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The Fish Community of the Lower Dead River, Michigan, a Tributary of Lake Superior

Richard E. Berg
Northern Michigan University

THE FISH COMMUNITY OF THE LOWER DEAD RIVER, MICHIGAN, A TRIBUTARY OF LAKE SUPERIOR

TITLE OF THESIS

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by

Richard E. Berg
(name)

This thesis is recommended for approval by the student's thesis committee

Chairman

Approved by 12/11/76, Dean of Graduate Studies.
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BY

Richard E. Berg

B.S., University of Wisconsin-Milwaukee

A Thesis

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Abstract

The lower 2.4 km of the Dead River, Marquette County, Michigan, was sampled from June, 1974, to December, 1975, with hoop nets, gill nets, trapnets, and electrofishing gear. Species collected in this portion of the river but not reported previously are the alewife (Alosa psuedoharengus), chinook salmon (Oncorhynchus tshawytscha), pink salmon (O. gorbuscha), coho salmon (O. kisutch), lake trout (Salvelinus namaycush), carp (Cyprinus carpio), golden shiner (Notemigonus crysoleucas), emerald shiner (Notropis atherinoides), spottail shiner (N. hudsonius), brown bullhead (Ictalurus nebulosus), trout-perch (Percopis omiscomaycus), burbot (Lota lota), brook silverside (Labidesthes sicculus), pumpkinseed (Lepomis gibbosus), bluegill (L. macrochirus), johnny darter (Etheostoma nigrum), logperch (Percina caprodes), and slimy sculpin (Cottus cognatus). The chinook and coho salmon had been planted by the Michigan Department of Natural Resources and were known to be present, but times of occupancy or relative abundance were not recorded in the literature. Three species of lampreys (Petromyzon marinus, Ichthyomyzon fossor, and Ichthyomyzon unicuspis) and one salmonid (Salmo salar) were not collected during this study but probably are still present.

Three species had been reported in the lower Dead River before but were not collected during this study and apparently are no longer present. These are: the brook trout (Salvelinus fontinalis), common shiner (Notropis cornutus), and ninespine stickleback (Pungitius pungitius). Successful reproduction was verified only for species found in the lentic zones of the river. These species are believed to

be year round residents although some members of the populations are believed to migrate back and forth between the river and Lake Superior.

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I especially wish to thank Paul R. Hannuksela and Ronald A. Raisanen for assistance in field work. Thomas Stauffer gave advice on the salmonid data.

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INTRODUCTION

The distribution of fishes in Michigan's tributaries to Lake Superior have been studied since 1850 when Agassiz first reported on Lake Superior species (Fowler, 1918). Fish found on Shiras's expeditions to Whitefish Point in Chippewa County were reported by Hankinson (1916). Starting in 1929 and continuing to 1938, John N. Lowe collected fish throughout the Upper Peninsula of Michigan including tributaries to Lake Superior (Taylor, 1954). Further work was done on the species of Isle Royale by Hubbs and Lagler (1947). In 1965, the Fish and Wildlife Service of the U.S. Department of the Interior published a distributional study of fish species in the tributaries of Lake Superior along the south shore in Michigan waters (Moore and Braem, 1965). Publications by Hubbs and Lagler (1964) and Scott and Crossman (1973) included a description of the distribution of fishes in the Lake Superior watershed. A recent study (Christie, 1974) was largely concerned with Great Lakes species, not those found specifically in its tributaries. These studies contributed to a general fish species list of the Lake Superior watershed.

One of the principal tributaries of Lake Superior in the Marquette area is the Dead River. The earliest report on fish species of the lower Dead River was made by Penny in 1840. He reported catching suckers in the rapids below the present hydroelectric Dam. This portion of the river was sampled for species of fish by Moore and Braem (1965) and to some extent by Seppala (1971). Earlier, Lowe had collected in the river but not on the lower portion (Taylor, 1954). Raisanen (1976)

sampled the extreme upper portion of the river.

Coinciding with my research, Wapora Inc., (Water Pollution Research Applications) sampled the lower river in October and November of 1975.

The Michigan Department of Natural Resources has records of salmonid plantings from 1970 to the present. These plantings have affected the fish community in the lower portion of the Dead River and formed the basis for a substantial sport fishery.

It appeared from the literature that little was known about Lake Superior tributaries on an all year basis, particularly the dynamics of fish communities. The lower Dead River had not been studied thoroughly in this regard. The objectives of my study were: (1) to identify the fish species occurring in the lower Dead River, (2) to obtain information on the dynamics of their populations, especially to identify what time of the year a species was present, where it was found in the river, and how it was utilizing the river, (3) to examine certain species for age, growth, and fecundity. The study extended from June 3, 1974 to December 31, 1975.

Figure 1. The lower Dead River. The river was divided into three study sections on the basis of physical characteristics.

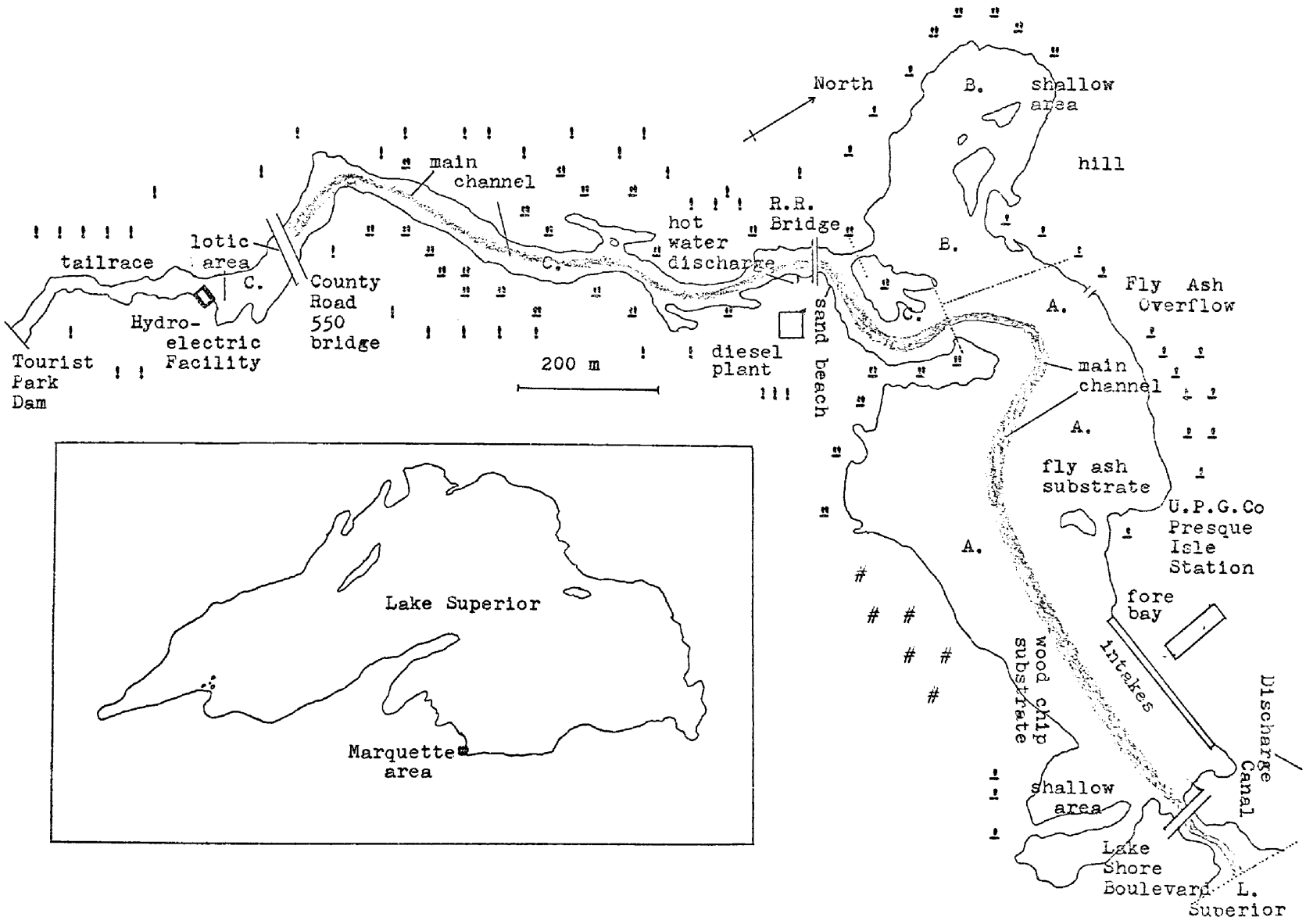
Key to characters:

! = mature forest lands
" = tag alder
$ = grass-weed community
# = abandoned industrial lands

STUDY AREA

The lower portion of the Dead River is defined in this study as that stretch of river between Tourist Park dam and Lake Superior. This portion of the river is depicted in Figure 1. The length of the lower Dead River is about 2.4 km from the dam, located in section 10, T48N, R25W, to its mouth in section 11, T48N, R25W. The Tourist Park Hydro Plant (Marquette Board of Light and Power Plant Number 3) and its associated dam prevents any upstream movement by fish. The pool and rapids area below the County Road 550 bridge were not sampled directly due to the continual presence of sport fishermen.

There were two cultural uses that influenced the conditions for the fish community in the river. One possible problem posed to the fish populations is the hydroelectric plant and its associated dam. The hydroelectric facility controls water flow in the lower portion of the river throughout the year. The average water flow is about 5.66m^3/ sec from September through March and 1.98 m^3/ sec from April through August (U.S. Army Corps of Engineers, 1973). When the hydroelectric plant is not releasing water, the river becomes little more than a backwater of Presque Isle Harbor. Those species whose spawning is dependent on current must coordinate their migrations with water flowage from the facility. The Upper Peninsula Generating Company's fossil fuel plant near the mouth of the river was withdrawing 4.81 m^3/ sec of water for cooling purposes under normal operating conditions until the summer of 1975 (U.S. Army Corps of Engineers, 1973). Discharge of the withdrawn water was by means of a canal directly to Presque Isle Harbor. This sometimes created a reverse water flow from Lake Superior to the


North
B.
shallow
area
hill
main
channel
R.R.
Bridge
hot
water
discharge
lotic
area
tailrace
C.
County
Road
550
bridge
Hydro-
electric
Facility
Tourist
Park
Dam
200 m
diesel
plant
sand beach
B.
C.
A.
Fly Ash
Overflow
main
channel
A.
fly ash
substrate
U.P.G.Co
Presque
Isle
Station
A.
fore
bay
intakes
wood chip
substrate
Discharge
Canal
shallow
area
Lake
Shore
Boulevard
L.
Superior
Lake Superior
Marquette
area

point of intake at the U.P.G.Co. facilities identified on Figure 1. In addition, reverse water flow probably occurred whenever the river water level was low and a seiche came in from Lake Superior.

The river was divided into three study sections (Figure 1). The first section, referred to as section A, is the Presque Isle delta which flows into Presque Isle Harbor. It has many characteristics of a lentic environment. Section B is the former river channel to Lake Superior, separated by two channels from the main river channel. The last section, C, is the upstream main river channel, and is strongly lotic if water is flowing through the hydroplant or over the dam.

The surrounding Dead River watershed has been glaciated. The result has left out-croppings of Precambrian bedrock and Jacobsville sandstone among deposits of granular soils, such as sand and gravel. These soils are very impervious to infiltration of water. Boulders and granite out-croppings are found on the northwest shore of section B and the northeast shore of section C near the 550 bridge. Along the north shore of section A, particularly around the U.P.C.Co. Presque Isle station, is an area where fly ash has been deposited.

The topography around section A is mostly flat and low to the water level. The land around section B is somewhat higher with a steep hill on the northeast shore. Section C is dominated by a ridge inland from both sides of the shoreline, except for small swampy areas along the shores about half the distance between the diesel plant and the County Road 550 bridge.

The principal ecological areas in section A are a beach zone at the mouth of Lake Superior, a grass-weed community along the north

shore, abandoned industrial properties with woody plants, shrubs, and grasses dominating the vegetation on the south shore, and a tag alder (Alnus incana) community on the west shore. The land around section B is dominated by a grass-weed community on the northeast and west shore and a tag alder community along the north and south shores. Along its shore section C has a tag alder community intermixed with some white birch (Betula papyrifera) and sugar maple (Acer saccharrum). A forest of mature trees is further inland on higher ground. The predominant trees here are sugar maple, jack pine (Pinus banksiana), and white pine (Pinus strobus).

Section A, depicted on figure 2, has an approximate mean width of 250 m, a length of 900 m, and an area of 23 hectares. Water depth varies from 2.4 m maximum depth in the channel to extensive shallow areas of less than 0.5 m outside the channel. North of the channel the bottom is largely a substrate of flyash while the area in the south portion is composed of wood chips and sawdust from a former sawmill and sandy areas with some log and metal debris scattered on the bottom. Temperature ranges from 0 C in the winter to 24 C in the summer. I considered this area a warm-water zone during the summer months. Current varied from moderate to none depending on the exact location in the river, time of year, and whether or not the dam was releasing water. In all but the channel there was little current. In the channel the current flowed up to about 25 cm/ sec. In addition, U.P. Generating Co. has a discharge of $2.42 \times 10^4 m^3$/ day as supernatant from ash settling ponds (U.S. Army Corps of Engineers, 1973). This creates an area of suspended flyash in a large pattern along the north shore.

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Figure 2. Section A. The U.P.G.Co. facilities are shown in the background.

The water in this area is frequently highly turbid with the greatly reduced transparency. Ice forms throughout the section in the winter except for the upstream portion of the channel.

The old river bed, referred to as section B and shown in Figure 3, is approximately 180 m wide, 375 m long, and 7 hectares in area. This section used to drain into Lake Superior on the other side of Presque Isle. Water depth was measured at a maximum of 2 m when the water level was at a minimum in summer. Only a small portion along the west bank was consistently less than 1 m deep throughout the year. The substrate consisted of muck with some areas of sandy bottom along the west shore. Temperature ranges from 0 C to 26.5 C over the year. Currents were very minimal in this area and not unidirectional. This is the only study section to be completely covered with ice during the winter period. The area has all the characteristics of a lentic, warm-water environment.

Section C, the main river channel, is approximately 100 m wide, 1200 m in length and 12 hectares in area. Immediately below the dam this section consists of a tailrace area and rapids. Figure 4 shows the portion of the rapids below County Road 550 bridge. Below the rapids the river forms a deep channel. Maximum water depth in the channel ranged from 4 m in the fall to about 3.5 m in the spring. The yearly pattern was observed to be high water levels from September through March and low water levels from April through August. Section C has a hard bottom with abundant wood and metal debris present. Temperature fell to -2 C in November 1974 and reached a high of 25 C in the summer. The diesel power plant near the railroad bridge releases water that was

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Figure 3. Section B. The northwest shore is in the background.

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Figure 4. Section C. The lotic area under the County Road bridge is shown.

used for cooling purposes on an occasional basis. This entire study section was relatively ice free until March or April when the current was visibly reduced. Currents often exceeded 25 cm/ sec during the fall. Two shallow bayous are located off this section; one on the northwest shore and the other on the southeast shore. Both of these areas are lentic in nature and are similar to section B. The portion of this study area below the railroad bridge is usually lentic in nature if the dam is not releasing a large volume of water. Heated effluent from the diesel plant is an occasional factor in creating a warm-water zone in this lower portion. During both summers of the study an oil slick formed downstream from the diesel plant. This was caused by seepage from subterranean oil tanks. The oil slick persisted until the sand beach in front of the diesel plant was removed and replaced with new sand.

Aquatic vegetation was studied by Bills (1971) during the month of May 1971. He found 5 species of Potamogeton in section A. Other macrophytes in this section included the genera Equisetum, Juncus, Scirpus, Sparganium, Typha, Anacharis, Sagittaria, Myriophyllum, Utricularia, Isoetes, Ranunculus, Nuphar, and Ceratophyllum. Among the Chlorophyta Bills found the genera Spirogyra, Ulothrix, Chara, and Nitella. Also present were many groups of diatoms. All of these plants were collected along the south shore outside the areas of sawdust and woodchips.

MATERIALS AND METHODS

Identification of the species collected in the river was through the use of Hubbs and Lagler (1964), Scott and Crossman (1973), and Eddy and Underhill (1974). Nomenclature used in this study follows Bailey et al. (1970). A few specimens of each species were preserved and entered into either my personal collection or that of Northern Michigan University Museum of Zoology. All were preserved in 10% formalin.

Since the fish community of the lower Dead River was believed to be varied as to species and population sizes, several sampling techniques were utilized. I used both passive netting and electrofishing in sampling the river. In addition, agencies such as the U.S. Department of the Interior Fish and Wildlife Service and Wapora Inc. were contacted for information. The Fish and Wildlife Service used electrofishing and fyke nets in their sampling (R.A. Braem, personal communication); while Wapora's staff used a large trap net, 1.5 m diameter of 89 mm stretched mesh (J. Hatch, personal communication). Wapora Inc. collected in section C for 96 hours in October and 288 hours in November in 1975.

The passive netting I used represented one of the easiest and least expensive ways to study the river. The equipment consisted of a 1.2 m diameter hoop net of 89 mm stretched mesh with a 15.2 m lead and 2 smaller 0.6 m diameter hoop nets of 25 mm stretched mesh with 4.9 m leads. Gill netting, another form of passive netting, was also employed frequently. These different forms of nets were set perpendicular to the current on the river bottom. In 1974, a 27.4 m long and 1.8 m deep

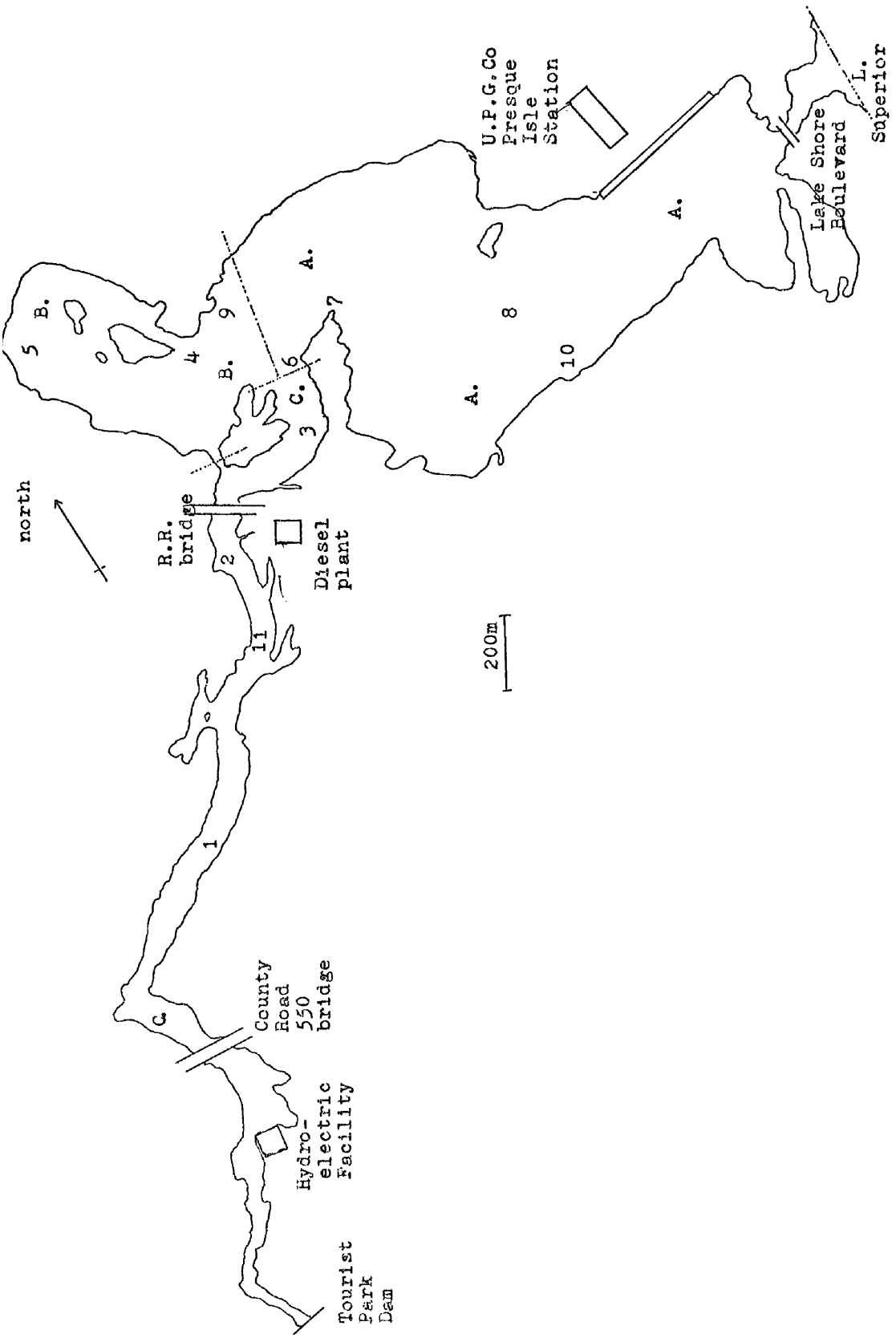
gill net of 89 mm stretched multifilament nylon mesh was used in the fall of 1974 and winter of 1975. Two 36.6 m long and 1.2 m deep gill nets of 64 mm stretched multifilament dacron mesh were employed during the fall of 1975.

Electrofishing equipment consisted of a boat-mounted unit of 230-V A.C. with an ideal operating current at 4 amperes and a backpack unit of 325-V D.C. with an operating current at 1 ampere. The boat-mounted unit was the least selective sampling unit used on the river. This unit was employed at night with one or two handnetters in operation in areas below the railroad bridge of less than 2 m depth. I began operation of the boat-mounted unit in Presque Isle Harbor before proceeding upstream. In contrast, the backpack unit was of lesser value except in the suspended flyash area on the north shore of section A. This unit was operated either from the stern of a 4.9 m rowboat or was carried on the back along the shoreline in shallow water.

Appendix Table A depicts the sampling routine and monthly hourly effort for the study sections. A total of 202 hours of effort was expended on section A, mostly with the boat-mounted electrofishing unit. On section B a sum of 373 hours was spent with all methods except gill netting. A total of 784 hours of effort were spent for section C. It was on this section that gill netting was the most important sampling method employed. Sampling stations are shown on Figure 5.

Figure 5. Sampling stations on the lower Dead River.

1 = 1.2 m hoop net and gill nets, 1974-1975.
2 = 1.2 m hoop net, 1974-1975.
3 = Trap net station, Wapora Inc., 1975.
4 = 1.2 m hoop net, 1974-1975.
5 = 1.2 m hoop net, 1974.
6 = 0.6 m hoop nets and gill nets, 1974-1975.
7 = 0.6 m hoop nets, 1974-1975.
8 = gill net, 1974-1975.
9 = 0.6 m hoop nets, 1975.
10 = 1.2 m hoop nets, 1974.
11 = 0.6 m hoop nets, 1974-1975.


north
Tourist Park Dam
Hydro-electric Facility
County Road 550 bridge
R.R. bridge
Diesel plant
U.P.G.Co Presque Isle Station
Lake Shore Boulevard
L. Superior
200m
A.
B.
C.
1
2
3
4
5
6
7
8
9
10
11

RESULTS

Species collected during the study are listed in Table 1. Thirty species in all were collected and except for two species of whitefish, all were found to occupy the river itself. Whitefish were caught near the river mouth in Presque Isle Harbor. The numbers of each species and the month in which they were captured are shown in Table 2. An attempt was made to determine the status of the various species of fishes occurring in the river during the months of the year. Table 3 denotes whether the sampled fish were resident adults, migratory adults, or young of the year. Adults were classified as either residents or as migrants by either lack of presence in the river throughout most of the year or relatively large increases in numbers of adults during the spawning time of the year for the species. In some cases it was not possible to identify an adult as either a resident or as a migrant. These were designated as unknowns. Young of the year were determined as such by their size.

In certain cases, Wapora, Inc. data are included in the tables. Their river survey in October and November, 1975, coincided with mine and they employed the use of a trap net, a form of passive netting not available to me. Certain species, such as the white sucker and coho salmon were captured by this net but not by my nets. I felt the combination of the two surveys tended to give a more complete listing of species for those 2 months.

Distributions of the species in the three sections of the river and Presque Isle Harbor at the river mouth are shown in Table 4.

Table 1. List of fishes obtained from the lower Dead River.

Class Osteichthyes - Bony Fishes

Order Clupeiformes
Family Clupeidae
Alosa pseudoharengus (Wilson), alewife

Order Salmoniformes
Family Salmonidae
Coregonus clupeaformis (Mitchill), lake whitefish[1]
Prosopium cylindraceum (Pallas), round whitefish[1]
Oncorhynchus gorbuscha (Walbaum), pink salmon
Oncorhynchus kisutch (Walbaum), coho salmon
Oncorhynchus tshawytscha (Walbaum), chinook salmon
Salmo gairdneri Richardson, rainbow trout
Salmo trutta Linnaeus, brown trout
Salvelinus namaycush (Walbaum), lake trout

Family Osmeridae
Osmerus mordax (Mitchill), rainbow smelt

Family Esocidae
Esox lucius Linnaeus, northern pike

Order Cypriniformes
Family Cyprinidae
Cyprinus carpio Linnaeus, carp
Notemigonus crysoleucas (Mitchill), golden shiner
Notropis atherinoides Rafinesque, emerald shiner
Notropis hudsonius (Clinton), spottail shiner

Family Catostomidae
Catostomus catostomus (Forster), longnose sucker
Catostomus commersoni (Lacépède), white sucker

Order Siluriformes
Family Ictaluridae
Ictalurus nebulosus (Lesueur), brown bullhead

Order Percopsiformes
Family Percopsidae
Percopis omiscomaycus (Walbaum), trout-perch

Order Gadiformes
Family Gadidae
Lota lota (Linnaeus), burbot

Table 1. Continued.

Order Atheriniformes
  Family Atherinidae
    Labidesthes sicculus (Cope), brook silverside

Order Perciformes
  Family Centrarchidae
    Ambloplites rupestris (Rafinesque), rock bass
    Lepomis gibbosus (Linnaeus), pumpkinseed
    Lepomis macrochirus Rafinesque, bluegill
    Micropterus dolomieui Lacépède, smallmouth bass

  Family Percidae
    Etheostoma nigrum Rafinesque, johnny darter
    Percina caprodes (Rafinesque), logperch
    Perca flavesens (Mitchill), yellow perch
    Stizostedion vitreum vitreum (Mitchill), walleye

  Family Cottidae
    Cottus cognatus Richardson, slimy sculpin

[1] The whitefishes were not collected in the Lower Dead River, but in the Presque Isle Harbor.

Table 2. Monthly records of fishes collected in 1974 and 1975.

Species	1974						1975											
	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
alewife	-[1]	-	-	4	-	-	-	-	-	-	-	-	-	-	14	-	-	-
lake whitefish	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
round whitefish	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
pink salmon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-
coho salmon	1	-	-	-	-	2	1	-	1	-	-	-	-	-	4	-	-	-
chinook salmon	-	1	2	4	-	14	3	5	2	5	-	-	-	2	7	-	7	6
rainbow trout	-	-	-	-	1	3	4	1	1	8	-	-	-	-	1	1	2	1
brown trout	-	-	-	-	-	-	1	-	1	1	-	-	-	-	1	-	-	1
lake trout	-	-	-	-	2	-	-	-	-	-	-	-	-	-	2	1	-	-
rainbow smelt	2	34	4	1	10	-	-	-	-	12	-	-	-	-	20	2	-	-
northern pike	2	2	12	11	1	-	-	-	-	15	6	1	7	6	4	-	1	1
carp	1	7	2	2	-	-	-	-	-	1	2	2	6	1	1	-	-	-
golden shiner	1	24	16	44	-	-	-	-	-	-	-	-	5	20	106	-	-	-
emerald shiner	3	9	3	11	1	-	-	-	-	-	-	-	-	3	3	-	-	-
spottail shiner	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-
longnose sucker	-	-	-	1	-	-	-	-	-	4	10	-	-	-	-	-	-	-
white sucker	71	45	45	45	59	5	-	-	6	43	36	12	67	49	43	2	-	-
brown bullhead	102	97	181	137	54	3	-	-	-	16	44	4	46	40	35	-	-	-
trout-perch	-	-	1	3	-	-	-	-	-	-	-	-	-	1	-	-	-	-
burbot	-	2	3	2	3	1	-	-	-	-	-	-	-	1	1	1	-	-
brook silverside	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
rock bass	22	25	30	47	7	1	-	1	-	1	8	-	24	23	21	-	-	-
pumpkinseed	5	4	8	10	-	-	-	-	-	1	3	-	4	11	2	-	-	-
bluegill	2	3	-	2	-	-	-	-	-	-	-	-	1	-	-	-	-	-
smallmouth bass	4	-	4	11	-	-	-	-	-	-	1	-	5	2	1	-	-	-

Table 2. Continued.

Species	1974 Jun	Jul	Aug	Sep	Oct	Nov	1975 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
johnny darter	7	3	8	4	7	-	-	-	-	-	6	3	29	5	2	-	-	-
logperch	1	1	3	4	-	-	-	-	-	-	-	-	7	6	-	-	-	-
yellow perch	40	84	51	46	14	-	-	-	-	-	6	-	67	39	52	-	-	-
walleye	-	1	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
slimy sculpin	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-

[1] X denotes the presence of lake whitefish during that month.

Table 3. Classification of fishes collected in the lower Dead River.

Key to characters:

R = resident adult of the species.
M = migratory adult of the species.
Y = young of the year.
U = either resident or migratory adult.

Species	1974						1975											
	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
alewife				M											M			
pink salmon															M			
coho salmon	Y					M	M		M						M			
chinook salmon		Y	M	M		M	M	M	M	M				M	M		M	M
rainbow trout					M	M	M	M	M						M	M	M	M
brown trout							M		M	M					M			M
lake trout					M										M	M		
rainbow smelt	M	MY	M	M	M					M					MY	M		
northern pike	R	R	RY	RY	R					R	R	R	RY	RY	R		R	R
carp	U	U	U	U						U	U	U	U	U	U			
golden shiner	R	R	R	RY									R	RY	RY			
emerald shiner	U	U	UY	UY	U									U	U			
spottail shiner				M											M			
longnose sucker				M						M	M							
white sucker	MR	RY	RY	RY	RY	R			MR	MR	MR	MR	RY	RY	RY	R		
brown bullhead	R	RY	RY	RY	RY	R				R	RY	R	RY	RY	RY			
trout-perch			M	M										M				
burbot		Y	Y	MY	M	M								M	M	M		
brook silverside	U																	
rock bass	RY	RY	RY	RY	R	R		R		R	R		RY	RY	RY			
pumpkinseed	R	R	RY	RY						R	R		R	RY	R			
bluegill	R	R	R	R									R					
smallmouth bass	UY		UY	UY							U		UY	UY	U			
johnny darter	RY	R	RY	R	R						R	R	RY	R	R			
logperch	R	R	RY	RY									RY	R				
yellow perch	MR	RY	RY	RY	RY						MR		RY	RY	RY			
walleye		M	M								M							
slimy sculpin	Y														M			

Table 4. Distribution of fishes in the lower Dead River in 1974 and 1975.

Key to characters:

A = Delta section of the river.
B = Old river channel.
C = Upstream section.
P = Presque Isle Harbor at the mouth of the river.
Z = All sections of the river and the harbor.

Species	1974 Jun	Jul	Aug	Sep	Oct	Nov	1975 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
alewife				P											BC			
pink salmon															AC			
coho salmon	A					C	C		C						AC	C^1	C^1	
chinook salmon		A	P	C		AC	C	C	C	C				CP	C	C^1	C	C
rainbow trout					A	C	C	C	C	C					C	CC^1	CC^1	C
brown trout							C		C	C					C		C^1	C
lake trout					AP										A	CC^1	CC^1	
rainbow smelt	P	P	P	P	P					ACP					A	C		
northern pike	BC	B	ABC	BC	A					BC	BC	BC	AB	ABC	AC		CC^1	C
carp	B	AB	AB	A						B	A	A	AB	A	B			
golden shiner	B	B	BC	ABC									ABC	AB	BC			
emerald shiner	B	B	BC	A	P									C	C			
spottail shiner				A											A			
longnose sucker				C						C	C							
white sucker	ABC	Z	Z	Z	ABC	AC			C	BC	ABC	ABC	ABC	ABC	Z	CC^1	C^1	
brown bullhead	AB	ABC	Z	Z	ABC	B				B	ABC	ABC	ABC	ABC	ABC			
trout-perch			P	A										P				
burbot		P	AP	P	ACP	C								A	C	C	C^1	
brook silverside	AP																	
rock bass	AB	ABC	ABC	ABC	ABC	B		C		B	B		ABC	ABC	AC			
pumpkinseed	B	B	BC	B						B	B		B	BC	B			
bluegill	B	B		B									B					
smallmouth bass	AB		BC	ABP							B		A	BC	B			
johnny darter	AB	AB	ABC	ABC	A						AB		ABC	AB	AC			
logperch	A	A	AB	A									A	A				
yellow perch	AB	ABC	Z	Z	A						AB		ABC	ABC	AB			
walleye		P	C								C							
slimy sculpin	A														A			

Wapora, Inc. data are included for the months of October and November of 1975. Certain species were common to both Wapora's survey and mine.

Appendix Table B lists the fish species and the numbers collected during the Wapora, Inc. survey in section C. Temperatures taken during the survey including Wapora Inc. data are listed in Appendix Table C. Wapora data is also included. Appendix Table D presents the age and growth results from scale reading and back calculations for certain species.

DISCUSSION

Excluding the whitefish captured near the river mouth, 28 species of fish were found in 1974 and 1975 in the lower Dead River. Eighteen of these - the alewife, chinook salmon, pink salmon, coho salmon, lake trout, carp, golden shiner, emerald shiner, spottail shiner, brown bullhead, trout-perch, burbot, brook silverside, pumpkinseed, bluegill, johnny darter, logperch, and slimy sculpin - had not been documented in the literature as being in the river.

Table 5 was compiled from my results and those of the Fish and Wildlife Service (R.A. Braem, personal communication) as a total species list for the lower Dead River. This table also includes the Atlantic salmon, Salmo salar, which was collected at the mouth of the river in Presque Isle Harbor by the Michigan DNR, and probably came from Wisconsin plantings in Lake Superior (P.R. Hannuksela, personal communication). The Michigan DNR introduced this species in 1976 to Cherry Creek, a tributary of the Chocolay River which enters Lake Superior about 10 km from the Dead River. It is quite possible that a few Atlantic salmon from this planting could stray into the Dead River on occasion.

Those species recorded in the river in the past (Taylor, 1954, Moore and Braem, 1965) but not found in my study were not listed. These included the ninespine stickleback, Pungitius pungitius, brook trout, Salvelinus fontinalis, and common shiner, Notropis cornutus. The sampling methods I employed over such a long period of time almost certainly would have collected these three species. This is especially

Table 5. A composite list of fishes of the lower Dead River showing the location in which they were captured and the original study.

Key to characters:

A = Delta section of the river.
B = Old river channel.
C = Upstream section.
P = Presque Isle Harbor at the river mouth.
Z = All sections of the river and the harbor.
U = Unknown study section.

Species	Present	Location found and study: Wapora Inc.	USF&WS	Michigan DNR
Ichthyomyzon fossor Reighard and Cummins			U[1]	
Ichthyomyzon unicuspis Hubbs and Trautman			U[1]	
Petromyzon marinus Linnaeus			U[1]	
Alosa pseudoharengus (Wilson)	BCP			
Coregonus clupeaformis (Mitchill)	P[2]			
Prosopium cylindraceum (Pallas)	P[2]			
Oncorhynchus gorbuscha (Walbaum)	AC			
Oncorhynchus kisutch (Walbaum)	AC	C		
Oncorhynchus tshawytscha (Walbaum)	ACP	C		
Salmo gairdneri Richardson	AC	C	U	
Salmo salar Linnaeus				P
Salmo trutta Linnaeus	C	C	U	
Salvelinus namaycush (Walbaum)	ACP	C		
Osmerus mordax (Mitchill)	ACP		U	
Esox lucius Linnaeus	ABC	C	U	
Cyprinus carpio Linnaeus	AB			
Notemigonus crysoleucas (Mitchill)	ABC			
Notropis atherinoides Rafinesque	Z			
Notropis hudsonius (Clinton)	A			
Catostomus catostomus (Forster)	C			
Catostomus commersoni (Lacépède)	Z	C	U	
Ictalurus nebulosus (Lesueur)	Z			
Percopis omiscomaycus (Walbaum)	AP			
Lota lota (Linnaeus)	ACP	C		
Labidesthes sicculus (Cope)	AP			
Ambloplites rupestris (Rafinesque)	ABC		U	
Lepomis gibbosus (Linnaeus)	BC			
Lepomis macrochirus Rafinesque	B			
Micropterus dolomieui Lacépède	Z		U	

Table 5. Continued.

Species	Location found and study			
	Present	Wapora Inc.	USF&WS	Michigan DNR
Etheostoma nigrum Rafinesque	ABC			
Percina caprodes (Rafinesque)	AB			
Perca flavesens (Mitchill)	Z		U	
Stizostedion vitreum vitreum (Mitchill)	CP		U	
Cottus cognatus Richardson	A			

[1] These species spawn in lotic water conditions such as found in section C. They are likely to have been captured in that area.

[2] The whitefishes were not captured in the lower Dead River study sections.

true of the brook trout, which has been planted in large numbers since 1967 in Marquette Harbor. Another salmonid, the splake, Salvelinus fontinalis ♂ x Salvelinus namaycush ♀, was introduced in 1974 to Marquette Harbor (Michigan DNR planting records). None were collected in the Dead River.

Those species collected by Moore and Braem (1965) and during the course of my survey are the following: rainbow trout, brown trout, rainbow smelt, northern pike, longnose sucker, white sucker, rock bass, smallmouth bass, yellow perch, and the walleye. Most of the salmonids and the alewife have either been stocked since 1965 or invaded Lake Superior from other Great Lakes. The warm-water fishes of the families Centrarchidae, Percidae, and Cyprinidae were not sampled by Moore and Braem. However, their sampling methods used electric barriers, low current backpack shockers, fyke nets, and chemical treatment in the main channel of the river. They sampled seasonally and concentrated their efforts in the lotic zones.

Earlier, Lowe had investigated the species composition of the Dead River at Hoist Dam in 1928, between McClure Dam and the power plant at Forestville in 1923, and in Marquette Bay of Lake Superior at unspecified locations in 1921, 1925, 1929, and 1930 (Taylor, 1954). He found the rainbow trout, brook trout, white sucker, golden shiner, pearl dace (Semotilus margarita), northern redbelly dace (Chrosomus eos, which is a junior synonym of Phoxinus eos), lake chub (Hybopsis plumbea, the current name of which is Couesius plumbeus), blacknose dace (Rhinichthys atratulus), longnose sucker, common shiner, fathead

minnow (Pimephales promelas), smallmouth bass, pumpkinseed, yellow perch, Iowa darter (Etheostoma exile), mottled sculpin (Cottus bairdi), and slimy sculpin in the Hoist Dam area and below the McClure Dam, all of which are at least 6.5 km above my study area. Of these, the rainbow trout, white sucker, golden shiner, longnose sucker, smallmouth bass, pumpkinseed, yellow perch, and slimy sculpin were collected in my survey. In Marquette Bay, Lowe found the emerald shiner, trout-perch, mottled sculpin, and slimy sculpin. I found all of these except the mottled sculpin.

It can be observed that only a few of the larger species were encountered in the lower portion of the river. Most of the Cyprinidae are missing. Species such as the common shiner are often sensitive about water turbidity and siltation (Scott and Crossman, 1973, Eddy and Underhill, 1974). The status of most of the cyprinids that Lowe collected is unknown today. Three species: the brook trout, common shiner, and ninespine stickleback, have apparently disappeared from the lower Dead River.

A number of species occur in the upper reaches of the Dead River that are not present in the lower portion. Raisanen (1976) found the brassy minnow (Hybognathus hankinsoni), blacknose shiner (Notropis heterolepis), northern redbelly dace, finescale dace (Phoxinus neogaeus), fathead minnow, creek chub (Semotilus atromaculatus), pearl dace, brook stickleback (Culaea inconstans), and Iowa darter in the Dead River drainage system in the McCormick Forest.

The Dead River is not the only river in Michigan to have undergone species changes over a period of time. Richards (1976)

recorded an increase in cold-water species from the 1920's to 1972 in moderate flow areas of the Au Sable River, while the species diversity, evenness, and number remained stable in the warm headwater habitat. Evenness was a ratio of species diversity over maximum species diversity. He stated that stability of water flow did affect species composition and diversity below hydroelectric dams where he recorded a decline in such areas for species diversity and evenness, but not for the number of species. The reduction in diversity and evenness was considered an indication of deteriorating water quality, especially for turbidity, and the result of unstable water flow. Richards implies that the composition of warm-water species is relatively stable under varying water flow conditions below hydroelectric dams while the composition of cold-water species is not. Eddy and Underhill (1974) state that in streams that became turbid and silted, game fish populations will become reduced and warm-water species such as suckers will increase.

The lotic area of section C in the lower Dead River is characterized by unstable water levels and flow throughout the year. Although not measured during my survey, turbidity from man's cultural use of the Dead River is at a high level. The discharge from the ash settling ponds in section C is especially high in turbidity. These are the conditions that appear to reduce species diversity.

All of the members of the Clupeidae, Salmonidae, Osmeridae, Percopsidae, Gadidae, and Cottidae are migratory species in relation to the lower Dead River. All of these are primarily cold-water fish. Table 3 shows the times the residents and migrants were found in the river. Their presence occasionally coincides with the spawning time for that

particular species. Sixteen of the 30 species are strictly migratory in relation to the Dead River as they were not found in the river during several months. Two other species, the white sucker and yellow perch, have their numbers increased by some migrants entering the river during their spawning season.

The only permanent residents of the river are those that are commonly associated with warm-water habitats throughout the year. Species such as these are often tolerant to turbidity and unstable water flow. The white sucker and brown bullhead are typical examples (Scott and Crossman, 1973). Tables 2 and 4 show a high degree of occurrence and widespread distribution of such species in the river. The brown bullhead, northern pike, white sucker, rock bass, johnny darter, and yellow perch were collected in either relatively large numbers or else stable numbers and in all habitats of the river at least once during the survey. It seems that in winter the majority of warm-water fishes are centered in Section B and delta portions of the river under the ice as they were not collected by gill netting in section C. An alternative possibility for their lack of being captured in the winter may have been their reduced activity or use of an inappropriate gill net for these species. They are not likely to winter in Lake Superior.

Ten species were considered to have successful reproduction in the river. All of the species that were verified for successful reproduction (Table 6) are basically from warm-water habitats. In the probable category were five cold-water species - alewife, pink salmon, rainbow smelt, longnose sucker, and burbot - and two warm-water species -

Table 6. Reproduction success for the fishes of the lower Dead River.

Species	successful reproduction			
	verified	probable	possible	doubtful
alewife		AB		
pink salmon				C
coho salmon			C	
chinook salmon			C	
rainbow trout			C	
brown trout			C	
lake trout				C
rainbow smelt		C		
northern pike	AB			
carp		AB		
golden shiner	AB			
emerald shiner			B	
spottail shiner				A
longnose sucker		C		
white sucker	C			
brown bullhead	ABC			
trout-perch				C
burbot		C		
brook silverside				A
rock bass	ABC			
pumpkinseed	B			
bluegill	B			
smallmouth bass	ABC			
johnny darter	ABC			
logperch		A		
yellow perch	AB			
walleye				C
slimy sculpin				A

A = Delta portion of the river
B = The old river channel
C = The upstream section

carp and logperch were from warm-water habitats. Eleven species fell into the possible or doubtful category.

Sections A and B were the more suitable areas for spawning, being particularly suitable for warm-water fishes. Only the white sucker was verified as successful at reproducing in the lotic water area below the 550 bridge and below the dam in section C. Table 7 shows the sequence of potential spawning in section C. It may be important that the white sucker is the last species to spawn. The salmonids, burbot, rainbow smelt, and longnose sucker all precede the white sucker run. Ellis and Roe (1917) found white sucker predation on the eggs of logperch to be significant. Although other researchers indicate that such predation may not be important (Scott and Crossman, 1973), it seems from Table 7 that white suckers are in a position to feed on the eggs of other species simply by being last to migrate to the lotic portion of section C.

A more likely possibility why spawning may not be successful for most of the migratory species is the variable water levels in section C created by the off and on again water release from the hydroelectric facility. Very low water levels and reduced flow conditions occur in the upper portion of section C when the facility is not operating. This may result in higher water temperatures, exposure of eggs or newly hatched fish to the air, and reduced aeration of the water. Changes are likely to be detrimental to the eggs and fry of all species, but especially for the cold-water species.

Perhaps the most significant result of this study is the identification and relative abundance of warm-water, relatively tolerant

Table 7. Weekly spawning sequence of fishes in the lotic area of section C.

Month	Species	Mean °C
Sep	chinook salmon	20.0
	pink salmon, chinook salmon	15.8
	coho salmon	14.0
	coho salmon	13.0
Oct	coho salmon	-
	coho salmon	-
	coho salmon	7.5
	coho salmon	8.3
Nov	coho salmon, brown trout	8.5
	chinook salmon	7.7
	chinook salmon	8.3
	chinook salmon	2.0
Dec	chinook salmon	-
	chinook salmon	4.0
	chinook salmon	3.0
	chinook salmon	-
Jan	rainbow trout	2.0
	rainbow trout	-
	rainbow trout	-
	rainbow trout	-
Feb	rainbow trout	1.0
	rainbow trout	-
	rainbow trout	-
	rainbow trout	-
Mar	rainbow trout	-
	rainbow trout	-2.0
	rainbow trout	-
	rainbow trout	-
Apr	rainbow trout	1.0
	longnose sucker	2.0
	longnose sucker	6.0
	rainbow smelt	6.0
May	rainbow smelt	7.5
	white sucker	10.0
	white sucker	14.2
	white sucker	-

species that were not previously reported in this portion of the Dead River. The species composition appears to have changed since Moore and Braem (1965) did their survey.

Discussion of Individual Species Collected.

Alosa psuedoharengus (Wilson)

A total of 18 alewives were collected; four from the harbor near the river mouth during 1974 and 14 from sections A and C during September, 1975. The specimens had a mean total length of 79 ± 15 mm. Annuli on scales revealed the presence of two age groups, both groups having females ripe with eggs. It appears that the alewife is a probable spawner in the river although no fry were collected in the river.

Coregonus clupeaformis (Mitchill)

A large school of lake whitefish was encountered near the mouth of the river on the night of June 4, 1974 during an electrofishing run. The school was about 25 m from the river mouth and some individuals may have entered the river. This species is not a usual resident of any river system in the Lake Superior Basin (Scott and Crossman, 1973).

Prosopium cylindraceum (Pallas)

One individual of this species, 117 mm TL, was taken in June of 1974 by electrofishing. The specimen, found in the harbor about 25 m from the river mouth, was a juvenile. No other specimens were taken.

Oncorhynchus gorbuscha (Walbaum)

The pink salmon is the only accidently released salmonid that has established itself in Lake Superior without annual planting. About 100 fingerlings were released into Thunder Bay on the Canadian Shore in 1955 (Schumacher and Eddy, 1960) and formed the progenitors of the population now present in Lake Superior's fish community.

The species has a 2 year life cycle, whether in marine or freshwater habitats (Eddy and Underhill, 1974). Three adult specimens (mean TL of 390±28 mm) were collected in sections A and C during the fall of 1975. I observed pink salmon below the dam and under the 550 bridge and estimated several hundred individuals for the entire spawning run in the middle of September. No nesting or mating behavior could be defined, but the species probably successfully reproduces in the river judging from the number of adults returning to spawn in the river.

Oncorhynchus kisutch (Walbaum)

The first coho salmon were planted in 1965 in Lake Superior tributaries from the Columbia River parent stock (Eddy and Underhill, 1974). Beginning in 1970 the Michigan DNR has stocked the Dead River annually from the Lake Shore Boulevard bridge with yearlings as follows: 75,000 in 1970, 122,458 in 1971, 76,204 in 1972, 100,017 in 1973, 100,023 in 1974, and 200,000 in 1975. The coho salmon has a maximum life cycle of 5 years in the coastal waters of British Columbia (Pritchard, 1940).

Adult coho salmon were collected by electrofishing and gill netting in November of 1974, and January, March, and September of 1975. A total of eight mature fish were collected in sections A and C. The mean total length was 483±134 mm. In addition, one fingerling was taken in section C by electrofishing in June, 1974. The staff of Wapora Inc. collected 10 specimens in late October and 45 collected in the same location in November, 1975, in section C. This species was

quite vulnerable to trap netting but not to gill netting.

Only a very few coho salmon were seen below the dam and below the 550 bridge. Coho salmon possibly reproduce in the Dead River, but not likely.

Oncorhynchus tshawytscha (Walbaum)

The chinook salmon, the largest of the Pacific salmon, was introduced in 1967 by the Michigan DNR to Lake Superior (Eddy and Underhill, 1974) and first planted in the Dead River during 1970 according to DNR records. Some 50,006 spring fingerlings were released that year from the Lake Shore Boulevard bridge. The subsequent releases in the Dead River took place in 1972 with 216,250 yearlings, in 1973 with 276,240 fingerlings, in 1974 with 100,188 fingerlings, and in 1975 with 150,429 spring fingerlings. The stock, originally from the Toutle River in the Columbia River system, has been able to reproduce in the Anna River near Munising (T. Stauffer, personal communication). However, no alevins or fingerlings that could have come from natural reproduction were collected in the Dead River. The species has a maximum life cycle of 5 years in Pacific coastal areas (Gilbert, 1913) but no age V fish were collected in the Dead River (Appendix Table D).

Three stocked juveniles were taken by electrofishing in July and August of 1974. Eighteen adults were collected by gill nets and electrofishing that year. Only adults were collected during 1975 when 15 salmon were captured by gill netting from January to April and 23 were taken from August to December by gill netting and electrofishing. The trap net used by Wapora Inc. collected five individuals

in late October and none in November (Appendix Table B).

One spawning run with two parts was identified for chinook salmon in the river. Chinook salmon began to appear in the river in late summer when water temperatures ranged from 13 to 17 C. The first 1974 chinook salmon were caught on September 20, while in 1975 the first appearance was on August 22. Characteristics of this portion of the spawning run are presented in Table 8. The second part of the run began in late October or early November, with water temperatures between 3-7 C and a strong current present in the river. Both parts of the run appeared to act independently of each other; there was no overlap between the September portion and the November portion. Redd construction was not verified in the study area below the dam and below the 550 bridge although mature fish were highly visible.

Between January and March, with water temperatures near 0 C, only males were collected in the river. The 10 males averaged 385 mm TL and released milt upon handling. It was apparent that with only males present spawning had been completed for that year. Scott and Crossman (1973) indicate that males have survived the spawning period by as much as 5 months. However, Ruth Mandapat, University of Washington, (personal communication) stated that no chinook salmon have been known to survive spawning in the state of Washington except for males under artificial conditions.

Five males collected in April averaged 577 mm TL. They were a vivid red along the lateral sides, had indistinct spots on the caudal fin, faded white edging along pelvic, anal, and caudal fins, and a normal jaw. One specimen of 735 mm TL was examined in the laboratory

Table 8. Aspects of chinook salmon during the spawning run.

First Part of Run	Second Part of Run
sample size: 15 fish	19 fish
dates: August-September, 1974-1975	November-December, 1974-1975
mean size: 758±103 mm	400±56 mm
male morphology: no hooked jaw	hooked jaw
male color: No white edging on pelvic, anal, and caudal fins. Spots on both lobes of the caudal fin. Rather light coloration on lateral sides.	White edging on pelvic, anal, and caudal fins. Spots on both lobes of caudal fins. Darker coloration.
sex ratio: 13 males:2 females	27 males:12 females
female color: A dark dorsal surface. Yellow-green lateral sides. Same edgings on fins as for male. Same caudal fin as male of this period.	A deep black dorsal color. Dark lateral sides. Same edgings on fins as for male. Same caudal fin as male of this period.
Age: Males- II and III. Females- II and III.	Males- I, II, and III. Females- II, III, and IV.

and appeared to have normal gut morphology with reduced testes. The specimen may have strayed into the Dead River by chance or it may be possible for males that survived the spawning season that long to resume normal feeding patterns.

Because no alevins or fingerlings were collected in the river and redd construction was not seen, it is unlikely that natural reproduction occurred for this species in the Dead River.

Salmo gairdneri Richardson

The rainbow trout, or steelhead, is another introduced salmonid that has been planted in the Marquette Harbor since 1969. Plantings off the Lake Shore Boulevard bridge consisted of 10,460 yearlings in 1969, 6,825 yearlings in 1970, and 14,000 fingerlings in 1973 (Michigan DNR planting records).

Four adult rainbow trout were taken in October and November of 1974 in sections A and C while additional adults, including several immature specimens less than 350 mm TL, were collected in the spring of 1975 in section C. The mean total length was 456±124 mm. I collected five additional rainbow trout in section C in the fall while Wapora Inc. collected six adults during their survey.

Rainbow trout from Lake Superior begin migrating upstream by October and usually spawn from late December to late April (Dodge and MacCrimmon, 1970). The Dead River population seems to fit into this cycle although nesting and spawning behavior was not identified. Rainbow trout are possibly, but not likely, successful spawners in the lower Dead River.

Salmo trutta Linnaeus

Annual plantings of brown trout in Marquette Harbor consisted of 10,000 to 20,275 yearlings between 1972 and 1975. I collected only 5 adult fish (mean TL of 565±44 mm) in section C. Wapora Inc. collected 3 individuals.

The brown trout, a fall spawner, probably does not successfully reproduce in the lower Dead River. The abundance of this species was low and no juvenile fish were collected.

Salvelinus namaycush (Walbaum)

Lake trout, a native salmonid, was occasionally found in the river in association with rainbow smelt. A specimen was taken in the harbor and another in section A during an electrofishing survey in October of 1974 when a total of 10 adult rainbow smelt were collected. Two lake trout were collected in September, 1975, by electrofishing and one in November by gill netting in sections A and C, respectively. The September sample also included 20 rainbow smelt taken before the lake trout were captured.

Spawning usually occurs in Lake Superior in October and November but is not a likely factor for the presence of lake trout in the river. Instead, it is most likely that the species entered the river following their prey, the rainbow smelt.

Osmerus mordax (Mitchill)

Rainbow smelt, an anadromous species, was collected by electrofishing with the boat-mounted unit during June, July, August, September, and October of 1974 in either the harbor near the river mouth or else

in section A. Twelve adult smelt were collected during April, 1975 in sections A and C. The mean total length was 182±14 mm. The September and October, 1975, electrofishing surveys also resulted in a collection of this species in section A.

During the April spawning season, attempts were made to observe a spawning population in the fast water area below the dam and under the 550 bridge without success. The spawning population, ranging between 79 and 285 mm TL, was probably relatively small during the years of the survey. The spring smelt fishery in the river may concentrate on some stray fish from other rivers in the nearby area, but successful reproduction probably occurs in spite of unstable water conditions in the spring.

Esox lucius Linnaeus

The northern pike was collected principally in section B during most of the months the survey was in progress. All methods of collecting were successful on this species. The species has a relatively wide distribution in the river and apparently a stable abundance in the warm-water areas of the river. The species is almost certainly a permanent resident of the river. Specimens were found to have a mean total length of 521±120 mm.

Ripe females were captured in April, 1975, in section B in areas of submerged vegetation. Spawning in shallow water, believed to be by northern pike, was seen in the same month. I also collected age I+ fish during the late summer months for both years. For these reasons, the northern pike is believed to reproduce in the Dead River.

Cyprinus carpio Linnaeus

Carp (mean TL of 579±133 mm) were collected mainly in the summer months in sections A and B. These two areas appeared to have the more favorable habitat for the species. The population seemed to be concentrated in the areas of submerged vegetation at night and in the area of constant suspension of flyash in the day. The flyash area along the north shore of section A has very low visibility. A group of about 25 adults were observed during a backpack shocking collection in this area in May, 1975. The limited sampling success did show an increase in abundance during July of both years. Specimens examined at this time were ripe fish. It is suspected that either spawners from Lake Superior may have swelled the population or else a higher degree of vulnerability to collecting increased the abundance.

Carp are known to spawn in concentrations of aquatic vegetation. Specimens taken in June through September were ripe, mature individuals usually displaying a more vivid coloration than those taken earlier. Carp probably reproduce in the river, although no juvenile carp were collected. This species is exceedingly wary (Scott and Crossman, 1973) and is difficult to collect.

Notemigonus crysoleucas (Mitchill)

Large numbers of golden shiners were seen and collected using the boom shocker only during the late summer months in sections A, B and the lower portion of C. During other seasons the species was probably present in deeper waters beyond the effective field of the boom shocker; it is not a resident of oligotrophic lakes (Scott and Crossman, 1973).

Mature golden shiners (mean total length 78±23 mm) were collected in a ripe condition in late August and early September when water temperatures began to reach 20 C. Spawning occurs in Michigan from June to August (Hubbs and Cooper, 1936) at 20 C (Dobie et al, 1948). The golden shiner was the most abundant minnow species in the river and is probably a permanent resident of the lower Dead River. The species spawned successfully during the years the survey was in progress.

Notropis atherinoides Rafinesque

Emerald shiners were collected largely by electrofishing from June to October and at least once in every section of the river and harbor. The mean total length was 98±9 mm.

Spawning probably occurs at 24 C (Scott and Crossman, 1973) in the Great Lakes. Temperatures of 24 C were attained in section B in July of 1974. However, ripe emerald shiners were not collected that year and only a few emerald shiners were taken in 1975. It appears that the emerald shiner, be it either a resident or a migrant species, is possibly successful at reproduction in the river. The river seems to fit all the criteria for successful midwater spawning of this species.

Notropis hudsonius (Clinton)

The spottail shiner was collected only twice during the survey. Single specimens were taken by electrofishing during September of each year in section A. The small numbers collected do not constitute a population of any significance.

Catostomus catostomus (Forester)

The longnose sucker, a migrant from Lake Superior, was collected principally in April and May of 1975 by gill netting in section C. The mean TL for specimens collected was 415±89 mm.

Longnose suckers spawn over gravel in currents of 30-45 cm/sec when water temperatures exceed 5 C (Scott and Crossman, 1973). These conditions are found under the 550 bridge in mid-April. Although spawning was not observed, it is probable that successful reproduction occurs.

This species was probably misidentified as the shorthead redhorse, Moxostoma macrolepidotum, by Seppala (1972).

Catostomus commersoni (Lacépède)

The white sucker, an abundant resident in the river, was collected as both fry and adults throughout the study period except for winter. The species was present in all sections of the river.

The species was considered to be one of the most profilic spawners in the river and I felt fecundity studies would be valuable to further assess the reproduction success of the species in the Dead River. Egg counts obtained from 17 fish collected in the spring of 1975 were used to calculate fecundity (Appendix Table E). The values are similar to those found by Raney and Webster (1942) in New York. For female white suckers over 481 mm in total length the mean fecundity count can be expected to exceed 50,000 eggs in the Dead River.

The white suckers spawn in either rivers or along lake shores in areas of gravel when water temperatures reach 10 C (Breder and Rosen,

1966). Large numbers of white suckers (mean TL of 576±214 mm) were taken in section C during April and May in ripe condition. The white sucker successfully reproduces as large numbers of fry were observed in the river, particularly section C, in July of both years. At that time the fry averaged 12 mm TL.

Ictalurus nebulosus (Lesueur)

The brown bullhead is the most abundant fish in the lower Dead River. This species was collected in considerable numbers during the summer months of 1974 by all sampling methods in all study sections. Relatively small numbers were taken in 1975 due to less sampling effort directed toward the species rather than a decreasing population. The mean total length was 223±76 mm.

Sections A, B, and the lower portion of C are highly suitable spawning areas from the information listed in Breder and Rosen (1966). Many schools of fry, approximately 10-12 mm TL, were seen in July in section B. The brown bullhead is a highly significant permanent resident of the river that successfully reproduces.

Percopis omiscomaycus (Walbaum)

Trout-perch were collected infrequently in section A of the river and twice in Presque Isle Harbor. It is very doubtful if trout-perch are present in the river in numbers large enough to spawn to any significant extent.

Lota lota (Linnaeus)

Burbot were collected as juvenile specimens in the summer months in the harbor area while adults were taken, usually in section C of the river, in the fall. The adult mean TL was 246±86 mm. Burbot generally broadcast spawn at night during midwinter at temperatures of 0.6-1.7 C on gravel substrates (Scott and Crossman, 1973). Burbot in the river seem to spawn much earlier that reported (Scott and Crossman, 1973). Females examined in late October and November had already voided their eggs and were probably moving downstream to return to deep water. Specimens were not collected after November. Either spawning occurred in water at 5.0-9.0 C or else, the females voided their eggs without actually mating with a male. However, the juvenile specimens collected at the river mouth in Presque Isle indicate that reproduction is occurring somewhere in the area. In my opinion, burbot are probably successful at spawning in the lower Dead River.

Labidesthes sicculus (Cope)

The brook silverside was reported in the Lake Superior watershed by Berg, et al. (1975) as a consequence of this survey. They were not taken after the initial collection of three specimens on June 4, 1974.

The sexual conditions of two specimens that were preserved suggests that the species may have been present for spawning in section A. The species apparently does not reside in the Dead River but possibly does in Lake Superior. Whether the species does become successful in the area is probably dependent on the availability of the required habitat for the life history of the species. It is doubtful that Lake Superior

meets those conditions.

Ambloplites rupestris (Rafinesque)

The rock bass is an abundant and widely distributed permanent resident of the lower Dead River. It was collected by every method employed in almost every month the survey was in progress. Total length of adults had a mean of 211±83 mm. Although nests were not found, fry of less than 15 mm were abundant in the river by July of 1974 and 1975. The species is quite likely to have reproduced in every section of the river during the study period.

Lepomis gibbosus (Linnaeus)

The pumpkinseed was collected in small numbers during the warm months in section B and section C. The mean total length was 153±60 mm. Although not very abundant, the species may have successfully reproduced as several age 0+ fish were taken in September of both years. These fish are likely permanent residents of the river in the lentic habitats.

Lepomis macrochirus Rafinesque

The bluegill was quite rare in the river as only eight individuals (mean TL of 106±31 mm) were collected during the warm months in section B. The species is limited to lentic habitats and is a likely permanent resident. Spawning probably occurred in section B; the presence of juveniles in September, 1974, confirmed successful reproduction.

Micropterus dolomeui Lacépède

Smallmouth bass were taken occasionally during the warm seasons by electrofishing and gill netting. Collections were made in all areas of the river and Presque Isle Harbor. The mean total length was 312±102 mm. Based on spawning requirements described in Breder and Rosen (1966), successful spawning could occur in any of the study sections and in the harbor. It is likely that spawning did occur there as indicated by the presence of small juveniles. Members of the species could be residents of the river or else migrants from Lake Superior.

Etheostoma nigrum (Rafinesque)

The johnny darter was found to be abundant and widely distributed in all sections of the river during the warmer months. The species is considered a permanent resident of the river. The mean total length was 34±16 mm. Spawning occurs in the spring on the underside of rocks as the water temperature increases (Atz, 1940). Spawning fish were collected in all sections of the river in the spring of 1975. The presence of fry substantiates successful spawning for that year.

Percina caprodes (Rafinesque)

Small numbers of logperch were collected in study sections A and B during the warmer months. Although they may occur in the harbor, it is most likely that the species is a resident of the river. Specimens had a mean total length of 137±30 mm. Spawning adults were not collected and although the two age groups were present in the

river, no firm evidence for successful reproduction could be found. Reproduction is probably successful for this species in the lower Dead River.

Perca flavecens (Mitchill)

The yellow perch was an abundant and widely distributed species that was collected by electrofishing in all study sections of the river. The mean total length was 179±43 mm. Some individuals were taken in ripe condition during May of 1975 in sections A and B. Spawning probably occurred in at least one of the study sections. Numerous fry were found by July throughout the river in both years. The yellow perch is considered to be a permanent resident of the river for which successful reproduction has been verified.

Stizostedion vitreum vitreum (Mitchill)

The walleye occurs on rare occasions in the Dead River. Priegel (1970) provides information which indicates spawning could occur in April or May in section C. However, only three specimens were taken during the survey making spawning an unlikely occurrence in the river. It is more likely that walleyes enter the river from Lake Superior to feed. The largest specimen, 740 mm TL, was collected less than 5 m from a small school of rainbow smelt in the harbor.

Cottus cognatus Richardson

The slimy sculpin, a resident of Lake Superior, was rarely found in the river. One specimen, identified to genus, was taken by electrofishing in 1974 but was lost in handling. Another was collected in September, 1975 and identified to species. Although section A

offers spawning locations for nests, apparently there were no individuals there to spawn. A larger population could enter the river to spawn in the spring and then return to deeper water after the eggs hatch. The evidence points only to possible reproduction success in the river.

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Appendix Table A. Sampling routine and monthly effort in hours on section A during the study.

	Hoop Net 1.2 m	Hoop Net 0.6 m	Electrofishing Boat	Backpack unit	Gill Net
1974					
Jun	24 hr	48 hr	2 hr		
Jul			2 hr		
Aug			2 hr		12 hr (nylon net)
Sep			2 hr		
Oct			2 hr		
Nov	36 hr				
1975					
Apr					12 hr (dacron net)
May	24 hr			2 hr	
Jun					
Jul			4 hr	2 hr	
Aug			2 hr		12 hr
Sep			2 hr		12 hr
	84 hr	48 hr	18 hr	4 hr	48 hr

Total: 202 hr on section A.

Appendix Table A. Continued. Sampling routine and monthly effort in hours on section B during the study.

	Hoop Net 1.2 m	Hoop Net 0.6 m	Electrofishing Boat	Backpack unit	Gill Net
1974					
Jun	48 hr		1 hr		
Jul	48 hr		2 hr		
Aug	72 hr		1 hr		
Sep	48 hr		1 hr		
Oct	24 hr				
Nov	24 hr				
1975					
Apr	24 hr				
May	24 hr	48 hr		2 hr	
Jun				2 hr	
Jul			2 hr		
Aug			1 hr		
Sep			1 hr		
	312 hr	48 hr	9 hr	4 hr	0 hr

Total: 373 hr on section B.

Appendix Table A. Continued. Sampling routine and monthly effort in hours on section C during the study.

	Hoop Net 1.2 m	Hoop Net 0.6 m	Electrofishing Boat	Backpack unit	Gill Net
1974					
Jun	36 hr	24 hr			
Jul					
Aug	36 hr	48 hr			12 hr
Sep	24 hr	24 hr			
Oct	24 hr	24 hr			
Nov	12 hr	24 hr			24 hr
1975					
Jan					12 hr
Feb					24 hr
Mar	12 hr				12 hr
Apr	24 hr	24 hr			48 hr
May	12 hr	24 hr		2 hr	24 hr
Jun				2 hr	
Jul					
Aug					48 hr
Sep					72 hr
Oct					24 hr
Nov					48 hr
Dec					48 hr
	180 hr	192 hr	0 hr	4 hr	396 hr

Total: 772 hr on section C.

Appendix Table B. The numbers of fishes sampled by Wapora Inc. in 1975 in section C.

Species	Oct	Nov
coho salmon	10	45
chinook salmon	5	-
rainbow trout	4	2
brown trout	-	3
lake trout	2	1
northern pike	-	1
white sucker	107	16
burbot	-	1

Trap net in operation from October 27 to November 18, total sampling effort: 528 hr.

Appendix Table C. Temperature Data (in °C). Wapora data is so indicated. Time is EST.

Date and Hour	section A	section B	section C	P.I. Harbor
6-4-74(1000)	-	-	18.5	-
6-4-74(2100)	18.0	-	-	-
6-12-74(900)	-	-	16.0	-
6-13-74(800)	-	14.0	-	-
6-19-74(800)	-	16.0	16.0	-
6-25-74(900)	-	19.0	16.0	-
7-1-74(2200)	16.0	18.0	18.0	16.0
7-9-74(900)	23.0	25.0	22.0	-
7-16-74(900)	-	23.0	22.0	-
7-22-74(900)	-	23.0	22.0	-
7-30-74(1500)	22.0	22.5	-	-
8-1-74(2100)	22.0	22.0	-	25.0
8-6-74(900)	-	21.0	20.0	-
8-13-74(800)	-	21.7	21.0	-
8-20-74(900)	-	23.0	21.0	-
8-27-74(900)	21.0	21.0	20.0	-
9-3-74(2030)	-	18.2	-	16.0
9-13-74(900)	-	17.0	15.5	-
9-20-74(700)	-	14.0	14.0	-
9-27-74(900)	-	13.5	13.0	-
10-4-74(900)	-	9.0	-	-
10-11-74(900)	11.0	-	-	-
10-11-74(1630)	14.0	14.0	-	20.5
10-25-74(930)	-	8.0	7.5	-
11-1-74(1100)	9.0	-	-	-
11-8-74(1100)	-	-	7.0	-
11-15-74(1000)	-	4.0	2.5	-
11-26-74(1230)	-	0.0	2.0	-
1-7-75(1000)	1.0	-	2.0	-
2-4-75(1200)	1.0	-	1.0	-
2-19-75(1100)	-	-	1.0	-
3-19-75(1200)	0.0	-	-2.0	-
4-4-75(1100)	1.0	-	1.0	-
4-11-75(1100)	1.0	-	2.0	-
4-23-75(1100)	-	-	5.5	-
4-25-75(1200)	5.0	-	6.0	-
4-30-75(1200)	-	-	6.0	-
5-6-75(1000)	7.5	12.0	7.5	-
5-13-75(1100)	-	13.5	-	-
5-14-75(900)	9.3	-	10.0	-

Appendix Table C. Continued.

Date and Hour	section A	section B	section C	P.I. Harbor
5-19-75(1000)	18.9	-	-	-
5-20-75(900)	-	16.0	14.2	-
5-27-75(900)	-	17.0	-	-
6-30-75(1600)	-	26.5	25.1	-
7-21-75(2200)	23.5	24.1	-	23.5
8-21-75(1300)	21.0	-	21.0	-
8-22-75(2030)	20.0	20.0	-	20.0
8-26-75(900)	21.1	-	21.0	-
9-5-75(900)	-	-	20.0	-
9-10-75(900)	-	16.4	16.0	-
9-13-75(2000)	14.0	-	-	14.5
9-30-75(2100)	-	-	13.0	-
10-28-75(1000)	-	-	9.0	-
11-3-75(Wapora)	-	-	8.5	-
11-10-75(Wapora)	-	-	8.3	-
11-4-75(Wapora)	-	-	8.5	-
11-11-75(1100)	-	-	7.0	-
11-11-75(Wapora)	-	-	7.0	-
11-17-75(Wapora)	-	-	5.8	-
11-18-75(Wapora)	-	-	5.0	-
11-18-75(1030)	-	-	7.0	-
12-9-75(1100)	-	-	4.0	-
12-16-75(1030)	-	-	3.0	-

Appendix Table D. Aspects of age and growth data from reading scales and back calculations (Fraser and Lee method) of lower Dead River fishes. The value for n was determined from scale and bone samples. Standard deviations were made for n greater than 2. All lengths are total lengths in mm.

Species	n	mean TL	Ages					
			I	II	III	IV	V	VI
alewife	8		49±13	102±17				
round whitefish	1	117						
pink salmon	3	390±28						
coho salmon	4	483±134						
chinook salmon	38		308±31	480±48	639±54	841		
rainbow trout	18		100±16	165±23	254±39	360±69	523±21	740
brown trout	5	565±44				3 or 4 annuli		
lake trout	2	735						
rainbow smelt	5	182±14						
northern pike	33		92±24	189±55	293±71	399±69	485±51	651
carp	7	579±99			between 3 and 11 annuli			
golden shiner	12	78±23						
emerald shiner	8	98±9						
spottail shiner	2	66						
longnose sucker	7	415±89			between 2 and 4 annuli			
white sucker	15		94±33	197±61	405±69	375±60	445±32	
brown bullhead	30	223±76						
trout-perch	5	102±17						
burbot	12	246±86						
brook silverside	3	78±9						
rock bass	11		46±4	81±23	157±24	207±15		
pumpkinseed	13		41±5	75±15	128±18	156±10		
bluegill	5	106±31			between 0 and 6 annuli			

Appendix Table D. Continued.

Species	n	mean TL	Ages					
			I	II	III	IV	V	IV
smallmouth bass	10	312±102			between 0 and 8 annuli			
johnny darter	12	34±16						
logperch	9	137±30			between 0 and 5 annuli			
yellow perch	22		37±9	74±18	112±30	196±52	264	
walleye	3	499±222			between 3 and 9 annuli			
slimy sculpin	2	less than 50						

Appendix Table E. Fecundity of the white sucker. Standard deviations are included for the maturity index and mean fecundity.

Size Class (mm)	n	mean weight (gm)	mean ovary weight (gm)	mean M.I.	mean fecundity
401-420	1	850.3	84.0	10	20,017
421-440	1	1295.7	159.7	12	38,056
441-460	1	1026.6	130.2	13	31,026
461-480	1	1269.0	175.5	14	41,821
481-500	2	1400.1	215.2	15±1	51,276 ±5030
501-520	3	1660.1	248.2	15±3	52,624 ±7593
521-540	7	1740.8	232.0	15±3	55,283 ±6642
541-560	1	1547.9	300.7	19	33,175

M.I. = maturity index = weight/ovary weight.