Box 1, Folder 10: Lake management plans, inventories and evaluations, 1980-1986. 1980-1986

[s.l.]: [s.n.], 1980-1986

https://digital.library.wisc.edu/1711.dl/VPQDOQXEBBUN28T

July, 1980

FISH LAKE ROCK REEF EVALUATION

by

Mike Dombeck
District Fisheries Biologist

Background

Fish Lake is a 125 acre lake on the Munising District in southeast Alger County. The Big Indian River flows into the northwest corner of Fish Lake and exits the northeast corner. The substrate along the shaol water area is predominantly sand with scattered areas of muck and marl. The lake is mesotrophic to eutrophic in nature with intermittent growths of submergent and emergent vegetation along the littoral area.

Fisheries surveys by the U.S. Forest Service in July and August of 1975 and DNR in July of 1977 showed a collapsed fish population structure dominated by large white suckers and black bullheads. The fishery was badly out of balance offering poor fishing. Both physical and biological parameters indicated that the fishery potential of Fish Lake was far greater then what existed there at the time of the surveys.

In past years Fish Lake has had the reputation of a good fishery. It plays a major role in the Indian River drainage which historically had spawning runs of both walleye and lake sturgeon up to Fish Lake and beyond. Fish Lake and other nearby lakes have also historically been used as feeding sites for the bald eagle and osprey.

Fish Lake Management Objectives

1. To restore and maintain a balanced fish population structure in Fish Lake dominated by large tertiary predators.

2. To restore and maintain a quality recreational fishery with high ecosystem values for wildlife including fish eating birds.

3. To use Fish Lake as a base for corrective management of the upper Big Indian River Lake Chain.

Corrective Action

1. The placement of a 1500 foot reef using 3-12" granitic rocks to provide spawning habitat for walleyes and other fishes requiring rock substrate which was lacking. The rock was placed from one foot above the high water mark to the five foot contour in the winter of 1978 and 1979 (See attached map).

2. Partial thinning of stunted panfish, suckers and bullheads using antimycin and fyke nets to reduce the numbers of problem species (Spring 1979).

3. Stocking of walleye fingerling to initially reestablish the predator component of the fishery (Summer 1979 & 1980).

The U.S. Forest Service constructed the rock reef. The M-DNR carried out the two remaining corrective measures.

Evaluation Objectives

1. To determine if and to what extent walleyes are using the rock reef.

2. To compare the occurance of fauna on the rock reef and adjacent sand substrate.

3. To assess the impacts of the 30,000 square foot rock reef on Fish Lake.

Evaluation Methods and Results

Electrofishing May 3rd and 7th, 1979, over equal areas of sand and newly installed rock reef during the walleye spawning season yielded the following results with water temperatures at 6°C and 8°C respectively:

	No. of fish taken over substrate.	
	Rock	Sand
Walleye	11	0
Northern Pike	0	9
Largemouth Bass	0	1
White Sucker	1	15
Bullhead	1	1
Bluegill	0	4
Black Crappie	0	1
Rock Bass	1	0
Yellow Perch	0	2

Using spot lights on April 24, 1980 two runs were made over the Fish Lake rock reef. Water temperature was 7°C. Seven walleye were observed the first run and 10 on the second run. All were adult fish. On April 28, 1980, eight adult walleye were observed on the rock reef. On both nights equal areas of sand shoreline were spot lighted and no walleyes were observed.

On April 30th and May 7th, 1980, the newly installed rock reef on Monocle Lake was spot lighted. A total of seven passes were made over the rock. Approximately 250 adult walleyes of various sizes were observed over the rock substrate while 17 walleyes were observed over sand substrate near the rock.

These observations indicate that the adult walleyes in spawning condition are homing in on the newly placed rock substrate.

Tom Stauffer, M-DNR research biologist and his staff are currently involved in a five year study sampling walleye eggs and fry on man made rock reefs. Stauffer et. al. placed egg trap pails in man made rock reefs on Six Mile Lake, Ottawa National Forest; Carp Lake, Chippewa County; and Manistique Lake, Mackinac County. Results reflect the number of walleye eggs laid and fry produced on the 408 square meter rock reef placed in Six Mile Lake.

		Confidence Limits	
	Mean	Upper	Lower
Fry	161,902	267,872	55,924
Fry and Live Eggs	233,858	376,274	91,435
Fry and All Eggs	275,233	439,632	110,827

The following results reflect the number of walleye eggs deposited on the man made rock reef which was placed in Carp Lake in two segments.

	Area (m^2)	Est. of Walleye eggs deposited
Reef No. 1	480	61,000
Reef No. 2	448	83,000

Egg pails placed in Manistique Lake were damaged by winter ice cover.

The results from Six Mile and Carp Lake indicate the success of the man made rock reef as a spawning facility for walleye. The majority of walleye eggs deposited in the egg trap pails were deposited at depth from 20 cm to 65 cm. Stauffer's next step will be to quantify the walleye fry produced from the rock reefs and relate them to the needs of the lakes.

An attempt was made to compare fish species using the rock and sand substrate. The following table summarizes the fishes collected by Dr. P. A. Doepkes' Ecology of Fishes class from Northern Michigan University (Completed on May 22, 1980). Seining equal areas of sand and rock yielded the following fish species:

	Rock Reef	Natural Substrate
White Sucker	0	+
Blackchin Shiner	+	+
Blacknose Shiner	+	+

con't

	Rock Reef	Natural Substrate
Bluntnose Minnow	+	+
Central Mudminnow	0	+
Rock Bass	+	0
Largemouth Bass	+	+
Black Crappie	+	+
Johnny Darter	+	+
Logperch	+	+

+ Present, 0 Absent

An equal amount of effort electrofishing over rock and sand in Fish Lake was performed on May 29, 1980. The following fishes were collected:

Fish	Rock Reef	Sand Substrate
Northern Pike	2	0
Largemouth Bass	1	4
Black Crappie	15	0
Bluegill	3	1
Yellow Perch	0	1
Rock Bass	2	1
Bullhead	3	4
White Sucker	0	4
TOTAL ORGANISMS	26	15

Differences in fish species using rock substrate compared to sand substrate are negligible but numbers of fish over the rock were greater.

An attempt was made to quantify and compare the invertebrates on the newly placed rock and sand in Fish Lake. 15 square meters of rock and 6 square meters of sand were sampled using a Homelite centrifugal pump. The following is a summary of invertebrate groups and numbers collected per square meter of substrate.

		Substrate	
		Rock	Sand*
Insecta			
Ephemeroptera	*Baetis*	143	6.3
	Hexogenia	0.1	0
	Chirotenetes	1.1	0

con't		Substrate	
		Rock	Sand*
Coleoptera		1.6	1
Trichoptera	Molanna	0	2.6
	Philoptamus	0.4	0
Diptera	Tendipes	4.0	44.6
	Chaoborus	0.5	0
	Tobanus	0	0.3
Arachnida			
Hydrachnellae	Hydryphantes	7.6	0.6
Crustacea			
Decapoda	?	1.3	0.3
Cladocera	Daphnia	11.3	0
	?	3.5	1
Copepoda	Cyclops	20.9	1
Amphipoda	?	3.6	15.3
Mollusca			
Gastropoda	Sinistral	.9	7.3
	Dextral	1.0	19
Pelecypoda		0.3	7.6
Oligochaeta		0.1	0
Total organisms per sq. meter		201.2	108.9

* Sand was sampled more efficiently due to lack of algae.

Dr. P. A. Doepkes' Ecology of Fishes Class sampled four one square meter quadrates on May 22, 1980 on sand and newly installed rock substrates. Results are listed below in numbers of organisms per square meter:

		Substrate	
		Rock	Sand
Platyhelminthes	Planaria	0.9	0
Annelida Hirudinea		1.0	0
Arthropoda			
Crustaces			
Amphipoda		0.8	0
Decapoda		9.8	0

con't

	Substrate	
	Rock	Sand
Insecta		
Coleoptera	0.4	0
Diptera	0.8	1.2
Ephemeroptera	143.9	0.1
Odonata	0.2	0
Trichoptera	1.4	0.4
Mollusca		
Gastropoda	1.8	4.4
Pelecypoda	0	0.7
TOTAL ORGANISMS	160.8	6.8

The newly installed rock substrate is inhabited by more species and greater numbers of invertebrates then the adjacent sand substrate.

Discussion

The results indicate that gravid adult walleye are homing in on the newly placed rock reefs in Fish, Monocle, Carp and Six Mile Lakes. Both walleye eggs and fry were recovered from the Six Mile and Carp Lake reefs indicating that successful reproduction is occurring. The 11 adult walleyes observed on the rock in Fish Lake may represent nearly the entire adult walleye population in Fish Lake. Walleye fingerlings stocked in Fish Lake in 1979 will be sexually mature in three to four years when they would utilize the rock as spawning substrate.

The study, "An Evaluation of Artificial Spawning Beds for Walleye" by Weber and Imber, Special Report No. 34, Colorado Division of Wildlife Fisheries Research Section, 1974, resulted in the following: Young of the year walleye population estimate in 1970 prior to rock reef construction was 493. Two 5,000 square foot rock reefs were placed in a 502 acre reservoir in 1971. The population estimates of young of the year walleye yielded 1,057 in 1972 and 5,499 in 1973.

Smallmouth bass, darters, and lake sturgeon also spawn on the rock substrate and can be expected to utilize the rock. The reestablishment of lake sturgeon in Fish Lake could greatly enhance this species in the Indian River system.

The results of the invertebrate fauna sampled in Fish Lake indicates greater numbers and species diversity on the rock substrate. Similar results were obtained in a study of an artificial reef placed in Smith Mountain Lake, Virginia conducted by the Virginia Cooperative Fishery Research Unit.

The rock provides a greatly increased surface area for the growth of algae (primary producitivity) increasing the lakes carrying capacity for various species of flora and fauna up the food chain, a more productive ecosystem. This would result in an increased carrying capacity for various species of fish. The rock also greatly increases the living space for fauna such as crayfish, utilizing the crevices and spaces between the rock. These animals are an important food source for various fish species such as bass, attracting them into shallower water where they become more available to fish eating birds. The various species of birds and small mammals that depend on the aquatic food base can be expected to benefit from the increased productivity and diversity provided by the rock reef.

To this point all public comments received concerning the installation of the Fish Lake rock reef and the reintroduction of walleye have been positive.

(MAPPED NOVEMBER 75)

FISH LAKE

KEY

S-FG : SAND & FINE GRAVEL, W/ ISOLATED AREAS OF COARSE GRAVEL NEAR SHORE

S : SAND, CLEAN BOTTOM

S-S : SAND W/ SILT OVERLAY

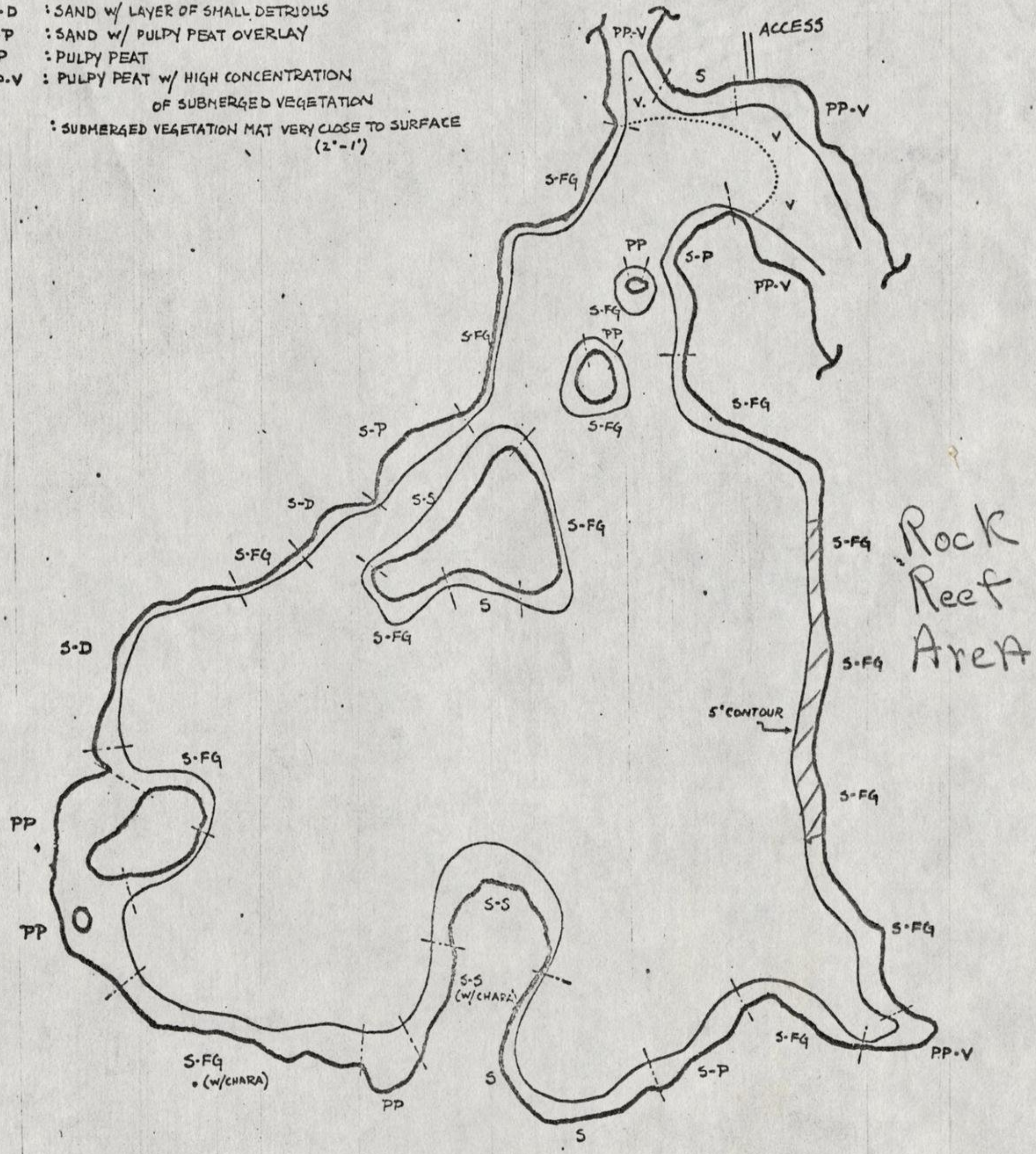
S-D : SAND W/ LAYER OF SMALL DETRIOUS

S-P : SAND W/ PULPY PEAT OVERLAY

PP : PULPY PEAT

PP-V : PULPY PEAT W/ HIGH CONCENTRATION OF SUBMERGED VEGETATION

V : SUBMERGED VEGETATION MAT VERY CLOSE TO SURFACE (2"-1')



LION-SCOUT-COUNCIL-SNIPE-REDJACK CHAIN OF LAKES MANAGEMENT PLAN

Munising Ranger District

Hiawatha National Forest

Cooperating With

Michigan Department of Natural Resources

Prepared by: /S/ Mike Dombeck Date 4/8/81
Mike Dombeck, Fisheries Biologist

Recommended by: Bill Bullen Date 4-22-81
Bill Bullen, District Fisheries Biologist

Recommended by: Jim Bruce Date 4-9-81
Jim Bruce, District Ranger

Approved by: Bernie Ylkanen Date 7-16-81
Bernie Ylkanen, Regional Fisheries Program Manager

Approved by: [illegible] Date [illegible]
Roy E. Droege, Forest Supervisor

DC

LION-SCOUT-COUNCIL-SNIPE-REDJACK CHAIN OF LAKES
MANAGEMENT PLAN
Munising Ranger District, Compartment 84
Alger County, T45N, R19W, Sec. 35, T44N, R19W, Sec. 2

Introduction

The purpose of this management plan is to summarize findings of the 1978 U.S. Forest Service fish population and habitat inventory of Lion-Scout-Council-Snipe-Redjack Chain of Lakes and to document the management strategy planned to improve the fisheries resource of the lake chain.

Background

Lake	Size	Average Depth	Maximum Depth
Lion	21 acres	13.5 feet	25
Scout	32	2.5	10
Council	16	6.0	20
Snipe	12	2.0	5
Redjack	12	8.0	25

These lakes are located in the Fish Lake Management Unit. All are connected by Rock Creek which is a tributary to the Indian River. All channels connecting the lakes are manageable. The limnological and fisheries characteristics of these lakes are similar, making it feasible to manage them as a single unit. A nonfunctioning old concrete water control structure exists at the outlet of Council Lake.

The water is clear with a pH of 8.8-9.2, total alkalinity of 84-88 ppm and a conductivity of 87-91 umhos. Aquatic vegetation is common. Shoreline bottom types are marl, sand, organic over sand and organic. Riparian vegetation is 60% northern hardwoods with mixed conifers and 40% alder-sweet gale and marsh. There are 6.1 miles of shoreline all under U.S. Forest Service ownership. The surrounding terrain has a rolling topography with gentle to step slopes down to the lakeshore. This chain of lakes is somewhat secluded and has a very high aesthetic value. There are two dispersed recreation sites on the lake chain, one on Council and one on Redjack, providing camping and carry-in boat access. The area is most easily reached from FH-13 via FR2261. Fishing, hunting, trapping, canoeing and hiking are the primary recreation activities. A variety of wildlife are common to the area which is also an eagle feeding territory. This is a unique and very beautiful area. Special efforts should be made to preserve its natural integrity as the resource is improved.

Fisheries Summary

Lion, Council, and Redjack support sport fishes while Scout and Snipe do not on a year around basis due to inadequate depths. Scout and Snipe contain fair northern pike spawning habitat but their real value is as riparian and aquatic habitat for wildlife, particularly waterflow and furbearers.

The fish population is out of balance. The fish biomass is dominated by large white suckers and bullheads which make up 51% of the total weight of fish sampled. Northern pike made up 17% of the total weight but the average size was small (19 inches). Bluegills made up 19.5% of the total weight but had an average size of only 4.5 inches. Largemouth bass made up 3% of the total weight and black crappies are present in limited numbers. (See attached fish collection summary.) The forage base is dominated by large suckers and bullheads and the predator base is low. Fair to good spawning habitat is present but fish cover is sparse.

Anglers report poor fishing which agrees with the 1978 survey results. The presently out of balance predator-prey fishery can be improved by chemical treatment or manual removal of the overly abundant suckers, bullheads and small bluegills. Chemical treatment is a viable option, depending upon the chemical to be used. Manual removal of target species using ½" mesh fyke nets is the best available alternative, followed by management of an effective predator either by introduction of tiger muskies or the already present northern pike.

The installation of shallow water (1-5 feet) and offshore (10-15 feet) cover structures in Lion, Council, and Redjack would increase cover and spawning habitat for bluegills, crappie and bass and add diversity to the ecosystem. The addition of offshore cover is especially important to previde badly needed crappie spawning habitat.

The refurbishment of the old water control structure at the outlet of Council will benefit the aquatic resource. A combination roughfish barrier/ water control structure would have dual benefits. It would prevent the migration of suckers into four of the five lakes from the Indian River. A water control structure could raise the water level by as much as three feet, greatly enhancing fish habitat and productivity.

Management Direction

U.S. Forest Service and Michigan-DNR cooperate in the preparation implementation of this plan. USFS participation is based on the Michigan Sikes Act Plan, page 43 and Land Management Plan, Part 1, Hiawatha National Forest, page 22.

Management Goals

To improve the fishing quality and to improve the predator prey balance in the Lion-Council Lake Chain. Manage for northern pike, largemouth bass, bluegills, black crappies and white suckers. To increase catchable panfish (crappies and bluegills) by 2 lb/ac. and to increase catchable northern pike by 2 lb/ac. in Lion, Council and Redjack Lakes.

Proposed Action

To manually remove 10-20 lb/acre of white suckers, rock bass, bullheads, northern pike and bluegills less than 6 inches in length. Based on professional judgement the standing crop in the subject lakes is estimated to be 25-40 lb/acre. The manual thinning of all bullheads, rock bass and large suckers over 15 inches will reduce competition with other species and increase their growth rates. Thinning northern pike will involve removing 50% of the northerns under 18 inches and releasing the other 50%. Those northerns released will be fin clipped in order to identify and release if caught again. The thinning of small northerns should increase the growth rate of the remaining pike by reducing the predation of numerous small northerns on the forage fish. Also, the technique will result in acquiring valuable information for future management of northern pike. Remove 50% of the bluegills under 6 inches in size. Because the waters are relatively unproductive, the removal of more than 50% of the bluegills under 6 inches will not provide a self-sustaining population 2-3 years later. Techniques for removal of half of the bluegill population will have to be developed or estimated by observing the declining catch rate. If project monitoring indicates that the pike and bass have not responded to the reduced competition, the possibility of stocking tiger muskies and/or largemouth bass to supplement the tertiary predator base should be considered.

The installation of ten crib-type cover structures per lake in Lion, Council and Redjack will enhance panfish cover and provide crappie spawning habitat. The installation of 20 shallow water (1-5 feet) tree top or brush cover structures will provide additional largemouth bass spawning habitat and cover. On site wood can be utilized to construct these structures.

The old water control structure at the outlet of Council Lake should be refurbished to function as a rough fish barrier and raise the water level.

The access to these lakes should not be improved. These lakes provide the opportunity to fish, canoe or hike in a secluded spot and enjoy its beauty.

Managing a portion of Snipe Lake's riparian zone for aspen is recommended. This would encourage beaver activity, resulting in related wildlife benefits.

Scheduling

Manual removal of target species will be carried out in the spring of 1982. If target is not achieved the netting should be repeated in 1983. The installation of 10 crib-type cover structures placed from 10-15 feet deep and 20 shallow water (1-5 feet) tree-top brush type cover structures will be installed in 1982, 1983 and 1984. This is an ideal project for HRP or volunteer help and can be carried out either in winter or summer depending upon the availability and scheduling of personnel. The refurbishment of the existing water control structure should take place in the summer of 1983 and can be done with HRP or volunteers. Project monitoring and evaluation will be carried out in 1984 and 1986.

FISH S[illegible] TAL LENGTH FREQUENCIES ([illegible]NCHES)

Air: ____________

Water: ____________

Month Day Year Set Time (Start End)

Water: Council-Redjack-Scout-Lion County: ________ T. ____ R. ____ S. ____

Collection Method: Fyke and gill net Unit Effort: ________

Location & Habitat: Various habitat along shoreline

Total Fish Taken: 1015 Total Hours Effort: ________ Hourly Rate: ________

Total weight: 251.2

SPECIES

T.L."	B.Crappie	Bluegill	P.Seed	R.Bass	W.Sucker	Bullhead	Y.Perch	LM Bass	N. Pike
2.0-2.4		4		2					
2.5-2.9		18	2	4					
3.0-3.4		36	7	11			1	1	
3.5-3.9		18	13	28	1		2		
4.0-4.4		55	13	12	11		8	1	
4.5-4.9		144	19	17	10		7	5	
5.0-5.4		90	35	7	4		1	2	
5.5-5.9	5	72	29	10	1			1	
6.0-6.4	2	22	13	1			1		
6.5-6.9		13	1	2	1	1			
7.0-7.4		6	2						
7.5-7.9				1	1				
8.0-8.4		1			1	1			
8.5-8.9						3			
9.0-9.4	1			2		2			
9.5-9.9	3					3		3	
10.0-10.4	3				1	11		1	
10.5-10.9	2					12			
11.0-11.4						8		1	3
11.5-11.9		1			1	6		1	
12.0-12.4						4		3	
12.5-12.9					3	1			
13.0-13.4					4	2			1
13.5-13.9					6				
14.0-14.4					9				1
14.5-14.9					5				
15.0-15.4					3				
15.5-15.9					7				2
16.0-16.4					5				
16.5-16.9					4				1
17.0-17.4					1				3
17.5-17.9					1				3
18.0-18.4					2				1
18.5-18.9					1				1
19.0-19.4									1
19.5-19.9					6				6
20.0-20.4									6
20.5-20.9									
21.0-21.4									4
21.5-21.9									4
22.0-22.4									
Total No.	16	552	152	94	70	55	20	29	37
% of Total Catch	1.5%	55%	15%	9%	7%	5%	2.0%	2.0%	3.5%
Mean Length	8.2	4.1	4.4	4.5	13.5	10.4	4.4	7.7	19.1
Total weight	3.5	49#	9.2#	12#	98.5#	27#	1.5#	7.75#	42.75#
% of Total Wt.	1.5%	19.5%	3.5%	5.0%	40%	11%	.5%	3%	17%

Projected Cost

1982	Manual removal	1,100
	10 Crib-type structures	1,500
	20 Tree-top brush structures	400
1983	Evaluation and monitoring	600
	10 Crib-type structures	1,500
	20 tree-top brush structures	400
	Refurbishment of water control structure	500
1984	Evaluation and monitoring	600
	10 Crib-type structures	1,500
	20 Tree-top brush structures	400
1986	Evaluation and monitoring	600
	TOTAL	9,100

Benefit Cost Ratio

Assumptions:

Projects will result in an average increase of 294 lbs. (6lb./ac.) on Lion, Council and Redjack available to the angler for a minimum of 10 years. One warmwater angler day = $25 = 1 lb. of catchable fish (M-DNR).

Benefit:

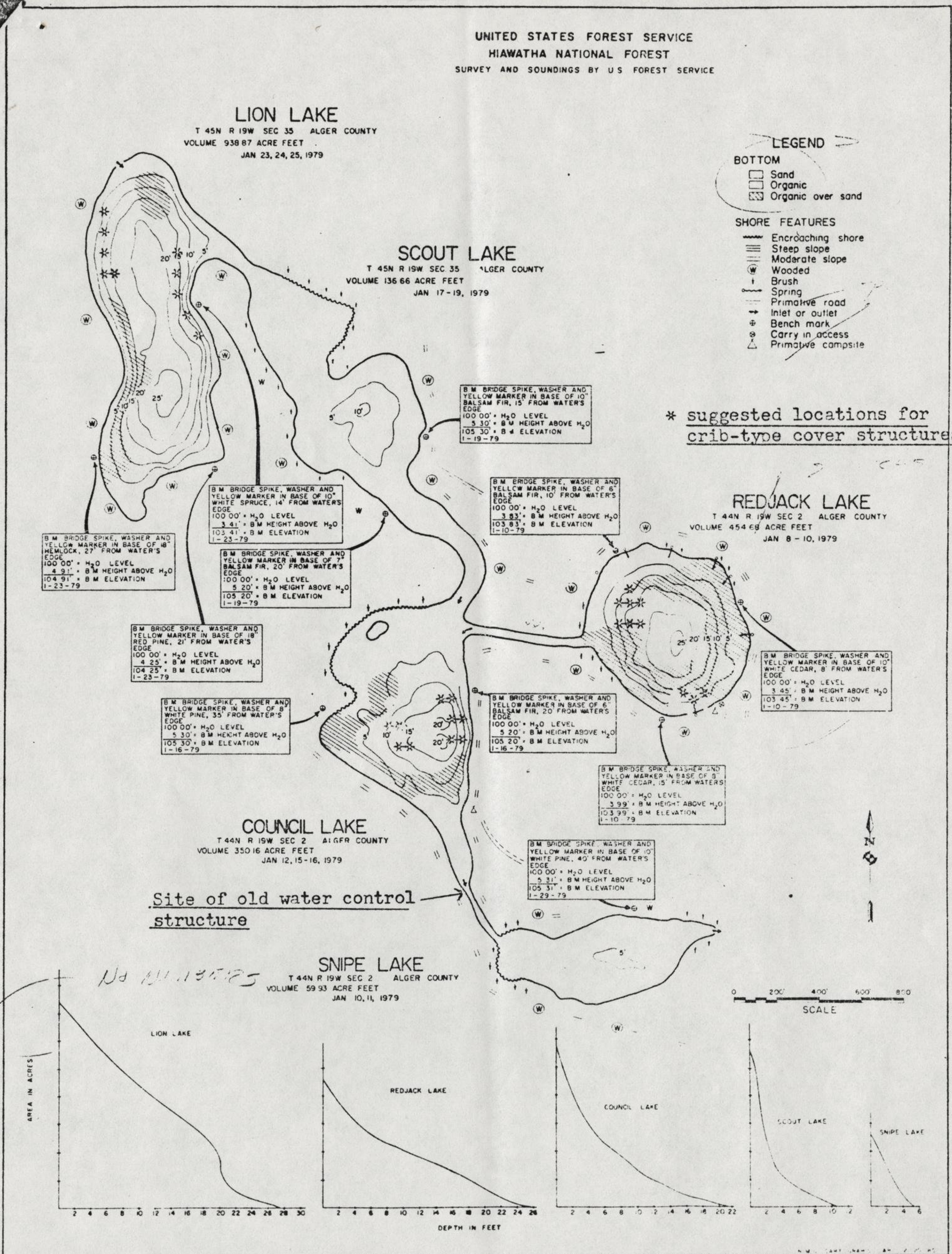
The opportunity to catch 294 lbs. of fish per year for 10 years 294 X 10 X $25 = $73,500.

Cost:

9,100

B/C Ratio

73,500/9,100 = 8.07:1



LION LAKE, SCOUT LAKE, REDJACK LAKE, COUNCIL LAKE AND SNIPE LAKE, ALGER CO, T 44, 45N - R 19W

HALFMOON LAKE MANAGEMENT PLAN

Munising Ranger District

Hiawatha National Forest

Cooperating With

Michigan Department of Natural Resources

Prepared by: /S/ Mike Dombeck Date 4/8/81
Mike Dombeck, Fisheries Biologist

Recommended by: Bill Bullen Date 4-22-81
Bill Bullen, District Fisheries Biologist

Recommended by: Jim Bruce Date 4-9-81
Jim Bruce, District Ranger

Approved by: Bernie Ylkanen Date 7-16-81
Bernie Ylkanen, Regional Fisheries Program Manager

Approved by: ____________ Date [illegible]
Roy E. Droege, Forest Supervisor

HALFMOON LAKE MANAGEMENT PLAN
Munising Ranger District, Compartment 84
Alger County, T45N, R19W, Sec. 34 and 35

Introduction

The purpose of this management is to summarize the findings of the 1978 U.S. Forest Service fish population and habitat inventory of Halfmoon Lake and to document the management strategy planned to improve the fisheries resource in Halfmoon Lake.

Background

Halfmoon Lake is a 32 acre (13 ha) lake in the Fish Lake Management Unit. It is a eutrophic (aged) lake with an average depth of 10 feet and a maximum depth of 22 feet. It has slightly stained water with a pH of 8.5, a total alkalinity of 86 mg/l and a conductivity of 89 umhos. Aquatic vegetation is common, occuring in 40% of the lake. Shoreline bottom types are organic, organic over sand and sand.

Riparian vegetation is 70% northern hardwoods with mixed conifers and 30% marsh. The surrounding terrain has a rolling topography with a moderate to steep slope down to the lake. There is 1.3 miles of shoreline of which 76% is under Forest Service ownership. Halfmoon Lake and its surrounding terrain has high aesthetic value and is somewhat remote. There is carry-in access via a private two-rut road from FR 2268. Fishing and waterfowl hunting are the primary recreation uses of Halfmoon Lake.

Fisheries Summary

The present fish population in Halfmoon Lake is out of balance. The fish biomass is dominated by abundant white suckers and bullheads which made up 53% of the total weight of fish sampled. Northern pike made up 31.6% of the total weight of fish sampled. The average size of the Northern Pike was small, 18.2 inches, while the average size of the suckers was 17.2 inches. Panfish populations are fair. Largemouth Bass are present but in very low numbers. The forage base is dominated by large suckers and bullheads.

Large predators are rare or absent. (See attached fish collection summary.) Spawning habitat for northern pike, panfish and largemouth bass is adequate but hiding cover and structure is inadequate. Anglers report fair to poor fishing. The primary species reportedly caught are small northern pike. These reports agree with the 1978 fisheries survey results.

Restructuring the fish population in Halfmoon to reduce numbers of large suckers and bullheads can be carried out by a chemical reclamation or manually, using nets. Chemical treatment is a viable option, depending upon the chemical to be used. The installation of shoreline (0-5 feet) and offshore (10-15 feet) cover will improve fish habitat and add diversity to the ecosystem.

Management Direction

U.S. Forest Service and Michigan-DNR cooperate in the preparation and implementation of this plan. USFS participation is based on the Michigan Sikes Act Plan, page 43, and Land Management Plan, Part 1, Hiawatha National Forest, page 22.

Management Goals

To improve the fishing quality and to improve the predator-prey balance in Halfmoon Lake. Manage for northern pike, largemouth bass, panfish and white suckers. To increase catchable size northern pike, largemouth bass and panfish by 3 lb/acre by reducing competition from large suckers and bullhead and inprove habitat by increasing cover.

Proposed Action

To remove 10-20 lb/acre of white suckers, bullheads, rock bass and northern pike. Based on professional judgement the standing crop in Halfmoon Lake is estimated to be 25-40 lb/acre. The thinning of all bullheads, rock bass and large suckers over 15 inches will reduce competition with other species and increase their growth rate. Thinning northern pike will involve the removal of 50% of the northern pike under 18 inches in length and releasing 50% of the northern pike under 18 inches in length. Those northern pike under 18 inches in length that are released will be fin clipped. On additional nettings, pike over 18 inches in length and previously fin clipped northern pike will be released along with 50% of the newly caught northern pike under 18 inches in length that will also be fin clipped. This technique will provide data for a northern pike population estimate which will be invaluable for future management. To install 10 crib-type cover structures along the west shore in 10-15 ft. of water will provide additional fish cover. The placement of 20 tree top or brush cover structures along the shoreline in less than 5 feet of water will also provide additional cover and improve largemouth bass spawning habitat. Cover structures can be built using on site materials.

Managing a portion of the riparian zone near the outlet of Halfmoon for aspen is recommended. This would encourage beaver activity resulting in the related wildlife benefits.

Scheduling

Manual removal of target fishes will be carried out in the spring of 1982. If the target is not achieved the project will be repeated in 1983. The construction and placement of cover structures will be carried out in 1982. This is an ideal project for HRP or volunteers and could be carried out either in winter or summer depending upon the availability of personnel. Project monitoring and evaluation will be carried out in 1984.*

Projected Cost

1982	Manual removal	400
	10 Crib-type cover structures	1500
	20 Tree-top brush structures	400
*1983	Monitoring	300
1984	Monitoring	300
	TOTAL	2900

Benefit Cost Ratio

Assumptions:

Project will result in an average additional 96 (3 lb/ac.) of catchable fish per year available to the angler. One warmwater angler day = $25 = 1 lb. of catchable fish (M-DNR).

Benefit:

The opportunity to catch an additional 96 lbs. of fish per year for 5 years. 96 X 5 X $25 = $12,000

Cost:

$2,900

B/C Ratio:

$12,000/$2,900 = 4.13:1

MICHIGAN DEPARTMENT OF CONSERVATION

FISH DIVISION

CONS. 8065
REV. 4/63

LAKE FISH COLLECTION AND AGE-GROWTH SUMMARY

Lake Halfmoon

County Alger   T. 45N   R. 19W   Sec. 34 & 35   Date 7-12 to 14, 1978

Weather   Air Temperature 25° C.   Water Temperature 18° C.

Seine 25' 1/4" mesh   Acres Seined .5   No. Hauls 8   Snags

Nets 3 fykes - 2 gills   Length 125'   Mesh Expt.   No. Sets 5   No. Lifts 8

Other Gear

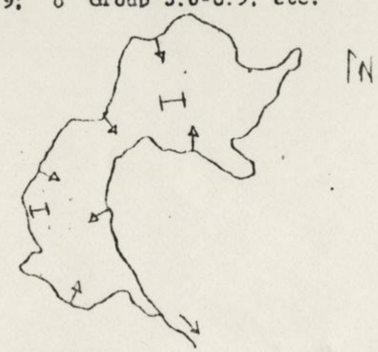
Species	2"	4"	6"	8"	10"	12"	14"	16"	18"	20"	22" +	Total No.	Total Wt.	Ave. Size	Per cent Catchable
Bluegill	2	36	58	10	1							107	9.5	5.4	18.7
Pumpkinseed		5	51	5								61	4.32	6.0	63.9
Northern Pike							3	3	17	11	1	35	34.9	18.2	2.85
Brown Bullhead			2	11	19	13						45	22.3	9.9	
White Sucker			1					6	5	5		17	36.2	17.2	
Rock Bass	3	7	6									16	2.0	4.4	31.25
Yellow Perch		10	2									12	1.0	4.3	00.00
Blacknose Shiner	50											50		2.0	
Blackchin Shiner	20											20		2.0	
Creek Chub	15											15		2.0	
Largemouth Bass	2											2		2.0	
Iowa Darter	15											15		2.0	
Johnny Darter	15											15		2.0	
Golden Shiners	50+											50+		2.0	
Totals........															

Analysis and comments: Panfish populations are fair, with no large perch. Forage base is dominated by very large white suckers and brown bullheads. Large predators (northern pike) seem to be absent or rare.

Fishing reports: Fair bluegill catches, northern pike mostly sublegal.

Catchables: Bluegill and Pumpkinseeds, 6"; Crappie and Perch, 8"; Bass, 10"; Pike, 20".   (Over)
Inch Groups: 2" Group 1.0-2.9; 4" Group 3.0-4.9; 6" Group 5.0-6.9, etc.

Test Net Locations



INDIAN RIVER WATERSHED

Part II

The Little Indian River

Fisheries Inventory and Management Plan

Prepared by:
Mike Dombeck
Chuck Bassett
Bob Miller

Recommended by: Jim Bruce Date 7-28-81
Jim Bruce, District Ranger

G H Lyon Jr. Date 8-4-81
G. H. Lyon, District Ranger

Bill Bullen Date 8-31-81
Bill Bullen, DNR District Fisheries Biologist

Date 9-1-81
John Schrouder, DNR District Fisheries Biilogist

Date 9-28-81
Bernie Ylkanen, DNR Regional Fisheries Program Manager

Date 10/14/81
Roy E. Droege, Forest Supervisor

I. INTRODUCTION

A. Purpose of Report

The purpose of this report is to summarize findings of 1978-1980 U.S. Forest Service fish population and habitat inventories on the Indian River. The river has been divided into three reaches that differ from each other in regard to characteristics of the fish populations, fish habitat, nature of stream bed sediments, nature of the riparian zone or other distinguishing factors. Management strategy for an individual reach will usually differ from that of the reach located immediately upstream or downstream from it.

B. Overview of Watershed and Past Fisheries Management

The Little Indian River originates in central Alger County from two spring ponds in T45N, R19W, Sec. 13 and 14 and flows in a southeast direction through east Alger County and southwest Schoolcraft County before emptying into the Big Indian River in T44N, R18W, Sec. 23. The total stream mileage is approximately 13 miles, of which 85% is under U.S. Forest Service ownership. There are about 12,800 acres in the Little Indian River drainage.

Primary land uses in the watershed are recreation and timber production. Sport fishing and wetland trapping are the primary recreational uses of the river. Two timber sales are presently being logged in the watershed.

The watershed has gently rolling hills vegetated by northern hardwoods, mixed conifer and aspen with tag alder, black spruce, and cedar swamps. Droughty infertile sands and wet sandy soils are the chief soil types of the watershed. There are a number of unnamed cold water spring tributaries to the Little Indian River. The outlet from Grassy Lake, Grassy Creek, is the only warm water tributary. The water quality of the stream is excellent. Ground inflow is substantial and annual fluctuations are small and gradual. The main fishing opportunity in the watershed is for brook trout. Past fisheries management in the Little Indian River has consisted of annual plants of hatchery brown trout and in 1979 Michigan-DNR fisheries personnel installed spawning gravel in the river near the headwaters.

A more specific description of the river and its environs will be given in the discussion of each reach.

Reach 3: Forest Road 2173, T44N, R18W, Sec. 10 to the confluence of the Indian River T44N, R18W, Sec. 15.

Reach 2: Forest Highway 13, T45N, R18W, Sec. 30 to the Forest Road 2173, T44N, R18W, Sec. 3.

Reach 1: Spring ponds in T45N, R19W, Sec. 13 and 14 to Forest Highway 13, T45N, R19W, Sec. 25.

II. SUMMARY

At present, the Little Indian is one of the best wild brook trout fisheries in the Hiawatha National Forest. The key to its quality appears to be the widespread availability of spawning gravel and spring seepage. Available food and cover is also good. The occasional spring ponds along the river enhance the food supply and fish growth. Results of fisheries surveys can be seen at M-DNR and USFS District offices.

Timber harvest in the Little Indian watershed is moderate. Two timber sales are being logged at present. Timber practices should be such as not to damage the fishery resource.

Recreational development on the watershed is virtually nonexistent. Access should not be improved. Increased access would be detrimental to the fishery.

Management of the Little Indian River should be directed toward preserving the present high quality wild brook trout population which is the result of the particular ground water geology and vegetation in the watershed. The following management recommendations will preserve and enhance the high quality trout habitat:

1. Maintain water temperature and ground water input at present levels.

2. Discourage riparian vegetation (tag alder) where it degrades stream habitat by encouraging conifer management along the immediate stream bank.

3. Discourage beaver activity in the watershed by not managing for aspen within 300 feet of the Little Indian River.

4. Encourage types of timber harvesting and recreational activities that will discourage soil erosion on riparian slopes.

5. Avoid creating easier vehicular access to the stream that would result in greater fishing pressure on the brook trout.

6. Identify and schedule all needed stream enhancement projects and provide for routine maintenance in the Forest program.

7. Schedule recurrent fish population and habitat surveys each ten years in the Forest program.

III. CHARACTERISTICS AND PROPOSED MANAGEMENT OF BACK REACH

A. Reach 3

1. Description

This reach is 5 miles long; 80% is under Forest Service riparian control. Access is poor to fair via County Road 445 and FS 2257.

Fishing and hiking are the primary recreational uses.

This reach has no spring ponds and the stream has a more uniform pool-riffle character. Bottom types are 95% sand and 5% gravel and cobble. Spring seepages are present but not to the same extent as in the upper reaches. Stream width ranges from 25-35 feet. Stream depth ranges from 0.5-3.5 feet. Current velocity ranges from 1.0-1.4 fps. Stream flow discharge averages 20-30 cfs. Well defined pools account for 35% of this reach, 15% is riffle, and the remaining 50% is runs and flats. There are numerous logs and wood debris in the stream. Instream vegetation is sparse. Beaver activity was not observed.

The surrounding terrain has a rolling topography. Ridges are lower, 10-30 foot ridges parallel the stream. Immediate banks are 1-3 feet high. No erosion was observed. Predominant riparian soils are kalkaska and rubicon sands and carbondale and lupton mucks. Riparian vegetation is black spruce, balsam fir, white cedar, paper birch, soft maple, elm, tag alder, and various grasses and sedges. Canopy closure is 50-100%. The adjacent uplands are northern hardwoods and red and white pine.

Forage species are common but not as abundant as in the upper reaches. Invertebrate forage is abundant. Spawning habitat is adequate in the upper portion of the reach but it is sparse in the lower reaches. Cover is good throughout the reach. Natural reproduction by brook trout occurs in this reach but not to the extent as in upstream area. Fishing pressure is heavy in this reach.

2. <u>Management Recommendations</u>

The value of this reach is high. This reach has one of the better native brook trout fisheries on the Forest.

a. <u>Fisheries</u>

The potential for fisheries habitat improvement is moderate; Forest Service riparian control is 80%. In the summer of 1982, U.S. Forest Service (Manistique District) will install: (1) 17 cubic yards of spawning gravel (¼ to 2") to improve trout spawning habitat. (2) Place 8 cubic yards of cobble (4 to 8") to stabilize the bank and provide hiding cover for spawning trout and juveniles and (3) secure stumps and logs in strategic locations along the riffle to provide increased hiding cover for spawning trout and juveniles. The Little Indian River is a high priority stream and will respond well to this type of habitat improvement work.

b. Timber

Timber management practices should be such as to not encourage beaver activity. Aspen should be discouraged within 300 feet of the stream. Growth of long-lived conifers and hardwoods should be encouraged along the stream.

c. Recreation

Fishing and hiking are the primary recreational uses. Access is fair and should not be improved. The area is not suitable for developed recreation.

B. Reach 2

1. Description

This reach is 4.25 miles long; 100% is under Forest Service riparian control. Access is poor to fair, seasonally, via Forest Road 2162, Forest Highway 13 and County Road 445. Fishing and trapping are the primary recreational uses.

The reach is characterized by highly variable gradient and channel dimensions. Four small spring ponds in the stream course are interspersed with swift gravel and rubble areas with abundant spring seepage along the base of the riparian slopes. Stream width ranges from 25-35 feet, stream depth ranges from 0.5-2.5 feet. The primary bottom type is sand and gravel with organic deposits and silt along the edge of the stream. Current velocity averages 1-1.5 FPS. Stream flow discharge increases from 10 cfs in Section 32 to 20 cfs at FR 2173. Poorly defined pools and runs account for 50% of this reach and the remaining 50% is riffle. There are numerous logs and tree branches in the stream. Instream vegetation is occasionally present.

The surrounding terrain has rolling topography with ridges 40-80 feet high. No erosion was observed. Predominant riparian soils are kalkaska and rubicon sands and carbondale and lupton mucks. Riparian vegetation is primarily black spruce, white cedar, balsam fir and tag alder.

Canopy closure is 50-75%. Open meadows near the spring ponds are vegetated by tag alder, tamarack, leather leaf, sweet gale and various sedges and grasses. The adjacent uplands are heavily wooded by northern hardwood and mixed conifers. Tag alder encroachement is causing stream degradation in some portions of the reach.

This fish population consists of native brook trout, introduced brown trout, white suckers and forage species. The brook trout population is doing very well while the brown trout population is poor at best. Forage species are abundant. Invertebrate forage is also abundant. Spawning habitat is adequate in the lower portion of the reach but could be improved in the upper portion of the reach just below FH 13 in Section 30. Cover is good but could be improved primarily in the upper portion of the reach.

Natural reproduction by native brook trout is good. Fishing pressure in this reach is light to moderate.

2. Management Recommendations

The value of this reach is high. This reach has one of the better native brook trout fisheries on the Forest.

a. Fisheries

The potential for fisheries habitat improvement is high; Forest Service riparian control is 100%. Enhance 5000 lineal feet of stream habitat in T45N, R18W, Sec. 30 and 32 consisting of: (1) Very selective cutting of stream side tag alder, (2) installation of 200 half-log cover devices to improve stream habitat, and (3) place 20 cubic yards of spawning gravel to improve trout spawning habitat. The Little Indian is a high priority stream and will respond positively to this type habitat improvement work.

b. Timber

Timber management practices should be such as to not encourage beaver activity. Aspen should be discouraged within 300 feet of the stream; growth of long-lived conifer and hardwood species should be encouraged along the stream.

c. Recreation

Fishing and trapping are the primary recreational uses. Access is fair and should not be improved. The area is not suitable for developed recreation.

A. Reach 1

1. Description

This reach is 3.25 miles long and includes the headwaters of the Little Indian River, 60% is under private ownership and 40% is under Forest Service riparian control. Access is good via a number of two rut roads, the Buckhorn Road (FR 2254) and Forest Highway 13. Fishing, trapping and waterfowl hunting are the primary recreational uses.

The stream flows from its headwaters through primarily tag alder lowland, lowland marsh, some cedar swamp and an occasional beaver meadow. Stream width and depth do not vary considerably. The average width is 12-15 feet and the average depth is 1-2 feet except for a .25 mile pond in T45N, R19W, Sec. 24 and 25 where the stream is approximately .13 miles wide and 6-8 feet deep with lentic (standing water) characteristics and abundant vegetative growth. Bottom types are primarily sand with organic deposits and silt along the edge of the stream. The current velocity is slow to moderate. Runs and flats account for 60% of this reach, shallow pools 30% and the remaining 10% riffle. Gradient is slight.

Predominant riparian soils are kalkaska and rubicon sands and carbondale and lupton mucks. Riparian vegetation consists of primarily tag alder and marsh grasses with mixed conifers on the slopes. Slopes adjacent to the stream run from gentle to moderate. Tag alder encroachment is causing stream degradation in some portions of the reach.

The fish population in this reach consists of fair numbers of primarily tag alder and marsh grasses with mixed conifers on the slopes. Slopes adjacent to the stream run from gentle to moderate. Tag alder encroachment is causing stream degradation in some portions of the reach.

The fish population in this reach consists of fair numbers of native brook trout, white suckers and abundant forage species. The majority of the brook trout present in this marsh are juveniles. Cover is fair to good for young of the year fish and adequate for adults. Spawning habitat is limited by the lack of a suitable substrate in most of the reach although abundant spring seepage is favorable. In the summer of 1979 Michigan-DNR personnel installed 4 gravel riffles (1400 sq. ft. total) in T45N, R19W, Sec. 14 just south of the headwaters to provide a suitable substrate for brook trout spawning. This reach provides a fair brook trout fishery although the average size fish caught is not large.

Summer water temperatures are within the tolerance of brook trout. One small tributary enters this reach in T45N, R19W, Sec. 24 from a spring pond just north of the river. This pond is probably utilized as an over-wintering area by brook trout.

2. Management Recommendations

The value of this reach is high. As the "headwaters" of the Little Indian River, it fulfills a critical habitat function for the total Indian River System. With placement of spawning gravel by the Michigan-DNR, the reproductive capability of this reach has been increased. As essential habitat for fish reproduction it is important to the river as a whole because fish are produced here to migrate downstream and occupy available niches for the older and larger adult fishes.

a. <u>Fisheries</u>

The potential for fisheries habitat improvement is low. Much of this reach is privately owned and the Michigan-DNR has completed a stream enhancement project (gravel placement) at the only suitable site along this reach. Maintenance of the spawning riffle should be done when needed.

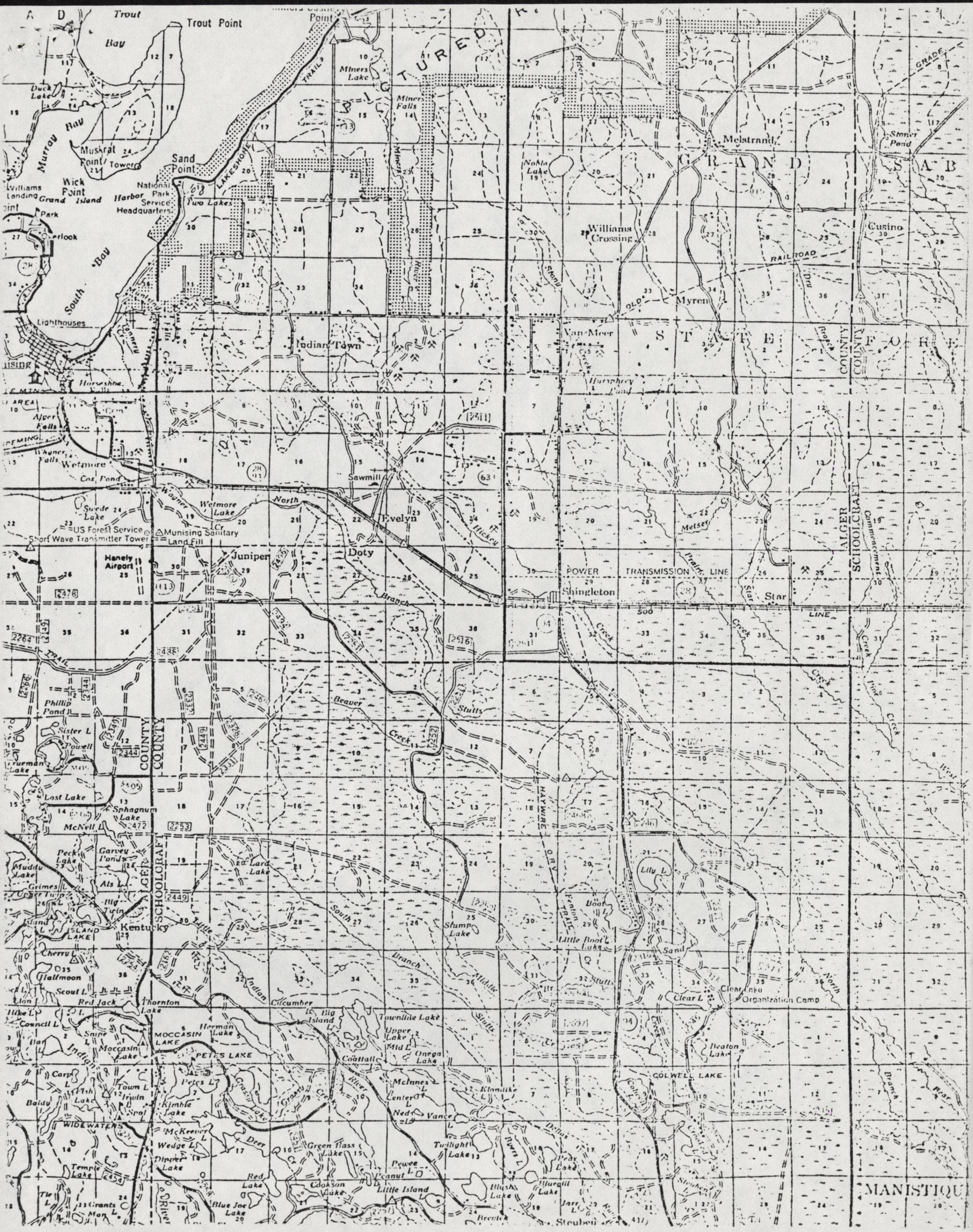
The high water quality in the reach should be preserved.

b. <u>Timber</u>

Timber management practices should be such as to not encourage beaver activity; this would be detrimental to the trout population. Aspen should be discouraged within 300 feet of the stream.

c. <u>Recreation</u>

Fishing and trapping are the primary recreation use. Access is good to the area and should not be improved. This area is not suitable for developed recreation sites.



Trout Point
Bay
Murray Bay
Duck Lake
Muskrat Point
Tower
Sand Point
Wick Point
Williams Landing
Grand Island
Harbor
National Park Service Headquarters
Two Lakes
Park
Overlook
South Bay
Lighthouses
Horseshoe Falls
Alger Falls
Wetmore
Cox Pond
Swede Lake
US Forest Service
Short Wave Transmitter Tower
Munising Sanitary Land Fill
Hanely Airport
Juniper
Wetmore Lake
Miners Lake
Miners Falls
PICTURED
LAKESHORE
TRAIL
Indian Town
Sawmill
Evelyn
Doty
North
Branch
Hickey
Beaver
Creek
Stutts
Phillip Pond
Sister L
Powell L
Trueman Lake
Lost Lake
Sphagnum Lake
McNeil L
Peck Lake
Garvey Ponds
Muddy Lake
Grimes
Upper Twin
Big Twin
Als
Island L
ISLAND LAKE
Kentucky
Cherry L
Halfmoon
Scout L
Red Jack
Thornton Lake
Council L
Snipe
Moccasin Lake
MOCCASIN LAKE
Herman Lake
PETES LAKE
Peters L
Carp L
Town L
Irwin
Kimble Lake
Baldy
WIDEWATERS
McKeever L
Wedge L
Dipper Lake
Temple Lake
Grants
Red Lake
Blue Joe Lake
Cookson Lake
Little Island
Peanut
Pewee
Green Bass Lake
Twilight Lake
Vance
Ned
McInnes
Center
Klondike
Coattail
Omega Lake
Upper Lake
Big Island L
Townline Lake
Cucumber
Indian
South
Middle
Stump Lake
Lard Lake
ALGER
SCHOOLCRAFT
COUNTY
Melstrand
GRAND
SABLE
Noble Lake
Williams Crossing
OLD RAILROAD GRADE
Myren
Van Meer
Humphrey Pond
Cusino
Stoner Pond
Dry
STATE
FOREST
Commencement
Metser
POWER TRANSMISSION LINE
Shingleton
Star
SOO LINE
Prairie
Creek
Stony
HAYWIRE
Fenton TRAIL
Lily L
Boot L
Little Boot Lake
Sand
Clear L
Clear Lake Organization Camp
Beaton Lake
COLWELL LAKE
Pear Lake
Blush Lake
Jarr L
Steuben
Brevort
Dollar
Fox
MANISTIQUE

HERMAN LAKE MANAGEMENT PLAN

Munising Ranger District

Hiawatha National Forest

Cooperating With

Michigan Department of Natural Resources

Prepared by: Mike Dombeck Date 7-29-81
Mike Dombeck, Fisheries Biologist

Recommended by: John Schrouder Date 8-2-81
John Schrouder, District Fisheries Biologist

Recommended by: Jim Bruce Date 8-3-81
Jim Bruce, District Ranger

Approved by: Bernhard Ylkanen Date 9-28-81
Bernie Ylkanen, Regional Fisheries Program Manager

Approved by: [illegible] Date 10/16/81
Roy E. Droege, Forest Supervisor

Herman Lake Management Plan
Munising District, Compartment 103
Schoolcraft County, T44N, R18W, Sec. 4 and 5

Introduction:

The purpose of this management plan is to summarize findings of the 1979 U.S. Forest Service fish population and habitat inventory of Herman Lake and to document the management strategy planned to improve the fisheries resource in Herman Lake. This is the first management plan concerning Herman Lake.

Background:

Herman Lake is an 81 acre (32.4 ha.) lake in the Pete's Lake Management Unit. It is a eutrophic (aged) lake with an average depth of 11.6 feet and a maximum depth of 25 feet. Aquatic vegetation is common occurring in about 40% of the lake. Shoreline bottom types are organic over sand and sand. Riparian vegetation is 70% northern hardwood with mixed conifers and 30% marsh. The surrounding terrain has a rolling topography with a gentle slope down to the lake. There are 2.3 miles of shoreline all in USFS ownership.

Herman Lake has slightly stained water with a pH of 7.5, total alkalinity of 53 mg/l, and a conductivity of 101 umohs. The water level in Herman Lake is 3 - 4 feet lower than in past years due to the deterioration of the beaver dam at the outlet. A great deal of fish hiding cover has been lost as the lake level receded. Lack of aspen is presently limiting the beaver.

Fishing, waterfowl hunting, and trapping are primary activities on Herman Lake. There is a dispersed recreation site on the northeast shore with an unimproved boat access. The access road is poor requiring a 4X4 vehicle much of the year.

Fish dependent birds are common to the Herman Lake area. It is on the edge of a known eagle-osprey feeding territory. Loons are regularly observed on the lake.

Fisheries Summary:

The present fish populations are out of balance. The fish biomass is dominated by large white suckers, bullheads, and abundant small stunted yellow perch. 51% of the total weight of fish sampled were suckers and bullheads while northern pike and largemouth bass made up 17%. Growth rates of all species of gamefish is low. (See attached fish collection summary).

A large amount of habitat for largemouth bass in Herman Lake has been lost since 1974 when the water level began to recede exposing logs, stumps, etc. Efforts are being made through timber management practices to encourage aspen near the outlet to provide a food source for beaver and encourage them to refurbish the dam. Constructing a dam is also a possibility which can be explored further.

Anglers report the fishing as poor which was verified by survey results. The fishery in Herman Lake is currently out of balance. The fishery can be improved by the removal of substantial numbers of suckers, bullheads, and perch. The thinning of these species could be accomplished by a chemical reclamation or manual removal using ½" fyke nets.

Management Direction:

Forest Service and Michigan DNR cooperate in the preparation and implementation of this plan. USFS participation is based on the Michigan Sikes Act Plan, p. 43, and the Land Management Plan, Part 1, Hiawatha National Forest, p. 22.

Management Goals

To improve the fishing quality and to improve the predator-prey balance in Herman Lake. Manage for northern pike, largemouth bass, pumpkinseeds, bluegills, yellow perch, and white suckers. To increase catchable fish by 2 lbs/ac.

Proposed Action

To remove 10 - 20 lbs/ac of white suckers, bullheads, and yellow perch using ½" fyke nets.

Based on professional judgement, the standing crop in Herman Lake is estimated to be 20 - 40 lbs/ac. The removal of 8 - 15 lbs/ac of suckers and bullheads and 2-5 lbs/ac of yellow perch is expected to increase the growth rates of panfish and increase the lake's standing crop of largemouth bass.

A suitable forage base for fish dependent birds will remain in the lake. It is expected that this action will result in an average increase of 2 lbs/ac of available catchable fish per year for five years. It is recommended that the access road into Herman not be improved. In the Pete's Lake Management Unit the majority of lakes have good access and receive relatively heavy use. Due to the poor access the natural integrity of Herman Lake has been maintained. Management should use this opportunity to maintain and protect the fish and wildlife and provide a more diversified recreation opportunity in this management unit.

The possibility of constructing a dam to raise the water level will be explored if the beaver do not rebuild the dam within ten years.

Scheduling:

Manual removal of target fishes will be programmed to be carried out in May or June of 1981 by the USFS. If a nesting loon is discovered during the project, the nesting site will be avoided. If target is not achieved, project will be repeated in 1982. Project evaluation and monitoring will be carried out in 1985*.

Projected Cost:

1981	$ 900.00 (USFS)
1985*	600.00 (USFS)
Total	$1,500.00

Benefit:
Cost Ratio:

Assumptions:

Project will result in an average additional 162 lbs (2 lbs/ac) of catchable fish per year available to the angler. One warm water angler day = $25 = 1 lb. catchable fish (M-DNR)

Benefit:

The opportunity to catch an additional 162 lbs. of fish per year for 5 years. 162 X 5 X $25 = $20,250

Cost:

$1,500

B/C Ratio:

$20,250/$1,500 = 13.5:1

N

Air:

7/24/79 - 7/27/79
Month Day Year Set Time (Start End)

Water: 24°

Water: Herman - 75 acres County: Schoolcraft T. 44 R. 18 S. 4,5

Collection Method: 10 ¾" fykes/per day 1 Gillnet Unit Effort:

Location & Habitat: various habitat

Total Fish Taken: 1523 Total Hours Effort: Hourly Rate:

Total Wt. Fish: 170

SPECIES

T.L."	Y. Perch	R. Bass	P. Seed	B. Gill	W. Sucker	Bl. Bullhead
2.0-2.4		5	26	15		
2.5-2.9	1	49	26			
3.0-3.4	603	13	137	6		
3.5-3.9	133	1	54			
4.0-4.4	81	5	30			
4.5-4.9	43	25	21	1		2
5.0-5.4	6	28	18			
5.5-5.9	6	10	6			1
6.0-6.4		9	2	1		
6.5-6.9	2	6	1	3		1
7.0-7.4	1	3				1
7.5-7.9	1	2				
8.0-8.4		6				1
8.5-8.9		4	1			
9.0-9.4	1					
9.5-9.9		1				
10.0-10.4		2				
10.5-10.9	1					1
11.0-11.4						1
11.5-11.9						1
12.0-12.4					1	4
12.5-12.9						3
13.0-13.4						8
13.5-13.9					1	11
14.0-14.4					1	3
14.5-14.9						2
15.0-15.4						
15.5-15.9						
16.0-16.4						
16.5-16.9						
17.0-17.4					2	
17.5-17.9						
18.0-18.4						
18.5-18.9						
19.0-19.4					2	
19.5-19.9					2	
20.0-20.4						
20.5-20.9						
21.0-21.4						
21.5-21.9						
% Total Wt.	7%	14%	10%	10%	16%	35%
Total No.	879	169	321	26	12	40
% of Total Catch	58%	11%	21%	2%	1%	3%
Mean Length	3.4	4.0	3.5	3.2	18.0	12.5
Total Weight	12.5	24.15	16.75		28.0	[illegible]

Air:
Water:

Month Day Year Set Time (Start End)

Water: Herman County: T. R. S.
Collection Method: 10 Fyke/day n 1 Gillnet Unit Effort:
Location & Habitat:
Total Fish Taken: Total Hours Effort: Hourly Rate:

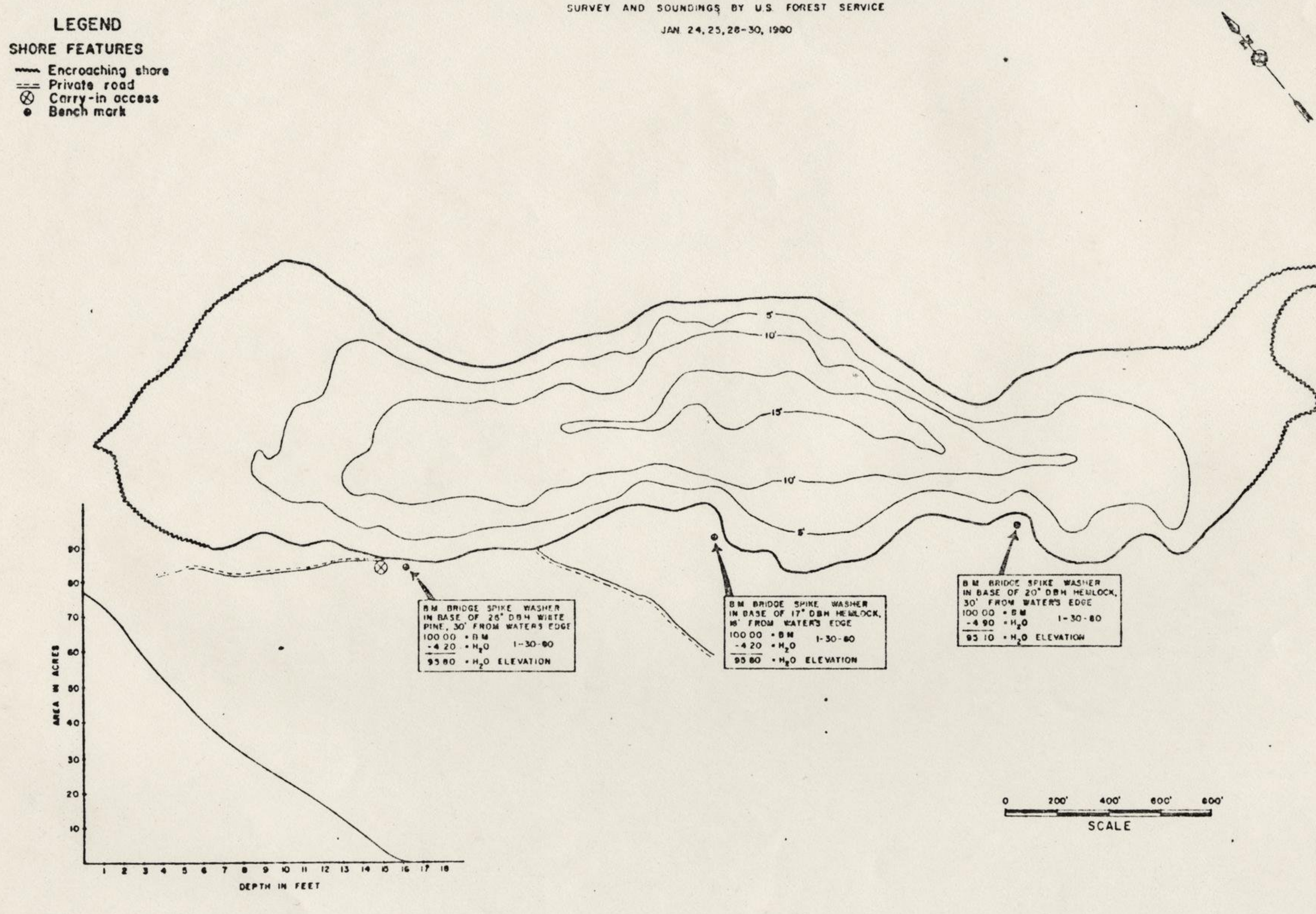
SPECIES

T.L."	LMB	N. Pike					
2.0-2.4							
2.5-2.9							
3.0-3.4	2						
3.5-3.9							
4.0-4.4							
4.5-4.9							
5.0-5.4							
5.5-5.9	1						
6.0-6.4	2						
6.5-6.9							
7.0-7.4							
7.5-7.9							
8.0-8.4							
8.5-8.9							
9.0-9.4	1						
9.5-9.9							
10.0-10.4	3						
10.5-10.9							
11.0-11.4	1						
11.5-11.9							
12.0-12.4							
12.5-12.9							
13.0-13.4							
13.5-13.9							
14.0-14.4	2						
14.5-14.9							
15.0-15.4	3						
15.5-15.9		1					
16.0-16.4	2						
16.5-16.9							
17.0-17.4							
17.5-17.9							
18.0-18.4							
18.5-18.9		1					
19.0-19.4		1					
19.5-19.9							
20.0-20.4							
20.5-20.9		1					
21.0-21.4							
21.5-21.9		2					
22.0-22.4		2					
Total No.	17	8					
% of Total Catch	1%	0.5%					
% of Total Wt.	11%	6%					
Total Weight	18.5	10					

UNITED STATES FOREST SERVICE
HIAWATHA NATIONAL FOREST

HERMAN LAKE

T 44N R 18W SECS 4,5 SCHOOLCRAFT COUNTY
VOLUME 553.99 ACRE FEET AREA 86.57 ACRES
SURVEY AND SOUNDINGS BY U.S. FOREST SERVICE
JAN. 24, 25, 28-30, 1980



NMU CARTOGRAPHIC LAB, 9-30-80

HERMAN LAKE, SCHOOLCRAFT CO., T 44N, - R 18W, SECS. 4,5

COOKSON LAKE MANAGEMENT PLAN

Munising Ranger District

Hiawatha National Forest

Cooperating With

Michigan Department of Natural Resources

Prepared by: Mike Dombeck Date 7-29-81
Mike Dombeck, Fisheries Biologist

Recommended by: John Schrouder Date 8-7-81
John Schrouder, District Fisheries Biologist

Recommended by: Jim Bruce Date 8-3-81
Jim Bruce, District Ranger

Approved by: Bernhard Ylkanen Date 9-29-81
Bernie Ylkanen, Regional Fisheries Program Manager

Approved by: Date 10/16/81
Roy E. Droege, Forest Supervisor

Cookson Lake Management Plan
Munising Ranger District, Compartment 106
Schoolcraft County, T44N, R18W, Sec. 21

Introduction:

The purpose of this management plan is to summarize findings of the 1980 U.S. Forest Service fish population and habitat inventory of Cookson Lake and to document the management strategy planned to improve the fisheries resource in Cookson Lake.

Background:

Cookson Lake is a 55 acre (22 ha.) lake in the Pete's Lake Management Unit. It is a eutrophic (aged) lake with an average depth of 10 feet and a maximum depth of 35 feet. It has slightly stained water with a pH of 8.6, a conductivity of 139 umhos, and a total alkalinity of 81 mg/l. Aquatic vegetation occurs in about 40% of the lake. Shoreline bottom types are 50% organic and 50% organic over sand. Riparian vegetation is 50% leatherleaf-sedge marsh and 50% alder-leatherleaf with aspen and birch on adjacent slopes. Deer Creek flows through Cookson Lake and a second small stream draining Red Lake flows into Cookson. Cookson has 2.2 miles of shoreline with 100% USFS ownership.

One dispersed campsite with an unimproved boat access is located on the lake. Cookson is one of the most popular fishing lakes in the Munising area. It has scenic beauty, a reputation for good fishing, easy access and camping area to make it very attractive to forest users. We have no record of fish dependent birds using Cookson Lake.

Fisheries Summary:

The present fish population is out of balance. Large white suckers and bullheads make up 76% of the total weight of fish sampled. Northern pike are common but their average size is small. The largemouth bass and panfish populations are marginal and can be improved. (See attached fish collection summary)

Anglers report poor fishing in Cookson Lake compared to past years. This lake appears to be a prime example of excessive fishing pressure resulting in the cropping off of the larger predators to the point that the fishery becomes out of balance. Restructuring the fish population in Cookson can be carried out by a chemical reclamation or manually using nets. The feasibility of installing a rough fish barrier at the lake's outlet to prevent migration of suckers from the Indian River should be explored. The possibility of increasing size limits of northern pike and largemouth bass should also be studied.

Management Direction:

U.S. Forest Service and Michigan-DNR cooperate in the preparation and implementation of this plan. USFS participation is based on the Michigan Sikes Act Plan, p. 43, and Land Management Plan, Part 1, Hiawatha National Forest, p. 22.

Management Goals:

To improve the fishing quality and to improve the predator-prey balance in Cookson Lake. Manage for northern pike, largemouth bass, panfish species present, and white suckers. To increase catchable size, northern pike, largemouth bass, and panfish by 2 lb/acre.

Proposed Action:

To remove 10 - 20 lb/ac of white suckers and bullheads using ½" mesh fyke net. Based on professional judgement the standing crop in Cookson Lake is estimated to be 20 - 40 lb/ac. The thinning of the suckers and bullheads will reduce competition with other species and increase their growth rates. Increasing size limits of pike and bass should be considered so they can function as predators in maintaining a balanced fish population in the lake over a long term basis. USFS will further explore the possibility of installing a rough fish barrier at the outlet of Cookson Lake.

Scheduling:

Manual removal of target fishes will be programed to be carried out in the spring of 1982 by USFS. If target is not achieved, the project will be repeated in 1983. Project monitoring and evaluation will be carried out in 1986.*

Projected Cost:

1982		$ 660 USFS
1986*		500 USFS
	Total	$1,160

Benefit:
Cost Ratio:

Assumptions:

Project will result in an average additonal 110 lbs (2lb/ac) of catchable fish per year available to the angler. One warm water a angler day = $25 = 1 lb. of catchable fish (M-DNR).

Benefit:

The opportunity to catch an additional 110 lbs. of fish per year for 5 years. 110 X 5 X $25 = $13,750

Cost:

$1,160

B/C Ratio:

$13,750/$1,160 = 11.8:1

NGTH - FREQUENCY SUMMARY SHEET

9/16-9/19/80 overnight sets Water: ________
Month Day Year Set Time (Start End)

Water: Cookson Lake County: Schoolcraft T.____ R.____ S.____
Collection Method: 6 Pyke nets and 2 gillnets Unit Effort: ________
Location & Habitat: various habitat around shoreline (see map)
Total Fish Taken: 459 Total Hours Effort: 144 Hourly Rate: 3.19
Total weight of fish: 312.25 lbs.

SPECIES

T.L."	Bluegill	Pumpkin.	Bullhead	W. Sucker	N. Pike	LM Bass	Rock Bass
2.0-2.4							
2.5-2.9	5					6	2
3.0-3.4	2					7	2
3.5-3.9	3	4				1	1
4.0-4.4	3	2					
4.5-4.9	6	4					1
5.0-5.4	6	2					3
5.5-5.9	[illegible]	[illegible]					7
6.0-6.4	14	10					3
6.5-6.9	11	6					2
7.0-7.4	7	6	1			1	1
7.5-7.9	4	2					5
8.0-8.4	6	2					5
8.5-8.9	3	1	1				3
9.0-9.4			9				
9.5-9.9			11	1			
10.0-10.4			32				
10.5-10.9			35				
11.0-11.4			35				
11.5-11.9		11					
12.0-12.4			8		1	2	
12.5-12.9			1	1			
13.0-13.4			1				
13.5-13.9				2	2		
14.0-14.4				2		1	
14.5-14.9				3	1		
15.0-15.4				2	2	2	
15.5-15.9				4	4	1	
16.0-16.4				7	3		
16.5-16.9				7	4		
17.0-17.4				14	6		
17.5-17.9				12	3		
18.0-18.4				9	3		
18.5-18.9				3			
19.0-19.4				1	3		
19.5-19.9					1		
20.0-20.4					1		
20.5-20.9					1		
21.0-21.4							
21.5-21.9							
22.0-22.4							
Total No.	81	53	154	69	35	21	34
% of Total Catch	17.6%	11.5%	36%	15%	7.6%	4.5%	7.4%
Mean Length	6.2	5.8	10.6	16.5	16.9	6.0	6.25
Total Weight	35.5*	*	101.0	136.25	32.25	7.25	*
% of Total Wt.	11.4%*	11.4%*	32.3%	43.6%	10.3%	2.3%	11.4%

*Total weight of panfish

SAMPLE NO.________________
(Continued)

____________________________ Lake Date ____________________________

Species							
Balance					N. Pike		
22.5-22.9					1		
23.0-23.4					1		
23.5-23.9							
24.0-24.4							
24.5-24.9							
25.0-25.4							
25.5-25.9							
26.0-26.4							
26.5-26.9							
27.0-27.4							
27.5-27.9							
28.0-28.4							
28.5-28.9							
29.0-29.4							
29.5-29.9							
30.0-30.4							
30.5-30.9							
31.0-31.4							
31.5-31.9							
32.0-32.4							
32.5-32.9							
33.0-33.4							
33.5-33.9							
34.0-34.4							
34.5-34.9							
35.0-35.4							
35.5-35.9							
36.0-36.4							
36.5-36.9							
37.0-37.4							
37.5-37.9							
38.0-38.4							
38.5-38.9							
39.0-39.4							
39.5-39.9							
40.0-40.4							
40.5-40.9							
41.0-41.4							
41.5-41.9							
42.0-42.4							
42.5-42.9							
43.0-43.4							
43.5-43.9							
44.0-44.4							
44.5-44.9							
% Catchable							
% Total Wt.							
Total Wt.							
% Total No.							
Total No.							

June 23 80 9:00 PM - 10:30 PM Water: ____________
Month Day Year Set Time (Start End)

Water: Cookson County: Alger T. 44N R. 18W S. 21
Collection Method: Coffeldt boomshocker Unit Effort: ____________
Location & Habitat: once around shoreline
Total Fish Taken: 48 Total Hours Effort: 1.5 Hourly Rate: 32 fish/hour

SPECIES

T.L."	N. Pike	W. Sucker	Bullheads	Bluegill	P. seeds	LM Bass	Rock Bass
2.0-2.4							
2.5-2.9							
3.0-3.4							
3.5-3.9							
4.0-4.4							
4.5-4.9							
5.0-5.4				1	1		
5.5-5.9				2	1		
6.0-6.4				2			1
6.5-6.9				3	3		
7.0-7.4				1			1
7.5-7.9							
8.0-8.4				1			
8.5-8.9							
9.0-9.4							
9.5-9.9			1				
10.0-10.4			4				
10.5-10.9			1				
11.0-11.4							
11.5-11.9		1					1
12.0-12.4							
12.5-12.9							
13.0-13.4						1	
13.5-13.9						1	
14.0-14.4							
14.5-14.9		1					
15.0-15.4	2	2					
15.5-15.9		2					
16.0-16.4		9					
16.5-16.9		2					
17.0-17.4		1					
17.5-17.9		1					
18.0-18.4							
18.5-18.9							
19.0-19.4	1						
19.5-19.9							
20.0-20.4							
20.5-20.9							
21.0-21.4							
21.5-21.9							
22.0-22.4							
Total No.	3	19	6	10	5	2	3
% of Total Catch	6.25%	39.5%	12.5%	21%	10.5%	4%	6.25%
Mean Length	16.5"	15.9"	10.2"	15.6"	6.2"	14.2"	8.4"
Total Weight	2.75#	35.5#	3.5#	*	*2.5#	2.5#	1.5#
% of Total Wt.	5.7%	73.5%	7.25%	*	*5%	5%	4%

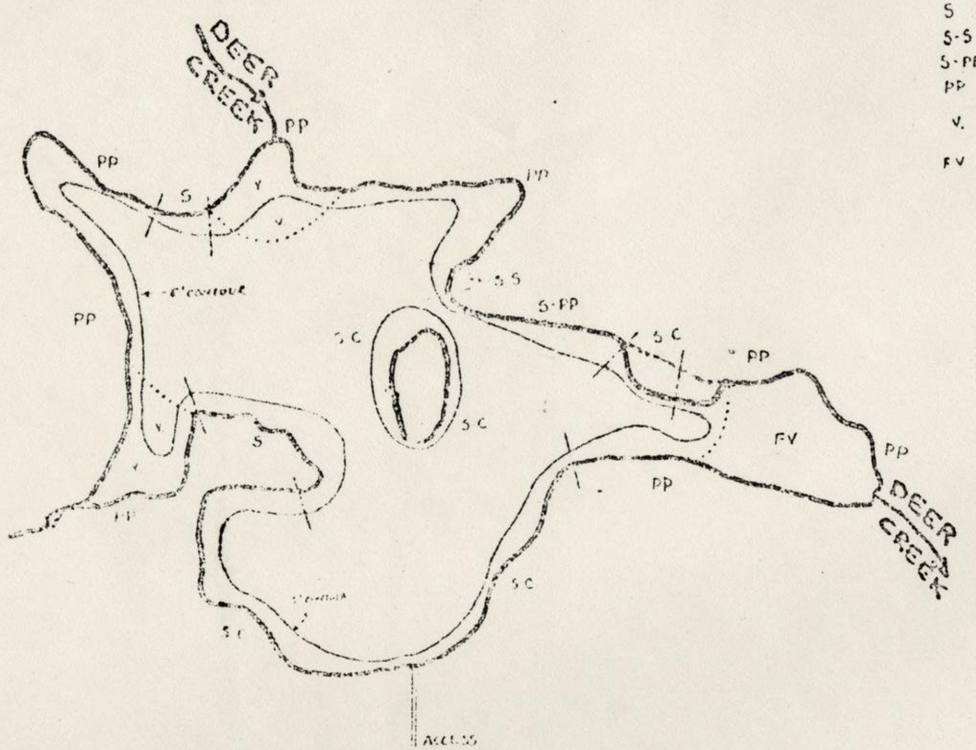
COOKSON LAKE

BOTTOM TYPES IN SHOAL AREAS

(MAPPED NOVEMBER 1975)

KEY

S-C SAND & CLAY MIX
S : SAND
S-S : SAND W/ SILT OVERLAY
S-PP : SAND W/ PULPY PEAT OVERLAY
PP : PULPY PEAT
V. : SUBMERGED VEGETATION MAT & CLOSE TO SURFACE. (6")
FV : CONCENTRATION OF FLOATING VEGETATION



N

SCALE: 8" = 1 MILE

AD-287
(9-80)

U. S. DEPARTMENT OF AGRICULTURE

Employee Suggestion

Write your suggestions below. If desired, attach additional information, charts, sketches, etc. In presenting your suggestion, show:

(1) What is the present method?
(2) Disadvantages of present method
(3) The proposed method, and
(4) Advantages and/or estimated savings, and reflect
a. Why is it necessary?
b. What is its purpose?
c. Where should it be done?
d. Who should do it?
e. How is the best way to do it?

BRIEF SUMMARY OF SUGGESTION

A simple technique to measure dissolved oxygen concentration (DO) very near the bottom (site of fish egg and larvae development) was developed. A kit to perform the measure can be assembled for $150, and samples can be run in less than 10 minutes.

DETAILED EXPLANATION

1, 2, 3 - See attachment.

4. This DO measurement technique is necessary to evaluate the quality of spawning and early life habitat of many game and non-game fish species. Insufficient DO is a factor limiting natural reproduction of some fishes; therefore, the costly stocking of hatchery-reared fingerlings is necessary to maintain adequate fisheries. The method provides the aquatic biologist, hydrologist, or technician with a means of identifying this critical limiting factor and provides a basis for planning, implementing, and evaluating aquatic habitat improvement measures to enhance natural reproduction of fishes.

   This technique will be published in the Transactions of the American Fisheries Society since it has application for both private industry and resource management agencies.

It is understood by the employee whose signature appears below that the suggestion submitted on this form may be granted an award only if adopted by the Government, by written notification or through practical application of the idea as a result of the suggestion, within two (2) years of the date of final action on the suggestion as defined in DPM chapter 451.

SUBMITTED BY (Signature—Agency—Division—City and State)	POSITION TITLE AND GRADE	DATE SUBMITTED
Michael P. Dombeck MR., MRS., MISS, MS. Michael P. Dombeck Chequamegon National Forest Park Falls, WI 54552	Fisheries Biologist GS-482-9	Sept 12, 1983 SUGGESTION NO.
RECEIVED BY (Name and title of supervisor)	DATE (Approved or referred)	SUGGESTION NO.

(Supervisor see reverse)

Form AD—287 (9/80)

A Method for Measuring Oxygen Microstratification

Michael P. Dombeck

United States Department of Agriculture, Forest Service

Chequamegon National Forest

Park Falls, Wisconsin 54552

Abstract

Reduction of dissolved oxygen concentration (DO) in aquatic environments by organic materials is common. A method to obtain accurate DO measures within 8 mm of the bottom was developed using oxygen-permeable dialysis tubing to obtain a 10 ml water sample followed by a modification of the micro-Winkler technique. Controlled experiments showed that DO within tubes reached 99 percent equilibrium with ambient water (via diffusion) in less than 3 hours in lotic waters, and less than 5 hours in lentic waters with experimental error of 0.05 mg/liter. A kit to perform the DO measures can be assembled for about $150 and samples can be run in less than 10 minutes.

Introduction

Reduction of dissolved oxygen concentration (DO) in aquatic environments by organic materials from cultural and natural sources is common. Oxygen microstratification at the substrate-water interface of hypolimnetic waters has a significant effect on the distribution and activity of benthic organisms (reviews by Brunden 1951; Mortimer 1971; Brinkhurst 1974). Fremling and Evans (1963) and Peterka and Kent (1976) described DO reductions associated with organic substrates in littoral waters. Low DO can adversely affect the early life development and growth of fishes, often resulting in high mortality (review by Doudoroff and Shumway 1970). Measuring DO of the thin stratum at the substrate-water interface using present techniques is accomplished with great difficulty, such as the pumping mechanism used by Peterka and Kent (1976). A simpler technique developed by Fremling and Evans (1963) employs the collection of 1 liter water samples utilizing polyethylene bags which can be placed in the desired location. DO within the bag reaches equilibrium with ambient water through diffusion. Disadvantages of this technique are (1) the relatively large water sample may reflect DO well above a thin micro-zone, and (2) the transfer of the sample from the polyethylene bag into a sample bottle may allow diffusion of atmospheric oxygen and yield a slightly higher DO measure. Conventional sampling techniques tend to disturb the thin stratum immediately above the bottom, and electronic probes are least accurate at very low DO. A simple, inexpensive, yet accurate technique for measuring microstratification of DO is described.

Materials and Methods

I modified the polyethylene bag technique of Fremling and Evans (1963). Oxygen-permeable standard cellulose dialysis tubing (Spectra/Por membrane tubing 16 mm diameter, molecular weight cutoff 12,000-14,000) was filled with distilled water and tied off with rubber bands at 100 mm intervals and cut to form tubular bags (16 x 100 mm) holding about 12 ml of water. Suspending the tubing in a vertical position prior to tying allowed air to escape and eliminated the problem of air bubbles being trapped in the individual sample bags.

To test these bags I determined the length of time required for the DO within the sample bag to reach equilibrium (via diffusion) with ambient water. Additionally, since DO measures are routinely made at different temperatures and in both standing and flowing water environments, the influence of these variables had to be determined.

Experimental Design

A deoxygenated environment was established by bubbling nitrogen gas (Fry 1951) through several air stones in a 50 liter carboy filled with water. DO in the carboy was monitored continuously using a YSI oxygen meter. In addition, oxygen determinations were made hourly on replicate samples using the azide modification of the standard Winkler method (American Public Health Association et al. 1975).

Previously prepared dialysis tubing sample bags were placed in the carboy. At one-half hour intervals during the first two hours, and at one-hour intervals thereafter, three bags (replicates) were removed for determination of DO. The experiment was terminated when the sample DO approximated the ambient DO. To determine the influence of temperature, the experiment was run at 7 and 21 C. Additionally, to determine time to equilibrium in a flowing versus a stagnant water environment, nitrogen was continuously bubbled during a series of temperature trials to constantly circulate the water in contact with the sample bags, similar to a lotic environment. A second series of temperature trials was run without circulation of water by bubbling to approximate a lentic environment.

Immediately upon removal of a sample bag from the carboy, the water sample was gently extracted using a 10 ml graduated hypodermic syringe (Leur-Lok). DO was subsequently determined using a modification of the microtechnique used by Burke (1962).

Storage of Reagents

Prior to taking water samples, manganous sulfate ($MnSO_4$), alkaline iodide azide (AIA), and ortho-phosphoric acid (H_2PO_4)

reagents were each placed into small reagent bottles and capped with a rubber septum. The reagents were dispensed by penetrating the septum with the hypodermic needle and drawing necessary volumes directly into the syringe containing the water sample. Starch indicator solution was dispensed from a dropper bottle, and phenyl arsine oxide (PAO) titrant was dispensed using a Hach digital titrator and titration cartridge.

DO Measurement Technique

The DO measurement technique was modified from the micro-Winkler technique used by Burke (1962) as follows:

1. Remove sample bag from ambient water, gently extract 10 ml water sample into hypodermic syringe.
2. Invert syringe and expel water to the 9.4 ml mark.
3. Draw 0.2 ml of $MnSO_4$, wipe needle tip, and rotate syringe gently to mix.
4. Draw 0.2 ml of AIA, wipe needle top, and mix. Place syringe in test-tube rack and allow precipitate to settle. Mix again.
5. Draw 0.2 ml of H_2PO_4, wipe needle and mix. Allow precipitate to dissolve.
6. Eject contents of syringe into a 25 ml flask.
7. Using the Hach digital titrator, dispense PAO until a pale yellow color is reached. Add one drop of starch indicator and titrate until blue color disappears.

8. Calculate DO as follows:

$$\text{DO (mg/liter)} = \frac{(8 \text{ meq } 0_2/\text{ml}) \text{ X (meq PAO) X (N of PAO)}}{9.4 \text{ ml (volume of sample)}}$$

Analysis of Data

Since the movement of oxygen between the inside of the bag and the surrounding environment is a diffusion reaction, the rate of oxygen movement is proportional to the difference (D) between the oxygen concentration of the environment and the oxygen concentration within the bag. This leads to an exponential relationship of the form

$$\ln(D) = \ln(Do) - kt$$

where D is the difference in oxygen concentrations within and without the bag at time t, DO is the oxygen concentration at t=0, and k is the rate constant. A linear regression of ln(D) on t was fitted to find the rate constants (k) for the experimental data.

The experimentally determined rate constants in the above equation were used to find the length of time needed for the difference in oxygen concentration to be reduced to 95% ($D = 0.95*Do$) and 99% ($D = 0.99*Do$) of the original value.

Results and Discussion

Time required for DO in dialysis tubing to reach 95% and 99% equilibrium with deoxygenated lotic and lentic waters at 7 and 21 C is given in table 1. Diffusion of DO through the dialysis tubing occurred more rapidly in lotic environment and no significant differences in rate were found between 7 and 21 C (95% equilibrium in 1-hour, 99% equilibrium in 2.7-hours). In the lentic environment, statistically significant differences in diffusion rate between the two temperatures did occur; however, from an applied perspective, they would likely be considered negligible. Figure 1 shows the results of movement of DO through the membrane versus time for lotic and lentic waters at 7 and 21 C. Experimental error for DO measurement within a sample bag was 0.05 mg/liter.

The DO measurement technique described was subsequently used to measure microlayers both in laboratory and field situations quickly and inexpensively. Sample bags can be placed at any level in the water column and titrations can be run in less than 10 minutes with little practice. A kit using the technique described can be assembled for approximately $150.00. Primary advantages of the technique include: the small sample of water necessary, making it adaptable to laboratory situations where a large number of replicate samples are needed; its adaptability to a wide variety of laboratory and field situations well beyond measuring microstratification of DO; its simplicity and low cost. Additionally, it provides the aquatic biologist or hydrologist a useable and accurate technique to measure environmental conditions.

Bear in mind that the time to equilibrium values given are specific to the particular dialysis tubing used, and by size and volume as well as shape. Therefore, time to equilibrium determinations must be made for any deviation of tubing and bag size.

References

American Public Health Association, American Water Works Association, and Water Pollution Control Federation. 1975. Standard Methods For The Examination of Water and Wastewater. Fourteenth edition. American Public Health Association, New York, New York, USA.

Brinkhurst, R.O. 1974. The Benthos of Lakes. MacMillan, London, England.

Brundin, L. 1951. The relation of oxygen microstratification at the mud surface to the ecology of the profundal bottom. Institute of Freshwater Research Drottningholm Report 32:32-45.

Burke, J. D. 1962. Determination of oxygen in water using a 10 ml syringe. Journal of the Elisha Mitchell Scientific Society 78:145-147.

Doudoroff, P., and D. L. Shumway. 1970. Dissolved oxygen requirements of freshwater fishes. FAO (Food and Agriculture Organization of the United Nations) Fisheries Technical Paper 86.

Fremling, C. R., and J. J. Evans. 1963. A method for determining the dissolved oxygen concentration near the mud-water interface. Limnology and Oceanography 8:363-364.

Fry, F.E.J. 1951. A fractioning column to provide water of various dissolved oxygen contents. Canadian Journal of Technology, 29:144-146.

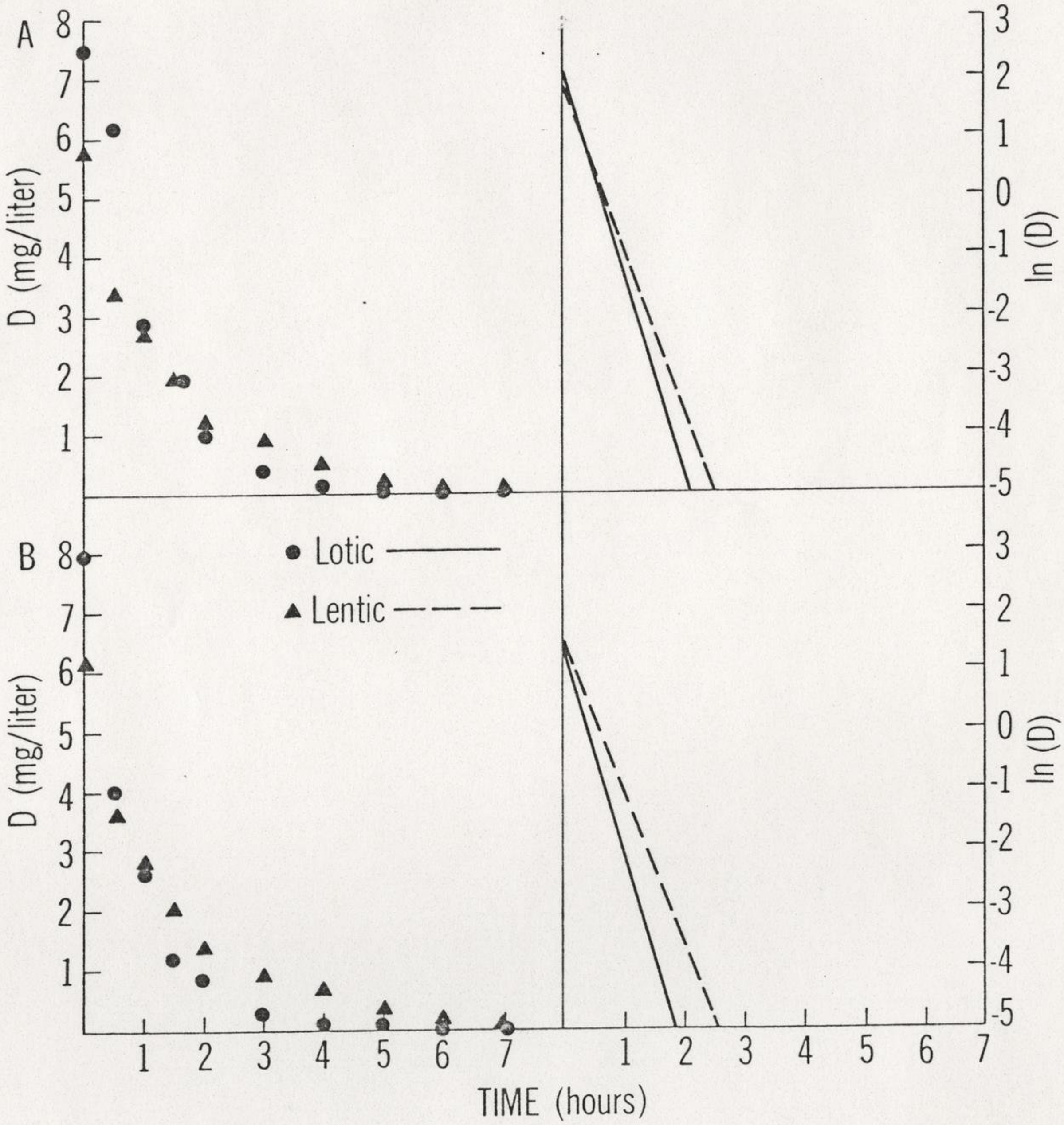
Mortimer, C. H. 1971. Chemical exchanges between sediments and water in the Great Lakes-speculations on probable regulatory mechanisms. Limnology and Oceanography 16:387-404.

Peterka, J. J., and J. S. Kent. 1976. Dissolved oxygen, temperature, and survival of young at fish spawning sites. United States Environmental Protection Agency EPA-600/3-76-113, Duluth, Minnesota, U.S.A.

Table 1. Time (hours) required for dissolved oxygen concentration in dialysis tubing to reach equilibrium with deoxygenated environment at 7 and 21 C and lotic and lentic waters.

	Temperature C	Time: 95% Equilibrium	Time: 99% Equilibrium
Lotic Water	21	1.0	2.7
	7	1.0	2.7
Lentic Water	21	1.8	4.1
	7	1.9	4.5

Figure 1--Difference (D) between dissolved oxygen concentration (DO) of environment and DO within sample bags versus time; A, at 21 C in lotic ($Ln(D)=2.01-0.95(time)$, $R^2=0.99$) and lentic ($Ln(D)=1.70-0.68(time)$, $R^2=0.97$) environments, and B, at 7 C in lotic ($Ln(D)=1.81-0.92(time)$, $R^2=0.99$) and lentic ($Ln(D)=1.73-0.62(time)$, $R^2=0.98$) environments. N=3.


A
B
D (mg/liter)
ln (D)
Lotic
Lentic
TIME (hours)

AD - 287
(9-80)

U. S. DEPARTMENT OF AGRICULTURE

Employee Suggestion

Write your suggestions below. If desired, attach additional information, charts, sketches, etc. In presenting your suggestion, show:

(1) What is the present method?
(2) Disadvantages of present method
(3) The proposed method, and
(4) Advantages and/or estimated savings, and reflect
a. Why is it necessary?
b. What is its purpose?
c. Where should it be done?
d. Who should do it?
e. How is the best way to do it?

BRIEF SUMMARY OF SUGGESTION

This is a simple technique to hatch muskellunge eggs in artificial turf incubators. It provides the resource manager with a cost-effective alternative to spawning habitat improvement and stocking hatchery reared muskellunge in waters where inadequate spawning habitat limits natural reproduction.

DETAILED EXPLANATION

1, 2, 3, - See attachment.

4. Loss or alteration of habitat, especially reproductive habitat is considered to be a major cause in the decline of natural muskellunge populations. Thus, the stocking of hatchery reared fingerlings is necessary to maintain fishable populations in most muskellunge waters. The commercial cost of a 10 inch hatchery reared muskellunge is $7.50 while costs at state operated hatcheries ranges from $2.50 to $14.00 varying both by state and year, not including distribution costs. The survival from stocked fingerling to catchable size is about 10%.

This technique eliminates the major portion of the costly hatchery operations by incubating the eggs in their natural environment. Since the eggs are incubated in the lake they hatch in syncrony with their natural prey which can only increase survival.

This technique will be published in the North American Journal of Fisheries Management since it has application for many other fish species well beyond that of muskellunge management. The technique is not only useful to resource management agencies, but also to private fish production operations and farm ponds. This project was done while I was on the Chequamegon N.F. in Region 9.

Submitted by:

Michael P. Dombeck, Fisheries Biologist, GS-482-12
Forest Service Fisheries & Wildlife Management
630 Sansome St., San Francisco, CA 94111

It is understood by the employee whose signature appears below that the suggestion submitted on this form may be granted an award only if adopted by the Government, by written notification or through practical application of the idea as a result of the suggestion, within two (2) years of the date of final action on the suggestion as defined in DPM chapter 451.

SUBMITTED BY (Signature—Agency—Division—City and State) MR., MRS., MISS, MS.	POSITION TITLE AND GRADE	DATE SUBMITTED
Michael P. Dombeck	Fisheries Biologist GS-482-12	2/5/86
		SUGGESTION NO.
RECEIVED BY (Name and title of supervisor)	DATE (Approved or referred)	SUGGESTION NO.

(Supervisor see reverse)

Form AD—287 (9/80)

ARTIFICIAL TURF INCUBATOR FOR MUSKELLUNGE EGGS

Michael P. Dombeck[1]

Chequamegon National Forest

Park Falls, Wisconsin 54552

[1]Present address: USDA Forest Service, 630 Sansome St. San Francisco, CA 94111

ABSTRACT

The purpose of this study was to determine the utility of artifical turf for the incubation of muskellunge (Esox masquinongy) eggs and to quantify survival muskellunge eggs were incubated in artificial turf incubators in five lakes in Michigan and Wisconsin. Mean survival to the swim-up stage from green eggs was 13% and from eyed eggs was 41%. This technique provides the manager with an economical alternative to spawning habitat improvement and stocking hatchery reared muskellunge in waters where inadequate spawning habitat limits natural reproduction.

INTRODUCTION

In many areas where the muskellunge Esox masquinongy once maintained healthy natural populations it has been extirpated or is sustained only through artificial propagation and stocking. Loss or alteration of habitat, especially reproductive habitat, is considered to be a major cause in the decline of native populations (Trautman 1981; Oehmcke et al. 1974). Natural reproduction in most of Wisconsin's 703 lakes and 48 streams containing fishable muskellunge populations is insufficient to maintain desired population levels. Consequently, an average of 140,000 muskellunge fingerlings and one million fry are stocked annually to supplement natural reproduction (Hanson et al. In press). The present cost of 10-12 inch muskellunge is $7.50 (Kalepp Fish Farms, Dorchester, Wisconsin) exclusive of distribution costs. Furthermore, survival of the hatchery product to legal size is 10% or less (Johnson 1978).

Quality of spawning habitat has been implicated as a major ecological factor determining muskellunge reproductive success. Comparative studies of spawning habitat in eight muskellunge lakes in Michigan, Minnesota, and

Wisconsin associated springtime dissolved oxygen concentration (DO) at the bottom-water interface with reproductive success (Dombeck et al. 1984). Four lakes with self-sustaining populations had high DO (mean, 6.0-8.4 mg/l) while the others with little or no natural reproduction had low DO (mean, 0.4-2.4 mg/l). Dissolved oxygen depletion was attributed to night-time respiration of dense submergent vegetation and/or decomposition of flocculent organic silts.

Muskellunge are sensitive to spawning habitat quality because they lack behavioral adaptations to avoid deleterious DO conditions. They typically spawn in shallow bays (3 ft) over muck bottoms covered with detritus and dead vegetation. Muskellunge eggs and larvae stay in direct contact with bottom materials throughout embryonic development. These considerations suggest that the muskellunge is adapted to spawning in clean-bottom oligotrophic waters. Where such habitat conditions are degraded reproduction is most often very poor. In many midwestern lakes human activities such as agriculture, shoreline disturbance, water-level stabilization, etc. have resulted in deposition of organic silts and dense weed growth over formerly clean bottoms. In such areas, management alternatives beyond stocking hatchery reared muskellunge are presently very limited. Aeration of high biological oxygen demand substrates by water-level management or removal of these substrates by dredging are options but usually not economically feasible.

Artificial turf has proven to be a suitable substitute for incubation of lake trout eggs (Swanson 1982) but the suitability of such substrate for incubation of muskellunge or other coolwater or warmwater species has not been determined. The objective of this study was to determine the utility of artificial turf for the incubation of muskellunge eggs and to quantify survival.

MATERIALS AND METHODS

The incubators were made up of four layers of 1 ft. square mats of Monsanto AstroTurf. Each layer consisted of two mats with turf sides facing each other. The four layers were sandwiched between two wooden frames fastened together with bolts. In 16 of the 56 incubators, Monsanto CH-4 AstroTurf was used on the upper side of each layer and Monsanto HD AstroTurf on the lower side of each layer. The 40 remaining incubators were constructed using HD AstroTurf mats on both the upper and lower side of each layer. The CH-4 has a lower blade density which allows for greater water circulation but does not hold the muskellunge eggs as firmly in place as the HD. Preliminary studies showed that when CH-4 mats were used for both sides of a layer some eggs rolled out and were lost.

Green eggs (fertilized water-hardened) and eyed eggs (incubated in a hatchery to the eyed stage) were provided by the Wisconsin and Michigan Departments of Natural Resources. Muskellunge eggs were sprinkled on the mats at a density of 500 eggs per square foot (layer) or 2,000 per incubator. Eggs were placed on the mats using a squeeze bottle with an orfice slightly larger than an individual egg. This method made it easier to evenly distribute the eggs on the mats and avoid egg clumping. The eggs were neither treated for fungus nor sorted to remove dead eggs. After the eggs were placed in the incubators each incubator was tied to a concrete anchor and submerged in water approximately 3 ft deep.

Green muskellunge eggs were placed in incubators in Sailor Creek Flowage and Round and Sailor lakes, Price County, Wisconsin in the Chequamegon National Forest on April 24, 1985. On May 1, 1985 green eggs were placed in incubators in Pomeroy and Moosehead lakes, Gogebic County, Michigan in the Ottawa National

Forest. Eyed eggs were placed in incubators in the same lakes on May 6 and 19, respectively. This timing was similar to the natural spawning cycle of local muskellunge. The eyed Michigan eggs were incubated at 48 F in the hatchery rather then the usual 55-60 F preferred for muskellunge (Johnson 1958) because there was no warmwater hatchery facility in Michigan's upper peninsula.

Incubators with turf layers made of CH-4/HD mats were placed only in Round Lake and Sailor Creek Flowage. Incubators made entirely of HD matts were placed in all five lakes. Prior to swim-up of the muskellunge fry, screen cages were placed around each incubator to prevent fry from escaping before they could be counted. Upon swim-up, the fry were counted and removed from each cage. Water temperatures were monitored each day throughout the egg incubation period.

For statistical purposes, each incubator was an experimental unit. There were four treatments: 1) green eggs in incubators made up of HD AstroTurf matts, 2) green eggs in incubators with CH-4 on the upper half of each layer and HD on the lower half (CH-4/HD), and 3-4) eyed eggs in each of the two types of incubators. There were four replicates of each treatment at each lake. Mean survival to swim-up was calculated for each treatment (four incubators) at each lake, and analysis of variance was used to determine significant differences between treatments (Snedecor and Cochran 1981). Survival was calculated as the number of fry reaching the swim-up stage of development.

RESULTS

Muskellunge swim-up fry were first observed in Sailor Lake, Wisconsin on May 16, 1985, 22 days after placement of the green eggs. Swim-up fry from the eyed eggs emerged simultaneously after 10 days of incubation. Swim-up fry emerged the same day in Sailor Creek Flowage but about three days later in Round Lake where water temperatures were about 3-5 F colder than the other two Wisconsin lakes throughout the incubation period. In the Michigan lakes, the first swim-up fry were observed on May 23, 1985 after 23 days of incubation of green eggs, and on May 27 after 12 days of incubation of eyed eggs. Fry emergence continued for 5-7 days after the first swim-up fry were observed.

No significant differences in survival were observed between incubators using the HD matts and the CH-4/HD matts. Therefore, the means of incubators using CH-4/HD matts were pooled with HD matts in the same lake. Significant differences ($F=9.6$, $P<.05$) in survival existed between green eggs and eyed eggs in all lakes (Table 1). Overall mean survival to the swim-up stage in the five lakes was 13% from green eggs and 41% from eyed eggs. The two Michigan lakes had significantly lower ($F=19.6$, $P<.01$) survival than the Wisconsin lakes for both green and eyed eggs (Table 1). Survival from green eggs ranged from 9% in Moosehead Lake to 15% in Sailor Lake and the two Round Lake sites. Highest survival (63%) from eyed eggs was observed in Sailor Lake while the lowest (15%) was observed in Moosehead Lake.

DISCUSSION AND MANAGEMENT IMPLICATIONS

This technique provides the resource manager with an alternative to stocking hatchery reared muskellunge in waters where inadequate spawning habitat limits natural reproduction and spawning habitat improvement is not feasible. Although survival rates are lower than those obtained in hatcheries, costs are less than labor-intensive hatchery operations. Additionally, in most states hatchery rearing facilities are unable to meet the demand for muskellunge needed to maintain the desired population levels.

Superficially, survival rates of 12% from fertilization to swim-up may seem low, however, this represents a great increase over hatching rates which occur in nature. Early life survival data for muskellunge are lacking, however, Latta (1971) reported that in the closely related and more prolific northern pike, survival in nature from egg to 7.5 cm size was 0.9%. Major causes of muskellunge egg and larvae mortality in nature likely include; 1) low DO, hydrogen sulfide, and other lethal conditions associated with highly reducing organic substrates (Dombeck et al. 1984), 2) predation (Scott and Crossman 1973), 3) physical damage due to intense wave action, 4) sudden decreases in water temperature (Johnson 1958) due to strong cold fronts, and 5) declining water levels stranding eggs and larvae. Additionally, only about 34% of eggs laid naturally are fertilized (Johnson et al. 1957 cited in Hess and Heartwell 1978) compared to 85-95% using the dry fertilization technique during hatchery spawn-taking operations (Johnson 1958).

Present results showed no significant difference in survival to swim-up between incubators of the two mat-construction types. The CH-4 mats were not used for the lower layer because preliminary studies in the spring of 1984 showed that the coarse blade density and spacing did not hold the muskellunge eggs firmly in place and many rolled out of the incubators and were lost. It is critically important that HD mats be used as the lower layer to prevent egg loss. The results suggest that either CH-4 or HD mats can be used as upper layers.

The results showed significantly higher survival of eyed eggs (mean, 41%) than green eggs (mean, 12%). This may be explained on the basis that green eggs not sorted for viability but only viable eyed eggs were used. Most hatchery managers observe low mortality of muskellunge eggs beyond the eyed stage. Likely causes of lower survival of green eggs are non-fertilization and suseptibility to <u>Saprolegnic</u> fungal infection since the green eggs were in the incubators about 12 days longer than the eyed eggs. Also the initial presence of nonviable green eggs likely enhances fungal infestations. Examination of the turf mats after the fry had emerged suggested, in fact, that fungal infection was responsible for much of the mortality. Under hatchery conditions the fungus <u>Saprolegnia</u> causes high mortality of cultured fish eggs (Brown and Gratzek 1980). Based upon incubation of muskellunge eggs under controlled laboratory conditions Dombeck et al. (1984) suggested that physical isolation of eggs from each other impedes fungal proliferation. It is likely that fungus-caused egg mortality in any type of artificial environment is a function of egg density, especially at warm water temperatures (above 60 F). Incubating lake trout eggs on the same type of artificial turf but at water temperatures near 40 F Swanson (1982) observed survival rates of 78%. The cold water temperatures likely impeded fungal growth on the lake trout eggs. It is likely that studies concerning the growth requirements of the fungi would yield results valuable to fish culturists.

The lower survival of eyed eggs in the two Michigan lakes (mean, 16%) compared to a mean survival of 53% in the three Wisconsin lakes is attributed to the egg source. The eyed-eggs in the Michigan lakes were incubated at low water temperature (48 F) in the hatchery. As these eyed eggs were being placed on the mats some breakage occured. Johnson (1958) noted that muskellunge eggs hatched in below normal water temperatures (48-50 F) use up yolk-sac food food materials without an increase in size and develop into weakened fry that may not feed. The presence of dead eggs or yolk on the mats enhanced fungal growth resulting in mortality of viable eggs as well.

The results indicate that use of either green or eyed-eggs can be of management utility. However, managers will face the trade-off between convenience and expense, on the one hand, and survival on the other. For example, green eggs could be taken from adults from the same water body where they are to be placed, thus eliminating hatchery and transportation costs and maintaining genetic integrity. But, survival rate may be rather low. In contrast, the use of eyed eggs involves hatchery costs but allows the manager a longer time frame to distribute incubators and provides higher surivival. In either case, after the eggs are placed in the lake incubators no more care is needed except to remove and refurbish the incubators at some convenient time.

Use of portable incubators facilitates the placement and incubation of eggs in environments conducive to egg development and larval survival. The incubators are bouyant and can be suspended at any depth well above deleterious bottom conditions. The eggs are held firmly in place by the turf blades which protect them from predators and physical damage from wave action. Finally, since fry emergence is largely controlled by temperature, the in situ incubation of eggs allows swim-up to occur in natural synchrony with zooplankton hatches which provide forage for fry.

Economic analysis

__Assumptions__: Estimated cost of 2,000 green muskellunge eggs (number of eggs placed in one incubator) is \$20. Estimated cost of 2,000 eyed eggs is \$50. Cost of materials and labor for constructing one incubator with a 10 year life is \$40, or an annual cost of \$5. Average cost of placing eggs in incubator and incubator placement and removal is \$50. The cost of hatchery reared muskellunge fry is \$.65 each (Kalepp Fish Farms, Dorchester, Wisconsin). Based on the results of this study survival to swim-up usnig AstroTurf incubators from green eggs is 10% and from eyed eggs is 40%.

__Benefit-cost ratio__:

Green eggs

$$\frac{200 \text{ fry} = \$130 \text{ (10\% survival)}}{\$20 \text{ (2,000 green eggs)} + \$5 \text{ (incubator cost)} + \$50 \text{ (placement)}} = \frac{1.7}{1}$$

Eyed Eggs

$$\frac{800 \text{ fry} = \$520 \text{ (40\% survival)}}{\$50 \text{ (2,000 eyed eggs)} + \$5 \text{ (incubator cost)} + \$50 \text{ (placement)}} = \frac{5}{1}$$

Note that this economic analysis is based upon the current cost of muskellunge fry from a commercial source. It is, therefore, most useful to private organizations or agencies that have no muskellunge production capability. State production costs are lower because large multi-species hatcheries are already in operation and not included in the costs and no profit is realized. Production costs of muskellunge vary greatly between states that have muskellunge production capability.

ACKNOWLEDGEMENTS

This was a cooperative project between the USDA Forest Service and the Wisconsin Department of Natural Resources. The Michigan Department of Natural Resources cooperated by supplying muskellunge eggs. The Fish America Foundation provided funding, in part, for materials. I am greatful to Mike Bablick, William Byers, Jerry Edde, Chuck Johnson, Jim Lealos, and Del Siler for logistic and technical assistance. I thank the many employees of the Forest Service and Michigan and Wisconsin departments of Natural Resources who provided assistance. I thank James Copeland, David Hanson, John Klingbiel, Jim Lealos, and Bruce Menzel for thier suggestions and review of this manuscript.

REFERENCES

Brown, E. E. and J. B. Gratzek. 1980. Fish farming handbook. AVI Westport, Connecticut, USA.

Dombeck, M. P., B. W. Menzel, and P. N. Hinz. 1984. Muskellunge spawning habitat and reproductive success. Transactions of the American Fisheries Society 11:205-216.

Hanson, D. A., M. D. Staggs, S. L. Serns, L. D. Johnson, and L. M. Andrews. In press. Survival of stocked muskellunge eggs, fry, and fingerlings in Wisconsin lakes. American Fisheries Society Special Publication 15.

Hess, L. and C. Heartwell. 1978. Literature review of large esocids (muskellunge, northern pike, hybrid tiger muskellunge). Pages 139-175 in J. Dube and Y. Gravel, editors. Proceedings of the 10th warmwater workshop. Northeastern Division, American Fisheries Society. Ministry of Tourism, Montreal, Canada.

Johnson, L. D. 1958. Pond culture of muskellunge in Wisconsin. Wisconsin Conservation Department Technical Bulletin 17.

Johnson, L. D. 1978. Evaluation of esocid stocking in Wisconsin. American Fisheries Society Special Publication 11:298-301.

Latta, W. 1971. The northern pike in Michigan: A commentary on regulations for fishing . Michigan Department of Natural Resources Research Division Report 241.

Oehmcke, A. A., L. Johnson, J. Klingbiel, and C. Winstrom. 1974. The Wisconsin muskellunge. Its life history, ecology, and management. Wisconsin Department of Natural Resources Publication 8-3600(74).

Scott, W. B. and E. J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184.

Swanson, B. L. 1982. Artificial turf as a substrate for incubating lake trout eggs on reefs in Lake Superior. Progressive Fish Culturist 44:109-111.

Trautman, M. B. 1981 The fishes of Ohio, revised edition. Ohio State University Press, Columbus, Ohio, USA.

Table 1. Mean number of survivors from green and eyed muskellunge eggs incubated on artificial substrate to swim-up fry stage ± 95% confidence interval. Percentage survival is given in parentheses. (n = number of incubators)

Lake	n	green eggs	eyed eggs
Michigan			
Moosehead	4	188±38 (9%)	304±102 (15%)
Pomeroy	4	195±57 (10%)	337±78 (17%)
Wisconsin			
Round	8	294±25 (15%)	957±136 (48%)
Sailor	4	295±51 (15%)	1260±356 (63%)
Sailor Ck. Flowage	8	243±20 (12%)	985±36 (49%)

U.S. DEPARTMENT OF AGRICULTURE

REFERENCE SLIP

DATE 7/24/86

TO

- Mike Dombeck F/WL R-5
- Bob Hollingsworth F/WL R-9
- Bob Nelson

- [ ] ACTION
- [ ] NOTE AND RETURN
- [ ] APPROVAL
- [ ] PER PHONE CALL
- [ ] AS REQUESTED
- [ ] RECOMMENDATION
- [ ] FOR COMMENT
- [ ] REPLY FOR SIGNATURE OF
- [x] FOR INFORMATION
- [ ] RETURNED
- [ ] INITIALS
- [ ] SEE ME
- [ ] NOTE AND FILE
- [ ] YOUR SIGNATURE

REMARKS This ought to make someone sit up and take notice! Hope it amounts to something

FROM Paul

U.S.G.P.O. 1985-526-216

FORM AD-514 (8-64)

Michael P. Dombeck
Chequamegon NF
Region 9

6159#(R9-8638)	DATE RECEIVED	DATE REFERRED
POSITION AND GRADE Fish Biologist GS-12	7/9/86	7/10/86

BRIEF DESCRIPTION OF SUGGESTION

A simple technique to hatch muskellunge eggs in artifical turf incubators.

SECTION 2 · REFERRAL

TO	FROM	ACKNOWLEDGMENT SENT TO
WO 1. WL/F 2. AM, Programs, 0331-S	Admin. Management	Region 9

NOTICE: Check appropriate box below.

[XX] EVALUATE THE ATTACHED SUGGESTION AND INDICATE YOUR ACTION BELOW. RETURN THE ORIGINAL TO THIS OFFICE.

[ ] ATTACHED IS AN EMPLOYEE SUGGESTION NEEDING FURTHER ACTION. OUR ACTION OR RECOMMENDATION IS SHOWN BELOW. YOUR HELP IN ARRIVING AT A FINAL DECISION WILL BE APPRECIATED.

SECTION 3 · ACTION TAKEN OR RECOMMENDATION

1. [X] HAS BEEN ADOPTED *(Complete Sections 4 and 5 if applicable)* in Wisconsin and Michigan
2. [X] RECOMMEND ADOPTION *(Complete Sections 4 and 5 if applicable)* throughout range of muskellunge and to other appropriate warmwater species
3. [ ] HAS BEEN REJECTED *(Complete Section 4)*
4. [ ] RECOMMEND REJECTION *(Complete Section 4)*
5. [ ] RECOMMEND REFERRAL TO ____
6. [ ] OTHER ACTION ____

SECTION 4 · EXPLANATION OF ACTION OR REASONS FOR RECOMMENDATION

This technique, if broadly applied, has the potential to dramatically reduce warmwater and coolwater hatchery costs. It is inexpensive, simple to apply, and because it works so well and requires only limited fisheries management skills, it has potential in remote locations and underdeveloped countries.

SIGNATURE OF APPRAISER	TITLE	DATE
Paul Brouha	National Fisheries Program Manager	7/17/86

AD-287-3 (A&B ASSEMBLY) (9-60)

APPRAISER'S COPY **REFERRAL AND APPRAISAL OF EMPLOYEE SUGGESTION**

AD-287-3 (REVERSE)

SECTION 5 - EVALUATION OF ADOPTED AND RECOMMENDED SUGGESTIONS

IF SUGGESTION IS ADOPTED AND INSTALLED, GIVE UNIT(S) AND LOCATION(S)	DATE INSTALLED
Michigan, Wisconsin	1984-85

WHERE ELSE COULD THIS IDEA BE USED?

Throughout natural range and introduced range of muskellunge, ie. Eastern North America as well as extensive sites where the fish has been introduced in the South and Western United States

IS CONTRIBUTION BEYOND NORMAL REQUIREMENTS OF EMPLOYEE'S POSITION?

☒ YES ☐ NO

MONETARY SAVINGS:

MANPOWER	MATERIALS	SPACE	OTHER	TOTAL
$	$	$	$	$2,040,000

EXPLAIN METHOD OF CALCULATING SAVINGS

Wisconsin DNR currently stocks 140,000 muskellunge fingerlings and 1,000,000 muskellunge fry annually. Fry cost $.65 each and fingerlings $7.50 each to raise in hatcheries. Assuming a 50% applicability of this technique, to Wisconsin waters, Hatchery production costs of $850,000 could be reduced to costs of $170,000 (a savings of $680,000). This $680,000 savings would accrue annually to the State of Wisconsin alone. Assuming similar hatchery operations in Michigan and in sum in the other states and provinces in the Muskellunge's range, one is led to multiply the $680,000 savings by a factor of 3 = $2,040,000 which is felt to be a conservative estimate for the muskellunge. Savings for other cool and warmwater species hatchery operations could be much larger if broad application of the technique occurred.

An award of $13,400 is recommended based on the tangible awards scale.

DESCRIBE INTANGIBLE SAVINGS

This technique has a potentially high benefit over a very broad area of application. It has the potential to dramatically reduce warmwater hatchery costs worldwide.

OTHER BENEFITS