connecticut Zoology Department), Daniel Merriman

and Keith Thomson (Yale University), Donn Rosen and Margaret Bullitt (American Museum of Natural History), James Böhlke (Academy of Natural Sciences of Philadelphia), William Jahoda (Northeastern Connecticut College), Charles Steinmetz, Jr. (Southern Connecticut College), William Krueger (University of Rhode Island), and Russell P. Hunter, Emeritus Professor of Fisheries, University of Connecticut.

To all of the above we extend our sincere thanks.

Walter R. Whitworth
Peter L. Berrien
Walter T. Keller

February 1968

TABLE OF CONTENTS

ILLUSTRATIONS

TABLES

Freshwater Fishes of Connecticut[1]

by

Walter R. Whitworth, Peter L. Berrien, and Walter T. Keller

ABSTRACT

Line drawings, distribution maps, generalized life histories, and identification aids are presented for the approximately 82 species of fishes reported from the freshwaters of Connecticut. Distributions of the freshwater-fish fauna are discussed.

INTRODUCTION

The primary purposes of this bulletin are to define, describe, and delineate the fishes found in the freshwaters of Connecticut. Freshwaters are herein defined as all inland waters and waters entering the sea that are not included in the zone invaded by saltwater during tidal movements. This zone was arbitrarily determined by observations of the general biota (flora and fauna), tidal flow (if present), and gradient at each collection location.

Linsley (1844) was among the first to delineate the freshwater-fish fauna of Connecticut. The localities of his collections were, in many cases, inexactly given—merely a town or river name—and the specimens were not placed in any of the major museums. Kendall (1908) compiled a partial list of the fish fauna, based mainly on reports by others. The Connecticut Board of Fisheries and Game made a comprehensive survey of the lakes and ponds, reporting life-history information (Webster, 1942) and occurrence (Thorpe, 1942) of 40 species of fishes found in 47 lakes and ponds. The Board later extended this survey to 154 lakes and ponds and reported general life-history requirements of 21 species of fishes (Connecticut Board of Fisheries and Game, 1959). Behnke and Wetzel (1960) compiled a check list of fishes found within the freshwaters and brackish waters of Connecticut, based on literature citations and collections made by the University of Connecticut and the Connecticut Board of Fisheries and Game. Collection localities in Connecticut have been reported for selected fishes by various authors, among them Ayres (1842-1843, 1843, 1845), Storer (1842), and Collette (1962).

[1]Contribution 305, Storrs Agricultural Experiment Station

COLLECTION OF DATA

Connecticut was arbitrarily divided into 9 major watersheds for the purposes of this study. Each major watershed was further subdivided into 2 to 38 small units. Approximately 750 sampling areas were selected with the aim of providing a more or less even distribution of effort throughout the state (fig. 1). Localities were selected using a Connecticut Atlas County Sectional Map for 1938; this also served as the road map. Once a tentative location was reached, problems of accessibility often dictated the selection of another location in that particular area. Collections were made primarily in the shallow sections (< 5 ft deep) of streams, impoundments, and estuaries close to roadways. The lengths of the areas sampled varied from approximately 20 to 400 yards and all habitats present were usually sampled.

Field notes made at each locality generally included time, water temperature, bottom type, stream size and gradient, turbidity, species of fishes taken (field identification), notes on fish reproduction (spawning activity, nests, breeding colors, nuptial tubercles, and eggs or milt exuded when the fishes were handled), and position and name of locality (in miles, to the nearest tenth, along a given compass direction from the center of a nearby town or city). Hardness or total alkalinity was measured periodically in each major watershed following standard methods (American Public Health Association, 1965). Criteria used in describing bottom type, stream size and gradient, and turbidity values are listed in table 1.

Collections of fishes were made with 3- to 50-ft woven-mesh nylon and knotted seines (⅛ in. to ¼ in. mesh) and occasionally by electrofishing. Seining techniques used were: pulling one end of a seine through the water in a semicircle around the other end held on shore; holding a seine across a stream and driving fishes downstream into it, then lifting the seine up; bringing small nets up under brush and overhanging banks; driving fish out of vegetation into nets set nearby. Most fishes were preserved in a 10 percent formalin solution (1 liter of commercial formalin diluted to 10 liters with water). Larger specimens of "common" game and forage fishes usually were released and their presence recorded in the field notes. Visceral cavities of large specimens preserved were slit (1 in. to 2 in.) on their right sides to insure hardening. Most specimens were hardened in the formalin solution for 2 to 7 days, then removed, washed in water, and transferred to 70 percent denatured ethyl alcohol (70 liters of denatured ethyl alcohol diluted to 95 liters with water) for permanent storage. (A solution of 40 percent isopropyl alcohol could have been used in place of 70 percent ethyl alcohol.) Fishes were identified and deposited in the ichthyology museum of the University of Connecticut. Keys useful in identifying fishes are those by Bigelow and Schroeder (1953), Brown (1957), Eddy (1957), Moore (1957), Trautman (1957), Hubbs and Lagler (1958), Vladykov (1960), and McAllister (1964).

Our collection records were augmented by visiting many of the eastern museums having collections of Connecticut fishes, inspecting the field records of former and present State employees concerned with fishes,

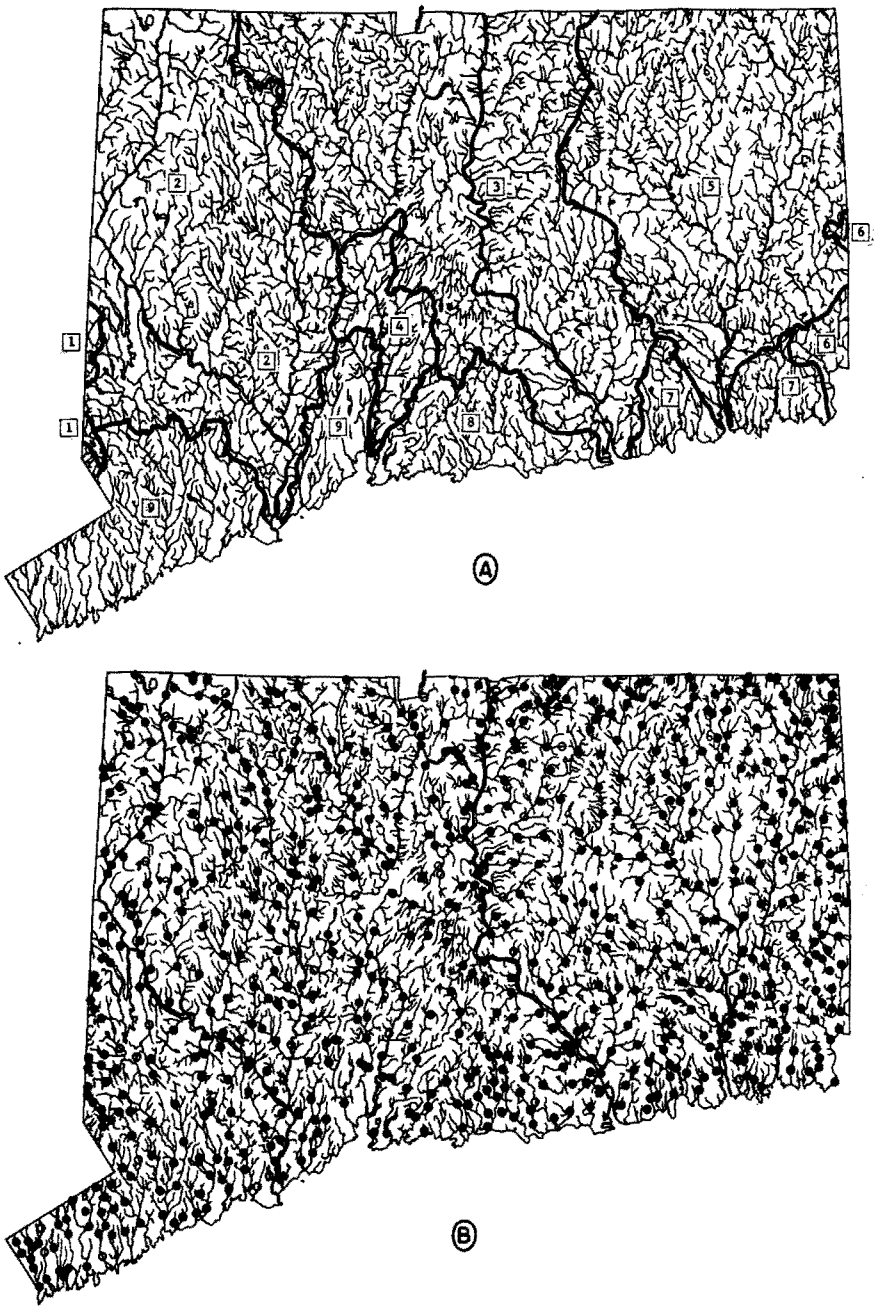


Fig. 1. *A*, Major watersheds of Connecticut: *1*, Hudson River; *2*, Housatonic River; *3*, Connecticut River; *4*, Quinnipiac River; *5*, Thames River; *6*, Pawcatuck River; *7*, eastern coastal streams; *8*, central coastal streams; *9*, western coastal streams.

B, Localities sampled during 1965-1967, •, collection localities where fishes were taken; o, collection localities where no fishes were taken.

Table 3.—Stream size and gradient at the localities where various species were collected.[1]

	Stream size						Stream gradient						
	Number of locations with data	Small	Small-intermediate	Intermediate	Intermediate-large	Large	Number of locations with data	Low	Low-intermediate	Intermediate	Intermediate-high	High	Impoundment
Lampetra lamottei (American brook lamprey)	1	100	—	—	—	—	1	—	—	100	—	—	—
Petromyzon marinus (sea lamprey)	1	—	100	—	—	—	1	100	—	—	—	—	—
Anguilla rostrata (American eel)	76	17	50	21	4	8	83	26	28	32	2	—	11
Alosa aestivalis (blueback herring)	8	—	25	12	—	62	8	88	12	—	—	—	—
A. pseudoharengus (alewife)	3	—	—	33	33	33	6	25	—	50	—	—	25
A. sapidissima (American shad)	3	—	—	—	—	100	2	67	—	—	—	—	33
Brevoortia tyrannus (Atlantic menhaden)	3	—	33	—	33	33	3	100	—	—	—	—	—
Anchoa mitchilli (bay anchovy)	2	—	—	50	—	50	2	100	—	—	—	—	—
Salmo gairdneri (rainbow trout)	4	—	75	25	—	—	4	—	100	—	—	—	—
S. trutta (brown trout)	57	28	47	25	—	—	56	5	39	48	4	—	4
Salvelinus fontinalis (brook trout)	119	60	37	2	—	—	121	9	40	40	8	1	2
Esox americanus (redfin pickerel)	81	38	46	12	—	4	88	32	40	18	1	—	9
E. lucius (northern pike)	2	—	—	—	50	50	2	100	—	—	—	—	—
E. niger (chain pickerel)	169	31	48	20	1	—	200	27	27	24	4	2	17
Campostoma anomalum (stoneroller)	3	—	67	33	—	—	3	—	33	67	—	—	—
Carassius auratus (goldfish)	5	20	40	40	—	—	8	25	—	38	—	—	38
Cyprinus carpio (carp)	8	12	25	25	25	12	8	50	12	25	—	—	12
Exoglossum maxillingua (cutlips minnow)	23	13	43	43	—	—	23	22	17	52	9	—	—
Notemigonous crysoleucas (golden shiner)	214	30	45	20	2	3	243	29	28	26	2	1	14
Notropis bifrenatus (bridled shiner)	50	24	52	22	2	—	56	32	23	26	5	—	12
N. cornutus (common shiner)	197	20	51	24	4	1	196	20	40	35	2	1	3

N. hudsonius (spottail shiner)	32	28	19	19	34	—	35	46	23	20	3	—	9
Pimephales notatus (bluntnose minnow)	2	—	50	50	—	—	2	—	50	50	—	—	—
P. promelas (fathead minnow)	1	100	—	—	—	—	1	—	100	—	—	—	—
Rhinichthys atratulus (blacknose dace)	334	45	42	12	1	1	331	11	40	41	5	2	2
R. cataractae (longnose dace)	97	27	50	20	3	—	97	6	38	48	5	1	1
Semotilus atromaculatus (creek chub)	111	44	42	11	2	1	113	19	34	41	3	1	3
S. corporalis (fallfish)	163	20	48	25	5	1	162	17	44	36	1	1	2
S. margarita (pearl dace)	2	100	—	—	—	—	2	—	50	50	—	—	—
Catostomus commersoni (white sucker)	352	32	45	18	3	2	358	21	37	34	4	1	4
Erimyzon oblongus (creek chubsucker)	35	26	54	20	—	17	40	35	12	32	5	—	15
Ictalurus catus (white catfish)	4	—	25	25	—	50	4	75	25	—	—	—	—
I. melas (black bullhead)	1	—	100	—	—	—	1	100	—	—	—	—	—
I. nebulosus (brown bullhead)	92	34	40	16	4	5	114	30	20	26	2	—	22
Microgadus tomcod (Atlantic tomcod)	1	—	—	—	—	100	1	100	—	—	—	—	—
Strongylura marina (Atlantic needlefish)	2	—	50	—	50	—	2	100	—	—	—	—	—
Cyprinodon variegatus (sheepshead minnow)	6	—	83	17	—	—	6	100	—	—	—	—	—
Fundulus diaphanus (banded killifish)	48	23	44	17	4	12	55	36	33	13	4	—	14
F. heteroclitus (mummichog)	25	4	48	24	12	12	22	73	14	9	5	—	—
F. majalis (striped killifish)	8	—	38	12	25	25	7	100	—	—	—	—	—
Lucania parva (rainwater killifish)	1	—	—	—	—	100	1	100	—	—	—	—	—
Menidia beryllina (tidewater silverside)	14	—	50	21	14	14	12	83	17	—	—	—	—
M. menidia (Atlantic silverside)	5	—	20	20	40	20	6	100	—	—	—	—	—
Apeltes quadracus (fourspine stickleback)	23	13	52	22	—	13	23	35	30	30	4	—	—
Culaea inconstans (brook stickleback)	1	100	—	—	—	—	1	—	100	—	—	—	—
Gasterosteus aculeatus (threespine stickleback)	1	—	100	—	—	—	1	100	—	—	—	—	—
Pungitius pungitius (ninespine stickleback)	9	33	44	22	—	—	8	25	25	50	—	—	—
Syngnathus fuscus (northern pipefish)	1	—	—	—	—	100	1	100	—	—	—	—	—
Cottus cognatus (slimy sculpin)	10	70	30	—	—	—	10	20	50	20	10	—	—
Morone americana (white perch)	16	6	19	19	—	56	22	50	23	—	—	—	27
Ambloplites rupestris (rock bass)	14	7	21	36	21	14	15	47	13	33	—	—	7
Enneacanthus obesus (banded sunfish)	3	33	33	33	—	—	9	—	—	33	—	—	67
Lepomis auritus (redbreast sunfish)	53	11	43	36	4	6	56	34	32	23	2	2	7
L. cyanellus (green sunfish)	4	50	50	—	—	—	5	20	20	40	—	—	20

table continues

Table 3.—Stream size and gradient at the localities where various species were collected, *continued*[1]

	Stream size						Stream gradient						
	Number of locations with data	Small	Small-intermediate	Intermediate	Intermediate-large	Large	Number of locations with data	Low	Low-intermediate	Intermediate	Intermediate-high	High	Impoundment
L. gibbosus (pumpkinseed)	212	29	44	20	4	3	261	26	26	24	3	1	20
L. macrochirus (bluegill)	82	24	52	20	2	1	107	27	32	16	2	—	23
Micropterus dolomieui (smallmouth bass)	9	—	22	33	44	—	9	22	44	44	—	—	33
M. salmoides (largemouth bass)	131	18	52	27	1	3	160	28	31	19	3	1	19
Pomoxis nigromaculatus (black crappie)	8	—	88	—	—	12	19	26	5	10	—	—	58
Etheostoma fusiforme (swamp darter)	15	47	40	13	—	—	22	18	4	45	—	—	32
E. olmstedi (tessellated darter)	201	27	44	21	4	3	208	21	40	32	2	—	5
Perca flavescens (yellow perch)	77	12	57	23	6	1	93	27	20	32	2	1	17
Mugil curema (white mullet)	1	—	—	—	—	100	1	100	—	—	—	—	—

[1]All figures are percent occurrence except those for the number of locations with data.

Table 4.—Bottom type and turbidity of the water at the localities where various species were collected[1]

	Bottom type											Turbidity			
	Number of locations with data	Clay	Silt	Mud	Sand	Gravel	Stone	Rock	Bedrock	Muck	Detritus	Number of locations with data	Clear	Moderately turbid	Turbid
Lampetra lamottei (American brook lamprey)	1	—	—	—	100	—	—	—	—	—	—	1	100	—	—
Petromyzon marinus (sea lamprey)	1	—	100	—	—	—	—	—	—	—	—	1	—	100	—
Anguilla rostrata (American eel)	84	4	10	—	23	25	23	5	1	2	8	86	49	41	10
Alosa aestivalis (blueback herring)	9	11	—	—	44	22	22	—	—	—	—	9	22	67	11
A. pseudoharengus (alewife)	4	—	—	—	50	—	—	50	—	—	—	4	—	50	50
A. sapidissima (American shad)	2	—	—	—	100	—	—	—	—	—	—	3	—	67	33
Brevoortia tyrannus (Atlantic menhaden)	4	—	25	—	25	50	—	—	—	—	—	4	25	75	—
Anchoa mitchilli (bay anchovy)	3	—	—	—	33	33	—	33	—	—	—	3	—	100	—
Salmo gairdneri (rainbow trout)	4	—	—	—	50	25	25	—	—	—	—	4	100	—	—
S. trutta (brown trout)	57	—	9	—	16	28	35	4	4	2	4	57	75	21	4
Salvelinus fontinalis (brook trout)	121	2	11	2	16	26	33	7	3	—	1	120	82	15	3
Esox americanus (redfin pickerel)	89	2	15	4	25	22	13	6	1	6	6	88	50	36	14
E. lucius (northern pike)	2	50	—	—	50	—	—	—	—	—	—	2	—	50	50
E. niger (chain pickerel)	200	1	14	2	14	20	24	8	5	4	9	204	70	27	3
Campostoma anomalum (stoneroller)	3	—	—	—	—	—	67	33	—	—	—	3	33	33	33
Carassius auratus (goldfish)	8	—	25	—	12	—	25	—	—	25	12	8	12	50	38
Cyprinus carpio (carp)	8	—	38	—	25	—	38	—	—	—	—	8	12	62	25
Exoglossum maxillingua (cutlips minnow)	23	—	13	—	4	30	35	9	—	9	—	23	65	30	4
Notemigonus crysoleucas (golden shiner)	244	2	15	4	19	20	20	10	2	3	7	244	54	34	13
Notropis bifrenatus (bridled shiner)	56	4	16	4	16	23	23	4	4	2	5	57	60	33	7
N. cornutus (common shiner)	198	1	14	4	17	16	30	10	6	2	1	196	57	36	7

table continues

Table 4.—Bottom type and turbidity of the water at the localities where various species were collected, *continued*[1]

	Bottom type											Turbidity			
	Number of locations with data	Clay	Silt	Mud	Sand	Gravel	Stone	Rock	Bedrock	Muck	Detritus	Number of locations with data	Clear	Moderately turbid	Turbid
N. hudsonius (spottail shiner)	35	11	6	—	34	11	14	14	3	6	—	36	19	58	22
Pimephales notatus (bluntnose minnow)	2	—	—	—	—	—	100	—	—	—	—	2	50	—	50
P. promelas (fathead minnow)	1	—	—	—	100	—	—	—	—	—	—	1	100	—	—
Rhinichthys atratulus (blacknose dace)	333	2	10	1	16	20	35	10	4	1	1	330	74	22	4
R. cataractae (longnose dace)	97	1	7	—	14	28	35	11	2	—	1	97	78	20	2
Semotilus atromaculatus (creek chub)	111	1	15	2	24	14	27	8	5	3	—	114	72	21	7
S. corporalis (fallfish)	164	2	7	1	18	24	33	9	3	2	1	162	64	31	6
S. margarita (pearl dace)	2	—	—	—	50	—	—	50	—	—	—	2	100	—	—
Catostomus commersoni (white sucker)	360	2	11	3	18	21	28	9	3	4	1	359	59	32	9
Erimyzon oblongus (creek chubsucker)	39	3	18	—	13	26	20	—	5	3	13	40	70	28	2
Ictalurus catus (white catfish)	4	25	—	—	50	—	—	—	—	—	25	4	25	75	—
I. melas (black bullhead)	1	—	—	—	100	—	—	—	—	—	—	1	100	—	—
I. nebulosus (brown bullhead)	115	3	15	4	16	23	10	10	4	8	7	115	47	37	16
Microgadus tomcod (Atlantic tomcod)	1	—	—	—	—	100	—	—	—	—	—	1	100	—	—
Strongylura marina (Atlantic needlefish)	2	—	—	—	—	100	—	—	—	—	—	2	50	50	—
Cyprinodon variegatus (sheepshead minnow)	6	—	—	—	33	33	—	17	—	17	—	6	50	50	—
Fundulus diaphanus (banded killifish)	56	5	7	5	27	18	25	—	2	5	5	57	40	46	14
F. heteroclitus (mummichog)	26	—	19	4	15	31	12	4	—	8	8	26	19	65	15
F. majalis (striped killifish)	9	—	11	—	—	56	—	11	—	11	11	9	22	67	11
Lucania parva (rainwater killifish)	2	—	—	—	—	100	—	—	—	—	—	2	50	50	—

table continues

Menidia beryllina (tidewater silverside)	14	—	7	7	28	28	7	7	—	7	7	14	14	78	7
M. menidia (Atlantic silverside)	7	—	14	—	14	28	—	14	—	14	14	7	—	86	14
Apeltes quadracus (fourspine stickleback)	24	—	8	8	21	38	21	—	—	—	4	24	54	33	13
Culaea inconstans (brook stickleback)	1	—	—	—	100	—	—	—	—	—	—	1	100	—	—
Gasterosteus aculeatus (threespine stickleback)	1	—	—	—	—	—	—	—	—	100	—	1	—	100	—
Pungitius pungitius (ninespine stickleback)	8	—	25	12	25	25	12	—	—	—	—	8	62	38	—
Syngnathus fuscus (northern pipefish)	1	—	—	—	—	100	—	—	—	—	—	1	100	—	—
Cottus cognatus (slimy sculpin)	10	—	20	—	10	20	20	—	10	—	20	10	90	10	—
Morone americana (white perch)	22	4	4	—	59	—	18	—	—	9	4	23	22	56	22
Ambloplites rupestris (rock bass)	15	—	27	—	33	13	20	7	—	—	—	15	47	47	7
Enneacanthus obesus (banded sunfish)	8	—	25	—	—	12	12	—	—	—	50	9	56	44	—
Lepomis auritus (redbreast sunfish)	56	—	18	4	18	21	27	5	4	2	2	56	46	45	9
L. cyanellus (green sunfish)	5	—	20	20	—	20	40	—	—	—	—	5	20	60	20
L. gibbosus (pumpkinseed)	259	2	12	4	18	19	22	8	4	2	8	262	54	35	10
L. macrochirus (bluegill)	105	1	15	5	21	12	25	7	3	4	8	106	42	42	15
Micropterus dolomieui (smallmouth bass)	12	—	8	—	17	25	42	8	—	—	—	13	62	38	—
M. salmoides (largemouth bass)	159	2	12	2	22	22	21	6	4	2	6	161	58	34	8
Pomoxis nigromaculatus (black crappie)	19	—	—	5	37	16	5	—	5	16	16	19	26	63	10
Etheostoma fusiforme (swamp darter)	21	—	10	—	24	19	38	5	—	—	5	22	91	9	—
E. olmstedi (tessellated darter)	209	3	11	2	20	22	26	7	4	3	1	208	62	32	6
Perca flavescens (yellow perch)	91	1	6	1	20	25	22	9	2	8	5	94	60	29	12
Mugil curema (white mullet)	3	—	—	—	—	67	—	—	—	33	—	3	33	67	—

[1]All figures are percent occurrence except those for the number of locations with data.

Table 5.—Total alkalinity and hardness of the water at the localities where various species were collected.

	Total alkalinity[1]				Hardness[1]			
	Number of locations with data	High	Low	Mean	Number of locations with data	High	Low	Mean
Lampetra lamottei (American brook lamprey)	—	—	—	—	1	120	120	120
Petromyzon marinus (sea lamprey)	—	—	—	—	—	—	—	—
Anguilla rostrata (American eel)	45	105	5	25	9	220	26	88
Alosa aestivalis (blueback herring)	5	36	18	29	1	44	44	44
A. pseudoharengus (alewife)	1	25	25	25	2	46	42	44
A. sapidissima (American shad)	1	36	36	36	1	44	44	44
Brevoortia tyrannus (Atlantic menhaden)	3	81	18	45	—	—	—	—
Anchoa mitchilli (bay anchovy)	—	—	—	—	—	—	—	—
Salmo gairdneri (rainbow trout)	1	13	13	13	—	—	—	—
S. trutta (brown trout)	13	79	6	22	19	120	13	38
Salvelinus fontinalis (brook trout)	40	83	7	21	28	142	6	43
Esox americanus (redfin pickerel)	31	119	9	38	19	96	8	46
E. lucius (northern pike)	1	33	33	33	—	—	—	—
E. niger (chain pickerel)	111	86	1	16	30	86	10	26
Campostoma anomalum (stoneroller)	2	42	15	28	—	—	—	—
Carassius auratus (goldfish)	4	23	11	18	1	38	38	38
Cyprinus carpio (carp)	7	117	9	54	1	122	122	122
Exoglossum maxillingua (cutlips minnow)	4	137	7	66	6	184	22	96
Notemigonus crysoleucas (golden shiner)	98	129	1	25	45	462	8	66
Notropis bifrenatus (bridled shiner)	32	117	6	29	14	152	13	74
N. cornutus (common shiner)	55	137	5	29	60	462	10	65
N. hudsonius (spottail shiner)	13	117	10	34	10	122	28	58
Pimephales notatus (bluntnose minnow)	1	42	42	42	—	—	—	—
P. promelas (fathead minnow)	1	50	50	50	—	—	—	—
Rhinichthys atratulus (blacknose dace)	96	100	3	24	82	276	10	59
R. cataractae (longnose dace)	26	79	3	24	34	160	12	53
Semotilus atromaculatus (creek chub)	14	100	3	31	33	276	14	60
S. corporalis (fallfish)	49	100	4	23	44	184	10	47
S. margarita (pearl dace)	1	10	10	10	—	—	—	—
Catostomus commersoni (white sucker)	115	137	1	28	92	462	6	59
Erimyzon oblongus (creek chubsucker)	27	70	4	17	12	92	8	34
Ictalurus catus (white catfish)	1	33	33	33	—	—	—	—
I. melas (black bullhead)	—	—	—	—	—	—	—	—
I. nebulosus (brown bullhead)	55	1	78	20	27	10	150	42
Microgadus tomcod (Atlantic tomcod)	—	—	—	—	—	—	—	—
Strongylura marina (Atlantic needlefish)	2	18	36	27	—	—	—	—

Table 5.—Total alkalinity and hardness of the water at the localities where various species were collected, *continued*

	Total alkalinity[1]				Hardness[1]			
	Number of locations with data	High	Low	Mean	Number of locations with data	High	Low	Mean
Cyprinodon variegatus (sheepshead minnow)	2	13	18	16	1	220	220	220
Fundulus diaphanus (banded killifish)	29	5	119	29	7	28	220	108
F. heteroclitus (mummichog)	12	12	81	36	1	220	220	220
F. majalis (striped killifish)	2	36	81	58	1	220	220	220
Lucania parva (rainwater killifish)	—	—	—	—	—	—	—	—
Menidia beryllina (tidewater silverside)	6	12	81	41	1	220	220	220
M. menidia (Atlantic silverside)	2	36	81	58	—	—	—	—
Apeltes quadracus (fourspine stickleback)	14	8	79	32	—	—	—	—
Culaea inconstans (brook stickleback)	1	50	50	50	—	—	—	—
Gasterosteus aculeatus (threespine stickleback)	1	12	12	12	—	—	—	—
Pungitius pungitius (ninespine stickleback)	7	7	68	28	—	—	—	—
Syngnathus fuscus (northern pipefish)	—	—	—	—	—	—	—	—
Cottus cognatus (slimy sculpin)	—	—	—	—	5	14	42	25
Morone americana (white perch)	10	7	78	30	3	38	44	41
Ambloplites rupestris (rock bass)	2	33	117	76	5	18	122	78
Enneacanthus obesus (banded sunfish)	8	9	24	15	1	12	12	12
Lepomis auritus (redbreast sunfish)	19	7	137	27	7	12	328	95
L. cyanellus (green sunfish)	1	34	34	34	1	28	28	28
L. gibbosus (pumpkinseed)	115	1	117	22	40	8	462	58
L. macrochirus (bluegill)	39	5	105	29	11	8	196	45
Micropterus dolomieui (smallmouth bass)	—	—	—	—	4	12	138	51
M. salmoides (largemouth bass)	62	4	78	21	25	8	462	48
Pomoxis nigromaculatus (black crappie)	9	6	105	28	5	8	26	18
Etheostoma fusiforme (swamp darter)	13	6	24	13	14	8	20	13
E. olmstedi (tessellated darter)	65	7	119	29	62	10	462	56
Perca flavescens (yellow perch)	38	4	137	26	25	8	160	37
Mugil curema (white mullet)	1	18	18	18	1	220	220	220

[1]mg/liter as equivalent $CaCo_3$.

similar in the major watersheds, total alkalinity and hardness values were generally lower in the Thames. The coastal-stream localities sampled tended to be small in size.

IDENTIFICATION OF FISHES

The basic "kind" of fish considered is the species (a population of morphologically and physiologically similar individuals that do not normally exchange hereditary materials with other related individuals). Species of similar general appearances that appear to be distinct from other species are presumed to be of a common origin and placed in the same genus. Genera having common features quite distinct from other genera are then assigned to the same family.

All described species of fishes have accepted scientific and common names. Scientific names are composed of a generic and a specific name (italicized) followed by the name of the individual or individuals who described the species, for example, *Amia calva* Linnaeus. The author's name is placed in parentheses if the fish was first described as belonging to a different genus, for example, *Notropis cornutus* (Mitchill). The starting date for this double-name system (binominal nomenclature) is the tenth edition of *Systema Naturae*, 1758, by Linnaeus. Rules governing the naming of species have been set down by the International Commission on Zoological Nomenclature. A list of accepted scientific and common names has been compiled by a joint committee of the American Fisheries Society and the American Society of Ichthyologists and Herpetologists (Bailey and others, 1960).

Scientific and common names are changed occasionally, because more intensive study may show that more than one species is contained within one presently defined species, or that several currently accepted species should be combined into one species. The names may also be changed to comply with the Rules of Zoological Nomenclature or to avoid misunderstanding between similar common names for different fishes.

Most fishes can be identified by their external appearance, using characteristics that do not change when the fishes are preserved: number of scales, number of spines and rays in various fins, and measurements of various parts of the body relative to other parts. Positive identification of some species utilizes internal characteristics. Before attempting to identify a fish one must have some knowledge of internal and external fish anatomy. Internal structures needed for identification are described in the keys and family descriptions. The locations of selected external structures, regions, counts, and measurements used in identifying and describing fishes are shown in figure 2. Fishes are extremely diverse; not all the structures shown are possessed by all species. Body proportions are obtained by measuring the appropriate areas with dividers (determining the length of each area with a millimeter rule) and performing the division indicated.

Counts and measurements are defined as follows (consult the glossary for definitions of other terms):

Total length—most anterior part of the head to the most posterior part of the caudal fin when the caudal rays are squeezed together.

Standard length—most anterior part of the head to the structural base of the caudal peduncle (base located by bending caudal fin laterally).

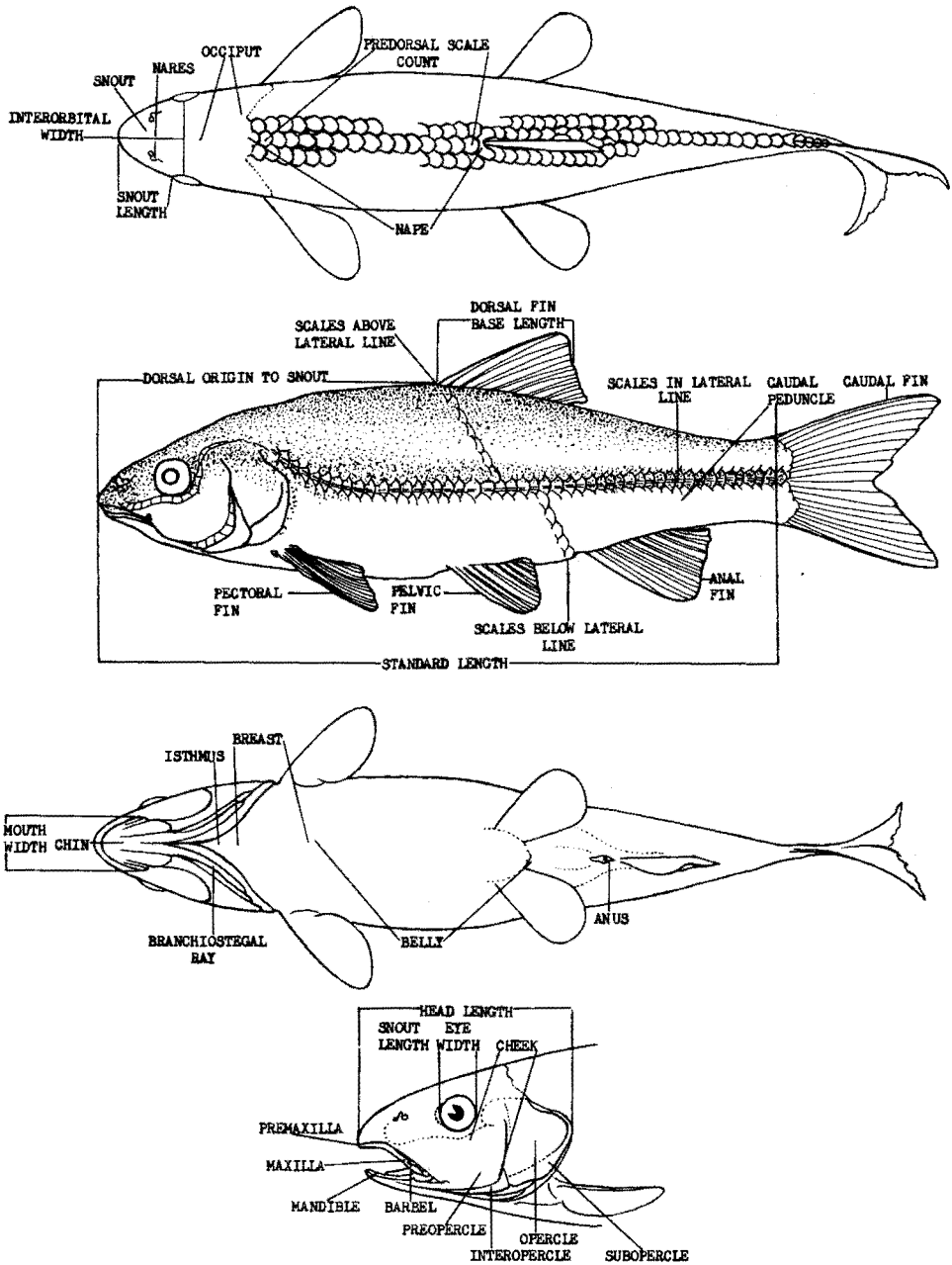


Fig. 2. External features of a fish, illustrated (top to bottom) by the dorsal, lateral, and ventral views of the fallfish and the lateral view of its head.

Head length—most anterior part of the head to the most posterior part of the opercular membrane.

Snout length—most anterior part of the middle of the upper lip to the anterior rim of the orbit.

Scales in lateral line—count all scales from the first scale in lateral line that touches the shoulder girdle to the structural base of the caudal peduncle (scale over the middle of the curve produced when the caudal fin is moved laterally). If no lateral line is visible, the mid-lateral scale row is counted.

Scales above lateral line—scales from the origin of the dorsal fin diagonally downward and backward to the lateral line (lateral-line scale not included).

Scales below lateral line—scales from origin of the anal fin diagonally upward and forward to the lateral line (lateral-line scale not included).

Dorsal- and anal-ray counts—all spines and rays are counted if they grade gradually from smallest to largest. One or two small rudimentary rays preceding the remainder of the longer rays are not counted. The last ray is not counted if it has the same base as the second to the last.

Predorsal-scale count—all scales that touch the mid-dorsal line from the occiput to the origin of the dorsal fin.

Interorbital width—distance across the top of the head between the bony margins of the eyes.

Mouth width—greatest horizontal distance across the mouth.

Identification of a fish involves reducing the number of possible species from which the unknown must be separated. First determine the family that contains the unknown species by using the "Key to the families of fishes found in the freshwaters of Connecticut." Select the alternative that best fits the specimen in the first couplet and continue choosing alternatives until you reach a family. Then consult that family in the "Annotated list of families and species." The information usually included for each family is its world-wide distribution, relative number of species, and a key to the species found in Connecticut. When special techniques are required to identify the species found in a family, explanations required to perform the techniques are also included. Many of the species found in Connecticut are the sole representatives of that family and your specimen is immediately identified in these cases. If the family contains more than one species continue choosing the best alternative in the species key until a species designation is reached. Once you have reached a species, compare the drawing, characteristics, and distribution given for that species with the unknown specimen. If the information does not agree, compare your specimen with the other species in the same family. If your specimen does not fit any of the species represented in that family retrace your steps in the "Key to families." Follow both alternatives to completion when uncertain of which way is correct (this also applies to the key to species in each family).

The ability to use a key comes only with practice and beginners should not become discouraged. After one becomes proficient he may use only selected portions of the keys. The keys are amply illustrated to show salient features; this section and the glossary should be consulted when there is doubt as to the meaning of an alternative or description. A species is often characterized by considerable variation in color, size,

body proportions, and body parts and cannot be represented by a static description. This variation is occasionally very dramatic between the sexes, adults and young, and spawning and nonspawning fishes. Individuals of a species may not have all the "normal" characteristics of that species and you should check as many specimens as possible and compare as many counts as possible when in doubt as to which of two closely related species the unknown specimen belongs. The descriptions given for each species generally contain the range of variation measured for selected characteristics; for the sake of brevity, only those characteristics that are helpful in identifying the species in Connecticut have been included. Characteristics readily evident from the line drawings are not included in the written descriptions, as the drawings are considered part of the descriptions. Wherever there is a possibility that the unknown fish may be a saltwater fish consult *Marine Fishes of Connecticut* (Thomson, Weed, and Taruski, in preparation, 1968) and try the key to the saltwater fishes. The species in question may be a saltwater fish that has not been reported from freshwater. If unidentifiable specimens or ones with characteristics or ranges outside of those given are found, please preserve them and send the specimens, with all pertinent information, including date, location, and collector, to the Ichthyologist at the University of Connecticut (Storrs, 06268).

Unless otherwise stated, the characteristics given apply only to fishes found in Connecticut. Characteristics reported in other areas are given only in the relatively few cases where no specimens were found in Connecticut. Hybrids and subspecies have not been considered in the keys. Some hybrids are easy to recognize, especially when the specific characteristics of the two parents do not overlap throughout the range of individual variation. When the differences between the two species are slight and there is an overlapping of individual variation it is extremely difficult, if not impossible, to identify hybrids. If you do find a specimen that keys out, more or less, to two species and does not fit either description exactly, you may have a hybrid. In hybrids many characteristics are intermediate between those of the two parents, although some favor one parent. Hybridization is quite common in some groups of fishes, such as the sunfishes. It is probably the result of unfavorable environmental conditions—adverse water temperatures, lack of sufficient sites in the "normal" spawning area, or high population density—that force one species to spawn in an area currently being used for spawning by a related species.

GLOSSARY

adipose fin—fleshy rayless fin on the back between the dorsal and caudal fins (fig. 9, p. 22)

air bladder—gas-filled sac in the dorsal portion of the abdominal cavity, consisting of 1 to 3 chambers

ammocoete—larval form of lampreys

anadromous—ascending rivers from the sea to spawn

anal fin—fin between the caudal fin and the anus (fig. 2, p. 15)

anterior—in the front
anus—posterior opening of the digestive tract (fig. 2, p. 15)
asymmetrical—the two sides (halves) differ (fig. 3, p. 20)
barbel—fleshy protuberance in the form of a thread, flap, or cone found around the mouth or chin (figs. 29, p. 53; 30, 31, p. 54)
belly—region on ventral side immediately behind pectoral fins extending to the anus (fig. 2, p. 15)
bicuspid—tooth with two tips
branchiostegal rays—elongated bones supporting the gill membranes (fig. 2, p. 15)
breast—region on ventral side between isthmus and a point immediately behind and below the pectoral fins (fig. 2, p. 15)
canine teeth—elongated conical teeth (fig. 48, p. 113)
catadromous—going from freshwater to the sea to spawn
caudal fin—tail fin (fig. 2, p. 15)
caudal peduncle—region behind the anal fin extending to the structural base of the caudal fin (fig. 2, p. 15)
cheek—region between the eye and the preopercle (fig. 2, p. 15)
chin—region between the halves of the lower jaw
circumoral teeth—innermost teeth lateral to the mouth (in lampreys)
ctenoid scale—one having tiny prickles (ctenii) on its posterior edge
cycloid scale—one having a smooth posterior edge
dentaries—the paired anterior bones of the lower jaw
dorsal—upper surface
fimbriate—fringed at the margin
frenum—a bridge of tissue that connects upper lip and snout
gill arch—a bony support for a gill (fig. 21, p. 33)
gill filaments—paired structures on the posterior face of the gill arch (fig. 21, p. 33)
gill rakers—structures on the anterior faces of the gill arches (fig. 21, p. 33)
genital papilla—a fleshy protuberance behind the anal opening
gular plate—a bony plate between halves of the lower jaw (fig. 5, p. 21)
heterocercal—the vertebral column arches upward posteriorly, supporting the caudal fin dorsally and ventrally; the lobes of the caudal fin are usually unequally lobed (fig. 4, p. 21)
homocercal—the vertebral column terminates posteriorily in a series of bones that support the entire caudal fin; the lobes of the caudal fin are usually equal (fig. 4, p. 21)
hypural plate—the modified last vertebra which supports the caudal fin
isthmus—the area anterior to the breast and lying between the lower jaws (fig. 2, p. 15)
inferior mouth—mouth located near or on the ventral side of the fish and the snout usually overhanging the lower lip (fig. 31, p. 54)
interopercle—bone in the opercular series anterior to the subopercle (fig. 2, p. 15)
jugular—refers to the location of the anus or pelvic fins when positioned anterior to the pectoral fins
larvae—young fish before they change in appearance and assume adult form
lateral—to the sides
lateral-line system—a series of pores and tubes branching on the head and extending along the sides of the body (fig. 2, p. 15)
lateral band—pigment stripes along the sides often extending along the head (for example, *Notropis bifrenatus*, p. 61)
lateral-line scales—scales bearing the lateral-line pores and tubes; counted from the shoulder girdle to the base of the tail; if no lateral line, count the scale row where the lateral line is "normally" found (fig. 2, p. 15)

leptocephalus—larva of the eel (*Anguilla rostrata*)
mandible—lower jaw (fig. 2, p. 15)
maxilla—bone on each half of the upper jaw immediately behind the premaxillae (fig. 2, p. 15)
myomere—muscular segment or impression (for example, *Petromyzon marinus*)
nape—region from the occiput to the origin of the dorsal fin (fig. 2, p. 15)
nares—paired nostrils, each with two openings, usually located dorsally in front of the eyes (fig. 2, p. 15)
nonprotractile—upper jaw is firmly bound to the snout and no groove separates jaw from the snout
nuptial tubercles—temporary cornifications (hardened protuberances) of the skin of adult males which appear just before or during the breeding season (for example, *Pimephales notatus*, p. 64)
occiput—dorsal surface of the head from above or immediately behind the eyes to the nape; in many species it separates the scaled and scaleless regions anterior to the dorsal fin (fig. 2, p. 15)
opercle—uppermost bone in opercular series (fig. 2, p. 15)
oral valve—thin membranes, attached behind the jaws, that prevent water from escaping through the mouth during respiratory movements
orbit—eyesocket
origin of fins—anterior end of dorsal or anal fin base
palatine teeth—teeth on the paired palatine bones located on the roof of the mouth
papilla—a small fleshy protuberance on the skin
parr—young salmonids that have not attained the adult color pattern
pectoral fins—the most anterior or dorsal set of paired fins (fig. 2, p. 15)
pelvic fins—the most posterior or ventral set of paired fins (fig. 2, p. 15)
peritoneum—membranous lining of the abdominal cavity
pharyngeal teeth—teeth on the pharyngeal bones (representing the fifth nonfunctional gill arch) located immediately posterior to the last functional gill arches. (fig. 25, p. 52)
posterior—to the rear
premaxilla—anterior bone of each half of the upper jaw (fig. 2, p. 15)
protractile—upper jaw not firmly bound to the snout and capable of being projected; separated from snout by a groove
pseudobranch—gill-like structure on the inner surface of the opercle (fig. 14, p. 23)
pyloric caeca—fingerlike projections from the digestive tract in the region of the stomach and small intestine (fig. 11, p. 22)
radii—grooves that radiate out from the center of the scale (focus)
snout—region of head from anterior margin of orbit to the tip of upper lip (fig. 2, p. 15)
soft dorsal—the dorsal fin that consists mainly of soft rays (for example, *Salvelinus fontinalis*, p. 45)
soft ray—support for the fins; usually segmented, in most cases branched, flexible, and paired when viewed from the front (fig. 10, p. 22)
spine—support for the fins; in most cases not segmented, but stiff, not branched, and not paired when viewed from the front (fig. 10, p. 22)
spinous dorsal—the dorsal fin that is supported by spines (for example, the first dorsal fins of the fishes in fig. 13, p. 23)
subopercle—bone of the opercular series below and behind the opercle (fig. 2, p. 15)
subterminal mouth—located below the most anterior point of the fish but not quite ventral (*Rhinichthys atratulus* in fig. 32, p. 54)

supramaxilla—bone of the upper jaw attached to the dorsoposterior end of the maxilla (fig. 2, p. 15)
terminal mouth—a mouth that is the most anterior point of body (sunfish in fig. 12, p. 23)
thoracic—pertaining to the breast (fig. 2, p. 15)
tricuspid—tooth with three tips (fig. 35, p. 83)
ventral—pertaining to the lower surface
vomer—unpaired bone on roof of the mouth immediately behind the upper jaw

KEY TO THE FAMILIES OF FISHES FOUND IN THE FRESHWATERS OF CONNECTICUT

1. Gills not covered by bony plate, 7 gill openings, no paired fins—Petromyzonidae (lampreys), p. 25
   Gills covered by bony plate (operculum), 1 gill opening, at least 1 set of paired fins—2

2. Skull asymmetrical (eyes on one side of the head)—Soleidae (soles), p. 118
   Skull symmetrical—3

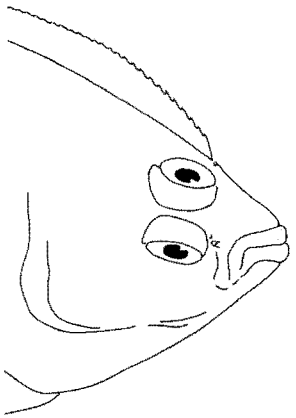


Fig. 3. Asymmetrical skull of a sole.

3. Dorsal, caudal, and anal fins continuous—Anguillidae (eels), p. 32
   Dorsal, caudal, and anal fins separate—4

4. Caudal fin heterocercal–5
Caudal fin homocercal–6

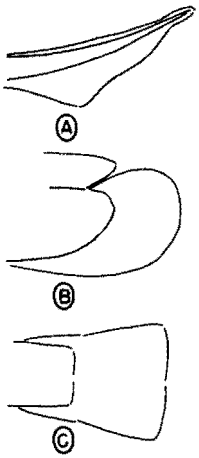


Fig. 4. Heterocercal tails of (A) a sturgeon, (B) the bowfin, and (C) the homocercal tail of a bullhead.

5. Gular plate present–Amiidae (bowfins), p. 31

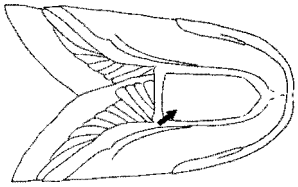


Fig. 5. Gular plate of the bowfin

Gular plate absent–Acipenseridae (sturgeons), p. 29

6. Both jaws elongated to form a long, slender, pointed beak – Belonidae (needlefishes), p. 82

Fig. 6. Head of a needlefish

Jaws not elongated to form a long beak–7

7. Head elongated into a long tubular snout – Syngnathidae (pipefishes and seahorses), p. 96

   Head not so elongated–8

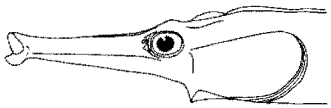


Fig. 7. Head of a pipefish

8. Chin with one or more barbels–9
   Chin without barbels–10

9. Chin with one barbel–Gadidae (codfish and hakes), p. 80
   Chin with several barbels–Ictaluridae (catfishes), p. 74

10. Belly with sawlike keel along midline–Clupeidae (herrings), p. 33

    Belly without sawlike keel–11

Fig. 8. Herring, showing sawlike belly

11. Adipose fin present–12

    Adipose fin absent–14

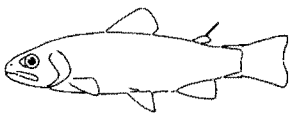


Fig. 9. Adipose fin of a trout

12. Spines present in the single dorsal fin–Percopsidae (trout perches), p. 79

    Spines absent in the single dorsal fin–13

Fig. 10. Front and side views of spines (left) and rays (right)

13. Stomach with 5 or fewer pyloric caeca, less than 100 scales in lateral line–Osmeridae (smelts), p. 47

    Stomach with 15 or more pyloric caeca, more than 100 scales in lateral line–Salmonidae (salmons, trouts, chars, and whitefishes), p. 39

Fig. 11. Ventral view of stomach and pyloric caeca of a trout

14. More than 2 dorsal spines—15
    0, 1, or 2 dorsal spines—21

15. Dorsal spines not connected by membranes—Gasterosteidae (sticklebacks), p. 91
    Dorsal spines connected by membranes—16

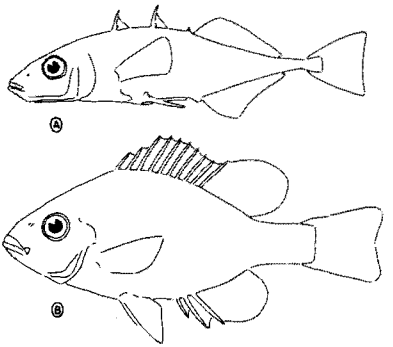
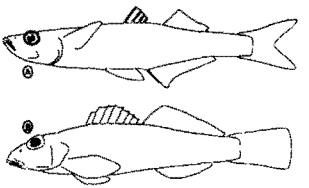


Fig. 12. Dorsal spines (A) not connected by a membrane (a stickleback) and (B) connected by a membrane (a sunfish)

16. No anal spines—Cottidae (sculpins), p. 97
    1 or more anal spines—17



17. Pelvic fins abdominal—20
    Pelvic fins thoracic, subjugular, or jugular—18

Fig. 13. Pelvic fins (A) abdominal (of a silverside) and (B) thoracic (of a darter)

18. 1 or 2 anal spines—Percidae (perches), p. 112
    3 or more anal spines—19

19. Pseudobranchiae concealed by a membrane—Centrarchidae (sunfishes), p. 100

    Pseudobranchiae exposed—Serranidae (sea basses), p. 98

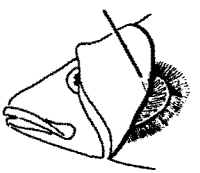


Fig. 14. Exposed pseudobranchia of a sea bass

20. One anal spine—Atherinidae (silversides), p. 90
    More than one anal spine—Mugilidae (mullets), p. 117

21. No dorsal spines—22
    1 or 2 dorsal spinelike rays—Cyprinidae (some minnows), p. 51

22. No visible lateral line—25 (But one sucker, *Erimyzon oblongus*, keys out here)
    Lateral line present—23

23. Pelvic fins abdominal and far back on body, snout resembles a duck's bill—Esocidae (pikes), p. 48

    Not as above—24

Fig. 15. Abdominal pelvic fins and ducklike snout of a pike

24. More than 10 dorsal rays—Catostomidae (suckers), p. 71
    Fewer than 10 dorsal rays—Cyprinidae (some minnows), p. 51

25. Mouth small, terminal and protractile, premaxilla forms edge of upper jaw—Cyprinodontidae (killifishes), p. 83
    Mouth large, maxilla extends beyond eye, mouth overhung by snout—Engraulidae (anchovies), p. 38

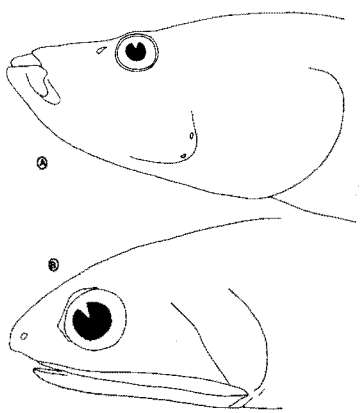


Fig. 16. Head of (A) a killifish and (B) an anchovy

ANNOTATED LIST OF FAMILIES AND SPECIES

Families are arranged phylogenetically, largely after the method of Greenwood and his co-workers (1966); genera and species are arranged alphabetically within each family. Names of fishes generally follow the terminology of R. M. Bailey and his associates (1960). Modifications of arrangement and nomenclature follow those suggested by Bailey and G. A. Moore (personal communications). A description and line drawing of each species are given and its general life history discussed; its distri-

bution in North America is listed and its distribution in Connecticut is shown on a map. The mode of occurrence of each species in Connecticut is described as follows: *introduced* = its natural range, as generally accepted, is separated from Connecticut by a mountain range, an intervening watershed, or salt water; *native* = its natural range, as generally accepted, includes Connecticut; *catadromous* = it spends most of its life in freshwater and goes to the sea to spawn; *anadromous* = it spends most of its life in the sea and comes into freshwaters to spawn; *amphidromous* = it apparently moves freely between saltwater and freshwater and does not require both environments to complete its life history; *visitor from saltwater* = occasionally found in freshwaters; *possible visitor from saltwater* = found in freshwaters in other areas and is present in the brackish waters of Connecticut.

Life-history information varies with the environment and the individual and, wherever possible, the generalized life history given for each species is based on personal observations or previous studies in Connecticut. A general life history is provided at the family level, rather than at the species level, if all the species in a family have similar generalized life histories.

On the distribution maps the following symbols are used for collection localities: ● a species occurrence in this survey, ▲ an accurate locality from a previous survey, and △ an inexact locality from a previous survey or record. Abbreviations of records referred to are as follows: UCML, unpublished data of the University of Connecticut Marine Laboratory; BFG, published and unpublished records of the Connecticut Board of Fisheries and Game; MCZ, Museum of Comparative Zoology, Harvard University; UCWF, University of Connecticut Fisheries Museum; UCMZ, University of Connecticut Museum of Zoology; BOL, Bingham Oceanographic Laboratory, Yale University; AMNH, American Museum of Natural History, and USNM, U. S. National Museum, Smithsonian Institution.

Family Petromyzonidae: Lampreys

Lampreys are found worldwide in coastal and inland waters and are quite different from the bony fishes. The characteristics most frequently used to separate the approximately 24 species of this family are the number of myomeres between the last gill opening and anus, and the structures of the mouth. Lampreys may be parasitic or nonparasitic and usually ascend streams to spawn. Nests (small depressions) are usually constructed in sand or gravel in spring. Adults die after spawning. Young lampreys (ammocoetes) burrow in the stream bottom and obtain food by filtering it from the water. Adults and young differ in appearance and after a few years in the bottom of the stream the young transform into the adult form and assume adult feeding habits.

Key to the species of adult lampreys found in Connecticut

1. Mouth with many large teeth—
Petromyzon marinus, p. 28

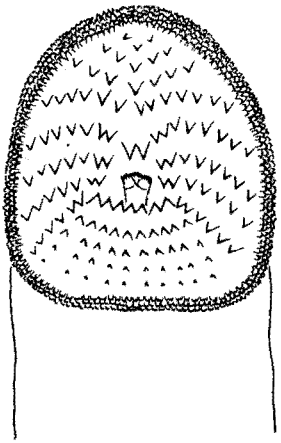


Fig. 17. Mouth of *Petromyzon marinus*

Mouth with scattered weak teeth—
Lampetra lamottei, p. 27

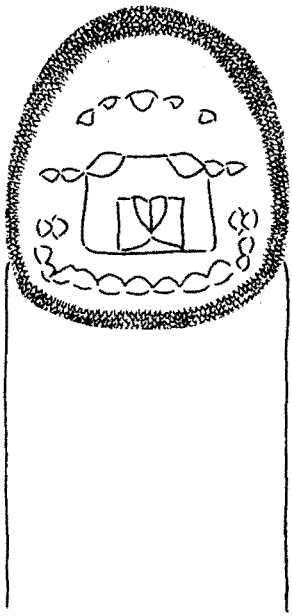


Fig. 18. Mouth of *Lampetra lamottei*

Key to the species of ammocoetes (after Vladykov, 1960)

1. Nonpigmented post-nostril area smaller than nostril itself—*Petromyzon marinus*, p. 28

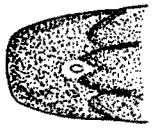


Fig. 19. Head of the ammocoete of *Petromyzon marinus*, dorsal view

Nonpigmented post-nostril area about twice size of nostril—*Lampetra lamottei*, p. 27

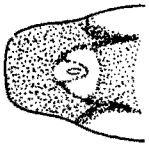
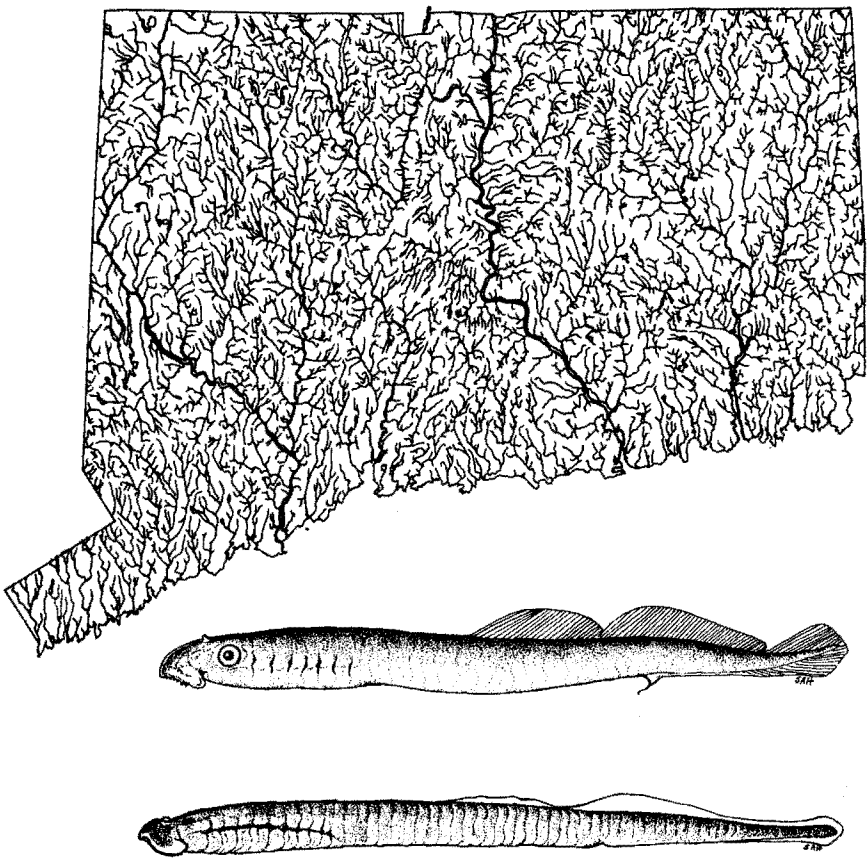


Fig. 20. Head of the ammocoete of *Lampetra lamottei*, dorsal view

Lampetra lamottei (LeSueur)—American brook lamprey—native

American brook lampreys are found in freshwaters along the Atlantic coast from New Hampshire to Maryland, west to Minnesota, and south to Tennessee.



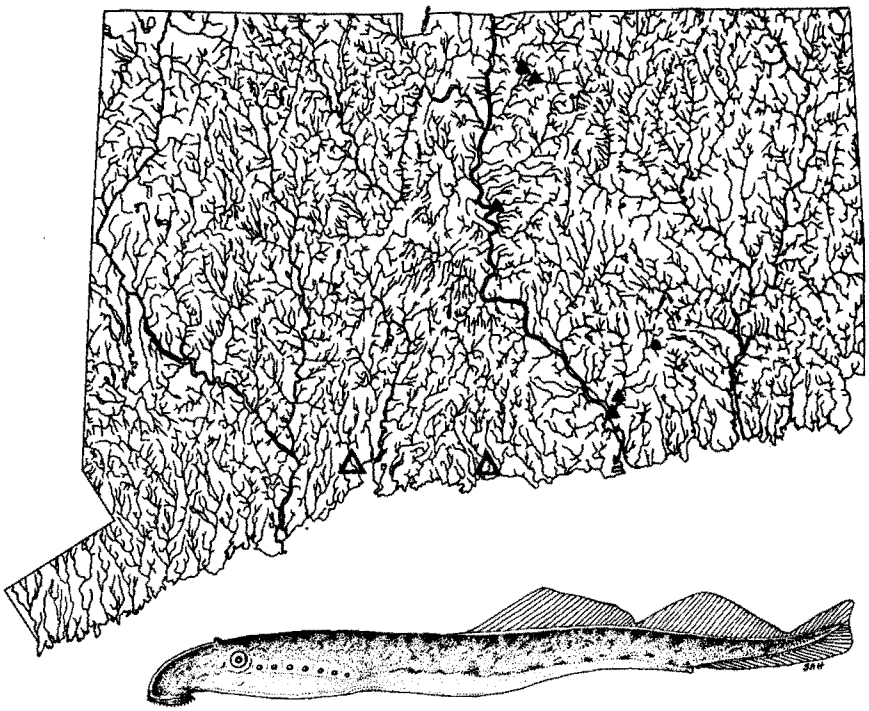
AMMOCOETE

The adult is olive green to brown dorsally, fading laterally, and whitish yellow ventrally. The dorsal fins are separate, the teeth are not in radiating rows, and there are 63-70 myomeres. Lengths up to 8 or 9 in. are reached.

Petromyzon marinus Linnaeus—sea lamprey—anadromous

Sea lampreys are found along the Atlantic coasts of Europe and North America and are landlocked in some freshwater lakes, for example, the Great Lakes. Triangles plotted are from R. P. Hunter (unpublished), UCML, and BOL.

The adult sea lamprey is grayish to blue black dorsally, fading laterally, and grayish whitish ventrally. The dorsal fins are separate, and the mouth



is a circular disk with fringed lips; radiating teeth are sharp. Circumoral teeth are bicuspid, the others are simple (4-7 in each row), and there are about 70 myomeres. Lengths of 5 ft are reached.

This lamprey spends most of its adult life in the sea. Prior to spawning, the digestive tract degenerates. Spawning movements occur mainly at night from May to June with the males usually preceeding the females to the spawning area. Nests are constructed in gravel riffles and males do most of the nest building. During spawning the male grasps the female's head with his suctorial mouth, wraps his body around hers, and the eggs and milt are then exuded.

Family Acipenseridae: sturgeons

Approximately 23 species are found in the salt waters, brackish waters, and freshwaters of the northern hemisphere. No specimens of either of the two species that should be found in Connecticut were collected or located in museums during the two years of this study. Reliable sources have reported large (4-6 ft) sturgeon below Enfield dam and near the mouth of the Connecticut River. We would greatly appreciate receiving information about or specimens of sturgeons from the freshwaters of Connecticut. Members of this family are generally slow to grow and to reach sexual maturity. Eggs are used to prepare the famous "caviar."

The information that follows was taken mainly from Vladykov and Greeley (1963).

Key to the species of sturgeons found in Connecticut

1. More than 23 anal rays—*Acipenser oxyrhynchus*
   Fewer than 23 anal rays—*Acipenser brevirostris*

Acipenser brevirostris LeSueur—shortnose sturgeon—possibly anadromous

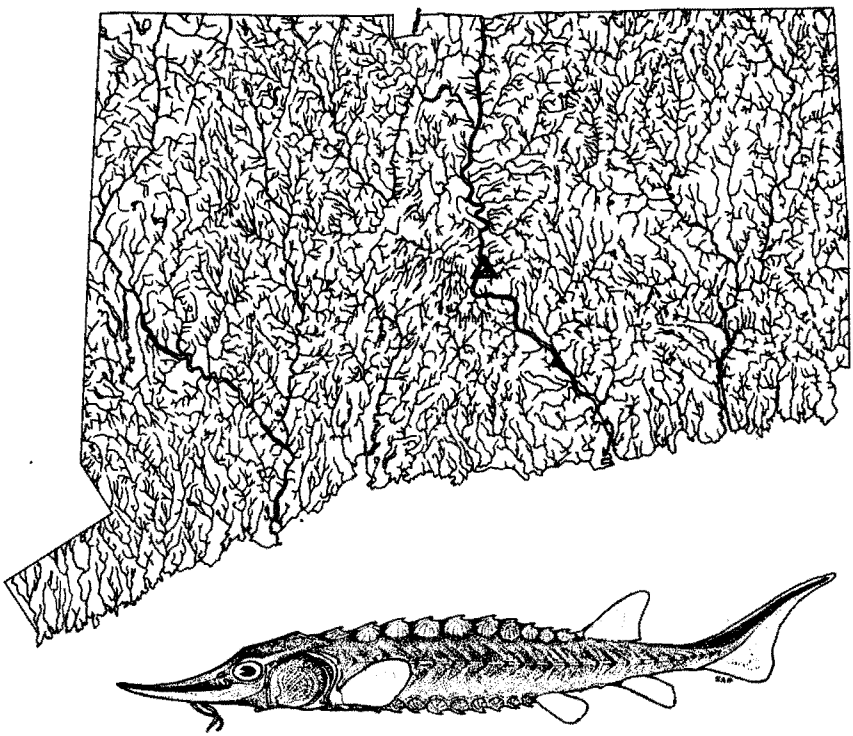
Shortnose sturgeon are found along the Atlantic coast in brackish waters, saltwaters, and freshwaters from New Brunswick to Florida.

The shortnose sturgeon is bluish black dorsally, paler laterally, and white ventrally. There are 8-13 dorsal plates, 22-23 lateral plates, 6-11 ventral plates, 41 dorsal rays, and 22 anal rays. Mouth width is less than 55 percent of the interorbital width. Lengths of about 3 ft are reached.

This sturgeon reaches sexual maturity in about 5 years and spawns in rivers in early spring. It is generally a bottom dweller and feeds on a wide variety of plant and animal materials.

Acipenser oxyrhynchus Mitchill—Atlantic sturgeon—anadromous

This species is found along the Atlantic coast in saltwaters, brackish waters, and freshwaters from Labrador to Georgia. The triangles plotted are from Galligan (1960).



YOUNG

The Atlantic sturgeon is bluish black dorsally, fading laterally, and white ventrally. There are 7-14 dorsal plates, 24-35 lateral plates, 8-12 ventral plates, 38-46 dorsal rays and 26-28 anal rays. Mouth width is over 62 percent of the interorbital width. Lengths up to 14 ft are reached.

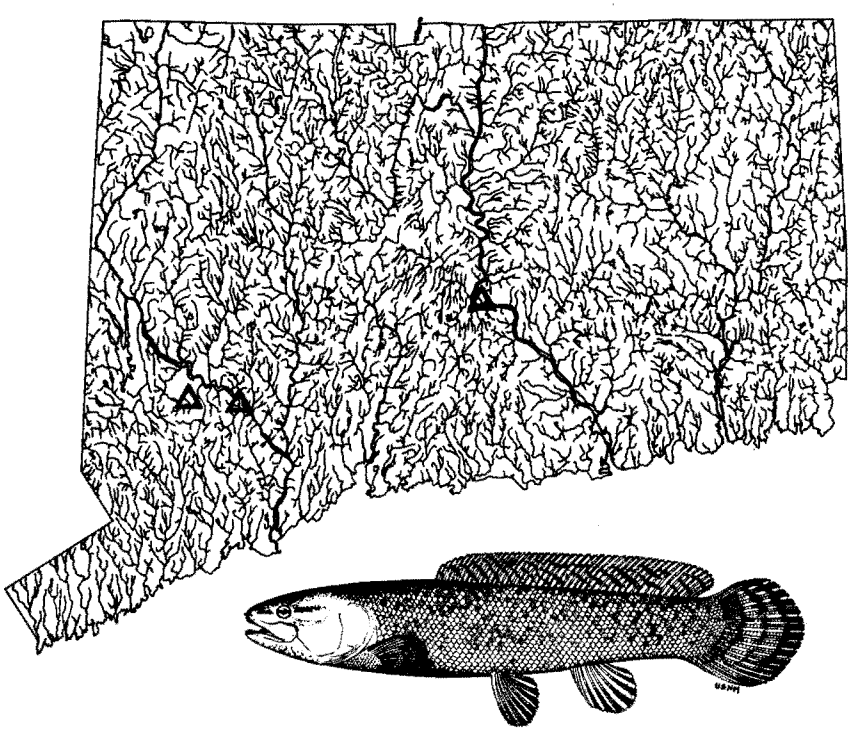
Atlantic sturgeons reach sexual maturity in 10-12 years and ascend rivers to spawn in early spring. Eggs are apparently broadcast in areas below waterfalls and are adhesive and demersal. Young spend the first few years of life in the tidal reaches of rivers. Adults are bottom dwelling and feed on both plant and animal materials.

Family Amiidae: bowfins

One species of this primitive family is found in the Mississippi, Lake Huron, and Lake Erie watersheds of eastern North America and on the Atlantic slope in Florida and the Carolinas. Triangles plotted are from Webster (1942). His report of the introduction of the bowfin was not verified and there is some doubt as to the authenticity of these records.

Amia calva Linnaeus—bowfin—introduced

The bowfin is dark olive dorsally, lighter laterally, whitish yellowish ventrally; its sides have greenish reticulations. Males have an orange-edged dark spot at the upper base of the caudal fin. Lengths up to 3 ft are reached.



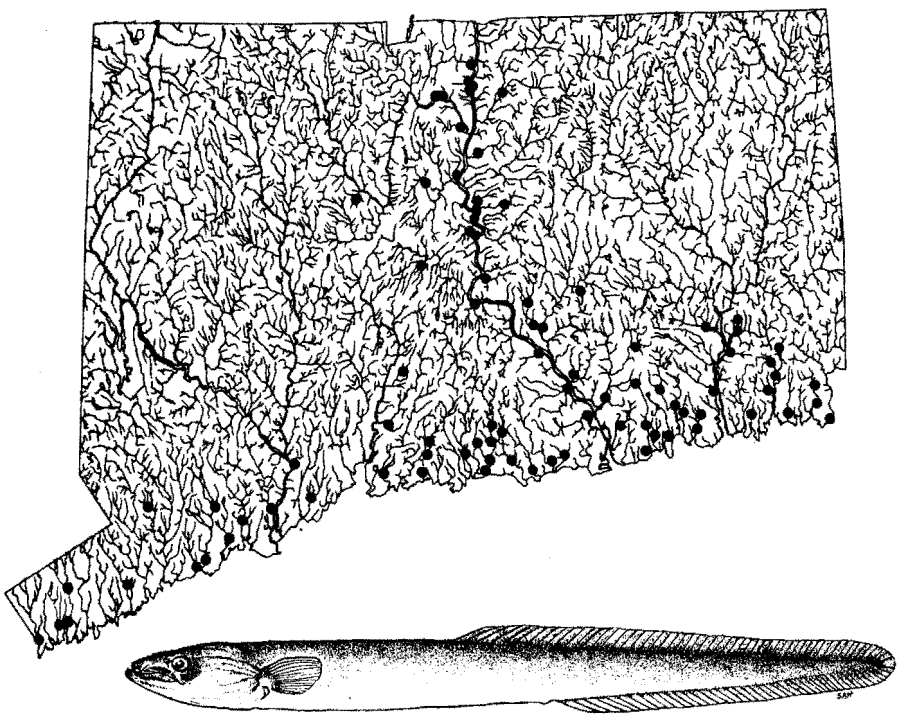
Bowfins are found mainly in lakes and slow-moving streams. Males build a nest (depression in the bottom) in spring. After the eggs hatch the young attach themselves to the nest with an adhesive organ on their snouts. When the young leave the nest they travel in dense schools and are guarded by the male until they are 3-4 in. long. This species feeds mainly on fish and large invertebrates.

Family Anguillidae: eels

The saltwaters, brackish waters, and freshwaters of the warm and temperate zones of the world contain approximately 16 species. All spawn in the sea and spend most of their lives in brackish waters and freshwaters. One species is found in Connecticut.

Anguilla rostrata (LeSueur)—American eel—catadromous

American eels ascend far inland in streams along the Gulf and Atlantic coasts, reaching most of the states east of the Rockies.



The American eel is brownish dorsally and laterally, yellow ventrally; pelvic fins are absent. Lengths up to 6 ft are reached.

This eel spawns in the South Atlantic (Sargasso Sea) in spring. The young males migrate into estuaries and the lower ends of rivers, while the females move far up rivers. They are nocturnal in habit and feed mainly on invertebrates and fish. After several years in freshwater, the mature fish return to the Sargasso Sea, spawn, and die.

Family Clupeidae: herrings

The freshwaters, saltwaters, and brackish waters of the world contain about 150 species, some anadromous. Most species are usually found in large schools. Young herrings are extremely difficult to identify.

Key to the species of herrings found in Connecticut

1. Head large, its length more than ⅓ standard length of fish—*Brevoortia tyrannus*, p. 37
   Head small, its length less than ⅓ standard length of fish—2

2. Fewer than 25 gill rakers on lower limb of first gill arch—*Alosa mediocris*, p. 35

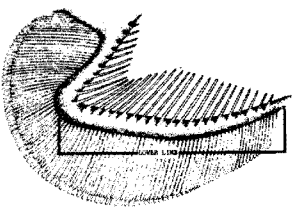


Fig. 21. First gill arch of *Alosa mediocris*

   More than 25 gill rakers on lower limb of first gill arch—3

3. Lower jaw outline rises fast, cheek patch wider than deep, tongue normally does not extend beyond premaxilla when mouth is held open—4
   Lower jaw outline less abrupt, cheek patch deeper than wide, tongue extends beyond premaxilla when mouth is held open—*Alosa sapidissima*, p. 36

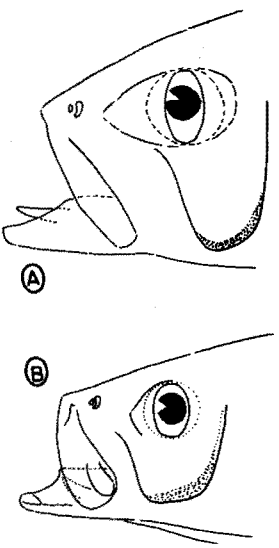
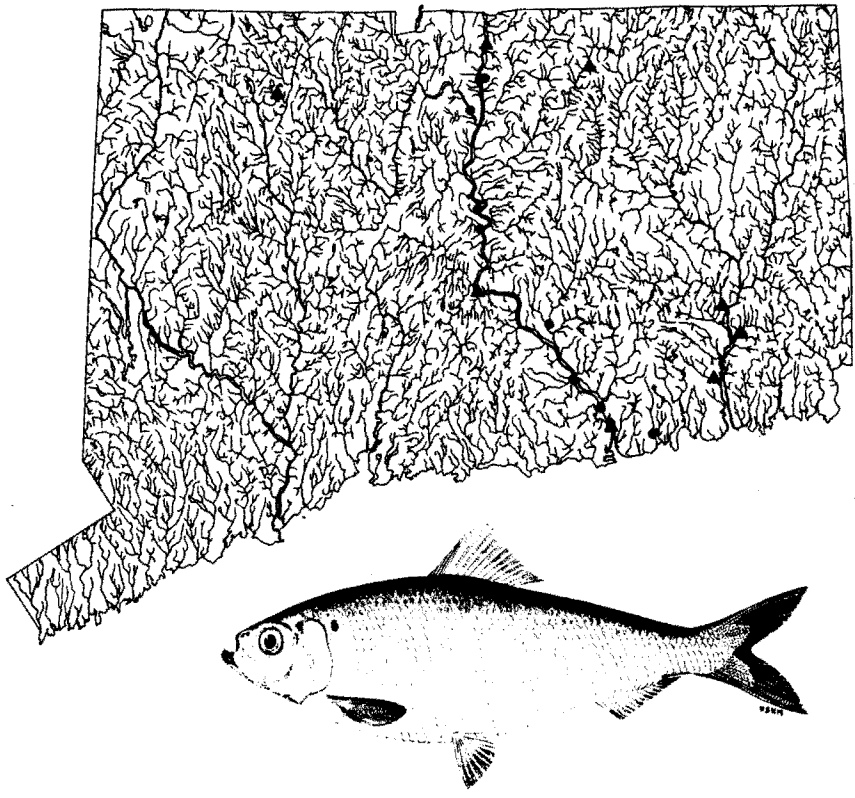


Fig. 22. *A*, Head of *Alosa sapidissima; B*, head of *A. pseudoharengus* and *A. aestivalis*

4. Peritoneum black, eye width generally less than snout length—*Alosa aestivalis*, p. 34
   Peritoneum silvery to dusky, eye width generally equal to or greater than snout length—*Alosa pseudoharengus*, p. 35

Alosa aestivalis (Mitchill)—blueback herring—anadromous

This herring is found in freshwaters, saltwaters, and brackish coastal waters from Nova Scotia to Florida. Triangles plotted are from BFG (1959), UCML, and BFG (unpublished).

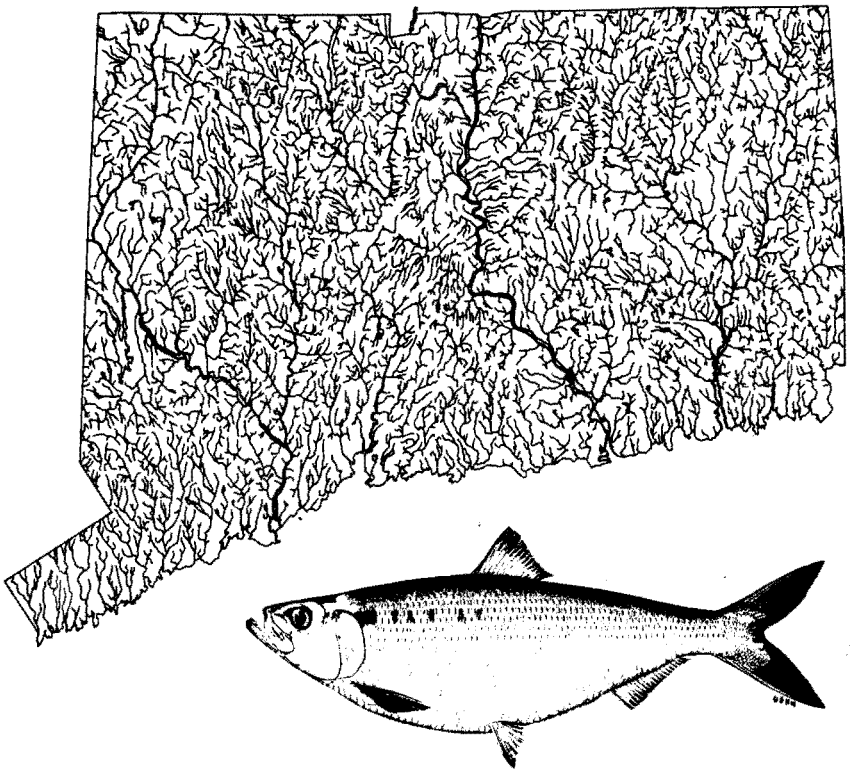


The blueback herring is bluish dorsally, silvery laterally, white ventrally, and there is a dark spot behind the head high on the side. There are 46-54 scales in the lateral line, 15-20 dorsal rays, 16-21 anal rays, and 41-51 gill rakers on the lower limb of the first arch. Lengths up to 1.3 ft are attained.

Blueback herring spawn in April-July and adults return to the sea soon after spawning. Their food consists of a variety of small plants and animals.

Alosa mediocris (Mitchill)—hickory shad—possibly anadromous

Hickory shad are found in coastal saltwaters, brackish waters, and freshwaters from New Brunswick to Florida. The triangle plotted is from BOL.

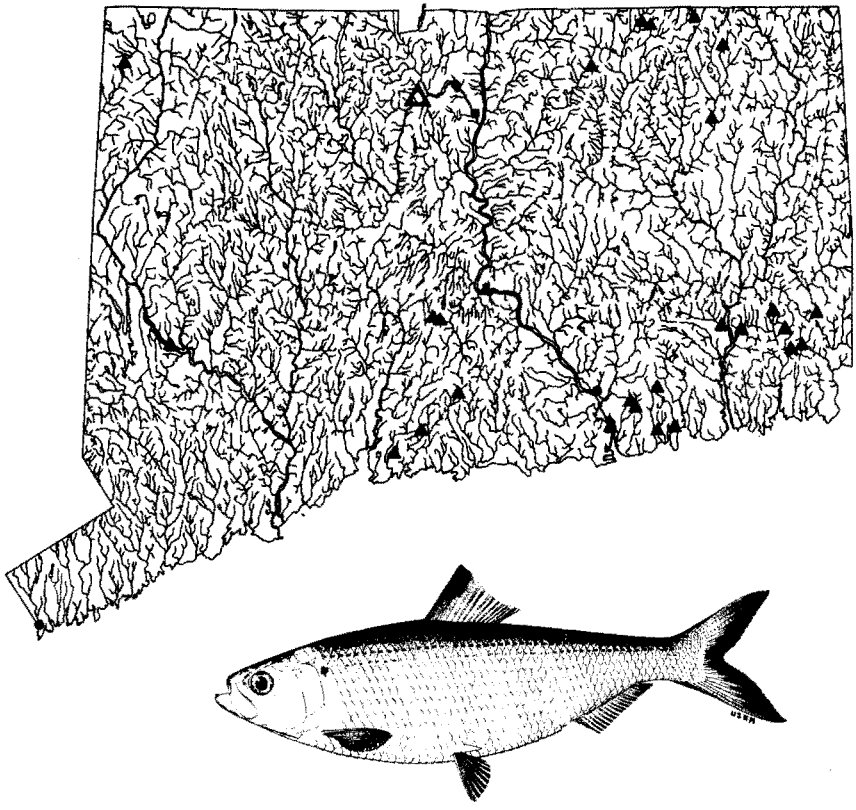


The color pattern is grayish dorsally, silvery laterally, white ventrally, and dark spot(s) are located high on the sides behind the head. There are 48-57 scales in the lateral line, 15-20 dorsal rays, 19-23 anal rays, and 18-23 gill rakers on the lower limb of the first arch. Lengths up to 2 ft are attained.

There is one report of hickory shad in the freshwaters of Connecticut. Their spawning habits have not been well documented in the state and whether they spawn in freshwaters, brackish waters, or saltwaters is not known.

Alosa pseudoharengus (Wilson)—alewife—anadromous

The alewife is found in coastal saltwaters, freshwaters, and brackish waters from Nova Scotia to the Carolinas; they are landlocked in many areas along the East Coast and in the Great Lakes. Triangles plotted are from UCML, BFG (1959), USNM, and BFG (unpublished).



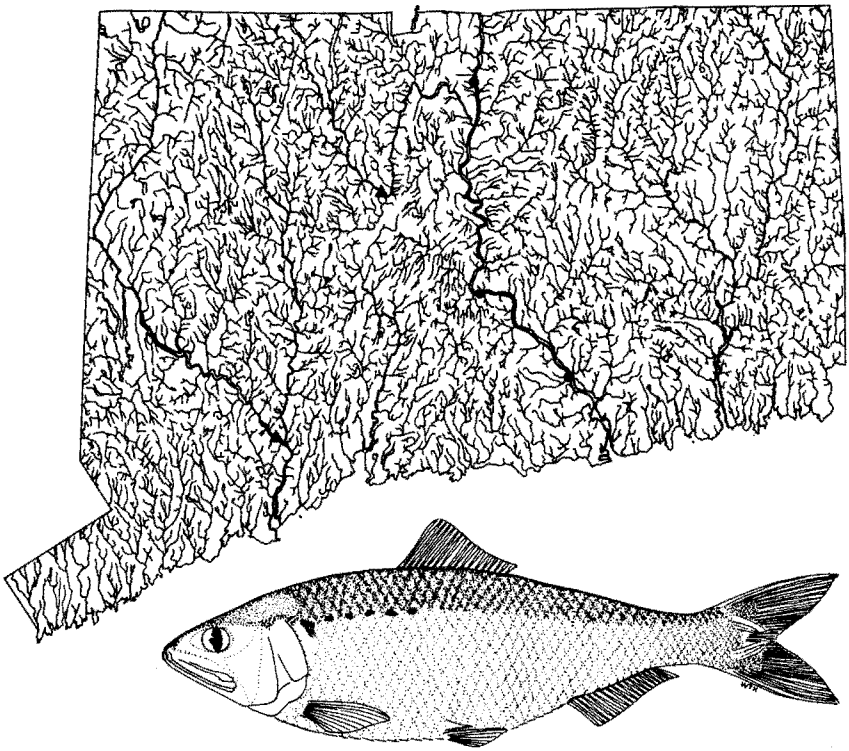
This species is grayish dorsally, silvery laterally, white ventrally, and has a dark spot high on the side behind the head; in some specimens, the scales on the upper sides have dusky lines. There are 42-50 scales in the lateral line, 38-44 gill rakers on lower limb of first arch, 15-19 dorsal rays, and 17-21 anal rays. Lengths up to 1.3 ft are attained.

Adults enter rivers in early spring (March-June) to spawn. Eggs are adhesive and attach to the bottom. Their food consists of small plants and animals.

Alosa sapidissima (Wilson)—American shad—anadromous

This shad is found in saltwaters, brackish waters, and coastal freshwaters from the St. Lawrence River to Florida; it has been widely introduced on the Pacific coast from California to Alaska. Triangles plotted are from USNM and UCWF.

The color pattern is bluish dorsally, silvery laterally, whitish ventrally, with a dark spot high on the side behind the head. There are 52-62 scales in the lateral line, 59-73 gill rakers on the lower limb of the first



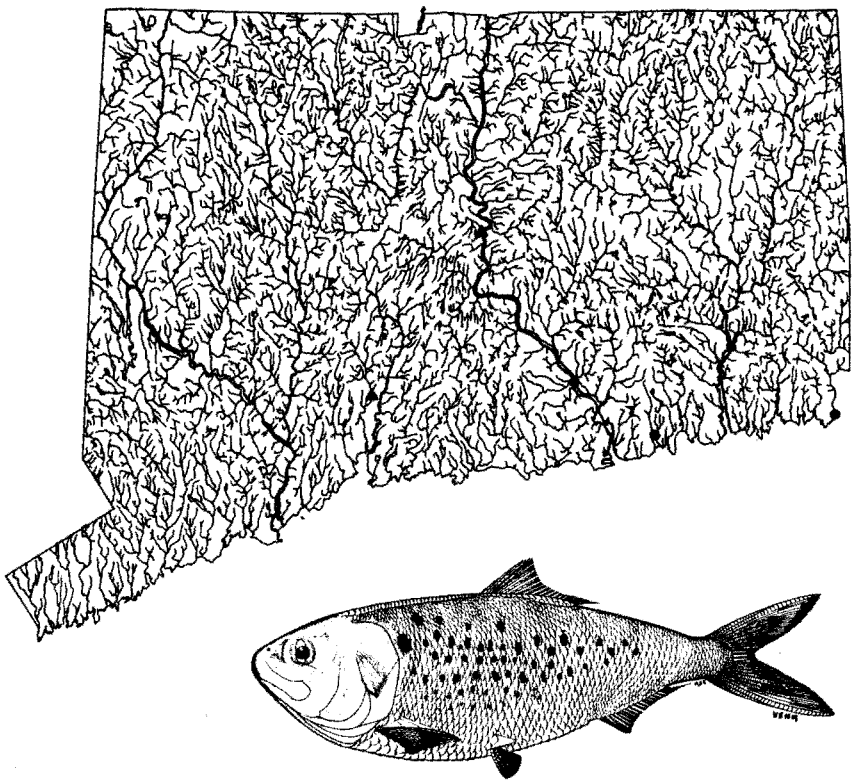
arch, 17-20 dorsal rays, and 20-23 anal rays. Lengths up to 2.5 ft are reached.

American shad enter the Connecticut and Housatonic Rivers to spawn in spring when the water temperature is between 50°-55° F (April-June). They probably do little feeding as they move upstream. Most of the spawning in Connecticut is thought to take place in the Connecticut River between Bissell Bridge and Enfield Dam. Adults may spawn more than once. After the eggs hatch the young stay in the river until late fall and then move into saltwater. They stay 3-4 years at sea and return to freshwater to spawn. A variety of plant and animal materials are eaten.

Brevoortia tyrannus (Latrobe)—Atlantic menhaden—visitor from saltwater

This menhaden is found in saltwaters, brackish waters, and rarely in coastal freshwaters from Nova Scotia to Argentina. Triangles plotted are from BOL and UCML.

The Atlantic menhaden is bluish to greenish dorsally, silvery laterally, white ventrally, with at least one dark spot high on the sides behind the head. There are 41-55 scales in the lateral line, 18-22 dorsal rays, 18-24 anal rays. Lengths up to 1.5 ft are reached.



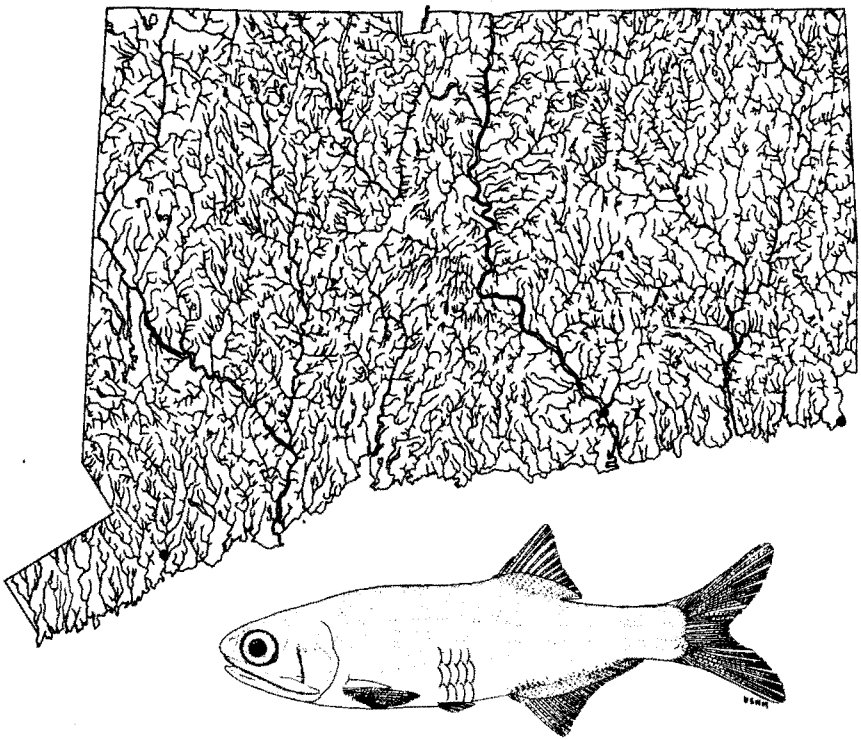
Family Engraulidae: anchovies

Anchovies are generally found in coastal saltwaters and brackish waters, rarely in freshwaters, and mainly in tropical areas. Only one of the approximately 75 species in this family is found in Connecticut waters.

Anchoa mitchilli (Valenciennes)—bay anchovy—possible visitor from saltwater

The bay anchovy is found in coastal saltwaters and brackish waters from Maine to Mexico, occasionally entering freshwaters.

Color pattern is greenish dorsally, silvery laterally, and white ventrally. There are 14-16 dorsal rays, 24-30 anal rays, 15-19 gill rakers on the lower limb of the first arch, and 38-44 scales in the lateral line. Lengths reach 5 in.



Family Salmonidae: salmons, trouts, chars, and whitefishes

The freshwaters, brackish waters, and saltwaters of the northern hemisphere contain about 70 species; many of these fishes are highly prized as food and for their fighting qualities.

Young trout and salmon have patterns different from those of their parents and are characterized by a series of dark blotches of various shapes and sizes on their sides. Because external characteristics are extremely variable and because hybrids and exotic species are occasionally stocked, some specimens will be obtained that are diffiuclt to identify.

Various crosses between selected members of this family have been made to obtain "superior" fishes, by both the Connecticut Board of Fisheries and Game and by private organizations and individuals. These fishes are "superior" to the present trout fauna because they grow faster, are capable of tolerating a wider range of environmental conditions, or are more palatable.

The "tiger" (progeny of female brown trout x male brook trout) resembles a brook trout with greatly enlarged dorsal mottlings. This hybrid has been stocked occasionally in streams throughout the state and is apparently infertile (BFG, unpublished data).

The "splake" (progeny of male brook trout x female lake trout) has characteristics about midway between the two parent species. This hybrid

has been stocked in Beach Pond, Green Falls Reservoir, and Wononskopomuc Lake (BFG, unpublished data). Many individuals of this hybrid, and their progeny, are fertile.

Some "exotic" species of salmonids have been introduced in various waters of the state but apparently have not become established. Specimens of cutthroat trout (*Salmo clarki* Richardson) have been stocked in Green Falls Reservoir, Wononskopomuc Lake, and Lake Saltonstall (BFG, unpublished data). This trout can be distinguished from the brown trout by the presence of a red streak in the crease of the jaw. An anadromous salmon—coho salmon, *Oncorhynchus kisutch* (Walbaum)—has been introduced in the Thames River system and may become established (BFG, unpublished data). This salmon is distinguished from the kokanee by having 19-25 gill rakers; kokanees have 30-39.

Key to the species of salmons, trouts, chars, and whitefishes found in Connecticut

1. Maxilla extends to least to middle of eye—2

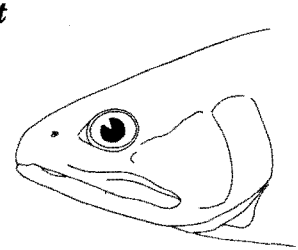


Fig. 23. Maxilla extending beyond middle of eye

Maxilla does not extend to middle of eye—*Prosopium cylindraceum*, p. 42

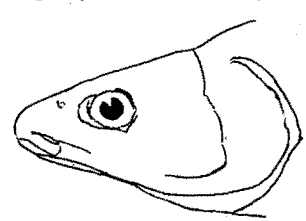


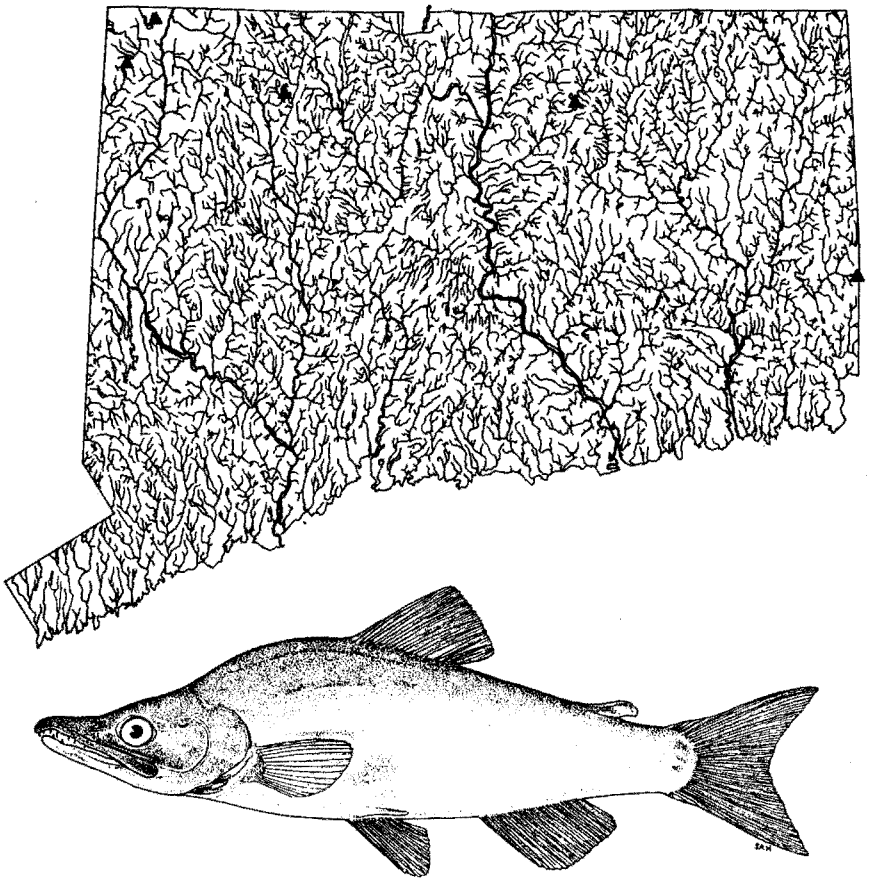
Fig. 24. Maxilla not extending beyond middle of eye

2. Anal fin with 13 or more rays—*Oncorhynchus nerka*, p. 41
   Anal fin with fewer than 13 rays—3
3. Color pattern of dark spots on a light background—4
   Color pattern of light spots on a dark background—6
4. Many tail spots—*Salmo gairdneri*, p. 42
   Few or no tail spots—5
5. Teeth on vomer poorly developed, spots smaller and commonly X-shaped—*Salmo salar*, p. 43
   Teeth on vomer well developed, spots large—*Salmo trutta*, p. 44

6. Caudal fin deeply forked, 11 anal rays—*Salvelinus namaycush*, p. 46
   Caudal fin shallowly concave, 9 anal rays—*Salvelinus fontinalis*, p. 45

Oncorhynchus nerka (Walbaum)—sockeye salmon—introduced

The sockeye salmon is found in saltwaters, brackish waters, and coastal freshwaters of Japan and western North America. Although most individuals are anadromous, landlocked forms are also present. The landlocked form, often called kokanee, has been widely introduced in the Great Lakes, on the East Coast and in the Rocky Mountain regions. Triangles plotted are from UCWF, Webster (1942) and BFG (unpublished).

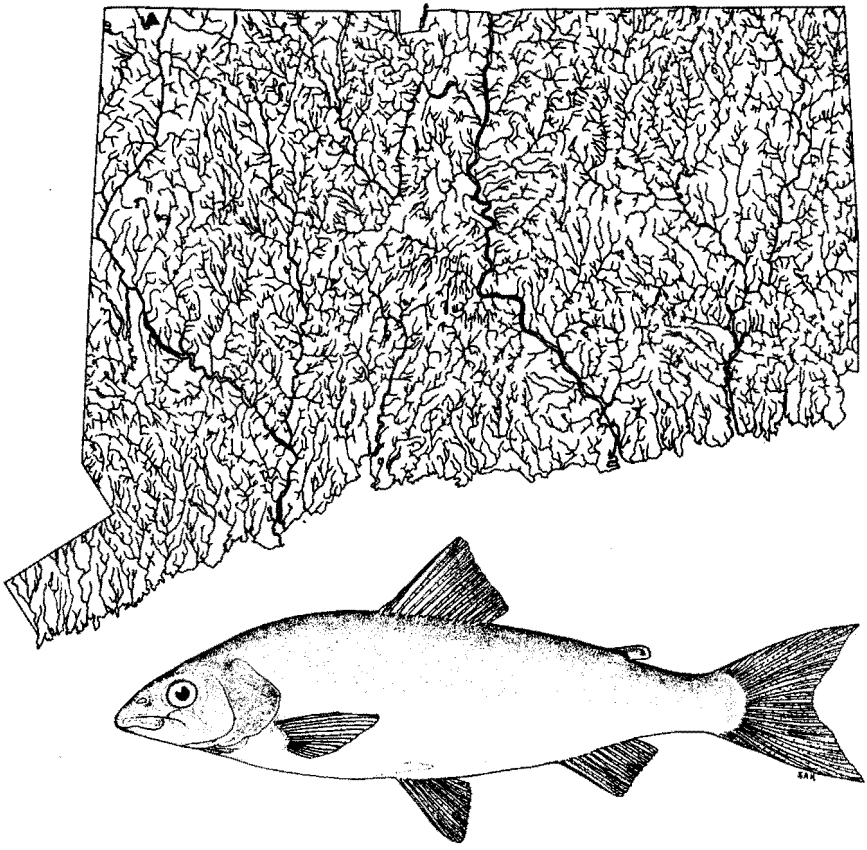


The kokanee is greenish dorsally, silvery laterally, white ventrally, and reaches lengths up to 2 ft. During the spawning season the fish becomes red and the snout of the male assumes the typical salmon "kyp."

Young kokanees grow for 1-4 years, then spawn in the fall and die after spawning. The species eats mainly invertebrates.

Prosopium cylindraceum (Pallas)—round whitefish—native

The round whitefish is generally found in lakes of northern North America and Siberia. In Connecticut it has been found only in East Twin Lake. The triangle plotted is from UCWF.



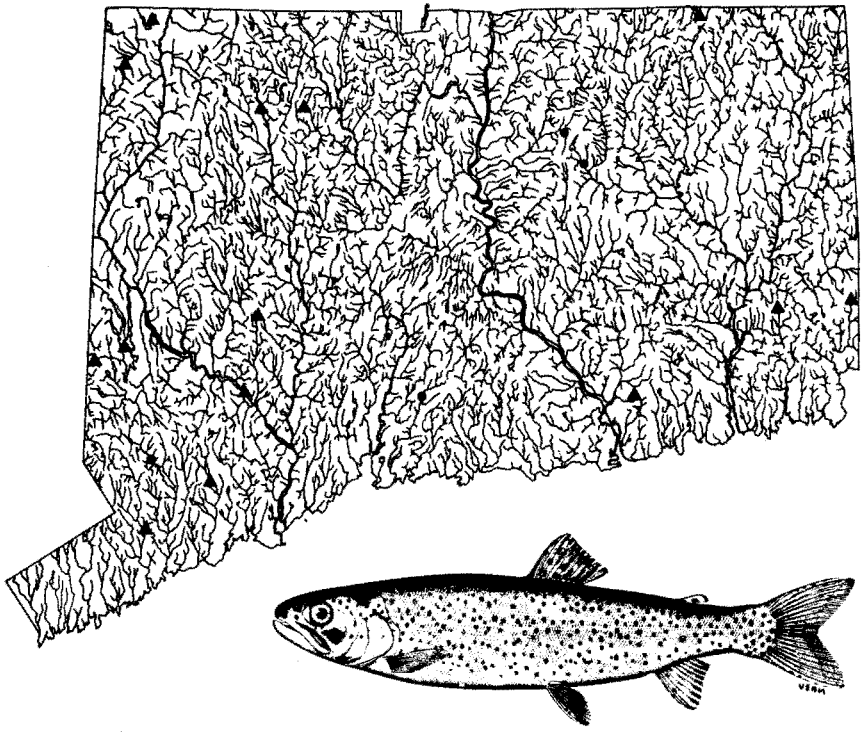
This whitefish is grayish olivaceous dorsally, silvery laterally, white ventrally, and reaches lengths up to 1.5 ft.

It is generally found in the deeper colder waters of a lake and feeds on invertebrates. Spawning probably occurs in the fall (October to December).

Salmo gairdneri Richardson—rainbow trout—introduced

The rainbow trout, native to the west coast of North America, has been widely introduced throughout much of the continent. Triangles plotted are from Webster (1942), BFG (1959) and BFG (unpublished).

This trout is greenish dorsally, silvery laterally with a pinkish band, white ventrally, and reaches lengths of 3 ft.



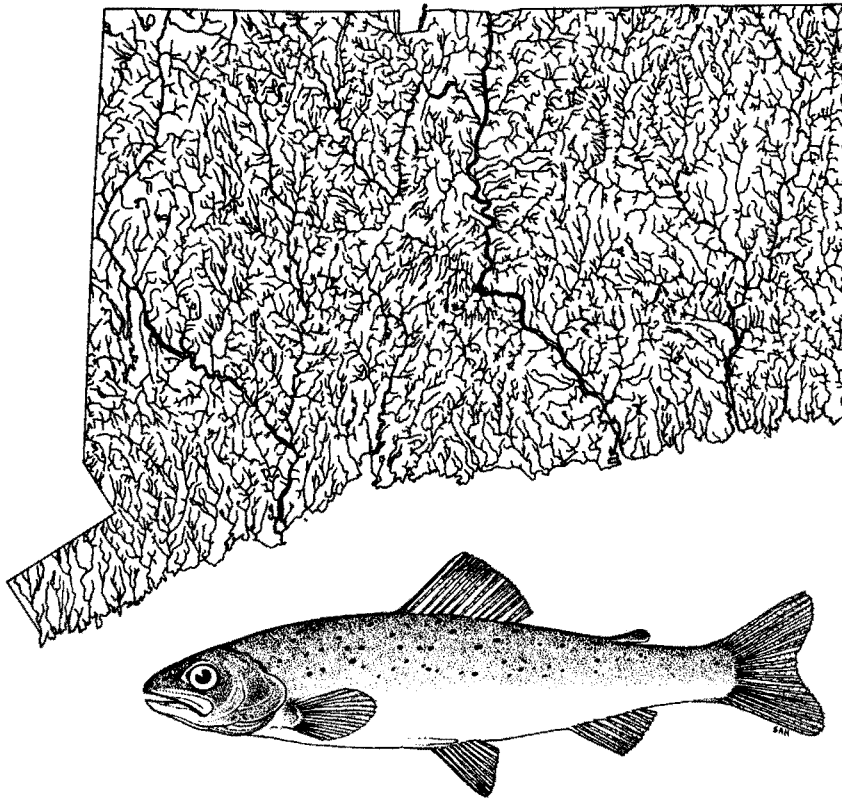
Spawning occurs in the spring (February to June), although a fall-spawning variety has been developed. Rainbow trout prefer cool, clean waters but do well in a variety of environments and tolerate warmer waters than do brown trout. Adults feed mainly on fish and invertebrates.

Salmo salar Linnaeus—Atlantic salmon—once anadromous

The Atlantic salmon is an anadromous fish found on both sides of the Atlantic Ocean. No rivers in North America south of Maine now support a significant run of Atlantic salmon. The last report of this species in Connecticut waters was in 1965 (UCML, unpublished data). The triangle plotted is from Merriman and Jean (1949).

Specimens from the ocean are silverish bluish green dorsally, silvery laterally, and white ventrally. They lose the silvery color in freshwater and become a reddish brown. Individuals reach lengths up to 5 ft.

Atlantic salmon first enter rivers in the spring and continue to do so until September. They spawn during October and November in riffles. Females build the nest or redd. Young spend 1-5 years in freshwater and then go to sea for 1-4 years before returning to freshwater to spawn.



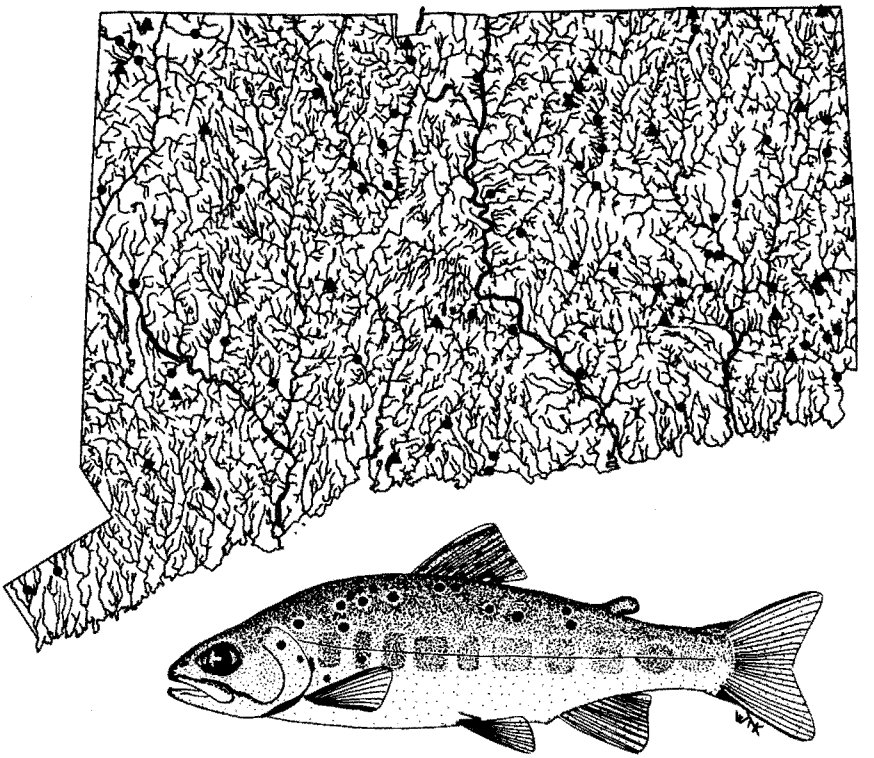
Young males may spawn before going to sea. Adults do not die after spawning and generally return to spawn again. The food of this species consists of fishes and invertebrates.

Salmo trutta Linnaeus—brown trout—introduced

The brown trout, native in Europe, has been widely introduced in the saltwaters, brackish waters, and freshwaters of most of North America. Some forms are anadromous and have been successfully introduced into the state by the Connecticut Board of Fisheries and Game. The triangles plotted are from BFG (unpublished), UCWF, MCZ, Webster (1942), and BFG (1959).

This trout in freshwater rivers is brownish dorsally and laterally, lighter ventrally, and has red and black spots on its sides. The coloration is silvery in lakes and at sea. Individuals reach 3.5 ft in length.

Spawning takes place in the fall and winter (October to February) over sand or gravel bottoms. Brown trout are tolerant of a wide range of environmental conditions. They feed more at night than during the day.

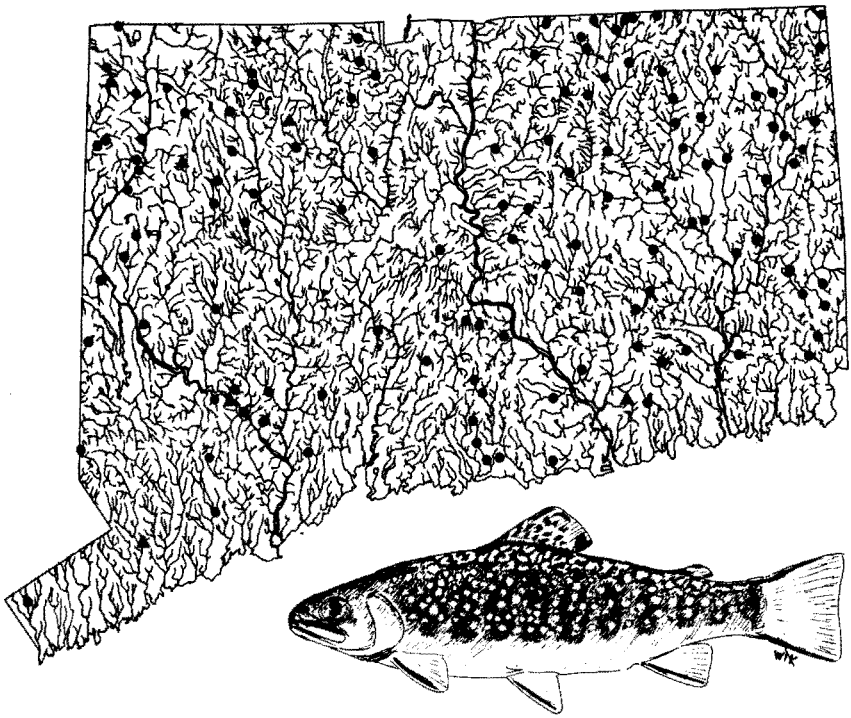


Their food consists of fish and invertebrates, and in freshwater lakes a few individuals commonly grow large at the expense of other fishes.

Salvelinus fontinalis (Mitchill)—brook trout—native

The brook trout has been widely introduced throughout most of North America. It is native to most of the north and to areas east of the Appalachians. Some specimens are anadromous. Triangles plotted are from Webster (1942), BFG (1959), and BFG (unpublished).

This species is olive green with grey mottled markings dorsally, lighter green laterally, and whitish ventrally, with red and yellow spots on the sides. The margins of the pelvic, pectoral, anal, and caudal fins are edged in white. It reaches lengths up to 2 ft.

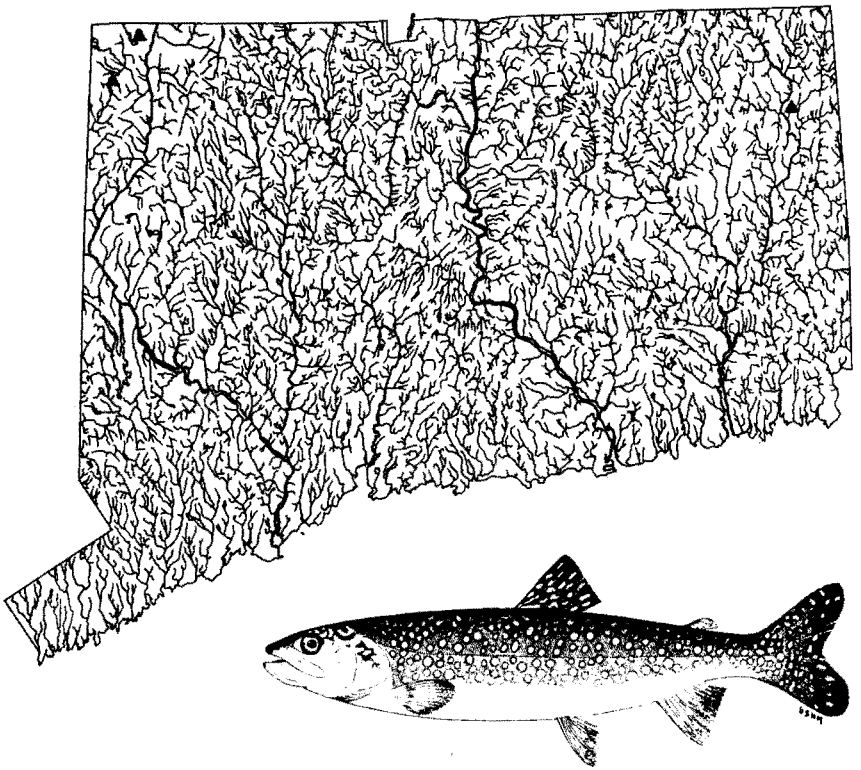


Brook trout prefer clear, cold streams with gravel bottoms. They spawn in the fall (September to November) in gravel areas. Adults eat invertebrates and fishes.

Salvelinus namaycush (Walbaum)—lake trout—introduced

This species is found in cold, clear lakes of northern North America and has been introduced outside this area with some degree of success. Triangles plotted are from BFG (unpublished), Webster (1942), and BFG (1959).

The lake trout is grayish dorsally, lighter laterally and ventrally, with yellowish or grayish spots on the sides. Lengths up to 4 ft are reached.



Deep areas of lakes are preferred, except in spring and fall. Spawning occurs in the fall over rocky bottoms with little or no nest preparation. Adults eat fishes and invertebrates.

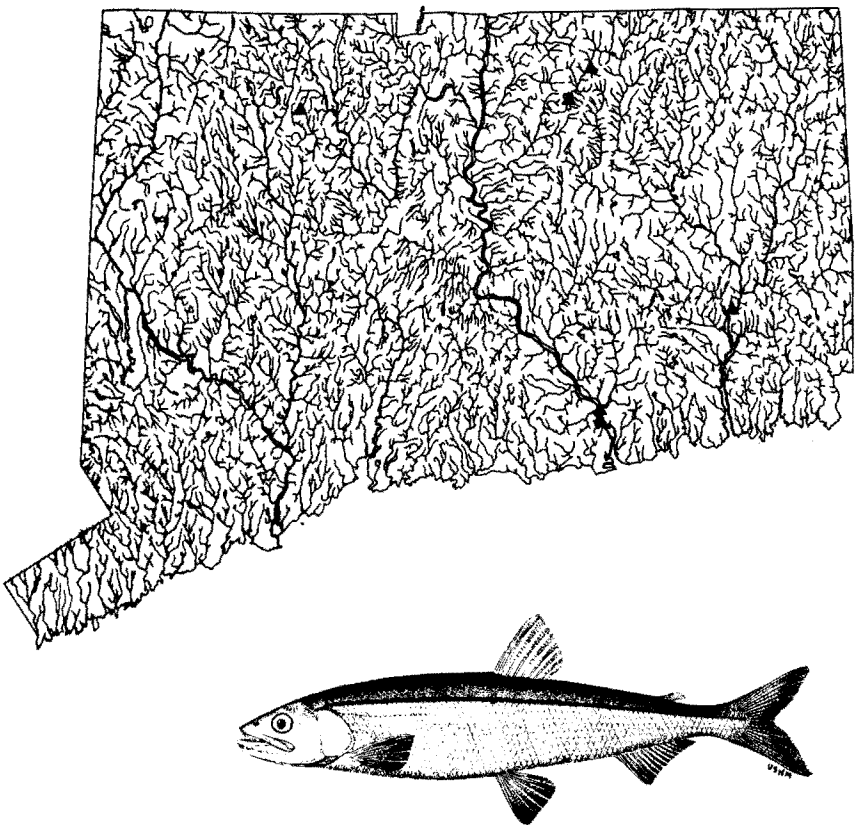
Family Osmeridae: smelts

Approximately 15 species are found in the saltwaters, brackish waters, and freshwaters of the northern hemisphere. Although most species are marine, some are anadromous and a few are strictly freshwater. One species enters the freshwaters of Connecticut.

Osmerus eperlanus (Linnaeus)—rainbow smelt—anadromous

This smelt is found in freshwaters, brackish waters, and coastal saltwaters of the East Coast from Labrador to Pennsylvania; on the West Coast from the Arctic Circle to Vancouver Island, British Columbia; populations are landlocked in Connecticut and in the Great Lakes. It is found not far from the shore along the coast and in the deeper parts of lakes when landlocked. Triangles plotted are from BFG (1959), Webster (1942), and BFG (unpublished data).

The rainbow smelt is olive green dorsally, silvery laterally, and white ventrally; there are 10-11 dorsal rays, 15-17 anal rays, 64-69 scales in the lateral line, and 7-8 branchiostegal rays. It reaches a length of 1 ft.



Spawning occurs at night in early spring (March-April) in brackish waters, saltwaters, or freshwaters not far from saltwater in Connecticut. Males develop nuptial tubercles and large groups of fish spawn at the same time. Adults eat algae, small invertebrates, and fishes.

Family Esocidae: pikes

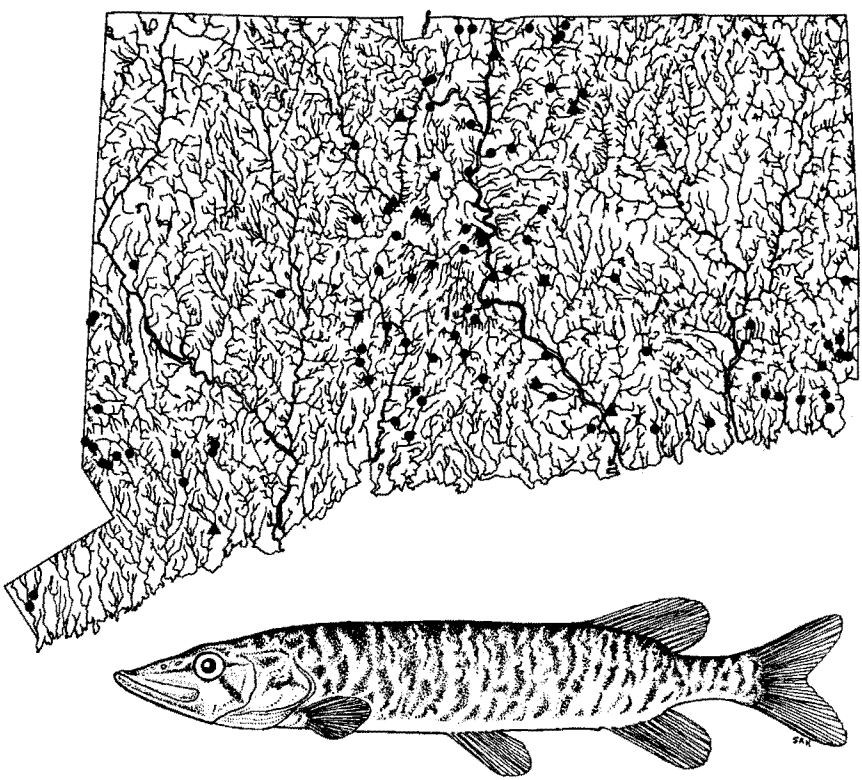
Five species are found in the freshwaters and occasionally in the brackish waters of the northern hemisphere. Pikes generally prefer shallow weedy areas, often going into deep water in the fall. They are usually solitary fish, found around weed beds and submerged vegetation. They congregate in shallow marshy areas in early spring to spawn. Eggs are broadcast over vegetation and receive no parental care. Most pikes have insatiable appetites and will swallow fish their own size. Adults are predatory and normally lie more or less motionless among or near vegetation. Four species are found in North America; the only one not present in Connecticut is the muskellunge. Hybridization between the redfin and chain pickerels is common (BFG, unpublished data).

Key to the species of pikes found in Connecticut

1. Cheeks and opercles fully scaled–2
   Cheeks fully scaled, opercles partly scaled–*Esox lucius*, p. 50
2. Snout length contained less than 2.4 times in head length–*Esox niger*, p. 50
   Snout length contained more than 2.4 times in head length–*Esox americanus*, this page

Esox americanus Gmelin–redfin pickerel–native

This pike is found from Texas through North Dakota and eastward; it has been widely introduced on the West Coast. The triangles plotted are from BFG (1959), MCZ, UCWF, and Webster (1942).

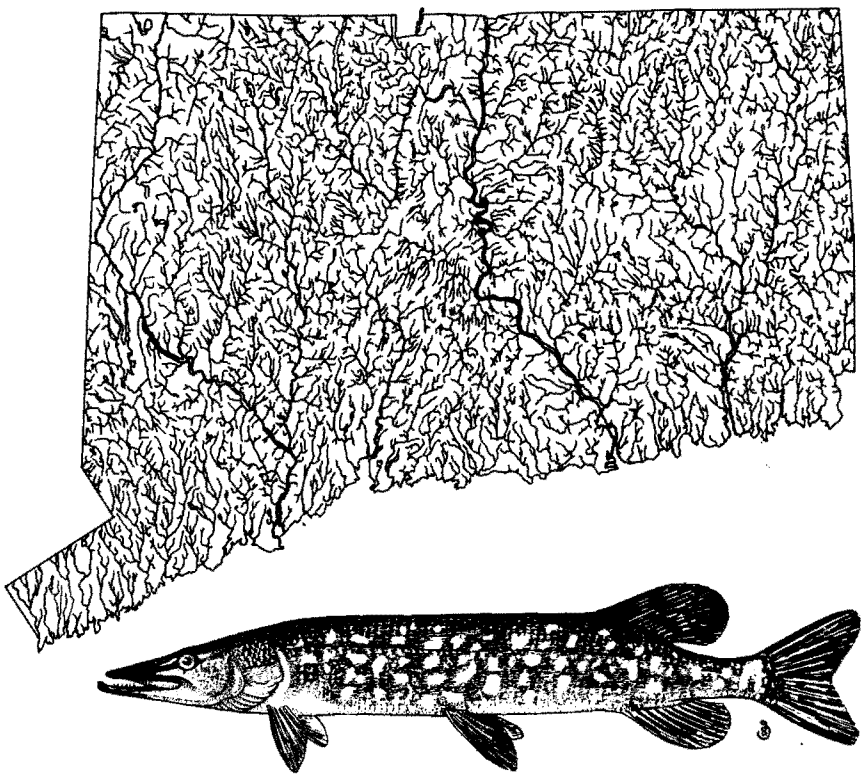


The redfin pickerel is dark green dorsally, grass green laterally, and lighter ventrally; the sides commonly have dark vertical markings (although the color pattern is quite variable); the fins are almost orange in color. There are 11-14 branchiostegals. The species reaches lengths of 1 ft.

This fish is most common in small streams in the lowland areas of the state.

Esox lucius Linnaeus—northern pike—introduced

Northern pike are found throughout much of northern North America; they have been widely stocked south of this range. The triangle plotted is from UCWF.

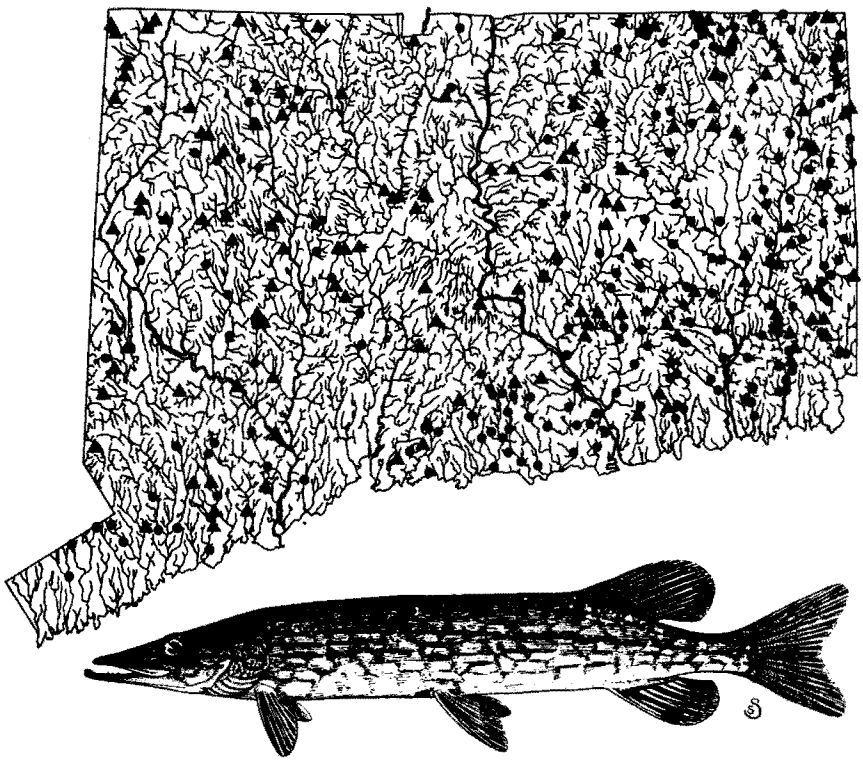


This species is dark green dorsally, grass green laterally, and lighter ventrally; the color pattern on the sides is commonly pale oval spots; fins are commonly yellowish. There are 14-16 branchiostegals. Northern pike reach lengths up to 3 ft.

Although this species has been widely stocked in Connecticut, is seems to be confined generally to the Connecticut River.

Esox niger LeSueur—chain pickerel—native

The chain pickerel is found in eastern and southern North America from Texas to New Brunswick; it has been introduced successfully outside this range.



This species is dark green dorsally, grass green laterally, and lighter ventrally; adults have chainlike markings on their sides; the fins are colorless. There are 14-16 branchiostegals. Individuals reach a length of 2 ft.

Family Cyprinidae: minnows

About 2,000 species are found in the freshwaters of the world. This large and diverse group of fishes is important as food for other fishes and for people in many parts of the world.

A characteristic which identifies members of this group is the number of pharyngeal teeth. Although this characteristic need not be used to identify the particular minnows found in Connecticut, instructions for its use follow. The location of the pharyngeal arch is shown in figure 25. It can be removed by holding the specimen in one hand while the thumbnail holds the operculum and gill arches forward. Using the other hand, remove the arch with a pair of fine forceps, after cutting the fleshy tendons from the posterior edge of the arch. Place the arch in Chlorox for 3-5 minutes to facilitate removal of the flesh. If left in the Chlorox too long, the arch may dissolve. Removal and cleaning of the arch is done most efficiently under a dissecting microscope. The first attempt to remove pharyngeal arches should be done on an expendable specimen, preferably a large one. Skill will come with a little practice.

When counting the number of teeth on the arches, look for broken teeth, lest you fail to include them in the count. Teeth are counted on

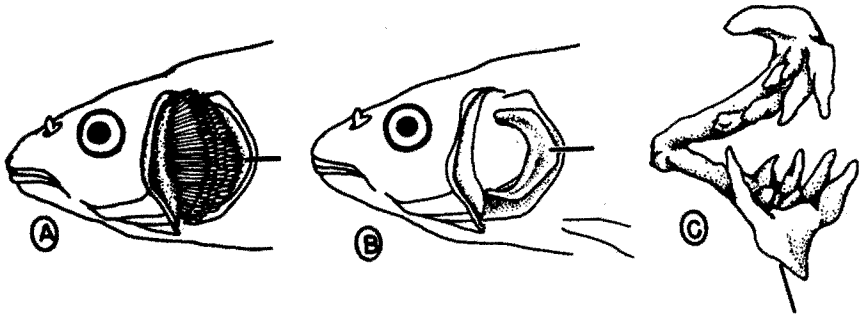


Fig. 25. Location of the pharyngeal bones and teeth of minnows. *A*, External view of head showing location of left pharyngeal bone; *B*, same view with gill arches removed; *C*, left and right pharyngeal bones removed, exposing the pharyngeal teeth.

the left arch first; in figure 25, for example, count the left arch (anterior row to posterior), then the right arch (most posterior to anterior). This count is expressed as 2, 4-4, 2.

Key to species of minnows found in Connecticut

1. Lower lip with cartilaginous edge not covered by skin; intestine long, air bladder encircled many times by the intestine–*Campostoma anomalum*, p. 55

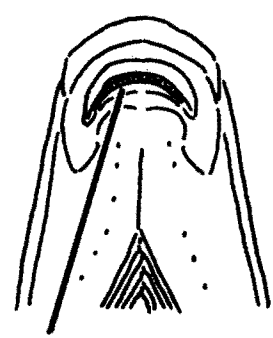


Fig. 26. Ventral view of the head of *Campostoma anomalum*

Lower lip without cartilaginous edge; intestine long or short, but not encircling air bladder–2

2. Lower jaw thickened posteriorly, forming conspicuous lobes–*Exoglossum maxillingua*, p. 58

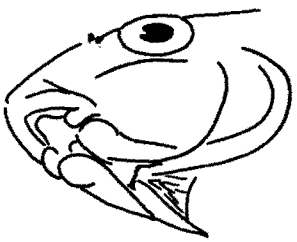


Fig. 27. Head of *Exoglossum maxillingua*

Lower jaw of usual form–3

3. A fleshy and scaleless keel between pelvic fins and anus–*Notemigonus crysoleucas*, p. 60

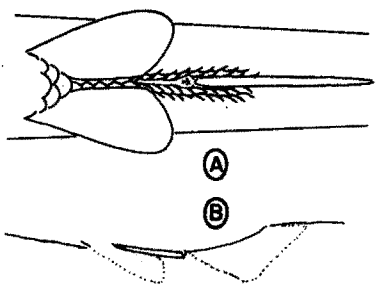


Fig. 28. "Keel" of *Notemigonous crysoleucas*: *A*, ventral; *B*, lateral

No fleshy and scaleless keel between pelvic fins and anus–4

4. Caudal fin forked–5
   Caudal fin not forked–*Tinca tinca*, p. 71
5. More than 15 rays (soft and hard) in the dorsal fin–*Carassius auratus*, p. 56
   Fewer than 15 rays in the dorsal fin–6
6. Barbels present–7
   Barbels absent–12

7. Two barbels on each side of jaw–*Cyprinus carpio*, p. 56

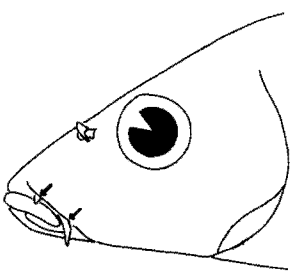


Fig. 29. Barbels of *Cyprinus carpio*

One barbel on each side of jaw–8

8. Barbels not terminal (small and hidden in a groove above upper jaw)—9

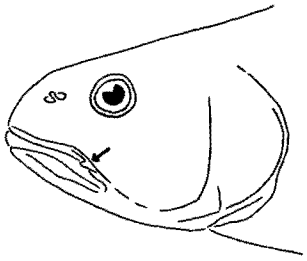


Fig. 30. Barbel of a *Semotilus*

Barbels terminal (at posterior end of maxilla)—11

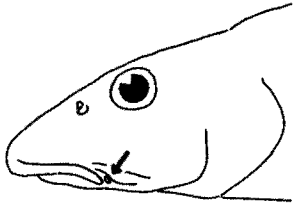


Fig. 31. Barbel of a *Rhinichthys*

9. Black spot at dorsal origin—*Semotilus atromaculatus*, p. 68
   No black spot at dorsal origin—10
10. 43-50 scales in lateral line—*Semotilus corporalis*, p. 69
    52-60 scales in lateral line, irregular-shaped black blotches on sides—*Semotilus margarita*, p. 70

11. Snout projecting little beyond a somewhat oblique mouth—*Rhinichthys atratulus*, p. 66

    Snout projecting well beyond a ventral mouth—*Rhinichthys cataractae*, p. 67

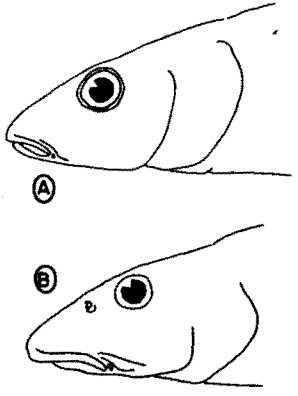


Fig. 32. Head of (A) *Rhinichthys atratulus* and (B) *R. cataractae*

12. More than 10 anal rays—*Leuciscus idus*, p. 59
    Fewer than 10 anal rays—13

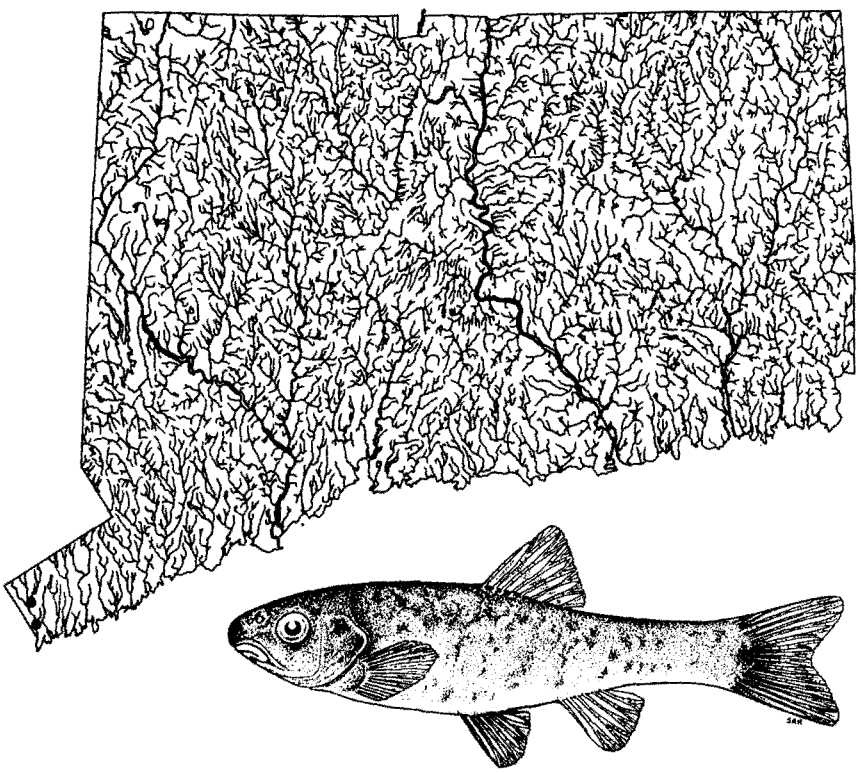
13. 7 anal rays—14
    8-9 anal rays—16

14. More than 40 scales in lateral line—15
    Fewer than 40 scales in lateral line—*Notropis bifrenatus*, p. 61

15. Mouth more ventral (than terminal), lateral line outlined in black—*Pimephales notatus*, p. 64
    Mouth more terminal (than ventral), lateral line not outlined in black—*Pimephales promelas*, p. 65

16. 8 anal rays—*Notropis hudsonius*, p. 63
    9 anal rays—*Notropis cornutus*, p. 62

Campostoma anomalum (Rafinesque)—stoneroller—introduced
This species is found over most of the United States east of the Rockies.



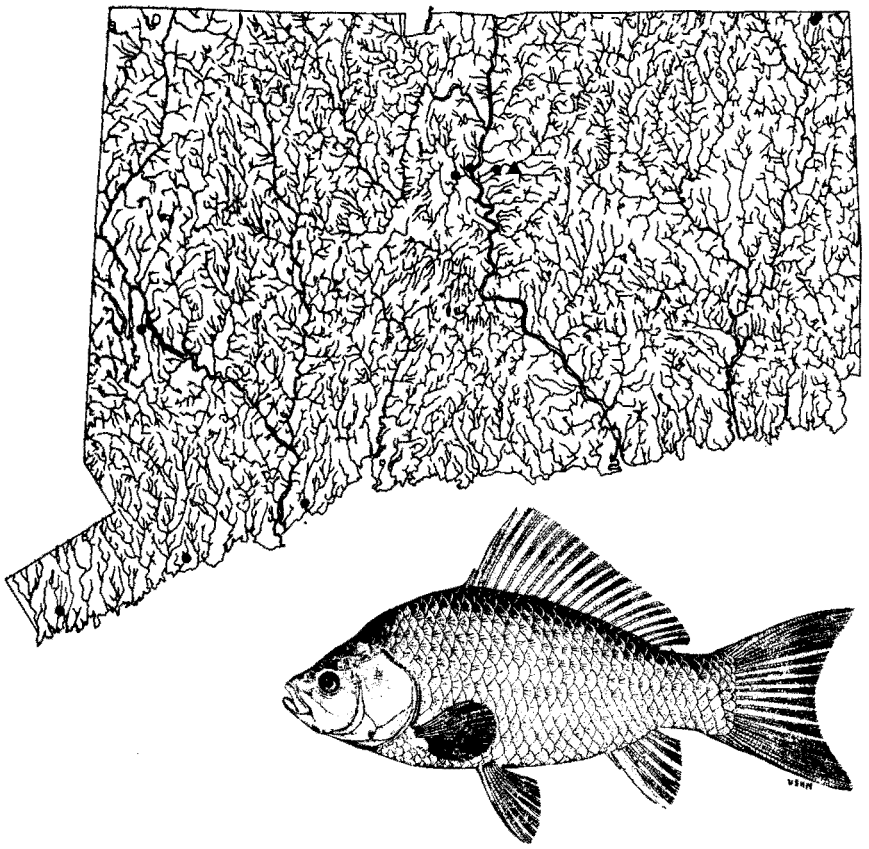
The stoneroller is brownish dorsally, lighter brown laterally, whitish ventrally, with many dark scales over the sides and back in adults; older young are a more or less uniform brown or golden-brown color and very young specimens have a black lateral band; breeding males with nuptial tubercles have much orange and black in their fins. Pharyngeal teeth are

0,4-4,0 or 1,4-4,1; lower lip has a cartilagineous sheath. The species reaches a length of 8 in.

Stonerollers spawn in spring in riffle areas. Their food consists of algae and small invertebrates.

Carassius auratus (Linnaeus)—goldfish—introduced

Numerous strains from a wild species in Asia have been introduced throughout most of North America. The triangle plotted is from BFG (1959).

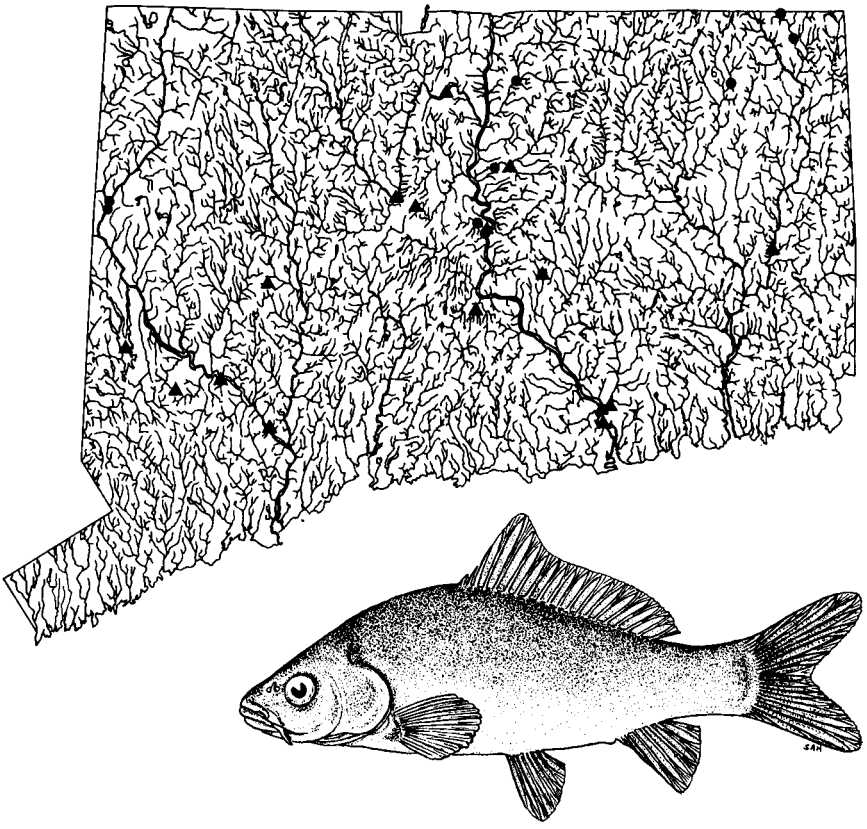


The goldfish is orange, gray, or bronze dorsally, and somewhat lighter laterally and ventrally. Pharyngeal teeth are 0,4-4,0. The first principal ray of both the dorsal and anal fin is hard and serrated on the posterior edge; there are 17-19 dorsal rays and 6-7 anal rays. Lengths of about 1 ft are reached.

This species is found in a wide variety of habitats. Spawning occurs in spring and early summer in shallow water; adhesive eggs are broadcast on vegetation.

Cyprinus carpio Linnaeus—carp—introduced

This Asiatic species has been introduced throughout most of North America. Triangles plotted are from BFG (1959), Webster (1942), BFG



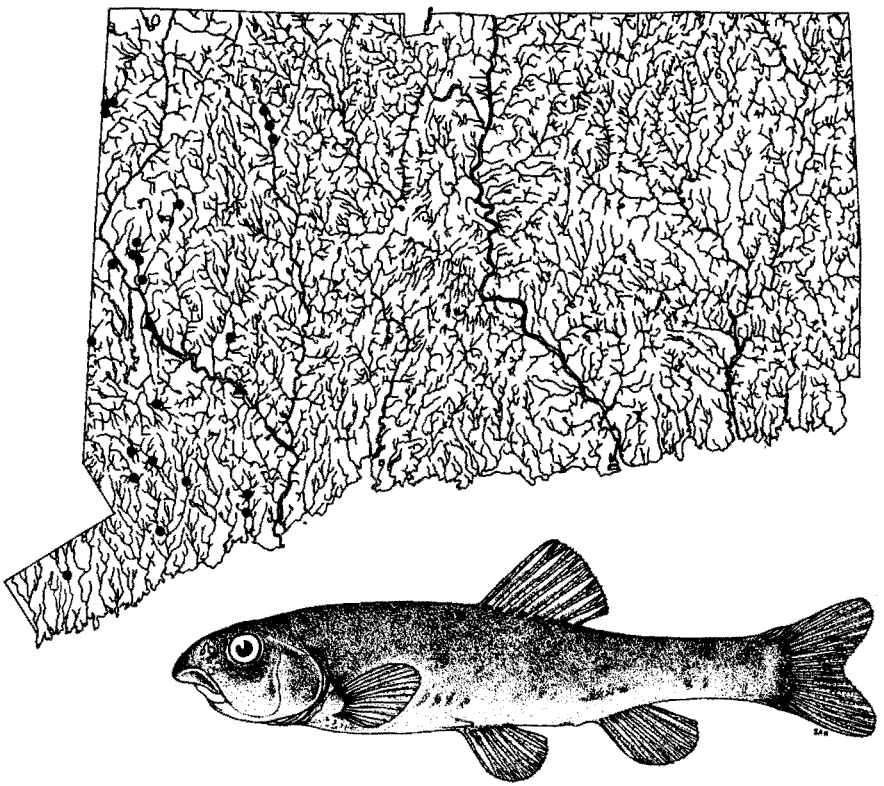
(unpublished), UCML (unpublished), and UCWF. Specimens have been found in brackish waters at Saybrook and in the lower Thames River (BFG, unpublished data).

Carp are grayish bronze dorsally, lighter laterally and ventrally. The mouth has two pairs of barbels. Carp are generally completely scaled. Some individuals are completely scaleless or partly so and are called "mirror" or "leather" carp. Lengths up to 4 ft are reached.

Waters of low gradient are preferred habitats. Spawning occurs in spring and eggs are broadcast over vegetation in shallow water. Carp consume a wide variety of plant and animal materials.

Exoglossum maxillingua (LeSueur)—cutlips minnow—native

The cutlips minnow is found east of the Appalachians and in the Lake Champlain and eastern Lake Ontario watersheds from the St. Lawrence River south to Virginia. Triangles plotted are from Webster (1942), and BOL.

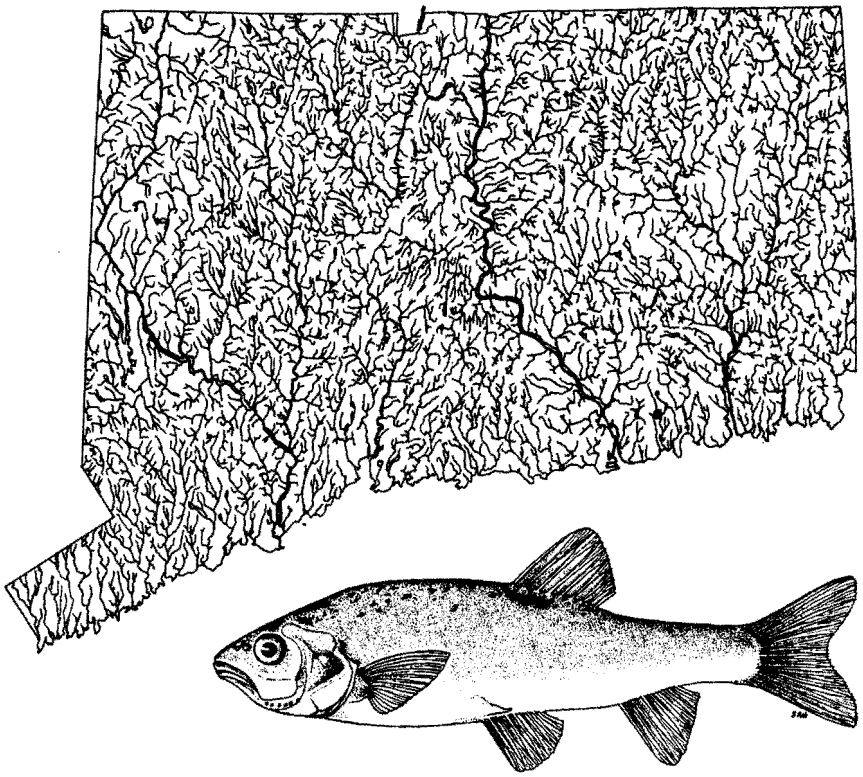


This species is brownish grayish dorsally, lighter laterally, and whitish ventrally; sides of the young have a dark lateral band with a caudal spot commonly present. Lower lips are trilobed. Lengths of 8 in. are reached.

Cutlips minnows are usually found in small streams in the western part of the state. They spawn in spring and feed on invertebrates and algae.

Leuciscus idus (Linnaeus)—golden orfe—introduced

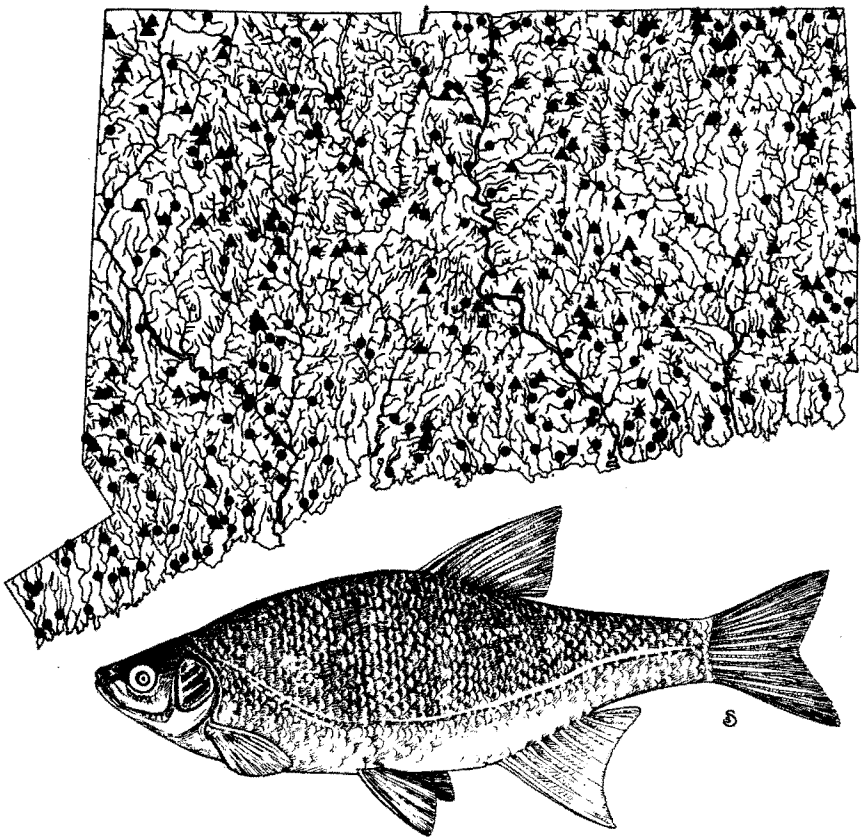
The golden orfe of Europe and western Siberia has been introduced in some areas of the United States but apparently has not become firmly established. One small pond in Connecticut has maintained a population since 1962 or 1963.



This species is golden dorsally, lighter and somewhat silvery laterally, white ventrally; all fins are reddish. Pharyngeal teeth are 3,5-5,3. There are 53-56 scales in the lateral line, 12-13 anal rays, and 9-10 dorsal rays. The species reaches lengths up to 1 ft.

Notemigonus crysoleucas (Mitchill)—golden shiner—native

The golden shiner occurs over most of North America east of the Rockies and has been introduced west of the Rockies. Triangles plotted are from BFG (1959), Webster (1942), and UCWF.

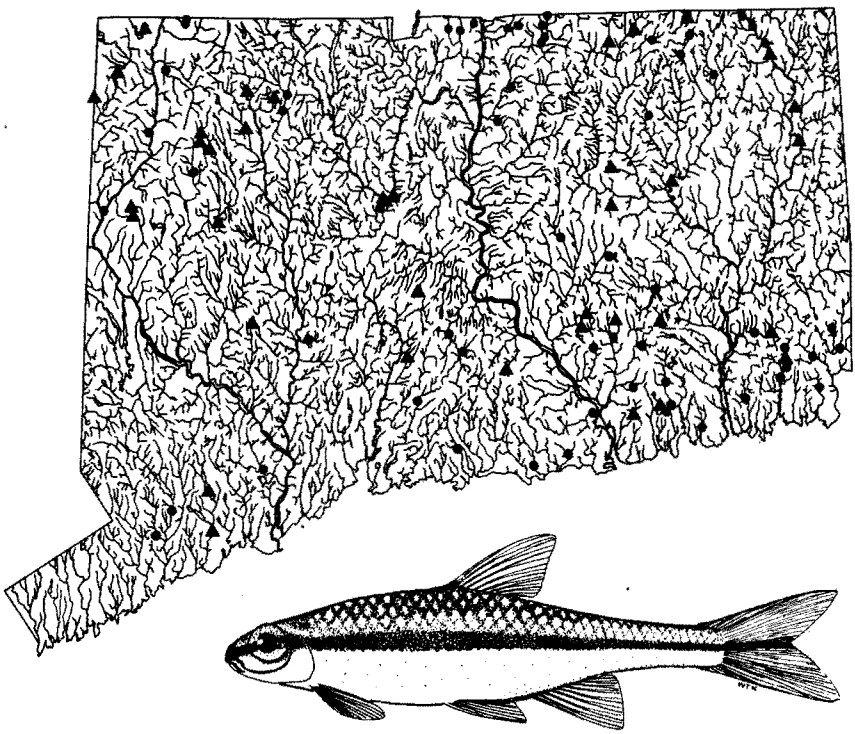


This species is a silvery, brassy, or dark brassy color dorsally and laterally; somewhat lighter gold or silver ventrally; the sides of some specimens have a dark lateral band. A thin fleshy keel lies between the pelvic fins and the anus along the midventral line of the abdomen. Lengths of 1 ft are reached.

Golden shiners are found in a wide variety of habitats. They broadcast their eggs over vegetation in late spring and summer. Their food consists of small invertebrates and algae.

Notropis bifrenatus (Cope)—bridled shiner—native

The bridled shiner is found from Maine to Virginia east of the Appalachians and west through the drainages of Lake Champlain and Lake Ontario. Triangles plotted are from BFG (1959), Webster (1942), BFG (unpublished), and UCWF.

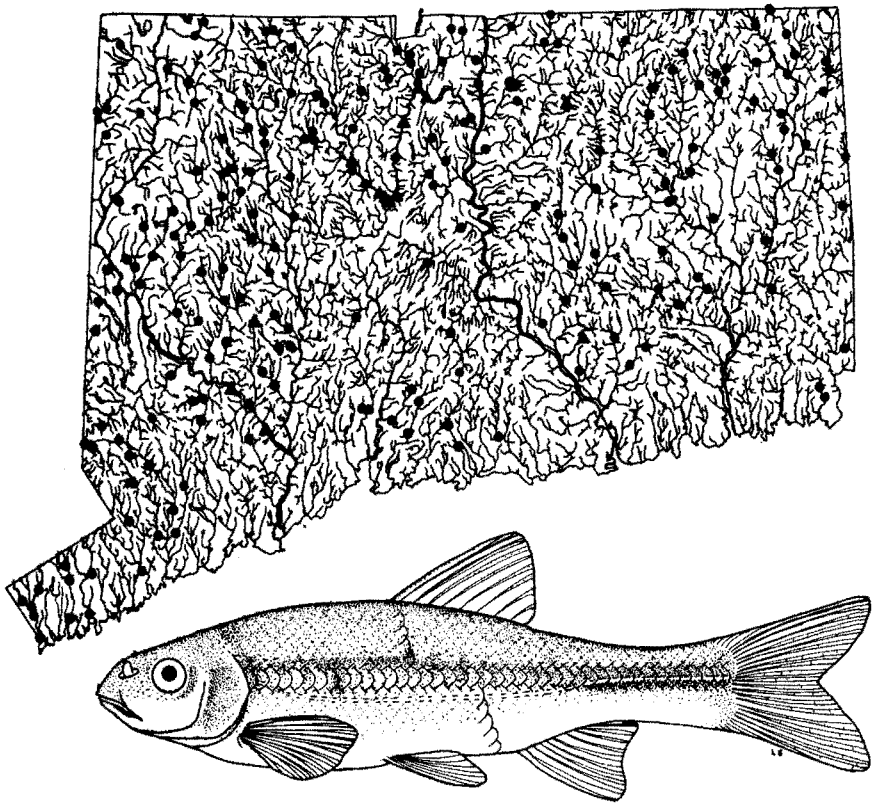


This shiner is straw colored dorsally and laterally to the black lateral band, yellowish silvery below the lateral band, and white ventrally; breeding males are bright yellow below the lateral band. Pharyngeal teeth are 0,4-4,0. Lengths up to 2 in. are attained.

Standing and flowing waters with sand and gravel bottoms and vegetation are the preferred habitat; spawning takes place in spring. Food consists of small plant and animal matter.

Notropis cornutus (Mitchill)—common shiner—native

This species is distributed throughout much of North America east of the Rockies. Triangles plotted are from Webster (1942) and UCWF.

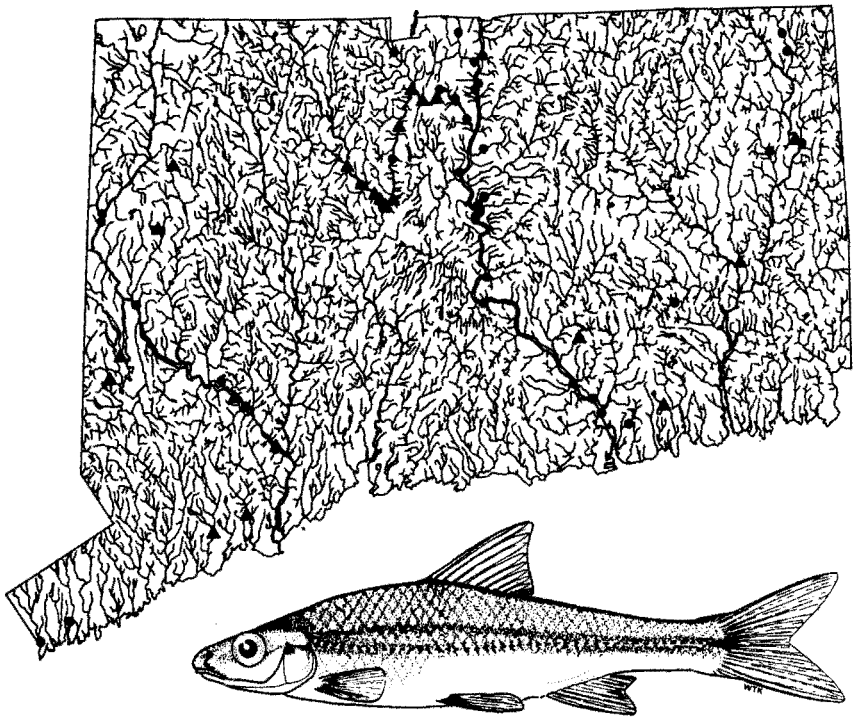


Common shiners are olivaceous dorsally with a dark mid-dorsal stripe, silver laterally, white ventrally; the sides commonly have scattered dark scales. Breeding males have tubercles, red fins, and reddish pigment on their bodies. Pharyngeal teeth are 2,4-4,2. Lengths of 8 in. are reached.

The preferred habitat is over sand and rock or the gravel bottoms of streams. Spawning takes place in spring. Their food consists of invertebrates and algae.

Notropis hudsonius (Clinton)—spottail shiner—native

The spottail shiner is found over much of northern and eastern North America. Triangles plotted are from UCWF, BFG (unpublished), Webster (1942), and BFG (1959).

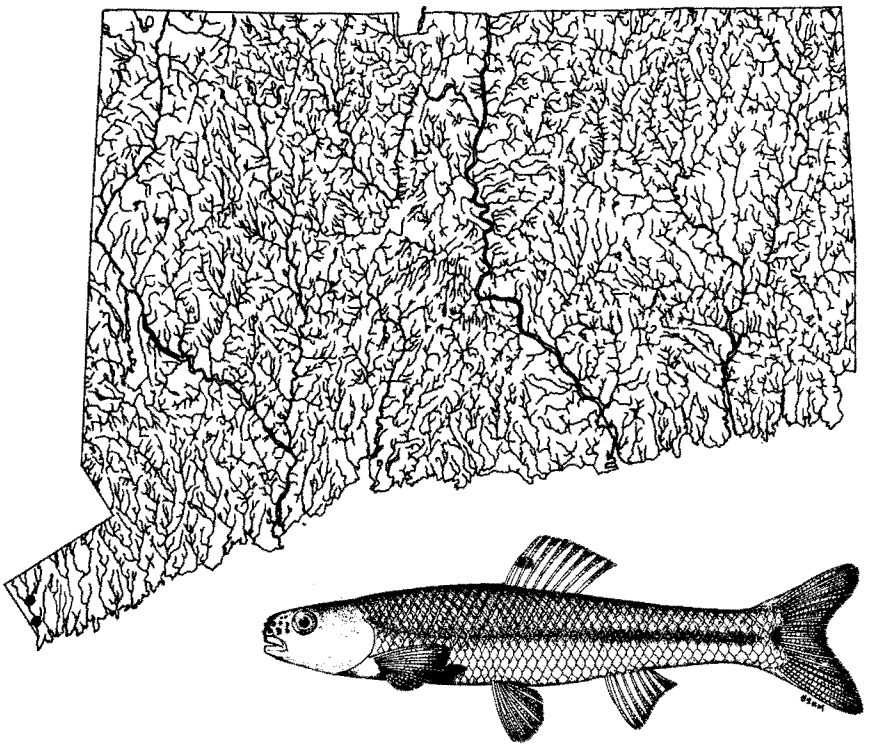


The color pattern is greenish dorsally, silvery laterally, white ventrally; a black caudal spot is commonly present; many preserved specimens have a dark lateral band. Breeding males develop nuptial tubercles but undergo no dramatic changes in coloration. Pharyngeal teeth are 2,4-4,2 or 2,5-5,2. Lengths up to 3 in. are reached.

Larger rivers and impoundments are preferred. This species spawns in early spring. It feeds on small invertebrates and plant materials.

Pimephales notatus (Rafinesque)—bluntnose minnow—native

This species is widely distributed throughout much of eastern North America.

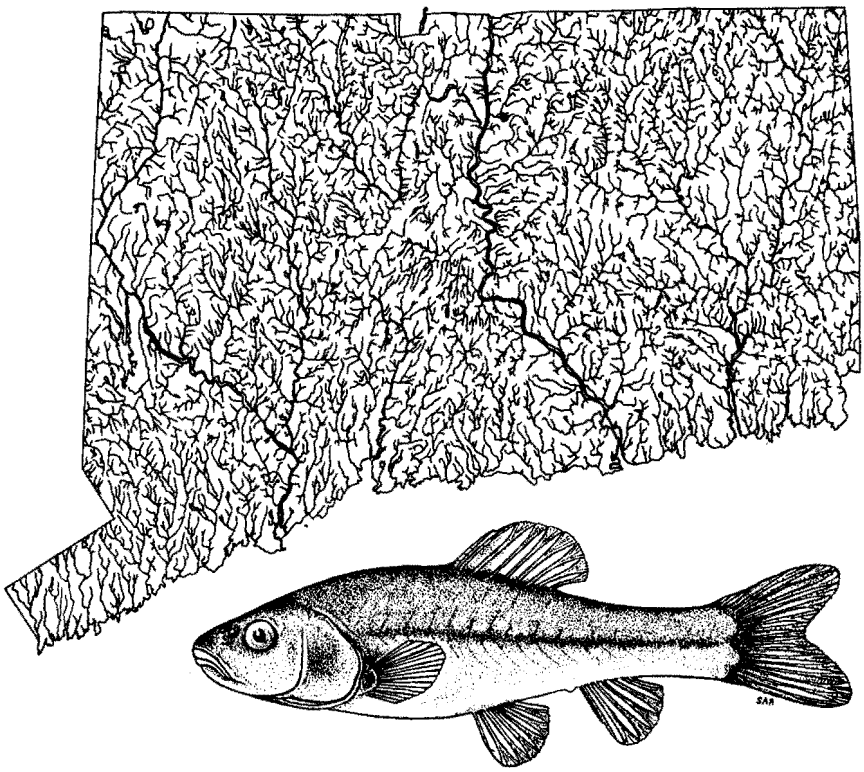


Bluntnose minnows are olivaceous dorsally, lighter laterally, white ventrally; a dark lateral band and caudal spot are usually present. Lengths of 3 in. are reached.

Spawning occurs in spring and the eggs are attached to the undersurface of rocks. The bluntnose minnow eats a wide variety of small plants and animals.

Pimephales promelas Rafinesque—fathead minnow—introduced

The fathead minnow is widely distributed throughout the United States, chiefly as a result of its use as a bait minnow.

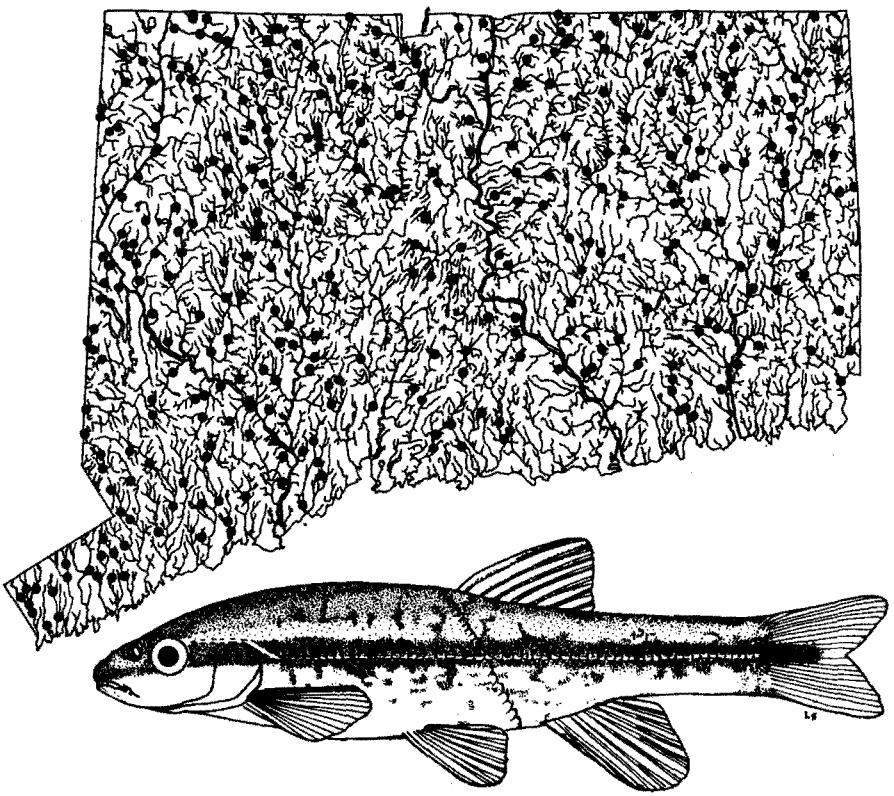


Fathead minnows are dark olivaceous dorsally, lighter laterally, and whitish yellowish ventrally; older fish have a purplish tinge. Breeding males develop nuptial tubercles and have accented coloring. A spongy pad, developed on the nape, is used to clean eggs. Adults reach lengths of 3 in.

This species spawns in spring to early summer and attaches its eggs to the undersurface of a variety of objects. Despite their tolerance of a wide variety of environmental conditions in others parts of their range, they have become established, in this state, only in part of the Connecticut River. Their food consists of a variety of plant and animal materials.

Rhinichthys atratulus (Hermann)—blacknose dace—native

This species is found from the Great Plains to the East Coast in northern North America south to Georgia, Alabama, and Mississippi. Triangles plotted are from Thorpe (1942) and UCWF.

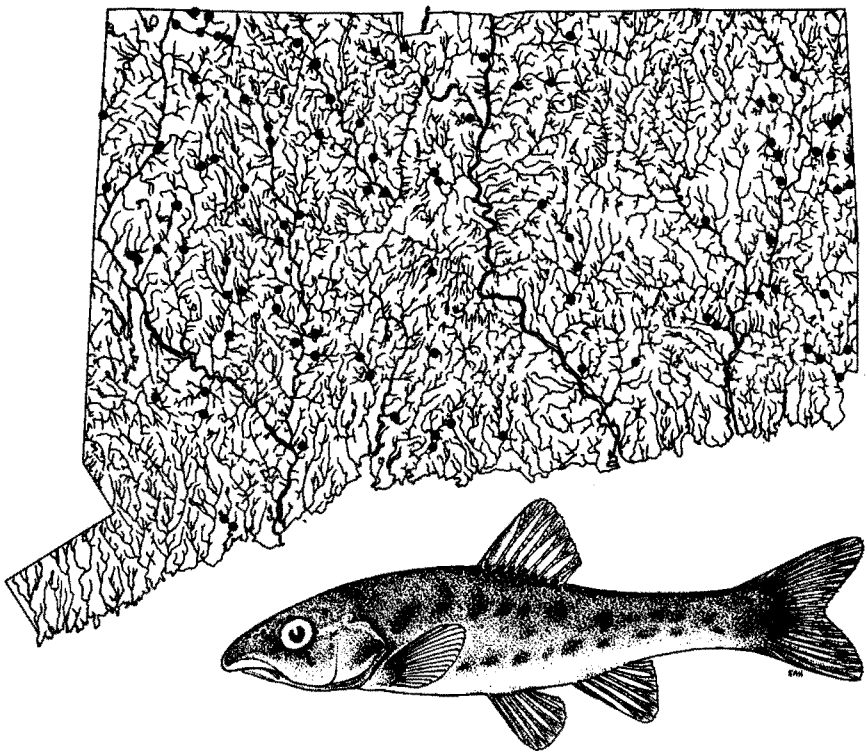


The blacknose dace is olivaceous dorsally, lighter laterally, whitish ventrally; its sides have a dark lateral band extending around the snout; dark scales are commonly present on sides and back; pelvic and pectoral fins are yellow. During the breeding season, the males develop pads between the rays of their pectoral fins, the lateral band has orange pigment throughout, and the pelvics and pectorals are reddish orange. There are 50-65 scales in the lateral line (common range, 54-60), and 32-43 predorsal scales (common range, 34-40). Adults reach lengths up to 3 in.

Blacknose dace are found in a wide variety of habitats but prefer riffle areas, where they spawn in early spring. They feed on algae and small invertebrates.

Rhinichthys cataractae (Valenciennes)—longnose dace—native

The longnose dace is found from coast to coast in northern North America, south along the Rockies and Appalachians. The triangle plotted is from UCWF.

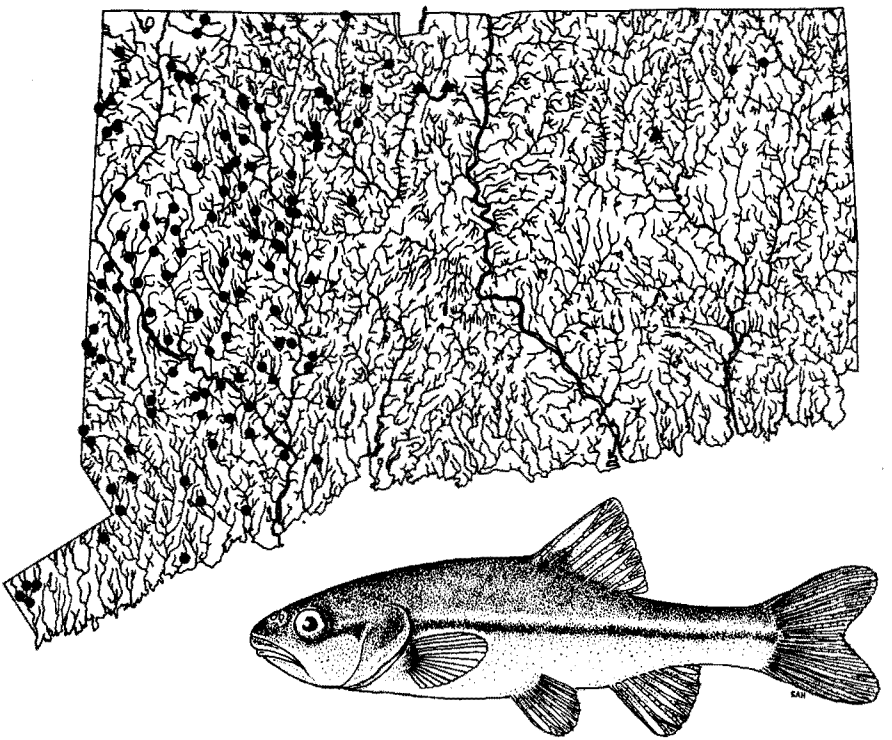


This species is olivaceous dorsally, lighter laterally, white ventrally; a dusky lateral band is commonly present but indistinct in some specimens; sides are commonly mottled; breeding males have reddish-orange upper lips. The profile is sharklike in appearance with the snout projecting far beyond the somewhat ventral mouth. There are 50-60 scales in the lateral line (common range, 53-59), and 29-39 predorsal scales (common range, 30-35). Adults reach lengths of 4 in.

Longnose dace prefer riffle areas, where they spawn in early spring. Their food consists of invertebrates and algae.

Semotilus atromaculatus (Mitchill)—creek chub—native

This species is found throughout most of eastern North America east of the Rockies. The triangles plotted are from UCMZ, Webster (1942), BFG (unpublished), and UCWF.

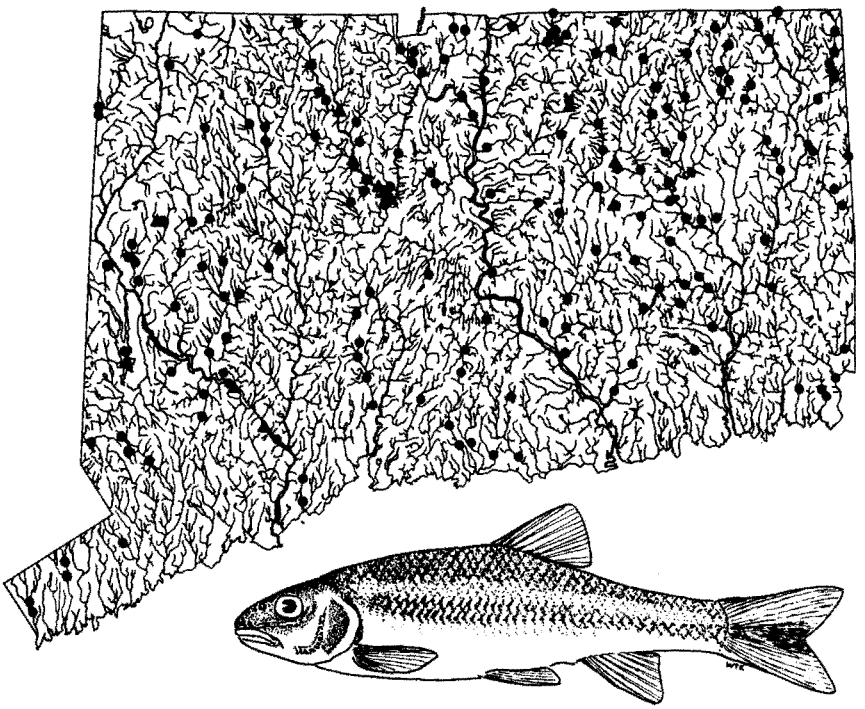


Creek chubs are dark bluish dorsally, lighter laterally, white ventrally, with a dark spot at the base of the anterior dorsal rays; there is a faint lavender cast to most of the body. Breeding males show a red color in the pelvic and anal fins and along the sides. Predorsal scales are small and crowded. Pharyngeal teeth are variable: 2,5-4,2; 2,4-4,2; 2,1,5-5,1,2 (2,6-6,2); 2,6-4,2; or 2,1,5-4,2. There are 53-58 scales in the lateral line, 10-13 scales above the lateral line, 6-10 scales below the lateral line, 33-37 predorsal scales and 28-32 scales in 4th scale row below the predorsal scale row. The dorsal origin is invariably behind the pelvic insertion. Adults reach lengths up to 6 in.

The creek chub spawns in spring in gravel areas at the base of pools or head of riffles. Males build and guard the nests. Their food consists of a variety of plant and small animal materials.

Semotilus corporalis (Mitchill)–fallfish–native

The fallfish is found in the St. Lawrence and Lake Ontario drainages, and from there south and east of the Appalachians to Virginia. The triangles plotted are from UCWF, Webster (1942), and BFG (1959).

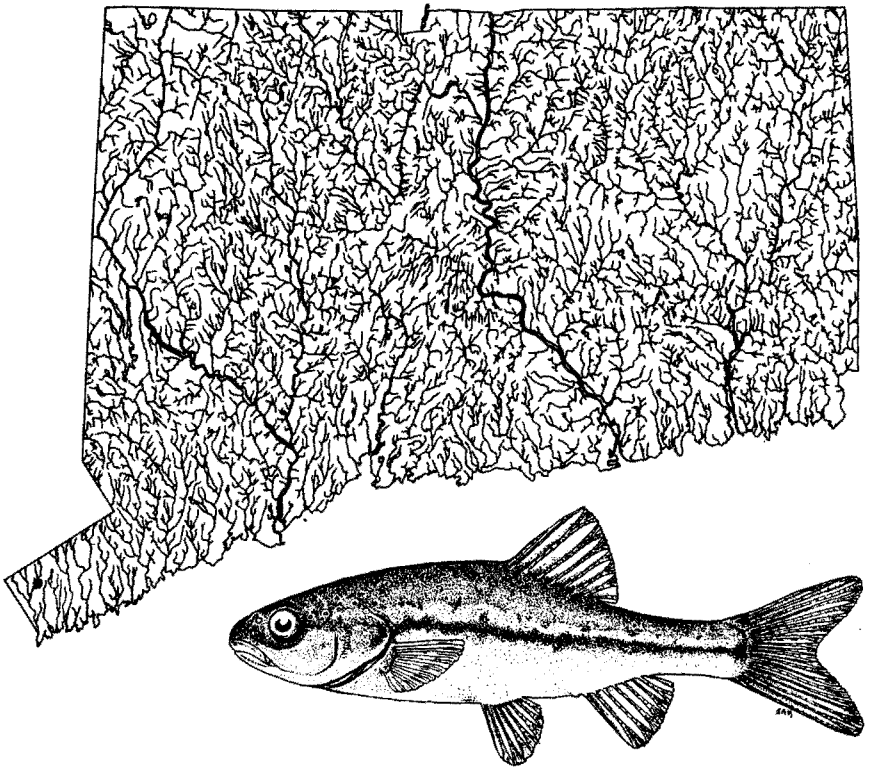


This species is silvery bronze dorsally, silvery laterally, white ventrally, and a dark lateral band may be present. There are 43-50 scales in the lateral line, 9-10 scales above the lateral line, 6-8 scales below the lateral line, 20-28 predorsal scales, and 17-24 scales in 4th scale row below the predorsal scale row. The dorsal origin is behind the pelvic insertion, occasionally directly over it. Pharyngeal teeth are variable: 2,5-4,2; 2,4-4,2; or 2,1,5-5,2 (2,6-5,2). Adults reach lengths up to 18 in.

Streams and lakes are the preferred habitats. Fallfish spawn in spring and males build the nests, which consist of a cone-shaped pile of pebbles, in pools or in lakes. A variety of plant and animal materials is consumed.

Semotilus margarita (Cope)—pearl dace—native

Pearl dace are found throughout much of Canada and the northern Great Lakes region and south on the Atlantic coast to Virginia.

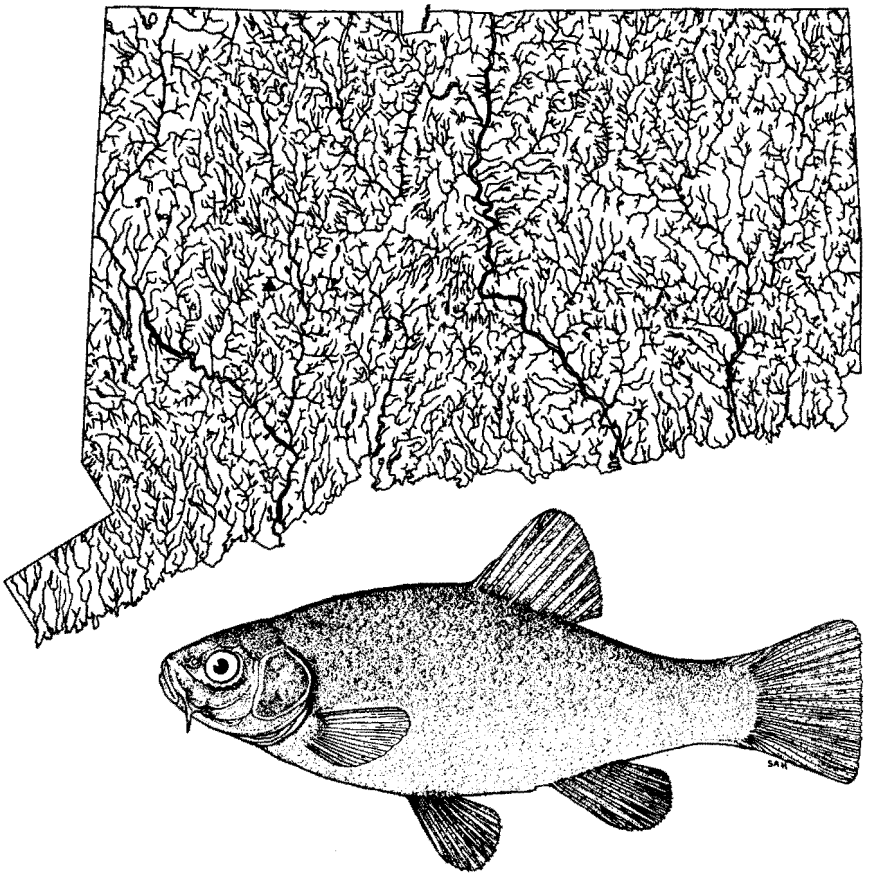


The pearl dace is olivaceous dorsally, lighter laterally, and white ventrally; the sides have small, dark, irregular blotches. The dorsal origin is behind the pelvic insertion. There are 52-57 scales in the lateral line, 11 scales above the lateral line, and 7 scales below it. Pharyngeal teeth are 2,5-4,2. Adults reach lengths up to 5 in.

This dace prefers clear, cold water and is commonly associated with trout. Spawning takes place in spring; males defend a territory but do not build nests. The food of this species consists of algae and small invertebrates.

Tinca tinca (Linnaeus)—tench—introduced

The tench, native to Europe, has been introduced into some parts of the United States with limited success—it has been established in one pond in Connecticut. The triangle plotted is from Webster (1942) and UCMZ.



This species is dark olive dorsally, slightly lighter laterally, and yellowish ventrally. It reaches lengths up to 2.5 ft.

Tench spawn in spring. They feed on a wide variety of plant and animal materials.

Family Catostomidae: suckers

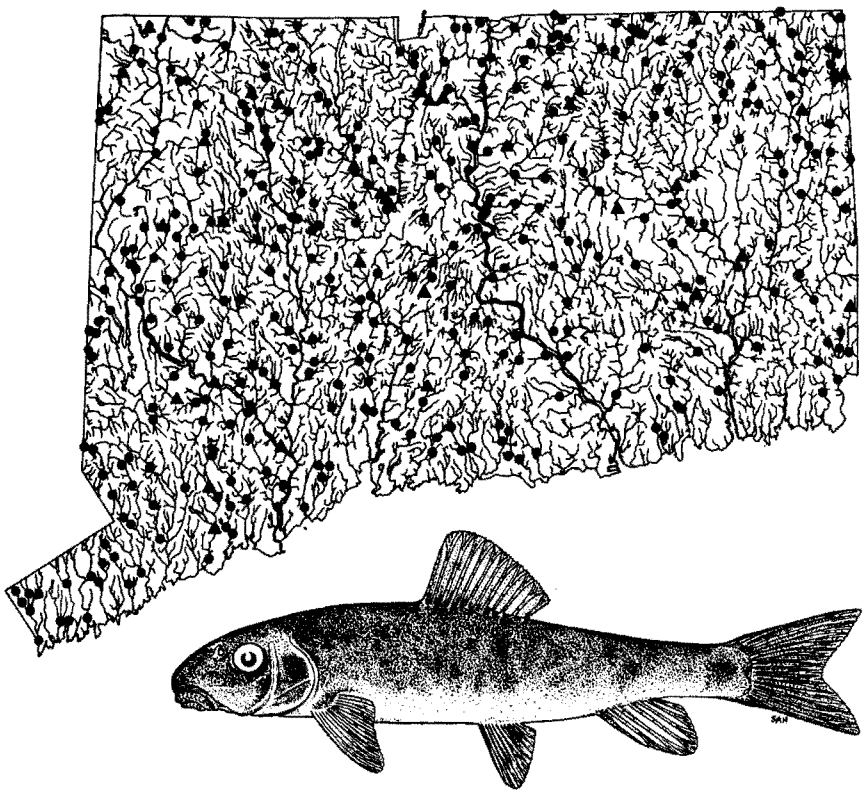
Approximately 65 species are found in freshwaters and occasionally in brackish waters of North and Central America and Asia. Pharyngeal teeth may be inspected using the technique described for minnows. Only one row of teeth is present. Most species of suckers are bottom-dwelling fishes and generally spawn in rivers and streams. They consume a variety of plant and animal materials.

Key to the species of suckers found in Connecticut

1. Lateral line complete–*Catostomus commersoni*, this page
   Lateral line not visible–*Erimyzon oblongus*, p. 73

Catostomus commersoni (Lacépède)–white sucker–native

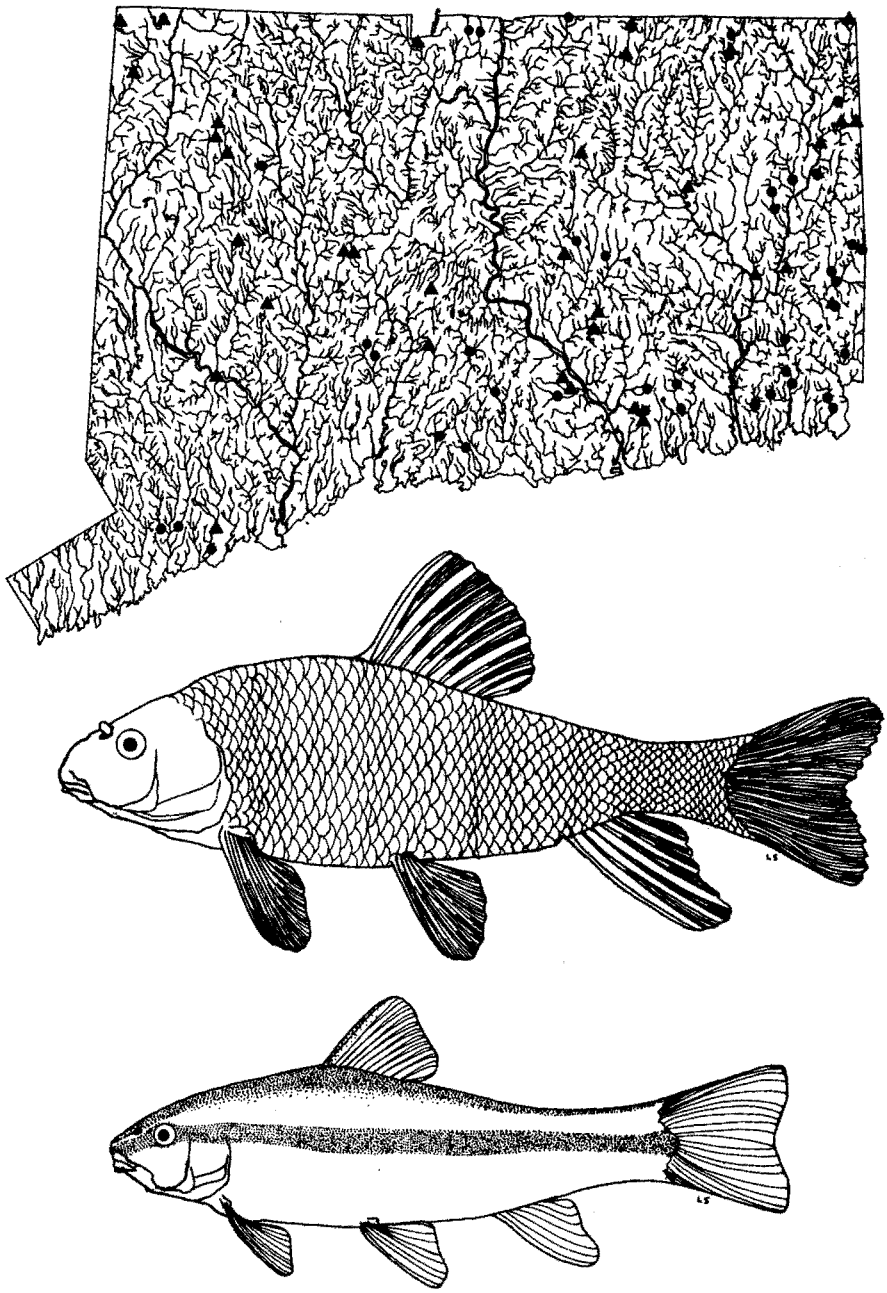
White suckers are found throughout most of North America east of the Rockies. The triangles plotted are from UCWF, Webster (1942), and BFG (1959).



This sucker is olive bronze dorsally and laterally, and light ventrally; young often have a series of 3 dark blotches on the sides. Males develop nuptial tubercles on the lower part of the caudal and all other fins, and on body scales. A dusky red band along the sides of males turns brilliant scarlet during the spawning act. Adults reach lengths up to 18 in.

White suckers spawn in early spring and move upstream in large numbers to spawn throughout the day and night in riffles. There is no nest preparation or care of eggs and young. After spawning adults move back into the deeper waters of lakes and rivers, while young prefer muddy shallows. The food of this species consists of a wide variety of plant and animal materials.

Erimyzon oblongus (Mitchill)—creek chubsucker—native



IMMATURE

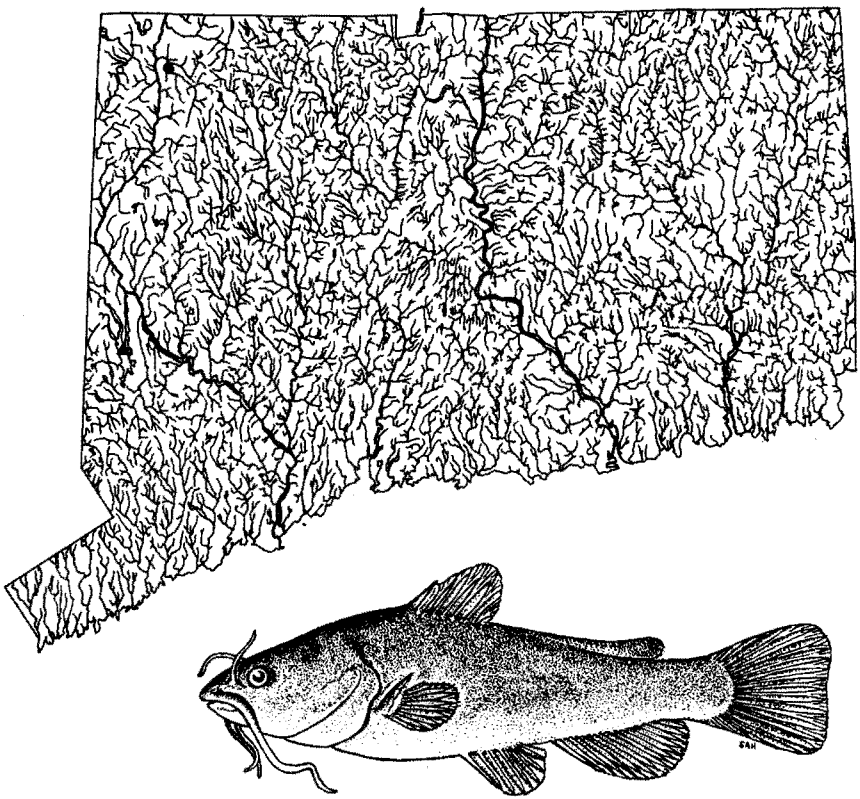
The white catfish is found in freshwaters and brackish coastal streams from New York to the Gulf of Mexico and has been introduced outside this range with some success. The triangles plotted are from BFG (1959) and BFG (unpublished).

This species is dark gray blue dorsally, lighter and somewhat mottled laterally, and whitish ventrally. Lengths of 2 ft are reached.

This catfish migrates up and down rivers for no apparent reason. The white-catfish population in the Connecticut River has increased steadily in the last few years, whereas the channel-catfish and brown-bullhead populations have declined. Spawning takes place in early summer. White catfish consume a wide variety of plant and animal materials.

Ictalurus melas (Rafinesque)—black bullhead—introduced

The black bullhead is found from the Rockies to the Appalachians, and has been widely introduced on both the East and West coasts. The triangle plotted is from BFG (unpublished).

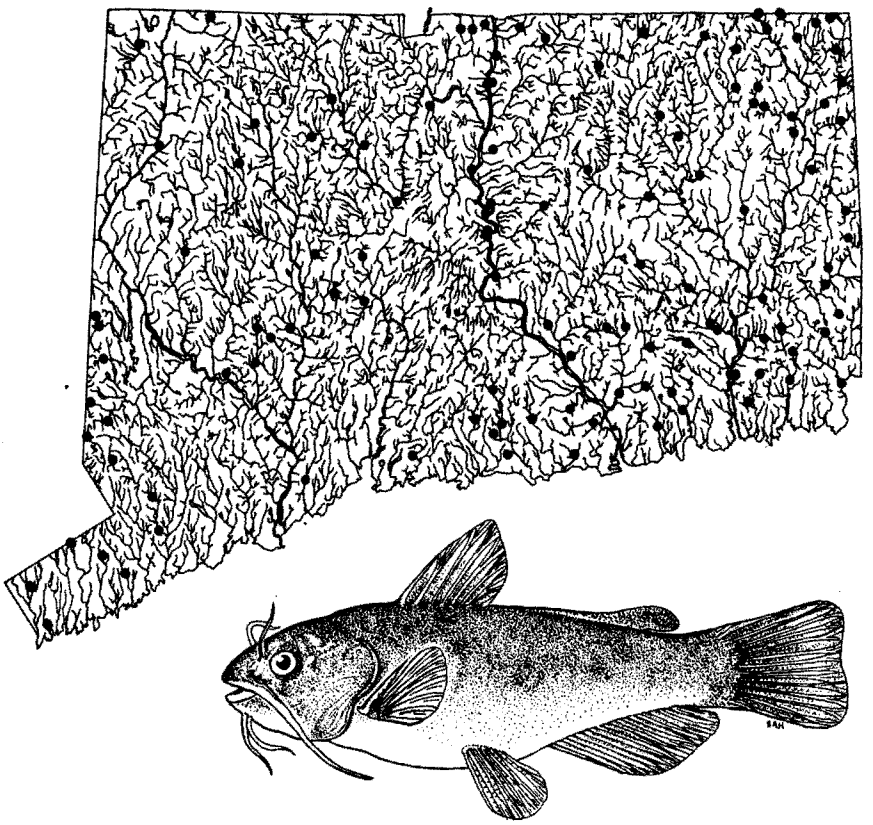


This species is brownish black dorsally, lighter laterally, and yellowish white ventrally. There are 16-22 anal rays; the posterior edges of the pectoral spines are without strong serrae; chin barbels are gray or black, at least at the bases. Lengths of 16 in. are reached by this species.

This bullhead is usually found in low-gradient streams and impoundments. Spawning occurs in spring and nests are constructed, beneath vegetation or debris, by cleaning the sediment from a small area. Eggs are laid in masses; an adult guards the eggs, fanning them occasionally. After the young hatch they remain in large compact schools for several days, guarded by one or both adults. This species consumes a wide variety of plant and animal materials.

Ictalurus nebulosus (LeSueur)—brown bullhead—native

Brown bullheads are found from the Mississippi River eastward. They have been widely introduced outside this range.

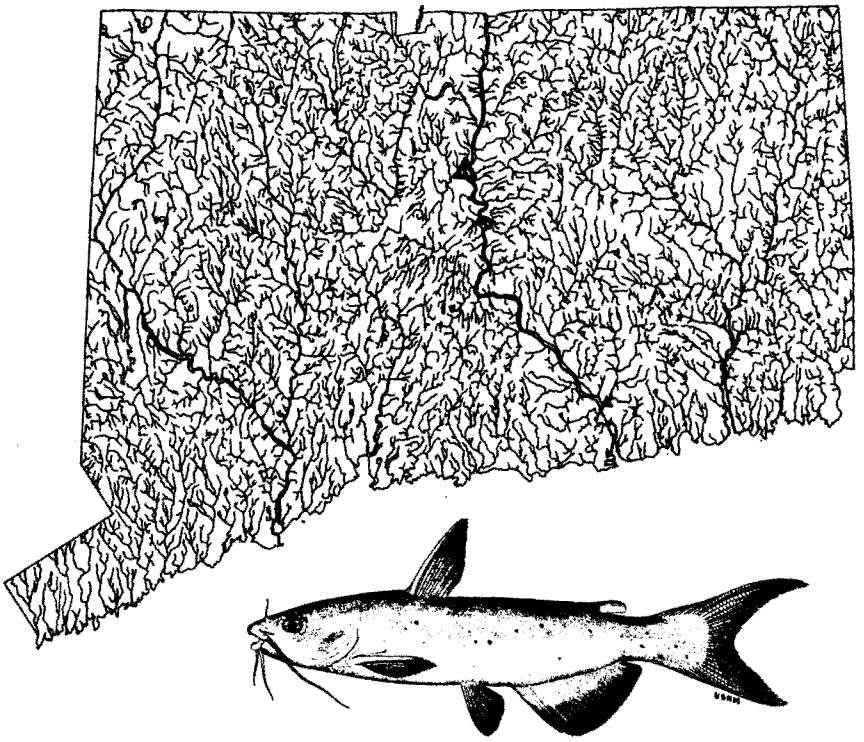


This bullhead is dark brown dorsally, somewhat lighter laterally, and yellowish whitish ventrally. Pectoral spines have strong serrae on the posterior edges. Lengths of 17 in. are reached by this species.

Brown bullheads have habits similar to those of the black bullhead and are found in a wide variety of habitats.

Ictalurus punctatus (Rafinesque)—channel catfish—introduced

This species is found from the Rockies to the Appalachians and has been widely and successfully introduced elsewhere. The triangles plotted are from UCML and UCWF.



This catfish is grayish blue dorsally, lighter laterally, white ventrally; its sides commonly bear scattered blue-black flecks.

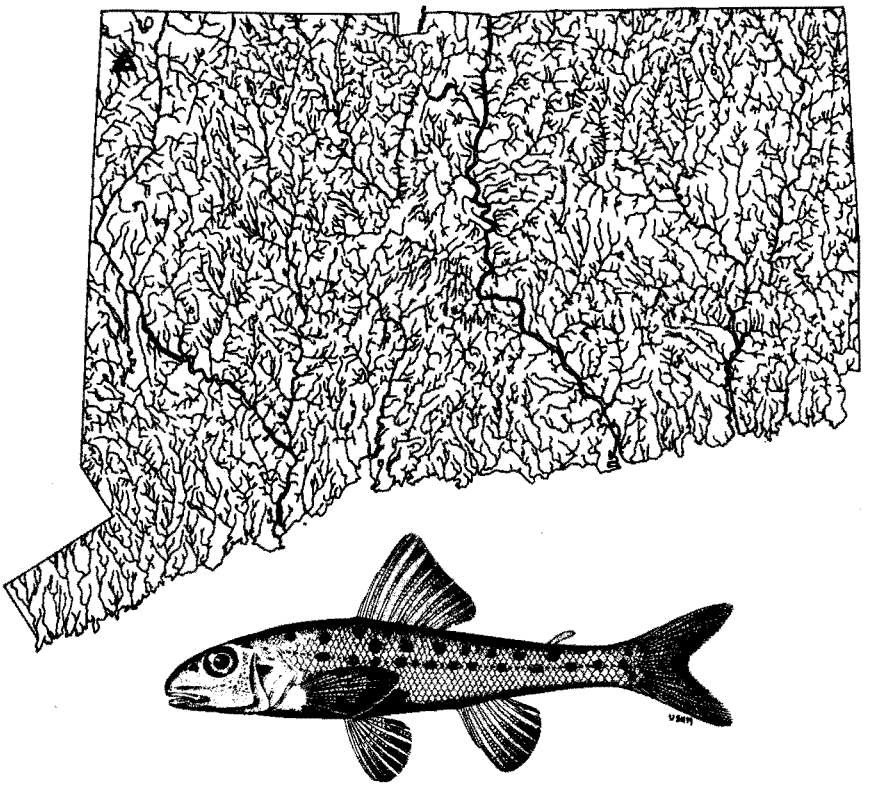
Channel catfish are generally found in lakes, ponds, and slow-moving rivers. They spawn in early spring in sunken hollow logs, muskrat holes, or other depressions in the bank. Their food consists of a wide variety of plant and animal materials, including fish.

Family Percopsidae: trout perches

Two species are found in the freshwaters of northern North America. No specimens of the only species reported from Connecticut have been reported since 1879.

Percopsis omiscomaycus (Walbaum)—trout perch—native

The trout perch is widely scattered in northern United States east of the Rockies and south to Virginia, Kentucky, Missouri, and Kansas. The triangle plotted is from MCZ.



This species is pale dorsally, laterally, and ventrally; faint spots lie above the lateral line as well as a row of spots along the lateral line. An adipose fin is present, the dorsal fin has 2 spines and 9-10 rays, and the anal fin has 1 spine and 6-7 rays. Adults reach lengths up to 6 in.

Trout perch are usually found in lakes, although they inhabit streams in the southern parts of their range. Spawning occurs in spring over shoal areas of lakes and gravel areas of tributary streams. They stay in deep water during the day and move into the shallows at night to feed, mainly on small invertebrates.

Family Gadidae: codfishes and hakes

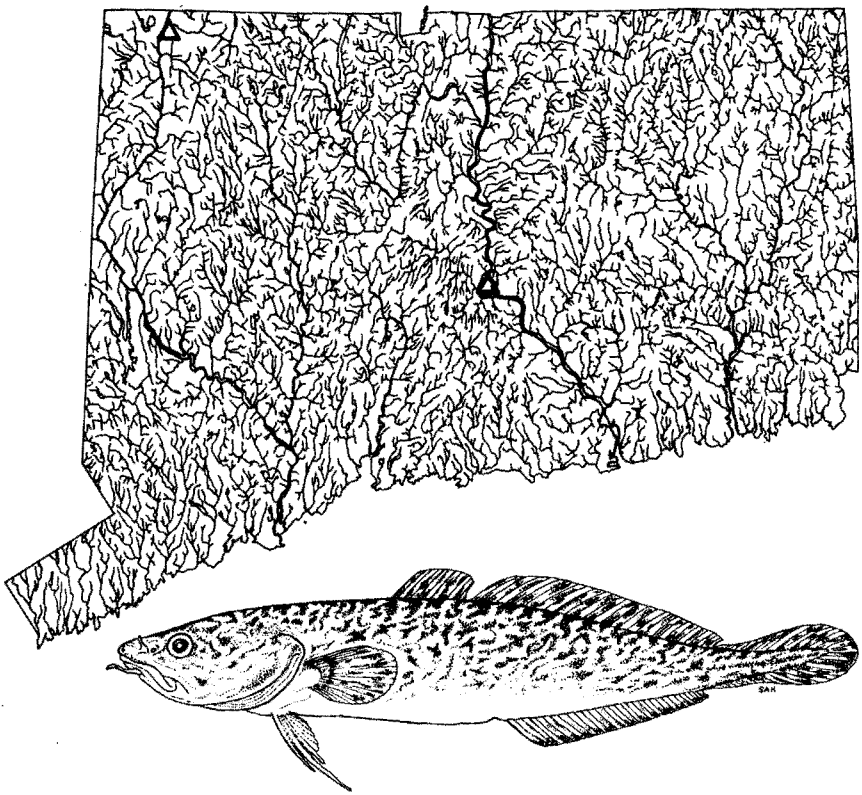
Approximately 140 species are found throughout the world, mainly in the northern seas.

Key to the species of codfishes found in Connecticut

1. 2 dorsal fins and 1 anal fin–*Lota lota,* this page
   3 dorsal fins and 2 anal fins–*Microgadus tomcod,* p. 81

Lota lota (Linnaeus)–burbot–native

The burbot is found in the freshwaters of Europe, northern Asia, and northern North America. Triangles plotted are from Linsley (1844), USNM, and AMNH. One specimen was reported taken near the junction of the Farmington and Connecticut Rivers in 1965 by J. Orintas; the last recorded specimen from Connecticut was captured in 1908.

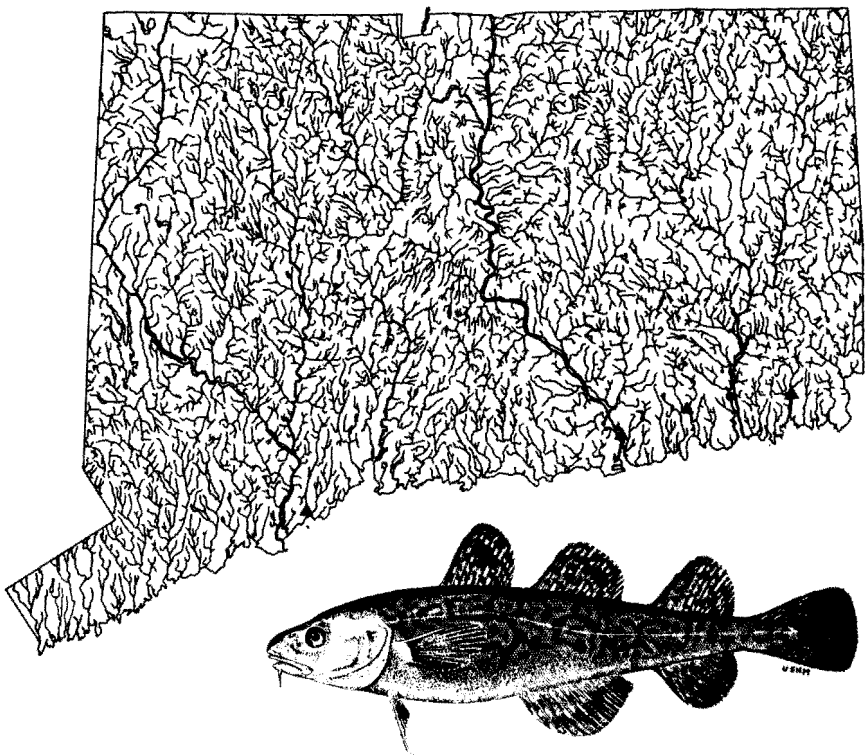


This species is mottled brown dorsally and laterally, and is lighter ventrally. Small embedded scales give the body a naked appearance. Specimens attain lengths up to 3 ft.

Burbots usually inhabit large rivers and lakes and are found at great depths. They spawn from November to March, migrating from small streams and lakes to large rivers. Their food consists mainly of fish.

Microgadus tomcod (Walbaum)—Atlantic tomcod—visitor from saltwater

This codfish is found along the Atlantic coast from Newfoundland to Virginia, occasionally entering freshwaters. Triangles plotted are from Booth (1967), UCML, and observations by P. Berrien.



The Atlantic tomcod is olivaceous dorsally, lighter laterally, yellowish ventrally, its sides are mottled with irregular blotches and markings. The species reaches lengths up to 1.5 ft.

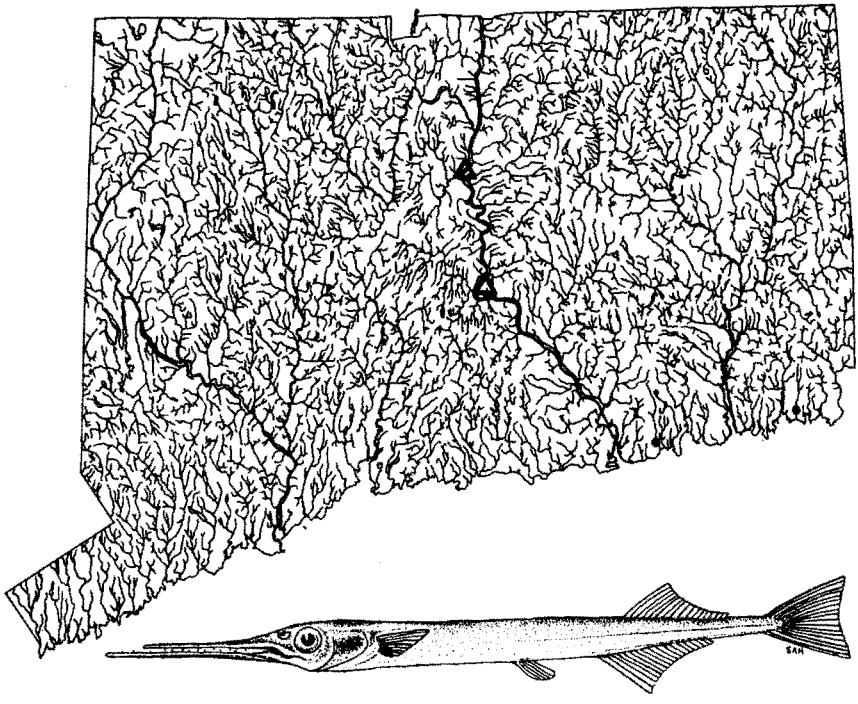
Bigelow and Schroeder (1953) and Booth (1967) believe it possible that they run into freshwater in winter while spawning in the estuaries.

Family Belonidae: needlefishes

Approximately 50 species are found in the warm and temperate seas of the world. One species enters the freshwaters of Connecticut.

Strongylura marina (Walbaum)—Atlantic needlefish—visitor from saltwater

This needlefish is found in shallow brackish waters, in saltwaters, and occasionally in coastal freshwaters from Maine to Brazil. The triangles plotted are from Ayres (1842-43) and USNM. Linsley (1844) reported the taking of Atlantic needlefish north of Hartford.



The Atlantic needlefish is greenish dorsally, silvery laterally, and white ventrally; there are 13-17 dorsal-fin rays and 17-21 anal-fin rays. Specimens reach 4 ft in length.

Family Cyprinodontidae: killifishes

Approximately 200 species are found in the freshwaters, brackish waters, and saltwaters of the tropical and warm-temperate regions of the world.

Key to the species of killifishes found in Connecticut

1. More than 30 scales in a series along the side—2
   Fewer than 30 scales in a series along the side—4
2. More than 40 scales in lateral series—*Fundulus diaphanus*, p. 85
   Fewer than 40 scales in lateral series—3
3. Head length contained more than 3.5 times in standard length—*Fundulus heteroclitus*, p. 86
   Head length contained less than 3.5 times in standard length—*Fundulus majalis*, p. 88
4. Jaw teeth conical—*Lucania parva*, p. 89
   Jaw teeth tricuspid—*Cyprinodon variegatus*, this page

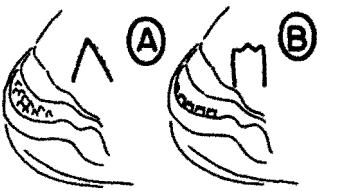
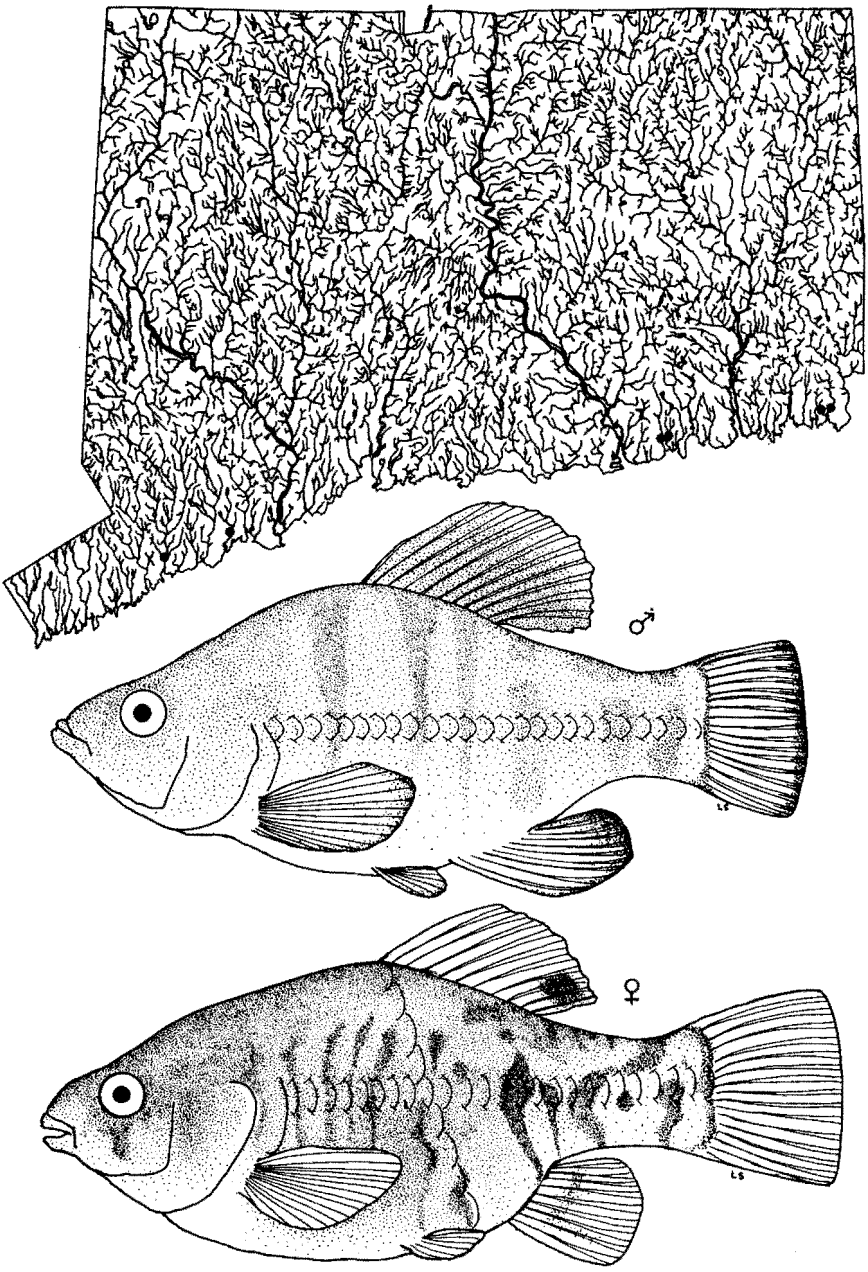


Fig. 35. (A) Conical and (B) tricuspid jaw teeth

Cyprinodon variegatus Lacépède—sheepshead minnow—possible visitor from saltwater

The sheepshead minnow is found in saltwaters, brackish waters, and occasionally in coastal freshwaters from Massachusetts to Mexico.

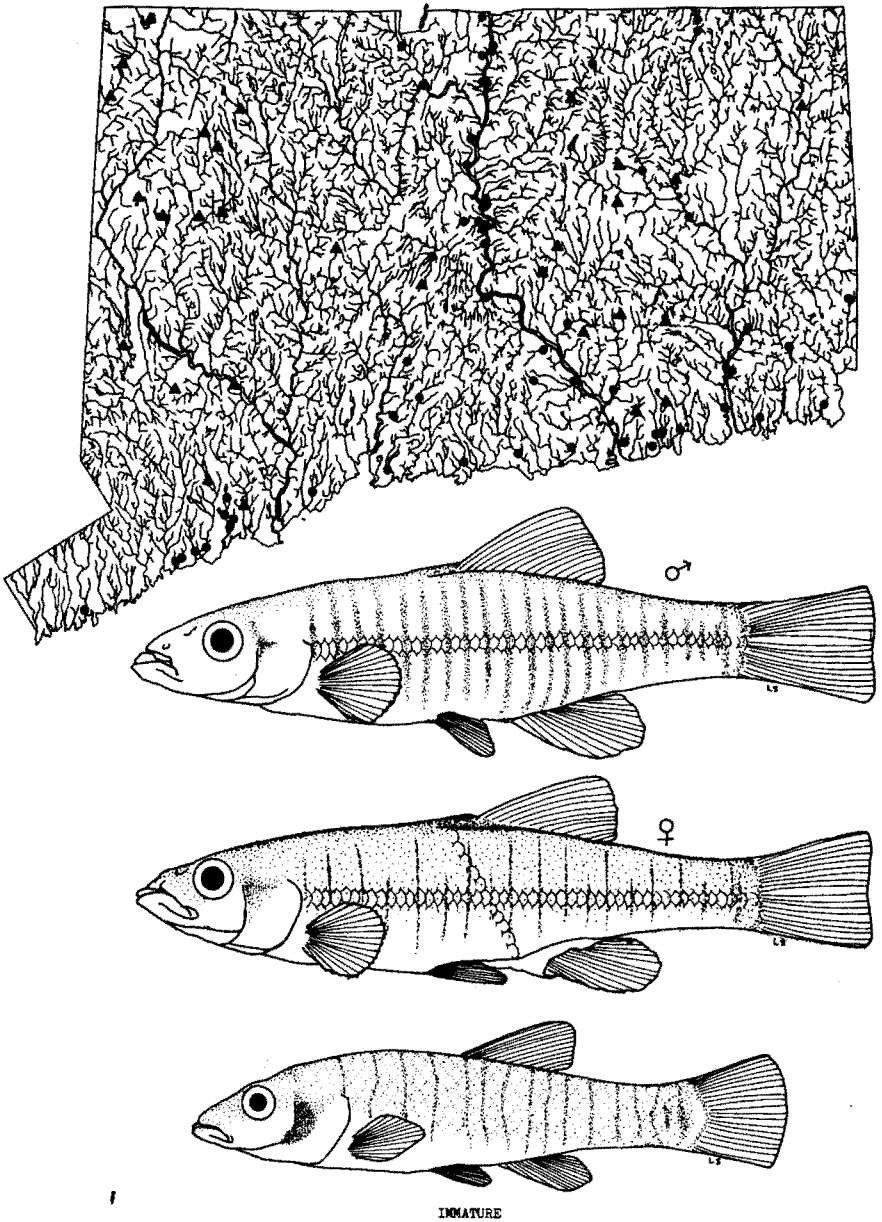
The males are olivaceous dorsally, lighter laterally, and yellowish whitish ventrally; their sides have obscure dark vertical bars. Females are similar except for a dark spot on the posterior interradial membranes of the dorsal fin. Breeding males are bluish green dorsally and on the upper sides, with an orange tinge ventrally and on the lower sides. Individuals reach lengths up to 3 in.



Although no specimens were collected in the freshwaters of Connecticut they have been reported in freshwaters elsewhere.

Fundulus diaphanus (LeSueur)—banded killifish—native

This killifish is widely distributed along the East Coast from Canada to South Carolina and west through the Great Lakes region. The triangles plotted are from BFG (unpublished), UCWF, and Thorpe (1942).



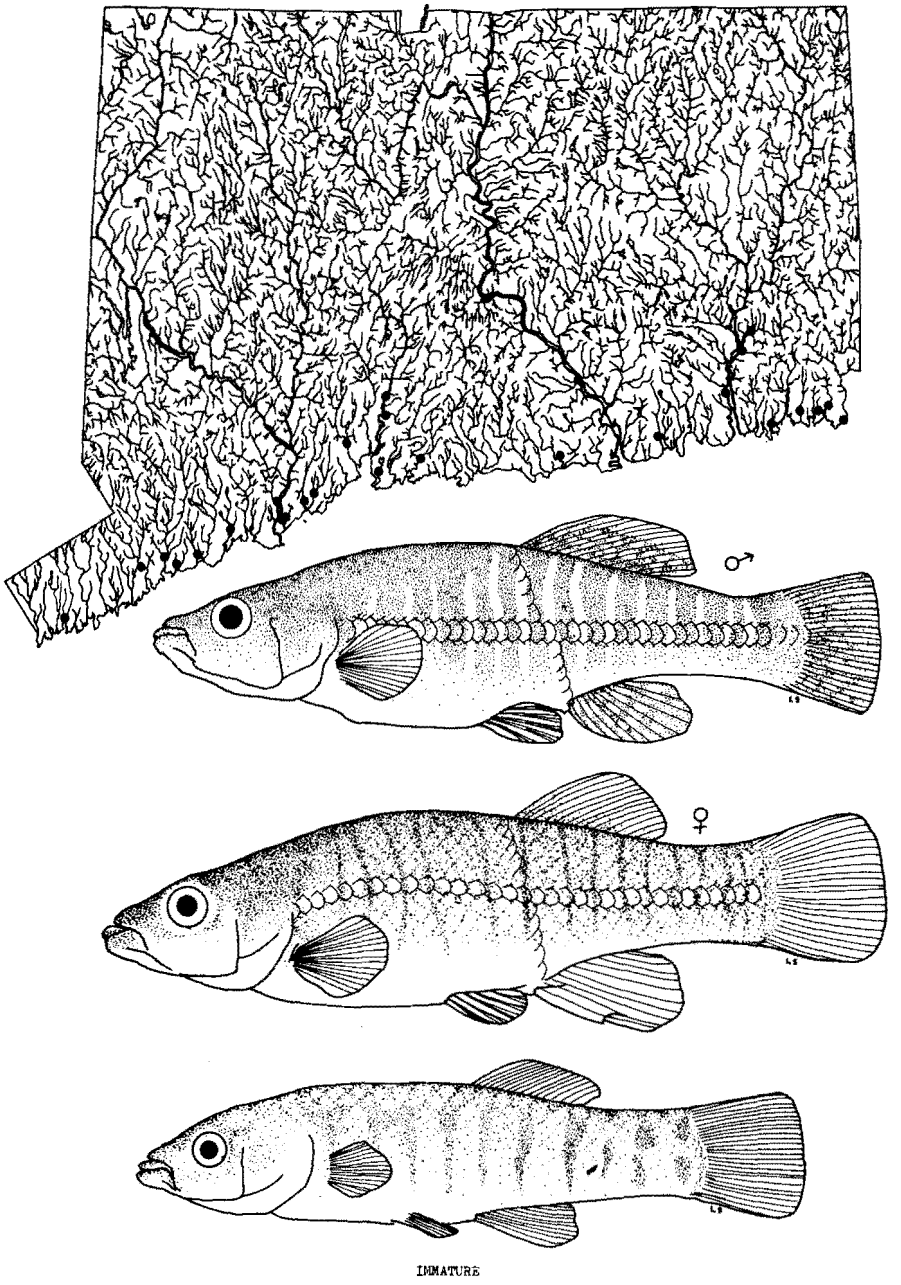
The banded killifish is olivaceous dorsally, lighter laterally, and whitish ventrally. Sides of males have 18-22 vertical bars, sides of females 14-16. Breeding males have yellow pigment on branchiostegal membranes and brighter colors throughout. There are 42-52 scales in the lateral series and 11-13 anal-fin rays. Specimens reach lengths up to 4 in.

This species prefers shallow areas of lakes, ponds, and sluggish streams, and occasionally estuaries. Banded killifish spawn throughout the summer, broadcasting eggs over vegetation. They usually travel in large schools. Their food consists of small plant and animal materials.

Fundulus heteroclitus (Linnaeus)—mummichog—amphidromous

The mummichog is found in freshwaters, brackish waters, and saltwaters along the Atlantic coast from Maine to Florida.

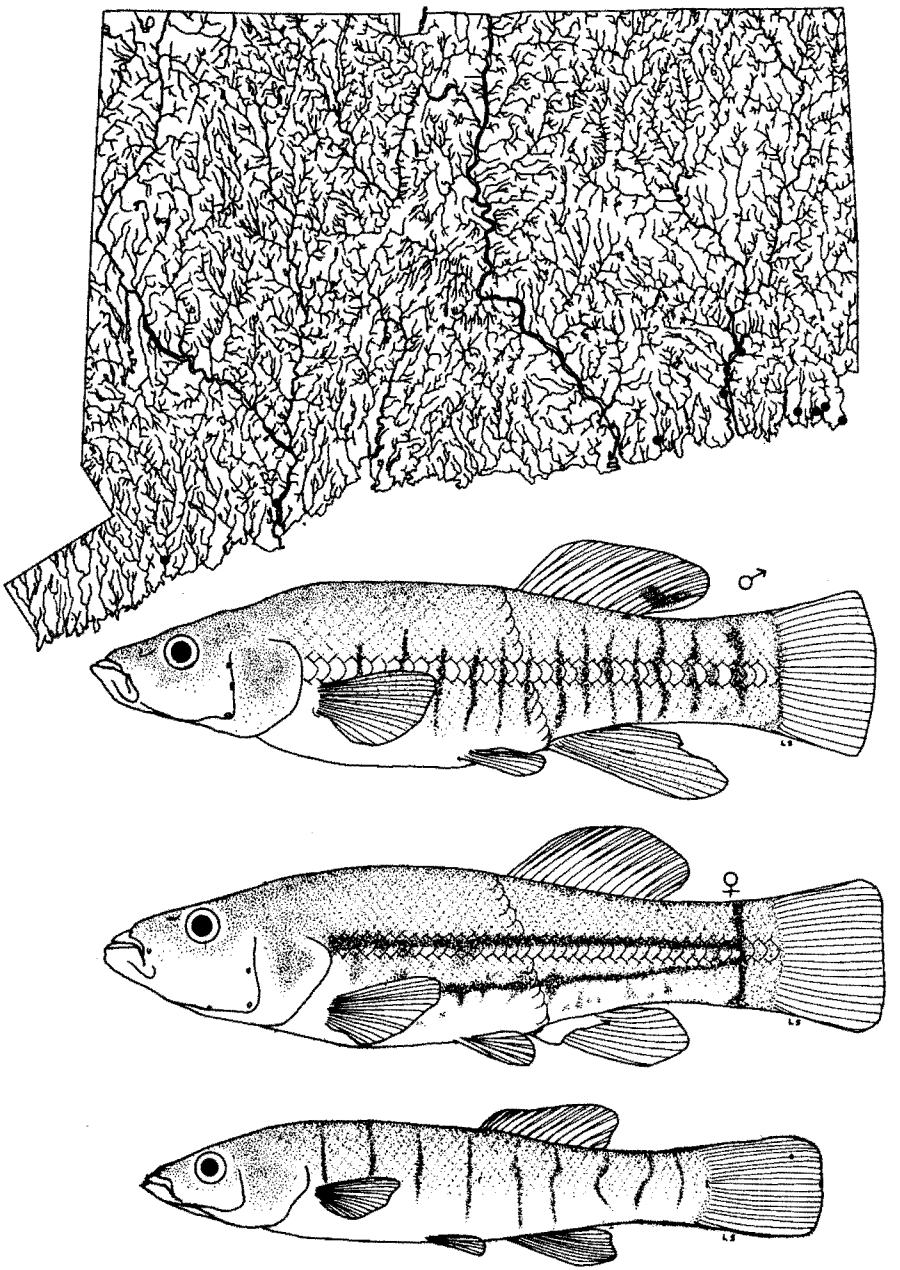
Males are bluish green dorsally, lighter laterally, and yellowish ventrally; their sides have 10-18 irregularly spaced silvery or black vertical bars. Females are olivaceous dorsally, lighter laterally, and whitish yellowish ventrally; their vertical bars are commonly indistinct. Breeding males are blackish dorsally and on the upper sides, and bright yellow ventrally and on the lower sides. There are 34-37 scales in the lateral series, 11-13 dorsal-fin rays, and 10-12 anal-fin rays. The dorsal and anal fins are smaller in females than males. The species reaches lengths of 6 in.



Mummichogs prefer the shallow, slow-moving waters of coastal areas. They spawn in shallow waters throughout the summer and feed on a variety of plant and animal materials.

Fundulus majalis (Walbaum)—striped killifish—possible visitor from saltwater

This killifish is found in brackish waters and saltwaters, and occasionally in coastal freshwaters from Massachusetts to Florida.

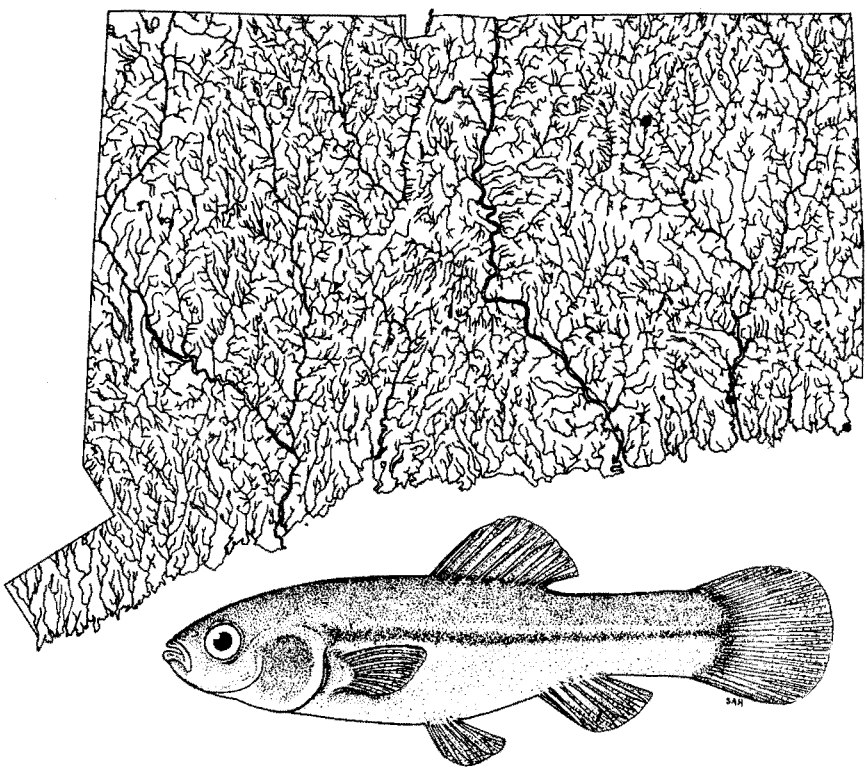


Males are olivaceous dorsally, lighter laterally, greenish yellow ventrally; generally there are 1 or 2 black spots on the posterior interadial membranes; the sides have 10-14 black vertical bars (the last bar intensified). Females are olivaceous dorsally, lighter laterally, and whitish ventrally; only the last one or two vertical bars are present and there are 1-3 horizontal bars along the sides. Breeding males are blackish dorsally and on the upper sides, and bright yellow ventrally and on the lower sides. There are 36-39 scales in the lateral series, 14-16 dorsal-fin rays, and 11-12 anal-fin rays. A length of 7 in. is reached by this species.

Although striped killifish have been reported in freshwaters elsewhere, they were collected only in the brackish and saltwaters of Connecticut.

Lucania parva (Baird and Girard)—rainwater killifish—possible visitor from saltwaters

The rainwater killifish is found in saltwaters, brackish waters, and occasionally in coastal freshwaters from Massachusetts to Texas, and in New Mexico.



This killifish is light olivaceous dorsally, lighter laterally, and silvery ventrally. There are 26-27 scales in the lateral series, 9 anal rays, and 10 dorsal rays. Lengths of 3 in. are reached.

Although reported from freshwaters elsewhere, this species has been collected only in saltwaters and brackish waters of Connecticut.

Family Atherinidae: silversides

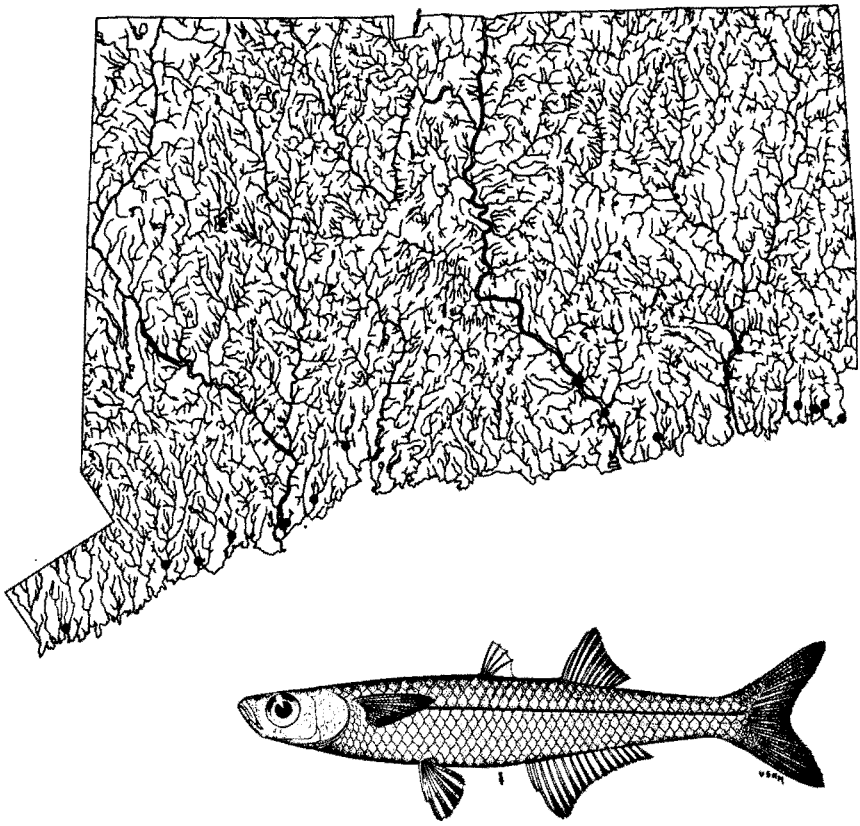
Approximately 140 species are found in the saltwaters, brackish waters, and freshwaters of the warm and temperate areas of the world.

Key to the species of silversides found in Connecticut

1. Anal fin with more than 22 rays—*Menidia menidia*, p. 91
   Anal fin with fewer than 22 rays—*Menidia beryllina*, this page

Menidia beryllina (Cope)—tidewater silverside—amphidromous

The tidewater silverside is found in saltwaters, brackish waters, and coastal freshwaters from Massachusetts to Veracruz. The triangle plotted is from UCMZ.

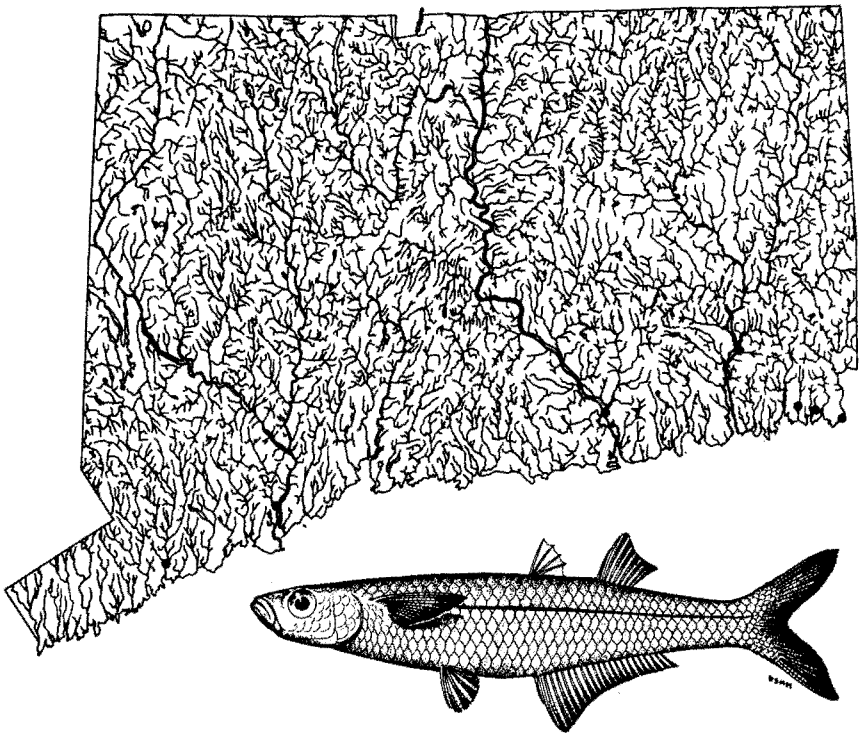


This silverside is greenish dorsally, silvery laterally, white ventrally; there is a dark longitudinal streak along the side. The species reaches lengths up to 3 in.

Spawning is in early summer. A variety of small plant and animal materials is consumed by this species.

Menidia menidia (Linnaeus)—Atlantic silverside—possible visitor from saltwater

This species is found in saltwaters, brackish waters and occasionally in coastal freshwaters from the Gulf of St. Lawrence to Florida.



The Atlantic silverside is greenish dorsally, silvery laterally, and white ventrally; there is a dark longitudinal streak along the side. The species reaches lengths up to 6 in.

This species was collected only in the brackish waters and saltwaters of Connecticut.

Family Gasterosteidae: sticklebacks

The saltwaters, brackish waters, and freshwaters of the Northern Hemisphere contain about 12 species. Sticklebacks spawn in early spring and continue to do so through much of the summer. Males select and defend a territory in vegetation, and build an elaborate nest of plant materials, held together with a kidney secretion. Females enter the nest and lay their eggs after elaborate courtship activities. Males then chase the females away and fertilize the eggs. The males guard the eggs until they hatch and watch the fry for a short time afterward. Sticklebacks feed on a variety of small plant and animal materials.

Key to the species of sticklebacks found in Connecticut

1. Pelvic bones joined–2
   Pelvic bones not joined – *Apeltes quadracus*, this page

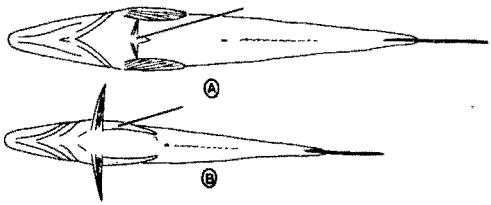


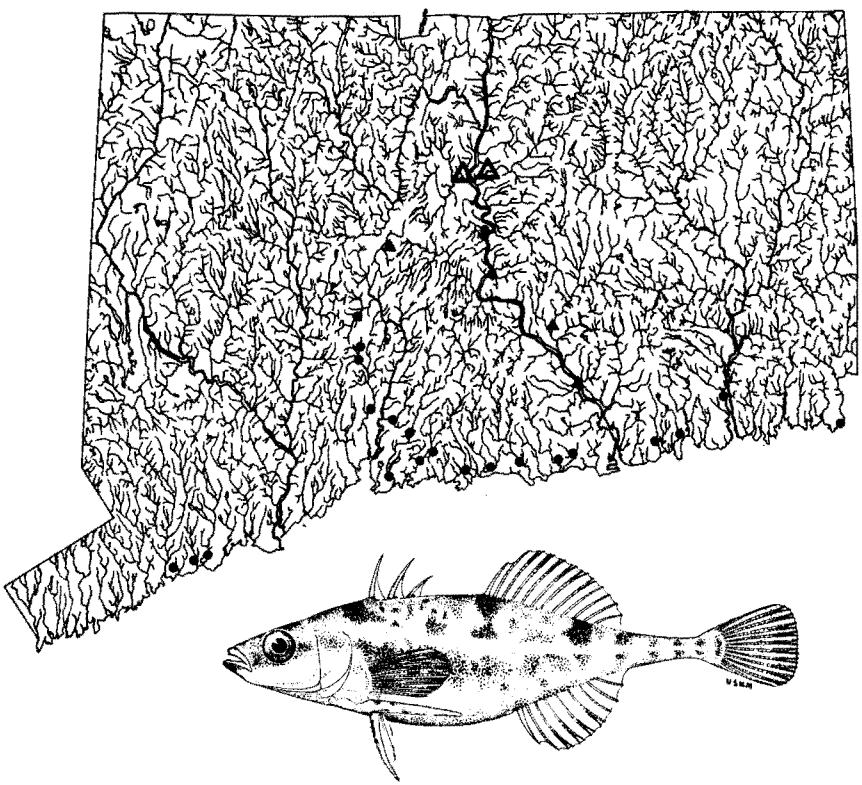
Fig. 36. Pelvic bones: *A*, joined and *B*, not joined

2. Caudal peduncle without a lateral keel–*Culaea inconstans*, p. 93
   Caudal peduncle with a lateral keel–3

3. 7-11 dorsal spines–*Pungitius pungitius*, p. 95
   0-4 dorsal spines–*Gasterosteus aculeatus*, p. 94

Apeltes quadracus (Mitchill)–fourspine stickleback–amphidromous

The fourspine stickleback is found in saltwaters, brackish waters, and freshwaters from Nova Scotia to Virginia. The triangles plotted are from Ayres (1943), Linsley (1844), UCWF, and BOL.

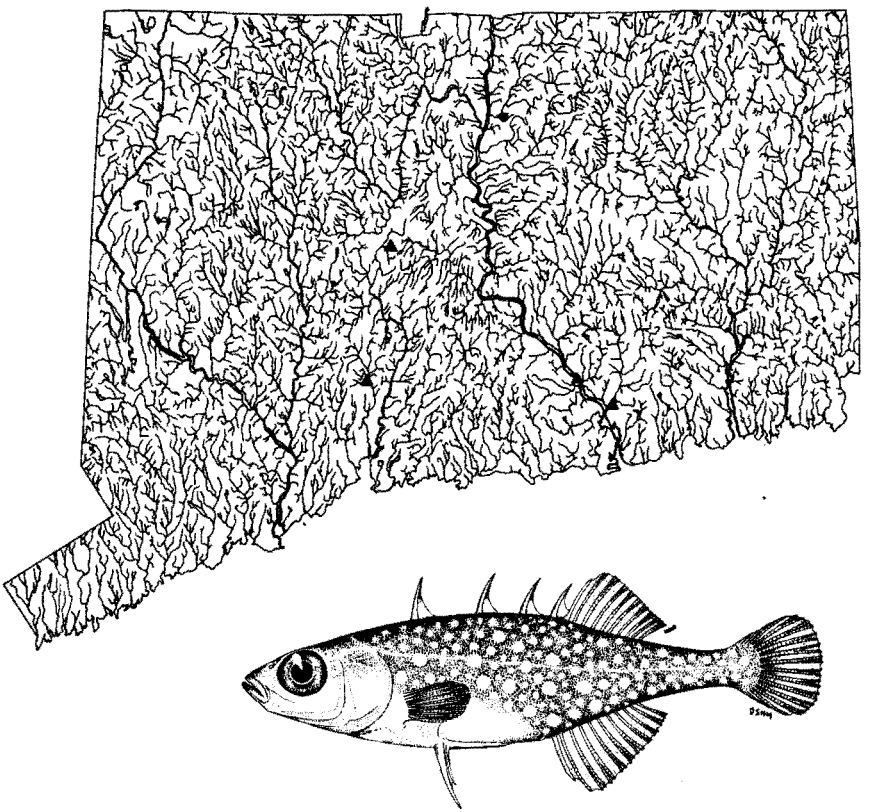


This stickleback is olivaceous dorsally, lighter laterally, silvery ventrally, and the sides have scattered dark markings. There are no bony plates; the pelvic bones are not joined and extend backward. There are 5-9 gill rakers on the first arch, 4-5 dorsal spines (9-13 rays), and 1 anal spine (7-10 rays). Lengths of 2 in. are attained by this species.

Fourspine sticklebacks are found in shallow coastal areas and low gradient streams.

Culaea inconstans (Kirtland)—brook stickleback—introduced

This stickleback is found in the freshwaters of northern North America, including the northern Mississippi, Great Lakes, and Hudson drainages. The triangles plotted are from UCMZ, BOL, and R. P. Hunter (personal communication).

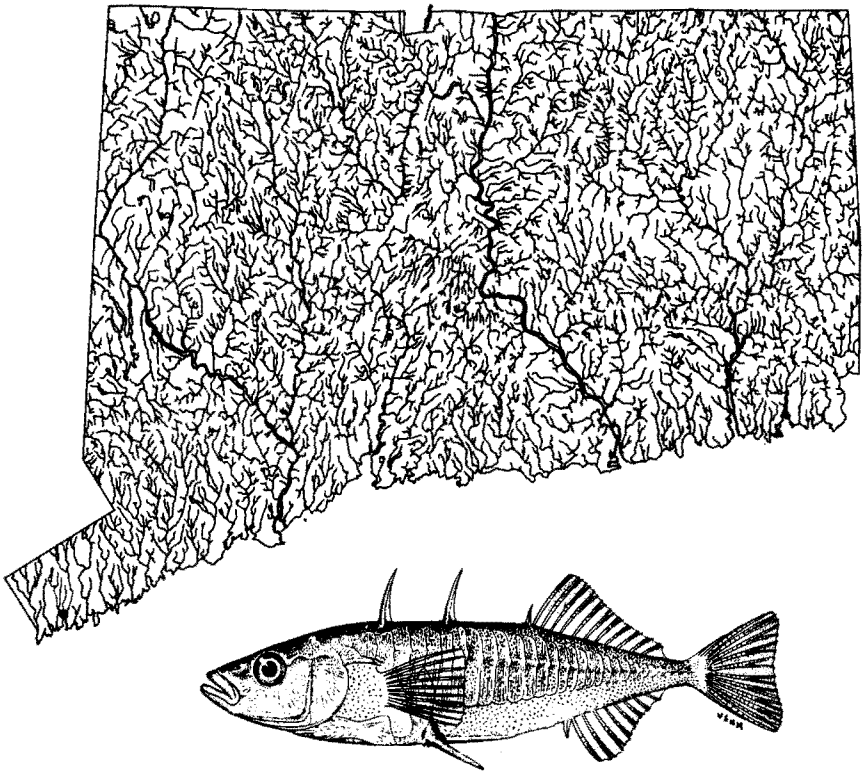


The brook stickleback is olivaceous dorsally, lighter laterally, and whitish yellow ventrally; the back and sides are spotted with lighter areas. There are 4-6 dorsal spines. Lengths of 3 in. may be reached.

This stickleback prefers boggy streams and lakes and is commonly found in trout streams in other areas.

Gasterosteus aculeatus Linnaeus—threespine stickleback—possible visitor from saltwater

The threespine stickleback is found in saltwaters, brackish waters, and freshwaters along both coasts of North America and in the Lake Ontario basin.

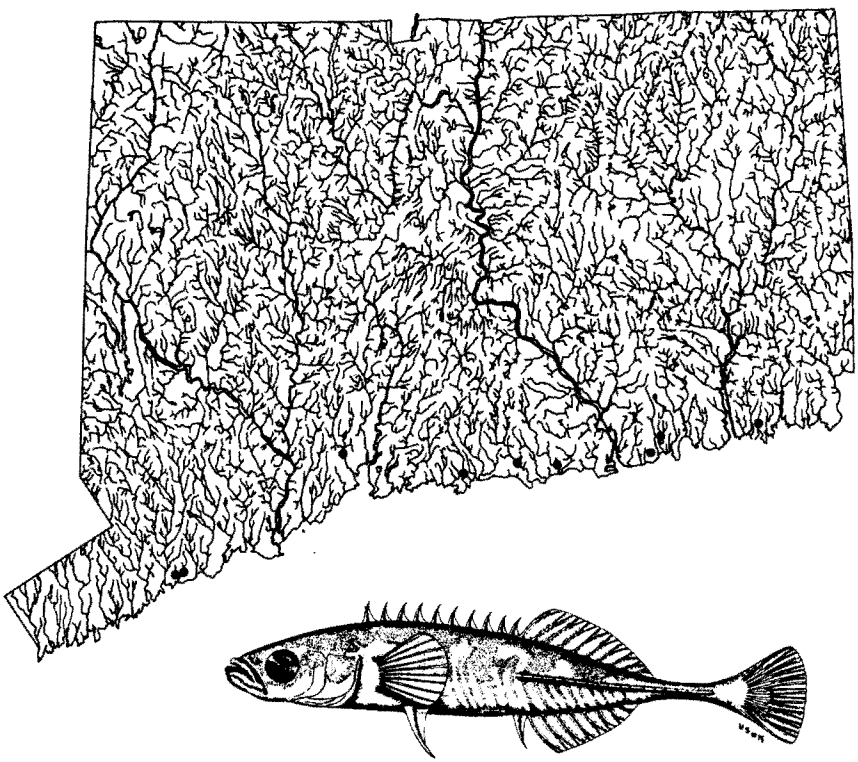


This species is olivaceous dorsally, and silvery laterally and ventrally. There are 28-33 bony plates on each side, 3-5 dorsal spines, and 10-14 rays. The species reaches lengths up to 4 in.

No specimens have been collected from the freshwaters of Connecticut.

Pungitius pungitius (Linnaeus)—ninespine stickleback—amphidromous

This stickleback is found in saltwaters, brackish waters, and freshwaters along the Atlantic coast south to New Jersey and in the Great Lakes.



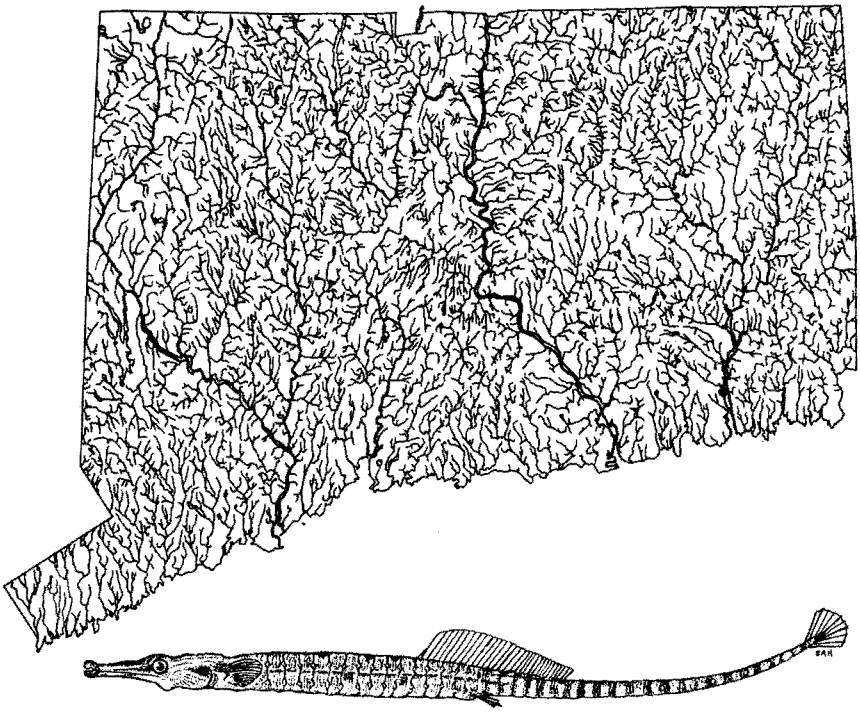
Ninespine sticklebacks are olivaceous dorsally and laterally, becoming silvery below the midline, and silvery ventrally. Males have reddish color on their heads during the breeding season. There are 7-12 dorsal spines, 10-15 gill rakers on the first arch, 0-15 lateral plates, no true scales; most specimens have a well-developed keel laterally. Lengths of 3 in. are reached by this species.

Family Syngnathidae: pipefishes and seahorses

Approximately 160 species are found in the saltwaters, brackish waters, and freshwaters of the tropical and temperate areas of the world. It is possible that one species enters the freshwaters of Connecticut.

Syngnathus fuscus Storer—northern pipefish—possible visitor from saltwater

The northern pipefish is found in saltwaters, brackish waters, and occasionally in fresh coastal waters from the Gulf of St. Lawrence to South Carolina.



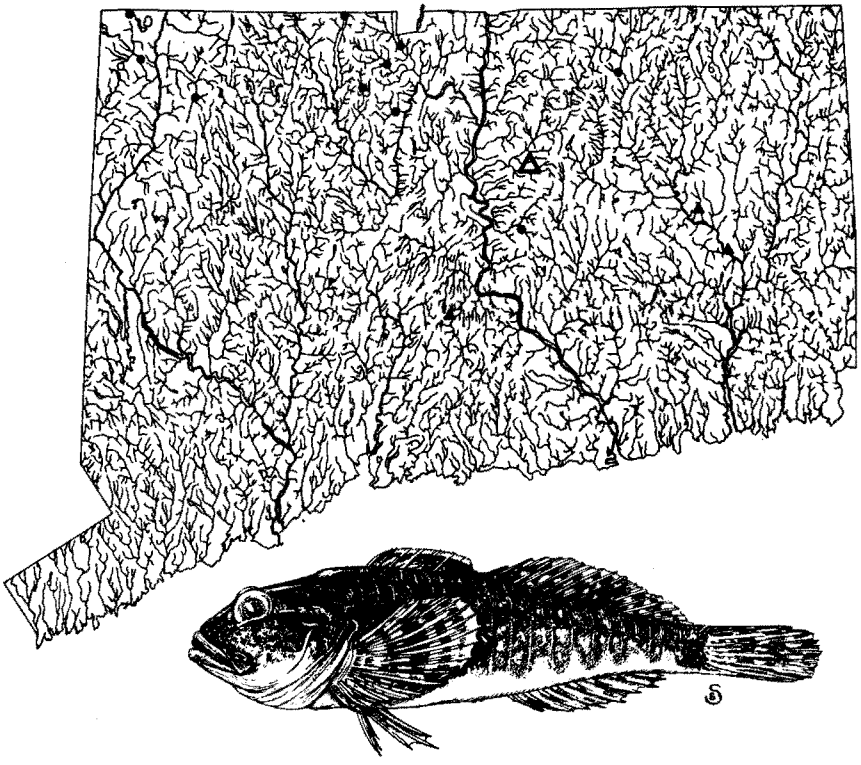
This pipefish is olivaceous dorsally, somewhat lighter laterally, and yellowish ventrally. The body appears four-sided posterior to the dorsal fin and is covered by bony plates; there are 18-20 scales before the vent and 36-42 behind it, and 35-41 dorsal-fin rays. Lengths of 1 ft are reached by this species.

Family Cottidae: sculpins

Approximately 300 species are found in the saltwaters, brackish waters, and freshwaters of the world. One species is found in the freshwaters of Connecticut.

Cottus cognatus Richardson—slimy sculpin—native

The slimy sculpin is spottily distributed in northern North America south to approximately the middle of the United States. Triangles plotted are from Linsley (1844), Ayers (1845), UCMZ, and UCWF. The range of *Cottus bairdi* Girard may include Connecticut; however, the characteristics given by McAllister (1964) indicate that all the specimens collected in the state and examined are *C. cognatus*.



This sculpin is brownish gray dorsally and laterally, lighter ventrally, with 2-3 mottled saddles under the soft dorsal. Males are generally dark during the spawning season and the spinous dorsal has a broad orange edge. The species reaches lengths of 4 in.

Slimy sculpins prefer moderately clear, cold streams, commonly those with vegetation. They spawn in spring, males setting up territories in rocky areas, and driving the females into their nests, where the eggs are laid on the underside of a rock and guarded by the males. A variety of plant and animal materials are consumed by this species.

Family Serranidae: sea basses

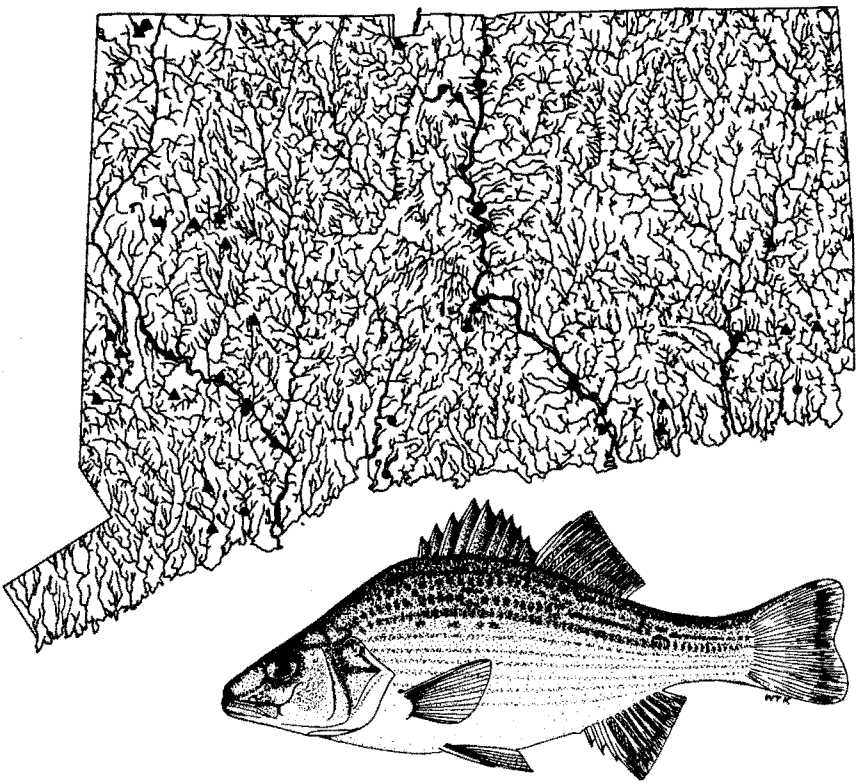
Approximately 400 species are found in saltwaters, brackish waters, and freshwaters of the tropical and temperate regions of the world.

Key to the species of sea basses found in Connecticut

1. Dorsal fins separate, sides striped—*Morone saxatilis*, p. 99
   Dorsal fins joined by a membrane, sides not striped—*Morone americana*, this page

Morone americana Gmelin—white perch—amphidromous

The white perch is found from Nova Scotia to South Carolina in freshwaters, brackish waters, and saltwaters. It is anadromous in parts of its range. The species has been introduced outside this range with some degree of success. The triangles plotted are from Thorpe (1942), BFG (1959), BFG (unpublished), and UCWF.



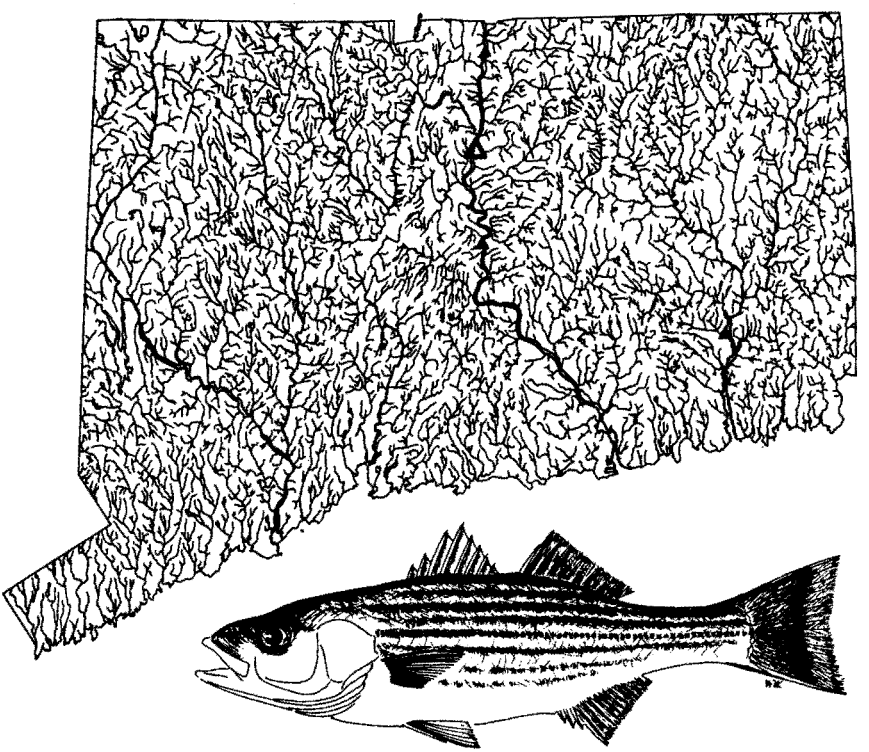
White perch are greenish gray dorsally, lighter and silvery laterally, and whitish ventrally; faint longitudinal lines are present in some specimens. Lengths of 1.5 ft are attained.

This species does not exhibit a definite spawning run from brackish to freshwater in Connecticut. Specimens are permanently landlocked in

many freshwater ponds and streams and some individuals may be permanent residents in freshwater. The food of this species consists of fish and small animals.

Morone saxatilis Walbaum—striped bass—amphidromous

The striped bass is found in saltwaters, brackish waters, and coastal freshwaters from New Brunswick to Florida, anadromous in parts of the range. Specimens have been widely stocked outside this range with some degree of success. The triangles plotted are from Linsley (1844), UCWF, and UCML.



This species is greenish gray dorsally, lighter laterally, silvery ventrally, and has 6-8 longitudinal stripes on the sides. There are 3 anal spines (11 rays) and 9-10 dorsal spines (12-13 rays). Lengths of 4 ft are reached.

Striped bass migrate into the freshwaters of Connecticut but there is no reliable evidence that they spawn there. Their food consists of fish and larger invertebrates.

Family Centrarchidae: sunfishes

Approximately 28 species are found in the freshwaters and occasionally in the brackish waters or saltwaters of North America. In spring and early summer each male selects and defends a territory in which he builds a nest. Nests are commonly constructed by clearing circular depressions of the bottom in shallow water. Males will spawn with as many females as they can lure to their nests.

Positive identification of small specimens of the genus *Lepomis* requires the removal of the pharyngeal bones (fig. 37). This is done by

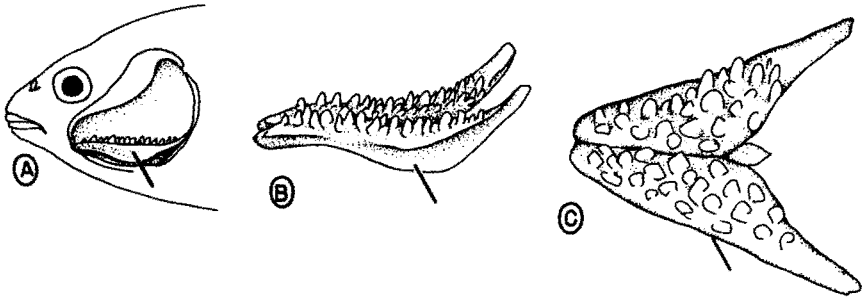


Fig. 37. Location of the pharyngeal bones of sunfishes. A, External view of head with gill arches removed, showing left pharyngeal base. *B*, Pharyngeal bones removed, lateral view. *C*, Pharyngeal bones removed, dorsal view.

pushing the operculum forward to expose the gill arches. When these are removed, the upper and lower pharyngeal bones are exposed. Removal of these bones is facilitated by severing the tendons holding the bone and then gently pulling on the bone. The pharyngeal bones may be cleaned in Chlorox, in the same manner as the pharyngeal bones of minnows are cleaned (p. 51). Drawings of typical pharyngeal bones of all species of the genus *Lepomis* are included with the appropriate species drawing.

Hybridization is common between the pumpkinseed and green sunfishes, bluegill and pumpkinseed, and redbreast sunfish and pumpkinseed (BFG, unpublished data).

Key to the species of sunfishes found in Connecticut

1. 3 anal spines—4
   More than 3 anal spines—2

2. Dorsal with 10 or more spines—*Ambloplites rupestris*, p. 103
   Dorsal with fewer than 10 spines—3

3. Length of dorsal-fin base less than distance from dorsal origin to posterior rim of orbit—*Pomoxis annularis*, p. 111
   Length of dorsal-fin base equal to or greater than distance from dorsal origin to posterior rim of orbit—*Pomoxis nigromaculatus*, p. 111

4. Caudal fin convex—*Enneacanthus obesus*, p. 104

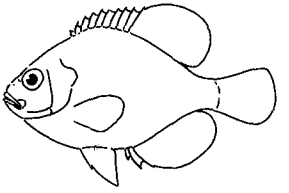


Fig. 38. Caudal fin of *Enneacanthus obesus*

   Caudal fin not convex—5

5. More than 55 lateral-line scales—6
   Fewer than 55 lateral-line scales—7

6. Maxilla generally extends beyond eye in adult; young have interrupted black markings along sides —*Micropterus salmoides*, p. 110

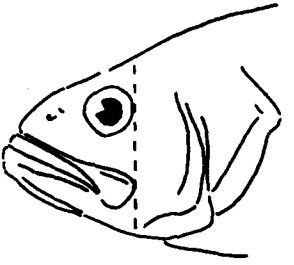


Fig. 39. Head of *Micropterus salmoides*

   Maxilla generally does not extend beyond eye in adult; young have no black markings on sides—*Micropterus dolomieui*, p. 109

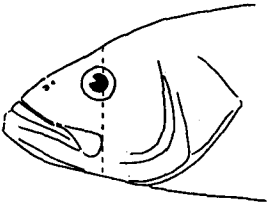


Fig. 40. Head of *Micropterus dolomieui*

7. When depressed, gill rakers reach base of second raker below—9

Fig. 41. Gill rakers of *Lepomis macrochirus* and *L. cyanellus*

When depressed, gill rakers do not reach base of second raker below—8

Fig. 42. Gill rakers of *Lepomis auritus* and *L. gibbosus*

8. Opercle long, black to its margin—*Lepomis auritus*, p. 105

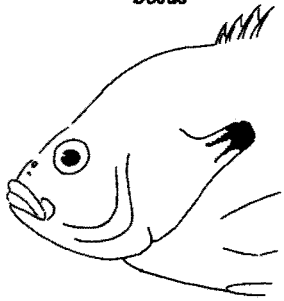


Fig. 43, Head of *Lepomis auritus*

Opercle short, a red spot near its margin—*Lepomis gibbosus*, p. 107

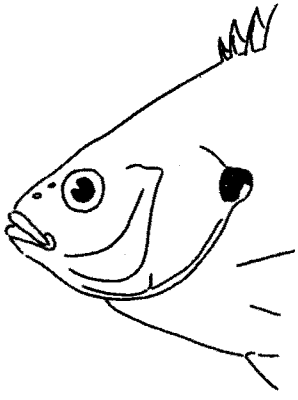


Fig. 44. Head of *Lepomis gibbosus*

9. Pectorals long and pointed, about equal to head length—*Lepomis macrochirus*, p. 108

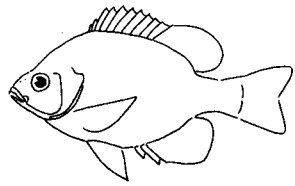


Fig. 45. *Lepomis macrochirus*

Pectorals short and rounded, less than head length—*Lepomis cyanellus*, p. 106

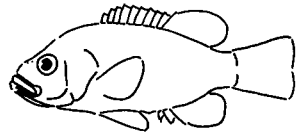
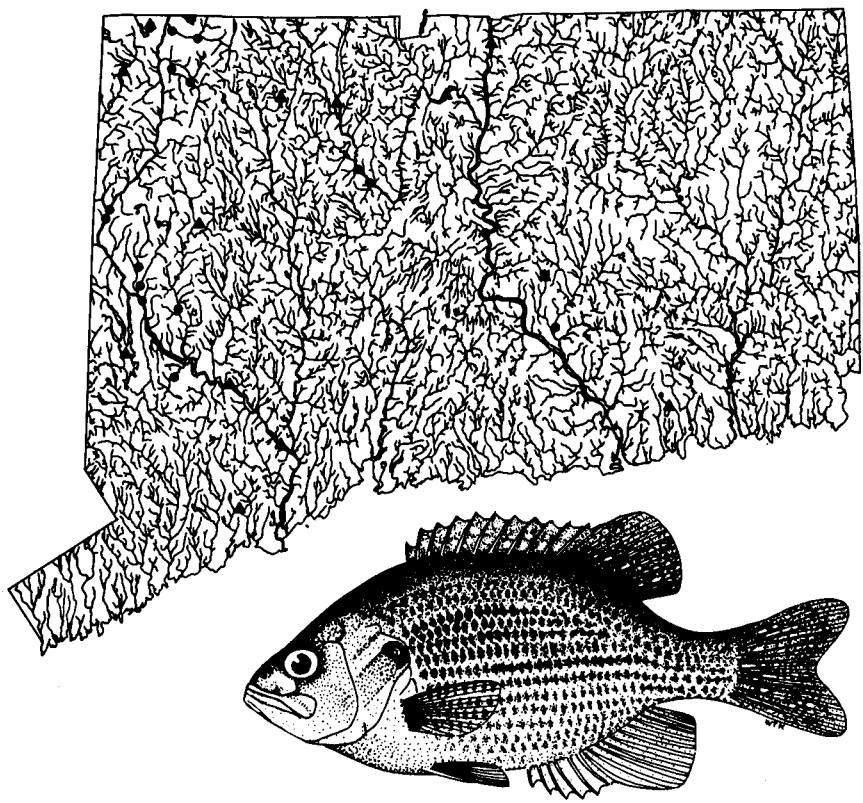


Fig. 46. *Lepomis cyanellus*

Ambloplites rupestris (Rafinesque)—rock bass—introduced

The rock bass is distributed in most of the freshwaters of North America from the Mississippi drainage eastward. The triangles plotted are from BFG (1959), UCMZ, Thorpe (1942) and BFG (unpublished).

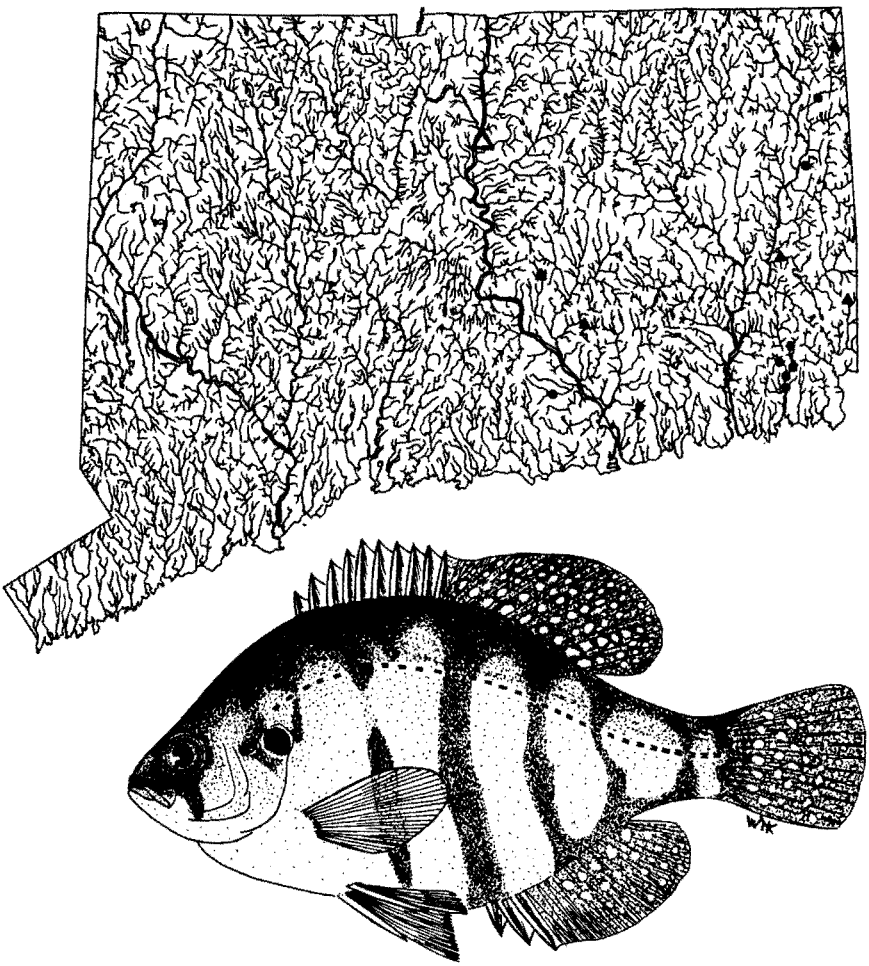


This species is dark brown to black dorsally, lighter laterally, and whitish ventrally; 4-6 dark saddles extend across the head and back, and the sides have scattered dark spots on most of the scales. There are 11-12 dorsal spines (9-11 rays), 5-6 anal spines (10-11 rays), 38-42 scales in the lateral line, 8-10 scales above the lateral line, and 13-16 scales below it. Lengths up to 1 ft are reached by this species.

Rock bass prefer clear streams with rock bottoms and tend to stay near pools and the shore. Their diet consists of invertebrates and fish.

Enneacanthus obesus (Girard) -banded sunfish—native

This sunfish is found in coastal freshwaters from New Hampshire to Georgia. The triangles plotted are from BFG (unpublished), MCZ, Connecticut Wildlife Conservation Bulletin (1961), and Thorpe (1942).

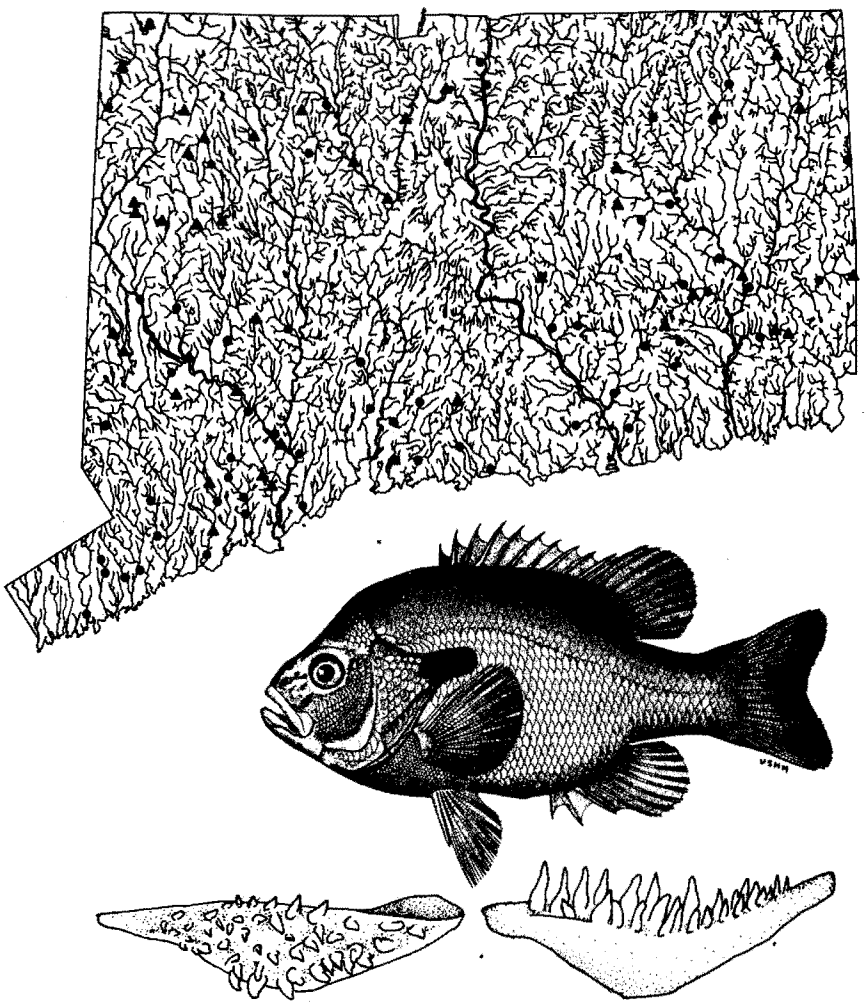


The banded sunfish is olivaceous dorsally, lighter and silvery laterally, and white ventrally; broad vertical bands extend across the back and down the sides; opercular spot, larger than the eye, is present. There are 9-10 dorsal spines (10-11 rays), 3 anal spines (10 rays), 29-33 scales in the lateral line, 10-13 scales below the lateral line, and 5-6 scales above it. Lengths up to 4 in. are reached by this species.

Banded sunfish prefer weedy lowland areas. Their food consists of small plant and animal materials.

Lepomis auritus (Linnaeus)—redbreast sunfish—native

The redbreast sunfish is found in freshwaters east of the Alleghenies from New Brunswick to Florida, along the Gulf of Texas, and north to Oklahoma. It has been widely introduced outside this area with some



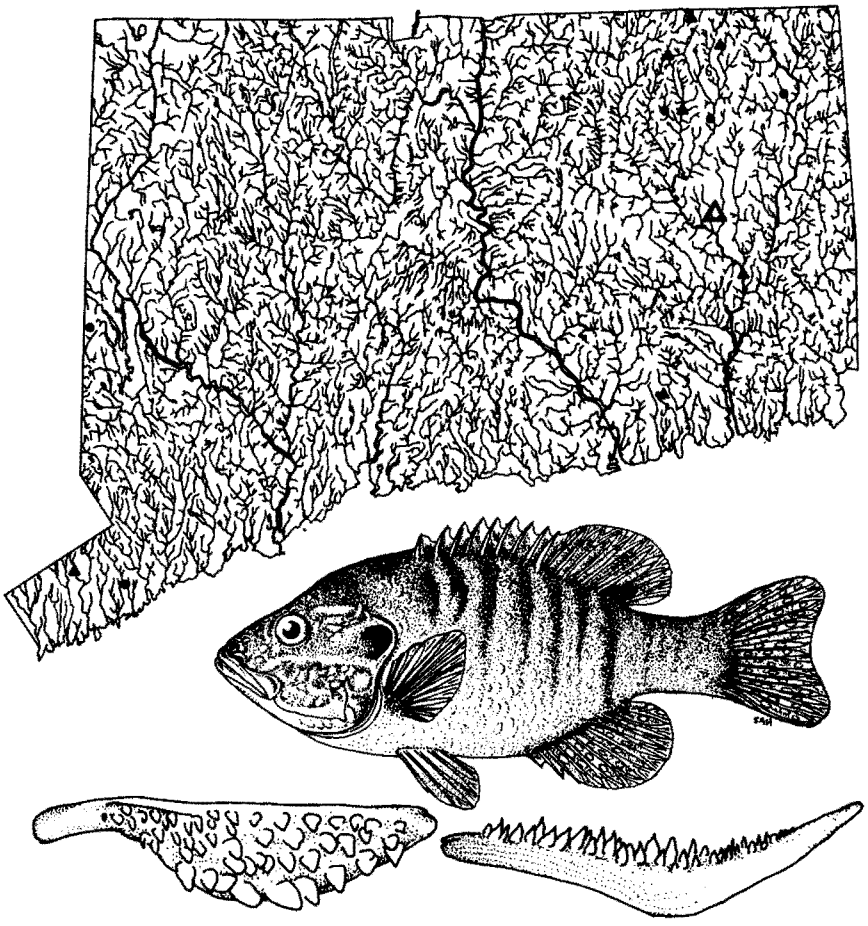
degree of success. The triangles plotted are from Linsley (1844), MCZ, UCWF, UCMZ, BFG (1959), Thorpe (1942), and BFG (unpublished).

This sunfish is dark olivaceous dorsally, lighter laterally, and yellowish white ventrally; the sides of some individuals have vertical bars; the opercle in adults is long and dark. There are 10 dorsal spines (11-12 rays), 2-3 anal spines (9-11 rays), 41-46 scales in the lateral line, 7-9 scales above the lateral line, and 14-16 scales below it. Lengths of about 1 ft are reached by this species.

Redbreast sunfish prefer rivers and streams but are found in lakes and ponds. They eat invertebrates and small fish.

Lepomis cyanellus Rafinesque—green sunfish—introduced

This sunfish is widely distributed in the freshwaters of North America east of the Rockies. The triangles plotted are from UCWF, BFG (unpublished), and UCMZ.



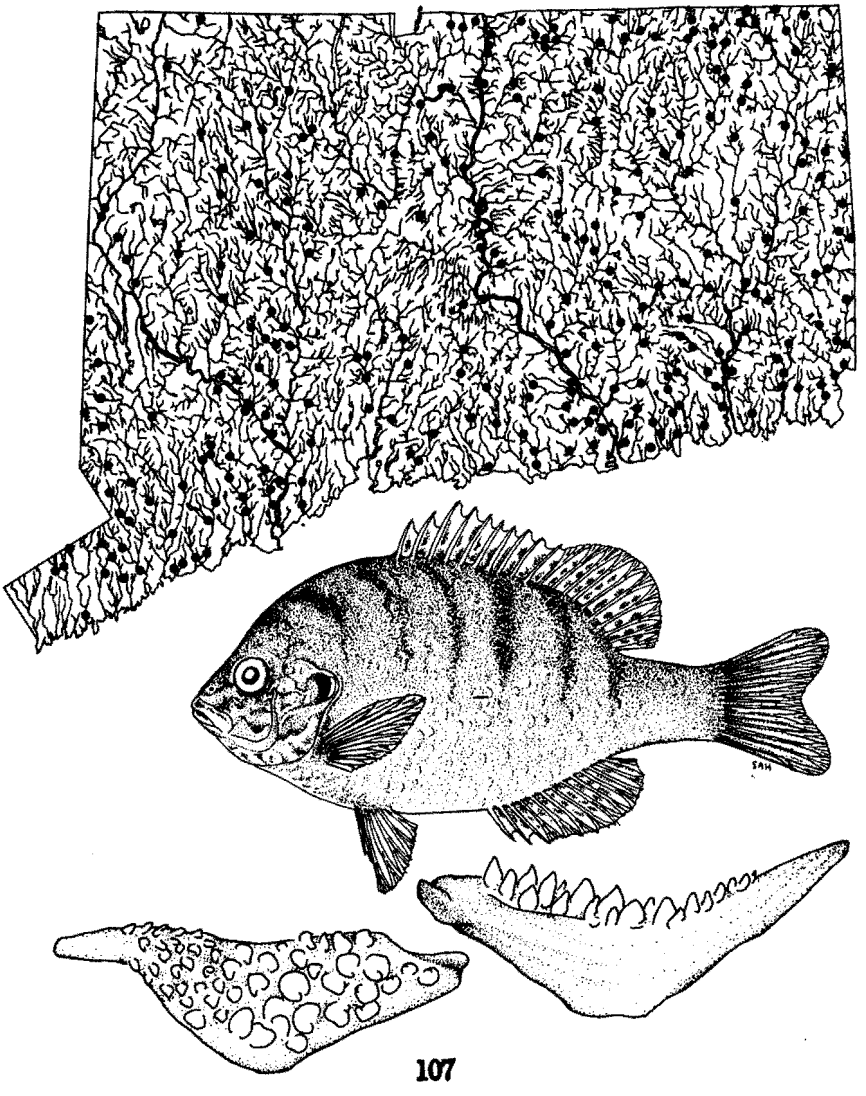
The green sunfish is dark olivaceous dorsally, slightly lighter laterally, with a green tinge, and yellowish ventrally. All fins of breeding males are

dark and margined with yellowish orange; their heads have iridescent blue-green streaks. There are 10-11 dorsal spines (11-12 rays), 3 anal spines (9-10 rays), 47-59 scales in the lateral line, 16-21 scales below the lateral line, and 8-11 scales above it. Lengths up to 1 ft are reached by this species.

Green sunfish are found in most environments but prefer small streams of low gradient and ponds. They are extremely tolerant of adverse environmental conditions. Their food consists of fish and invertebrates.

Lepomis gibbosus (Linnaeus)—pumpkinseed—native

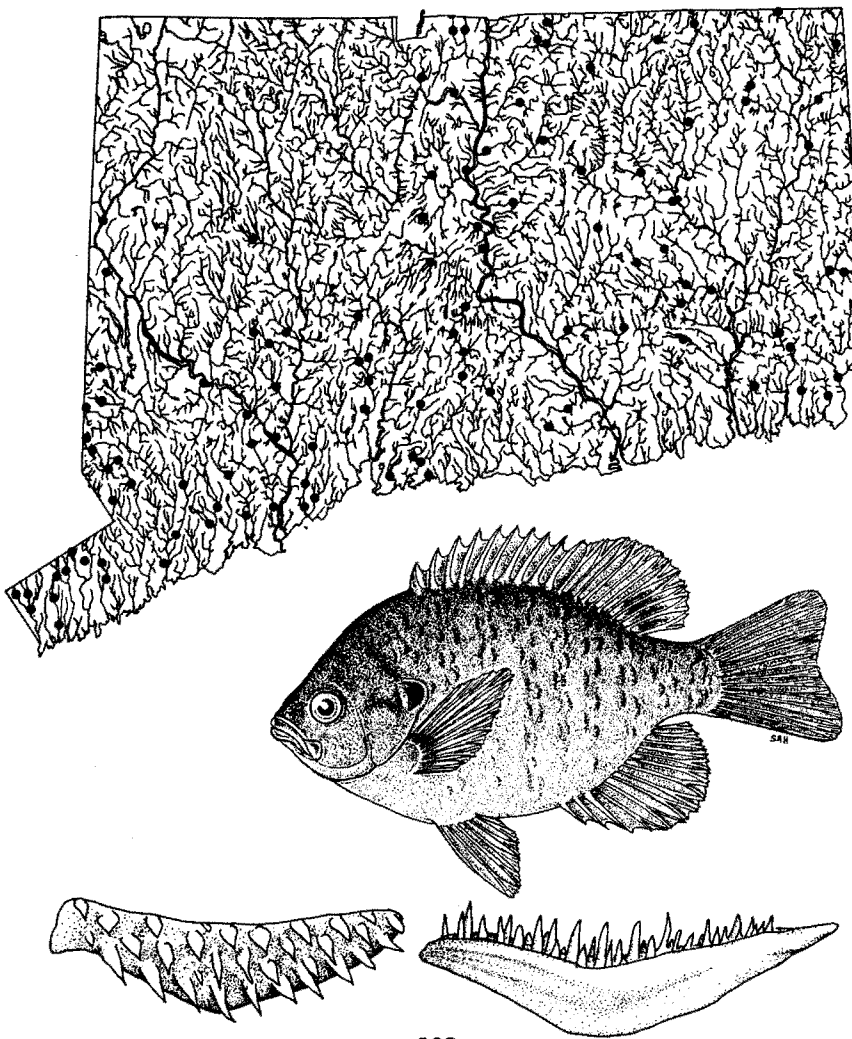
This species is found in freshwaters throughout most of the northern half of eastern North America and has been widely introduced outside of this range.



The pumpkinseed is olive green dorsally, lighter laterally, and orangish yellow ventrally. Its sides have small spots of orange, yellow, blue, and green; many specimens have 7-10 faint vertical bars. The opercular spot has a black center, usually margined with red. Breeding males are brightly colored, with bright blue streaks on the side of the head, bright orange breast, bright yellow pelvics, and bluish posterior edge of the caudal. There are 10-11 dorsal spines (11-12 rays), 3 anal spines (9-11 rays), 36-47 scales in the lateral line, 7-8 scales above the lateral line, and 13-16 scales below it. Lengths of about 1 ft are reached by this species.

Pumpkinseeds are found in a variety of habitats, including both standing and flowing bodies of water. Their food consists of invertebrates and small fishes.

Lepomis macrochirus Rafinesque—bluegill—introduced



This sunfish is found in freshwaters throughout most of eastern North America and has been widely introduced within and outside of this range.

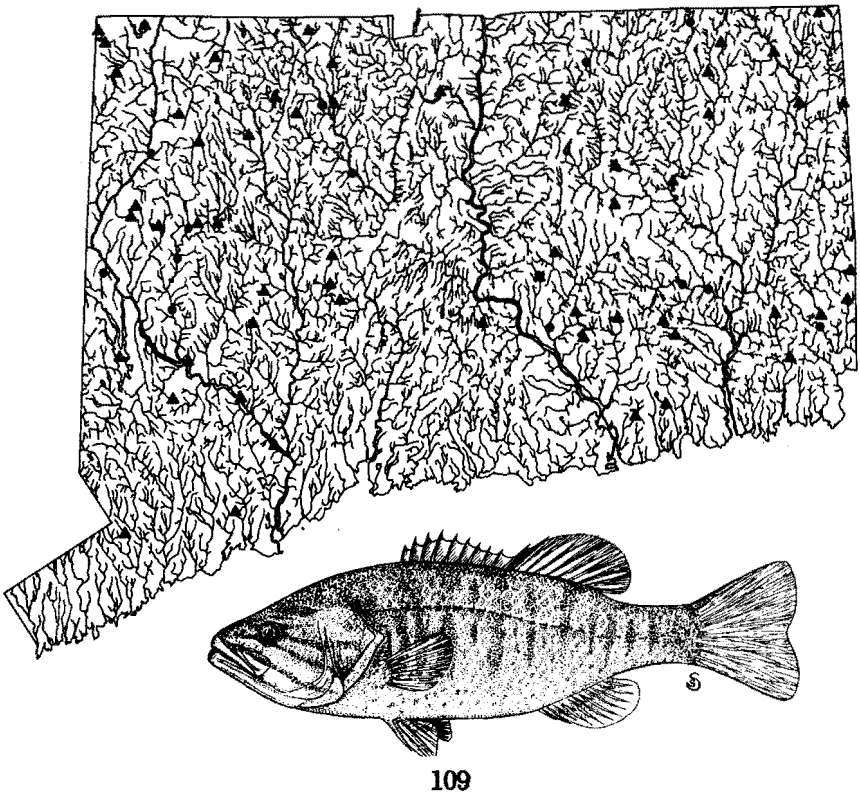
The bluegill is light to dark olivaceous dorsally, lighter laterally, and whitish, yellowish, orangish, or bluish ventrally. The sides have 5-9 vertical bars, and there is a dark spot near the base of the posterior edge of the soft dorsal. There are 10-11 dorsal spines (11-12 rays), 3 anal spines (9-11 rays), 38-47 scales in the lateral line, 14-16 scales below the lateral line, and 7-8 scales above it. Lengths of about 1 ft are reached.

Bluegills prefer lakes and ponds and the sluggish parts of rivers. They are usually found in schools and feed on invertebrates and small fishes.

Micropterus dolomieui Lacépède—smallmouth bass—introduced

This bass is widely distributed in the freshwaters of North America from the Mississippi drainage eastward. The triangles plotted are from Thorpe (1942) and BFG (1959).

The smallmouth bass is brownish dorsally, slightly lighter laterally, yellowish white ventrally; its back is mottled with olive-green markings, and its sides commonly have vertical bars. The maxilla generally extends to the posterior edge of the pupil with the mouth closed, and the shortest dorsal-spine length is commonly one half or more that of the longest spine. There are 72-80 scales in the lateral line, 19-27 scales below the

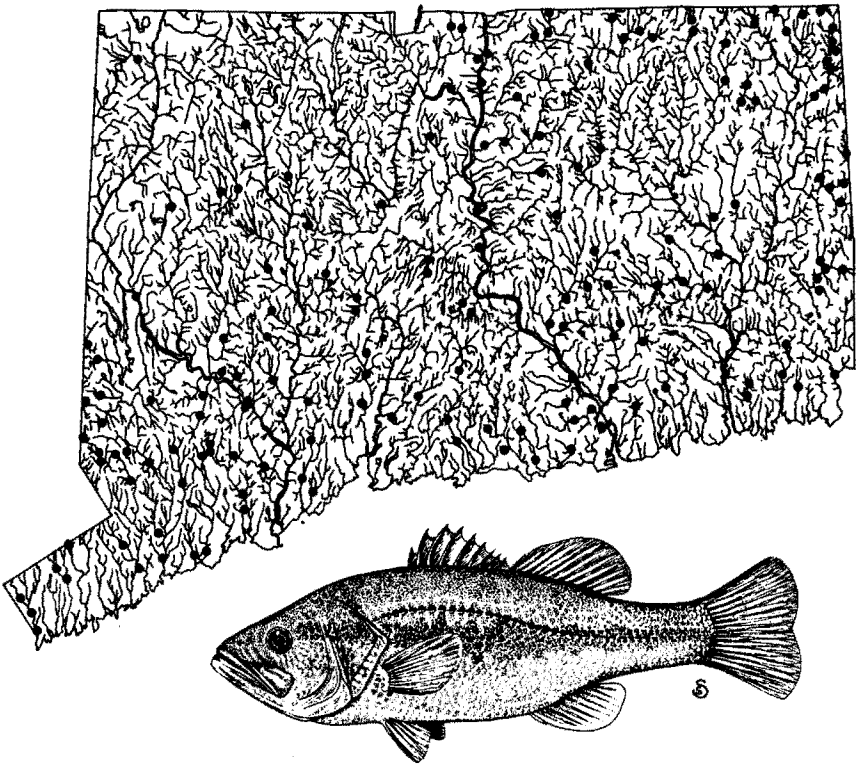


lateral line, 12-15 scales above it, 10-11 dorsal spines (13-14 rays), and 2-3 anal spines (10-11 rays). Lengths of about 1.5 ft are reached.

This species prefers the clear waters of lakes and flowing streams. Its food consists of larger invertebrates and fishes.

Micropterus salmoides (Lacépède)—largemouth bass—introduced

The largemouth bass is widely distributed in the freshwaters of most of North America east of the Mississippi drainage.

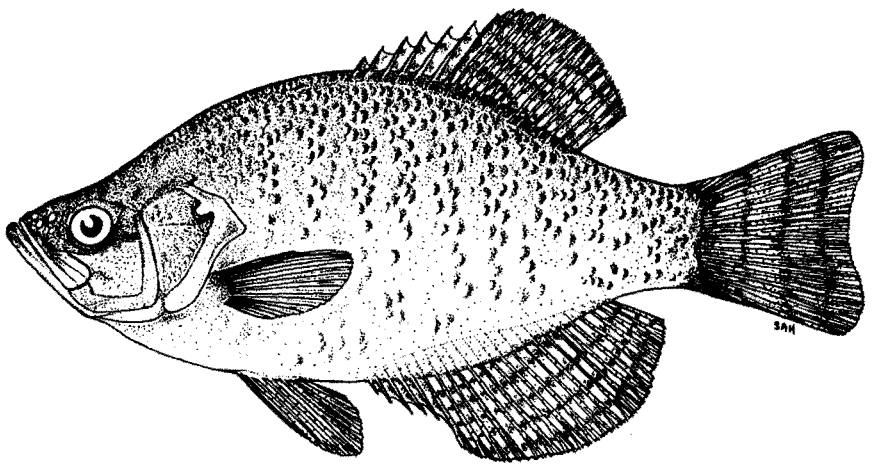


This species is dark brown dorsally, lighter laterally, and whitish ventrally (coloration is sharper in young); a solid or broken lateral band is usually present. The maxilla extends at least to posterior edge of the orbit with the mouth closed, and the shortest dorsal spines are generally less than one half the length of the longest dorsal spine. There are 10 dorsal spines (12-13 rays), 2-3 anal spines (10-11 rays), 59-66 scales in the lateral line, 8-9 scales above the lateral line, and 17-19 scales below it. Lengths of 2 ft are reached by this species.

Largemouth bass are found in weedy, mud-bottomed lakes and in sluggish streams. They favor warmer water than the smallmouth bass. Their food consists of invertebrates and fishes.

Pomoxis annularis Rafinesque—white crappie—introduced

The white crappie is found in the freshwaters of the Mississippi drainage eastward to the Alleghenies. It has been successfully introduced outside of this range. Although Behnke and Wetzel (1960) reported a BFG record from the Connecticut River, we did not obtain specimens or other records of this species. The two species of *Pomoxis* are difficult to distinguish and we would greatly appreciate receiving any specimen identified as a white crappie.



This crappie is olive green dorsally, silvery laterally, silvery white ventrally; the sides have chainlike vertical bands; the dorsal, anal, and caudal fins have dark spots. There are 4-8 dorsal spines (generally 5-6), 13-15 rays, 5-6 anal spines (17-18 rays), and 38-48 scales in the lateral line. The dorsal-fin-base distance is less than the distance from the dorsal origin to the posterior rim of the orbit. Lengths of 1.5 ft are reached by this species.

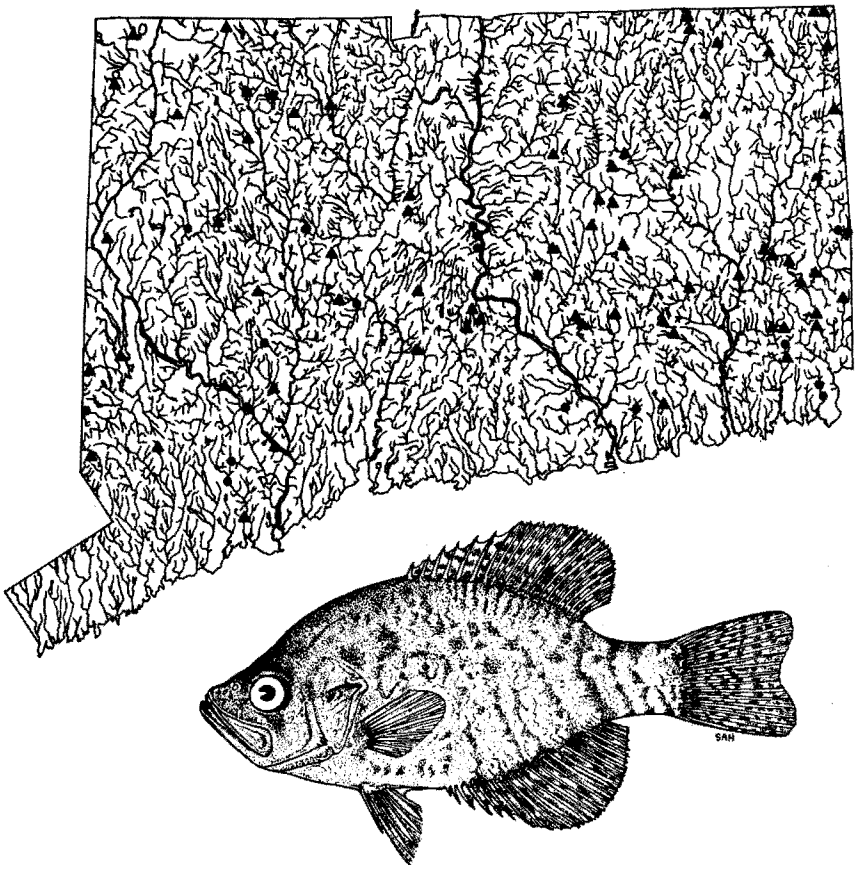
White crappies prefer ponds, lakes, and the sluggish parts of streams. They are more tolerant of a wider range of environmental conditions than are black crappies. Their food consists of invertebrates and small fishes.

Pomoxis nigromaculatus (LeSueur)—black crappie—introduced

This crappie is found in most of the freshwaters of North America from the Mississippi Valley eastward. The triangles plotted are from BFG (1959), UCMZ, UCWF, and Thorpe (1942).

This species is olive green dorsally, silvery laterally, and whitish silver ventrally. The head, sides, and back are mottled with blue-black spots, the dorsal, anal, and caudal fins with blotches of black pigments. Pigments are intensified in breeding males. The distance from the dorsal origin to the posterior rim of the orbit is equal to or greater than the distance to the dorsal-fin base. There are 7-8 dorsal spines (15-16 rays), 6-8 anal spines (17-19 rays), 37-46 scales in the lateral line, 7-8 scales

above the lateral line, and 14-16 scales below it. Lengths up to 1.5 ft are reached by this species.



Black crappies are found in clear lakes and in the sluggish parts of streams. They eat invertebrates and fishes.

Family Percidae: perches

Approximately 125 species are found in the freshwaters of the Northern Hemisphere, mainly in North America and Europe. The subfamily Etheostomatinae (darters) is found only in North America and contains about 110 species.

Key to the species of perches found in Connecticut

1. Maxilla extends past middle of eye, air bladder present—3
   Maxilla does not extend past middle of eye, air bladder absent—2

2. Least depth between lateral line and first dorsal-fin base contained less than 4 times in depth below lateral line—*Etheostoma olmstedi*, p. 114

   Least depth between lateral line and first dorsal-fin base contained more than 4 times in depth below lateral line—*Etheostoma fusiforme*, p. 113

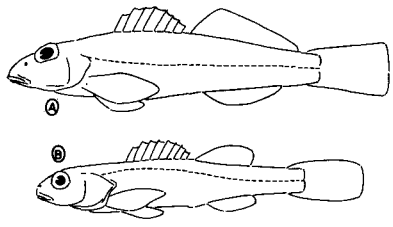


Fig. 47. (A) *Etheostoma olmstedi*, (B) *E. fusiforme*

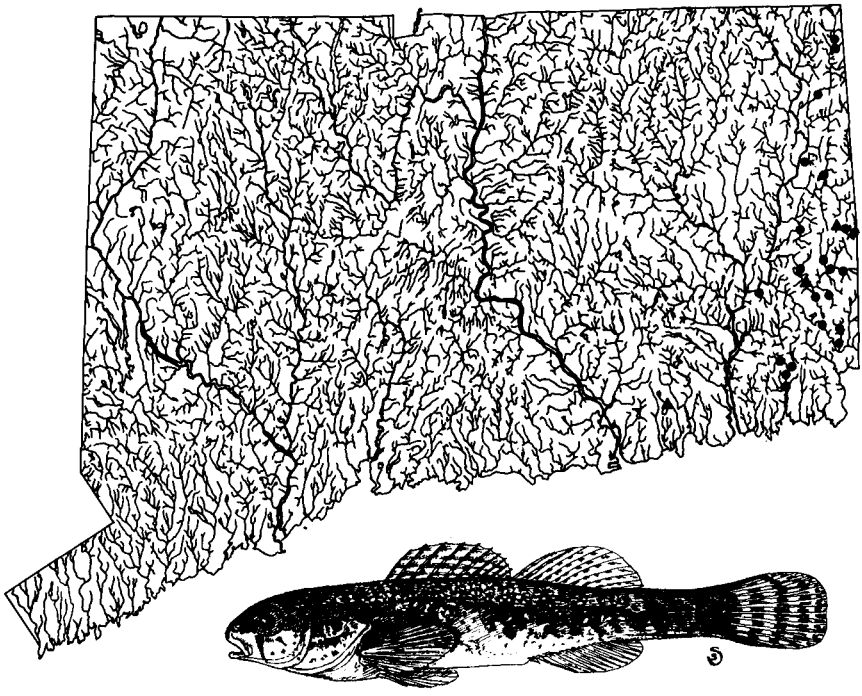
Fig. 48. Head-on view of mouth of *Stizostedion vitreum*

3. Canine teeth present—*Stizostedion vitreum*, p. 116

   Canine teeth absent—*Perca flavescens*, p. 115

Etheostoma fusiforme (Girard)—swamp darter—native

The swamp darter is found in coastal freshwaters from Maine to North Carolina. The triangles plotted are from UCMZ, and Thorpe (1942).

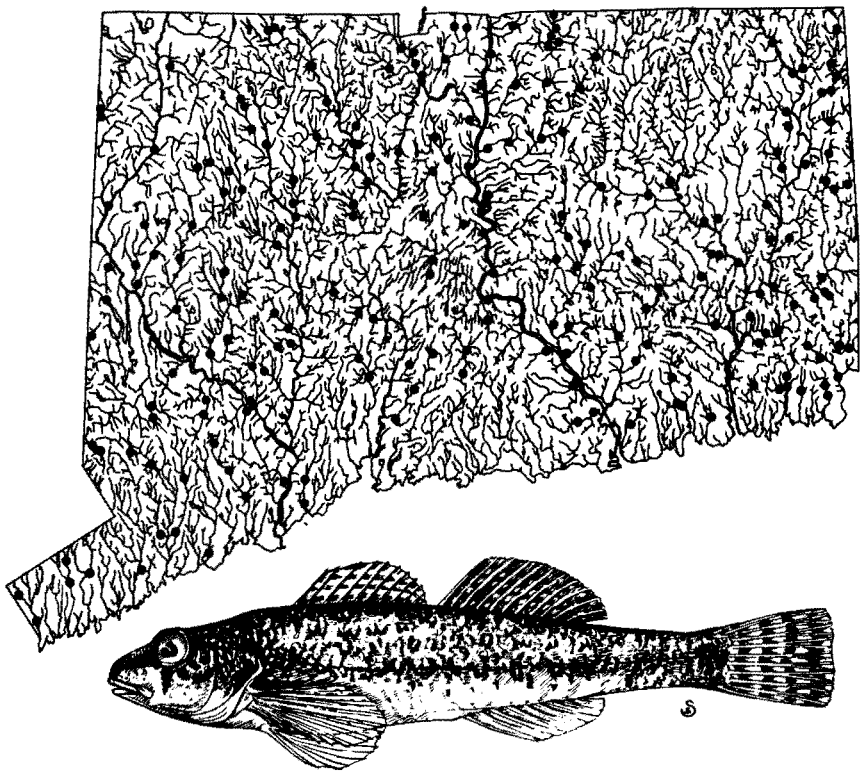


This darter is dark olivaceous dorsally, lighter laterally, whitish yellow ventrally; the back and sides have dark irregular blotches; there is a dark lateral band, varying from obscure to well defined. The mouth is ventral, subterminal, or terminal, premaxillae are not protractile. There are 9-11 dorsal spines (8-11 rays), 2 anal spines (6-8 rays), 44-54 scales in the lateral line, 9-12 scales below the lateral line, and 4-5 scales above it. Lengths of 3 in. are reached.

Swamp darters are found in ponds, swamps, lakes, streams, and backwaters of streams over mud, detritus, sand, and gravel bottoms in eastern Connecticut. They spawn in May-June in vegetation. A variety of small invertebrates are consumed.

Etheostoma olmstedi Storer—tessellated darter—native

The tessellated darter is found in freshwaters from North Carolina to the Lake Ontario drainage and northeastward. The species was described by Storer in 1842 from specimens found in Hartford by Charles H. Olmsted, President of the Hartford Natural History Society.



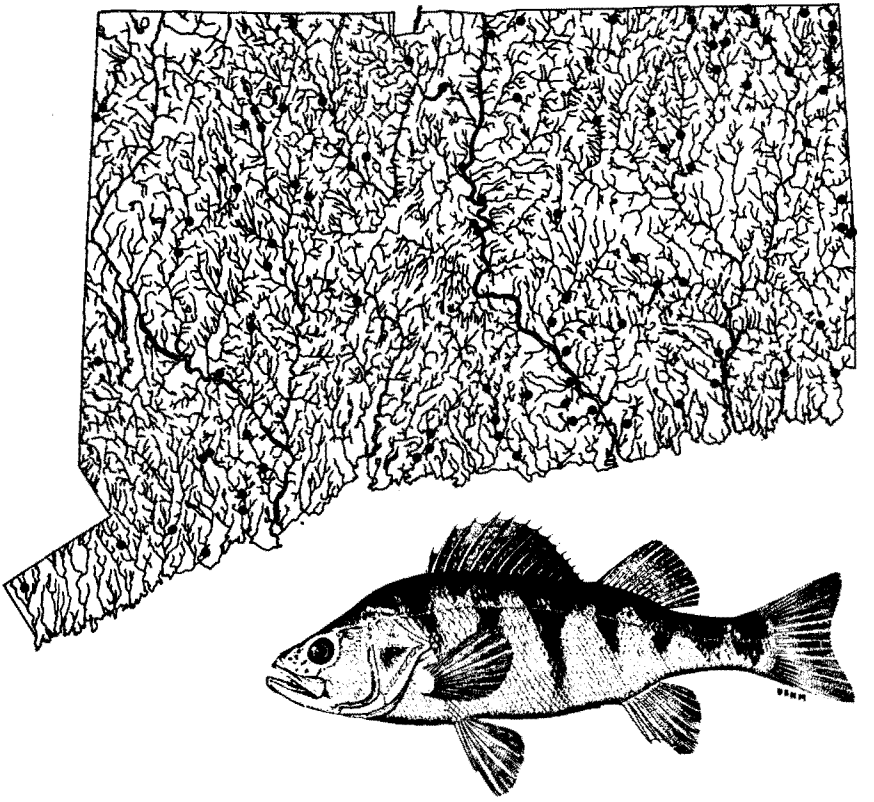
This darter is olivaceous dorsally, lighter laterally, yellowish ventrally, and on its sides is a row of dark blotches that commonly appear

W-shaped. The premaxillae are protractile, the mouth ventral or subterminal. There are 43-50 scales in the lateral line, 5-7 scales above the lateral line, 8-10 scales below it, 8-10 dorsal spines (13-15 rays), and 1-2 anal spines (8-9 rays). Lengths of 4 in. are reached.

Tessellated darters are found in quiet waters and riffles of streams and occasionally in lakes and ponds. They spawn in late spring; eggs are laid on the under surfaces of rocks and guarded by the males until they hatch. Food consists of a variety of small invertebrates.

Perca flavescens (Mitchill)—yellow perch—native

The yellow perch is widely distributed in freshwaters from the Mississippi drainage eastward. It has been introduced widely and successfully outside this range.

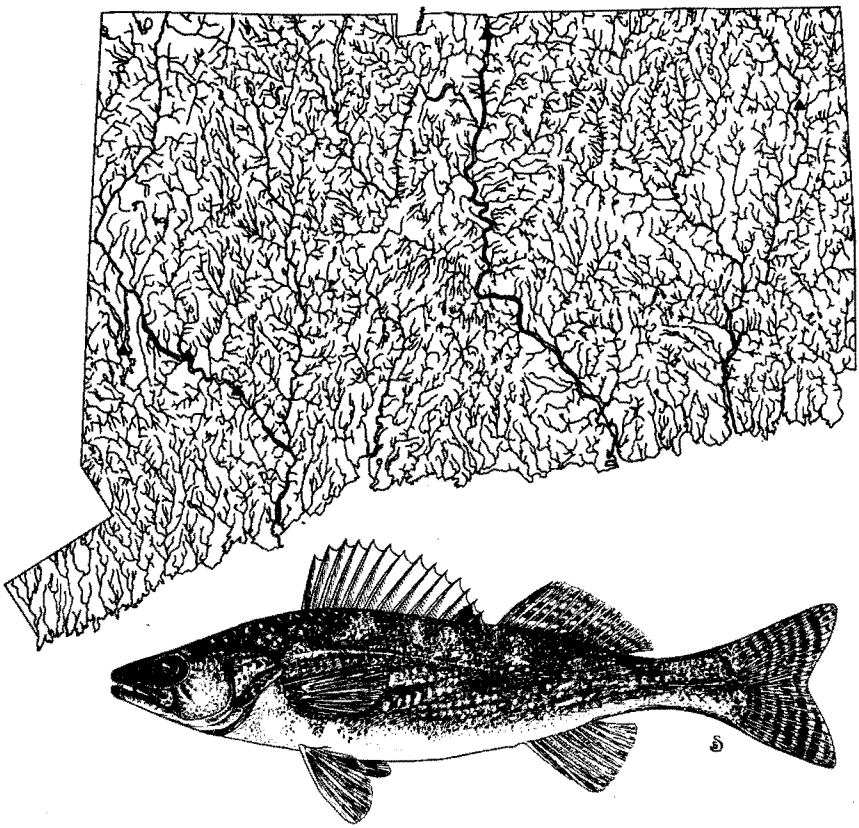


This species is dark greenish yellow dorsally, lighter laterally, whitish yellow ventrally, with 6-9 dark bands across the back and sides, and a spinous dorsal with a dark blotch posteriorly. There are 53-65 scales in the lateral line, 2 anal spines (7-8 rays), 12-15 dorsal spines, and a soft dorsal with 1-2 spines and 13-15 rays. Lengths up to 1.5 ft are reached by this species.

Yellow perch are found in clear lakes and in the sluggish parts of streams. They spawn in shallow weedy areas in early spring, soon after the ice goes out, males usually preceding females to the spawning areas. Eggs are deposited in long ribbons bound together by a jellylike substance and are attached to plants. Yellow perch travel in large schools and feed on invertebrates and fishes.

Stizostedion vitreum (Mitchill)—walleye—introduced

Walleyes are spottily distributed in the freshwaters of eastern North America south to the Gulf States. They are widely introduced within and outside of this general range. The triangles plotted are from BFG (1959), UCWF, Thorpe (1942), and BFG (unpublished).



This species is olivaceous dorsally, lighter laterally, yellowish white ventrally; some specimens have 6-8 obscure saddles dorsally, and a dusky spot on the posterior interradial membranes of the spinous dorsal. There are 81-86 scales in the lateral line, 12-13 dorsal spines (20-21 rays), and 2 anal spines (11 rays). Lengths of 2.5 ft are reached.

In early spring, adults move upstream or into the shallows of lakes

to spawn, usually over rocky bottoms. Eggs are broadcast and no parental care is given to the eggs or young. Although walleyes are slow growing, they have tremendous appetites, eating mainly fishes.

Family Mugilidae: mullets

Approximately 100 species are found in the saltwaters, brackish waters, and freshwaters of the warm and temperate areas of the world.

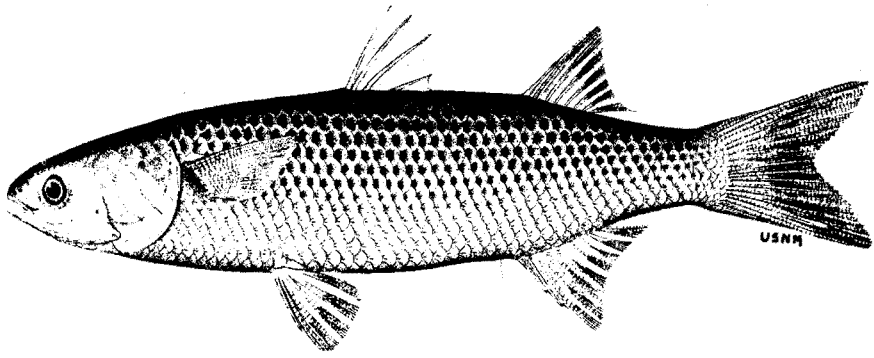
Key to the species of mullets found in Connecticut

1. 11 spines and rays in the anal fin, few scales on the second dorsal —*Mugil cephalus*, this page

   12 spines and rays in the anal fin (rarely 11 in young), many scales on the second dorsal—*Mugil curema*, this page

Mugil cephalus Linnaeus—striped mullet—possible visitor from saltwater

This mullet is found in saltwaters, brackish waters, and occasionally in freshwaters of the Atlantic coast from Cape Cod to Brazil and on the lower Pacific coast.



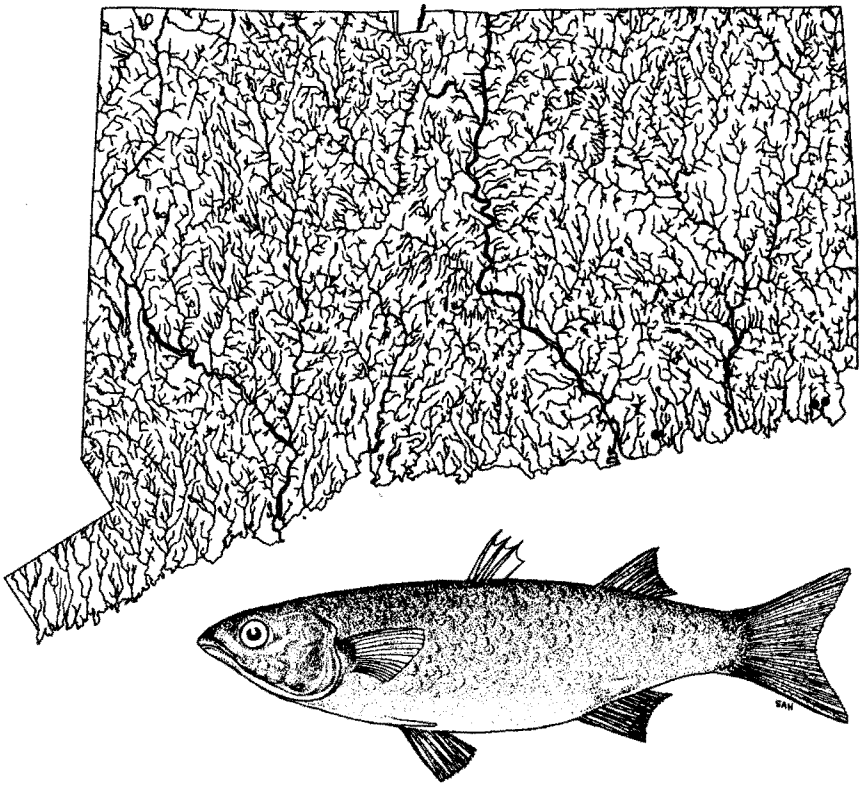
The striped mullet is bluish gray dorsally, silvery laterally and ventrally; scales on the sides have dark spots that form clear to obscure longitudinal lines. The soft dorsal and anal fins are almost naked, and there are 11 elements in the anal fin. Secondary teeth are bicuspid. Lengths of 2 ft are reached by this species.

No collections or records of this species were obtained in the freshwaters of Connecticut.

Mugil curema Valenciennes—white mullet—possible visitor from saltwater

The white mullet has approximately the same general distribution as the striped mullet.

This species is similar in appearance to the striped mullet, differing in the following ways: it lacks the longitudinal lines on the sides, and the soft dorsal and anal fins are scaly. There are 12 elements in the anal fin;



the secondary teeth are simple. Lengths of about 2 ft are reached by this species.

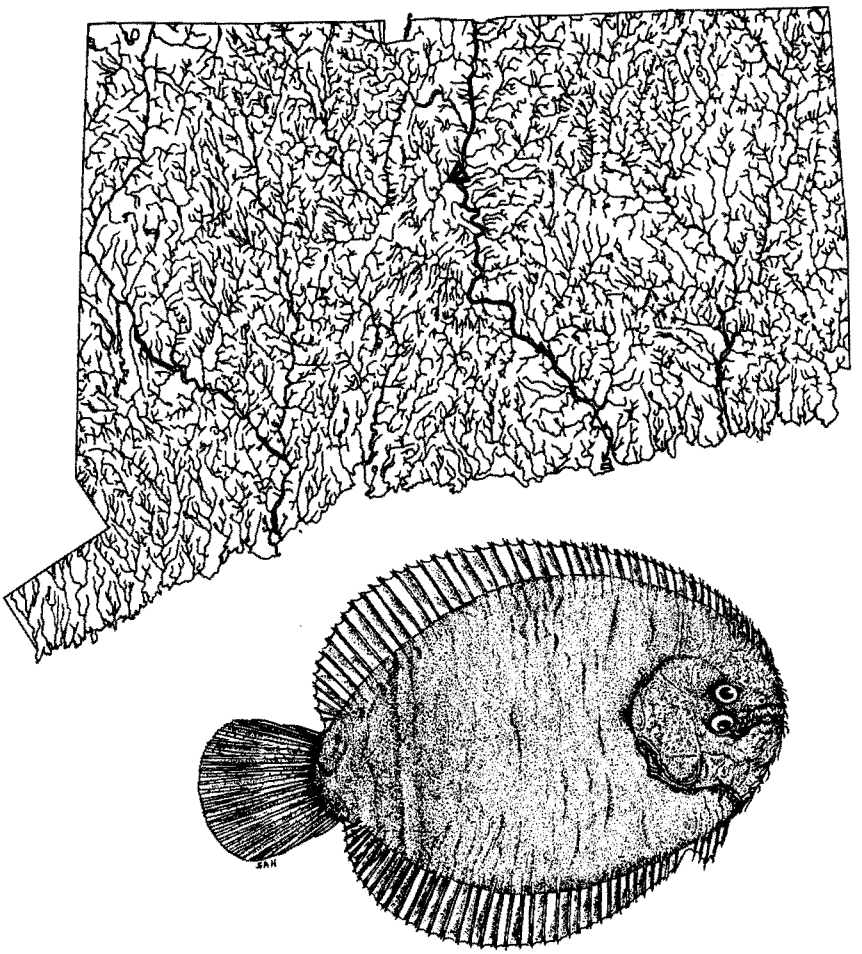
Family Soleidae: soles

Approximately 127 species are found in the saltwaters, brackish waters, and occasionally in the freshwaters of the world. One species may enter the freshwaters of Connecticut.

Trinectes maculatus (Bloch and Schneider)—hogchoker—visitor from saltwater

The hogchoker is found in brackish waters, saltwaters, and occasionally in coastal freshwaters from Maine to Panama. The triangles plotted are from Ayres (1842-1843) and BOL.

This species is olivaceous with vertical bars on the eyed side and whitish on the blind side. It is right handed, has no pectoral fins, and the



right pelvic fin is continuous with the anal fin. Specimens reach lengths up to about 10 in.

DISCUSSION OF METHODS

The collecting methods used in this investigation work well in shallow streams, the type of area sampled. However, they are not adequate for collecting in the deep-water areas of rivers, especially where the rivers enter the sea, or in the deeper parts of lakes, ponds, and impoundments. The use of other collecting techniques, such as trap netting, gill netting, night seining, poisoning, and more extensive electrofishing would more fully document the distributions reported. We were not able to use these methods because of the time factor and, to some extent, the cost. These techniques should be fully exploited in future work.

Differences in collection methods caused the discrepancies between

Table 6.—Check list of the fishes that have been found or may be found in the freshwaters of Connecticut

NATIVE FISH

Lampetra lamottei—American brook lamprey
Prosopium cylindraceum—round whitefish
Salvelinus fontinalis—brook trout
Esox americanus—redfin pickerel
Esox niger—chain pickerel
Exoglossum maxillingua—cutlips minnow
Notemigonus crysoleucas—golden shiner
Notropis bifrenatus—bridled shiner
Notropis cornutus—common shiner
Notropis hudsonius—spottail shiner
Pimephales notatus—bluntnose minnow
Rhinichthys atratulus—blacknose dace
Rhinichthys cataractae—longnose dace
Semotilus atromaculatus—creek chub
Semotilus corporalis—fallfish
Semotilus margarita—pearl dace
Catostomus commersoni—white sucker
Erimyzon oblongus—creek chubsucker
Ictalurus nebulosus—brown bullhead
Percopsis omiscomaycus—trout perch
Lota lota—burbot
Fundulus diaphanus—banded killifish
Cottus cognatus—slimy sculpin
Enneacanthus obesus—banded sunfish
Lepomis auritus—redbreast sunfish
Lepomis gibbosus—pumpkinseed
Etheostoma fusiforme—swamp darter
Etheostoma olmstedi—tessellated darter
Perca flavescens—yellow perch

VISITORS FROM SALTWATER

Brevoortia tyrannus—Atlantic menhaden
Strongylura marina—Atlantic needlefish
Microgadus tomcod—tomcod
Trinectes maculatus—hogchoker

POSSIBLE VISITORS FROM SALTWATER

Anchoa mitchilli—bay anchovy
Cyprinodon variegatus—sheepshead minnow
Fundulus majalis—striped killifish
Lucania parva—rainwater killifish
Syngnathus fuscus—northern pipefish
Mugil cephalus—striped mullet
Mugil curema—white mullet
Gasterosteus aculeatus—threespine stickleback
Menidia menidia—Atlantic silverside

INTRODUCED FISH

Amia calva—bowfin
Oncorhynchus nerka—kokanee
Salmo gairdneri—rainbow trout
Salmo trutta—brown trout
Salvelinus mamaycush—lake trout
Esox lucius—northern pike
Campostoma anomalum—stoneroller
Cyprinus carpio—carp
Carassius anatus—goldfish
Leuciscus idus—golden orfe
Pimephales promelas—fathead minnow
Tinca tinca—tench
Ictalurus catus—white catfish
Ictalurus melas—black bullhead
Ictalurus punctatus—channel catfish
Culaea inconstans—brook stickleback
Ambloplites rupestris—rock bass
Lepomis cyanellus—green sunfish
Lepomis macrochirus—bluegill
Micropterus dolomieui—smallmouth bass
Micropterus salmoides—largemouth bass
Pomoxis annularis—white crappie
Pomoxis nigromaculatus—black crappie
Stizostedion vitreum—walleye

AMPHIDROMOUS FISH

Fundulus heteroclitus—mummichog
Menidia beryllina—tidewater silverside
Apeltes quadracus—fourspine stickleback
Pungitius pungitius—ninespine stickleback
Morone americana—white perch
Morone saxatilis—striped bass

CATADROMOUS FISH

Anguilla rostrata—American eel

ANADROMOUS FISH

Petromyzon marinus—sea lamprey
Acipenser oxyrhynchus—Atlantic sturgeon
Alosa sapidissima—American shad
Alosa aestivalis—blueback herring
Alosa pseudoharengus—alewife
Osmerus eperlanus—rainbow smelt

POSSIBLY ANADROMOUS OR ONCE ANADROMOUS

Acipenser brevirostris—shortnose sturgeon
Salmo salar—Atlantic salmon
Alosa mediocris—hickory shad

Table 6, *continued*

FRESHWATER FISHES REPORTED IN WATERSHEDS IN CONNECTICUT OR WATERSHEDS ADJACENT TO CONNECTICUT AND WHICH MAY BE FOUND IN CONNECTICUT

Umbra pygmaea (DeKay): Long Island, New York, (Greeley, 1939).

Chrosomus eos Cope: Connecticut River watershed, Massachusetts, (McCabe, 1942); upper Connecticut River watershed, New Hampshire (Baily and Oliver, 1939; Carpenter and Siegler, 1947); Mohawk-Hudson River watershed, New York (Greeley, 1935); upper Hudson River watershed, New York (Greeley, 1933).

Chrosomus neogaeus (Cope): upper Hudson River watershed, New York (Greeley, 1933).

Hybognathus hankinsoni Hubbs: Mohawk-Hudson River watershed, New York (Greeley, 1935); upper Hudson River watershed, New York (Greeley, 1933).

Hybognathus nuchalis Agassiz: Connecticut River watershed, New Hampshire (Baily and Oliver, 1939; Carpenter and Siegler, 1947); lower Hudson River watershed, New York (Greeley, 1937); Mohawk-Hudson River watershed, New York (Greeley, 1935); upper Hudson River watershed, New York (Greeley, 1933).

Hybopsis plumbea (Agassiz): Connecticut River watershed, Massachusetts (McCabe, 1942; McCabe, unpublished data); Connecticut River watershed, New Hampshire (Baily and Oliver, 1939; Carpenter and Siegler, 1947); upper Hudson River watershed, New York (Greeley, 1933).

Notropis amoenus (Abbott): lower Hudson River watershed, New York (Greeley, 1937); Mohawk-Hudson River watershed, New York (Greeley, 1935).

Notropis analostamus (Girard): lower Hudson River watershed, New York (Greeley, 1937); Mohawk-Hudson River watershed, New York (Greeley, 1935).

Notropis atherinoides Rafinesque: Mohawk-Hudson River watershed, New York (Greeley, 1935); upper Hudson River watershed, New York (Greeley, 1933).

Notropis heterodon (Cope): upper Hudson River watershed, New York (Greeley, 1933).

Notropis heterolepis Eigenmann and Eigenmann: upper Hudson River watershed, New York (Greeley, 1933).

Notropis spilopterus (Cope): lower Hudson River watershed, New York (Greeley, 1937); Mohawk-Hudson River watershed, New York (Greeley, 1935); upper Hudson River watershed, New York (Greeley, 1933).

Notropis rubellus (Agassiz): lower Hudson River watershed, New York (Greeley, 1933); Mohawk-Hudson River watershed, New York (Greeley, 1935); upper Hudson River watershed, New York (Greeley, 1933).

Notropis volucellus (Cope): Connecticut River watershed, Massachusetts (McCabe, personal communication).

Catostomus catostomus (Forster): Housatonic River watershed and Connecticut River watershed, Massachusetts (McCabe, 1942, 1946, and McCabe, unpublished data); lower Hudson River watershed, New York (Greeley, 1937); Mohawk-Hudson River watershed, New York (Greeley, 1935); upper Hudson River watershed, New York (Greeley, 1933).

Hypentelium nigricans (LeSueur): lower Hudson River watershed, New York (Greeley, 1937); Mohawk-Hudson River watershed, New York (Greeley, 1935).

Ictalurus natalis (LeSueur): Hudson River watershed, New York (Greeley, 1933, 1935, 1937); Thames River watershed, Massachusetts (McCabe, 1946); Connecticut River watershed, Massachusetts (McCabe, 1942); Connecticut River watershed, New Hampshire (Carpenter and Siegler, 1947; Rostlund, 1952).

Noturus flavus Rafinesque: Hudson River watershed, New York (Greeley, 1933, 1935; Rostlund, 1952).

Table 6, *concluded*

Noturus gyrinus (Mitchill): Hudson River watershed, New York (Greeley, 1933, 1935, 1937); Connecticut River Watershed, Massachusetts (McCabe, 1946).
Noturus insignis (Richardson): Hudson River watershed, New York (Greeley, 1935, 1937).
Aphredoderus sayanus (Gilliams): Long Island (Ayers, 1842-1843; Greeley, 1939).
Labidesthes sicculus (Cope): Hudson River watershed, New York (Greeley, 1935).
Acantharchus pomotis (Baird): Hudson River estuary (Greeley, 1937).
Chaenobryttus gulosus (Cuvier): Hudson River watershed, New York (Greeley, 1937).
Enneacanthus gloriosus (Holbrook): Hudson River watershed, New York (Greeley, 1937).
Etheostoma blennioides Rafinesque: Hudson River watershed, New York (Greeley, 1935).
Etheostoma flabellare Rafinesque: Hudson River watershed, New York (Greeley, 1935).
Percina caprodes (Rafinesque): Hudson River watershed, New York (Greeley, 1933, 1935, 1937).
Percina peltata (Stauffer): Hudson River watershed, New York (Greeley, 1937).

distributions recorded in previous surveys, mainly by the Connecticut Board of Fisheries and Game, and those reported in this survey. In the surveys reported by that Board, gill and trap nets, as well as electrofishing in ponds and lakes, were the chief techniques used. Because the Board has made surveys of the state's lakes and ponds for many years, the overall freshwater distributions shown for most species are probably complete. The main area in which all surveys appear to be incomplete is the saltwater-freshwater mixing zone. More work in this area would make possible a more complete delineation of the distributions of visitors from saltwater and document the inclusion of some that are listed in this bulletin as possibly being such visitors.

DISCUSSION OF DISTRIBUTIONS

The freshwater-fish fauna of Connecticut (table 6) has been divided into three groups based on the movements of the fish to the freshwaters of Connecticut; native (by way of freshwaters), introduced (man's activities), and closely associated with the sea (anadromous, possibly anadromous or once anadromous, catadromous, amphidromous, and visitor from saltwater). There are 29 native species, 24 introduced species, and 20 species closely related to the sea. Adding the 9 species of possible visitors from saltwater to the last group, makes each major category of almost equal importance as a contributor to the freshwater-fish fauna. Introduced species and species closely associated with the sea could be distributed in any watershed of the state because the former are controlled by man and the latter are not restricted by saltwater. Distributions of native species of fishes were interpreted by studying individual species-distribution maps, and calculating the percentage of species common to two watersheds (number of species common/total number of species in both watersheds).

Table 7.–Percentages of native species common to the major watersheds

Hudson–western coastal	55	Thames–eastern coastal	86
Hudson–Housatonic	50	Thames–Pawcatuck	82
Hudson–Quinnipiac	53	Thames–Quinnipiac	77
Hudson–Connecticut	46	Quinnipiac–eastern coastal	80
Hudson–central coastal	53	Quinnipiac–Pawcatuck	84
Hudson–Thames	48	eastern coastal–Pawcatuck	95
Hudson–eastern coastal	48	all coastal, Pawcatuck, and	
Hudson–Pawcatuck	50	Quinnipiac–western coastal	
western coastal–Housatonic	76	and Housatonic	79
western coastal–Quinnipiac	77	all coastal, Pawcatuck, and	
western coastal–Connecticut	73	Quinnipiac–Connecticut,	
western coastal–central coastal	73	Quinnipiac, and central coastal	71
western coastal–Thames	76	all coastal, Pawcatuck, and	
western coastal–eastern coastal	71	Quinnipiac–eastern coastal,	
western coastal–Pawcatuck	67	Pawcatuck, and Thames	84
Housatonic–Quinnipiac	71	western coastal and Housatonic–	
Housatonic–Connecticut	81	Connecticut, Quinnipiac, and	
Housatonic–central coastal	68	central coastal	79
Housatonic–Thames	76	western coastal and Housatonic–	
Housatonic–eastern coastal	65	eastern coastal, Pawcatuck,	
Housatonic–Pawcatuck	62	and Thames	71
Connecticut–central coastal	70	Connecticut, Quinnipiac, and	
Connecticut–Thames	88	central coastal–eastern coastal,	
Connecticut–eastern coastal	71	Pawcatuck, and Thames	84
Connecticut–Pawcatuck	75	Connecticut–all coastal,	
Connecticut–Quinnipiac	74	Pawcatuck, and Thames	74
central coastal–Thames	73	Housatonic–all coastal,	
central coastal–eastern coastal	75	Pawcatuck, and Quinnipiac	71
central coastal–Pawcatuck	83	Thames–all coastal, Pawcatuck,	
central coastal–Quinnipiac	94	and Quinnipiac	84

Both the distribution maps and percentages of common species (table 7) show that most species of native fishes are widely distributed throughout the state. The percentages of native species common between the major watersheds are very high, except where one of the watersheds is the Hudson. Relationships between the Hudson and all other watersheds are similar (46-55 percent). The probable reasons for these lower percentages of common species are the small number of collecting sites in the Hudson drainage and the fact that most of them are in headwater areas. The number of collecting sites in other watersheds is large and the coverage of the habitats present is more complete. If the Hudson drainage is omitted, a comparison of the percentages of species common to the western (Housatonic and western-coastal), central (Connecticut, central-coastal, and Quinnipiac), and eastern (Thames, Pawcatuck, and eastern-coastal) regions of the state shows that there is a progressive increase from western to central (79 percent) and central to eastern (84 percent) and a decrease between the eastern and western regions

(71 percent). The reason for this difference is that some species (cutlips minnow, pearl dace, creek chub, and bluntnose minnow) entered from the west and are moving eastward and other species (banded sunfish and swamp darter) entered from the east and are apparently moving westward. The latter group is found in New York, usually in coastal streams close to New Jersey, and on Long Island, indicating a movement through freshwaters into Connecticut around the tip of Long Island, probably during the period when the coastal plain of Connecticut encompassed Long Island. There seems to be no valid reason why they did not move westward along the coast after entering Connecticut.

Movements of fishes into the freshwaters of Connecticut probably were along three routes: through freshwaters along the Atlantic coast east of the Appalachians, from the sea, and through freshwaters from the north. In addition, fishes have been introduced by man into Connecticut.

Movements of fishes along the Atlantic coast east of the Appalachians could have been in waters of low salt content when the glaciers were retreating, from coastal stream to coastal stream during floods and hurricanes, or by stream captures. Some freshwater fishes have a high degree of salt tolerance and may have moved from stream to stream by swimming a short distance through saltwater or brackish water. Redbreast sunfishes, swamp darters, tessellated darters, banded sunfishes, and redfin pickerels probably used one of these means to enter Connecticut.

Movements of fishes from the sea included those of fishes which require both saltwater and freshwater to complete their life histories (anadromous and catadromous fishes), irregular movements into freshwaters (visitors from saltwater), apparent free movements into both saltwater and freshwater (amphidromous fishes), and fishes that were recently derived from saltwater fishes (banded killifish and brook trout). Species that moved, or do move from the sea may have been in Connecticut before the glacial period and returned following glaciation or may have been southern species that moved north to Connecticut during a warm period following glaciation.

Movements of fishes from the north through freshwaters were probably through waterways that existed, or still exist, as part of the drainages of the St. Lawrence River, Great Lakes, and the Mississippi River. After the retreat of the Pleistocene ice, the movements of freshwater fishes were retarded and few of them returned from the north to the more isolated coastal rivers of Connecticut, although the cutlips minnow, fallfish, and bridled shiner moved from the east to the Great Lakes region. Only a few northern glacial relict species still remain in parts of Connecticut (slimy sculpin, round whitefish, burbot, and trout perch).

Regulated, unregulated, and accidental activities (by the Connecticut Board of Fisheries and Game, U.S. Soil Conservation Service, U.S. Fish and Wildlife Service, clubs, and individuals) have introduced fish for sport purposes (kokanee, rainbow trout, brown trout, lake trout, northern pike, black crappie, white catfish, channel catfish, rock bass, bluegill, smallmouth bass, largemouth bass, and walleye) and for bait (stoneroller and fathead minnow). Other species have been introduced accidentally along with another species (brook stickleback with fathead minnow, white crappie with black crappie, green sunfish with bluegill, black bull-

head with channel catfish or brown bullhead); others as pondfish (golden orfe, carp, goldfish, and tench), and some for no apparent reason —for example, the bowfin, a fish that has not been seen for many years.

Factors affecting the distribution of fishes in the freshwaters of Connecticut can be divided arbitrarily into physical (floods, hurricanes, waterfalls, crustal uplifts, stream captures, temperatures, and stream- and lake-hydrography), chemical (concentrations of dissolved substances and gases) and biological (competition for food and spawning areas, diseases, parasites, predation, and the activities of man).

Physical factors probably played an important role in the distribution of fishes in Connecticut. Flint's (1930) investigations showed that many of the state's streams and rivers were blocked at various points by glacial till or melting blocks of ice during the recessions of the glaciers, causing mixing of the waters of the following watersheds: the western coastal and Housatonic with the Hudson; the Connecticut with the Housatonic and Thames; the Thames with the Connecticut and Pawcatuck; numerous exchanges between the coastal streams also took place. The absence of certain bottom types, water-flow characteristics, and temperatures have probably restricted the distribution of certain fishes in Connecticut, for instance, slimy sculpin and brook trout. During floods and hurricanes the waters of adjacent low-gradient streams may have mixed and an exchange of fishes taken place.

Chemical factors—those which were measured during the present study and those of which records were found—seemed to have had little direct effect on the distributions of fishes.

Biological factors, especially the activities of man, appear to have had the greatest effect on the distribution of fishes. Fishing; poisoning waters to remove certain species of fish or plants; agriculture, construction, and industrial practices that add organic and inorganic compounds to the waters; the introduction of competitive, predatory, and forage species; the construction of dams, such as those in the Farmington and Quinnibaug Rivers, which restrict the movements of fishes and decrease the rate of water flow, allowing the water to become warm; the digging of canals; stream improvements—all these have had some effect on the distribution of fishes in Connecticut. The effect of effluents, industrial and domestic, are quite apparent in the Naugatuck River, in which a varied and large fish fauna was found above Torrington and virtually no fishes found south of that city. Siltation of spawning areas has definitely restricted the distribution of some species.

REFERENCES

Adams, C. C., and Hankinson, T. L., 1928, The ecology and economics of Oneida Lake fish: Roosevelt Wildlife Annals 1, p. 241-548.

American Public Health Association, American Water Works Association, and Water Pollution Control Federation, 1965, Standard Methods for the Examination of Water and Wastewater, 12th ed.: New York, Am. Pub. Health Assoc., Inc., 769 p.

Anderson, W. D., Jr., 1964, Fishes of some South Carolina coastal plain streams: Quart. Jour. Florida Acad. Sci., 27, p. 31-54.

Anderson, W., 1957, Early development, spawning, growth, and occurrence of the silver mullet (*Mugil curema*) along the South Atlantic coast of the United States: Fish and Wildlife Services Fisheries Bull. 57, p. 397-414.

———, 1958, Larval development, growth, and spawning of the striped mullet (*Mugil cephalus*) along the South Atlantic coast of the United States: Fish and Wildlife Service Fisheries Bull. 58, p. 501-519.

Atkins, C. G., 1874, On the salmon of eastern North America and its artificial culture: Rept. U.S. Fish Comm. for 1872-1873, p. 226-237.

AuClair, R. P., 1960 (reprinted 1964), White perch in Maine: Maine Dept. of Inland Fisheries and Game, 16 p.

Ayres, W. O., 1842-1843, Enumeration of the fishes of Brookhaven, Long Island, with remarks upon the species observed: Boston Jour. Nat. History, v. 4, p. 255-292.

———, 1843, Descriptions of four species of fish from Brookhaven, Long Island, all of which are believed to be new: Boston Jour. Nat. History, v. 4, p. 292-302.

———, 1845, An attempt to prove that *Cottus cognatus* of Richardson, *Cottus viscosus* of Haldeman, and *Uranidea quiescens* of DeKay, are one species, and are identical with *Cottus gobio* of Linnaeus: Boston Jour. Nat. History, v. 5, p. 116-136.

Backus, R. H., 1953, The marine and freshwater fishes of Labrador: Unpub. Ph.D. dissert., Cornell Univ.

Bailey, R. M., Lachner, E. A., Lindsey, C. C., Robins, C. R., Roedal, P. M., Scott, W. B., and Woods, L. P., 1960, A list of common and scientific names of fishes from the United States and Canada: Am. Fisheries Soc. Spec. Pub. 2, 102 p.

Behnke, R. J., and Wetzel, R. M., 1960, A preliminary list of the fishes found in the fresh waters of Connecticut: Copeia 1960, p. 141-143.

Berry, F. H., and Rivas, L. R., 1962, Data on six species of needlefishes (Belonidae) from the western Atlantic: Copeia 1962, p. 152-160.

Bigelow, H. B., and Schroeder, W. C., 1953, Fishes of the Gulf of Maine: Fish and Wildlife Service Fisheries Bull. 53, 577 p.

Booth, R. A., 1967, Post larval development and spawning ecology of the tomcod, *Microgadus tomcod*: Unpub. Ph.D. dissert., Univ. of Connecticut.

Boschung, H. T., and Hemphill, A. F., 1960, Marine fishes collected from inland streams of Alabama: Copeia 1960, p. 73.

Brown, J. L., 1957, A key to the species and subspecies of the cyprinodont genus *Fundulus* in the United States and Canada east of the continental divide: Jour. Wash. Acad. Sci., 47(3), p. 69-77.

Bulkley, R. V., 1963, Natural variation in spotting, hyoid teeth counts, and coloration of yellowstone cutthroat trout *Salmo clarki lewisi* Girard: U.S.D.I. Spec. Sci. Rept. Fisheries no. 460, 11 p.

Buss, K., 1965, *In* A. J. McClane (ed.), McClane's Standard Fishing Encyclopedia and International Angling Guide: New York, Holt, Rhinehart and Winston, p. 389, 715.

Carpenter, R. G., and Siegler, H. R., 1947, A sportsman's guide to the fresh-water fishes of New Hampshire: New Hampshire Fish and Game Comm., 87 p.
Cole, C. F., 1965, Additional evidence for separation of *Etheostoma olmstedi* Storer from *Etheostoma nigrum* Refinesque: Copeia 1965, p. 8-13.
Collette, B. B., 1962, The swamp darters of the subgenus *Hololepis* (Pisces, Percidae): Tulane Studies in Zool, v. 9(4), p. 115-211.
Connecticut State Board of Fisheries and Game, 1942, A fishery survey of important Connecticut lakes: Connecticut Geol. Nat. Hstory Survey Bull. 63, 339 p.
——, 1959, A fishery survey of the lakes and ponds of Connecticut: Hartford, Connecticut State Board of Fisheries and Game, 395 p.
Connecticut Wildlife Conservation Bulletin, 1958a, Fisheries highlights of 1957: Connecticut Wildlife Conserv. Bull. 4(2), p. 5.
——, 1958b, New catfish in Connecticut: Connecticut Wildlife Conserv. Bull. 4(5), p. 8.
——, 1961, Sunfishes. Part 14, Wildlife of Connecticut: Connecticut Wildlife Conserv. Bull. 7(4), p. 5.
——, 1962. Striped bass. Part 20, Wildlife of Connecticut: Connecticut Wildlife Conserv. Bull. 8(4), p. 4.
——, 1965, White catfish. Part 36, Wildlife of Connecticut: Connecticut Wildlife Conserv. Bull. 11(2), p. 4.
Crossman, E. J., 1966, A taxonomic study of *Esox americanus* and its subspecies in eastern North America: Copeia 1966, p. 1-20.
Darlington, P. J., Jr., 1957, Zoogeography: the Geographical Distribution of Animals: New York, John Wiley and Sons, 675 p.
Dean, B., 1917, A Bibliography of Fishes: New York, Russell and Russell, Inc., 3 v.
Deevey, E. S., Jr., and Bishop, J. S., 1942, Limnology. *In* A fishery survey of important Connecticut lakes: Connecticut Geol. Nat. History Survey Bull. 63, p. 69-121.
DeKay, J. E., 1842, Fishes. *In* Zoology of New York: The New York fauna: Albany, Thurlow Weed, 415 p.
DeSylva, D. P., 1965, *In* A. J. McClane (ed.), McClane's Standard Fishing Encyclopedia and International Angling Guide: New York, Holt, Rinehart and Winston, p. 93, 353, 396, 579-580, 617.
DeSylva, D. P., Kalber, F. A., Jr., and Shuster, C. H., Jr., 1962, Fishes and ecological conditions in the shore zone of the Delaware River Estuary, with notes on other species collected in deeper water: Univ. Delaware Marine Lab. Information Ser. Pub. 5, 164 p.
Dobie, J., Meehan, O. L., Snieszko, S. F., and Washburn, G. N., 1956, Raising bait fishes: U.S.D.I., Fish and Wildlife Service Circ. 35, 124 p.
Ebeling, A. W., 1961, *Mugil galapagensis*: A new mullet from the Galapagos Islands with notes on related species and a key to the Mugilidae of the eastern Pacific: Copeia 1961, p. 295-304.
Eddy, S., 1957, How to Know the Freshwater Fishes: Dubuque, Iowa, William C. Brown, 253 p.
Flint, R. F., 1930, The glacial geology of Connecticut: Connecticut Geol. Nat. History Survey Bull. 47, 294 p.
Fowler, H. W., 1907, A supplemental account of the fishes of New Jersey: Ann. Rept. New Jersey State Museum, Part III, p. 251-350.
Galligan, J. P., 1960, History of the Connecticut River sturgeon fishery: Connecticut Wildlife Conserv. Bul. 6(1), 12 p.
Gerald, J. W., 1966, Food habits of the longnose dace *Rhinichthys cataractae*: Copeia 1966, p. 478-485.

Nichols, P. R., 1966, The striped bass: U.S. Fish and Wildlife Serv. Fishery Leaflet 592, 6 p.

Pearcy, W. G., and Richards, S. W., 1962, Distribution and ecology of fishes of the Mystic River estuary, Connecticut: Ecology, v. 43, p. 248-259.

Raney, E. C., 1940, Breeding behavior of the common shiner. *Notropis cornutus* (Mitchill): Zoologica, v. 25, p. 1-13.

Rostlund, E., 1952, Freshwater fish and fishing in native North America: Univ. California Pub. in Geography, v. 9, 314 p.

Saila, S. B., and Horton, D., 1957, Fisheries investigations and management in Rhode Island lakes and ponds: Rhode Island Div. of Fish and Game, Fisheries Pub. 3, 134 p.

Shapior, S., 1947, Geographic variation in *Fundulus diaphanus*, a cyprinodontid fish: Unpub. Ph.D. dissert., Univ. of Michigan.

Sterba, G., 1963, Freshwater fishes of the world: New York, Viking Press, 878 p.

Storer, D., 1842, Descriptions of two new species of fishes: Boston Jour. Nat. History, v. 4, p. 58-62.

Tagatz, M. E., and Dudley, D. L., 1961, Seasonal occurrence of marine fishes in four shore habitats near Beaufort, North Carolina, 1957-60: U.S. Fish and Wildlife Service Spec. Sci. Rept., Fisheries 390, 19 p.

Thorpe, L. M., 1942, Fishery management, *In* A fishery survey of important Connecticut lakes: Connecticut Board of Fisheries and Game, Connecticut Geol. Nat. History Survey Bull. 63, p. 15-68, 289-295, 299-335.

Trautman, M. B., 1957, The Fishes of Ohio: Columbus, Ohio State University Press, 683 p.

Underhill, J., 1961, Intra-specific variation in the common shiner, *Notropis cornutus frontalis* (Agassiz) from Minnesota and South Dakota: Proc. Minn. Acad. Sci., v. 29, p. 259-266.

Vladykov, V. D., 1960, Description of young ammocoetes belonging to two species of lampreys: *Petromyzon marinus* and *Entosphenus lamottenii*: Jour. Fisheries Restarch Board of Canada, v. 17, p. 267-288.

Vladykov, V. D., and Greeley, J. R., 1963, Order Acipenseroidei, *In* Fishes of the western North Atlantic, Pt. 3, Sears Found. for Marine Research, Yale Univ., p. 24-60.

Webster, D. A., 1942, The life histories of some Connecticut fishes, *In* A fishery survey of important Connecticut lakes: Connecticut Board of Fisheries and Game, Connecticut Geol. Nat. History Survey Bull. 63, p. 122-227.

Westman, T. H., 1938, Studies on the reproduction and growth of the fathead minnow: Copeia 1938, p. 57-61.

Young, K. M., 1950, Observations on the distribution of the genus *Fundulus* in the upper Chesapeake Bay: Unpub. M. S. Thesis, Univ. of Maryland.

INDEX