A STUDY OF THE STREAM OCCURRENCE OF PROSOPIUM CYLINDRACEUM IN THE UPPER GREAT LAKES REGION WITH SPECIAL REFERENCE TO MICHIGAN'S AUSABLE RIVER

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ABSTRACT

A STUDY OF THE STREAM OCCURRENCE OF
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by Stanton J. Kleinert

This investigation was undertaken to assess the potential of the round whitefish, P. cylindraceum as a sports fisheries species in the Great Lakes Region. Since the species is usually available to the fisherman's hook only during shoreward or stream migrations from the Great Lakes or when living as a permanent resident within streams, the study has been confined to streams. Presently the species is an almost negligible constituent of the upper Great Lakes commercial fisheries. Round white fish are, however, of interest to sports fishermen in at least two localities including Michigan's AuSable River and the south eastern Lake Superior shore line and tributaries.

The investigation is dichotomous in nature dealing with two populations of round white fish: the permanent stream residents of the AuSable River and the migratory stream residents of the upper Great Lakes.

Ecological observations and specimen collections were made of the permanent stream population of the AuSable River during the spring, summer, and fall of 1961. Length and age information was obtained from scale samples of 10 adult fish taken from the river population. Morphometric measures were performed on four of the adult fish and compared statistically with a sample of 10 adult P. cylindraceum from Lake Huron secured by Koelz(1929).

The stream population of migratory P. cylindraceum was studied indirectly by means of library research, the aid of the Michigan Conservation

Department, and frequent correspondence and interviews with a number of persons. The main purpose of the study of the migratory fish being the assessment of the distribution, numbers of participant fish, and times of occurrence of the stream migrations from the lakes.

The study confirmed the opinion held by Hubbs and Lagler (1958) that P. cylindraceum of the AuSable River represents the only permanent stream population of the species known to occur within the entire Great Lakes Drainage. The species was known to occur in the river before the turn of the century and without question immigrated from Lake Huron populations. The limited morphometric evidence secured by the study suggests that populations of AuSable River and Lake Huron round whitefish differ morphometrically. Physiological differences in tolerances might also be expected to occur between populations of fish separated by environments as diverse as the lake and stream conditions of existance.

The study revealed the AuSable River round whitefish to grow rapidly, reaching the adult size of 13 to 15 inches total length in three years time with considerable growth occurring throughout the year. The river fish appear to be resistant to fishing pressure and have been reported to have maintained their numbers successfully over a number of years. The environmental preferences of the stream fish are similar to the preferences of trout with the exception that P. cylindraceum seems to require a greater minimum volume of water for existence.

The desirable qualities of the AuSable River stream dwelling species may recommend the fish for propagation in new streams in the future but such action is unlikely since the species has been shown to be competitive with trout (Rawson and Elsey 1948). The real future of P. cylindraceum as a sports fisheries species is probably related to

the migratory lake populations.

The abundant evidence of stream migrations into a number of tributaries of Lake Superior and the knowledge of shoreward movements during the spring and fall in Lake Huron and in Lake Michigan suggest that the stream migration of P. cylindraceum may be a general phenomenon occurring wherever lake populations are encountered. The time of the streamward migrations in Lake Superior have been established to occur during the spring and during the fall where there is sufficient flow. The number of fish taking part in the migrations is not known, however, sufficient numbers of P. cylindraceum are reported to aggregate in the vicinity of Michigan's Two Hearted River to support a moderate spring and fall recreational fishery. The writer believes that future investigation will reveal a number of additional locations in the upper Great Lakes Region that will support a recreational fishery for the species.

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CHAPTER I

INTRODUCTION

The purpose of this study is to investigate the stream occurrence of the round whitefish, Prosopium cylindraceum, in the Great Lakes Region. The study investigates the natural history of the stream dwelling races of the species and focuses on distributional, morphological, ecological, growth, and economic considerations. The investigation is dichotomous in nature dealing with two populations of round whitefish: the permanent stream residents of the AuSable River and the migratory stream residents of the Upper Great Lakes.

This investigation was originally undertaken to assess the potential of P. cylindraceum as a sport fish in the Great Lakes Region. Since the species is usually available to the fisherman's hook only during inshore or upstream migrations from the Great Lakes or when living as a permanent resident within streams the writer has confined the study to streams.

Currently the very close relative of the round whitefish, the mountain whitefish, P. williamsoni of the Rocky Mountain Region is a valuable and economically important species sought by recreational fishermen of the West. The close similarity of P. cylindraceum and P. williamsoni would suggest that the round whitefish could also come to play an important role in the sports fishery. If round whitefish are found to be widely distributed, abundant, and acceptable to sports fishermen of the Great Lakes Region then an additional resource would be available which has only begun to be realized.

This paper will not deal with all aspects of the natural history of P. cylindraceum, but will concentrate on several specific areas accessible to the writer. These specific areas include: I. The genus Prosopium, II. Distribution of P. cylindraceum in the Great Lakes Region, III. Stream distribution of P. cylindraceum in the AuSable River, IV. The distribution of P. cylindraceum applied to the concept of limiting factors, V. Morphometric studies of AuSable River and Lake Huron samples of P. cylindraceum, VI. Notes on the life history of P. cylindraceum, VII. Length and age measures of P. cylindraceum, and VIII. The economic potential of P. cylindraceum in the Great Lakes Region.

In spite of an extensive distribution extending for several thousand miles from eastern United States to central Siberis, P. cylindraceum remains little known. Much of our meager knowledge of P. cylindraceum has resulted incidentally to studies centered about economically more important species. In 1960 Dr. W. B. Scott, Curator of Fishes of the Royal Ontario Museum published a paper summarizing the current information of P. cylindraceum and P. williamsoni. This valuable publication further reveals the need for work in many areas of the natural history of the fish. Especially lacking, has been knowledge concerning the stream occurrence and migratory behavior of the species.

Material for the present study has been obtained during a series of weekend collecting expeditions to the AuSable River extending through the spring, summer, and fall of 1961. Additional data has been secured through the Michigan Department of Conservation; whose field workers provided new round whitefish distribution information. Library research has been carried on at The University of Michigan Museum of Zoology.

Time permitting, the writer would have investigated several tributaries of the Upper Great Lakes during the spring and fall movements of the species. Such information would have been valuable in establishing the extent and the magnitude of the round whitefish fisheries resources.

In spite of the time limitation a base of information, concerning the stream occurrence of P. cylindraceum, has been secured and hopefully may lead to increased interest and further research.

CHAPTER II

REPORT OF THE STUDY

I. THE GENUS PROSOPIUM

Characteristics of the genus

The taxonomy of the whitefishes is a difficult area of study due to the morphological variability of the group. Individuals within a species frequently vary from one body of water to another and often vary considerably in the same body of water (Dymond and Hart 1927, Hart 1931). It is of little wonder that considerable synonomy and many differences of opinion have arisen during the history of Coregonine classification.

Fortunately a serious attempt has been made to resolve taxonomic confusion among the North American fishes by the work of the American Fisheries Society Committee on Common and Scientific Names of Fishes during 1959. The committee has ruled that the whitefishes are not sufficiently different from the trouts to warrant a family status. The whitefishes then comprise the subfamily Coregoninae within the family Salmonidae. The committee recognizes three genera in the subfamily Coregoninae, the genus Coregonus, the genus Prosopium, and the genus Stenodus.

The main characters of the genera comprizing the subfamily Coregoninae have been summarized by Dymond (1947). The genus Coregonus has toothless jaws, two flaps between the nostrils, and a somewhat compressed body form. The genus Prosopium displays toothless jaws, a

single flap between the nostrils, and a subterere body form. Fishes of the genus Stenodus possess jaws, vomer, palatines, and tongue with bristle-like teeth and have a long maxillary and prominent lower jaw.

Other characters serve to distinguish the genus Prosopium. Walters (1955) noted that juvenile Prosopium have parr marks (absent in Coregonus), and that Prosopium is not known to hybridize with either Stenodus or Coregonus. Nordon (1958) discovered that members of the genus Prosopium retain a basibranchial plate as do the members of the trout family. The discovery of the basibranchial plate in Prosopium has led Nordon to suggest that the genus comprises the most primitive group of whitefishes and bears a close relationship to the trout-like precursor of the present Salmoninae and Coregoninae subfamilies of fishes.

Species within the genus Prosopium

The American Fisheries Society (1960) recognizes six species within the genus Prosopium. Three of the species, the Bear Lake whitefish, Prosopium abyssicola (Snyder), the Bonneville cisco, P. gemmiferum (Snyder), and the Bonneville whitefish, P. spilonotus (Snyder) are confined to Bear Lake, Idaho and Utah. Bear Lake is part of the Great Salt Lake Drainage that was formerly part of the ancient Lake Bonneville in the Columbia River System. Snyder (1919) believed the Prosopium of Bear Lake to represent an ancient and isolated fish fauna. The remaining species of Prosopium have a wide distribution and include the mountain whitefish, P. williamsoni (Girard), the round whitefish, P. cylindraceum (Pallas), and the pygmy whitefish, P. coulteri (Eigenmann and Eigenmann). The mountain whitefish is found predominantly in the streams of western North America confined to Washington, Oregon,

Idaho, Nevada, Colorado, Wyoming, Montana, British Columbia and western Alberts (Scott 1960). The round whitefish is restricted to lakes and infrequently found in streams extending from the states of Maine, New York, and Connecticut, from Labrador and Quebec, southward to New Brunswick and westward through all provinces to northern British Columbia, the Northwest Territories, throughout the Great Lakes (except Lake Erie), Alaska, and westward through the Bering Sea Drainage of Siberia (Hubbs and Lagler 1958, Scott 1960). Prosopium coulteri is found in isolated places along the Pacific Slope of northern North America and in Lake Superior (Hubbs and Lagler 1958).

The occurrence of all six species of Prosopium in North America, while only P. cylindraceum extends into Siberia, suggests that the genus originated in North America and has only recently entered Siberia. Another interesting zoogeographical problem concerns the discontinuous distribution of P. coulteri. A gap of approximately 1100 miles separates the Lake Superior and Pacific Slope occurrence of P. coulteri providing an unsolved mystery to ichthyologists (Eschmeyer and Bailey 1955).

The similarity of P. cylindraceum and P. Williamsoni

There is an impressive similarity of ecological preference, morphology and behavior between round whitefish and mountain whitefish. The characters which are used to separate the two fish are variable (Dymond 1943, McHugh 1939) and complicate the species classification. Holt (1960) used analysis of variance procedures on a number of specimens and concluded that P. cylindraceum is distinguishable from P. williamsoni.

Until recently the two species were believed to be separated geographically. In 1961 McGill reported observing distinct populations of round whitefish and mountain whitefish occupying the same area of the Liard River of British Columbia.[1] According to McGill the two species could be readily distinguished and interbreeding was not in evidence. McGill also indicated an environmental difference in preference between the two species although they were often found together. The mountain whitefish, P. williamsoni, preferred the swift, turbulent waters of the river while the round whitefish, P. cylindraceum, seemed to inhabit the pool areas. The mountain whitefish had pointed upturned snouts, while the round whitefish did not show this character. McGill reported observing the mountain whitefish overturning small stones with the aid of the pointed snout in search of aquatic insects.

It is generally agreed that P. cylindraceum and P. williamsoni constitute definite and distinct species. The two species are closely related, however, and past research performed on P. williamsoni may prove instructive to our present understanding of P. cylindraceum. Frequent reference will be made to the mountain whitefish of the West during the ensuing discussions of this paper.

II. DISTRIBUTION OF P. CYLINDRACEUM IN THE GREAT LAKES REGION

Permanent populations

Hubbs and Lagler (1958) described the species as occurring in the Great Lakes, including Lake Nipigon but excluding Lake Erie, and in the

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[1]Mr. D. McGill was part of an ichthylogical survey party from the University of British Columbia collecting in the Liard River system during the summer of 1961. The information was obtained during a conversation with Mr. McGill in Ann Arbor, Michigan in September 1961.

AuSable River of Michigan. The permanent stream occurrence of the species may possibly be extended to include the Two Hearted River of Michigan's Upper Peninsula and the St. Mary's River joining Lake Superior and Lake Huron. Round whitefish have been reported to occur in the Two Hearted and St. Mary's Rivers, but are suspected to be transient populations from the lakes. Future study is necessary to reveal whether the round whitefish of these two rivers are permanent or migratory populations.

Migratory stream penetrations

An interesting and unexplored area of investigation has been the streamward migration of round whitefish from the Great Lakes. Limited evidence suggests that fall and spring shoreward movements and streamward migrations occur wherever lake populations of the species are encountered. The numbers of fish participating in upstream migrations and the number of streams penetrated is presently unknown, but the available evidence suggests that the larger streams throughout the Upper Great Lakes are entered and that great numbers of round whitefish participate.

Mr. L. R. Anderson, the District Four Fisheries Supervisor of the Michigan Conservation Department, has noted spring and fall stream migrations of Lake Superior populations of round whitefish by the number of fishermen that gather near the river mouths to catch the species[2]. Mr. Anderson terms these migrations the spring feeding run and the fall

[2]Mr. Anderson provided the information, through correspondence written in answer to the writer's inquiries, during the fall of 1961.

spawning run. During the spring the run seems to be spread out along the entire coast, the fish are said to be smaller in size, and the fish do not swim as far up the streams. During the fall the migration is more concentrated around the stream mouths, the fish are larger, and the fish penetrate further upstream. During the recent fall run Mr. Anderson estimated that 2000 or more round whitefish were caught by sport fishermen in the vicinity of the mouth of the Two Hearted River by October 23, 1961. Often smaller streams are accessible to the spring run because of increased water levels, while low fall water levels in smaller streams prevent the fall migration.

Mr. Anderson has noted the occurrence of spring and fall migrations in a number of streams located in Alger, Luce, and Chippewa Counties of Michigan. Mr. D. Curry of the Michigan Department of Conservation has reported numbers of round whitefish at the mouth of the Presque Isle and Carp Rivers in Gogebic and Ontonagon Counties of Michigan.[3] Koelz (1929) reported fall runs of the species around Gargantua and Michipicoten Islands in Lake Superior and noted the presence of spawning P. cylindraceum at the mouth of the Cascade River and at the mouth of the Devils Track River, both tributaries of Lake Superior, in December. Dr. W. B. Scott, the Curator of Fishes at the Royal Ontario Museum, has spoken of the aggregation of P. cylindraceum in the lower reaches of Canadian tributaries of Lake Superior during the fall.[4] Such an aggregation occurs at the mouth of the Montreal River and is apparently for spawning purposes.

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[3]Information contained in a letter sent to the writer from James A. Scully, Regional Fisheries Supervisor, of the Michigan Department of Conservation, November 1, 1961.

[4]Information contained in a letter received by the writer from Dr. Scott, October 6, 1961.

During recent years (1950-1962) the United States Fish and Wildlife Service has been operating a vast network of stream barriers along Lake Superior for purposes of studying the stream migration of the sea lamprey (Petromyzon marinus). Mr. F. H. Dahl Fishery Biologist with the United States Bureau of Commercial Fisheries Laboratory, located at Marquette, Michigan has noted that round whitefish have been captured in only four weirs of this network located in the Two Hearted River, Dead Sucker River, Sucker River, and Beaver Lake Outlet.[5] These records do not discount the belief that widespread stream migrations of round whitefish do occur because barrier operations are initiated in late March and concluded by mid September. Data is not available during the round whitefish spawning migration period taking place in October and November. The general absence of the species in streams during the spring suggests three equally likely possibilities: the spring migration could occur before the middle of March, the spring migration may not generally occur or the spring migration may be more limited to coastal waters as Mr. Anderson has suggested.

Upstream migration from the Great Lakes is a common phenomenon for a number of species. Applegate (1950) recorded the movement of 2,929 white suckers, Catostomus commersoi, 17,881 smelt, Osmerus mordax, 7,281 lake chubs, Hybopsis plumbea, 5,798 Great Lakes Longnose dace, Rhinichthys cataractae, plus smaller numbers of thirteen additional species. These fishes were counted at the Carp Creek Weir during upstream migrations from Lake Michigan, April 7th to July 15th, 1948.

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[5]Information taken from a letter written to the author by Mr. Dahl, February 28, 1962.

Table I gives the locations of the streams where migrations are known to occur. Figure 1 presents a visual picture of these locations. The evidence readily reveals that the migration of the species is a widespread phenomenon in Lake Superior.

The stream penetrations of P. cylindraceum from Lake Superior may include every major stream of the drainage as there is no reason to believe the streams of Table I constitute the only migration locations. Stream migrations are equally probable in Lake Michigan and Lake Huron. Koelz (1929) noted the fall inshore movement of the species in Lake Michigan and Lake Huron. Round whitefish could then be taken by commercial fishermen during November and December. The fish were congregated over honeycomb rock and gravel in two to six fathoms of water where spawning was taking place. Koelz did not explore river mouths in his researches and does not indicate the stream migration of P. cylindraceum from Lake Michigan and Lake Huron. Nevertheless, if spawning round whitefish do seek out honecomb rock in comparatively shallow water for spawning, the lower portions of many streams would fulfill these spawning conditions and might be expected to sustain the fall migration. Koelz noted round whitefish in two to three fathoms of water in Lake Michigan near Northport on April 1, 1921; a few were found in equally shallow water near Alpena on Lake Huron in April shortly after the ice left the lake, and near Grand Marais, Minnesota on Lake Superior, the fish remained in the shallows until July. These few observations confirm the shallow water occurrence of the species at a number of points in the spring.

In view of the abundant evidence it is quite certain that aggregations of P. cylindraceum do occur at the mouths of streams or ascend

Table I. Stream Penetrations of Migratory Prosopium Cylindraceum within the Upper Great Lakes Region

Stream and Time of Occurrence	Worker
Mouth of the Mosquito, Seven Mile, Hurricane, and Sucker Rivers, mouth of Sable Creek, mouth and lower portion of Sable Creek, Alger County, Michigan. Runs occur in the spring and in the fall when there is sufficient flow.	Anderson* 1961
Mouth of the Blind Sucker River, mouth and lower portion of the Two Hearted River during both spring and fall, Little Two Hearted River at the mouth during the spring, Luce County, Michigan.	Anderson 1961
Mouth of Pendills Creek during the spring, reports occurrence below the Sault Rapids of the St. Marys River in Chippewa County, Michigan, but does not specify time of occurrence.	Anderson 1961
Mouth of Presque Isle and Carp Rivers in Gogebic and Ontonagon Counties of Michigan. Does not specify time of occurrence.	Curry 1934-35
Mouth of the Cascade and Devils Track Rivers of Minnesota during December.	Koelz 1929
The Creeks of Gargantua and Michipicoten Island, Ontario during the fall.	Koelz 1929
The mouth of the Montreal River, Ontario in the spring.	Scott 1961

*Information contained in a letter written to the author from Mr. Anderson during the Fall of 1961. Mr. L. R. Anderson is the District Four Fisheries Supervisor of the Michigan Conservation Department and has kept in close association with the streams mentioned during recent years.

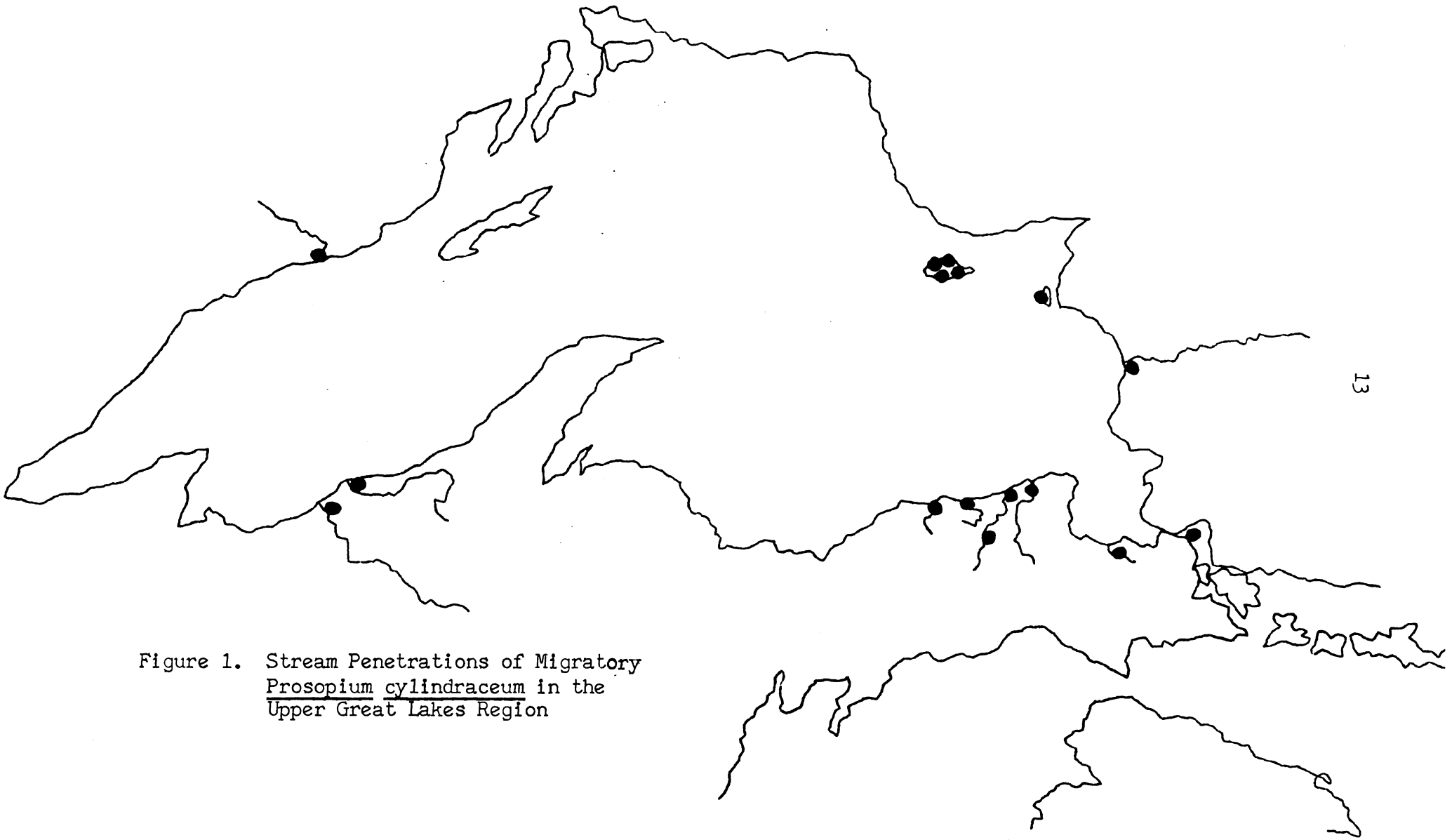


Figure 1. Stream Penetrations of Migratory Prosopium cylindraceum in the Upper Great Lakes Region

streams at many locations within the Upper Great Lakes Region during the fall. Evidence for the spring migration is less conclusive. The spring migration may be a general shoreward migration occasionally encompassing the lower portions of streams. In the future, the distribution of P. cylindraceum should be extended to include the portions of those streams where migrations do occur.

Previous distribution of the species

One would suspect P. cylindraceum were once more abundant in the southern portion of the range than is the case today. Two unsubstantiated lines of evidence may suggest that the species once had a wider distribution (at least in Michigan). Prior to 1900 Indians were said to have speared whitefish along the banks of the Grand River near Grand Rapids. It is not definitely known if this event actually did take place, whether the fish were permanent or migratory residents, or if the reported whitefish were a species other than P. cylindraceum. Evermann and Smith (1896) report that P. cylindraceum was collected by F. N. Clark near Northville, Michigan. This reference is suspected to be in error as reports of round whitefish from this locality have not come to light either before or since this early record.

III. STREAM DISTRIBUTION OF P. CYLINDRACEUM WITHIN THE AUSABLE RIVER

Physiography of the AuSable River

The AuSable River originates in the sandy conifer country of the north central portion of Michigan's lower Peninsula and flows 115 miles eastward into Lake Huron (Hudgins 1958). The river drains approximately 1450 square miles of heavily glaciated soils. The soil constituents are

mostly sand, clay, and combination aggregates of loose glacial till. At no point within the river drainage is there an exposed outcroping of bed rock and many springs are encountered in the upper reaches of the river.

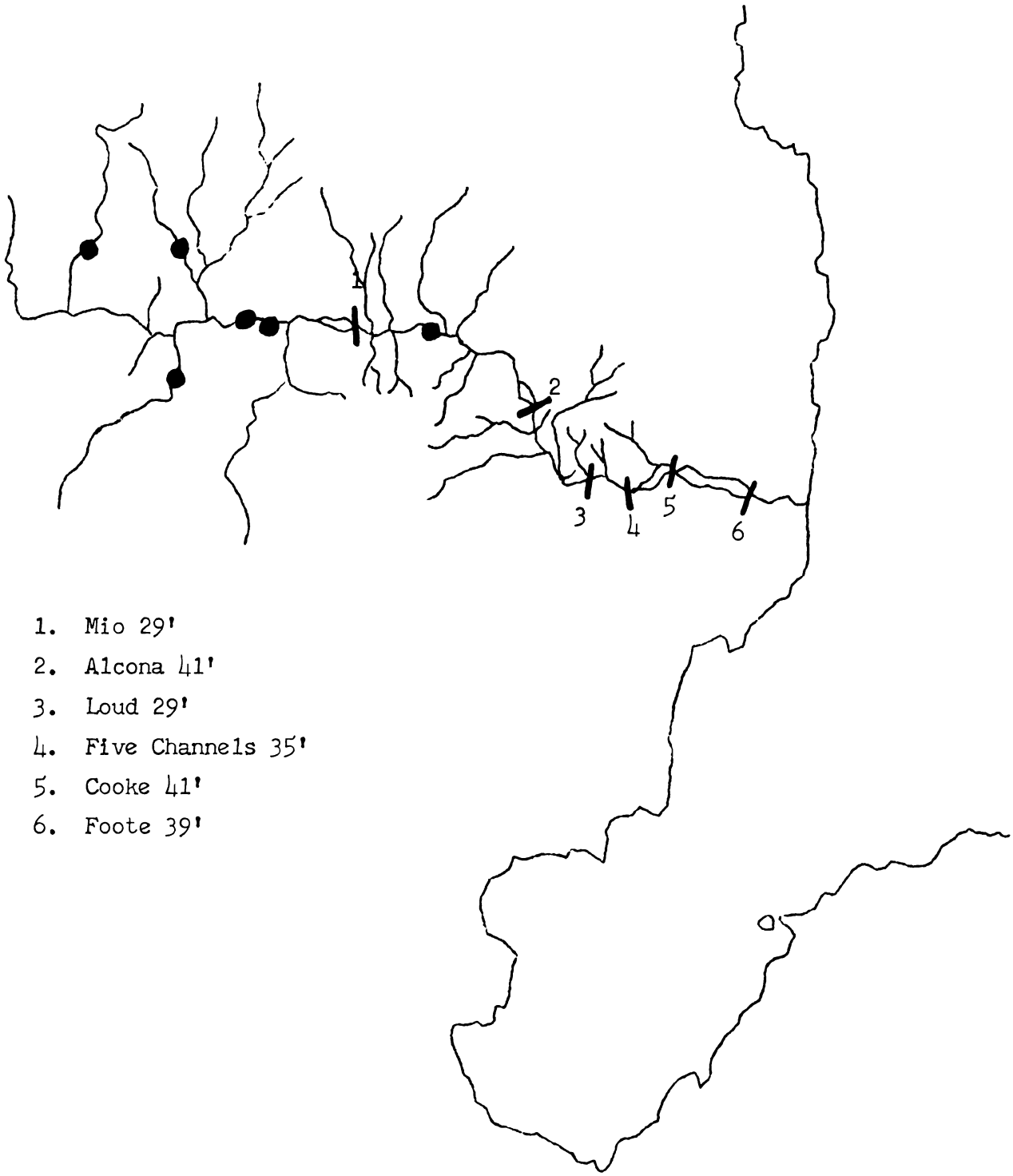
The river system can be divided into upper and lower portions on the basis of physiography. The distinct character of the upper river is encountered from the vicinity of the Alcona dam extending upstream. The upper river is characterized by a cold, clear, and generally uniform flow of water, averaging about 1000 cubic feet per second for the entire year at Mio. Since there are few communities along this region of the drainage pollution is considered to be slight or even negligible and the water temperatures seldom exceed the mid-sixties farenheit during the summer. This portion of the river is one of Michigan's popular trout fishing and canoeing areas. The present study was performed on a sample of P. cylindraceum taken from the upper river.

Below the Alcona Dam conditions begin to change marking the lower river. The stream velocity lessens, water turbidity increases, and warmer summer stream temperatures are encountered.

Present occurrence of the species

Round whitefish seem to be confined to the upper AuSable River as they have not been reported as occurring below the Alcona Dam (Figure 2). The distribution of P. cylindraceum in the upper river is rather specific and the fish show a preference for certain limited sections of the stream. Dr. D. Shetter of the Michigan Conservation Department has observed them in the North Branch of the river in the vicinity of Kellogg Bridge, in the South Branch near several of the deep holes below Smith

Figure 2. Present Occurrence of Prosopium cylindraceum in the AuSable River Drainage



1. Mio 29'
2. Alcona 41'
3. Loud 29'
4. Five Channels 35'
5. Cooke 41'
6. Foote 39'

Bridge, and in the main stream of the AuSable River between the mouth of the South Branch and the mouth of the North Branch.[6] The writer has found them fairly abundant between McMasters and Parmalee Bridges where most of the field work of this study was conducted. Mr. B. L. Jacob of the Michigan Conservation Department reports of fishermen catching round whitefish along the AuSable River several miles below Mio.[7]

Recent physical changes applied to the species distribution

The AuSable River round whitefish are unique being the only resident stream population of the species presently known to occur in the vast Great Lakes Drainage. Since the species is common in the Upper Great Lakes and is known to reside in only one stream among hundreds of Great Lakes tributaries it may be inferred that the river residents have evolved from Lake Huron ancestors. The entry of the species into the river may have begun during the spawning migration from Lake Huron with round whitefish remaining in the lower reaches of the river where lake conditions were approximated. Succeeding generations could then have pressed upstream gradually adapting to the swift stream conditions of the upper river.

Presently more than sixty miles of river separate the upper AuSable population of P. cylindraceum from their Lake Huron ancestors. The species may have been distributed continuously from Lake Huron upstream to the shallow headwaters of the AuSable before the impoundment construction on the lower river. The impoundments have greatly altered

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[6]Information taken from a letter written to the writer by Dr. Shetter, August 31, 1961.

[7]Information taken from a letter written to the writer by Mr. Jacob, October 6, 1961.

the physical character of the lower river making conditions marginal or unsuitable for habitation by round whitefish.

The earliest accounts indicate the species was present in the river prior to the turn of the century. Michael (1903) reported Coregonus quadrilateralis (since changed to P. cylindraceum) to be present in the AuSable River and Mrs. Lottie Sheppard, an elderly resident of Mio, has reported catching "ciscoes", a local name for the round whitefish, before the turn of the century, about seven miles below Mio.

Earlier records speak mainly of the grayling with reference to the AuSable River. Apparently by 1894 the grayling were becoming greatly depleted and brook trout were considered to be desirable fish to introduce to the river (Michigan Biennial Report 1883-84). Since the early records give no further mention of P. cylindraceum in the AuSable it may have been that the species was not particularly abundant in the stream at that time.

Great physical changes were taking place along the AuSable River during the later half of the 19th century. Lumbering and forest fires had reduced the cover along the stream, Beginning in 1911 the Consumers Power Company began constructing a series of Impoundments which profoundly altered the physical character of the river. Six dams were constructed for the purpose of producing hydroelectric power and were to occupy the following order:

Plant Name	Year in Service	Head (Fall)
Mio (upstream)	1916	29
Alcona	1923	41
Loud	1913	29
Five Channels	1912	35
Cooke	1911	41
Foote	1918	39

The impoundments acted to change the once swift, cold stream condition into a lake-stream type of environment characterized by warmer water temperatures. A number of species of fish present in the impoundments today, such as bluegill, Lepomis macrochirus, pumpkinseed, Lepomis gibbosus, and yellow perch, Perca flavescens would certainly never have been able to exist in the river previously. The construction of the impoundments has further created stream barriers preventing the migration of fishes as all water normally passes through the turbines. Overflow from the dams is reported to be a rare occurrence.

The AuSable River Drainage today contains 72 different species of fish according to the records of the University of Michigan Museum of Zoology (Table II). A number of these species have been introduced and have found suitable environmental conditions among the variety of aquatic habitats created by the impoundments.

The Michigan Department of Conservation was extremely active in introducing new fish species to Michigan waters in former years and the writer at first suspected that the stream whitefish of the AuSable River could have been introduced by man. Van Oosten (1957) has pointed out that 19 exotic species of fish were introduced and reintroduced in Michigan since 1870. Only 5 of these 19 species have become permanent residents (rainbow trout, Salmo gairdneiri, brown trout, Salmo trutta, goldfish, Carassius auratus, carp, Cyprinus carpio, and smelt, Osmerus mordax).[8] The literature does reveal stream whitefish, P. Oregoneum (presently regarded as a subspecies of P. williamsoni) were considered as desirable fish to introduce in Michigan (Michigan Game and Fish Biennial Report 1915-16) but this introduction was not indicated in succeeding literature.

[8]Taken from the Proceedings of the 24th annual meeting of the Association of Midwest Game and Fish Commissioners July 10-12, 1957, pp. 17-22.

Table II. Species of Fishes Occurring within the AuSable River Drainage

Fishes of the AuSable River Drainage

Ichthyomyzon fossor (Northern brook lamprey)
Prosopium cylindraceum (round whitefish)
Salmo gairdneri (rainbow trout)
Salmo trutta (brown trout)
Salvelinus fontinalis (brook trout)
Catostomus commersoni (white sucker)
Hypentelium nigricans (Northern hog sucker)
Chrosomus eos (northern redbelly dace)
Pimephales notatus (bluntnose minnow)
Semotilus margarita (pearl dace)
Hybopsis biguttata (hornyhead chub)
Hybopisis micropogon (river chub)
Notemigonus crysoleucas (golden shiner)
Notropis cornutus (common shiner)
Notropis volucellus (mimic shiner)
Chrosomus neogaeus (finescale dace)
Pimephales promelas (fathead minnow)
Rhinichthys atratulus (blacknose dace)
Rhinichthys cataractae (longnose dace)
Semotilus atromaculatus (creek chub)
Ictalurus melas (black bullhead)
Ictalurus natalus (yellow bullhead)
Ictalurus nebulosus (brown bullhead)
Esox lucius (northern pike)
Umbra limi (central mudminnow)
Etheostoma migrum (johnny darter)
Percina maculata (blackside darter)
Etheostoma microperca (least darter)
Perca flavescens (yellow perch)
Etheostoma caeruleum (rainbow darter)
Etheostoma exile (Iowa darter)
Stizostedion vitreum (walleye)
Micropeterus salmodies (largemouth bass)
Micropterus dolomieui (smallmouth bass)
Ambloplites rupestris (rock bass)
Lepomis cyanellus (green sunfish)
Lepomis gibbosus (pumpkinseed)
Lepomis megalotis (longear sunfish)
Lepomis macrochirus (bluegill)
Cottus bairdi (mottled sculpin)
Cottus cognatus (slimy sculpin)
Eucalia inconstans (brook stickleback)

Table II (cont.)

Fishes of the AuSable River Drainage Occurring Below the Alcona Dam

Moxostoma anisurum (silver redhorse)
Moxostoma erythrurum (golden redhorse)
Moxostoma valenciennesi (greater redhorse)
Cyprinus carpio (carp)
Hybognathus hankinsoni (brassy minnow)
Notropis hudsonius (spottail shiner)
Notropis umbratillis (redfin shiner)
Percina copelandi (channel darter)
Fundulus diaphanus (banded killifish)
Percina caprodes (logperch)

Fishes of the AuSable River Drainage confined to the river mouth and Proximal Areas

Catostomus catostomus (longnose sucker)
Notropis atherinoides (emerald shiner)
Notropis stramineus (sand shiner)
Notropis spilopterus (spotfin shiner)
Ictalurus punctatus (channel catfish)
Noturus flavus (stonecat)
Noturus gyrinus (tadpole madtom)
Esox americanus vermiculatus (grass pickerel)
Percopis omiscomaycus (trout-perch)
Pomoxis annularis (white crappie)
Pomoxis nigromaculatus (black crappie)
Labidesthes sicculus (brook silverside)
Aplodinotus grunniens (freshwater drum)
Petromyzon marinus (sea lamprey)

Morphological measurements made on a sample of several fish from the AuSable River population confirm the species to be P. cylindraceum, Although introductions of stream whitefish from the West may have been considered in Michigan there is no evidence to suggest these introductions were ever made.

IV. THE DISTRIBUTION OF PROSOPIUM CYLINDRACEUM APPLIED TO THE CONCEPT OF LIMITING FACTORS

Thermal limitations

The abundance of round whitefish in Canada, Siberia, and Alaska, and the absence of the fish from warm temperate regions clearly indicate a limited tolerance for warmer water temperatures as does the absence of the species from the warmer lower portions of the AuSable River. Since the upper AuSable River rises to summer temperatures in the mid-sixties farenheit the fish can tolerate temperatures of this magnitude. In fact fish have been caught by fishermen when the water temperature was as high as 61° F., indicating feeding activity occurs even at high water temperatures.

Depth limitations

Koelz (1929) reported limited numbers being taken throughout the summer from the upper Great Lakes at depths from 5 to 12 fathoms and a few as deep as 32 fathoms which probably marks the limit of depth. The AuSable River population of the species seem to reside in holes and the deeper portions of the upper river although fishermen have caught them in the swift runs of the river between McMasters and Parmalee Bridges where the water does not exceed three feet in depth. The stream fish appear to require a certain minimum volume of water as they do not

extend very far up the South Branch, the North Branch, or the shallow headwaters of the Middle Branch of the AuSable. Round whitefish have not been recorded as occurring in Big Creek or any of the lesser tributaries of the upper AuSable River.

Turbidity limitations

The species is geographically confined to oligotrophic lake conditions and clear cold-water streams. Excessive turbidity may be a factor which prevents the establishment of the fish in Lake Erie. More likely it is the combinations of temperature, turbidity, depth conditions, available oxygen, and a multiplicity of other factors which combine to make conditions unsuitable for P. cylindraceum in Lake Erie and within the lower AuSable.

Why the species has become established in the AuSable River

The Great Lakes Region represents a marginal condition for P. cylindraceum. North of the Great Lakes the fish is widespread and abundant. South of the Great Lakes the fish ceases to exist while within the Great Lakes Region the fish is confined to those areas where more northern conditions are approximated. The deep oligotrophic upper Great Lakes and the upper reaches of the AuSable River provide an extension of more northern ecological conditions permitting the species to exist.

Surprisingly the AuSable River of Michigan is the only stream in the Great Lakes Drainage definitely known to contain a permanent population of round whitefish.[9] Since the round whitefish of the four Great

[9]Michigan's Two Hearted River and St. Marys Rivers are suspected but not confirmed to contain permanent populations of the species.

Lakes have access to a number of drainage systems and do occasionally move into streams, especially during spring and fall, it is interesting that the AuSable River should be exclusively chosen as a permanent residence.

The AuSable River differs from many of the other rivers of the Great Lakes Drainage by having a series of large impoundments along its course. The impoundments bear no positive relationship to the presence of round whitefish and have been shown to make conditions marginal or uninhabitable for the species by creating a shallow lake stream type of environment characterized by warmer water temperatures. Closer investigations reveal that the upper AuSable drains a rural area of glacial soils composed of sands, clays, and combination soils. These soils act as a reservoir for water and insure a uniform flow of cold water to the river system. The AuSable is a moderately swift river carrying a substantial volume of well oxygenated water amounting to 1000 cubic feet per second at Mio and increasing in volume downstream. These characters do not give the AuSable a unique position among Great Lakes Tributaries but may indicate some of the environmental factors round whitefish require. Michigan's Manistee River closely approximates the physical features of the AuSable as do a number of other rivers, which do not contain P. cylindraceum. The reason for the occurrence of the species exclusively in the AuSable, when several other Great Lakes Tributaries seem to be equally suitable for the species, is open for further inquiry.

V. MORPHOMETRIC STUDIES OF AUSABLE RIVER AND LAKE HURON SAMPLES OF PROSOPIUM CYLINDRACEUM

Methods

A morphometric study compared a sample of four adult fish collected from the AuSable River in 1961 with a sample of ten adult fish collected by Koelz (1929) from Lake Huron. The fish were measured in accordance with the procedures and measures established by Koelz during his extensive work with the Great Lakes Coregonids.

The Mann-Shitney U test was used to determine significant differences in central tendency between the various measures taken on the two samples of fish. The .05 level was established to represent significance under the null hypothesis. The more refined randomization test for two independent samples was also employed in cases where the Mann-Whitney U test did not quite reach significance at the .05 level.

Results

The measures which showed significant differences between the AuSable River and Lake Huron samples were the standard length-dorsal base length ratio, the snout to dorsal distance-head length ratio, the head length-snout length ratio, and the number of dorsal rays (Table III). These measures indicate the AuSable River sample fish have a longer dorsal base, containing a greater number of dorsal rays, a longer snout, and show a greater snout to dorsal distance than do the older Lake Huron sample of fish. The 1961 AuSable River sample of fish then appear to be separated from their 1929 Lake Huron counterparts by the position, base length, and number of rays within the dorsal fin and the snout length.

Table III. Morphometric Measures of a Sample of Prosopium Cylindraceum from the AuSable River of Michigan

Specimen Number	1	2	3	4
	mm.	mm.	mm.	mm.
Standard length (L)	325	325	313	314
Total length	383	380	364	363
Fork length	358	359	338	339
Snout to dorsal (SD)	152	146	140	144
Dorsal to adipose (DA)	133	136	126	120
Snout to anal (SA)	258	275	237	250
Adipose to caudal (AT)	55	55	53	57
Head (H)	64	64	59	62
Head depth (HD)	40	33	35	35
Occiput (O)	48	48	46	46
Snout (S)	18	18	17	19
Maxillary (M)	14	15	11	13
Mandible (J)	19	18	21	22
Eye (E)	12	12	12	12
Fin lengths				
Pectoral (P)	45	46	45	49
Pelvic (V)	43	41	42	42
Fin bases				
Dorsal base (DB)	38	38	35	40
Anal base (AB)	26	34	24	30
Dorsal coefficient (DC)	1.21	1.05	1.2	1.23
Anal coefficient (AC)	1.35	0.97	1.4	1.31
Pectoral-ventral distance(PV)	100	106	95	96
Ventral-anal distance (AV)	90	95	86	89
Orbit	12	12	12	12
Gill rakers (R)	17	16	18	15
Scales in lateral line	93	87	90	86
Fin rays				
Dorsal (DR)	14	12	13	12
Pectoral (PR)	14	13	14	17
Ventral (VR)	11	11	11	11
Anal (AR)	10	7	10	10
Branchiostegal rays (BR)	8	7	7	6
Sex	female	female	female	female

Table III (Cont.)

Measurement ratios for the AuSable River Sample of 1961

Specimen No.	L/H	L/O	L/DB	L/AB	SD/H	SA/H	H/E	H/S	PV/P
1	5.1	6.8	8.6	12.5	2.4	4.0	5.3	3.6	2.2
2	5.1	6.8	8.6	9.6	2.3	4.3	5.3	3.6	2.3
3	6.3	6.8	8.9	13.0	2.4	4.0	5.0	3.5	2.1
4	5.1	6.8	7.9	10.5	2.3	4.0	5.2	3.3	1.9

Measurement ratios and ray counts of a Lake Huron sample obtained by Koelz

Specimen No.	L/H	L/O	L/DB	L/AB	SD/H	SA/H	H/E	H/S
19	5.3	6.7	9.5	11.0	2.3	4.1	4.3	3.5
69	5.0	6.7	9.0	13.1	2.1	3.9	4.6	3.7
222	5.0	6.5	9.6	12.1	2.1	3.9	4.0	3.8
330	5.2	6.7	9.4	13.0	2.2	4.0	4.1	3.5
431	4.8	6.6	8.8	12.5	2.1	3.9	4.4	3.9
1070	5.2	6.8	8.9	10.8	2.3	4.0	4.5	3.6
1104	5.1	7.1	9.0	13.3	2.2	4.0	4.5	3.9
1096	5.2	7.2	9.1	11.0	2.2	4.1	4.9	3.7
2497	5.0	6.5	8.7	13.1	2.2	3.9	4.2	3.8
2519	5.0	6.6	9.1	12.7	2.2	3.9	4.2	4.1

Specimen No.	PV/P	DR	AR	VR	PR	DC	AC	BR
19	1.9	11	10	11	16	1.3	1.2	7
69	1.9	12	10	11	16	1.2	1.3	7
222	2.0	11	10	11	15	1.3	1.3	7
330	2.0	12	10	11	15	1.2	1.4	7
431	1.9	11	10	11	16	1.2	1.3	8
1070	2.0	12	11	11	18	1.2	1.2	7
1104	2.1	11	10	12	16	1.2	1.6	8
2497	2.0	11	10	10	15	1.2	1.3	7
2519	1.8	11	11	11	16	1.3	1.3	7

The 31 year time separation of the two samples of fish make the present analysis of morphometric differences between lake and river fish a difficult task. It is sufficient to note that differences were observed between the two samples of fish and these differences could very possibly occur if present samples of adult lake and river fish were compared statistically. The point of the morphometric inquiry was to determine if the Lake Huron and AuSable River fish are one and the same. A definite answer to this question cannot be given until present samples are compared, but the limited morphometric evidence derived from this study would suggest that lake and river fish differ morphometrically. Physiological differences in tolerances may also be expected to occur between populations of fish which are separated by environments as diverse as the lake and stream conditions of existence.

Fisheries workers should take into account the differences between lake and stream round whitefish if the species is to be introduced to new waters. The stream fish of the AuSable may not be able to survive in a lake environment just as Lake Huron specimens may not be able to tolerate the swift stream condition of the upper AuSable.

Reasons for morphometric differences

Present samples of fish from both bodies of water would quite probably yield significant differences with respect to morphometry as did the 1961 AuSable River sample of fish when compared to the 1929 Lake Huron sample. The reasons for morphometric differences between two samples of fish coming from isolated populations may be due to a number of causes related to both heredity and environment.

The AuSable River population of the species represent a relatively

small and isolated population, which at some point in time left Lake Huron and became established in the river environment. Intermingling of the lake and river populations was possible, although not very probable with respect to the distant upper river races, until the construction of the impoundments finally subdivided the lake and river species. The study of population genetics reveals that subdivision produces the same effect as inbreeding in a large population. The effect of subdivision is to increase the proportion of both types of homozygotes in the entire population and decrease the number of heterozygotes. Selection could further act to morphologically separate the river and lake populations by favoring one genetic type. The shallow river-lake environment characterized by rapid fluctuations in temperature differs considerably from the more stable environment of Lake Huron and may be expected to further favor morphometric and physiological changes from the Lake Huron stock. Finally the factor of chance alone can serve to separate two isolated populations especially over an extended length of time.

VI. NOTES ON THE LIFE HISTORY OF PROSOPIUM CYLINDRACEUM

Spawning

Koelz (1929) observed that the upper Great Lakes fish spawned in November and December. During this period pearl organs could be observed on the males, females were gravid with eggs, and specimens often contained previously eaten eggs within their stomachs. In regard to Connecticut Lakes, Kendall and Goldsborough (1908) state that the fish ascend streams to spawn the last of October or early November, the spawn being emitted at the surface of the water and one or more males

accompanying each female during the act. The adhesive eggs are 1/8 inch in diameter and semibuoyant at first but gradually settle to the bottom and are hatched in early spring on rising temperatures. A fish taken from the South Branch of the AuSable on November 7, 1961 had not yet spawned, the eggs were firmly contained in the body cavity, but the large size of the eggs and the great volume of the egg mass crowding the body cavity indicated spawning would soon occur. Mountain whitefish, P. williamsoni, were observed by Brown (1952) to congregate in the shallow water of Mol Heron Creek, Montana at dusk on November 2, 1951 (water 32°F.). Shortly after dark a group of 30 mountain whitefish were observed to begin spawning. It is quite likely that P. cylindraceum spawns after dark as does P. williamsoni.

Associations

Adult P. cylindraceum are found living in association with brown trout, brook trout, rainbow trout, and suckers in the AuSable River. Most round whitefish are caught one at a time by the river fishermen although occasionally several will be caught in quick succession from one location suggesting schooling behavior. Lake populations do show schooling behavior as do stream populations of mountain whitefish during spawning periods.

The whereabouts of immature P. cylindraceum in the river remains a mystery. Seining operations proved quite unsuccessful due to water depth, current, and numerous obstructions, and no young round whitefish were taken. The immature of the species are not taken with hook and line. Brown (1952) found fingerling mountain whitefish in the quiet areas near shore of the West Gallatin River, Montana during the spring,

the fingerlings disappeared by June 15th and no amount of effort could locate them in water which could be waded or seined, however, collections of fingerlings were made in the deep pools on November 2, 1949 with the aid of an electric shocker.

Nocturnal activity

Hart (1931) found that the species was caught in nets only during the night in a Lake Nipigon study suggesting nocturnal activity. Sport fishermen along the AuSable River catch round whitefish during daylight hours and often the mid-day hours of bright days are preferred times. The river fish are not generally sought after dark and there is little evidence to suggest the extent of nocturnal activity. Residents of the Mio area of the river have been reported to have illegally speared the species at night by torch light with considerable success during the 1920's.

Food

Food of Great Bear Lake, North West Territories specimens included caddis fly larvae, chironomids, mayflies and craneflies (Kennedy 1949). Lake Nipigon specimens were found to contain caddis larvae, mayfly nympths chironomid larvae, and small mollusks (Dymond 1926). The mountain whitefish, P. williamsoni, of the Yellowstone and Gallatin Rivers principally fed on midge larvae and adult chironomids during the fingerling stage, while 81 percent of all food taken by the adults was found to be immature caddis flies and stone flies in equal amounts (McHugh 1940). The mountain whitefish of these two streams were found to continue feeding throughout the winter. Although a food study was not performed on the AuSable River fish, the adults were often noted to

contain fine gravel, indicating immature caddis flies or other bottom dwelling organisms had been eaten. The scale annuli of the AuSable River fish were often not clearly distinct suggesting feeding activity and subsequent growth take place throughout the winter. The round whitefish of the AuSable River may feed actively throughout the winter as do their mountain cousins. Rawson and Elsey (1948) observed mountain whitefish were strongly competitive with rainbow trout for amphipods, aquatic and terrestrial insects within Pyramid Lake, Alberta. The various food studies mentioned indicate round whitefish are certainly competitors with trout for a number of food items.

VII. LENGTH AND AGE MEASURES OF PROSOPIUM CYLINDRACEUM

Methods

Scale samples from 10 adult AuSable River specimens were pressed on clear plastic sheets with the aid of a roller press, placed in a scale projector, and projected on a screen, the magnification being 23X. The scales used in this study were obtained from the side of the fish above the lateral line and below the middle of the dorsal fin. The scales were unusual in that there was only a slight difference in the separation of spring and summer circuli as compared to fall and winter circuli. Considerable scale growth was observed during the periods when the circuli were closer together indicating substantial growth during the fall and winter as well as the rest of the year. The scales of a specimen removed from the AuSable River on April 30, 1961 showed significant marginal growth beyond the last annulus establishing the time of annulus formation to be early in the month of April or prior to the month of April.

Since all of the scale samples were from adult specimens the Dahl-Lea direct proportion method of scale analysis was used to determine the growth history of the fish (Lagler 1956). This method of scale analysis is subject to error because the procedure does not account for growth of the fish occurring before scales are formed and does not allow for differential growth rates of the scale margin and body length. The error introduced by the Dahl-Lea method is very likely to cause an overestimation or underestimation of the length of a fish during the early years of development. This error would probably result in an underestimation of length as was demonstrated to hold true with the related whitefish, the lake herring (Coregonus artedi) of Lake Huron (Van Oosten 1929). Until a larger sample of fish, containing the species at all ages of development, is secured from the AuSable River and a regression equation of scale length-body length growth can be calculated the present data must be tentatively accepted.

Intraspecies length-age comparisons

The 10 specimens analyzed ranged in total length from 13 to 15 inches. Nine of the fish showed three snnuli and one fish had four annuli indicating the adult size is reached in three years (Table IV). Kennedy (1949) found P. cylindraceum of Great Bear Lake, North West Territories required five years to reach a length comparable to the three year old AuSable River fish. The data of Rawson (1951) from Great Slave Lake, North West Territories and the data of Cooper and Fuller (1945) from Moosehead Lake, Maine show that five years and eight years respectively are required for P. cylindraceum to reach a length equivalent to the length of the three year old AuSable River

Table IV, Length and Age Measures for a 1961 Sample of Prosopium Cylindraceum from the AuSable River of Michigan

Specimen No.	Total length at annulus* I	II	III	IV	Total Length	Date
1	133	255	342		383	May 22
2	166	246	349		380	April 30
3	140	260	317		364	May 21
4	145	259	347		363	June 25
5	131	226	312		330	May 13
6	134	273	335		355	May 13
7	152	244	252		368	May 13
8	150	247	311		343	May 13
9	145	248	310		330	May 2
10	137	218	289	350	355	May 2
Averages	143	248	327	350		

Specimen No.	Standard length at annulus I	II	III	IV	Standard length
1	113	212	291		325
2	142	210	278		325
3	120	224	273		313
4	128	226	301		314
5	113	194	268		283
6	120	240	294		312
7	131	210	304		318
8	137	225	284		313
9	123	211	264		284
10	118	189	250	297	
Averages	125	214	281	297	

*All measures are in millimeters

fish. The mountain whitefish of the Logan River, Utah requires from 5 to 6 years to reach a similar length (Sigler 1951).

The more rapid growth of the AuSable River P. cylindraceum may simply be a reflection of more southern or lower altitude conditions enabling a greater productivity of waters. It would be interesting to conduct a comparative growth study of the species in the Great Lakes Region to discover if the rapid three year growth of the river sample is unusual or characteristic of this geographical locality.

A significant feature of round whitefish growth is the rapid increase in length during the first two years of life. A 74.8 percent total length increase has been calculated between the formation of the first and second annuli of the AuSable River sample. This figure is very likely an underestimate of the actual growth taking place as has been pointed out (see page 27). Van Oosten (1929) found lake herring reached, at the end of the second year, nearly 50 percent of the weight attained in the sixth and nearly 50 percent of the length reached in the sixth year of life is completed at the end of the first growth year. The whitefishes as a group may all display this rapid early growth.

Interspecies length-age comparisons

The limited data available suggest P. cylindraceum of the AuSable grows more rapidly than most stream species of northern Michigan. Shetter and Leonard (1943) found that the brook trout of Hunt Creek, a stream located 20 miles from the AuSable study area, required 3 years to reach a total length of 8 inches. Shetter and Hazzard (1939) working in three northern lower peninsula streams of Michigan found brown trout to require 3 years to reach a total length of 9.7 inches and rainbow

trout to require 2 years to reach 7 inches in total length. The one AuSable River fish species that may equal or exceed the growth of P. cylindraceum would be the white sucker, Catostomus commersoni. Length-age data does not seem to be available on stream populations of white suckers, however, Carlander and Hiner (1943) found the white suckers of Vermillion Lake, Minnesota to reach a standard length of 10.6 inches by the third year. If the white suckers of the river grow at this rate they would equal or surpass the growth of P. cylindraceum.

VIII. THE ECONOMIC POTENTIAL OF P. CYLINDRACEUM IN THE GREAT LAKES REGION

Commercial fisheries

Commercially round whitefish are harvested from Lakes Huron, Michigan, and Superior as well as large Canadian Lakes such as Lake Nipigon and Great Bear Lake. Koelz described the commercial role of round whitefish as a fish of secondary commercial importance taken incidental to the harvest of other whitefishes and lake trout. Statistically speaking 42,000 pounds of round whitefish were taken from Lake Huron in 1945 representing .004 of the total poundage catch (Anderson and Power 1945), 13,000 pounds were taken in 1952 representing .002 of the total poundage catch (Anderson and Power 1952), and 9,000 pounds were taken in 1959 representing .001 of the total poundage catch (Power 1959). Round whitefish are equally insignificant in the total catches of Lakes Michigan and Superior.

The species is more abundant than commercial fisheries statistics reveal. Koelz (1929) noted that P. cylindraceum may not be detected in waters where they are abundant because the species seldom becomes intangled

in pound or gill nets set for larger fish and the species is never seen swimming in the open lake as are herring, but like the herring the species often enter harbors where they are taken with hand lines.

Recreational fishery

Prosopium cylindraceum may prove to have great importance as a sport fish similar to its close relative the mountain whitefish of the West. The fish do appear to be present in numbers in certain localities. Mr. L. R. Anderson District Four Fisheries Supervisor of Michigan mentioned that on one day in October 1961, 50 to 75 fishermen were strung out between the mouth of the Big and Little Two Hearted Rivers and that 200 menominee (round whitefish) and 15 to 20 rainbow trout were caught by fishermen using worms with heavy lead. If the fall and spring migrations of round whitefish are found to occur generally in the many tributaries of the upper Great Lakes then a new fisheries resource of considerable magnitude would be open to the sport fisherman.

In the areas of the AuSable River studied, round whitefish are best known to the worm fishermen, although wet fly fishermen report occasional catches. A creel census taken along a one mile section of the AuSable located midway between McMasters Bridge and Parmalee Bridge revealed worm fishermen caught .25 trout (Salmo trutta, Salmo gairdneri, Salvelinus fontinalis), .1 P. cylindraceum, and .03 Catostomus commersoni per fishing hour during the 1961 fishing season (Table V). The contribution of P. cylindraceum is actually more significant than the numbers indicate because these fish usually average between 13 and 15 inches in length when caught and average 3/4 pound or more in weight. Characteristically the round whitefish is the largest fish in the fishermen's creel.

Table V. Creel Census of a One Mile Section of the AuSable River Located Between McMasters and Parmalee Bridges, April 30th to September 10th, 1961

Date	Number and Species Caught*			Fishing Hours
	Trout	Whitefish	Suckers	
April 30	1	1	1	14
April 31	2	0	0	10
May 2	0	2	0	2
May 6	0	0	0	3
May 7	2	0	0	9
May 13	4	4	0	16
May 21	2	1	0	5
May 22	7	1	0	5
June 4	2	0	0	6
June 18	0	0	0	4
June 19	0	0	1	5
June 20	1	0	0	2
June 25	0	1	0	8
July 18	0	0	0	6
August 26	0	0	0	4
Sept. 9	3	0	1	3
Sept. 10	2	0	0	3
Totals	26	10	3	104

Average number of fish caught per fishing hour by species

trout	.25
whitefish	.1
suckers	.03

*Data applies to bait or worm fishermen.

Two experienced sport fishermen of the AuSable River, Mr. M. Fluke and Mr. G. Salm speak of a consistency in size and number of round whitefish caught in the stream during the past twenty years, while the trout fishing success has been observed to progressively diminish in response to increased angling pressure. It is interesting to note fishermen report a consistency in the size of P. cylindraceum caught. Fish smaller than 12 inches are rarely reported by river fishermen possible due to the exceedingly small mouth of young whitefish which makes the incorporation of a large fish hook nearly impossible. The apparent absence of fishing mortality on the younger fish may be the factor insuring a good yearly yield of adult fish to the fisherman. The river fish have been shown to reach a 13 to 15 inch size in 3 years time indicating a considerably faster growth than usually occurs among most stream fish with the possible exception of the white sucker.

Prosopium cylindraceum of the AuSable River has been shown to be a desirable fish because of rapid growth, the apparent lack of fishing mortality among the young, and the apparent maintenance of numbers under increasing fishing pressure. Should stream trout populations become severely depleted under the increased fishing pressure sure to occur in future years then perhaps P. cylindraceum will be considered a desirable stream fish to propagate and introduce to new locations.

Authorities differ concerning the food qualities of the fish. Koelz considered it low in palatability and an overall inferior species. Other writers (Evermann and Goldsborough 1907, Webster 1941) speak of P. cylindraceum as an important food fish. The fish is blessed with the palatable name of whitefish and generally is enthusiastically received as a food fish along the AuSable River. The sporting qualities

of the species are good if not spectacular.

A discussion of the recreational fishery potential of round whitefish would be incomplete without considering the existing mountain whitefish sport fishery of the West. Wyoming has abundant populations of mountain whitefish in the Green River, Wind River, Snake River, and Tongue River Systems. The state allows the sportsmen to take 25 of the species per day. Eiserman (1962) indicates mountain whitefish have good appetites during the coldest months of the winter and this is a good time for the fishermen to take them in Wyoming. Eiserman also maintains that in streams where water temperatures drop near freezing, trout eat less and less, providing the fishermen opportunity to take mountain whitefish with little effect on trout numbers. From information gathered from Wyoming Game and Fish Department Personnel Creel Census Checks, the average size of mountain whitefish taken during the winter is almost 13 inches. The largest fish checked was 3 1/2 pounds, 22 inches long, taken along the Snake River.

CHAPTER III

CONCLUSION

The study has investigated the stream occurrence of P. cylindraceum in the upper Great Lakes Region and has secured information about both the permanent stream dwelling population of the AuSable River of Michigan, and the stream migrating populations from Lake Michigan, Lake Huron, and Lake Superior.

Annual spring and fall migrations of round whitefish into streams and shallow shore areas have been observed at a number of points along Lake Superior. Shoreward migrations have been noted in Lake Michigan and Lake Huron (Koelz 1929), but stream migrations do not appear to have been investigated in these lakes. The abundant evidence of stream migrations in a number of tributaries of Lake Superior and the knowledge of inshore movements during the spring and fall in Lake Michigan and Lake Huron suggest that the stream migration of P. cylindraceum may be a general phenomenon occurring wherever lake populations are encountered.

During the spring and fall migrations sufficient numbers of fish are encountered in the vicinity of the mouth of the two Hearted River on Lake Superior to support a moderate recreational fishery. If round whitefish are found to be equally abundant within the proximal areas of other upper Great Lakes tributaries than a recreational fishery of considerable magnitude could be established.

The study confirmed the opinion held by Hubbs and Lagler (1958) that P. cylindraceum of the AuSable River represents the only permanent

stream population of the species known to occur within the vast 287,770 square mile Great Lakes Drainage. Reports of round whitefish living in Michigan's Two Hearted and St. Marys Rivers have been brought to light, but these populations are suspected to be seasonal migrants from the lakes.

The AuSable River round whitefish have lived in the stream for at least 60 years as early records taken at the turn of the century indicate their presence. The stream population seems to have evolved from Lake Huron ancestors as both morphological and written evidence discount the idea that the fish have been introduced by man. At one time the fish were believed to occur along the entire length of the river, but now the species is confined to the upper river because of the recent impoundment construction and resulting modifications in habitat propagated by man on the lower river.

The 1961 AuSable River sample of round whitefish were found to differ significantly at the .05 level from their 1929 Lake Huron counterparts with respect to the position, base length, and number of rays forming the dorsal fin and the snout length. This limited morphometric evidence would not prove but would suggest that present populations of river and lake fish differ morphometrically. Physiological differences in tolerances might also be expected to occur between populations of fish separated by environments as diverse as the lake and stream conditions of existence.

The AuSable River P. cylindraceum were found to attain the adult size of 13 to 15 inches total length in three years exceeding the growth rate of most stream fish for the northern lower peninsula of Michigan. The scale growth pattern of the species suggests growth

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occurs throughout the year. River fishermen have indicated the number and size of round whitefish in the stream to be quite consistent during recent years, while the number and size of trout have steadily diminished during the same period of time. The reported maintenance of numbers among the species may be due to the fact that fishermen do not catch immature round whitefish permitting survival of the species to adulthood.

The species is presently found in certain sections of the upper river and requires cool water temperatures and a definite minimum volume of water for existence. The ecological conditions required by round whitefish are very similar to those needed by trout, but the species does not seem to inhabit the shallow feeder creeks, or the shallow source streams of the AuSable where trout are abundant.

The rapid growth, apparent maintenance of numbers under increasing fishing pressure, and acceptability by the fishermen are certainly characters making the AuSable River P. cylindraceum an economically valuable stream species. Perhaps the future will witness research on P. cylindraceum and the introduction of the stream species to new waters. Since food studies indicate round whitefish are competitive with trout considerable time may pass before such introductions are forthcoming.

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